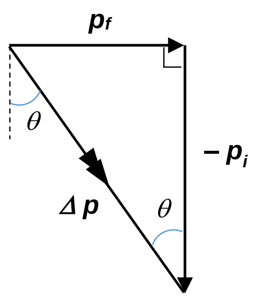
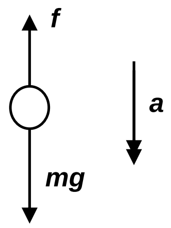
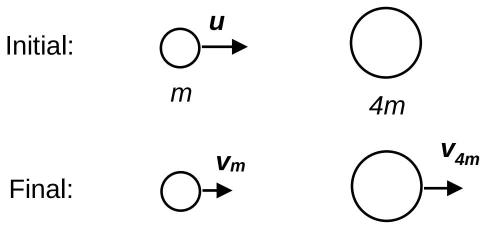
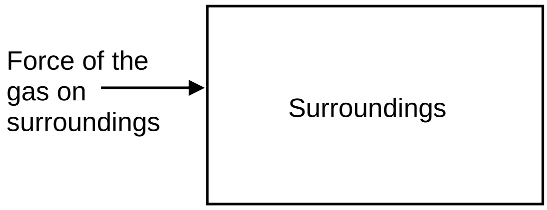
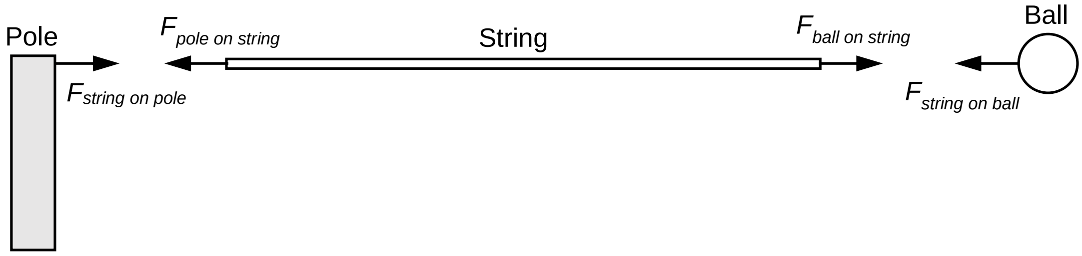
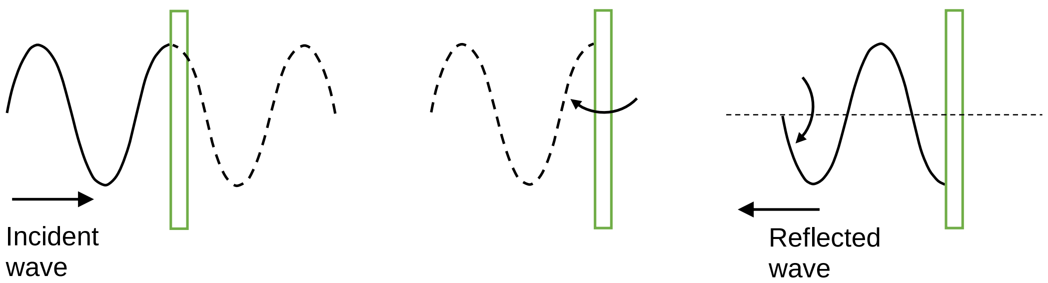
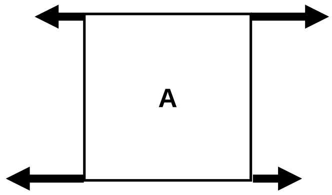
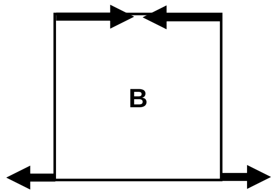
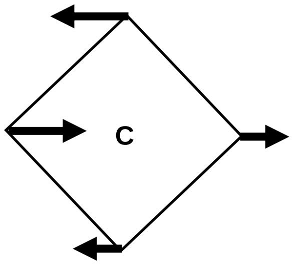
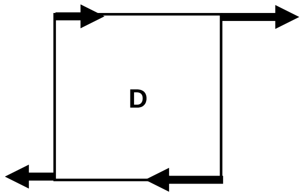
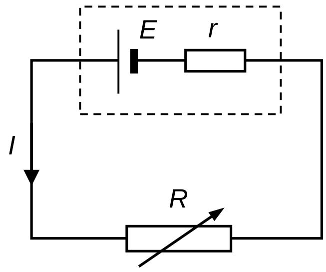
2010 H2 Paper 1

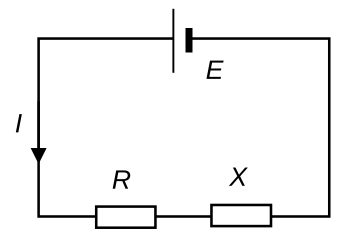
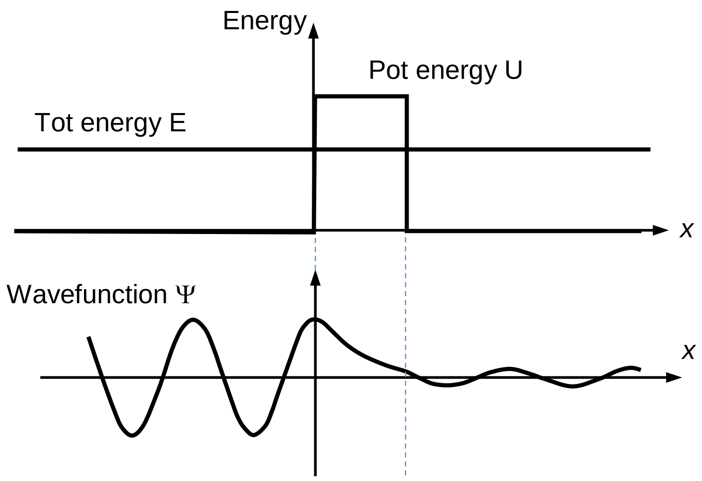
QN.	ANS	Explanation
1	A	$s=\frac{1}{2}gt^2 \Rightarrow t^2=\frac{2}{g}s$. Since the best-fit line passes through the origin, there is little or no systematic error. Also, the value of the gradient is $\frac{2}{g}=0.204 \Rightarrow g=9.80\text{ m s}^{-2}$, which is close to the accepted value of *g*. Thus the obtained value of *g* is accurate. The scatter in the data points indicated the presence of significant random errors in the experiment. These introduced an uncertainty to the value of the gradient obtained, and ultimately an uncertainty to the value of *g* derived. Thus the obtained value of *g* is imprecise. Note that high precision implies low random error: good accuracy implies low systematic error.
