Edexcel Maths D1

Mark Scheme Pack

2001-2015

EDEXCEL - LONDON EXAMINATIONS

Stewart House 32 Russell Square London WC1B 5DN

January 2001

Advanced Supplementary/Advanced Level

General Certificate of Education

Subject **DECISION MATHEMATICS 6689** Paper No. **D1**

Question number	Scheme	Marks

1) (a)

	1	2	6	4	5	3
	Office	*A*	*B*	*C*	*D*	*E*
~~Office~~	~~—~~	~~8~~	~~16~~	~~12~~	~~10~~	~~14~~
~~*A*~~	⑧	~~—~~	~~14~~	~~13~~	~~11~~	~~9~~
~~*B*~~	~~16~~	~~14~~	~~—~~	~~12~~	~~15~~	⑪
~~*C*~~	~~12~~	~~13~~	~~12~~	~~—~~	~~11~~	⑧
~~*D*~~	⑩	~~11~~	~~15~~	~~11~~	~~—~~	~~10~~
~~*E*~~	~~14~~	⑨	~~11~~	~~8~~	~~10~~	~~—~~

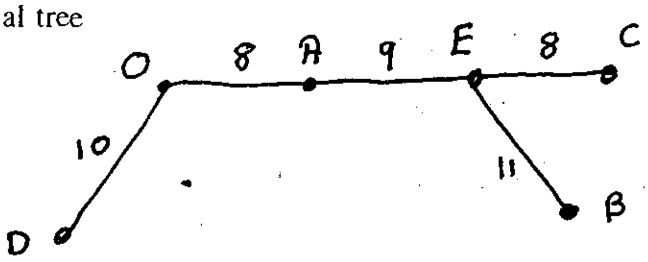
M1 A1 OA, AE (inc order)

Order of selecting edges

OA, AE, EC, OD, EB

M1 A1 rest (inc order

Final tree



A1

(5)

(*b*) Minimum total length of cable.

10 + 8 + 9 + 8 + 11 = 46

B1 √(1)

f.t. from tree/table

$\boxed{6}$

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(2)	(a) As there are 11 names in the list the middle location is $[\frac{1}{2}(11+1)] = 6$ ie JONES	
	Comparison 1: HUSSAIN occurs <u>before</u> JONES	M1 A1
	So list 2 is 1. ALLEN, 2. BALL, 3. COOPER 4. EVANS, 5 HUSSAIN.	
	middle is now $[\frac{1}{2}(1+5)] = 3$ ie COOPER	A1
	Comparison 2: HUSSAIN occurs <u>after</u> COOPER	M1 A1
	so list 3 is 4. EVANS, 5 HUSSAIN middle is now $[\frac{1}{2}(4+5)] = 5$	
	Comparison 3 HUSSAIN has been found at position 5	A1 (6)
	(b) Maximum number of comparisons with a list of 11 names is 4	B1 cao (1)
		$\boxed{7}$

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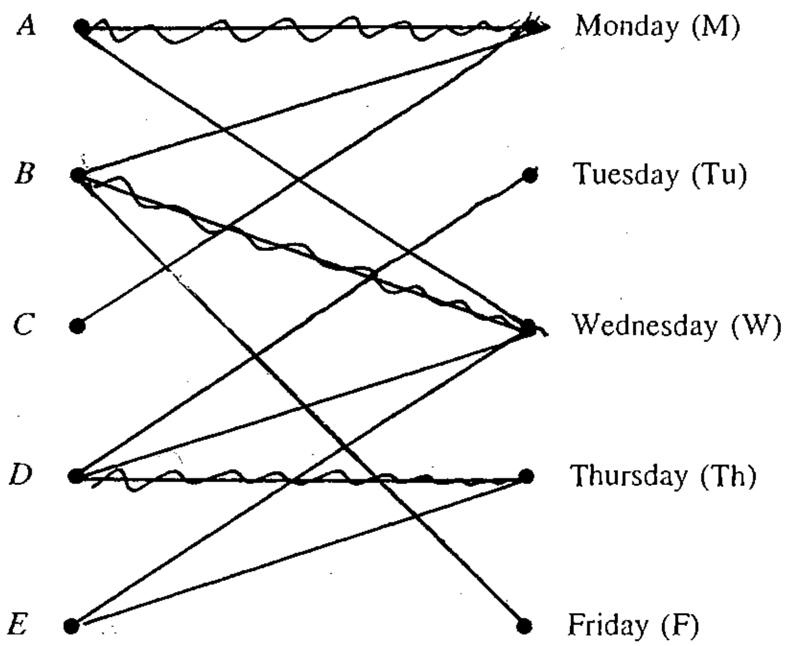
<table>
<tr><th>Question number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>(3)</td><td>(a)
<table>
<tr><td>vertex</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td></tr>
<tr><td>valency</td><td>3</td><td>2</td><td>4</td><td>3</td><td>3</td><td>3</td></tr>
</table>
Odd vertices are A, D, E and F.</td><td>B1 cao</td></tr>
<tr><td></td><td>Possible pairings   Shortest routes   Total
(A, F) and (D, E)   AF + DE (60) + (90)   150*
(A, E) and (D, F)   AFGE + DGF (170) + (70)   240
(A, D) and (E, F)   ACD + EGF (120) + (110)   230</td><td>M1 A1</td></tr>
<tr><td></td><td>So repeat AF and DE</td><td>A1√</td></tr>
<tr><td></td><td>Possible route AFEDEGDCBACGFA</td><td>A1√ (5)</td></tr>
<tr><td></td><td>(b) Total length of this route
= Total weight of edges + 150</td><td>M1</td></tr>
<tr><td></td><td>= 690 + 150 = 840 m</td><td>A1√ (2)</td></tr>
<tr><td></td><td></td><td>7</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

MARKS.

(4) (a)



B1

B1 (2)

(b) C – M = A – W = B – F (break through)

Changing status

C = M – A = W – B – F

Matching now D = Th, C = M, A = W, B = F

M1 A1

A1 (3)

(c) E – Th = D – Tu

Changing status

E = Th – D = Tu

So complete matching is

A = W, B = F, C = M, D = Tu, E = Th

M1 A1

A1 (3)

$\boxed{8}$

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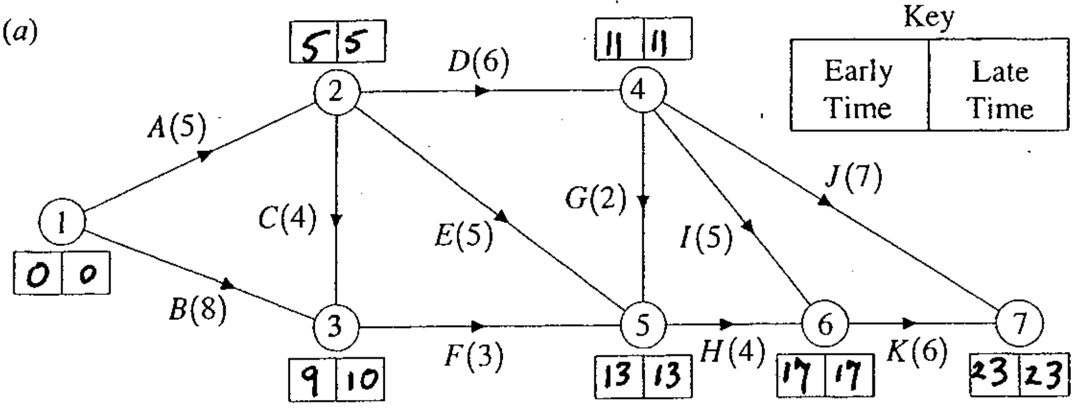
MARKS

(5) (*a*)



$e_1 = 0$, $e_2 = 5$, $e_3 = 9$ B1

$e_4 = 11$, $e_5 = \max(10, 12, 13) = 13$ M1 A1

$e_6 = \max(16, 17) = 17$, $e_7 = \max(18, 23) = 23$ B1

$l_7 = 23$, $l_6 = 17$, $l_5 = 13$

$l_4 = \min(16, 12, 11) = 11$, $l_3 = 10$ M1 A1 (6)

$l_2 = \min(6, 8, 5) = 5$, $l_1 = \min(2, 0) = 0$

(*b*) Critical activities A, D, G, H, K A1✓

Length of critical path $5 + 6 + 2 + 4 + 6 = 23$ A1✓ (2)

(*c*) M1 A1

M1 A2 -1ee

0 5 10 15 20 23 25

A	A	A	A	A	D	D	D	D	D	D	G	G	H	H	H	H	K	K	K	K	K	K		
B	B	B	B	B	B	B	B	E	E	E	E	E	J	J	J	J	J	J	J					
					C	C	C	C	F	F	F	I	I	I	I	I								

(5)

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(6)

(*a*) (i) *SAET* .... 5 — B1 cao

(ii) *SBDT* .... 4 — B1 cao

(iii) *SCFT* .... 3 — B1 cao (3)

(*b*)

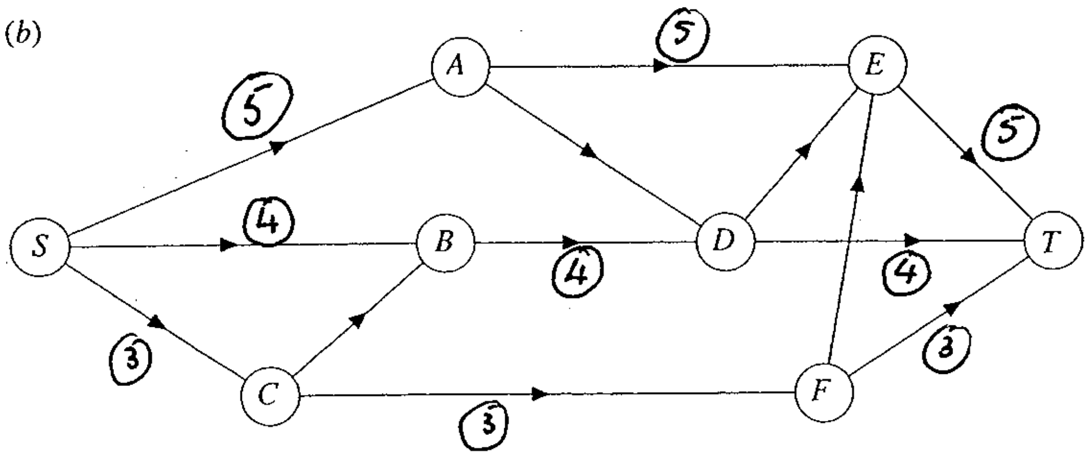

Diagram 1

B1 (1)

(*c*)

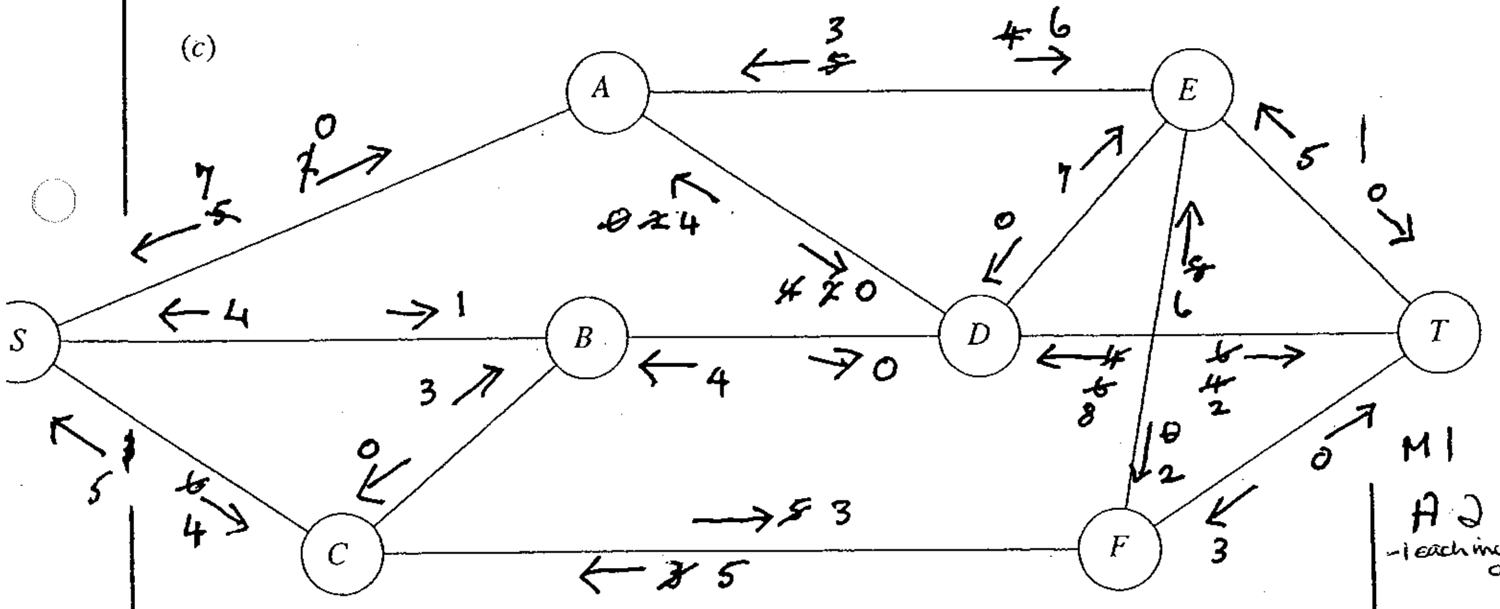

Diagram 2

M1

A2 -1 each incorrect arc

Flow augmenting routes

S A D T flow 2 — B1

S C F E A D T flow 2 — B1

Total flow 12 +2+2 =16 — A1 (6)

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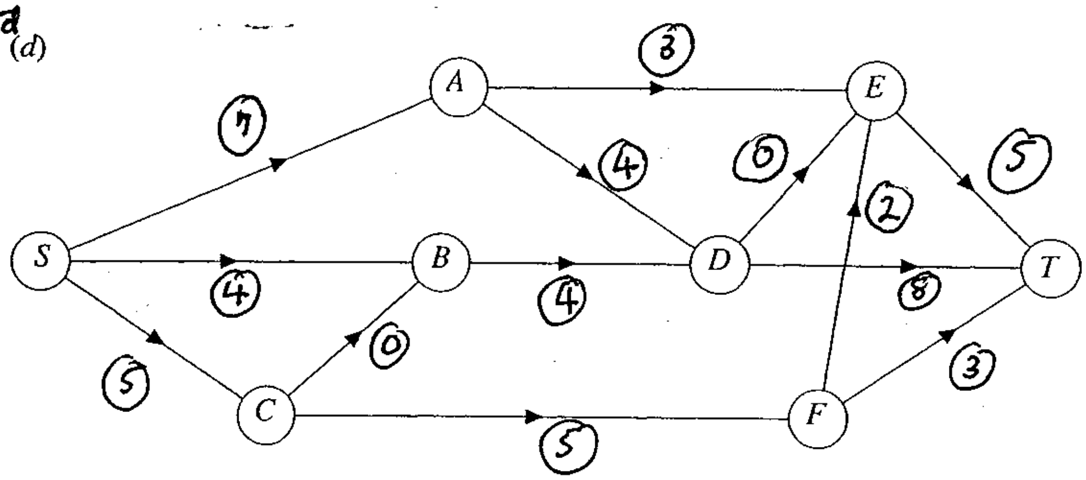
Question number	Scheme	Marks
6 contd (d)	 Diagram 3	M1 A1√ (2)
(e)	There is a cut of capacity 16 consisting of ET, FT, AD and BD [Alt: ET is saturated and FT is saturated. Only possible route to T is then DT. But as AD and BD are saturated no flow into D is possible]	M1 A1 (2)
		14

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Question number	Scheme	Marks
(7) (a)	Cotton $1.x + 2y \leqslant 70$ (available)	B1
	Wool $3x + 2y \leqslant 90$ (available)	B1
	Non negativity $x \geqslant 0, y \geqslant 0$.	(2)
(b)	Income £P where $P = 30x + 40y$	
	Objective to maximise P	
	Adding slack variables r and s	
	$x + 2y + r = 70$	
	$3x + 2y + s = 90$	M1
	So initial tableau is	

Basic Var	x	y	r	s	Value	
r	1	②	1	0	70	←
s	3	2	0	1	90	
P	-30	-40	0	0	0	
		↑				

A1

A1 (3)

Question number	Scheme	Marks
(c)	θ values row 1 : 70/2 = 35 *	
	row 2 : 90/2 = 45	M1 A1
	So ringed ② is pivot	
	Second tableau is then	

Basic Var	x	y	r	s	Value	
y	$\frac{1}{2}$	1	$\frac{1}{2}$	0	35	
s	②	0	-1	1	20	←
P	-10	0	20	0	1400	
	↑					

M1 A1

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Question number	Scheme	Marks

4 (contd)

θ values row 1 : $35/\frac{1}{2} = 70$

row 2 : $20/2 = 10$ * — M1 A1

So ringed ② is pivot

Third tableau is

Basic Var	x	y	r	s	Value
y	0	1	$3/4$	$-1/4$	30
x	1	0	$-1/2$	$1/2$	10
P	0	0	15	5	1500

A1

So $x = 10$, $y = 30$, $P = 1500$ — A1√ (8)

(d) $x + 2y = 70$ goes through (0, 35) (70, 0)

$3x + 2y = 90$ goes through (0, 45) (30, 0) — M1 A1

So A is (0, 35) D is (30, 0)

C is given by $x + 2y = 70$

and $3x + 2y = 90$

so $x = 10$ and $y = 30$ — M1 A1 (4)

(e) Initial tableau relates to O ($x=0, y=0, P=0$) — B1

Second tableau relates to A ($x=0, y=35$ $P=1400$) — B1

Third tableau relates to C ($x=10, y=30$ $P=1500$) — B1 (3)

$\boxed{20}$

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June 2001

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Final

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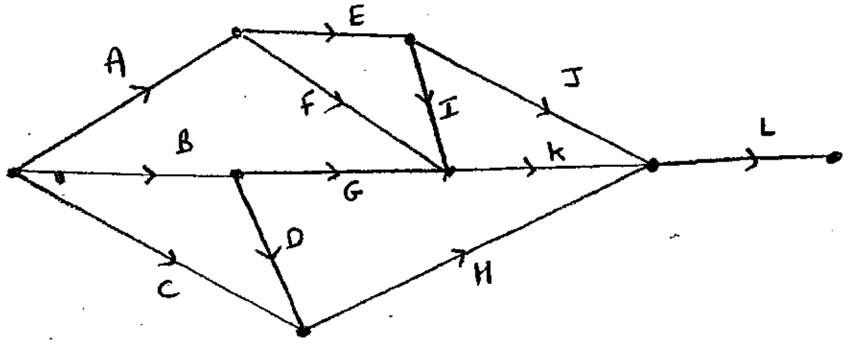
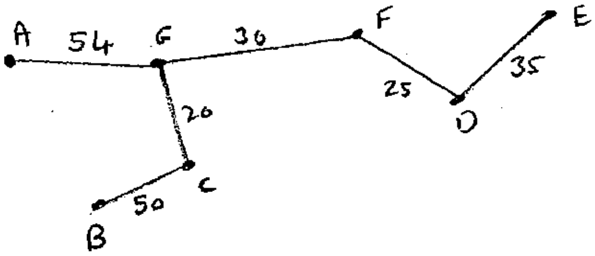
Question number	Scheme	Marks
1)		M1 (A → G) A1 A1✓(H → k) A1 (L) B1 arrows $\boxed{5}$
2) (a)	GC, FD, FG ; DE, BC, GA	M1 A1 ; M1 A1 (4)
(b)		B1✓
	Cost = (20 + 25 + 30 + 35 + 50 + 54), × 1 000 = £214 000	M1 A1 (3) $\boxed{7}$
3)	odd vertices B, C, F and G pairings BC + FG = 38 + 40 = 78 BF + CG = 66 + 68 = 134 BG + CF = 35 + 28 = 63 * Repeat BG and CF Minimum distance = 440 + 63 = 503m Route e.g. $A\underline{GB}CDE\overline{F}\underline{CF}\overline{G}BA$	B1 M1 A1 A1 (BF+CG) (4) M1 A1✓ B1 (3) $\boxed{7}$

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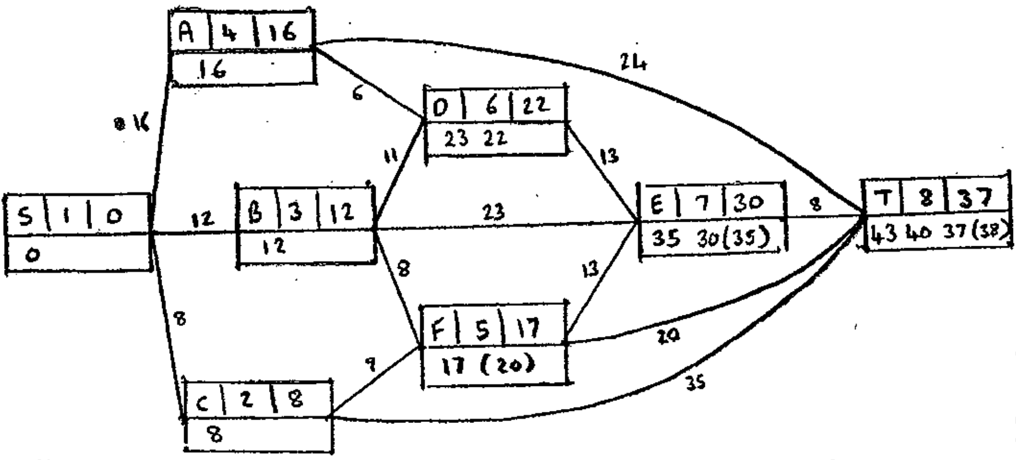
Question number	Scheme	Marks
4) (a)		M1 (Dijkstra) A1 (S, A, B, C) A1√(D, E) A1√(rest) A1√ (order) (5)
	either e.g. Trace back, Include an arc xy if y already included and weight of xy = final label of y − final label of x	B2, 1
	or e.g. T ← F : 37 − 17 = 20 (FT) F ← C : 17 − 8 = 9 (CF) C ← S : 8 − 0 = 8 (SC)	
	shortest route : SCFT length 37 km	A1 (3)
(b)	Need shortest path S to E plus ET	M1
	shortest path S to E is SCFE length 30km from above	A1√
	∴ SCFET length 38 km	A1√ (3)
		$\boxed{11}$

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Question number	Scheme		Marks
5) (a)	either Bubbling from left	or Bubbling from right	
	90 50 55 40 20 35 30 25 45	90 50 55 40 20 35 30 25 45	M1
	90 55 50 40 20 35 30 25 45	90 50 55 40 20 35 30 45 25	
	90 55 50 40 35 20 30 25 45	90 50 55 40 20 35 45 30 25	
	90 55 50 40 35 30 20 25 45	90 50 55 40 20 45 35 30 25	
	90 55 50 40 35 30 25 20 45	90 50 55 40 45 20 35 30 25	
	90 55 50 40 35 30 25 45 20	90 50 55 45 40 20 35 30 25	
	90 55 50 40 35 30 45 25 20	90 55 50 45 40 20 35 30 25	A1 (1st pass)
	90 55 50 40 35 45 30 25 20	90 55 50 45 40 35 20 30 25	A1√(2nd pass)
	90 55 50 40 45 35 30 25 20	90 55 50 45 40 35 30 20 25	A1√(3rd pass)
	90 55 50 45 40 35 30 25 20	90 55 50 45 40 35 30 25 20	A1 cso
			(5)
(b)	$\frac{475}{120} \simeq 3.96$ so lower bound is 4 tapes		M1 A1 (2)
(c)	Tape 1 : 90 + 30 (full) Tape 2 : 55 + 50	Tape 3 : 45 + 40 + 35 (full) Tape 5 : 20 Tape 4 : 35 + 30 + 25 + 20	M1 A1 A1 (3)
(d)	e.g. Tape 1 : 90 + 30 (full) Tape 2 : 55 + 35 + 30 (full) Tape 3 : 45 + 40 + 35 (full) Tape 4 : 50 + 25 + 20 + 20		M1 A1 (2)
			$\boxed{12}$

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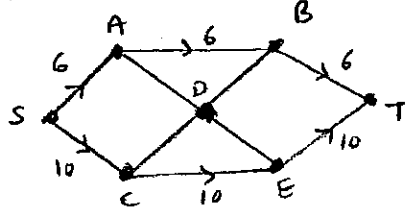
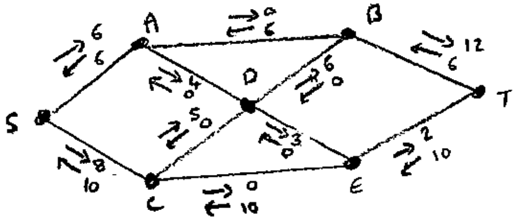
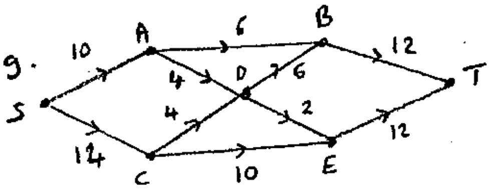
Question number	Scheme	Marks
6) (a)	Finds a cut less than 30 eg AB, AD, CD, CE - 25 giving its value or AB, BD, ET - 24 or a consideration of flow input / flow output through e.g. A and C	M1 A1 A1 (3)
(b)	(i) SABT - 6 (ii) SCET - 10	B1 B1 (2)
(c)		B1 (1)
(d)		M1 A1 M1 A1
	e.g. SADBT - 4 SCDBT - 2 SCDET - 2 , ∴ max flow 24	A1 B1 (6)
(e)	e.g. 	M1 A1 (2)
(f)	Refers to max flow – min cut theorem and the cut through AB, BD, ET of value 24	M1 A1 (2) $\boxed{16}$

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Question number	Scheme	Marks
7 (a)(i)	Slack variables, used to enable us to write inequalities as equalities all ≥ 0	M1 A1
(ii)	$P - 3x - 6y - 4z = 0$	B1 (3)

(b)

b.v.	x	y	z	r	s	t	value		
r	1	0	1	1	0	0	4		
s	1	④	2	0	1	0	6	$R_2 \div 4$	M1
t	1	1	2	0	0	1	12		
P	-3	-6	-4	0	0	0	0		

b.v.	x	y	z	r	s	t	value		
									A1 (R_2)
r	①	0	1	1	0	0	4		
y	$\frac{1}{4}$	1	$\frac{1}{2}$	0	$\frac{1}{4}$	0	$1\frac{1}{2}$		M1
t	$\frac{3}{4}$	0	$1\frac{1}{2}$	0	$-\frac{1}{4}$	1	$10\frac{1}{2}$	$R_3 - R_2$	A1
P	$-1\frac{1}{2}$	0	-1	0	$1\frac{1}{2}$	0	9	$R_4 + 6R_2$	A1
									A1√ (pivot)

b.v.	x	y	z	r	s	t	value		
x	1	0	1	1	0	0	4		M1
y	0	1	$\frac{1}{4}$	$-\frac{1}{4}$	$\frac{1}{4}$	0	$\frac{1}{2}$	$R_2 - \frac{1}{4}R_1$	A1
t	0	0	$\frac{3}{4}$	$-\frac{3}{4}$	$-\frac{1}{4}$	1	$7\frac{1}{2}$	$R_3 - \frac{3}{4}R_1$	A1
P	0	0	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	0	15	$R_4 + 1\frac{1}{2}R_1$	A1 (10)

Question number	Scheme	Marks
(c)	Maximum profit is £15	M1 A1√
	when $x = 4$ kg, $y = \frac{1}{2}$ kg, $z = 0$ kg	A1√
	The first and second constraints have no slack	B1√
	There is a slack of $(7\frac{1}{2})$ in the third constraint	(4)

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Question 2 Prims Algorithm (a) only

Part (a) is worth 4 marks. If they use Prim they will get 2 marks maximum. Put S.C in the margin.

M1 – Their first 4 arcs correct
– tree growing in a connected manner

A1 – cao

E.g. for M marks

starting at	A	AG, GC, GF, FD	for M1
starting at	B	BC, CG, GF, FD	for M1
starting at	C	CG, GF, FD, DE	for M1
starting at	D	DF, FG, GC, DE	for M1
starting at	E	ED, DF, FG, GC	for M1
starting at	F	FD, FG, GC, DE	for M1
starting at	G	GC, GF, FD, DE	for M1

SG James

Q 5a Ascending

MARK AS MISREAD - unless they reverse in (a)

Left to Right

90 50 55 40 20 35 30 25 45
50 90 55 40 20 35 30 25 45
50 55 90 40 20 35 30 25 45
50 55 40 90 20 35 30 25 45
50 55 40 20 90 35 30 25 45
50 55 40 20 35 90 30 25 45
50 55 40 20 35 30 90 25 45
50 55 40 20 35 30 25 90 45
50 55 40 20 35 30 25 45 90 (M1A1)
50 40 55 20 35 30 25 45 90
50 40 20 55 35 30 25 45 90
50 40 20 35 55 30 25 45 90
50 40 20 35 30 55 25 45 90
50 40 20 35 30 25 55 45 90
50 40 20 35 30 25 45 55 90 (A1✓)
40 50 20 35 30 25 45 55 90
40 20 50 35 30 25 45 55 90
40 20 35 50 30 25 45 55 90
40 20 35 30 50 25 45 55 90
40 20 35 30 25 50 45 55 90
40 20 35 30 25 45 50 55 90 (A1✓)
20 40 35 30 25 45 50 55 90
20 35 40 30 25 45 50 55 90
20 35 30 40 25 45 50 55 90
20 35 30 25 40 45 50 55 90
20 30 35 25 40 45 50 55 90
20 30 25 35 40 45 50 55 90
20 25 30 35 40 45 50 55 90 (A1cso)

Stop.

Now subtract (a) 2A's

Right to Left

90 50 55 40 20 35 30 25 45
90 50 55 40 20 35 25 30 45
90 50 55 40 20 25 35 30 45
90 50 55 20 40 25 35 30 45
90 50 20 55 40 25 35 30 45
90 20 50 55 40 25 35 30 45
(M1A1) 20 90 50 55 40 25 35 30 45
20 90 50 55 40 25 30 35 45
20 90 50 55 25 40 30 35 45
20 90 50 25 55 40 30 35 45
20 90 25 50 55 40 30 35 45
(A1✓) 20 25 90 50 55 40 30 35 45
20 25 90 50 55 30 40 35 45
20 25 90 50 30 55 40 35 45
20 25 90 30 50 55 40 35 45
(A1✓) 20 25 30 90 50 55 40 35 45
20 25 30 90 50 55 35 40 45
20 25 30 90 50 35 55 40 45
20 25 30 90 35 50 55 40 45
20 25 30 35 90 50 55 40 45
20 25 30 35 90 50 40 55 45
10 25 30 35 90 40 50 55 45
20 25 20 35 40 90 50 55 45
20 25 30 35 40 90 50 45 55
20 25 30 35 40 90 45 50 55
20 25 30 35 40 45 90 50 55
20 25 30 35 40 45 50 90 55
(A1cso) 20 25 30 35 40 45 50 55 90

Stop

Now subtract (a) 2A's

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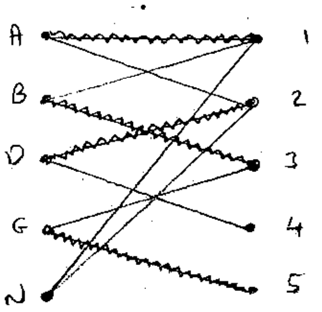
1)	(a)		B1 B1 (2)
	(b)	Possible paths $N <$ 1 = A − 2 = D − 4 $\quad$ 2 = D − 4 N = 1 − A = 2 − D = 4 or N = 2 − D = 4 A − 2 D − 4 A − 1 D − 4 B − 3 G − 5 B − 3 G − 5 N − 1 N − 2	M1 A1 A1
	(c)	Gives second alternating path	A1 (4) 6
2)	(i)	10 names so middle is $[\frac{1}{2}(10+1)] = 6$ FEW SABINE must occur after FEW so list reduces to 7. Osborne 8. Paul 9. Swift 10. Turner middle location is $[\frac{1}{2}(10+7)] = 9$ SWIFT SABINE must occur before SWIFT, so list reduces to 7. Osborne 8. Paul middle location is $[\frac{1}{2}(7+8)] = 8$ PAUL SABINE must occur after PAUL, but there is no entry in list after PAUL ∴ SABINE not in list	M1 A1 A1 ✓ A1 ✓ A1 cso (5)
	(ii)	Iterations reduce list to maximum lengths as follows 1000, 500, 250, 125, 62, 31, 15, 7, 3, 1 (Final iteration to check if list of 1 is the correct name) ∴ 10 iterations (accept 11)	M1 A1 cao (2) 7

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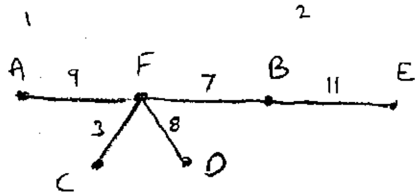
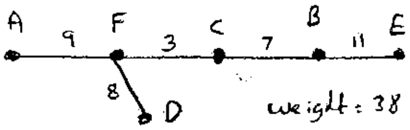
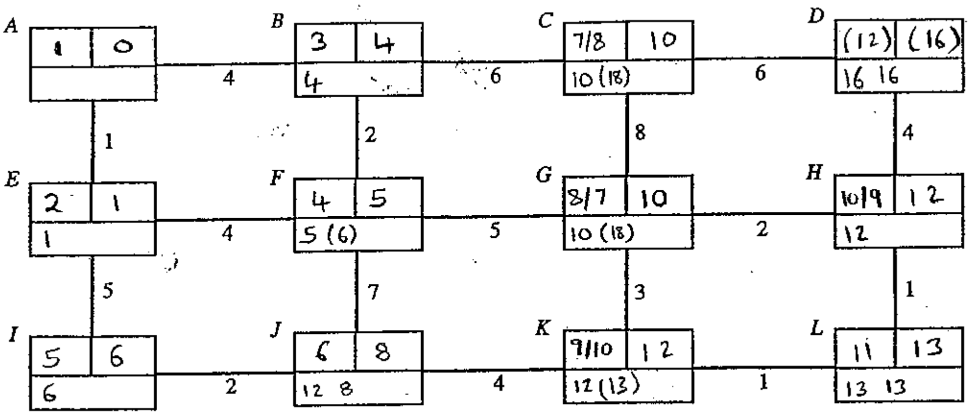
Subject **DECISION MATHEMATICS 6689** Paper No. **D1**

Question number	Scheme	Marks
3)(i)(a)	method: choose vertex nearest to A and add to tree choose vertex nearest to any vertex on tree repeat last step until all vertices included } or an account of the specific solution to this problem	M1 A1
	Order of arc selection: AF, FC, FB or BC, FD, EB	M1 A1 (4)
b)	 or 	B1✓ B1✓
(c)	Not unique - gives other one, or convincing explanation	B1 (3)
(ii)(a)	number of edges = 7 − 1 = 6	B1
(b)	number of vertices = n + 1	B1 (2) 9
4) (a)		m1(Dijkstra) A1 A1✓ A1 (4)
	Traceback. Include arc xy if y is already on the path and length of arc xy = final label of y − final label of x or a detailed account for this question	B2,1,0
	path is { A E F G H L A E I J K L } (of length 13)	A1
(b)	States other path	B1 (4) 8

EDEXCEL FOUNDATION

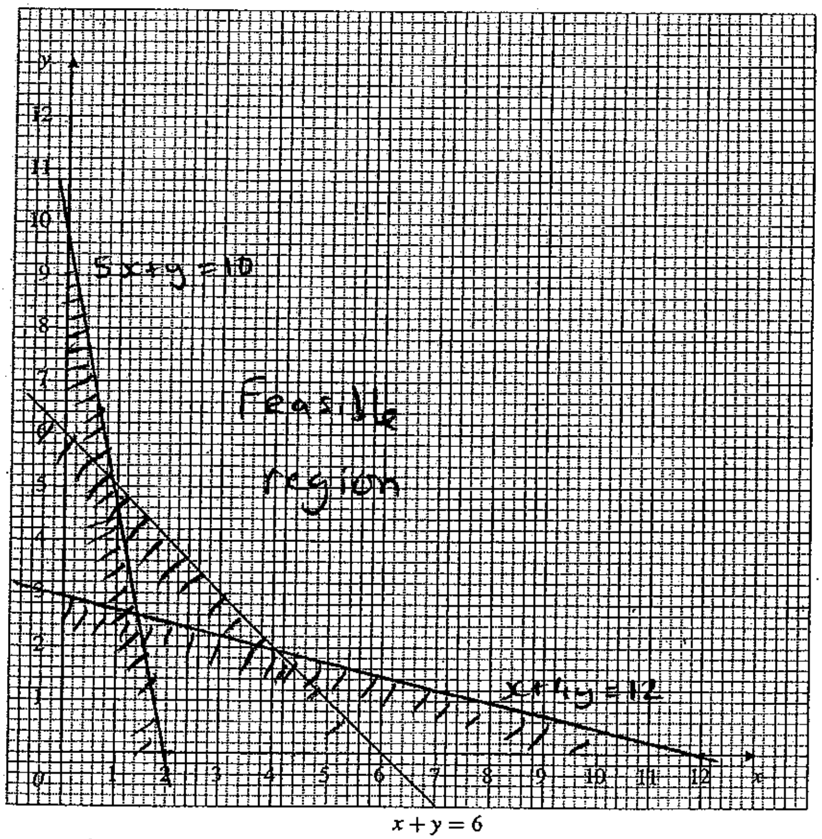
Stewart House 32 Russell Square London WC1B 5DN

January 2002

Advanced Supplementary/Advanced Level

General Certificate of Education

Subject DECISION MATHEMATICS 6689 **Paper No. D1**

Question number	Scheme	Marks
5) (a)	Chemical A $5x + y \geqslant 10$ *	B1
	chemical B $2x + 2y \geqslant 12 \rightarrow x + y \geqslant 6$ *	B1
	chemical C $\frac{1}{2}x + 2y \geqslant 6 \rightarrow x + 4y \geqslant 12$ *	B1
	$x \geqslant 0$ $y \geqslant 0$ – from context	B1 (4)
(b)		B1√ B1√ B1 (3)
(c)	$T = 2x + 3y$	B1 (1)
(d)	Profit line or point testing (≥3)	M1 A1
	$x = 4$ $y = 2$, $T = 14$	A1 A1√ (4)
(e)	Three (or more) variables e.g A blend of three fertilizers x, y and z	M1 A1 (2) 14

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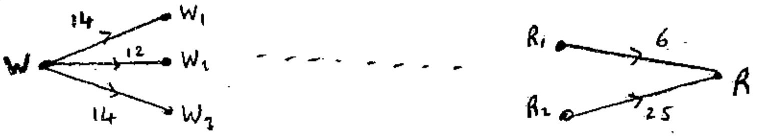
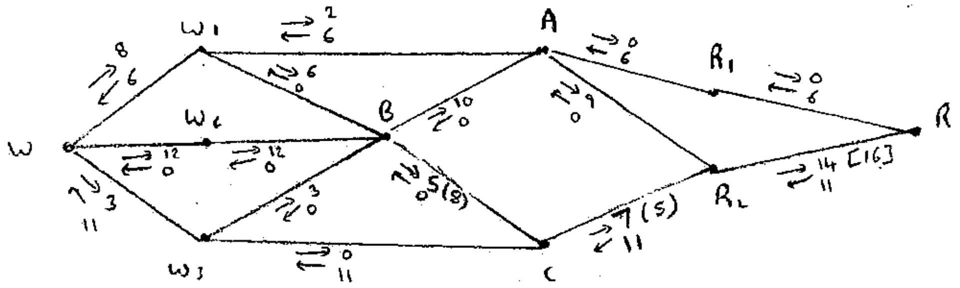
Subject **DECISION MATHEMATICS 6689** Paper No. **D1**

Question number	Scheme	Marks
6) (a)		M1 A1 A1 (3)
(b)	(i) WW_1AR_1R – 6 (ii) WW_3CR_2R – 11	B1 B1 (2)
(c)	 e.g. WW_1BAR_2R – 6 WW_1AR_2R – 2 WW_2BCR_2R – 5 WW_2BAR_2R – 1 max flow 31	M1 A1 A1 A1 A1√ (5)
(d)	correct for <u>their</u> network	B1√ (1)
(e)	<u>All</u> candidates to receive 3 marks	(3)
		$\boxed{14}$

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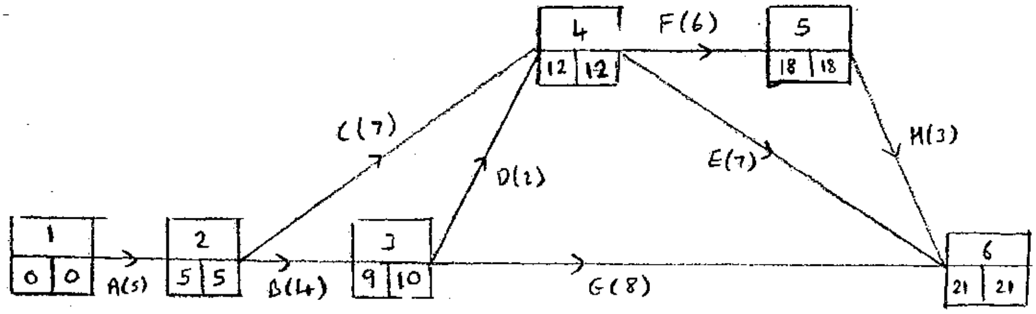
Subject **DECISION MATHEMATICS 6689** Paper No. **D1**

Question number | Scheme | Marks

7) (a)



Forward pass M1 A1
Backward pass M1 A1
(4)

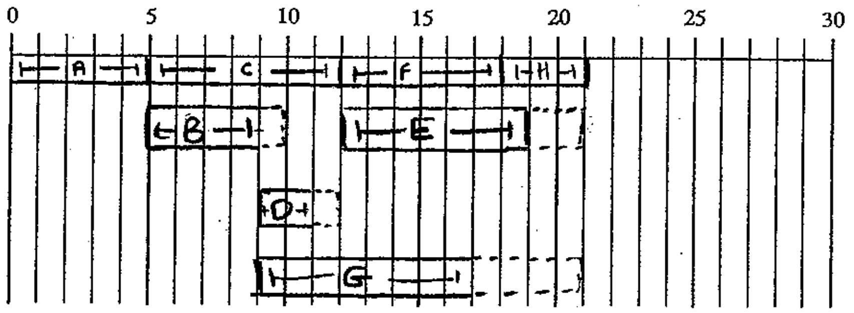
(b) activities A, C, F and H, length 21

B1, B1√ (2)

(c) Float for B is 1 (: 10 - 5 - 4)
D is 1 (= 12 - 9 - 2)
E is 2 (= 21 - 12 - 7)
G is 4 (= 21 - 9 - 8)

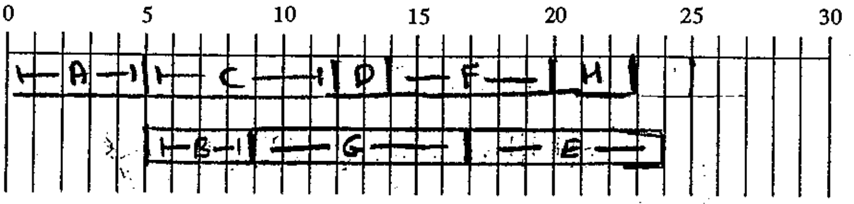
M1
A1
A1 (3)

(d)



M1 A1
A1√
A1
(4)

(e) e.g.



M1 A1
A1

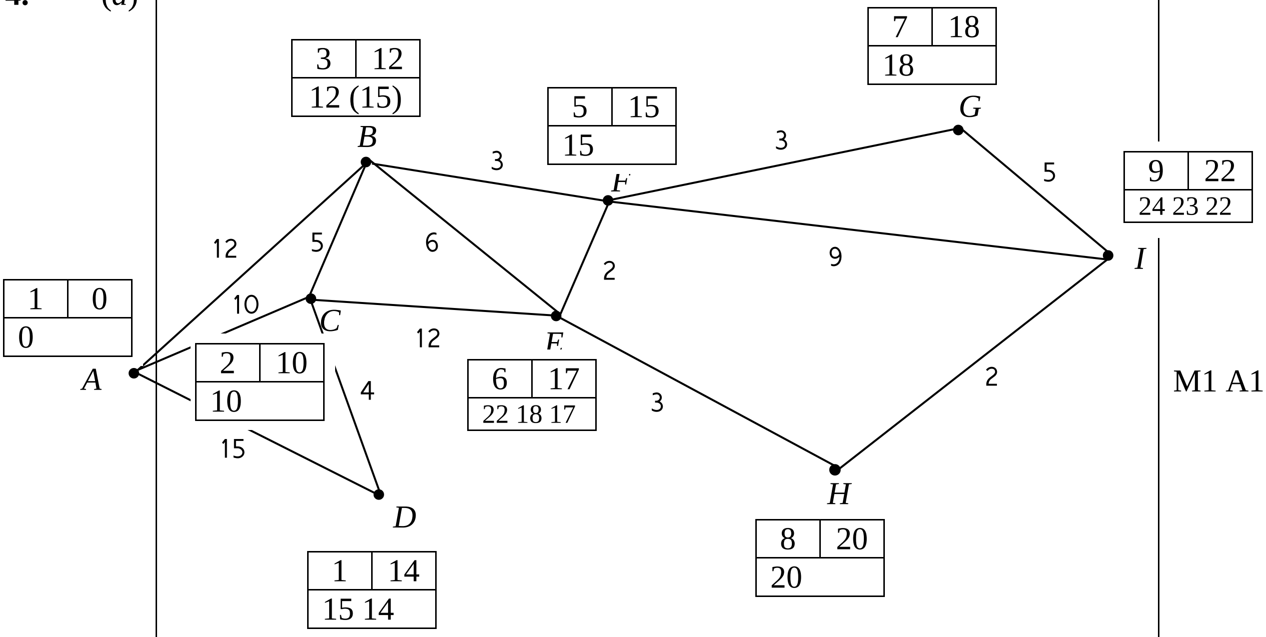
24 days

A1 (4)

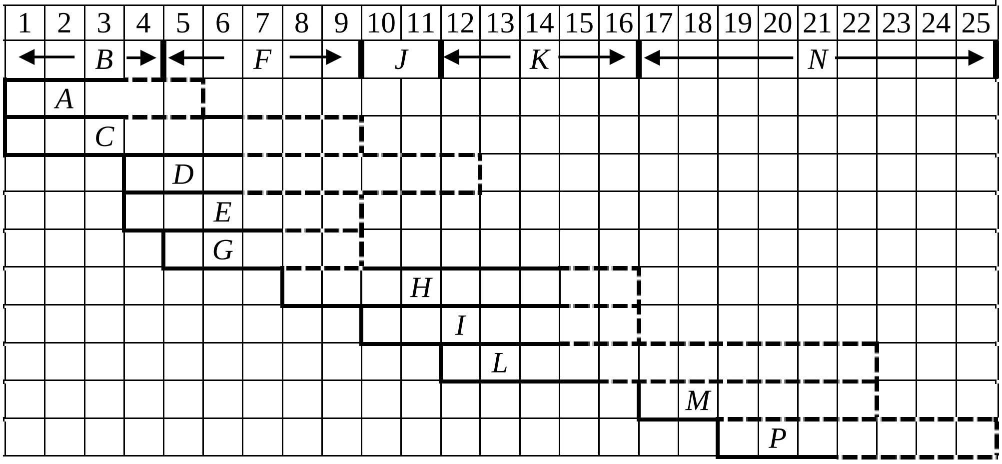
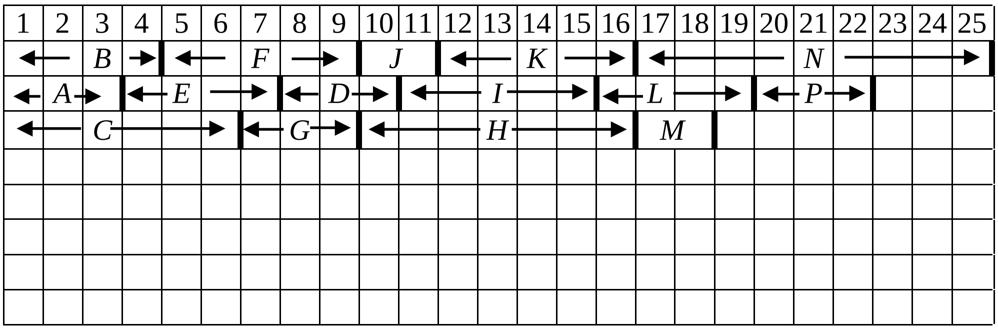
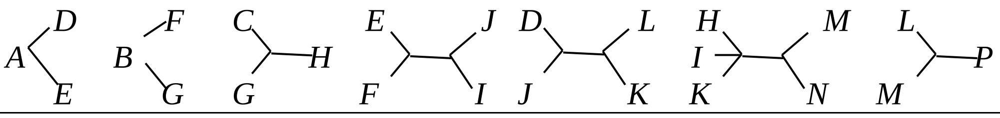
$\boxed{17}$

EDEXCEL DECISION MATHEMATICS D1 (6689) - JUNE 2002 PROVISIONAL MARK SCHEME

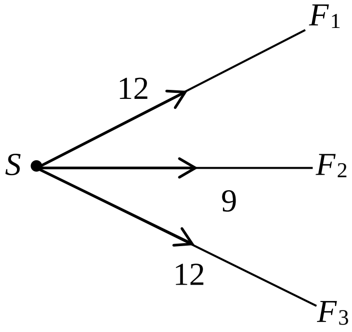
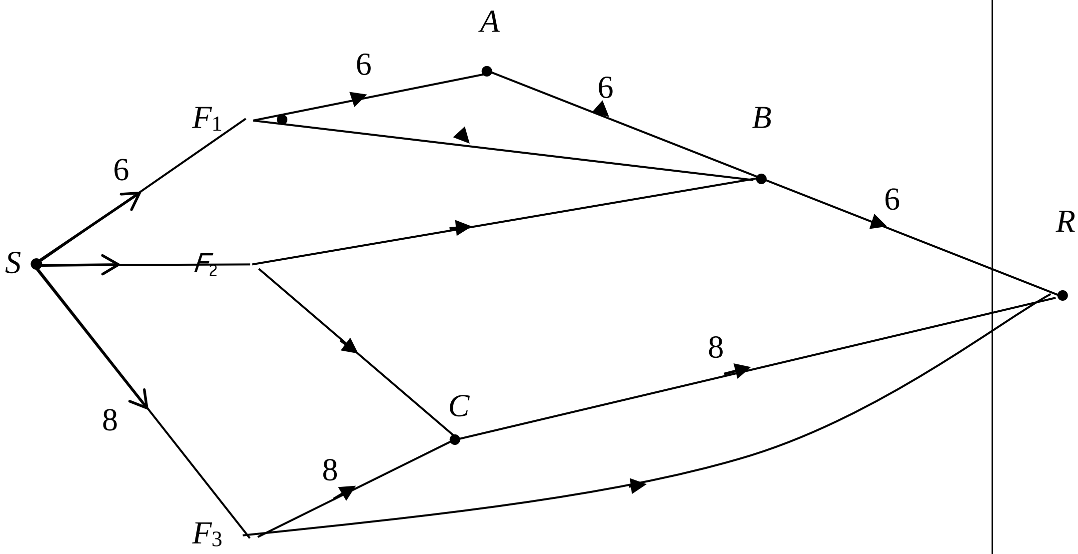
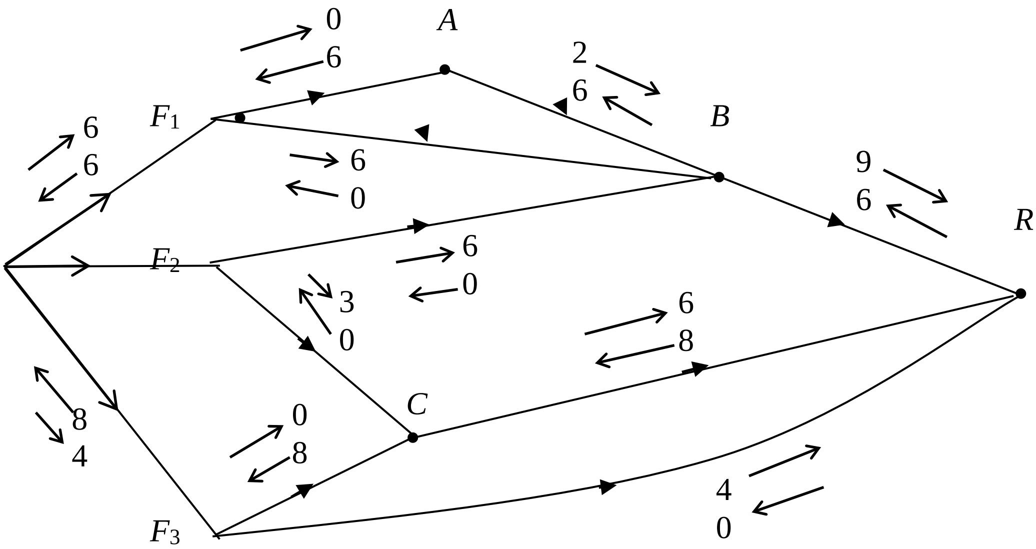
Question Number	Scheme	Marks
1.	6 1 18 12 ⑨ 0 5 13 14	M1
	18 12 ⑬ 14 $\boxed{9}$ 6 1 ⓪ 5	
	18 ⑭ $\boxed{13}$ ⑫ $\boxed{9}$ 6 ① 5 $\boxed{0}$	A1
	⑱ $\boxed{14}$ $\boxed{13}$ $\boxed{12}$ $\boxed{9}$ 6 $\boxed{5}$ $\boxed{1}$ $\boxed{0}$	A1
	$\boxed{18}$ $\boxed{14}$ $\boxed{13}$ $\boxed{12}$ $\boxed{9}$ ⑥ $\boxed{5}$ $\boxed{1}$ $\boxed{0}$	
	$\boxed{18}$ $\boxed{14}$ $\boxed{13}$ $\boxed{12}$ $\boxed{9}$ $\boxed{6}$ $\boxed{5}$ $\boxed{1}$ $\boxed{0}$	A1
	Datchet (18), Wraysbury (14), Staines (13), Feltham (12), Halliford (9), Ashford (6), Poyle (5), Colnbrook (1), Laleham (0).	A1 **(5)**
		(5 marks)
2. (*a*)	No negative elements in the profit row.	B1 **(1)**
(*b*)	$P = 11, x = 1, y = \frac{1}{3}, z = 0;\ r = \frac{2}{3}\ s = 0, t = 0$	M1 A1; A1 **(3)**
(*c*)	$P + z + s + t = 11$	B1
	$\Rightarrow P = 11 - z - s - t$ so increasing *z*, *s* or *t* would decrease *P*.	B1 **(2)**
		(6 marks)
3. (*a*)	$1 - C$ $1 - C$	B1
	$2 - B$ $2 - A$	B1 **(2)**
	$3 - B$ and $3 - D$	
	$4 - E$ $4 - B$	
	$5 - D$ $5 - A$	
(*b*)	$2 - B = 4 - C = 1 - E$	M1 A1
	$2 - D = 5 - E$	M1 A1 **(4)**
		(6 marks)

Question Number	**Scheme**	**Marks**
4. (*a*)		M1 A1 A1 **(3)**
	Shortest route *ABFEHI*, length 22 km	B1 B1 **(2)**
(*b*)(i)	Odd vertices *A* and *I* only, shortest route between them needs to be repeated, hence repeat	M1
	AB, *BF*, *FE*, *EH*, *HI*	A1
(ii)	e,g. $\underline{A\overline{B}}\underline{\overline{F}B}\overline{EF}GI\underline{F\overline{E}}\underline{\overline{H}I}\underline{HE}CDAC\overline{BA}$	A1 **(3)**
(ii)	91 + 22 = 113 km	M1 A1 **(2)**
		(Marks 10)

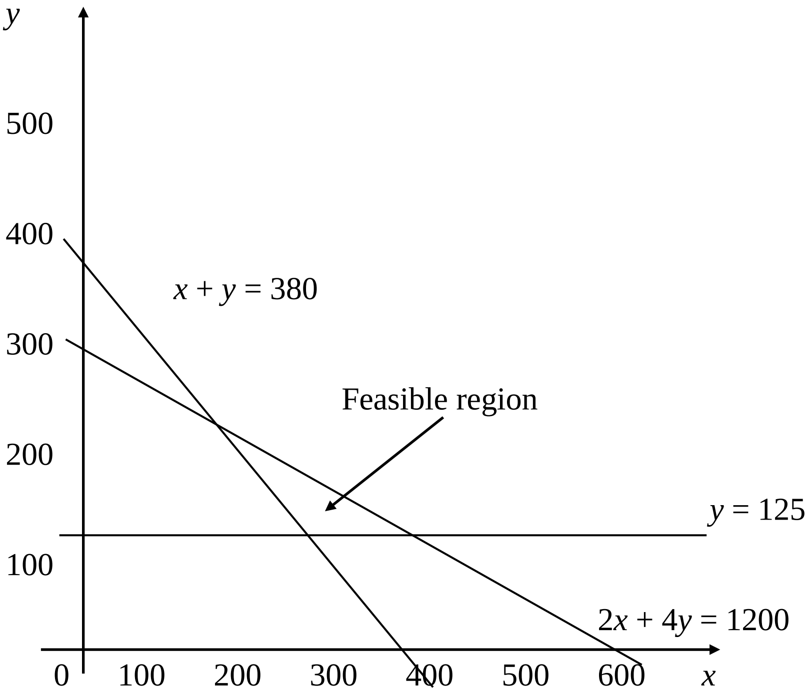
<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>5. (<i>a</i>)</td><td>
<table>
<tr><th>a</th><th>b</th><th>c</th><th>d</th><th>e</th><th>f</th><th>$f = 0$?</th></tr>
<tr><td>645</td><td>255</td><td>2.53</td><td>2</td><td>510</td><td>135</td><td>No</td></tr>
<tr><td>255</td><td>135</td><td>1.89</td><td>1</td><td>135</td><td>120</td><td>No</td></tr>
<tr><td>135</td><td>120</td><td>1.13</td><td>1</td><td>120</td><td>15</td><td>No</td></tr>
<tr><td>120</td><td>15</td><td>8</td><td>8</td><td>120</td><td>0</td><td>Yes</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td><td>M1 A1
M1 A1
A1
A1</td></tr>
<tr><td></td><td>The answer is 15</td><td>A1 (7)</td></tr>
<tr><td>(<i>b</i>)</td><td>The first row would be
255 645 0.40 0 0 255 No</td><td>M1 A1</td></tr>
<tr><td></td><td>But the second row would then be the same as the first row above, and the solution thereafter would be the same.</td><td>A1 (3)</td></tr>
<tr><td>(<i>c</i>)</td><td>Finds the H.C.F of a and b.</td><td>B1 (1)</td></tr>
<tr><td></td><td></td><td>(11 marks)</td></tr>
</table>

Question Number	Scheme	Marks
6. (*a*)	Critical activities *B*, *F*, *J*, *K*, *N* (not *I*); length 25 hours	B1; B1 **(2)**
(*b*)	$A = 5 - 0 - 3 = 2$ $C = 9 - 0 - 6 = 3$ $D = 11 - 3 - 3 = 5$ $E = 9 - 3 - 4 = 2$ $G = 9 - 4 - 3 = 2$ $H = 16 - 7 - 7 = 2$ $I = 16 - 9 - 5 = 2$ $L = 22 - 11 - 4 = 7$ $M = 22 - 16 - 2 = 4$ $P = 25 - 18 - 3 = 4$	M1 A1 ft A1 **(3)**
(*c*)		M1 A1 A1 ft A1 ft
(*d*)		M1 A1
	3 workers needed	A1 **(3)**
	Precedences: 	**(12 marks)**

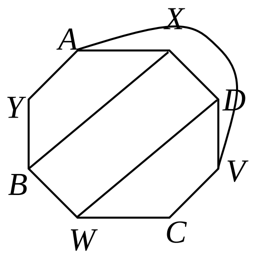
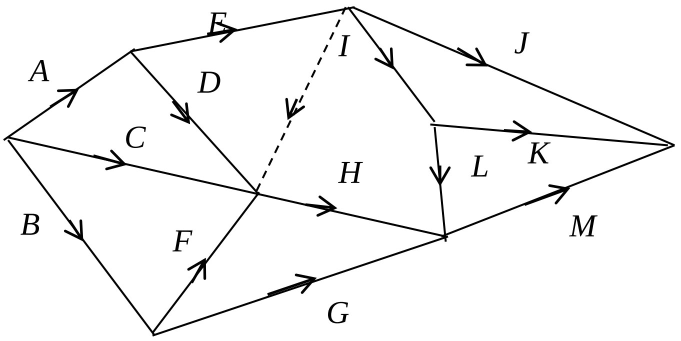
ft = follow through mark

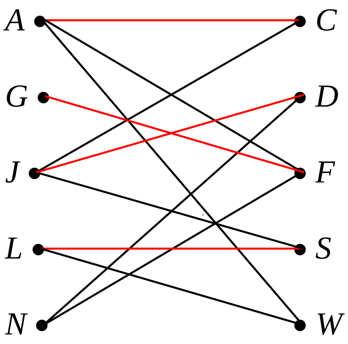
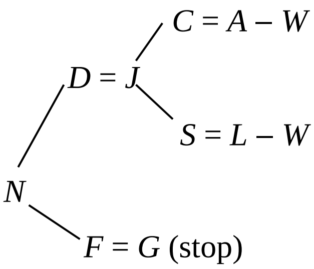
Question Number	Scheme	Marks
7. (*a*)		M1 A1 **(2)**
(*b*) (i)	$SF_1ABR = 6$	B1
(ii)	$SF_3CR = 8$	B1 **(2)**
		
(*c*)(i)		M1 A1
	e.g. $SF_1BR = 6$, $SF_2BR = 3$, $SF_2CR = 3$, $SF_3R = 4$	A1 A1
	Total flow = 30	A1 **(5)**
(ii)	Max flow – min cut theorem	M1
	Cut BR, F_2C, F_3C, F_3R	A1 **(2)**

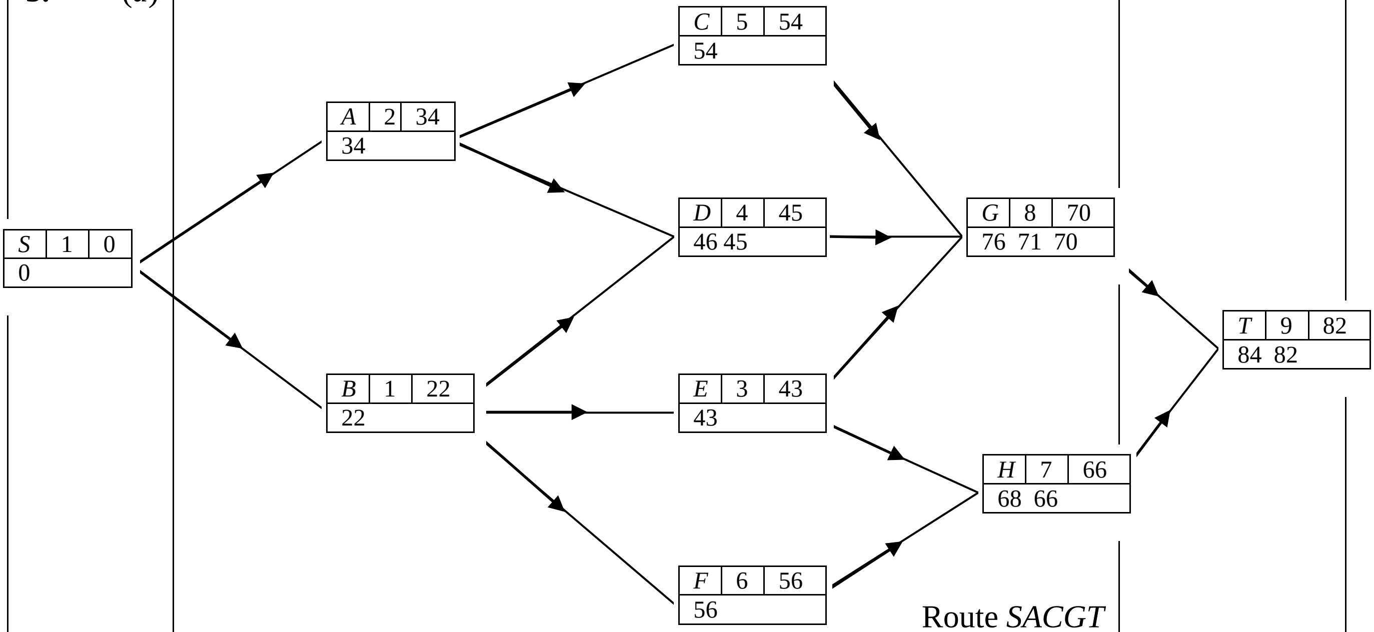
		(11 marks)

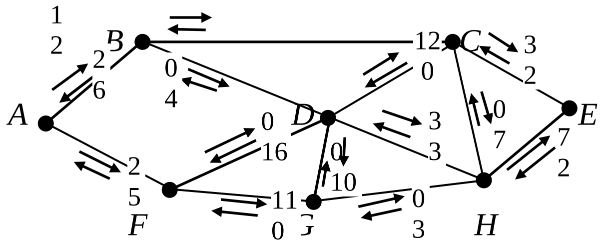
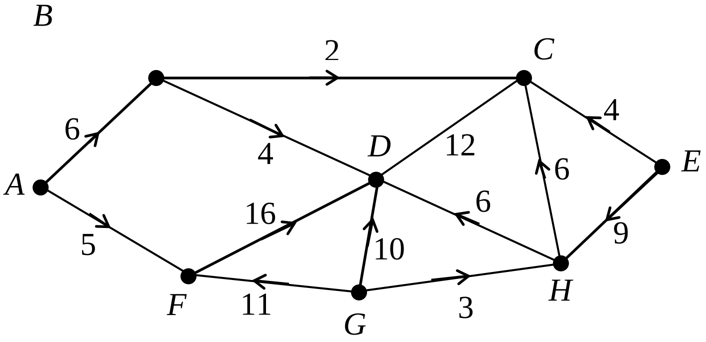
Question Number	Scheme	Marks
8. (*a*)	$x + y \geq 380$	B1
	$y \geq 125$	B1
	$2x + 4y \leq 1200$	B1 **(3)**
(*b*)	$c = 3x + 2y$	B1 **(1)**
(*c*)		B1 B1 B1 B1 **(4)**
	Use of profit line or points testing	M1
	Minimum intersection of $x + y = 380$ and $2x + 4y = 1200$	
	$x = 160$, $y = 120$, cost = £920	A1 A1 **(3)**
(*d*)	Maximum at intersection of $y = 125$ and $2x + 4y = 1200$	M1
	$x = 350$, $y = 125$, cost = £1300	A1 A1 **(3)**
		(14 marks)

EDEXCEL DECISION MATHEMATICS D1 (6689) - NOVEMBER 2002 PROVISIONAL MARK SCHEME

Question Number	Scheme	Marks
1. (*a*)	(*A*, *X*, *D*, *V*), *C*, *W*, *B*, *Y*, *A*	M1, A1 **(2)**
(*b*)		M1 A1 **(2)**
		(4 marks)
2. (*a*)		M1 A1 (*A* →*F*) A1 (dummy) A1 (*G* → *M*) A1 (1 start + 1 finish) **(5)**
(*b*)	*H*, *I* and *J* all depend on *E*, but *I* and *J* depend *only* on *E* whereas *H* depends on *E and C* and *D* and *F*	B1 **(1)**
		(6 marks)

Question Number	Scheme	Marks
3. (*a*)		B1, B1 **(2)**
(*b*)		
	So either $N = D – J = C – A = W$ Or $N = D – J = S – L = W$	M1 A1
	Matchings $A – W$, $G – F$, $J – C$, $L – S$ and $N – D$ Or $A – C$, $G – F$, $J – S$, $L – W$ and $N – D$	A1 **(3)**
(*c*)	If J does D, N must do F, leaving G without a sport to coach.	B2, 1, 0 **(2)**
		(7 marks)
4. (*a*)	Odd nodes C, F, G, H	B1
	$CF + GM = 12 + 8 = 20$	
	$CG + FM = 9 + 7 = 16$	M1
	$CM + FG = 9 + 10 = 19$	A1
	So CG and FH should be repeated	A1 **(4)**
(*b*)	FH is the shortest path so finish at G	B2, 1, 0
	Length of route = 137 + 7 = 144	B1 **(3)**
		(7 marks)

Question Number	Scheme		Marks
5. (*a*)		Route *SACGT*	
		length 82	A1 ft **(6)**
(*b*)	E.g. 82 – 12 = 70 *GT* 70 – 16 = 54 *CG* 54 – 20 = 34 *AC* 34 – 34 = 0 *SA*	Work back from *T*. Include arc *XY* if *Y* already lies on the path and arc length *XY* = Final label of *Y* – final label of *X*	B2, 1,0 **(2)**
(*c*)	Shortest route *S* to *H* + *HT*		M1
	SBFHT length 84		A1 **(2)**
6. (*a*)	Left to right	Right to left	M1
	55 80 25 84 25 34 17 75 3 5	55 80 25 84 25 34 17 75 3 5	
	80 55 84 25 34 25 75 17 5 3	84 55 80 25 75 25 34 17 5 3	A1
	80 84 55 34 25 75 25 17 5 3	84 8 55 75 25 34 25 17 5 3	A1
	84 80 55 34 75 25 25 17 5 3	84 80 75 55 34 25 25 17 5 3	A1
	84 80 55 75 34 25 25 17 5 3		
	84 80 75 55 34 25 25 17 5 3		
	Sort complete, no more changes		A1 **(5)**
(*b*)	403 ÷ 100 = 4.03 ∴ 5 bins		M1 A1 **(2)**
(*c*)	Bin 1 84 5		
	Bin 2 80 17 3		
	Bin 3 75 25		
	Bin 4 55 34		M1 (to 34)
	Bin 5 25		A1 (to 2nd 25)
			A1 **(3)**
			(10 marks)

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>7. (<i>a</i>)</td><td><i>A</i>, <i>E</i> and <i>G</i></td><td>B2, 1, 0</td></tr>
<tr><td>(<i>b</i>)</td><td>45</td><td>B1 (3)</td></tr>
<tr><td>(<i>c</i>)</td><td>
</td><td>M1
A1</td></tr>
<tr><td></td><td>e.g <i>EHD</i> – 2</td><td>M1 A1</td></tr>
<tr><td></td><td><i>ECHD</i> – 1</td><td>M1 A1 (6)</td></tr>
<tr><td>(<i>d</i>)</td><td>
</td><td>M1 A1</td></tr>
<tr><td></td><td>Maximum Flow 48</td><td>B1 (3)</td></tr>
<tr><td>(<i>e</i>)</td><td>Max flow – Min cut theorem</td><td>M1</td></tr>
<tr><td></td><td>Cut through <i>DB</i>, <i>DC</i>, <i>DH</i>, <i>DG</i>, <i>DF</i></td><td>A1 (2)</td></tr>
<tr><td></td><td></td><td>(14 marks)</td></tr>
</table>

Question Number	Scheme	Marks

8. (*a*)

Objective: Maximise $P = 4x + 5y = 3z$ — B1

Subject to $3x + 2y + 4z \leq 35$ — B1

$x + 3y + 2z \leq 20$ — B1

$4x + 5y + 3z \leq 24$ — B1 **(4)**

(*b*)

Basic Variable	x	y	z	r	s	t	Value		
r	2	0	$\frac{5}{4}$	1	0	$-\frac{1}{2}$	23	$R_1 - 2R_2$	M1
s	$-\frac{1}{2}$	0	$-\frac{1}{4}$	0	1	$-\frac{3}{4}$	2	$R_2 - 3R_3$	A1
y	$\frac{1}{2}$	1	$\frac{3}{4}$	0	0	$\frac{1}{4}$	6	$R_3 \div 4$	M1
P	$-\frac{3}{2}$	0	$\frac{3}{4}$	0	0	$\frac{5}{4}$	30	$R_4 + 5R_3$	A1 **(4)**

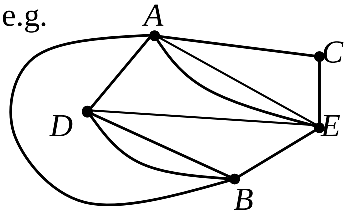
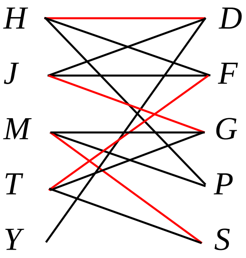
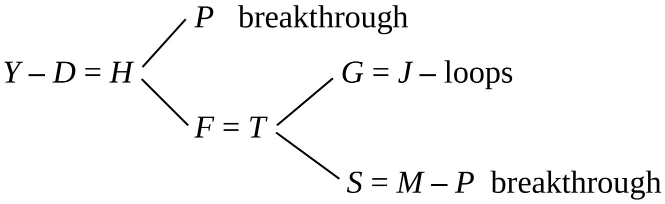
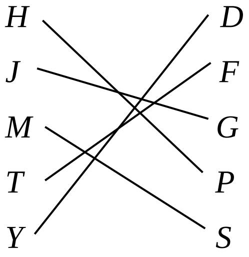
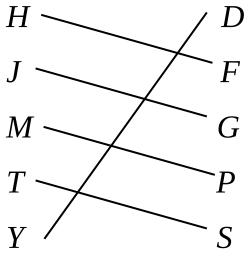
Basic Variable	x	y	z	r	s	t	Value		
x	1	0	$\frac{5}{4}$	$\frac{1}{2}$	0	$-\frac{1}{4}$	$\frac{23}{2}$	$R_1 \div 2$	M1
s	0	0	$\frac{3}{8}$	$\frac{1}{4}$	1	$-\frac{7}{8}$	$\frac{31}{4}$	$R_2 + \frac{1}{2}R_1$	A1
y	0	1	$\frac{1}{8}$	$-\frac{1}{4}$	0	$\frac{3}{8}$	$\frac{1}{4}$	$R_3 - \frac{1}{2}R_1$	M1
P	0	0	$\frac{21}{8}$	$\frac{21}{8}$	0	$\frac{7}{8}$	$\frac{189}{4}$	$R_4 + \frac{3}{2}R_1$	A1 **(4)**

$P = 47\frac{1}{4}$ $x = 11\frac{1}{2}$, $y = \frac{1}{4}$, $z = 0$ — M1 A1 A1 **(3)**

(*c*)

There is some slack $\left(7\frac{3}{4}\right)$ on S, so *do not* increase blending; therefore increase Processing and Packing which are both at their limit at present — B2, 1,0 **(2)**

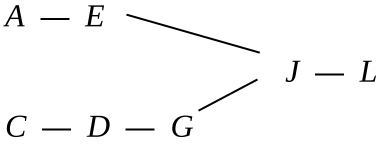
(17 marks)

Question number	Scheme	Marks
1.	e.g.  Finding a Hamiltonian cycle, e.g. $A\ C\ E\ B\ D\ A$	B1
	Re-drawing graph – Hamiltonian cycle at least	M1
	Separating arcs into two sets correctly	A1
	All correctly drawn	A1 (4)
		(4 marks)
2. (*a*)		B1 B1 (2)
(*b*)		M1 A1
	changing status, the possible alternating paths are (i) $Y = D - H = P$	
	or (ii) $Y = D - H = F - T = S - M = P$	A1
	giving the following matching (i) or (ii) $H - P$ $H - F$ $J - G$ $J - G$ $M - S$ $M - P$ $T - F$ $T - S$ $Y - D$ $Y - D$  	A1 (4)
		(6 marks)

Question number	Scheme	Marks
3.	$y + z \leq \frac{1}{2}x \quad \Rightarrow \quad 2(y + z) \leq x$	B1 (1)
	$y \geq \frac{10}{100}(x + y + z) \quad \Rightarrow \quad x + z \leq 9y$	M1 A1 (2)
	$y \geq \frac{20}{100}(x + y + z) \quad \Rightarrow \quad x + z \geq 4y$	M1 A1 (2)
	$z \geq \frac{1}{2}y \quad \Rightarrow \quad 2z \geq y$	B1
	$x \geq 0,\ y \geq 0,\ z \geq 0,$	
	$x + y + z \geq 250$	B1
	objective function: minimise; $c = 20x + 26y + 36z$	B1; B1 (4)
		(9 marks)
4. (*a*)	*B* and *E* are the only odd vertices, repeating a route between them will make them even	B1 (1)
(*b*)	$BA + AE = 17 + x$	
	$BD + DE = 2x + 9$	
	$BC + CE = 21$	M1 A1 (2)
(*c*)	$2x + 9 < x + 17$ and $2x + 9 < 21$	
	$x < 8$ and $x < 6$	M1 A1
	$\therefore\ 0 < x < 6$ for both to be true in context	A1 (3)
(*d*)	If $x = 7$, repeated route is $BC + CE$	B1
	Total time is $(3(7) + 47) + 21 = 89$	M1 A1 (3)
		(9 marks)

Question number	Scheme	Marks
5. (*a*)	$x = 31$, $y = 17$	B1 B1 (2)

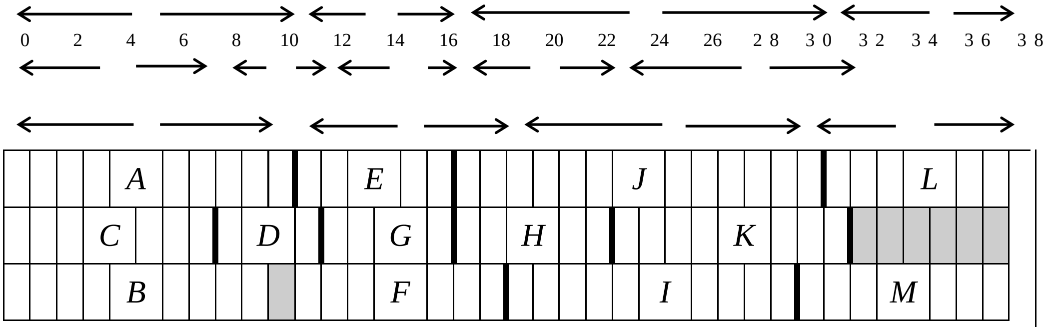
(*b*)



M1 A1 (2)

(*c*) 107 ÷ 38 = 2.8 (1 d.p.) ∴ 3 workers — M1 A1 (2)

(*d*) For example,



(10 marks)

6. (*a*)(i) left to right **or** right to left

left to right

25	22	30	18	29	21	27	21
25	30	22	18	29	21	27	21
25	30	22	29	18	21	27	21
25	30	22	29	21	18	27	21
25	30	22	29	21	27	18	21
25	30	22	29	21	27	21	18
30	25	29	22	27	21	21	18
30	29	25	27	22	21	21	18
30	29	27	25	22	21	21	18
30	29	27	25	22	21	21	18

right to left

25	22	30	18	29	21	27	21
25	22	30	18	29	27	28	21
25	22	30	29	18	27	21	21
25	30	22	29	18	27	21	21
30	25	22	29	18	27	21	21
30	29	25	22	27	18	21	21
30	29	27	25	22	21	18	21
30	29	27	25	22	21	21	18
30	29	27	25	22	21	21	18

(ii)

M1

A1 (1st pass)

A1

A1

A1 cso (5)

(*b*)(i)

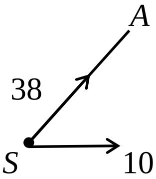
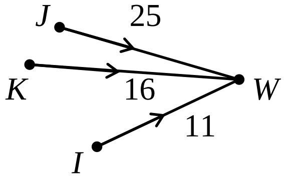
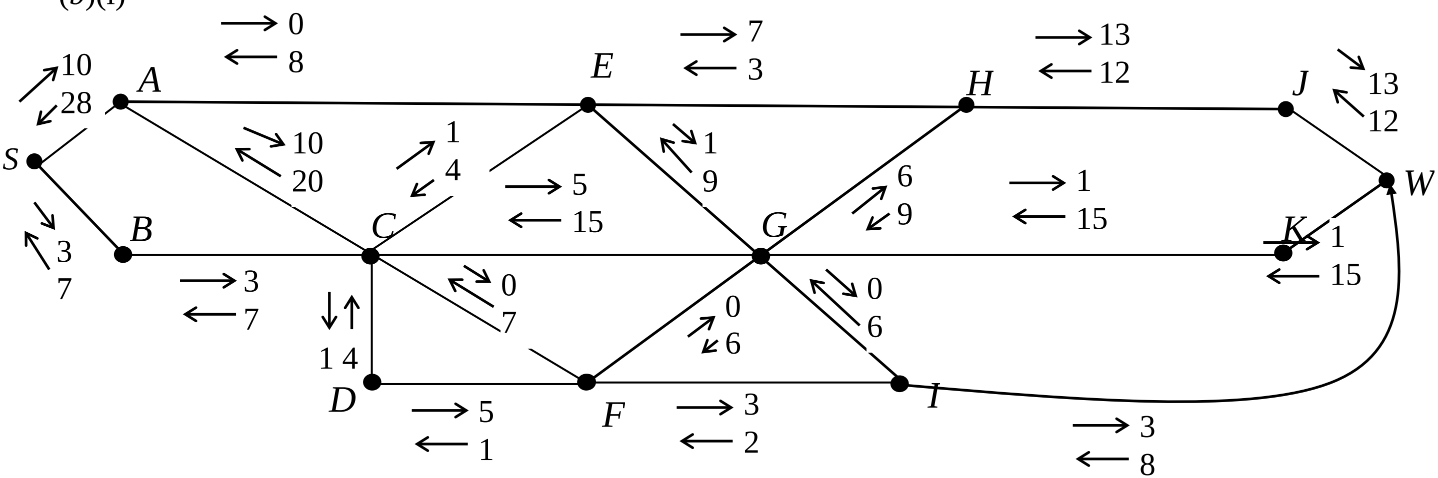
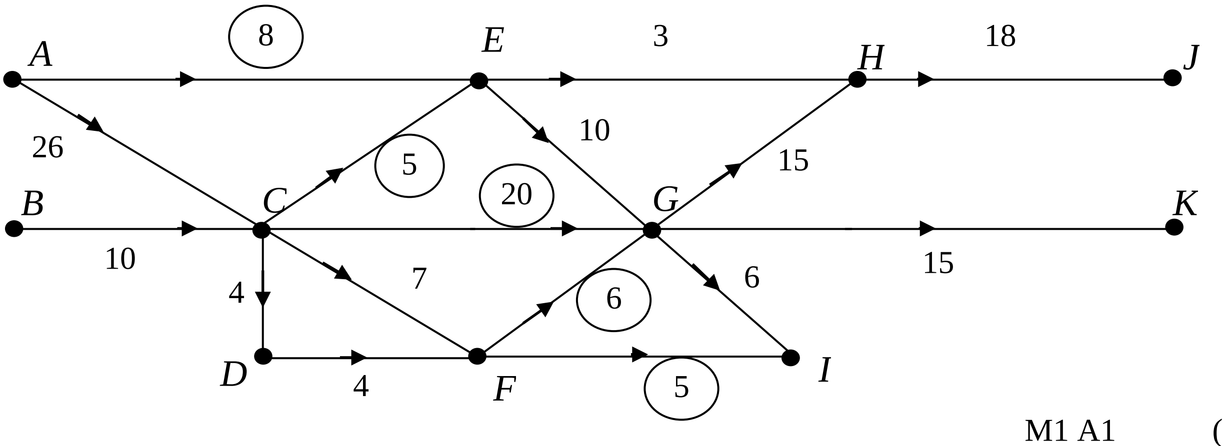
rod	1	30	18
	2	29	21
	3	27	22
	4	25	21

M1 (to the 22)

A1 (2)

(ii) 193 ÷ 50 = 3.86, ∴ 4 rods needed, so minimum — M1 A1 (2)

(9 marks)

Question number	Scheme	Marks
7. (*a*)	 and 	M1 A1 A1 (3)
(*b*)(i)		M1 A1 A1 (3)
	For example,	
	S B C D F I W – 3	M1 A1
	S A C G H J W – 5	A1
	S A C E G H J W – 1	A1 (4)
(ii)	Maximum flow 44	B1 (2)
	States valid cut *AE, CE, CG, FG, FI*	B1 (2)
(*c*)		M1 A1 (2)
		(14 marks)

Question number	Scheme	Marks
8. (*a*)	$2x + 3y + 4z \leq 8$	B1
	$3x + 3y + z \leq 10$	B1
	$P = 8x + 9y + 5z$	B1 (3)
(*b*)		

↓ (*y*)

b.v	*x*	*y*	*z*	*r*	*s*	Value
r	2	③	4	1	0	8
s	3	3	1	0	1	10
P	–8	–9	–5	0	0	0

↓ (*x*)

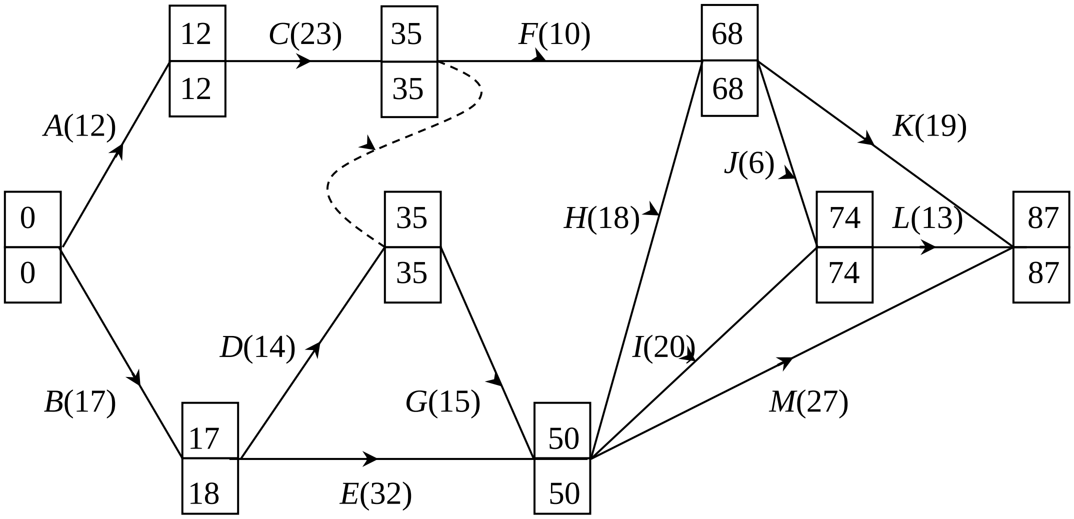
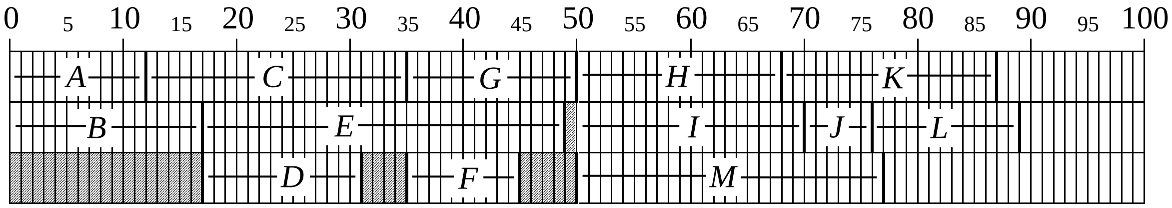
b.v	*x*	*y*	*z*	*r*	*s*	Value		
								M1
y	$\frac{2}{3}$	1	$\frac{4}{3}$	$\frac{1}{3}$	0	$\frac{}{3}$	$R_1 \div 3$	A1
s	①	0	–3	–1	1	2	$R_2 - 3R_1$	M1
P	–2	0	7	3	0	24	$R_3 + 9R_1$	A1

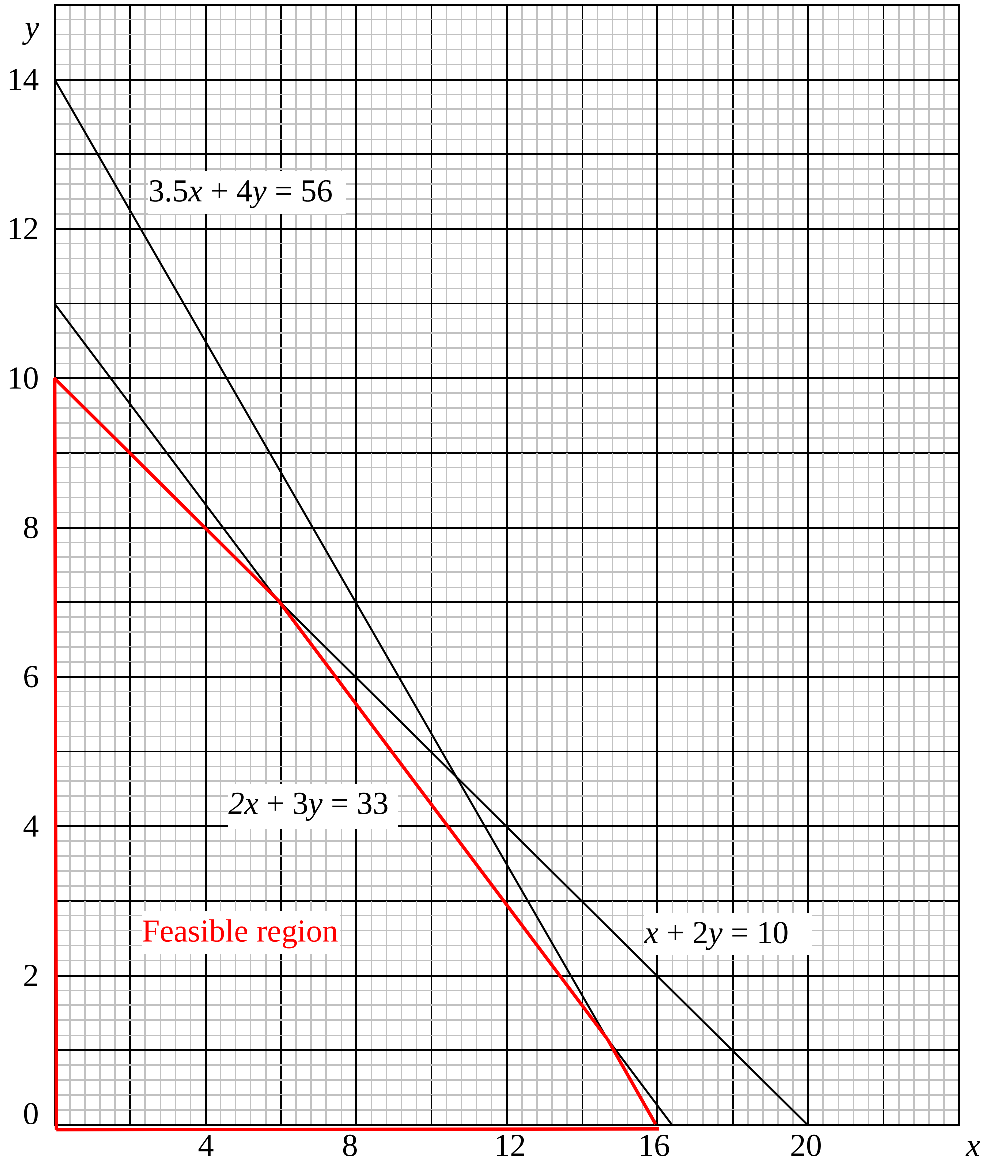
b.v	*x*	*y*	*z*	*r*	*s*	Value		
								M1
y	0	1	$\frac{10}{3}$	1	$-\frac{2}{3}$	$\frac{4}{3}$	$R_1 - \frac{2}{3}R_2$	A1
x	1	0	–3	–1	1	2		M1
P	0	0	1	1	2	28	$R_3 + 2R_2$	A1 (8)

