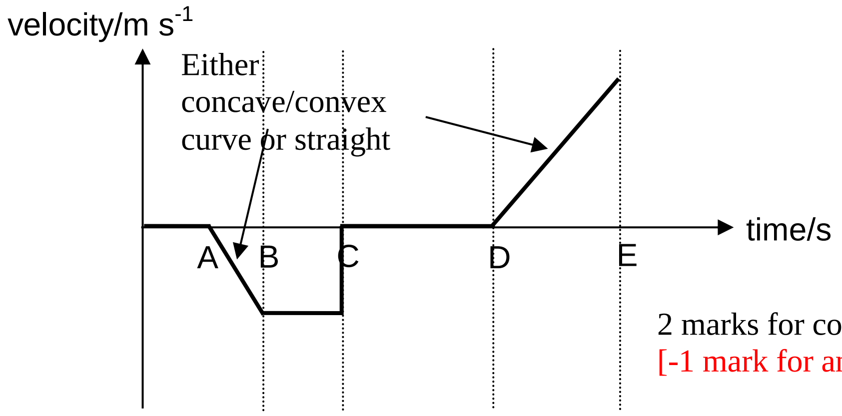
2015 MI H1Phy P2 solution

Section A:

1	**(a)**	The statement is invalid because Object is moving towards P as displacement from P is decreasing . **[1]** It is speeding up as (magnitude of) the gradient which denotes speed, is increasing with time **[1]** It is accelerating towards P as its speed is increasing towards P. **[1]**	B1 B1 B1
	(b)	Velocity is defined as the rate of change of displacement. **[1]**	B1
	(c)	 2 marks for correct graph [-1 mark for any part wrong]	

2	a) at equilibrium, forces in the vertical direction cancel out. Sum of vertical components of 8 cables' maximum tension = maximum weight of traffic + weight of section of roadway $8(T_{max}\sin 50°) = m_{traffic}g + m_{roadway}g$ **[1]** $8(7.8 \times 10^5 sin50°) = m_{traffic}(9.81) + (350 \times 10^3)(9.81)$ **[1]** $4.780 \times 10^6 = m_{traffic}(9.81) + 3.434 \times 10^6$ $m_{traffic} = 1.372 \times 10^5$ kg mass of traffic = <u>140</u> tonne **[1]** b) Increase in tension = force constant x extension Extension = increase in tension / force constant **[1]** $= \frac{5.2\times10^5}{7.0\times10^6} = 0.074$ m **[1]** Increase in extension = <u>0.074</u> m c) (i) This to ensure that the cable remains within its elastic limit, and returns to its original length when the traffic load is removed, **[1]** since the breaking tension could	

		extend far into the region of plastic deformation causing the bridge to sag permanently even if the cables are not broken. (ii) The flexible attachment allows the bridge to accommodate the expansion and contraction of the bridge as the temperature varies throughout the day. **[1]** (iii) This helps to spread out traffic mass, as lorries tend to be much heavier than cars, thereby preventing any section from being overloaded. **[1]** (iv) High-sided lorries have a high centre of gravity and large vertical surface area. They thus have a lower stability and experience a much greater wind force compared to cars. If they tilt or topple, they can cause damage to themselves, other vehicles and the bridge. **[1]**	

3	**(a)**		The principle of superposition of waves states that when **two or more waves of the same kind superimpose, the displacement of the resultant wave is the vector sum of displacements of the individual waves. [1]**	B1
	(b)		When the phase difference is π radians, Resultant amplitude: $A_R = (\sqrt{5} - 1)X$ **[1]** Intensity $I = kA^2$ Wave 1: $I_1 = kX^2$ Wave 2: $I_2 = k(\sqrt{5}X)^2$ The resultant intensity $I_R = k(\sqrt{5} - 1)^2 X^2 = (1.53)\ kX^2 = 1.53\ Y$ **[1]**	A1 A1
	(c)	**(i)**	Young's Double slit formula $x = \frac{\lambda D}{a}$ Rearrange: $D = \frac{a}{\lambda}x$ gradient = a/λ where a is the separation between slits. **[1]** From the graph, gradient $= \frac{5}{10 \times 10^{-3}} = 500$ **[1]** Hence a = gradient x λ = 500 x 530 x 10^{-9} m = 2.65 x 10^{-4} m **[1]**	M1 C1 A1
		(ii)	$D = \frac{a}{\lambda}x$ When a is halved, the gradient of the graph will be halved. **[1]** Slope of line Z is 250. The fringe separation x will be doubled but the intensity remains the same. **[1]**	M1 A1

