

Markscheme

May 2017

Physics

Higher level

Paper 2

16 pages

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Question			Answers	Notes	Total
1	a	i	$\frac{1}{2}v^2 = 0.24gh$ ✓ $v = 11.9 \text{ «ms}^{-1}\text{»}$ ✓	Award GPE lost $= 65 \times 9.81 \times 30 = \text{«19130 J»}$. Must see the 11.9 value for MP2, not simply 12. Allow $g = 9.8 \text{ ms}^{-2}$.	2
	a	ii	internal energy is the total KE «and PE» of the molecules/particles/atoms in an object ✓ temperature is a measure of the average KE of the molecules/particles/atoms ✓	Award [1 max] if there is no mention of molecules/particles/atoms.	2
	b	i	arrow vertically downwards from dot labelled weight/W/mg/gravitational force/ F_g / $F_{\text{gravitational}}$ AND arrow vertically upwards from dot labelled reaction force/R/normal contact force/ N / F_N ✓ $W > R$ ✓	Do not allow gravity. Do not award MP1 if additional 'centripetal' force arrow is added. Arrows must connect to dot. Ignore any horizontal arrow labelled friction. Judge by eye for MP2. Arrows do not have to be correctly labelled or connect to dot for MP2.	2

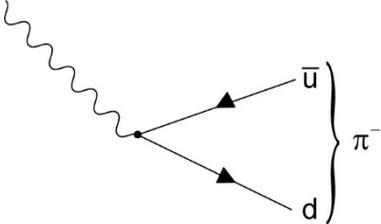
Question			Answers	Notes	Total
1	b	ii	<p>ALTERNATIVE 1</p> <p>recognition that centripetal force is required / $\frac{mv^2}{r}$ seen ✓</p> <p>= 468 «N» ✓</p> <p>W/640 N (weight) is larger than the centripetal force required, so the skier does not lose contact with the ground ✓</p> <p>ALTERNATIVE 2</p> <p>recognition that centripetal acceleration is required / $\frac{v^2}{r}$ seen ✓</p> <p>a = 7.2 «ms⁻²» ✓</p> <p>g is larger than the centripetal acceleration required, so the skier does not lose contact with the ground ✓</p> <p>ALTERNATIVE 3</p> <p>recognition that to lose contact with the ground centripetal force ≥ weight ✓</p> <p>calculation that v ≥ 14 «ms⁻¹» ✓</p> <p>comment that 12 «ms⁻¹» is less than 14 «ms⁻¹» so the skier does not lose contact with the ground ✓</p> <p>ALTERNATIVE 4</p> <p>recognition that centripetal force is required / $\frac{mv^2}{r}$ seen ✓</p> <p>calculation that reaction force = 172 «N» ✓</p> <p>reaction force > 0 so the skier does not lose contact with the ground ✓</p>	<p><i>Do not award a mark for the bald statement that the skier does not lose contact with the ground.</i></p>	3