Question number	Scheme	Marks
(*c*)	$P = 28$	M1
	$x = 2, \quad y = \frac{4}{3}$	A1
	$z = 0, \quad r = 0, \quad s = 0$	A1 (3)
		(14 marks)

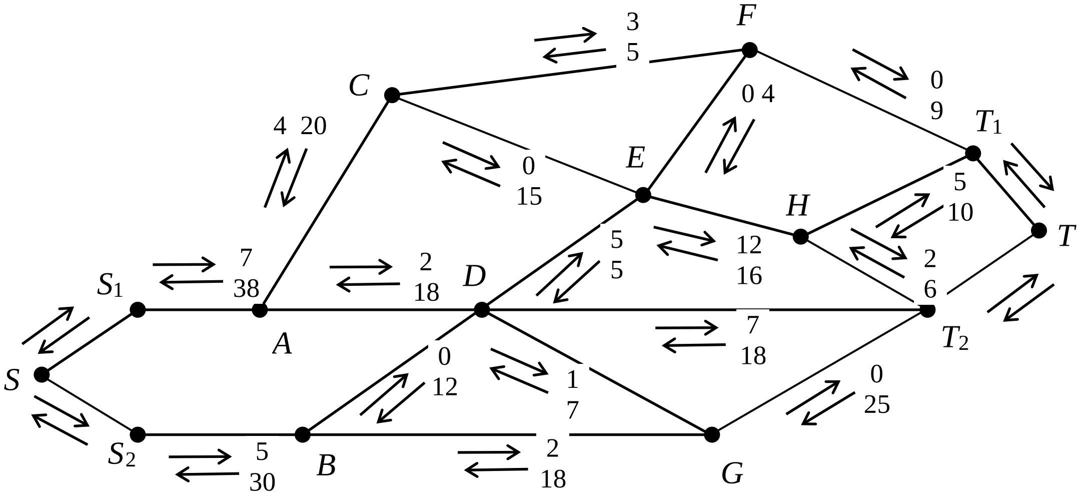
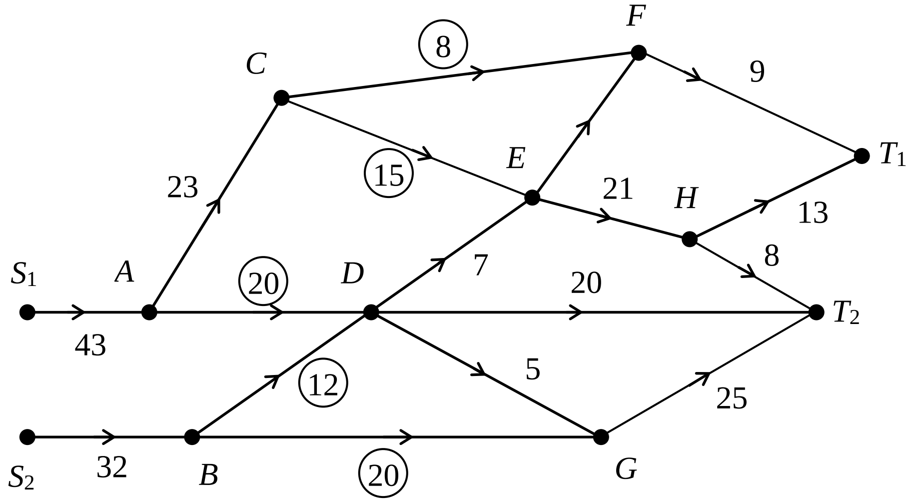
Question number	Mark scheme	Marks
1.	e.g. $C - 2 = A - 5 = E - 4$ cs $C = 2 - A = 5 - E = 4$	M1 A1
	$F - 1 = B - 3 = D - 6$ cs $F = 1 - B = 3 - D = 6$	M1 A1
	$\therefore A = 1$, $B = 3$, $C = 2$, $D = 6$, $E = 4$, $F = 1$	A1 (5)
		(5 marks)
2. (*a*)	Each arc contributes 2 to the sum of degrees, hence this sum must be even. Therefore there must be an even (or zero) number of vertices of odd degree.	B2, 1, 0 (2)
(*b*)	If $x > 9$, $10\frac{1}{2}x - 26 = 100$,	B1, M1 A1
	$\Rightarrow x = 12$	A1 (4)
	(If $x < 9$, $11\frac{1}{2}x - 35 = 100 \Rightarrow x = 11\frac{17}{23}$ inconsistent)	
		(6 marks)
3. (*a*)	For example: • In Prim the tree always ‘grows’ in a connected fashion; • In Kruskal the shortest arc is added (unless it completes a cycle), in Prim the nearest unattached vertex is added; • There is no need to check for cycles when using Prim; • Prim can be easily used when network given is matrix form	B3, 2, 1, 0 (3)
(*b*) (i)	Either *AC*, *AB*, *BD*, *BE*, *EF*, *EG* (if starts at *A* or *C*)	
	or *BD*, *BA*, *AC*, *BE*, *EF*, *EG* (if starts at *B* or *D*)	
	or *EF*, *EG*, *BE*, *BD*, *BA*, *AC* (if starts at *E* or *F*)	
	or *GE*, *EF*, *BE*, *BD*, *BA*, *AC* (if starts at *G*)	M1 A1
(ii)	*EF*, *AC*, *BD*, *BA*, *EG*, *BE*	M1 A1 (4)
		(7 marks)

Question number	**Mark scheme**	**Marks**
4. (*a*)	For example	
	$R\quad P\quad B\quad Y\quad T\quad \textcircled{K}\quad M\quad H\quad W\quad G$	M1 A1
	$B\quad \textcircled{H}\quad G\quad \boxed{K}\quad R\quad P\quad Y\quad \textcircled{T}\quad M\quad W$	A1 ft
	$B\quad \textcircled{G}\quad \boxed{H}\quad \boxed{K}\quad R\quad \textcircled{P}\quad M\quad \boxed{T}\quad Y\quad \textcircled{W}$	A1 ft
	$\textcircled{B}\quad \boxed{G}\quad \boxed{H}\quad \boxed{K}\quad \textcircled{M}\quad \boxed{P}\quad \textcircled{R}\quad \boxed{T}\quad \boxed{W}\quad \textcircled{Y}$	A1 ft (5)
	$B\quad G\quad H\quad K\quad M\quad P\quad R\quad T\quad W\quad Y$	
(*b*)	$\left[\frac{10+1}{2}\right] = 6$ Palmer; reject Palmer → Young	M1 A1
	$\left[\frac{5+1}{2}\right] = 3$ Halliwell; reject Boase → Halliwell	A1
	$\left[\frac{4+5}{2}\right] = 5$ Morris; reject Morris	
	List reduces to Kenney – name found, search complete	A1 (4)
		(9 marks)

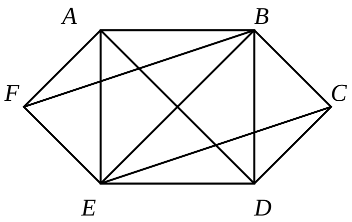
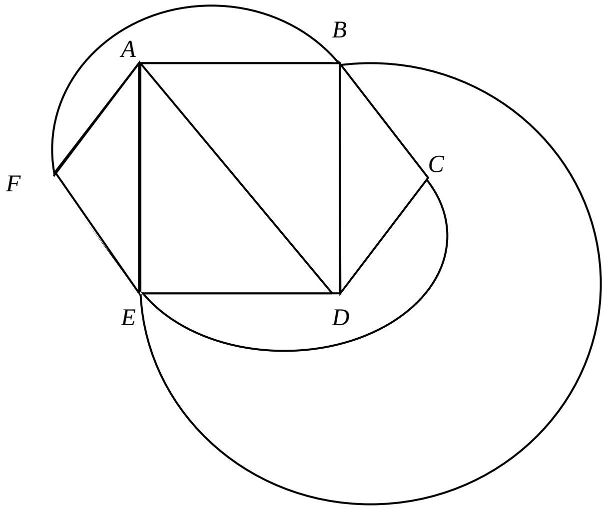
Question number	Mark scheme	Marks
5. (*a*)		M1 A1 A1 A1 (4)
(*b*)	*A*, *C*, *G*, *H*, *J*, *K*, *L*	M1 A1 (2)
(*c*)	35 – 17 – 14 = 4	M1 A1 (2)
(*d*)	226 ÷ 87 = 2.6 (1 dp), ∴ 3 workers	M1 A1 (2)
(*e*)	For example:  Worker 1: *A C G H K* Worker 2: *B E I J L* Worker 3: *D F M* New shortest time is 89	M1 A1 A1 A1 A1 (5)
		(15 marks)

Question number	Mark scheme	Marks
6. (*a*)	(P =) $300x + 500y$	B1
(*b*)	Finishing $3.5x + 4y \leq 56 \Rightarrow 7x + 8y \leq 112$ (or equivalent)	B1
	Packing $2x + 4y \leq 40 \Rightarrow x + 2y \leq 20$ (or equivalent)	B1 (3)
(*c*)		B4, 3, 2, 1, 0 (4)
	(NB: The graph prints OK on my machine, but looks wrong on screen)	

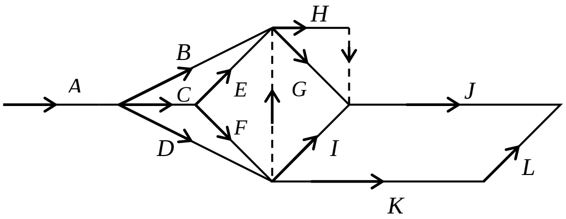
Question number	**Mark scheme**	**Marks**
6. (*d*) (cont.)	For example: *Point testing:* test all (5) points in feasible region find profit at each and select point yielding maximum	B1
	Profit line: draw profit lines with gradient $-\frac{3}{5}$ select point on profit line furthest from the origin	B1 (2)
(*e*)	Optimal point is (6, 7); make 6 Oxford and 7 York	M1; A1 ft
	Profit = £5300	A1 ft (3)
(*f*)	The line 3.5x + 4y = 49 passes through (6, 7) so reduce finishing by 7 hours	M1 A1 ft A1 (3)
		(15 marks)

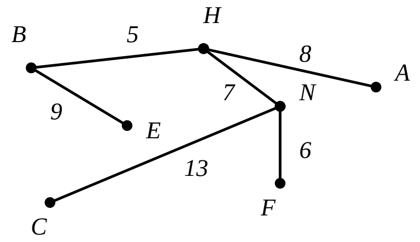
Question number	Mark scheme	Marks
7. (*a*)	Adds *S* and *T* and arcs	M1
	$SS_1 \geq 45$, $SS_2 \geq 35$, $T_1T \geq 24$, $T_2T \geq 58$	A1 (2)
(*b*)	Using conservation of flow through vertices $x = 16$ and $y = 7$	B1 B1 (2)
(*c*)	$C_1 = 86$, $C_2 = 81$	B1 B1 (2)
(*d*)		M1 A1 M1
	e.g. $S\ S_1\ A\ D\ E\ H\ T_2\ T - 2$	A1
	$S\ S_1\ A\ C\ F\ E\ H\ T_1\ T - 3$	A1
	$S\ S_2\ B\ G\ D\ T_2\ T - 2$	A1 (6)
(*e*)	For example: 	M1 A1
	Flow 75	A1 (3)
(*f*)	Max flow – min cut theorem cut through *CF*, *CE*, *AD*, *BD*, *BG* (value 75)	M1 A1 (2)
		(18 marks)

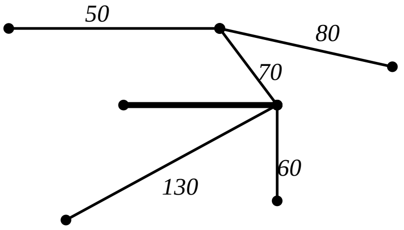
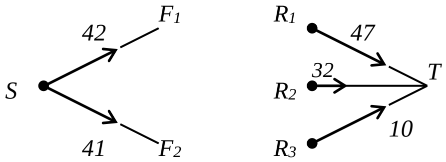
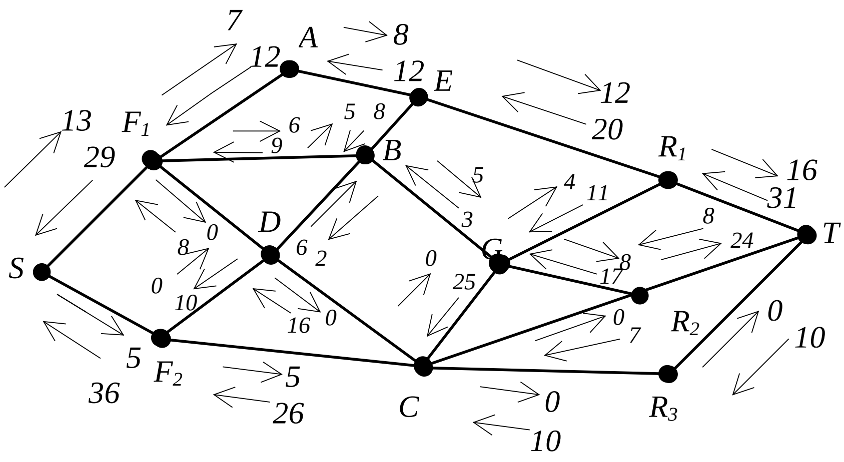
EDEXCEL DECISION MATHEMATICS D1 (6689)
PROVISIONAL MARK SCHEME NOVEMBER 2003

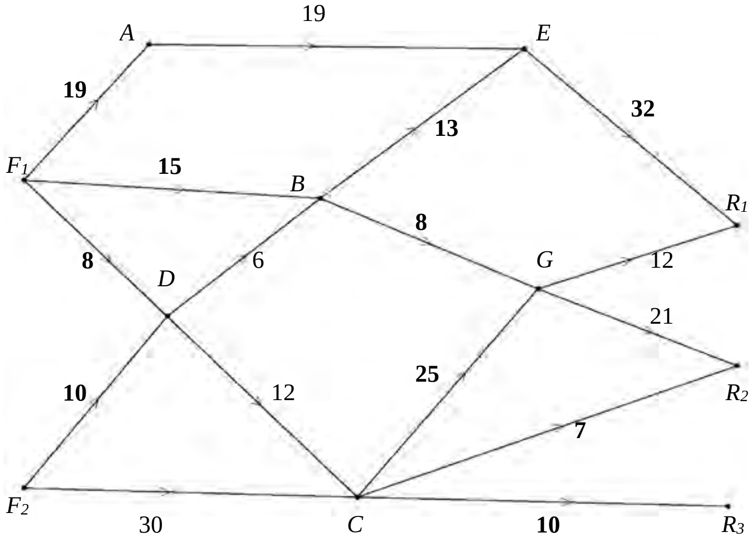
Question Number	Scheme	Marks
1.	**(a)** All arcs must be traversed twice. (So no arc needs repeating more than twice.) All valencies therefore even.	B1 (1)
	(b) e.g. *CECAEFEAFABFBACDBDGFGDC*	M1 A1
	$\text{length} = 2 \times 6$ $= \underline{12km}$	A1 (3)
		4
2.	**(a)** 	B1 (1)
	(b) 	M1 A1 A1 A1 (4)
	$\therefore$ planar, so product can be built	**5**

EDEXCEL DECISION MATHEMATICS D1 (6689)
PROVISIONAL MARK SCHEME NOVEMBER 2003

Question Number	Scheme	Marks
3.	**(a)** Add A to 3, B to 4, C to 1 and F to 5 in a distinctive way	B1 (1)
	(b) e.g. D – 3 = A – 1 = C – 4 = B – 2	M1
	C.S. D = 3 – A = 1 – C = 4 – B = 2	A1 (2)
	E – 5 = F – 6	M1
	C.S. E = 5 – F = 6	A1
	A = 1 B = 2 C = 4 D = 3 E = 5 F = 6	A1 (3)
		6
4.	**(a)** **e.g.**	
		M1 A1 A1 A1 A1 A1 (6)
	(b) D will only be critical if it lies on a longest route.	
	ABEG – 14 ACFG – 15 ACDEG – 13 + x	M1
	So D critical if $x \geq 2$ (must be $\geq$ not >)	A1 (2)
		8
5.	**(a)** Bin 1 – 75+20	M1
	Bin 2 – 70 +20	A1
	Bin 3 – 60+40	A1
	Bin 4 – 50+35	
	Bin 5 – 20	
		A1
	5 Planks needed: cost £15	A1 (5)
	Wastage = 5+10+0+15+80 = 110cm	

Question Number	Scheme	Marks
5. (cont)	**(b)** Bin 1 (1.5m) – 75+70 Bin 2 (1.5m) – 60+50+40 Bin 3 (1m) – 35+20+20+20 or Bin 1 (1m) –75+20 Bin 2 (1.5m) –70+60+20 Bin 3 (1.5m) –50+40+35+20	M1 A1 A1
	Cost £11 1.5m lengths better value than 1m lengths to use as many as possible	A1 (4) **9**
6.	**(a) i** A connected graph with no cycles, loops or multiple edges	B1
	ii A tree that includes all vertices	B1
	iii A spanning tree of minimum total length	B1 (3)
	(b) E.g. • In Kruskal the shortest <u>arc</u> is added (unless it completes a cycle), in Prim the nearest unattached <u>vertex</u> is added • There is no need to check for cycles when using Prim, but there is when using Kruskal • In Prim the tree always "grows" in a connected fashion • Kruskal starts with the shortest edge, Prim with any vertex	B1 (1)
	(c) BH, NF, HN, HA, BE, NC; length = 48	M1 A1; A1
		A1 (4)

Question Number	Scheme	Marks
6. (cont)	**(d)** 	B1
	New cable – 390m	M1 A1 (3)
		11
7.	**(a)** $x = 3$, $y = 26$	B1, B1 (2)
	(b) 	M1 A1 A1 (3)
	(c) 	M1 A1 A1 (3)

Question Number	**Scheme**	**Marks**
7. **(cont)**	**(c)** **(cont.)** e.g. S F_1 A E R_1 T – 7	DM1
	S F_1 B E R_1 T – 5	A1
	S F_1 B G R_1 T – 1	A1
	S F_2 C D B G R_2 T - 4	A1 (4)
	(d) **e.g.**  	B1
	Max Flow 82	B1 (2)
	(e) **e.g.**	
	F_1 A, BE, BG, CG, CR_2, CR_3 (=82)	
	Or ER_1, BG, CG, CR_2, CR_3 (=82)	M1 A1 (2)
		16

Question Number	Scheme	Marks
8.	**(a)** $x+2y+4z \le 24$	B1
	(b) **i** $x + 2y + 4z + s = 24$	B1 √
	ii $s\ (\ge 0)$ is the slack time on the machine in hours	B1
	(c) 1 Euro	B1 (4)

(d)

b.v	x	y	z	r	s	value
r	$\frac{3}{2}$	**2**	0	1	$-\frac{3}{2}$	14
z	1/4	1/2	1	0	1/4	6
p	0	-1	0	0	1	24

R_1-6R_2
$R_2 \div 4$
R_3+4R_2

M1 A1√ A1 (3)

b.v	x	y	z	r	s	value
y	3/4	1	0	1/2	- 3/4	7
z	- 1/8	0	1	- 1/4	5/8	$\frac{5}{2}$
p	3/4	0	0	1/2	1/4	31

$R_1 \div 2$
R_2- ½ R_1
R_3+R_1

M1 A1√ A1 (3)

Profit = 31 Euros $\quad \underset{\text{medium}}{y = 7} \quad \underset{\text{large}}{z = 2.5} \quad x = r = s = 0$

M1 A1√ A1√ (3)

(e)	Cannot make ½ a lamp	B1 (1)
(f)	e.g. (0, 10, 0) or (0, 6, 3) or (1, 7, 2)	B1
	checks in **both** inequalities	B1 (2)
		16

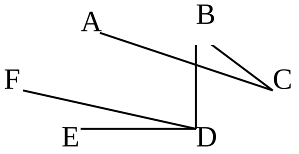
EDEXCEL 6689 DECISION MATHEMATICS D1 JANUARY 2004 MARK SCHEME

Question	Mark Scheme	Marks
1. (a)	A graph consisting of two distinct sets of vertices X and Y in which… arcs can only join a vertex in X to a vertex in Y.	B1 B1 (2)
(b)	A path from an unmatched vertex in X to an unmatched vertex in Y… ..which alternately uses arcs in/not in the matching.	B1 B1 (2)
(c)	The (1-1) matching / pairing of some elements of X with elements of Y.	B1
(d)	A 1-1 matching between all elements of X onto Y	B1 (2) **(6)**
2. (a)	Yes, there are no negative values in the profit row	B1 (1)
(b)	$p = 63,\ x = 0,\ y = 7,\ z = 0,\ r = \frac{9}{2,},\ s = \frac{2}{3},\ t = 0$	M1, A1, A1, (3)
(c)	$\frac{63}{7} = 9$	M1, A1 (2) **(6)**

Question	**Mark Scheme**	**Marks**
3. (a)	$C_1 = 7 + 14 + 0 + 14 = 35$	B1
	$C_2 = 7 + 14 + 5 = 26$	B1
	$C_3 = 8 + 9 + 6 + 8 = 31$	B1 (3)
(b)	Either Min cut = Max flow and we have a flow of 26 and a cut of 26 or C2 is through saturated arcs	B1 (1)
(c)	Using EJ (capacity 5) e. g – will increase flow by 1– ie increase it to 27 since only one more unit can leave E. - BEJL - 1	M1 A1
	Using FH (capacity 3) e. g.– will increase flow by 2 – ie increase it to 28 since only two more units can leave F. - BFHJL - 2	
	Thus choose option 2 add FH capacity 3.	A1 (3)
		(7)
4. (a)	BD + FG = 1.3 + 0.9 = 2.2 *	M1
	BF + DG = 1.5 + (1.3 + 0.7) = 3.5	A1
	BG + DF = 0.7 + (0.9 + 0.8) = 2.4	A1
	Repeat BD and FG	(3)
	Route e.g. $GABC\underline{DB}F\overline{E}D\overline{B}G\underline{FG}$	B1
	Length = 8.9 + 2.2 = 11.1 km	M1 A1 (3)
(b)	Only now need to repeat BF of length 1.5 < 2.2	M1 A1 √
	Length = 8.9 +1.5 = 10.4 km saving 0.7 (km)	A1 √ (3)
		(9)

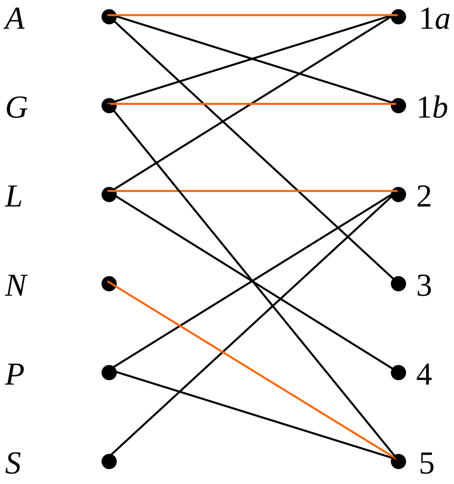
EDEXCEL 6689 DECISION MATHEMATICS D1 JANUARY 2004 MARK SCHEME

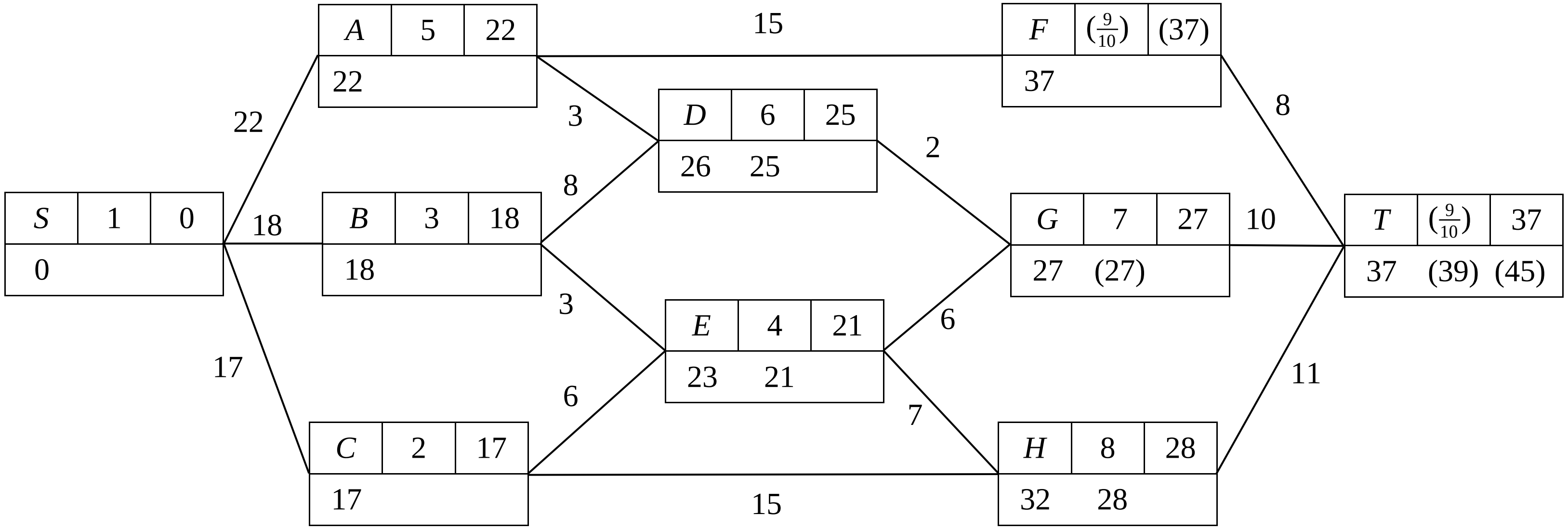
<table>
<tr><th>Question</th><th>Mark Scheme</th><th>Marks</th><th></th></tr>
<tr><td>5. (a)</td><td>
<table>
<tr><th>a</th><th>b</th><th>c</th><th>Integer?</th><th>Output list</th><th>a = b?</th></tr>
<tr><td>90</td><td>2</td><td>45</td><td>Yes</td><td>2</td><td>No</td></tr>
<tr><td>45</td><td>2</td><td>22.5</td><td>No</td><td></td><td></td></tr>
<tr><td>45</td><td>3</td><td>15</td><td>Yes</td><td>3</td><td>No</td></tr>
<tr><td>15</td><td>2</td><td>7.5</td><td>No</td><td></td><td></td></tr>
<tr><td>15</td><td>3</td><td>5</td><td>Yes</td><td>3</td><td>No</td></tr>
<tr><td>5</td><td>2</td><td>2.5</td><td>No</td><td></td><td></td></tr>
<tr><td>5</td><td>3</td><td>$1\frac{2}{3}$</td><td>No</td><td></td><td></td></tr>
<tr><td>5</td><td>5</td><td>1</td><td>Yes</td><td>5</td><td>Yes</td></tr>
</table>

Output list: 2,3,3,5</td><td>M1
A1
A1 √
M1
A1
M1
A1√</td><td>(7)</td></tr>
<tr><td>(b)</td><td>Gives the prime factorisation of a</td><td>B2, 1, 0</td><td>(2)</td></tr>
<tr><td>(c)</td><td>C = 1</td><td>B1</td><td>(1)</td></tr>
<tr><td></td><td></td><td></td><td>(10)</td></tr>
<tr><td>6. (a)</td><td><i><u>See overlay</u></i></td><td>B1
B1</td><td>(2)</td></tr>
<tr><td>(b)</td><td>BD, $\left(\frac{A\ C}{D\ F}\right)$, BC, Not CD, DE

Length = 18 km</td><td>M1
A1, A1
B1
B1</td><td>(5)</td></tr>
<tr><td>(c)</td><td>DB, DF, BC, CA, DE [5,2,4,1,6,3,]</td><td>M1 A1 A1</td><td>(3)</td></tr>
<tr><td></td><td></td><td></td><td>(10)</td></tr>
</table>

Question	Mark Scheme	Marks
7. (a)	*See overlay*	B5, 4, 3, 2, 1, 0 (5)
(b)	Either point testing or profit line	M1
	A $(3\frac{5}{6}, 3\frac{1}{2}) \rightarrow 25\frac{1}{6}$, B $(8\frac{1}{2}, 3\frac{1}{2}) \rightarrow 34\frac{1}{2}$, *Accept* C (4,8) → 48 *and* D (3,6) → 36	
	Profit line gradient $-\frac{2}{5}$	A1
	Identifies A $(3\frac{5}{6}, 3\frac{1}{2})$ cost $25\frac{1}{6}$	A1, A1 (4)
(c)	Either point testing or profit line	M1
	A $(3\frac{5}{6}, 3\frac{1}{2}) \rightarrow$ not integer so try (4,4) → 20 Profit line *B* $(8\frac{1}{2}, 3\frac{1}{2}) \rightarrow$ not integer so try (8,4) → 32 → try (7,5) → 31 gradient $-\frac{3}{2}$	
	Accept C (4,8) → 28 *and* D (3,6) → 21	A1
	Identifies (8,4) profit 32.	A1 A1 (4) **(13)**
8. (a)	$x = 0$, $y = 7$, $z = 9$	B1, B1, B1, (3)
(b)	Length = 22, critical activities B D E L	B1, B1, (2)
(c) (i)	Float on N = 22 – 14 – 3 = 5	B1
(ii)	Float on H = 16 – 5 – 3 = 8	M1 A1 (3)
(d)	*See overlay*	B4, 3,2,1,0 (4)
(e)	Attempt at 1. e.t. and e.e.t. 22 hours	M1 A1 (2) **(14)**

EDEXCEL DECISION MATHEMATICS D1 (6689) – JUNE 2004 PROVISIONAL MARK SCHEME

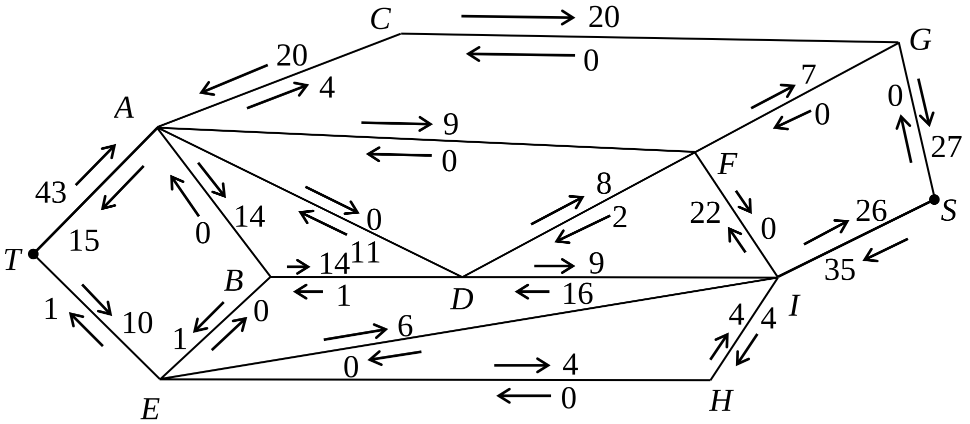
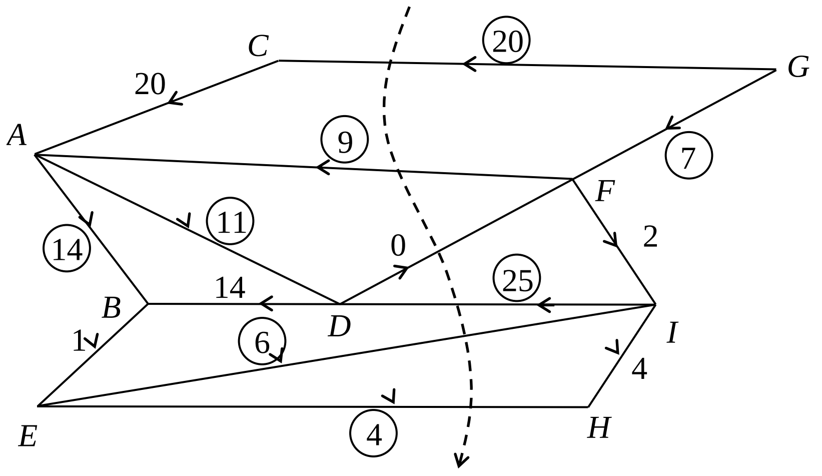
Question Number	**Scheme**	**Marks**
1. (*a*)		B1 B1 (2)
(*b*)	For example:	
	(i) $P – 2 = L – 4$ c.s. $P = 2 – L – 4$	M1
	(ii) $S – 2 = L – 1a = A – 3$ c.s. $S = 2 – L = 1a – A = 3$	A1
	giving	
	$A – 1$, $G – 1$, $L – 4$, $N – 5$, $P – 2$	
	$A – 3$, $G – 1$, $L – 1$, $N – 5$, $S – 2$	A1 (3)
(*c*)	Sam must do 2 and Nicola must do 5, leaving Philip without a task.	B2, 1, 0 (2)
		(7 marks)

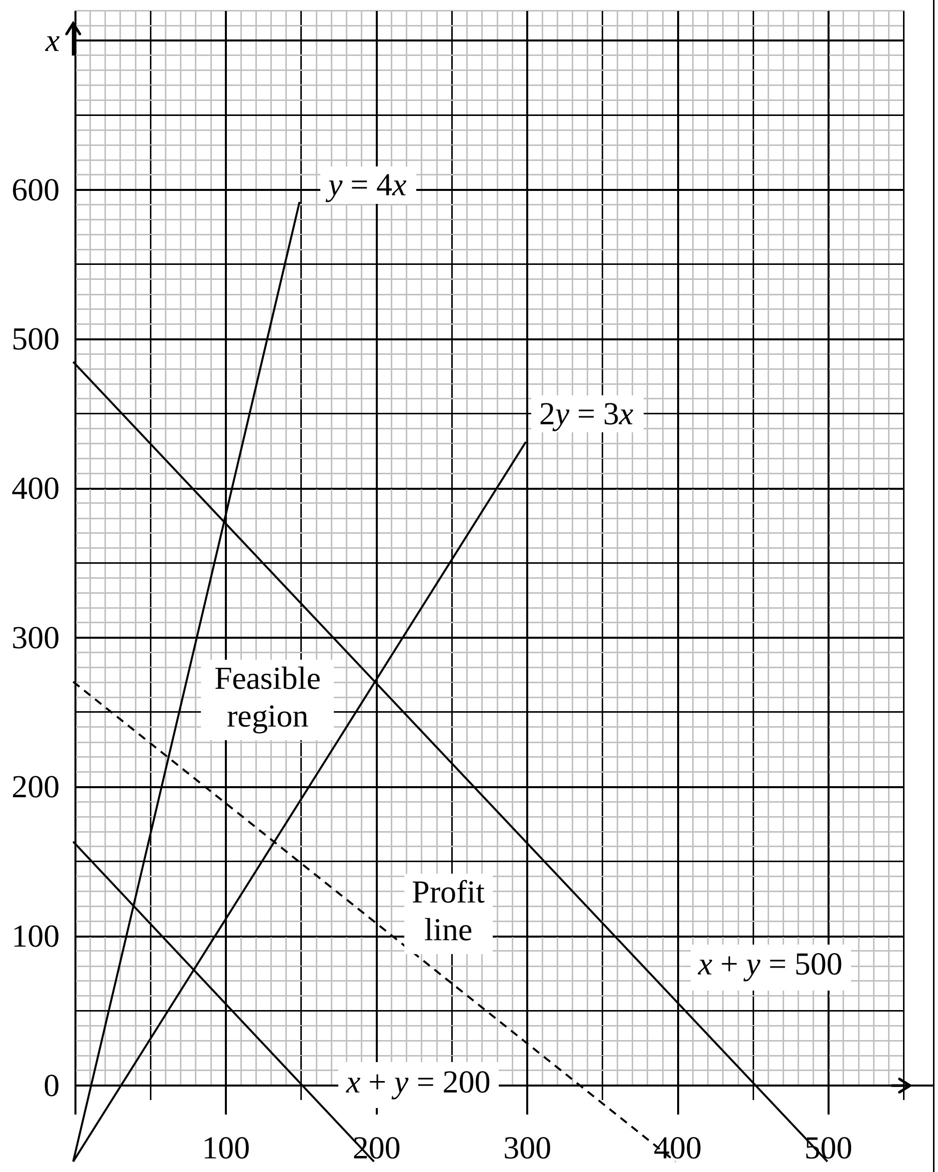
Question Number	Scheme	Marks
2. (*a*)		M1 A1 A1 ft
	Time = 37 minutes	A1 ft (4)
(*b*)	Either *S* – *A* – *D* – *G* – *T* or *S* – *B* – *E* – *G* – *T*	A1 ft
	Not unique, e.g. gives other path	A1 ft (2)
(*c*)	*S* – *C* – *E* – *G* – *T* 39 minutes	M1 A1 (2)
		(8 marks)

Question Number	Scheme	Marks
3. (*a*)	Idea of travelling along each *arc* at least once and seeking to do so in a minimum total. *Practical* meaning of arcs/numbers.	B1 (1)
(*b*)	*AB* + *DF* = 32 + 9 = 41	M1 A1
	AD + *BF* = 25 + 15 = 41	
	AF + *BD* = 18 + 24 = 42	A1
	Repeat *either AE* + *EB* and *DF* or *AD* and *BF*	A1 ft (4)
(*c*)	Not unique, e.g. gives other solution	A1 ft
(*d*)	258 + 41 = 299	B1 (2)
(*e*)	*DF* is the shortest so start/finish at *A*/*B*	M1 A1 (2)
		(9 marks)

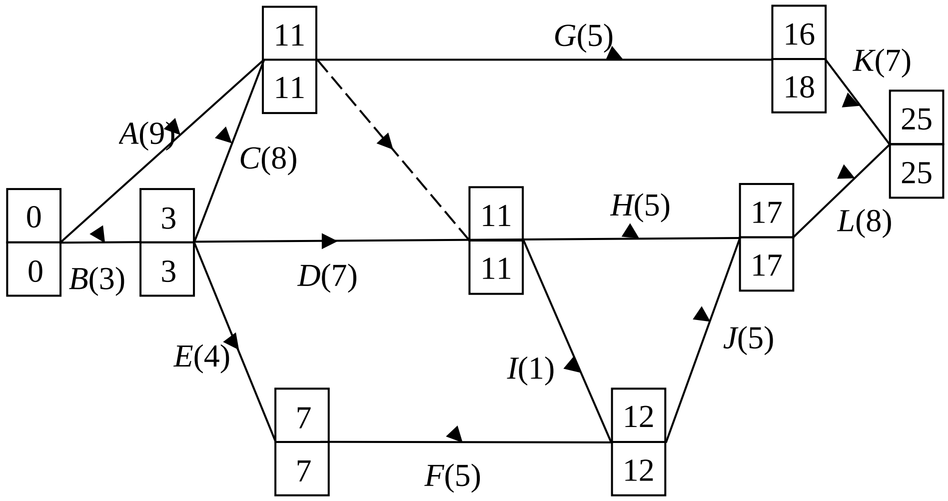
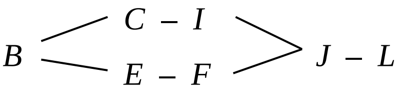
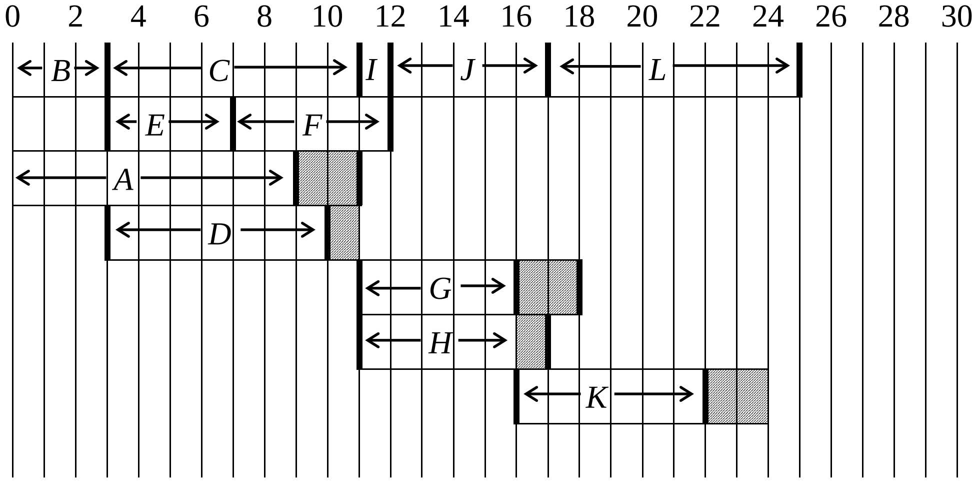
EDEXCEL DECISION MATHEMATICS D1 (6689) – JUNE 2004 PROVISIONAL MARK SCHEME

Question Number	Scheme	Marks
4. (*a*)	The list is not in *alphabetical* order	B1 (1)
(*b*)	Use of Bubble Sort or Quick Sort	M1
	For example:	
	Bubble sort	
	G N M Y L B C E S P	
	B G N M Y L C E P S 1st pass	
	B C G N M Y L E P S 2nd pass	
	B C E G N M Y L P S 3rd pass	
	B C E G L N M Y P S 4th pass	
	B C E G L M N P Y S 5th pass	A1
	B C E G L M N P S Y 6th pass	
	No more changes	
	Quick sort	A1
	G N M Y L Ⓑ *C E S P*	
	$\boxed{B}$ | *G N M Y* Ⓛ *C E S P* 1st pass	A1 (4)
	B | *G* Ⓒ *E* | $\boxed{L}$ | *N M* Ⓨ *S P* 2nd pass	
	B | $\boxed{C}$ | *G* Ⓔ | *L* | *N M* Ⓢ *P* | $\boxed{Y}$ 3rd pass	
	B | *C* | $\boxed{E}$ | *G* | *L* | *N* Ⓜ *P* | $\boxed{S}$ | *Y* 4th pass	
	B | *C* | *E* | Ⓖ | *L* | $\boxed{M}$ | *N* Ⓟ | *S* | *Y* 5th pass	
	B | *C* | *E* | $\boxed{G}$ | *L* | $\boxed{M}$ | *N* | $\boxed{P}$ | *S* | *Y* 6th pass	
	No sublists > 2 and no more changes	
(*c*)	1 2 3 4 5 6 7 8 9 10	
	B C E G L M N P S Y	
	$\frac{[10+1]}{2} = 6$ Manchester discard first half of list and pivot	M1 A1
	$\frac{[7+10]}{2} = 9$ Southampton discard last half of list and pivot	
	$\frac{[7+8]}{2} = 8$ Plymouth discard last half of list and pivot	A1
	Final term 7 Newcastle, therefore word found at 7	A1 (4)
		(9 marks)

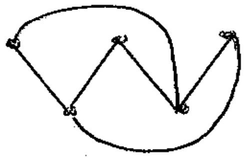
Question Number	Scheme	Marks
5. (*a*)	$x = 9$, $y = 16$	B1 B1 (2)
(*b*)	Initial flow = 53 – either finds a flow-augmenting route or demonstrates not enough saturated arcs for a minimum cut	B1 B1 (2)
(*c*)		M1 A1 (2)
	e.g. *IDA* – 9	A1
	IFDA – 24	A1
	max flow – 64	B1 (3)
(*d*)		M1 A1 (2)
(*e*)	Max flow – min cut	M1
	Finds a cut *GC*, *AF*, *DF*, *DJ*, *EI*, *EH* value 64	A1 (2)
	Note: must not use supersource or supersink arcs.	
		(13 marks)

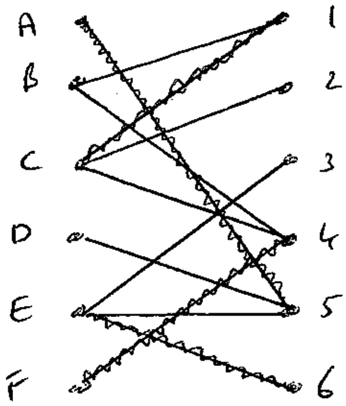
Question Number	Scheme	Marks
6. (*a*)	Maximise $P = 30x + 40y$ (or $P = 0.3x + 0.4y$)	B1
	subject to $x + y \geq 200$	B1
	$x + y \leq 500$	B1
	$x \geq \frac{20}{100}(x + y) \Rightarrow 4x \geq y$	M1 A1
	$x \leq \frac{40}{100}(x + y) \Rightarrow 3x \geq 2y$	A1 (6)
(*b*)		B1 ft ($x + y = 200$, $x + y = 500$) B1 ft ($y = 4x$) B1 ft ($2y = 3x$) B1 ft (shading) B1 (labels)
	(NB: Graph looks OK onscreen at 75% magnification but may print out misaligned)	

Question Number	Scheme	Marks
6. (*c*)	Point testing or profit line	A1
(cont.)	Intersection of $y = 4x$ and $x + y = 500$	A1
	(100, 400) Profit = £190 (units must be clear)	A1 (3)
		(11 marks)

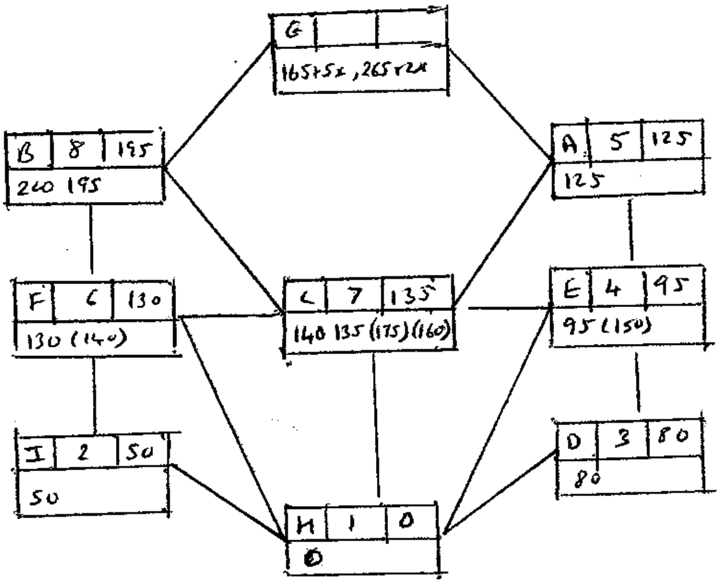
Question Number		Scheme	Marks
7.	(*a*)	E.g. It shows dependence but is not an activity; *G* depends on *A* and *C* only but *H* and *I* depend on *A*, *C* and *D*.	B1 (1)
	(*b*)		M1 A1 M1 A1
	(*c*)	 so *B*, *C*, *E*, *F*, *I*, *J*, *L*	A1 (5)
	(*d*)	*A*: 11 – 0– 9 = 2 *D*: 11 – 3 – 7 = 1 *G*: 18 – 11 – 5 = 2 * *H*: 17 – 11 – 5 = 1 *K*: 25 – 16 – 7 = 2 *	M1 A1 (non *) A1 (*) (3)
	(*e*)		M1 A1 A1 A1 (4)
	(*f*)	Gantt chart at time 8 *C*, *F*, *A* and *D* , must be happening ∴ 4 workers needed	M1 A1 (2) **(15 marks)**

November 2004
6689 Decision Mathematics D1
Mark Scheme

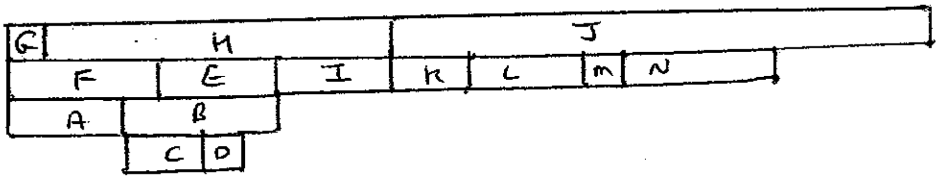
Question Number	Scheme	Marks
1 (a)	(By conservation of flow at B, C and D) $\underline{x = 11}$ $\underline{y = 5}$ $\underline{z = 12}$ (√ x−6) (√ y+7)	B3,2√,1√,0 (3)
(b)	$\underline{\text{Flow is } 31}$ (max flow = min cut), cut through $\underline{AB, AC \text{ and } SD}$	B1 B1 (2) $\boxed{5}$
2 (a)(i)	A graph is planar if it can be drawn so that <u>no arcs</u> <u>cross</u> – other than at vertices	B1
(ii)	A cycle that passes through <u>every</u> vertex of a graph <u>once</u> and <u>returns</u> to its starting vertex	B2,1,0 (3)
(b) (i)	e.g. 	M1 A1
(ii)	It is not possible to find an Hamiltonian cycle	B1 (3) $\boxed{6}$

Question Number	Scheme	Marks
3) (a)		B1
(b)		B1 (2)
(c)	e.g. $B - 1 = C - 2$ c.s. $B = 1 - C = 2$ $A = 5$, $B = 1$, $C = 2$, $E = 6$, $F = 4$	M1A1 B1(c.s) A1✓ (4)
(d)	e.g. • Both A and D are only matched to 5, once one has been assigned the other can not be. • E is the only person who can do 3, and the only person who can do 6 if they are assigned to one of these the other can not be done.	B2,1,0 (2) $\boxed{8}$

Question Number	Scheme	Marks
4) (a)	e.g. 45 37 18 $\boxed{46}$ 56 79 90 81 51	
	or 37 18 $\boxed{45}$ 56 79 46 90 81 51	m1 A1
	or 45 37 46 18 $\boxed{51}$ 56 79 90 81	(2)
(b)	56 45 79 46 37 90 81 51 18	
	or 90 45 56 37 79 46 18 81 51	m1 A1 (2)
(c)	$\left[\frac{1+11}{2}\right] = 6$ value 44 discard top	m1
	$\left[\frac{7+11}{2}\right] = 9$ value 71 discard top	A1
	$\left[\frac{10+11}{2}\right] = 11$ value 94 discard bottom	A1
	List reduces to 10th value. This is 73 so 73 has been located as the 10th value	A1 (4)
		$\boxed{8}$
5 (a)	$B_1G + B_2E = 26 + 30 = 56$	m1 A1
	$B_1B_2 + EG = 65 + 18 = 83$	A1
	$B_1E + B_2G = 41 + 42 = 83$	
	Repeat B_1D, DG, B_2A, AE	A1 (4)
	Route e.g. F A B_2 A C E A E F D B_1 D H G D G F	B1
	length = 129 + 56 = 185 km	m1 A1✓ (3)
(b)	now only E and G are odd – repeat EF, FG only	B1
	length = 129 + 18 = 47 km	m1 A1 (3)
		$\boxed{10}$

Question Number	Scheme	Marks
6 (a)		M1 A1 A1✓ A1✓ (4)
	Via A HEAG length $165 + 5x$ Via B HECBG length $265 + 2x$	M1 A1 A1 (3)
(b)	$165 + 5x < 265 + 2x \Rightarrow x < 33\frac{1}{3}$ So range is $0 \leq x < 33\frac{1}{3}$	M1 A1✓ A1✓ (3)
		10

Question Number	Scheme	Marks
7 (a)	maximum (P =) $0.4x + 0.2y$ (accept $40x + 20y$)	B1
	subject to $x \le 6.5$	
	$y \le 8$	
	$x + y \le 12$	B5,4,3,2,1,0
	$y \le 4x$	
	$y \ge 0$	(6)
(b)	Point testing or Profit line	
	$(6.5, 5.5) \Rightarrow$ 6500 type x and 5500 type y	M1 A1 A1 (3)
(c)	$P = 0.4(6500) + 0.2(5500)$	M1
	$= £3\,700$	A1 (2)
		$\boxed{11}$

Question Number	Scheme	Marks
8(a)	$x = 12 \quad y = 24 \quad z = 19$	B3,2,1,0 (3)
(b)	Allows J and K to be given a unique representation using events	B1 (1)
(c)	F – E – I – J G – H /	M1A1 (2)
(d)	No effect, B has a total float of 2	M1A1 (2)
(e)	eg. • Total of activities = 54, 54 ÷ 24 = 2.25 so 2 workers not enough • 54 ÷ 2 = 27 hours per worker, so 2 workers can not finish in 24 hours • Argument about the activities that need to be completed by t = 7 or 10	B2,1,0 (2)
(f)		M1A1 A1 A1 A1 (5)
(g)	10 extra hours ∴ £280	M1 A1 (2)
		$\boxed{17}$

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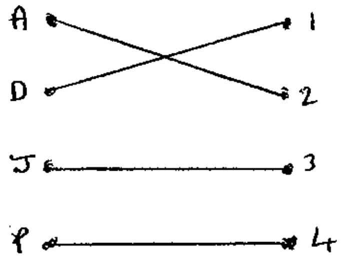
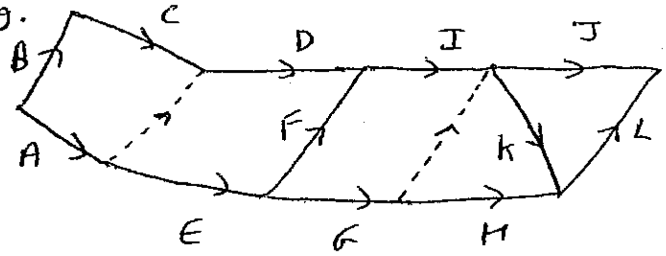
January 2005

Advanced Subsidiary/Advanced Level

General Certificate of Education

Subject: **Decision Maths** Paper: **D1**

Question Number	Scheme	Marks
1)(a)		B1 (1)
(b)	e.g. $S-3=J-4=P-6$ c.s. $S=3-J=4-P=6$ and $T-2=A-1=D-5$ c.s. $T=2-A=1-D=5$ $A=1$ $D=5$ $J=4$ $P=6$ $S=3$ $T=2$	m1 A1 (2) ↑ (m1) A1 A1 (3) 6
2 (a)	D depends on A and C, but E depends on A only H depends on G only, but J and K depend on G and I	B1 B1 (2)
(b)	eg. 	m1 A1 A1 A1 A1 (5) 7
3) (a)	(i) FH, AD, DE, CE, (not DC), $\begin{Bmatrix} BC \\ EG \end{Bmatrix}$, (not AC), CF, HI, (not FI), IJ_{stop}	m1 A1 A1 (3)
	(ii) AD, DE, EC, $\begin{Bmatrix} BC \\ EG \end{Bmatrix}$, CF, FH, HI, IJ stop.	m1 A1 A1 (3)
(b)	Start off the tree with AB and FI, then apply Kruskal	B2,1,0 (2) 8

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Subject: **Decision Maths** Paper: **D1**

Question Number	Scheme	Marks
4) (a)	E.g. 650 431 245 643 455 710 234 162 452 134 650 643 710 455 431 245 234 162 452 134 650 710 643 455 431 245 452 234 162 134 710 650 643 455 431 452 245 234 162 134 710 650 643 455 452 431 245 234 162 134 Stop.	M1 A1 A1√ A1√ A1 (5)
(b)	Bin 1 710 + 245 Bin3 643+162+134 Bin 5 431 Bin 2 650 + 234 Bin 4 455 + 452	M1 A1 A1√A1 (4)
(c)	eg $\frac{4116}{1000} = 4.116$ ∴ 5 bins needed ∴ optimal	M1 A1√ (2) 11

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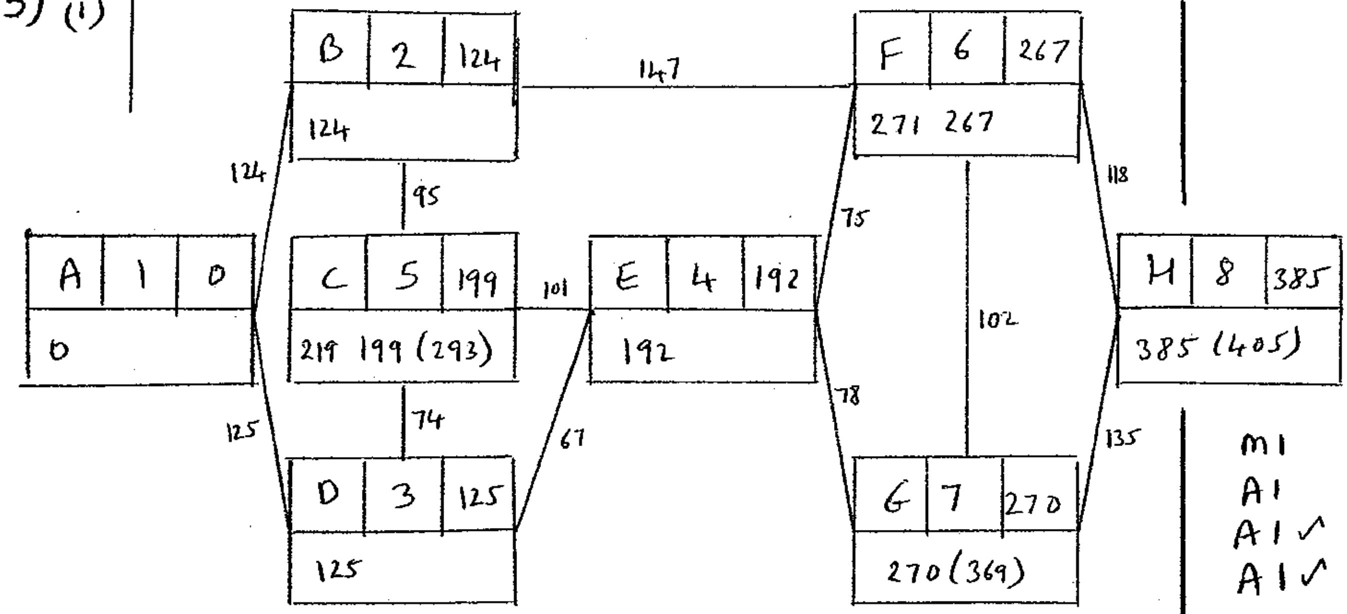
Subject: **Decision Maths** Paper: **D1**

Question Number	Scheme	Marks
5) (i)		M1 A1 A1✓ A1✓
	shortest distance is 385m	A1 (5)
(ii)	odd vertices B, C, D, G	M1
	BC + DG = 95 + 145 = 240 *	A1
	BD + CG = 169 + 179 = 348	A1
	BG + CD = 249+74 = 323	A1 (4)
	Repeat BC, DE and EG	
	eg. A BCB FHGF EGEC DEDA	B1
	length 1241 + 240 = 1481m	B1 (2)
		$\boxed{11}$

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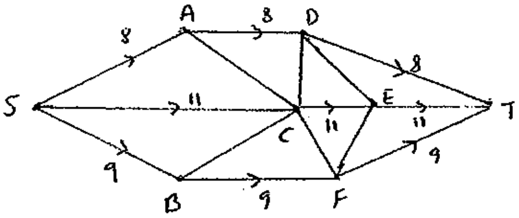
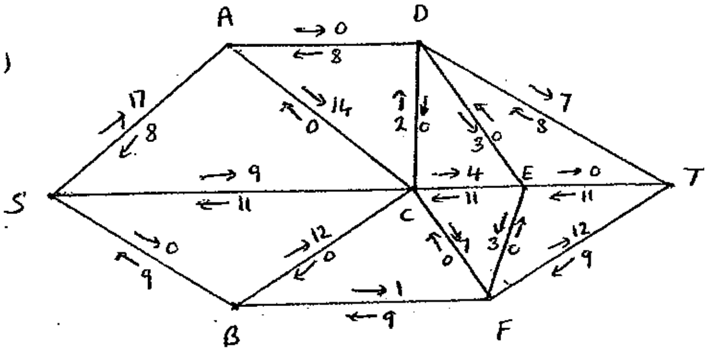
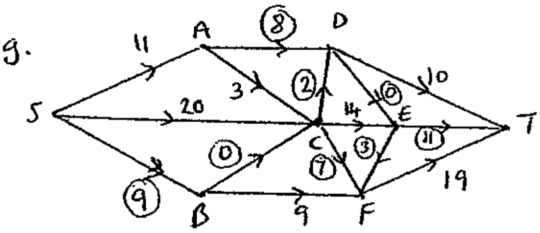
January 2005

Advanced Subsidiary/Advanced Level

General Certificate of Education

Subject: **Decision Maths** Paper: **D1**

Question Number	Scheme	Marks
6)(a)	SADT – 8 SCET – 11 SBFT – 9	B2, 1, 0
(b)		B1 (3)
(c) (i)		M1 A1 (2)
	e.g. SACDT – 2 SCFT – 6 SACEFT – 3 SACFT – 1 max flow 40	A1 A1 A1 (3)
(ii)	eg. 	M1 A1 (2)
(iii)	Max flow – min cut theorem cut AD, CD, DE, ET, ET, CF, BC, SB ie {SACE}{BDFT}	M1 A2, 0 (3)
(d)	Idea of a directed flow through a system of arcs from S to T practical	B1 (1) 14

EDEXCEL

190 High Holborn London WC1V 7BH

January 2005

Advanced Subsidiary/Advanced Level

General Certificate of Education

Subject: **Decision Maths** Paper: **D1**

Question Number	Scheme	Marks

7) (a) Maximize $P = 50x + 80y + 60z$ — B1

subject to

$x + y + 2z \leq 30$

$x + 2y + z \leq 40$ — B3, 2, 1, 0

$3x + 2y + z \leq 50$ — (4)

where $x, y, z \geq 0$

(b) Initialising tableau — B1√

bv	x	y	z	r	s	t	value
r	1	1	2	1	0	0	30
s	1	$\boxed{2}$	1	0	1	0	40
t	3	2	1	0	0	1	50
P	-50	-80	-60	0	0	0	0

m1

chooses correct pivot, divides R_2 by 2 — A1√

States correct row operations $R_1 - R_2$, $R_3 - 2R_2$, $R_4 + 80R_2$, $R_2 \div 2$ — A1 (4)

(c) The solution found after one iteration has a slack of 10 units of black per day — B2, 1, 0 (2)

(d) (i)

bv	x	y	z	r	s	t	value
r	$\frac{1}{2}$	0	$\boxed{3/2}$	1	$-1/2$	0	10
y	$\frac{1}{2}$	1	$1/2$	0	$1/2$	0	20
t	2	0	0	0	-1	1	10
P	-10	0	-20	0	40	0	1600

(given)

bv	x	y	z	r	s	t	value
z	$1/3$	0	1	$2/3$	$-1/3$	0	$6\,2/3$
y	$1/3$	1	0	$-1/3$	$2/3$	0	$16\,2/3$
t	2	0	0	0	-1	1	10
P	$-3\frac{1}{3}$	0	0	$13\,1/3$	$33\frac{1}{3}$	0	$1733\,1/3$

$R_1 \div 3/2$ — m1 A1

$R_2 - 1/2 R_1$

R_3 — no change — m1 A1

$R_4 + 20R_1$ — (4)

(ii) Not optimal, a negative value in profit row — B1√

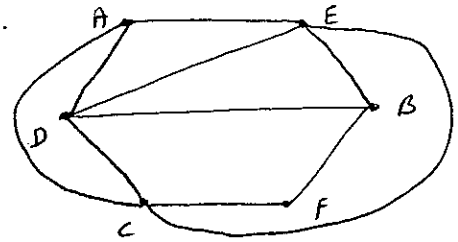
(iii) $x = 0$ $y = 16\,2/3$ $z = 6\,2/3$ — m1 A1√

$P = £1733.33$ $r = 0$, $s = 0$, $t = 10$ — A1√ (4)

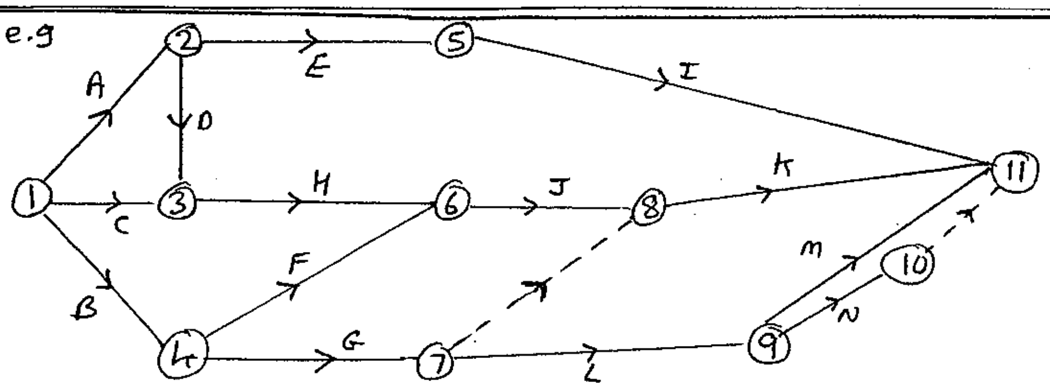
Publication Scheme.

edexcel

June 2005
6689 Decision D1
Mark Scheme

Question Number	Scheme	Marks
1)	e.g. 74 28 63 54 54 49 37 68 54	m1
	74 63 54 68 $\boxed{54}$ 28 49 37 54 49	A1
	74 63 68 $\boxed{54}$ $\vert$ $\boxed{49}$ 28 37 63 37	
	74 68 $\boxed{63}$ $\vert$ $\vert$ $\vert$ $\boxed{37}$ 28 68 (28)	A1✓
	74 $\boxed{68}$ $\vert$ $\vert$ $\vert$ $\vert$ $\vert$ $\boxed{28}$	
	74 68 63 54 54 49 37 28 sort complete	A1 (4)
	∴ Ali, Sophie, Eun-Jung, {Katie + Marciana}, Peter, Rory, Bobby	A1 (1) $\boxed{5}$
2)(a)	e.g. A E B F C D A	m1 A1 (2)
(b)	e.g. 	m1 A1 A1 (3)
(c)	State that one of these arcs (AF or EF) [Named], crosses at least one arc in each set. [Named arcs]	B2, 1/0 (2) $\boxed{7}$
3)(a)	AC + DF = 8 + 9 = 17 ←	m1 A1
	AD + CF = 15 + 16 = 31	
	AF + CD = 13 + 7 = 20	A1 (3)
	length = 77 + 17 = 94 km	m1 A1✓ (2)
(b)	shortest arc is CD (7) so use A and F as end points	B2, 1, 0 (2) $\boxed{7}$

4) (a) e.g



M1
A1
A1
A1 (4)

(b) Reference to K, J, G and L – K depends on J and G, but L depends on G only — B2, 1, 0

Both M and N must be uniquely represented in terms of events. — B1 (3)

$\boxed{7}$

---

5) (a) E – 4 = B – 2 = D – 1 = A – 3 = C – 5   change status to give — M1 A1

matching A = 3 B = 2 C = 5 D = 1 E = 4 — A1 (3)

E – 4 = B – 2 = D – 3 = C – 5   change status to give — M1 A1

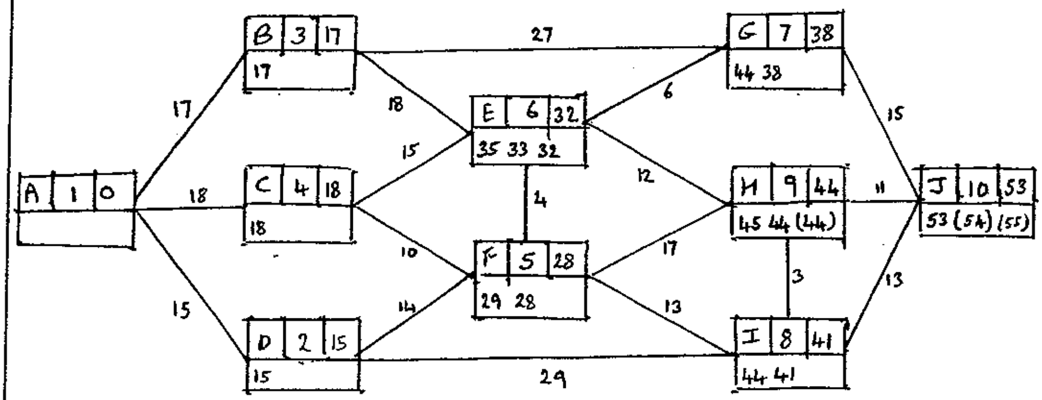
matching A = 1 B = 2 C = 5 D = 3 E = 4 — A1 (3)

(b) e.g. Reference to B + E and 4 + 2 — B2, 1, 0 (2)

$\boxed{8}$

---

6) (a)



M1
A1
A1✓
A1✓

Route: A C F E G J

length: 53 km — A1 (5)

(b) General explanation – trace back from J
- Include arc XY if Y is already on path and if difference in final labels equals length of arc.

Specific explanation –
53 – 15 = 38 GJ
38 – 6 = 32 EG
32 – 4 = 28 FE
28 – 10 = 18 CF
18 – 18 = 0 AC

B2/1/0 (2)

(c) e.g. ADFEGJ or ACEGJ ; length 54 km — M1A1; A1 (3)

$\boxed{10}$

7) (a) r, s and t are unused amounts of birdseed (in kg), suet blocks and peanuts (in kgs) that Polly has at the end of each week after she has made up and sold her packs.

B2, 1, 0 (2)

(b)

b.v.	x	y	z	r	s	t	value	
z	$\frac{2}{5}$	$\frac{1}{2}$	1	$\frac{1}{10}$	0	0	14	$R_1 \div 10$
s	$\enclose{circle}{\frac{2}{5}}$	-1	0	$-\frac{2}{5}$	1	0	4	$R_2 - 4R_1$
t	$-\frac{1}{5}$	$\frac{1}{2}$	0	$-\frac{3}{10}$	0	1	18	$R_3 - 3R_1$
P	-90	-25	0	65	0	0	9100	$R_4 + 650R_1$

M1 A1

M1

A2√, 1√, 0 (5)

(c) $x = 0$ $y = 0$ $z = 14$ $r = 0$ $s = 4$ $t = 18$ $P = £91$

M1

A2√1√0 (3)

(d) $P - 90x - 25y + 65r = 9100$ (o.e.)

M1 A1√

(e) $P = 9100 + 90x + 25y - 65r$

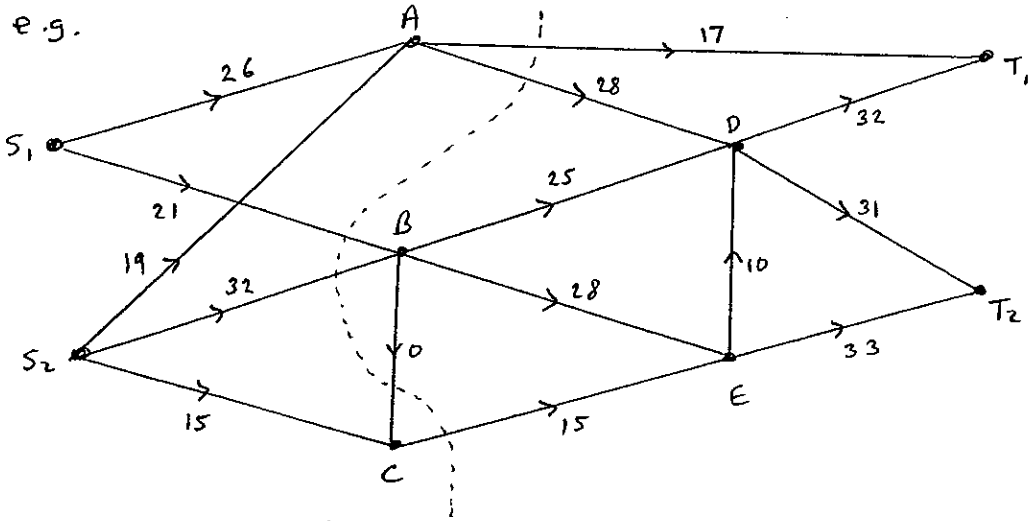
So increasing x or y would increase the profit

Ⓑ1√ (3)

(f) The $\frac{2}{5}$ in the x column and 2nd (s) row.

B2√1√, 0 (2)

$\boxed{15}$

8 (a)	$SS_1 - 47$, $SS_2 - 87$, $T_1T - 51$, $T_2T - 73$ added to diagram 1	M1 A1 (2)
(b)	$SS_1 \substack{\rightarrow 0 \\ \leftarrow 47}$, $SS_2 \substack{\rightarrow 38 \\ \leftarrow 49}$, $T_1T \substack{\rightarrow 8 \\ \leftarrow 43}$, $T_2T \substack{\rightarrow 20 \\ \leftarrow 53}$	M1 A1 (2)
(c)	e.g. $S S_2 A D T_1 T$ — 2 $S S_2 C E T_2 T$ — 1 $S S_2 C E D T_2 T$ — 10 $S S_2 C E B D T_1 T$ – 4 maximum flow – 113	M1 A4,3,2,1,0 B1 (6)
(d)	e.g. 	M1 A1 (2)
(e)	max flow - min cut theorem; cut AT_1, AD, S_1B, S_2B, BC, CE	M1 A1 (2)
(f)	Idea of a <u>directed</u> flow along arcs; from S to T; through a system/network; practical	B2,1,0 (2) $\boxed{16}$

June 2005
6689 Decision D1
Mark Scheme

final

Question Number	Scheme	Marks
1)	e.g. 74 28 63 54 54 49 37 68 54	M1
	74 63 54 68 $\boxed{54}$ 28 49 37 54 49	A1
	74 63 68 $\boxed{54}$ │ $\boxed{49}$ 28 37 63 37	
	74 68 $\boxed{63}$ │ │ │ $\boxed{37}$ 28 68 (28)	A1√
	74 $\boxed{68}$ │ │ │ │ │ $\boxed{28}$	
	74 68 63 54 54 49 37 28 sort complete	A1 (4)
	∴ Ali, Sophie, Eun-Jung, {Katie + Marciana}, Peter, Rory, Bobby	A1 (1) $\boxed{5}$

Q1 M1 Pivot clear list > $\boxed{P}$ >. Bubble sort etc. M0

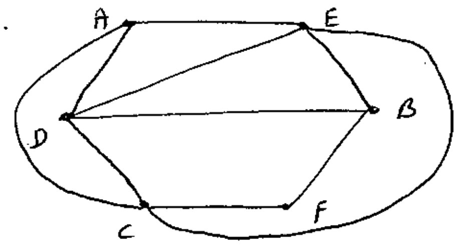
A1 1st pass correct, next pivots correctly selected consistently

A1√ 2nd + 3rd passes correct, pivots for next pass selected consistently each time. Penalise fragmented list here

(or list rewritten or all chosen as pivots)

A1 c.s.o. + stop statement (o.e.). Penalise non-sig no. errors here. Penalise "sloppyness" here

A1 c.a.o. accept c.a. even if MR.

Question Number	Scheme	Marks
2)(a)	e.g. A E B F C D A	M1 A1 (2)
(b)	e.g. 	M1 A1 A1 (3)
(c)	States that one of these arcs (AF or EF) [Named], crosses at least one arc in each set. [Named arcs]	B2, 1/0 (2) $\boxed{7}$

Q2(a) M1 Each letter written and present exactly once – apart from possibly start + finish vertex

A1 a correct route – starts and finishes at A

(b) M1 Cycle drawn as hexagon + at least 1 other arc added to diagram

A1 at least 2 arcs added to hexagon

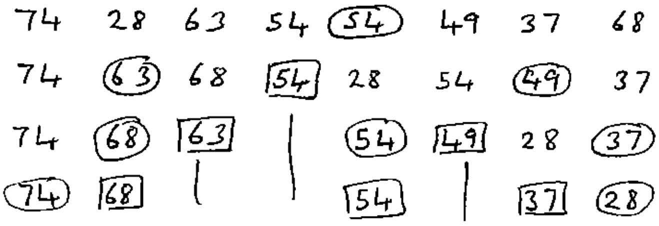
A1 c.a.o.

(c) B2 Good explanation AF or EF crosses named "inside" arc + named "outside" arc.

B1√ AF or EF crosses named arc. "close". 'bad' sets B1. If 1 crossing visible on graph give bod

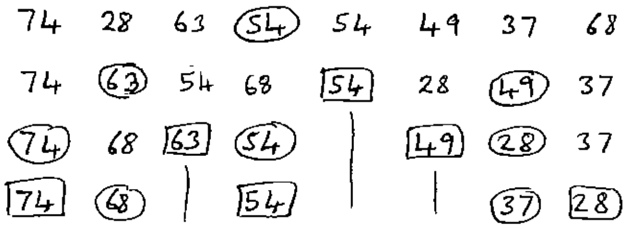
Q 1 Alternative correct answers

(i)



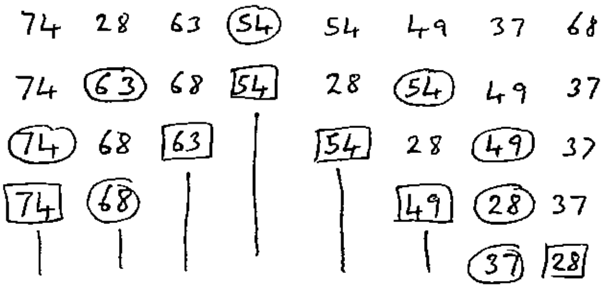
54 M1
63 49 A1
68 37 (54)
A1✓

(ii)



54 M1
63 49 A1
74 28 (54)
A1✓

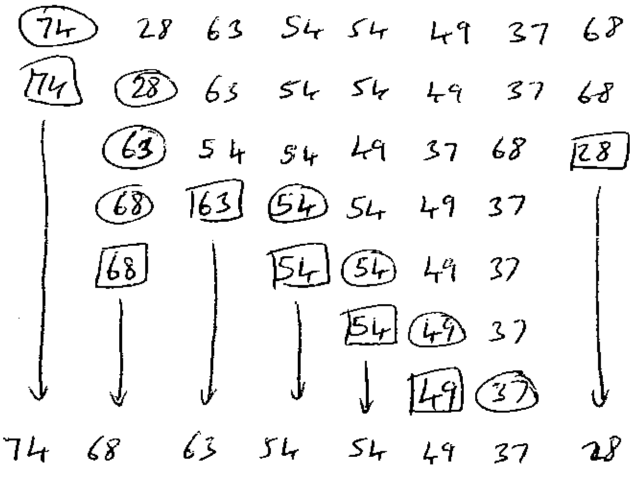
(iii)



54 M1
63, 54 A1
74, 49
28 (68)
(37)
A1✓

1st in list

(iv)



74 M1
28
63 A1✓
(68) 54
54
49
(37) A1

Ali, Sophie, Eun-Jung, Kate, Marciana, Peter, Rory, Bobby

Q1 MISREADS

-2 for MR

										MR
(a)	74	28	63	54	(54)	49	37	68	54	M1
	28	54	㊾	37	$\boxed{54}$	74	(63)	68	49 63	A1
	28	㊲	$\boxed{49}$	(54)	|	$\boxed{63}$	74	(68)	37 68 (54)	
	㉘	$\boxed{37}$	|	$\boxed{54}$	|	|	$\boxed{68}$	(74)		A1✓
										MR
(b)	74	28	63	54	(54)	49	37	68	54	M1
	28	㊾	37	$\boxed{54}$	74	63	(54)	68	49, 54	A1
	28	㊲	$\boxed{49}$	|	$\boxed{54}$	74	(63)	68	37, 63	
	㉘	$\boxed{37}$	|	|	|	$\boxed{63}$	74	(68)	68 (28)	
	|	|	|	|	|	|	$\boxed{68}$	(74)		A1✓
										MR
(c)	74	28	63	(54)	54	49	37	68	54	M1
	28	(54)	49	37	$\boxed{54}$	74	(63)	68	54, 63	A1
	28	㊾	37	$\boxed{54}$	|	$\boxed{63}$	(74)	68	49 74	
	㉘	37	$\boxed{49}$	|	|	|	68	$\boxed{74}$	28	
	$\boxed{28}$	㊲	|	|	|	|	|	|		A1✓
										MR
(d)	74	28	63	(54)	54	49	37	68	54	M1
	28	㊾	37	(54)	74	(63)	54	68	49 63	A1
	㉘	37	$\boxed{49}$	|	(54)	$\boxed{63}$	(74)	68	28, 74, (54)	
	$\boxed{28}$	㊲	|	|	$\boxed{54}$	|	(68)	$\boxed{74}$		A1✓

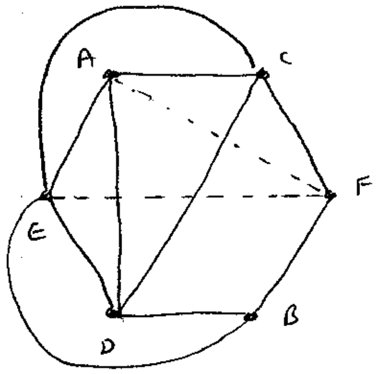
If candidate reverse list then restore full marks.
names or numbers

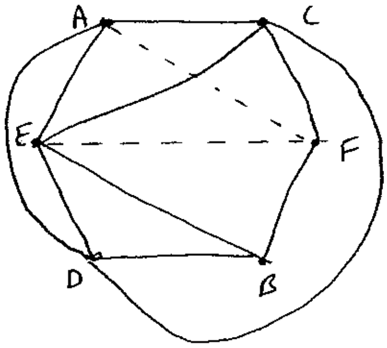
Bobby, Rory, Peter, Katie + Marciana, Eun-Jung, Sophie, Ali

Q2 Some egs. Hamiltonian cycles + diagrams for Q2

A C F B D E A

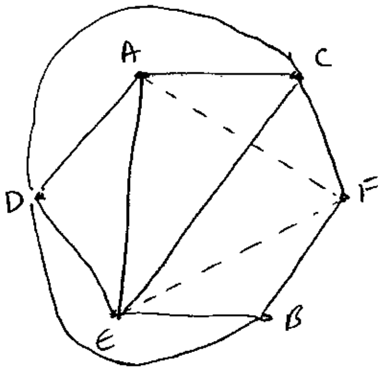
A E D B F C A

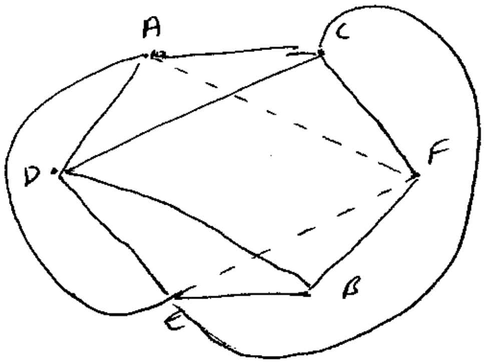




A C F B E D A

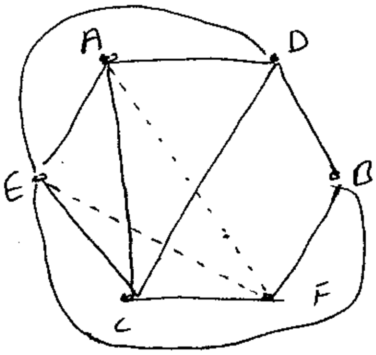
A D E B F C A

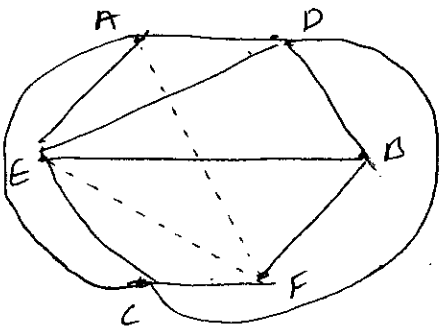




A D B F C E A

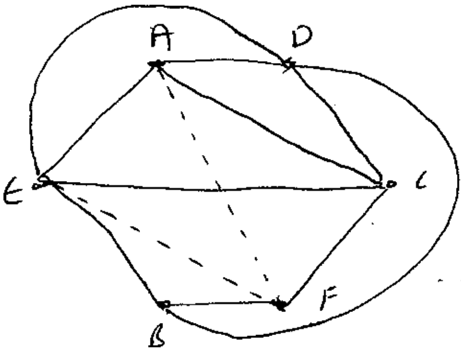
A E C F B D A

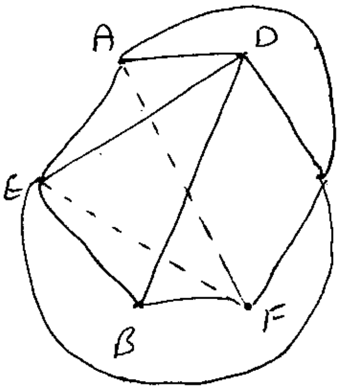




A D C F B E A

A E B F C D A





3)(a)	AC + DF = 8 + 9 = 17 ← AD + CF = 15 + 16 = 31 AF + CD = 13 + 7 = 20	M1 A1 A1 (3)
	length = 77 + 17 = 94 km	M1 A1√ (2)
(b)	shortest arc is CD (7) so use A and F as end points	B2, 1, 0 (2) 7

Q 3(a) M1 3 pairs of 4 odd vertices (different) ACDF

A1 2 pairs + "totals" correct

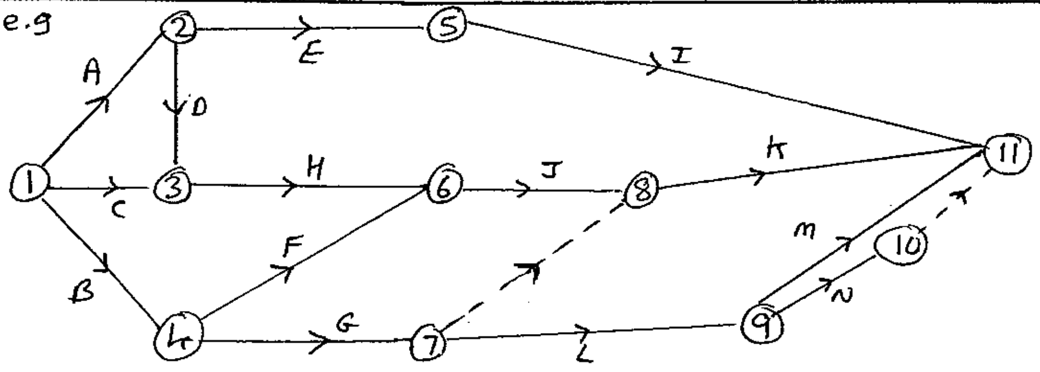
A1 All 3 pairs + totals correct 17 31 20

M1 77 + <u>their</u> shortest or plausible list

A1√ cao + km

(b) B2 CD identified as the smallest or arc, to be repeated <u>and</u> A + F stated as end points

B1 <u>either</u> CD identified as the smallest or arc to be repeated <u>or</u> A + F stated as end points. 'bod' gets B1 or picks smallest out of at least two routes

4)(a)	e.g  	M1 A1 A1 A1 (4)
(b)	Reference to K, J, G and L – K depends on J and G, but L depends on G only Both M and N must be uniquely represented in terms of events.	B2, 1, 0 B1 (3) 7

4 (a) M1 6 activities + 1 dummy, activity on arc. <u>Condone lack of events throughout</u>

Max 2 off for arrows

A1 A – F + arrow + 1 start

A1 G – K + dummy "⑦–⑧" (ignore label on dummy) + arrow on dummy + other arrows (penalise once only)

A1 L – N + dummy +1 finish "⑩–⑪" <u>Note</u>: dummy may be on M or N (ignore label on dummy) + arrow on dummy + other arrows (penalise once only)

(b) B2 Complete + clear K, J, G, L referred to explanation clear + correct

B1 Nearly there. "Bod" gets B1. All there but confused explanation / vague. KJGL referred to

B1 Unique representation (o.e). Start + finish at same events.

5) (a)	$E-4=B-2=D-1=A-3=C-5$ change status to give matching $A=3$ $B=2$ $C=5$ $D=1$ $E=4$	M1 A1 A1 (3)
	$E-4=B-2=D-3=C-5$ change status to give matching $A=1$ $B=2$ $C=5$ $D=3$ $E=4$	M1 A1 A1 (3)
(b)	e.g. Reference to $B+E$ and $4+2$	B2, 1, 0 (2) $\boxed{8}$

Q5 (a) M1 1st path E to 5

A1 c.a.o + c.s.

A1 matching c.a.o must be clear, must √

M1 2nd path E to 5

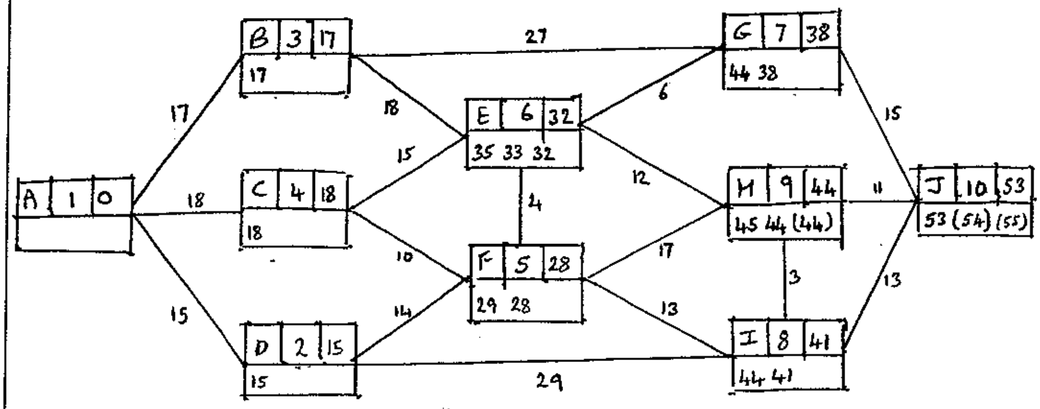
A1 c.a.o. + c.s. (don't penalise $\overset{c.s.}{\wedge}$ twice)

A1 matching c.a.o. must be clear, must √

(b) B2 Full clear explanation B, E, 2 and 4 linked. (+D) o.e – lots of alternatives

B1 Probably 3 out of 4 referred to, may be explanation confused, superflous films or times introduced. "b.o.d gets B1"

6) (a)



Route: A C F E G J
length: 53 km

M1
A1
A1 ✓
A1 ✓
A1
(5)

(b) General explanation - trace back from J
- Include arc XY if Y is already on path and if difference in final labels equals length of arc.

Specific explanation -
53 - 15 = 38 GJ
38 - 6 = 32 EG
32 - 4 = 28 FE
28 - 10 = 18 CF
18 - 18 = 0 AC

B2/1/0 (2)

(c) e.g. ADFEGJ or ACEGJ ; length 54 km

M1 A1 ; A1 (3)

10

6 (a) M1 In E or F or G or H or I w.v. large replaced by small . 1

A1 A, B, C, D, F correct (order in rising sequence)

A1 ✓ E G I correct + labelling order (penalise order of labelling only once)

A1 ✓ H, J correct + labelling (penalise order of labelling only once)

A1 Route + length (both) condone lack of km.

