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	**D**	Density $\rho = \frac{m}{V}$ where $V \propto r^3 \propto d^3$ $\left(\frac{\Delta\rho}{\rho}\right)\times 100\% = \left(\frac{\Delta m}{m} + 3\frac{\Delta d}{d}\right)\times 100\%$ $= \left(\frac{0.1}{32.5} + 3\left(\frac{0.04}{1.87}\right)\right)\times 100\%$ $= 6.7\%$
3	**C**	$F_x = 15\cos 20^\circ + 6.0\sin 40^\circ = 17.95 \approx 18.0\text{ N}$ $F_y = 15\sin 20^\circ - 6.0\cos 40^\circ = 0.5340 \approx 0.534\text{ N}$
4	**B**	At highest point, vertical component of the velocity is zero. Hence the ratio is $\frac{v\sin\theta}{v} = \sin\theta$.
5	**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
6	**D**	$s = ut + \frac{1}{2}at^2$ $a = \frac{2h}{(t_2^2 - t_1^2)}$ Using $g\sin\theta = a$, $g = \frac{2h}{(t_2^2 - t_1^2)\sin\theta}$
7	**B**	When the bucket is moving at uniform speed, $T - mg = 0$ $T = mg$ When the bucket is decelerating uniformly, $mg - T' = ma$ $T' = m(g - a)$ $= m\left(g - \frac{v}{t}\right)$ Difference in tension = $T' - T$ $= m\left(g - \frac{v}{t}\right) - mg$ $= -\frac{mv}{t}$

8	**A**	Rate of change of momentum $= \dfrac{\Delta(mv)}{t}$ $= v_{rel}\dfrac{\Delta m}{t}$ $= v_{rel}\dfrac{(\rho \times \text{vol of water expelled})}{t}$ $= v_{rel}\dfrac{(\rho \times \pi r^2 h)}{t}$ $= v\rho\pi r^2 \dfrac{h}{t}$ $= v\rho\pi r^2 v$ $= \rho\pi r^2 v^2$ $= 1000 \times \pi \times 0.012^2 \times 10^2$ $= 45$ N
9	**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, $p_{\text{before throw}} = p_{\text{after throw}}$ $0 = m_{ball}u_{ball} + m_{Charlie}(-u_{Charlie})$ $0 = (1.5)(2.5) + (60)(u_{Charlie})$ $u_{Charlie} = -0.0625$ 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, $p_{\text{before catch}} = p_{\text{after catch}}$ $(60)(-0.0626) + (1.5)(-2.5) = (61.5)(v_{\text{after catch}})$ $v_{\text{after catch}} = -0.122$ m s^{-1}
10	**D**	A collision is elastic if relative speed of approach equals relative speed of separation. $u_1 - (-u_2) = v_2 - v_1$ $u_1 + u_2 = v_2 - v_1$ Options A and B are wrong. An elastic collision is also one in which K.E. is conserved. total initial K.E. of system = total final K.E. of system $\dfrac{1}{2}mu_1^{\ 2} + \dfrac{1}{2}mu_2^{\ 2} = \dfrac{1}{2}mv_1^{\ 2} + \dfrac{1}{2}mv_2^{\ 2}$ $u_1^{\ 2} + u_2^{\ 2} = v_1^{\ 2} + v_2^{\ 2}$
11	**C**	$T\cos 18° = W$ $T = \dfrac{520}{\cos 18°} = 550$ N $T\sin 18° = R$ $R = \dfrac{520}{\cos 18°}(\sin 18°) = 170$ N

