AQA Maths M2

Topic Questions from Papers

Energy, Work and Power

Answers

1 (a)	$P=(30\times 42)\times 42$ $=52920$ W AG	M1 A1	2	Finding force Correct answer from $P=Fv$
(b)(i)	$F=1200\times 9.8\sin 5°+30v$	M1A1		Finding force. Correct force
	$52920=(1200\times 9.8\sin 5°+30v)v$	dM1		Using $P=Fv$
	$v^2+392\sin 5° v-1764=0$	A1	4	Correct equation from correct working AG
(ii)	$v=\dfrac{-392\sin 5°\pm\sqrt{(392\sin 5°)^2-4\times 1\times(-1764)}}{2\times 1}$	M1		Solving quadratic
	$v=28.3$ or -62.4			
	$v=28.3$ ms^{-1}	A1	2	Correct solution
	Total		**8**	

(Q4, Jan 2006)

2 (a)	$\dfrac{100}{0.4}e=10\times 9.8$	M1		Use of Hookes law and equilibrium
	$e=0.392$ m	A1	2	Correct length
(b)	$EPE=\dfrac{1}{2}\times\dfrac{100}{0.4}\times 0.6^2=45$ J AG	M1 A1	2	Use of EPE formula Correct value from correct working
(c)(i)	$45=\dfrac{1}{2}\times\dfrac{100}{0.4}(x-0.4)^2+\dfrac{1}{2}\times 10v^2+10\times 9.8(1-x)$	M1 A1 M1		Expression for EPE with $(x\pm 0.4)^2$ Correct EPE Four term energy equation
	$45=125(x-0.4)^2+5v^2+98(1-x)$	B1		Correct GPE
		A1		Correct equation
	$5v^2=98x-98+45-125x^2+100x-20$	dM1		Solving for v^2
	$v^2=39.6x-25x^2-14.6$ AG	A1	7	Correct result from correct working
(ii)	$39.6x-25x^2-14.6=0$			
	$25x^2-39.6x+14.6=0$			
	$x=\dfrac{39.6\pm\sqrt{39.6^2-4\times 25\times 14.6}}{2\times 25}$	M1		Solving quadratic
	$=1$ or 0.584	A1		Correct solutions
	$x=0.584$	A1	3	Appropriate value selected **SC** Only correct answers given, award M1A1.
	Total		**14**	

(Q7, Jan 2006)

3 (a)	EPE $= \frac{1}{2}\times\frac{30}{0.5}\times 1.3^2 = 50.7$ J	M1 A1	2	use of EPE formula correct EPE
(b)(i)	$50.7 = \frac{1}{2}\times 2v^2 + \frac{1}{2}\times\frac{30}{0.5}\times 0.8^2$ $50.7 = v^2 + 19.2$ AG $v = \sqrt{31.5} = 5.61$ ms^{-1}	M1 A1 A1 dM1 A1	5	three term energy equation two terms correct all terms correct solving for v correct v from correct working
(ii)	$50.7 = \frac{1}{2}\times 2v^2$ $v = \sqrt{50.7} = 7.12$ ms^{-1}	M1 A1 A1	3	two term energy equation correct equation correct velocity
(c)	$\frac{1}{2}\times 2v^2 = 50.7 - 1.8\times 0.1\times 2\times 9.8$ $v = \sqrt{47.172} = 6.87$ ms^{-1}	M1 A1 M1 A1 A1	5	finding friction force correct friction force three term energy equation correct equation correct velocity
	Total		**15**	

(Q3, June 2006)

4 (a)	$\frac{1}{2}\times 35\times v^2 = 35\times 9.8\times 10$ $v = 14$ (ms^{-1})	M1 A1 A1	3	Energy method
(b)	Air resistance or friction	B1	1	
(c)	Energy lost = $35\times 9.8\times 10 - \frac{1}{2}\times 35\times 12^2 \quad (=910)$ Work done: $F\times 20 \quad (=910)$ $20F = 910 \quad F = 45.5$(N)	M1 A1 m1 A1	4	Difference attempted $\pm$ $F > 0$
	Total		**8**	

(Q1, Jan 2007)

5 (a)	$2g = \frac{49 \times x}{0.5}$	M1 A1		
	$\underline{x = 0.2}$	A1	3	
(b)	EPE $= \frac{49 \times (0.2)^2}{2 \times 0.5}$	M1		
	= 1.96 (J)	A1	2	
(c)(i)	$1.96 = \frac{49 \times x^2}{2 \times 0.5} + 0.8 \times 9.8 \times (0.2 + x)$	M1 A3		All terms attempted for M1 -1 EE from A3
	$x^2 + 0.16x - 0.008 = 0$	A1	5	
(ii)	$x = \frac{0.16 \pm \sqrt{0.16^2 + 4 \times 0.008}}{2}$	M1		
	$x = 0.04$	A1	2	$x = 0.04$ only identified
	Total		**12**	

(Q8, Jan 2007)