2	C	Change in velocity, $\Delta \boldsymbol{p} = \boldsymbol{p_f} - \boldsymbol{p_i} = \boldsymbol{p_f} + (-\boldsymbol{p_i})$  Magnitude of $\Delta \boldsymbol{p}$ = $\sqrt{(6^2+8^2)}=10\text{ m s}^{-1}$ $\theta=\tan^{-1}\left(\frac{6}{8}\right)=37^{\circ}$ Direction of $\Delta \boldsymbol{p}$ is 37° E of S. Note that $\Delta \boldsymbol{p}$ is the difference of 2 vectors.
3	C	$\frac{\Delta\rho}{\rho}=2\frac{\Delta d}{d}+\frac{\Delta V}{V}+\frac{\Delta L}{L}+\frac{\Delta I}{I}$ $2\frac{\Delta d}{d}=0.017;\ \frac{\Delta V}{V}=0.02;\ \frac{\Delta L}{L}=0.01;\ \frac{\Delta I}{I}=0.033$ The measurement of *L* gives rise to the least uncertainty in the value for ρ, as it contributes the least amount of fractional uncertainty.
4	D	Taking down as positive, Newton's 2nd law gives $mg-f=ma$  where *f* is the air resistance and can be generally be assumed to be proportional to speed *v* at low speed. Thus $mg-kv=ma$ $a=g-\left(\frac{k}{m}\right)v$,where *k* is a constant. As the object is released from rest, its initial speed is zero, and *a* is equal to *g*, thus options B and C are incorrect. As time passed, the object's speed *v* increases and *a* gets smaller and smaller, until eventually *a* = 0 when (*k*/*m*)*v* = *g*. The object has reached terminal speed.

