Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2017

Physics

Higher level

Paper 2

16 pages

Question			Answers	Notes	Total
1	a	i	$\frac{1}{2}v^2 = 0.24gh$ ✓ $v = 11.9$ «$m\,s^{-1}$» ✓	*Award GPE lost* $= 65 \times 9.81 \times 30 =$ ***«19130 J»***. *Must see the 11.9 value for MP2, not simply 12.* *Allow g = 9.8 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/$F_{gravitational}$ ***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**

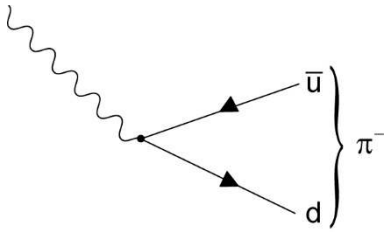
Question			Answers	Notes	Total
1	b	ii	***ALTERNATIVE 1*** recognition that centripetal force is required / $\frac{mv^2}{r}$ seen ✓ = 468 «N» ✓ W/640 N (weight) is larger than the centripetal force required, so the skier does not lose contact with the ground ✓ ***ALTERNATIVE 2*** recognition that centripetal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

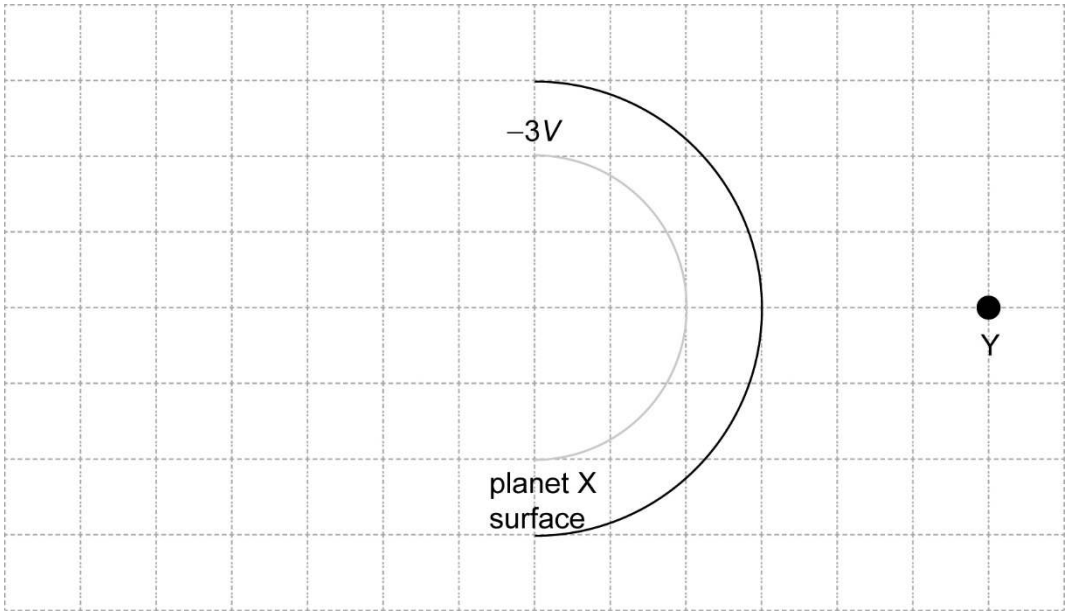
Question			Answers	Notes	Total
1	c		***ALTERNATIVE 1*** $0 = 8.2^2 + 2 \times a \times 24$ therefore $a =$ «–»1.40 «m s^{-2}» ✓ friction force $= ma = 65 \times 1.4 = 91$ «N» ✓ coefficient of friction $= \frac{91}{65 \times 9.81} = 0.14$ ✓ ***ALTERNATIVE 2*** $KE = \frac{1}{2}mv^2$ = 0.5 x 65 x 8.2^2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