6 (a)	Kinetic energy = $\frac{1}{2} \times 5 \times 10^2$	M1		Full method
	$= 250$ J	A1	2	
(b)	Using conservation of energy: KE when box hits ground = Initial KE + Change in potential energy	M1		Could have sign errors
	$= 250 + 5 \times 30 \times g$	A1ft		
	= 1720 J	A1	3	AG; SC2 $5 \times 35.1 \times g = 1720.$ ...
(c)	$\frac{1}{2}mV^2 = 1720$	M1		
	$V^2 = 688$	A1		
	$\therefore$ Speed is 26.2 m s^{-1}	A1	3	CAO; accept $\sqrt{688}$ or $4\sqrt{43}$; SC2 26.3
(d)	No air resistance	E1		Or no resistance forces
	Box is a particle	E1	2	Deduct 1 mark for unacceptable third reason
	Total		**10**	

(Q1, June 2007)

7 (a)	EPE is $\frac{\lambda x^2}{2l}$ $= \frac{200(0.5)^2}{2\times 2}$ $= 12.5$ J	 M1 A1	 2	
(b)	When string becomes slack, using $\frac{1}{2}mv^2$ = loss in EPE: $\frac{1}{2}\times 5\times v^2 = 12.5$ Speed is $\sqrt{5}$ m s^{-1}	 M1 A1 A1	 3	 NB Using $\sqrt{5}$ to answer (a) and thus (b) $\Rightarrow$ no marks AG
(c)	Resolving vertically, $R = 5g$ $F = \mu R$ $0.4 \times 5g = 2g$ Using change in energy = work done: $2g \times 0.5 =$ $\frac{1}{2}\times 5\times\left(\sqrt{5}^2\right) - \frac{1}{2}\times 5\times v^2$ $9.8 = 12.5 - \frac{5}{2}v^2$ $v^2 = 1.08$ Speed is 1.04 m s^{-1}	B1 M1 M1 M1 A1,A1 A1	 7	 M1 for force × distance A1 first term (or 12.5) A1 second term (inc –)
	Total		**12**	

(Q6, June 2007)

8 (a)	Kinetic energy = $\frac{1}{2}\times 0.6\times 15^2$ $= 67.5$ J	M1 A1	 2	
(b)	Using $mgh = \frac{1}{2}mv^2$: $67.5 = 0.6 \times g \times h$ $\Rightarrow h = \frac{67.5}{0.6g}$ $= 11.5$ m	M1 A1 A1	 3	
(c)	When 3 m above ground level: Change in PE is $0.6 \times g \times 3$ $= 17.64$ J $\therefore$ KE of ball is $67.5 - 17.64$ $= 49.86$ J Speed of ball is $\sqrt{\frac{49.86}{\frac{1}{2}\times 0.6}}$ $= 12.9$ m s^{-1}	 M1 A1 m1 A1	 4	 Dep on M1 No KE given: speed = 12.9 SC3
(d)	eg ball is a particle, no air resistance, weight is the only force acting etc	E1	1	Accept no spin, no wind
	Total		**10**	

(Q1, Jan 2008)

9 (a)	EPE = $\dfrac{\lambda x^2}{2l}$ $= \dfrac{300\times(1.5)^2}{2\times 4}$ = 84.375 = 84.4 J	 M1 A1	 2	
(b)	When string is slack, gain in PE is mgh = 6 × g × 1.5sin30 = 44.1 J KE = EPE – gain in PE = 84.375 – 44.1 = 40.275 $\frac{1}{2}.6.v^2 = 40.275$ v = 3.66	 M1 A1 m1 A1 A1	 5	 AG
(c)	At A, PE gained above initial position is 6 × g × 5.5 sin30 = 161.7J This is more than initial elastic potential energy ∴ particle will not reach A	 B1 B1 E1	 3	 Or PE above position string slack is 117.6 KE at A is –77.3 **Or** Using $v^2 = u^2 + 2as$ a = 0.5g B1 s = 1.37 or 1.366 B1 [or 2.87 above starting point] Hence stops before A E1 Vertical height above sling slack is 0.683 Vertical height above starting point is 1.435
	Total		**10**	

(Q6, Jan 2008)

10 (a)	Using power = force × velocity Power = (40 × 50) × 50 ∴ = 100,000 watts	 M1 A1	 2	
(b)	When speed is 25, max force exerted is $\frac{100000}{25}$ = 4000N ∴ Accelerating force is 3000N Using $F = ma$ $3000 = 1500\,a$ $a = 2$ ms $^{-2}$	 B1 M1 A1	 3	 Need 3 terms eg '4000' ± 1000 = *ma* or 2000 ± 1000 = *ma* M0 for 1000 = *ma*
(c)	When van is at maximum speed force against gravity is $mg\sin 6$ (parallel to slope) Force against gravity and resistance is $mg\sin 6 + 40\,v$ = $1536.6 + 40\,v$ Speed is maximum when $1536.6 + 40v = \frac{100000}{v}$ $40\,v^2 + 1536.6\,v - 100\,000 = 0$ Speed is 34.4 ms $^{-1}$	 B1 M1 A1 M1 A1 A1	 6	 For 3 terms; $\frac{100000}{v}$ and 1 other term correct CAO
	Total		**11**	