4	**(a)**	(i)	Fixed Resistor / ohmic conductor / metal at constant temperature **[1]**	A1
		(ii)	Thermistor **[1]**	A1
	(b)	(i)	6V **[1]**	A1
		(ii)	3 mA **[1]**	A1
		(iii)	Resistance of P = 6 / 6 x 10^{-3} = 1000 Ω **[1]** Resistance of Q = 6 / 3 x 10^{-3} = 2000 Ω **[1]** Effective resistance $= \frac{1000 \times 2000}{1000 + 2000} = 667\ \Omega$ **[1]**	M1 M1 A1
	(c)	(i)	Terminal p.d. = 3 + 6 **[1]** = 9 V **[1]**	M1 A1

		(ii)	Rate of heat dissipated by the battery = I^2R = $(3 \times 10^{-3})^2 \times 2$ = 1.80×10^{-5} W **[1]**	A1

5	a) If $g \propto 1/x^2$, then $g = k/x^2$ where k is some constant of proportionality. Hence the product gx^2 should be a constant. Reading off the graph for values of x and g, tabulate the results below. (table below)	

x	x^2	g (m s^{-2})	gx^2
r	r^2	9.8	$9.8r^2$
$2r$	$4r^2$	2.5	$10r^2$
$3r$	$9r^2$	1.1	$9.9r^2$
$4r$	$16r^2$	0.6	$9.6r^2$
$5r$	$25r^2$	0.4	$10r^2$

Working out at least 3 values of gx^2 **[2]**
Since the product of gx^2 is approximately constant ($\approx 10r^2$) for five consecutive readings beyond the Earth's surface**[1]**, it can be concluded that g is inversely proportional to x^2.

b) Since $g \propto 1/x^2$, at $x = 60r$,

$$g = \left(\frac{1}{60}\right)^2 g_{\text{Earth surface}}\ [1] = \left(\frac{1}{60}\right)^2 (9.8) = 2.7 \times 10^{-3}\ \text{m s}^{-2}\quad \textbf{[1]}$$

g at the Moon's distance = $\underline{2.7 \times 10^{-3}}$ m s^{-2}

c) Since $g \propto 1/x^2$, then $x = \frac{1}{\sqrt{g}}$, hence

$$\frac{r_{\text{Orbit}}}{r_{\text{Earth}}} = \sqrt{\frac{g_{\text{Earth}}}{g_{\text{Orbit}}}} \Longrightarrow r_{\text{Orbit}} = r_{\text{Earth}}\sqrt{\frac{g_{\text{Earth}}}{g_{\text{Orbit}}}} = (6370)\sqrt{\frac{9.8}{8.81}} = 6718\ \text{km}\ \textbf{[1]}$$

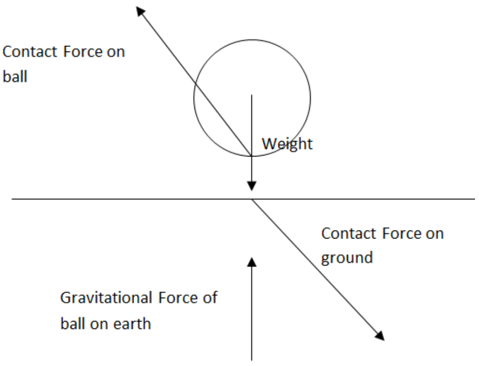
The height of the Station above the Earth,

$$h = r_{\text{Orbit}} - r_{\text{Earth}} = 6718 - 6370 = 348\ \text{km}\ \textbf{[1]}$$

height of the Station = <u>348</u> km

Section B:

6 (a)	Kinetic energy is a scalar and has no direction while momentum is a vector and has direction. **[1]**	B1
6 (b)(i)	mv **[1]**	A1
6(b)(ii)	0.5 mv^2 **[1]**	A1
6(c)	mv=2.4	

