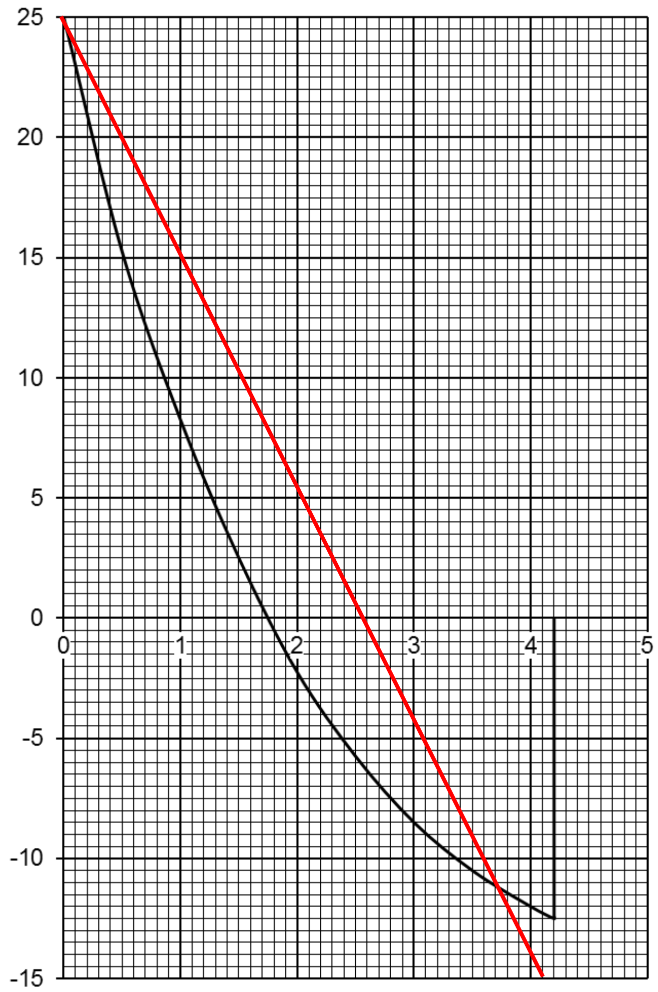
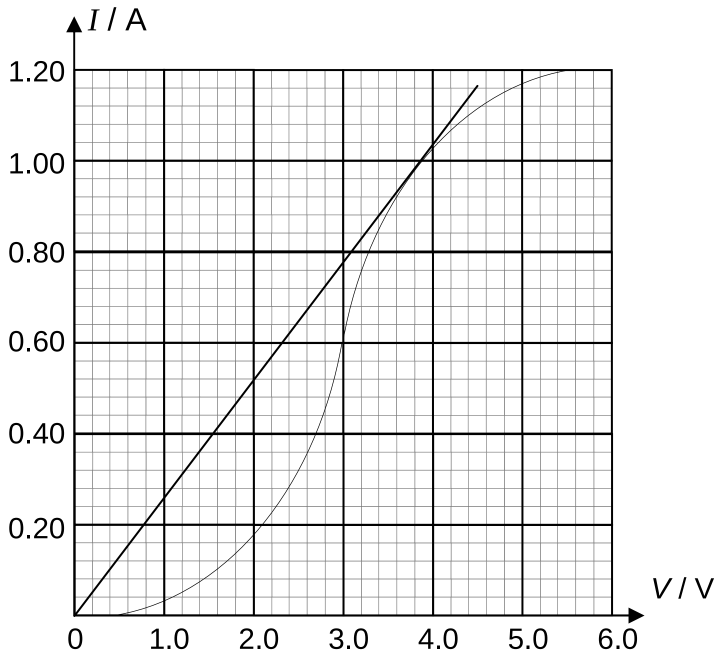
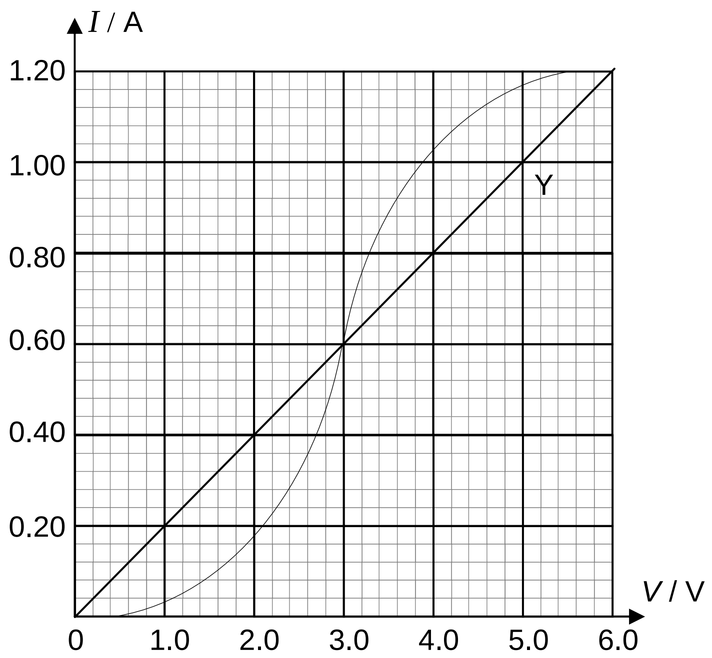
Answers to JC2 Preliminary Examination Paper 2 (H1 Physics)

