Qn	Ans	Discussion
1	**C**	base units of P = base units of $(\rho A v^n)$ $(\text{kg m s}^{-2})(\text{m s}^{-1}) = (\text{kg m}^{-3})(\text{m}^2)(\text{m s}^{-1})^n$ $\text{kg m}^2\,\text{s}^{-3} = \text{kg m}^{-3+2+n}\,\text{s}^{-n}$ Comparing the indices for s, $n = 3$
2	**A**	Option A – Non-linear gradient indicates largest change in velocity with time Option B – Almost constant gradient indicates almost constant velocity with no acceleration. Option C – Constant gradient indicates constant velocity with no acceleration Option D – Zero velocity
3	**D**	$s = ut + \frac{1}{2}at^2$ $a = \frac{2h}{(t_2^2 - t_1^2)}$ Using $g\sin\theta = a$, $g = \frac{2h}{(t_2^2 - t_1^2)\sin\theta}$
4	**A**	Rate of change of momentum $= \frac{\Delta(mv)}{t}$ $= v_{rel}\frac{\Delta m}{t}$ $= v_{rel}\frac{(\rho \times \text{vol of water expelled})}{t}$ $= v_{rel}\frac{(\rho \times \pi r^2 h)}{t}$ $= v\rho\pi r^2 \frac{h}{t}$ $= v\rho\pi r^2 v$ $= \rho\pi r^2 v^2$ $= 1000 \times \pi \times 0.012^2 \times 10^2$ $= 45$ N

5	**C**	Assume Charlie throws the ball to the right and take rightwards as positive. Consider Charlie and the ball as 1 system, Before throwing the ball, $p_{\text{before throw}} = p_{\text{after throw}}$ $0 = m_{ball}u_{ball} + m_{Charlie}\left(-u_{Charlie}\right)$ $0 = (1.5)(2.5) + (60)(u_{Charlie})$ $u_{Charlie} = -0.0625 \text{ m s}^{-1}$ Charlie is moving to the left with speed 0.0625 m s^{-1} after throwing the ball. Consider the returning ball and Charlie as 1 system now, $p_{\text{before catch}} = p_{\text{after catch}}$ $(60)(-0.0626) + (1.5)(-2.5) = (61.5)(v_{\text{after catch}})$ $v_{\text{after catch}} = -0.122 \text{ m s}^{-1}$
6	**C**	$T\cos 18° = W$ $T = \dfrac{520}{\cos 18°} = 550 \text{ N}$ $T\sin 18° = R$ $R = \dfrac{520}{\cos 18°}\left(\sin 18°\right) = 170 \text{ N}$
7	**C**	Taking moments about pivot, $P\left(30\right) = Q\left(70\right)$ $\dfrac{P}{Q} = \dfrac{7}{3}$
8	**C**	$P = \dfrac{mg\Delta h}{\Delta t} = \dfrac{\rho V g \Delta h}{\Delta t} = \dfrac{1000 \times 0.2 \times 9.81 \times 10}{5 \times 60} = 65.4 \text{ W}$ $P \text{ required} = \dfrac{65.4}{0.4} = 163.5 \text{ W}$
9	**A**	Time taken for hour hand to complete one revolution, $T = 12 \times 60 \times 60$ Angular speed, $\omega = \dfrac{2\pi}{T} = 1.5 \times 10^{-4} \text{ rad s}^{-1}$
10	**D**	Since $v = r\omega,\ \omega = \dfrac{v}{r}$ *and* $a = \omega^2 r$ When r reduces to $\dfrac{1}{2}r$ and ω increases to 2ω, $v_{new} = 2\omega\ (\dfrac{1}{2}r) = v$ and $a_{new} = (\dfrac{1}{2}r)(2\omega)^2 = 2a$
11	**B**	Gravitational field strength due to mass M is directly proportional to the mass M and inversely proportional to the (square of the) distance. Considering the system of the 3 masses, Planet 1 has the smallest mass, hence the neutral point is B (closest point to the Planet 1). A is wrong because it is along the straight line connecting the centres of Planet 1 and Planet 2. If we to consider only the neutral point between only Planet 1 & Planet 2 excluding Planet 3, A would be the answer.