(b) B2 ✓ Complete version of one of the 2 given explanations

B1 ✓ All these bar one step. 'bod' gets B1

(c) M1 Route A to J avoiding CF

A1 c.a.o or a description

A1 54 (condone lack of km)

7) (a) r, s and t are unused amounts of bird seed (in kg), suet blocks and peanuts (in kgs) that Polly has at the end of each week after she has madeup and sold her packs. — B2, 1, 0 (2)

(b)

b.v.	x	y	z	r	s	t	value	
z	$\frac{2}{5}$	$\frac{1}{2}$	1	$\frac{1}{10}$	0	0	14	$R_1 \div 10$
s	$\textcircled{\frac{2}{5}}$	-1	0	$-\frac{2}{5}$	1	0	4	$R_2 - 4R_1$
t	$-\frac{1}{5}$	$\frac{1}{2}$	0	$-\frac{3}{10}$	0	1	18	$R_3 - 3R_1$
P	-90	-25	0	65	0	0	9100	$R_4 + 650R_1$

M1 A1

M1

A2√, 1√, 0 (5)

(c) $x = 0$ $y = 0$ $z = 14$ $r = 0$ $s = 4$ $t = 18$ $P = £91$ — M1 A2√1√0 (3)

(d) $P - 90x - 25y + 65r = 9100$ (o.e.) — M1 A1√

(e) $P = 9100 + 90x + 25y - 65r$

So increasing x or y would increase the profit — Ⓑ√ (3)

(f) The $\frac{2}{5}$ in the x column and 2^{nd} (s) row. — B2√1√, 0 (2)

$\boxed{15}$

7 (a) B2 Ref to "unused" & "bird seed, suet blocks & peanuts".

B1 Ref to "unused" or bird seed etc or muddled explanation. "bad" sets B1 must engage with context

(b) M1 Correct pivot chosen

A1 pivot row correct c.a.o. incl b.v.

M1√ correct row operations used (all 3) - at least 1 non zero or 1 term correct in each row. While row √ ⇒ M0

A2√ non-pivotal rows correct; -1 each error √ on error in pivot choice only. Penalise b.v once only

(c) M1 3 variables stated - must have completed b.v. + value columns (or 1's and zeros) on tableau. Any negatives M0

A2√ all 7 c a o Need £91√ but accept 9100

A1√ at least 4 c a o (Condone P = 9100√)

(d) M1√ P, (-)90x, (-)25y, 65r and 9100 (or 91) all present and one = sign

A1√ c a o (o.e.)

(e) Ⓑ√ stating that increasing x or y would increase profit, probably re-arranging profit equation. Generous.

(f) B2√ $\frac{2}{5}$ identified, x column and 2^{nd} (s) row. Accept ringed in last tableau

B1√ 'bad' sets B1, If √ from their "optimal" tableau B1,

Q 7 (b) notes

1) Wrong pivot chosen in col z. (- usually 4)   M0 then for M1A2✓

(a)
(chan4)

b.V.	x	y	z	r	s	t	value	
r	-1	$2\frac{1}{2}$	0	1	$-2\frac{1}{2}$	0	-10	$R_1 - 10R_2$
z	$\frac{1}{2}$	$\frac{1}{4}$	1	0	$\frac{1}{4}$	0	15	$R_2 \div 4$
t	$-\frac{1}{2}$	$1\frac{1}{4}$	0	0	$-\frac{3}{4}$	1	15	$R_3 - 3R_2$
P	-25	$-187\frac{1}{2}$	0	0	$162\frac{1}{2}$	0	9750	$R_4 + 650R_2$

(b)
(chan3)

b.V	x	y	z	r	s	t	value	
r	$\frac{2}{3}$	$-1\frac{2}{3}$	0	1	0	$\frac{-10}{3}$	-60	$R_1 - 10R_3$
s	$\frac{2}{3}$	$-1\frac{2}{3}$	0	0	1	$\frac{-4}{3}$	-20	$R_2 - 4R_3$
z	$\frac{1}{3}$	$\frac{2}{3}$	1	0	0	$\frac{1}{3}$	20	$R_3 \div 3$
P	$-133\frac{1}{3}$	$83\frac{1}{3}$	0	0	0	$216\frac{2}{3}$	13000	$R_4 + 650R_3$

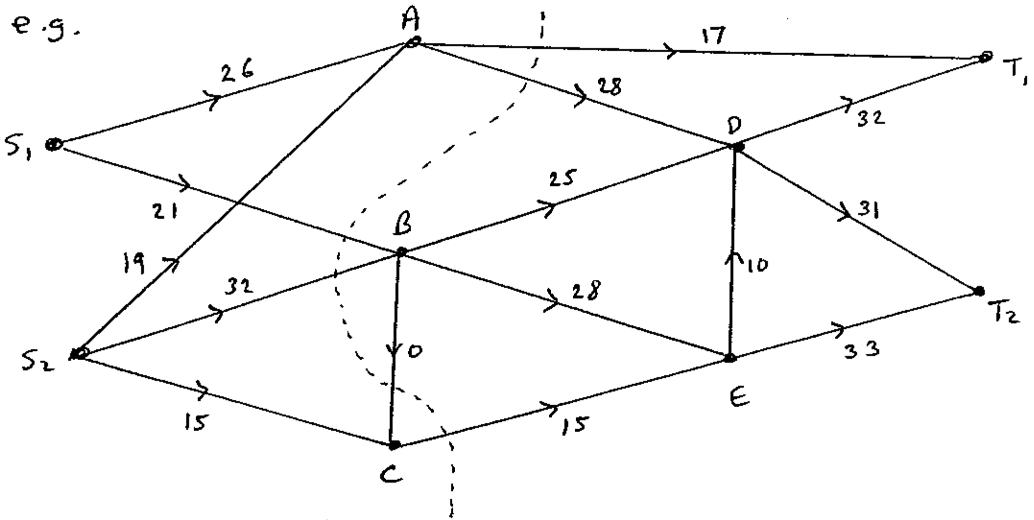
2) MISREADS - use col x or col y.   - 2 A marks if earned.

(a)

b.V.	x	y	z	r	s	t	value	
r	0	3	2	1	-2	0	20	$R_1 - 4R_2$
x	1	$\frac{1}{2}$	2	0	$\frac{1}{2}$	0	30	$R_2 \div 2$
t	0	$1\frac{1}{2}$	1	0	$-\frac{1}{2}$	1	30	$R_3 - R_2$
P	0	-175	50	0	175	0	10500	$R_4 + 350R_2$

(b)

b.v.	x	y	z	r	s	t	value	
y	$\frac{4}{5}$	1	2	$\frac{1}{5}$	0	0	28	$R_1 \div 5$
s	$1\frac{1}{5}$	0	2	$-\frac{1}{5}$	1	0	32	$R_2 - R_1$
t	$-\frac{3}{5}$	0	-1	$-\frac{2}{5}$	0	1	4	$R_3 - 2R_1$
P	-70	0	50	70	0	0	9800	$R_4 + 350R_1$

8 (a)	$SS_1 - 47$, $SS_2 - 87$, $T_1T - 51$, $T_2T - 73$ added to diagram 1	M1 A1 (2)
(b)	$SS_1 \overset{\rightarrow 0}{\leftarrow 47}$, $SS_2 \overset{\rightarrow 38}{\leftarrow 49}$, $T_1T \overset{\rightarrow 8}{\leftarrow 43}$, $T_2T \overset{\rightarrow 20}{\leftarrow 53}$	M1 A1 (2)
(c)	e.g. $S S_2 A D T_1 T$ — 2 $S S_2 C E T_2 T$ — 1 $S S_2 C E D T_2 T$ — 10 $S S_2 C E B D T_1 T$ — 4 maximum flow - 113	M1 A4,3,2,1,0 B1 (6)
(d)	e.g. 	M1 A1 (2)
(e)	max flow - min cut theorem; cut AT_1, AD, S_1B, S_2B, BC, CE	M1 A1 (2)
(f)	Idea of a <u>directed</u> flow along arcs; from S to T; through a system/network; practical	B2,1,0 (2) $\boxed{16}$

If all 4 nos. zero then M0

8(a) M1 4 arcs added correctly + 4 numbers given (diagram 1 only) condone lack of arrows

A1 c.a.o (diagram 1 only) penalise arrow errors here

(b) M1 4 arcs, 2 numbers and 2 arrows $\rightleftarrows$ per arc

A1 c.a.o.

(c) M1 2 correct routes + flows found (flow > 10 get M0) (condone initial f. a. routes only if clearly separated from new ones.)

A4 all flows + routes found to 17 more.

A3 ≥3 flows + routes to 15 more or flow increased above 17 more.

A2 ≥3 flows + routes to 11 more or

A1 at least 2 flows + routes found to 5 more.

B1 113 c.a.o.

(d) M1 Consistent flow of 101+, complete clear (doesn't need to ✓ from (c))

A1 correct flow of 113 including arrows

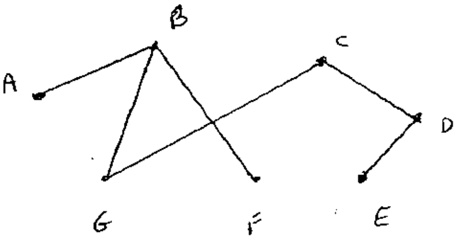
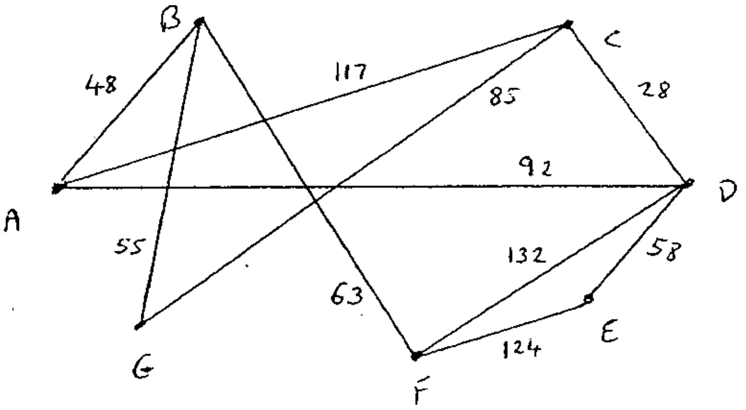
(e) M1 Flow of 113 + cut attempted + max flow - min cut theorem referred to (3 out of 4)

A1 cao

(f) B2 all 4 bits there

B1 2 out of 4 there.

January 2006
6689 Decision D1
Mark Scheme

Question Number	Scheme	Marks
1) (a)	There are 2 unmatched vertices on each side – the algorithm only matches one on each side per iteration.	B1 (1)
(b)	e.g. E – 3 = C – 1 c.s. E = 3 – C = 1	$\boxed{m1}$ A1 (2)
	F – 5 = A – 6 = D – 2 = B – 4 c.s. F = 5 – A = 6 – D = 2 = B – 4	$\boxed{m1}$ A1 (2)
	A = 6 B = 4 C = 1 D = 2 E = 3 F = 5	$\boxed{m1}$ A1 (2) $\boxed{7}$
2) (a)	AB, BG, BF ⋮ GC, CD, DE {1 2 5 6 7 4 3}	M1A1 A1 (3)
	weight 337m	B1
		B1✓ (2)
(b)		M1 A1 A1 (3)
(c)	AB + CF = 48 + 160 = 208	M1 A1
	AC + BF = 117 + 63 = 180 *	A1
	AF + BC = 111 + 140 = 251	A1 (4)
	e.g. $A\overline{B}\underline{FB}G\underline{C}\overline{\underline{A}C}DEFDA$	A1
	length 802 + 180 = 982 m	M1 A1✓ (3) $\boxed{15}$

3)

A	B	n	C	D	E
1.618	-0.618	1	1.618	-0.618	1
		2	2.618	0.382	1
		3	4.236	-0.236	2
		4	6.854	0.146	3
		5	11.089	-0.090	5

M1 A1 A1 (3)
M1 A1✓ 1
A1✓
A1
A1 (5)

Output : 1, 1, 2, 3, 5 — A1✓ (1)

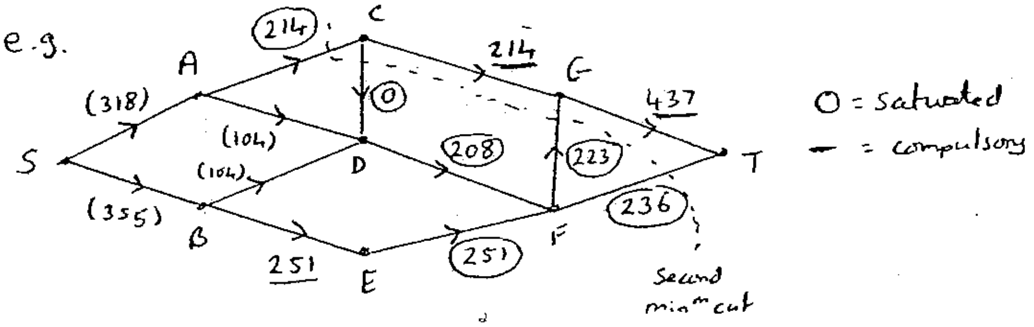
$\boxed{9}$

4) a) (i) A cut is a division of the vertices of a flow network into 2 sets, one containing the source(s) and the other containing the sink(s). — B1

(ii) A cut whose capacity is least — B1 (2)

(b) $c_1 = 1038$, $c_2 = 673$ — B1, B2, 0 (3)

(c) e.g.



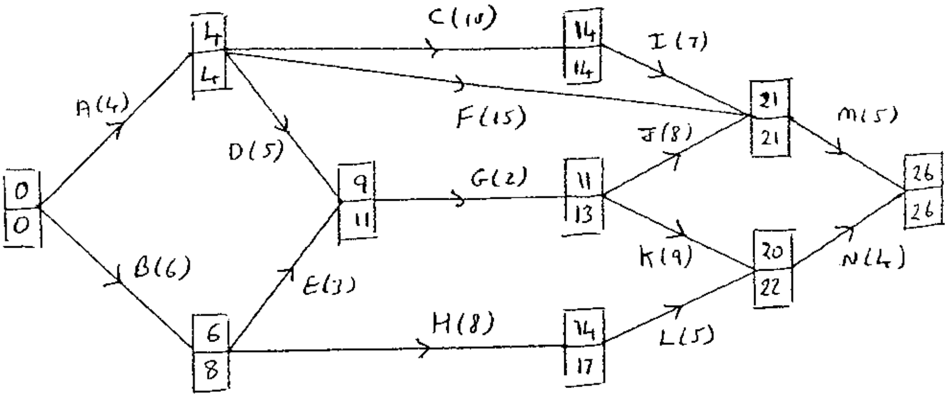
M1
A1
A1 (3)

(d) A C , C D , G F, F T — B1 (1)

(e) DE would not allow any further flow into EF
DG would cross both minimum cuts – D can take extra flow, GT can accept it. Flow increases by 86 to 759 (accept either number) — B2,1,0 (2)

$\boxed{11}$

5 (a)



M1 A1

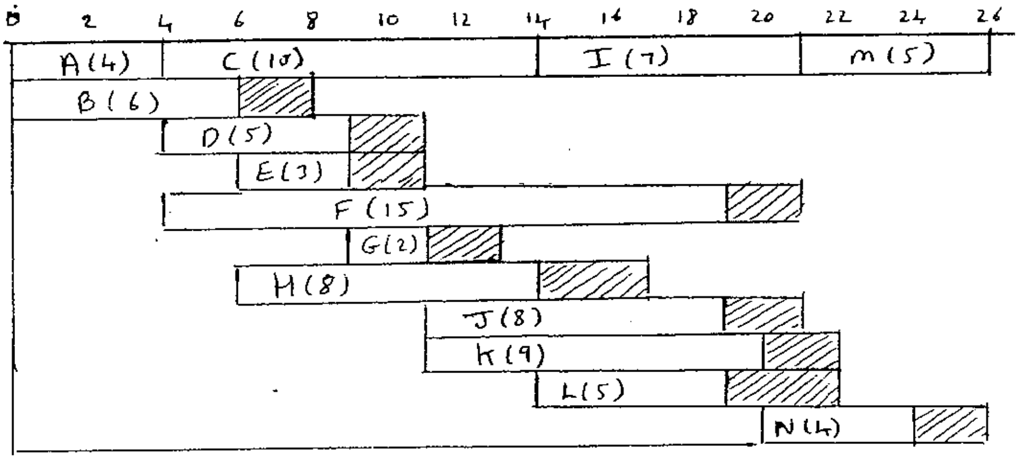
M1 A1

(4)

(b) A C I M length 26

B1 B1√ (2)

(c)



M1

A3,2√,0

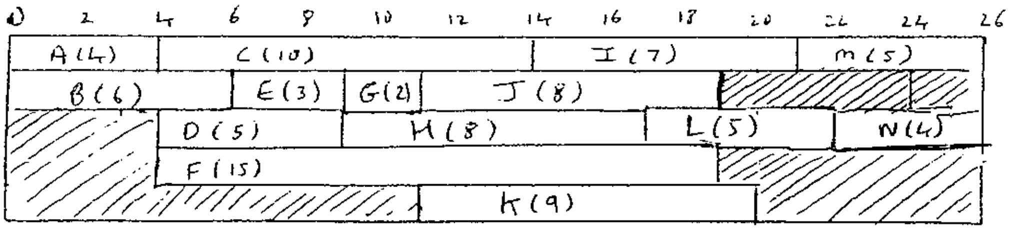
(4)

(d) 5 workers needed eg ref to 13-14 when C, F, H, J and K must be taking place
eg ref to 18-19 when I F J K L must be taking place

B2,1,0

(2)

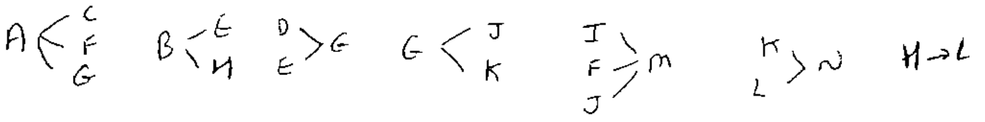
(e) E.g.



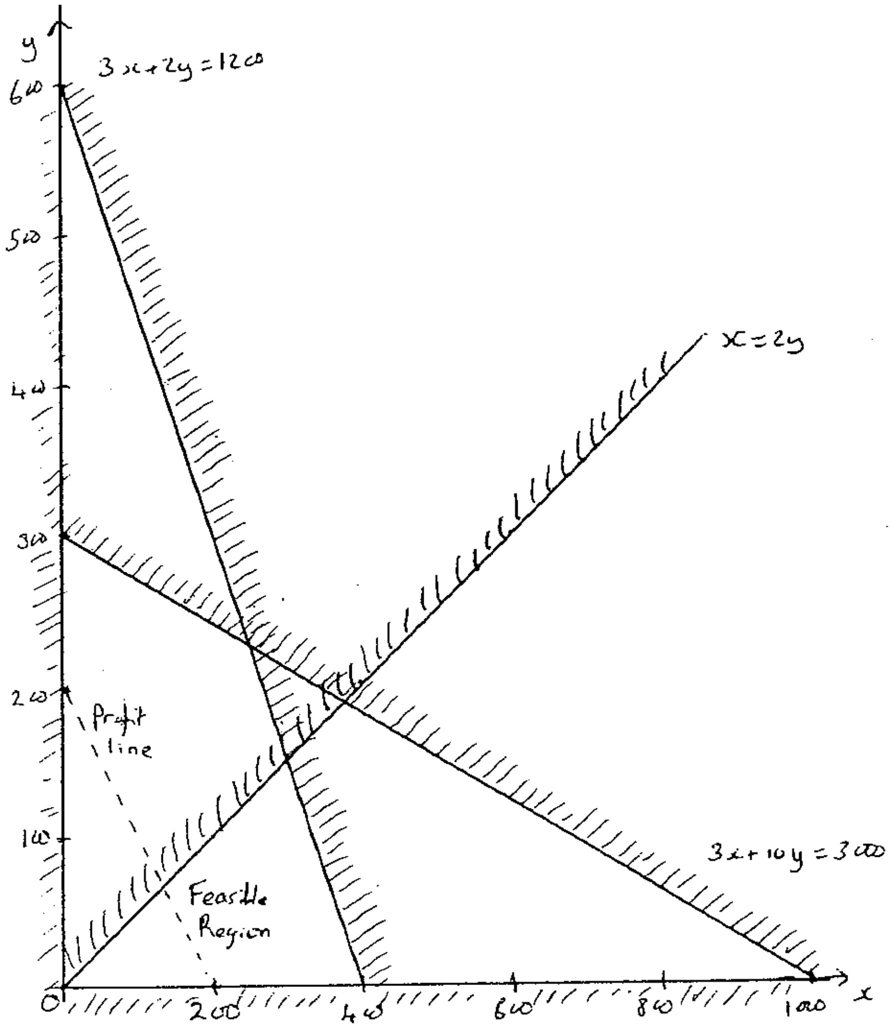
M1

A2,1,0

(3)



15

6. a)	Maximise, $(P=)\ 15x + 15y$ Subject to $3x + 10y \leq 3000$ $3x + 2y \leq 1200$ $x \geqslant 2y$ $x, y \geqslant 0$	B1, B1 B3, 2, 1, 0 (5)
(b)		B 6,5,4,3,2,1,0 (6)
(c)	profit line or vertex testing, (300, 150), profit = £ 67.50	M1 A1 A1 (3)
(d)	Production of stickers should be increased since this would move the intersection point further from the origin.	B2, 1, 0 (2)
(e)	e.g.. The constraint lines would be far outside the feasible region - so they would not affect it.	B2, 1, 0 (2) 18

June 2006
6689 Decision Maths D1
Mark Scheme

Question Number	Scheme	Marks
1)	eg 52 48 50 45 64 47 53	m1
	52 50 48 64 47 53 45	A1
	52 50 64 48 53 47 45	
	52 64 50 53 48 47 45	A1✓
	64 52 53 50 48 47 45	A1
	64 53 52 50 48 47 45	$\boxed{4}$
	no further changes – list sorted	

M1 Bubble sort – 1st pass complete – end term 45 or 64, consistent L→R or R→L Shuttle, Quick etc get M0

A1 First 2 passes correct } condone 'shrinking' list

A1 ✓ Next 2 passes correct (if L←R next pass) }

A1 Final pass + final statement/rewrites list cso – must see whole list

Question Number	Scheme	Marks
2) (a)	A path from an unmatched vertex in X to an unmatched vertex in Y, which alternately uses arcs in/not in the matching. (where X and Y are distinct sets of vertices.)	B2, 1, 0 (2)
(b)	e.g. R – B = A – P c.s. R = B – A = P	m1 A1 (2)
	S – F = M – C = D – K c.s. S = F – M = C – D = K	m1 A1
	∴ A = P D = K H = Y M = C R = B S = F	A1 (3)
		$\boxed{7}$

(a) B2 A good, complete answer

B1 Partially correct – unmatched to unmatched or arcs in/not in the matching one enough "bad" sets B1

(b) M1 Path from/to R/S to/from K/P

A1 c.a.o incl c.s.

M1 Second path from remaining LH vertex to remaining RH vertex

A1 c.a.o incl. c.s. (penalise c.s only once)

A1 Must ✓ from 2 correct paths cao

Notes for question 1

Q 1 Bubble R → L

52	48	50	45	64	47	53	M1
64	52	48	50	45	53	47	
64	53	52	48	50	45	47	A1
64	53	52	50	48	47	45	A1
No further change - list sorted							A1

Misreads - sorting into ascending order

(note - if candidates reverse list full credit is gained)

L → R (ascending - misread) MR

52	48	50	45	64	47	53	M1
48	50	45	52	47	53	64	
48	45	50	47	52	53	64	A1
45	48	47	50	52	53	64	
45	47	48	50	52	53	64	A1
No further change - list sorted							A1

4 - 2 for MR

R → L

52	48	50	45	64	47	53	MR M1
45	52	48	50	47	64	53	
45	47	52	48	50	53	64	A1
45	47	48	52	50	53	64	
45	47	48	50	52	53	64	A1
No further change - list sorted							A1

4 - 2 for MR

Notes for Q 2

(b)(i) $R - B = A - P$

$S - F = m - C = D - K$

(ii) $R - B = A - F = m - C = D - K$

$S - F = A - P$

(iii) $S - F = m - C = D - K$

$R - B = A - P.$

(iv) $S - F = m - Y = H - B = A - P.$

$R - B = H - Y = m - C = D - K$

$A = P$
$D = K$
$H = Y$
$m = C$
$R = B$
$S = F$

3)(a)	AC + EG = 44 + 35 = 79	M1
	AE + CG = 41 + 36 = 77 *	A1
	AG + CE = 36 + 45 = 81	A1
	Repeat AD, DE, CF and FG	A1√ (4)
(b)	length = 394 + 77 = 471 km	B1√ (1)
(c)	Since EG is the smallest chose to repeat this hence start and finish at A and C.	M1 A1√ (2) $\boxed{7}$

(a) M1 3 pairs of their odd vertices (different)

A1 One pairing and total correct – ie one line correct

A1 all 3 pairings and total correct

A1√ Correct arcs identified – must be 2⁺ pairings to chose from. AD DG CF FG

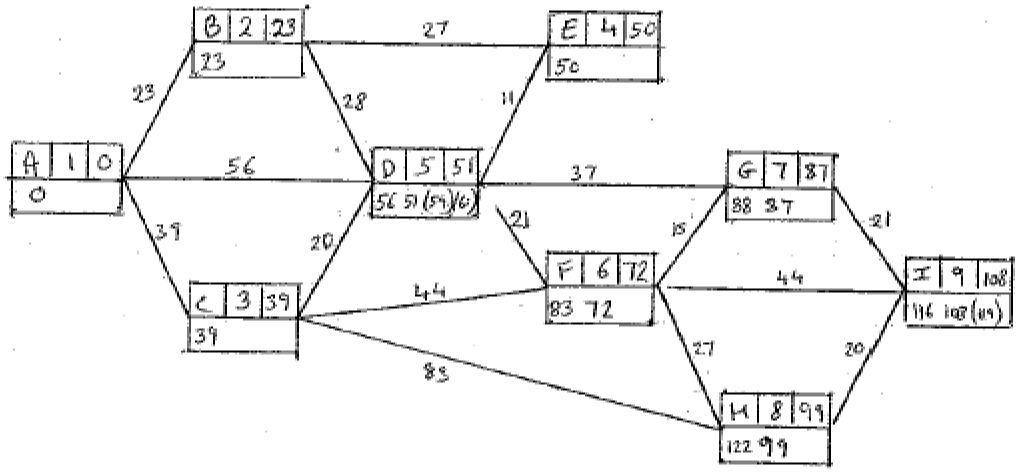
(b) B1 471 (km) 394 + their shortest – must be 2 pairings to choose from.

(c) M1 Identifies $\left\{\begin{matrix}35\\EG\end{matrix}\right\}$ as smallest – or identifies their smallest from 2^+ pairings & totals

A1√ from 2^+ pairings + totals

4(a) A path is a (finite) sequence of edges, such that the end vertex of one edge is the start vertex of the next and in which no vertex appears more than once / no cycles — B2, 1, 0 (2)

(b)



m1
A1
A1
A1√

shortest path: ABDFGI , length: 108 miles — A1, A1√ (6)

(c) e.g.
108 - 21 = 87 GI
87 - 15 = 72 FG
72 - 21 = 51 DF
51 - 28 = 23 BD
23 - 23 = 0 AB

or
- traceback from I
- include arc XY if Y is already on the path and if the difference in final labels equals the length of arc

B2√1√0 (2)

(d) A B E D F G I length 118 miles — m1 A1 (2)

$\boxed{12}$

(a) B2 A good, complete description

B1 close - mostly there. "bod" set B1 "route" "series" may be ok.

(b) m1 In D, F, G, H or I working values large replaced by small

A1 A, B, C, E correct labels in a rising sequence

A1 D, F correct labels√ } penalise order of labelling once only.

A1√ G H I correct labels√ }

A1 Path c.a.o.

A1√ Length √ from I accept 108 if a correct path

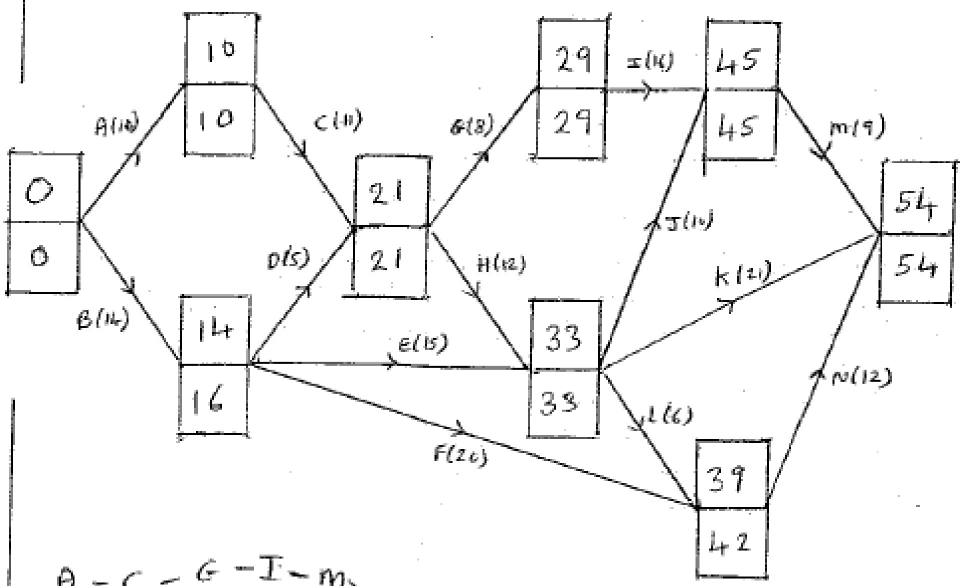
(c) B2 √ complete version of one of the 2 given explanations

B1 √ All there bar one step "bod" set B1 - easy mark

(d) m1 Route A to I including E

A1 cao

5 (a)



M1
A1 (2)

M1
A1 (2)

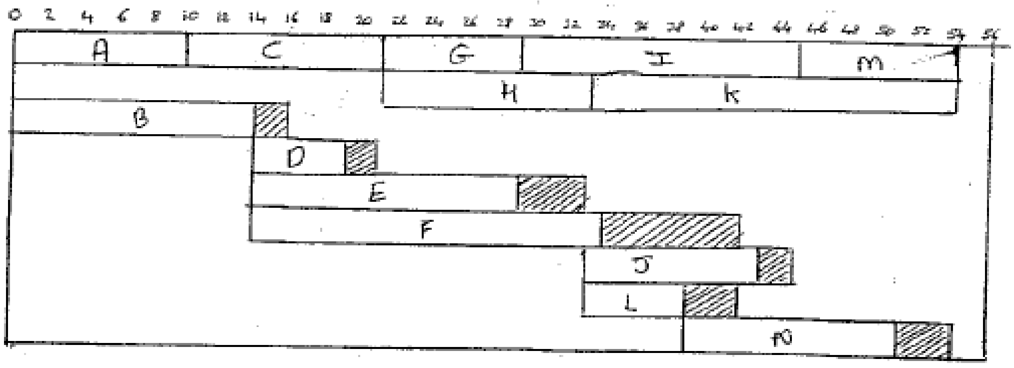
(b) A – C – G – I – M
H – K

A1 (1)

(c) Float on D = 21 – 5 – 14 = 2
Float on F = 42 – 20 – 14 = 8

B1✓
M1 A1✓ (3)

(d)



M1
A1
A1✓
A1
(4)

(e) Day 15: C
Day 25: G, H, E, F

B1
B2,1,0 (3)

15

Q5(a) M1 All top boxes completed → increasing generally

A1 C.A.O.

M1 All lower boxes completed ← decreasing generally

A1 c.a.o

(b) A1 c.a.o all 7 listed - no extras

(c) B1✓ cao ✓ from diagram } top & bottom at both ends

M1 method correct or ✓ correct answer } must see appropriate working for M1

A1✓ cao ✓ from diagram.

(d) M1 At least one of their critical paths + 3 non-critical stated including floats
must be complete answer ✓

A1 critical activities correct

A1✓ 4 non-critical activities correct ✓ from diagram must include a float per activity

A1 cao - on non critical

(e) B1 cao

B2 cao

B1 if one extra or one omission

6) (a)

$7x + 10y + 10z + r = 3600$

$6x + 9y + 12z + s = 3600$ B2, 1, 0

$2x + 3y + 4z + t = 2400$

$P - 35x - 55y - 60z = 0$ B2, 0 (4)

(b)

b.v.	x	y	z	r	s	t	value	Row ops.
r	2	$\boxed{5/2}$	0	1	$-5/6$	0	600	$R_1 - 10R_2$
z	$1/2$	$3/4$	1	0	$1/12$	0	300	$R_2 \div 12$
t	0	0	0	0	$-1/3$	1	1200	$R_3 - 4R_2$
P	-5	-10	0	0	5	0	18000	$R_4 + 60R_2$

m1
A1
m1
A1√
B1
(5)

b.v.	x	y	z	r	s	t	value	Row ops.
y	$4/5$	1	0	$2/5$	$-1/3$	0	240	$R_1 \div 5/2$
z	$-1/10$	0	1	$-3/10$	$1/3$	0	120	$R_2 - 3/4 R_1$
t	0	0	0	0	$-1/3$	1	1200	R_3 stt
P	3	0	0	4	$5/3$	0	20400	$R_4 + 10R_1$

m1
A1√
m1
A1
(4)

(c) $P = 20400 \quad x = 0 \quad y = 240 \quad z = 120$

$r = 0 \quad s = 0 \quad t = 1200$

m1
A2√, 1√, 0
$\boxed{16}$

D1 June 2006 Q6(b) - wrong pivot choice

(i) 10 in z column

b.v.	x	y	z	r	s	t	value	Row ops.	m0
z	$\frac{7}{10}$	1	1	$\frac{1}{10}$	0	0	360	$R_1 \div 10$	m1
s	$-\frac{12}{5}$	-3	0	$-\frac{6}{5}$	1	0	-720	$R_2 - 12R_1$	A1✓
t	$-\frac{4}{5}$	-1	0	$-\frac{2}{5}$	0	1	960	$R_3 - 4R_1$	B0
P	7	5	0	6	0	0	21 600	$R_4 + 60R_1$	m0 m0

(ii) 4 in z column

b.v.	x	y	z	r	s	t	value	Row ops	m0
r	2	$\frac{5}{2}$	0	1	0	$-\frac{5}{2}$	-2400	$R_1 - 10R_3$	m1
s	0	0	0	0	1	-3	-3600	$R_2 - 12R_3$	A1✓ B0
z	$\frac{1}{2}$	$\frac{3}{4}$	1	0	0	$\frac{1}{4}$	600	$R_3 \div 4$	m0
P	-5	-10	0	0	0	15	36 000	$R_4 + 60R_3$	m0

D1 June 2006 Q6(b) Misreads.

(i) chooses 7 in x column

b.v.	x	y	z	r	s	t	value	Row ops.	
x	1	$\frac{10}{7}$	$\frac{10}{7}$	$\frac{1}{7}$	0	0	$514\frac{2}{7}$	$R_1 \div 7$	$\frac{360}{49}$
s	0	$\frac{3}{7}$	$\frac{24}{7}$	$-\frac{6}{7}$	1	0	$514\frac{2}{7}$	$R_2 - 6R_1$	$\frac{150}{49}$
t	0	$\frac{1}{7}$	$\frac{8}{7}$	$-\frac{2}{7}$	0	1	$1371\frac{3}{7}$	$R_3 - 2R_1$	$\frac{1200}{49}$
P	0	-5	-10	5	0	0	18000	$R_4 + 35R_1$	

1st 5 marks as scheme

b.v.	x	y	z	r	s	t	value	Row ops.		
x	1	$\frac{5}{4}$	0	$\frac{1}{2}$	$-\frac{5}{12}$	0	509.9135...	$R_1 - \frac{10}{7}R_2$	407.93	
z	0	$\frac{1}{8}$	1	$-\frac{1}{4}$	$\frac{7}{24}$	0	150	$R_2 \div \frac{24}{7}$	1200	M1
t	0	0	0	0	$-\frac{1}{3}$	1	1367.930...	$R_3 - \frac{8}{7}R_2$		A1
P	0	$-\frac{15}{4}$	0	$\frac{5}{2}$	$\frac{35}{12}$	0	18030.612...	$R_4 + 10R_2$		

[to my final tableau]

M1
A1

−2 for Misread

(ii) chooses 10 in y column

b.v.	x	y	z	r	s	t	value	Row ops.
y	$\frac{7}{10}$	1	1	$\frac{1}{10}$	0	0	360	$R_1 \div 10$
s	$-\frac{3}{10}$	0	3	$-\frac{9}{10}$	1	0	360	$R_2 - 9R_1$
t	$-\frac{1}{10}$	0	1	$-\frac{3}{10}$	0	1	1320	$R_3 - 3R_1$
P	$\frac{7}{2}$	0	-5	$5\frac{1}{2}$	0	0	19800	$R_4 + 55R_1$

1st 5 marks as scheme

[to my final tableau]

Next 4 marks as scheme

−2 for Misread

6 (a) B2 } First 3 equations c.a.o −1 each error, but penalise only 1 error per equation
B1 } inequalities get B0

B2 c a o (B1 for a "little slip")

(b) M1 Correct pivot chosen and some attempt to deal with whole row

A1 pivot row correct c.a.o including b.v.

M1 Correct row operations used (all 3) – at least 1 non-zero or 1 term correct in each row. whole row ✗ ⇒ M0

A1√ non-pivoted rows correct; √ on error in pivot choice only

(5) B1 Row operations correctly stated. (condone lack of $R_2 \div 12$) must be in terms of new pivot row

+ some attempt to deal with whole row
⇒ M1√ Correct pivot chosen, √ from previous tableau. No negatives in value of previous tableau or M0)

A1√ c a o including b.v. but √ from previous tableau

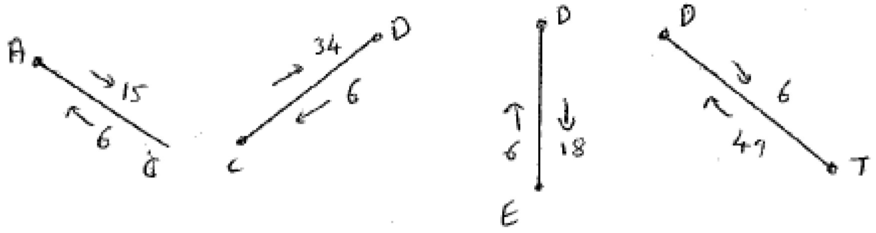
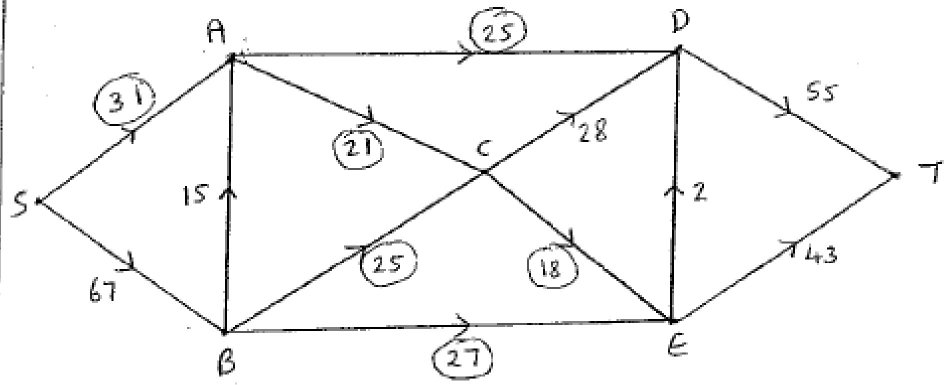
⇒ M1 Correct row operations used (all 3) – at least 1 non-zero or 1 term correct in each row. whole row ✗ ⇒ M0

(4) A1 c.a.o.

If reading top → bottom M0. Must be a final tableau. Irrespective M0
(c) M1 3 variables stated – must have completed b.v. and value columns (or 1's and zeros) on tableau. Any negative M0

A2√ all 7 correct

A1√ at least 4 correct

7) (a)	$C_1 = 103$, $C_2 = 177$, flow = 76	B1, B1, B1 (3)
(b)		M1 A1 (2)
(c)	e.g. SBCDT – 6 SBCDET – 1 SBACDET – 15 max. flow is 98	M1 A 3,2,1,0 B1 (5)
(d)		M1 A1 (2)
(e)	Maximum flow = minimum cut cut through AD, AC, BC and BE	M1 A1 (2)
		14

7)(a) B1 103 cao

B1 177 cao

B1 76 cao

(b) M1 2 numbers added to each of the 4 arcs

A1 cao

(c) M1 1 correct route + flows found (flow ≥ 15 set M0) (condone initial flow augmenting route, only if clearly separated from the rest)

A3 all routes + flows found to 22 more

A2 2 routes + flows found to 12^+

A1 1 route + flows found to 6^+

B1 98 cao

(d) M1 Consistent flow of 77^+, complete, clear (doesn't need to √ from (c))

A1 c.a.o

(e) M1 Flow of 98 + cut attempted + max flow min cut theorem referred to (3 out of 4)

A1 cao

Mark Scheme (Results)
January 2007

GCE

GCE Mathematics

Decision Mathematics D1 (6689)

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January 2007
6689 Decision D1
Mark Scheme

Question Number	Scheme	Marks
1)	$\left[\frac{1+10}{2}\right] = \underline{6 \text{ Nicky}}$ – reject top of list.	M1
	$\left[\frac{7+10}{2}\right] = \underline{9 \text{ Trevor}}$ – reject bottom of list	A1
	$\left[\frac{7+8}{2}\right] = \underline{8 \text{ Steve}}$ – reject bottom of list	A1
	$[7] = \underline{7 \text{ Preety}}$ – reject	A1
	Nigel <u>not</u> in list.	$\boxed{4}$

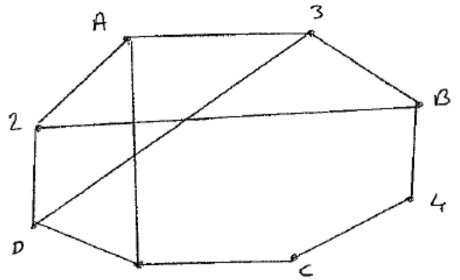
Question Number	Scheme	Marks
2) (a)	$G - 3 = J - 4 = L - 5$	M1
	change status: $\underline{G = 3 - J = 4 - L = 5}$	A1
	Improved matching: $E = 2$ $G = 3$ $J = 4$ $L = 5$	B1 (3)
(b)	e.g. George and Yi wen may both only be assigned to 3	B1 (1)
(c)	$Y - 3 = G - 2 = E - 4 = J - 1$	M1
	change status: $\underline{Y = 3 - G = 2 - E = 4 - J = 1}$	A1
	complete matching: $E = 4$ $G = 2$ $J = 1$ $L = 5$ $Y = 3$	A1 (3)
		$\boxed{7}$

3) (a) A bipartite graph — B1 (1)

(b) A, 3, B, 4, C, 1, D, 2, A — B2, 1, 0 (2)

(c) Redrawing — M1

A1



Identifying that it is not planar — A1√ (3)

$\boxed{6}$

4) (a)

b.v.	x	y	z	r	s	Value	Row ops
z	$\frac{1}{2}$	0	1	$\frac{1}{4}$	0	20	$(R_1 \div 4)$
s	0	4	0	$-\frac{1}{2}$	1	120	$R_2 - 2R_1$
P	8	-8	0	5	0	400	$R_3 + 20R_1$

M1 A1

M1 A1√

A1√

(5)

(b) $P + 8x - 8y + 5r = 400$ — B1√ (1)

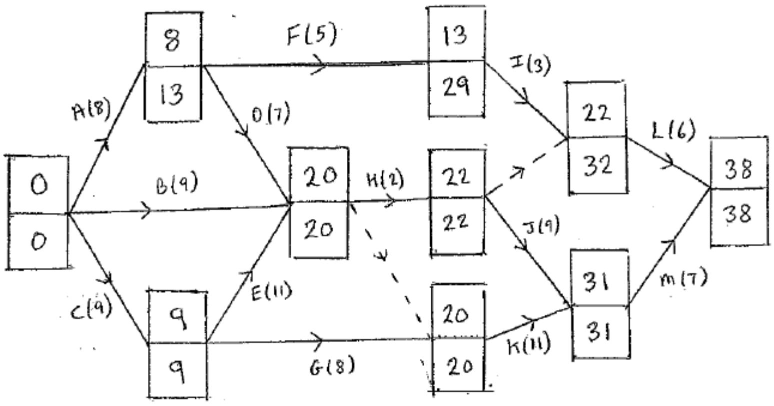
(c) Not optimal since there is a negative number in the profit row — B1√ (1)

$\boxed{7}$

5 (a)	e.g. Each edge contributes 2 to the sum of degrees, hence this sum must be even. Therefore there must be an even (or zero) number of vertices of odd degree Hence there cannot be an odd number of vertices of odd degree	B2,1,0 (2)
(b)	CD + FH = 200 + 220 = 420 * CF + DH = 180 + 380 = 560 CH + DF = 400 + 160 = 560	M1 A1 A1
	repeat CA, AD and FH	A1 (4)
(c)	length = 4180 + 420✓ = 4600 m	B1✓ (1) $\boxed{7}$

6) (a) J depends on H alone, but L depends on H and I — B1 (1)

(b)



M1 A1

M1 A1

(4)

(c) Total float on D = 20 - 7 - 8 = 5

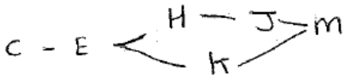
Total float on E = 20 - 11 - 9 = 0

Total float on F = 29 - 5 - 8 = 16

M1 A1√

A1 (3)

(d)

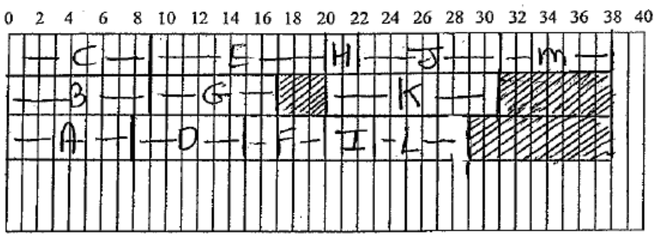


M1 A1 (2)

(e) $\frac{95}{38}$ = 2.5 so 3 workers

M1 A1√ (2)

(f) e.g.



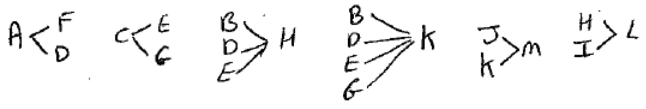
19

M1 A1

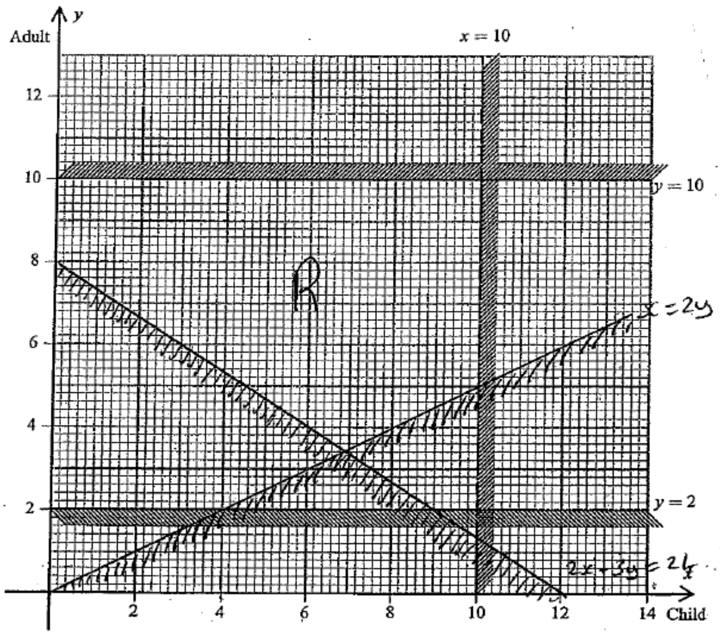
A1

A1

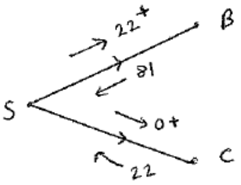
(4)

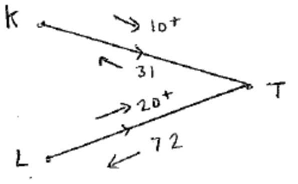


$\boxed{16}$

7) (a)	To show a strict inequality	B1 (1)
(b)	There must be fewer than 10 children There must be between 2 and 10 adults, inclusive.	B1 B2, 1, 0 (3
(c)	$2x + 3y \geqslant 24$ $x \leq 2y$	B1 B1 (2)
(d)	Diagram 1 	B1✓ (2x+3y=24) B1✓ (x=2y) B1✓shading B1 (R) (4
(e)	minimum 0 children 8 Adults - 8 passengers maximum 9 children 10 Adults - 19 passengers	M1 A1 B1 B1 (4) $\boxed{14}$

8) (a)





m1 A1
A1
(3)

(b) 103

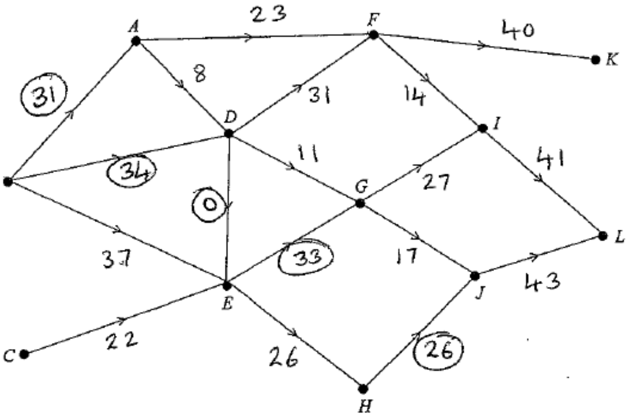
B1 (1)

(c) e.g. SBEGILT - 3
SBEDFKT - 5
SBEHJGDFKT - 4
SBEGDFILT - 9

m1
A 4,3,2,1,
(5)

(d) e.g.

Diagram 3



Flow value 124 (given)

m1 A1
A1
(3)

(e) Max flow = min cut
cut through AB, BD, DE, EG, HJ

m1 A1 (2

14

Mark Scheme (Results)

Summer 2007

GCE

GCE Mathematics

Decision Mathematics D1 (6689)

Edexcel Limited. Registered in England and Wales No. 4496750
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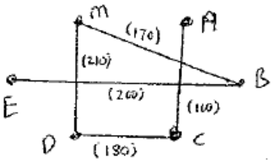
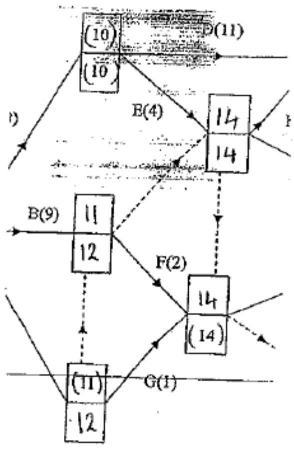
June 2007
6689 Decision Mathematics
Mark Scheme

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>1)</td><td>A graph is planar if it <u>can be drawn</u> in a plane in such a way that <u>no two edges meet</u> each other, except at a vertex to which they are both incident</td><td>B2,1,0
[2]</td></tr>
<tr><td>2) (a)</td><td>To obtain a complete matching the number of vertices on each side must be equal.</td><td>B2,1,0
(2)</td></tr>
<tr><td>(b)</td><td>e.g. L – 3 = H – 5 = J – 1a = A – 4
c.s. L = 3 – H = 5 – J = 1a – A = 4
A = 4 H = 5 L = 3
E = 1b J = 1a m = 2</td><td>M1 A1
A1 (3)</td></tr>
<tr><td>(c)</td><td>H and L can now both only do 3. So a complete matching is not possible (other answers possible)</td><td>B2,1,0 (2)
[7]</td></tr>
<tr><td>3) (a)</td><td>
<table>
<tr><th>A</th><th>x</th><th>y</th><th>x even?</th><th>x = 0 ?</th></tr>
<tr><td>0</td><td>54</td><td>63</td><td>Y</td><td></td></tr>
<tr><td></td><td>27</td><td>126</td><td>N</td><td></td></tr>
<tr><td>126</td><td>26</td><td></td><td></td><td>N</td></tr>
<tr><td></td><td>13</td><td>252</td><td>N</td><td></td></tr>
<tr><td>378</td><td>12</td><td></td><td></td><td>N</td></tr>
<tr><td></td><td>6</td><td>504</td><td>Y</td><td></td></tr>
<tr><td></td><td>3</td><td>1008</td><td>N</td><td></td></tr>
<tr><td>1386</td><td>2</td><td></td><td></td><td>N</td></tr>
<tr><td></td><td>1</td><td>2016</td><td>N</td><td></td></tr>
<tr><td>3402</td><td>0</td><td></td><td></td><td>Y</td></tr>
</table>
A = 3402</td><td>M1 A1
A1✓
M1
A1✓
A1
B1✓ (7)</td></tr>
<tr><td>(b)</td><td>The product xy.</td><td>B2,1,0
(2)</td></tr>
</table>

4) (a)	odd vertices B. D, F, H	
	BD + FH = 21 + 20 = 41	M1 A1
	BF + DH = 19 + 20 = 39 *	A1
	BH + DF = 23 + 18 = 41	A1
	[Repeat BE, EF, DG and GH]	
	shortest route = 125 + 39 = 164 km	A1√(5)
(b)	Seek to keep the least pairing – DF/18	B1√
	Therefore start/finish at B and H.	B1√ (2) $\boxed{7}$
5) (a)	MB, BE, MD, DC, CA	M1 A1 A1 (3)
(b)	 	B1√(1)
(c)	170 + 200 + 210 + 180 + 100 = 860	B1. (1)
(d)	(A cycle is formed when an arc is used that connects two vertices already connected to each other in the tree) Prim's algorithm always selects arcs that bring a vertex not in the tree into the tree, so cycles can't happen	B2,1,0 (2) $\boxed{7}$

6) (a)



(b) A E H K

A E L

(c) Idea of 'critical'
- zero float, no delay, immediate
- if late project will finish late
etc.

Idea of 'path'
- from start to end event + continuous
- the event forming end of one activity forms the start of the next
- sequence or series or link or run - - -

S.c. "longest path" gets 1st B1 only.

(a) B3, 2, 1, 0 (3)

(b) B2, 1, 0 (2)

(c) B1

B1 (2)

(d) $\frac{110}{30}$ ($= 3.7/36$) ∴ 4 workers

M1
A1 (2)

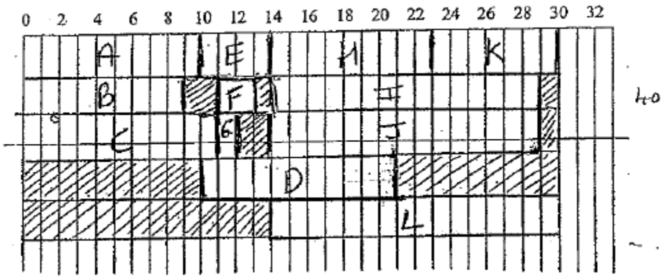
(e) D, H, I, J, L

B2, 1, 0 (2)

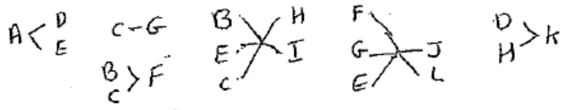
(f) It will not be possible to find a solution with 4 workers to complete the project in the minimum time. 5 workers will be needed.
Accept "an extra worker is required"

B1 (1)

(g) e.g.



M1
A1
A1
(3)



$\boxed{15}$

7) (a) $P - 2x - 4y - 3z = 0$ (o.e.) B2, 0 (2)

(b) $12x + 4y + 5z \leq 246$ B1

$9x + 6y + 3z \leq 153$ B1

$5x + 2y - 2z \leq 171$ B1 (3)

(c)

basic variable	x	y	z	r	s	t	Value
r	12	4	5	1	0	0	246
s	9	⑥	3	0	1	0	153
t	5	2	-2	0	0	1	171
P	-2	-4	-3	0	0	0	0

b.v.	x	y	z	r	s	t	Value	Row operations
r	6	0	3	1	$-2/3$	0	144	$R_1 - 4R_2$
y	$3/2$	1	$1/2$	0	$1/6$	0	25.5	$R_2 \div 6$
t	2	0	-3	0	$-1/3$	1	120	$R_3 - 2R_2$
P	4	0	-1	0	$2/3$	0	102	$R_4 + 4R_2$

M1 A1

M1 A1✓

B1✓

b.v.	x	y	z	r	s	t	Value	Row operations
z	2	0	1	$1/3$	$-2/9$	0	48	$R_1 \div 3$
y	$1/2$	1	0	$-1/6$	$5/18$	0	1.5	$R_2 - \frac{1}{2}R_1$
t	8	0	0	1	-1	1	264	$R_3 + 3R_1$
P	6	0	0	$1/3$	$4/9$	0	150	$R_4 + R_1$

M1 A1

M1 A1

(9)

(d) $P = 150$ $x = 0$ $y = 1.5$ $z = 48$ M1 A1✓

$r = 0$ $s = 0$ $t = 264$ A1✓ (3)

(e) (The third constraint) $t \neq 0$ B1✓ (1)

$\boxed{18}$

8) (a)	85	B1
(b)	$C_1 = 140$, $C_2 = 104$	B1, B1 (3)
(c)	e.g.	
	S B D F H J T - 4	M1 A1
	S B D F G T - 1	
	S B D F C H I T - 2	A1
	S B D F C H J T - 2	A1
	S B D E G T - 10	A1
		(5)
(d)	max flow - min cut theorem, flow is 104, mincut is C_2	M1 A1 (2)
		$\boxed{10}$

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Mark Scheme (Pre-Standardisation)
January 2008

GCE

GCE Mathematics (6689/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

January 2008
6689 Decision Mathematics D1
Mark Scheme

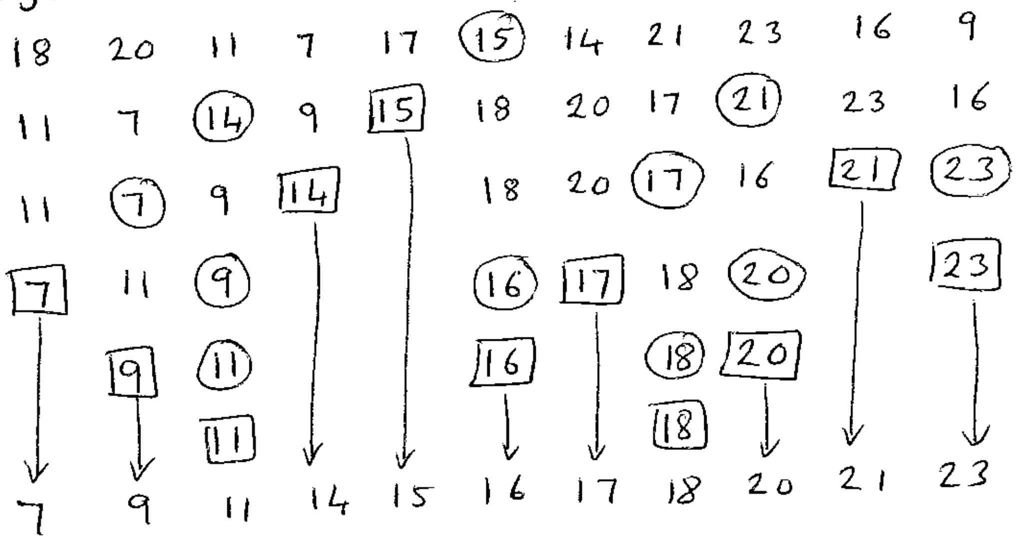
Question Number	Scheme	Marks
1 (a)(i)	A path from an unmatched vertex in one set to an unmatched vertex in the other set	B1
	..which alternately uses arcs not in / in the matching.	B1 (2)
(ii)	A one-to-one pairing of	B1
	some elements of one set with the other set	B1 (2)
(b)	e.g. $D - 3 = C - 5$ change status $D = 3 - C = 5$	M1 A1
	$E - 2 = A - 1$ change status $E = 2 - A = 1$	M1 A1
	$A = 1$ $B = 4$ $C = 5$ $D = 3$ $E = 2$	A1 (5)
		$\boxed{9}$

Decision Maths D1 (6689) Jan 2008

Q1(a)i 1B1 Unmatched to unmatched
2B1 Alternate **arcs** not in/in [not vertices/nodes, not 'zigzag']
ii 3B1 One – to- one
4B1 Elements of one set with elements of the other.
(b) 1M1 'Path' starting at D or E, finishing at 1 or 5 – or vice versa.
1A1 A correct path – including change status.
2M1 'Path' from remaining unmatched (D/E) to unmatched (1/5) or v.v.
2A1 A second correct path – incl. c.s, but don't' penalise c.s. twice.
3A1 Complete matching, must follow through from two correct paths.

Possible alternating paths and matchings

Path 1	Path 2	A	B	C	D	E
D-3-C-1	E-2-A-1-C-5	1	4	5	3	2
D-3-C-1	E-4-B-1-C-5	2	1	5	3	4
D-3-C-5	E-2-A-1	1	4	5	3	2
D-3-C-5	E-4-B-1	2	1	5	3	4
D-3-C-4-B-1	E-2-A-1-B-3-D-4-C-5	1	3	5	4	2
D-3-C-4-B-1	E-2-A-1-B-4-C-5	1	4	5	3	2
D-3-C-4-B-1	E-4-C-5	2	1	5	3	4
D-4-B-1	E-2-A-1-B-3-C-5	1	4	5	3	2
D-4-B-1	E-2-A-1-B-4-D-3-C-5	1	4	5	3	2
D-4-B-1	E-4-D-3-C-5	2	1	5	3	4
D-4-B-3-C-1	E-2-A-1-C-5	1	3	5	4	2
D-4-B-3-C-1	E-4-D-3-B-1-C-5	2	1	5	3	4
D-4-B-3-C-5	E-2-A-1	1	3	5	4	2
D-4-B-3-C-5	E-4-D-3-B-1	2	1	5	3	4
E-2-A-1	D-3-C-5	1	4	5	3	2
E-2-A-1	D-4-B-3-C-5	1	3	5	4	2
E-4-B-1	D-3-C-5	2	1	5	3	4
E-4-B-1	D-4-E-2-A-1-B-3-C-5	1	3	5	4	2
E-4-B-3-C-1	D-3-B-1-C-5	2	1	5	3	4
E-4-B-3-C-1	D-3-B-4-E-2-A-1-C-5	1	4	5	3	2
E-4-B-3-C-1	D-4-E-2-A-1-C-5	1	3	5	4	2
E-4-B-3-C-5	D-3-B-1	2	1	5	3	4
E-4-B-3-C-5	D-3-B-4-E-2-A-1	1	4	5	3	2
E-4-B-3-C-5	D-4-E-2-A-1	1	3	5	4	2

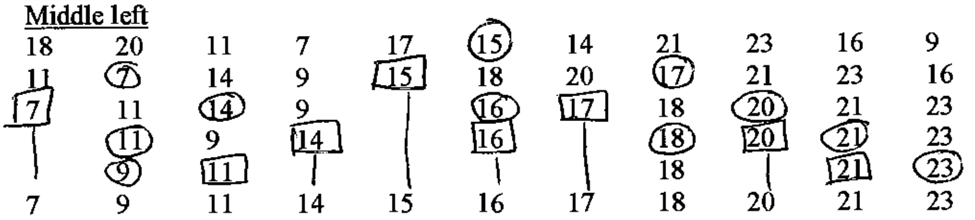
Question Number	Scheme	Marks
2(a)	E.g.  	m1 A1 A1√ A1√ A1 (5)
(b)	CF ✓ GI ✓ {BC or BF – accept one, reject one {CD ✓ EF ✓ DF × HI ✓ BE × AB ✓ AC × EG ✓ Tree complete	m1 A1 A1 A1 (4)
(c)	107 m	B1 (1)
		$\boxed{10}$

6689 Decision Mathematics D1
January 2008 Advanced Subsidiary/Advanced Level in GCE Mathematics

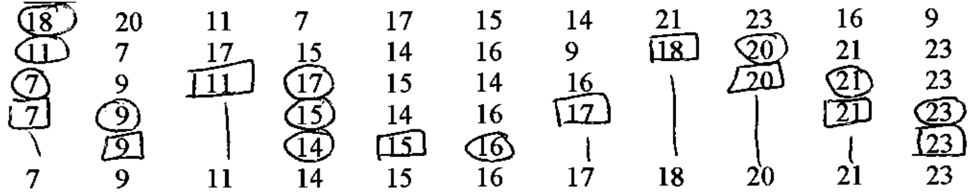
Q2(a)	**1M1**	Pivot chosen & 2 sublists, one < pivot, one > pivot
	1A1	1st pass correct, all of the next set of pivots chosen, and done so consistently (condone 1 term lists)
	1A1ft	as above for 2nd pass.
	1A1ft	All correct, follow through, pivots must be chosen consistently
(b)	**1M1**	Using Kruskal – CF then GI
	1A1	First 4 arcs chosen correctly
	2A1	All arcs chosen correctly (condone lack of rejection here)
	3A1	All correct including rejections
(c)	**B1**	cao

Alternative correct solutions

Middle left

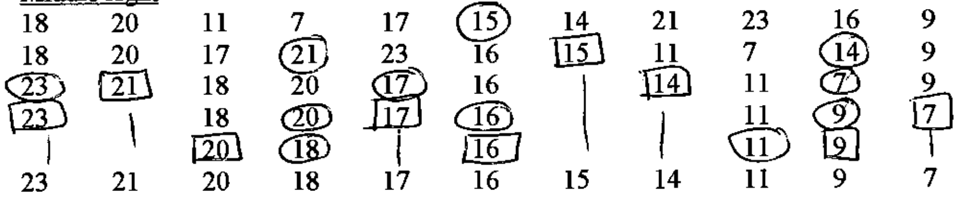


First

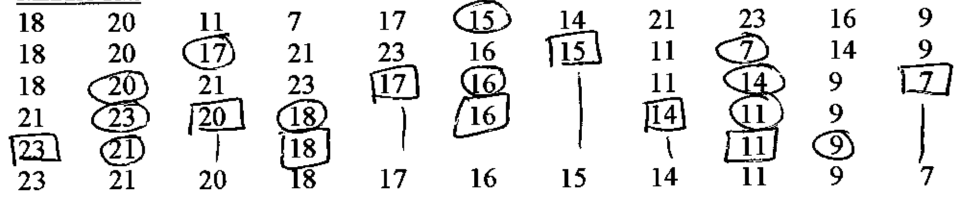


Misreads – loose last 2 **A** marks earned **(NOTE: Reversing list at end removes MR)**

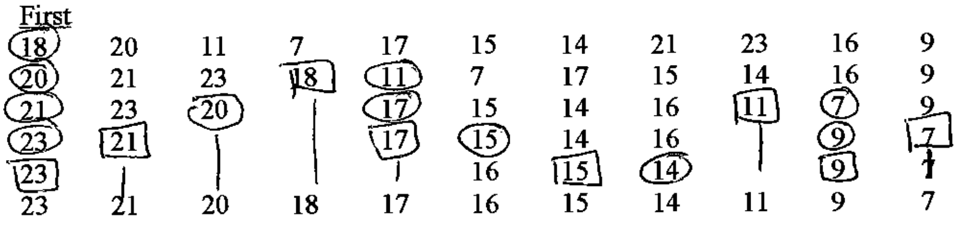
Middle right



Middle left

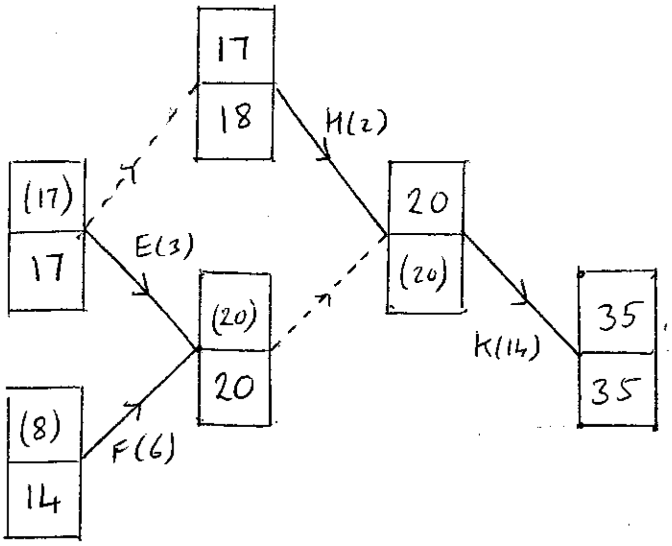


First

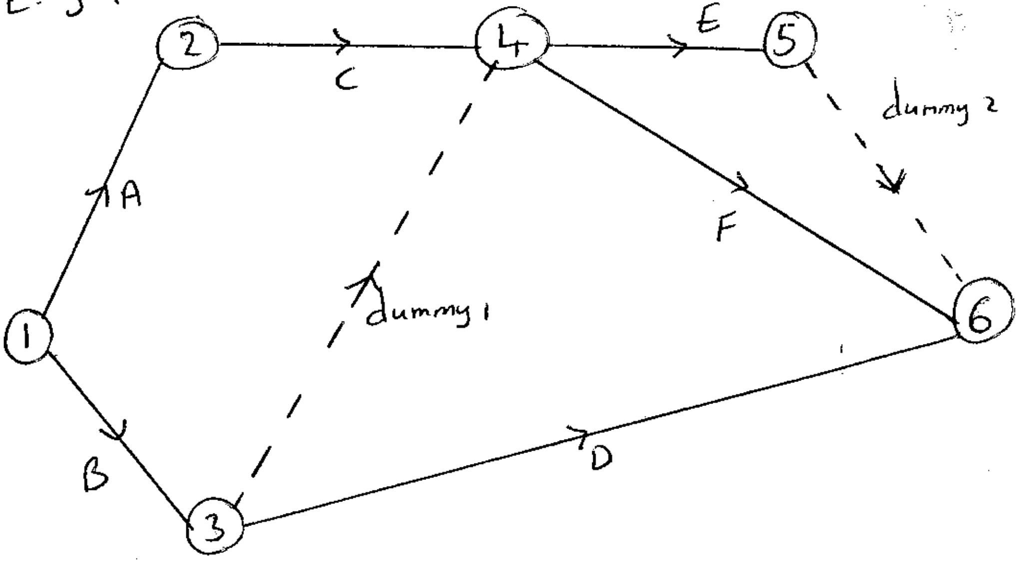


Question Number	Scheme	Marks
3 (a)	CD + FG = 0.7 + 0.6 = 1.3 *	m1A1
	CF + DG = 0.5 + 0.9 = 1.4	A1
	CG + DF = 1.1 + 0.5 = 1.6	A1
	repeat CD and FG	
	A possible route e.g.	
	A C D C F G F D G E D A E B A	A1
	length : 11 + 1.3 = 12.3 km	A1√ (6)
(b)	(i) Each arc has to be traversed twice	B1 (1)
	(ii) 2 × 11 = 22 km	B2,0 (2)
		$\boxed{9}$

Q3(a)	**1M1**	3 distinct pairings of their 4 odd nodes
	1A1	one line correct (condone missing total)
	2A1	2 lines correct including totals
	3A1	All three lines correct including totals
	4A1	15 letters, repeat CD and FG, start/finish A, A to G there.
	5A1ft	11+ **thier** minimum
(b)i	**1B1**	cao ‘twice’ probably the trigger
ii	**2B1**	22
	3B1	22km

Question Number	Scheme	Marks
4) (a)		M1 A1 M1 A1 (4)
(b)	Total float on D = 18√ − 5 − 9 = 4√ G = 25 − 8 − 10 = 7 I = 25 − 20 − 3 = 2	M1 A2,1√,0 B1 (4)
(c)	Critical activities: B E J M	B1 (1)
(d)	Lower bound = $\frac{102}{35}$ = 2.914 ∴ 3 workers	M1 A1 (2) $\boxed{11}$

Q4(a) **1M1** Top 3 boxes completed, generally ascending L to R
1A1 cao
2M1 Bottom 4 boxes completed, generally descending R to L
2A1 cao
(b) **1M1** Correct (ft) three numbers visible for at least one calculation.
1A1ft one correct value (ft on D)
1A1 2 correct values
1B1 3 correct values (even if no working seen)
(c) **1B1** cao
(d) **1M1** 102 ÷ 35ft
1A1 cao

Question Number	Scheme	Marks
5) (a)	E.g. 	M1 A1 A1 A1 (4)
	Dummy 1 is needed to show dependancy. E and F depend on C and B, but D depends on B only Dummy 2 is needed so that each activity can be uniquely represented in terms of its event.	B3,2,1,0 (3) $\boxed{7}$

Q5(a) **1M1** Activity on arc, all activities present, condone lack of events

1A1 A,B,C,D and first dummy correct

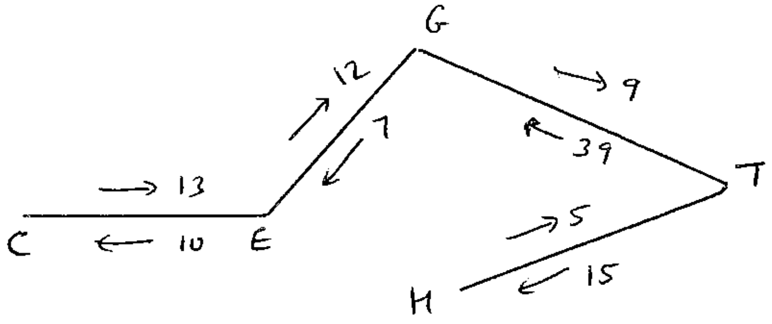
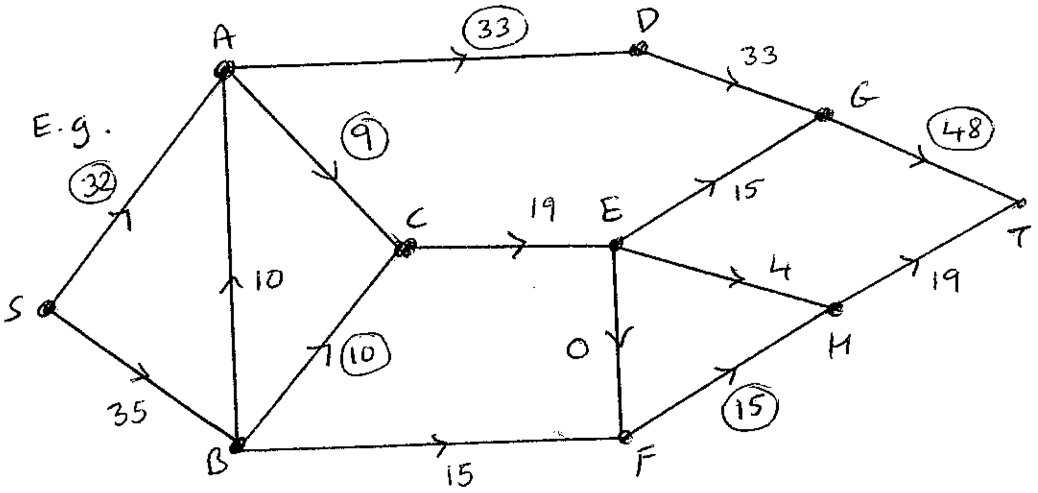
2A1 E, F and second dummy correct (on E or F)

3A1 All arrows – including on dummies, one start and one finish

(b) **1B1** Dummy 1 correctly justified – give bod

2B1 Dummy 2 correctly justified – give bod

3B1 A bonus for two good answers

Question Number	Scheme	Marks
6 (a)	A cut divides the vertices into two sets, one set containing the source(s) and the other the sink(s).	B2,1,0 (2)
(b)		m1 A1 (2)
(c)	E.g. SBACEGT – 9 SBADGEHT – 1 SBFEHT – 3	m1 A1 A1 A1 (4)
(d)	E.g. 	m1 A1 (2)
(e)	Flow value 67	B1 (1)
(f)	Max flow-min cut theorem cut through AD, AC, BC, EF, FH	m1 A1 (2)
		$\boxed{13}$

Q6(a)	**1B1**	Close, bod, probably 2 out of three points below
	2B1	Good complete answer, 2 'sets'; source and sink seperated; vertices
(b)	**1M1**	Two numbers on each arc
	1A1	cao
(c)	**1M1**	1 correct route and a flow value stated. Any flow>9 gets M0
	1A1	1 valid route with valid flow
	2A1	2 distinct valid routes with valid flows found to >3
	3A1	All routes and flows found to 13
(d)	**1M1**	Consistent flow pattern >55
	1A1	cao
(e)	**1B1**	cao
(f)	**1M1**	Depends flow of 67, 3 out of 4 words in theorem, cut attempted
	1A1	valid cut

Routes
Do not use: SA or BC
Increases needed for solution:
(NOTE treat back flows as negative e.g. EG+9 and GE+1 gives EG+8)

SB + 13	**AC+9**	**AD+1**	**BA+10**	**BF+3**
CE+9	**DG+1**	**EG+8**	**EH+4**	**GT+9**

Question Number	Scheme	Marks
7) (a)	$y \geqslant 2x$	B2,1,0 (2)
(b)	$x + 2y = 160$ correctly drawn $y = 60$ correctly drawn and distinctive (strict inequality) Shading correct	B4,3,2,1,0 (4)
(c)	R correct	B1✓ (1)
(d)	Profit line added or Point testing seen correctly done 70 boxes identified	m1 A1 A1 (3)
(e)	$(P=)\ 1.2x + 1.4y$	B1 (1)
(f)	Profit line added or Point testing seen correctly done (32, 64) identified	m1 A1/A1 A1 (4)
(g)	£128.00	A1✓ (1) $\boxed{16}$

Q7(a)	**1B1**		2 (or ½) one correct side, condone any inequality or equals, or bod
	2B1		cao
(b)	**1B1**		Errors to look for: y = 60 distinct in some way
	2B1	-1 e,e.	lines correct to ≤ 1 small square 1 at axis
	3B1		Labels on lines
	4B1		Ruler
(c)	**1B1ft**		R 'correct', ft their lines, but shading needs to be correct
(d)	**1M1**		Attempt at profit line (axis to axis) or point testing 2 points
	1A1		Profit line correct (within 1 sm square) or three points tested correctly
	2A1		cao
(e)	**1B1**		cao
(f)	**1M1**		Attempt at profit line (axis to axis) or point testing 2 points
	1A1ft		correct but ft their R and their (e) for profit line and 3 point testing
	2A1		correct (so a mark for correct with no need to ft)
	3A1		cao (32, 64) only
(g)	**4A1**		cao follow through (ignore units).

Mark Scheme (Results)

Summer 2008

GCE

GCE Mathematics (6689/01)

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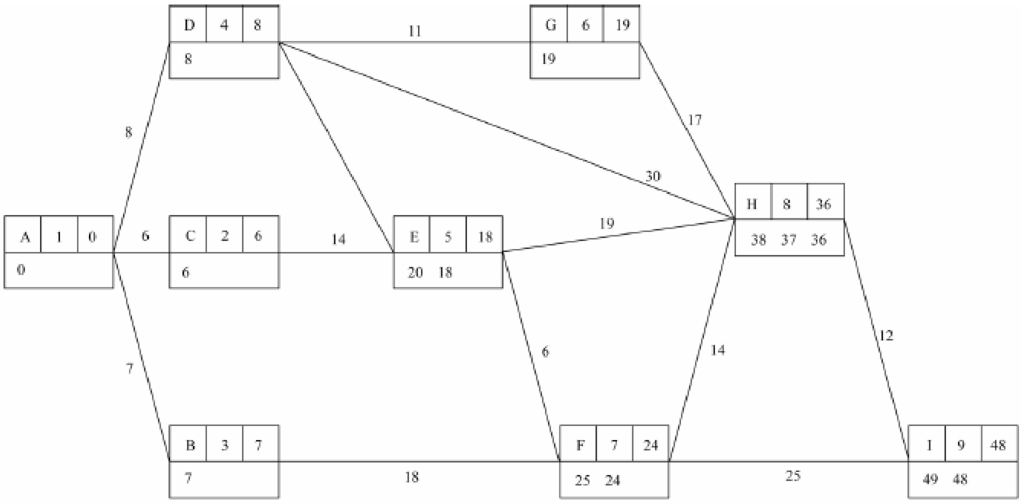
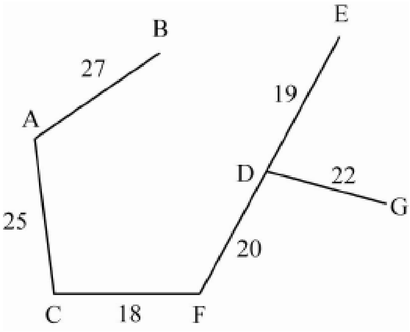
June 2008
6689 Decision Mathematics D1
Mark Scheme

Question Number	Scheme	Marks
Q1		
(a)	$\frac{502}{100} = 5.02$ so 6 tapes.	M1 A1 (2)
(b)	Bin 1: 29, 52 Bin 2: 73 Bin 3: 87 Bin 4: 74 Bin 5: 47, 38 Bin 6: 61 Bin 7: 41	M1 A1 A1 (3)
(c)	Bin 1: 87 Bin 2: 74 Bin 3: 73 Bin 4: 61, 38 Bin 5: 52, 47 Bin 6: 41, 29	M1 A1 A1 (3)
	Notes: (a) 1M1: $(502 \pm 40) \div 100$ (maybe implicit) 1A1: cao 6 tapes (b) 1M1: Bin 1 correct and at least 8 values put in bins 1A1: Condone one error, (e.g. extra, omission, 'balanced'swap). 2A1: All correct (c) 1M1: Bin 1 correct and at least 8 values put in bins 1A1: Condone one error, (e.g. extra, omission, 'balanced'swap). 2A1: All correct	**Total 8**

Question Number	Scheme	Marks
Q2 (a)	G – 5 = W – 3 change status G = 5 – W = 3	M1 A1 (2)
(b)	A – no match E = 2 G = 5 R = 4 W = 3	A1 (1)
(c)	e.g. R is the only person who can do 1 and the only person who can do 4	B 2, 1, 0 (2)
(d)	A – 2 = E – 3 = W – 4 = R – 1 change status A = 2 – E = 3 – W = 4 – R = 1 A = 2 E = 3 G = 5 R = 1 W = 4	M1 A1 A1 (3) **Total 8**
	Notes: (a) 1M1: Path from G to 3 1A1: CAO including change status (stated or shown), chosen path clear. (b) 2A1: CAO must ft from stated path (c) 1B1: Correct answer, may be imprecise or muddled (bod gets B1) but all nodes refered to must be correct. 2B1: Good, clear, correct answer. (d) 1M1: Path from A to 1 1A1: CAO including change status (stated or shown) but don't penalise twice. Chosen path clear. 1A1: CAO must ft from stated path **Misread** (remove last two A or B marks if earned.) A – 2 = E – 3 c.s. A=2 – E = 3 Matching A = 2, E = 3, R = 4 W = 5 Then G – 5 = W – 4 = R – 1 c.s. G = 5 – W = 4 – R =1 Matching A = 2, E = 3, G = 5, R = 1, W = 4	

Question Number	Scheme	Marks
Q3 (a)		M1 A1 A1ft
	Route: ADGHI	A1
	Length: 48 (km)	A1ft (5)
(b)	Odd vertices are A and H	B1
	Attempt to find shortest route from A to H = ADGH	M1
	New length: 197 + 36 = 233	A1ft
	Route: e.g. ADGHGDACEDHIFHEFBA (18)	A1 (4)
	Notes: (a) 1M1: Smaller number replacing larger number in the working values at E or F or H or I. (generous – give bod) 1A1: All values in boxes A to E and G correct 2A1ft: All values in boxes F, H and I correct (ft). Penalise order of labelling just once. 3A1: CAO (not ft) 4A1ft: Follow through from their I value, condone lack of units here. (b) 1B1: A and H identified in some way – allow recovery from M mark. 1M1: Accept, if correct, path, or its length. Accept attempt if finding shortest. 1A1ft: 197 + their shortest A to H (36) 2A1: A correct route.	**Total 9**

Question Number	Scheme	Marks
Q4 (a)	e.g. • Prims starts with any vertex, Kruskal starts with the shortest arc. • It is not necessary to check for cycles when using Prim. • Prims adds nodes to the growing tree, Kruskal adds arcs. • The tree ‘grows’ in a connected fashion when using Prim. • Prim can be used when data in a matrix form. Other correct statements also get credit.	B 2, 1, 0 (2)
(b)(i)	e.g. AC, CF, FD, DE, DG, AB.	M1, A1, A1 (3)
(ii)	CF, DE, DF, not CD, not EF, DG, not FG, not EG, AC, not AD, AB. [18, 19, 20, not 21, not 21 , 22 , not 23, not 24, 25, not 26, 27]	M1, A1, A1 (3) **Total 8**
	Notes: (a) 1B1: Generous one correct difference. If bod give B1 2B1: Generous two distinct, correct differences. (b) 1M1: Prim’s algorithm – first three arcs chosen correctly, in order, or first four nodes chosen correctly, in order. 1A1: First five arcs chosen correctly; all 7 nodes chosen correctly, in order. 2A1: All correct and arcs chosen in correct order. 2M1: Kruskal’s algorithm – first 4 arcs selected chosen correctly. 1A1: All six non-rejected arcs chosen correctly. 2A1: All rejections correct and in correct order and at correct time. 	

Question Number	Scheme	Marks
Q5		
(a)	$x = 9,\ y = 11$	B1,B1 (2)
(b)	AC DC DT ET	B2,1,0 (2)
(c)	36	B1 (1)
(d)	$C_1 = 49,\ C_2 = 48,\ C_3 = 39$	B1,B1,B1 (3)
(e)	e.g. SAECT	B1 (1)
(f)	maximum flow = minimum cut cut through DT, DC, AC and AE	M1 A1 (2)
		Total 11
	Notes: (a) 1B1: cao (permit B1 if 2 correct answers, but transposed) 2B1: cao (b) 1B1: correct (condone one error – omission or extra) 2B1: all correct (no omissions or extras) (c) 1B1: cao (d) 1B1: cao 2B1: cao 3B1: cao (e) 1B1: A correct route (flow value of 1 given) (f) 1M1: Must have attempted (e) and made an attempt at a cut. 1A1: cut correct – may be drawn. Refer to max flow-min cut theorem three words out of four.	

Question Number	Scheme	Marks

Q6

(a)

b.v	x	y	z	R	s	t	value
r	4	$\frac{7}{3}$	$\frac{5}{2}$	1	0	0	64
s	1	3	0	0	1	0	16
t	4	2	2	0	0	1	60
P	-5	$-\frac{7}{2}$	-4	0	0	0	0

b.v	x	y	z	R	s	t	value	Row ops
r	0	$\frac{1}{3}$	$\frac{1}{2}$	1	0	-1	4	R_1- $4R_3$
s	0	$\frac{5}{2}$	$-\frac{1}{2}$	0	1	$-\frac{1}{4}$	1	$R_2 - R_3$
x	1	$\frac{1}{2}$	$\frac{1}{2}$	0	0	$\frac{1}{4}$	15	$R_3 \div 4$
P	0	-1	$-\frac{3}{2}$	0	0	$\frac{5}{4}$	75	$R_4 + 5R_3$

M1 A1

M1
A1ft A1

b.v	x	y	z	R	s	t	value	Row ops
z	0	$\frac{2}{3}$	1	2	0	-2	8	$R_1 \div \frac{1}{2}$
s	0	$\frac{17}{6}$	0	1	1	$-\frac{5}{4}$	5	$R_2 + \frac{1}{2}R_1$
x	1	$\frac{1}{6}$	0	-1	0	$\frac{5}{4}$	11	$R_3 - \frac{1}{2}R_1$
P	0	0	0	3	0	$-\frac{7}{4}$	87	$R_4 + \frac{3}{2}R_1$

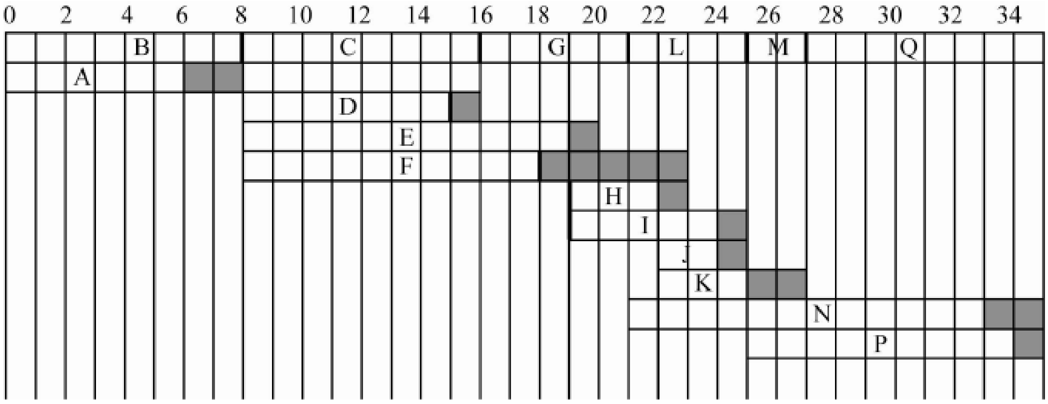
M1 A1ft

M1 A1

(9)

(b) There is still a negative number in the profit row. B1 (1)

Total 10

Question Number	Scheme	Marks
Q7 (a)	v = 16 w = 25 x = 23 y = 20 z = 8	B3,2,1,0 (3)
(b)	B C G L M Q	B1 (1)
(c)	Float on H = 23ft – 19 – 3 = 1 Float on J = 25 – 22 – 2 = 1	B1 B1 (2)
(d)		M1 A1 A1 A1 (4)
(e)	E has one day of float, so project can still be completed on time.	B2,1,0 (2)
(f)	e.g • At time 23 ½ activities L, I, J and N must be taking place • At time 13 ½ or 14 ½ activities C, D, E and F must be taking place So 4 workers needed.	B2,1,0 (2)
		Total 14

Question Number	Scheme	Marks
Q8	Maximise (P=) $0.2\,a + 0.15\,b$ or $20\,a + 15\,b$ **o.e.**	B1 B1 (2)
	Subject to	
	$a + b \leq 800$	B1
	$a \geq 2b$	B2,1,0
	$50 \leq b \leq 100$	B1
	$a \geq 0$	B1
		(5)
		Total 7
	Notes: 1B1: ‘Maximise’ 2B1: ratio of coefficients correct 3B1: cao 4B1: ratio of coefficients of a and b correct. 5B1: inequality correct way round i.e. □$a \geq$□ b 6B1: cao accept < – accept two separate inequalities here 7B1: cao	
	• Penalise < and > only once with last B mark earned • Be generous on letters a, b, A, B, x, y etc and mixed, but remove last B mark earned if inconsistent or 3 letters in the ones marked.	