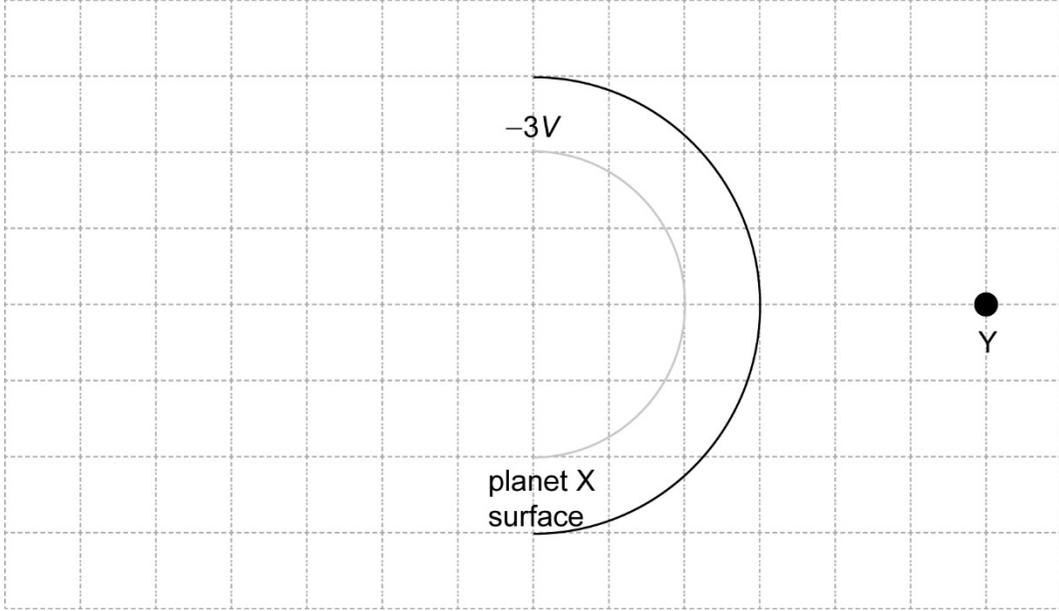
Question		Answers	Notes	Total
1	c	<p>ALTERNATIVE 1</p> <p>$0 = 8.2^2 + 2 \times a \times 24$ therefore $a = \llcorner \rightarrow \llcorner 1.40 \llcorner \text{ms}^{-2} \llcorner \checkmark$</p> <p>friction force = $ma = 65 \times 1.4 = 91 \llcorner \text{N} \llcorner \checkmark$</p> <p>coefficient of friction = $\frac{91}{65 \times 9.81} = 0.14 \checkmark$</p> <p>ALTERNATIVE 2</p> <p>$KE = \frac{1}{2}mv^2 = 0.5 \times 65 \times 8.2^2 = 2185 \llcorner \text{J} \llcorner \checkmark$</p> <p>friction force = $KE/\text{distance} = 2185/24 = 91 \llcorner \text{N} \llcorner \checkmark$</p> <p>coefficient of friction = $\frac{91}{65 \times 9.81} = 0.14 \checkmark$</p>	<p><i>Allow ECF from MP1.</i></p>	3
	d i	<p>$\llcorner 76 \times 9.6 \llcorner = 730 \checkmark$</p> <p>Ns OR $\text{kg ms}^{-1} \checkmark$</p>		2
	d ii	<p>safety net extends stopping time \checkmark</p> <p>$F = \frac{\Delta p}{\Delta t}$ therefore F is smaller $\llcorner \text{with safety net} \llcorner$</p> <p>OR</p> <p>force is proportional to rate of change of momentum therefore F is smaller $\llcorner \text{with safety net} \llcorner \checkmark$</p>	<p><i>Accept reverse argument.</i></p>	2

Question		Answers	Notes	Total
2	a	when 2 waves meet the resultant displacement ✓ is the «vector» sum of their individual displacements ✓	<i>Displacement should be mentioned at least once in MP 1 or 2.</i>	2
	b	$\lambda = \frac{4.7 \times 10^{-3} \times 0.35 \times 10^{-3}}{2.4} \checkmark$ $= 6.9 \times 10^{-7} \text{ «m»} \checkmark$ answer to 2 SF ✓	<i>Allow missed powers of 10 for MP1.</i>	3
	c	green wavelength smaller than red ✓ fringe separation / distance between maxima decreases ✓	<i>Allow ECF from MP1.</i>	2
	d	bright central maximum ✓ subsidiary maxima «on either side» ✓ the width of the central fringe is twice / larger than the width of the subsidiary/secondary fringes/maxima OR intensity of pattern is decreased ✓	<i>Allow marks from a suitably labelled intensity graph for single slit diffraction.</i>	2 max

Question		Answers	Notes	Total	
3	a	solar heating panel converts solar/radiation/photon/light energy into thermal energy AND photovoltaic cell converts solar/radiation/photon/light energy into electrical energy ✓	Accept <i>internal energy</i> of water.	1	
	b	power received = $240 \times 25000 = \text{«}6.0 \text{ MW}\text{»}$ ✓ efficiency $\text{«} = \frac{1.6}{6.0} \text{»} = 0.27 / 27\%$ ✓		2	
	c	i	area = $\pi \times 17^2 \text{ «} = 908 \text{ m}^2 \text{»}$ ✓ power = $\frac{1}{2} \times 908 \times 1.3 \times 7.5^3 \text{ «} = 0.249 \text{ MW}\text{»}$ ✓ number of turbines $\text{«} = \frac{1.6}{0.249} = 6.4 \text{»} = 7$ ✓	Only allow integer value for MP3. Award [2 max] for 25 turbines (ECF from incorrect power) Award [2 max] for 26 turbines (ECF from incorrect radius)	3
		ii	«efficiency is less than 100 % as» not all KE of air can be transferred to KE of blades OR air needs to retain KE to escape ✓ thermal energy is lost due to friction in turbine/dynamo/generator ✓	Allow velocity of air after turbine is not zero.	2

