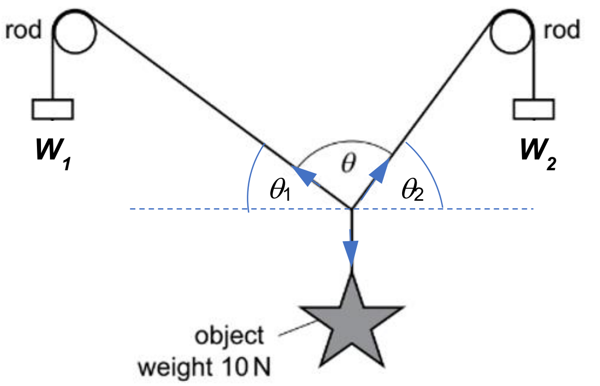
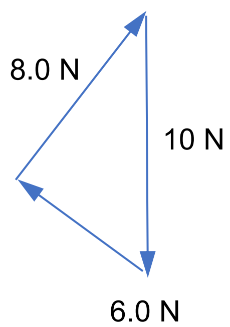
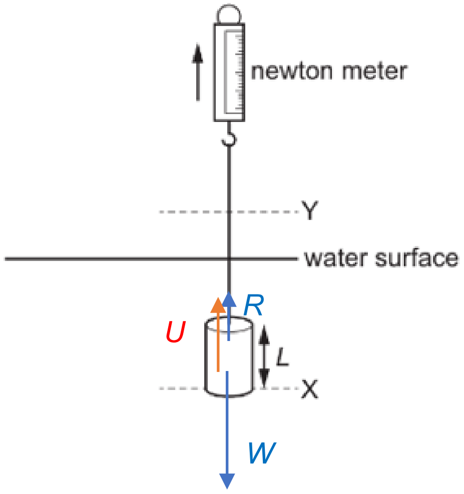
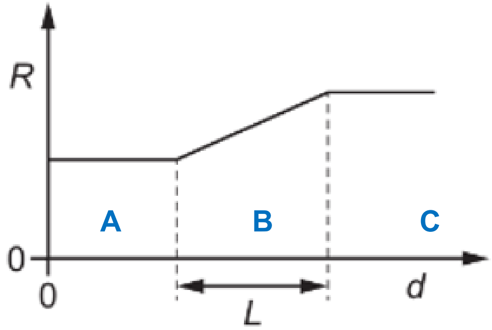
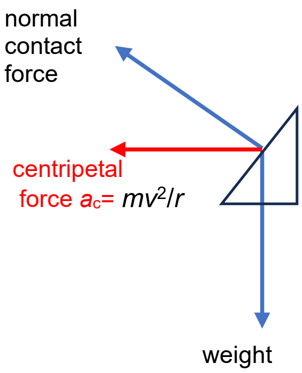
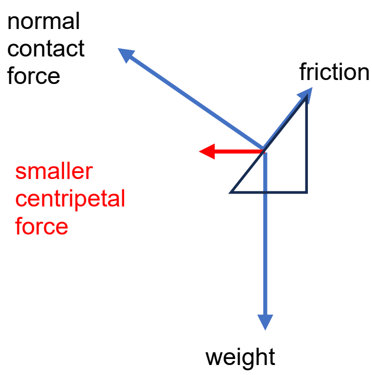
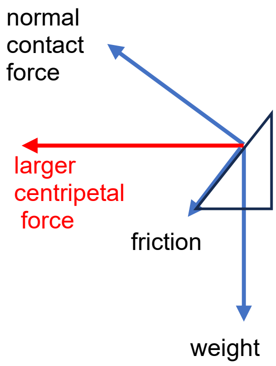
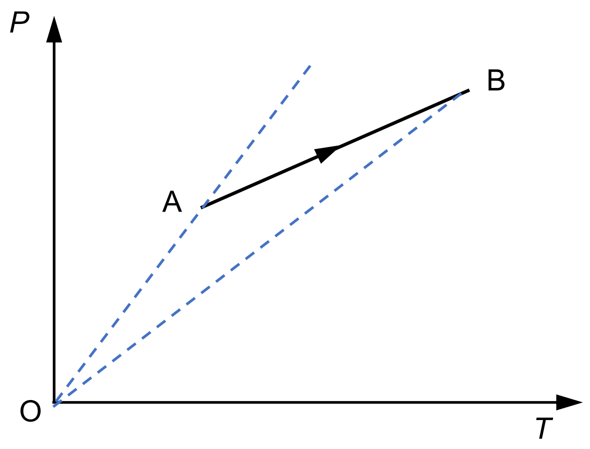
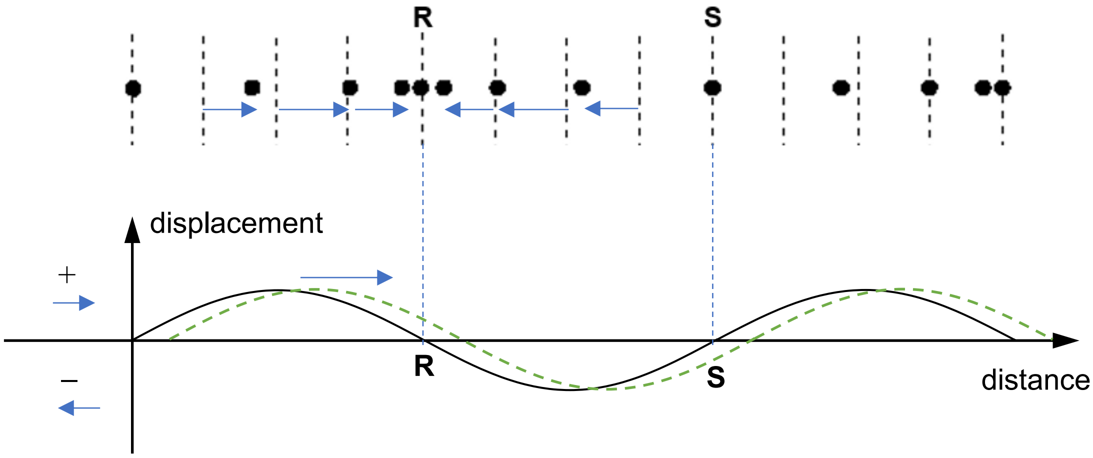
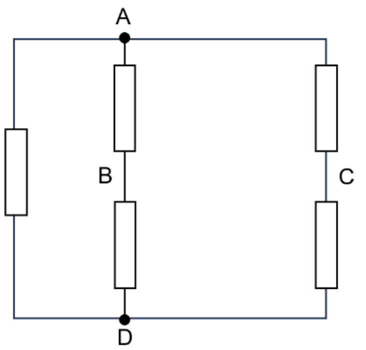
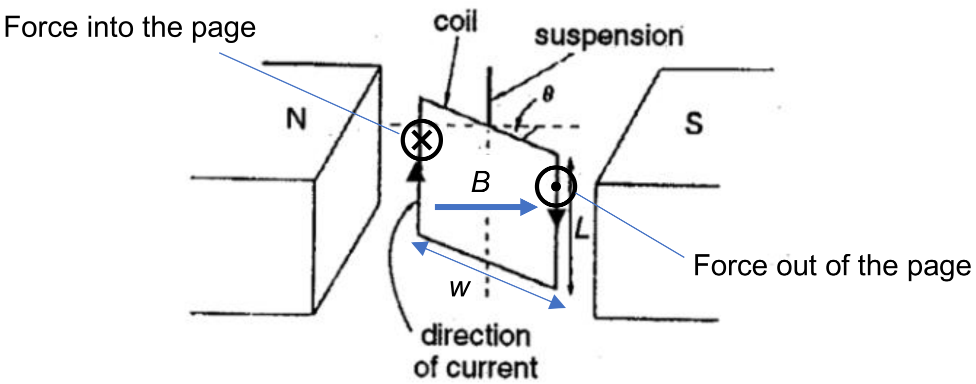
2023 H2 Physics Prelim Paper 1 Suggested Solutions

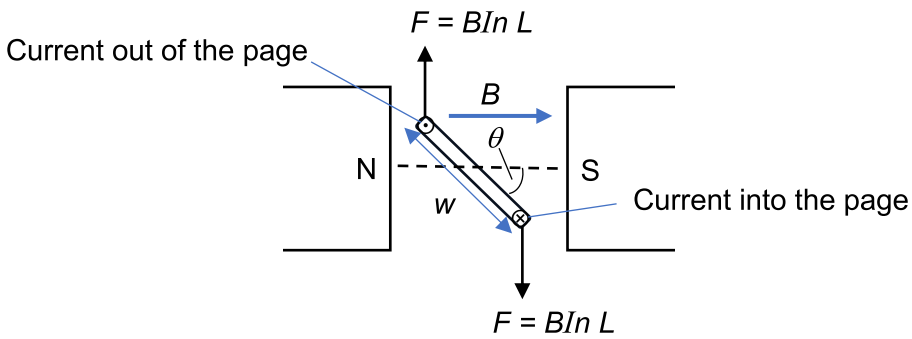
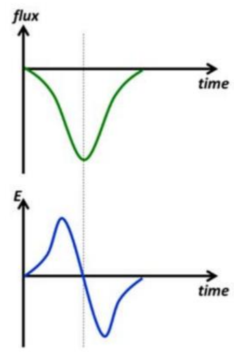
	ANS	Suggested solutions
1	**D**	magnetic flux Φ = magnetic flux density B x area A, magnetic flux density, $B = F / I L$ Unit of magnetic flux Φ = unit of $(F / I L)$ A Wb = (kg m s^{-2}) A^{-1} m^{-1} m^2 = kg m^2 s^{-2} A^{-1}
2	**D**	intensity I = (Power P) / (surface area A) $I = \frac{P}{4\pi r^2}$ $P = 4\pi r^2 I = 4\pi (2.0)^2 (0.25) = 12.566$ W $\frac{\Delta P}{P} = \frac{\Delta I}{I} + 2\frac{\Delta r}{r}$ $\frac{\Delta P}{12.566} = \frac{0.05}{0.25} + 2\left(\frac{0.1}{2.0}\right) = 0.3$ $\Delta P = 4$W
3	**D**	Initially, the speed of the car is increasing in the forward direction. **At X, the car reaches maximum speed (where acceleration is zero).** Beyond X, as the acceleration is in the opposite direction to the velocity, the car slows down in speed at an increasing rate to Y then at a decreasing rate to Z; but the car keeps moving in the forward direction even at Z as the positive change in velocity from O to X (positive area under the *a*-*t* graph) is still greater than the negative change in velocity from X to Z (negative area under the *a*-*t* graph). **Therefore, maximum displacement is at Z.**