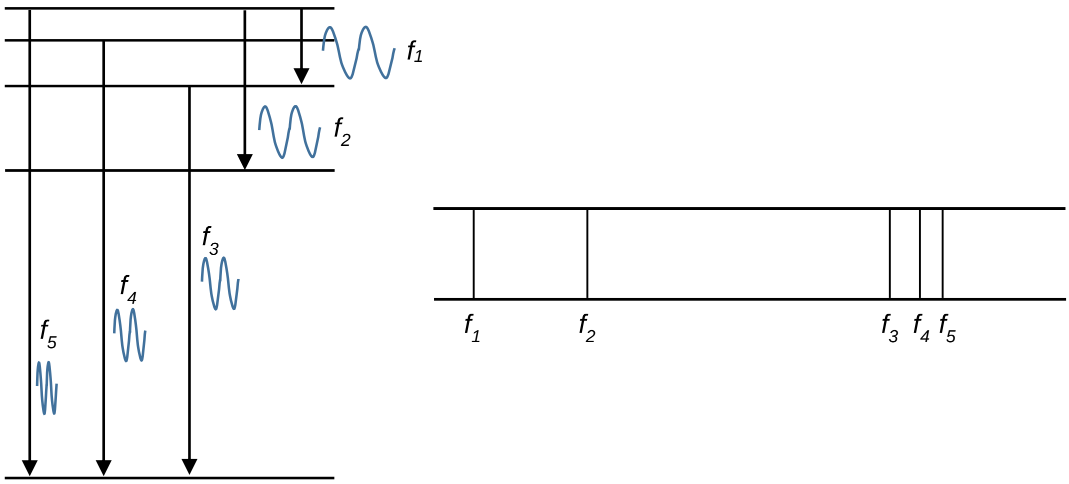
5	**A**	Take down as positive. From light gate 1 to light gate 2, using $s = ut + \frac{1}{2}at^2$, we have $s_1 = 0 + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$ …….. (1) Also, the speed of the object at light gate 2 is, using $v = u + at \Rightarrow v = gt$. From light gate 2 to light gate 3, using $s = ut + \frac{1}{2}at^2$, we have $s_2 = (gt)t + \frac{1}{2}gt^2 = \frac{3}{2}gt^2$ …….. (2) (2) – (1) gives $s_2 - s_1 = gt^2$ or $g = \frac{s_2 - s_1}{t^2}$
6	**B**	Take right as positive:  Conservation of momentum gives $\sum p_i = \sum p_f$ $m(+u) + 0 = m(+v_m) + 4m(+v_{4m})$ …(1) Since collision is elastic, Relative speed of approach = Relative speed of separation $u = v_{4m} - v_m$ …(2) (2) → $v_{4m} = u + v_m$ …(3) (3) in (1) → $mu = mv_m + 4m(u + v_m) \Rightarrow v_m = -\frac{3}{5}u$
7	**B**	Applying Newton's 2nd law to the 6.0 kg block and taking right as positive, the resultant force on it is: $F = ma = 6.0a$ N, where a is its acceleration. But a is also the acceleration of the system comprising both the blocks. Thus $\sum F = ma \Rightarrow (54 - 6.0) = (6.0 + 2.0)a$ $a = 6.0 \text{ m s}^{-1}$ Thus resultant force on the 6.0 kg block $F = 6.0(6.0) = 36$ N
8	**A**	U = weight of air displaced = (mass of air displaced) x g = $(\rho_{air} V_{droplet})g$, where ρ_{air} is the density of air and $V_{droplet}$ is the volume of the droplet. $W = (\rho_{water} V_{droplet})g$. Since $\rho_{air} << \rho_{water}$, $U << W$, thus options B and C are incorrect. Also, the water droplet is in equilibrium, so there is no net force on it and thus $R + U = W$. Option A is the only force diagram drawn to the correct scale.

