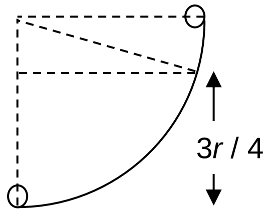
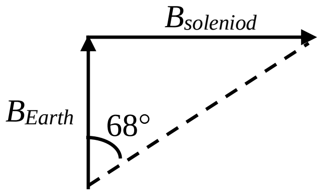
Qn	Ans	Discussion
1	B	mass of car $\approx 2000\,\text{kg}$ speed $\approx 100\,\text{km h}^{-1} \approx 28\,\text{m s}^{-1}$ $\text{KE} = \frac{1}{2}mv^2 = 0.784\,\text{MJ}$ 80 gsm (grams per square metre) of A4 paper A4 area 210 mm x 297 mm = 0.062 m^2 Mass of A4 paper = 5.0 g
2	C	$\dfrac{\text{KE}_{\text{top}}}{\text{KE}_{\text{initial}}} = \dfrac{\frac{1}{2}m\left(u\cos\theta\right)^2}{\frac{1}{2}mu^2} = cos^2\,\theta$
3	A	At steady speed of 1.4 m s^{-1}, air resistance = weight component along slope 1.4 k = (80.0)(9.81)sin5° k = 48.857 At steady speed of 5.5 m s^{-1}, air resistance = (5.5)(48.857) = 268.71 N Additional force required = 268.71 – (80.0)(9.81)sin5°= 200 N (2 s.f.)
4	B	$x_1 = 10.0 - 7.5 = 2.5\,\text{cm}$ At constant speed: $mg = kx_1$ $mg = kx_1 - (1)$ When slowing down: $mg - kx_2 = ma - (2)$ Sub(1) into (2) $kx_1 - kx_2 = ma - (3)$ $\dfrac{(3)}{(1)} \rightarrow \dfrac{a}{g} = \dfrac{x_1 - x_2}{x_1}$ $x_2 = 1.99 \approx 2.0\,\text{cm}$ new length $= 10.0 - 2.0 = 8.0\,\text{cm}$
5	B	Applying cosine rule, $\left(\Delta v\right)^2 = \left(20\right)^2 + \left(15\right)^2 - 2\left(20\right)\left(15\right)\cos 45°$ $\Delta v = 14.2\,\text{m s}^{-1}$ $\Delta p = m\Delta v$ $= 0.140(14.2)$ $= 2.0\,\text{N s}\,(2\,\text{s.f.})$
6	C	Considering X, Y and Z as a system, F = 6 ma Considering X as a system, F – F_{YX} = ma F_{YX} = 5 ma = 5/6 F

7	**A**	Taking moments about the contact of the beam with the wall, Sum of clockwise moments = sum of anti-clockwise moments $(T\cos30°)(L\sin60°) = (T\sin30°)(L\cos60°) + (1/2W)(L\sin60°)$ $T = 85$ N (2 s.f.)
8	**B**	$E_p = E_T$ $mgr = ½\, m\, (4^2)$ $gr = 8$ If the mass possesses 75% of E, it means E has decreased by 25%. Let x be the point where GPE has decreased by $E/4$, $E_p = E_x$ $mgr = mg(3r/4) + ½\, m\, v^2$ $v^2 = ½\, gr$ $v = 2.0$ m s^{-1} 
9	**C**	As $v = r\,\omega$, Since ω is constant and r is decreasing at a steady rate with time, $v \propto r \propto t$ Graph is a straight line, negative gradient but with a non-zero speed (as $r \neq 0$)
10	**D**	All geostationary satellites must have the same radius, and angular velocity $\omega = \frac{2\pi}{T}$. Hence, they will have the same linear speed.
		Why C is incorrect $m r \omega^2 = \frac{GMm}{r^2}$ where r - radius of orbit $T^2 = \frac{4\pi^2}{GM} r^3$ $(24\times60\times60)^2 = \frac{4\pi^2}{(6.67\times10^{-11})(6.0\times10^{24})} r^3$ $r = 4.231\times10^7$ m height from surface, $h = 4.231\times10^7 - R$
11	**A**	$M d \omega^2 = \frac{GM(3M)}{(d+D)^2}$ ……(1) $3M D \omega^2 = \frac{GM(3M)}{(d+D)^2}$ ……(2) Compare (1) & (2), $d = 3D$ ……(3) From (2) $\omega^2 = \frac{GM(3M)}{(3D+D)^2}\left(\frac{1}{3MD}\right)$ $\omega^2 = \frac{GM}{16D^3}$ ……(4)

		KE of 2 stars $= \frac{1}{2}M\left(d\,\omega\right)^2 + \frac{1}{2}3M\left(D\,\omega\right)^2$ $= \frac{1}{2}M\left(3D\right)^2\omega^2 + \frac{1}{2}3M\left(D\,\omega\right)^2$ $= \frac{9}{2}M\,D^2\omega^2 + \frac{3}{2}M\,D^2\omega^2$ $= 6\,M\,D^2\omega^2$ $= 6\,M\,D^2\left(\frac{GM}{16D^3}\right)$ $= \frac{3GM^2}{8D}$
		Wrong answers: (B) Total $KE = \frac{GM(3M)}{2(3D)} = \frac{G\,M^2}{2\,D}$ (C) Total $KE = \frac{GM(3M)}{2D} = \frac{3G\,M^2}{2\,D}$ (D) Total $KE = \frac{GM(3M)}{2(3D)} + \frac{GM(3M)}{2D} = \frac{2GM^2}{D}$
12	**D**	Same temperature implies thermal equilibrium. Hence all 3 objects are in thermal equilibrium and have the same temperature. However the heat capacity of each material is different, so the amount of internal energy is different. Objects in thermal equilibrium can exchange thermal energy, but there will be no net exchange of thermal energy.
13	**B**	As n and T are constant, $pV = nRT$ $p_1V_1 = p_2V_2$ $30V_1 = 10V_2$ $V_2 = 3V_1$
14	**C**	$\sqrt{\frac{250^2+300^2+400^2+100^2+500^2}{5}} = 340$ m s^{-1} (2 s.f.)
15	**C**	$ma = mg - N$ $ma = mg \quad if\ N = 0$ $m\omega^2 x_0 = mg$ $x_0 = \frac{g}{\omega^2} = \frac{9.81}{\left(2\pi f\right)^2} = \frac{9.81}{4\pi^2\left(2.0\right)^2} = 6.2$ cm (2 s.f.)
16	**A**	Graph shows U vs r of object undergoing simple harmonic motion. Hence $F = -kr$. Alternatively, $F = -\frac{dU}{dr}$, magnitude and direction of F can be obtained from negative gradient of the graph.

