OCR Maths M2

Topic Questions from Papers

Energy, Work and Power

Answers

1	(i)	½.700.20^2 or ½.700.15^2	B1		either K.E.	
		700x9.8x400sin5°	B1		correct P.E.	
		½.700.15^2+700.9.8.400sin5°= ½.700.20^2 + W.D.	M1		for 4 terms with W.D.	
		W.D. = 178,000 J	A1	4	or 178 kJ	
	(ii)	D=200 + 700.9.8sin5°	M1			
		D = 798 N	A1		may be implied	
		P = Dx15 = 12,000 = 12kW	A1	3	AG **(11,968W)**	
	(iii)	D' = 11,968÷20 = 598	M1			
		D'-700.9.8sin5°-200 = 700a	M1			
		a = 0.285 ms^{-2} (±)	A1	3	allow 0.283 (from 12kW)	**10**
		Alternative for false assumption			**of constant acceleration**	
	(i)	D-700 x 9.8sin5° = 700a and $15^2 = 20^2$ + 2a. 400	M1		(D = 445, a = -0.21875)	
		W.D. = 400xD = 178,000	A1		2 marks (out of 4) maximum	

(Q6, June 2005)

2	(i)a	100 J	B1	1		
	b	7500 Nm	B1	1		
	(ii)	400cosα x 25 =7500 + 100	M1		sc N II gets M1A1only.This M1 for total M (a=0.08)&A1for α	
		√ for = a + b	A1√			
		α = 40.5	A1	3	or 0.707 rads	**5**

(Q3, Jan 2006)

3	(i)	F = 300/12	M1			
		R = 25	A1	2		
	(ii)	P=17.5x12 (R_2=17.5 & F_2 = 17.5)	M1		n.b. B1 only for 210 W without working	
		P = 210 W	A1	2		
	(iii)	500 = Fx12	M1			
		F = 41.67 or 500/12 aef	A1			
		41.67 – 25 – 75x9.8sin1°= 75a	M1			
			A1			
		0.0512 ms^{-2}	A1	5	or 0.051	
	(iv)	PE = 75x9.8x200sin10° (25530)	B1		**OR** 75x9.8sin10° -120= 75a (M1 + A1)	
		WD = 200x120 (24000)	B1			
		½.75v^2 =	M1		a = 0.102 (A1)	
		½.75.13^2+75x9.8x200sin10°-200.120	A1		v^2 =169+2x0.102x200 (M1)	
		14.5 ms^{-1}	A1	5	v = 14.5	**14**

(Q7, Jan 2006)

4		mgh = 35 x 9.8 x 4	M1			
			A1			
		mgh/t = 1372/10	M1		watch out for extras	
		137 W	A1	4	or 0.137 kW	**4**

(Q1, June 2006)

5	(i)	P = 13500 W	B1	1	or 13.5 kW	
	(ii)	500 = 13500/v v = 27 ms^{-1}	M1 A1	 2		
	(iii)	15000/25 – 500 = 950a a = 0.105 or 2/19	M1 A1 A1	 3	2 parts to F A0 for 900a or 100/950	
	(iv)	15000/26–500 – 950.9.8sin5° = 950a a = (–) .773 ms^{-2}	M1 A1 A1	 3	3 parts to F A0 for 900a s.c. accept 0.77	**9**

(Q4, June 2006)

6	(i)	½x80x5^2 or ½x80x2^2 either KE	B1		1000/160	
		70 x 25	B1		1750	
		80x9.8x25sin20°	B1		6703.6	
		WD=½x80x5^2-½x80x2^2+70x25+80x9.8x25sin20°	M1		4 parts	
		9290	A1	5		
	(ii)	Pcos30°x25	B1		or a=0.42	
		Pcos30°.25=9290 / Pcos30°-70-80x9.8sin20°=80a	M1			
		P = 429 /if P found 1st then Pcos30°x25 =9290 ok	A1	3		**8**

(Q4, Jan 2007)

7	(i)	D = 3000/5^2 = 120	M1			
			A1	2	**AG**	
	(ii)	120 – 75 = 100a	M1			
		a = 0.45 ms^{-2}	A1	2		
	(iii)	100x9.8x1/98	B1		weight component	
		3000/v^2=3v^2+100x9.8x1/98	M1			
		3000 = 3v^4 + 10v^2	A1		aef	
		solving quad in v^2	M1		(v^2 = 30)	
		v = 5.48 ms^{-1}	A1	5	accept √30	**9**

(Q5, Jan 2007)

8	40 cos35°	B1		
	WD = 40cos35° x 100	M1		
	3280 J	A1 **3**	ignore units	**3**

(Q1, June 2007)