9	**B**	Taking moments about point X, 220(3.0) = 180(1.5) + *Load* (0.80) *Load* = 490 N
10	**B**	The work done by the expanding gas *is on its surroundings*, thus we could take the surroundings as our system of interest, and consider the displacement of the 'Force of the gas on surroundings' to find the work done.  Newton's 3rd law tells us that Force of the gas on surroundings = Pressure force of surroundings on the gas If we are to use $p\Delta V$ to calculate the work done by the expanding gas on the surroundings, then the constant p must refer to the constant pressure of the surroundings. The pressure of the gas need not be kept constant, and in fact is not constant as the gas expands. If the pressure of the gas is somehow kept constant as it expands but the pressure of the surroundings is changing then the work done by the gas on the surroundings will require a more detailed analysis than just $p\Delta V$. (By a similar argument, if we are to use $p\Delta V$ to calculate the work done on a contracting gas, then the constant p must refer to the pressure of the gas being kept constant.)
11	**D**	$P = Fv = mav$ a constant $\Rightarrow$ $v^2 = 2as$ since u = 0. Thus $P = ma\sqrt{2as} \quad \Rightarrow \quad P \propto \sqrt{s}$
12	**D**	$v = r\omega$ and $a = r\omega^2$. ω constant and r constant imply v and a would both increase.
13	**D**	The string is in tension. The centripetal force on the ball is provided by the force that the string exerts on the ball. 
14	**B**	Total energy = KE + PE $= \left(\frac{1}{2}mv^2\right) + \left(-\frac{GMm}{r}\right)$ $= m\left(\frac{v^2}{2} - \frac{GM}{r}\right)$

15	**B**	Since the mass of the Moon is so small relative to the Earth, it is likely that the neutral point is closer to the Moon than the Earth, thus options C and D are incorrect. It is impossible to have the vector sum of the fields due to the Moon, Earth and Sun to be zero at point A. Point B is thus the most likely position for the neutral point.
16	**D**	The new graph is lower, flatter and slightly shifted to the left.
17	**B**	Total energy = max KE $= \frac{1}{2}mv_o^2 = \frac{1}{2}m\omega^2 x_o^2$ $= \frac{1}{2}(8.0 \text{ x } 10^{-3})\left[2\pi(40)\right]^2 (5.0 \text{ x } 10^{-3})^2 = 6.3 \text{ mJ}$
18	**C**	—
19	**C**	Heat lost by P = Heat gained by Q $M_P c(T_P - T) = M_Q c(T - T_Q)$ where *c* is the specific heat capacity of steel. Since $M_P > M_Q$, we have $(T_P - T) < (T - T_Q)$.
20	**D**	At a distance *r* away from the initial disturbance, the energy available is spread evenly over the circumference 2π*r*. Note that this is distribution of energy in 2D instead of 3D. $\frac{E}{2\pi r} \propto \text{Amp}_r^{\ 2}$, where Amp_r is the amplitude of the ripple at *r*. If there is no energy lost during propagation, *E* is constant, thus $(\text{Amp})_{1200} = \left(\frac{150}{1200}\right)^{1/2} (\text{Amp})_{150}$ $= \left(\frac{1}{8}\right)^{1/2} (2.0 \text{ mm}) = 0.71 \text{ mm}$
21	**C**	At the barrier, the resultant wave must be a node. The only possible reflected wave that can sum with the incident wave to give a zero displacement at the barrier is that in option C. In general, when a *transverse* incident wave encounters a denser medium, the reflected wave can be obtained as follows:  <u>Step 1</u>: Extends wave into barrier – dotted curve. <u>Step 2</u>: Flip dotted curve about barrier boundary. <u>Step 3</u>: Flip dotted curve about incident line – *there is a phase change of 180°* since the reflection is from a denser medium.

22	**A**	$x = \frac{\lambda L}{a}$. λ, L constant $\Rightarrow x \propto \frac{1}{a}$.
23	**A**	$d \sin\theta = n\lambda \Rightarrow \theta = \sin^{-1}\left(\frac{n\lambda}{d}\right)$
24	**B**	 No net force. Net clockwise moment.  No net force. No net moment.  No net force. Net anti-clockwise moment.  No net force. Net clockwise moment.