Question			Answers	Notes	Total
2	a		when 2 waves meet the resultant displacement ✓ is the «vector» sum of their individual displacements ✓	*Displacement should be mentioned at least once in MP 1 or 2.*	**2**
	b		$\lambda = \frac{4.7\times10^{-3}\times0.35\times10^{-3}}{2.4}$ ✓ $= 6.9\times10^{-7}$ «m» ✓ answer to 2 SF ✓	*Allow missed powers of 10 for MP1.*	**3**
	c		green wavelength smaller than red ✓ fringe separation / distance between maxima decreases ✓	*Allow ECF from MP1.*	**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 ✓	*Allow marks from a suitably labelled intensity graph for single slit diffraction.*	**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 internal **energy** of water.*	**1**
	b		power received $= 240 \times 25000 =$ «6.0 MW» ✓ efficiency $\left(= \frac{1.6}{6.0}\right) = 0.27 / 27\%$ ✓		**2**
	c	i	area $= \pi \times 17^2 = 908\,\text{m}^2$ ✓ power $= \frac{1}{2} \times 908 \times 1.3 \times 7.5^3 = 0.249\,\text{MW}$ ✓ number of turbines $\left(= \frac{1.6}{0.249} = 6.4\right) = 7$ ✓	*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 «$= \frac{8.5\times10^{3}}{240}$» $= 35$«A» ✓		1
	a	ii	$R = \frac{1.7\times10^{-8}\times10}{6.0\times10^{-6}}$ ✓ $= 0.028$ «Ω» ✓	*Allow missed powers of 10 for MP1.*	2
	a	iii	power $=$ «$35^{2}\times0.028$» $= 34$ «W» ✓	*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 ✓ drift velocity decreases «so current decreases» ✓ «as V constant so» R increases ✓	*Award **[0]** for suggestions that the speed of electrons increases so resistance decreases.*	3
	c		recognition that power = flow rate × $c\Delta T$ ✓ flow rate «$= \frac{\text{power}}{c\Delta T}$» $= \frac{8.5\times10^{3}}{4200\times35}$ ✓ $= 0.058$ «kg s^{-1}» ✓ kg s^{-1} / g s^{-1} / l s^{-1} / ml s^{-1} / m^{3} s^{-1} ✓	*Allow MP4 if a bald flow rate unit is stated. Do not allow imperial units.*	4

Question			Answers	Notes	Total
5	a		*Meson:* quark-antiquark pair ✓ *Baryon:* 3 quarks ✓		**2**
	b	i	***Alternative 1*** strange quark changes «flavour» to an up quark ✓ changes in quarks/strangeness happen only by the weak interaction ✓ ***Alternative 2*** Strangeness is not conserved in this decay «because the strange quark changes to an up quark» ✓ Strangeness is not conserved during the weak interaction ✓	*Do not allow a bald answer of weak interaction.*	**2**
		ii	arrows drawn in the direction shown ✓ 	*Both needed for **[1]** mark.*	**1**
		iii	W^- ✓	*Do not allow W or W^+.*	**1**
	c		it lowers the cost to individual nations, as the costs are shared ✓ international co-operation leads to international understanding ***OR*** historical example of co-operation ***OR*** co-operation always allows science to proceed ✓ large quantities of data are produced that are more than one institution/research group can handle ✓ co-operation allows effective analysis\collaboration of able scientists ✓	*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 $= \frac{6.67\times10^{-11}\times3.1\times10^{21}}{1.2\times10^{6}}$ ✓ «$= 1.72\times10^{5}\ \text{Jkg}^{-1}$» equate to $\frac{1}{2}v^2$ ✓ $v = 590$ «ms^{-1}» ✓	*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 $\frac{1.72\times10^{5}}{3.3\times10^{5}}=0.52$ ***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		***ALTERNATIVE 1*** $\frac{T_1^2}{T_2^2} = \frac{m_1}{m_2}$ ✓ mass = 0.38 / 0.39 «kg» ✓ ***ALTERNATIVE 2*** «use of $T = 2\pi\sqrt{\frac{m}{k}}$» $k = 28$ «Nm^{-1}» ✓ «use of $T = 2\pi\sqrt{\frac{m}{k}}$» $m = 0.38 / 0.39$ «kg» ✓	*Allow ECF from MP1.*	2
	c		$\omega = «\frac{2\pi}{0.74}» = 8.5$ «rads^{-1}» ✓ total energy $= \frac{1}{2} \times 0.39 \times 8.5^2 \times \left(4.8 \times 10^{-2}\right)^2$ ✓ = 0.032 «J» ✓	*Allow ECF from (b) and incorrect ω .* *Allow answer using k from part (b).*	3
	d		spring constant/k/stiffness would increase ✓ *T* would be smaller ✓ fractional uncertainty in *T* would be greater, so fractional uncertainty of mass of block would be greater ✓		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 ✓	*Do not allow a bald statement of rarefaction or answers that don't include reference to the movement of coils.* *Allow ECF from MP1 if the movement of the coils imply a compression.*	**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		*Observation 1:* particle – photon energy is below the work function ***OR*** $E = hf$ and energy is too small «to emit electrons» ✓ wave – the energy of an *em* wave is independent of frequency ✓ *Observation 2:* 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 ✓		**4**
	b	**i**	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» ✓	*Do not allow a bald answer of 6.63 x 10^{-34} Js or 6.6 x 10^{-34} Js.*	**2**
		ii	***ALTERNATIVE 1*** minimum energy required to remove an electron «from the metal surface» ✓ ***ALTERNATIVE 2*** energy required to remove the least tightly bound electron «from the metal surface» ✓		**1**
		iii	***ALTERNATIVE 1*** reading of *y* intercept from graph in range $3.8 - 4.2 \times 10^{-19}$ «J» ✓ conversion to $eV = 2.4 - 2.6$ «e V» ✓ ***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 $eV = 2.4 - 2.6$ «e V» ✓		**2**

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