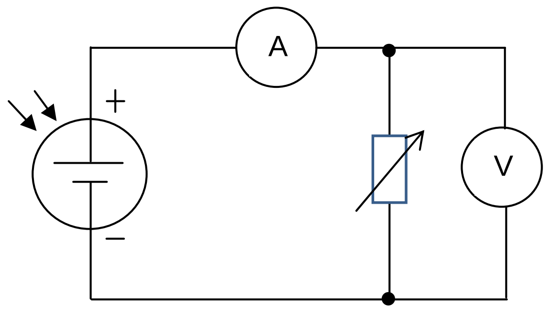
Suggested Solutions:

No.	Solution
1(a)	The gradient of the graph represents the acceleration, which is changing with speed. This suggests that the resultant force acting on the ball is changing with speed, and since weight is constant, it must have meant that air resistance changes with speed.
1(b)	For the upward motion, loss in k.e. = gain in g.p.e. + energy lost $\frac{1}{2}\times 0.350\times 25^2 = (0.350\times 9.81\times 19) + \text{energy lost}$ energy lost = 44.14 J For the downward motion, loss in g.p.e. = gain in k.e. + energy lost $0.350\times 9.81\times 19 = \left(\frac{1}{2}\times 0.350\times 12.5^2\right) + \text{energy lost}$ energy lost = 37.89 J Therefore, ratio $= \frac{44.14}{37.89}$ ≈ 1.16
1(c)(i)	1.75 s

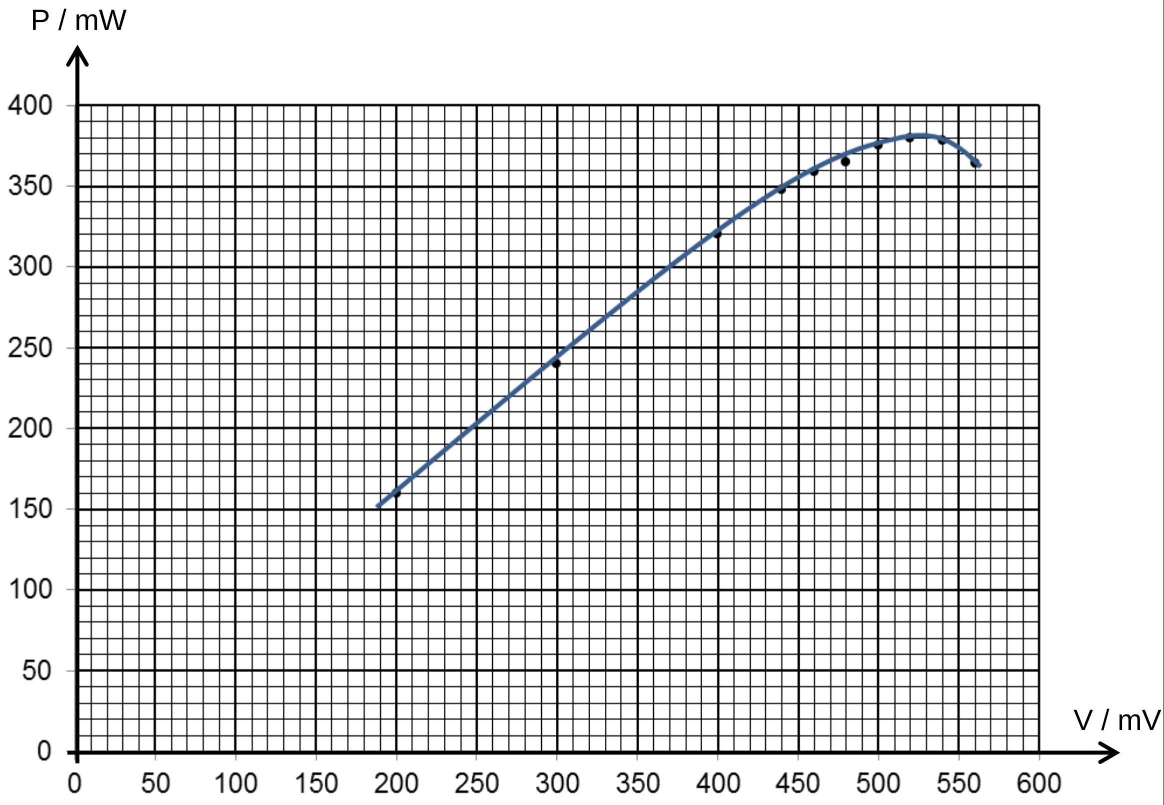
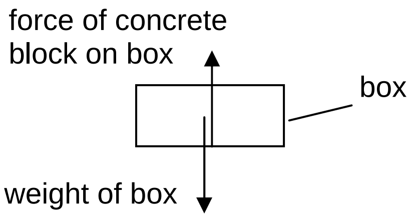
1(c)(ii)	
1(c)(iii)	Maximum height $= \frac{1}{2} \times 2.55 \times 25$ $\approx 31.9\,\text{m}$
2(a)	Initially, block B has maximum gravitational potential energy. When block B falls, it loses gravitational potential energy. Both block A and B gain kinetic energy. The spring stretches beyond its original length and there is an increase in elastic potential energy in the spring. As the spring gains elastic potential energy and stretches the system beyond its equilibrium position, there is loss in kinetic energy of the blocks. The blocks come to a rest momentarily when block B has fallen to a maximum distance. At this position, the elastic potential energy in the spring is equal to the total loss in gravitational potential energy of block B. The kinetic energy of the blocks is zero.