	$0.5\ mv^2=45$ $v=37.5\ ms^{-1}$ **[1]** $m=0.064$ kg **[1]**	A1 A1
6(d)(i)	F=ma, $a= 3125\ ms^{-2}$ at=v - u (3125)(t)=37.5 - 0 **[1]** ⇒ t = 0.012 s **[1]**	M1 A1
6(d)(ii)	$s = ut + 0.5at^2$ $= (37.5)(0.012)+0.5(-3125)(0.012)^2$ **[1]** = 0.225 m **[1]**	M1 A1
6(e)(i)	Ft =160 (0.025) **[1]** $\Delta p = 4.0 \Rightarrow p_f - p_i = 4.0 \Rightarrow p_f = 4.0\ kg\ m\ s^{-1}$ **[1]**	M1 A1
6(e)(ii)	$v = 62.5\ m\ s^{-1}$ **[1]**	A1
6(f)	Change in KE = $KE_{final} - KE_{initial}$ = ½ (0.064) $(62.5)^2$ - 45 = 80 J **[1]** Mean power = change in KE / total time = 80 / (0.037) **[1]** = 2162 W **[1]**	C1 C1 A1
6(g)	As the tennis racket hits the ball, the racket strings undergo extension. The force exerted by the string increases as the string elongates **[1]**, according to Hooke's Law. Therefore, it is unlikely that a constant force can be applied. **[1]**	M1 A1
6(h)	 correct diagram with contact and weight on ball [1] action-reaction pair for ground-ball [1] action-reaction pair for earth-ball [1]	A1 A1 A1

7	a) (i) The phenomenon is the photoelectric effect. A monochromatic source of electromagnetic radiation is incident on a metal electrode E (Emitter). **[1]** If the radiation has a frequency above emitter E's threshold frequency f_o, photoelectrons will be emitted from E. The existence of a threshold frequency f_o, below which no photoelectron is emitted, proves that electromagnetic radiation comprises discrete quanta, each of energy hf_o. **[1]** The dependence of the stopping potential V_s on the photon energy hf_o rather than radiation intensity is further proof of the particulate nature of radiation. **[1]**	

The absence of a noticeable time delay between the arrival of the incident photons and the emission of the photoelectrons is another piece of evidence that photons interact individually with the photoelectrons which absorb their energy. **[1]**

(ii) The phenomenon is interference.
A two-source interference is set up using visible light (wavelength between 400 nm and 750 nm). Light from the source is first passed through a single slit which acts as a single point source for the two slits separated a distance *a* apart. **[1]**

The bright regions are locations where waves from the two slits arrive in phase and undergo constructive interference. **[1]**

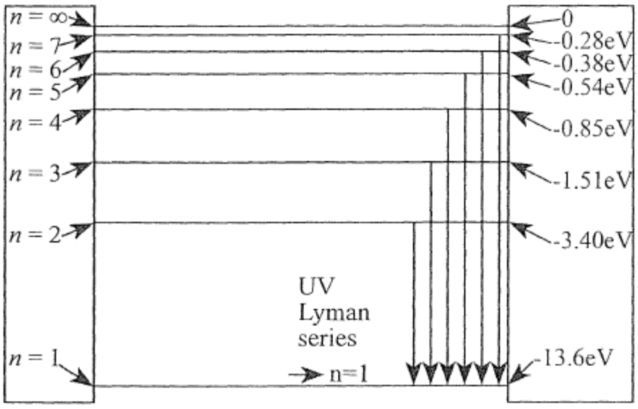
The dark regions are locations where waves from the two slits arrive anti-phase and undergo destructive interference. **[1]**

The ability to undergo superposition to produce an interference pattern demonstrates the wave nature of electromagnetic radiation.

b) deBroglie wavelength $\lambda = \frac{h}{mv}$ **[1]** $= \frac{6.63\times10^{-34}}{(9.11\times10^{-31})(8.37\times10^{6})}$ **[1]**
$= 8.70 \times 10^{-11}$ m **[1]**

wavelength = $\underline{8.70 \times 10^{-11}}$ m

c) (i) The energy levels for the other five values in the table are shown in the figure below.