9 (i)	WD = ½x250x150^2 –½x250x100^2	M1		
	1 560 000	A1	1 562 500	
	450 000 = 1 560 000/t	M1		
	3.47	A1 **4**		
(ii)	F = 450 000/120	M1		
	3750	A1		
	3750 = 250a	M1		
	15 ms^{-2}	A1 **4**		**8**

(Q3, June 2007)

10 (i)	½ . 70 .4^2	M1	
	560 J	A1 **2**	
(ii)	70 x 9.8 x 6	M1	
	4120	A1 **2**	4116
(iii)	60d	B1	
	8000 = 560 + 4120 + 60d	M1	4 terms
		A1 ✓	✓ their KE and PE
	55.4 m	A1 **4**	**8**

(Q5, June 2007)

11	F = 0.2 mg cos30°	M1	=
		A1	= (1.6974m) (49√3/50m)
	0.2mgcos30° x d	B1	a=0.2gcos30°+gsin30°
	mg x d x sin30°	B1	a= (±) 6.60
	d=½x25/(0.2x9.8cos30°+9.8xsin30°)	M1	$0 = 5^2 – 2x6.60d$
	1.89 m	A1 **6**	**6**

(Q2, Jan 2008)

12 (i)	45 000/v = kv	M1	
	k = 50	A1 **2**	**AG**
(ii)	45 000/20 – 50x20 = 1200a	M1	
		A1	
	a = 1.04 m s^{-2}	A1 **3**	
(iii)	P/15 = 50x15 + 1200x9.8sin10°	M1	
		A1	
	41 900 W	A1 **3**	**8**

(Q4, Jan 2008)

13	200cos35°	B1	
	200cos35° x d = 5000	M1	
	d = 30.5 m	A1 **3**	**3**

(Q1, June 2008)

14	$0.03R = ½x0.009(250^2 – 150^2)$	M1	$150^2 = 250^2 + 2a$ x 0.03
	0.03R	B1	a = ±2x10^6/3 or ±666,667 (A1)
	either K.E.	B1	F = 0.009a (M1)
	R = 6000 N	A1 ✓ **4**	✓ unit errors **4**

(Q2, June 2008)

15 (i)	D = 12000/20	B1	
	12000/20=k x 20 + 600 x 9.8 x 0.1	M1	
	k = 0.6	A1 **3**	**AG**
(ii)	16000/v = 0.6v + 600 x 9.8 x 0.1	M1	
	0.6 v^2 + 588v – 16000 = 0	M1	attempt to solve quad. (3 terms)
	v = 26.5 m s^{-1}	A1 **3**	
(iii)	16000/32 – 0.6 x 32 = 600a	M1	
		A1	
	a = 0.801 m s^{-2}	A1 **3**	0.80 or 0.8 **9**

(Q3, June 2008)

16 (i)	$P/10 - 800x9.8\sin12° - 100k = 800x0.25$	M1	$P/10 = D_1$ ok
		A1	D_1 ok
	$P/20 - 400k = 800x0.75$	M1	$P/20 = D_2$ ok
		A1	$D_1 = 2D_2$ needed for this A1
	solving above	M1	
	$k = 0.900$	A1	**AG** 0.9000395
	$P = 19\ 200$	A1 **7**	or 19.2 kW (maybe in part (ii))
(ii)	$0.9\ v^2 = 28\ 800/v$	M1	ok if $19200/v$
	solving above	M1 *	$(v^3 = 32\ 000)$
	$v = 31.7$ m s^{-1}	A1 **3**	**10**

(Q4, Jan 2009)

17	½×75×12^2 or ½×75×3^2 (either KE)	B1	M1 $12^2 = 3^2 + 2a \times 180$
	75×9.8×40 (PE)	B1	A1 $a = 0.375$ (3/8)
	R×180 (change in energy = 24337)	B1	M1 $75 \times 9.8 \times \sin\theta - R = 75a$
	½×75×12^2=½×75×3^2+75×9.8×40–R×180	M1	A1 $R = 135$
	R = 135 N	A1 **5**	(max 4 for no energy) **5**

(Q1, June 2009)

18 (i)	$R = F = P/v = 44\ 000/v = 1400$	M1	
	$v = 31.4$ m s^{-1}	A1 **2**	
(ii)	$44\ 000/v = 1400 + 1100 \times 9.8 \times 0.05$	M1	must have g
		A1	
	$v = 22.7$ m s^{-1}	A1 **3**	
(iii)	22 000/10 + 1100×9.8×0.05 – 1400	M1	
	= 1100a	A1	**8**
	$a = 1.22$ m s^{-2}	A1 **3**	

(Q2, June 2009)

19	75×9.8×40	B1	Average Speed = 40÷120
	(75×9.8×40)÷120	M1	(75×9.8)×(Average speed)
	245 W	A1 **[3]**	**3**

(Q1, Jan 2010)