17	**D**	$A = A_0 \sin\theta$ where A_0 – amplitude of wave at transmitter $A^2 = A_0^2 \sin^2\theta$ $P_R \propto I_R \propto A^2 = A_0^2 \sin^2\theta$ $P_T \propto I_T \propto A_0^2 = \dfrac{A^2}{\sin^2\theta}$
18	**B**	$\dfrac{\lambda}{2} = 0.49 - 0.15$ $\lambda = 0.68\ m$ $v = f\lambda$ $330 = f(0.68)$ $f = 490\ \text{Hz}\ (2\ \text{s.f.})$
19	**D**	The glass block has higher refractive index. Hence, the speed of wave and the wavelength is smaller. The number of wavelengths within the thickness of the glass block is more than the same thickness in air. Hence, central maximum position where the 2 waves have no path difference is above the original position.
20	**B**	Let y be the distance from Q, and x be the distance from $4Q$ $\dfrac{Q}{4\pi\varepsilon_0 y^2} = \dfrac{4Q}{4\pi\varepsilon_0 (x+y)^2}$ $\left(\dfrac{x+y}{y}\right)^2 = 4$ $x + y = 2y$ $y = x$
21	**A**	The particle can be either positively or negatively charged. The particle will be deflected at the point of entry. Electric field lines (and the equipotential lines) are closer together, hence has a stronger electric field strength.
22	**C**	$d = \dfrac{m}{AL} \rightarrow A = \dfrac{m}{dL}$ $R = \dfrac{\rho L}{A} = \dfrac{\rho L}{\frac{m}{dL}} = \dfrac{\rho L^2 d}{m} \rightarrow m = \dfrac{\rho L^2 d}{R}$ Since L and R are the same, $\dfrac{m_a}{m_c} = \dfrac{\rho_a}{\rho_c} \times \dfrac{d_a}{d_c} = \dfrac{2}{1} \times \dfrac{1}{3} = 0.67$ (2 s.f.)

23	**A**	Option A is correct since resistance of A is 15 Ω while resistance of B is 10 Ω. Option B is incorrect since power of A = 0.40 W while power of B = 0.60 W. So power dissipated in B is only 1.5 times of that in A. Option C is incorrect since total current = 0.30 + 0.20 = 0.50 A Option D is incorrect since at 0.20 A, A will have 2.0 V across it while B will have 3.0 V across it.
24	**C**	Assuming $B_{solenoid}$ is to the right,  $\tan\theta = \frac{B_{solenoid}}{B_{Earth}}$ $B_{solenoid} = B_{Earth}\tan\theta$ $= 2.0\times10^{-5}\tan 68° \quad = 4.95\times10^{-5}$ $B_{solenoid} = \mu n I$ $4.95\times10^{-5} = (4\pi\times10^{-7})(\frac{20}{15\times10^{-2}})I$ $I = 0.30$ A (2 s.f.)
25	**B**	Sliding the rod right or left will induce an e.m.f. across the rod. Since the rod is in the centre of the metal frame, it will produce currents in opposite directions in the left and right sections of the frame. When the magnitude of the magnetic flux density increases, the frame experiences an increase in magnetic flux linkage out of the plane of the paper. By Lenz’s law, an induced current will flow in the frame to create a magnetic field into the plane of the paper to oppose this change. Hence, this leads to a clockwise current flowing through the frame.
26	**C**	$T = \frac{1}{f} = \frac{1}{50} = 0.02\text{ s} = 2\text{ div}$ $\text{time-base} = \frac{0.02}{2} = 10\text{ ms div}^{-1}$ $V = 2.8\text{ V} = 1.4\text{ div}$ $\text{Y-gain} = \frac{2.8}{1.4} = 2.0\text{ V div}^{-1}$
27	**A**	The cut-off wavelength corresponds to the most energetic photon released.
28	**D**	The uncertainty principle is independent of the experiment equipment. These uncertainties would remain because they originate in the wave like nature of matter.
29	**C**	$\Delta m = [(235.04393 + 1.00866) - (140.91440 + 91.92617 + 3\times1.00866)]u$ $\Delta m = 3.088\times10^{-28}\,kg$ $E = (\Delta m)c^2$ $= 2.78\times10^{-11}$ J (3 s.f.)

30	**B**	$\ln C = mt + c$ $\text{grad} = \dfrac{0 - 5.20}{26.0 - 0} = -0.2 = \lambda$ $t_{1/2} = \dfrac{\ln 2}{\lambda}$ $= \dfrac{\ln 2}{0.2}$ $= 3.5\text{ s (2 s.f.)}$