OCR
Oxford Cambridge and RSA

GCE

Mathematics

Unit **4736**: Decision Mathematics 1

Advanced Subsidiary GCE

Mark Scheme for June 2015

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Here are the subject specific instructions for this question paper

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key

steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A

(accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

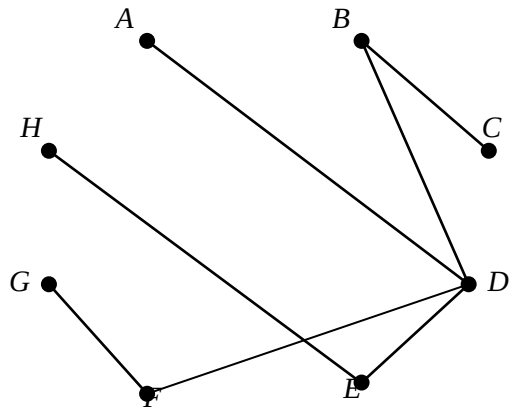
If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question			Answer	Mark	Guidance
1	(i)		7 9 15 10 4 26 5 comparisons and 4 swaps	M1 A1 B1 **[3]**	Swapping 15 with 7 and then with 9 (list starts 7 9 ...) Correct list after first pass, if unclear take last list shown 5 comparisons and 4 swaps (both written, not tally marks)
	(ii)		7 4 9 10 15 26 2 comparisons and 1 swap	B1 B1 **[2]**	Correct list (after fourth pass), if unclear take last list shown 2 comparisons and 1 swap
	(iii)		15	B1 **[1]**	15 stated (cao) 5+4+3+2+1 (without 15) gets B0
	(iv)		7 15 9 26 10 4 1 comparison and 1 swap	B1 B1 **[2]**	Correct list after first pass (must see all six values), if unclear take last list shown 1 comparison and 1 swap (both written, condone a tally mark)
	(v)		7 9 10 15 26 4 3 comparisons and 2 swaps	B1 B1 **[2]**	Correct list after fourth pass (must see all six values), if unclear take last list shown 3 comparisons and 2 swaps (written, not tally marks)
	(vi)		5 comparisons and 5 swaps	B1 **[1]**	Both written, not tally marks
	(vii)		Shuttle sort, because it uses fewer than 15 comparisons Know this because (any of): - fourth pass only used 3 comparisons not the maximum of 4 - 12 comparisons used - 3 fewer comparisons - with shuttle sort the number of comparisons on any pass is either the same as the number of swaps or is 1 more, so maximum number of comps possible in this case is 12	M1 A1 **[2]**	Choosing shuttle <u>and</u> saying that it uses fewer comparisons (Note: 'more efficient' is in the question) Evidence that candidate knows <u>why</u> shuttle uses fewer comparisons in this case, and is not just guessing Allow 4^{th} (or 3^{rd}) pass does not need to shuttle all the way Allow comparisons must be <u>at most</u> 9 + 5 (or 9 + 4 or 9 + 3) Allow comparisons <u>at most</u> 14 (or 13) But NOT comparisons = 14 (or 13)

2	**(i)**		The removed vertex is at the end of a branch (has order 1) in the original minimum spanning tree OR only one edge (arc) gets removed from the tree OR the remaining arcs in tree are *still* connected	B1 **[1]**	Accept 'the number of edges is *still* 1 less than the number of vertices' Do not accept answers that just describe what a spanning tree is
	(ii)		*BD* = 5 *FG* = 5 *DE* = 6 *DF* = 7 *EH* = 7 *BC* = 8 ~~*DG* = 8~~ ~~*GH* = 8~~ *AD* = 9 ~~*CD* = 9~~ ~~*EG* = 9~~ ~~*AB* = 10~~ ~~*AE* = 10~~ ~~*CF* = 10~~  Weight = 47	 M1 A1 B1 B1 **[4]**	 No crossing out as far as *BC* = 8, then *DG* and *GH* crossed out *AD* = 9 not crossed out Accept × for crossing out or ✓ for not crossed out, or similar Condone crossing out the rows required and leaving the others unchanged, or anything else that is consistent as far as *AD* = 9 Correct tree (may be drawn so that arcs do not cross) Try to mark intention if ambiguous because of erased arcs 47 (cao)
	(iii)		Weight of tree with *A* removed = 47 – 9 = 38 Lower bound = 38 + 9 + 10 = 57	M1 A1 **[2]**	38 (cao) Final answer 38 = M0 unless stated as min connector 57 (cao) Final answer 57 = M1 A1
	(iv)		*A* – *D* – *B* – *C* – *F* – *G* – *H* – *E* – *A* 9 5 8 10 5 8 7 10 Upper bound = 62	M1 A1 B1 **[3]**	Evidence of starting *A* – *D* – *B* – *C* (may be deduced from working on table or a diagram if no written list is given) Correct cycle written down, including return to *A* (condone a list that then joins final *E* back to *A* at start 62(cao)