(Q4, June 2008)

11 (a)	Work done = $\int_0^e \frac{\lambda x}{l}\,dx$	M1		
	$= \left[\frac{\lambda x^2}{2l}\right]_0^e$	A1		Needs limit of 0
	$= \frac{\lambda e^2}{2l}$	A1	3	AG
	Or Area under a straight line = average force × distance = $\frac{\lambda e^2}{2l}$			
(b)(i)	Using $T = \frac{\lambda x}{l}$			
	$5g = \frac{150 \times x}{0.6}$	M1		
	Extension is 0.196 m	A1	2	
(ii)	EPE $= \frac{\lambda x^2}{2l}$			
	$= \frac{150 \times (0.3)^2}{2 \times 0.6}$	M1		
	= 11.25 J	A1	2	
(iii)	When x above P,			
	EPE $= \frac{150 \times (0.3 - x)^2}{2 \times 0.6}$	M1 A1		for $\frac{150 \times (\ldots - x)^2}{2 \times 0.6}$
	PE[relative to P] = (–)5 × g × x	M1		for 5 × g × distance
	KE + EPE [at new point] = EPE [at P] – gain in PE	M1		4 terms, all signs correct, 2 terms correct
	$\frac{1}{2}mv^2 + \frac{150 \times (0.3 - x)^2}{2 \times 0.6} =$ $\frac{150 \times (0.3)^2}{2 \times 0.6} - 5gx$	A1		
	$\frac{1}{2}mv^2 + \frac{150 \times (x^2 - 0.6x)}{2 \times 0.6} = -5gx$	m1		Equation involving terms in v^2, x^2 and x only
	$\frac{1}{2}.5.v^2 + 125x^2 - 75x = -49x$			
	$v^2 = 10.4x - 50x^2$	A1	7	
(iv)	Particle is at rest when $v = 0$			
	$10.4x - 50x^2 = 0$	M1		
	$x = 0$ [not required]			
	Or $x = \frac{10.4}{50} = 0.208$ m above P.	A1	2	
	Total		**16**	

(Q8, June 2008)

12 (a)	Initial KE = $\frac{1}{2}mv^2$ = $\frac{1}{2} \times 6 \times 12^2$ = 432 J	 M1 A1	 2	 Allow one of m and v incorrect
(b)(i)	When it hits the ground, conservation of energy gives KE = Initial KE + loss in PE = $432 + 6 \times g \times 4$ = 667.2 = 667 J (3sf)	 M1 A1	 2	 Need $6 \times g \times 4$ or 235.2 AG
(ii)	$667.2 = \frac{1}{2} \times 6 \times v^2$ Speed is 14.9 m s^{-1}	M1A1 A1	 3	
(iii)	Stone is a particle No air resistance	B1 B1	 2	Not g constant No other forces acting
	Total		**9**	

(Q2, Jan 2009)

13 (a)	At maximum speed, tractive force = resistance force Using power = force × velocity: 800 000 = F × 40 F = 20 000 N	 M1 M1 A1	 3	
(b)	Using force × distance = work done = change in energy: $20\,000\, s = \frac{1}{2} \times 60\,000 \times (40^2 - 36^2)$ Distance = 456 m	 M1 A1 A1 A1	 4	 M1 Fs = change of KE A1 2 of 3 terms correct A1 all 3 terms correct
	Total		**7**	

(Q6, Jan 2009)

14 (a)	When acceleration is zero, tension = gravitational force $\frac{784x}{16} = 80g$ $x = 16$, $x + 16 = 32$ m Length of cord is 32 m	 M1 A1 A1	 3	 Both terms correct A1 for $x = 16$
(b)(i)	When bungee jumper comes to rest, EPE = $\frac{784 \times x^2}{2 \times 16}$ $= \frac{49x^2}{2}$ Change in PE = $80 \times g \times (16 + x)$ $\frac{49x^2}{2} = 80 \times 9.8 \times (16 + x)$ $x^2 = 32x + 512$ $x^2 - 32x - 512 = 0$	 M1 M1 A1 A1	 4	 Or $80 \times g \times 65 - \left(80g\left[16 + x\right]\right)$ $\left(\text{or } 80g\left(49 - x\right)\right)$ AG
(ii)	$x = \frac{32 \pm \sqrt{32^2 + 2048}}{2}$ $x = 43.7128$ Distance below point of jump is 43.7 + 16 = 59.7 m Distance between jumper and ground is 65 – 59.7 = 5.29 m	M1 A1 M1 A1	 4	 Accept 5.287, 5.3
	Total		**11**	

(Q9, Jan 2009)

15 (a)	KE $= \frac{1}{2} \times 55 \times 3^2$ $= 247.5$ J	M1 A1	 2	
(b)	Change in PE as slides down: $mgh = 55 \times 9.8 \times 20 \cos 30$ $= 9335.7\ldots$ Using Conservation of Energy: KE at end of slide $= 247.5 + 9335.7$ $= 9580$ J Speed of Anne is $\sqrt{\frac{9583}{\frac{1}{2} \times 55}}$ $= 18.7$ m s^{-1}	 M1 A1 m1 A1 m1 A1	 6	 Need cos 30 or sin 30 'a' + '9335.7' accept 9583
(c)	Anne is a particle; no air resistance	E1	1	
	Total		**9**	