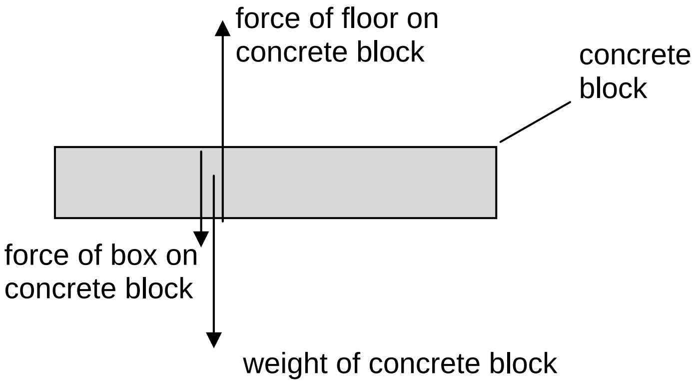
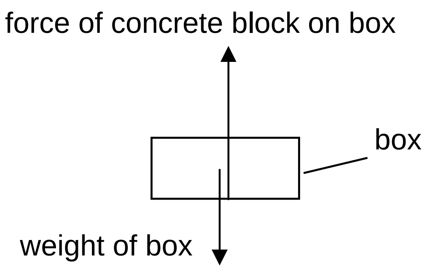
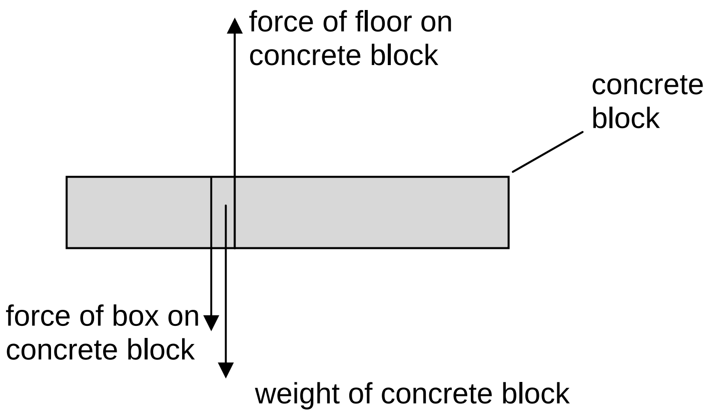
2(b)(i)	When block B has fallen to its maximum distance, it comes to rest momentarily. Let the maximum distance fallen be *h*. Loss in GPE of block B = Gain in EPE in spring $mgh = \frac{1}{2}kx^2$ $mgh = \frac{1}{2}kh^2$ $h = \frac{2mg}{k} = \frac{2(10)(9.81)}{400} = 0.491$ m
2(b)(ii)	Half of the maximum distance = $\frac{1}{2}(0.491) = 0.24525$ m loss in GPE of block B = gain in EPE of spring + gain in KE of blocks A and B $mgh' = \frac{1}{2}kx'^2 + \frac{1}{2}(M+m)v^2$ $\frac{1}{2}(2+10)v^2 = 10(9.81)(0.24525) - \frac{1}{2}(400)(0.24525)^2$ $6v^2 = 12.0295$ $v = 1.42$ m s^{-1}
3(a)	 Smallest resistance of X = $\frac{3.8}{0.98}$ =3.9 Ω