25	**A**	The spheres are conductors of opposite charge, thus the charges on the spheres would be concentrated on the sides of the spheres facing each other, since opposite charge attracts (reject option B). Field lines have to be perpendicular to the surface of the spheres and be denser between the spheres. The field lines also cannot be equally spaced (see options C and D), because that would suggest that the field strength is the same at any point along the perpendicular bisector between the spheres.
26	**B**	$E = I(r + R)$ E, r constant; R decreases $\Rightarrow$ I increases $\therefore P_r = (I^2 r)$ increases, and $V_R = IR = (E - Ir)$ decreases. 
27	**C**	$E = (6.0)r + (6.0)(1.2)$ ….. (1) $E = (5.0)r + (5.0)(1.6)$ ….. (2) Solving gives r = 0.80 Ω and E = 12 V.
28	**C**	Note that resistance is the ratio of V to I, not the gradient of the tangent at the point.

29	**D**	In series, the same current I = 0.3 A passes through both R and X. From graph V_X = 1.0 V, V_R = 1.5 V. Thus E = 1.0 + 1.5 = 2.5 V. In parallel, $V_X = V_R$ = 2.5 V. From graph I_X = 0.5 A, I_R = 0.5 A. Thus I = 0.5 + 0.5 = 1.0 A. 
30	**A**	$R_{Tot} = \left(\frac{1}{R}+\frac{1}{6.0}+\frac{1}{3.0}\right)^{-1} + 10 + \left(\frac{1}{40}+\frac{1}{10}\right)^{-1}$. When R = ∞, max $R_{Tot} = \left(0+\frac{1}{6.0}+\frac{1}{3.0}\right)^{-1} + 10 + \left(\frac{1}{40}+\frac{1}{10}\right)^{-1} = 20\ \Omega$. When R = 0, min $R_{Tot} = 0 + 10 + \left(\frac{1}{40}+\frac{1}{10}\right)^{-1} = 18\ \Omega$.
31	**C**	Magnetic force on XY and ZW = nBIL = 20 × 0.83 × 4.5 × 0.17 = 0.635 N Torque of couple due to forces on XY and ZW = 0.635 × 0.11 N m
32	**C**	The magnetic flux $\phi = BA$ has the same value at all locations in the core at any point in time. Therefore $\Delta\phi$ is the same for any cross-section of the core. Consequently, the smaller the cross-sectional area A, the greater the variation in the magnetic flux density B.
33	**B**	$f = \frac{1}{T} = \frac{1}{25 \times 10^{-3}} = 40$ Hz , $V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{110}{\sqrt{2}} = 78$ V
34	**A**	The wavefunction on the other side of the potential barrier must have the same wavelength as the incident wavefunction, since the electron energy must stay constant. However the probability of finding the electron on the other side of the barrier is smaller, so the wavefunction after the barrier must have a smaller amplitude. Within the barrier, the wavefunction is that of an exponentially decaying function. It is also required that the wavefunction must remain smooth and continuous at the boundaries. Note that the diagram in each option of the question is composed of actually 2 sets of graphs superimposed together and could be better understood if separated as shown below: 

35	**D**	Use Einstein's Photoelectric Equation: $hf = W + (E_k)_{max}$.
36	**D**	The energy of a photon = *hf* = difference in energies between levels in a transition. 
37	**A**	Refer to Band Theory.
38	**B**	Do you know what the wavelength or frequency of red light is? And henceforth be able to calculate the energy of a red photon?
39	**C**	Number of neutrons in each nuclide = (Mass number – atomic number).
40	**C**	After time *t*, $\dfrac{\text{Number of Tin nuclei}}{\text{Number of Antimony nuclei}} = 6 \Rightarrow \dfrac{N}{N_o} = \dfrac{1}{7}$ But $\dfrac{N}{N_o} = \left(\dfrac{1}{2}\right)^{t/\text{half-life}}$ Thus $\dfrac{1}{7} = \left(\dfrac{1}{2}\right)^{t/60}$ giving t = 168.4 days.