Advanced Higher Physics Christmas Homework Solutions

Question			Expected response	Max mark	Additional guidance
1	a		$a=\frac{dv}{dt}=1\cdot 2t$ $\int \frac{dv}{dt}\cdot dt=\int 1\cdot 2t.dt$ (1) $v=0\cdot 6t^2+c$ (1) At t = 0, v = 1·4, c = 1·4 (1) $v=0\cdot 6t^2+1\cdot 4$	3	Alternative for step 1 $a=1\cdot 2t$ $\int a.dt=\int 1\cdot 2t.dt$ Alternative for step 2 $\int_{1\cdot 4}^{v} dv=\int_{0}^{t} 1\cdot 2t.dt$ $v-1\cdot 4=0\cdot 6t^2$ Final line must be shown, otherwise, maximum of 2 marks
1	b		$3\cdot 8=0\cdot 6t^2+1\cdot 4$ $t=\sqrt{\frac{2\cdot 4}{0\cdot 6}}$ (1) $t=2\cdot 0$ (s) (1) $\frac{ds}{dt}=0\cdot 6t^2+1\cdot 4$ $\frac{ds}{dt}.dt=\ 0\cdot 6t^2+1\cdot 4.dt$ $s=0\cdot 2t^3+1\cdot 4t+c$ (1) $t=0, s=0, c=0$ $s=0\cdot 2(2\cdot 0)^3+2\cdot 8$ $s=4\cdot 4$ m (1)	4	$s=\int_0^2 0\cdot 6t^2+1\cdot 4.dt$ $s=0\cdot 2(2\cdot 0)^3+2\cdot 8$ $v=0\cdot 6t^2+1\cdot 4$ $\int v.dt=\int 0\cdot 6t^2+1\cdot 4.dt$ Alternative $s=\int_0^2 0\cdot 6t^2+1\cdot 4.dt$ $s=0\cdot 2(2\cdot 0)^3+2\cdot 8$
2	a		central force $=m\omega^2 r$ (1) $=0\cdot 2\times 6\cdot 0^2\times 0\cdot 35$ (1) $=\ 2\cdot 5$ N (1)	3	Accept: 3, 2·52, 2·520
2	b		$\tan\theta=\frac{F_c}{F_w}$ (1) $\tan\theta=\frac{2\cdot 5}{mg}=\frac{2\cdot 5}{0\cdot 35\times 9\cdot 8}$ (1) $\theta=36°$ (1)	3	Accept: 40, 36·1,36·09
2	c		θ would decrease (1) Central force decreases, weight stays the same. (1)	2	

3	a		$I = \frac{1}{2}mr^2$ (1) $I = 0 \cdot 5 \times 0 \cdot 115 \times 0 \cdot 015^2$ (1) $I = 1 \cdot 3 \times 10^{-5}\,\text{kg}\,\text{m}^2$ (1)	3	
3	b		$\omega = \frac{v}{r}$ (1) $\omega = \frac{1 \cdot 60}{0 \cdot 015}$ (1) $\omega = 1 \cdot 1 \times 10^2\ (\text{rad}\,\text{s}^{-1})$ - $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ (1) $0 \cdot 28 = 0 \cdot 1472 + \frac{1}{2}I(1 \cdot 1 \times 10^2)^2$ (1) $I = \frac{2 \times 0 \cdot 1328}{(1 \cdot 1 \times 10^2)^2}$ $I = 2 \cdot 2 \times 10^{5}\ \text{kg}\,\text{m}^2$ (1)	5	
3	c		Energy is lost. Or Calculation assumes no energy is lost. (1)	1	