Question			Answers	Notes	Total
4	a	i	$I = \frac{8.5 \times 10^3}{240} = 35 \text{ «A» } \checkmark$		1
	a	ii	$R = \frac{1.7 \times 10^{-8} \times 10}{6.0 \times 10^{-6}} \checkmark$ $= 0.028 \text{ «}\Omega\text{» } \checkmark$	Allow missed powers of 10 for MP1.	2
	a	iii	power = $\text{«}35^2 \times 0.028\text{»} = 34 \text{ «W» } \checkmark$	Allow 35 – 36 W if unrounded figures for R or I are used. Allow ECF from (a)(i) and (a)(ii).	1
	b		«as temperature increases» there is greater vibration of the metal atoms/lattice/lattice ions OR increased collisions of electrons \checkmark drift velocity decreases «so current decreases» \checkmark «as V constant so» R increases \checkmark	Award [0] for suggestions that the speed of electrons increases so resistance decreases.	3
	c		recognition that power = flow rate $\times c\Delta T \checkmark$ flow rate $\text{«} = \frac{\text{power}}{c\Delta T} \text{»} = \frac{8.5 \times 10^3}{4200 \times 35} \checkmark$ $= 0.058 \text{ «kgs}^{-1}\text{» } \checkmark$ $\text{kgs}^{-1} / \text{g s}^{-1} / \text{l s}^{-1} / \text{ml s}^{-1} / \text{m}^3 \text{ s}^{-1} \checkmark$	Allow MP4 if a bald flow rate unit is stated. Do not allow imperial units.	4

Question		Answers	Notes	Total
5	a	<p>Meson: quark-antiquark pair ✓</p> <p>Baryon: 3 quarks ✓</p>		2
	b	<p>i</p> <p>Alternative 1</p> <p>strange quark changes «flavour» to an up quark ✓</p> <p>changes in quarks/strangeness happen only by the weak interaction ✓</p> <p>Alternative 2</p> <p>Strangeness is not conserved in this decay «because the strange quark changes to an up quark» ✓</p> <p>Strangeness is not conserved during the weak interaction ✓</p>	Do not allow a bald answer of weak interaction.	2
		<p>ii</p> <p>arrows drawn in the direction shown ✓</p> 	Both needed for [1] mark.	1
		<p>iii</p> <p>W^- ✓</p>	Do not allow W or W^+ .	1
	c	<p>it lowers the cost to individual nations, as the costs are shared ✓</p> <p>international co-operation leads to international understanding OR historical example of co-operation OR co-operation always allows science to proceed ✓</p> <p>large quantities of data are produced that are more than one institution/research group can handle ✓</p> <p>co-operation allows effective analysis\collaboration of able scientists ✓</p>	Any one.	1 max

Question		Answers	Notes	Total
6	a	the field lines/arrows are further apart at greater distances from the surface ✓		1
	b	circle centred on Planet X ✓ three units from Planet X centre ✓ 		2
	c	loss in gravitational potential = $\frac{6.67 \times 10^{-11} \times 3.1 \times 10^{21}}{1.2 \times 10^6}$ ✓ «= $1.72 \times 10^5 \text{ Jkg}^{-1}$ » equate to $\frac{1}{2}v^2$ ✓ $v = 590 \text{ «ms}^{-1}\text{»}$ ✓	Allow ECF from MP1.	3

Question		Answers	Notes	Total
6	d	available energy to melt one kg 1.72×10^5 «J» ✓ fraction that melts is $\frac{1.72 \times 10^5}{3.3 \times 10^5} = 0.52$ OR 52% ✓	Allow ECF from MP1. Allow 53% from use of 590 ms^{-1} .	2