Mark Scheme (Results)

January 2009

GCE

GCE Mathematics (6689/01)

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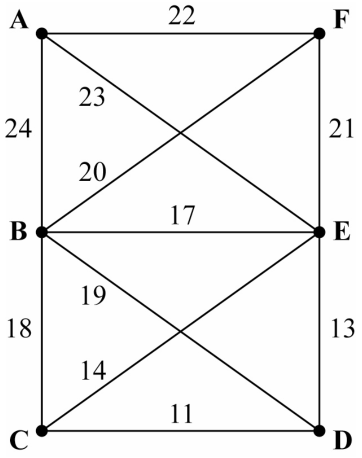
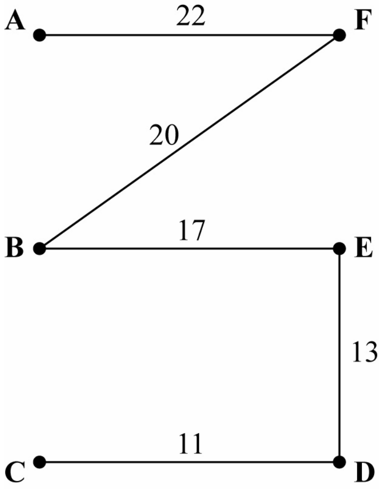
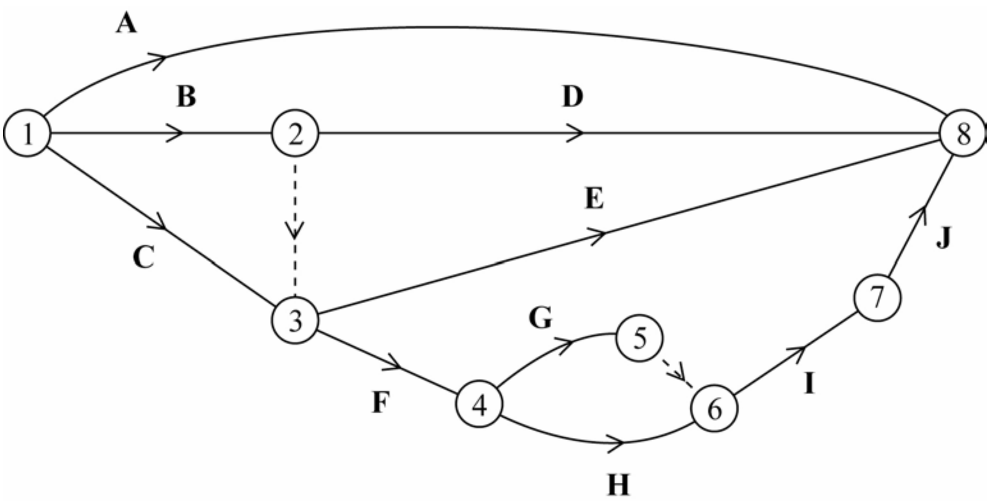
January 2009
6689 Decision D1
Mark Scheme

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>1
(a)</td><td>e.g.
<table>
<tr><td>M</td><td>L</td><td>J</td><td>H</td><td>K</td><td>T</td><td>R</td><td>I</td></tr>
<tr><td>J</td><td>H</td><td>I</td><td>K</td><td>M</td><td>L</td><td>T</td><td>R</td></tr>
<tr><td>H</td><td>J</td><td>I</td><td>K</td><td>M</td><td>L</td><td>R</td><td>T</td></tr>
<tr><td>H</td><td>I</td><td>J</td><td>K</td><td>L</td><td>M</td><td>R</td><td>T</td></tr>
<tr><td>H</td><td>I</td><td>J</td><td>K</td><td>L</td><td>M</td><td>R</td><td>T</td></tr>
</table>Sort complete.</td><td>M1
A1
A1ft
A1ft
A1cso
(5)</td></tr>
<tr><td>(b)</td><td>1st choice $\left[\frac{1+8}{2}\right] \to 5$ Lauren reject right
2nd choice $\left[\frac{1+4}{2}\right] \to 3$ John reject right
3rd choice $\left[\frac{1+2}{2}\right] \to 2$ Imogen reject right
4th choice 1 Hannah reject
List now empty so Hugo not in list</td><td>M1 A1
A1ft
A1 (4)
[9]</td></tr>
<tr><td></td><td>Notes:
(a) 1M1: quick sort, pivots, p, chosen and two sublists one <p one >p. If choosing 1 pivot per iteration only M1 only.
1A1: first pass correct and next pivots chosen correctly/consistently.
2A1ft: second pass correct, next pivots correctly/consistently chosen.
3A1ft: third pass correct, next pivots correctly/consistently chosen.
4A1: all correct, cso.
(b) 1M1: binary search, choosing pivot, rejecting half list. If using unsorted list, M0. Accept choice of K for M1 only.
1A1: first pass correct, condone ‘sticky’pivot here, bod.
2A1ft: second pass correct, pivot rejected.
3A1: cso.</td><td></td></tr>
</table>

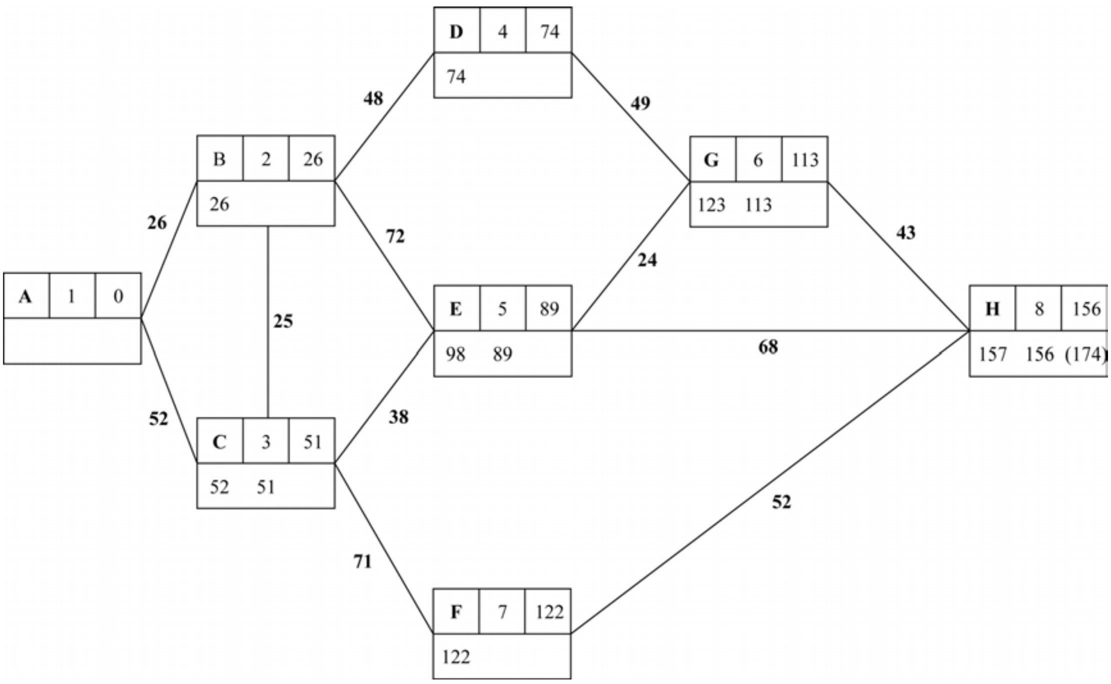
Question Number	Scheme	Marks
2 (a)		M1 A1 A1 (3)
(b)	CD, DE, reject CE, BE, reject BC, reject BD, BF, reject EF, AF 11 13 14 17 18 19 20 21 22	M1 A1 A1 (3)
		B1
	Weight of tree 83 (m)	B1 (2) **[8]**
	Notes: (a) 1M1: More than 10 arcs 1A1: all arcs correct 2A1: all values correct (b) 1M1: First three arcs correctly chosen 1A1: All used acrs selected correctly 2A1: All rejected arcs selected in correct order (c) 1B1: CAO for arcs – numbers not needed. NO ft. 2B1: CAO 83, condone units	

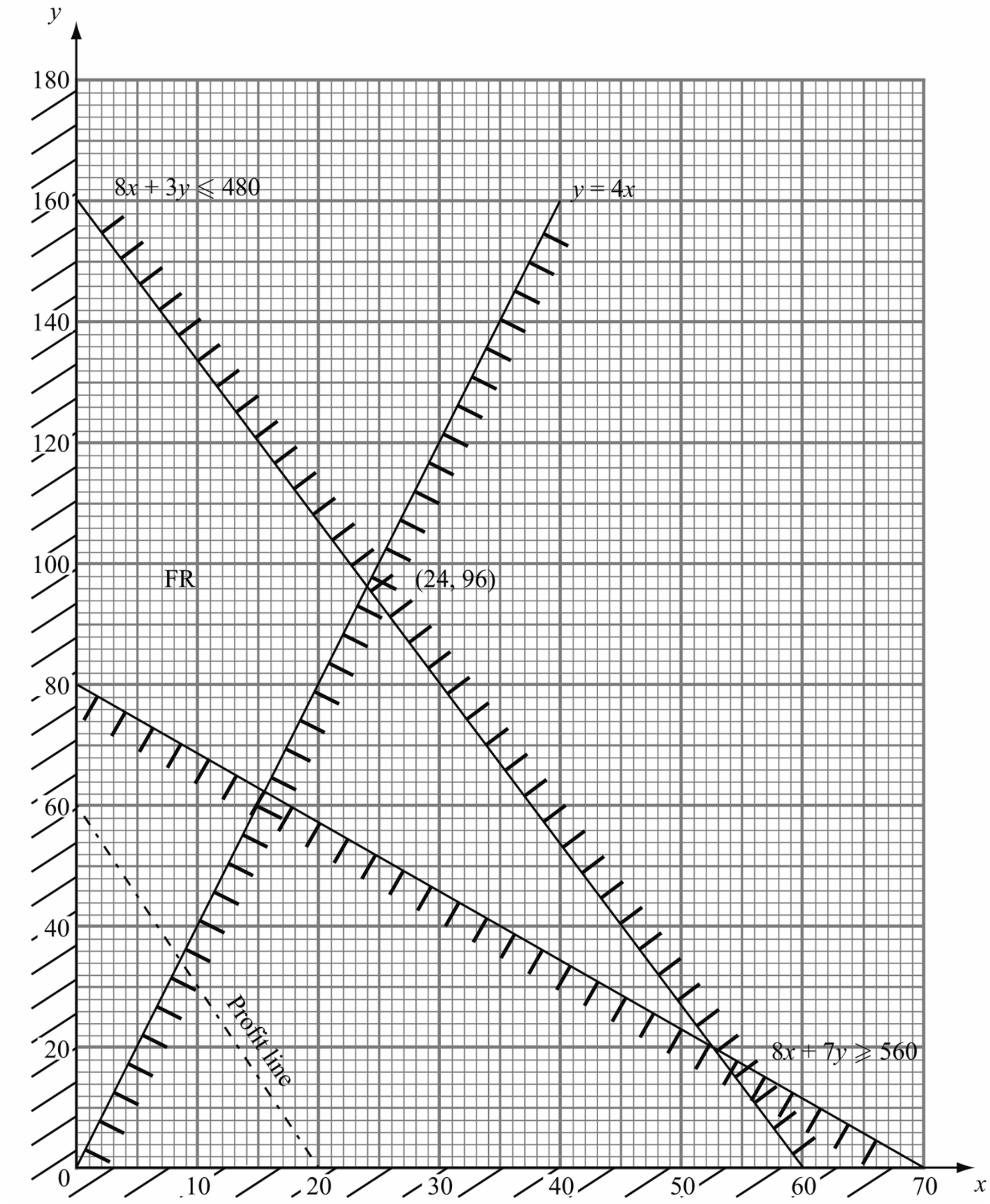
<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>**3**
(a)</td><td>
</td><td>M1
A1
A1
A1
A1 (5)</td></tr>
<tr><td>(b)</td><td>1st dummy – D depends on B only, but E and F depend on B and C
2nd dummy – G and H both must be able to be described uniquely in terms of the events at each end.</td><td>B1
B1
(2)

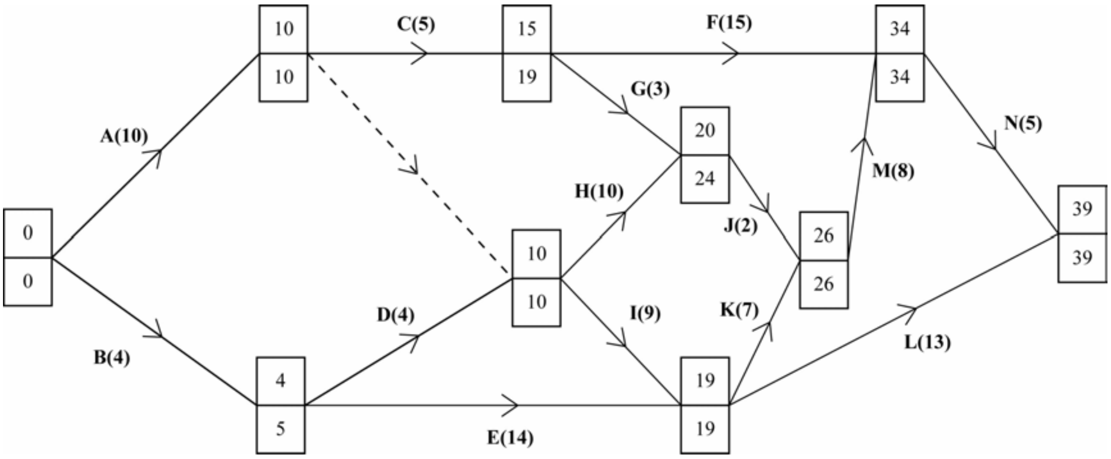
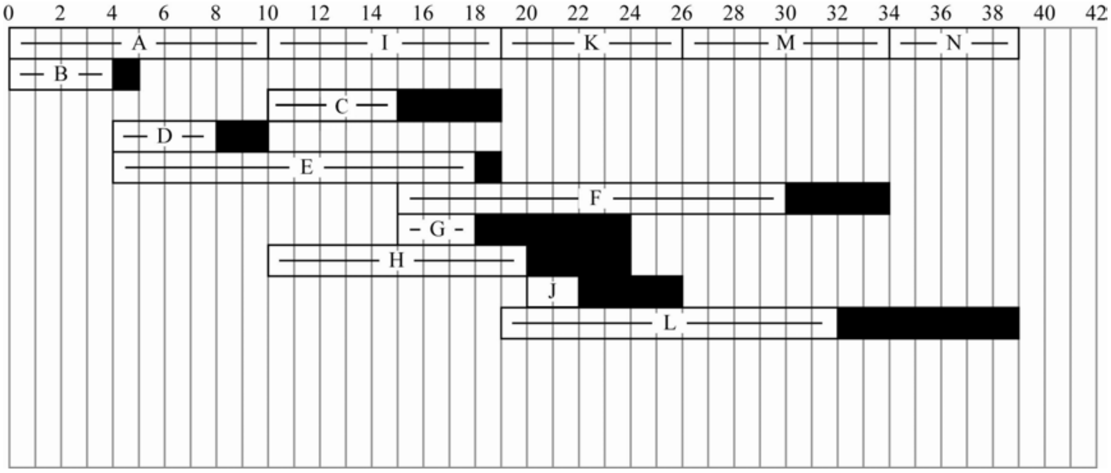
[7]</td></tr>
<tr><td></td><td>**Notes:**
(a) 1M1: one start and A to C and one of D, E or F drawn correctly
1A1: 1st dummy (+arrow) and D, E and F drawn correctly
2A1: G, H, I and J drawn in correct place
3A1: second dummy (+arrow) drawn in a correct place
4A1: cso. all arrows and one finish.
(b) 1B1: cao, but B, C, D, E and/or F referred to, generous
2B1: cao, but generous.</td><td></td></tr>
</table>

Question Number	Scheme	Marks
4		
(a)	Alternating path B – 3 = A – 5 change status B = 3 – A = 5	M1 A1
	A = 5 B = 3 C = 2 D = 1 E = 6 F unmatched	A1 (3)
(b)	e.g. C is the only person able to do 2 and the only person able to do 4. Or D, E and F between them can only be allocated to 1 and 6.	B2, 1, 0 (2)
(c)	Alternating path F – 6 = E – 1 = D – 2 = C – 4 change status F = 6 – E = 1 – D = 2 – C = 4	M1 A1
	A = 5 B = 3 C = 4 D = 2 E = 1 F = 6	A1 (3)
		[8]
	Notes: (a) 1M1: Path from B to 5. 1A1: Correct path including change status 2A1: CAO my matching, may be drawn but if so 5 lines only and clear. (b) 1B1: Close, a correct relevant, productive statement bod generous 2B1: A Good clear answer generous (c) 1M1: Path from F to 4. No ft. 1A1: Correct path penalise lack of change status once only 2A1: CAO may be drawn but if so 6 lines only and clear	

Question Number	Scheme	Marks
5		
(a)	Odd vertices C, D, E, G	B1
	CD + EG = 17 + 19 = 36 ←	M1 A1
	CE + DG = 12 + 25 = 37	
	CG + DE = 28 + 13 = 41	A1
	Length = 543 + 36 = 579 (km)	A1ft (5)
(b)	CE (12) is the shortest	M1
	So repeat CE (12)	A1ft
	Start and finish at D and G	A1ft (3)
		[8]
	Notes: (a) 1B1: cao (may be implicit) 1M1: Three pairings of their four odd nodes 1A1: one row correct 2A1: all correct 3A1ft: 543 + their least = a number. Condone lack of km (b) 1M1ft: Identifies their shortest from a choice of at least 2 rows. 1A1ft: indicates their intent to repeat shortest. 2A1ft: correct for their least.	

Question Number	Scheme	Marks
Q6 (a)	 Shortest route: A B C E G H Length: 156 (km)	M1 A1 A1ft A1 A1ft (5)
(b)	New route: A B E G H Length: 165 (km)	B1 B1 (2) **[7]**
	Notes: (a) 1M1: Dijkstra's algorithm, small replacing larger in at least one of the sets of working values at C, E, G or H 1A1: Values correct at vertices A to E. 2A1ft: Values correct at vertices F to H, penalise order only once. 3A1: cao 4A1ft: 156ft (b) 1B1: cao ABEGH 2B1: 165 Special Case Accept 166 if ABDGH listed as the path.	

Question Number	Scheme	Marks
7 (a)		B1 B1 B1 (lines) B1 (shading) B1 (R found) B1 (labels) (6)
(b)	Point testing or Profit line method Minimum point (0, 80); Value of 80 Maximum point (24, 96); Value of 168	M1 A1 B1 A1 B1 A1 (6) **[12]**

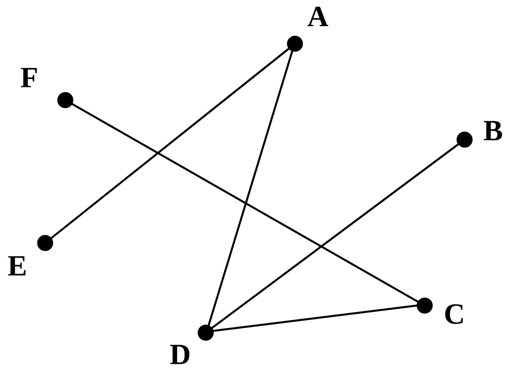
Question Number	Scheme	Marks
8 (a)		M1 A1 M1 A1 (4)
(b)	A, I, K, M, N; Length 39	B2,1,0; B1 (3)
(c)	Float on F is 34 – 15 – 15 = 4 Float on G is 24 – 15 – 3 = 6	M1 A1 B1 (3)
(d)		M1 A1 M1 A1 (4)
(e)	e.g. At time 14 ½ there are 4 tasks I, E, H and C must be happening.	B2,1,0 (2) **[16]**

Mark Scheme (Results)
Summer 2009

GCE

GCE Mathematics (6689/01)

June 2009
6689 Decision Mathematics D1
Mark Scheme

Question Number	Scheme	Marks
Q1 (a)	AD, AE, DB; DC, CF	M1 A1; A1 (3)
(b)		B1 (1)
(c)	Weight 595 (km)	B1 (1)
		[5]
	Notes: (a) 1M1: Using Prim – first 2 arcs probably but condone starting from another vertex. 1A1: first three arcs correct 2A1: all correct. (b) 1B1: CAO (c) 1B1: CAO condone lack of km.	
	<u>Apply the misread rule, if not listing arcs or not starting at A.</u> So for M1 (only) Accept numbers across the top (condoning absence of 6) Accept full vertex listing Accept full arc listing starting from vertex other than A	
	[AD AE DB DC CF] {1 4 5 2 3 6} ADEBCF BD AD AE CD CF {3 1 5 2 4 6} BDAECF CD AD AE BD CF {3 5 1 2 4 6} CDAEBF DA AE DB CD CF {2 4 5 1 3 6} DAEBCF EA AD DB DC CF {2 4 5 3 1 6} EADBCF FC CD AD AE BD {4 6 2 3 5 1} FCDAEB	

Question Number	Scheme	Marks
Q2 (a)	$\frac{230}{60} = 3.8\dot{3}$ so 4 needed	M1 A1 (2)
(b)	Bin 1: 32 17 9 Bin 2: 45 12 Bin 3: 23 28 Bin 4: 38 16 Bin 5: 10	M1 A1 A1 A1 (4)
(c)	e.g. Bin 1: 32 28 Bin 2: 38 12 10 Bin 3: 45 9 Bin 4: 23 17 16	M1 A1 A1 (3) **[9]**
	Notes: (a) 1M1: Their 230 divided by 60, some evidence of correct method 3.8 enough. 1A1: cso 4. (b) 1M1: Use of first fit. Probably 32, 45 and 17 correctly placed. 1A1: 32, 45, 17, 23, 38 and 28 placed correctly 2A1: 32, 45, 17, 23, 38, 28, 16, 9 placed correctly. 3A1: cao (c) 1M1: Use of full bin – at least one full bin found and 5 numbers placed. 1A1: 2 full bins found Eg [32+28 and 38+12+10] [23+28+9 and 16+12+32] [32+28 and 23+16+12+9] [38+12+10 and 23+28+9] 2A1: A 4 bin solution found. **Special case for (b) misread using first fit decreasing.** Give M1A1 (max) Bin 1: 45 12 Bin 2: 38 17 Bin 3: 32 28 Bin 4: 23 16 10 9 M1 for placing 45, 38, 32, 28 and 23 correctly A1 for cao.	

Question Number	Scheme	Marks
Q3		
(a)	H – 2 = M – 5 = R – 4 change status to give	M1 A1
	C = 3 (E unmatched) H = 2 M = 5 R = 4 S = 1	A1 (3)
(b)	e.g. C is the only person who can do 3 and the only person who can do 6	B1 (1)
(c)	e.g. E – 5 = M – 2 = H – 1 = S – 3 = C – 6 change status to give	M1 A1
	C = 6 E = 5 H = 1 M = 2 R = 4 S = 3	A1 (3)
		[7]
	Notes: (a) 1M1: Path from H to 4 1A1: correct path and change status 2A1: CAO must follow from correct path. (b) 1B1: CAO or e.g reference to E 5 M 2 H 1 S (c) 1M1: Path from E to 6 1A1: CAO do not penalise lack of change status a second time. 2A1: CAO must follow from a correct path	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>Q4</td><td>
<table>
<tr><td>M</td><td>J</td><td>E</td><td>K</td><td>H</td><td>B</td><td>L</td><td>P</td><td>N</td><td>D</td><td>B</td></tr>
<tr><td><i>B</i></td><td>M</td><td>J</td><td>E</td><td>K</td><td>H</td><td>L</td><td>P</td><td>N</td><td>D</td><td>H</td></tr>
<tr><td><i>B</i></td><td>E</td><td>D</td><td><i>H</i></td><td>M</td><td>J</td><td>K</td><td>L</td><td>P</td><td>N</td><td>D L</td></tr>
<tr><td><i>B</i></td><td><i>D</i></td><td>E</td><td><i>H</i></td><td>J</td><td>K</td><td><i>L</i></td><td>M</td><td>P</td><td>N</td><td>(E) K P</td></tr>
<tr><td><i>B</i></td><td><i>D</i></td><td><i>E</i></td><td><i>H</i></td><td>J</td><td><i>K</i></td><td><i>L</i></td><td>M</td><td>N</td><td><i>P</i></td><td>(J) N</td></tr>
<tr><td><i>B</i></td><td><i>D</i></td><td><i>E</i></td><td><i>H</i></td><td><i>J</i></td><td><i>K</i></td><td><i>L</i></td><td>M</td><td><i>N</i></td><td><i>P</i></td><td>(M)</td></tr>
</table>

Sort completed

$\left[\frac{1+10}{2}\right]=6$ Katie reject left

$\left[\frac{7+10}{2}\right]=9$ Natsuko reject right

$\left[\frac{7+8}{2}\right]=8$ Miri reject right

7 = Louis name found

Notes:

(a) 1M1: quick sort, pivots, p, identified, two sublists one <p one >p.

If choosing one pivot only per iteration, M1 only.

1A1: first pass correct, next pivot(s) chosen consistently.

2A1ft: second pass correct, next pivot(s) chosen consistently

3A1ft: third pass correct, next pivot(s) chosen consistently

4A1: cso List re-written or end statement made or each element been chosen as a pivot.

(b) 1M1: binary search, choosing pivot rejecting half list.

If using unordered list then M0.

If choosing J M1 ony

1A1: first two passes correct, condone ‘sticky’pivots here, bod.

2A1ft: third pass correct, pivots rejected.

3A1: cso, including success statement.

Special case for (b) – If just one letter out of order, award maximum of M1A1A0A0
</td><td>M1 1A1

2A1ft

3A1ft

4A1 (5)

M1

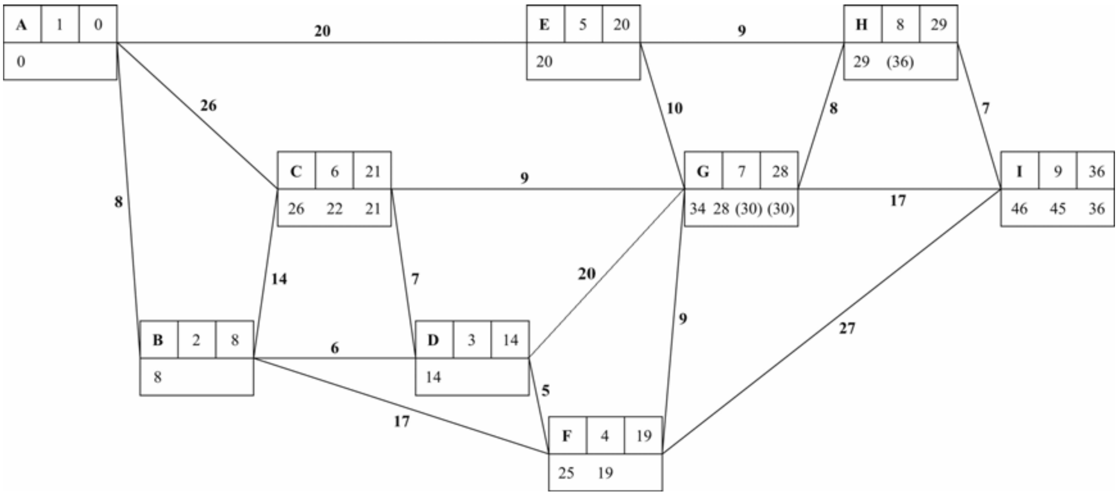
1A1

2A1ft

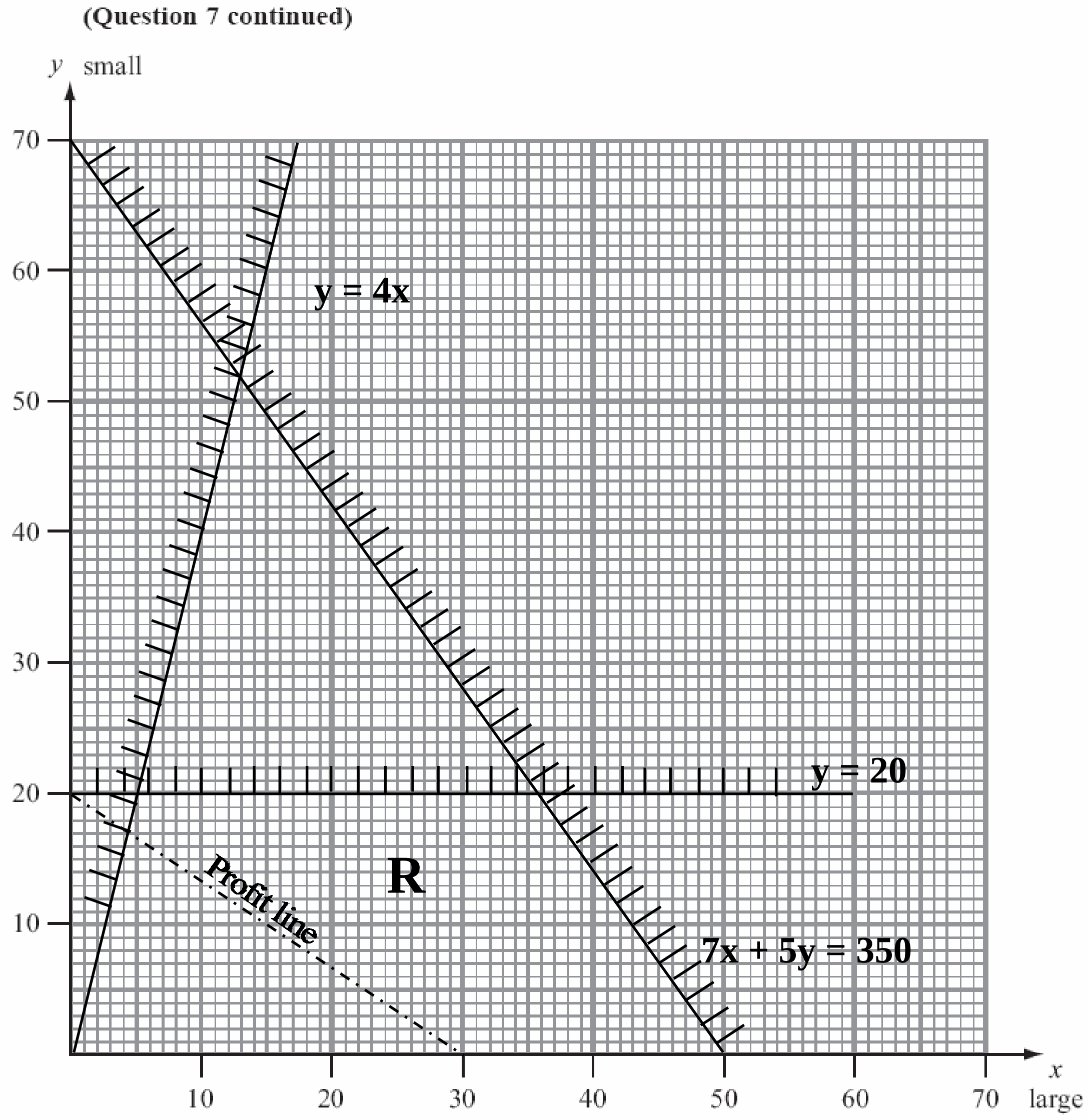
3A1 (4)

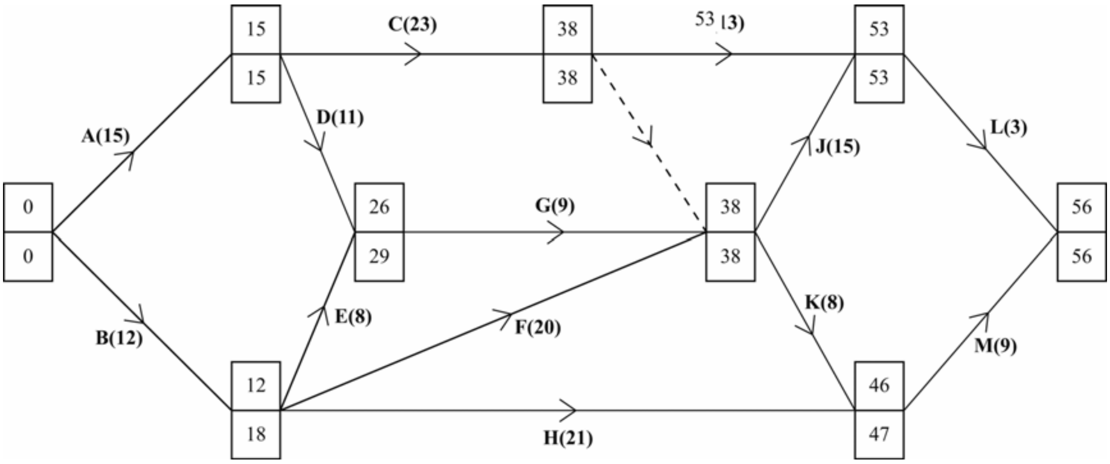
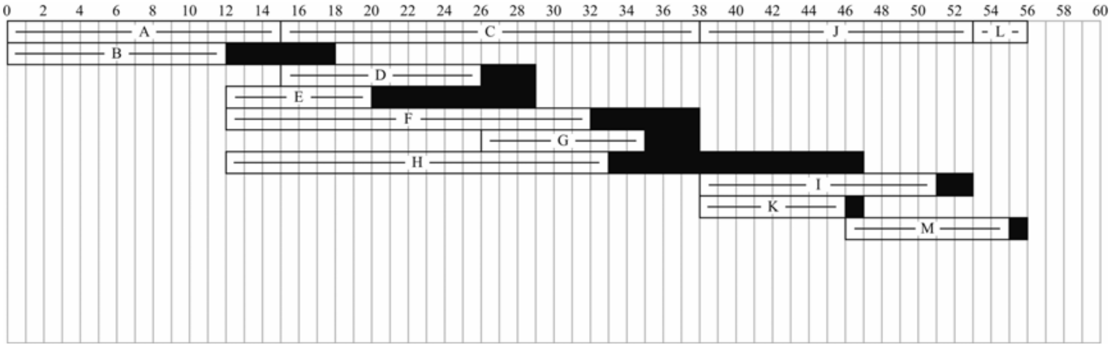
[9]</td></tr>
</table>

Question Number	Scheme	Marks
Q5 (a)	CD + EG = 45 + 38 = 83 CE + DG = 39 + 43 = 82 ← CG + DE = 65 + 35 = 100 Repeat CE and DG Length 625 + 82 = 707 (m)	M1 1A1 2A1 3A1 4A1ft 5A1ft (6)
	DE (or 35) is the **smallest** So finish at C. New route 625 + 35 = 660 (m)	M1 A1ft A1ft=1B1 (3) **[9]**
	Notes: (a) 1M1: Three pairings of their four odd nodes 1A1: one row correct 2A1: two rows correct 3A1: three rows correct 4A1ft: ft their least, but must be the correct shortest route arcs on network. (condone DG) 5A1ft: 625 + their least = a number. Condone lack of m (b) 1M1: Identifies their shortest from a choice of at least 2 rows. 1A1ft: ft from their least or indicates C. 2A1ft = 1Bft: correct for their least. (Indept of M mark)	

Question Number	Scheme	Marks
Q6 (a)		M1 1A1 2A1ft 3A1ft 4A1ft
	Route: A E H I	5A1
(b)	Shortest distance from A to G is 28 km	B1ft
		[7]
	Notes: (a) 1M1: Small replacing big in the working values at C or F or G or I 1A1: Everything correct in boxes at A, B, D and F 2A1ft: ft boxes at E and C handled correctly but penalise order of labelling only once 3A1ft: ft boxes at G and H handled correctly but penalise order of labelling only once 4A1ft: ft boxes at I handled correctly but penalise order of labelling only once 5A1: route cao A E H I (b) 1B1ft: ft their final label at G condone lack of km	

Question Number	Scheme	Marks
Q7 (a)	$7x+5y\le 350$	M1 A1 (2)
(b)	$y\le 20$ e.g. make at most 20 small baskets $y\le 4x$ e.g. the number of small (y) baskets is at most 4 times the number of large baskets (x). {E.g if y = 40, x =10, 11, 12 etc. or if x = 10, y = 40, 39, 38}	B1 B1 (2)
(c)	(see graph next page) Draw three lines correctly Label R	B3,2,1,0 B1 (4)
(d)	(P=) $2x + 3y$	B1 (1)
(e)	Profit line or point testing. x = 35.7 y = 20 precise point found. Need integers so optimal point in R is (35, 20); Profit (£)130	M1 A1 B1 B1;B1 (5)
		[14]
	Notes: (a) 1M1: Coefficients correct (condone swapped x and y coefficients) need 350 and any inequality 1A1: cso. (b) 1B1: cao 2B1: cao, test their statement, need both = and < aspects. (c) 1B1: One line drawn correctly 2B1: Two lines drawn correctly 3B1: Three lines drawn correctly. Check (10, 40) (0, 0) and axes 4B1: R correct, but allow if one line is slightly out (1 small square). (d) 1B1: cao accept an expression. (e) 1M1: Attempt at profit line or attempt to test at least two vertices in their feasible region. 1A1: Correct profit line or correct testing of at least three vertices. **Point testing:** (0,0) P= 0; (5,20) P = 70; (50,0) P = 100 $\left(35\frac{5}{7},20\right)=\left(\frac{250}{7},20\right)$ P = $131\frac{3}{7}=\frac{920}{7}$ also (35, 20) P = 130. Accept (36,20) P = 132 for M but not A. **Objective line:** Accept gradient of 1/m for M mark or line close to correct gradient. 1B1: cao – accept x co-ordinates which round to 35.7 2B1: cao 3B1: cao	

Question Number	Scheme	Marks
(c)		

Question Number	Scheme	Marks
Q8 (a)		M1 A1 M1 A1 (4)
(b)	A C J L	B1 (1)
(c)	Total float for M = 56(ft) – 46 – 9 = 1 Total float for H = 47 – 12 – 21 = 14	M1 A1ft B1 (3)
(d)		M1 A1 M1,A1 (4)
(e)	1pm day 16: C 1pm day 31: C F G H	B1ft B2ft,1ft,0 (3) **[15]**

Mark Scheme (Results)
January 2010

GCE

Decision Mathematics D1 (6689)

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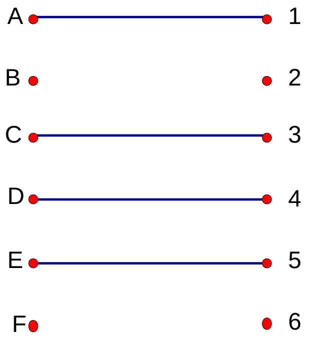
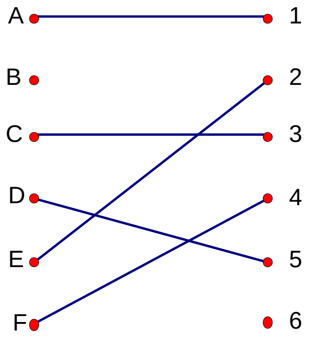
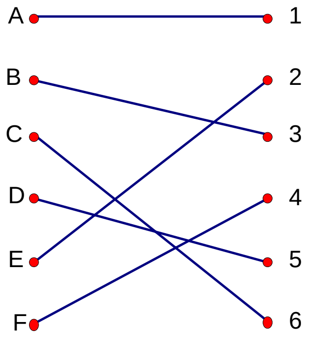
January 2010

Publications Code UA022719

January 2010
6689 Decision Mathematics D1
Mark Scheme

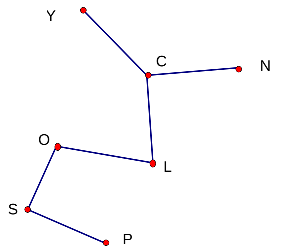
Question Number	Scheme	Marks
Q1(a)	 Initial map	B1 (1)
Q1(b)	  E.g. Path 1 F-4-D-5-E-2 Path 2 B-3-C-6 Matching A : 1, B : 3, C : 6, D : 5, E : 2, F : 4	M1 A1 M1 A1 A1 (5) **[6]**

Question Number	Scheme	Marks
Q1(b)	Question 1(b) Alternative Solutions	

	Path 1	Path 2	Matching					
			A	B	C	D	E	F
1	B-3-C-1-A-2	F-3-B-4-D-5-E-1-C-6	2	4	6	5	1	3
2	B-3-C-1-A-2	F-3-B-4-D-5-E-2-A-1-C-6	1	4	6	5	2	3
3	B-3-C-1-A-2	F-4-D-5-E-1-C-6	2	3	6	5	1	4
4	B-3-C-1-A-2	F-4-D-5-E-2-A-1-C-6	1	3	6	5	2	4
5	B-3-C-4-D-5-E-1-A-2	F-3-B-4-C-6	2	4	6	5	1	3
6	B-3-C-4-D-5-E-1-A-2	F-4-C-6	2	3	6	5	1	4
7	B-3-C-6	F-3-B-4-D-5-E-1-A-2	2	4	6	5	1	3
8	B-3-C-6	F-3-B-4-D-5-E-2	1	4	6	5	2	3
9	B-3-C-6	F-4-D-5-E-1-A-2	2	3	6	5	1	4
10	B-3-C-6	F-4-D-5-E-2	1	3	6	5	2	4
11	B-4-D-5-E-2	F-3-C-6	1	4	6	5	2	3
12	B-4-D-5-E-2	F-4-B-3-C-6	1	3	6	5	2	4
13	B-4-D-5-E-1-A-2	F-3-C-6	2	4	6	5	1	3
14	B-4-D-5-E-1-A-2	F-4-B-3-C-6	2	3	6	5	1	4
15	F-3-C-1-A-2	B-3-F-4-D-5-E-1-C-6	2	3	6	5	1	4
16	F-3-C-1-A-2	B-3-F-4-D-5-E-2-A-1-C-6	1	3	6	5	2	4
17	F-3-C-1-A-2	B-4-D-5-E-1-C-6	2	4	6	5	1	3
18	F-3-C-1-A-2	B-4-D-5-E-2-A-1-C-6	1	4	6	5	2	3
19	F-3-C-4-D-5-E-1-A-2	B-3-F-4-C-6	2	3	6	5	1	4
20	F-3-C-4-D-5-E-1-A-2	B-4-C-6	2	4	6	5	1	3
21	F-3-C-6	B-3-F-4-D-5-E-1-A-2	2	3	6	5	1	4
22	F-3-C-6	B-3-F-4-D-5-E-2	1	3	6	5	2	4
23	F-3-C-6	B-4-D-5-E-1-A-2	2	4	6	5	1	3
24	F-3-C-6	B-4-D-5-E-2	1	4	6	5	2	3
25	F-4-D-5-E-2	B-3-C-6	1	3	6	5	2	4
26	F-4-D-5-E-2	B-4-F-3-C-6	1	4	6	5	2	3
27	F-4-D-5-E-1-A-2	B-3-C-6	2	3	6	5	1	4
28	F-4-D-5-E-1-A-2	B-4-F-3-C-6	2	4	6	5	1	3

Notes

(a) B1 cao preferably just 4 lines, but accept if unambiguous.
(b) M1 attempt at a path from B or F to 2 or 6
A1 correct path – including change status
M1 attempt at a second path from F or B to 6 or 2
A1 correct path – including change status (do not penalise change status twice)
A1 correct matching; must follow from 2 correct paths

<table>
<tr><th>Question Number</th><th colspan="2">Scheme</th><th>Marks</th></tr>
<tr><td>Q2(a)</td><td colspan="2">(i) All pairs of vertices connected by a path, but not describing complete graph.
(ii) No cycles
(iii) All nodes connected (accept definition of minimum spanning tree)</td><td>B1
B1
B1
(3)</td></tr>
<tr><td>Q2(b)</td><td colspan="2">Kruskal's (algorithm)</td><td>B1
(1)</td></tr>
<tr><td>Q2(c)(i)</td><td colspan="2">L-O 56 — Using Prim. first 2 correct
L-C 60
C-N 62
O-S 63 — Next 2
S-P 43
C-Y 156 — Finish
Total length 440 (miles) — Total</td><td>M1
A1
A1
A1 =B1</td></tr>
<tr><td>Q2(c)(ii)</td><td>Tree correct</td><td> </td><td>B1
(5)
[9]</td></tr>
</table>

Q2(c)

Accept weights as indicating arcs.

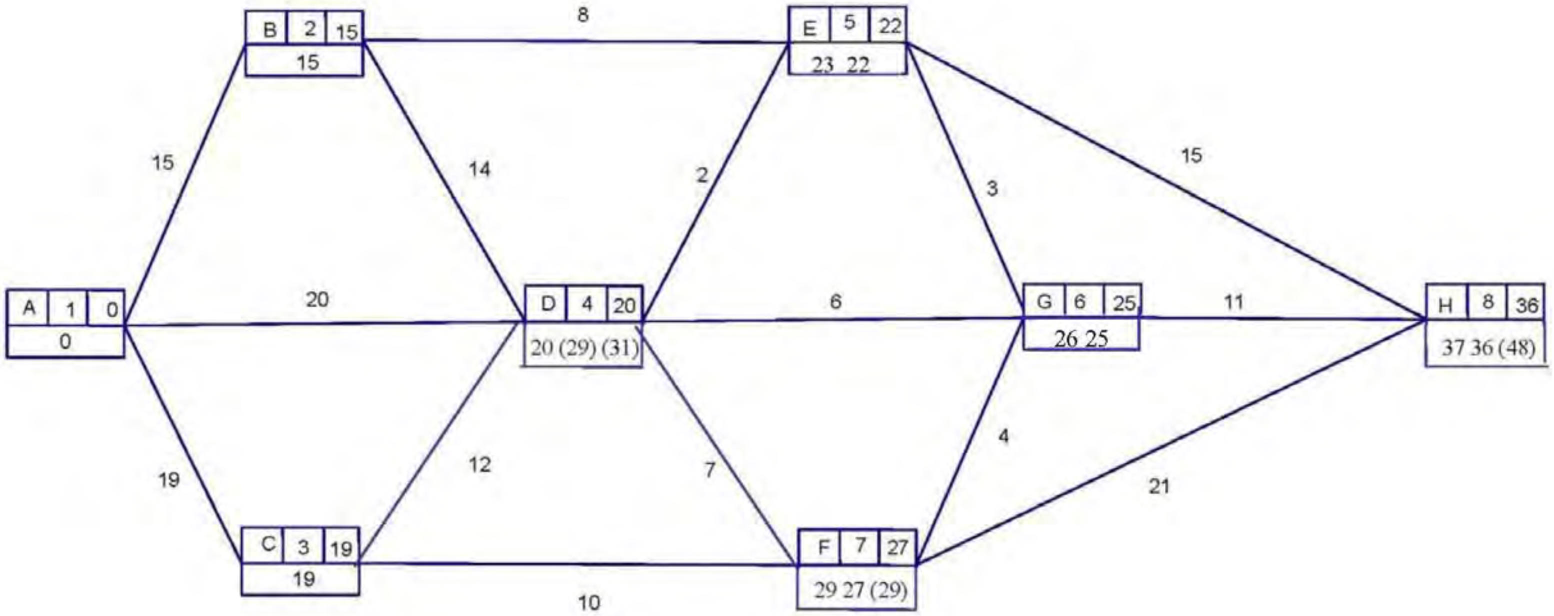
Misreads – award M1 A0 A0 for these:

- Vertices, not edges given L O C N S P Y
- Numbers across top, edges either incorrect or not given: 3 1 4 2 6 5 7.

Also accept these, misreading And not starting at L – again M1A0A0

Started at	Minimum arcs	nodes	Numbers
C	CL,LO,CN,…..	CLONSPY	1243657
N	NC,CL,LO,OS,SP,CY	NCLOSPY	2314657
O	OL,LC,CN,OS,….	OLCNSPY	3241657
P	PS,SO,OL,LC,CN.CY	PSOLCNY	5463127
S	SP.SO,…	SPOLCNY	5463217
Y	YC,CL,LO,CN,..	YCLONSP	2354761

Q3(a)



Clear method to include at least 1 update (look at E, F, G or H)	M1
BCDE correct	A1
FGH correct	A1ft
Route ADEGH	A1
Total time 36 Minutes	A1ft (5)

Question Number	Scheme	Marks
Q3(b)	Odd nodes are A, B, C, H	M1
	AB + CH = 15 + 25 = 40	A1
	AC + BH = 19 + 22 = 41	A1
	AH + BC = 36 + 22 = 58	A1
	(40 is the shortest, repeating AB and CF + FG + GH)	
	Must be choosing from at least two pairings for this last mark Shortest time = 167 + 40 = 207 minutes. 167 + their shortest	A1ft (5)
		[10]

Question Number	Scheme											Marks
Q4(a)	0.6	4.0	2.5	3.2	0.5	**2.6**	0.4	0.3	4.0	1.0	**2.6**	
	4.0	**3.2**	4.0	2.6	0.6	2.5	0.5	**0.4**	0.3	1.0	**3.2 0.4**	M1
	4.0	**4.0**	3.2	2.6	0.6	2.5	**0.5**	1.0	0.4	**0.3**	**4.0 0.5**	A1
	4.0	4.0	3.2	2.6	0.6	**2.5**	1.0	0.5	0.4	0.3	**2.5**	A1ft
	4.0	4.0	3.2	2.6	2.5	0.6	**1.0**	0.5	0.4	0.3	**1.0**	A1ft
	4.0	4.0	3.2	2.6	2.5	1.0	**0.6**	0.5	0.4	0.3		A1 cso (5)
Q4(b)	Length 1:	4										
	Length 2:	4										
	Length 3:	3.2	0.6								left column & 1.0 in place	M1
	Length 4:	2.6	1.0	0.4							0.6 & 0.5	A1
	Length 5:	2.5	0.5	0.3							0.4	A1
											All correct (c.s.o)	A1 (4)
Q4(c)	19.1/4 = 4.775 so 5 lengths needed, accept total is 19.1m, or refer to 0.9 ‘spare .											B1
	Yes, the answer to (b) does use the minimum number of bins.											DB1 (2) **[11]**

Notes for Q4(a)

1M1 Pivot, p, chosen. List sorted, >p, p. <p or <p, p, >p. **If only choosing 1 pivot per iteration M1 only**
1A1 1st pass correct and chosen next **two** pivots correctly for sublists >1
2A1ft 2nd pass correct and chosen next **two** pivots correctly for sublists >1
3A1ft 3rd pass correct and next pivot for sublist >1 chosen correctly.
4A1 cso.

Misread in part (a)

- If they have misread a number **at the start of part (a), so genuinely miscopied** and got for example 0.1 instead of 1.0 then mark the whole question as a misread – removing the last two A or B marks earned. This gives a maximum total of 9.

- If they misread their own numbers **during the course of part (a)** then count it as an **error in part (a)** but mark parts (b) and (c) as a misread. So they would lose marks in (a) for the error and then the last two A or B marks earned in (b) and (c) - giving a maximum of 8 or maybe 7 marks depending on how many marks they lose in (a).

The most popular misread is the one listed above – where 1.0 has changed to 0.1 giving
4.0 4.0 3.2 2.6 2.5 0.6 0.5 0.4 0.3 **0.1** at the end of (a) for this one (b) and (c) are:

(b) Length 1: 4
Length 2: 4
Length 3: 3.2 0.6 0.1
Length 4: 2.6 0.5 0.4 0.3
Length 5: 2.5

(c) 18.2/4 = 4.55 so 5 bins, or total is 18.2 or 1.8 ‘spare’
Yes answer in (b) uses the minimum number of bins.

Alternate solutions for Question 4

Choosing middle left

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 0.5)
0.6	4.0	2.5	3.2	2.6	4.0	1.0	**0.5**	0.4	0.3	(pivots 3.2, 0.4)
4.0	4.0	**3.2**	0.6	2.5	2.6	1.0	**0.5**	**0.4**	0.3	(pivots 4.0, 2.5)
4.0	4.0	**3.2**	2.6	**2.5**	0.6	1.0	**0.5**	**0.4**	**0.3**	(pivots 0.6)
4.0	**4.0**	**3.2**	**2.6**	**2.5**	1.0	**0.6**	**0.5**	**0.4**	**0.3**	
4.0	**4.0**	**3.2**	**2.6**	**2.5**	**1.0**	**0.6**	**0.5**	**0.4**	**0.3**	

Choosing first

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 0.6)
4.0	2.5	3.2	2.6	4.0	1.0	**0.6**	0.5	0.4	0.3	(pivots 4.0, 0.5)
4.0	2.5	3.2	2.6	4.0	1.0	**0.6**	**0.5**	0.4	0.3	(pivots 2.5, 0.4)
4.0	3.2	2.6	4.0	**2.5**	1.0	**0.6**	**0.5**	**0.4**	0.3	(pivots 3.2)
4.0	4.0	**3.2**	2.6	**2.5**	**1.0**	**0.6**	**0.5**	**0.4**	**0.3**	
4.0	**4.0**	**3.2**	**2.6**	**2.5**	**1.0**	**0.6**	**0.5**	**0.4**	**0.3**	

OR (alternate choosing first)

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 0.6)
4.0	2.5	3.2	2.6	4.0	1.0	**0.6**	0.5	0.4	0.3	(pivots 4.0, 0.5)
4.0	**4.0**	2.5	3.2	2.6	1.0	**0.6**	**0.5**	0.4	0.3	(pivots 2.5, 0.4)
4.0	**4.0**	3.2	2.6	**2.5**	1.0	**0.6**	**0.5**	**0.4**	0.3	(pivots 3.2)
4.0	**4.0**	**3.2**	2.6	**2.5**	**1.0**	**0.6**	**0.5**	**0.4**	**0.3**	
4.0	**4.0**	**3.2**	**2.6**	**2.5**	**1.0**	**0.6**	**0.5**	**0.4**	**0.3**	

Question 4 sorting into ASCENDING order (full marks if then reversed, otherwise MISREAD)

Middle left

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 0.5)
0.4	0.3	**0.5**	0.6	4.0	2.5	3.2	2.6	4.0	1.0	(pivot 0.4, 3.2)
0.3	**0.4**	**0.5**	0.6	2.5	2.6	1.0	**3.2**	4.0	4.0	(pivot 2.5, 4.0)
0.3	**0.4**	**0.5**	0.6	1.0	**2.5**	2.6	**3.2**	**4.0**	4.0	(pivot 0.6)
0.3	**0.4**	**0.5**	**0.6**	1.0	**2.5**	**2.6**	**3.2**	**4.0**	**4.0**	

Middle right

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 2.6)
0.6	2.5	0.5	0.4	0.3	1.0	**2.6**	4.0	3.2	4.0	(pivot 0.4, 3.2)
0.3	**0.4**	0.6	2.5	0.5	1.0	**2.6**	**3.2**	4.0	4.0	(pivot 0.5, 4.0)
0.3	**0.4**	**0.5**	0.6	2.5	1.0	**2.6**	**3.2**	4.0	**4.0**	(pivot 2.5)
0.3	**0.4**	**0.5**	0.6	1.0	**2.5**	**2.6**	**3.2**	4.0	**4.0**	(pivot 1.0)

First (1)

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 0.6)
0.5	0.4	0.3	**0.6**	4.0	2.5	3.2	2.6	4.0	1.0	(pivot 0.5, 4.0)
0.4	0.3	**0.5**	**0.6**	2.5	3.2	2.6	1.0	**4.0**	4.0	(pivots 0.4, 2.5)
0.3	**0.4**	**0.5**	**0.6**	1.0	**2.5**	3.2	2.6	**4.0**	**4.0**	(pivots 3.2)
0.3	**0.4**	**0.5**	**0.6**	**1.0**	**2.5**	2.6	**3.2**	**4.0**	**4.0**	

First (2)

0.6	4.0	2.5	3.2	0.5	2.6	0.4	0.3	4.0	1.0	(pivot 0.6)
0.5	0.4	0.3	**0.6**	4.0	2.5	3.2	2.6	4.0	1.0	(pivot 0.5, 4.0)
0.4	0.3	**0.5**	**0.6**	2.5	3.2	2.6	1.0	4.0	**4.0**	(pivots 0.4, 2.5)
0.3	**0.4**	**0.5**	**0.6**	1.0	**2.5**	3.2	2.6	4.0	**4.0**	(pivots 3.2)
0.3	**0.4**	**0.5**	**0.6**	**1.0**	**2.5**	2.6	**3.2**	4.0	**4.0**	

Question Number	Scheme	Marks
Q5		

(a)

S	T	R	R>0?	Output	
25000	0	17000	y		Line 1
	3400				Line 2
		7000			Line 3
			y		Line 4
	4450				Line 5
		-5000			Line 6
			n		Line 7
				4450	

Lines 1 & 2: M1A1
Lines 3-7: M1A1

Output correct: A1
(5)

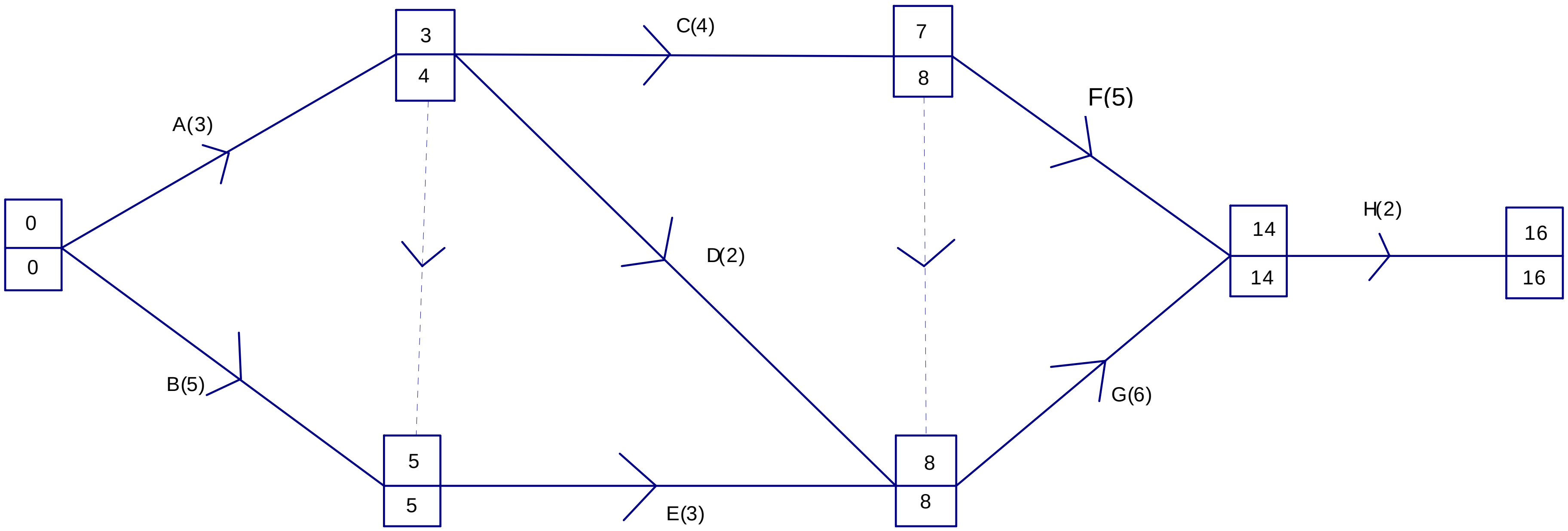
(b) Tax on £25 000 is £4450 B1ft
(1)

(c) Tax free sum = £8000: B1
(1)

[7]

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>Q6(a)</td><td>The dotted line represents a dummy activity.
It is necessary because C and D depend only on A, but E depends on A and B.</td><td>B1
B1
(2)</td></tr>
<tr><td>Q6(b)</td><td>
<table>
<tr><th>Activity</th><th>Immediately preceding activity</th><th></th></tr>
<tr><td>A</td><td>-</td><td></td></tr>
<tr><td>B</td><td>-</td><td></td></tr>
<tr><td>C</td><td>A</td><td></td></tr>
<tr><td>D</td><td>A</td><td>To this point</td></tr>
<tr><td>E</td><td>A,B</td><td></td></tr>
<tr><td>F</td><td>C (A)</td><td>For E & F, accepting correct “extra”</td></tr>
<tr><td>G</td><td>C, D, E</td><td></td></tr>
<tr><td>H</td><td>F, G</td><td>Last two rows, correct only,</td></tr>
</table>
</td><td>B1
B1
B1
(3)</td></tr>
</table>

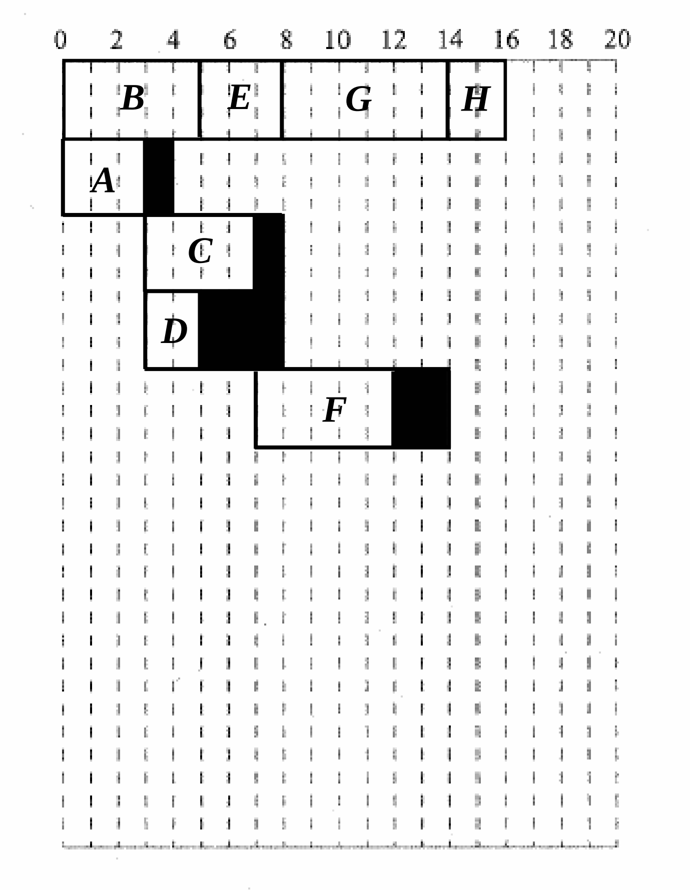
Q6(c)

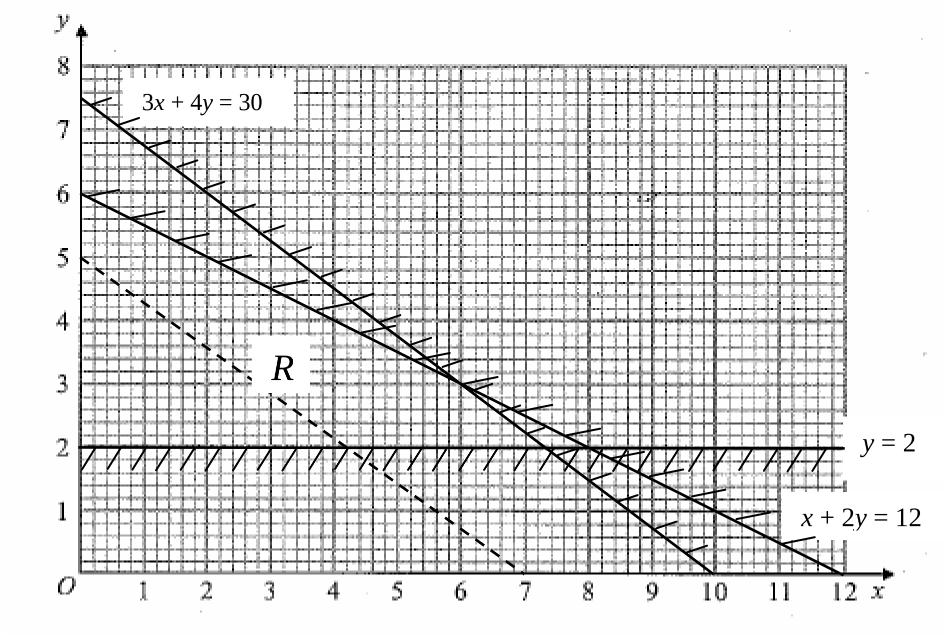


Early times	M1A1	
Late times	M1A1	(4)

Q6(d) Critical activities: B, E, G, H B1

Critical path: 16 days B1ft (2)

Question Number	Scheme	Marks
Q6(e)		
	At least 6 activities placed including at least 3 floats	M1
	Critical Activities	A1
	A + C	A1
	D + F	A1 (4)
		[15]

Question Number	Scheme	Marks
Q7(a)	$x + 2y \le 12$ $(150x + 300y \le 1800)$	M1A1 (2)
Q7(b)	$0.9x + 1.2y \le 9$ $\rightarrow$ $3x + 4y \le 30$ (*)	M1 A1 cso (2)
Q7(c)	(You need to buy) at least 2 large cupboards.	B1 (1)
Q7(d)	Capacity C and 140%C So total is $Cx + \frac{140}{100}Cy$ Simplify to $7y + 5x$ (*)	 M1 A1cso (2)
Q7(e)	 Graph: $y \ge 2$ $0.9x + 1.2y \le 12$ $(3x + 4y \le 30)$ $x + 2y \le 12$ $(150x + 300y \le 1800)$ Lines labelled & drawn with a ruler Shading, Region identified	 B1 B1 B1 B1 B1, B1 (6)
Q7(f)	Consider points and value of $5x + 7y$: Or draw a clear profit line (7,2) → 49 or (7 ⅓,2) → 50 ⅔, or (7.3, 2) → 50.5 (6,3) → 51 (0,6) → 42 (0,2) → 14 Best option is to buy 6 standard cupboards and 3 large cupboards.	M1A1 A1 A1 (4) **[17]**

Question 7 notes

(a) 1M1 – correct terms, accept = here, accept swapped coefficients.
1A1 – cao does not need to be simplified.

(b) 1M1 – correct terms, must deal with cm/m correctly, accept = here.
1A1 – cso **answer given**.

(c) 1B1 – cao 'at least' and '2' and 'large'.

(d) 1M1 – '1.4' or '5 x 40%'maybe '5+2' seen, they **must** be **seen** to engage with 140% in some way.
1A1 – cso **answer given.**

Lines should be within 1 small square of correct point at axes.

(e) 1B1 – correctly drawing y = 2.
2B1 – correctly drawing $3x + 4y = 30$ [$0.9x + 1.2y = 12$]
3B1 – correctly drawing $x + 2y = 12$ [$150x + 300y = 1800$], **ft only** if swapped coefficients in (a) (6,0) (2,8).

These next 3 marks are only available for candidates who have drawn at least 2 lines, including at least one 'diagonal' line with negative gradient.

4B1 – Ruler used. At least 2 lines labelled including one 'diagonal' line.
5B1 – Shading, or R correct, b.o.d. on their lines.
6B1 – all lines and R correct.

(f) 1M1 At least 2 points tested **or** objective line drawn with correct m or 1/m, minimum intercepts 3.5 and 2.5.
1A1 – 2 points correctly tested **or** objective line correct.
2A1 – 3 points correctly tested **or** objective line correct and distinct/labelled.
3A1 – 6 standard and 3 large, accept (6,3) if very clearly selected in some way.

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Mark Scheme (Results)

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GCE

GCE Decision Mathematics D1 (6689/01)

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Summer 2010
Decision Mathematics D1 6689
Mark Scheme

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>Q1
(a)</td><td>
<table>
<tr><td>H</td><td>V</td><td>L</td><td>A</td><td>N</td><td>J</td><td>S</td><td>T</td><td>P</td><td>(N)</td></tr>
<tr><td>H</td><td>L</td><td>A</td><td>J</td><td>N</td><td>V</td><td>S</td><td>T</td><td>P</td><td>(A, T)</td></tr>
<tr><td>A</td><td>H</td><td>L</td><td>J</td><td>N</td><td>S</td><td>P</td><td>T</td><td>V</td><td>(L, P)</td></tr>
<tr><td>A</td><td>H</td><td>J</td><td>L</td><td>N</td><td>P</td><td>S</td><td>T</td><td>V</td><td>(J)</td></tr>
<tr><td>A</td><td>H</td><td>J</td><td>L</td><td>N</td><td>P</td><td>S</td><td>T</td><td>V</td><td></td></tr>
</table>
</td><td>M1
A1
A1ft

A1cso
4</td></tr>
<tr><td>(b)</td><td>1st choice $\left[\frac{1+9}{2}\right]=5$ Nicky, reject 1 - 5
2nd choice $\left[\frac{6+9}{2}\right]=[7.5]=8$ Tom, reject 8 - 9
3rd choice $\left[\frac{6+7}{2}\right]=[6.5]=7$ Sharon, reject 7
4th choice 6 Paul name found</td><td>M1A1
A1

A1cso
4

Total 8</td></tr>
<tr><td></td><td>**Notes:**
(a) 1M1: quick sort, pivots, p, chosen and two sublists one <p one >p.
1A1: first pass correct and next pivots chosen correctly/consistently.
2A1ft: second pass correct, next pivots correctly/consistently chosen.
3A1: all correct, cso.
(b) 1M1: binary search on what they think is a alphabetical list, choosing pivot, rejecting half list.
1A1: first pass correct, condone ‘sticky’ pivot here, bod generous
2A1: second pass correct, pivot rejected.
3A1: cso.
Note: If incorrect list in (a) mark (b) as a misread.</td><td></td></tr>
</table>

Q1 Alternative solutions

Middle right

H	V	L	A	$\boxed{N}$	J	S	T	P	(N)	M1
H	L	$\boxed{A}$	J	$\boxed{N}$	V	S	$\boxed{T}$	P	(A T)	A1
$\boxed{A}$	H	$\boxed{L}$	J	$\boxed{N}$	S	$\boxed{P}$	$\boxed{T}$	V	(L P)	A1ft
$\boxed{A}$	H	$\boxed{J}$	$\boxed{L}$	$\boxed{N}$	$\boxed{P}$	$\boxed{S}$	$\boxed{T}$	$\boxed{V}$	(J)	
A	$\boxed{H}$	J	L	N	P	S	T	V		A1 cso

list sorted

Middle left

H	V	L	A	$\boxed{N}$	J	S	T	P	(N)	M1
H	$\boxed{L}$	A	J	$\boxed{N}$	V	$\boxed{S}$	T	P	(L S)	A1
H	$\boxed{A}$	J	$\boxed{L}$	$\boxed{N}$	$\boxed{P}$	$\boxed{S}$	$\boxed{V}$	T	(A V)	A1ft
$\boxed{A}$	$\boxed{H}$	J	$\boxed{L}$	$\boxed{N}$	$\boxed{P}$	$\boxed{S}$	T	$\boxed{V}$	(H)	
A	H	$\boxed{J}$	L	N	P	S	$\boxed{T}$	V		A1 cso

First

$\boxed{H}$	V	L	A	N	J	S	T	P	(H)	M1
$\boxed{A}$	$\boxed{H}$	$\boxed{V}$	L	N	J	S	T	P	(V)	A1
$\boxed{A}$	$\boxed{H}$	$\boxed{L}$	N	J	S	T	P	$\boxed{V}$	(L)	
$\boxed{A}$	$\boxed{H}$	$\boxed{J}$	$\boxed{L}$	$\boxed{N}$	S	T	P	$\boxed{V}$	(N)	A1ft
$\boxed{A}$	$\boxed{H}$	$\boxed{J}$	$\boxed{L}$	$\boxed{N}$	$\boxed{S}$	T	P	$\boxed{V}$	(S)	
$\boxed{A}$	$\boxed{H}$	$\boxed{J}$	$\boxed{L}$	$\boxed{N}$	$\boxed{P}$	$\boxed{S}$	$\boxed{T}$	$\boxed{V}$		A1 cso

Question Number	Scheme	Marks

Q2

(a) DE GF DC $\left\{\begin{matrix}\text{not CE}\\ \text{BD}\end{matrix}\right\}$ EG (not EF not CF) AC (not AB) GH

M1 A1 A1 **3**

(b)

	A	B	C	D	E	F	G	H
A	-	31	30	-	-	-	-	-
B	31	-	-	**24**	-	-	-	38
C	30	-	-	**22**	24	**29**	-	-
D	-	**24**	**22**	-	18	-	-	**34**
E	-	-	24	18	-	28	**26**	-
F	-	-	**29**	-	28	-	21	-
G	-	-	-	-	**26**	21	-	**33**
H	-	38	-	**34**	-	-	**33**	-

B2, 1, 0 **2**

(c) AC CD DE BD GE GF GH

M1 A1 A1 **3**

(d) Weight: 174

B1 **1**

Total 9

Notes:

(a) 1M1: Kruskal’s algorithm – first 4 arcs selected chosen correctly.
1A1: All seven non-rejected arcs chosen correctly.
2A1: All rejections correct and in correct order and at correct time.

(b) 1B1: condone two (double) errors
2B1: cao

(c) 1M1: Prim’s algorithm – first four arcs chosen correctly, in order, **or** first five nodes chosen correctly, in order.{A,C,D,E,B….}
1A1: First six arcs chosen correctly **or** all 8 nodes chosen correctly, in order. {A,C,D,E,B,G,F,H}
2A1: All correct and arcs chosen in correct order.

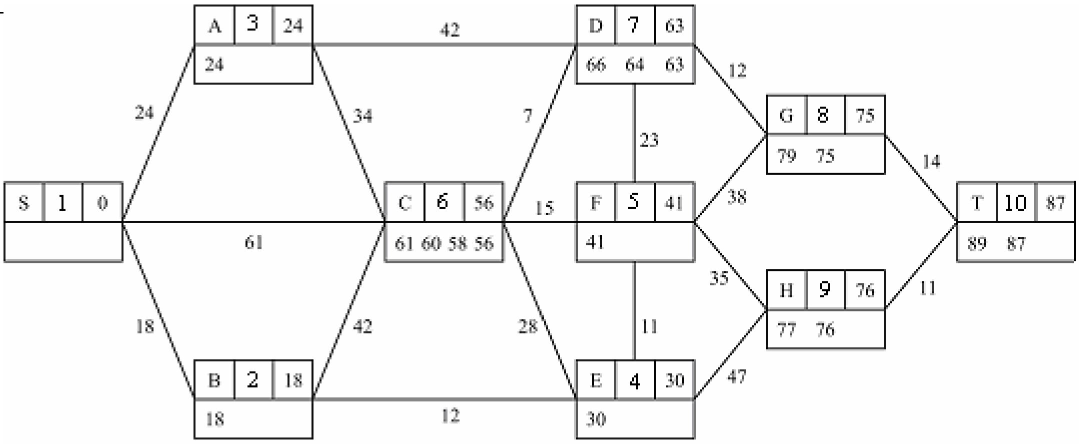
(d) 1B1: cao

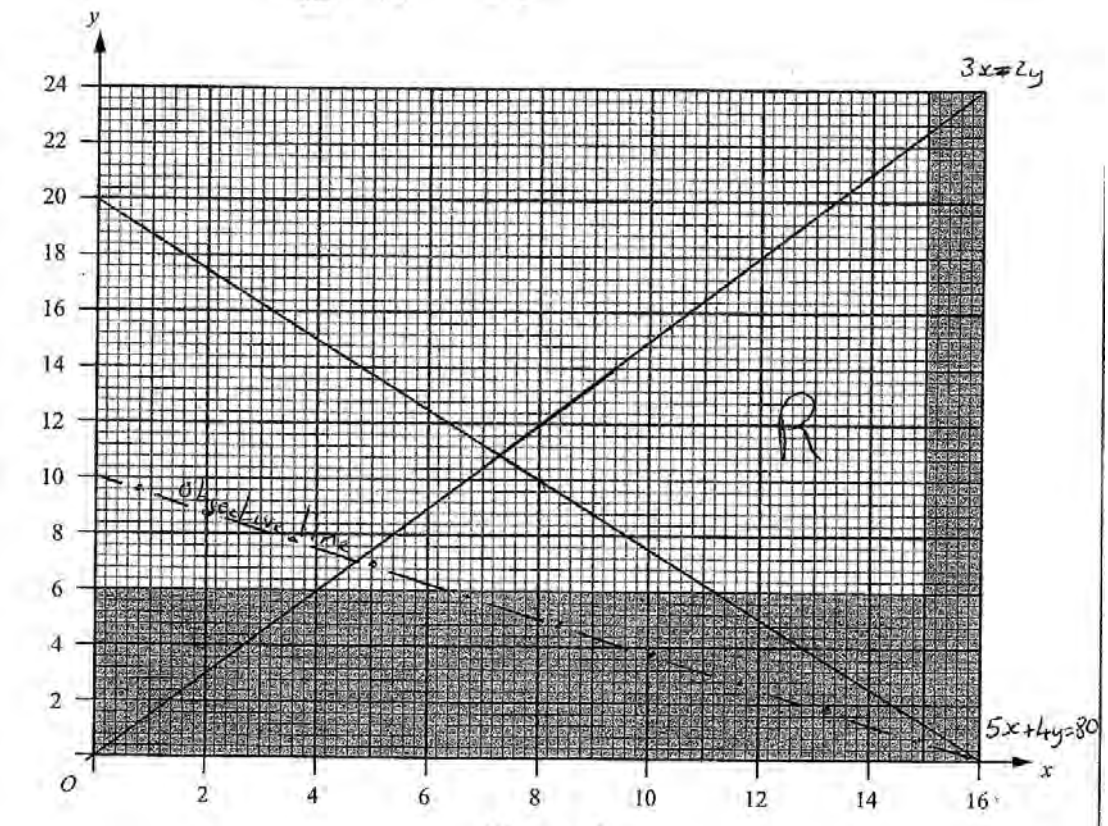
Starting at	Minimum arcs required for M1	Nodes	order
A	AC CD DE DB	ACDEB(GFH)	15234(768)
B	BD DE DC	BDEC(GFAH)	(7)1423(658)
C	CD DE DB	CDEB(GFAH)	(7)4123(658)
D	DE DC DB	DECB(GFAH)	(7)4312(658)
E	ED DC DB	EDCB(GFAH)	(7)4321(658)
F	FG GE ED DC DB	FGEDCB(AH)	(7)654312(8)
G	GF GE ED DC DB	GFEDCB(AH)	(7)654321(8)
H	HG GF GE	HGFE(DCBA)	(8765)4321

Question Number	Scheme	Marks
Q3 (a)	e.g. total weight is 239, lower bound is $\frac{239}{60}=3.98$ so 4 bins.	M1 A1 **2**
(b)	Bin 1 : 41 Bin 4 : 36 Bin 2 : 28 + 31 Bin 5 : 32 Bin 3 : 42 Bin 6: 29	M1 A1 A1 **3**
(c)	Full Bins : 28 + 32 31 + 29 The other 3 items (42, 41, 36) require 3 separate bins	M1 A1 **2**
(d)	There are 5 items over 30. No two of these 5 can be paired in a bin, so at least 5 bins will be required.	B2, 1, 0 **2** **Total 9**
	Notes: (a) 1M1: Any correct statement, must involve calculation 1A1: cao (accept 4 for both marks) (b) 1M1: Bins 1 and 2 correct and at least 6 values put in bins 1A1: Bins 1,2,3 and 4 correct. 2A1: All correct (c) 1M1: Attempt to find two full bins and allocate at least 6 values 1A1: cao (d) 1B1: Correct argument may be imprecise or muddled (bod gets B1) 2B1: A good, clear, correct argument.(They have answered the question ‘why?’)	
	Misread in (b) First Fit Decreasing Bin 1: 42 Bin 2: 41 Bin 3: 36 Bin 4: 32 28 Bin 5: 31 29 (Remove up to two A marks if earned – so M1 max in (b) if first 4 bins correct.)	

Question Number	Scheme	Marks
Q4		
(a)	BC + EG = 10.4 + 10.1 = 20.5 smallest	M1 A1
	BE + CG = 8.3 + 16.1 = 24.4	A1
	BG + CE = 14.9 + 11.9 = 26.8	A1
	So repeat tunnels BA, AC and EG	A1
		5
(b)	Any route e.g. ACFGDCABDEGEBA	B1
	Length = 73.3 + their 20.5 = 93.8km	M1 A1
		3
(c)	The new tunnel would make C and G even.	
	So only BE would need to be repeated.	B1
	Extra distance would be 10 + 8.3 = 18.3 < 20.5 [91.6 < 93.8]	
	So it would decrease the total distance.	DB1
		2
		Total 10
	Notes: (a) 1M1: Three pairings of their four odd nodes 1A1: one row correct 2A1: two rows correct 3A1: all correct 4A1: correct **arcs** identified (b) 1B1: Any correct route (14 nodes) 1M1: 73.3 + ft their least, from a choice of at least two. 1A1: cao (c) 1B1: A correct explanation, referring to BE and relevant numbers (8.3, 12.2, 2.2, 18.3,81.3, 91.6) maybe confused, incomplete or lack conclusion –bod gets B1 2B1D: A correct, clear explanation all there + conclusion (ft on their numbers.)	

Question Number	Scheme	Marks
Q5	e.g.	
(a)	G – 3 = E – 2 = A – 4 = S – 6	M1
	Change status G = 3 – E = 2 – A = 4 – S = 6	A1
	Improved matching	A1
	A = 4 (C unmatched) E = 2 G = 3 J = 5 S = 6	**3**
(b)	e.g. Both C and J can only be matched to 5	B2, 1, 0
	Both 1 and 6 can only be done by S	**2**
(c)	C – 5 = J – 4 = A – 2 = E – 6 = S – 1	M1
	Change status C = 5 – J = 4 – A = 2 – E = 6 – S = 1	A1
	Complete matching	
	A = 2 C = 5 E = 6 G = 3 J = 4 S = 1	A1
		3
		Total 8
	Notes: (a) 1M1: Path from G to 6 or 1 1A1: CAO including change status (stated or shown), chosen path clear. 2A1: CAO must ft from stated path, diagram ok (b) 1B1: Correct answer, may be imprecise or muddled (bod gets B1) all relevant nodes should be referred to and must be correct, but condone one (genuine) slip. 2B1: Good, clear, correct answer. (c) 1M1: Path from C to 1 or 6 [whichever they didn't use before.] 1A1: CAO including change status (stated or shown), chosen path clear. (Don't penalise change status twice.) 2A1: CAO must ft from stated path, diagram ok	
	Alt (a) G – 3 = E – 2 = A – 4 = S – 1 c.s. G = 3 – E = 2 – A = 4 – S = 1 A = 4, (C unmatched), E = 2, G = 3, J = 5, S = 1 (c) C – 5 = J – 4 = A – 2 = E – 6 c.s. C = 5 – J = 4 – A = 2 – E = 6 A = 2, C = 5, E = 6, G = 3, J = 4, S = 1	

Question Number	Scheme	Marks
Q6 (a)		M1 A1 A1ft A1
	Route: SBEFHT Time: 87 minutes	B1 B1ft **6**
(b)	Accept demonstration of relevant subtractions, or general explanation.	B2ft,1ft, 0 **2**
(c)	Route: EFHT	B1 **1**
		Total 9
	Notes: (a) 1M1: Smaller number replacing larger number in the working values at C or D or G or H or T. (generous – give bod) 1A1: All values in boxes S, A, B, E and F correct 2A1ft: All values in boxes C and D (ft) correct. Penalise order of labelling errors just once. 3A1: All values in boxes G, H and T correct 1B1: CAO (not ft) 2B1ft: Follow through from their T value, condone lack of units here. (b) 1B1ft: Partially complete account, maybe muddled, bod gets B1 2B1ft: Complete, clear account. (c) 1B1: CAO	

Question Number	Scheme	Marks
Q7		
(a)	To indicate the strict inequality	B1 **1**
(b)	$3x = 2y$ and $5x + 4y = 80$ added to the diagram. R correctly labelled.  Diagram 1	B1, B1 B1 **3**
(c)	[Minimise C =] $500x + 800y$	B1, B1 **2**
(d)	Point testing or Profit line Seeking integer solutions (11, 7) at a cost of £ 11 100.	M1 A1 M1 B1, B1 **5** **Total 11**

Notes:

(a) 1B1: CAO

(b) 1B1: $3x = 2y$ passing through 1 small square of (0,0) and (12, 18), but must reach x = 15

2B1: $5x + 4y = 80$ passing through 1 small square of (0, 20) and (16, 0) (extended if necessary) but must reach y = 6

3B1: R CAO (condoning slight line inaccuracy as above.)

(c) 1B1: Accept expression and swapped coefficients. Accept 5x + 8y for 1 mark

2B1: CAO (expression still ok here)

(d) 1M1: Profit line [gradient accept reciprocal, minimum length line passes through (0, 2.5) (4, 0)] **OR** testing 2 points in their FR near two different vertices.

1A1: Correct profit line **OR** 2 points correctly tested in correct FR (my points)

e.g

$(7\tfrac{3}{11}, 10\tfrac{10}{11}) = 12\,363\tfrac{7}{11}$ or $(7,11) = 12\,300$

$(8,10) = 12\,000$

$(8,11) = 12\,800$

$(11\tfrac{1}{5}, 6) = 10\,400$ or $(11, 6) = 10\,300$

$(15, 6) = 12\,300$ or $(15, 7) = 13\,100$

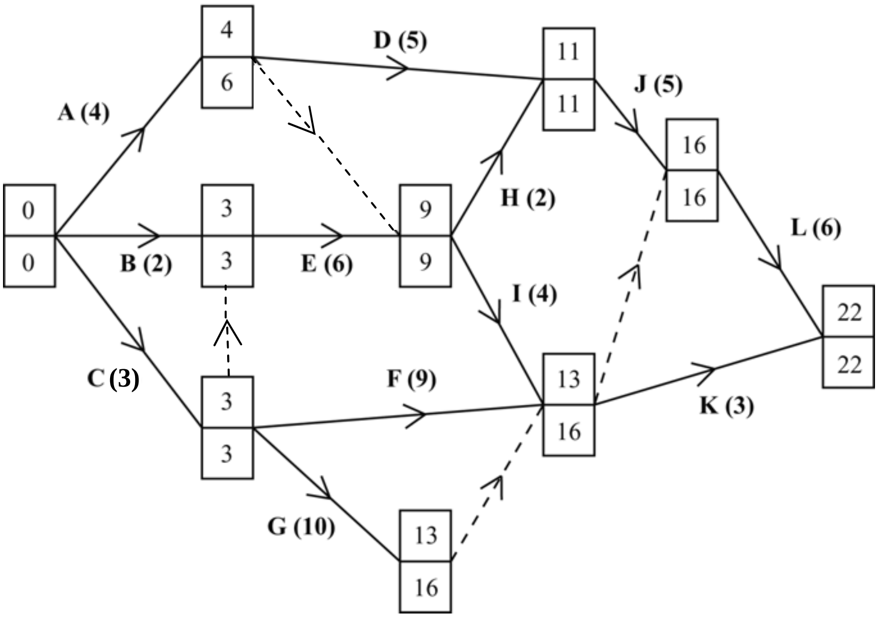
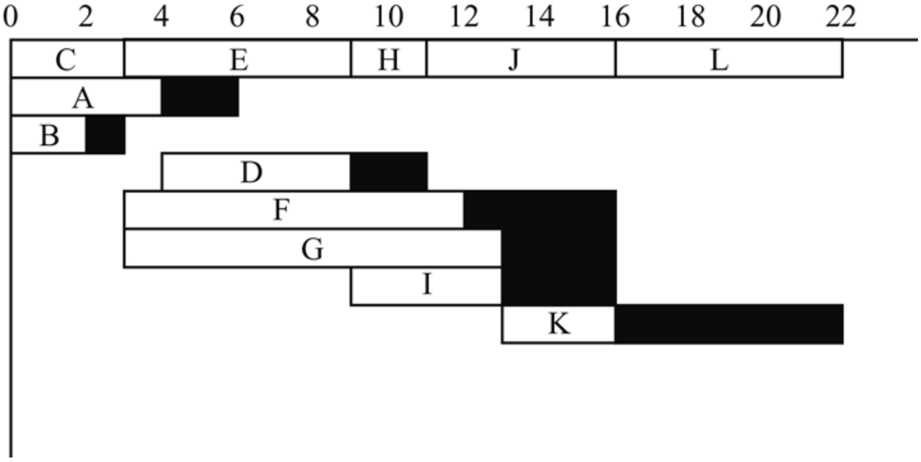
$(15, 22\tfrac{1}{2}) = 25\,500$ or $(15, 22) = 25\,100$

$(11, 7) = 11\,100$

2M1: Seeking integer solution in correct FR (so therefore no y = 6 points)

1B1: (11,7) CAO

2B1: £11 100 CAO

Question Number	Scheme	Marks
Q8 (a)		M1 A1 M1 A1 **4**
(b)	Critical activities: C E H J L	B1 **1**
(c)		M1 A1 A1 A1 **4**
(d)	4 workers needed e.g. at time 8 ½ (noon on day 9) activities E, D, F and G must be happening.	B2, 1, 0 **2**
		Total 11

Notes for Q8

(a) 1M1: Top boxes completed generally increasing left to right.
1A1: CAO.
2M1: Bottom boxes completed generally decreasing right to left.
2A1: CAO.

(b) 1B1: Critical activities cao.

(c) 1M1: At least 10 activities placed, at least five floats. Scheduling diagram gets M0.
1A1: my critical activities correct.
2A1: condone one error on my non-critical activities.
3A1: my non-critical activities correct.

(d) 1B1: A correct statement, details of either time (7<time<9, 8<day<10), or activities, bod gets B1. Allow 1 B mark (only) on ft from their 12 activity, 7 float diagram.
2B1: A correct, complete full statement details of time and activities.