3	**(i)**		A: (3.5, 2) $\Rightarrow P = 9.5$ B: (1.5, 3) $\Rightarrow P = 10.5$ (Optimum) vertex is (1.5, 3) (Optimal) $P = 10.5$	M1 A1 A1 **[3]**	Checking vertices (a correct calculation or a correct value for A or B) or using a line of constant profit or equivalent (may be implied from optimum vertex or optimal P correct) Identifying (1.5, 3) or B as optimum vertex, allow use of a star, arrow or underlining, condone not written in coordinate form Identifying 10.5 as optimal value, allow use of a star, arrow, underlining or 10.5 associated with (1.5, 3) or B in working, having already chosen this as the optimum vertex
	(ii)		(3, 2)	B1 **[1]**	Need not be written in coordinate form, no working necessary
	(iii)		Each (either) of the other points (A and/or B) have larger values for both x and y (and $k > 0$ so $x + ky$ is bigger) OR (profit lines have negative slope but) lines joining D to A (or B) and C to B (or A) both have positive slope (1, 0.5) to (3.5, 2) or (1.5, 3) and (0.5, 1.5) to (3.5, 2) or (1.5, 3) both have positive slope	B1 **[1]**	Comparing the x values and the y values (imply referring to k being positive or value of $x+ky$ or slope of profit lines) Allow 'they (C and D) have smaller values of x and y', provided answer refers (directly or indirectly) to *both* C and D as well as *both* x and y' OR 'profit line has negative gradient so crosses C and D first' NOT 'coordinates of C and D are smaller', 'these points are nearer to the origin', '$x + ky$ is bigger at the other points' without further explanation NOT descriptions about y values only (e.g. 'A and B are higher up')
	(iv)		$3.5 + 2k > 1.5 + 3k$ or using gradient of $AB = -\frac{1}{2}$ $\Rightarrow k < 2$	M1 A1	Comparing A and B (for k positive), may be implied from sight of 2 as a critical value (not just one of many trials) or –1/2 as a gradient $k < 2$ (o.e.) seen as part of answer, allow $\leq$
			$3.5 + 2k > 1 + 0.5k$ or using gradient of $AD = \frac{3}{5}$ $\Rightarrow k > -1\frac{2}{3}$ [hence $-1\frac{2}{3} < k < 2$]	M1 A1 **[4]**	Comparing A and D, may be implied from sight of –5/3 as a critical value (but not just as one of many trials) or 3/5 as a gradient $k > -1\frac{2}{3}$ (o.e.) seen as part of answer, allow $\geq$ -5/3, accept 3 sf or better, condone -1.66. If -1.6 is seen with a possible dot or line above, bod recurring decimal (Ignore other working, e.g. A and C)

4 (i)

$P = 80x + 31y + 100z$

B1 **[1]**

$80x + 31y + 100z$ (not a scaled multiple here)

(ii)

60 hours available for planting, wheat takes $4x$, potatoes $2y$ and soya beans z hours, hence $4x + 2y + z \leq 60$

B1

Need any of 'hours', 'planting', 'time', 'wheat takes 4', or equivalent Note: $4x + 2y + z \leq 60$ was given

$x \leq 25$, $z \leq 10$

B1

Upper limits for both wheat and soya beans, written as two correct algebraic inequalities, condone <

$x + y + z \leq 40$

B1

Acreage constraint written as a correct algebraic inequality, condone <

[3]

(iii)

Initial tableau

P	x	y	z	s	t	u	v	RHS
1	–80	–31	–100	0	0	0	0	0
0	4	2	1	1	0	0	0	60
0	1	0	0	0	1	0	0	25
0	0	0	1	0	0	1	0	10
0	1	1	1	0	0	0	1	40

Rows and slack variable columns may be in a different order

B1 Objective row correct (or a positive multiple of this), correct or follow through from part (i), but do not back credit

B1 Constraint row corresponding to $4x + 2y + z \leq 60$

B1 Exactly three more constraint rows, with slack variables, correct or follow through their constraints from (ii) if possible, but do not back credit

Pivot on z column row 4 (constraint $z \leq 10$)

P	x	y	z	s	t	u	v	RHS
1	–80	–31	0	0	0	100	0	1000
0	4	2	0	1	0	–1	0	50
0	1	0	0	0	1	0	0	25
0	0	0	1	0	0	1	0	10
0	1	1	0	0	0	–1	1	30