4	**B**	The acceleration is downwards, thus resultant force is downwards. The magnitude of the force exerted on the block by the floor (upwards) is always less than the magnitude of the weight of the block (downwards). If the block is placed on a weighing scale in the lift, the scale will read a value less than its original weight.
5	**C**	The weights W_1 and W_2 provide the tension forces, balancing the weight of the object in equilibrium. Drawing a vector triangle of proportional magnitudes:  Recognize it is a 6-8-10 right-angled triangle. (similar to a 3-4-5). Analysing the horizontal components in equilibrium: 6.0 cos θ_1 = 8.0 cos θ_2 $\Rightarrow \theta_1 < \theta_2$ Thus, W_1 = 6.0 N, W_2 = 8.0 N

6	C	 At the initial position, the forces acting on the cylinder are weight *W*, upthrust *U* and tension *R*. Magnitude of the sum of upward forces *U* and *R* is equal to downward weight *W*. As the metal cylinder is slowly raised, **In region A:** cylinder is still fully submerged in water hence upthrust *U* remains the same, and weight W always remain the same throughout, hence tension *R* is constant. **In region B:** cylinder is being pulled out of the water so upthrust *U* decreases at a constant rate due to the volume submerged in water decreases at a constant rate. Hence, *R* increases at a constant rate. **In region C:** cylinder is fully out of the water hence upthrust *U* is zero so *W* = *R* remains constant.