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Mark Scheme (Results)

January 2011

GCE

GCE Decision Mathematics D1 (6689/01)

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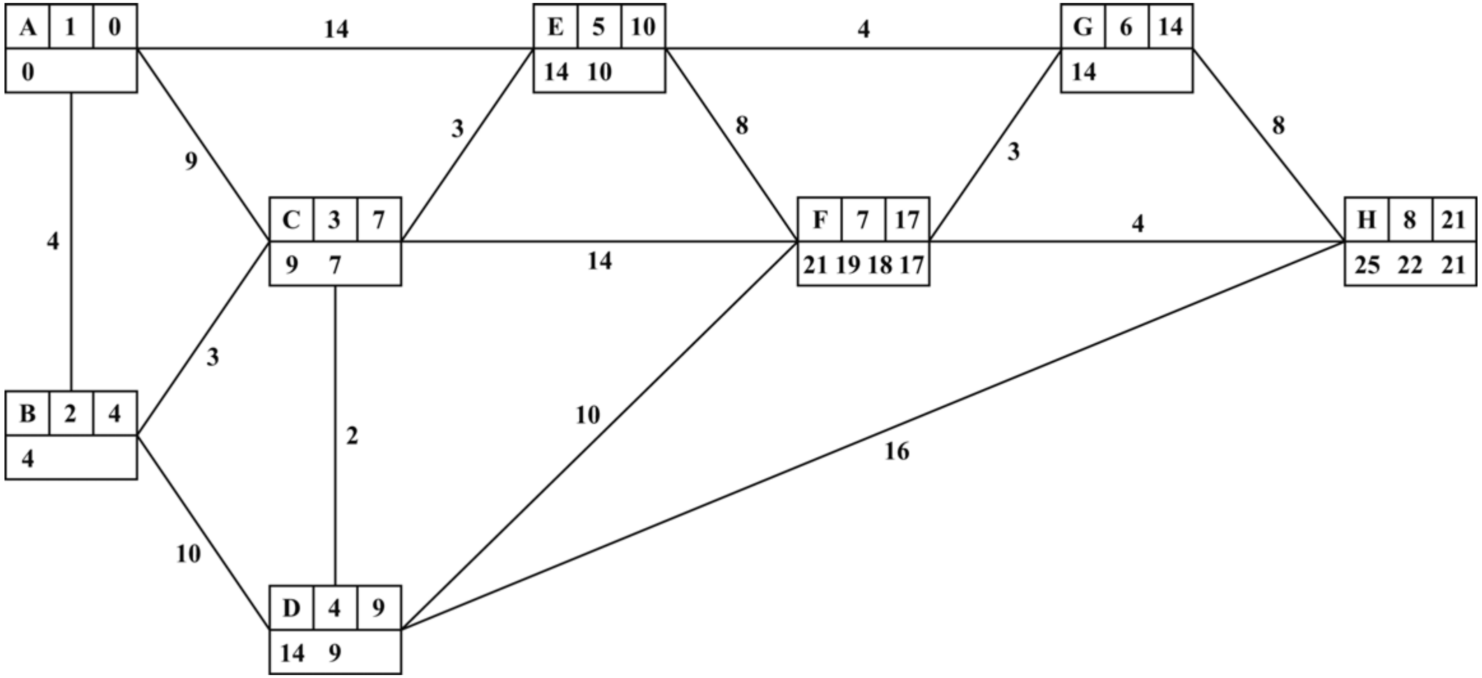
January 2011

Publications Code UA026247

January 2011
Decision Mathematics D1 6689
Mark Scheme

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>1.
(a)</td><td>

The length of the shortest route is 21 miles</td><td>M1 A1
A1ft
A1
A1ft
(5)</td></tr>
</table>

Question Number	Scheme	Marks
(b)	Shortest route: A B C E G F H	B1 (1)
(c)	Shortest route: H F G E C Length of shortest route: 21 – 7 = 14 miles	B1ft B1ft (2) **[8]**
	Notes	
(a)	1M1: Smaller number replacing larger number in the working values at C or D or G or E or F or H. (generous – give bod) 1A1: All values in boxes A, B and C correct. (Condone missing wv at A) (Allow order of labelling starting at 0) 2A1ft: All values in boxes D, E and G (ft) correct . Penalise order of labelling errors just once, G must be labelled before F. 3A1: All values in boxes F and H correct 4A1ft: Follow through from their H value, condone lack of units here.	
(b)	1B1: CAO (either way round)	
(c)	1B1ft: only ft if their shortest route goes through C, in which case accept their route reversed up to C (either way round) 2B1ft: only ft if their shortest route goes through C, in which case accept their route length (or final value at H) -7.	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>2.
(a)</td><td>Lower bound = $\frac{173}{50} = 3.46$ so 4 bins</td><td>B1 B1
(2)</td></tr>
<tr><td>(b)</td><td>Bin 1: 23 + 11 + 10 Bin 4: 35
Bin 2: 29 + 14 Bin 5: 17
Bin 3: 34</td><td>M1 A1
A1
(3)</td></tr>
<tr><td>(c)</td><td>e.g.
<table>
<tr><td>23</td><td>29</td><td>11</td><td>34</td><td>10</td><td>14</td><td>35</td><td>17</td></tr>
<tr><td>29</td><td>23</td><td>34</td><td>11</td><td>14</td><td>35</td><td>17</td><td>10</td></tr>
<tr><td>29</td><td>34</td><td>23</td><td>14</td><td>35</td><td>17</td><td>11</td><td>10</td></tr>
<tr><td>34</td><td>29</td><td>23</td><td>35</td><td>17</td><td>14</td><td>11</td><td>10</td></tr>
<tr><td>34</td><td>29</td><td>35</td><td>23</td><td>17</td><td>14</td><td>11</td><td>10</td></tr>
<tr><td>34</td><td>35</td><td>29</td><td>23</td><td>17</td><td>14</td><td>11</td><td>10</td></tr>
<tr><td>35</td><td>34</td><td>29</td><td>23</td><td>17</td><td>14</td><td>11</td><td>10</td></tr>
</table>
List sorted - no more changes</td><td>M1
A1
A1ft
A1cso
(4)</td></tr>
<tr><td>(d)

Alt (c)</td><td>Bin 1: 35 + 14 Bin 3: 29 + 17
Bin 2: 34 + 11 Bin 4: 23 + 10
<table>
<tr><td>23</td><td>29</td><td>11</td><td>34</td><td>10</td><td>14</td><td>35</td><td>17</td><td></td></tr>
<tr><td>35</td><td>23</td><td>29</td><td>11</td><td>34</td><td>10</td><td>14</td><td>17</td><td></td></tr>
<tr><td>35</td><td>34</td><td>23</td><td>29</td><td>11</td><td>17</td><td>10</td><td>14</td><td>A1</td></tr>
<tr><td>35</td><td>34</td><td>29</td><td>23</td><td>17</td><td>11</td><td>14</td><td>10</td><td></td></tr>
<tr><td>35</td><td>34</td><td>29</td><td>23</td><td>17</td><td>14</td><td>11</td><td>10</td><td>A1ft</td></tr>
</table></td><td>M1 A1
A1cso
(3)
[12]</td></tr>
</table>

Question Number	Scheme	Marks
	Notes	
(a)	1M1= 1B1: Cao 4 1A1= 2B1: either $(173 \pm 20) \div 50$ or 3<answer<4 seen.	
(b)	1M1: First four items placed correctly and at least 6 values put in bins 1A1: Bin 1 correct (condone cumulative totals) 2A1: All correct (condone cumulative totals)	
(c)	1M1: Bubble sort, one pass complete end term 35 or 10, consistent direction. 1A1: First two passes correct 2A1ft: Next two passes correct 3A1: cso + ‘final’ or re-listing etc.	
(d)	1M1: Bin 3 correct and at least 6 values put in bins 1A1: two bins correct (condone cumulative totals) 2A1: cso (condone cumulative totals)	
Misread for Q2(c)	**Sorting into ascending order** **If list reversed into descending order at end, allow full marks**	

(i) Left to right

23	29	11	34	10	14	35	17	
23	11	29	10	14	34	17	35	
11	23	10	14	29	17	34	35	A1
11	10	14	23	17	29	34	35	
10	11	14	17	23	29	34	35	A1ft

List in order

(ii) right to left

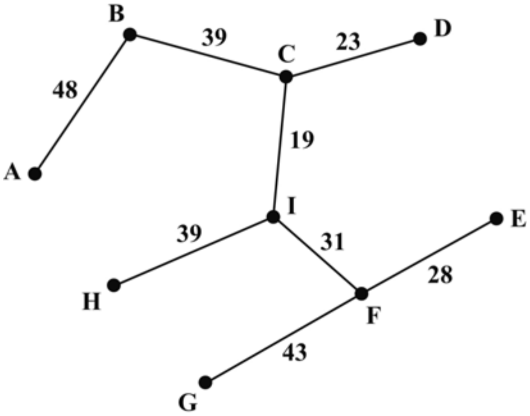
23	29	11	34	10	14	35	17	
10	23	29	11	34	14	17	35	
10	11	23	29	14	34	17	35	A1
10	11	14	23	29	17	34	35	
10	11	14	17	23	29	34	35	A1ft

List in order

If list not reversed remove last 2A if earned

Numbers changing during the course of the sort

- If the number change does not alter the sort (e.g. 23 becomes 25) remove final A only. If persists in (d) but does not affect answer similarly remove final A only in (d).
- If the number alters the sort (e.g 23 becomes 32) mark as a misread in (c) and if persists in (d) mark (c) and (d) together as a misread – so just take 2 marks off in total for these two sections.

Question Number	Scheme	Marks
3.		
(a)	CI CD (not DI) EF FI (not EI not DE) $\left\{\begin{matrix}\text{BC}\\\text{HI}\end{matrix}\right\}$ (not BI) GF (not GI not HG) AB	M1 A1 A1 (3)
(b)	AB BC CI CD FI EF IH FG	M1 A1 A1 (3)
(c)	 Weight: 270	B1 B1 (2)
(d)	Start off the tree with DI and HG and then apply Kruskal’s algorithm	B2,1, 0 (2) **[10]**
	Notes	
(a)	1M1: Kruskal’s algorithm – first 4 arcs selected chosen correctly. 1A1: All eight non-rejected arcs chosen correctly.(Working seen in (a)) 2A1: All rejections correct and in correct order and at correct time.	
(b)	1M1: Prim’s algorithm – first four arcs chosen correctly, in order, or first five nodes chosen correctly, in order.{A, B,C,I, D} (arcs not arc lengths) 1A1: First six arcs chosen correctly; all 9 nodes chosen correctly, in order.{A,B,C,I,D,F,E,H,G}[1 2 3 5 7 6 9 8 4] 2A1: cso	
(c)	1B1: cao (condone lack of numbers) 2B1: 270 cao	
(d)	1B1: Kruskal’s algorithm + some argument 2B1: Kruskal’s algorithm + start with the two arcs. (o.e)	

Question Number	Scheme	Marks
4.		
(a)	Bipartite graph	B1
(b)	e.g.	
	J – 3 = B – 6 = K – 1	M1
	Change status J = 3 – B = 6 – K = 1	A1
	A = 2 B = 6 (D unmatched) J = 3 K = 1 M = 5	A1
		(3)
(c)	e.g.	
	D – 2 = A – 6 = B – 1 = K – 4	M1
	Change status D = 2 – A = 6 – B = 1 – K = 4	A1
	A = 6 B = 1 D = 2 J = 3 K = 4 M = 5	A1
		(3)
		[7]
	Notes:	
(a)	1B1: Cao, but be charitable on spelling, award if phonetically close.	
(b)	1M1: Path from J to 1 or 4 (or vice versa) 1A1: CAO including change status (stated or shown), chosen path clear. 2A1: CAO must ft from stated path, diagram ok	
(c)	1M1: Path from D to 4 or 1 (or vice versa) 1A1: CAO including change status (stated or shown),but only penalise once per question, chosen path clear. 2A1: CAO must ft from stated paths, diagram ok. Must have both M's.	

Alternative answers:

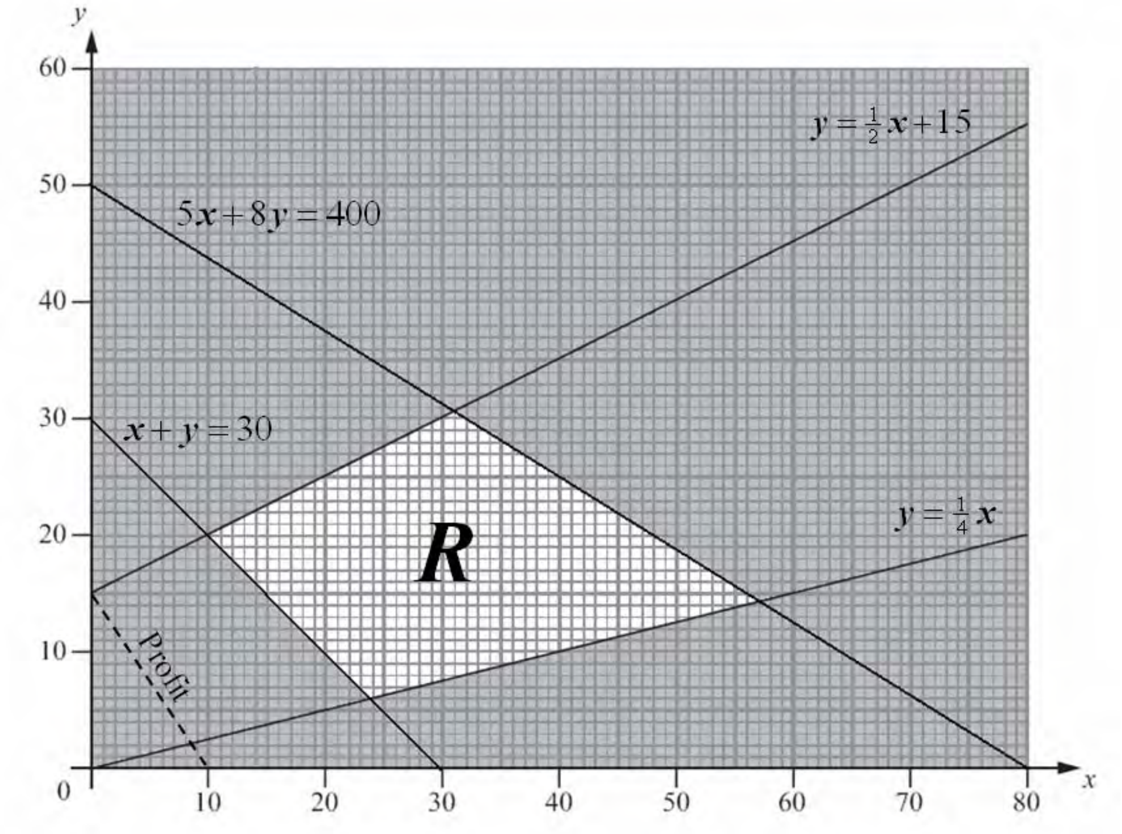
(b)

Path	A B D J K M
J – 3 – B – 1	2 1 – 3 6 5
J – 3 – B – 6 – K – 1	2 6 – 3 1 5
J – 3 – B – 6 – K – 4	2 6 – 3 4 5

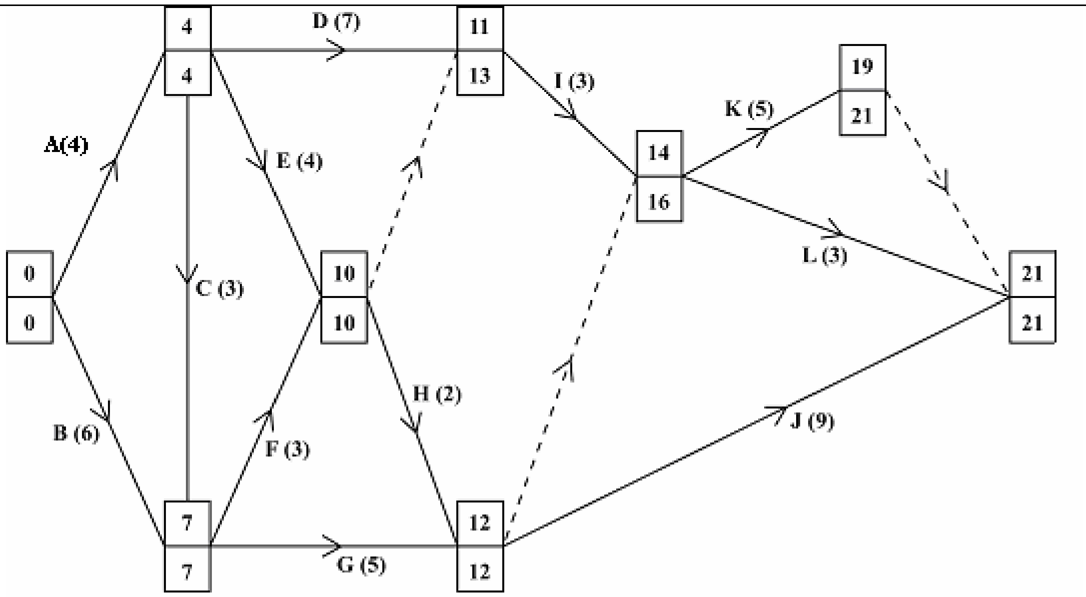
(c)

Path	A B D J K M
D – 2 – A – 6 – K – 4 D – 5 – M – 2 – A – 6 – K – 4	6 1 2 3 4 5 6 1 5 3 4 2
D – 2 – A – 6 – B – 1 – K – 4 D–5–M– 2 – A – 6 – B – 1– K – 4	6 1 2 3 4 5 6 1 5 3 4 2
D – 2 – A – 6 – B – 1 D – 5 – M – 2 – A – 6 – B – 1	6 1 2 3 4 5 6 1 5 3 4 2

Question Number	Scheme	Marks
5. **(a)**	AD + FI = 4.5 + 5.3 = 9.8 AF + DI = 5.8 + 3.9 = 9.7 smallest AI + DF = 5.9 + 5.1 = 11.0 e.g. ABDGIGDEIHFEACFEA	M1 A1 A1 A1 A1 (5)
(b)	Roads AE, EF (or AEF), DG and GI (or DGI) should be repeated. Length is 31.6 + 9.7 = 41.3 km	B1 M1A1ft
(c)	We now only have to repeat one pair of odd vertices, one of which can not be D. (FI = 5.3, AF = 5.8 and AI = 5.9) FI gives the smallest of the three so choose to repeat FI (FHI) The machine should be collected from A.	M1 A1 DA1 (3) **[11]**
	Notes	
(a)	1M1: Three pairings of their four odd nodes 1A1: one row correct 2A1: two rows correct 3A1: all correct 4A1: Any correct route (17 nodes)	
(b)	1B1: correct **arcs** identified 1M1: 31.6 + ft their least, from a choice of at least two. 1A1: ft has correctly their plausible least (from a choice of at least two) to 31.6.	
(c)	1M1: Identifies need to repeat one pairing, not including D (maybe implicit) or listing of potential repeats. 1A1: Identifies FI as least. 2DA1: dependent on their identifying FI as repeat	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>6.</td><td> </td><td></td></tr>
<tr><td>(a)</td><td>$4y \geq x$ o.e.
$2y \leq x + 30$ o.e</td><td>B1 B1
B1 B1
(4)</td></tr>
<tr><td>(b)</td><td>$x + y = 30$ and $5x + 8y = 400$ added to the graph
shading correct
R correct</td><td>B1, B1
B1ft
B1
(4)</td></tr>
<tr><td>(c)</td><td>Profit line attempted
Correct profit line
(10, 20)</td><td>M1
A1
B1
(3)
[11]</td></tr>
</table>

Question Number	Scheme	Marks
	Notes	
(a)	1B1: ratio of coefficients correct (i.e. equation of line correct) 2B1: inequality correct way round.($ay \geq bx$ o.e.) 3B1: ratio of coefficients correct (i.e equation of line correct) 4B1: inequality correct way round.	
(b)	1B1: $x + y = 30$ drawn cao 2B1: $5x + 8y = 400$ drawn cao 3B1ft: shading correct or implied from lines with negative gradient. 4B1: cao	
(c)	1M1: Profit line – intersecting both axes. Minimum (2,0) to (0,3). Accept reciprocal gradient here. 1A1: a correct line 2A1=1B1: cao (e.g not '10x + 20y')	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>7.
(a)</td><td>
<table>
<tr><th>Activity</th><th>Immediately preceding activities</th></tr>
<tr><td>G</td><td>B, C</td></tr>
<tr><td>H</td><td>E, F</td></tr>
<tr><td>I</td><td>D, E, F</td></tr>
<tr><td>J</td><td>G, H</td></tr>
<tr><td>K</td><td>G, H, I</td></tr>
<tr><td>L</td><td>G, H, I</td></tr>
</table>
</td><td>B3,2,1,0
(3)</td></tr>
<tr><td>(b)</td><td>Dummy from 6 to 7 needed because K and L depend on G H and I, but J depends on G and H only.
Dummy from 8 to 9 needed because no two activities may share both the same start event number and the same finish event number.</td><td>B3,2,1,0
(3)</td></tr>
<tr><td>(c)</td><td>
</td><td>M1 A1
M1 A1
(4)</td></tr>
<tr><td>(d)</td><td>Critical activities: $A\ C \begin{Bmatrix} F\ H \\ G \end{Bmatrix} J$</td><td>B2,1,0
(2)</td></tr>
<tr><td>(e)</td><td>Total float on activity K= 21 – 14 – 5 = 2</td><td>M1 A1ft
(2)</td></tr>
<tr><td>(f)</td><td>Lower bound is $\frac{54}{21} = 2.57 = 3$</td><td>B1 B1ft
(2)
[16]</td></tr>
</table>

Question Number	Scheme	Marks
	Notes	
(a)	1B1: Any two rows correct 2B1: Any 4 rows correct 3B1: all correct	
(b)	1B1: first dummy (precedence) explained, maybe confused, be generous, give bod. 2B1: first dummy clearly explained – all relevant activities referred to. Must refer to K and/or L; H and/or G; I and J 3B1: second dummy (uniqueness) explained, maybe confused, be generous, give bod.	
(c)	1M1: All top boxes completed generally increasing left to right.(Condone one rogue) 1A1: cao. 2M1: All bottom boxes completed generally decreasing right to left. (Condone one rogue) 2A1: cao.	
(d)	1B1: Critical activities correct condone one omission or extra. SC allow ACGJ for B1 only 2B1: Critical activites cao	
(e)	1M1ft: Correct calculation seen – all three numbers at least once. 1A1ft: Float correct >0	
(f)	1M1 = 1B: 3 1A1ft= 2B1ft:Correct calculation seen or ‘ 2< answer< 3	

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Mark Scheme (Results)

June 2011

GCE Decision D1 (6689) Paper 1

June 2011
Publications Code UA027669

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

   - M marks: method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
   - A marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
   - B marks are unconditional accuracy marks (independent of M marks)
   - Marks should not be subdivided.

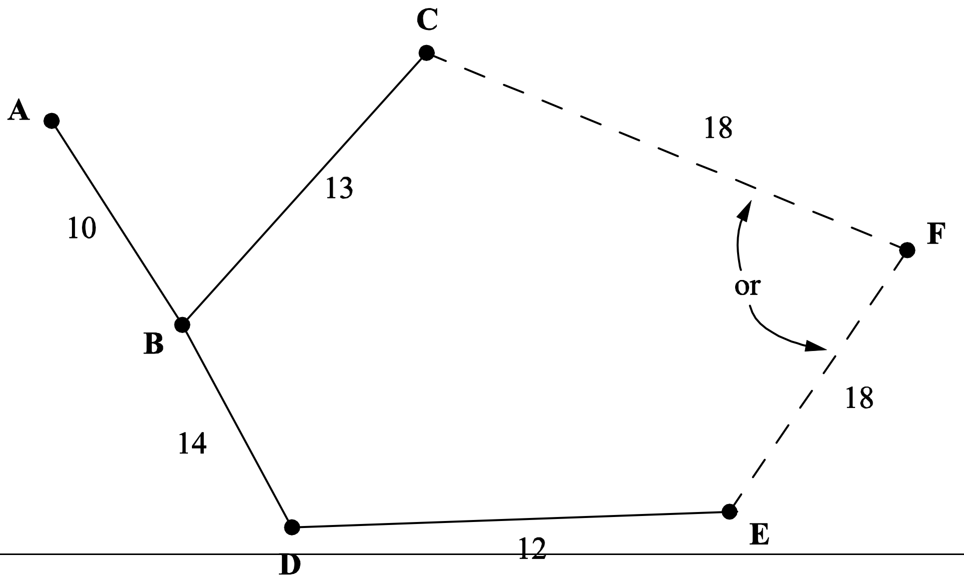
3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol ✓ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper
   - └ The second mark is dependent on gaining the first mark

June 2011
Decision Mathematics D1 6689
Mark Scheme

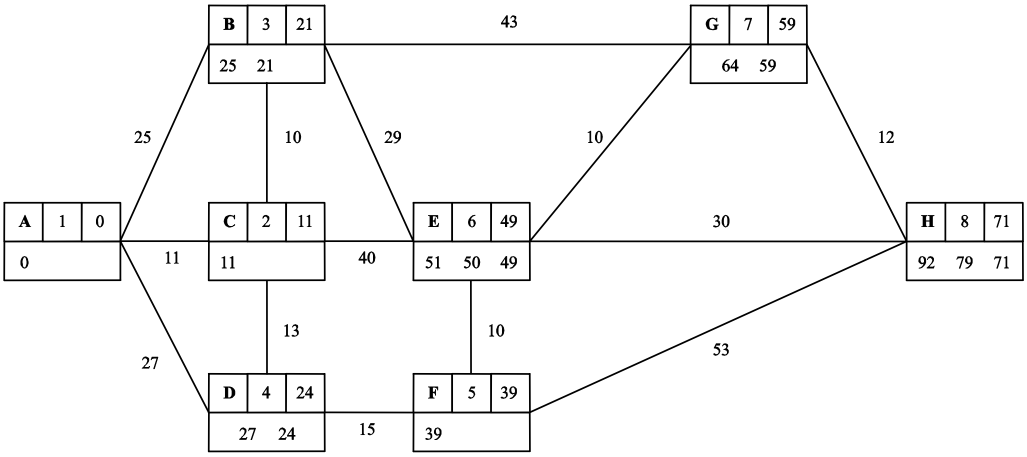
Question Number	Scheme	Marks
1. **(a)**	The list is not in alphabetical order.	B1 (1)
	E.g. A Quick sort	
(b)	J M C B T $\boxed{H}$ K R G F H	M1
	C B $\boxed{G}$ F $\boxed{H}$ J M $\boxed{T}$ K R G T	
	C $\boxed{B}$ F $\boxed{G}$ $\boxed{H}$ J M $\boxed{K}$ R $\boxed{T}$ B K	A1
	$\boxed{B}$ C $\boxed{F}$ $\boxed{G}$ $\boxed{H}$ J $\boxed{K}$ M $\boxed{R}$ $\boxed{T}$ F R	
	$\boxed{B}$ C $\boxed{F}$ $\boxed{G}$ $\boxed{H}$ J $\boxed{K}$ M $\boxed{R}$ $\boxed{T}$	A1
	Sort complete + named correctly	A1= B1 (4)
(c)	Pivot 1 = $\left[\frac{1+10}{2}\right] = 6$ Jenny reject 1 - 6	M1 A1
	Pivot 2 = $\left[\frac{7+10}{2}\right] = 9$ Richard reject 9 - 10	A1ft
	Pivot 3 = $\left[\frac{7+8}{2}\right] = 8$ Merry reject 8	
	Pivot 4 = 7 Kim - name found	A1 (4) **9**
	Notes:	
(a) B1	CAO – phonetically close	
(b) M1	Quick sort – pivots, p, selected and first pass gives <p, p, >p.	
1A1	First two passes correct, pivots chosen consistently for third pass	
2A1	CAO Sort completed correctly	
3A1=2B1	'Stop' + plus correct name for their sort – phonetically close	
(c) M1	Using their 'sorted list' + choosing middle right pivots+ discarding/retaining half the list. It their list is not in full alphabetical order M1 only.	
1A1	First pass correct ie 6th item for a correct list (no sticky pivots)	
2A1	Second and third passes correct ie 9th and 8th items from a correct list (no sticky pivots)	
3A1	CSO search complete + 'found'	

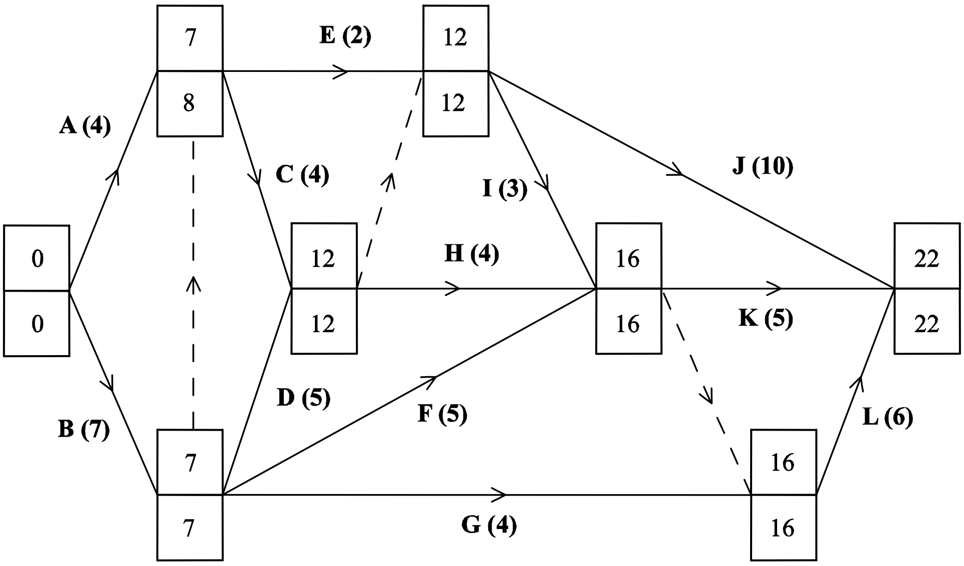
Question Number	Scheme	Marks
2. **(a)(i)**	A tree is a connected graph with no cycles/circuit	B1
(a)(ii)	A minimum spanning tree is a tree that contains all vertices and the total length of its arcs (weight of tree) is as small as possible.	B1 B1 (3)
(b)	AB, DE, BC; $\left\{\begin{matrix}\text{reject AC}\\ \text{BD}\end{matrix}\right\}$ reject BE, reject CE, use either EF or CF	M1; A1 A1 (3)
(c)		B1 (1)
(d)	No, there are two solutions since either EF or CF should be used.	B1 (1) **8**
	Notes	
(a)1B1	Connected + no cycles	
2B1	Contains all vertices	
3B1	Total length of arcs used minimised or minimum weight. (Not shortest/smallest etc.)	
(b)M1	First four arcs selected correctly in correct order.	
1A1	Arcs selected correctly at correct time	
2A1	Rejections correct and at correct time	
(c)B1	CAO	
(d)B1	CAO - mark explanation must specify two arcs of 18 or two 18's or ref to EF and CF	

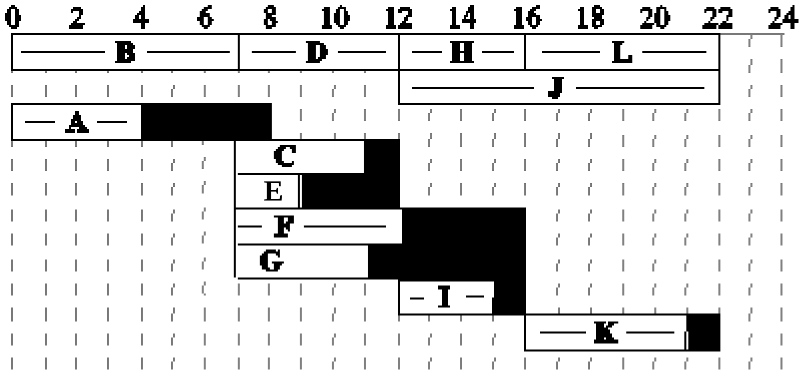
Question Number	Scheme	Marks
3. **(a)**	$6x+5y\le 60$ $2x+3y\ge 12$ $3x\ge 2y$ $x\le 2y$	B2,1,0 (2)
(b)	Drawing objective line{ (0,3) (1,0)} Testing at least 2 points Calculating optimal point Testing at least 3 points $\left(7\frac{1}{17},3\frac{9}{17}\right)=\left(\frac{120}{17},\frac{60}{17}\right)\approx(7.06,3.53)$	M1 A1 DM1 A1 awrt (4)
(c)	$24\frac{12}{17}=\frac{240}{17}\approx 24.7$ (awrt)	B1 (1)
(d)	(6,4)	B1 (1) **8**
Notes:	$\left(3\frac{3}{7},1\frac{5}{7}\right)=\left(\frac{24}{7},\frac{12}{7}\right)\approx(3.43,1.71)\rightarrow 12$ $\left(1\frac{11}{13},2\frac{10}{13}\right)=\left(\frac{24}{13},\frac{36}{13}\right)\approx(1.85,2.77)\rightarrow 8.3\ 07692\ \left(8\frac{4}{13}=\frac{108}{13}\right)$ $\left(4\frac{4}{9},6\frac{2}{3}\right)=\left(\frac{40}{9},\frac{20}{3}\right)\approx(4.44,6.67)\rightarrow 20$ $\left(7\frac{1}{17},3\frac{9}{17}\right)=\left(\frac{120}{17},\frac{60}{17}\right)\approx(7.06,3.53)\rightarrow 24.7\ 05882\ \left(24\frac{12}{17}=\frac{420}{17}\right)$	
	Notes	
(a)1B1	Any two inequalities correct, accept < and > here (but not = of course).	
2B1	All four correct. Must be $\le$ and $\ge$ here	
(b)1M1	Drawing objective line or its reciprocal OR testing two vertices in the feasible region (see list above) points correct to 1 dp.	
1A1	Correct objective line OR two points correctly tested (1 dp ok)	
2DM1	Calculating optimal point either answer to 2 dp or better or using S.E's (correct 2 equations for their point + attempt to eliminate one variable.); OR Testing three points correctly and optimal one to 2dp.	
2A1	CAO 2 dp or better.	
(c)B1	CAO	
(d)B1	CAO not (4,6).	

Question Number	Scheme	Marks
4. **(a)**	[Given A – 3 = R – 4 = C – 5] $A-1=H-2$ $A-1=H-3=R-4=C-5$	M1 A1 A1 (3)
(b)	$A=3, C=5,\ H=1,\ (\text{J unmatched}),\ R=4$	B1 (1)
(c)	Alternating path : $J-4=R-3=A-1=H-2$ Change status : $J=4-R=3-A=1-H=2$ $A=1,\ C=5,\ H=2,\ J=4,\ R=3$	M1 A1 A1 (3) **7**
	Notes	
(a)M1	Path from A to 2 or 5 - or vice versa	
1A1	One correct path selected OR tree showing the missing two paths only.	
2A1	Both correct paths listed separately	
(b)B1	CAO	
(c)M1	Path from J to 2 – or vice versa	
1A1	Correct path including change status	
2A1	CAO must follow through from stated path.	

Question Number	Scheme	Marks
5. **(a)**	$AC+DF=9+13=22 \leftarrow$ $AD+CF=16+8=24$ $AF+CD=17+7=24$ Repeat **arcs** AC, DG and GF	M1 A1 A1 A1 A1ft (5)
(b)	E.g. ADCACGDGFGECBEFBA Length of route $=98+22=120\left(\text{km}\right)$	B1 B1ft (2)
(c)	CF (8) is the shortest link between 2 odd nodes excluding D Repeat CF (8) since this is the shortest path excluding D. We finish at A Length of route = 98 + 8 = 106 (km)	M1 A1ft A1ft (3) **10**
 (a)M1 **1A1** **2A1** **3A1** **4A1ft** **(b)1B1** **2B1ft** **(c)M1** **1A1ft** **2A1ft**	**Notes** Three pairings of their four odd nodes One row correct including pairing and total Two rows correct including pairing and total Three rows correct including pairing and total Their smallest repeated **arcs** stated accept DGF or arcs clear from selected row. Correct route any start point, 17 nodes, AC, DG and GF repeated CAO 98 + their least out of a choice of at least 2. Attempting just one repeated path excluding D; accept AC, AF and CF listed **A** and their least repeat [should be CF (CEF)] **clearly stating this as least** 98 + their least from their working in (a)	

Question Number	Scheme	Marks
6. **(a)**	 ACDFEGH Length 71 (km)	M1 A1 (ABCD) A1ft (EF) A1ft (GH) A1 A1ft (6)
(b)	E.g. 71 – 12 = 59 GH 49 – 10 = 39 FE 24 – 13 = 11 CD 59 – 10 = 49 EG 39 – 15 = 24 DF 11 – 11 = 0 AC Or Trace back from H including arc XY if (Y already lies on the path and) the difference of the final values of X and Y equals weight of arc XY.	B2,1,0 (2)
(c)	ACBEGH Length 72 (km)	B1 B1 (2) **10**
	Notes	
(a)M1	Big replaced by smaller at least once at B or D or E or G or H	
1A1	A, B, C, D boxes all correct, condone lack of 0 in ‘s working value	
2A1ft	E and F ft correctly	
3A1ft	G and H ft correctly	
4A1	CAO	
5A1ft	ft on their final value.	
(b)1B1	Attempting an explanation, at least 3 stages or one half of general explanation	
2B1	Correct explanation – all six stages, both halves of explanation	
(c)1B1	CAO	
2B1	CAO	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>7.
(a)</td><td>
<table>
<tr><th>Activity</th><th>Proceeded by</th><th>Activity</th><th>Proceeded by</th><th>Activity</th><th>Proceeded by</th></tr>
<tr><td>(A)</td><td>(-)</td><td>E</td><td>A B</td><td>I</td><td>C D E</td></tr>
<tr><td>(B)</td><td>(-)</td><td>(F)</td><td>(B)</td><td>J</td><td>C D E</td></tr>
<tr><td>C</td><td>A B</td><td>(G)</td><td>(B)</td><td>K</td><td>F H I</td></tr>
<tr><td>(D)</td><td>(B)</td><td>H</td><td>C D</td><td>L</td><td>F G H I</td></tr>
</table>
</td><td>B3,2,1,0
(3)</td></tr>
<tr><td>(b)</td><td>


</td><td>M1 A1
M1 A1
(4)</td></tr>
<tr><td>(c)</td><td>Critical activities are B D J H L</td><td>M1 A1
(2)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>(d)</td><td>


</td><td>M1 A1
M1 A1
(4)</td></tr>
</table>

Question Number	Scheme	Marks
(e)	E.g. Between time 7 and 16, 3 workers could do 3 x 9 = 27 days work. Activities C, D, E, F, G, H, I and 4 days of J need to be done This totals 31 days work. So it is not possible to complete the project with three workers. OR If three workers are used three activities H, J and I need to happen at time 13.5, this reduces the float on F and G, meaning that at 10.5 D, C, F and G need to be happening. Our initial assumption is incorrect hence four workers are needed.	B3,2,1,0 (3) **16**
	Notes	
(a)1B1	Any two rows correct	
2B1	Any four rows correct	
3B1	All seven rows correct	
(b)1M1	**All** top boxes complete, values generally increasing left to right, condone one rogue	
1A1	CAO	
2M1	**All** bottom boxes complete, values generally decreasing R to L, condone one rogue	
2A1	CAO	
(c)M1	Accept dummies, repeats and condone one absence or one extra; or BDHL or BDJ	
A1	CAO (dummies and repeats ok)	
(d)1M1	At least 9 activities including at least 4 floats. Do not accept scheduling diagram.	
1A1	Critical activities dealt with correctly	
2M1	All 12 activities including at least 7 floats	
2A1	Non-critical activities dealt with correctly.	
(e)1B1	Attempt at explanation – one correct idea.	
2B1	Good explanation, some imprecise or vague statements – give bod	
3B1	Fully correct explanation. No bod needed	

Question Number	Scheme	Marks
8.	Let x be the number of type A radios and y be the number of type B radios.	B1
	$\left(\text{Maximise P} =\right)15x+12y$	B1
	Subject to	
	$x \geq 50$	B1
	$\frac{1}{5}(x+y) < x$ (accept $\leq$) $\left[y < 4x\right]$	B1
	$\frac{2}{5}(x+y) > x$ (accept $\geq$) $\left[2y > 3x\right]$	B1
	$3x+2y \leq 200$	B1
	$y \geq 0$	B1
		7
	Notes	
1B1	Defining x and y; Must see 'number of'	
2B1	CAO objective function $15x+12y$	
3B1	CAO $x \geq 50$	
4B1	CAO o.e $\frac{1}{5}(x+y) < x \Rightarrow y < 4x$	
5B1	CAO o.e $\frac{2}{3}(x+y) > x \Rightarrow 2y > 3x$	
6B1	CAO o.e $3x+2y \leq 200$	
7B1	CAO $y \geq 0$	

Question Number	Scheme		Marks
Q1 b	**Additional solutions**		
	Quick sort middle left		
	J M C B $\boxed{T}$ H K R G F	T	M1
	J M C B $\boxed{H}$ K R G F $\boxed{T}$	H	
	C $\boxed{B}$ G F $\boxed{H}$ J $\boxed{M}$ K R $\boxed{T}$	B M	A1
	$\boxed{B}$ C $\boxed{G}$ F $\boxed{H}$ $\boxed{J}$ K $\boxed{M}$ R $\boxed{T}$	G J	
	$\boxed{B}$ $\boxed{C}$ F $\boxed{G}$ $\boxed{H}$ $\boxed{J}$ K $\boxed{M}$ R $\boxed{T}$	C	
	B C F G H J K M R T		A1
	Quick sort complete		A1
	Bubble sort left to right		
	J M C B T H K R G F		
	J C B M H K R G F T	T in place, consistent direction	M1
	C B J H K M G F R T		
	B C H J K G F M R T	Passes 1 and 2 correct	A1
	B C H J G F K M R T		
	B C H G F J K M R T		
	B C G F H J K M R T		
	B C F G H J K M R T	Sort correct	A1
	Bubble sort complete	sort named correctly + ‘stop’	A1
	Bubble right to left		
	J M C B T H K R G F		
	B J M C F T H K R G	B in place, consistent direction	M1
	B C J M F G T H K R		
	B C F J M G H T K R	Passes 1 and 2 correct	A1
	B C F G J M H K T R		
	B C F G H J M K R T		
	B C F G H J K M R T	Sort correct	A1
	Bubble sort complete	sort named correctly + ‘stop’	A1
	Sorting into reverse alphabetical order – this is acceptable		
	e.g. Quick sort middle right		
	J M C B T $\boxed{H}$ K R G F	H	M1
	J M $\boxed{T}$ K R $\boxed{H}$ C B $\boxed{G}$ F	T G	
	$\boxed{T}$ J M $\boxed{K}$ R $\boxed{H}$ $\boxed{G}$ C $\boxed{B}$ F	K B	A1
	$\boxed{T}$ M $\boxed{R}$ $\boxed{K}$ J $\boxed{H}$ $\boxed{G}$ C $\boxed{F}$ $\boxed{B}$	R F	
	T R M K J H G F C B		A1
	Quick sort complete		A1

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Mark Scheme (Results)

January 2012

GCE Decision D1 (6689) Paper 1

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January 2012
Publications Code UA030319

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol √ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

General Principals for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q), \text{ where} |pq| = |c|$, leading to x = ...

$(ax^2 + bx + c) = (mx + p)(nx + q), \text{ where} |pq| = |c| \text{ and } |mn| = |a|$, leading to x = …

2. Formula

Attempt to use correct formula (with values for *a*, *b* and *c*), leading to x = …

3. Completing the square

Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c, \quad q \neq 0$, leading to x = …

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

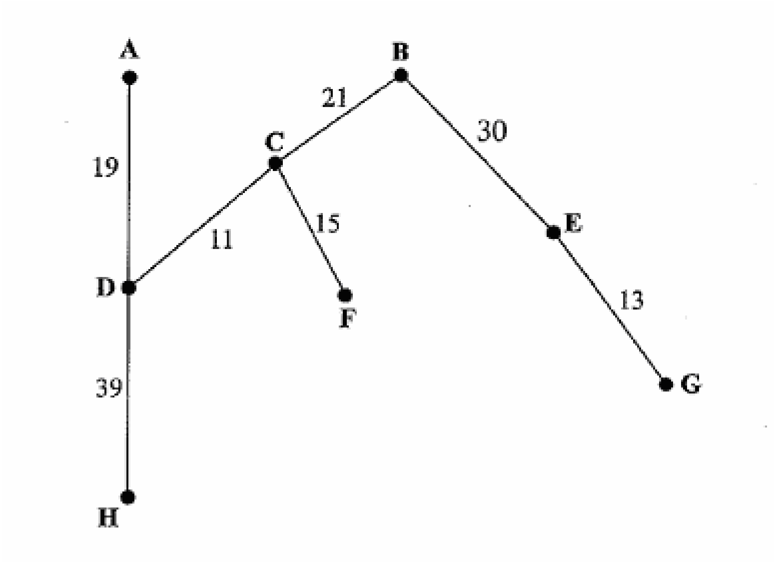
Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

January 2012
6689 Decision Mathematics D1
Mark Scheme

Question Number	Scheme	Marks
Q1		
(a)	DC, EG, CF, reject DF; AD, BC, reject AB, BE, reject EF and FG, DH	M1; A1 A1 **3**
(b)	AD, DC, CF, CB; BE; EG, DH	M1;A1; A1 **3**
(c)		B1 **1**
(d)	Weight of tree = 148 (km)	B1 **1** **Total 8**

Notes

a1M1: First three arcs correctly chosen and DF rejected. Accept weights for all 3 marks.
Special case: If all 7 arcs, in correct order, but no rejections seen at all, then award M1 only.
a1A1: All arcs/weights in tree selected correctly at correct time.
a2A1: All rejections correct and at the right time.
b1M1: First four arcs/weights correctly chosen, or first five nodes ADCFB chosen in order.
Special case : If Prim but not starting at A please send to review.
b1A1: First five arcs/weights correctly chosen, or all nodes in order A, D, C, F, B, E, G, H.
b2A1: CSO (must be arcs/weights). E.g no ‘reject’ arcs
c1B1: CAO mark what you see at (c).
d1B1: CAO mark what you see at (d).

Question Number	Scheme	Marks
Q2		
(a)	BD + EF = 10 + 17 = 27	M1 A1
	BE + DF = 15 + 10 = 25 ¬	A1
	BF + DE = 20 + 14 = 34	A1
	Repeat **arcs** BC, CE and DF	A1ft
	Length of route = 129 + 25 = 154	B1ft
		6
(b)	We add BF(12) to the network so only have to repeat DE (14)	M1
	Length of route is therefore 129 + 12 + 14 = 155	A1 **2**
	155>154 so his route would be increased	
		Total 8

Notes

a1M1: Three pairings of their four odd nodes
a1A1: One row correct including pairing and total
a2A1: Two rows correct including pairing and total
a3A1: Three rows correct including pairing and total
a4A1ft: Their smallest repeated **arcs**, (accept BCE).
a1B1ft: 129 + their least out of a choice of at least two possible, distinct, pairings.
b1M1: DE identified, using/repeating 12 + their DE [ft from (a)]
b1A1: CAO, conclusion, numerical argument e.g. ref to 155 or 26 etc.

Question Number	Scheme	Marks
Q3		
(a)	A bipartite graph consists of two sets of vertices X and Y. The edges only join vertices in X to vertices in Y, not vertices within a set.	B2,1,0 **2**
(b)	A Matching is the pairing of some or all of the elements of one set, X, with elements of a second set, Y.	B2,1,0 **2**
(c)	Alternating path: J – 4 = E – 2 = C – 3 Change status: J = 4 – E = 2 – C = 3	M1 A1
	C = 3, E = 2, G = 1, H = 6, J = 4, (S unmatched)	A1 **3**
(d)	Alternating path: S – 6 = H – 3 = C – 2 = E – 5 Change status: S = 6 – H = 3 – C = 2 – E = 5	M1 A1
	C = 2, E = 5, G = 1, H = 3, J = 4, S = 6	A1 **3**
		Total 10

Notes

a1B1: 2 sets of vertices

a2B1: arcs must go from one set into the other.

b1B1: pairing or one to one.

b2B1: element(s) from 1 set with element(s) of the other.

c1M1: Path from J to 3 - or vice versa

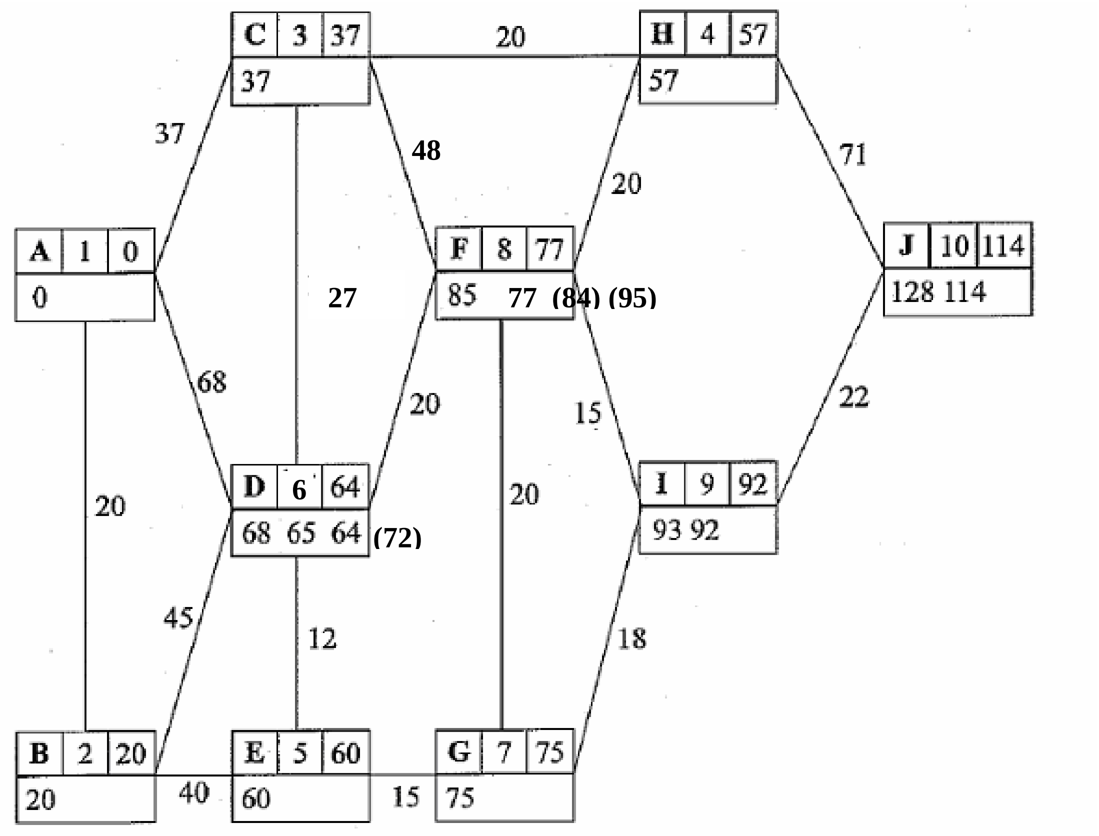
c1A1: CAO including change status (stated or shown), chosen path clear.

c2A1: CAO unambiguous. Must ft from stated path, diagram ok

d1M1: Path from S to 5 (or vice versa)

d1A1: CAO including change status (stated or shown), but only penalise once per question, chosen path clear.

d2A1: CAO unambiguous. Must ft from stated paths, diagram ok. Must have both M’s.

Question Number	Scheme	Marks
Q4 (a)	 ACHFIJ 114 minutes	M1 A1(BCH) A1ft(DE) A1ft(FG) A1(IJ) B1 B1ft **7**
(b)	Route: ABEGIJ length 115 (minutes)	B1, B1 **2** **Total 9**

Notes

In (a) Accept any rising sequence for order of labelling. Order of working values is crucial.

a1M1: Big replaced by small in working values at least once at D or F or I or J.

a1A1: A, B, C, H boxes all correct, condone lack of 0 in A’s working value

a2A1ft: E and D ft, based on their order of labelling. Penalise order of labelling only once.

a3A1ft: G and F ft, based on their order of labelling. Penalise order of labelling only once.

a4A1: I and J CAO. Penalise order of labelling only once.

a1B1: Route CAO

a2B1ft: 114, or their final value ft.

b1B1: route CAO.

b2B1: length CAO.

Question Number	Scheme	Marks
Q5		
(a)	Bin 1: 5, 1, 8, 5 Bin 4: 8, 12	M1 (1st 6 terms)
	Bin 2: 13, 2 Bin 5: 15	
	Bin 3: 16 Bin 6: 10	A1(next 3)
		A1 **3**
(b)	E.g Bubbling left to right (see alts)	
	5 1 8 13 16 5 8 2 15 12 10	M1
	5 8 13 16 5 8 2 15 12 10 1	A1
	8 13 16 5 8 5 15 12 10 2 1	
	13 16 8 8 5 15 12 10 5 2 1	A1ft
	16 13 8 8 15 12 10 5 5 2 1	
	16 13 8 15 12 10 8 5 5 2 1	A1ft
	16 13 15 12 10 8 8 5 5 2 1	
	16 15 13 12 10 8 8 5 5 2 1 + ‘sorted’	A1 **5**
(c)	Bin 1: 16, 2, 1 Bin 4: 12, 8	M1 (to 8s)
	Bin 2: 15, 5 Bin 5: 10, 8	A1 (to 5s)
	Bin 3: 13, 5	A1 **3**
(d)	E. g. $\frac{95}{20} = 4.75$ so a minimum of 5 bins needed.	M1 A1 **2** **Total 13**

Notes

a1M1: Bin 1 correct 13 and 16 in bins 2 and 3.

a1A1: Bin 2 correct 8 in bin 4.

a2A1: CAO

b1M1: End number (greatest/least) in place. Consistent direction throughout.

b1A1: first pass correct.

b2A1ft: 2nd and 3rd passes correct – so end three numbers in place.

b3A1ft: 4th and 5th passes correct – so end five numbers in place.

b4A1: cso including ‘sorted’, or extra pass (es), ruling off, boxed, ticked etc.

c1M1: Bins 4 and 5 correct, others started.

Special case: If list at end of (b) wrong give M1 only for their 1st 7 terms placed correctly.

c1A1: Bins 2 and 3 correct up to the 5s.

c2A1: cao

d1M1: Numerical argument. E.g. Attempt to find lower bound o.e., consideration of ‘spare room’. Etc. (Accept ‘5 items $\geq$ 10’ o.e for M1 only)

d1A1: correct numerical argument; conclusion (the yes/no) may follow from (c).

Alternatives for Question 5(b)

Right to left

5	1	8	13	16	5	8	2	15	12	10	**1M1**
16	5	1	8	13	15	5	8	2	12	10	**1A1**
16	15	5	1	8	13	12	5	8	2	10	
16	15	13	5	1	8	12	10	5	8	2	**2A1ft**
16	15	13	12	5	1	8	10	8	5	2	
16	15	13	12	10	5	1	8	8	5	2	**3A1ft**
16	15	13	12	10	8	5	1	8	5	2	
16	15	13	12	10	8	8	5	1	5	2	
16	15	13	12	10	8	8	5	5	1	2	
16	15	13	12	10	8	8	5	5	2	1 + Stop	**4A1**

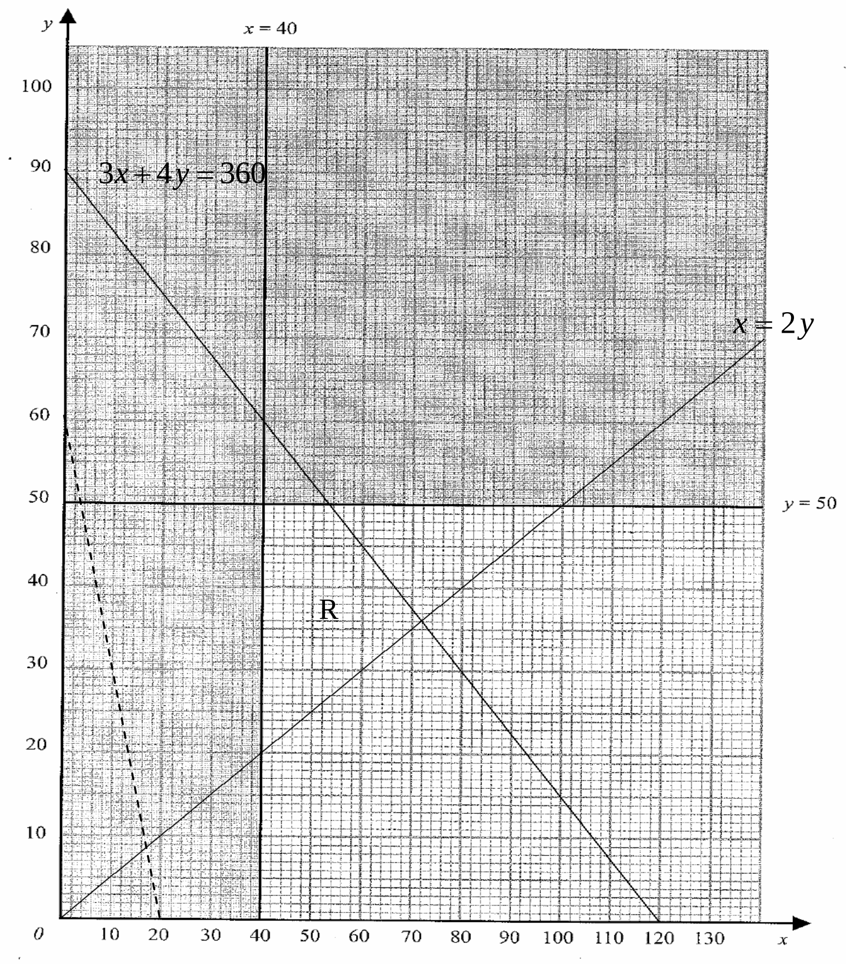
Misreads – allow recovery if list reversed.

Left to right ascending

5	1	8	13	16	5	8	2	15	12	10	**1M1**
1	5	8	13	5	8	2	15	12	10	16	**1A1**
1	5	8	5	8	2	13	12	10	15	16	
1	5	5	8	2	8	12	10	13	15	16	**2A1ft**
1	5	5	2	8	8	10	12	13	15	16	
1	5	2	5	8	8	10	12	13	15	16	**3A1ft**
1	2	5	5	8	8	10	12	13	15	16 + stop	**4A1**

Right to Left ascending

5	1	8	13	16	5	8	2	15	12	10	**1M1**
1	5	2	8	13	16	5	8	10	15	12	**1A1**
1	2	5	5	8	13	16	8	10	12	15	
1	2	5	5	8	8	13	16	10	12	15	**2A1ft**
1	2	5	5	8	8	10	13	16	12	15	
1	2	5	5	8	8	10	12	13	16	15	**3A1ft**
1	2	5	5	8	8	10	12	13	15	16 + stop	**4A1**

Question Number	Scheme	Marks
Q6		
(a)	(Edgar should plant) at least 40 apple trees. (Edgar should plant) at most 50 plum trees.	B1 **1**
(b)		B1 B1 B1ft B1 **4**
(c)		B1 **1**
(d)		M1 A1 DM1 A1 **4**
(e)	(P =) $60x + 20y$ Drawing objective line Calculating optimal point (72, 36) (£) 5 040	B1 **1** **Total 11**

Q6 Notes:

a1B1: CAO, both. Must be $\leq$ and $\geq$ not < and >.

b1B1: $3x + 4y = 360$ CAO. If extended it must go axis to axis within one small square. Must be long enough to form the correct feasible region. Lines should be drawn with a ruler.

b2B1: $x = 2y$ If extended must go through (0,0) and (120, 60) within one small square. Must be long enough to form the correct feasible region. Lines should be drawn with a ruler.

b3B1ft: ft their lines for correct shading on one of their lines. Implicit if R is correct.

b4B1: Region R correct, CAO. Must be labelled.

c1B1: CAO

d1M1: Drawing objective line or its reciprocal.

d1A1: Correct objective line. Axis to axis (0, 30) to (10, 0) minimum.

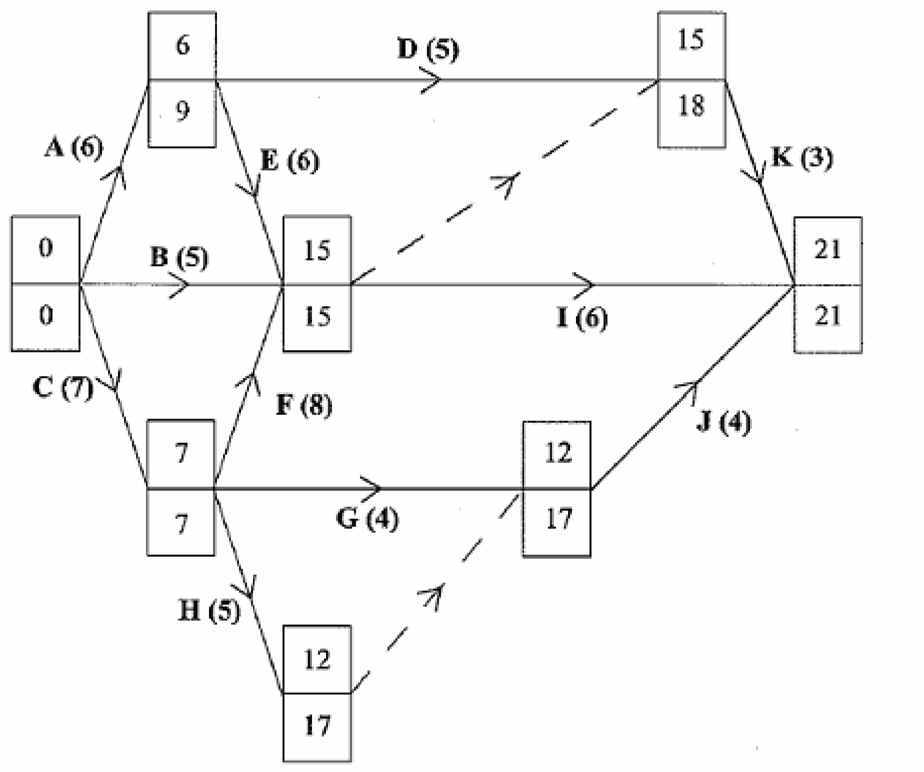
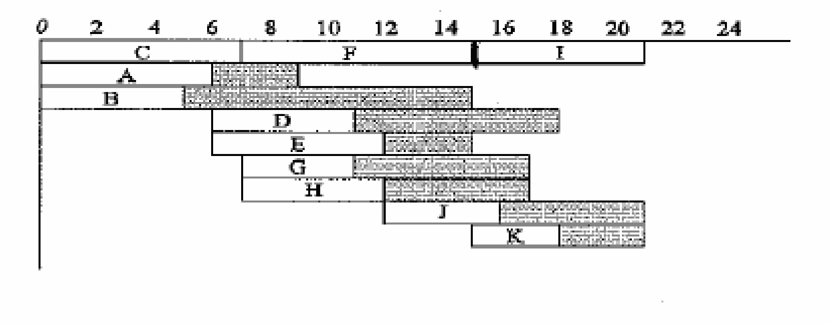
d2DM1: Depends on 1st M and correct region. Finding their correct optimal point.

d2A1: CSO

e1B1: CAO

The vertices in R are:

(40, 20) (40, 50) ($53\frac{1}{3}$, 50) (72, 36)

Question Number	Scheme	Marks
Q7		
(a)(i)	I depends on B, E and F only, K depends on B, E, F **and** D	B1 DB1
(ii)	This is so that G and H will not share the same start and end events. So that G and H can be uniquely described in terms of their end events.	B1 **3**
(b)		M1 A1 M1 A1 **4**
(c)		M1 A1ft B1 **3**
(d)	Total float on D = 18 – 5 – 6 = 7	M1 A1cso **2**
(e)	Total float on G = 17 – 4 – 7 = 6 Lower bound = $\frac{59}{21} = 3$ workers 	M1 A1 M1 A1 **4** **Total 16**

Q7 Notes

ai1B1: K, I, D and at least one of B, E, F referred to. Correct statement but maybe incomplete give bod here.
ai2DB1: Clear correct statement. No bod.
aii3B1: correct statement referring to either events or activities. (‘unique’ alone not enough)
b1M1: All top boxes complete, values generally increasing left to right, condone one rogue
b1A1: CAO
b2M1: All bottom boxes complete, values generally decreasing R to L, condone one rogue
b2A1: CAO
c1M1: Correct calculation seen once, all three numbers correct (ft).
c1A1ft: one float ($\geq$ 0) correct.
c1B1: Both floats correct (independent of working)
d1M1: Attempt to calculate a lower bound. [51-67 / their finish time]. Accept awrt 2.81
d1A1: CSO.
e1M1: At least 7 activities including at least 4 floats. Do not accept scheduling diagram.
e1A1: Critical activities dealt with correctly
e2M1: All 11 activities including at least 8 floats
e2A1: Non-critical activities dealt with correctly

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Mark Scheme (Results)

Summer 2012

GCE Decision D1
(6689) Paper 1

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Summer 2012
Publications Code UA031965

Summer 2012
6689 Decision Maths 1
Mark Scheme

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol √ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ┌ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
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- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question 1 (c) Misread
Usual rule, remove the last 2 A marks awarded in (c) if list not reversed.

Note: if final list is reversed in (c), award full credit

20	33	19	24	31	22	27	18	25	M1
20	19	24	31	22	27	18	25	33	
19	20	24	22	27	18	25	31	33	A1
19	20	22	24	18	25	27	31	33	
19	20	22	18	24	25	27	31	33	A1ft
19	20	18	22	24	25	27	31	33	
19	18	20	22	24	25	27	31	33	
18	19	20	22	24	25	27	31	33	
List in order									A1 CSO

20	33	19	24	31	22	27	18	25	M1
18	20	33	19	24	31	22	27	25	
18	19	20	33	22	24	31	25	27	A1
18	19	20	22	33	24	25	31	27	
18	19	20	22	24	33	25	27	31	A1ft
18	19	20	22	24	25	33	27	31	
18	19	20	22	24	25	27	33	31	
18	19	20	22	24	25	27	31	33	
List in order									A1 CSO

Summer 2012
6689 Decision Mathematics D1
Mark Scheme

Question Number	Scheme	Marks
1.(a)	$\frac{219}{50} = 4.38$ so lower bound is 5 bins	M1 A1 **(2)**
(b)	Bin 1: $\boxed{20}$ $\boxed{19}$ Bin 2: $\boxed{33}$ Bin 3: $\boxed{24}$ $\underline{22}$ Bin 4: $\underline{31}$ 18 Bin 5: $\underline{27}$ Bin 6: 25	$\boxed{\text{M1}}$ $\underline{\text{1A1}}$ 2A1 **(3)**
(c)	e.g (left to right)	
	20 33 19 24 31 22 27 18 25	
	33 20 24 31 22 27 19 25 18	M1
	33 24 31 22 27 20 25 19 18	1A1
	33 31 24 27 22 25 20 19 18	
	33 31 27 24 25 22 20 19 18	2A1ft
	33 31 27 25 24 22 20 19 18	
	List in order	3A1 CSO **(4)**
(d)	Bin 1: $\boxed{33}$ Bin 2: $\boxed{31}$ 19 Bin 3: $\boxed{27}$ $\underline{22}$ Bin 4: $\boxed{25}$ $\boxed{24}$ Bin 5: $\underline{20}$ 18	$\boxed{\text{M1}}$ $\underline{\text{1A1}}$ 2A1 **(3)**
		Total 12

Notes for question 1

a1M1 219 (186-252) /50

a1A1 CAO correct calc seen or awrt 4.4 + 5

b1M1 First four terms placed correctly in bins 1, 2 and 3. (Condone cumulative totals here only.)

b1A1 First seven terms placed correctly.

b2A1 CAO

c1M1 Bubble sort. Consistent direction throughout sort, end number (greatest/least) in place.

c1A1 first and second passes correct – so end two numbers in place

c2A1ft 3rd and 4th passes correct – so end four numbers in place.

c3A1 CSO; including ‘sorted’**or** final list rewritten in (c) **or** ‘final pass’ o.e. A **clear statement** in (c).

d1M1 **Must be using ‘sorted’ list** in decreasing order . First five terms correct.

d1A1 First seven terms correct.

d2A1 CAO

SC for 1(d) If ‘**sorted’** list is wrong from (c) then award M1 only in (d) for their first seven terms correctly placed.

Alt for (c) right to left

20 33 19 24 31 22 27 18 25	
33 20 31 19 24 27 22 25 18	M1
33 31 20 27 19 24 25 22 18	1A1
33 31 27 20 25 19 24 22 18	
33 31 27 25 20 24 19 22 18	2A1ft
33 31 27 25 24 20 22 19 18	
33 31 27 25 24 22 20 19 18	
List in order	3A1 CSO

<table>
<tr><td>**2.(a)**</td><td>Either (i) G – 3 = C – 2 = F – 1 = D – 4
or (ii) G – 5 = E – 4
or (iii) G – 5 = E – 1 = D – 4
Change status
Either (i) G = 3 – C = 2 – F = 1 – D = 4
or (ii) G = 5 – E = 4
or (iii) G = 5 – E = 1– D = 4
Giving matchings:
<table><tr><td></td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr><tr><td>(i)</td><td>2</td><td>4</td><td>5</td><td>1</td><td>3</td></tr><tr><td>(ii)</td><td>3</td><td>1</td><td>4</td><td>2</td><td>5</td></tr><tr><td>(iii)</td><td>3</td><td>4</td><td>1</td><td>2</td><td>5</td></tr></table></td><td>M1 1A1
2A1
3A1 **(4)**</td></tr>
<tr><td>**(b)**</td><td>Gives another solution</td><td>M1 1A1 2A1
(3)
Total 7</td></tr>
</table>

Notes for question 2

Mark the candidates best attempt as part (a)

a1M1 Path from G to 4 - or vice versa

a1A1 CAO chosen path clear.

a2A1 Change status step clear stated or shown. [Only accept ‘change status’; ‘c.s.’; sight of the connectives being swapped]

a3A1 CAO must ft from stated path, diagram ok

b1M1: A second path from G to 4 (or vice versa)

b1A1: CAO including change status (stated or shown), chosen path clear.

b2A1: CAO must ft from stated paths, diagram ok.

Notes for question 3

a1B1 All four arcs CAO (+ see below)

a2B1 All four weights CAO.

Additional notes for (a)

- If B0 B0 but three arcs and their weights correct then give B1 B0.
- If extra arcs and weights remove second B mark (so B1 B0 max)
- If just one of DB or DE or DC missing, mark remainder of question as a misread.
- If two or more arcs are missing send to review.
- If DF used instead of DG, ignore references to this in (b)

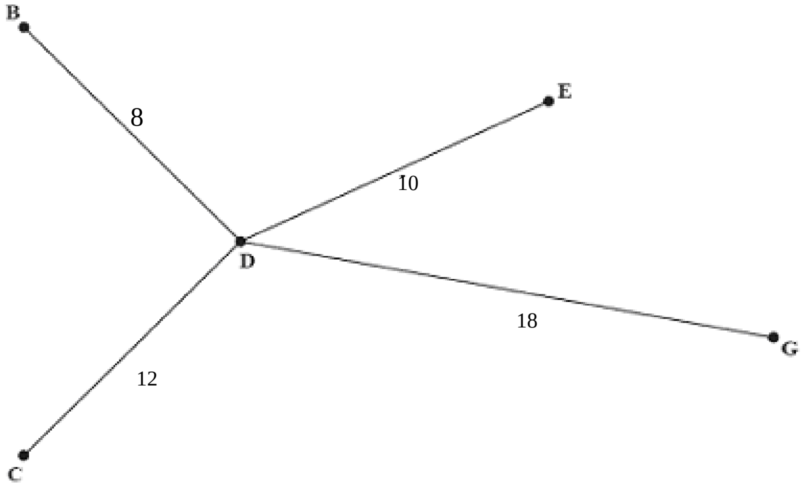
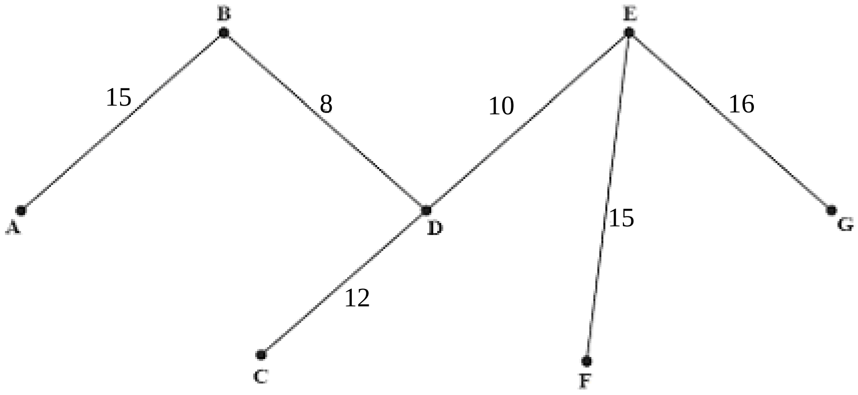
b1M1 First three arcs correctly chosen and **at least one rejection seen at some point.** (Kruskal not Prim.)

b1A1 First five arcs selected correctly; BD, DE, CD, then (in either order) EF, AB

b2A1 CAO including necessary rejections.

c1B1 CAO condone missing weights.

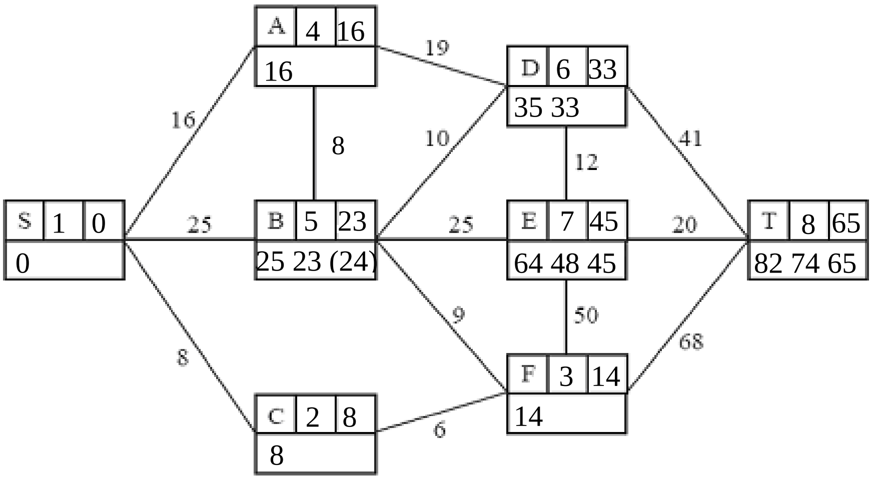
d1B1 CAO

Question Number	Scheme	Marks
3(a)		1B1 2B1 **(2)**
(b)	BD(8), DE(10), CD(12), reject BE(13), {EF(15), AB(15)}, {EG(16), reject CF(16)} reject remainder of arcs.	M1 1A1 2A1 **(3)**
(c)		B1 **(1)**
(d)	Weight of tree = 76 (km)	B1 **(1)** **Total 7 marks**

Question Number	Scheme	Marks
4(a)	The valency of a vertex is the number of edges incident to it.	B2,1,0 **(2)**
(b)	DE + HI = 131 + 75 = 206 DH + EI = 146 + 137 = 283 DI + EH = 143 + 62 = 205* Arcs EH, DF and FI will be traversed twice.	M1 1A1 2A1 3A1 4A1ft **(5)**
(c)	Route length = 1436 + 205 = 1641(m)	B1ft **(1)**
(d)	Since HI is removed only D and E are odd, So only the route between DE need to be repeated Route length = 1436 – 75 (for HI) + 131 = 1492(m)	M1 A1 **(2)**
(e)	Route should start and finish at D and E. E.g DCFDAEBGEFKIFHJGHE (18 vertices)	M1, A1 **(2)**
		12 marks

Notes for question 4

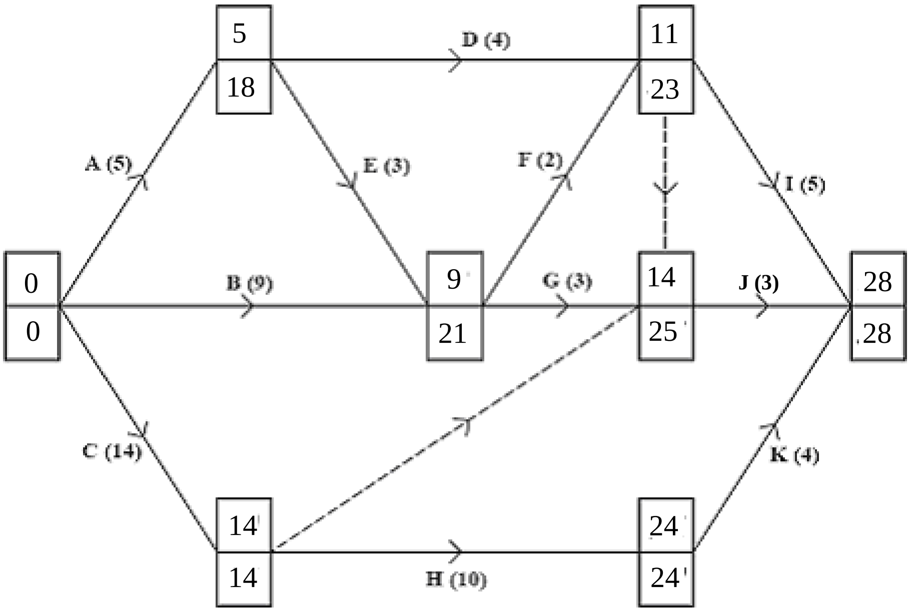
a1B1 Give bod but refers to arc/edge and to node/vertex
a2B1 A clear, correct statement. CAO.
b1M1 Three pairings of their four odd nodes
b1A1 One row correct including pairing and total
b2A1 Two rows correct including pairing and total
b3A1 Three rows correct including pairing and total
b4A1ft Their smallest repeated **arcs**, (accept DFI).
c1B1ft **Must have a choice of at least two pairs seen in part (b).** 1436 + their least from (a).
d1M1 Aim to include their DE(131) [ft from (b)] and remove HI(75) **or** 1436+131-75
d1A1 CAO 1492. Must see method though, NMS gets M0.
e1M1 D and E identified as start and finish nodes. We do not have to see a route here.
e1A1 CAO must see a route. 18 vertices; Each of A–K present; 3E’s, 3F’s, 2D’s,2G’s and 2H’s.

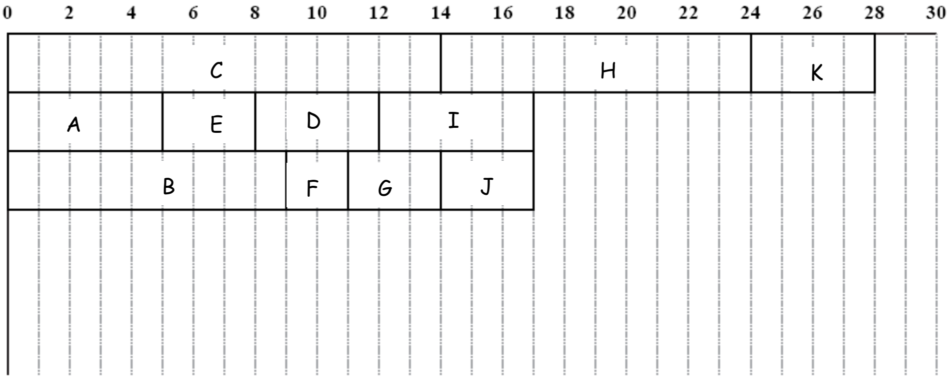
Question Number	Scheme	Marks
5(a)	 SCFBDET ; length 65	M1 A1(SCFA) A1ft (BD) A1(ET) 1B1; 2B1ft **(6)**
(b)	E.g. 65 – 20 = 45 ET; 45 – 12 = 33 DE; 33 – 10 = 23 BD; 23 – 9 = 14 FB; 14 – 6 = 8 CF; 8 – 8 = 0 SC **Or** Work back from T, including arc XY if the weight of arc XY = the difference in the final values of X and Y.	B2ft, 1ft, 0 **(2)**
(c)	SCFBET; length 68	B1; B1 **(2)** **Total 10**

Notes for question 5

a1M1 Big replaced by smaller at least once at B or D or E or T.
a1A1 S, C, F and A boxes all correct, condone lack of 0 in A’s working value
a2A1ft B and D ft correctly. Penalise order of labelling only once per question.
a3A1 E and T correct. Penalise order of labelling only once per question.
a1B1 Route CAO
a2B1ft their final value ft.
b1B1ft Attempting an explanation, at least 3 stages or one half of general explanation.
b2B1ft Correct explanation – all stages, both halves of explanation
c1B1 Route CAO.
c2B1 length CAO.

Amplification for (b)
General explanation:
1B1 for partial explanation e.g.‘working backwards/traceback’ or ref to arcs and final value differences
2B1 for working backwards **from T** + include an arc XY if weight of XY = final value of Y – final value of X.
Demonstration:
1B1 for three correct calculations for **their** network
2B1 for all calculations correct **and** linking arcs/nodes to those calculations. Arc lengths and final values visible.

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>
<table>
<tr><th>Act.</th><th>I.P.A.</th><th>Act.</th><th>I.P.A.</th><th>Act.</th><th>I.P.A</th></tr>
<tr><td>A</td><td>-</td><td>E</td><td>A</td><td>I</td><td>D F</td></tr>
<tr><td>B</td><td>-</td><td>F</td><td>B E</td><td>J</td><td>C D F G</td></tr>
<tr><td>C</td><td>-</td><td>G</td><td>B E</td><td>K</td><td>H</td></tr>
<tr><td>D</td><td>A</td><td>H</td><td>C</td><td></td><td></td></tr>
</table>
</td><td>B2, 1, 0
(2)</td></tr>
<tr><td>(b)</td><td>


</td><td>1M1 1A1
2M1 2A1
(4)</td></tr>
<tr><td>(c)</td><td>Total float on E = 21 – 5 – 3 = 13</td><td>M1 A1
(2)</td></tr>
<tr><td>(d)</td><td>$\frac{62}{28} = 2.21$ so lower bound is 3 workers</td><td>M1 A1 (2)</td></tr>
<tr><td>(e)</td><td>e.g.


</td><td>1M1 1A1
2A1 3A1
(4)
Total 14</td></tr>
</table>

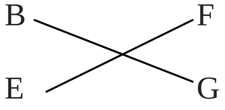
Question 6
a1B1 Any 3 rows completed correctly
a1B2 All five rows completed correctly
b1M1 All top boxes complete, values generally increasing left to right, condone one rogue
b1A1 CAO
b2M1 All bottom boxes complete, values generally decreasing R to L, condone one rogue. Condone missing 0 or 28 for the M only.
b2A1 CAO
c1M1 Correct calculation seen all three numbers correct (ft). Float ≥ 0 .
c1A1 CAO
d1M1 Attempt to find lower bound. [52-72 / their finish time] accept awrt 2.2.
d1A1 CAO – correct calculation seen or awrt 2.2, then . [Beware 28/11 gives 3 also, so 3 with no working gets M0A0.]
e1M1 Not a cascade chart. 4 ‘workers’ used at most. At least 7 activities. If in doubt send to review.
e1A1: CHKAB correct. C- 14; H – 10; K – 4; A – 5; B – 9. A and B completed by their late finish times. (A by time = 18 B by time = 21).

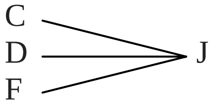
Now you need to check the last 6 activites – the last two marks are for D, E, F, G, I, J only

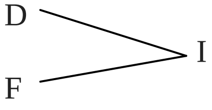
First check that they have only used three workers and that all 11 activities are present (just once).

Then check precedences: You have these on the mark scheme in (a).
Each row of the table in (a) could give rise to 1 error (only)
I'd suggest you check these ones first since they are most likely to generate errors.

- F must not start until after B and E are complete.
- G must not start until after B and E are complete.
- J must not start until after C, D, F are complete.
- I must not start until after D and F are completed



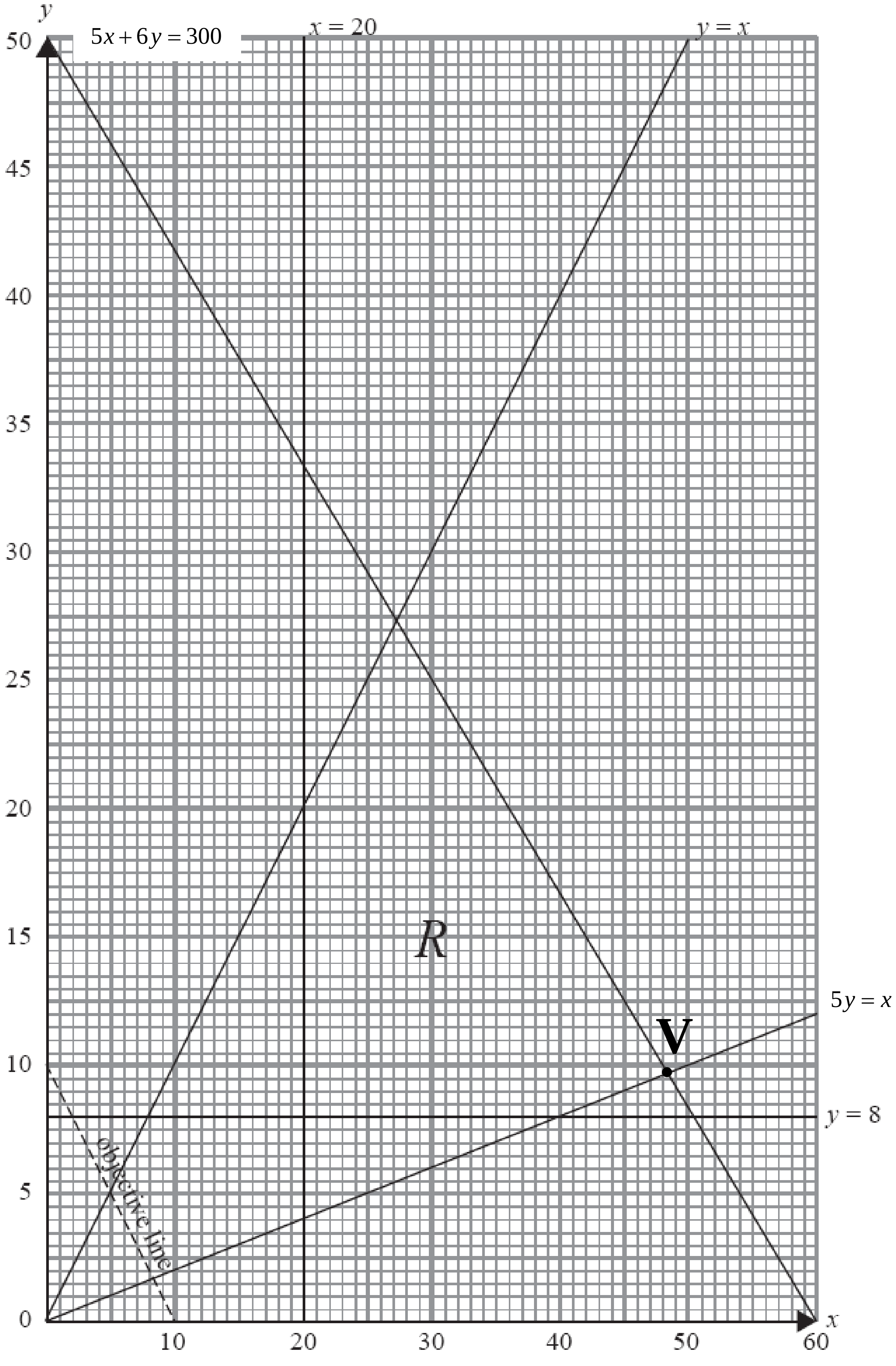




You need to check the others too of course.
Finally you need to check the length of each activity.
Length 5 - A, I
Length 4 – D
Length 3 – E, G, J
Length 2 – F
Length 9 – B

e2A1: 3 workers. All 11 activities present (just once). Condone one error either precedence, or activity length, on activities D, E, F, G I, J.
e3A1: 3 workers. All 11 activities present (just once). No errors on activities D, E, F, G I, J.

Please use the pen or highlighter tool to indicate any errors to your team leader.
Usually we use a vertical line to indicate precedence errors, indicating the overlap,
and a horizontal line to indicate an activity of incorrect length.


y
5x + 6y = 300
x = 20
y = x
50
45
40
35
30
25
20
15
10
5
0
R
V
5y = x
y = 8
objective line
10
20
30
40
50
60
x

Question Number	Scheme	Marks
7 (a)	$y \leq x$	B1 **(1)**
(b)	$y \geq \frac{1}{6}(x+y)$ $6y \geq x+y$ $5y \geq x$	B2,1,0 **(2)**
(c)	$5x+6y \leq 300$	B1 **(1)**
(d)	Two lines and shading correctly added	B1 B1 **(2)**
(e)	R correctly labelled	B1 **(1)**
(f)	Objective line correctly drawn and labelled Optimal vertex labelled	M1 A1 A1 **(3)**
(g)	Buy 48 standard and 10 luxury cars, Expected profit £4640 per week	1B1 2B1, 3B1 **(3)** **13 marks**

Notes for question 7

a1B1 CAO

b1B1 Either of my first two lines. Must have three terms, two in *y* and one in *x*.

b2B1 CSO. (Answer given) must have $\geq$ throughout.

c1B1 CAO

In (d) If lines do not meet both axis then extend as necessary, but must extend beyond the feasible region. Use the line drawing tool to check.

d1B1 $5y = x$ drawn correctly, passes within a small square of (0,0) and (50, 10). Ignore shading.

d2B1 $5x + 6y = 300$ drawn correctly, passes within a small square of (0, 50), (30, 25) and (60, 0) Ignore shading.

e1B1 CAO – **but must have scored both marks in (d)**

f1M1 Drawing objective line with correct gradient, use line drawing tool to check if necessary. You can give BOD here if it is close. If their line is shorter than the length equivalent to that of line (0, 5) to (5, 0), please send to review.

f1A1 Correct objective line drawn (so no BOD) and their correct V labelled, or clearly indicated, or coordinates written to 1 dp.

f2A1 CSO, R correct, my V labelled or clearly indicated, or coordinates written to 1dp so awrt (9.7, 48.4).

g1B1 Finding vertex, in my R, with integer coordinates. Must be within 2 small squares of their V and must be maximising, so accept only; (48, 10), (47, 10), (46, 11), (27, 27), (28, 26).

g2B1 CAO (48, 10)

g3B1 CAO 4640

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Rewarding Learning

Mark Scheme (Results)

January 2013

GCE Decision Mathematics D1 6689/01

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January 2013
Publications Code UA034373

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $\ast$ The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but incorrect answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of ‘0’ or ‘1’ for each mark, or “trait”, as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

January 2013
6689 Decision Mathematics 1
Mark Scheme

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>**1 (a)**</td><td><table><tr><th>N</th><th>E</th><th>R</th><th>Qn</th></tr><tr><td>72</td><td>8</td><td>8.5</td><td>N</td></tr><tr><td></td><td>8.5</td><td>8.485 294 118</td><td>N</td></tr><tr><td></td><td>8.485 294 118</td><td>8.485 281 374</td><td>N</td></tr><tr><td></td><td>8.485 281 374</td><td>8.485 281 374</td><td>Y</td></tr></table>
Output is R = 8.485 281 4</td><td>M1
A1
A1
A1ft **(4)**</td></tr>
<tr><td>**(b)**</td><td>We would get a negative output for R/ We would get the negative square root</td><td>B1 **(1)**</td></tr>
<tr><td>**(c)**</td><td>E cannot be zero</td><td>B1 **(1)**
Total 6 marks</td></tr>
<tr><td></td><td>**Notes**
a1M1: At least **two** rows of cells in just E and R completed.
a1A1: CAO first two rows correct giving exact values or awrt 7dp (the exact second value for R is $\frac{577}{68}$).
a2A1: CAO third and fourth rows awrt 7dp
a3A1ft: Output for R **must** follow through from **their** final value for R awrt 7dp – candidate **must** have answered ‘yes’ to score this mark. Output either on the answer line (or on the second page) or stated in the table but **must** be in the column for R below the row which contains ‘yes’.
Condone N = 72 on each row and entries appearing on separate rows throughout for full marks. Allow e.g. ticks/crosses etc. for yes/no.

b1B1: Mention of ‘negative’ scores B1 however do not accept incorrect statements but bod that ‘negative’ only is implicitly describing the effect on the output. Accept ‘other square root’.
c1B1: CAO (nothing/null etc. scores B0). Condone E = 0.</td><td></td></tr>
</table>

Question Number	Scheme	Marks
2 (a)	Pivot 1 = $\left[\frac{1+26}{2}\right]=\left[13.5\right]=14$ letter N reject A – N	M1 A1
	Pivot 2 = $\left[\frac{15+26}{2}\right]=\left[20.5\right]=21$ letter U reject U – Z	
	Pivot 3 = $\left[\frac{15+20}{2}\right]=\left[17.5\right]=18$ letter R reject R – T	A1
	Pivot 4 = $\left[\frac{15+17}{2}\right]=16$ letter P – located	A1 **(4)**
(b)	E.g. The maximum number of letters at the start of each iteration is 26, 13, 6, 3, 1	M1
	So a maximum of 5 iterations is necessary	A1 **(2)**
		Total 6 marks
	Notes a1M1: Choosing middle right pivot (choosing middle left is M0) + discarding/retaining half the list. M1 **only** for an ‘incorrect’ list - allow 1 error (e.g. two letters interchanged) or one omission or 1 extra letter. a1A1: First pass correct i.e. N found as pivot for a correct list and either using O to Z in 2nd pass or discarding A to N (so therefore no ‘sticky’ pivots – sticky is when the letter being considered is retained in the next pass) a2A1: Second and third passes correct i.e. U and R (no sticky pivots). **Special case**: Allow recovery for this mark if a sticky pivot is used in first pass but sticky pivots are not used in the 2nd and 3rd passes. So after retaining N incorrectly the 2nd pass would give T and the 3rd pass would give Q leaving a list with N O P. a3A1: CSO (correct solution only – all three previous marks must have been awarded to score this mark) search complete + ‘found’ (accept ‘found’, ‘located’, ‘stop’, etc. but not just the letter; must be convinced that P has been located). **If no alphabetical list seen then withhold the final A mark in part (a)**. If the alphabetical list is not given then bod that candidate is using the correct ordered list (which is implied by the correct passes). Listing the alphabet and then numbering the alphabet and referring to the corresponding numbers is fine for full marks. Candidates may renumber their list for each pass to calculate pivots. However, use of numbers and comparing to 16 without any reference to the alphabet is M0. b1M1: Numerical argument; listing size of list, using logs, etc. b1A1: Correct complete argument.	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>3 (a)</td><td>(i) C – 4 = N – 6 = J – 3 = R – 2 or (ii) O – 6 = J – 3 = R – 2

Change status to give
(i) C = 4 – N = 6 – J = 3 – R = 2 or (ii) O = 6 – J = 3 – R = 2

Improved matching is:
<table>
<tr><th></th><th>C</th><th>G</th><th>J</th><th>N</th><th>O</th><th>R</th></tr>
<tr><td>(i)</td><td>4</td><td>5</td><td>3</td><td>6</td><td></td><td>2</td></tr>
<tr><td>(ii)</td><td></td><td>5</td><td>3</td><td>4</td><td>6</td><td>2</td></tr>
</table></td><td>M1

A1

A1 (3)</td></tr>
<tr><td>(b)</td><td>E.g. Tasks 1 and 5 can only be done by George
E.g. Charlie can only do task 4 and Olivia can only do task 6 which means that Nurry can’t be allocated a task as Nurry can only do tasks 4 and 6</td><td>B2, 1, 0 (2)</td></tr>
<tr><td>(c)</td><td>O – 6 = N – 4 = C – 5 = G – 1 or C – 5 = G – 1
Change status to give O = 6 – N = 4 – C = 5 – G = 1 or C = 5 – G = 1
Maximum matching is: C = 5, G = 1, J = 3, N = 4, O = 6, R = 2</td><td>M1
A1
A1 (3)

Total 8 marks</td></tr>
<tr><td></td><td>Notes
a1M1: An alternating path (e.g. letter - number - letter - …) from C or O to 2 or vice versa.

a1A1: CAO – a correct path including change status either stated (only accept ‘change (of) status’ or ‘c.s.’) or shown (all symbols e.g. (... – ... = ...) interchanged (... = ... – ...)). Chosen path clear.

a2A1: CAO must follow from the correct stated path. Accept on a clear diagram (with five arcs only).