Question		Answers	Notes	Total
7	a	acceleration/restoring force is proportional to displacement ✓ and in the opposite direction/directed towards equilibrium ✓		2
	b	<p>ALTERNATIVE 1</p> $\frac{T_1^2}{T_2^2} = \frac{m_1}{m_2} \quad \checkmark$ <p>mass = 0.38 / 0.39 «kg» ✓</p> <p>ALTERNATIVE 2</p> <p>«use of $T = 2\pi\sqrt{\frac{m}{k}}$» $k = 28 \text{ «Nm}^{-1}\text{»}$ ✓</p> <p>«use of $T = 2\pi\sqrt{\frac{m}{k}}$» $m = 0.38 / 0.39 \text{ «kg»}$ ✓</p>	Allow ECF from MP1.	2
	c	$\omega = \left\langle \frac{2\pi}{0.74} \right\rangle = 8.5 \text{ «rads}^{-1}\text{»} \quad \checkmark$ <p>total energy = $\frac{1}{2} \times 0.39 \times 8.5^2 \times (4.8 \times 10^{-2})^2 \quad \checkmark$</p> <p>= 0.032 «J» ✓</p>	Allow ECF from (b) and incorrect ω . Allow answer using k from part (b).	3
	d	<p>spring constant/k/stiffness would increase ✓</p> <p>T would be smaller ✓</p> <p>fractional uncertainty in T would be greater, so fractional uncertainty of mass of block would be greater ✓</p>		3

Question			Answers	Notes	Total
	e	i	left ✓		1
		ii	coils to the right of P move right and the coils to the left move left ✓ hence P at centre of rarefaction ✓	<i>Do not allow a bald statement of rarefaction or answers that don't include reference to the movement of coils.</i> <i>Allow ECF from MP1 if the movement of the coils imply a compression.</i>	2

Question		Answers	Notes	Total
8	a	the size of the <u>induced</u> emf ✓ is proportional/equal to the rate of change of flux linkage ✓	The word 'induced' is required here. Allow correctly defined symbols from a correct equation. 'Induced' is required for MP1.	2
	b i	varying voltage/current in primary coil produces a varying magnetic field ✓ this produces a change in flux linkage / change in magnetic field in the secondary coil ✓ a «varying» emf is induced/produced/generated in the secondary coil ✓ voltage is stepped down as there are more turns on the primary than the secondary ✓	Comparison of number of turns is required for MP4.	4
	b ii	output voltage = $\frac{90 \times 240}{1800}$ ✓ = 12 «V» ✓		2
	c	laminated core reduces eddy currents ✓ less thermal energy is transferred to the surroundings ✓		2
	d	for a certain power to be transmitted, large V means low I ✓ less thermal energy loss as $P = I^2R$ / joule heating ✓		2

Question		Answers	Notes	Total	
9	a	<p><i>Observation 1:</i> particle – photon energy is below the work function OR $E = hf$ and energy is too small «to emit electrons» ✓ wave – the energy of an <i>em</i> wave is independent of frequency ✓</p> <p><i>Observation 2:</i> particle – a single electron absorbs the energy of a single photon «in an almost instantaneous interaction» ✓ wave – it would take time for the energy to build up to eject the electron ✓</p>		4	
	b	i	<p>attempt to calculate gradient of graph = $\frac{4.2 \times 10^{-19}}{6.2 \times 10^{14}}$ ✓ = $6.8 - 6.9 \times 10^{-34}$ «Js» ✓</p>	Do not allow a bald answer of 6.63×10^{-34} Js or 6.6×10^{-34} Js.	2
		ii	<p>ALTERNATIVE 1 minimum energy required to remove an electron «from the metal surface» ✓</p> <p>ALTERNATIVE 2 energy required to remove the least tightly bound electron «from the metal surface» ✓</p>		1
		iii	<p>ALTERNATIVE 1 reading of y intercept from graph in range $3.8 - 4.2 \times 10^{-19}$ «J» ✓ conversion to eV = $2.4 - 2.6$ «eV» ✓</p> <p>ALTERNATIVE 2 reading of x intercept from graph «$5.8 - 6.0 \times 10^{14}$ Hz» and using hf_0 to get $3.8 - 4.2 \times 10^{-19}$ «J» ✓ conversion to eV = $2.4 - 2.6$ «eV» ✓</p>		2

Question		Answers	Notes	Total
9	c	line parallel to existing line ✓ to the right of the existing line ✓		2