[2]

(ii) The arrows, showing the energy released when an electron moves to level 1 from each of the higher levels, are shown in the figure above. **[1]**

(iii) wavelength, $\lambda = \frac{hc}{E_4 - E_2}$ **[1]** $= \frac{(6.63\times10^{-34})(3.00\times10^{8})}{-1.36\times10^{-19} - 5.43\times10^{-19}}$ **[1]**
$= 4.89 \times 10^{-7}$ m **[1]**

wavelength = $\underline{4.89 \times 10^{-7}}$ m

(iv) Visible light falls between 400 nm (violet) and 750 nm (red).
radiation is <u>visible light</u> **[1]**

(v) The photons of ultraviolet **[1]** radiation have individual energy slightly greater than that of visible light.

d) Bohr's theory of the hydrogen atom models the electron as being in a circular orbit about the nucleus comprising a single proton. This model is reasonably accurate due to the radial symmetry of the single-electron hydrogen.
However, in multi-electron atoms where there are interactions between electrons, the assumption of the model is not accurate.

8

a) (i) Total length of the coil
$= 1500 \text{ turns} \times \text{circumference of the tube}$

$= 1500(2\pi r) = 1500(2\pi)(22 \times 10^{-3})[\mathbf{1}] = 207 \text{ m}$ **[1]**

length = <u>210</u> m

(ii) Resistance, $R = \rho l / A$, where ρ is the wire's resistivity, l its length and A its cross-sectional area.

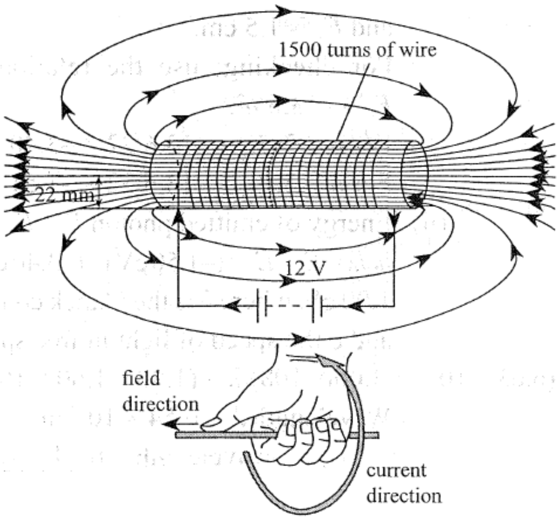
$R = \frac{\rho l}{A}[\mathbf{1}] = \frac{\rho l}{\pi r^2} = \frac{(1.7\times10^{-8})(207.3)}{\pi(0.86\times10^{-6})^2}[\mathbf{1}] = 1.52\ \Omega$ **[1]**

resistance = <u>1.5</u> Ω

(iii) Current, $I = \frac{E}{R} = \frac{12}{1.516}[\mathbf{1}] = 7.92 \text{ A}$ **[1]**

current = <u>7.9</u> A

b) The magnetic field pattern within and around the solenoid is shown below. The direction is determined by the right-hand grip rule with the fingers of the right hand wrapped around the direction of the current, the thumb points in the direction of the magnetic field.



Parallel field lines within solenoid [1]

Field lines around solenoid [1]

Direction of arrows [1]

c) (i) When a current *I* flows through the rectangular coil in the direction of CD, it produces a magnetic field that interacts with the magnetic flux density *B* of the solenoid. **[1]**

Since the current in CD is perpendicular to the magnetic field, a magnetic force F acts on CD. The direction of F can be determined by Fleming's left hand rule. **[1]**

The turning effect (moment) of the magnetic force F is the product of the force and the perpendicular distance (either CB or DE) from the line of action of the force to the pivotal axis BE. **[1]**

(ii) The magnetic force $F = BIL\sin\theta$. The direction of the current in CB is parallel to that of the magnetic flux density ($\theta = 0°$), while that in DE antiparallel ($\theta = 180°$). Since $\sin 0° = \sin 180° = 0$, no magnetic force acts on CB and DE. **[1]**

(iii) 1. From C to D (out of the plane of the paper). **[1]**

2. From the principle of moments, for the rectangular coil to remain in equilibrium, the additional anticlockwise moment due to the magnetic force about the pivot BE must equal the clockwise moment due to the rebalancing force of 5.7×10^{-4} N. **[1]**

$(BIL \sin 90°)(0.106 \text{ m}) = (5.7 \times 10^{-4} \text{ N})(0.077 \text{ m})$ **[1]**
$(BIL)(0.106) = 4.389 \times 10^{-5}$ N m
$B (4.9) (0.025) = 4.14 \times 10^{-4}$ N **[1]**
$B = 3.38 \times 10^{-3}$ T.

Magnetic flux density = 3.38×10^{-3} T **[1]**
Full name of unit = tesla **[1]**