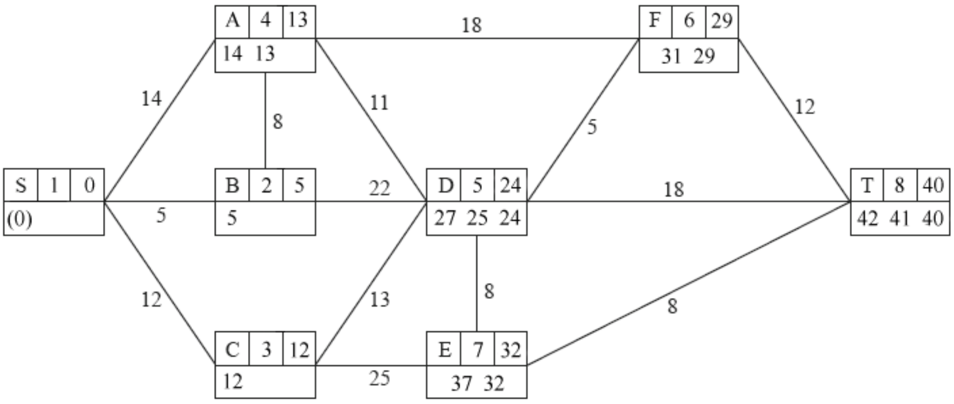
b1B1: Correct idea, may be imprecise or muddled (bod gets B1) all relevant nodes must be referred to and must be correct.

b2B1: Good, clear, complete, correct answer (this needs to be checked carefully e.g. G can only do tasks 1 and 5 is B1 only).

c1M1: A second alternating path from O or C to 1 (whichever letter (of O or C) that they didn’t use before) or vice versa.

c1A1: CAO including change status (stated or shown), chosen path clear.

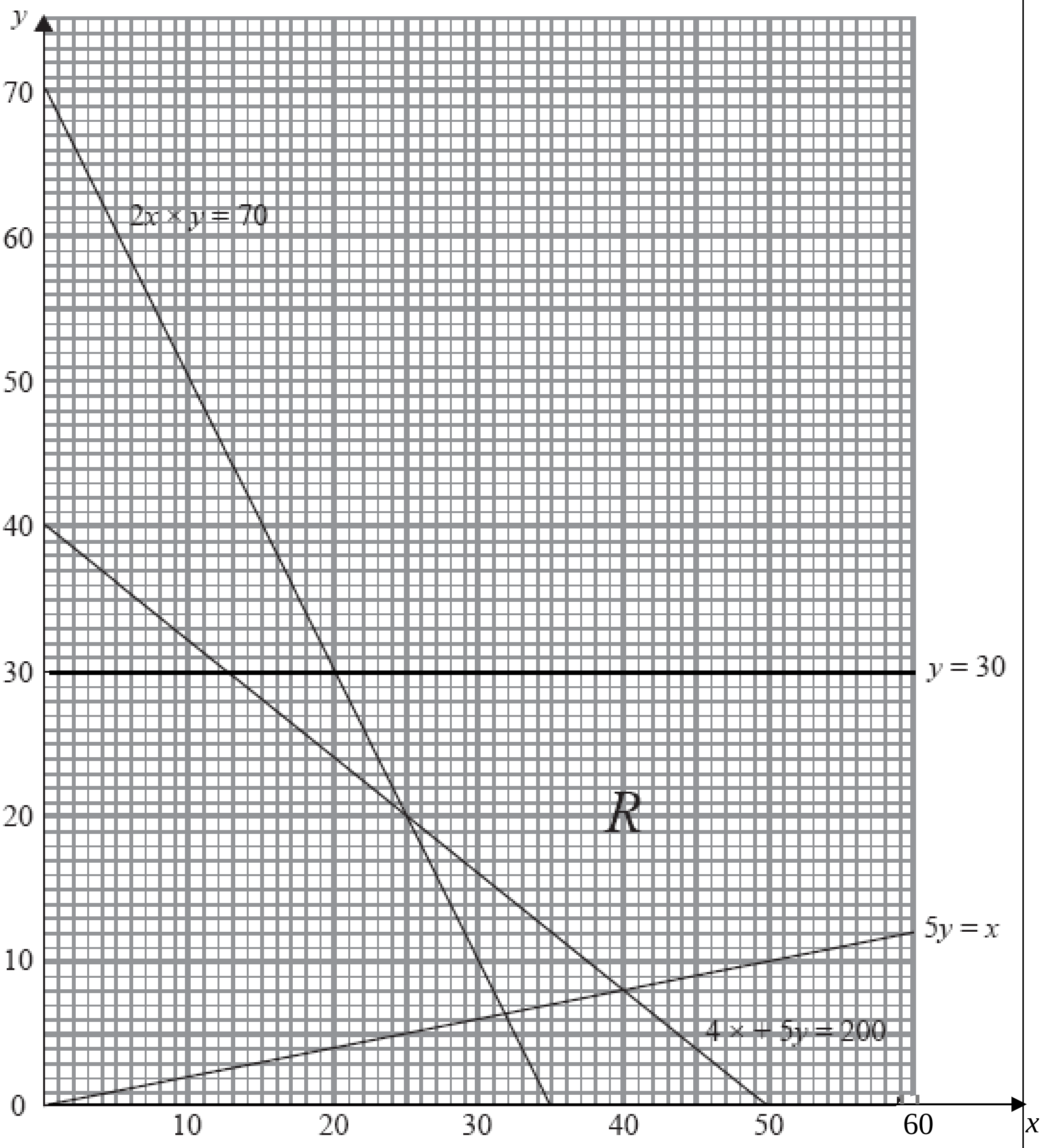
c2A1: CAO must follow from two correct stated paths (so both previous M marks must have been awarded). Accept on a clear diagram (with six arcs only).</td><td></td></tr>
</table>

Question Number	Scheme	Marks
4 (a)	A path is a (i) finite sequence of edges, such that (ii) the end vertex of one edge in the sequence is the start vertex of the next, and in which (iii) no vertex appears more than once.	B2, 1, 0 **(2)**
(b)	 Shortest path: SBADET Length: 40 (miles)	M1 A1 (S,A, B, C) A1ft (D, F) A1 (E, T) B1 B1ft **(6)**
(c)	Shortest distance S to F = 29 (miles)	B1ft **(1)**
(d)	SADET or SCDET; of length 41 (miles)	B1 B1 **(2)**
		Total 11 marks
	Notes a1B1: One of the three points made clearly or two suggested. Arcs (edges)/ vertices (nodes) must be referred to correctly. Do not condone incorrect technical language e.g. point for vertex. a2B1: All three points made clearly. b1M1: A larger value replaced by a smaller value at least once at A or D or E or F or T. b1A1: **All** values in S, A, B and C correct. The working values at A must be in the correct order. Condone lack of 0 in S's working value. b2A1ft: All values in D and F ft correctly and working values in the correct order. F must be labelled before E but penalise order of labelling only once per question. b3A1: All values in E and T correct and working values in the correct order. Penalise order of labelling only once per question. b1B1:Route CAO b2B1ft: Their final value ft (if answer is not 40 ft their final value at T) c1B1ft: Their final value ft (if answer is not 29 ft their final value at F) d1B1: Either route CAO d2B1: Length CAO (condone lack of (or incorrect) units throughout)	

Question Number	Scheme	Marks
5 (a)	AC (32) CF (14) DF (12) EF (17); BE (15) FI(18); IJ (10) GJ (9) DH (19)	M1 A1; A1 **(3)**
(b)	146 x 80 = (£) 11 680	M1 A1 **(2)**
(c)	BF + GH = 32 + 40 = 72 BG + FH = 39 + 25 = 64* BH + FG = 57 + 37 = 94 Roads BE, EG and FH need repeating	M1 A3,2,1,0 A1ft A1 **(6)**
(d)	379 + 64 = 443 (km)	B1ft **(1)**
(e)	Ben should choose to repeat FH (25) since this is the shortest. He should choose B and G as his start and finish vertices Route length is 379 + 25 = 404 (km)	M1 A1 A1 **(3)**
		Total 15 marks
	Notes Accept the **weight** of each arc to represent the arcs (as each value is unique). a1M1: First four arcs correctly chosen **or** first five nodes correctly chosen (A, C, F, D, E, …). Any rejections seen during selection scores **M0**. Order of nodes may be seen at the top of a matrix. a1A1: First six arcs correctly chosen **or** all nodes correctly chosen (A, C, F, D, E, B, I, J, G, H). Order of nodes may be seen at the top of a matrix. a2A1: CSO (must be considering arcs for this final mark). b1M1: $80\times$ their MST weight. Accept a value in the interval $\left[114,178\right]\times 80$ for this mark. If no working is seen then M0 unless answer is correct. b1A1: CAO (11680 with no working scores both marks). c1M1: Three distinct pairings of **their** four odd nodes. c1A1: Any one row correct including pairing **and** total. c2A1: Any two rows correct including pairing **and** total. c3A1: All three rows correct including pairing **and** total. c4A1ft: Their smallest **arcs** repeated (e.g. accept BEG or BG via E but **not** just BG). BEG (or e.g. BG via E) could appear in their working. c5A1: CAO BE, EG and FH. Accept BEG or BG via E (could appear in working) but not just BG. d1B1ft: correct answer of 443 **or** 379 + their least out of a choice of at least **two** totals given in part (c). e1M1: FH (or 25) specifically identified as **least**. e1A1: B and G identified as the start and finish nodes. e2A1: 404 CAO (condone lack of (or incorrect) units throughout).	

Question Number	Scheme	Marks
	Misread in (a): Starting at a node other than A scores **M1 only – must** have the first four arcs (or five nodes or numbers) correct.	

Starting at	Minimum Arcs required for M1 only	Nodes	Order
B	BE,EF,DF,CF	B, E, F, D, C	(10)15423(8967)
C	CF,DF,EF,BE	C, F, D, E, B	(10)51342(8967)
D	DF,CF,EF,BE	D, F, C, E, B	(10)53142(8967)
E	BE,EF,DF,CF	E, B, F, D, C	(10)25413(8967)
F	DF,CF,EF,BE	F, D, C, E, B	(10)53241(8967)
G	GJ,IJ,FI,DF	G, J, I, F, D	(10)(86)5(7)41(9)32
H	DH,DF,CF,EF	H, D, F, C, E	(10)(6)4253(9)1(78)
I	IJ,GJ,FI,DF	I, J, G, F, D	(10)(86)5(7)43(9)12
J	GJ,IJ,FI,DF	J, G, I, F, D	(10)(86)5(7)42(9)31

Question Number	Scheme	Marks
6.		

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>$5y \ge x$</td><td>B1 B1
(2)</td></tr>
<tr><td>(b)</td><td>$2x + y \ge 70$ and $4x + 5y \ge 200$</td><td>B3,2,1
(3)</td></tr>
<tr><td>(c)</td><td>Two lines correctly added</td><td>B1 B1
(2)</td></tr>
<tr><td>(d)</td><td>R correctly labelled</td><td>B1 (1)</td></tr>
<tr><td>(e)
(f)</td><td>(T =) 10<i>x</i> + 4<i>y</i>
<table>
<tr><th>Vertex</th><th>Time (mins)</th></tr>
<tr><td>(20,30)</td><td>320</td></tr>
<tr><td>(25, 20)</td><td>330</td></tr>
<tr><td>(40, 8)</td><td>432</td></tr>
<tr><td>(60,12)</td><td>648</td></tr>
<tr><td>(60,30)</td><td>720</td></tr>
</table>
So produce 20 celebration arrangements, 30 party arrangements taking 320 (minutes)

Notes
a1B1: Ratio of coefficients correct (i.e. equation of line correct)

a2B1: Inequality correct way round ($\mathrm{ay} \ge \mathrm{bx}$ o.e.) do not accept a strict inequality

b1B1: One equation correct

b2B1: One constraint correct, including inequality (but accept strict inequality here)

b3B1: Both constraints correct, including correct inequalities

c1B1: One line drawn correctly. Must pass within one small square of (25, 20) and if line extended must go from axis to axis through the points of intersection with the axes within one small square. Line must be long enough to form the feasible region. Check using length measurement tool if required. Ignore shading.

c2B1: Both lines drawn correctly. See above for accuracy. Ignore shading.

d1B1: R labelled (not just implied by shading) – must have scored both marks in (c).

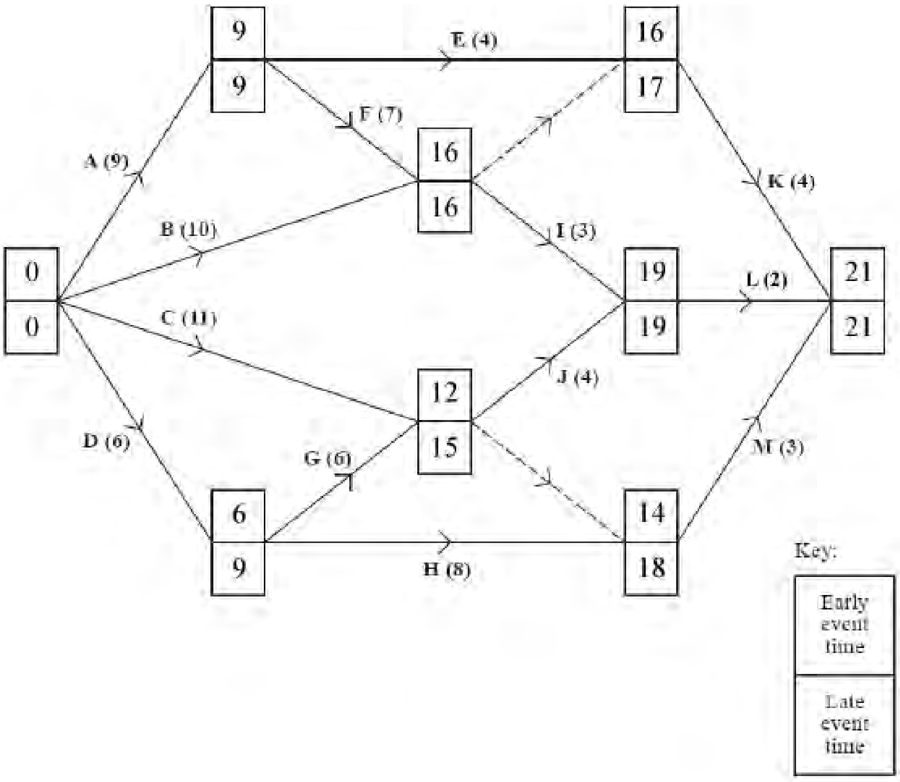
e1B1: CAO (isw if $(\mathrm{T} =)10\mathrm{x} + 4\mathrm{y}$ ‘simplified’ to $\mathrm{k}(10\mathrm{x} + 4\mathrm{y})$ but if $(\mathrm{T} =)10\mathrm{x} + 4\mathrm{y}$ not stated then B0)</td>
<td>B1 (1)

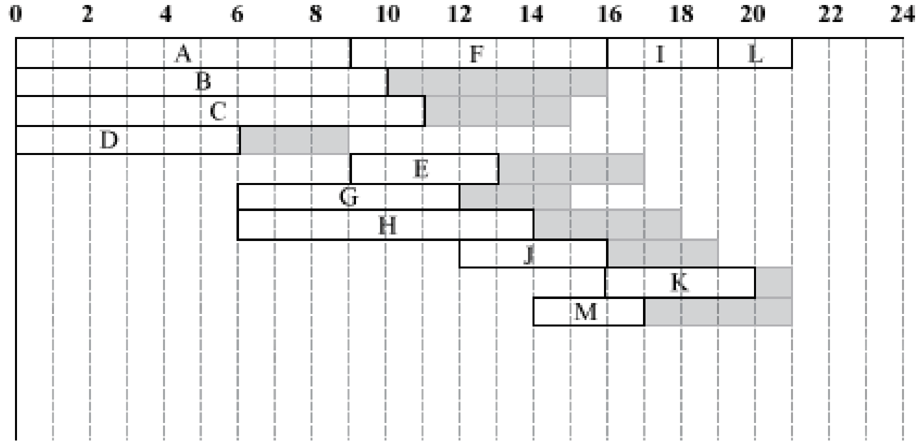
M1
A1
A1

A1
(4)

Total 13 marks</td></tr>
</table>

Question Number	Scheme	Marks
	f1M1: At least three of **their** (**or** the correct) R vertices found (by either reading off their graph or using simultaneous equations) **and** tested using **their** T (or the correct T). Objective line method (only) is **M0**. f1A1: Three vertices found and tested correctly CAO (must be using three of the **correct** vertices (see table above) and the values for T must be correct). f2A1: All five vertices found and tested correctly CAO (**all** values of T must be correct). f3A1: CAO number of each **and** time, both correct and it must be clear that $x = 20$ and $y = 30$ (accept as coordinates). If values appear in e.g. a table it must be clear that (20, 30) and 320 has been selected (condone lack of/incorrect units on the time).	

Question Number	Scheme	Marks
7 (a)	Activity K depends on activities E, F and B, but activity I depends on F and B only.	B2, 1, 0 **(2)**
(b)		M1 A1 M1 A1 **(4)**
(c)	Critical activities are: A, F, I, L	B1 **(1)**
(d)	Total float on G = 15 – 6 – 6 = 3	M1 A1 **(2)**

Question Number	Scheme	Marks
(e)		M1 A1 A1 A1 **(4)**
(f)	Activities A, C and D must be happening at time 5.5	B1 **(1)**
(g)	E.g. Activities F, B, C and G together with $9<$ time<10 stated So 4 workers are needed	M1 A1 **(2)** **Total 16 marks**
	Notes a1B1: K, I, E and at least one of B or F referred to. Correct statement but may be incomplete give bod here. a2B1: Clear correct statement no bod (at least one of only B or F referred to can score this mark). b1M1: All top boxes complete, values generally increasing left to right, condone one 'rogue' (if values do not increase from left to right then if one value is ignored and then the values do increase from left to right then this is considered to be only one rogue value). b2A1: CAO b2M1: All bottom boxes complete, values generally decreasing right to left, condone one rogue. Condone missing 0 **or** 21 for the M only. b2A1: CAO c1B1: CAO d1M1: Correct calculation seen, all three numbers correct (ft), float ≥ 0 d1A1: CAO (no ft on this mark) e1M1: At least 9 activities including at least 5 floats. Scheduling diagram scores M0. e1A1: The correct critical activities dealt with correctly e2A1: All correct non-critical activities present with floats with 5 non-critical activities correct	

Question Number	Scheme	Marks
	e3A1: All 9 non-critical activities correct f1B1: CAO g1M1: A statement with the correct number of workers and details of either time **or** activities correct. If no part of their statement is correct then allow M mark (only) on the ft with time **and** activities from their **13 activity, 9 float** diagram. **Scheduling** the activities only or a **lower bound calculation** argument scores **M0**. g1A1: A correct, complete full statement details of time **and** activities (The two options are F, B, C and G with $9 < \text{time} < 10$ or F, C, G and H with $10 < \text{time} < 11$). Please note strict inequalities for the time. Allow e.g. **on** 'day 10' as equivalent to $9 < \text{time} < 10$.	

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Summer 2013

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Summer 2013
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- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- [The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

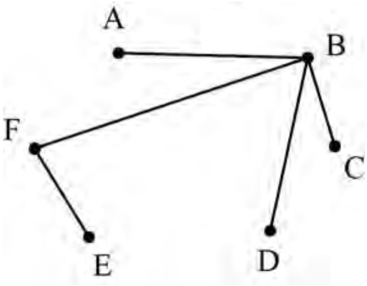
7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

Question Number	Scheme	Marks
1. (a)	C – 5 = F – 2 = D – 6 change status to give C = 5 – F = 2 – D = 6 Improved matching is (A unmatched) B = 4, C = 5, D = 6, E = 1, F = 2	M1 A1 A1 **(3)**
(b)	E.g. activities 3 and 4 can only be done by B E.g. both A and E can only do activity 1	B1 **(1)**
(c)	A – 1 = E – 6 = D – 2 = F – 4 = B – 3 Change status to give A = 1 – E = 6 – D = 2 – F = 4 – B = 3 Complete matching is A = 1, B = 3, C = 5, D = 2, E = 6, F = 4	M1 A1 A1 **(3)** **(7 marks)**

Notes for Question 1

a1M1: An alternating path (e.g. letter – number – letter – ...) from C to 6 or vice versa
a1A1: CAO – a correct path including change status **either** stated (only accept 'change (of) status' **or** 'c.s.') **or** shown (**all** symbols e.g. (...–... = ...) **interchanged** (... = ... – ...)). Chosen path clear.
a2A1: CAO must follow from the correct stated path. Accept on a **clear** diagram (with five arcs **only**).
b1B1: A good, clear, complete, correct answer (all relevant nodes must be referred to and must be correct)
c1M1: An alternating path from A to 3 or vice versa.
c1A1: CAO including change status (stated or shown), chosen path clear.
c2A1: CAO must follow from **two correct** stated paths (so **both** previous M marks must have been awarded). Accept on a **clear** diagram (with six arcs only).

Question Number	**Scheme**	**Marks**
2. (a)	AB(85), BC(100), BD(135); BF(150), EF(140).	M1 A1; A1 **(3)**
(b)		B1 **(1)**
(c)	610 (minutes)	B1 **(1)**
(d)	E.g. (any three) • Kruskal starts with the shortest arc, Prim starts with any node. • It is necessary to check for cycles when using Kruskal, not with Prim. • When using Prim the ‘growing’ tree is always connected. • When using Kruskal arcs are considered in ascending order of weight. • Prim can be used when the network is given in matrix form. • Prim adds nodes to the growing tree, Kruskal adds arcs. Other correct statements also get credit	B1 B1 B1 **(3)**
		(8 marks)

Notes for Question 2

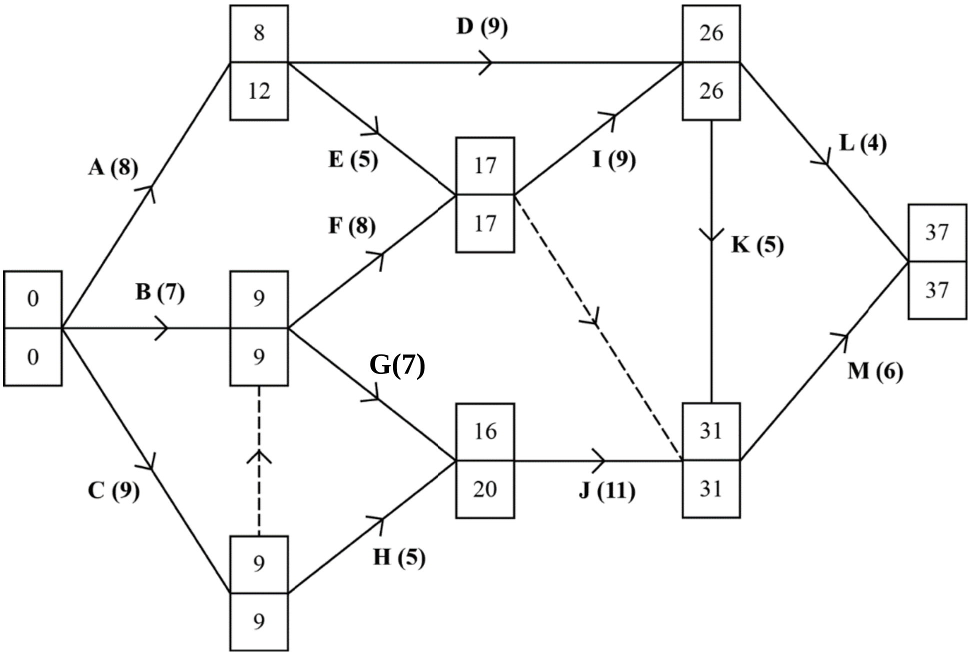
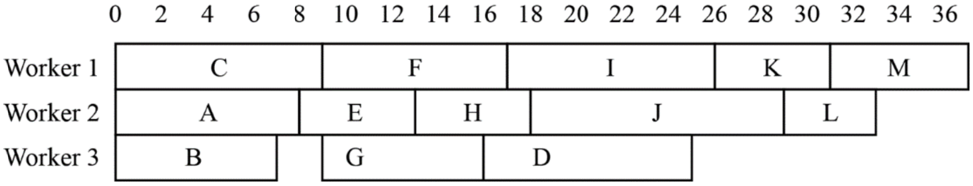
a1M1: Prim's – first three arcs correctly chosen **or** first four nodes correctly chosen, in order.{A, B, C, D,….}. Any rejections seen during selection is **M0**. Order of nodes may be seen across the top of the matrix {1, 2, 3, 4, –, –}
a1A1: First four arcs correctly chosen **or** all six nodes correctly chosen {A, B, C, D, F, E}. Order of nodes may be seen across the top of the matrix {1, 2, 3, 4, 6, 5}
a2A1: CSO (must be considering arcs for this final mark).

Misread: Starting at a node other than A scores **M1 only – must** have the first three arcs (or four nodes or numbers) correct.

Starting at	Minimum arcs required for M1	Nodes	order
A	AB BC BD	ABCD(FE)	1234(65)
B	AB BC BD	BACD(FE)	2134(65)
C	BC AB BD	CBAD(FE)	3214(65)
D	BD AB BC	DBAC(FE)	3241(65)
E	EF BF AB	EFBA(CD)	43(56)12
F	EF BF AB	FEBA(CD)	43(56)21

b1B1: CAO (weights on arcs not required)
c1B1: CAO (condone lack of/incorrect units)
d1B1: One correct statement.
d2B1: A second correct statement.
d3B1: A third correct statement.

In part (d) all technical language must be correct (so do not condone point for vertex/node etc.)

Question Number	Scheme	Marks
3. (a)		M1 A1 M1 A1 **(4)**
(b)	Total float on H = 20 – 9 – 5 = 6	M1 A1 **(2)**
(c)	93/37 = 2.5135 so 3 (workers)	M1 A1 **(2)**
(d)		M1 A1 M1 A1 **(4)**
		(12 marks)

Notes for Question 3

a1M1: **All** top boxes complete, values generally increasing left to right, condone one rogue.
a1A1: CAO.
a2M1: Bottom boxes complete, values generally decreasing right to left, condone one rogue. Condone missing 0 or 37 for the M mark only.
a2A1: CAO
b1M1: Correct calculation seen. All three numbers correct (ft).
b1A1: Float correct (no follow through on this mark)
c1M1: Attempt to find lower bound. [82 – 104 / their finish time] accept awrt 2.5
c1A1: CAO – correct calculation seen or awrt 2.5, then 3. (Beware 37/13 gives 3 also, so 3 with no working gets M0A0.)
d1M1: Not a cascade chart. 4 workers used at most. At least 8 new (10 in total) activities placed.
d1A1: The critical activities (F I K M) and B correct. F – 8; I – 9; K – 5; M – 6; B – 7. B completed by 9 (its late finish time).

Now check the last 6 activities – the last two marks are for D, E, G, H, J and L only

First check that there are only three workers and that all 11 new (13 in total) activities are present (just once).

Then check precedences (see table below) – each row of the table could give rise to 1 error only in precedences

Finally check the length of each activity (see number in brackets in the activity column in the table below)

Activity	I.P.A	Activity	I.P.A
A (8)	-	H (5)	C
B (7)	-	I (9)	E F
C (9)	-	J (11)	G H
D (9)	A	K (5)	D I
E (5)	A	L (4)	D I
F (8)	B C	M (6)	E F J K
G (7)	B C		

d2M1: 3 workers. All 11 new (13 in total) activities present (just once). Condone one error either precedence, or activity length, on activities D, E, G, H, J and L.
d2A1: 3 workers. All 11 new (13 in total) activities present (just once). No errors on activities D, E, G, H, J and L.

Question Number	Scheme	Marks
4.(a)	E.g. a quick sort	
	S J H A C $\boxed{K}$ P D T L pivot K	M1
	J H $\boxed{A}$ C D $\underline{K}$ S P $\boxed{T}$ L pivots A T	
	$\underline{A}$ J H $\boxed{C}$ D $\underline{K}$ S $\boxed{P}$ L $\underline{T}$ pivots C P	A1
	$\underline{A}$ $\underline{C}$ J $\boxed{H}$ D $\underline{K}$ L $\underline{P}$ S $\underline{T}$ pivot H (L) (S)	A1
	$\underline{A}$ $\underline{C}$ D $\underline{H}$ J $\underline{K}$ L $\underline{P}$ S $\underline{T}$ sort completed + named correctly	A1 **(4)**
(b)	Pivot 1 = $\left[\frac{1+10}{2}\right] = 6$ Komal, L is after K so reject 1 - 6	M1 A1
	Pivot 2 = $\left[\frac{7+10}{2}\right] = 9$ Sam, L is before S so reject 9 - 10	A1
	Pivot 3 = $\left[\frac{7+8}{2}\right] = 8$ Polly, L is before P so reject 8	
	Pivot 4 = 7 Lydia – name found	A1 cso **(4)**
		(8 marks)

Notes for Question 4

a1M1: Quick sort – pivots, p, selected and first pass gives <p, p, >p.
a1A1: First two passes correct, pivots chosen consistently for third pass.
a2A1: CAO sort completed correctly
a3A1: 'Stop' + correct name for their sort – phonetically close
b1M1: Using their 'sorted list' + choosing middle right pivots+ discarding/retaining half the list. If their list contains one error (one error is either a missing letter, an extra letter or one letter incorrectly placed) then M1 only in part (b).
b1A1: First pass correct i.e. 6th item from a correct list and retaining L – T (no sticky pivots)
b2A1: Second and third passes correct i.e. 9th (S) and 8th (P) items from a correct list (no sticky pivots).
b3A1: CSO search complete + 'found'

Notes for Question 4 Continued

Additional solutions

Quick sort middle left

S J H A $\boxed{C}$ K P D T L	Pivot C	M1
$\boxed{A}$ $\underline{C}$ S J H $\boxed{K}$ P D T L	Pivots (A) and K	
$\underline{A}$ $\underline{C}$ J $\boxed{H}$ D $\underline{K}$ S $\boxed{P}$ T L	Pivots H and P	A1
$\underline{A}$ $\underline{C}$ $\boxed{D}$ $\underline{H}$ $\boxed{J}$ $\underline{K}$ $\boxed{L}$ $\underline{P}$ $\boxed{S}$ T	Pivots (D, J, L) and S	
$\underline{A}$ $\underline{C}$ $\underline{D}$ $\underline{H}$ $\underline{J}$ $\underline{K}$ $\underline{L}$ $\underline{P}$ $\underline{S}$ T		A1
Quick sort complete		A1

Bubble sort left to right

S J H A C K P D T L		
J H A C K P D S L T	T in place, consistent direction	M1
H A C J K D P L S T	Passes 1 and 2 correct	A1
A C H J D K L P S T		
A C H D J K L P S T		
A C D H J K L P S T	Sort correct	A1
Bubble Sort complete	Sort named correctly + ‘stop’	A1

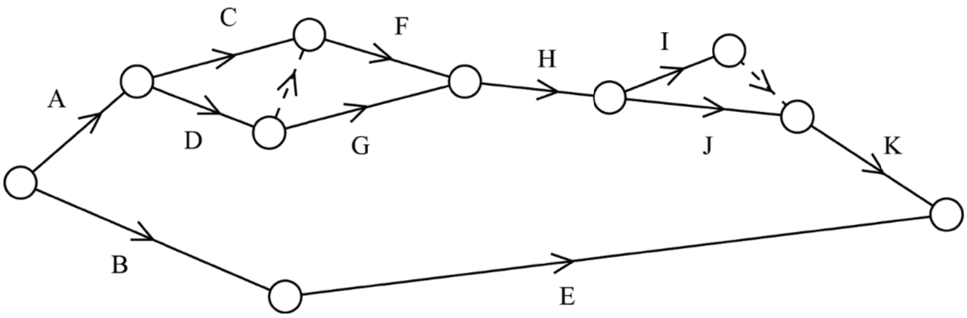
Bubble sort right to left:

S J H A C K P D T L		
A S J H C D K P L T	A in place, consistent direction	M1
A C S J H D K L P T	Passes 1 and 2 correct	A1
A C D S J H K L P T		
A C D H S J K L P T		
A C D H J S K L P T		
A C D H J K S L P T		
A C D H J K L S P T		
A C D H J K L P S T	Sort correct	A1
Bubble Sort complete	Sort named correctly + ‘stop’	A1

Sorting into reverse alphabetical order is acceptable for full marks

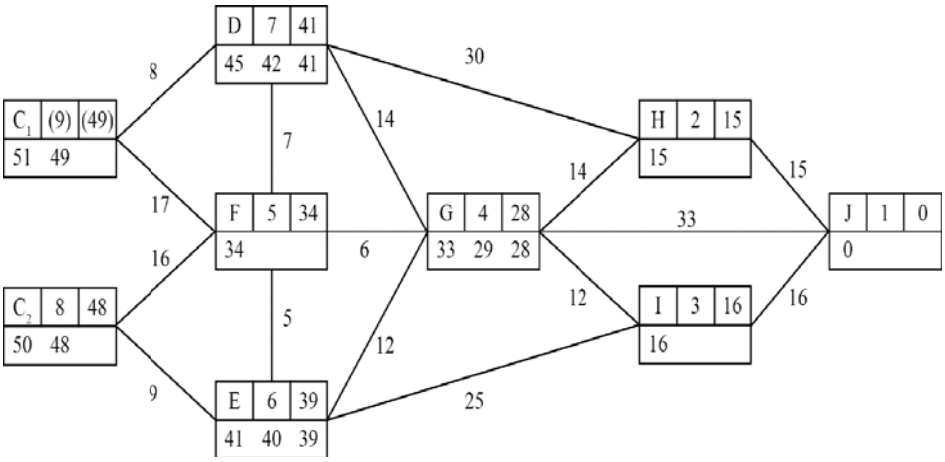
Question Number	Scheme	Marks
5. (a)	AF + GH = 15 + 31 = 46* AG + FH = 32 + 15 = 47 AH + FG = 30 + 17 = 47 so repeat arcs AB, BF and GH	M1 A3,2,1.0 A1 **(5)**
(b)	E.g. ABCDBFDEHGFHGAFBA (17 nodes) length = 181 + 46 = 227	B1 B1 ft **(2)**
(c)	One path will have to be repeated. The shortest is 15 So repeat AF, use G and H as the start and finish. **or** repeat FH, use A and G as the start and finish.	M1 A1A1 **(3)** **(10 marks)**

Notes for Question 5
a1M1: Three distinct pairings **of their** four odd nodes a1A1: Any one row correct including pairing **and** total a2A1: Any two rows correct including pairing **and** total a3A1: All three rows correct including pairing **and** total a4A1: CAO correct **arcs** identified AB, BF and GH. Accept ABF or AF via B (check to see if via B appears in working) but **do not** accept AF for this mark b1B1: Any correct route (checks: 17 nodes, the route starts and ends at A, pairings AB, BF and GH appear twice in the route and every letter from A to H (inclusive) appears at least once). b2B1ft: correct answer of 227 **or** 181 + their least out of a choice of at least **two** totals given in part (a) c1M1: Identifies need to repeat one pairing (maybe implicit) and 15 (or either AF or FH) specifically identified as the **least** c1A1: Repeat (either AF **or** FH) identified clearly c2A1: G and either A **or** H identified as start and finish.

Question Number	Scheme	Marks
6. (a)		M1 A1 (One start A – E) A1 (F – J + dummy 1) A1 (K + dummy 2) A1 (all arrows + finish) **(5)**
(b)	1st dummy – G depends on D only, F depends on C and D. 2nd dummy – I and J must be expressed uniquely in terms of their end events.	B1 B1 **(2)** **(7 marks)**

Notes for Question 6

a1M1: 7 activities and one dummy placed. Must be considering activity on arc (activity on node is M0).
a1A1: One start + A, B, C, D and E dealt with correctly.
a2A1: F, G, H, I and J and 1st dummy dealt with correctly.
a3A1: K and 2nd dummy dealt with correctly.
a4A1: CSO - all arrows present and correctly placed with one finish.
b1B1: First dummy correctly described (C, D, F and G referred to)
b2B1: Second dummy correctly described (mention of ‘uniqueness’ alone is not sufficient for this mark).

Question Number	Scheme	Marks
7. (a)	E.g. We would be able to find the shortest distance from J to every other vertex. E.g. We would only need to apply Dijkstra's algorithm once.	B1 **(1)**
(b)	 Shortest route is C_2EFGIJ length 48 (miles)	M1 A1 (G, H, I J) A1(D, E, F) A1ft (C_1, C_2) A1 A1ft **(6)** **(7 marks)**

Notes for Question 7

a1B1: CAO

b1M1: A larger value replaced by a smaller value at least once in the working values at either G, E, D, C_1 or C_2.

b1A1: All values in G, H, I and J correct. The working values at G must be in the correct order. Condone lack of 0 in the working value at J.

b2A1: All values in D, E and F correct and the working values in the correct order. Penalise order of labelling only once per question. (F, E and D labelled in that order with G, H, I and J labelled before F).

b3A1ft: All values in C_1 and C_2 ft correct and the working values in the correct order. Penalise order of labelling only once per question. (C_2 labelled after all other nodes (D to J) – condone lack of final value or order of labelling for C_1)

b4A1: Route CAO

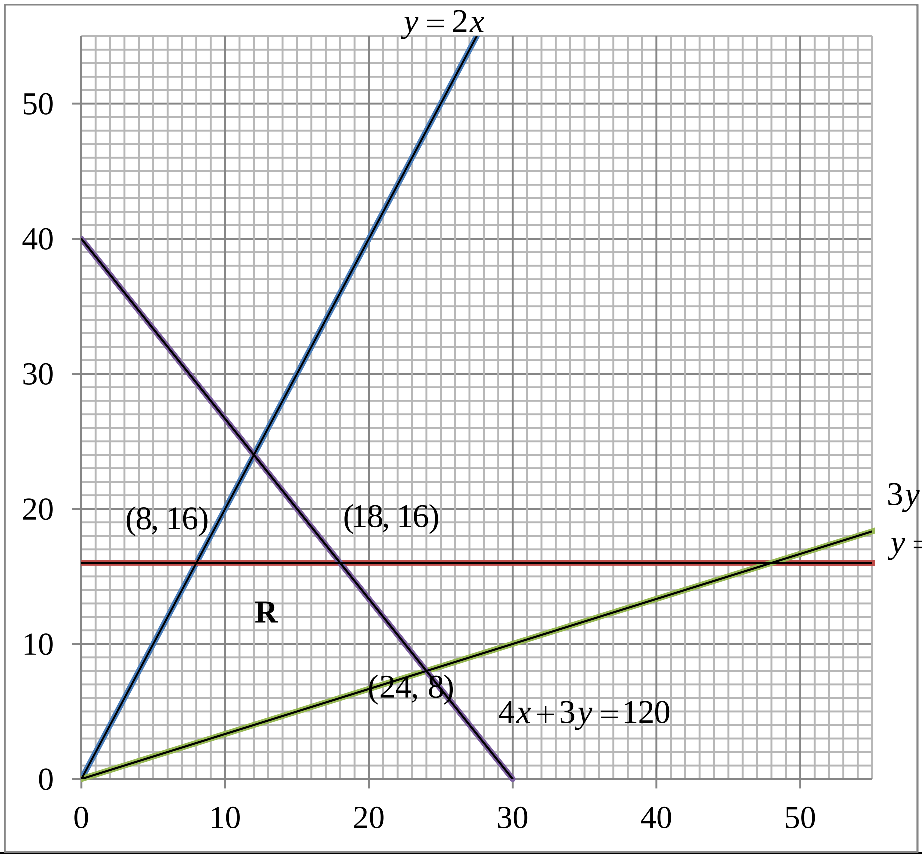
b5A1ft: Their final value ft (if answer is not 48 ft their final value at either C_1 or C_2 dependent on their route)

If the candidate uses either C_1 or C_2 as the starting vertex then this is **not** a misread. They can score a maximum of M1A0A0A0A1A1ft. If starting at:

C_1 – M1 for a larger value replaced by a smaller value at either C_2, F, G, H, I or J , then A0 A0 A0 then A1 for the route (C_1DFGIJ) and then A1 for 49 (or ft their final value at J).

C_2 – M1 for a larger value replaced by a smaller value at either C_1, F, G, H, I or J, then A0 A0 A0 then A1 for the route (C_2 EFGIJ) and then A1 for 48 (or ft their final value at J).

If the candidate uses both C_1 and C_2 as the starting vertices then award M1 for a larger value replaced by a smaller value at either F, G, H, I or J, then A0 A0 A0 then A1 for the correct route only (C_2 EFGIJ) and A1 for 48 (no ft).

Question Number	**Scheme**	**Marks**
8. (a)	$y \leq 16$; and $y \leq 2x$	B1; M1 A1 **(3)**
(b)	$4x + 3y \leq 120$	M1 A1 **(2)**
(c)	$x \leq \frac{3}{4}(x + y)$ so $4x \leq 3x + 3y$ so $x \leq 3y$	M1 A1 **(2)**
(d)	The correct two lines (4x + 3y = 120, x = 3y) R labelled correctly	B1 B1 B1 **(3)**
(e)	(P =) $45x + 30y$	B1 **(1)**
(f)	At (0,0) P = 0 At (8, 16) P = 840 At (18, 16) P = 1 290 At (24, 8) P = 1 320	M1 A1 (any 2) A1 (any 3) A1 (all 4)
(g)	So optimal point is (24, 8) giving (£)1 320	B1 **(5)**
		**(16 marks)**

Notes for Question 8
a1B1: CAO for $y \leq 16$ a1M1: Coefficients correct, accept =, <, >, ≤,≥ here a1A1: CAO b1M1: Coefficients correct and 120 accept =, <, >, ≤,≥ here b1A1: CAO c1M1: Accept non-integer coefficients here, accept =, <, >, ≤,≥ here, coefficients correct. c1A1: CAO must be integer coefficients. d1B1: $4x + 3y = 120$ correctly drawn. The line must pass within one small square of the point (18, 16) and if line extended must go from axis to axis through the points of intersection with the axes within one small square. The line must be long enough to form the feasible region. Check using measurement tool if required. Ignore shading. d2B1: $x = 3y$ correctly drawn. The line must pass within one small square of the origin and the point (24, 8). The line must be long enough to form the feasible region. Ignore shading. d3B1: R labelled (not just implied by shading) – **must** have scored the first two marks in this part. e1B1: CAO (isw if ($P =$) $45x + 30y$ is simplified to $k(45x + 30y)$ but if $45x + 30y$ not stated then B0) f1M1: At least two of **their**¸ **or** the correct R vertices found (either by reading off their graph or using simultaneous equations) **and** tested using their P**.** Objective line method (only) is M0. f1A1: Two vertices found and tested correctly CAO (must be using two of the **correct** vertices and the values for P must be correct). f2A1: Three vertices found and tested correctly CAO (must be using three of the **correct** vertices and the values for P must be correct). f3A1: All four vertices found and tested correctly CAO (**all** values of P must be correct). g1B1: CAO for profit (condone lack of £)

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- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

Question Number	Scheme	Marks
1. (a)	Bipartite (graph)	B1 **(1)**
(b)	e.g. (**see below for alternatives**) First alternating path: B – 4 = L – 3 = H – 2 Change status to give B = 4 – L = 3 – H = 2 Improved matching: A = 1, B = 4, H = 2, (I unmatched), L = 3 R = 5	 M1 A1 A1
	Second alternating path: I – 1 = A – 3 = L – 5 = R – 6 Changing status to give: I = 1 – A = 3 – L = 5 – R = 6 Complete matching: A = 3, B = 4, H = 2, I = 1, L = 5, R = 6	M1 A1 A1 **(6)**
		7 marks

Notes for Question 1

Possible 1st paths	A	B	H	I	L	R	Subsequent 2nd paths
B – 4 – L – 3 – H – 2	1	4	2	-	3	5	I – 1 – A – 3 – L – 5 – R – 6
B – 4 – L – 5 – R – 6	1	4	3	-	5	6	I – 1 – A – 3 – H – 2
I – 1 – A – 3 – H - 2	3	-	2	1	4	5	B – 4 – L – 5 – R – 6

a1B1: CAO, but be charitable on spelling, award if phonetically close.
b1M1: An alternating path (e.g. letter – number – letter – ...) from either B to 2 or 6 or from I to 2 – or vice versa
b1A1: CAO – a correct path including change status **either** stated (only accept 'change (of) status' **or** 'c.s.') **or** shown (**all** symbols e.g. (...–... = ...) **interchanged** (... = ... – ...)). Chosen path clear.
b2A1: CAO must follow from the correct stated path. Accept on a **clear** diagram (with five arcs **only**).
b2M1: A second alternating path from the remaining (unused) I or B to the remaining (unused) 6 or 2 - or vice versa.
b3A1: CAO including change status (stated **or** shown), chosen path clear
b4A1: CAO must follow from **two correct** stated paths (so **both** previous M marks must have been awarded).
Accept on a **clear** diagram (with six arcs only).

Question Number	Scheme	Marks
2.(a)	Bin 1: **0.6 0.2** 0.4 0.5 0.1 Bin 3: **1.6** Bin 2: **1.5** 0.3 Bin 4: 0.7 0.9	M1 A1 A1 **(3)**
(b)		
	0.6 1.5 1.6 0.2 0.4 $\boxed{0.5}$ 0.7 0.1 0.9 0.3 pivot 0.5	M1
	0.6 1.5 $\boxed{1.6}$ 0.7 0.9 $\underline{0.5}$ 0.2 0.4 $\boxed{0.1}$ 0.3 pivots 1.6 0.1	A1
	$\underline{1.6}$ 0.6 1.5 $\boxed{0.7}$ 0.9 $\underline{0.5}$ 0.2 $\boxed{0.4}$ 0.3 $\underline{0.1}$ pivots 0.7 0.4	
	$\underline{1.6}$ 1.5 $\boxed{0.9}$ $\underline{0.7}$ 0.6 $\underline{0.5}$ $\underline{0.4}$ 0.2 $\boxed{0.3}$ $\underline{0.1}$ pivots 0.9 0.3 (0.6)	A1ft
	$\underline{1.6}$ 1.5 $\underline{0.9}$ $\underline{0.7}$ 0.6 $\underline{0.5}$ $\underline{0.4}$ $\underline{0.3}$ 0.2 $\underline{0.1}$ sort complete	A1cso **(4)**
(c)	Bin 1: **1.6** 0.4 Bin 2: **1.5** 0.5 Bin 3: **0.9 0.7** 0.3 0.1 Bin 4: 0.6 0.2	M1 A1 A1 **(3)**
(d)	e.g. 6.8/2 = 3.4 so yes a minimum of 4 bins is needed	B1 **(1)** **11 marks**

Notes for Question 2

a1M1: First four items placed correctly and at least six values put in bins. (Condone cumulative totals here only.)
a1A1: Bin 1 correct
a2A1: CSO All correct
b1M1: Quick sort – pivot, p, chosen (must be choosing middle left or right – choosing first/last item as the pivot is M0) and first pass gives >p, p, <p. So after the first pass the list should read (values greater than the pivot), pivot, (values less than the pivot). **If only choosing 1 pivot per iteration M1 only**
b1A1: First pass correct, next two pivots chosen consistently for second pass.
b2A1ft: second and third passes correct (ft from their first pass and choice of pivots) – need not be choosing pivots for the fourth pass for this mark.
b3A1: CSO (correct solution only – all previous marks in this part **must** have been awarded) including 'sort complete' – this could be shown by the final list being re-written or 'sorted' statement or each item being used as a pivot.

c1M1: **Must be using 'sorted' list** in descending order. First four items placed correctly and at least six values put in bins. (Condone cumulative totals here only.)
c1A1: First seven items placed correctly (so Bin 1 and 2 correct, Bin 3 containing 0.9 and 0.7 and Bin 4 containing 0.6)
c2A1: CSO

SC for part (c) If '**sorted**' list is wrong from part (b) (i.e. one error e.g. a missing number, an extra number or one number incorrectly placed) then award M1 only in (c) for their first seven items correctly placed.

d1B1: A conclusion based on their answer to part (c) together with either a correct lower bound calculation or based on the total > 6 or full bins (three of the bins are full in part (c)).

Notes for Question 2 Continued

Part (b) **Using middle left as pivot**

0.6	1.5	1.6	0.2	$\boxed{0.4}$	0.5	0.7	0.1	0.9	0.3	pivot 0.4	M1
0.6	1.5	$\boxed{1.6}$	0.5	0.7	0.9	$\underline{0.4}$	0.2	$\boxed{0.1}$	0.3	pivots 1.6 0.1	A1
$\underline{1.6}$	0.6	1.5	$\boxed{0.5}$	0.7	0.9	$\underline{0.4}$	$\boxed{0.2}$	0.3	$\underline{0.1}$	pivots 0.5 0.2	
$\underline{1.6}$	0.6	$\boxed{1.5}$	0.7	0.9	$\underline{0.5}$	$\underline{0.4}$	$\boxed{0.3}$	$\underline{0.2}$	$\underline{0.1}$	pivots 1.5 (0.3)	A1ft
$\underline{1.6}$	$\underline{1.5}$	0.6	$\boxed{0.7}$	0.9	$\underline{0.5}$	$\underline{0.4}$	$\underline{0.3}$	$\underline{0.2}$	$\underline{0.1}$	pivot 0.7	
$\underline{1.6}$	$\underline{1.5}$	0.9	$\underline{0.7}$	0.6	$\underline{0.5}$	$\underline{0.4}$	$\underline{0.3}$	$\underline{0.2}$	$\underline{0.1}$	sort complete	A1cso

Misreads

- If they have misread a number **at the start of part (a), so genuinely miscopied** and got say 1.0 instead of 0.1 then mark the whole question as a misread – removing the last two A or B marks earned. This gives a maximum total of 9.
- If they have used the correct numbers in part (a) and they then use incorrect numbers in part (b) (say 1.0 instead of 0.1) from the beginning of the sort or misread their own numbers **during part (b)** then count it as an **error in part (b)** but mark part (c) as a misread – giving a maximum of 8 or maybe 7 marks depending on how many marks they lose in (b).

Sorting list into ascending order in (b)

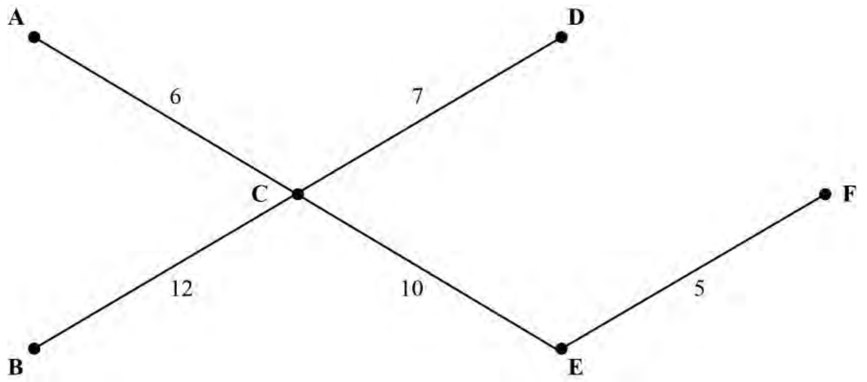
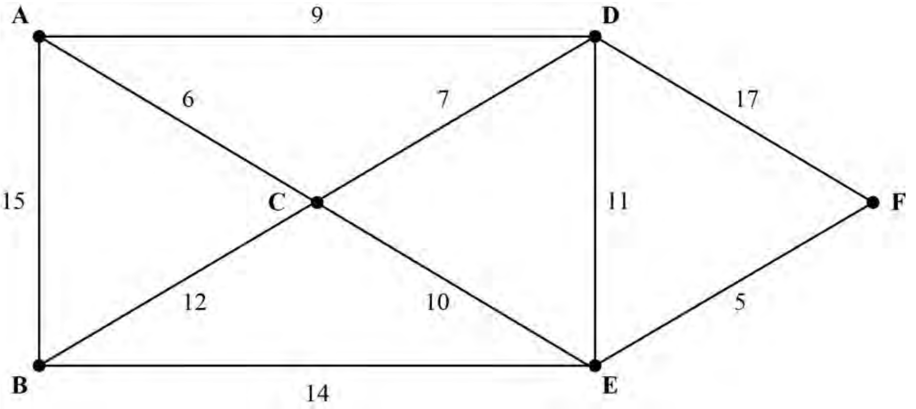
- If the candidate sorts the list into ascending order and reverses the list **in part (b)** then they can score full marks.
- If the list is not reversed in part (b) then mark as a misread (so remove the last two A marks if earned in part (b)). If the list is reversed at the start of part (c) but not in part (b) then still treat this as a misread. If the list is still in ascending order in part (c) award no marks for first fit increasing. If the candidate says that the list needs reversing in part (b) but doesn't actually show the reversed list in part (b) then remove the final A mark.

Ascending (middle left)

0.6	1.5	1.6	0.2	$\boxed{0.4}$	0.5	0.7	0.1	0.9	0.3	(0.4)	M1
0.2	$\boxed{0.1}$	0.3	$\underline{0.4}$	0.6	1.5	$\boxed{1.6}$	0.5	0.7	0.9	(0.1, 0.6)	A1
$\underline{0.1}$	$\boxed{0.2}$	0.3	$\underline{0.4}$	0.6	1.5	$\boxed{0.5}$	0.7	0.9	$\underline{1.6}$	(0.2, 0.5)	
$\underline{0.1}$	$\underline{0.2}$	$\boxed{0.3}$	$\underline{0.4}$	$\underline{0.5}$	0.6	$\boxed{1.5}$	0.7	0.9	$\underline{1.6}$	((0.3), 1.5)	A1ft
$\underline{0.1}$	$\underline{0.2}$	$\underline{0.3}$	$\underline{0.4}$	$\underline{0.5}$	0.6	$\boxed{0.7}$	0.9	$\underline{1.5}$	$\underline{1.6}$	(0.7)	
$\underline{0.1}$	$\underline{0.2}$	$\underline{0.3}$	$\underline{0.4}$	$\underline{0.5}$	0.6	$\underline{0.7}$	0.9	$\underline{1.5}$	$\underline{1.6}$		A1cso+complete

Ascending (middle right)

0.6	1.5	1.6	0.2	0.4	$\boxed{0.5}$	0.7	0.1	0.9	0.3	(0.5)	M1
0.2	0.4	$\boxed{0.1}$	0.3	$\underline{0.5}$	0.6	1.5	$\boxed{1.6}$	0.7	0.9	(0.1, 1.6)	A1
$\underline{0.1}$	0.2	$\boxed{0.4}$	0.3	$\underline{0.5}$	0.6	1.5	$\boxed{0.7}$	0.9	$\underline{1.6}$	(0.4, 0.7)	
$\underline{0.1}$	0.2	$\boxed{0.3}$	$\underline{0.4}$	$\underline{0.5}$	$\boxed{0.6}$	$\underline{0.7}$	1.5	$\boxed{0.9}$	$\underline{1.6}$	(0.3, (0.6), 0.9)	A1ft
$\underline{0.1}$	0.2	$\underline{0.3}$	$\underline{0.4}$	$\underline{0.5}$	$\underline{0.6}$	$\underline{0.7}$	$\underline{0.9}$	1.5	$\underline{1.6}$		A1cso+complete

Question Number	Scheme	Marks
3.(a)	AC, CD, CE; EF; BC	M1; A1; A1 **(3)**
(b)		B1 **(1)**
(c)		B1 B1 **(2)**
(d)	EF, AC, CD, reject AD, CE, reject DE, CB	M1 A1 A1 **(3)**
(e)	Time = 40 (days)	B1 **(1)** **10 marks**

Notes for Question 3

Accept the **weight** of each arc to represent the arcs (as each value is unique).

a1M1: Prim's – first three arcs correctly chosen **or** first four nodes correctly chosen {A, C, D, E, ...}. Any rejections seen during selection **M0**. Order of nodes may be seen at the top of the matrix {1, – , 2, 3, 4, –}
a1A1: First four arcs correctly chosen **or** all six nodes correctly chosen {A, C, D, E, F, B}. Order of nodes may be seen at the top of the matrix {1, 6, 2, 3, 4, 5}
a2A1: CSO (must be considering arcs for this final mark).

Misread: Starting at a node other than A scores **M1 only** – **must** have the first three arcs (or four nodes or numbers) correct.

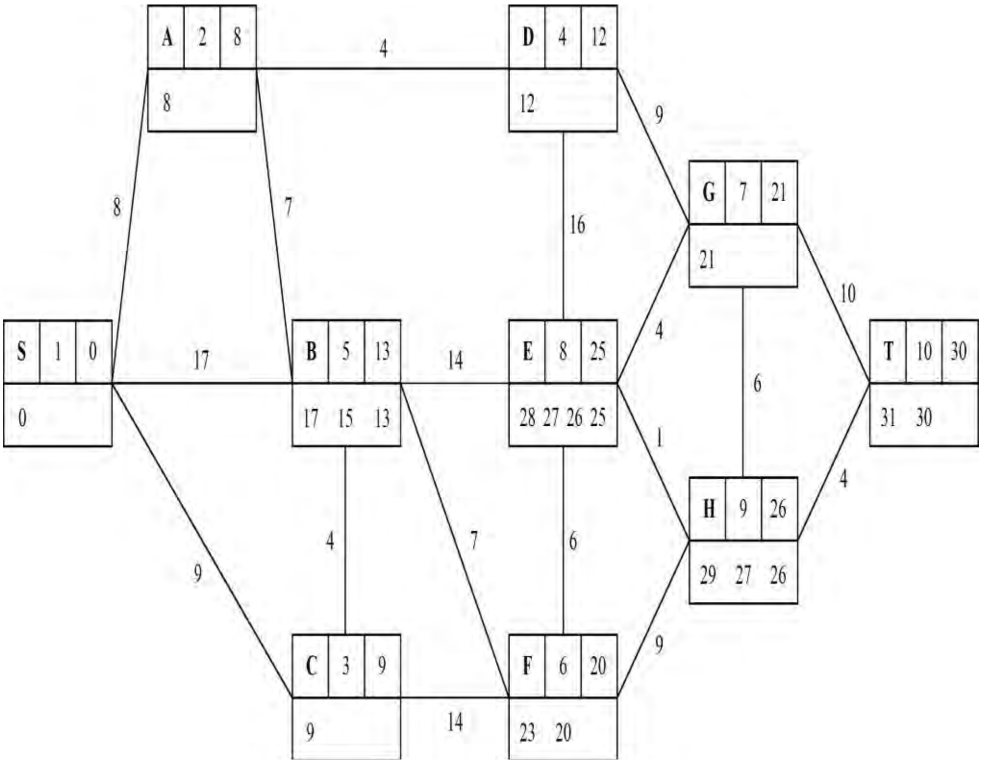
Starting at	Minimum arcs required for M1	Nodes	Order
A	AC CD CE	ACDE(FB)	1(6)234(5)
B	BC AC CD	BCAD(EF)	3124(56)
C	AC CD CE	CADE(FB)	2(6)134(5)
D	CD AC CE	DCAE(FB)	3(6)214(5)
E	EF CE AC	EFCA(DB)	4(6)3(5)12
F	EF CE AC	FECA(DB)	4(6)3(5)21

b1B1: CAO (weights not required)
c1B1: Any four arcs added correctly (weights not required)
c2B1: CAO (including weights) – bod if arcs 'appear' to be crossed out (they may be using the network diagram to answer part (d)).
d1M1: Kruskal's – first three arcs correctly chosen and **at least one rejection seen at some point**.
d1A1: All five arcs selected correctly EF, AC, CD, CE, CB.
d2A1: CAO All selections and rejections correct (in correct order and at the correct time).

- Listing all the arcs in order and then listing those arcs in the tree in the correct order is fine for **full marks** (this implies that rejections are correct and at the correct time)
- Listing all the arcs in order and just drawing the MST is **M0**

SC for part (d): If the network diagram is incorrect in part (c) **and it is clear that the candidate has used part (c) (instead of the original table) to answer part (d)** then award **M1 only** for the first three arcs correctly chosen and at least one rejection seen at some point provided their network is connected and contains at least nine arcs.

e1B1: CAO (ignore lack/incorrect units)

Question Number	**Scheme**	**Marks**
4.(a)	 Shortest path S to T: SADGEHT Length of shortest path S to T: 30 (miles)	M1 A1 (A,B,C,D) A1 (E,F,G) A1ft(H and T) A1 A1ft **(6)**
(b)	Shortest path S to T via F: SCBFEHT Length is 31 (miles)	B1 B1 **(2)** **8 marks**

Notes for Question 4

a1M1: A larger value replaced by a smaller value at least once in the working values at either B or E or F or H or T.

a1A1: **All** values in A, B, C and D correct. The working values at B must be in the correct order.

a2A1: **All** values in E, F and G correct and the working values in the correct order. Penalise order of labelling only once per question (F, G and E labelled in that order and F must be labelled after A, B, C and D).

a3A1ft: **All** values in H and T ft correct and the working values in the correct order. Penalise order of labelling only once per question (H and T labelled in that order and H labelled after all other nodes).

a4A1: Route CAO.

a5A1ft: ft on their final value (if answer is not 30 ft their final value at T).

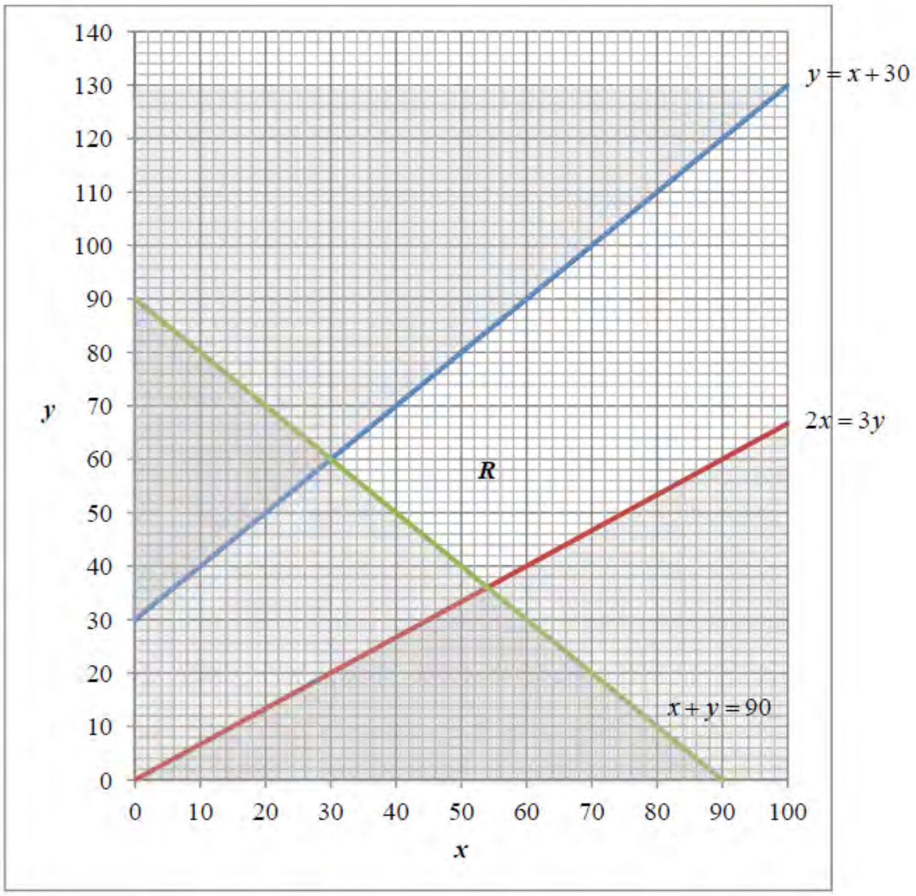
b1B1: Route CAO

b2B1: Length CAO (condone lack of (or incorrect) units throughout).

Question Number	Scheme	Marks
5. (a)	AB + DE = 44 + 30 = 74* AD + BE = 42 + 35 = 77 AE + BD = 39 + 38 = 77 Repeat arcs AC, BC and DE	M1 A3.2.1.0 A1 **(5)**
(b)	E.g. ABCADCBEDFGDEGHECA (18 nodes) Length: 344 + 74 = 418	B1 B1ft **(2)**
(c)	One of AB (44), AD (42) or BD (38) will still have to be repeated. **BD(38) is the shortest** So start at E and **finish at A**, route length now is 344 + 38 = **382**	M1 A1 DA1 **(3)** **10 marks**

Notes for Question 5

a1M1: Three distinct pairings of **their** four odd nodes
a1A1: Any one row correct including pairing **and** total
a2A1: Any two rows correct including pairing **and** total
a3A1: All three rows correct including pairing **and** total
a4A1: CAO correct **arcs** identified AC, BC and DE. Accept ACB or AB via C (check to see if via C appears in working) but **do not** accept AB for this mark
b1B1: Any correct route (checks: eighteen nodes (or seventeen arcs), the route starts and ends at A, pairings AC, BC and DE appear twice in the route and that every letter (A to H inclusive) appears at least once).
b2B1ft: correct answer of 418 **or** 344 + their least out of a choice of at least **two** totals given in part (a)
c1M1: **Either** identifies the need to repeat one pairing which does not include E (could list potential repeats) **or** identifies the need to repeat BD (or 38).
c1A1: Identifies the need to repeat one pairing which does not include E **and** this is BD (38) **because it is the least**. To score the first two marks the candidate must make it clear that they need to repeat **BD because it has the least weight of those pairings that do not include E**.
c2DA1: correct finishing point (A) and length (382). This mark is dependent on them identifying BD (38) as the repeat.

Question Number	Scheme	Marks
6. (a)	He must buy at least 90 boats in total (**x + y 90**)	B1 (1)
(b)	E.g. The number of 2-seater boats(x) must be less than or equal to 1.5 times the number of 4-seater boats (y). (check: y = 2, x = 3, 2, 1, ...) **(2x 3y)** E.g. The number of 4-seater boats (y) must be greater than or equal to 2/3 the number of 2-seater boats (x). (check: x = 3, y = 2, 3, 4, ...)	B1 B1 **(2)**
(c)	The correct 3 lines added; x + y = 90; 3y = 2x; y = x + 30 Region, R labelled	B1; B1; B1 B1 **(4)**
(d)	(minimise C =) 100x + 300y	B1 **(1)**
(e)	Method clear – either at least 2 vertices tested or objective line drawn (54, 36), so 54 2-seater and 36 4-seater At a cost of £16 200	M1 A1 B1 B1 **(4)** **12 marks**
		

Notes for Question 6

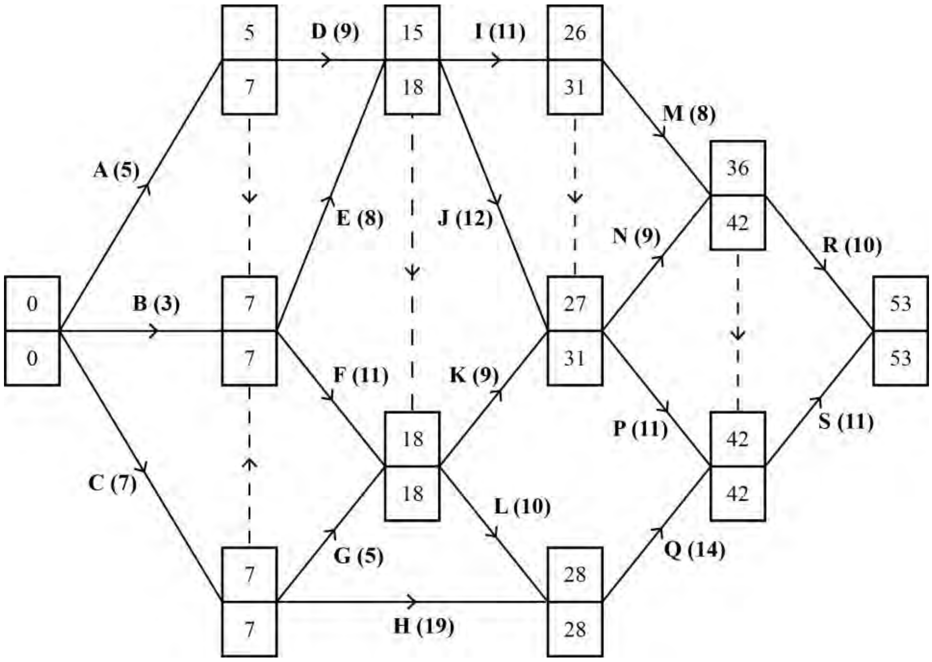
a1B1: CAO (must have ‘boats’, ‘least’, ‘90’, must be talking about boats **not** cost)
b1B1: For a statement in context with either the ratio of coefficients correct (the 2 with the 2-seater and the 3 with the 4-seater) **or** inequality correct with correct numbers present but not in the correct ratio.
b2B1: Clear accurate correct statement in context.
c1B1: x + y = 90 correctly drawn. Must pass within one small square of the points of intersection with the axes
c2B1: 3y = 2x correctly drawn. Must pass within one small square of the origin and (90, 60).
c3B1: y = x + 30 correctly drawn. Must pass within one small square of (0, 30) and (60, 90).
c4B1: Region, R, correctly labelled – not just implied by shading – must have scored all three previous marks in this part.
d1B1: CAO (isw if 100x + 300y‘simplified’ to k(100x + 300y) but if 100x + 300y not stated then B0)
e1M1: Line must be correct to within one small square if extended from axis to axis **OR** attempting to find two vertices of their R (or the correct R) by either reading off their graph or using simultaneous equations **and** testing using **their** objective function.
e1A1: Correct objective line (same condition that the line must be correct to within one small square if extended from axis to axis) **OR** testing (30, 60) correctly (giving 21 000) **and** testing (54, 36) correctly (giving 16 200).
e1B1: Correct point identified. (Condone in terms of x and y rather than in terms of boats.)
e2B1: CAO – condone lack of/incorrect units on the cost.

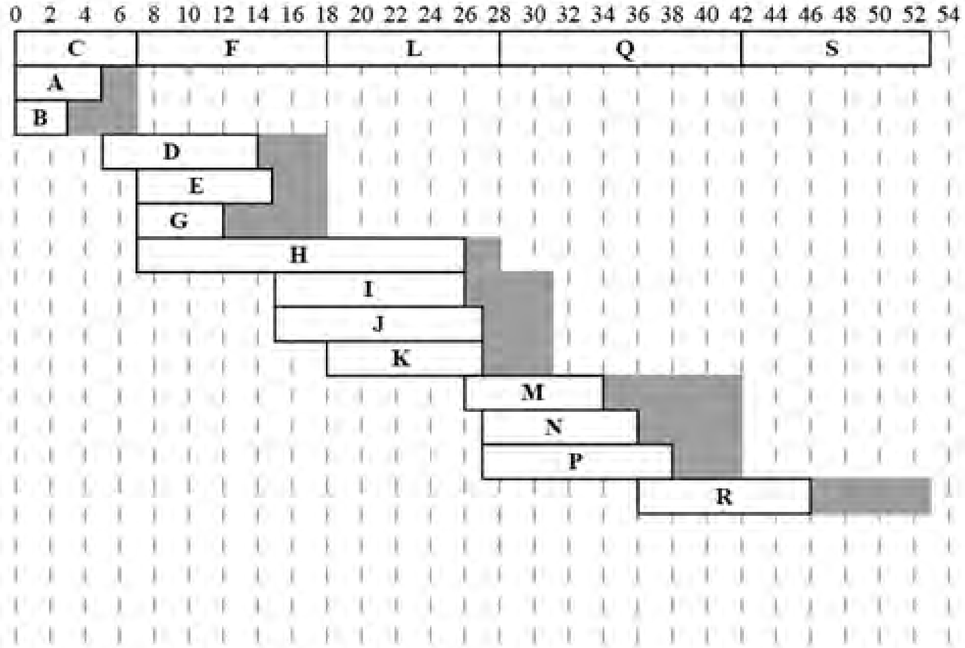
Examples for part (b) scoring B1 B1 (**useful check:** when y = 2, x = 3, 2, 1, … **or** when x = 3, y = 2, 3, 4, ...)

- Twice the number of 2-seater boats must be at most three times the number of 4-seater boats
- Three times the number of 4-seater must be at least twice the number of 2-seater boats
- **For every three 2-seater boats there must be at least two 4-seater boats** (or multiple of this ratio)
- **For every two 4-seater boats there must be at most three 2-seater boats** (or multiple of this ratio)
- At most 60% of the total boats are 2-seater
- At least 40% of the total boats are 4-seater

Examples of B1 B0 – **in each case either the inequality is the correct way round OR the 2 is with 2-seater boats and the 3 is with the 4-seater boats** (accept multiples of 2 and 3) (useful numbers: when y = 2, x = 3, 4, 5,… when x = 3, y = 2, 1, …, when y = 3, x = 2, 1, …, when x = 2, y =3, 4, 5, …)

- Twice the number of 2-seater boats must be at least three times the number of 4-seater boats
- Three times the number of 4-seater must be at most twice the number of 2-seater boats
- Three times the number of 2-seater must be at least twice the number of 4-seater boats
- **For every three 2-seater boats there must be at most two 4-seater boats (or multiple of this ratio)**
- **For every two 4-seater boats there must be at least three 2-seater boats (or multiple of this ratio)**
- **For every two 2-seater boats there must be at least three 4-seater boats (or multiple of this ratio)**
- **For every three 4-seater boats there must be at most two 2-seater boats (or multiple of this ratio)**
- At least 60% of the total boats are 2-seater
- At most 40% of the total boats are 4-seater
- At least 60% of the total boats are 4-seater
- At most 40% of the total boats are 2-seater

Question Number	Scheme	Marks
7.(a)		M1 A1 M1 A1 **(4)**
(b)	Float on M = 42 – 26 – 8 = 8	M1 A1 **(2)**
(c)(i) **(c)(ii)**	2 day delay on P – no effect on the project completion date (float on P is 4) 2 day delay on Q – project finishes 2 days late (Q is a critical activity)	B1 B1 **(2)**
(d)	(172/53 = 3.245, so) a minimum of 4 workers needed	B1 **(1)**

Question Number	Scheme	Marks
(e)		M1 A1 (any 6 more) M1 A1 (all 11) **(4)**
(f)	E.g. Activities H, I, J, K and L together with 22 < time < 26 stated. So 5 workers needed	M1 A1 **(2)**
(g)	The cascade gives a higher lower bound, so (f) is better.	M1 A1 **(2)**
		17 marks

Notes for Question 7

Notes:

a1M1: All top boxes complete, values generally increasing left to right, condone one 'rogue' (if values do not increase from left to right then if one value is ignored and then the values do increase from left to right then this is considered to be only one rogue value)
a1A1: CAO.
a2M1: All bottom boxes complete, values generally decreasing right to left, condone one 'rogue'.
a2A1: CAO
b1M1: Correct calculation seen – all three numbers correct (ft), float 0.
b1A1: Float correct (no ft on this mark)
c1B1: CAO
c2B1: CAO
d1B1: 4 with (or without) working scores this mark
e1M1: At least six activities added including six floats. Scheduling diagram scores M0.
e1A1: Six activities including their floats dealt with correctly.
e2M1: All remaining eleven activities including all eleven floats.
e2A1: CAO.

Examples for part (f):

Example 1: Activities H, I, J, K and L with $22 < \text{time} < 26$ so 5 workers needed.
Example 2: At $10 < \text{time} < 14$, F, D, E and H must be happening. Activity G must be happening $7 < \text{time} < 18$ but its duration is 5 so it must also occur at some point in the interval $10 < \text{time} < 14$ so 5 workers needed.

f1M1: Example 1: A statement with the correct number of workers (5) **and** the correct activities (H, I, J, K and L) with some mention of time, **or**
Example 2: A statement with the correct number of workers (5), the correct activities (F,D,E and H) with some mention of time **and** an indication that G **must** be happening with the other four activities at some point - give bod but e.g. 'at time 11 F, D, E, G and H must be happening' is **M0**). **Scheduling** the activities only scores **M0**.

f1A1: A correct, complete full statement with details of both time **and** activities. Candidates only need to give a time within the intervals stated.

Please note strict inequalities for the time. Allow e.g. **on** 'day 23' as equivalent to $22 < \text{time} < 23$.

g1M1: **Must have attempted both parts (d) and (f). Their** higher lower bound chosen + attempt at a reason.

Allow for the M mark a reason which argues that e.g. the cascade chart gives a better lower bound (e.g. it takes into account exactly when activities must be taking place) **or** e.g. the calculation gives a better lower bound (e.g. as it takes into account the sum of all the activities) but without specifically answering the question of which of the two bounds is better. Give bod on an attempt at a reason.

g1A1: CAO plus a correct reason given. Acceptable reasons e.g. the cascade gives a larger value **or** the bound for the cascade shows that the project cannot be done with fewer workers, etc.

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Mark Scheme (Results)

January 2014

Pearson Edexcel International
Advanced Level

Decision Mathematics 1 (WDM01/01)

Edexcel and BTEC Qualifications

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January 2014
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EDEXCEL GCE MATHEMATICS

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These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
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- * The answer is printed on the paper
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4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

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7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. (a)	Either 11 10 14 8 13 6 4 15 7 17	M1 A1 **(2)**
	Or 4 11 17 10 14 8 13 6 7 15	
(b)	e.g. using middle right	
	11 17 10 14 8 $\boxed{13}$ 6 4 15 7 pivot 13	M1
	17 $\boxed{14}$ 15 $\underline{13}$ 11 10 8 $\boxed{6}$ 4 7 pivots 14, 6	1A1
	17 $\boxed{15}$ $\underline{14}$ $\underline{13}$ 11 10 $\boxed{8}$ 7 $\underline{6}$ 4 pivots 15, 8 (4)	
	17 $\underline{15}$ $\underline{14}$ $\underline{13}$ 11 $\boxed{10}$ $\underline{8}$ 7 $\underline{6}$ 4 pivots (17), 10, (7)	2A1ft
	17 $\underline{15}$ $\underline{14}$ $\underline{13}$ 11 $\underline{10}$ $\underline{8}$ 7 $\underline{6}$ 4 (sort complete)	3A1 **(4)**
(c)	$\frac{105}{26} \approx 4.0385$ so 5 bins needed	M1 A1 **(2)**
		8 marks

Notes

a1M1: Bubble sort, end number in place correctly.
a1A1: CAO – isw after one complete pass

SC for (a): If list sorted into ascending order – must be fully correct so either
17 11 14 10 13 8 6 15 7 4 or 17 11 15 10 14 8 13 6 4 7 scores M1A0

b1M1: Quick sort – pivots, p, selected and first pass gives <p, p, >p. **If only choosing 1 pivot per iteration M1 only. Using bubble sort in this part is M0.**
b1A1: First pass correct, pivots chosen consistently for second pass.
b2A1ft: Second and third passes correct (ft from their first pass and choice of pivots) – need not be choosing the pivot for the fourth pass for this mark.
b3A1: CSO all correct including choice of pivots for the fourth pass and then **either** a 'stop' statement **or** final re-listing **or** using each item as a pivot.

Note: In part (b) if **either** ascending quick sort (which is not reversed at the end of the sort) **or** using the list after part (a) then mark as a misread (so remove the final two A marks earned in this part – so max of 2/4 in (b)). If list is reversed in part (b) after ascending quick sort then full marks can be awarded. If attempting quick sort on ordered list then M0.

c1M1: Attempt to find lower bound (105 ± 17) / 26, **or** answer correct to 3 significant figures (either truncated or rounded) so accept 4.03 or 4.04). Must be a numerical argument.
c1A1: CSO including 5 (5 with no working scores M0).

Notes for Question 1 continued

Alternatives to 1(b)

Middle left ascending

11	17	10	14	$\boxed{8}$	13	6	3	15	7	pivot 8	M1
11	17	$\boxed{10}$	14	13	15	$\underline{8}$	6	$\boxed{4}$	7	pivots 10, 4	1A1
11	17	$\boxed{14}$	13	15	$\underline{10}$	$\underline{8}$	$\boxed{6}$	7	$\underline{4}$	pivots 14, 6	
$\boxed{17}$	15	$\underline{14}$	$\boxed{11}$	13	$\underline{10}$	$\underline{8}$	7	$\underline{6}$	$\underline{4}$	pivots 17, 11, (7)	2A1ft
$\underline{17}$	15	$\underline{14}$	13	$\underline{11}$	$\underline{10}$	$\underline{8}$	7	$\underline{6}$	$\underline{4}$	sort complete	3A1

Misreads for 1(b)

Middle right											Middle left										
11	17	10	14	8	$\boxed{13}$	6	4	15	7	pivot 13	11	17	10	14	$\boxed{8}$	13	6	4	15	7	pivot 8
11	10	8	$\boxed{6}$	4	7	$\underline{13}$	17	$\boxed{14}$	15	pivots 6, 14	6	$\boxed{4}$	7	$\underline{8}$	11	17	$\boxed{10}$	14	13	15	pivots 4, 10
4	$\underline{6}$	11	10	$\boxed{8}$	7	$\underline{13}$	$\underline{14}$	17	$\boxed{15}$	pivots 8, 15	$\underline{4}$	$\boxed{6}$	7	$\underline{8}$	$\underline{10}$	11	17	$\boxed{14}$	13	15	pivots 6, 14
4	$\underline{6}$	7	$\underline{8}$	11	$\boxed{10}$	$\underline{13}$	$\underline{14}$	$\underline{15}$	17	pivot 10	$\underline{4}$	$\underline{6}$	7	$\underline{8}$	$\underline{10}$	$\boxed{11}$	13	$\underline{14}$	$\boxed{17}$	15	pivots 11, 17
4	$\underline{6}$	7	$\underline{8}$	$\underline{10}$	11	$\underline{13}$	$\underline{14}$	$\underline{15}$	17	sort complete	$\underline{4}$	$\underline{6}$	7	$\underline{8}$	$\underline{10}$	$\underline{11}$	13	$\underline{14}$	15	$\underline{17}$	sort complete

:

Question Number	Scheme	Marks
2. (a)	AB, BC, CF, CE; FG, AD; EH, HI	M1; 1A1; 2A1 **(3)**
(b)	£191	B1 **(1)**
(c)(i)	CF, reject CE, AB, FG;{AD, reject AC}, reject DG, {reject BE, reject DF}, EH, reject FH, HI (Note BC and EF are already in the tree)	M1; 1A1 2A1
(ii)	e.g. Prim cannot be used since with Prim the tree 'grows' in a connected fashion e.g. Kruskal can build its tree from disconnected fragments	B2,1,0 **(5)**
(d)	£147	B1 **(1)**
		10 marks

Notes

a1M1: First four arcs (AB, BC, CF, CE) correctly chosen, or first five nodes (ABCFE) correctly chosen in order. **If any rejections seen at any point then M1 (max) only.**

a1A1: First six arcs correctly chosen (AB, BC, CF, CE, FG, AD), or all nodes in order (ABCFEGDHI).
a2A1: CSO (must be arcs).
b1B1: CAO
ci1M1: Kruskal's - first three arcs (CF, AB, FG) correctly chosen and **at least one rejection seen at some point.**
ci1A1: All arcs in tree selected correctly at correct time (CF, AB, FG, AD, EH, HI). Ignore any reference to BC and EF.
ci2A1: CSO including all rejections correct and at the correct time. Ignore any reference to BC and EF.
cii1B1: Partially correct answer – e.g. an indication that the arcs (BC and EF) are not connected **or** any mention of the tree being (initially) disconnected - so in both of these examples a pertinent correct statement is made but no explicit mention is made to either of the two minimum connector algorithms (i.e. no mention is made of Prim requiring arcs to be connected or that Kruksal can grow in a disconnected fashion). Give bod but for this mark there must be some mention of the 'unconnected' nature of the two initial arcs or problem. Note: describing how Kruskal can be adapted to find the MST scores no marks.
cii2B1: Fully correct answer (so either Kruskal allows a tree to be formed from initially unconnected arcs or Prim requires the arcs/tree to be connected at all times - so linking the correct algorithm with the issues of this particular problem) – do not condone incorrect technical language for this mark (e.g. vertex for arc, point for vertex etc.)
d1B1: CAO

Question Number	Scheme	Marks

Notes for Question 2 continued

Misread: Starting at a node other than A scores **M1 only** – must have the first four arcs (or five nodes) correct.

Starting at	Minimum arcs required for M1 only	Nodes
A	AB, BC, CF, CE	ABCFE
B	AB, BC, CF, CE	BACFE
C	CF, CE, FG, BC	CFEGB
D	AD, AB, BC, CE	DABCE
E	CE, CF, FG, BC	ECFGB
F	CF, CE, FG, BC	FCEGB
G	FG, CF, CE, BC	GFCEB
H	EH, CE, CF, FG	HECFG
I	HI, EH, CE, CF	IHECF

Question Number	Scheme	Marks
3. (a)	A matching is a **pairing** of some or all of the elements of **one set** X, **with** elements of **another** set Y	1B1 2B1 **(2)**
(b)	B – 5 = S – 4 = T – 6 Change status to give B = 5 – S = 4 – T = 6 Improved matching: B = 5, C = 1, (H unmatched), K = 2, S = 4, T = 6	M1 1A1 2A1 **(3)**
(c)	Either H – 6 = T – 4 = S – 2 = K – 1 = C – 3 Changing status to give: H = 6 – T = 4 – S = 2 – K = 1 – C = 3 Complete matching: B = 5, C = 3, H = 6, K = 1, S = 2, T = 4	 M1 1A1 2A1 **(3)**
	Alternative H – 6 = T – 4 = S – 5 = B – 2 = K – 1 = C – 3 Changing status to give: H = 6 – T = 4 – S = 5 – B = 2 – K = 1 – C = 3 Complete matching: B = 2, C = 3, H = 6, K = 1, S = 5, T = 4	**8 marks**

Notes

a1B1: pairing or one to one
a2B1: element(s) from one set with element(s) of the other.
b1M1: Alternating path from B to 6 - or vice versa
b1A1: CAO including change status (stated or shown), chosen path clear.
b2A1: CAO. Must follow from correct stated path, diagram okay (must be a clear diagram with only five arcs)
c1M1: Alternating path from H to 3 (or vice versa)
c1A1: CAO including change status (stated or shown), chosen path clear.
c2A1: CAO. Must follow from two correct stated paths, diagram okay (must be a clear diagram with only six arcs). Must have scored both M marks in part (b) and (c).

Question Number	Scheme	Marks
4. (a)	AE + IJ = 56 + 38 = 94	M1 1A1
	AI + EJ = 54 + 39 = 93*	2A1
	AJ + EI = 47 + 48 = 95	3A1
	Repeat arcs AB, BD, DH, HI, EG and GJ.	4A1 **(5)**
(b)	Length: 367 + 93 = 460 metres	B1ft **(1)**
(c)	Only AE needs to be repeated so new length is 367 + 35 + 56 = 458 metres	M1
	So the distance travelled by the robot is decreased	A1ft **(2)**
		8 marks

Notes

a1M1: Three distinct pairings of **their** four odd nodes

a1A1: One row correct including pairing **and** total

a2A1: Two rows correct including pairing **and** total

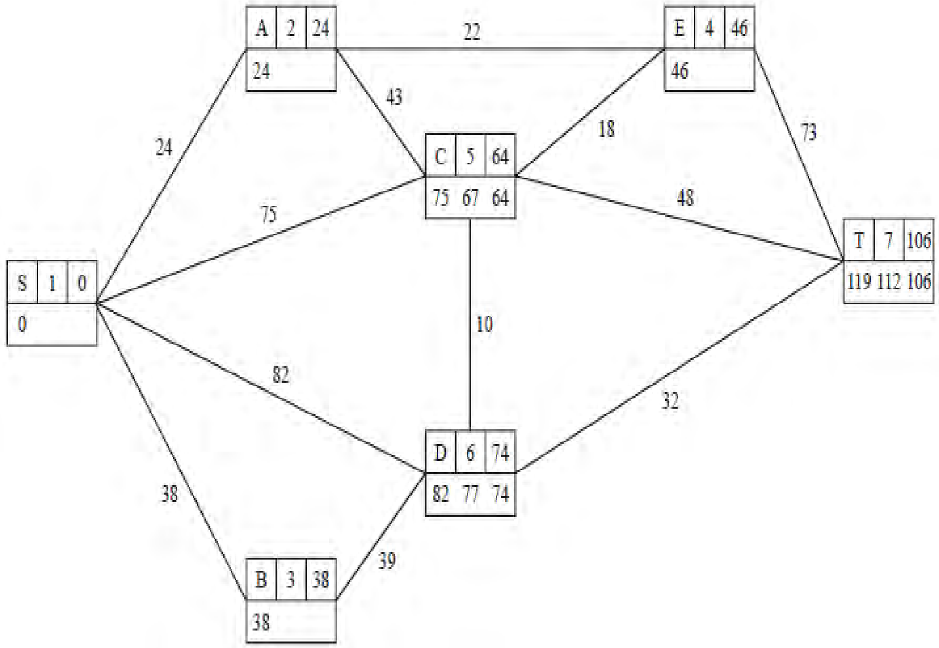
a3A1: Three rows correct including pairing **and** total

a4A1: CAO correct **arcs** identified AB, BD, DH, HI, EG, GJ (accept ABDHI and EGJ).

b1B1ft: **Must have a choice of at least two pairs seen in part (a)**. 379 + their least from (a).

c1M1: Aim to include their AE (56) [ft from (a)] and add IJ (35) **or** 35 + '56' **or** 367 + 35 + '56'. Must see a numerical argument. Or if AE + IJ was the smallest pairing from (a) then comparing/mention of 35 with 38.

c1A1ft: Correct calculation and conclusion from their working.

