2014 Prelim Exam 2 - H1 Physics Paper 2 Solutions

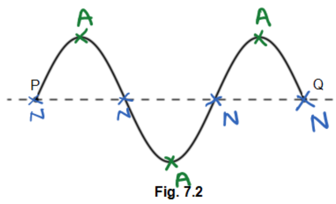
Q		Comments
1(a)	$a = g \sin 40°$ [C1] $= 6.31$ m s^{-2} [A1]	
1(b)	Kinematics method: Distance travelled down the slope AB = 5.3 ÷ sin40° = 8.245 m [C1] Using $v^2 = u^2 + 2as$, $v_B^2 = 2.5^2 + 2(6.30)(8.245)$ [M1, can award even for using wrong value of *s*] $v_B = 10.5$ m s^{-1} [A0]	
1(c)	Find time taken to travel down the slope AB, t_{AB}: Using $v = u + at$, 10.5 = 2.5 + 6.30 t_{AB}. $t_{AB} = 1.27$ s [C1] For the constant speed motion along BC, distance = speed x time: Length of BC = 10.5 x (2.5 – 1.27) [M1, award for use of constant speed] = 12.9 m [A1]	
1(d)	Work done by friction = frictional force x length of CD = 290 x 3.1 = 899 J [C1] By the Principle of Conservation of Energy: Loss in KE along CD = Gain in GPE + WD against friction [M1] $\frac{1}{2}(250)(10.5^2 - v_D^2) = (250)(9.81)(3.1 \sin 28°) + 899$ [C1] = 8.63 m s^{-1} [A1]	
1(e)	Spring constant k = F/x = 80000 / 1.5 = 53333 N m^{-1} [M1] By the Principle of Conservation of Energy: Loss in KE = Gain in EPE $\frac{1}{2}(250)\ 3.0^2 = \frac{1}{2}(53333)(x)^2$ [C1] x = 0.205 m [A1]	
2(a)	The <u>ratio of V / I values</u> for resistor R obtained from the figure is a constant of 20 Ω [B1]	*Many students mentioned that the resistance is given by the inverse gradient of the graph which is incorrect. Resistance is always given by the ratio of V/I which is a constant at any point on the graph.*
2(b)(i)	When *E* = 4.0 V, current in the battery = current through Y + current through R	*Generally well done, except that some students failed to sum the*