7	B	Option A: Wrong because only when the force is reduced and the rubber band follows the path QRO to zero, then Y is the EPE recovered. Option B: Correct as total work done or minimum energy to stretch the rubber band to *e* is the area under the force-extension graph = (X + Y). Option C: Wrong as X is the net work done on the rubber band during the entire process. Option D: Wrong as Y is the EPE recovered when the rubber band is stretched and returned to zero extension.
8	B	The required centripetal force is the vector sum of the horizontal component of friction and the horizontal component of normal contact force. **At *v***  **below *v***  **above *v***  When the car is moving below *v*, the required centripetal force (which is acting horizontally) is smaller; thus, frictional force should act upwards along incline to oppose the horizontal component of the normal contact force as shown below. When the car is moving above the mentioned speed, the required centripetal force (which is acting horizontally) is larger; thus, frictional force should act downwards along incline to assist the horizontal component of the normal contact force as shown .

9	**A**	The gravitational force is the **only force** acting on the satellite. This force is providing the centripetal force required to maintain the satellite's orbital motion ($F_G = F_C$).
10	**A**	The gravitational potential at the surface of a planet is directly proportional to the planet's mass, and inversely proportional to its radius (or diameter). Hence, the potential at Mars' surface is approximately (0.1 / 0.5) x (-63 MJ kg^{-1}) = -13 MJ kg^{-1}.