Question Number	Scheme	Marks
5. (a)	 Shortest path S to T: SAECDT Length of shortest path S to T: 106 km	M1 1A1 (SABE) 2A1 (CD) 3A1ft (T) 4A1 5A1ft **(6)**
(b)	Shortest paths S to T excluding CE: SACDT and SBDT Length is 109 km	DM1 1A1 2A1 **(3)** **9 marks**

Notes

a1M1: Big replaced by smaller at least once in the working values at either C or D or T.

a1A1: S, A, B and E boxes all correct, including order of labelling.

a2A1: C and D boxes all correct (including working values in the correct order). Penalise order of labelling only once per question (so C and D labelled in that order with C labelled after S, A, B and E).

a3A1ft: T correct ft (including working values in the correct order). Penalise order of labelling only once per question (so T labelled after all other nodes).

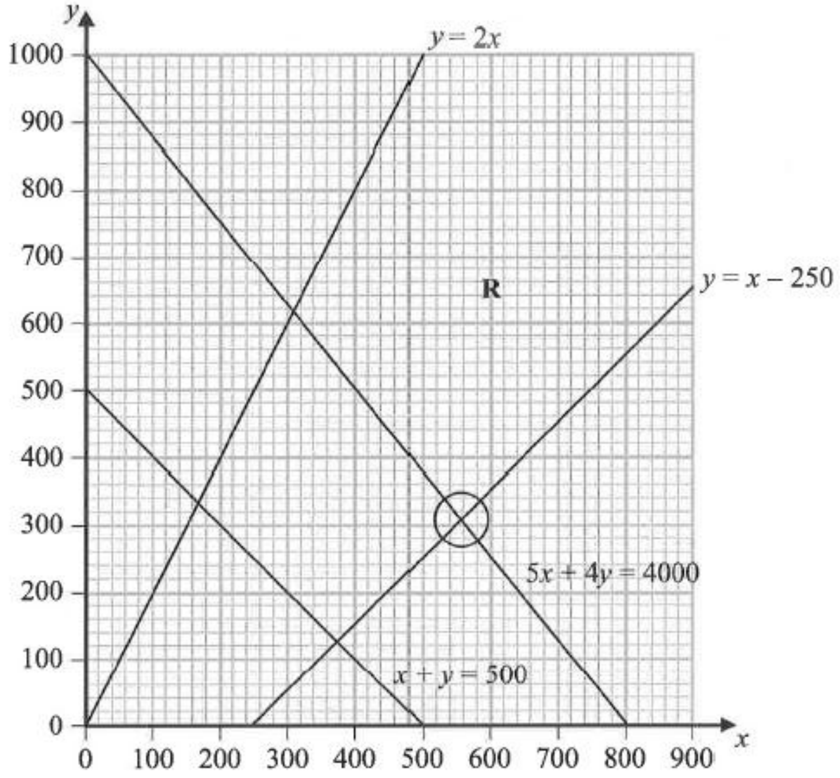
a4A1: Route (SAECDT) CAO

a5A1ft: ft on their final value (if their answer is not 106 ft their final value at T) – ignore incorrect/lack of units.

b1DM1: Must have scored the M mark in (a). Finding at least one correct path from S to T excluding arc CE.

b1A1: Both paths correct (SACDT and SBDT)

b2A1: Length (109) CAO (ignore incorrect/lack of units)

Question Number	Scheme	Marks
6. (a)		B3, 2, 1, 0 4B1 R labelled **(4)**
(b)	Use SE to find exact intersection of $5x + 4y = 4000$ with $y = x - 250$ Use SE to find exact intersection of $5x + 4y = 4000$ with $y = 2x$	1M1 2M1
	$P\left(555\frac{5}{9}, 305\frac{5}{9}\right)$, and $\left(307\frac{9}{13}, 615\frac{5}{13}\right)$	1A1, 2A1
	Attempting to evaluate C at **both** points **and** selecting optimal point	3M1
	$C_p = \; 2\times555\frac{5}{9}+5\times305\frac{5}{9}=2638\frac{8}{9}$ $\left[\text{other is } 3692\frac{4}{13}\right]$	3A1 **(6)**
(c)	Maximum value of $k = 861\frac{1}{9}$	M1 A1 **(2)**
		12 marks

Notes

(a) Lines must pass though one small square of points stated.

a1B1: for two lines drawn correctly
a2B1: for three lines drawn correctly
a3B1: for all four lines drawn correctly

Question Number	Scheme	Marks

Notes for Question 6 continued

$x + y = 500$ passes through (0, 500), (250,250), (500, 0)
$5x + 4y = 4000$ passes through (0, 1000), (400,500), (800, 0)
$y = 2x$ passes through (0, 0), (200,400), (400, 800)
$y = x - 250$ passes through (250, 0), (500,250), (700, 450)

a4B1: Region, R, labelled correctly - not just implied by shading - must have scored all three previous marks in this part.

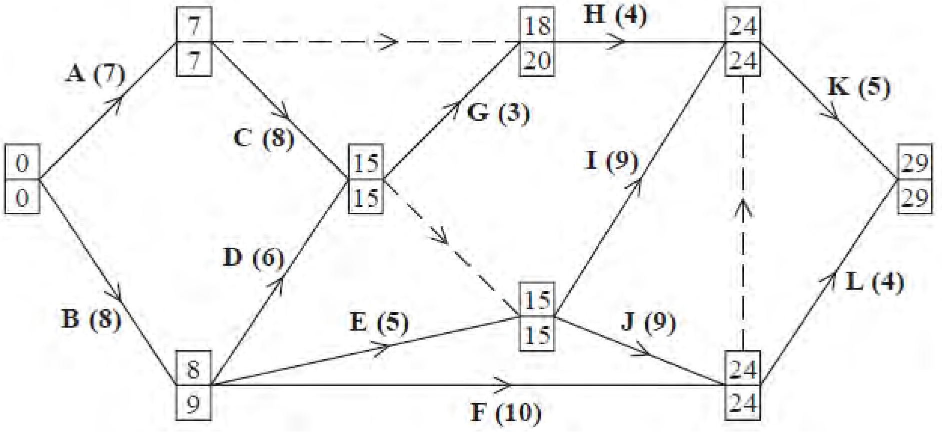
b1M1: Must see simultaneous equations ($y = x - 250$ and $5x + 4y = 4000$) being used to find 'exact' point (or correct to 2 dp) – must get to $x = \cdots$ or $y = \cdots$.
b2M1: Must see simultaneous equations ($y = 2x$ and $5x + 4y = 4000$) being used to find 'exact' point (or correct to 2 dp) – must get to $x = \cdots$ or $y = \cdots$.
b1A1: accept awrt (555.56, 305.56) exact answers are $\left(\frac{5000}{9}, \frac{2750}{9}\right)$ or $\left(555\frac{5}{9}, 305\frac{5}{9}\right)$
b2A1: accept awrt (307.69, 615.38) exact answers are $\left(\frac{4000}{13}, \frac{8000}{13}\right)$ or $\left(307\frac{9}{13}, 615\frac{5}{13}\right)$

SC: If no working shown and coordinates are given exactly or correct to 2dp then award M0M0A1A1 (if one coordinate correct then M0M0A1A0 or M0M0A0A1 – award in order as given in b1A1 and b2A1)

b3M1: Evaluating C at **both** of their points and **clearly selecting** their optimal point
b3A1: CAO, accept answer correct to 4 s.f. (either truncated or rounded) – so accept either the correct exact answer or an awrt to either 2638 or 2639 - must be clearly **selected** as optimal value $\left(\text{exact values are } \boldsymbol{\frac{23750}{9}} \textbf{ or } \boldsymbol{2638\frac{8}{9}} \text{ the other value is } \frac{48000}{13} \text{ or } 3692\frac{4}{13}\right)$
c1M1: Seeking to find $x + y$ at their optimal point.
c1A1: CAO, accept awrt 861.11 $\left(\text{exact value is } \frac{7750}{9} \text{ or } 861\frac{1}{9}\right)$

Question Number	Scheme	Marks

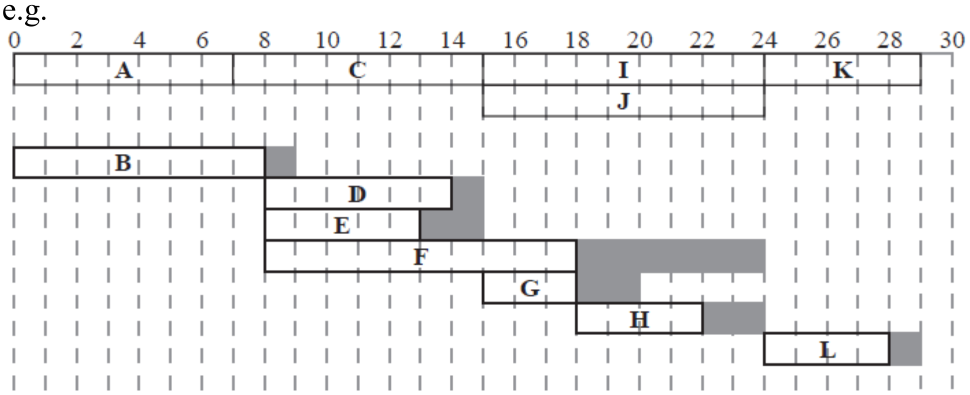
7. (a)



1M1 1A1

2M1 2A1 **(4)**

(b) e.g.



1M1 1A1

2M1 2A1 **(4)**

(c) Four workers e.g.

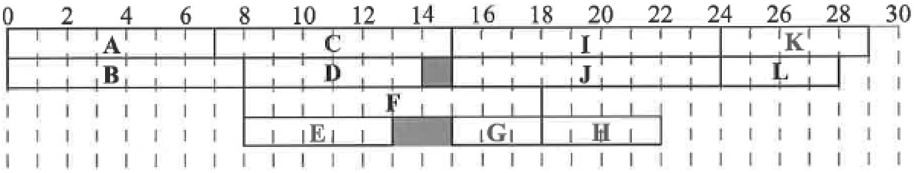
between 17 < time < 18, four activities I, J, F and G need to be happening

1B1 2B1

(2)

(d) e.g.

M1 1A1



2A1 3A1 **(4)**

14 marks

Notes

a1M1: All top boxes complete, values generally increasing left to right, condone one rogue value.
a1A1: CAO

Question Number	Scheme	Marks

Notes for Question 7 continued

a2M1: All bottom boxes complete, values generally decreasing right to left, condone one rogue value. Condone missing 0 or 29 for the M only.
a2A1: CAO
b1M1: Not a scheduling diagram. At least 9 activities including at least 4 floats.
b1A1: Critical activities dealt with correctly.
b2M1: All 12 activities including at least 7 floats.
b2A1: Non-critical activities dealt with correctly.
c1B1: A correct answer of 4, with the correct activities (IJFG) and some mention of time.
c2B1: A correct statement with details of time and activities. Note strict inequality on time – note that **on** day 18 is equivalent to 17 < time < 18.
d1M1: Not a cascade chart. 4 'workers' used at most. At least 7 activities.
d1A1: ABCIJK correct. A – 7; B – 8: C – 8; I – 9; J – 9; K – 5. B completed by its late finish time (9).
d2A1: 4 workers. All 12 activities present (just once). Condone one error either precedence, or activity length, on activities D, E, F, G, H, L.
d3A1: 4 workers. All 12 activities present (just once). No errors on activities D, E, F, G, H, L

Activity	Duration	I.P.A.		Activity	Duration	I.P.A.
A	7	-		**G**	**3**	**C D**
B	8	-		**H**	**4**	**A G**
C	8	A		I	9	C D E
D	**6**	**B**		J	9	C D E
E	**5**	**B**		K	5	F H I J
F	**10**	**B**		**L**	**4**	**F J**

Question Number	Scheme	Marks
8.	Minimise $(C) = 660x + 600y$	B1
	Subject to: $20x + 50y \geq 15000 \Rightarrow 2x + 5y \geq 1500$	1M1 1A1
	$\frac{2}{5}(x + y) \leq x \leq \frac{3}{5}(x + y)$	2M1
	Which simplifies to $2y \leq 3x$ **and** $2x \leq 3y$ or equivalent. $(x, y \geq 0)$	2A1, 3A1
		6 marks

Notes

1B1: CAO Expression correct and 'minimise'. Accept working in £'s (C) = 6.6*x* + 6*y*
1M1: Condone incorrect inequality (but not equals) sign seen here.
1A1: CAO Must have 2*x*, 5*y* and 1500.
2M1: Correct method, dealing with both 40% and 60% of total items – need to see both $\frac{2}{5}(x + y)$ **and** $\frac{3}{5}(\mathrm{x} + \mathrm{y})$ as part of an inequality (not an equation).
2A1: CAO for the 40% inequality – accept strict inequality
3A1: CAO for the 60% inequality – accept strict inequality - may be combined into one inequality

SC: if 2A0 and 3A0 then award SCA1A0 for either $k(2y) \leq k(3x)$ or $k(2x) \leq k(3y)$ for any positive integer k.

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<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Pivots</td></tr>
<tr><td>M</td><td>S</td><td>Q</td><td>C</td><td>E</td><td>P</td><td>B</td><td>F</td><td>O</td><td>E</td></tr>
<tr><td>C</td><td>B</td><td>E</td><td>M</td><td>S</td><td>Q</td><td>P</td><td>F</td><td>O</td><td>B,P</td></tr>
<tr><td>B</td><td>C</td><td>E</td><td>M</td><td>F</td><td>O</td><td>P</td><td>S</td><td>Q</td><td>(C),F,Q</td></tr>
<tr><td>B</td><td>C</td><td>E</td><td>F</td><td>M</td><td>O</td><td>P</td><td>Q</td><td>S</td><td>O,(S)</td></tr>
<tr><td>B</td><td>C</td><td>E</td><td>F</td><td>M</td><td>O</td><td>P</td><td>Q</td><td>S</td><td>(M)</td></tr>
</table>
Sort complete</td><td>M1
A1
A1ft
A1 (4)</td></tr>
<tr><td>(b)</td><td>Pivot 1 = $\left[\frac{1+9}{2}\right] = 5$ McCANN reject 1-5
Pivot 2 = $\left[\frac{6+9}{2}\right] = 8$ QUAGLIA reject 8-9
Pivot 3 = $\left[\frac{6+7}{2}\right] = 7$ PATEL
P = PATEL, name found (so 3 iterations)</td><td>M1
A1
A1 (3)</td></tr>
<tr><td>(c)</td><td>e.g. $\log_2 641 = 9.324$, so 10 or maximum number of items in each pass:
641, 320, 160, 80, 40, 20, 10, 5, 2, 1
so 10 iterations</td><td>M1
A1 (2)
(9 marks)</td></tr>
</table>

Notes for Question 1

a1M1: Quick sort – pivots, p, selected and first pass gives <p, p, >p. **If only choosing one pivot per iteration M1 only.**
a1A1: First pass correct, next two pivots chosen correctly for second pass.
a2A1ft: Second and third passes corrrect (follow through from their first pass and choice of pivots) – and next pivot(s) chosen consistently for fourth pass.
a3A1: CSO and 'sort complete' this could be shown **either** by a 'stop' statement **or** final list re-written **or** using each item as a pivot.
b1M1: Choosing middle right pivot (choosing middle left is M0) + discarding/retaining half the list. M1 **only** for an 'incorrect' list – allow 1 error (e.g. two letter interchanged) or 1 omission or 1 extra.
b1A1: First and second passes correct i.e. 5th and 8th items for a correct list **and** second half rejected (no sticky pivots).
b2A1: CSO Third pass correct i.e. 7th item for a correct list + "found" (accept 'found', 'located', 'stop', etc. but not just the letter; must be convinced that P has been located). The number of iterations does **not** need to be stated explicitly.

Part (c): Candidates who consider maximum number of values at the start of each iteration:

- **M1** for at least 641, 320, 160, 80, … or embedded in a calculation e.g. [641+1] / 2 = 321, [320 + 1] / 2 = 161, [160 + 1] / 2 = 81, [80 + 1] / 2 = …
- **M1 A1** 641, 320, 160, 80, 40, 20, 10, 5, 2, 1 so 10 iterations

Candidates who consider maximum number of values at the end of each iteration:

- **M1** for at least 320, 160, 80, …
- **M1 A1** 320, 160, 80, 40, 20, 10, 5, 2, 1 so 10 iterations (so 9 iterations is A0).

Question Number	Scheme	Marks

Other numerical arguments

(The maximum number of iterations is the least integer value of n such that)

- **M1** $2^n > 641$ then **either** taking logs of both sides and attempt to solve for n (accept $2^n = 641$) **or** stating $n = 9.32$ ... (answer given correct to 1 dp).
- **M1 A1** the above with $n = 10$ (no errors if calculation seen) (allow recovery from equals).
- **M1** those candidates who state $2^n > 641$ and state $n = 10$ with no working unless 2^9 also considered.
- **M1** $\log_2 641 = \cdots$
- **M1 A1** ... = 9.32 ... (answer given correctly to 1 dp) and hence 10.
- $\frac{641}{2^n}$ considered with $n = 10$ is **M1** showing explicitly that $n = 10$ is the first value that gives value less that 1 gets **A1** (it is not sufficient to just say that $\frac{641}{2^{10}}$ is less than 1 either $\frac{641}{1024}$ or 0.625… (correct to 1 dp) must be seen).
- Candidates who say that halving 641 ten times gives a value less than 1 (or equal to 1) **M1 only**. Accept = 1 as when candidates talk about halving/dividing by 2 it is not always clear if they mean half the list or half the numbers in the list. However if the candidate explicitly shows that halving 641 ten times gives a value less than 1 which must be given either exactly or correct to 1 dp then **A1**.
- An answer of 10 with no working **M0**

Middle left for (a)

									Pivots
M	S	Q	C	**E**	P	B	F	O	E
C	B	E	M	S	**Q**	P	F	O	C,Q
B	C	E	M	**P**	F	O	Q	**S**	(B), P, (S)
B	C	E	M	**F**	O	P	Q	S	F
B	C	E	F	**M**	O	P	Q	S	M
B	C	E	F	**M**	O	P	Q	S	(O)

Sort complete

Question Number	Scheme	Marks
2. (a)	(i) Complete matching: A matching where **every** member of **set** X is **paired** with a single member of set Y and vice-versa. (ii) Difference: A maximal matching is where the number of edges is as **large as possible** without necessarily pairing all vertices. A complete matching pairs **all** vertices.	B1 B1 B1 **(3)**
(b)	E.g. Alternating path: C – L = A – O Change status: C = L – A = O Improved matching: A = O, B = M, C = L, E = N, F = P	M1 A1 A1 **(3)**
(c)	E.g. Alternating path: D – M = B – K Change status: D = M – B = K Complete matching: A = O, B = K, C = L, D = M, E = N, F = P	M1 A1 A1 **(3)** **(9 marks)**

Notes for Question 2

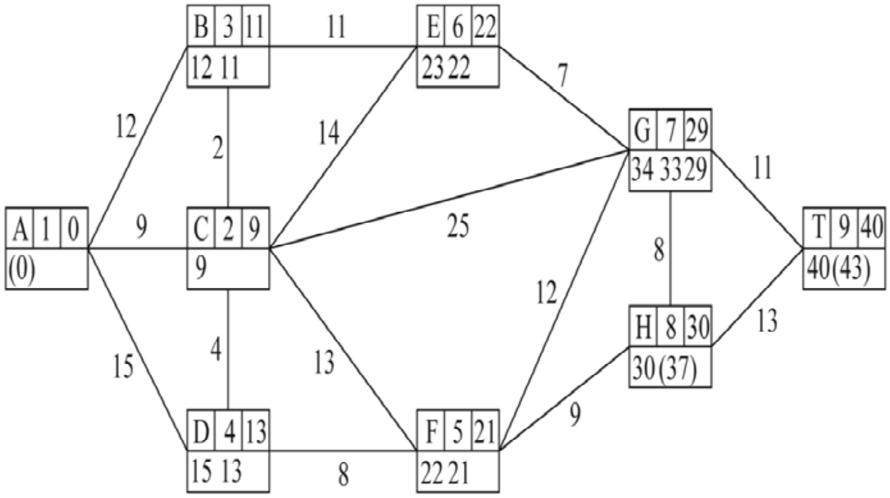
a1B1**:** Complete: pairing or one to one.
a2B1: Complete: **all** elements from one **set** with all elements of the other ('all' and 'set' must be mentioned at least once).
a3B1: Difference: **all** compared to **at most**. Give bod but **must** mention 'all' compared to 'at most'.
b1M1: An alternating path from C to O or K (or vice versa).
b1A1: CAO – a correct path including change status either stated **or** shown. Chosen path clear.
b2A1: CAO must follow from the correct stated path. Accept on a clear diagram (with five arcs only).
c1M1: An alternating path from D to K or O, whichever one (of O or K) they didn't use in (b) (or vice versa).
c1A1: CAO – a correct path including change status either stated **or** shown. Chosen path clear.
c2A1: CAO must follow from two correct stated paths (so both previous M marks must have been awarded). Accept on a **clear** diagram (with six arcs only).

Improved matching:

Path 1	**A**	**B**	**C**	**D**	**E**	**F**
C-L-A-O	O	M	L		N	P
C-L-A-K	K	M	L		N	P

Complete matching:

Path 1	**Path 2**	**A**	**B**	**C**	**D**	**E**	**F**
C-L-A-O	D-M-B-K	O	K	L	M	N	P
C-L-A-O	D-N-E-K	O	M	L	N	K	P
C-L-A-K	D-M-B-K-A-O	O	K	L	M	N	P
C-L-A-K	D-N-E-K-A-O	O	M	L	N	K	P

Question Number	Scheme	Marks
3. (a)	 Quickest route is ACBEGT Length of quickest route is 40 (minutes)	M1 A1 (ABCD) A1 (FEG) A1ft (HT) A1 B1ft **(6)**
(b)	Quickest journey A to F is ACDF So quickest journey A to T via F is ACDFHT = 43 (minutes)	M1 A1 **(2)**
(c)	e.g. Add 2 to each arc except GT and HT (or AB, AC and AD)	M1 A1 **(2)** **(10 marks)**

Notes for Question 3

a1M1**:** A larger value replaced by smaller value at least once in the working values at either B or D or E or F or G.

a1A1**:** All values in boxes A, B, C and D correct and the working values in the correct order, including order of labelling.

a2A1**:** All values in boxes F, E and G correct and the working values in the correct order. Penalise order of labelling errors only once per question.

a3A1ft: All values in boxes H and T correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question.

a4A1**:** CAO for the route.

a1B1ft: Follow through on their final value at T – if their answer is not 40 follow through their final value at T.

b1M1: **Any** path from A to T via **their** shortest path from A to F.

b1A1: 43 and ACDFHT

c1M1: Valid general method – any mention of adding 2 to the weight of the arcs.

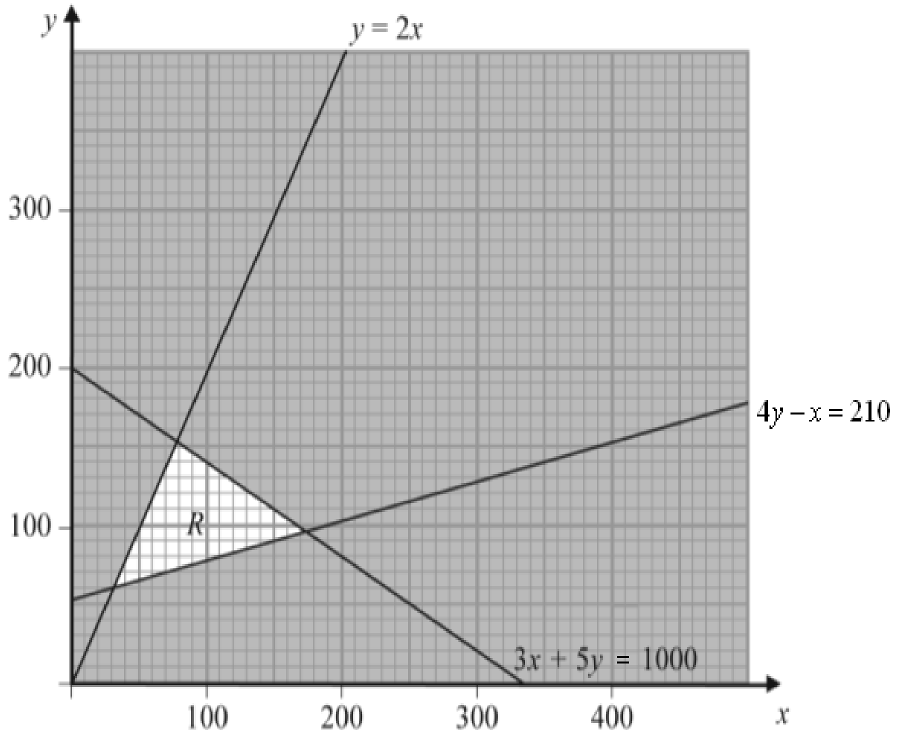
c1A1: CAO – so adding 2 to each arc except {GT, HT} or {AB, AC, AD}.

Question Number	Scheme	Marks
4. (a)	E.g. (any three) • Kruskal starts with the shortest arc, Prim starts with any node. • It is necessary to check for cycles when using Kruskal (or it is not necessary to check for cycles when using Prim). • When using Prim the 'growing' tree is always connected. • When using Kruskal arcs are considered in ascending order of weight. • Prim can be used when the network is given in matrix form. • Prim add nodes to the growing tree, Kruskal adds arcs.	B1 B1 B1 **(3)**
(b)	DE, EB, BL, LF, BH; HG, GA, ES; SP, MP, AR	M1 A1 A1 **(3)**
(c)	ES + LG = 24 + 15 = 39 smallest EL + S(FL)G = 17 + 55 = 72 E(L)G + L(F)S = 32 + 40 = 72 Repeat ES and LG	M1 A1 (2 correct) A1 (3 correct) A1 **(4)**
(d)	The caretaker should repeat EL(17) as it is the minimum pair not including G (ES: 24, EL: 17, LS: 40) Therefore he should (start at G and) finish at S Length of route: 341 + 17 = 358 (metres)	M1 A1 A1 **(3)** **(13 marks)**

Notes for Question 4

In (a) all technical language must be correct (so do not accept point for vertex/node etc.).

a1B1: Any one correct difference.
a2B1: Any two correct differences.
a3B1: Any three correct differences.
b1M1: First five arcs correctly chosen in order (do not accept weights) **or** first six nodes correctly chosen in order. {D,E,B,L,F,H}. **If any rejections seen at any point then M1 (max) only.**
b1A1: First eight arcs correctly chosen in order **or** all nodes correctly chosen in order. {D,E,B,L,F,H,G,A,S,P,M,R}.
b2A1: CSO – all arcs correctly stated.
Misread: Starting at a node other than D scores **M1 only** – must have the first five arcs (or six nodes) correct (and in the correct order).
c1M1: Three pairings of the **correct** four odd nodes.
c1A1: Two rows correct including pairing **and** total.
c2A1: Three rows correct including pairing **and** total.
c3A1: (Repeat) ES and LG.
d1M1: Identified the need to repeat one path of the three (ES, EL, LS) which does not include G (maybe implicit) or listing of possible repeats - if M0 in (c) must state all three possible paths. Stating any path (ES, EL, LS) is sufficient for this mark.
d1A1: Identifies EL **as the least of those paths not including G.** They have to explicitly state that EL is the least path that does not include G or they can list all three paths and then say EL is the least.
d2A1: CAO - finish at S **and** length of route 358.

Question Number	Scheme	Marks
5. (a)	$3x + 5y \leq 1000$	B1 **(1)**
(b)		B1 $3x + 5y = 1000$ B1 $y = 2x$ B1 $4y - x = 210$ B1 R **(4)**
(c)	Objective is to maximise (P =) $x + y$	B1 **(1)**
(d)	$(A=)(30,60)$, $(B=)\left(76\frac{12}{13},153\frac{11}{13}\right)$, $(C=)\left(173\frac{9}{17},95\frac{15}{17}\right)$ At A, P = 90 At B, P = $230\frac{10}{13}$ At C, P = $269\frac{7}{17}$ So C is optimal point Testing integer solutions around C, x = 173 and y = 96 is optimal integer solution, so they should make 173 soft toys and 96 craft sets	M1 A1 A1 M1 A1 M1 A1 **(7)** **(13 marks)**

Notes for Question 5

a1B1: CAO

b1B1: $3x + 5y = 1000$ passing through one small square of (0, 200), (200, 80), ($333\frac{1}{3}$, 0).

b2B1: $y = 2x$ passing through one small square of (0, 0), (100, 200), (150, 300).

b3B1: $4y – x = 210$ passing through one small square of (0, 52.5), (200, 102.5), (400, 152.5).

b4B1: Region, R, correctly labelled – not just implied by shading – must have scored all three previous marks in this part.

cB1: CAO – correct expression.

d1M1: Attempt to solve two of the correct equations simultaneously, up to x =… or y =…

d1A1: At least 1 correct R vertex found correct to at least 2dp (rounded or truncated) - (30, 60), (76.923…, 153.846…), (173.529…, 95.705…). If **any** vertex is stated correctly (with or without working) then this scores M1A1.

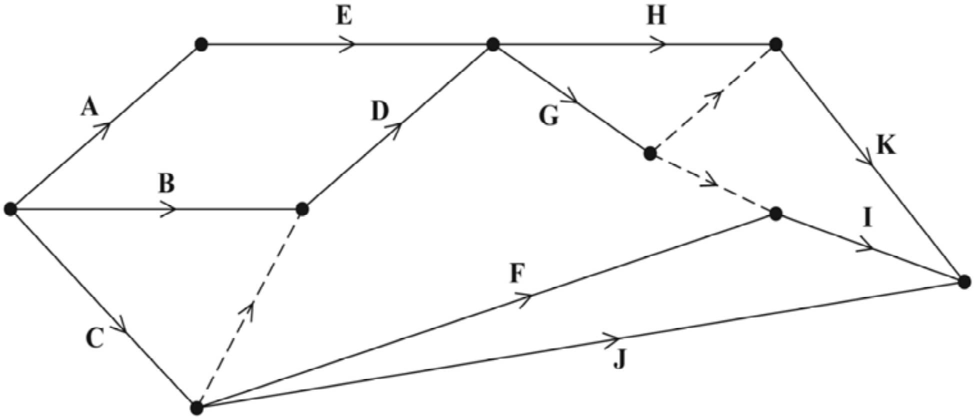
d2A1: All correct R vertices found **exactly. Must** be working for determining points B and C. B$\left(\frac{1000}{13}, \frac{2000}{13}\right)$, C$\left(\frac{2950}{17}, \frac{1630}{17}\right)$.

d2M1: Evaluating the correct objective function at at least two of their points for their feasible region – allow this mark if vertices have been read off their graph. Condone for this M mark those candidates who state their coordinates and then test the ‘nearest’ integer values. E.g. if they state (76.9, 153.8) then allow for the M mark those that test either one of (76, 153), (77, 153), (76, 154) or (77, 154) **only** – maybe implied by their value for P.

d3A1: All three correct P values either given exactly $\left\{90, \frac{3000}{13}, \frac{4580}{17}\right\}$ **or** to at least 1 dp (rounded or truncated) $\{90, 230.769\,\ldots, 269.411\,\ldots\}$. They must be testing the exact coordinates for this mark.

d3M1: Testing the correct inequalities for at least two of (173, 95), (173, 96), (174, 95), (174, 96).

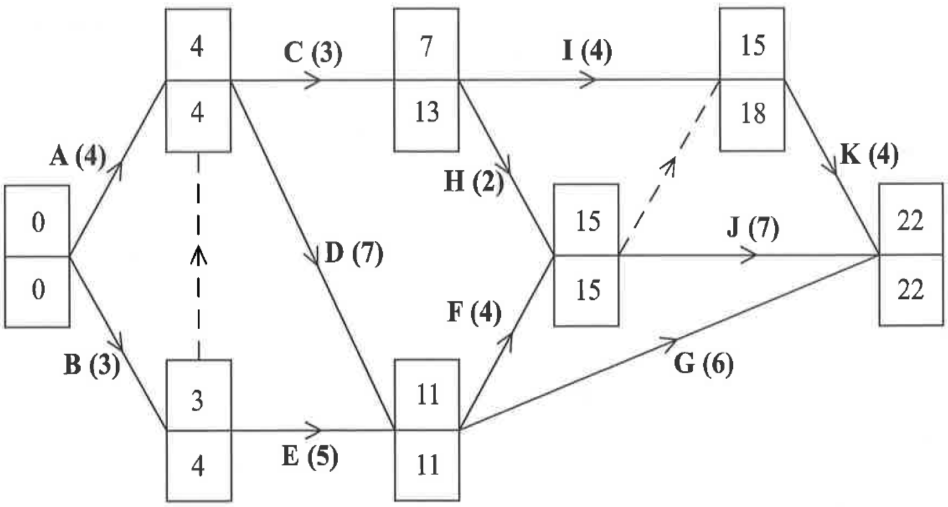
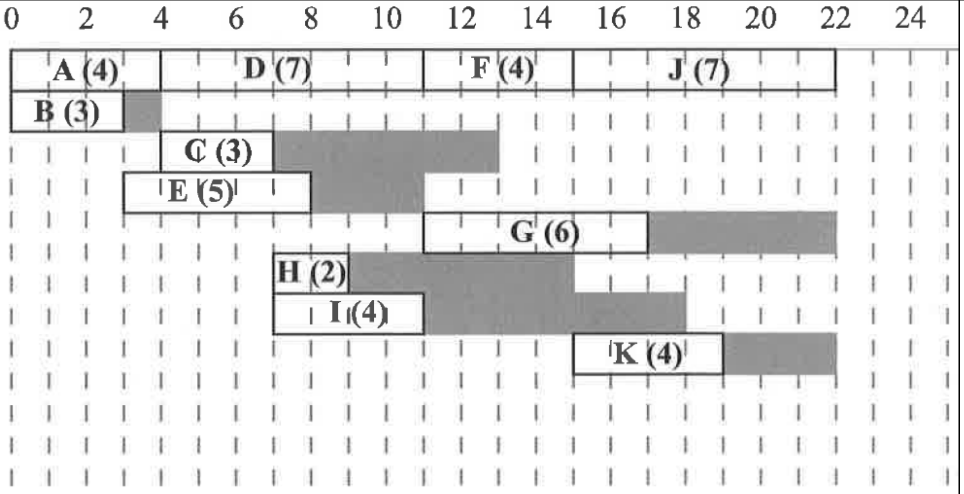
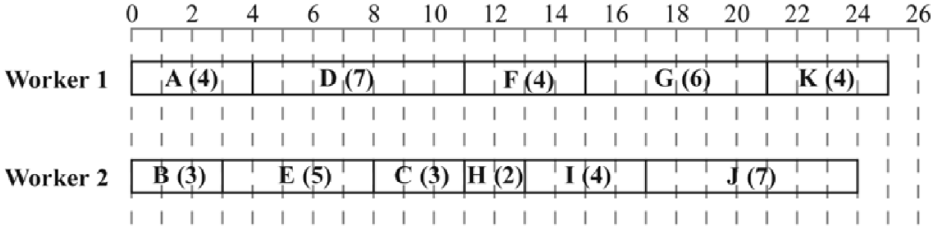
d4A1: CSO (all previous marks in (d) must have been awarded) accept $x = 173$ and $y = 96$ or as coordinates.

Question Number	Scheme	Marks
6. (a)		M1 A1 A1 A1 A1 **(5)**
(b)	Dummies are either needed: to show dependency (where subsequent activities **do not all** depend on the same preceding activities), **or** so that an activity can be uniquely represented in terms of its events.	B1 B1 **(2)** **(7 marks)**

Notes for Question 6

In (a) condone lack of, or incorrect, numbered events throughout – also 'dealt with correctly' means that the activity starts from the correct event but not necessarily finishes at the correct event. **Activity on node is M0.** Ignore incorrect or lack of arrows for the first four marks in (a) only.

a1M1: 7 activities (labelled on arc) and one dummy placed.
a1A1: One start + activities A, B, C and E dealt with correctly.
a2A1: Activities D, F, G, H and J and the 1st dummy dealt with correctly.
a3A1: Activities I, K and the 2nd and 3rd dummies dealt with correctly.
a4A1: CSO - **all** arrows present and correctly placed with one finish.
b1B1: dependency + some explanation of what this means, generous – allow a correct example based on the correct network diagram in the MS (**not** based on their diagram).
b2B1: uniqueness – please note that e.g. 'so that activities can be defined uniquely' is **not** sufficient to earn this mark. There must be some mention of describing activities in terms of the event at each end. However, give bod on statements that imply that an activity begins and ends at the same event.

Question Number	Scheme	Marks
7.(a)		M1 A1 A1 **(3)**
(b)	ADFJ Length 22	B1 B1 **(2)**
(c)		M1 A1 M1 A1 **(4)**
(d)	i) D & E ii) J & G	B1 B1 **(2)**
(e)	e.g. 	M1 A1 A1 **(3)** **(14 marks)**

Notes for Question 7

a1M1: All top boxes and all bottom boxes completed. Values generally increasing from left to right (for top boxes), and values generally decreasing from right to left (for bottom boxes). Condone missing 0 **or** 22 for M only (for bottom boxes). Condone one rogue value in top boxes **and** one rogue value in bottom boxes.
a1A1: CAO for top boxes.
a2A1: CAO for bottom boxes.
b1B1: CAO path.
b2B1: CAO length.
c1M1: At least 8 different activities including at least 4 floats.
c1A1: Critical activities dealt with correctly.
c2M1: The correct 11 activities (only once) including at least 7 floats.
c2A1: Non-critical activities dealt with correctly.
d1B1: CAO
d2B1: CAO
e1M1: 2 lines for 2 workers or 3 lines for 3 workers, all 11 activities present (just once) with time ≤ 25.
e1A1: 2 workers. Condone one error either precedence or activity length. Time must be 25.
e2A1: 2 workers. No errors.

Activity	Duration	IPA
A	4	-
B	3	-
C	3	A, B
D	7	A, B
E	5	B
F	4	D, E
G	6	D, E
H	2	C
I	4	C
J	7	F, H
K	4	F, H, I

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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Decision Mathematics 1R (6689/01R)

Summer 2014
Publications Code UA038492

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol √ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- [The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. (a)	Bin 1: $\boxed{31}$ $\boxed{10}$ $\underline{19}$ Bin 2: $\underline{\boxed{38}}$ 12 Bin 3: $\boxed{45}$ Bin 4: $\underline{47}$ Bin 5: $\underline{35}$ Bin 6: $\underline{28}$	$\boxed{\text{M1}}$ $\underline{\text{A1}}$ A1 **(3)**
(b)	e.g. middle right 31 10 38 45 $\boxed{19}$ 47 35 28 12 Pivot 19 31 38 45 $\boxed{47}$ 35 28 $\boxed{19}$ 10 $\boxed{12}$ Pivots 47, 12 $\boxed{47}$ 31 38 $\boxed{45}$ 35 28 $\boxed{19}$ $\boxed{12}$ $\boxed{10}$ Pivots 45 (10) $\boxed{47}$ $\boxed{45}$ 31 38 $\boxed{35}$ 28 $\boxed{19}$ $\boxed{12}$ $\boxed{10}$ Pivot 35 $\boxed{47}$ $\boxed{45}$ $\boxed{38}$ $\boxed{35}$ 31 $\boxed{28}$ $\boxed{19}$ $\boxed{12}$ $\boxed{10}$ Pivot 28 (38) $\boxed{47}$ $\boxed{45}$ $\boxed{38}$ $\boxed{35}$ $\boxed{31}$ $\boxed{28}$ $\boxed{19}$ $\boxed{12}$ $\boxed{10}$ (sort complete)	 M1 A1 A1ft A1 **(4)**
(c)	Bin 1: $\boxed{47}$ 12 Bin 2: $\boxed{45}$ 10 Bin 3: $\boxed{38}$ $\boxed{19}$ Bin 4: $\boxed{35}$ Bin 5: $\boxed{31}$ $\boxed{28}$	$\boxed{\text{M1}}$ A1 **(2)**
(d)	$\frac{265}{60} \approx 4.417$ so yes 5 bins is optimal	M1 A1 **(2)** **11 marks**

Notes for Question 1

a1M1: First four items placed correctly in bins 1, 2 and 3. (Condone cumulative totals here only.)
a1A1: First eight terms placed correctly.
a2A1: CSO – all correct.
b1M1: Quick sort – pivots, p, selected and first pass gives <p, p, >p. **If only choosing one pivot per iteration M1 only**.
b1A1: First pass correct, next two pivots chosen correctly for second pass.
b2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots) – and net pivot(s) chosen consistently for fourth pass.
b3A1: CSO including choice of pivots for the fifth pass and 'sort complete' – this could be shown **either** by a 'stop' statement **or** final list being re-written **or** using each item as a pivot.
c1M1: Must be using list in descending order (independent of (b)). First seven terms placed correctly.
c1A1: CAO
d1M1: E.g. Attempt to find lower bound (265 ±47) / 60, (oe) could remark on number of items >30. The argument must be numerical in nature.
d1A1: CSO including 5.

SC for (c): if the 'sorted' list they use in (c) has one 'error' from (b) (e.g. a missing number, an extra number or one number incorrectly placed) then M1 only can be awarded in (c) (for the first seven items). If there is more than one 'error' then M0. Allow full marks in (c) if a correct list is used in (c) even if the list is incorrect at the end of (b).

Question Number	Scheme	Marks

Sorting list into ascending order in (b)

- If the candidate sorts the list into ascending order and reverse the list **in (b)** then they can score full marks in (b).
- If the list is not reversed in (b) then mark as a misread (so remove the last two A marks earned in (b)). If the list is reversed at the start of (c) but not in (b) then still treat this as a misread. If the list is still in ascending order in (c) award no marks for first fit increasing. If the candidate says that the list needs reversing in (b) but doesn't actually show the reversed list in (b) then remove the final A mark in (b).

Misreads

- If they have misread a number **at the start of (a)**, **so genuinely miscopied** a number (before starting the question) then please mark the whole question as a misread (so remove the final two A/B marks earned).
- If they make an error during the quick sort then mark this as an error. They can still earn the M mark in (c) (see SC above).

Middle left

31	10	38	45	$\boxed{19}$	47	35	28	12	Pivot 19	
31	38	$\boxed{45}$	47	35	28	$\boxed{19}$	$\boxed{10}$	12	Pivot 45, 10	M1 A1
$\boxed{47}$	$\boxed{45}$	31	$\boxed{38}$	35	28	$\boxed{19}$	$\boxed{12}$	$\boxed{10}$	Pivot (47), 38, (12)	
$\boxed{47}$	$\boxed{45}$	$\boxed{38}$	31	$\boxed{35}$	28	$\boxed{19}$	$\boxed{12}$	$\boxed{10}$	Pivot 35	A1ft
$\boxed{47}$	$\boxed{45}$	$\boxed{38}$	$\boxed{35}$	$\boxed{31}$	28	$\boxed{19}$	$\boxed{12}$	$\boxed{10}$	Pivot 31	
$\boxed{47}$	$\boxed{45}$	$\boxed{38}$	$\boxed{35}$	$\boxed{31}$	$\boxed{28}$	$\boxed{19}$	$\boxed{12}$	$\boxed{10}$	list in order	A1cso

Ascending order (middle right)

31	10	38	45	$\boxed{19}$	47	35	28	12	Pivot 19	
10	$\boxed{12}$	$\boxed{19}$	31	38	45	$\boxed{47}$	35	28	Pivot 12, 47	M1 A1
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	31	38	$\boxed{45}$	35	28	$\boxed{47}$	Pivot (10), 45	
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	31	38	$\boxed{35}$	28	$\boxed{45}$	$\boxed{47}$	Pivot 35	A1ft
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	31	$\boxed{28}$	$\boxed{35}$	$\boxed{38}$	$\boxed{45}$	$\boxed{47}$	Pivot 28, (38)	
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	$\boxed{28}$	$\boxed{31}$	$\boxed{35}$	$\boxed{38}$	$\boxed{45}$	$\boxed{47}$	list in order	A1cso

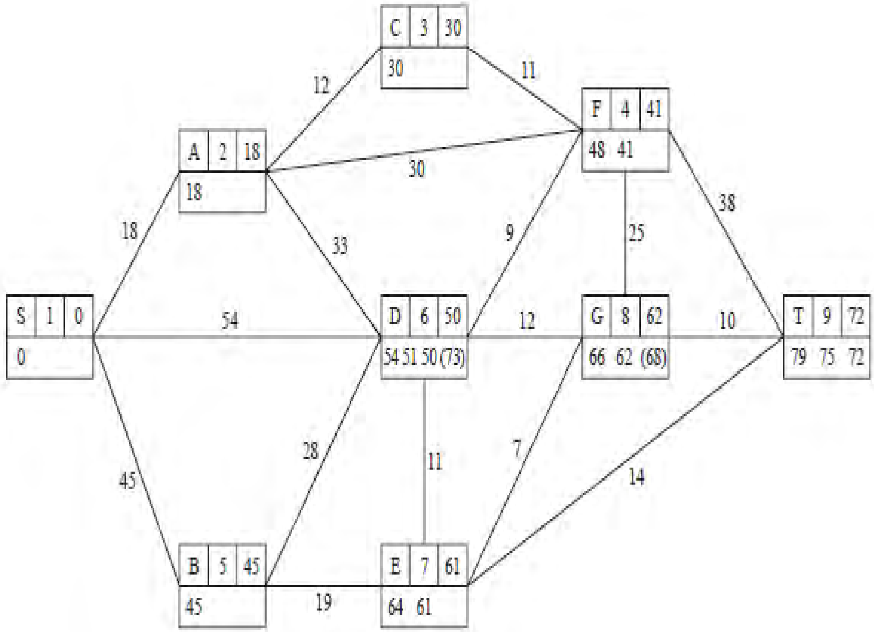
Ascending order (middle left)

31	10	38	45	$\boxed{19}$	47	35	28	12	Pivot 19	
$\boxed{10}$	12	$\boxed{19}$	31	38	$\boxed{45}$	47	35	28	Pivot 10, 45	M1 A1
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	31	$\boxed{38}$	35	28	$\boxed{45}$	$\boxed{47}$	Pivot (12), 38, (47)	
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	31	$\boxed{35}$	28	$\boxed{38}$	$\boxed{45}$	$\boxed{47}$	Pivot 35	A1ft
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	$\boxed{31}$	28	$\boxed{35}$	$\boxed{38}$	$\boxed{45}$	$\boxed{47}$	Pivot 31	
$\boxed{10}$	$\boxed{12}$	$\boxed{19}$	$\boxed{28}$	$\boxed{31}$	$\boxed{35}$	$\boxed{38}$	$\boxed{45}$	$\boxed{47}$	list in order	A1cso

Question Number	Scheme	Marks
2. (a)	e. g. Activities 1 and 3 both can only be done by Hugo	B2, 1, 0 **(2)**
(b)	J to 1 should be chosen e. g. J to 1 would release H to do 3. e. g. if H is retrained then tasks 1 and 3 can still only be done by H.	M1 A1 **(2)**
(c)	A – 2 = P – 4 = C – 5 = J – 1 = H – 3 Change status A = 2 – P = 4 – C = 5 – J = 1 – H = 3 Complete matching: A = 2, C = 5, H = 3, J = 1 and P = 4	M1 A1 A1 **(3)** **7 marks**

Notes for Question 2

a1B1: A statement with the correct employees and tasks that attempts a reason why a complete matching is not possible. BOD gets the mark here. Note e.g. ‘Hugo is the only one who can do both 1 and 3’ or ‘Hugo can only do 1 and 3’ are both B1 only.
a2B1: Fully correct, including all pertinent names and activities. No incorrect information given.
b1M1: J to 1 selected with a reason given. One of H, 1 or 3 must be mentioned.
b1A1: A correct reason given – must explicitly explain why J with 1 allows a complete matching to occur e.g. H can now do 3, or the candidate explains that if Hugo is re-trained there are still two tasks, 1 and 3, that can only be done by one employee, H.
c1M1: An alternating path from A to 3 (or vice versa).
c1A1: CAO – a correct path including change status either stated **or** shown. Chosen path clear.
c2A1: CAO must follow from the correct stated path. Accept on a clear diagram (with five arcs only).

Question Number	Scheme	Marks
3. (a)		M1 A1 (SACFB) A1 (DE) A1ft (GT)
	Shortest path S to T: SACFDGT Time of shortest path S to T is 72 (minutes)	A1 A1ft **(6)**
(b)	Shortest paths S to T including E: SACFDET Time is 75 (minutes), so 3 (minutes) longer.	DB1 B1, B1ft **(3)** **9 marks**

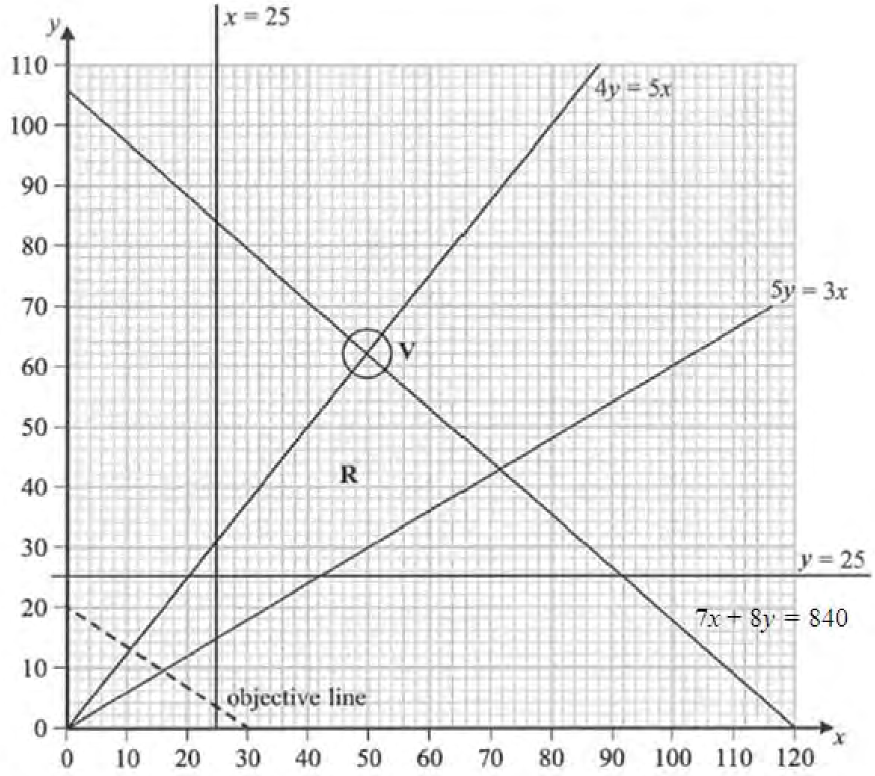
Notes for Question 3

a1M1: A larger value replaced by smaller value at least once in the working values at either D or E or F or G or T.
a1A1: All values in S, A, C, F and B correct and the working values in the correct order, including order of labelling.
a2A1: All values in D and E correct and the working values in the correct order. Penalise order of labelling only once per question.
a3A1ft: All values in G and T correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question.
a4A1: CAO for the route.
a5A1ft: Follow through on their final value at T – if their answer is not 72 follow through their final value at T.
b1DB1: Must have scored the M mark in (a). Path correct.
b1B1: CAO time of new route correct.
b2B1ft: Time difference correct (ft their previous times).

Question Number	Scheme	Marks
4. (a)	B(E)D + FI = 32 + 38 = 70 B(C)F + D(E)I = 25 + 36 = 61* B(E)I + D(E)F = 20 + 52 = 72 Length = 359 + 61 = 420	M1 A1 A1 A1 A1ft **(5)**
(b)	Time taken = $\frac{420}{15}\times 120 = 3360$ (seconds)	M1 A1 **(2)**
(c)	e.g. If we start at an odd vertex we will **finish** at another **odd** vertex. This removes the need to repeat the route between them. So we just have to consider **one repeated route** rather than two.	B2,1,0 **(2)**
(d)	Choose to repeat the **shortest** route **BI** (20) Therefore **start at D** (and finish at F) New length = 359 + 20 = 379 Time taken = $\frac{379}{15}\times 120 + 2\times 119 = 3270$ (seconds)	B1 B1 B1 B1 **(4)**
		13 marks

Notes for Question 4

a1M1: Three pairings of the **correct** four odd nodes.
a1A1: One row correct including pairing **and** total.
a2A1: Two rows correct including pairing **and** total.
a3A1: Three rows correct including pairing **and** total.
a4A1ft: 420 or 359 + their least.
b1M1: Their length ÷ 15 × 120 – from at least two totals seen in (a).
b1A1: CAO
c1B1: One of (i) idea of finishing at an odd vertex (ii) only having to repeat one route rather than two.
c2B1: Correct complete argument – including both (i) and (ii) from c1B1.
d1B1: Identifies BI as the **shortest** route.
d2B1: start at D – dependent on identifying BI (20) as the repeat.
d3B1: CAO
d4B1: CAO

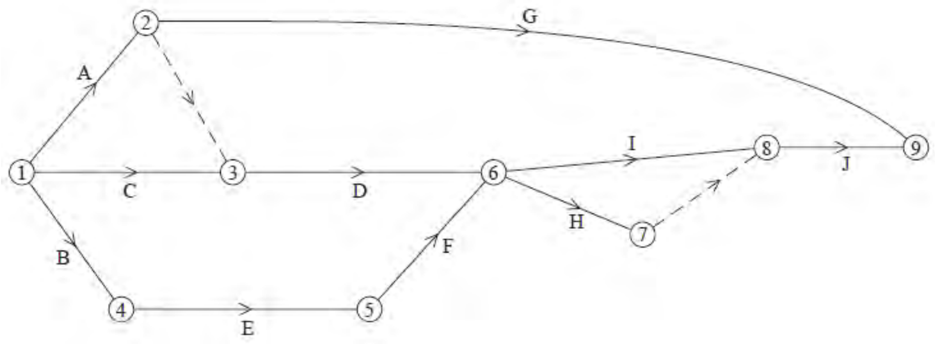
Question Number	Scheme	Marks
5. (a)		B1 B1 B1 B1 R **(4)**
(b)	Drawing an objective line accept reciprocal gradient correct objective line minimum length equivalent to (0, 10) to (15,0) V labelled correctly	M1 A1 A1 **(3)**
(c)	V$\left(49\frac{7}{17},61\frac{13}{17}\right)$	M1 A1**(2)**
(d)	Testing the correct inequalities for points with integer coordinates (50, 61)	M1 A1 **(2)** **11 marks**

Notes for Question 5

In (a) lines **must** pass through one small square of the points stated:

$7x + 8y = 840$ passes through (0, 105), (40, 70), (80, 35), (120, 0)
$4y = 5x$ passes through (0, 0), (40, 50), (80, 100)
$5y = 3x$ passes through (0, 0), (50, 30), (100, 60)

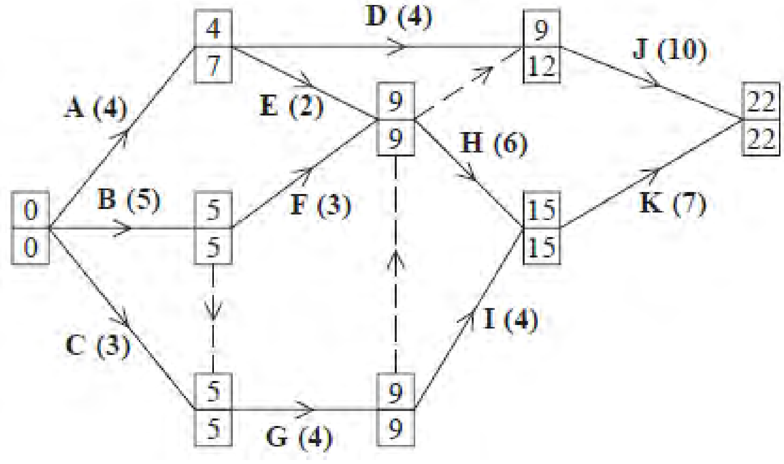
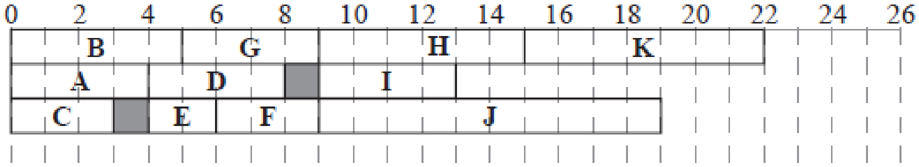
a1B1: One line other than $x = 25$ or $y = 25$ correctly drawn.
a2B1: Two lines other than $x = 25$ or $y = 25$ correctly drawn.
a3B1: All five lines correctly drawn.
a4B1: Region, R, correctly labelled – not just implied by shading – must have scored all three previous marks in this part.
b1M1: Drawing the correct objective line or its reciprocal. Line must be correct to within one small square if extended from axis to axis.
b1A1: Correct objective line.
b2A1: V labelled clearly on their graph. This mark is dependent on the correct five line segments that define the boundary of the feasible region.
cM1: Simultaneous equation being used to find **their** V (but not from $x = 25$ or $y = 25$). Must get to $x = \ldots$ and $y = \ldots$
cA1: Correct coordinates of V stated **exactly** as $\left(\frac{840}{17}, \frac{1050}{17}\right)$ or $\left(49\frac{7}{17}, 61\frac{13}{17}\right)$. If the correct coordinates are stated exactly with no working then this scores M1A0.
d1M1: Testing the correct inequalities for at least three of (49, 61), (49, 62), (50, 61), (50, 62).
d1A1: CAO (50, 61).

Question Number	Scheme	Marks
6. (i)		M1 (7 activities + 1 dummy) A1 (start + ABCE) A1 (DFG + 1st dummy) A1 (HIJ + 2nd dummy) A1cso
(ii)	1st dummy – G depends on A only, but D depends on A and C. 2nd dummy – This is so that H and I will not share the same start and end events **or** so that H and I can be uniquely described in terms of their end events.	B1 B1 **7 marks**

Notes for Question 7

In (i) condone lack of, or incorrect, numbered events throughout – also 'dealt with correctly' means that the activity starts from the correct event but not necessarily finishes at the correct event. **Activity on node is M0.**
Ignore incorrect or lack of arrows for the first four marks in (i) only.

1M1: 7 activities (labelled on arc) and one dummy placed.
1A1: One start + activities A, B, C and E dealt with correctly.
2A1: Activities D, F and G and the 1st dummy dealt with correctly.
3A1: Activities I, H and J and the 2nd dummy dealt with correctly.
4A1: CSO – **all** arrows present and correctly placed with one finish.
1B1: CAO - all relevant activities must be referred to – so activities D, G, A and C must all be mentioned for this mark
2B1: CAO – please note that e.g. 'so that activities can be defined uniquely' is **not** sufficient to earn this mark. There must be mention of describing activities uniquely **in terms of the event at each end**. However, give bod on statements that imply that an activity begins at ends at the same event.

Question Number	Scheme	Marks
7. (a)		M1 A1 M1 A1 **(4)**
(b)	Total float for D = 12 – 4 – 4 = 4	M1 A1 **(2)**
(c)	$\frac{52}{22} \approx 2.36$ so 3 workers	M1 A1 **(2)**
(d)	e.g. 	M1 A1 A1 **(3)** **11 marks**

Notes for Question 7

a1M1: All top boxes complete, values generally increasing left to right, condone one rogue.
a1A1: CAO
a2M1: All bottom boxes complete, values generally decreasing right to left, condone one rogue. Condone missing 0 **or** 22 for the M only.
a2A1: CAO
b1M1: Correct calculation for their activity D seen – their three numbers correct. Final value must be non-negative.
b1A1: CAO – no ft on this mark. The answer of 4 (with no working) scores no marks.
c1M1: Attempt to find lower bound: [42-62 / their finish time].
c1A1: CAO – correct calculation seen then 3. No working scores M0 A0.
d1M1: Not a cascade chart. 3 'workers' used at most and at least 7 activities placed.
d2A1: 3 workers. All 11 activities present (just once). Condone one error either precedence, time interval or activity length.
d3A1: 3 workers. All 11 activities present (just once). No errors.

For reference:

Activity	Duration	Time interval	IPA
A	4	0 – 7	-
B	5	0 – 5	-
C	3	0 – 5	-
D	4	4 – 12	A
E	2	4 – 9	A
F	3	5 – 9	B
G	4	5 – 9	B, C
H	6	9 – 15	E, F, G
I	4	9 – 15	G
J	10	9 – 22	D, E, F
K	7	15 – 22	H, I

Question Number	Scheme	Marks
8.	Minimise $C = 3x + 2y$	B1
	Subject to:	
	$x + y \geq 1000$	B1
	$\frac{1}{4}\left(x + y\right) \leq x,$ simplifies to $y \leq 3x$	M1 A1
	$2x \leq y$	M1 A1
	($x, y \geq 0$)	
		6 marks

Notes for Question 8

1B1: CAO – expression correct and 'minimise'.
2B1: CAO

1M1: Correct method – must see $\frac{1}{4}(x + y)\blacksquare x$ where ■ is any inequality or =. The bracket must be present or implied by later working.

1A1: CAO – simplified – answer must have integer coefficients.

2M1: Correct method – one of $2x\blacksquare y$ or $x\blacksquare 2y$ where ■ is any inequality or =.

2A1: CAO – answer must have integer coefficient.

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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Decision Mathematics 1 (6689/01)

Summer 2014
Publications Code UA038482

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

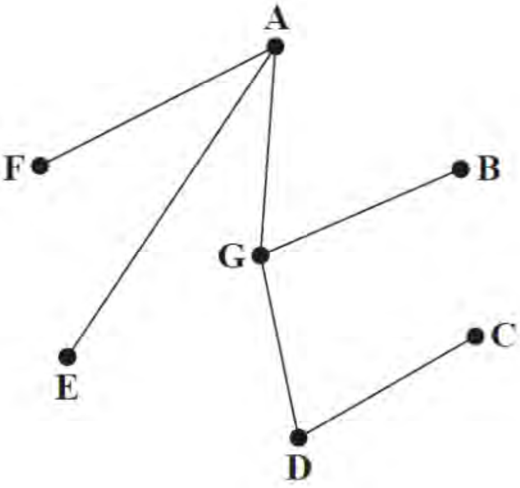
   - bod – benefit of doubt
   - ft – follow through
   - the symbol √ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper or ag- answer given
   - ∟ or d… The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1.(a)	AG, DG, AF; AE BG; CD	M1 A1 A1 **(3)**
(b)		B1 **(1)**
(c)	Weight of tree = 298 (s)	B1 **(1)** **5 marks**

Notes for Question 1

a1M1: First three arcs correctly chosen in order (AG, DG, AF, … or weights 42, 41, 48, …) **or** first four nodes correctly chosen in order. {A.G,D,F,…} **If any rejections seen at any point then M1 (max) only.** Order of nodes may be seen at the top of the matrix {1, -, -, 3, -, 4, 2} so please check the top of the matrix carefully.

a1A1: First five arcs correctly chosen in order (AG, DG, AF, AE, BG or weights 42, 41, 48, 50, 58,…) **or** all seven nodes correctly chosen in order. {A,G,D,F,E,B,C}. Order of nodes may be seen at the top of the matrix so for the first two marks accept {1, 6, 7, 3, 5, 4, 2} (**do not** condone any missing numbers e.g. the number 7 must be above C).

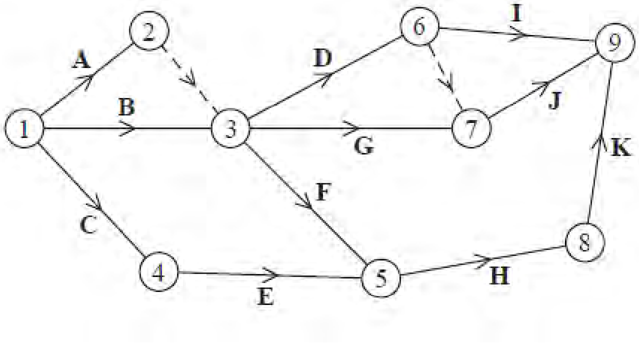
a2A1: CSO - all **arcs** correct and chosen in the correct order. They must be considering arcs for this final mark (do not accept a list of the weights of each arc, nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen).

Misread: Starting at a node other than A scores **M1 only** – **must** have the first three arcs (or four nodes or numbers) correct (and in the correct order).

Starting at	Minimum arcs required for M1	Nodes	Order
A	AG DG AF	AGDF(EBC)	1(6)(7)3(5)42
B	BG DG AG	BGDA(FEC)	41(7)3(6)(5)2
C	CD DG AG	CDGA(FEB)	4(7)12(6)(5)3
D	DG AG AF	DGAF(EBC)	3(6)(7)1(5)42
E	EA AG DG	EAGD(FBC)	2(6)(7)41(5)3
F	FA AG DG	FAGD(EBC)	2(6)(7)4(5)13
G	GD AG AF	GDAF(EBC)	3(6)(7)2(5)41

b1B1: CAO (condone lack of weights on arcs).

c1B1: CAO (condone lack of units).

Question Number	Scheme	Marks
2. (a)		M1 A1 A1 A1 A1 **(5)**
(b)	1st dummy – A and B both must be able to be described uniquely in terms of the events at each end. 2nd dummy – I depends on D only but J depends on D and G.	B1 B1 **(2)** **7 marks**

Notes for Question 2

Throughout part (a) condone lack of numbered events throughout – also ‘dealt with correctly’ means that the activity starts from the correct event (but not necessarily finishing at the correct event) e.g. ‘H dealt with correctly’ requires F and E leading into the same event and H starting from that event (but not necessarily H leading into K). **Activity on node is M0**.

a1M1: 7 activities and one dummy placed.
a1A1: One start + activities A, B, C and E dealt with correctly.
a2A1: Activities D, F, G, H and K and the 1st dummy dealt with correctly.
a3A1: Activities I and J and the 2nd dummy dealt with correctly.
a4A1: CSO (all four previous marks must have been awarded) - **all** arrows present and correctly placed with one finish – condone lack of arrows for the first four marks only. No ‘extra’ activities.

Note that another valid solution would be the dummy going from event 3 to event 2 and D, G and F coming out of event 2. Or the candidate could start with a dummy from event 1 to ensure the uniqueness of activities A and B.

b1B1: CAO – with no incorrect terminology (e.g. event for activity) - please note that e.g. ‘so that activities can be defined uniquely’ is not sufficient to earn this mark. There must be a mention of describing activities uniquely **in terms of the events at each end**. However give bod on statements that imply that an activity begins and ends at the same event e.g. ‘so that activites do not have the same start and finish’ is sufficient for B1.
b2B1: CAO – all relevant activities must be referred to – so activities D, G, I **and** J must all be mentioned for this mark.

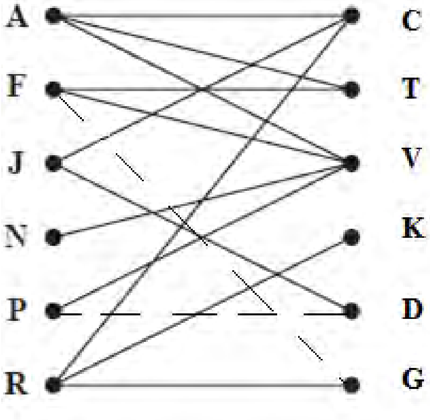
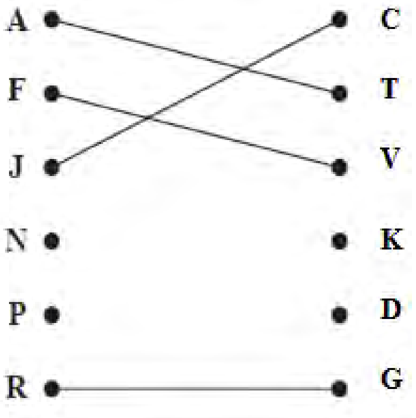
Question Number	Scheme	Marks
3. (a)	D(A)E + F(J)K = 35 + 15 = 50* D(HJ)F + E(FJ)K = 24 + 40 = 64 D(HJ)K + EF = 33 + 25 = 58 Arcs DA, AE, FJ, JK will be traversed twice Route length = 451 + 50 = 501 (km)	M1 A1 (2 correct) A1 (3 correct) A1 A1ft **(5)**
(b)	Vertex J would appear 3 times in the shortest inspection route	B1 **(1)**
(c)	We only have to repeat one pair of odd vertices which does not include vertex K (DE = 35, DF = 24, EF = 25) DF is the smallest of the three so repeat DF (DH, HJ, JF) and therefore the other hut should be built at E Route e.g. EADEHDHJFBEFCGFJHLGKJLMK The length of the route is 475 (km)	M1 A1 A1 A1ft **(4)** **10 marks**

Notes for Question 3

a1M1: Three distinct pairings of the **correct** four odd nodes.
a1A1: **Any** two rows correct including pairings **and** totals.
a2A1: **All** three rows correct including pairings **and** totals.
a3A1: CAO correct **arcs** clearly (**not** just in their working) stated: DA, AE, FJ, JK. Accept DAE, FJK **or** DE via A, FK via J. Do not accept DE, FK.
a4A1ft: The correct answer of 501 **or** 451 + their smallest repeat out of a choice of at least **two** totals seen.

b1B1: CAO (3)

c1M1: Identifies the need to repeat one pairing not including K (maybe implicit) or listing of possible repeats – this mark is dependent on scoring the M mark in (a). Stating any pairing that does not include K is sufficient for this mark.
c1A1: Identifies DF **as the least of those pairings not including K and** E as the position of the other hut. They have to explicitly state that DF is the least pairing that does not include K **or** they can list all three pairings (DE, DF, EF) and then say DF is the smallest as this implicitly implies that they are considering only pairings that do not include K.
c2A1: Any correct route (checks: starts at E and finishes at K (or vice-versa), 24 vertices (D, G, L appear twice and E, F, H, J appear three times and every other letter appears at least once).
c3A1ft: Correct answer of 475 **or** 451+ their DF (i.e. the least pairing that does not include K – so their smallest of DE, DF or EF).

Question Number	Scheme	Marks
4. (a) (b)	 	B1 B1 **(2)**
(c)	Alternating path either N – V = F – T = A – C = J – D or P – V = F – T = A – C = J – D Change status N = V – F = T – A = C – J = D or P = V – F = T – A = C – J = D Improved matching A = C, F = T, J = D, N = V, (P unmatched), R = G or A = C, F = T, J = D, (N unmatched), P = V, R = G	M1 A1 A1 **(3)**
(d)	e.g. both K and G can only be allocated to R e.g. N and P can only be allocated to V	B1 **(1)**
(e)	Alternating path P – D = J – C = A – T = F – G = R – K or N – V = P – D = J – C = A – T = F – G = R – K Change status P = D – J = C – A = T – F = G – R = K or N = V – P = D – J = C – A = T – F = G – R = K Complete matching A = T, F = G, J = C, N = V, P = D, R = K	M1 A1 A1 **(3)** **9 marks**

Notes for Question 4

a1B1: CAO – condone the addition of an arc from F to G and/or one from P to D only.

b1B1: CAO – these four arcs and no additional ones.

c1M1: An alternating path (e.g. letter 1st set – letter 2nd set – letter 1st set - …) from **either** N **or** P **to** D – or vice versa.
c1A1: CAO – a correct path including change status **either** stated (only accept 'change (of) status' **or** 'c.s.') **or** shown (**all** symbols e.g. (…-…=…-…) **interchanged** (…=…-…=…). Chosen path clear.

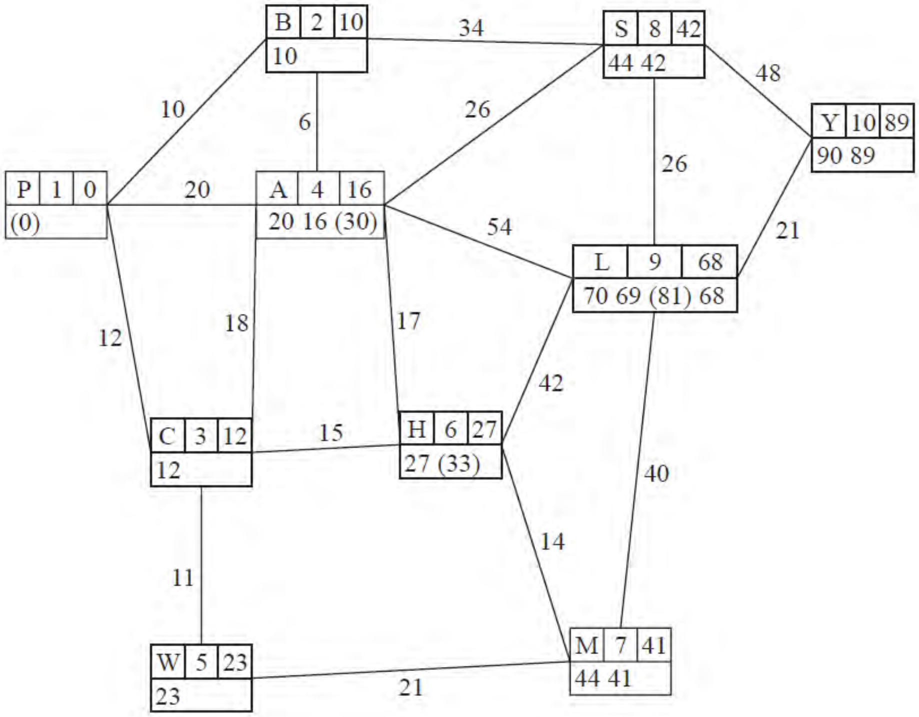
e.g.

- N – V = F – T = A – C = J – D
  N = V – F = T – A = C – J = D Scores M1A1 (change status shown)
- change status N – V = F – T = A – C = J – D Scores M1A1 (change status stated)
- c.s. N – V = F – T = A – C = J – D Scores M1A1 (change status stated)
- N – V = F – T = A – C = J – D
  c.s. N = V – F = T – A = C – J = D Scores M1A1 (change status stated and shown)
- N – V = F – T = A – C = J – D
  N = V, F = T, A = C, J = D, … Scores M1A0 (no change status stated or shown)

c2A1: CAO must follow from the correct stated path. Accept on a **clear** diagram (with five arcs **only**). Condone lack of P or N being stated as unmatched.

d1B1: CAO (completely correct statement) – do not accept a general statement (specific nodes must be referred to). Note that these need to be checked carefully e.g. V can only be allocated to N and P is B0.

e1M1: A second alternating path from either N (if P used in (c)) or P (if N used in (c)) to K (or vice-versa)
e1A1: CAO including change status (stated **or** shown), chosen path clear.
e2A1: CAO must follow from **two correct** stated paths (so **both** previous M marks must have been awarded). Accept on a **clear** diagram (with six arcs only).

Question Number	Scheme	Marks
5. (a)		M1 A1 (PBCAW) A1 (HMS) A1ft (LY)
	Shortest route: P – B – A – S – L – Y Length: 89 (miles)	B1 B1ft **(6)**
(b)	Shortest route: P – C – H – M – L – Y Difference in routes: (41 + 40 + 21) – 89 = 13 (miles)	B1 M1 A1 **(3)** **9 marks**

Notes for Question 5

In part (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at L the working values must be 70 69 68 – in that order (70 68 69 is incorrect).

The values in brackets in the working values at P, A, H and L can be ignored but if a candidate does have additional values at these nodes then they must be these ones only. Penalise any other/incorrect working values with the corresponding A mark. It is also important that the order of labelling is checked carefully – some candidates start with a working value of 0 at P (rather than 1) – this is fine.

Also the order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, … will be penalised once (see notes below) but 1, 2, 3, 5, 6, … is fine.

a1M1: A larger value replaced by smaller value at least once in the working values at either A or M or L or S or Y.

a1A1: All values in P, B, C, A and W correct. The working values at A must be in the correct order. Condone lack of 0 in P's working value. Ignore additional working value of 30 at the end of A (may read 20 16 30 – rather than 20 16 - at A).

a2A1: All values in H, M and S correct and the working values in the correct order. Penalise order of labelling only once per question (H, M and S labelled in that order and H must be labelled after P, B, C, A and W). Ignore additional working value of 33 at the end of H (may read 27 33).

a3A1ft: All values in L and Y correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question (L and Y labelled in that order and L labelled after all other nodes). Ignore additional working value of 81 at L - may read 70 69 81 68 – rather than 70 69 68 – which is fine – however, 70 69 68 81 is incorrect and loses this mark.

To follow through check that all the working values at L follow from the candidate's final values from nodes A, H, M and S in whatever order the candidate has labelled these four nodes and that the final value and order of labelling follows through correctly. Repeat for Y (which will have working values from S and L).

a1B1: CAO for the route

a2B1ft: Follow through on their final value at Y – if answer is not 89 ft their final value at Y (condone lack of units)

b1B1: CAO for the route

b1M1: Their final value at M + 40 + 21 - accept a value of 102 (with no other working) for this mark.

b1A1: CAO (condone lack of units) – accept, as a minimum,102 followed by 13 for both marks. If 13 with no working then award the previous M mark but withhold the final A mark

Question Number	Scheme	Marks
6. (a)	Bin 1: 24 14 8 Bin 2: x 19 6 Bin 3: 25 17 Bin 4: 9	M1 A1 A1 **(3)**
(b)	e.g. using middle right 24 14 8 x $\boxed{19}$ 25 6 17 9 pivot 19 24 $\boxed{x}$ 25 $\underline{19}$ 14 8 $\boxed{6}$ 17 9 pivots x 6 24 $\boxed{25}$ $\underline{x}$ $\underline{19}$ 14 8 $\boxed{17}$ 9 $\underline{6}$ pivots 25 17 $\underline{25}$ 24 $\underline{x}$ $\underline{19}$ $\underline{17}$ 14 $\boxed{8}$ 9 $\underline{6}$ pivots (24) 8 $\underline{25}$ 24 $\underline{x}$ $\underline{19}$ $\underline{17}$ 14 $\boxed{9}$ $\underline{8}$ $\underline{6}$ pivot 9 $\underline{25}$ 24 $\underline{x}$ $\underline{19}$ $\underline{17}$ 14 $\underline{9}$ $\underline{8}$ $\underline{6}$ (sort complete)	M1 (quick sort) A1 (1st pass/pivots for 2nd) A1ft (2nd and 3rd passes correct) A1cso **(4)**
(c)	(i) Bin 1: 25 24 (ii) Bin 1: 25 24 Bin 2: x 19 9 Bin 2: x 19 8 Bin 3: 17 14 8 6 Bin 3: 17 14 9 6	M1 A1 A1 A1 **(4)**
(d)	$x + 19 + 9 = 50 \Rightarrow x = 22$ $x + 19 + 8 = 50 \Rightarrow x = 23$	B2,1,0 **(2)** **13 marks**

Notes for Question 6

a1M1: First four items placed correctly and at least six values put in bins (so bin 1 correct and the *x* in bin 2). If a candidate gives *x* a value in the given interval then allow this for the M mark in (a) only.
a1A1: First seven items placed correctly (so bins 1 and 2 correct and 25 in bin 3)
a2A1: cso – all correct

b1M1: Quick sort, pivot, p, chosen (must be choosing middle left or right – choosing first/last item as pivot is M0) and first pass gives >p, p, <p. So after the first pass the list should read (values greater than the pivot), pivot, (values less than the pivot). **If only choosing one pivot per iteration M1 only**
b1A1: First pass correct, next two pivots chosen correctly for second pass. If a candidate gives *x* a value in the given interval then allow this for the M mark and first A mark only in (b).
b2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots) – need not be choosing pivot(s) for the fourth pass for this mark.
b3A1: CSO (correct solution only- all previous marks in this part **must** have been awarded) including choice of pivots for the fifth pass and 'sort complete' – this could be shown **either** by a 'stop' statement **or** final list being re-written **or** using each item as a pivot.

c1M1: **Must be using 'sorted' list** in decreasing order. First four items placed correctly and at least six values put in bins (so bin 1 correct and the *x* and 19 in bin 2). If a candidate has given *x* a value in (c) then M0.
c1A1: First six values correct (bin 1 corerct, the *x* and 19 in bin 2, the 17 and 14 in bin 3)
c2A1: One allocation correct
c3A1: Both allocations correct - both allocations must be clear.

d1B1: A correct value of *x* stated (working not necessary) – dependent on one correct allocation in (c).
d2B1: Both values correctly calculated (with relevant working) – dependent on both allocations correct seen in (c). **If more than two values for *x* stated (e.g. all possible integer values) then no marks in (d).**

SC for (c): if 'sorted' list has one error from (b) (e.g. a missing number, an extra number or one number incorrectly placed) then M1A1 can be awarded in (c) (for four items (M1) and six items (A1) correctly placed - see above). However no marks in (d). If there is more than one error then M0.

Part (b) **Using middle left as pivot**

24	14	8	x	$\boxed{19}$	25	6	17	9	pivot 19	
24	$\boxed{x}$	25	$\underline{19}$	14	8	$\boxed{6}$	17	9	pivots x 6	M1 A1
$\boxed{24}$	25	$\underline{x}$	$\underline{19}$	14	$\boxed{8}$	17	9	$\underline{6}$	pivots 24 8	
25	$\underline{24}$	$\underline{x}$	$\underline{19}$	$\boxed{14}$	17	$\underline{8}$	9	$\underline{6}$	pivots (25) 14 (9)	A1
25	$\underline{24}$	$\underline{x}$	$\underline{19}$	17	$\underline{14}$	9	$\underline{8}$	$\underline{6}$	sort complete	A1cso

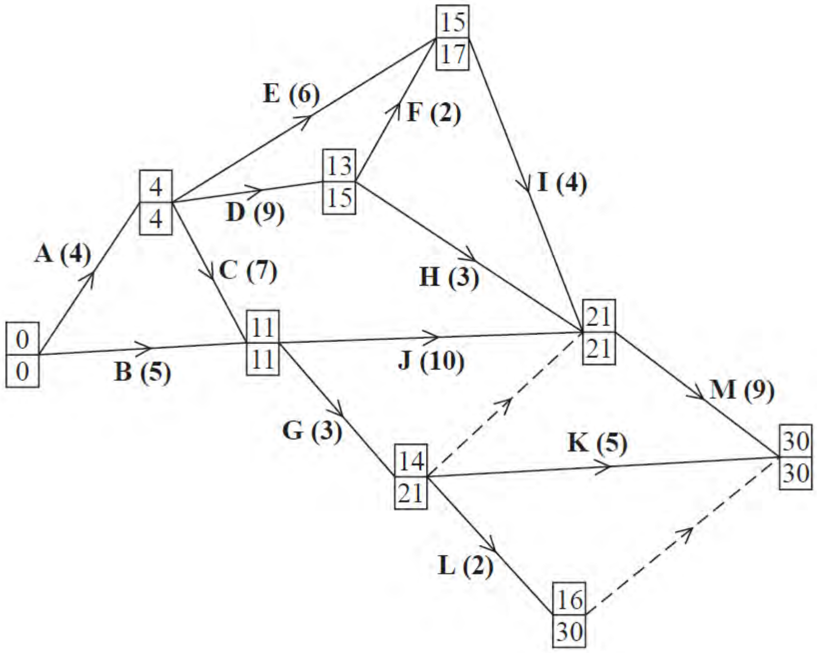
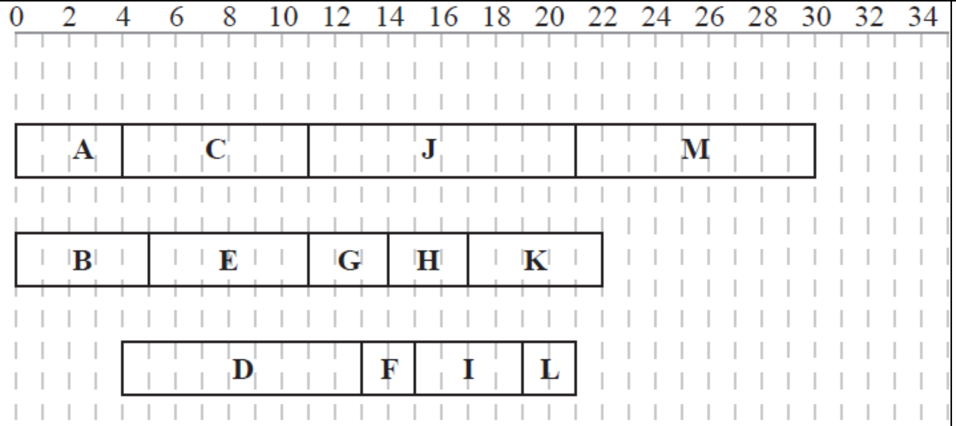
Misreads

- If they have used the correct numbers at any point in part (a) and then use incorrect numbers in part (b) (say 71 instead of 17) from the beginning of the sort or misread their own numbers **during part (b)** then count it as an **error in part (b)** (so they will lose at least the final A mark but should be able to gain at least the M mark and ft A mark) – then mark part (c) according to the SC above.

Sorting list into ascending order in (b)

- If the candidate sorts the list into ascending order and reverse the list **in part (b)** then they can score full marks in (b).
- If the list is not reversed in part (b) then mark as a misread (so remove the last two A marks if earned in (b)). If the list is reversed at the start of (c) but not in (b) then still treat this as a misread. If the list is still in ascending order in part (c) award no marks for first fit increasing. If the candidate says that the list needs reversing in part (b) but doesn't actually show the reversed list in (b) then remove the final A mark in (b).

Ascending (middle left)										Ascending (middle right)								
24	14	8	x	$\boxed{19}$	25	6	17	9	M1	24	14	8	x	$\boxed{19}$	25	6	17	9
14	8	$\boxed{6}$	17	9	$\underline{19}$	24	$\boxed{x}$	25	A1	14	8	$\boxed{6}$	17	9	$\underline{19}$	24	$\boxed{x}$	25
$\underline{6}$	14	$\boxed{8}$	17	9	$\underline{19}$	$\underline{x}$	$\boxed{24}$	25		$\underline{6}$	14	8	$\boxed{17}$	9	$\underline{19}$	$\underline{x}$	24	$\boxed{25}$
$\underline{6}$	$\underline{8}$	14	$\underline{17}$	9	$\underline{19}$	$\underline{x}$	$\underline{24}$	25	A1	$\underline{6}$	14	$\boxed{8}$	9	$\underline{17}$	$\underline{19}$	$\underline{x}$	24	$\underline{25}$
$\underline{6}$	$\underline{8}$	$\boxed{14}$	9	$\underline{17}$	$\underline{19}$	$\underline{x}$	$\underline{24}$	25		$\underline{6}$	$\underline{8}$	14	$\boxed{9}$	$\underline{17}$	$\underline{19}$	$\underline{x}$	24	$\underline{25}$
$\underline{6}$	$\underline{8}$	9	$\underline{14}$	$\underline{17}$	$\underline{19}$	$\underline{x}$	$\underline{24}$	25	A1cso	$\underline{6}$	$\underline{8}$	$\underline{9}$	14	$\underline{17}$	$\underline{19}$	$\underline{x}$	24	$\underline{25}$

Question Number	Scheme	Marks
7. (a)	The total float $F(i,j)$ of activity (i,j) is defined to be $F(i,j) = l_j - e_i -$ duration (i,j), where $e_i$is the **earliest** time for event i and $l_j$is the **latest** time for event j **(see note below)**	B2,1,0 **(2)**
(b)		M1 A1 A1 **(3)**
(c)	Critical activities: A C J M	B1 **(1)**
(d)	G can be delayed by 21 – 11 – 3 = 7 (days)	M1 A1 **(2)**
(e)	$\frac{69}{30} = 2.3$ so lower bound is 3 workers	M1 A1 **(2)**
(f) e.g.		M1 A1 A1 A1 **(4)** **14 marks**

Notes for Question 7

a1B1: For the first mark: the idea that total float is ‘how long an activity can be delayed for’. Give bod.
a2B1: For both marks: A clear correct statement e.g. the **total** amount of time that an activity may be delayed from its **early** start without delaying the project **finish** time. The candidate must clearly demonstrate a knowledge that total float = latest finish – earliest start – duration of activity. Ignore comments that infer that total refers to the sum of the floats for all activities in an activity network. Note that B1B0 should be awarded for an answer that has the pertinent idea of ‘float’ (see a1B1 above) and B1B1 for a clear correct statement (see a2B1 above) – B0B1 cannot be awarded in this part.
b1M1: All top boxes and all bottom boxes completed. Values generally increasing from left to right (for top boxes) and values generally decreasing from right to left (for bottom boxes) . Condone missing 0 or 30 for M only (for bottom boxes). Condone one rogue value in top boxes **and** one rouge value in bottom boxes (if values do not increase from left to right (or decrease right to left) then if **one** value is ignored and then the values do increase from left to right (or decrease right to left) then this is considered to be one rogue value).
b1A1: CAO for top boxes.
b2A1: CAO for bottom boxes.

c1B1: CAO

d1M1: Correct calculation for their activity G seen - all three numbers correct (ft). Final value must be non-negative.
d1A1: CAO (no follow through on this A mark). Answer of 7 with no working scores no marks in this part.

e1M1: Attempt to find lower bound [59 – 79 / their finish time]
e1A1: CAO – correct calculation seen then 3. [As 30/13 also gives 3, an answer of 3 with no working scores M0A0.]

f1M1: Not a cascade chart. 4 ‘workers’ used at most and at least 8 activities placed.
f1A1: The critical (A, C, J, M) activities and B and D correct A – 4, C – 7, J – 10, M – 9, B – 5, D – 9. B must be completed by its late finish time (11) and D must start after A and finishing before its late finish time (15).

Now check the last 7 activities – the last two marks are for E, F, G, H, I, K and L **only**

First check that there are only three workers and that all 13 activities are present (just once).

Then check precedences (see table below) – each row of the table could give rise to 1 error only in precedences

Finally check the length of each activity and the time interval in which the activity must take place (interval is inclusive).

Activity	Duration	Time interval	IPA
E	6	4 – 17	A
F	2	13 – 17	D
G	3	11 – 21	B, C
H	3	13 – 21	D
I	4	15 – 21	E, F
K	5	14 – 30	G
L	2	14 – 30	G

f2A1: 3 workers. All 13 activities present (just once). Condone one error either precedence, time interval or activity length, on activities E, F, G, H, I, K and L only.
f3A1: 3 workers. All 13 activities present (just once). No errors on activities E, F, G, H, I, K and L.

Question Number	Scheme	Marks
8. (a)	$y \leq 2x, \quad 5y \geq 2x, \quad 2x + y \leq 36, \quad 4x + y \geq 36$	B2,1,0 **(2)**
(b)	B(6,12), C(9,18), D(15,6)	B1
	$A\left(\frac{90}{11}, \frac{36}{11}\right)$,	B1
	at A: $F = \frac{90}{11} + \frac{36}{11}k$, at B: $F = 6 + 12k$, at C: $F = 9 + 18k$, at D: $F = 15 + 6k$	B1
	$\frac{90}{11} + \frac{36}{11}k < 6 + 12k$ and $9 + 18k < 15 + 6k$	M1
	$k > \frac{1}{4}$ and $k < \frac{1}{2}$	A1
	$\frac{1}{4} < k < \frac{1}{2}$	A1 **(6)** **8 marks**

Notes for Question 8

a1B1: Any two correct inequalities (condone strict inequalities).
a2B1: CAO (equalities cannot be strict for this mark).

As there are a number of different methods that the candidates can adopt – consider the candidate's full response and mark each attempt according to the notes below – award the candidate the marks for their best response/attempt. However, do not mix the approaches together e.g. if they find the exact coordinates of all four vertices and then state that the maximum gradient of P is -2 then this would score the first two marks only (method 1).