(Q2, June 2009)

16	Force acting against gravity is $mg\sin\theta$	M1		Or 147000
	Force acting against gravity and resistance is $mg\sin\theta + 200000$	m1		200 000 + ‘mg sin θ’
	$= 600000g\sin\theta + 200000$			
	$= 347000$	A1		
	Using power = force × velocity	M1		
	= 347000 × 24	A1F		
	= 8330 kW	A1	6	
	Total		**6**	

(Q5, June 2009)

17 (a)	$\text{EPE} = \dfrac{\lambda x^2}{2l}$			
	$= \dfrac{180 \times 0.8^2}{2 \times 1.2}$	M1		
	= 48 J	A1	2	
(b)	Using initial EPE = KE when string becomes slack:	M1		
	$48 = \dfrac{1}{2} \times 5 \times v^2$	A1F		
	$v = \sqrt{\dfrac{96}{5}}$			
	= 4.38 m s^{-1}	A1F	3	ft $\sqrt{\dfrac{'a'}{2.5}}$
(c)	Normal reaction is $5g$ or 49	M1		
	Frictional force is $5g \times \mu$	m1A1		
	Work done by frictional force is $5\mu g \times 2$	m1		
	$= 10\mu g$	A1		
	Stops at wall $\Rightarrow 10\mu g = 48$	m1		m1 $10\mu g = 'a'$
	$\mu = 0.490$	A1	7	accept $\dfrac{24}{49}$ OE
	Total		**12**	

(Q6, June 2009)

18	Work done = $Fs\cos\theta$	M1		Accept $Fs\sin\theta$ for M1
	$= 40 \times 5 \times \cos 30$	A1		
	= 173 J	A1	3	
	Total		**3**	

(Q1, Jan 2010)

19 (a)	When $x \geq 22$, KE is $\frac{1}{2} \times 49 \times v^2$ EPE is $\frac{1078(x-22)^2}{2 \times 22}$	M1A1		M1 for any $\frac{1078p^2}{2 \times 22}$
	Change in PE is $49 \times g \times x$			
	Conservation of energy: $\frac{1}{2} \times 49 \times v^2 + \frac{1078(x-22)^2}{2 \times 22} = 49 \times g \times x$	M1A1 A1		M1 3 terms (KE, PE, EPE) A1 2 terms correct A1 all 3 terms correct
	$\frac{49}{2}v^2 + \frac{49}{2}(x-22)^2 = 49gx$ $v^2 + (x-22)^2 = 19.6x$			SC3 $\frac{49}{2}v^2 + \frac{49}{2}e^2 = 49g(e+22)$ [could use x for e]
	$5v^2 = 318x - 5x^2 - 2420$	A1	6	AG
(b)	If x is not greater than 22, cord is not stretched	B1	1	
(c)	At maximum value of x, $v = 0$ $\therefore 5x^2 - 318x + 2420 = 0$	M1		
	$x = \frac{318 \pm \sqrt{318^2 - 4 \times 5 \times 2420}}{2 \times 5}$	m1		dep on M1 above
	x = 54.76.. or 8.84..	A1		A1 for either solution
	= 54.8	E1	4	Needs to give a reason for deletion of second root. Both roots must be positive: one above 22, one below 22
(d)(i)	When speed is a maximum, $a = 0$ tension = gravitational force	M1		**or** $\frac{d(5v^2)}{dx} = 318 - 10x$
	$\frac{1078(x-22)}{22} = 49g$ $x - 22 = 9.8$	A1		= 0 at maximum speed $\Rightarrow 318 - 10x = 0$
	$x = 31.8$	A1	3	AG
(ii)	From part (a), $v^2 = 19.6 \times 31.8 - 9.8^2$	M1		
	$v = 22.96$ Maximum speed is $23.0\,\mathrm{m\,s^{-1}}$	A1	2	
	Total		**16**	

(Q8, Jan 2010)

20 (a)	Kinetic energy = $\frac{1}{2} \times 3 \times 4^2$	M1		
	= 24 (J)	A1	2	
(b)	PE lost is			
	= $3 \times g \times 51$	M1		
	= $153g$ or 1499.4			
	= 1500 J	A1	2	Accept 1499, $153g$
(c)(i)	KE is $24 + 153g$	M1		M1 '(a)' + '(b)'
	= 1523.4			
	= 1520 J	A1		(if done (c)(i) in (b) 0 marks; if done (b) and then (c)(i) in (b) M1 only)
(ii)	Using KE = $\frac{1}{2}mv^2$			
	v^2 = 1015.6	M1		
	Speed of stone is 31.9 ms^{-1}	A1	4	Accept 31.8 from 1520
				If use constant acceleration formulae in 2D, possible 4 marks in (c) BUT **no marks** if initial speed is treated as being vertical
(d)	eg Stone is a particle	E1	1	
	No air resistance			Not no resistance; accept no wind resistance
	Total		**9**	