11	**B**	This is an extension from $Q = mc\Delta T$, considering the rate of thermal energy removed. $\frac{dm}{dt}c\Delta T = \frac{dE}{dt} = P$ $\frac{dm}{dt} = \frac{P}{c\Delta T}$ $= \frac{6.7\times10^9 / 60}{4200\times(14.0-6.0)} = \frac{6.7\times10^9}{4200\times8.0\times60}$ kg s^{-1}
12	**C**	Assume that temperature is constant, then the product of pressure and volume, pV is constant. Further assume that the cross-sectional area of the tube is constant, then pl is constant. When at angle θ, $p = P_{atm} + \rho_{Hg}gl_{Hg}\cos\theta$ When the tube is upright (0°), $p = P_{atm} + \rho_{Hg}gl_{Hg}$, where Hg is mercury, **pressure is maximum, *l* is minimum.** When the tube is horizontal (90°), and $p = P_{atm}$ When the tube is inverted (180°), $p = P_{atm} - \rho_{Hg}gl_{Hg}$, **pressure is minimum, *l* is maximum.** As angle varies from 0° to 360°, l varies sinusoidally, following an inverted cosine function.
13	**C**	On the *P-T* diagram, using $p = \left(\frac{nR}{V}\right)T$, the volume is inversely proportional to the gradient of line passing through the origin. gradient of OA > gradient of OB Thus, volume of the gas increases, and positive work is done <u>by</u> the gas in the process AB (or work done <u>on</u> the gas is negative, $W < 0$). Temperature increases from A to B implies that internal energy of the ideal gas increases in the process, i.e. $\Delta U > 0$.  By First Law of Thermodynamics, $\Delta U = W + Q \Rightarrow Q = (\Delta U - W) > 0$ Thus heat is supplied to the gas.
14	**D**	The pendulum performs simple harmonic motion at small angles. You may see the pendulum swing as a part of a non-uniform vertical circular motion. Let angular displacement be θ. Thus, linear displacement $x \approx r\theta = (1.0)\theta = \theta$ At angular displacement is 0.050 rad, horizontal amplitude x_0 = 0.050 m. At angular displacement is 0.030 rad, horizontal displacement x = 0.030 m. Using the equation given in the formula list,

		linear velocity, $v = \pm\omega\sqrt{x_0^2 - x^2}$ $= \pm\frac{2\pi}{T}\sqrt{x_0^2 - x^2}$ $= \pm\frac{2\pi}{2.0}\sqrt{0.050^2 - 0.030^2}$ $= \pm 0.13 \text{ m s}^{-1}$ $\because v = r\omega = (1.0)\omega = \omega$ angular speed, $\omega = v = 0.13 \text{ rads}^{-1}$
15	**B**	Using Malus' law, the intensity of transmitted light (I) through polarisers is proportional to $I_0 \cos^2\theta$, where I_0 is the intensity of transmitted through the first polariser, θ is the angle between two polarisers. Unpolarized light loses exactly half of its intensity after it passes through polariser W no matter what the direction of polarising for polariser X is: 0.50 I_0. The angle between polariser W and X is 10°, the transmitted intensity after X would be $0.50I_0 \times \cos^2(40° - 30°) = 0.48I_0$. The angle between polariser X and Y is 20°, the transmitted intensity after Y would be $0.48I_0 \times \cos^2(60° - 40°) = 0.43I_0$.
16	**B**	Since the wave is travelling from left to right, at the next instant, every particle will "copy" what its current left neighbour is doing. Hence, R is moving to the right, while S is moving to the left. Alternatively, drawing the displacement-distance graph,  Sketching in the wave profile for the next moment, wave particle at R goes into the positive region, meaning that it is moving to the right; wave particle at Q goes into the negative region, meaning that it is moving to the left.
17	**C**	P is travelling towards left and Q is travelling towards right. Let their amplitudes be *A*. Given that at *t* = 0, P has a negative cosine profile and Q has a positive cosine profile, hence, the resulting stationary wave would produce zero amplitude, Y. *T*/4 later, both P and Q have a negative sine profile, the resultant amplitude would correspond to Z. *T*/2 later, the resultant amplitude would be zero. 3*T*/4 later, the resultant amplitude would correspond to X. Hence, the correct answer is Y Z Y X.