12	**C**	Taking moments about pivot, $P(30) = Q(70)$ $\frac{P}{Q} = \frac{7}{3}$
13	**B**	Action-reaction pair must act on different bodies.
14	**A**	$\frac{\Delta TE}{t} = \frac{\Delta U}{t}$ $\frac{\Delta TE}{t} = \frac{mgh}{t} = mgv$ $= (60)(9.81)(\frac{240 \times 1000}{3600}) = 39 \text{ kW}$
15	**C**	$P = Fv$ With constant force, velocity increases linearly with time, P also increases linearly. $P = F(\sqrt{2as})$ $P^2 = F^2(2as)$ With constant force, power increases non-linearly with distance.
16	**C**	$P = \frac{mg\Delta h}{\Delta t} = \frac{\rho V g \Delta h}{\Delta t} = \frac{1000 \times 0.2 \times 9.81 \times 10}{5 \times 60} = 65.4 \text{ W}$ $P \text{ required} = \frac{65.4}{0.4} = 163.5 \text{ W}$
17	**A**	Time taken for hour hand to complete one revolution, $T = 12 \times 60 \times 60$ Angular speed, $\omega = \frac{2\pi}{T} = 1.5 \times 10^{-4} \text{ rad s}^{-1}$
18	**D**	Since $v = r\omega,\ \omega = \frac{v}{r}$ *and* $a = \omega^2 r$ When r reduces to $\frac{1}{2}r$ and ω increases to 2ω, $v_{new} = 2\omega\ (\frac{1}{2}r) = v$ and $a_{new} = (\frac{1}{2}r)(2\omega)^2 = 2a$
19	**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, then A would be the answer.
20	**B**	The circuit is equivalent to 2 sets of parallel resistors in series with each other. Effective resistance $= \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} \times 2$ $= R$

21	**D**	Total potential drop from J to L = 3 *IR* where *I* is the current through series resistors *R* and 2*R* [Path JML] Potential $V_L = 0$, potential $V_J = 3IR$ Potential drop across JM = *IR* and potential drop across ML = 2*IR*
22	**B**	$E = I(R + r)$ $E = (1.00 \times 3.0) + 1.00r$ $E = (0.40 \times 12.0) + 0.40r$ Hence, $3.0 + r = 4.8 + 0.40r$ $\therefore r = 3.0\ \Omega$
23	**A**	$\frac{1}{R_{PQ}} = \frac{1}{3.0} + \frac{1}{(6.0 + 4.0 + 5.0)} \Rightarrow R_{PQ} = 2.50\ \Omega$ $\frac{1}{R_{PR}} = \frac{1}{(5.0 + 3.0)} + \frac{1}{(6.0 + 4.0)} \Rightarrow R_{PR} = 4.44\ \Omega$ $\frac{1}{R_{PS}} = \frac{1}{6.0} + \frac{1}{(5.0 + 4.0 + 3.0)} \Rightarrow R_{PS} = 4.00\ \Omega$ $\frac{1}{R_{QS}} = \frac{1}{(6.0 + 3.0)} + \frac{1}{(5.0 + 4.0)} \Rightarrow R_{QS} = 4.50\ \Omega$ Largest current is when resistance is lowest, i.e. across PQ.
24	**C**	By potential divider principle, $V_{LDR} = \frac{R_{LDR}}{(R_{LDR} + R)} \times 10$ When R_{LDR} = 5.3 Ω, V_{LDR} = 4.5 V $4.5 = \frac{5.3}{(5.3 + R)} \times 10$ $R = 6.478\ \Omega$ When R_{LDR} = 3.1 Ω, $V_{LDR} = \frac{3.1}{(3.1 + 6.478)} \times 10$ $= 3.23$ V
25	**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.
26	**C**	Determine the force on wire Z due to X and Y and find the resultant force.

27	**B**	magnetic force provides centripetal force. $Bqv = \frac{mv^2}{r}$ $r = \frac{mv}{Bq}$ $r_1 = \frac{mv}{B_1 q}$ Since $r_2 = r_1$, $r_2 = \frac{mv}{B_2 2q}$ $B_2 = \frac{1}{2} B_1$
28	**A**	Majority of the particles will still pass through without deviation. Although the charge of the gold nucleus is higher, the probability of head on interaction remains approximately the same and atom consists mainly of space.
29	**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.
30	**A**	At t = 4T, Activity of A = $\left(\frac{1}{2}\right)^4 A_0$ Activity of B = $\left(\frac{1}{2}\right)^2 A_0$ $\frac{\text{activity of A}}{\text{activity of B}} = \left(\frac{1}{2}\right)^2 = 0.25$