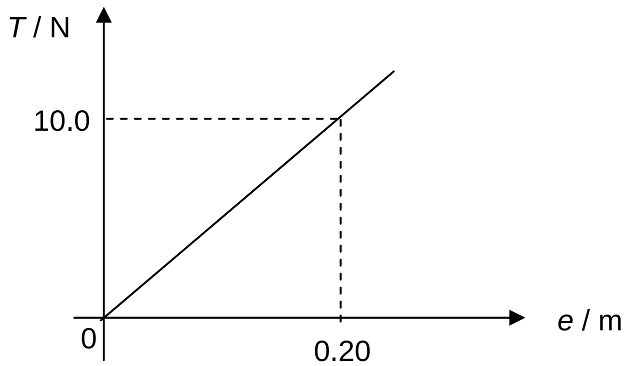
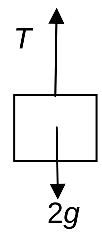
3(b)(i)	The ratio of the potential difference across the resistor to the current through it is 5.0.
3(b)(ii)	
3(b)(iii)	p.d. across X and resistor are both 5.0 V. Current = 1.18 + 1.0= 2.2 A
3(c)(i)	Current from battery = 0.76 A
3(c)(ii)	The current flowing through the circuit must be the same. At this current, p.d. across X = 3.2 V and p.d. across the resistor is 3.8 V. The total p.d. is 7.0 V.
4(a)	Magnetic flux density is defined as the force acting on a conductor of unit length, carrying unit current, placed perpendicularly to the magnetic field.
4(b)(i)	By the principle of moments/for rotational equilibrium, $\sum$clockwise moment $=\sum$anti-clockwise moment $(BI\ell)(w)=(mg)(d)$ $B=\dfrac{mgd}{I\ell w}$ $=\dfrac{(50\times10^{-3})(9.81)(2.0\times10^{-2})}{(10)(3.0\times10^{-2})(5.0\times10^{-2})}$ $=0.654$ T ≈ 0.65 T

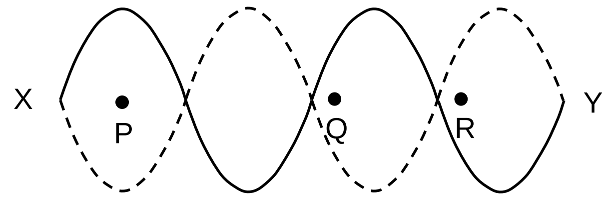
4(b)(ii)	It will be larger than the actual value If the weight of the wire is ignored, the additional clockwise moment caused by it will be wrongly attributed to the magnetic force, hence the value calculated will be larger than the actual value. OR A larger mass of brass weight is needed to balance the additional clockwise moment caused by the weight of the wire, causing the calculated value of *B* to increase.
5(a)	
5(b)	see table below

V /mW	*I* / mA	P / mW
460	780	359
480	760	365

5(c)	 [2]
5(d)	Maximum power = 380×10^{-3} W
5(e)(i)	Maximum power $= 380 \times 10^{-3} \times 8$ = 3.04 W
5(e)(ii)	Average power $= \dfrac{4}{24} \times 3.04$ $= 0.507$ W
6(a)(i)	If body A exerts a force on body B, then body B will exert the same type of force of equal magnitude but opposite in direction on body A.
6(a)(ii) 1.	

6(a)(ii) 2.	
6(a)(ii) 3.	The forces are the force of box on concrete block downwards and the force of concrete block on box upwards.
6(a)(iii) 1.	
6(a)(iii) 2.	
6(a)(iii) 2.	The forces are the force of box on concrete block downwards and the force of concrete block on box upwards.