B1 Pivot choice (may be implied from iterated tableau), follow through their initial tableau, allow pivot from x, y or z column

M1 Structure of tableau correct (i.e. all of: five rows and nine columns of numbers, five (or allow six) basis columns, including P (e.g. P, z, s, t and v), no negative values in RHS column, value of objective has increased)

A1 Correct tableau after one iteration (cao)

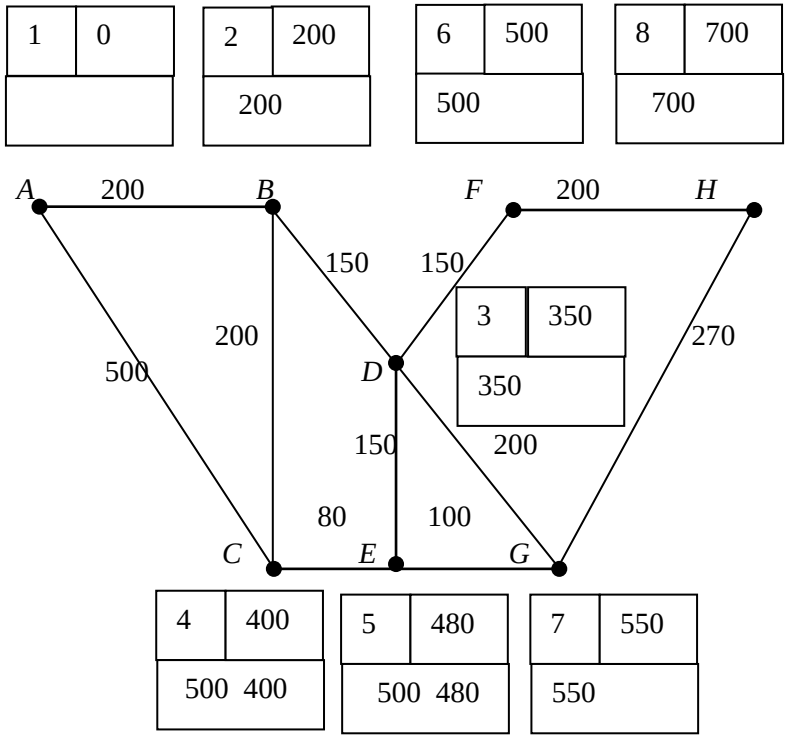
Row 1′ = Row 1 + 100 × Row 4′ (or Row 1 + 100 × Row 4)
Row 2′ = Row 2 – Row 4′ (or Row 2 – Row 4)
Row 5′ = Row 5 – Row 4′ (or Row 5 – Row 4)
(allow r1 + 100 × r4′, r1 + 100 × r4, r1 + 100 × pr, etc
but not just + 100 row 4, +100pr, +100, etc)

Follow through their (possibly incomplete) initial tableau and valid (positive) pivot choice if possible

B1 Correct expression for their objective row

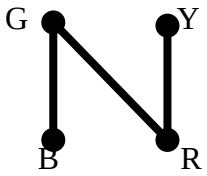
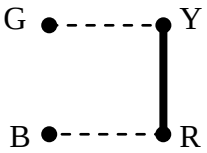
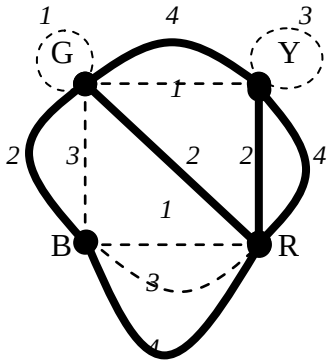
B1 Correct expressions for their other rows, where rows have changed, and no incorrect expressions

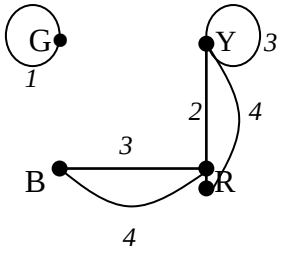
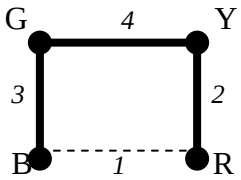
[8] Must be of form *current row ± multiple of pivot row*

	(iv)		$x = 12.5$, $y = 0$, $z = 10$ Plant 12.5 acres of wheat and 10 acres of soya beans Leave 17.5 acres unplanted	B1 M1 A1 **[3]**	All three correct ($x = 12.5$, etc). Ignore extras (s, t, etc.) Interpretation of <u>correct</u> values with <u>names</u> of crops (no potatoes may be implied) without rounding to integers, 'acres' may be implied 17.5 unplanted, 17.5 left over (cao)
5	**(i)**		 $A - B - D - F - H$	M1 M1 dep A1 B1 ft B1 **[5]**	Temporary labels correct (with no extras) at B, C and D (may imply a temporary label if seen as a permanent label) Temporary labels correct (with no extras) at E, F and G All permanent labels correct (not implied) (Must be on RHS at top, not with boxes swapped) Order of labelling correct for their permanent (or implied permanent) labels (must be on LHS at top, A must be 1 not 0) Allow correct or follow through. This **route** (written forwards or backwards, condone shown on diagram **if obvious**) (cao)