20 (i)	D – 400 = 700 × 0.5 D = 750 N	M1 A1 **[2]**	3 terms
(ii)	P = 750 × 12 9 000 W or 9 kW	M1 A1ft **[2]**	
(iii)	P/35 = 400 14 000 W or 14 kW	M1 A1 **[2]**	
(iv)	D = 14000/12 3500/3 = 400 + 700×9.8sinθ θ = 6.42°	B1ft M1 A1 A1 **[4]**	May be implied 3 terms Their P/12 **10**

(Q4, Jan 2010)

21 (i)	D = 128 000/80 (= 1600) $k(80)^2 = 128\ 000/80$ k = ¼ R = 900 N FT	B1 M1 A1 A1 B1 **5**	 Driving force = resistance FT on their k (R = 3600k)
(ii)	D = 128 000 / 60 (= 2133⅓) 2000 x 9.8 x sin2° 6400/3-900-2000 x 9.8 x sin2° = 2000a $a = 0.275\ m\ s^{-2}$	B1 B1 M1 A1 **4**	 4 terms required **9**

(Q3, June 2010)

22 (i)	R = 0.2 x 9.8 x cos30° (= 1.70) F = 0.1 x 9.8 x cos30° (= 0.849) FT ½ x 0.2 x 11^2 - ½ x 0.2 v^2 = 0.2 x 9.8 x 5sin30 + 5 x 0.849 $v = 5.44\ m\ s^{-1}$	B1 B1 M1 A1 A1 A1 **6**	 FT on their R, but not R =0.2g Use of conservation of energy **AG**
Or last 4 marks of (i)	F + 0.2gsin30 = ±0.2a a = ±9.1 $v^2 = 11^2 + 2$ x a x 5 $v = 5.44\ m\ s^{-1}$	M1 A1 M1 A1	Use of N2L, 3 terms Complete method to find v

(Q7, June 2010)

23	**(i)**		$(k25^{3/2}) \times 25 = 15000$ $k = 4.8$ **AG**	M1 A1 A1 **[3]**	Tractive force x speed = power
	(ii)		$R = 4.8 \times 16^{3/2}$ $T - 4.8x16^{3/2} + 700gx1/15 = 700x0.3$ $P = 59.9 \times 16$ $P = 958$ W	B1 M1 A1 M1 A1 **[5]**	307.2 N2L, 4 terms to find tractive force (T) Allow cv(R), R not 600; (T = 59.866..) 16xTractive force

(Q2, Jan 2011)

24	**(i)**		WD = 100cos20 x 30 WD = 2820 J	M1 A1 **[2]**	Product of 3 relevant elements. Angle could be 5, 25 or complements 2819.1...
	(ii)		PE = 25g x 30sin5 PE = 641	M1 A1 **[2]**	Product of weight and vertical height. Allow without g 640.6
	(iii)		 2819.1 = 640.6 + 30x70 + $25v^2/2$ v = 2.51 ms^{-1}	M1 A1ft A1 A1 **[4]**	4 term energy equation ft(cv 2820 and cv 641) cao
		OR	25a = 100cos20 -70 -25gsin5 a = 0.105 $v^2 = 2 \times 30 \times$ 'a' v = 2.51	*M1 A1 dep*M1 A1 **[4]**	4 term equation Allow 0.1 here Or equivalent complete method cao

(Q4, Jan 2011)

25 i	PE = 70x3g KE change =$70x(2.1^2 - 1.4^2)/2$ PE change + KE change 2143.75 J	B1 B1 M1 A1 [4]	2058 85.75 Must include evaluation Accept 2140. Allow all values to be negative.
ii	 20(90 + T) = 2143.75 T = 17.1875 N	M1 A1ft A1 [3]	Work done = Energy change used ft(cv(2143.75)) accept 17.2
OR	 70g.0.15 – 90 – T = 70.(-0.06125) T = 17.1875 N	M1 A1 A1 [3]	Use of $v^2=u^2 + 2as$ to find a AND use of N2 law(4 terms) accept 17.2

(Q1, June 2011)

26 i	21000/25 0 = 21000/25 – 25k – 1250gsin2 k = 16.5	B1 M1 A1 A1 [4]	Use of force = power/speed 3 terms cv(21000/25)
ii	 21000/v= 16.5v v = 35.7 ms^{-1}	M1 A1ft A1 [3]	 ft on cv(k)

(Q2, June 2011)

27	(i)		25000/10 1500*g*sin5 2500 – 750 – 1500*g*sin5 = 1500*a* *a* = 0.313	B1 B1 M1 A1 A1 [5]	 1281.1 Attempt at N2L with 4 terms. cv(1500*g*sin5); cv(2500) not 25000. Allow 0.31
	(ii)		WD against resistance = 750*d* WD by engine = 25000×28 (= 700000) Change in PE = 1500*g* × *d*sin5 Change in KE = ±½ ×1500 × ($20^2 - 10^2$) 25000×28 = ½ ×1500 ×($20^2 - 10^2$) + 750*d* + 1500*g* × *d*sin5 *d* = 234	B1 B1 B1 B1 M1 A1 A1 [7]	750*h*/sin5 1500*g* × *h* Use of correct formula for KE. Use conservation of energy, at least 3 used including WD by engine.