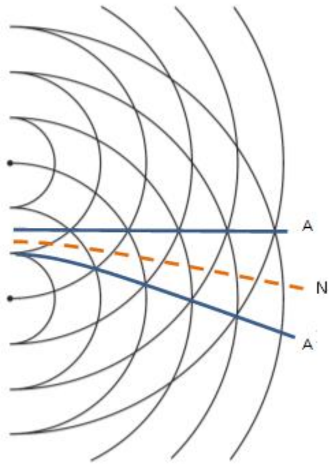
	$= 0.09 + 0.2$ $= 0.29$ A [A1]	*current through both components and only gave the current through resistor R.*
2(b)(ii)	When $E = 8.0$ V, Resistance of Y = Resistance of R $= 20\ \Omega$ [M1] Hence, total resistance = $R_Y // R_R$ $= 10\ \Omega$ [A1] **OR** Total current through the battery = 0.8 A [M1] Total resistance = $E / I = 8.0 / 0.8 = 10\ \Omega$ [A1]	*Generally well done.*
2(c)(i)	e.m.f E of the battery = p.d. across Y + p.d across R $= 6.0 + 4.0$ $= 10$ V [A1]	*Generally well done.*
2(c)(ii)	Power Ratio = $I^2 R_Y / IE$ $= I^2\left(\frac{V_y}{I}\right) / IE$ $= \frac{V_y}{E}$ [M1] $= 6.0 / 10$ $= 0.60$ [A1]	*Many students misread the pd. across component Y to be 0.4 instead of 0.6. 0.4 is the p.d across the resistor instead.*
3(a)(i)	Work function energy is the <u>minimum energy</u> of a photon needed to <u>emit an electron</u> from the metal surface. [B1]	*Quite well done. However, weaker students have the misconception that the photons are emitted from surface or they could have left out the word 'minimum' energy of the photon.*
3(b)(i)	<u>Method 1 (Substituting one value on the line to photoelectric equation)</u> $E_{photon} = \phi + E_{Max}$ $6.63 \times 10^{-34} \times 4.0 \times 10^{15} = \phi + 2.0 \times 10^{-18}$ [C1] $\phi = 6.52 \times 10^{-19}$ J [A1] <u>Method 2 (Finding threshold frequency)</u> Extending the line to the x axis allow the threshold frequency f_0 to be obtained, hence $f_0 = 1.0 \times 10^{15}$ Hz (allow $\pm 0.05 \times 10^{15}$) [C1] Work function energy = $hf_0 = 6.63 \times 10^{-34} \times 1.0 \times 10^{15}$ $= 6.63 \times 10^{-19}$ J [A1]	*A significant no. of student managed to work out the solution. However many graphical errors were made, e.g. they should not simply use from the lowest value on the line given, equating gradient which is h to work function energy. Though the question requires the answer to be in J, there are some who converted their correct answer to eV.*
3(b)(ii)	<u>Energy is required to bring other electrons deeper in the metal to the surface</u> [B1]. The electron at the <u>metal surface</u> require the least amount of energy to be emitted, hence it has the <u>maximum kinetic energy</u> [B1]. Hence there is a range of kinetic energy up to a maximum value for the electrons.	*Poorly attempted. Many wrongly thought that the energy of photons can be varied, even though the frequency of photon is fixed while other may have the wrong idea that work function energy is different for electrons at different depth in the metal. A significant no wrongly use the concept of X-ray in this situation.*
3(b)(iii)	A <u>straight line with the same gradient</u> [B1] that is displaced to the left with a <u>smaller x-intercept</u> [B1].	*Surprisingly, many students are unable to plot the graph. Many did not extend the line to cut the x-axis to show a smaller work*

		function energy. Others wrongly thought that a smaller work function energy cause the gradient of the graph to change.
3(c)	Intensity of the incident radiation <u>does not affect the energy of each photon</u> [M1] (but determines the rate of photon arrival on the metal surface). With the <u>work function energy of the same metal unchanged [A1]</u>, the maximum kinetic energy of the photoelectron remains the same, i.e. is not affected. Alternative solution Intensity of the incident radiation <u>does not affect the energy of each photon</u> [M1] (but determines the rate of photon arrival on the metal surface). Since <u>the interaction between the photon and electron is a 1 to 1</u> [A1], the maximum kinetic energy of the photoelectron remains the same, i.e. is not affected.	*Poorly done. Many misinterpreted and went on to explain how intensity of the radiation affect photocurrent, instead of why intensity does not affect maximum kinetic energy of the photons. Students are strongly encouraged to explain in words, rather than stating the photoelectric equation with symbol unexplained.*
4(a)	From zero to *r*, the acceleration due to gravity increases as the <u>mass of the Earth beneath that point increases</u>. Thus, the gravitational acceleration becomes bigger until it reaches the Earth's surface. [B1]	
4(b)	Since $g \propto \frac{1}{x^2}$, then $g = \frac{k}{x^2}$ where *k* is the proportionality constant Thus, $gx^2 = k$ = constant [B1] Taking at least 3 points from the graph x | g / m s^{-2} | gx^2 | %diff from average 1.1r | 8.00 | 9.68r^2 | +0.4% 3r | 1.07 | 9.63r^2 | -0.1% 4r | 0.60 | 9.60r^2 | -0.4% | Average | 9.64r^2 | [M1] Since the product $gx^2 = k$ for the three values are less than 5%, *g* obeys the inverse square relation. [A1]	
4(c)	Assuming the relation is Using g = 9.64r^2/x^2 $g = \frac{9.64r^2}{(60r)^2}$ [M1] *g* at Moon's distance = 0.00268 m s^{-2} [A1]	
4(d)(i)	Since *g* obeys the inverse square relation $g \propto \frac{1}{r^2}$ Then, $\frac{g_{r+h}}{g_r} = \left(\frac{r}{r+h}\right)^2$ $\frac{8.81}{9.81} = \left(\frac{6370}{6370+h}\right)^2$ [M1]	