(Q2, June 2010)

21 (a)	Using power = force × velocity			
	Power = (30 × 48) × 48	M1		
	= 69120 watts	A1	2	AG
(b)	When speed is 40 m s^{-1},			
	max force exerted is $\frac{69120}{40}$			
	= 1728 N	B1		
	Accelerating force is '1728' – 1200 N	M1		
	Using $F = ma$:			
	$528 = 1200a$	m1		
	$a = 0.44$ m s^{-2}	A1	4	
(c)	Force exerted by engine is $\frac{69120}{v}$	B1		
	Force exerted by the engine = $30v - mg\sin 3$	M1		(Use of cos3 delete A1,A1 of 3 A terms)
	$30v - 615.47$ (or $1200g\sin 3$) = $\frac{69120}{v}$	A1A1		A2 All terms correct A1 Two terms correct
	$30v^2 - 615.47v - 69120 = 0$	A1		SC3 for $30v^2 + 615.47v - 69120 = 0$
	$v = \frac{615.47 \pm \sqrt{615.47^2 + 4\times30\times69120}}{2\times30}$	M1		
	Speed is 59.3 m s^{-1}	A1	7	
	Total		**13**	

(Q6, June 2010)

22 (a)	PE lost is $= 4 \times g \times 5 \cos 70$ = 67.0 J	M1A1	2	M1 $4 \times g \times 5 \times \cos$ or $\sin 20$ or 70
(b)	KE is loss of PE ⇒ KE is 67.0 J	B1	1	ft
(c)	Using KE = $\frac{1}{2}mv^2$ $v^2 = 33.5$ Speed of particle is 5.79 m s^{-1}	 M1 A1	 2	 (ft from (b))
	Total		**5**	

(Q2, Jan 2011)

23 (a)	PE is $400 \times g \times 8$ $= 3200\,g$ [or 31 360]	B1	1	
(b)	KE is $\frac{1}{2} \times 400 \times 2^2$ = 800	B1	1	
(c)	Work done per minute is 32 160 J Power = 32 160 ÷ 60 = 536 W	 M1 A1	 2	 $[(a)+(b)] \div 60$ CAO Accept 537 from 31 400 in (a)
	Total		**4**	

(Q3, Jan 2011)

24 (a)	Work done = $\int_0^e \frac{\lambda x}{l}\,dx$	M1		Condone lack of limits and 'dx'
	$= \left[\frac{\lambda x^2}{2l}\right]_0^e$	A1		Must include limits from integral
	$= \frac{\lambda e^2}{2l}$	A1	3	AG
(b)(i)	Using $T = \frac{\lambda x}{l}$, $7g = \frac{196x}{2}$	M1		M1 could use $3g$ or $4g$ – at least 1 side correct
	$x = \frac{14g}{196}$	A1		
	$= 0.7$	A1	3	
(ii)	By C of Energy, when next at rest, EPE (initial) = PE change (for platform) + EPE (when at rest)			
	$\frac{196\times0.7^2}{2\times2} = 4\times g\times(0.7-x)+\frac{196x^2}{2\times2}$	M1A1 A1		M1 3 terms (not including $\frac{1}{2}mv^2$) A1 2 of 3 terms correct A1 all correct
	$2.45 = 2.8 - 4x + 5x^2$ $100x^2 - 80x + 7 = 0$ $(10x - 7)(10x - 1) = 0$ $x = 0.1$	 m1 A1 A1	 6	 [last A1, must give 0.1, not 0.1 and 0.7]
	<u>Alternative</u>			
(b)(ii)	$\frac{196\times0.7^2}{2\times2} = 4gX + \frac{196(0.7-X)^2}{2\times2}$	(M1) (A1) (A1)		(where X is distance moved upwards)
	$4gX = 98\times0.7X + 49X^2$	(m1)		
	$X = 0,\ 0.6$	(A1A1)		
(iii)	Max speed when $T = mg$	M1		
	$4g = \frac{196x}{2}$	A1		
	$x = 0.4$	A1	3	Or mid-point of values 0.2 and 0.6 above SC2
	Total		**15**	

(Q7, Jan 2011)

25 (a)	KE = $\frac{1}{2}\times 58\times 2^2$	M1		M1: Correct fully substituted expression for KE.
	= 116 J	A1	2	A1: CAO
(b)	Change in PE: mgh = 58 × 9.8 × 7	M1		M1: Expression for PE with 58 and 9.8 or 9.81 with 6 or 7 for the height (or 11 and 4, 11 and 5 or 10 and 4).
	= 3978.8	A1		A1: Accept 3980 or 3970 or 3978 or 3979 or 3978.8. Accept 3982 or 3983 or 3980.
	KE = 3978.8 + 116 J = 4094.8 J	M1		M1: Adding their two previous answers.
	Speed of Kim is $\sqrt{\frac{4094.8}{\frac{1}{2}\times 58}}$	dM1		dM1: Seeing expression for v (not v^2), dependent on second M1
	= 11.88 m s^{-1} = 11.9 m s^{-1}	A1	5	A1: Accept 11.88 or 11.8 or 11.9 Accept 11.88 or 11.8 or 11.9 or AWRT 11.89 from g = 9.81. Obtaining $v=\sqrt{u^2+2gh}$ followed by incorrect substitution M0M1M1, unless h is 6 or 7, which is M1M1M1 11.0 (from h = 6) M1M1M1 $v=\sqrt{2^2+2\times g\times 7}$ M1M1M1 $=\sqrt{141.2}$ A1 $=11.9$ A1 $v=\sqrt{4+14g}$ M1M1M1A1 $=11.9$ A1 $v=\sqrt{2^2+12g}$ M1M1M1
	Total		**7**	