6(b)(i)	
6(b)(ii) 1.	Applying Hooke's law, $F = ke \Rightarrow k = \frac{F}{e} = \frac{10.0}{0.20} = 50 \text{ N m}^{-1}$ At maximum extension = 4.0 – 2.5 = 1.5 m Maximum tension = (50)(1.5) = 75 N
6(b)(ii) 2.	$T - 2g = 2a$ $a = \frac{75 - 2.0 \times 9.81}{2.0} = 27.7 \text{ m s}^{-2}$  Vertically upwards.
6(b)(iii) 1.	Taking momentum upwards as positive, change in momentum = $mv - mu$ = (2.0)[1.5 – (–4.0)] = 11 kg m s^{-1} Direction is vertically upwards.
6(b)(iii) 2.	$F = \frac{\Delta p}{\Delta t} = \frac{11}{0.20} = 55 \text{ N}$
6(b)(iv)	It is not a violation of the conservation of momentum when the book and the Earth are taken as a single system. In this case, the force acting on the book by the Earth, that is the weight of the book, results in a reaction force of the book attracting the Earth. This will cause the Earth to 'move' upwards and thus net change in momentum is zero.
7(a)	Stationary waves are formed when two progressive waves with the same amplitude, frequency, speed and are moving in opposite direction meet and superpose.

7(b)	Stationary waves : Energy is not propagated Progressive waves: Energy is propagated. Stationary waves: particles in a stationary wave have varying amplitude between 2 nodes. Progressive wave: particles in a progressive wave have the same fixed amplitude.
7(c)(i) **7(c)(ii)** **7(c)(iii)**	
7(c)(iv)	Since the length of the string is 0.40 m and there are 4 antinodes, λ = 0.2 m $f = \frac{v}{\lambda} = \frac{80}{0.2} = 400\,\text{Hz}$
7(c)(v)	Tension in string, T Mass per unit length of string, μ Note: $v = \sqrt{\frac{T}{\mu}}$
7(d)(i)	A maximum is obtained at R when the waves in the two paths meet and <u>superpose constructively (constructive interference)</u> occurs. The <u>path difference</u> between the direct wave from T and the reflected wave (reflected at ground) is equivalent to <u>integer multiple of</u> λ.
7(d)(ii)	Minimum path difference = 1 λ = 2000 m (Distance of path taken by reflected wave) – (2.4×10^4) = 1 λ (Distance of path taken by reflected wave) – (2.4×10^4) = 2000 m Distance of path taken by reflected wave =26000 m
7(d)(iii)	$f = \frac{c}{\lambda} = \frac{3\times10^8}{2.0\times10^3} = 1.5\times10^5\,\text{Hz}$
7(d)(iv)	The resonator is configured to resonate at a particular frequency, allowing the antenna to <u>amplify sinusoidal waves at that radio wave frequency</u>.
8(a)	Photoelectric effect is the emission of electrons from a metal surface when it is exposed to electromagnetic radiation of sufficiently high frequency.

8(b)(i)	$\text{intensity} = \frac{\text{power}}{\text{area}}$ $= \frac{nhf}{tA}$ $f = \frac{c}{\lambda} = 1 \times 10^{15}$ Hz $\left(\frac{n}{t}\right)_{photons} = 1.21 \times 10^{16}$
8(b)(ii)	$\text{current} = \frac{\text{charge}}{\text{time}}$ $= \frac{nq}{t}$ $\left(\frac{n}{t}\right)_{electrons} = 3.125 \times 10^{10}$
8(b)(iii)	2.58×10^{-6}
8(b)(iv)	Some of the incident photons were reflected from the surface of the metal and therefore not all the photons incident was absorbed. The second reason would be that although an electron in the metal may absorb an incident photon, it may be too deep inside the metal such that the electron could not escape from the metal.
(b)(v)	$hf = \Phi + eV_S$ $hf = \frac{h(3 \times 10^8)}{300 \times 10^{-9}} / 1.6 \times 10^{-19} = 4.14$ eV Stopping potential $= 1.1$ eV $\Phi = 3.04$ eV
8(c)	1. There is no time lag between photon incident and electron emission. If the arriving photon has an energy that is more than what is required to eject the photoelectron, this energy is instantaneously transferred to the electron. This accounts for the instantaneous emission without time lag. The electron can't accumulate energy over a period of time which is possible only if light is a wave. 2. Photoelectrons are emitted only when the frequency of the radiation exceeds the threshold frequency of the metal. This shows that photon is a packet of energy with fixed discrete amount of energy. 3. With increase in the intensity of the beam, the kinetic energy of the emitted electrons remains the same as shown by the constant stopping potential. This provides evidence that photon is a packet of energy with fixed discrete amount of energy. The packet of energy is the particulate nature.

8(d)(i)	13.6 eV – 3.4 eV = 10.2 eV = 1.63×10^{-18}J
8(d)(ii)	13.6 eV =2.18×10^{-18}J
8(d)(iii)	This photon will be absorbed as the electron need not be excited to any specific higher energy levels but instead will be ionised and it will leave with the remaining energy as its kinetic energy.