	$h = 352\ km$ [A1]	
4(d)(ii)	The above equation is only valid if the work done is near the Earth's surface where *g* is still 9.81 m s^{-2}. [B1] At greater height, the value of *g* decrease significantly as can be seen in Fig. 7.1. Hence, the above equation is not valid. [B1]	
5(a)(i)	*BI* sin ϑ ..[B1].	*Generally well done*
5(a)(ii)	Into the paper [B1]…	*Many students mentioned that the direction of the force was 'downwards' instead of 'into the paper' which is an incorrect description for a 3D perspective.*
5(a)(iii)	$I = \frac{Q}{t}$ $I = \frac{ne}{t}$ $I = \frac{(5.60 \times 10^{21})(1.60 \times 10^{-19})}{60}$ [M1] $I = 15.0$ A [A1] Therefore, *F* / *L* = *BI* sin 30° = (2.60 x 10^{-2})(15.0)(0.5) [M1] = 0.194 N m^{-1} [A1]	*Generally well done. Some students however did not take into account the number of electrons flowing through the conductor was for 1 minute instead of per second.*
5(b)(i)	- Concentric circles, anticlockwise [B1] - Increasing separation distance between concentric circles [B1]	*Students should only draw 4 concentric circles with increasing separation distance around conductor X only as the required by the question.*
5(b)(ii)	To the left towards conductor X [B1]	*Generally well done.*
5(c)(i)	Magnetic flux density caused by conductor X = $2.0 \times 10^{-7}\left(\frac{4.0}{0.03}\right)$ [M1] = 2.7 x 10^{-5} Force per unit length acting on conductor Y = BI_Y = 2.7 x 10^{-5} (6.0) [M1] = 1.6 x 10^{-4} N m^{-1} [A1]	*Students who attempted this part did not clearly differentiate which current (4.0 A or 6.0 A) ought to be used in the given expression for magnetic flux density and which current to use when calculating the force per unit length on conductor Y. Those who could not show clearly, this substitution were not given credit.*
5(c)(ii)	The forces are equal.[B1] - The force depends on the product of the two currents which is the same [B1] OR	*Many failed to understand that the forces on both conductors are action and reaction pairs and the magnitude depends on the product of the currents flowing in the conductors. Hence, even*

	The forces are an action and reaction pair according to N3L [B1]	*though the currents were not equal, the forces acting on both conductors are still equal.*
5(d)(i)	The separation distance will decrease (the coil will be compressed) [B1] - The current flowing in both the loops of the coil is in the same direction, [B1] Hence, they are attractive leading to a reduction in separation of the two loops [B1]	*Quite a number of students could in fact apply the understanding from parts (c) to answering this part correctly. Those students could also clearly explain the 3 points convincingly and were given full credit.*
5(d)(i)	When the separation distance is unchanged, Weight of mass = Attractive force between the loops of the coil [M1] $mg = BIL$ $= 2.0 \times 10^{-7}\left(\frac{I}{x}\right)IL$ $(0.3 \times 10^{-3})(9.81) = 2.0 \times 10^{-7}\left(\frac{I^2}{0.0075}\right)(2\pi)(0.047)$ [M1] I = 19 A [A1]	*Though quite a handful of students could apply the required concept to calculate this part, the conversion of units and substitution of the required values into the relevant expressions were often done incorrectly, leading to wrong computation.*
6(a)(i)	Work done by a force is defined as the product of the force and the displacement in the direction of the force. [B1]	
6(a)(ii)	Define both quantities to be different. Or having same base units need not mean that the quantities are the same. [B1]	
6(b)(i)	While leaping upward, GPE increase = 70 x 9.81 x 0.45 = 309 J [B1] Decrease in KE = increase in GPE = 309 J [B1] KE at the highest point = ½ $(70)(3.7)^2$ – 309 = 170 J [B1] Energy is conserved or no work done against air resistance since that is negligible. [B1] (note: penalize for saying KE at highest point = 0 J)	
6(b)(ii)	Gravitational potential energy decreases by 3.0 x 9.81 x 8.2 = 241J [B1] Kinetic energy increases by ½ x 3.0 x 5.8^2 = 50.5 J [B1] Work done against friction = decrease in GPE – increase in KE [C1] = 241 – 50.5 = 191 J [A1]	
6(b)(iii)	Gravitational potential energy decreases by (0.050) x (9.81) x (0.45) = 0.221 J [B1] Kinetic energy did not change. Work done against viscous force = decrease in GPE = 0.221 J [B1]	
6(c)(i)	EPE = (Triangular area enclosed by the line and the x-axis, up to M = 3.2 kg) x 9.81 Triangular area = [1/2 x 3.2 x 0.12] = 0.192 [M1]	