(Q1, June 2011)

26 **(a)**	$90\,\mathrm{km\,h^{-1}} = 90 \times \frac{1000}{3600}\,\mathrm{m\,s^{-1}}$ $= 25\ \mathrm{m\,s^{-1}}$ **AG**	B1	1	B1: Must see $\frac{1000}{3600}$ or $\frac{1000}{60^2}$.
(b)	Resistance is 5000 N Using power = force × velocity = 5000 × 25 = 125 kW	B1 M1 A1	 3	B1: Obtaining 5000. M1: Using $P = Fv$ with 25 and their F. A1: Correct final answer, must be in kW. 125W or 125 000 W B1M1 125 B1M1A1
	Total		**4**	

(Q5, June 2011)

27 (a)	EPE $= \dfrac{\lambda x^2}{2l}$			
	$= \dfrac{1800\times(4)^2}{2\times 6}$	B1 M1		B1: Extension = 4. M1: Substitution of 6, 1800 and their extension into EPE formula.
	$= 2400$ J	A1	3	A1: Correct EPE
(b)	$\dfrac{1800\times(x)^2}{2\times 6} = \dfrac{1}{2}\times 200\times 8^2$	M1		M1: Equation with EPE and KE terms, both correct.
	$x^2 = 42.67$ $x = 6.53$ m	A1		A1: Correct extension. Accept $\dfrac{8\sqrt{6}}{3}$ or 6.53 or AWRT 6.532.
	Distance from O is 12.5 m	A1	3	A1: Correct distance. Accept 12.5 or AWRT 12.53.
(c)	Resistance force is 800 N Work done by resistance force is $800 \times (x + 6)$	B1		B1: Correct work done by resistance force.
	C of Energy gives $\dfrac{1800\times(x)^2}{2\times 6} + 800\times(x+6) = \dfrac{1}{2}\times 200\times 8^2$	M1A1 A1		M1: Three energy terms, KE, Work Done and EPE. A1: EPE correct. A1: Correct equation.
	$150x^2 + 800(x+6) = 6400$ $3x^2 + 16x - 32 = 0$ or $150x^2 + 800x - 1600 = 0$	A1		A1: Correct quadratic equation with no brackets.
	$x = \dfrac{-16 \pm \sqrt{16^2 + 4\times 3\times 32}}{2\times 3}$	dM1		dM1: Solving their quadratic equation with correct formula and correct substitution
	$x = 1.5497$	A1		A1: Correct positive solution stated. Accept 1.54 or 1.55 or AWRT 1.55.
	Distance from O is 7.55 m	A1	8	A1: Correct distance from O. Accept 7.55 or 7.54 or AWRT 7.55.
	OR Use d for distance: $800 \times d$	(B1)		B1: Correct work done by resistance force.
	C of Energy gives $\dfrac{1800\times(d-6)^2}{2\times 6} + 800\times d = \dfrac{1}{2}\times 200\times 8^2$ $150d^2 - 1000d - 1000 = 0$ $3d^2 - 20d - 20 = 0$	(M1A1) (A1A1) (A1)		M1: Three energy terms, KE, Work Done and EPE. A1: Seeing $d - 6$ in EPE A1: EPE correct. A1: Correct equation. A1: Correct quadratic equation with no brackets.
	$x = \dfrac{-20 \pm \sqrt{20^2 + 4\times 3\times 20}}{2\times 3}$	(dM1)		dM1: Solving their quadratic equation.
	$d = 7.55$	(A1)		A1: Correct distance from O. Accept 7.55 or 7.54 or AWRT 7.55.
	Total		**14**	

(Q9, June 2011)

28 (a)	KE at P = $\frac{1}{2}\times 25\times 60^2$	M1		correct
	= 45 000 J	A1	2	
(b)	change in PE as it falls:			
	mgh = 25 × 9.8 × 34	M1		correct
	= 8330	A1	2	ISW
(c)(i)	using Conservation of Energy:			
	KE at ground = 8330 + 45 000	M1		ft C's (a) and (b)
	= 53 330 J	A1	2	ft if M1 gained in (a) and (b)
	(= 53 300 J to 3sf)			
(ii)	speed of packet is $\sqrt{\frac{53330}{\frac{1}{2}\times 25}}$	M1		ft C's (c)(i)
	= 65.3 m s^{-1}	A1	2	CAO
	Total		**8**	

(Q1, Jan 2012)