5	a		The (minimum) velocity/speed that a mass must have to escape the gravitational field (of a planet). (1)	1	Do not accept *escape gravitational force*. Accept: *escape gravitational well*, *velocity required to reach infinity*, *velocity required to give a total energy of* 0 J
5	b		$E_k + E_p = 0$ (1) $\frac{1}{2}mv^2 - \frac{GMm}{r} = 0$ (1) $v^2 = \frac{2GM}{r}$ $v = \sqrt{\frac{2GM}{r}}$ (1)	3	$E_k = E_p$ award 0 marks Start with $\frac{1}{2}mv^2 = \frac{GMm}{r}$ award 0 marks
5	c		$v = \sqrt{\frac{2GM}{r}}$ (1) $v = \sqrt{\frac{2 \times 6{\cdot}67 \times 10^{-11} \times 6{\cdot}0 \times 10^{24}}{1{\cdot}09 \times 10^{7}}}$ (1) $v = 8{\cdot}6 \times 10^{3}\ \text{m s}^{-1}$ (1)	3	Accept: 9, 8·57, 8·569
6	a		Line B. (1) Object B is accelerating or in a non-inertial frame of reference. (1)	2	Curved lines on spacetime graphs correspond to non-inertial frames of reference (accelerating) which is governed by the General Theory of Relativity
6	b		Time on clock P will appear to move faster. Or Time on clock Q will appear to move slower. (1) Time passes more slowly at the rear of an accelerating object. Or Time between pulses from clock Q would take longer to arrive at the astronaut. (1)	2	
6	c		The effects of gravity are exactly equivalent to the effects of acceleration. (1)	2	

			The plane accelerating downwards exactly "cancels out" the effects of being in a gravitational field. Or Plane and passengers are falling at the same rate due to the gravitational field (are in "free fall"). (1)		
7	a	i	The distance from the centre of a black hole at which not even light can escape. Or The distance from the centre of a black hole to the event horizon. (1)	1	
7	a	ii	$R_{Schwarzschild} = \frac{2GM}{c^2}$ (1) $R_S = \frac{2 \times 6{\cdot}67 \times 10^{-11} \times (14{\cdot}8 \times 2 \times 10^{30})}{(3 \times 10^8)^2}$ (1) (1) $R_S = 4{\cdot}4 \times 10^4$ m (1)	4	Independent (1) mark for $(14{\cdot}8 \times 2 \times 10^{30})$ Accept: 4, 4·39, 4·387
7	b		Chi Cygni is red compared to Zeta Cygni B which is blue-white. Or Chi Cygni is larger than Zeta Cygni B. Or Chi Cygni has a lower temperature than Zeta Cygni B. Any two statements for 1 mark each.	2	
8	a	i	Electrons behave like waves. (1)	1	
8	a	ii	Photoelectric effect. Or Compton scattering. Or Indication of collision and transfer of energy. (1)	1	

8	b		$\lambda = \frac{h}{p}$ or $\lambda = \frac{h}{mv}$ **(1)** $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{4 \cdot 4 \times 10^{6} \times 9 \cdot 11 \times 10^{-31}}$ **(1)** $\lambda = 1 \cdot 7 \times 10^{-10}$ m **(1)**	3	Accept: 2, 1·65,1·654
8	c		$\lambda = \frac{h}{p}$ $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{300 \times 0 \cdot 02}$ **(1)** $\lambda = 1 \cdot 1 \times 10^{-34}$ m **(1)** This value is so small (that no diffraction would be seen). Or The de Broglie wavelength of the bullet is much smaller than the gap. **(1)**	3	
9	a		$\frac{1}{2}mv^2 = E$ **(1)** $v = \sqrt{\frac{2E}{m}}$ $v = \sqrt{\frac{2 \times 3 \cdot 6 \times 10^{6} \times 1 \cdot 6 \times 10^{-19}}{1 \cdot 673 \times 10^{-27}}}$ **(1)** **(1)** $v = 2 \cdot 6 \times 10^{7}$ ms^{-1} **(1)**	4	Independent **(1)** mark for ($3 \cdot 6 \times 10^{6}$ x $1 \cdot 6 \times 10^{-19}$) Accept: 3, 2·62, 2·624
9	b	i	The perpendicular component of velocity results in circular motion. Or The perpendicular component of velocity results in a central or centripetal force. **(1)** The parallel component of velocity is constant. Or The parallel component of velocity is not subject to a horizontal force or equivalent. **(1)**	2	