	EPE = 1.88 J [A1]	
6(c)(ii)	Since the mass is in equilibrium, the tension in the spring = weight of mass M [M1] k x 0.12 = 3.2 x 9.81 [M1] k = 260 N cm^{-1} [A0]	
6(c)(iii) 1.	increase in GPE = mgΔh = 3.2 x 9.81 x 0.036 = 1.13 J [A1]	
6(c)(iii) 2.	decrease in EPE = ½ $(262)(0.12)^2$ – ½ $(262)(0.12 – 0.036)^2$ [C1] = 0.96 J [A1]	
6(c)(iii) 3.	The answers are not the same because work is done on the mass by the hand in raising the mass [B1] and this has to be considered such that: The increase in GPE = (decrease in EPE) + WD by hand [B1]	
7(a)	Interference refers to the result/effect/outcome/phenomenon of two or more waves of the same type overlapping/superimpose.	It is important to state that the waves of the same type.
7(b)(i)	v = fλ λ = 40 / 50 [M1] λ = 0.80 m [A1]	
7(b)(ii)	The wave from P travel along string and reflect at Q [B1]. Hence the 2 waves travel in opposite directions. The incident and reflected waves, which have the same amplitude, speed and frequency/wavelength travelling in opposite directions, interfere / superpose to form a stationary wave [B1]	Most students did not get the second mark. Students must continue to describe the overlapping of 2 waves and the conditions for stationary wave formation are met.
7(b)(iii) 1.	 Fig. 7.2 nodes labelled at P, Q and the two points at zero displacement [B1] antinodes labelled at the three points of maximum displacement [B1]	The nodes and antinodes must be labelled accurately at the positions. Students can consider to use "crosses" to mark out the positions accurately.
7(b)(iii) 2.	Length of PQ is equal to 1.5λ PQ = 1.5 × 0.80 = 1.2 m [A1]	
7(b)(iii) 3.	horizontal line through PQ drawn on Fig. 5.2 [B1] T = 1 / f = 1/50 = 0.020s = 20 ms [B1] 5 ms is ¼ of cycle [B1]	A number of students have a misconception that the next wave form is to the right.
7(c)(i)	To produce 2 water waves with circular wavefronts, 2 (ball-typed) dippers are used. [B1] To ensure that they are coherent, the dippers are connected to the same vibrator source / motor. [B1] [Note: Also accept 1 dipper as source and 2 slits] For observations of interference patterns, a lamp is set-up above the tank and a screen below the tank. [B1]	For the source of waves, the use of loudspeakers or the dropping of 2 balls into the water simultaneously are not acceptable. The lamp and screen are not mentioned by most students.

7(c)(ii)	 1. two correct lines labelled A [B1] correct line labelled N [B1]	Using the ruler to draw the antinodal may not be a good idea, as the line needs to pass through all the points where constructive interference took place, and joining these points may not give a fully straight line.
7(d)(i)	$v = f\lambda$ $320 = 400\lambda$ [M1] $\lambda = 0.80$ m [A1]	
7(d)(ii)	Distance SPX is 7.0 m and distance SX is 5.0 m, hence the path difference is 2.0 m which is equivalent to 2.5 λ. [M1] If there's no phase change of π radians at P, the waves would have met anti-phase and minimum occurs. Since, in this special case, there's a π radians of phase change upon reflection at P, the 2 waves meet in phase instead. It results in a maximum. [A1]	Most students did not approach this question by working out the path difference as the first step. A number of students who attempted to work out the path difference used (5.0 – 4.0 =1.0 m), which is wrong.