29 (a)	using power = force × velocity			
	power = (25 × 42) × 42	M1		
	∴ power is 44 100 watts	A1	2	
(b)	when speed is 15 m s^{-1},			
	max force exerted is $\frac{44100}{15}$			
	= 2940N	B1		
	resistance force is 25 × 15 = 375N			
	accelerating force is 2940 – 375N	M1		
	= 2565			
	using $F = ma$			
	2565 = 1500a	m1		
	a = 1.71 m s^{-2}	A1	4	
	Total		**6**	

(Q4, Jan 2012)

30 (a)	using $\text{EPE} = \frac{\lambda x^2}{2l}$, $\text{EPE} = \frac{32 \times 2.2^2}{2 \times 0.8}$ = 96.8 J	M1 B1 A1	3	B1 for 2.2
(b)	by C of Energy, when next at rest, EPE (initial) = work done against friction + EPE (when at rest) $96.8 = F \times 5 + \frac{32 \times 1.2^2}{2 \times 0.8}$ $5F = 96.8 - 28.8$ frictional force is 13.6N	M1A1 M1A1 B1 A1	6	M1A1 for work done by friction or $5F$ M1 3 terms; A1 all correct B1 28.8
(c)	at B, tension is $\frac{32 \times 1.2}{0.8}$ = 48N tension > friction hence particle starts to move	B1 E1	2	
(d)	when particle is next at rest, work done against friction is EPE at B 13.6 × distance = 28.8 distance is 2.1176 = 2.12 m	M1 A1	2	CAO
(e)	total distance is 5 + 2.1176 = 7.12 m	B1	1	ft from M1 in (d) or total distance × 13.6 = original EPE, 96.8 total distance is 7.12 m
	Total		**14**	

(Q8, Jan 2012)

31 (a)	KE = $\frac{1}{2} \times 76 \times 28^2$	M1		All terms correct
	= 29 792 J	A1	2	
	= 29 800 J			
(b)	Change in PE: mgh = 76 × 9.8 × 31 J	M1		All terms correct
	= 23 088.8 J	A1	2	
	= 23 100 J			
(c)(i)	KE when touches down on ground			
	= 29 792 + 23 088.8J	M1		Their values, one correct
	= 52 881 J			
	= 52 900 J	A1	2	CAO
(ii)	Speed of Alan is $\sqrt{\frac{52881}{\frac{1}{2} \times 76}}$	M1		
	= 37.304 m s^{-1}			
	= 37.3 m s^{-1}	A1	2	CAO
	Total		**8**	

(Q1, June 2012)

32 (a)	Initial EPE = $\frac{\lambda x^2}{2l}$			
	$= \frac{120 \times (0.5)^2}{2 \times 5}$	M1		M1 for formula with extension 0.5
	= 3 J	A1		
	Initial KE is $\frac{1}{2} \times 0.4 \times 9^2$ = 16.2 J			
	When block is at *A*, $\frac{1}{2}mv^2 = 3 + 16.2$	M1		
	$v^2 = 19.2 \div 0.2 = 96$			
	Speed is 9.80 m s^{-1}	A1	4	Accept $4\sqrt{6}$; condone 9.79
(b)(i)	Normal reaction is $mg = 0.4g$	M1		
	Frictional force is $0.4\mu g$ N	A1		
	Work done by frictional force is $5.5 \times (0.4\mu g)$ or $2.2\mu g$	m1		
	C of Energy, when at *A*, gives $19.2 - 5.5 \times (0.4\mu g) = \frac{1}{2} \times 0.4 \times v^2$	M1		Three terms, eg initial energy in (a) (=3 or 19.2); work done; KE at *A*.
		A1		Fully correct
	$19.2 - 2.2\mu g = 0.2v^2$			
	$v = \sqrt{96 - 11\mu g}$	A1	6	Ft $v = \sqrt{\left(v^2 \text{ in (a)}\right) - 11\mu g}$
(ii)	Speed when rebounding is $\frac{1}{2}\sqrt{96 - 11\mu g}$	B1ft		
	Block is stationary at *B*			
	$\frac{1}{2} \times 0.4 \times \frac{1}{4}(96 - 11\mu g) - 2.2\mu g$	M1		Three terms
		A1		Two terms correct with sign
	$= \frac{120 \times (0.5)^2}{2 \times 5}$	A1		Third term correct with sign
	$\frac{1}{2} \times 0.1(96 - 11\mu g) - 2.2\mu g = 3$			
	$4.8 - 2.75\mu g = 3$	A1		Or $4.8 - 0.55\mu g - 2.2\mu g = 3$
	$\mu = 0.0668$	A1	6	
	Total		**16**	

(Q8, June 2012)

33 (a)	KE = $\frac{1}{2} \times 0.16 \times 11^2$ = 9.68 J	M1 A1	 2	
(b)	Change in PE: mgh = 0.16 × 9.8 × 5 = 7.84 J	M1 A1	 2	
(c)(i)	KE when reached point *B* = 9.68 – 7.84 J = 1.84 J	 M1 A1	 2	 **'(a)' – '(b)'** cao
(ii)	Speed of ball is $\sqrt{\frac{1.84}{\frac{1}{2} \times 0.16}}$ = 4.7958 m s^{-1} = 4.80 m s^{-1}	M1 A1	 2	If added in **(c)(i)** 0 marks for **(c)(i)** 14.8 M1A1for **c(ii)** Condone 4.8,4.79
	Total		**8**	