Method 1 (point testing)
b1B1: The coordinates of B, C and D stated exactly.
b2B1: The coordinates of A stated exactly.
b3B1: The objective function calculated in terms of k at either A or B or C or D.
b1M1: Either (their objective function at A) $<$ (their objective function at B) **or** (their objective function at C) $<$ (their objective function at D) (condone equals sign or any inequality).
b1A1: Either $k > \frac{1}{4}$ **or** $k < \frac{1}{2}$ **or** $k \geq \frac{1}{4}$ **or** $k \leq \frac{1}{2}$.
b2A1: CAO $\frac{1}{4} < k < \frac{1}{2}$ **or** $\frac{1}{4} \leq k \leq \frac{1}{2}$ (or as separate inequalities)

Method 2 (objective line method I)
Comparing the gradient of the objective function to the gradient of the two lines with negative gradient.
b1B1: The **minimum** gradient (of P) stated as -4 – **must** see explicit mention of minimum.
b2B1: The **maximum** gradient (of P) stated as -2 – **must** see explicit mention of maximum.
b3B1: Gradient of objective function stated as $-\frac{1}{k}$.
b1M1: Comparing gradient of objective function to either -2 or -4.
Final two marks as in method 1.

Method 3 (objective line method II)
b1B1: **Minimum** P parallel to $4x + y = \cdots$ (limiting case) – **must** see explicit mention of minimum.
b2B1: **Maximum** P parallel to $2x + y = \cdots$ (limiting case) – **must** see explicit mention of maximum.
b3B1: Re-arranging equations (either seen or implied) to give $x + \frac{y}{4} = \cdots, x + \frac{y}{2} = \cdots$
b1M1: Compare coefficients of y in the objective function & lines.
Final two marks as in method 1.

SC: If **no** working seen (max 3/6 marks)

k ■ $\frac{1}{2}$ **or** k ■ $\frac{1}{4}$ (where ■ is any inequality or equals) award first B mark.
$k > \frac{1}{4}$ **or** $k < \frac{1}{2}$ **or** $k \geq \frac{1}{4}$ **or** $k \leq \frac{1}{2}$ award the first two B marks.
$\frac{1}{4} < k < \frac{1}{2}$ **or** $\frac{1}{4} \leq k \leq \frac{1}{2}$ award the first three B marks.

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Mark Scheme (Results)

January 2015

Pearson Edexcel International A Level in Decision Mathematics 1 (WDM01/01)

Edexcel and BTEC Qualifications

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate’s response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

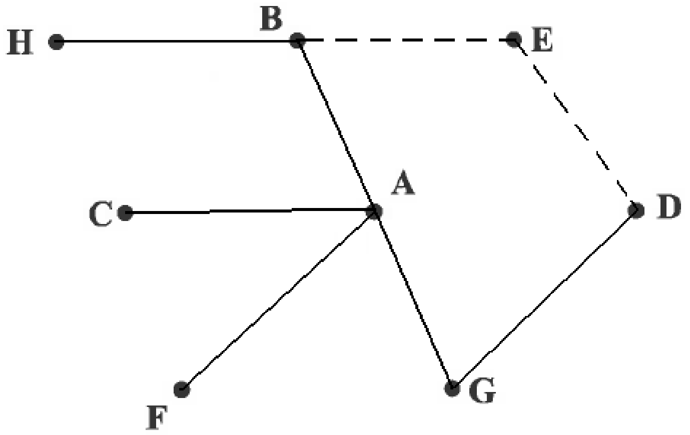
   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\sqrt{}$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper or ag- answer given
   - ⎿ or d… The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. (a)	AC, AB, BH; AF AG; DG, DE or BE	M1 A1 A1 **(3)**
(b)	 Weight of tree = 73 (mins)	B1 B1 **(2)**
(c)	No – there are two different MST (with a weight of 73) either with DE or BE	B1 **(1)** **6 marks**

Notes for Question 1

a1M1: First three arcs correctly chosen in order {AC, AB, BH,…} **or** first four nodes correctly chosen in order{A, C, B, H,…}. **If any rejections seen at any point then M1 (max) only**. Order of nodes may be seen at the top of the matrix {1, 3, 2, -, -, -, -, 4} so please check the top of the matrix carefully.
a1A1: First five arcs correctly chosen in order {AC, AB, BH, AF, AG,…}**or** all eight nodes correctly chosen in order{A, C, B, H, F, G, D, E}. Order of nodes may be seen at the top of the matrix so for the first two marks accept {1, 3, 2, 7, 8, 5, 6, 4} (**do not** condone any missing numbers e.g. the number 8 must be above E).
a2A1: CSO – all **arcs** correct stated and chosen in the correct order. Candidates must be considering arcs for this final mark (do not accept a list of nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen). Allow DE **or** BE for the final arc but not DE **and** BE.
Misread: Starting at a node other than A scores **M1 only** – must have the first three arcs (or four nodes) correct (and in the correct order).
b1B1: CAO (condone lack of weights on arcs) – condone, say, a dashed line between B and E if arc DE is in the tree (or vice-versa).
b2B1: CAO (73) (condone lack of units).
c1B1: CAO – mention of two different MST with either arc BE or DE.

Question Number	Scheme	Marks
2. (a)	e.g. B can only do task 2 and F can only do task 6 therefore E will have no allocation as E can only do tasks 2 and 6 e.g. D has to do task 4 as task 4 can only be done by D therefore task 5 has to be done by A as task 5 can only be done by A and D which leaves task 3 with no worker as only A can do task 3	B1 **(1)**
(b)	C – 1 = A – 3 C – 1 = A – 5 = D – 4	B1 B1 **(2)**
(c)	A = 3, B = 2, C = 1, D = 5, E = 6 (F unmatched) A = 5, B = 2, C =1, D = 4, E = 6 (F unmatched)	B1 B1 **(2)**
(d)	Alternating path F – 6 = E – 2 = B – 5 = D – 4 **or** F – 6 = E – 2 = B – 5 = A – 3 Change status F = 6 – E = 2 – B = 5 – D = 4 **or** F = 6 – E = 2 – B = 5 – A = 3 Complete matching A = 3, B = 5, C = 1, D = 4, E = 2, F = 6	M1 A1 A1 **(3)** **8 marks**

Notes for Question 2

a1B1: CAO – must be a completely correct statement.
b1B1: CAO (C – 1 = A – 3).
b2B1: CAO (C – 1 = A – 5 = D – 4).
c1B1: CAO (A = 3, B = 2, C = 1, D = 5, E = 6).
c2B1: CAO (A = 5, B = 2, C =1 , D = 4, E = 6).
d1M1: An alternating path from F to either 3 or 4 (or vice-versa).
d1A1: CAO – a correct path including change status **either** stated (only accept ‘change (of) status’ or ‘c.s.’) **or** shown. Chosen path clear.
d2A1: CAO must follow from the correct stated path. Accept on a clear diagram (with six arcs only).

Question Number	Scheme	Marks
3. (a)	Bin 1: **1.1** **0.7** **0.9** $\underline{0.2}$ Bin 2: **1.9** 0.4 0.5 Bin 3: $\underline{2.1}$ Bin 4: $\underline{2.3}$ Bin 5: 1.7	**M1** $\underline{\text{A1}}$ A1 **(3)**
(b) (i) **(ii)**	1.1 1.9 0.9 2.1 0.7 2.3 0.4 0.5 1.7 0.2 Comparisons: 9 Swaps: 7	M1 A1 B1 B1 **(4)**
(c)	e.g. using middle right 1.9 1.1 2.1 0.9 2.3 $\boxed{0.7}$ 0.5 1.7 0.4 0.2 pivot 0.7 1.9 1.1 2.1 $\boxed{0.9}$ 2.3 1.7 $\underline{0.7}$ 0.5 $\boxed{0.4}$ 0.2 pivots 0.9 0.4 1.9 1.1 $\boxed{2.1}$ 2.3 1.7 $\underline{0.9}$ $\underline{0.7}$ 0.5 $\underline{0.4}$ 0.2 pivot(s) 2.1 (0.5) (0.2) 2.3 $\underline{2.1}$ 1.9 $\boxed{1.1}$ 1.7 $\underline{0.9}$ $\underline{0.7}$ 0.5 $\underline{0.4}$ 0.2 pivot(s) (2.3) 1.1 2.3 $\underline{2.1}$ 1.9 $\boxed{1.7}$ $\underline{1.1}$ $\underline{0.9}$ $\underline{0.7}$ 0.5 $\underline{0.4}$ 0.2 pivot 1.7 2.3 $\underline{2.1}$ 1.9 $\underline{1.7}$ $\underline{1.1}$ $\underline{0.9}$ $\underline{0.7}$ 0.5 $\underline{0.4}$ 0.2 (sort complete)	M1 A1 A1ft A1 **(4)**
(d)	Bin 1: **2.3** $\underline{0.7}$ Bin 2: **2.1** $\underline{0.9}$ Bin 3: **1.9** **1.1** Bin 4: **1.7** 0.5 0.4 0.2	**M1** $\underline{\text{A1}}$ A1 **(3)** **14 marks**

Notes for Question 3

a1M1: First four numbers placed correctly and at least six numbers put in bins. Condone cumulative totals here only.
a1A1: First seven numbers placed correctly.
a2A1: CSO – all correct.
bi1M1: Bubble sort, end number in place correctly.
SC **for M1 only**: 0.7 1.1 0.9 1.9 0.2 2.1 0.4 0.5 1.7 2.3 (ascending from left-hand end).
0.2 1.1 0.7 1.9 0.9 2.1 0.4 2.3 0.5 1.7 (ascending from right-hand end).
2.3 1.1 0.7 1.9 0.9 2.1 0.2 1.7 0.4 0.5 (descending from right-hand end).
bi1A1: CAO – isw after one complete pass.
bii1B1: Comparisons correct (9).
bii2B1: Swaps correct (7).
c1M1: Quick sort – pivots, p, selected and first pass gives >p, p, <p. **If only choosing 1 pivot per iteration M1 only. Using bubble sort in this part is M0.**
c1A1: First pass correct and next pivots chosen correctly/consistently for second pass.
c2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots) – next pivot(s) chosen correctly/consistently for fourth pass.
c3A1: CSO – including choice of pivot for the fifth pass and then either a ‘stop’ statement or final re-listing or using each item as a pivot.
d1M1: **Must be using ‘sorted’ list** in decreasing order (independent of (c)). First five numbers placed correctly and at least six numbers put in bins. **First-fit increasing is M0**.
d1A1: First seven numbers placed correctly.
d2A1: CSO – all correct.

Question Number	Scheme	Marks

SC for (d): If the ‘sorted’ list used in (d) has one ‘error’ from (c) (e.g. a missing number, an extra number or one number incorrectly placed) then **M1 only** can be awarded in (d) (for the first five numbers placed correctly). If there is more than one ‘error’ then M0. Allow full marks in (d) if a correct list is used in (d) even if the list is incorrect at the end of (c).

Sorting list into ascending order in (c)

- If the candidate sorts the list into ascending order and reverses the list in (c) then they can score full marks in (c).
- If the list is not reversed in (c) then mark as a misread (so remove the last two A marks earned in (c)). If the list is reversed at the start of (d) but not in (c) then still treat this as a misread. If the candidate says that the list needs reversing in (c) but doesn’t actually show the reversed list in (c) then remove the final A mark earned in (c).

Middle left

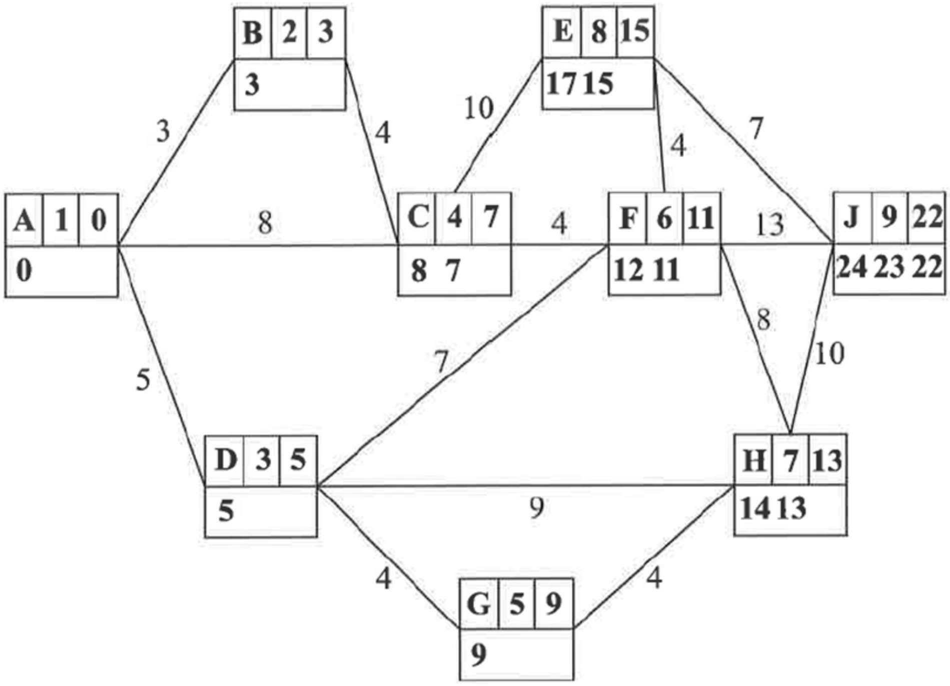
1.9	1.1	2.1	0.9	$\boxed{2.3}$	0.7	0.5	1.7	0.4	0.2	Pivot 2.3	
$\underline{2.3}$	1.9	1.1	2.1	0.9	$\boxed{0.7}$	0.5	1.7	0.4	0.2	Pivot 0.7	M1 A1
$\underline{2.3}$	1.9	1.1	$\boxed{2.1}$	0.9	1.7	$\underline{0.7}$	0.5	$\boxed{0.4}$	0.2	Pivot 2.1 0.4	
$\underline{2.3}$	$\underline{2.1}$	1.9	$\boxed{1.1}$	0.9	1.7	$\underline{0.7}$	0.5	$\underline{0.4}$	0.2	Pivot 1.1 (0.5) (0.2)	A1ft
$\underline{2.3}$	$\underline{2.1}$	$\boxed{1.9}$	1.7	$\underline{1.1}$	0.9	$\underline{0.7}$	0.5	$\underline{0.4}$	0.2	Pivot 1.9 (0.9)	
2.3	$\underline{2.1}$	$\underline{1.9}$	1.7	$\underline{1.1}$	0.9	$\underline{0.7}$	0.5	$\underline{0.4}$	0.2	(sort complete)	A1

Ascending order (middle right)

1.9	1.1	2.1	0.9	2.3	$\boxed{0.7}$	0.5	1.7	0.4	0.2	Pivot 0.7	
0.5	$\boxed{0.4}$	0.2	$\underline{0.7}$	1.9	1.1	2.1	$\boxed{0.9}$	2.3	1.7	Pivot 0.4 0.9	M1 A1
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	$\underline{0.9}$	1.9	1.1	$\boxed{2.1}$	2.3	1.7	Pivot (0.2) (0.5) 2.1	
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	$\underline{0.9}$	1.9	$\boxed{1.1}$	1.7	$\underline{2.1}$	2.3	Pivot 1.1 (2.3)	A1ft
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	$\underline{0.9}$	$\underline{1.1}$	1.9	$\boxed{1.7}$	$\underline{2.1}$	2.3	Pivot 1.7	
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	$\underline{0.9}$	$\underline{1.1}$	$\underline{1.7}$	1.9	$\underline{2.1}$	2.3	sort complete	A1

Ascending order (middle left)

1.9	1.1	2.1	0.9	$\boxed{2.3}$	0.7	0.5	1.7	0.4	0.2	Pivot 2.3	
1.9	1.1	2.1	0.9	$\boxed{0.7}$	0.5	1.7	0.4	0.2	$\underline{2.3}$	Pivot 0.7	M1 A1
0.5	$\boxed{0.4}$	0.2	$\underline{0.7}$	1.9	1.1	$\boxed{2.1}$	0.9	1.7	$\underline{2.3}$	Pivot 0.4 2.1	
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	1.9	$\boxed{1.1}$	0.9	1.7	$\underline{2.1}$	$\underline{2.3}$	Pivot (0.2) (0.5) 1.1	A1ft
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	0.9	$\underline{1.1}$	$\boxed{1.9}$	1.7	$\underline{2.1}$	$\underline{2.3}$	Pivot (0.9) 1.9	
0.2	$\underline{0.4}$	0.5	$\underline{0.7}$	0.9	$\underline{1.1}$	1.7	$\underline{1.9}$	$\underline{2.1}$	$\underline{2.3}$	sort complete	A1

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>4. (a)</td><td>

Shortest route: ABCFEJ
Length: 22 (metres)</td><td>M1
A1 (ABDC)
A1(GFH)
A1ft (EJ)
A1
A1ft (6)</td></tr>
<tr><td>(b)</td><td>AE + FJ = 15 + 11 = 26
AF + EJ = 11 + 7 = 18*
AJ + EF = 22 + 4 = 26
Arcs AB, BC, CF, EJ will be traversed twice</td><td>M1 A1ft
A1ft
A1ft
A1 (5)</td></tr>
<tr><td>(c)</td><td>Route: e.g. ABADGHDFHJEJFECFCBCA
Length: 100 + 18 = 118</td><td>B1
B1ft (2)</td></tr>
<tr><td>(d)</td><td>Start at E, finish at J (or vice versa) or start at C, finish at J (or vice-versa)
Length: 100 – 3 – 4 + 4 = 97 (metres)</td><td>M1 A1
B1 (3)
16 marks</td></tr>
</table>

Notes for Question 4

a1M1: A larger value replaced by a smaller value at least once in the working values at either C or E or F or H or J.

a1A1: All values in A, B, C and D correct and the working values in the correct order, including order of labelling. Condone lack of 0 in A’s working value.

a2A1: All values in F, G and H correct and the working values in the correct order. Penalise order of labelling only once per question. Condone an additional working value at H of 19 after the 13.

a3A1ft: All values in E and J correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question.

a4A1: CAO (ABCFEJ) for the route.

a5A1ft: Follow through on their final value at J – if their answer is not 22 follow through their final value at J (condone lack of units).

b1M1: Three pairings of the **correct** four odd nodes.

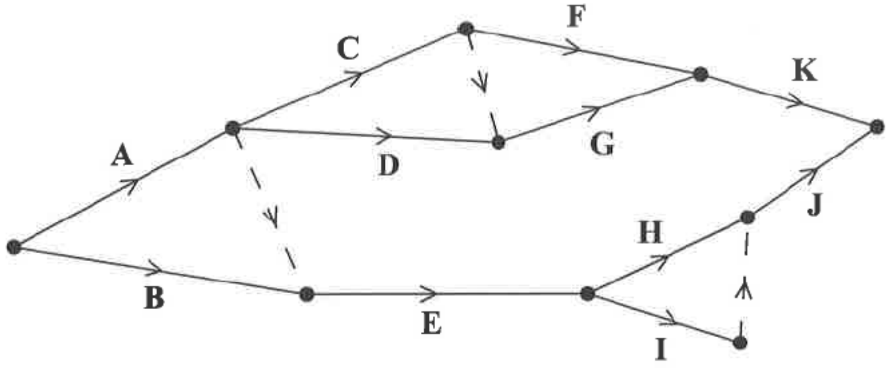
b1A1ft: One row correct including pairing **and** total (the ft on the first three A marks in (b) is for using their final values at E, F and J from (a) for the lengths of AE, AF and AJ only).

b2A1ft: Two rows correct including pairings **and** totals.

b3A1ft: All three rows correct including pairings **and** totals.

b4A1: The smallest repeat **arcs** AB, BC, CF and EJ clearly stated. Accept ABCF, EJ but **not** AF.

Question Number	Scheme	Marks
c1B1: Any correct route (checks: 20 nodes, starting and finishing at A, pairings AB, BC, CF, EJ appear twice in the route and that A, C and F appear three times, B, D, E, H and J appear twice and G appears once). c2B1ft: Correct answer of 118 **or** 100 + their least out of a choice of at least **two** totals given in (b). d1M1: Any consideration/mention of all the odd nodes (C, E, F and J) **or** consideration/mention of all the odd pairings (CE, CF, CJ, EF, EJ, FJ) **or** consideration/mention of arcs EF **and** CF (and no others) having least weight **or** EF **and** CF (and no others) having a weight of 4 **or** listing one correct starting and finishing point (must be clear). d1A1: Both combinations of starting and finishing points correct (E and J + C and J) and no others. d1B1: CAO (97)		

Question Number	Scheme	Marks
5. (a)		M1 A1 A1 A1 A1 **(5)**
(b)	Dummies are needed to show either – dependency where subsequent activities **do not all** depend on the **same** preceding activities – that an activity can be **uniquely** represented in terms of its end events	B1 B1 **(2)** **7 marks**

Notes for Question 5

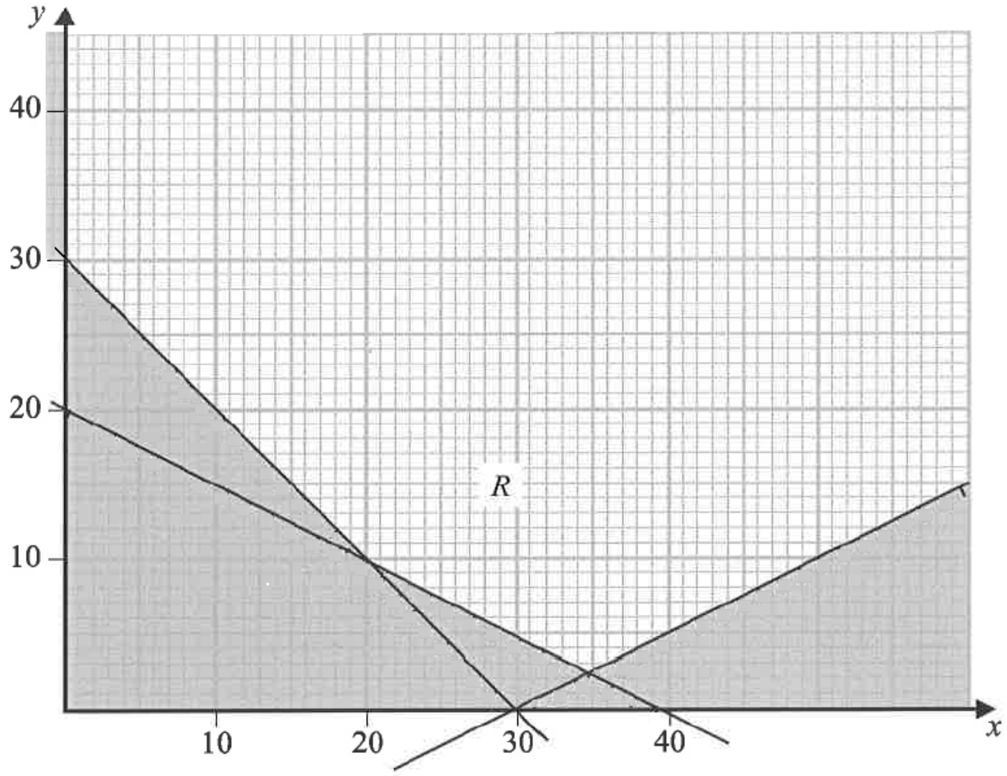
In (a) condone lack of, or incorrect, numbered events throughout – also 'dealt with correctly' means that the activity starts from the correct event but may not finish at the correct event. **Activity on node is M0**.

Do not penalise the same error twice with the first three A marks, for example, if activity C is not labelled (but the arc is present) then this will lose the first A mark and the final (CSO) A mark – they can still earn the second A mark on the bod.

a1M1: Eight activities (labelled on arc), one start and at least one dummy placed.
a1A1: Activities A, B, 1st dummy (+ arrow) and C, D and E dealt with correctly.
a2A1: 2nd dummy (+ arrow) and F, G and K dealt with correctly.
a3A1: Activities H, I, 3rd dummy (+ arrow) and J dealt with correctly.
a4A1: CSO – **all** arrows present **and** correctly placed with one finish.

Penalise lack of, or incorrect, arrows on the dummies only once with the first three A marks (on the first occurrence).

b1B1: Dependency + some explanation of what this means, bod – allow a correct example using any nodes/letters.
b2B1: Uniqueness – please note that, for example, 'so that activities can be defined uniquely' is not sufficient to earn this mark. There must be some mention of describing activities either in terms of the event **at each end** or in terms of an activities **events**. However, give bod on statements that imply that an activity begins and ends at the same event.

Question Number	Scheme	Marks
6. (a)	$x + y \geq 30$	B1 **(1)**
(b)	$x \geq 0,\ y \geq 0$	B1 **(1)**
(c)		B1 B1 B1 B1 **(4)**
(d)	Objective line drawn (34,3) so 34 red hats and 3 green hats	M1 A1 A1 **(3)**
(e)	$34r + 3g = 107.5$ $g = 3r$ Leading to $r = 2.50$ and $g = 7.50$ So a red hat costs £2.50 and a green hat costs £7.50	B1ft B1 DB1 **(3)** **12 marks**

Notes for Question 6

a1B1: CAO ($x + y \geq 30$).

b1B1: CAO (accept $x, y \geq 0$ **or** *x* and *y* are non-negative) – do not accept strict inequalities.

In (c) lines must pass through one small square of the points stated:

$x + y = 30$ passes through (0, 30), (15, 15), (30, 0)
$2y + x = 40$ passes through (0, 20), (20, 10), (40, 0)
$2y - x = -30$ passes through (30, 0), (50, 10), (60, 15)

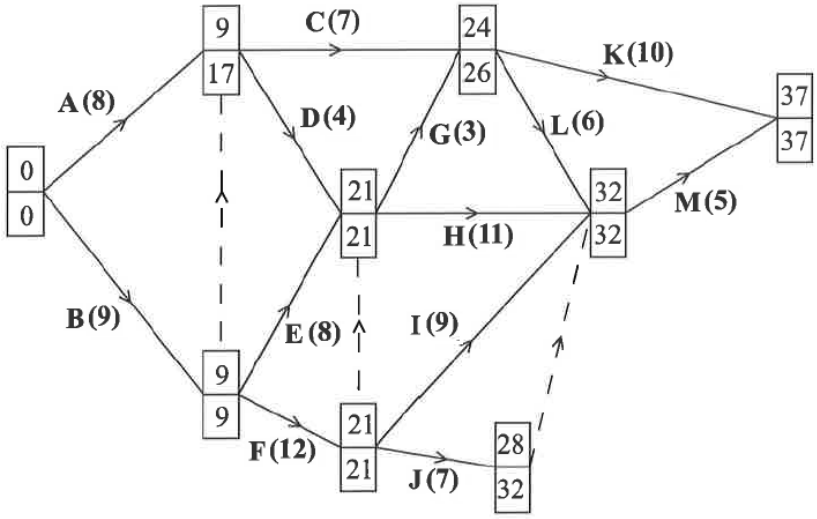
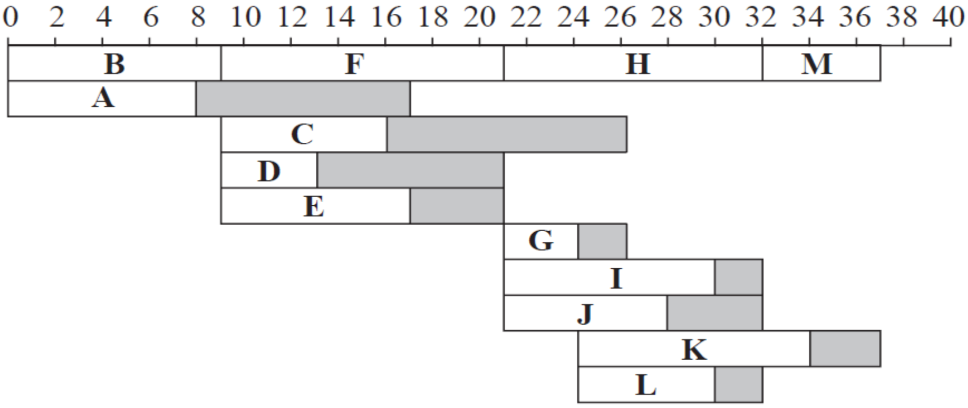
c1B1: $x + y = 30$ drawn correctly.

c2B1: $2y + x = 40$ drawn correctly.

c3B1: $2y - x = -30$ drawn correctly.

c4B1: Region, R, correctly labelled – not just implied by shading - must have scored all three previous marks in this part. Condone lack of shading for $x \geq 0$.

Question Number	Scheme	Marks
	d1M1: Drawing the correct objective line or its reciprocal $\left(m = -3 \text{ or } -\frac{1}{3}\right)$. Line must be correct to within one small square if extended from axis to axis. d1A1: Correct objective line $\left(m = -\frac{1}{3}\right)$ – condone lack of labelling of the objective line. d2A1: Correct point identified – accept as a coordinate (34, 3). e1B1ft: A 'correct' equation involving **their** optimal point from (d) (accept any values even if non-integer) and 107.50. e2B1: CAO on the relationship between the costs of green hats and red hats ($g = 3r$) – this mark may be implied e.g. $34r + 3(3r) = 107.5$ would score the first two marks in this part. e3DB1: CAO – this mark is dependent on having the correct optimal point (34, 3) in (d).	

Question Number	Scheme	Marks
7. (a)	$x = 12$ $y = 3$	B1 B1 **(2)**
(b)		M1 A1 A1 **(3)**
(c)	Lower bound = $\frac{99}{37} = 2.675\ldots$ so 3 workers	B1 **(1)**
(d)		M1 A1 A1 A1 **(4)**
(e)	Lower bound is 5 workers – e.g. activities H, I, J, K and L together with $27 < \text{time} < 28$	M1 A1 **(2)** **12 marks**

Notes for Question 7

a1B1: Correct value (12) for x.
a2B1: Correct value (3) for y.

b1M1: All (but one) boxes complete and any three values correct.
b1A1: Any five values correct.
b2A1: CAO (all seven values correct).

c1B1: CSO – no incorrect working – if 3 workers with no working then give on the bod.

d1M1: At least nine activities including at least five floats. **Scheduling diagram scores M0**.
d1A1: The correct critical activities (B, F, H and M) dealt with correctly.
d2A1: All correct non-critical activities present with floats with five non-critical activities correct.
d3A1: All nine non-critical activities correct.

Question Number	Scheme	Marks
e1M1: A statement with the correct number of workers (5) **and** the correct activities (H, I, J, K and L) with some mention of time. e1A1: A completely correct statement with details of both time **and** activities. Candidates only need to give a time within the correct interval. Please note the strict inequalities for the time interval. Allow for example, ‘on day 28’ as equivalent to 27 < time < 28.		

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Mark Scheme (Results)

Summer 2015

Pearson Edexcel International A Level in Decision Mathematics 1 (WDM01/01)

Edexcel and BTEC Qualifications

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Summer 2015
Publications Code IA041219

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

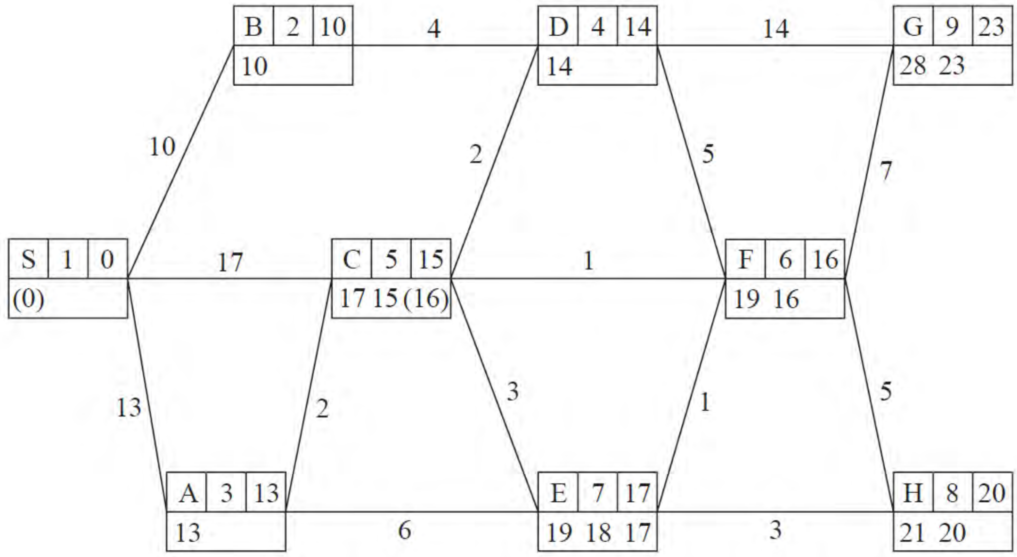
   - bod – benefit of doubt
   - ft – follow through
   - the symbol √ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - ⎿ or d… The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. (a)	 Shortest distance: 23 (km) Shortest route: S – A – C – F – G	M1 A1 (SABDC) A1 (FE) A1ft (HG) A1ft A1 **(6)**
(b)	Shortest distance: 20 (km) Shortest route: S – A – C – F – E – H	B1ft B1 **(2)** **(8 marks)**

Notes for Question 1

a1M1: A larger value replaced by a smaller value at least once in the working values at either C or E or F or G or H
a1A1: All values in S, A, B, D and C correct. The working values at C must be in the correct order. Condone lack of 0 in S's working value
a2A1: All values in F and E correct and the working values in the correct order. Penalise order of labelling only once per question (F and E must be labelled in that order and F must be labelled after S, A, B, D and C)
a3A1ft: All values in H and G correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question (H and G must be labelled in that order and H labelled after all other nodes (excluding G))
a4A1ft: If their answer is not 23 follow through their final value at G (condone lack of units)
a5A1: CAO for the route (S – A – C – F – G)

b1B1ft: If their answer is not 20 follow through their final value at H (condone lack of units)
b2B1: CAO for the route (S – A – C – F – E – H)

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>2.(a)</td><td>In the first pass we compare the first value with the second value and we swap these values if the second is larger than the first
We then compare the value which is now second with the third value and swap if the third is larger than the second. We continue in this way until we reach the end of the list</td><td>M1 A1 (2)</td></tr>
<tr><td>(b)(i)
(ii)</td><td>The smallest value will be in the correct final position after the first pass
Maximum number of passes is $n-1$</td><td>B1
B1 (2)</td></tr>
<tr><td>(c)</td><td>
<table>
<tr><td></td><td>11</td><td>9</td><td>4</td><td>13</td><td>5</td><td>1</td><td>7</td><td>12</td><td>8</td></tr>
<tr><td>1st pass:</td><td>11</td><td>9</td><td>13</td><td>5</td><td>4</td><td>7</td><td>12</td><td>8</td><td>1</td></tr>
<tr><td>2nd pass:</td><td>11</td><td>13</td><td>9</td><td>5</td><td>7</td><td>12</td><td>8</td><td>4</td><td>1</td></tr>
<tr><td>3rd pass:</td><td>13</td><td>11</td><td>9</td><td>7</td><td>12</td><td>8</td><td>5</td><td>4</td><td>1</td></tr>
<tr><td>4th pass:</td><td>13</td><td>11</td><td>9</td><td>12</td><td>8</td><td>7</td><td>5</td><td>4</td><td>1</td></tr>
<tr><td>5th pass:</td><td>13</td><td>11</td><td>12</td><td>9</td><td>8</td><td>7</td><td>5</td><td>4</td><td>1</td></tr>
<tr><td>6th pass:</td><td>13</td><td>12</td><td>11</td><td>9</td><td>8</td><td>7</td><td>5</td><td>4</td><td>1</td></tr>
</table>
Sort complete</td><td>M1
A1
A1ft
A1(cso) (4)</td></tr>
<tr><td>(d)</td><td>Bin 1: $\underline{13}$ $\underline{8}$
Bin 2: $\underline{12}$ $\underline{9}$
Bin 3: $\underline{11}$ 7 1
Bin 4: 5 4</td><td>$\underline{\text{M1}}$ A1 (2)
(10 marks)</td></tr>
<tr><td colspan="3">Notes for Question 2</td></tr>
<tr><td colspan="3">a1M1: Comparing first value with second value, swap if second is larger (oe) – must be clear that the first value in the list is being compared with the second value in the list and swapping if the second is larger than the first
a1A1: Compare second with third, (third with fourth), and so on until the end of the list – must be clear that after the first comparison the second value in the list is compared with the third value and so on until the end of the list

bi1B1: CAO (on smallest value oe) – allow 1 (this is the smallest value from the list in (c))
bii2B1: CAO

c1M1: Bubble sort. Consistent direction, end number (1) in place. Do check these carefully as some candidates show the result of each comparison and swap in the first pass. Consider the placement of the candidate’s numbers, rather than what the candidate labels each line of their pass. For example, assume that the first time that the 1 appears at the end of the list is the end of their first pass
c1A1: First and second passes correct – so end two numbers in place
c2A1ft: Third and fourth passes correct following through from the candidate’s second pass
c3A1: CSO – including either a ‘sort complete’ statement or final list rewritten/seventh pass

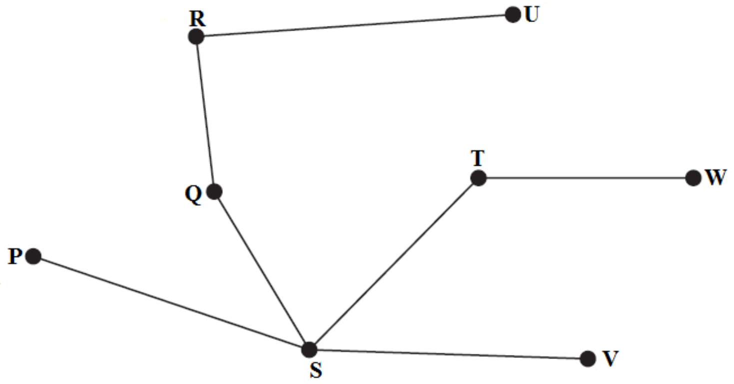
d1M1: Bins 1 and 2 correct and 11 in Bin 3 (so first 5 values correctly placed) – no follow through on an incorrect list from (c)
d1A1: CSO</td></tr>
</table>

Question Number	Scheme	Marks

Sorting list into ascending order in (c)

- If the candidate sorts the list into ascending order and reverses the list then they can score full marks
- If the list is not reversed then mark as a misread. If the candidate says that the list needs reversing but doesn’t actually show the reversed list then remove the final A mark earned

Misreads - if there is a ‘misread’ of a single number (this could take the form of an extra number, a number missing, or a number changed, for example, 31 rather than 13) before starting the sort in (c) then mark as a misread. If they ‘misread’ more than one number then M0. If they miscopy one of their own numbers during the sort then this is an accuracy error and loses the corresponding A mark(s)

Question Number	Scheme	Marks
3.(a)	e.g. P – Q – S – P	B1 **(1)**
(b)	As vertex Q appears more than once… … P – Q – R – T – Q – S is not an example of a path on G	B1 DB1 **(2)**
(c)	PS, ST, SV; QS, QR; RU, TW	M1; A1; A1 **(3)**
(d)	ST SV PS QS (not QT) QR (not PQ) (not TV) RU TW	M1 A1 A1 **(3)**
(e)		B1 **(1)**
(f)	$20 < x < 31$	B2,1,0 **(2)** **(12 marks)**

Notes for Question 3

a1B1: Any closed path on G (**must** begin **and** end with the same vertex) – check that no vertex (except the start and end vertex) appears more than once

b1B1: No + attempt at a reason – **any** mention of cycle/circle/loop etc. **or repeated** vertex/node/point etc. is sufficient for this mark (condone incorrect technical language) – give bod

b2DB1: No + correct reason – no bod – must refer to vertex Q appearing twice (in the walk – **not** just that a vertex is repeated) or that it contains the cycle Q – R – T – Q (**not** just that it contains a cycle). All technical language must be correct for this mark

c1M1: Prim's – First three arcs correctly chosen in order (PS, ST, SV, … or weights 13, 9, 11, …) **or** first four nodes {P, S, T, V, …} correctly chosen in order. If any rejections seen at some point then M1 (max) only. Order of nodes may be seen at the top of a matrix/table {1, -, -, 2, 3, -, 4, -}

c1A1: First five arcs correctly chosen in order (PS, ST, SV, QS, QR, … or weights 13, 9, 11, 14, 16, …) **or** all eight nodes {P, S, T, V, Q, R, U, W} correctly chosen in order. Order of nodes may be seen at the top of a matrix so for the first two marks accept {1, 5, 6, 2, 3, 7, 4, 8} (**no** missing numbers)

c2A1: CSO – all **arcs** correctly **stated** and chosen in the correct order. They must be considering arcs for this final mark (do not accept a list of the weights of each arc, nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen)

Misread: Starting at a node other than P scores **M1 only** – **must** have the first three arcs (or four nodes or numbers) correct (and in the correct order) – condone rejections seen for this mark

Question Number	Scheme	Marks

d1M1: Kruskal's – first four arcs (ST, SV, PS, QS,… or weights 9, 11, 13, 14,…) chosen correctly in order and **at least one rejection seen at some point**
d1A1: All seven arcs (ST, SV, PS, QS, QR, RU, TW or weights 9, 11, 13, 14, 16, 20, 24) chosen correctly in order and no additional arcs
d2A1: CSO – all selections and rejections correct (in correct order and at the correct time) – do not accept weights only for this mark

- Listing all the arcs in order and then listing those arcs in the tree in the correct order is fine for **full marks** (this implies that rejections are correct and at the correct time)
- Listing all the arcs in order and just drawing the MST is **M0**

e1B1: CAO (condone lack of/incorrect weights on arcs)

f1B1: $x < 31$ or $x \leq 31$ or $x < 30$ or $x \leq 30$
f2B1: Either $20 < x < 31$ or $21 \leq x \leq 30$

Question Number	Scheme	Marks
4.(a)	A path from an unmatched vertex in one set to an unmatched vertex in the other set… …which alternately uses arcs not in/in the matching	B1 B1 **(2)**
(b)	Initial matching: A = 3, B = 2, D = 4 (C and E unmatched) Improved matching: A = 4, B = 3, D = 1, E = 2 (C unmatched)	B1 B1 **(2)**
(c)	e.g. (**see below for alternatives**) Alternating path: C – 3 = B – 2 = E – 5 Change status to give: C = 3 – B = 2 – E = 5 Complete matching: A = 4, B = 2, C = 3, D = 1, E = 5	M1 A1 A1 **(3)** **(7 marks)**

Notes for Question 4

Possible paths	A	B	C	D	E
C – 3 – B – 2 – E – 5	4	2	3	1	5
C – 4 – A – 1 – D – 5	1	3	4	5	2
C – 4 – A – 3 – B – 2 – E – 5	3	2	4	1	5

a1B1: **Unmatched** to **unmatched** (vertex/node may be implied but do not accept arc) – technical language (if used) must be correct
a2B1: (Alternate) **arcs not in/in** (arc(s) (**not** vertices/nodes) must be explicitly mentioned)

In (b) ignore the candidates labelling in this part – for example, give bod on candidates who call the initial matching the improved matching (and vice-versa) or those that state the initial matching under (ii). Condone lack of unmatched vertices stated. Both the initial and improved matching may be stated **or** drawn – do check carefully the top of the second page for these drawn there. Only accept a clear diagram with exactly three or four arcs

b1B1: CAO (A = 3, B = 2, D = 4)
b2B1: CAO (A = 4, B = 3, D = 1, E = 2)

c1M1: An alternating path from C to 5 (or vice – versa)
c1A1: CAO – a correct path including change status **either** stated **or** shown. Chosen path clear
c2A1: CAO – must follow from correct stated path. Accept on a clear diagram (with five arcs only).

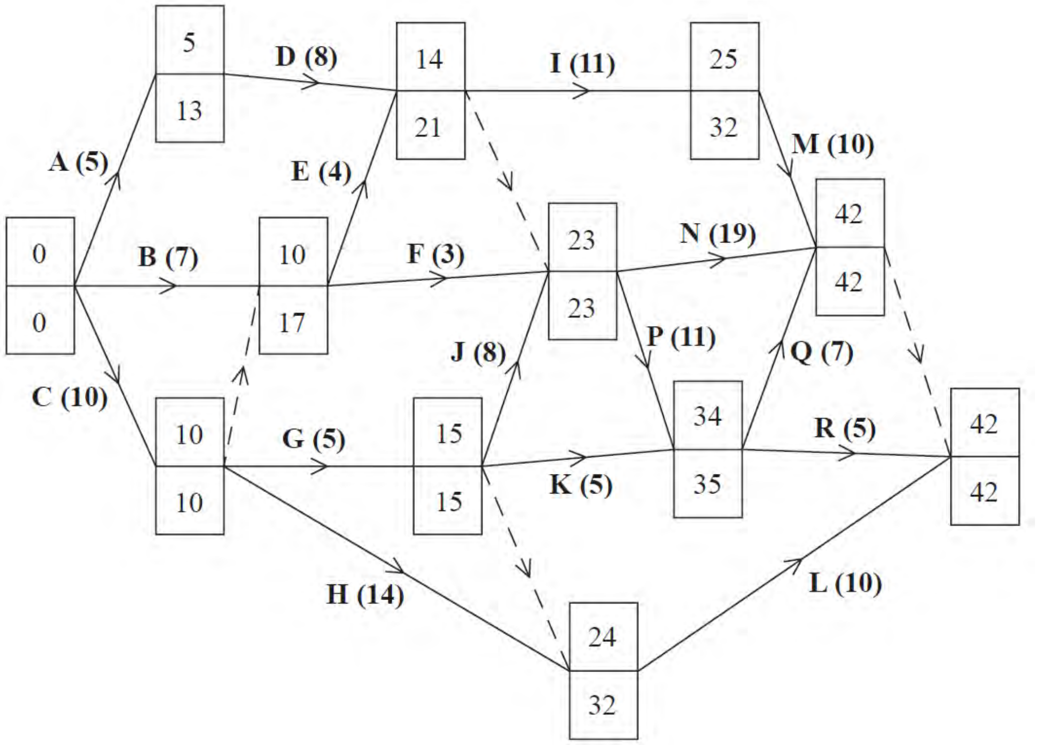
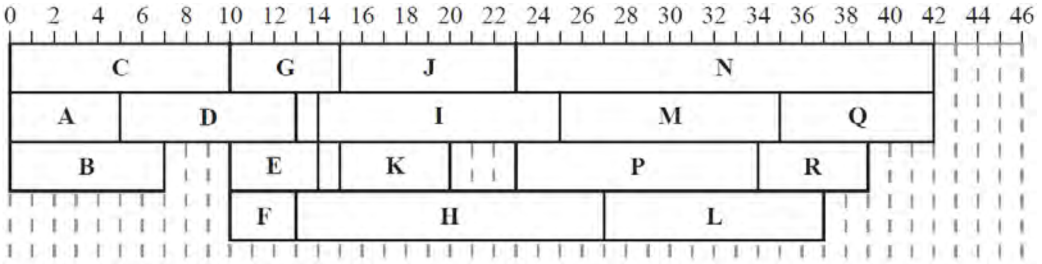
Question Number	Scheme	Marks
5.(a)	A(BC)E + H(F)G = 15 + 13 = 28* A(BDF)H + E(F)G = 30 + 7 = 37 A(BDF)G + E(F)H = 21 + 16 = 37 Repeat arcs: AB, BC, CE, HF, FG Length: 214 + 28 = 242 (km)	M1 A1 A1 A1 A1 A1ft **(6)**
(b)	4	B1 **(1)**
(c)	EG (7) is the shortest link between two odd nodes excluding H Repeat EG (7) since this is the shortest path excluding H We finish at A Length of route = 214 + 7 = 221 (km)	M1 A1 A1 **(3)** **(10 marks)**

Notes for Question 5

a1M1: Three distinct pairings of the correct four odd nodes
a1A1: One row correct including pairings **and** totals
a2A1: Two rows correct including pairings **and** totals
a3A1: All three rows correct including pairings **and** totals
a4A1: The smallest repeat **arcs** (accept ABCE, HFG but not AE, HG)
a5A1ft: Correct answer of 242 **or** 214 + their least

b1B1: CAO (4)

c1M1: Identifies the need to repeat one path of the three (AE, EG, AG) which does not include H (maybe implicit) or listing of only these possible repeats – this mark is dependent on either scoring the M mark in (a) or stating all three posssible paths
c1A1: Identifies EG as the least **and** A as the finishing point. They have to explicitly state the EG is the least path (but they do not need to include that it is the least of those that do not include H as this is the least of all six possible paths)
c2A1: CAO (221)

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>6.(a)</td><td>
<table>
<tr><th>Activity</th><th>Immediately preceded by</th><th>Activity</th><th>Immediate preceded by</th><th>Activity</th><th>Immediately preceded by</th></tr>
<tr><td>A</td><td>-</td><td>G</td><td>C</td><td>M</td><td>I</td></tr>
<tr><td>B</td><td>-</td><td>H</td><td>C</td><td>N</td><td>D E F J</td></tr>
<tr><td>C</td><td>-</td><td>I</td><td>D E</td><td>P</td><td>D E F J</td></tr>
<tr><td>D</td><td>A</td><td>J</td><td>G</td><td>Q</td><td>K P</td></tr>
<tr><td>E</td><td>B C</td><td>K</td><td>G</td><td>R</td><td>K P</td></tr>
<tr><td>F</td><td>B C</td><td>L</td><td>G H</td><td></td><td></td></tr>
</table>
</td><td>B2,1,0 (2)</td></tr>
<tr><td>(b)</td><td>
</td><td>M1
A1
M1
A1 (4)</td></tr>
<tr><td>(c)</td><td>Float on D = 21 – 5 – 8 = 8</td><td>B1 (1)</td></tr>
<tr><td>(d)</td><td>Lower bound is $\frac{142}{42} = 3.38 ... = 4$</td><td>B1 (1)</td></tr>
<tr><td>(e)</td><td>e.g.

</td><td>M1
A1
A1
A1 (4)

(12 marks)</td></tr>
</table>

Question Number	Scheme	Marks

Notes for Question 6

a1B1: Any four rows correct
a2B1: All eight rows correct

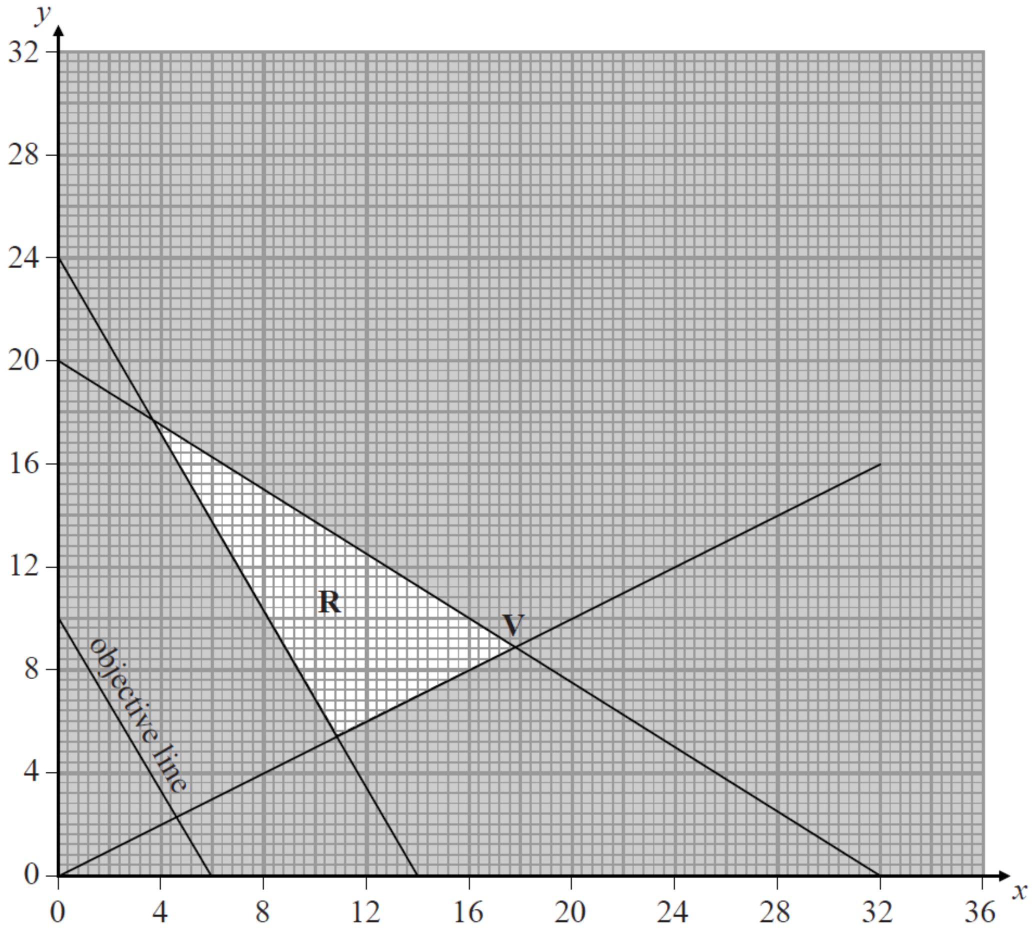
b1M1: **All** top boxes complete, values generally increasing in the direction of the arrows (‘left to right’), condone one rogue
b1A1: CAO
b2M1: **All** bottom boxes complete, values generally decreasing in the opposite direction of the arrows (‘right to left’), condone one rogue.
b2A1: CAO

c1B1: CAO – correct calculation seen

d1B1: CAO – either a **correct** calculation seen **or** awrt 3.4 **then** 4. An answer of 4 with no working scores B0

e1M1: Not a cascade chart. 5 workers used at most, at least 8 new (14 in total) activities placed
e1A1: 4 workers. All 11 new (17 in total) activities present (just once). Condone **two** errors **either** precedence **or** time interval **or** activity length
e2A1: 4 workers. All 11 new (17 in total) activities present (just once). Condone **one** error **either** precedence **or** time interval **or** activity length
e3A1: CAO

Activity	Duration	Time interval	IPA
D	8	5 – 21	A
E	4	10 – 21	B, C
F	3	10 – 23	B, C
H	14	10 – 32	C
I	11	14 – 32	D, E
K	5	15 – 35	G
L	10	24 – 42	G, H
M	10	25 – 42	I
P	11	23 – 35	D, E, F, J
Q	7	34 – 42	K, P
R	5	34 – 42	K, P

Question Number	Scheme	Marks
7.(a)	$60x+35y\ge 840$ or $x+\frac{7}{12}y\ge 14\Rightarrow 12x+7y\ge 168$ $15x+24y\le 480$ or $\frac{1}{4}x+\frac{2}{5}y\le 8\Rightarrow 5x+8y\le 160$	M1 A1 M1 A1 **(4)**
(b)	$2y \ge x$	M1 A1 **(2)**
(c)		B1 $12x+7y=168$ B1 $5x+8y=160$ B1 $2y=x$ B1 R correct **(4)**
(d)(i) **(d)(ii)**	Objective line correctly drawn (and labelled) Optimal vertex labelled $V\left(\frac{160}{9},\frac{80}{9}\right)$	B1 DB1 M1 A1 **(4)**
(e)	Make 17 hardbacks and 9 paperbacks, expected profit (£)1344	B1 B1 **(2)** **(16 marks)**

Question Number	Scheme	Marks
Notes for Question 7		

a1M1: Two of three coefficients correct with correct inequality sign in unsimplfied form **or** all three coefficients correct with any sign $(=, <, >, \leq, \geq)$
a1A1: CAO (the correct answer with no working can imply M1 only)
a2M1: Two of the three coefficients correct with correct inequality sign in either unsimplified or simplified form **or** all three coefficients correct with any sign $(=, <, >, \leq, \geq)$
a2A1: CAO (the correct answer with no working can imply M1A1)

b1M1: **Either** both coefficients correct (accept $=, <, >, \leq, \geq$ here) **or** $y \geq 2x$
b1A1: CAO

c1B1: $12x + 7y = 168$ drawn correctly, does not pass outside of a small square of (0, 24) and (14, 0). Ignore shading
c2B1: $5x + 8y = 160$ drawn correctly, does not pass outside of a small square of (0, 20) and (32, 0). Ignore shading
c3B1: $2y = x$ drawn correctly, does not pass outside of a small square of (0, 0), (16, 8) and sufficiently long enough to define the feasible region. Ignore shading
c4B1: R labelled correct (not just implied by shading) – must have earned all previous marks in this part

di1B1: Drawing the correct objective line on the graph, use line drawing tool to check if necessary. Line must not pass outside of a small square if extended from axis to axis
di2DB1: V labelled clearly on their graph. This mark is dependent on **both** the correct three line segments that define the boundary of the feasible region **and** the correct objective line
dii1M1: The simultaneous equations $5x + 8y = 160$ and $x = 2y$ being used in an attempt to find V – must get to x=⋯ or y=⋯ (condone one error in the solving of the simultaneous equations)
dii1A1: CAO $\left(\frac{160}{9}, \frac{80}{9}\right)$ or $\left(17\frac{7}{9}, 8\frac{8}{9}\right)$ (coordinates must be exact) – the correct answer with no working can imply M1A1

e1B1: CAO (17, 9) – accept $x = 17, y = 9$
e2B1: CAO ((£)1344)

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Mark Scheme (Results)

Summer 2015

Pearson Edexcel GCE in Decision Mathematics 1 (6689/01)

Edexcel and BTEC Qualifications

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Summer 2015
Publications Code UA041213

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol √ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper or ag- answer given
   - └ or d… The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks

affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. (a)	There are two unmatched vertices in each set (the algorithm matches only one vertex from one set to one vertex in the other set once per iteration)	B1 **(1)**
(b)	B – 4 = C – 5 D – 2 = A – 3 = F – 6 = E – 1	M1 A1 **(2)**
(c)	A = 3, (B unmatched), C = 4, D = 2, E = 5, F = 6	B1 **(1)**
(d)	Alternating path: B – 4 = C – 5 = E – 1 Change status: B = 4 – C = 5 – E =1 Complete matching: A = 3, B = 4, C = 5, D = 2, E = 1, F = 6	M1 A1 **(2)** **6 marks**
	Notes for Question 1	

a1B1: CAO – an understanding that there are **two unmatched vertices** in **each set**. However, be generous, and see below examples that we would accept for B1

- Both B and D (or 1 and 5) are unmatched
- Two vertices in set X (or two in set Y) are unmatched
- There are four unmatched nodes (or there are more than two unmatched nodes)
- There are two pairs of nodes that are not matched (on one side of the graph)
- There are two vans (or deliveries) that are not matched to deliveries (or vans)
- There are two vertices on the left (or two on the right) that have not been matched
- Two vertices in set X and Y are unmatched (bod)

Examples for B0:

- There are two unmatched nodes
- There are two sets of unmatched nodes
- Ther are two unmatched arcs in each set

So accept poor terminology (for example, point for vertex, side for set, etc.) but not incorrect terminology (arc for vertex, etc.) and accept contextualised answers (‘vans’ rather than ‘vertices’)

b1M1: One correct alternating path (accept any symbol connecting the vertices, for example, B – 4 – C – 5, or B4C5). Note that 5 – C = 4 – B and 1 – E = 6 – F = 3 – A = 2 – D (so paths from 5 to B and 1 to D) are fine
b1A1: Both paths correct (isw if more than two paths are stated)

c1B1: CAO – condone lack of B or 1 being stated as unmatched. The improved matching may be stated **or** drawn – do check carefully the top of the second page for the improved matching drawn there. Only accept a clear diagram with exactly five arcs

d1M1: The **correct** alternating path from B to 1 (or vice-versa) **and then either** (i) **or** (ii)

(i) the ‘change status’ **either** stated in words (but only accept ‘change (of) status’ **or** ‘c.s.’ not ‘change state’ etc.) **OR** shown (**all** symbols e.g. (…-…=…-…) **interchanged** (…=…-…=…).
(ii) the correct complete matching either stated **or** drawn – only accept a clear diagram with exactly six arcs – do check carefully the top of the second page for the complete matching drawn there.

d1A1: CAO – all three parts – the correct alternating path **and** the change status either stated **or** shown **and** the complete matching either stated **or** drawn

Question Number	Scheme	Marks
2.(a)	e.g. using middle right 18 29 48 9 42 $\boxed{31}$ 37 24 27 41 pivot 31 18 29 $\boxed{9}$ 24 27 $\underline{31}$ 48 42 $\boxed{37}$ 41 pivots 9, 37 $\underline{9}$ 18 29 $\boxed{24}$ 27 $\underline{31}$ $\underline{37}$ 48 $\boxed{42}$ 41 pivots 24, 42 $\underline{9}$ 18 $\underline{24}$ 29 $\boxed{27}$ $\underline{31}$ $\underline{37}$ 41 $\underline{42}$ 48 pivot(s) (18), 27, (41), (48) $\underline{9}$ 18 $\underline{24}$ $\underline{27}$ 29 $\underline{31}$ $\underline{37}$ 41 $\underline{42}$ 48 sort complete (pivot (29))	M1 (quick) A1 (1st pass/pivots for 2nd pass) A1ft (2nd/3rd passes and pivot(s) for 4th pass) A1 (cso + sort complete) **(4)**
(b)	e.g. left to right 72 53 89 91 68 67 90 77 83 75 (end of 1st pass): 53 72 89 68 67 90 77 83 75 $\boxed{91}$ (end of 2nd pass): 53 72 68 67 89 77 83 75 $\boxed{90 \quad 91}$ (end of 3rd pass): 53 68 67 72 77 83 75 $\boxed{89 \quad 90 \quad 91}$ (end of 4th pass): 53 67 68 72 77 75 $\boxed{83 \quad 89 \quad 90 \quad 91}$ (end of 5th pass): 53 67 68 72 75 $\boxed{77 \quad 83 \quad 89 \quad 90 \quad 91}$ sort complete	M1 (bubble) A1 (1st and 2nd passes) A1ft (3rd and 4th passes) A1 (cso + sort complete) **(4)**
(c)	Pivot 1 = $\left[\frac{1+20}{2}\right]$ = 11 number 53 68 is after 53 so reject 1 - 11 Pivot 2 = $\left[\frac{12+20}{2}\right]$ = 16 number 77 68 is before 77 so reject 16 – 20 Pivot 3 = $\left[\frac{12+15}{2}\right]$ = 14 number 72 68 is before 72 so reject 14 – 15 Pivot 4 = $\left[\frac{12+13}{2}\right]$ = 13 number 68 – number found	M1 A1 A1(cso) **(3)** **11 marks**
	Notes for Question 2	

a1M1: Quick sort, pivot, p, chosen (must be choosing middle left or right – **choosing first/last item as pivot is M0**) and first pass gives <p, p, >p. So after the first pass the list should read (values less than the pivot), pivot, (values greater than the pivot). **If only choosing one pivot per iteration M1 only**

a1A1: First pass correct **and** next pivot(s) chosen correctly for second pass (but second pass does not need to be correct)

a2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots) – **and** next pivot(s) chosen correctly for the fourth pass

a3A1: CSO (correct solution only – all previous marks in this part **must** have been awarded) including ‘sort complete’ – this could be shown by the final list being re-written or ‘sorted’ statement or each item being used as a pivot

b1M1: Bubble sort. Consistent direction, end number (greatest/least) in place. Do check these carefully as

Question Number	Scheme	Marks

some candidates show the result of each comparison and swap in the first pass
b1A1: First and second passes correct – so end two numbers in place
b2A1ft: Third and fourth passes correct following through from the candidate’s second pass
b3A1: CSO (correct solution only) – including either a ‘sort complete’ statement **or** final list rewritten/sixth pass
c1M1: Choosing middle right pivot (choosing middle left is M0) + discarding/retaining half the list. So 53 (the 11th value) found as a pivot and either rejecting the first 11or 10 values or retaining the final 9 or 10 values
c1Al : First and second passes correct i.e. 53 found and either using 67 to 91 in 2nd pass or discarding 9 to 53 (so therefore no 'sticky' pivots in the first two passes — sticky is when the pivot is retained in the next pass). Then 77 found and either using 67 to 75 in 3rd pass or discarding 77 to 91
c2A1 : CSO - search complete + 'found' (accept 'found', 'located', 'stop', etc. but not just, for example, the number underlined; must be convinced that 68 has been located and is not a pivot or a number in a sublist with only one value)

Sorting list into descending order in either (a) and/or (b)

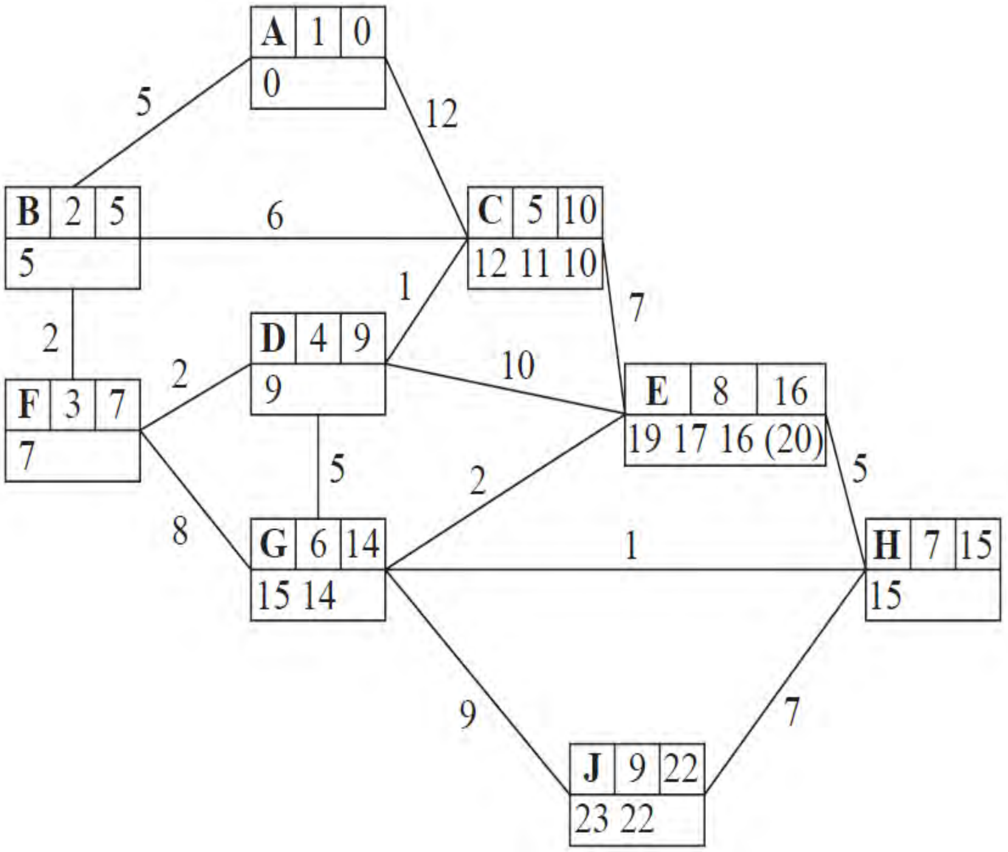
- If the candidate sorts the list into descending order and reverses the list then they can score full marks
- If the list is not reversed then mark as a misread (so remove the last two A marks earned). If the candidate says that the list needs reversing but doesn’t actually show the reversed list then remove the final A mark earned

Misreads - if there is a ‘misread’ of a single number (this could take the form of an extra number, a number missing, or a number changed, for example, 13 rather than 31) before starting either sort or the binary search then mark as a misread. If they ‘misread’ more than one number then M0. If they miscopy one of their own numbers during the sort then this is an accuracy error and loses the corresponding A mark(s)

Using middle left quick sort in (a): (note: for full marks must identify 24 as a pivot but no sort complete statement required as pivoting on the 24 produces no further swaps)

$18 \quad 29 \quad 48 \quad 9 \quad \boxed{42} \quad 31 \quad 37 \quad 24 \quad 27 \quad 41$ pivot 42
$18 \quad 29 \quad 9 \quad \boxed{31} \quad 37 \quad 24 \quad 27 \quad 41 \quad \underline{42} \quad 48$ pivot(s) 31, (48)
$18 \quad 29 \quad \boxed{9} \quad 24 \quad 27 \quad \underline{31} \quad \boxed{37} \quad 41 \quad \underline{42} \quad 48$ pivots 9, 37
$\underline{9} \quad 18 \quad \boxed{29} \quad 24 \quad 27 \quad \underline{31} \quad \underline{37} \quad 41 \quad \underline{42} \quad 48$ pivot(s) 29, (41)
$\underline{9} \quad 18 \quad \boxed{24} \quad 27 \quad \underline{29} \quad \underline{31} \quad \underline{37} \quad 41 \quad \underline{42} \quad 48$ pivot 24
$\underline{9} \quad 18 \quad \underline{24} \quad 27 \quad \underline{29} \quad \underline{31} \quad \underline{37} \quad 41 \quad \underline{42} \quad 48$ (sort complete)

Right to left bubble sort in (b):
72 53 89 91 68 67 90 77 83 75
(end of 1st pass): 53 72 67 89 91 68 75 90 77 83
(end of 2nd pass): 53 67 72 68 89 91 75 77 90 83
(end of 3rd pass): 53 67 68 72 75 89 91 77 83 90
(end of 4th pass): 53 67 68 72 75 77 89 91 83 90
(end of 5th pass): 53 67 68 72 75 77 83 89 91 90
(end of 6th pass): 53 67 68 72 75 77 83 89 90 91 (sort complete)

Question Number	Scheme	Marks
3.(a)	 Shortest route: A – B – F – D – G – H – J Length: 22 (km)	M1 A1 (ABFDC) A1 (GH) A1ft (EJ) A1 A1ft **(6)**
(b)	E.g. 22 – 7 = 15 JH, 15 – 1 = 14 HG, 14 – 5 = 9 GD, 9 – 2 = 7 DF, 7 – 2 = 5 FB, 5 – 5 = 0 BA **Or** Trace back from J including arc XY if (Y already lies on the path and) the difference of the final values of X and Y equals the weight of arc XY.	B2, 1, 0 **(2)**
(c)	Shortest route: A – B – F – D – G – E – G – H – J Length: 26 (km)	B1 B1 **(2)** **10 marks**
	Notes for Question 3	

In (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at C the working values must be 12 11 10 – in that order (12 10 11 is incorrect).
The 20 in brackets in the working values at E is not required but if a candidate does have a value after the 16 then it must be this value only. This value, if present, must also be in the correct place (after the 16). Penalise any other/incorrect working values with the corresponding A mark. Lastly, it is also important that the order of labelling is checked carefully – some candidates start with a label of 0 at A (rather than 1) – which is fine. Also the order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, … will be penalised once (see notes below) but 1, 2, 3, 5, 6, … is fine. Errors in the final values and working values are penalised before errors in the order of labelling.

Question Number	Scheme	Marks

a1M1: A larger value replaced by smaller value at least once in the working values at either C or G or E or J
a1A1: All values in A, B, F, D and C correct. The working values at C must be in the correct order. Condone lack of 0 in A's working value
a2A1: All values in G and H correct and the working values in the correct order. Penalise order of labelling only once per question (G and H must be labelled in that order and G must be labelled after A, B, F, D and C)
a3A1ft: All values in E and J correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question (E and J must be labelled in that order and E labelled after all other nodes (excluding J)). Ignore additional working value of 20 at E – so the working values may read 19 17 16 20 – rather than 19 17 16 – which is fine – however 20 19 17 16 is incorrect and loses this mark

To follow through E check that all the working values at E follow from the candidate's final values from nodes C, D, G and H (in the order that the candidate has labelled these four nodes) and that the final value, and order of labelling, follows through correctly. Repeat this process for J (which will have working values from G and H)
a4A1: CAO for the route (from either A to J or J to A)
a5A1ft: If their answer is not 22 follow through their final value at J (condone lack of units)

For (b) candidates usually give either a general explanation or a demonstration of how they determined their shortest route. If a candidate gives both a general explanation and a demonstration then mark both and award the best mark (but do not mix the two schemes together)

General Explanation:

For the first B mark any indication of 'working backwards' or 'tracing back' through the network – it must be clear from the candidates explanation that they are considering working backwards through the network but give bod for seeing just the phrase 'working backwards' (oe)

For the second B mark we must see

- Working backwards **from J**
- Including an **arc** (XY) if the **difference** of the **final values** (of X and Y) is equal to the **weight** (of the arc XY)

Must include all the words in bold (or their equivalent, for example, distance for weight, edge for node,…) – technical language must be correct

Demonstration:

For the first B mark we must see two consecutive correct calculations working backwards from J for **their** network. They do not have to link the corresponding nodes for this first mark, for example, 22 – 7 = 15, 15 – 1 = 14 is sufficient for this mark (also note that 22 – 15 = 7, etc. is equivalent). Condone poor notation for this mark, for example, 22 – 7 = 15 – 1 = 14… is fine for B1

For the second B mark we must see all the correct calculations (so no follow through) from J to A **and** the linking of **all** arcs/nodes to these calculations, for example, J: 22 – 7 = 15 H, H: 15 – 1 = 14 G, etc. is acceptable. **All** values (including the 22 and 0) **and** nodes (including J and A) must be present

c1B1: CAO shortest route (A – B – F – D – G – E – G – H – J)
c2B1: CAO correct length (26) – condone lack of units

Question Number	Scheme	Marks
4.(a)	e.g. (each arc contributes 1 to the orders of two nodes, and so) the sum of the orders of all the nodes is equal to twice the number of arcs Which implies that the sum of the orders of all the nodes is even and therefore there must be an even (or zero) number of vertices of odd order hence there cannot be an odd number of vertices of odd order.	B1 B1 **(2)**
(b)	(Start at) D and (end at) E (or vice-versa)	B1 **(1)**
(c)	A(C)B + D(BC)E = 120 + 300 = 420 A(CB)D + B(C)E = 290 + 130 = 420 A(C)E + BD = 150 + 170 = 320* Repeat arcs AC, CE and BD	M1 A1 (2 rows) A1 (3 rows) A1 **(4)**
(d)	Length 2090 + 320 + 130 = 2540 (m)	M1, A1 **(2)**
(e)	(Finishing Point is) D Difference in routes = 2540 – (2090 + 130 +130) = 190 (m)	B1 M1, A1 **(3)** **12 marks**
	Notes for Question 4	

a1B1: **Either** stating that the sum of the order of the nodes = 2(number of arcs) **or** that each arc contributes 1 to the order of two nodes. For this mark there must be a **clear correct statement linking the order of nodes to arcs**

a2B1: For stating that as the sum (of the orders) of the nodes is even this implies that there must be an even number of nodes of odd order (or there cannot be an odd number of nodes of odd order). Candidates may argue that if the sum (of the order) of the nodes is odd then this implies that the number of arcs cannot be integer valued (oe) which is fine. For this mark there must be a correct statement that the **sum of the nodes is even together with the correct conclusion.** Note that for the first B mark it must be clear that the candidate is considering the order of the nodes but for the second B mark it is sufficient to for candidates to say ‘the sum of the nodes…’. Furthermore, it is possible to score B0B1 (for example, a candidate may simply state the sum of the nodes is even and state the correct conclusion which would score the 2nd B mark only)

b1B1: Correct start and finish points (D, E)
c1M1: Three distinct pairings of the **correct** four odd nodes
c1A1: **Any** two rows correct including pairings **and** totals
c2A1: **All** three rows correct including pairings **and** totals
c3A1: CAO correct **arcs** clearly (**not** just in their working) stated: AC, CE, BD. Accept ACE **or** AE via C. Do not accept AE
d1M1: 2090 + 130 + (their smallest total from (c)); must be at least two distinct pairings of the correct four odd nodes in (c) **or** for 2410 only (forgetting to add the additional 130)
d1A1: CAO (2540) – if no working seen then the correct answer implies both marks in (d)

e1B1: CAO (D)
e1M1: Their answer to (d) – (2090 + 130 + their BE) (if AB included in (d)) **or** their answer to (d) – (2090 + their BE) (if AB not included in (d)) **or** (their smallest total (320) from (c) – their BE (130)) – by ‘their BE’ this is their smallest pairing which does not include A. This mark is dependent on **either** scoring the M mark in (c) **or** considering all three pairings (DE, BE, BD) that do not include A
e1A1: CAO (190) – condone lack of units – if the correct answer is seen with no calculation and/or method seen then award the M mark only. Candidates who did not include AB (130) in their inspection route (in (d)) can still earn full marks in (e) for the correct answer of 190

Question Number	Scheme	Marks
5.(a)	Kruskal: BC, AB, (not AC), DE, CD, DF, (not $\substack{\text{BF}\\ \text{CE}}$), EJ, FH, (not HJ), (not BD), GH	M1 A1 A1 **(3)**
(b)	Prim: GH, FH, DF, DE; CD, BC; AB, EJ	M1; A1; A1 **(3)**
(c)	98 (km)	B1 **(1)**
(d)(i) **(ii)** **(iii)**	$\frac{m}{2}$ $n-1$ $m \geq 2(n-1)$ (oe)	B1 B1 B1 **(3)** **10 marks**
	Notes for Question 5	

a1M1: Kruskal's – first four arcs BC, AB, DE, CD,…(or weights 6, 7, 10, 11, …) chosen correctly in order and **at least one rejection seen at some point**

a1A1: All eight arcs BC, AB, DE, CD, DF, EJ, FH, GH (or weights 6, 7, 10, 11, 13, 15, 16, 20) chosen correctly in order and no additional arcs

a2A1: CSO All selections and rejections correct (in correct order and at the correct time) – do not accept weights only for this mark

- Listing all the arcs in order and then listing those arcs in the tree in the correct order is fine for **full marks** (this implies that rejections are correct and at the correct time)
- Listing all the arcs in order and just drawing the MST is **M0**

b1M1: First four arcs correctly chosen in order (GH, FH, DF, DE, … or weights 20, 16, 13, 10,…) **or** first five nodes{G, H, F, D, E,…} correctly chosen in order. **If any rejections seen at any point then M1 (max)** only. Order of nodes may be seen at the top of a matrix/table {-, -, -, 4, 5, 3, 1, 2, - }

a1A1: Prim's - first six arcs correctly chosen in order (GH, FH, DF, DE, CD, BC,… or weights 20, 16, 13, 10, 11, 6,…) **or** all nine nodes{G, H, F, D, E, C, B, A, J} correctly chosen in order.. Order of nodes may be seen at the top of a matrix so for the first two marks accept {8, 7, 6, 4, 5, 3, 1, 2, 9} (**no** missing numbers)

a2A1: CSO - all **arcs** correctly **stated** and chosen in the correct order. They must be considering arcs for this final mark (do not accept a list of the weights of each arc, nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen)

Misread: Starting at a node other than G scores **M1 only – must** have the first four arcs (or five nodes or numbers) correct (and in the correct order) – condone rejections seen for this mark

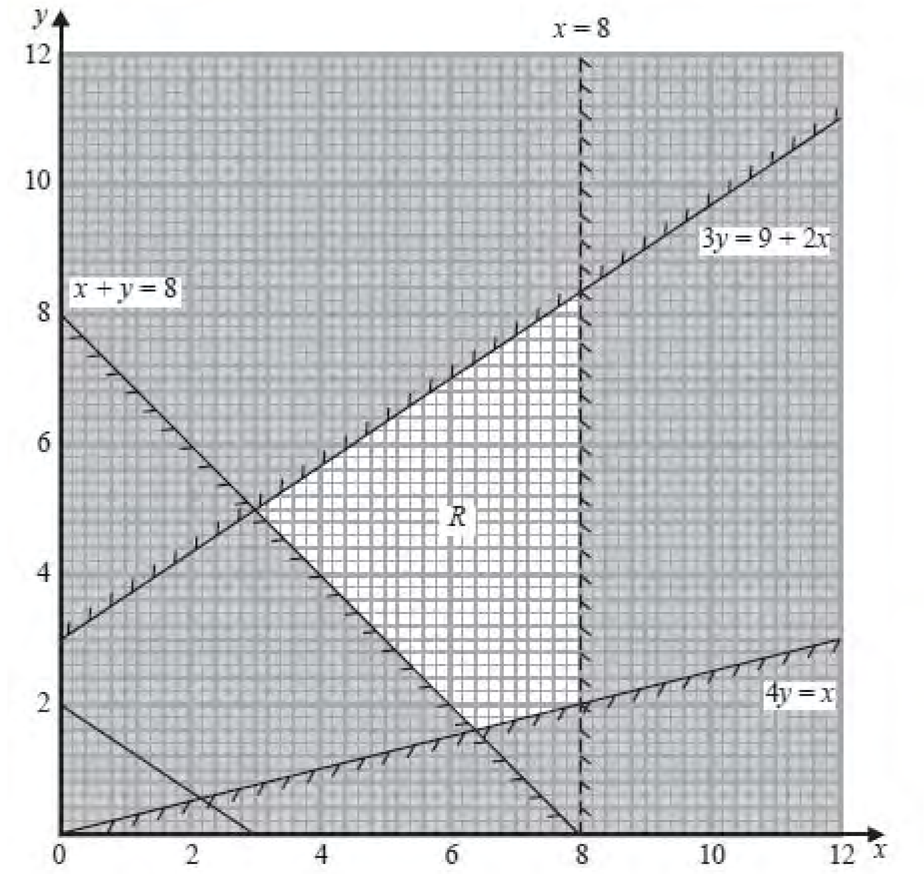
Starting at	Minimum arcs required for M1	Nodes	Order
A	AB BC CD DE	ABCDE	12345----
B	BC AB CD DE	BCADE	31245----
C	CB AB CD DE	CBADE	32145----
D	DE CD BC AD	DECBA	54312----
E	ED CD BC AD	EDCBA	54321----
F	FD DE CD BC	FDECB	-54231---
H	HF DF DE CD	HFDEC	--5342-1-
J	JE DE CD BC	JEDCB	-5432---1

c1B1: CAO (98) – condone lack of units

diB1: CAO (oe e.g. 0.5*m*)

diiB1: CAO

diiiB1: CAO (oe, for example, $n-1 \leq \frac{1}{2}m$) – must include correct bracketing (if required) – do not accept strict inequality

Question Number	Scheme	Marks
6.(a)		B1 $(x + y = 8)$ B1 $(3y = 9 + 2x)$ B1 $(4y = x)$ B1 $(x = 8)$ - **must be distinct from the other three lines** **(4)**
(b)	Correct R labelled	B1 **(1)**
(c)	Objective line drawn $\text{V}\left(\frac{32}{5}, \frac{8}{5}\right)$ (oe)	B1 M1 dA1 **(3)**
(d)	$(C =)\frac{88}{5}$ (oe)	B1 **(1)**
(e)	(7,7) 35	B1 B1 **(2)**
(f)	$y \leq \frac{5}{3}x \therefore k = \frac{5}{3}$ (oe)	M1 A1 **(2)**
		13 marks
	Notes for Question 6	

The line $x = 8$ must be distinct from the other three lines in some way. Some candidates may show the strict inequality as a solid line and the other three lines as dashed lines – this is acceptable for all four marks in part (a). If a candidate has a mixture of dashed and solid lines (say two of each) then withold the final B mark earned

a1B1: $x + y = 8$ correctly drawn. Must pass within one small square of (0, 8), (4, 4) and (8, 0)

a2B1: $3y = 9 + 2x$ correctly drawn. Must pass within one small square (0, 3), (6, 7) and sufficiently long enough to define the feasible region

a3B1: $4y = x$ correctly drawn. Must pass within one small square of the origin and (8, 2)

a4B1: $x = 8$ correctly drawn. Must be sufficiently long enough to define the feasible region. This must be shown as a dashed line or distinctive from the other three lines (see note above)

Question Number	Scheme	Marks

b1B1: Region, R, correctly labelled – **all lines** must have been drawn correctly but condone $x = 8$ not distinct from the other three lines (so must have scored either B1B1B1B1 or B1B1B1B0 in (a))

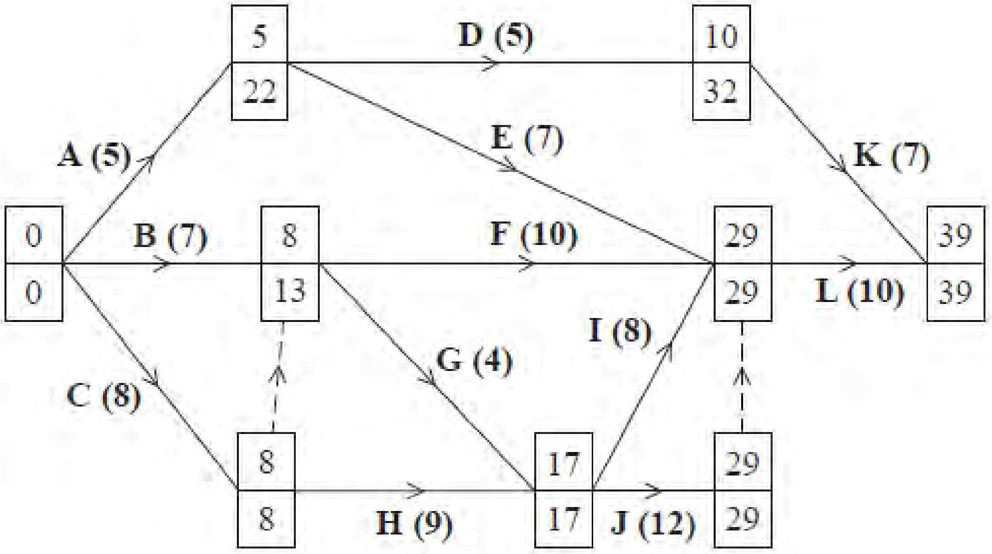
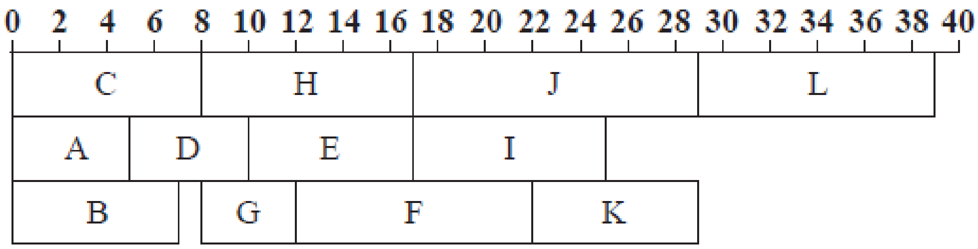
Note that if no objective line is drawn then no marks in (c)

c1B1: Drawing a correct objective line – if their line is shorter than the length equivalent to that of the line from (0, 1) to (1.5, 0) then B0. Line must be correct to within one small square if extended from axis to axis
c1M1: Candidates must have drawn either the correct objective line or its reciprocal. If they have drawn the correct objective line they must be solving $x + y = 8$ and $4y = x$. If they have drawn the reciprocal objective line line they must be solving $x + y = 8$ and $3y = 9 + 2x$. Must get to either $x = ...$ or $y = ...$ (condone one error in the solving of the simultaneous equations). The correct exact answer $\left(\frac{32}{5}, \frac{8}{5}\right)$, or for the reciprocal (3, 5), can imply this mark
c1dA1: CAO – the correct exact coordinate $\left(\frac{32}{5}, \frac{8}{5}\right)$ or $(6.4, 1.6)$ or $\left(6\frac{2}{5}, 1\frac{3}{5}\right)$ - this mark is dependent on the correct objective line seen (so must have scored the B mark). If B1 awarded then the correct answer with no working scores M1A1

d1B1: CAO or 17.6 or $17\frac{3}{5}$

e1B1: CAO vertex (7, 7) (accept $x = 7$, $y = 7$)
e2B1: CAO value (35)

f1M1: $(k =)\frac{5}{3}$ or $\frac{3}{5}$ or 1.6 or 0.6 or $1\frac{2}{3}$
f1A1: CAO $(k =)\frac{5}{3}$ (oe)

Question Number	Scheme	Marks
7.(a) and (b)		B1 B1 B1 **(3)** M1 A1 M1 A1 **(4)**
(c)	Lower bound = $\frac{92}{39}$ =2.35… so 3 workers	M1 A1 **(2)**
(d)	e.g. 	M1 A1 A1 A1 **(4)** **13 marks**
	Notes for Question 7	

a1B1: Any two of the four arcs (E, F, I or the dummy) drawn correctly (from correct vertex to correct vertex) – activities must be labelled with the correct letter (but condone no weights or arrows) and the dummy must be shown as a dashed line (but condone no arrow)
a2B1: All four arcs (E, F, I and the dummy) drawn correctly – must be labelled with the correct letter (but condone no weight or arrows) and the dummy must be shown as a dashed line (but condone no arrow)
a3B1: CAO – all three activities (E, F and I) and the one dummy drawn correctly – activities must be labelled with the correct letter and the activities and dummy must have the correct arrows (**do check carefully that all arrows are present**) but condone lack of (or incorrect) weights on the activity arcs

In (b) the M marks are dependent on scoring at least the first mark in (a)
In (b) the A marks are dependent on scoring at least the first two marks in (a)

b1M1: All top boxes complete (condone lack of 0 for the M mark only), values generally increasing in the direction of the arrows (‘left to right’), condone one ‘rogue’ value (if values do not increase in the direction of the arrows then if one value is ignored and the remaining values do increase in the direction of the arrows then this is considered to be a single rogue value). Note that all values in the top boxes could be incorrect but it can still score the M mark if the values are **increasing** in the way stated above – **this mark is dependent on the first mark having being awarded in (a)**

Question Number	Scheme	Marks

b1A1: CAO – all values correct in the top boxes – **this mark is dependent on the first two marks having being awarded in (a)**
b2M1: All bottom boxes complete (condone lack of 39 and/or 0 for the M mark only), values generally decreasing in the opposite direction of the arrows ('right to left'), condone one 'rogue' – **this mark is dependent on the first mark having being awarded in (a)**
b2A1: CAO – all values correct in the bottom boxes – **this mark is dependent on the first two marks having being awarded in (a)**
c1M1: Attempt to find lower bound: (a value in the interval [80 – 104] / their finish time) **or** (sum of the activities / their finish time) **or** (as a minimum) an awrt 2.4
c1A1: CSO – either a **correct** calculation seen **or** awrt 2.4 **then** 3. An answer of 3 with no working scores M0A0

d1M1: Not a cascade (Gantt) chart. 4 'workers' used at most and at least 8 activities placed
d1A1: The critical (C, H, J, L) activities and A, B and D correct. A must be completed by its late finish time (22), B must be completed by its late finish time (13) and D must start after A and finish before its late finish time (32)

Activity	Duration	Time interval	IPA
C	8	0 – 8	-
H	9	8 – 17	C
J	12	17 – 29	H
L	10	29 – 39	J
A	5	0 – 22	-
B	7	0 – 13	-
D	5	5 – 32	A

Now check the last 5 activities – the last two marks are for E, F, G, I and K **only**

First check that there are only three workers and that all 12 activities are present (just once)

Then check precedences (see table below) – each row of the table could give rise to 1 error only in precedences

Finally check the length of each activity and the time interval in which the activity must take place (interval is inclusive)

Activity	Duration	Time interval	IPA
E	7	5 – 29	A
F	10	8 – 29	B, C
G	4	8 – 17	B, C
I	8	17 – 29	G, H
K	7	10 – 39	D

d2A1: 3 workers. All 12 activities present (just once). Condone **one** error **either** precedence **or** time interval **or** activity length, on activities E, F, G, I and K only (note: one activity could have more than one error, for example, activity G could have an error in duration and an error in IPA – this is two errors **not** one)
d3A1: 3 workers. All 12 activities present (just once). No errors on activities E, F, G, I and K

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