18	**B**	Reading from the graph, a distance on the screen of 1.10 mm corresponds to a phase difference of 3.5 x 2π radians. Since point P is 0.70 mm away from the central maximum, the phase difference there is (0.70 / 1.10) x (3.5 x 2π) = 14.0 radians. The reduced phase difference (i.e., modulo 2π, to get a value between 0 and 2π radians) is 14.0 - 4π = 1.4 radians.
19	**C**	Option A is the definition of electric potential not electric field strength. Option B is incorrect because the potential gradient is the electric field strength, hence a vector quantity. Option C is correct. Option D is about potential difference not potential gradient.
20	**D**	The acceleration on the electron is constant under the influence of the uniform E-field. Applying equations of motion for uniform acceleration in Kinematics: $v^2 = u^2 + 2as, \quad u = 0$ $v = \sqrt{2as}$ $v \propto \sqrt{s}$ The graph in D correctly depicts this relationship.
21	**C**	Charge Q = Area under I-t graph = ½(0.5)(1+2)(60 x60) = 2700 C Energy transferred i.e. work done on charge = QV = 5.0 x 2700 = 13500 J
22	**C**	Initially, when distance x (less than mid-way of OZ from O) increases, with a small change in distance x, the cross-sectional area increases, resulting in smaller increases in R. Later, when distance x (more than mid-way of OZ from O) increases, with a small change in distance x, the cross-sectional area decreases, resulting in larger increases in R.
23	**C**	Since potentials at points C and B are equal, we can remove the resistor between them.  $\frac{1}{R_{AD}} = \frac{1}{6.0} + \frac{1}{12.0} + \frac{1}{12.0}$ $\frac{1}{R_{eff}} = \frac{4}{12.0}$ $R_{eff} = 3.0\,\Omega$
24	**D**	The forces acting on the vertical sides of the coil = $nBIL$, since the current in the vertical wires are always perpendicular to the horizontal magnetic field.  Side view

		 Plan view (or top view) The angle is required only for the perpendicular distance between the lines of action of the forces $w\cos\theta$. The moment of the couple is $F \times d_{\perp} = nBIL\, w\cos\theta$.
25	D	Take the upper side of the coil as our reference area. As the north pole of the magnet approaches this area from far, the magnetic flux linkage across this area increases from zero to a maximum (negative value). Then drop to zero as the north pole leaves this area. The graph of flux against time is as shown. The negative of the gradient of this graph is the *E* - *t* graph. 
26	B	The magnetic flux (BA) through the tranformer is the same for both primary and secondary coils. By Faraday's Law, the average induced emf in the secondary coil = change of flux linkage/ time $$\left\|\varepsilon\right\| = \frac{\Delta\Phi}{\Delta t} = \frac{N\Delta\phi}{\Delta t} = \left\|\frac{(50)(0.00-0.54)}{0.18}\right\| = 150\text{ V}$$
27	C	In Fig. (a), for sinusoidal a.c., $V_{r.m.s.\ for\ (a)} = \frac{V_P}{\sqrt{2}}$ In Fig. (b), for the case of full square wave ac, $V_{peak} = V_{r.m.s.}$, the mean power is $\langle P\rangle_{full} = \frac{V_{Peak}^2}{R}$ But Fig. (b) represents a half-wave rectified square wave, $\langle P\rangle_{half} = \frac{V_{Peak}^2}{2R}$ $$\frac{V_{r.m.s. for\ (b)}^2}{R} = \frac{V_{Peak}^2}{2R} \rightarrow V_{r.m.s.\ for\ (b)} = \frac{V_P}{\sqrt{2}}$$ Thus, the ratio $$\frac{V_{r.m.s.\ for\ (a)}}{V_{r.m.s.\ for\ (b)}} = \frac{\frac{V_P}{\sqrt{2}}}{\frac{V_P}{\sqrt{2}}} = 1$$

28	**A**	By Photoelectric Equation: $hf = \Phi + KE_{max}$ Work function of the metal, $\Phi = hf - KE_{max} = (6.63\times10^{-34})(1.0\times10^{15}) - (2.6\times10^{-19}) = 4.03\times10^{-19}$ J $E = hf' - \Phi = (6.63\times10^{-34})(2.5\times10^{15}) - (4.03\times10^{-19}) = 1.3\times10^{-18}$ J
29	**D**	Energy released = $BE_{products} - BE_{reactants}$ = (8.2 × 146) + (8.6 × 87) – (7.6 × 235) = 159.4 MeV
30	**B**	L, R, X are all alpha particles (i.e. having charge of +2e and least penetration power through solid).