(Q5, Jan 2012)

28	(i)		Driving Force = 20000/20 (= 1000) 20000/20 – 800 = 1600*a* *a* = 0.125 ms^{-2}	B1 M1 A1 A1 **[4]**	 Attempt at N2L with 3 terms. Signs may not be correct at this stage. Using their 20000/20, but not 20000 Allow $\frac{1}{8}$
	(ii)		20000/*v* DF – 800 – 1600*g*sin4 = 0 *v* = 10.6 ms^{-1}	B1 M1 A1 A1 **[4]**	 3 terms with attempt at resolving weight; *g* can be omitted at this stage; if F = ….. then F = 0 somewhere to award M aef

(Q2, June 2012)

29	**(i)**		18cos15 x 6 104 J	M1 A1 A1 **[3]**	Force component x distance	
	(ii)		18cos15 x 6/5 or ans(i)/5 20.9 W	M1 A1 **[2]**	Force component x distance/5 Allow 20.8	

(Q1, Jan 2013)

30	**(i)**		DF = 15000/15 DF – *k* x $15^{1/2}$ = 1500 x 0.4 *k* = 103	B1 M1 A1 A1 **[4]**	 N2L, 3 terms and attempt at DF. Numerical DF Allow $^{80\sqrt{15}}/_{3}$	
	(ii)		P/30 = *k*$30^{1/2}$ P = 17000W	M1 A1 A1 **[3]**	 Using cv(k) Allow 17(.0)kW, 16900W, 16.9kW, 12000√2W	

(Q2, Jan 2013)

31	**(i)**		Use I = mv 3.6 ms^{-1}	M1 A1 **[2]**	-3.6 gets A0	
	(ii)		$\pm(\frac{1}{2} \times 0.5 \times 3.6^2 - \frac{1}{2} \times 0.5 \times v^2)$ 0.5 x g x 0.3 Use of conservation of energy v = 2.66 ms^{-1}	B1 B1 M1 A1 **[4]**	Three terms	
	OR		a = -gsinθ s = 0.3/sinθ Use $v^2 = u^2 + 2as$ v = 2.66 ms^{-1}	B1 B1 M1 A1	θ angle of plane to horizontal $a \neq -g$, $s \neq 0.3$.	
	(iii)		Change in energy = $\pm(\frac{1}{2} \times 0.5 \times 3^2 - 0.5 \times g \times 0.2)$ Equate to force x distance 3.175 N	M1 A1 M1 A1 **[4]**	Difference of KE and PE Attempt at 0.2/sin30 for dist, 3 terms Allow 3.18	
	OR		Using $v^2 = u^2 + 2as$ to find a Resolve parallel to plane 0.5gcos60 + F = 0.5 x cv(11.25) F = 3.175	M1 M1 A1 A1	Use v = 0, attempt at s =0.2/sin30 N2L used with cv(11.25), 3 terms Consistent signs Allow 3.18	

(Q6, Jan 2013)

32		**(i)**	$0.75 \times g \times 8$ 58.8 J	M1 A1 **[2]**	Weight × distance Allow –58.8
		(ii)	$+/-(\frac{1}{2} \times 0.75 \times v^2 - \frac{1}{2} \times 0.75 \times 2^2)$ $\frac{1}{2} \times 0.75 \times v^2 - \frac{1}{2} \times 0.75 \times 2^2 = 58.8$ $v = 12.7$ m s^{-1}	*M1 A1 dep*M1 A1 **[4]**	Attempt at change in KE Equate their change in KE to their PE from **(i)**
	OR	**(ii)**	$a = g\sin\theta$ $s = {}^{8}/_{\sin\theta}$ $v^2 = 2^2 + 2 \times g\sin\theta \times {}^{8}/_{\sin\theta}$ $v = 12.7$ m s^{-1}	B1 B1 M1 A1 **[4]**	θ is angle of slope to horizontal. Not $a = g$, not $s = 8$

(Q1, June 2013)

33		**(i)**	20000/32 $R = 20000/32$ $R = 625$ N	B1 M1 A1 **[3]**	 cao
		(ii)	$F + 1500g\sin 2 - 625 = 1500 \times 0.1$ Power = $32 \times F$ Power = 8380 W or 8.38 kW	M1 A1ft M1 A1 **[4]**	Using Newton 2, all forces used. ft their R from (i) SC $F - 1500g\sin 2 - 625 = 1500 \times 0.1$ Using their F. 8383.27…. SC 41200 W or 41.2 kW (41216.7…)

(Q2, June 2013)