12	**A**	$pV = nRT$ $\frac{1}{p} = \frac{V}{nRT}$ When n and T are decreased by half, gradient increases by 4.
13	**D**	$Q = (mc\Delta\theta)_{ice} + ml_f + (mc\Delta\theta)_{water}$ $= 2.1(2108)(4.5) + 2.1(334 \times 10^3) + 2.1(4190)(96)$ $= 1.57\ \text{MJ}$
14	**C**	The volume of the molecules is much smaller in comparison to the volume of container.
15	**D**	There are no oscillations, and the amplitude will return to equilibrium in a short time.
16	**B**	$v = \pm\omega\sqrt{x_o^2 - x^2}$ $(v')^2 = \omega^2\left(A_o^2 - \left(\frac{A_o}{2}\right)^2\right) = \frac{3}{4}v^2$ $\frac{\text{kinetic energy}}{\text{total energy}} = \frac{3}{4}$
17	**B**	Wavelength is from compression to compression. 100 m spans across 5 wavelengths. Therefore, $\lambda = \frac{100}{5} = 20$ m Using $v = f\lambda$, $350 = f(20)$ Therefore, frequency $= 18$ Hz
18	**C**	$\lambda = \frac{v}{f} = \frac{36}{400}$ $\frac{\Delta x}{\lambda} = \frac{\Delta\phi}{2\pi}$ $\Delta\phi = \frac{\Delta x}{\lambda}(2\pi)$ $= \frac{0.18}{\frac{36}{400}}(2\pi)$ $= 4\pi$ *A* phase difference of 2π is equivalent to a phase difference of 4π.
19	**B**	Consider Rayleigh's criterion, $\theta \approx \frac{\lambda}{b}$ $\frac{\theta_{new}}{\theta_{old}} = \frac{b_{old}}{b_{new}} = 0.5$ Therefore, $\theta_{new} = 2.0 \times 10^{-2}$ rad

20	**B**	Since potential is a scalar quantity and distances of A and C to B are the same, potential due to A cancels the potential due to C. Thus, the potential at B is due to charge at D alone. $V = \dfrac{1}{4\pi(8.85x10^{-12})}(\dfrac{100\times10^{-6}}{20\times10^{-2}})$ $= +4.5$ MV
21	**B**	Direction of electric field line is directed away from a positive charge that sets it up in the first place. Whether the field strength increases or not depends on how closely together the electric field lines are to one another. However, the further the distance from the electric field line, the lesser is the electric potential due to the positive charge.
22	**B**	The circuit is equivalent to 2 sets of parallel resistors in series with each other. $\text{Effective resistance} = \left(\dfrac{1}{R}+\dfrac{1}{R}\right)^{-1}\times 2$ $= R$
23	**D**	Total potential drop from J to L = 3 IR where I is the current through series resistors R and 2R [Path JML] Potential $V_L = 0$, potential $V_J = 3IR$ Potential drop across JM = IR and potential drop across ML = 2IR
24	**C**	The path cannot be due to a magnetic field because the magnetic force acting on the charged particle will be into the page (positive charge) or out of the page (negative charge). Hence, the field must be an electric field and since the charged particle is deflected downwards, the charge is positive.
25	**D**	Let the velocity of the rod down the slope be v. e.m.f. induced = $B\,L\,v\cos\theta$ current induced = e.m.f. induced / R Magnetic force = $B\,I\,L$ to the left When terminal velocity is achieved, Net F along slope = 0 Resolving forces along the slope, $mg\sin\theta = \text{ magnetic force}\cos\theta$ $= B\times\dfrac{BLv\cos\theta}{R}\times L\cos\theta$ $v = \dfrac{mgR\tan\theta}{B^2L^2\cos\theta}$

26	**B**	Note that as the value of V is a straight line with a constant gradient, the square of this function will be a curve. Option D is wrong because it is obtained from an alternating function of constant V_0. Option C is wrong because it is obtained from an alternating sinusoidal function. Option A is wrong because it is the root-mean-square voltage is not the average voltage. Note: $V_{rms} = \sqrt{\frac{1}{T/2}\int_0^{T/2} V(t)^2\,dt} = \sqrt{\frac{2}{T}\int_0^{T/2}\left(\frac{V_0}{T/2}t\right)^2 dt} = \sqrt{\frac{2}{T}\int_0^{T/2}\frac{4V_0^2}{T^2}t^2 dt}$ $= \sqrt{\frac{8V_0^2}{T^3}\left[\frac{t^3}{3}\right]_0^{T/2}} = \sqrt{\frac{8V_0^2}{T^3}\frac{T^3}{3\times 8}}$ $= \sqrt{\frac{V_0^2}{3}} = \frac{V_0}{\sqrt{3}}$
27	**A**	Photoelectric equation: $hf = \Phi - eV_s$ where $\Phi = hf_m$ $V_s = \left(\frac{h}{e}\right)f - \Phi$ Smaller work function means threshold frequency f_m is lower. Gradient of $V_s - f$ graph $\left(=\frac{h}{e}\right)$ is constant. Hence the line for the new metal should be parallel to the original line but shifted to the left.
28	**A**	When operating voltage is decreased, the electrons have less energy and the cut-off wavelength λ_1 is longer. Since the target material has not changed, there is no difference in the characteristic spectrum and hence there is no change in λ_2.
29	**A**	Majority of the particles will still pass through without deviation. Although the charge of the gold nucleus is the same, the probability of head on interaction remains approximately the same and atom consists mainly of empty space.
30	**A**	Y and Z are more stable than X. Hence, the binding energy per nucleon of X should be lower than that of Y and of Z.