9	b	ii	$v = 2\cdot6\times10^{-27}\times\sin 50 = 2\cdot0\times10^{7}$ (1) $\frac{mv^2}{r} = qvB$ (1) $\frac{1\cdot673\times10^{-27}\times(2\cdot0\times10^{7})^2}{r}$ $= 1\cdot60\times10^{-19}\times2\cdot0\times10^{7}\times58\times10^{-6}$ (1) $r = 3\cdot6\times10^{3}$ m (1)	4	Accept: 4, 3·61, 3·606
9	b	iii	The anti proton will turn in the opposite direction. Or The anti proton helix pitch will be greater. Or The radius of curvature of the anti proton will be smaller. Any two statements for 1 mark each.	2	
10	a		Acceleration or unbalanced force is directly proportional, and in the opposite direction to displacement. (1)	1	$a = -ky$, $F = -ky$ acceptable
10	b	i	$\omega = \frac{2\pi}{T}$ (1) $\omega = \frac{2\pi}{3}$ (1) $\omega = 2\cdot1$ (rad s^{-1}) (1) $a = (-)\omega^2 y$ (1) $1\cdot28 = (-)2\cdot1^2\times y$ (1) $y = 0\cdot29$ m	5	Accept: 0·3, 0·290, 0·2902
10	b	ii	$v = (\pm)\omega\sqrt{A^2 - y^2}$ (1) $v = (\pm)2\cdot1\sqrt{0\cdot29^2 - 0\cdot10^2}$ (1) $v = (\pm)0\cdot57\ m s^{-1}$ (1)	3	Accept: 0·6, 0·572, 0·5716
11	a		$\varphi = \frac{2\pi x}{\lambda}$ (1) $3\cdot5 = \frac{2\pi\times0\cdot28}{\lambda}$ (1) $\lambda = 0\cdot50$ m (1)	3	Accept: 0·5, 0·503, 0·5027

11	b	i	$\lambda = 0\cdot25$ $v = f\lambda$ $v = 5\cdot0 \times 0\cdot25$ $v = 1\cdot3\ \text{ms}^{-1}$ (1)	1	Accept: 1, 1·25, 1·250
11	b	ii	$\frac{I_1}{A_1^2} = \frac{I_2}{A_2^2}$ or I is proportional to A^2 (1) $\frac{I_1}{0\cdot03^2} = \frac{5I_1}{A_2^2}$ (1) $A_2 = 0\cdot07\ \text{m}$ (1)	3	Accept: 0·1, 0·067, 0·0671
12	a		Division of wavefront. (1)	1	
12	b	i	$\Delta x = \frac{\lambda D}{d}$ (1) $\Delta x = \frac{510\times10^{-9}\times2\cdot5}{3\cdot0\times10^{-4}}$ (1) $\Delta x = 4\cdot3\times10^{-3}\ \text{m}$ (1)	3	Accept: 4, 4·25, 4·250
12	b	ii	%Uncertainty in $\lambda = \frac{2\times100}{510} = 0\cdot40\%$ (1) %Uncertainty in D$= \frac{0\cdot05\times100}{2\cdot5} = 2\%$ (1) %Uncertainty in d$= \frac{0\cdot00001\times100}{0\cdot0003} = 3\cdot33\%$ (1) %Uncertainty in $\Delta x = \sqrt{2^2 + 3\cdot3^2} = 3\cdot9\%$ (1) Absolute uncertainty in $\Delta x = 3\cdot9\% \times 4\cdot3\times10^{-3}$ Absolute uncertainty in $\Delta x = 1\cdot7\times10^{-4}\ \text{m}$ (1)	5	Accept: 2, 1·68, 1·677
13	a	i	The tablet emits plane polarised light. (1)	1	
13	a	ii	The brightness would gradually reduce from a maximum at 0º to no intensity at 90º. (1) It would then gradually increase in intensity from 90º to 180º where it would again be a maximum. (1)	2	
13	b		$\tan\theta_1 = n$ (1) $\theta_1 =$ Brewster's angle $\tan\theta_1 = 1\cdot33$ (1) $\theta_1 = 53\cdot1^\circ$ (1) $\theta = 90 - 53\cdot1 = 36\cdot9^\circ$ (1)	4	Accept: 37, 36·94, 36·939