(Q1, Jan 2013)

34	Force acting against gravity is $mg\sin\theta$ Force acting against gravity and resistance is $mg\sin\theta$ + 8000 = 1500 × g × $\sin\theta$ + 8000 = 8588 N or 8590 N Using power = force × velocity = 8588 × 22 = 188 936 W = 189 kW	 M1 A1 M1 dep A1 A1	 5	Condone $\cos\theta$ or -1 for M marks Accept 188.9 or 188
	Total		**5**	

(Q3, Jan 2013)

35 (a)	Work done = $\int_0^e \frac{\lambda x}{l}\,\mathrm{d}x$	M1		SC1 $\int_0^e \frac{\lambda e}{l}\,de$
	$= \left[\frac{\lambda x^2}{2l}\right]_0^e$	A1		SC1 $\int \frac{\lambda x}{l}\,dx$ with no limits
	$= \frac{\lambda e^2}{2l}$	A1	3	
(b)(i)	Using $T = \frac{\lambda x}{l}$:			
	$5g = \frac{392x}{1.6}$	M1		
	$x = \frac{5g \times 1.6}{392}$ $= 0.2$			
	Extension is 0.2 m	A1	2	
(ii)	When extension is 0.6 m, EPE $= \frac{\lambda x^2}{2l}$	B1		B1 for 0.6
	$= \frac{392 \times (0.6)^2}{2 \times 1.6}$	M1		
	$=$ 44.1 J	A1	3	
(iii)	Let y metres be distance particle is above A. C of energy, when particle has speed 0.8 m s^{-1}, gives			
	$5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$	M1A1		M1 4 terms, 2 correct M1A1 4 terms, 3 correct M1A2 4 terms correct
	$= \frac{392 \times (0.6)^2}{2 \times 1.6}$	A1F		Ft answer to **(b)(ii)**
	$49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2$ $49y - 147y + 122.5y^2 + 1.6 = 0$ $122.5y^2 - 98y + 1.6 = 0$			
	$y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm 93.9148}{245}$			
	$=$ 0.016674 and 0.7833	A1		if x used instead of $0.6 - y$, A1 here for $x = 0.5833...$
	Speed first becomes 0.8 when y = 0.0167	E1	5	
	Total		**13**	

(Q8, Jan 2013)

36 (a)	$KE = \frac{1}{2} \times 52 \times 7^2$ = 1274 J = 1270 J	M1 A1	 2	
(b)	Change in PE: $mgh = 52 \times 9.8 \times 8$ = 4076.8 Carol's KE when she reaches the net = 1274 + 4076.8 J = 5350.8 J = 5350 J	M1 A1 A1	 3	
(c)	Speed of Carol is $\sqrt{\frac{5350.8}{\frac{1}{2} \times 52}}$ = 14.3457 m s^{-1} = 14.3 m s^{-1}	M1A1 A1	 3	
	Total		**8**	

(Q2, June 2013)

37	Using power = force × velocity 240 000 = F × 20 F = 12 000 Accelerating force is 12 000 – 5000 = 7000 N Using $F = ma$ 22 000a = 7000 a = 0.318 or $\frac{7}{22}$ m s^{-2}	 M1A1 A1 B1 M1 A1	 6	
	Total		**6**	

(Q7, June 2013)

38 (a)(i)	Using $T = \frac{\lambda x}{l}$ Tension in string is $\frac{60 \times 2.5}{3}$ $= 50$ N Frictional force on A [using $F = \mu R$] is $0.4 \times 8 \times g$ $= 31.36$ N which is less than tension in string Thus particle A moves towards the hole	 B1 B1 B1	 3	
(ii)	Gravitational force on B is $3g = 29.4$ which is less than tension in string Thus particle B moves towards the hole	B1 B1	 2	
(b)	$\text{EPE} = \frac{\lambda x^2}{2l}$ $= \frac{60 \times (2.5)^2}{2 \times 3}$ $= 62.5$ J	 M1 A1	 2	
(c)	Let x be the distance B has moved upwards Work done by friction [on A] is 31.36×0.46 $= 14.4256$ $= 14.43$ J When B is at rest, extension is $2.04 - x$ $\text{EPE} = \frac{\lambda x^2}{2l}$ $= \frac{60 \times (2.04 - x)^2}{2 \times 3}$ $= 10(2.04 - x)^2$ J C of Energy, when particle B is at rest, gives $3 \times g \times x + 10(2.04 - x)^2 + 14.4256$ $= 62.5$ $10x^2 - 11.4x - 6.4584 = 0$ $x = 1.555$ and -0.415 Particle B is first at rest when it has moved upwards 1.56 m	 M1 A1 B1 M1A1 A1 A1	 7	 Or $10x^2 - 11.4x - 6.454 = 0$ Accept 1.55
	Total		**14**	

(Q9, June 2013)