	(ii)		*A* – *B* – *C* – *E* *A* – *B* – *D* – *G*	B1 B1 **[2]**	This route (written forwards or backwards) (cao) This route (written forwards or backwards) (cao)
	(iii)		Not all even vertices <u>or</u> (some) odd vertices <u>or</u> (any of) *B*, *C*, *E* and *G* odd Accept 'not Eulerian' or 'non-Eulerian'	B1 **[1]**	Stating that there is at least one odd order vertex May give specific orders, but need to pick out (at least one of) *B*, *C*, *E* and *G* as causing the problem
	(iv)		*B C* = 200 *B E* = 280 *B G* = 350 *E G* = 100 *C G* = 180 *C E* = 80 (total = 300) (total = 460) (total = 430) Repeat *BC* and *EG* = 300 Length of shortest route = 2200 + 300 = 2500 metres or 2.5 km	B1 M1 A1 **[3]**	Seeing at least four of these six paths and their lengths (or replace a pair of path weights by their sum) Do not imply this mark from answer Selecting *BC* and *EG* (may be implied from answer 2500) 2500 or 2.5 (units may be implied)

	(v)		3020 metres or 3.02 km	B1	**3020** or 3.02
			[Nadia needs to deliver to both sides of *BD*, *DE*, *DF*, *DG*, *EG*, *FH*, *GH* and one side of *AC*, starting at *E* and ending at *A*] *BD* + *DE* + *DF* + *DG* + *EG* + *FH* + *GH* twice 150 + 150 + 150 + 200 + 100 + 200 + 270 = 1220 2440 OR Total distance to be delivered to = 2 × 2200 = 4400 metres	B1	Evidence needs to be numerical Evidence of summing these arc weights (need not see total) May be implied from sight of **1220** or **2440** OR implied from sight of **2 × 2200** or **4400**
			CA (or *AC*) = 500 OR Nadia has already delivered *ABCE* = 480 and Sheng-Li along *ABCE* and *CA* = 980 OR Nadia has travelled 480 metres and Sheng-Li 1060	B1	Sight of *CA* (or *AC*) = **500** (**500 and *CA***) OR sight of both **480 and 980** OR sight of **1460** OR sight both **480 and 1060** OR sight of **1540**
			Nadia needs to travel *EC* = 80 to connect the two pieces together [2440 + 500 + 80 = 3020 or 4400 – 480 – 980 = 2940; 2940 + 80 = 3020]	B1 **[4]**	*EC* = **80** (**80 and *EC***) *EA* or *ECA* = **580** is sufficient evidence for the last two marks, even if seen when talking about 'odd nodes' or 'ends', although 580 on its own (without *EA* or *ECA*) is not enough

6	**(i)**		Cube 2 	B1 **[1]**	Correct graph
	(ii)		2	B1 **[1]**	(cao)
	(iii)		Cube 4 	B1 **[1]**	Adding arc YR, and no others Only need to check solid line
	(iv)			M1 A1 **[2]**	(Six) arcs for cubes 2 and 4 added Only need to check solid lines Labelling correct

	(v)		(G will have order 2, so) cannot use any more arcs directly joined to G. This means that we have to use the arc labelled *2* joining Y to R, so we cannot use the arc labelled *3* joining Y to Y. So we must use the arc labelled *3* joining B to R. But then we need an arc labelled *4* joining B to Y, and there isn't one. <u>OR</u> We must either use the loop joining Y to Y and a pair of arcs joining B to R or we must form a triangle joining Y, B and R. If we use the arc labelled 3 joining Y to itself we would need an arc labelled *2* joining B to R, but there isn't one. We cannot form a triangle joining Y, B and R since there are no arcs directly joining Y to B.	M1 A1 **[2]**	Other arcs joined directly to G (it) cannot be used, soi The other three vertices would need to have order 2 Showing that it is not possible to have one arc labelled *2*, one labelled *3* and one labelled *4* with Y, B and R each having order two Note: the graph need not be connected For reference: 
	(vi)			B1 **[1]**	This labelled graph (cao)
	(vii)		Front Back B R R Y Y G G B Front Back B G R B Y R G Y	M1 A1 **[2]**	Either tower correct Both correct

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