Assessment Schedule – 2015

Scholarship Physics (93103)

Evidence Statement

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)(i)	The photoelectric effect is the observed release of electrons when sufficiently energetic photons impact on the metal surface. Below the energetic threshold, no electrons are released. At the energetic threshold, electrons of zero kinetic energy are produced. The incident photon delivers a fixed amount of energy ($E = hf$). The incident energy of the photon equals the kinetic energy of the liberated electron plus the energy required to liberate the electron (work function).	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(ii)	The classical explanation should have resulted in a time delay of the release of the electrons – no time delay was measured. No lower limit would exist for the incident frequency to eventually release electrons. Idea of the photon is required to explain the phenomenon.			
(b)	Similarities: • Both experience a centripetal force, and both forces are inversely proportional to the square of the orbital radius. • Both orbit about the centre of mass of the system (not about the centre of mass of the more massive object in the system). Differences: • The centripetal force is supplied by electrostatic attraction in the hydrogen atom and by gravitational force in the Earth / Moon system. • The electron orbits are obviously quantised (restricted to specific possible values), while the possible orbital radius of the Moon is effectively continuous. (The gap between the quantum levels of the Moon's orbit is unmeasurably small.)			
(c)(i)	At maximum, both waves arrive in phase. As the frequency increased, the wavelength decreases (constant velocity) and therefore, as the path difference is constant, at some frequency the waves will be completely out of phase (minima).			
(ii)	The lowest frequency to generate a maximum = 200 Hz. The longest wavelength is 1.2 m. The path difference is unchanged throughout. This means that at 200 Hz the path difference was 1 wavelength which is 1.2 m. Speed of sound = $f\lambda$ = 240 m s^{-1}			

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TWO (a)	At the top $\frac{mv^2}{r} = mg$ $r = r_2 - \frac{\pi r_1}{2}$ $v^2 = g(r_2 - \frac{\pi r_1}{2})$	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(b)	KE at start = KE at top + GPE gained $\frac{mv_i^2}{2} = mg\frac{(r_2 - \frac{\pi r_1}{2})}{2} + mg(2r_2 + r_1 - \frac{\pi r_1}{2})$ $v_i^2 = g(5r_2 - (\frac{3\pi}{2} - 2)r_1$			
(c)	The bat hitting the ball: $M_B V_B = M_B V_{B2} + mV_{Ball}$ (conservation of momentum – appropriate as long as assume batter doesn't apply an impulse during the collision) ½ $M_B V_B^2 =$ ½ $M_B V_{B2}^2 +$ ½ $m V_{Ball}^2$ (conservation of KE as stated in the question) $V_{Ball}^2 = \frac{M_B}{m}\left(V_B^2 - V_{B2}^2\right) = \frac{M_B}{m}\left(V_B + V_{B2}\right)\left(V_B - V_{B2}\right)$ $\left(V_B - V_{B2}\right) = \frac{mV_{Ball}}{M_B}$ $V_{Ball}^2 = \frac{M_B}{m}\left(V_B + V_{B2}\right) \times \frac{mV_{Ball}}{M_B}$ $V_{Ball} = (V_B + V_{B2}) = 2V_B$ (since the bat hardly slows at all)			
(d)	The linear velocity is reduced (there is GPE removed from the initial KE) but the angular velocity is increased (since the radius of the swing is reducing towards zero while the linear velocity is reducing to some fixed positive value).			

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THREE (a)	Vertical velocity component = $V\sin\phi$ Time to highest point = $\frac{v\sin\phi}{g}$ Total time of flight = $\frac{2v\sin\phi}{g}$ Range = Total time of flight × Horizontal component of velocity $R=\frac{2v\sin\phi}{g}\times v\cos\phi=\frac{2v^2\sin\phi\cos\phi}{g}$ $=\frac{v^2\sin 2\phi}{g}$	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(b)	$\sin 2\phi=R\frac{g}{v^2}=80\times\frac{9.81}{28^2}=1$ $\phi=45°$ Time of flight $=\frac{\text{Range}}{\text{Horizontal velocity}}=\frac{80}{28\cos 45°}$ $T=4.0406\text{ s}=4.04\text{ s}$			
(c)(i)	$R=80=R_1+R_2=\frac{28^2\sin 2\phi}{g}+\frac{14^2\sin 2\phi}{g}$ $\sin 2\phi=0.8\ \ \phi=26.56°$ $R_1=\frac{28^2\sin 53.2°}{9.81}=64\text{ m}\quad R_2=16\text{ m}$ Time to first bounce $=\frac{64}{28\cos 26.6°}=2.556\text{ s}$ Time from first to second $\frac{16}{14\cos 26.6°}=1.278\text{ s}$ Total time of flight $=3.83\text{ s}$			
(ii)	The second throw, with its lower elevation has a greater horizontal component velocity, and this allows for a shorter total flight time, despite the loss of speed caused by the bounce.			

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(d)	Time up $= \dfrac{v\sin\phi}{g}$ Distance gained up $= \dfrac{v^2\sin^2\phi}{2g}$ Distance fallen $= \dfrac{v^2\sin^2\phi}{2g} + 2$ Time down $= \sqrt{\dfrac{2d}{g}} = \sqrt{\dfrac{2\left(\dfrac{v^2\sin^2\phi}{2g} + 2\right)}{g}}$ Total time of flight $= \dfrac{v\sin\phi + \sqrt{v^2\sin^2\phi + 4g}}{g}$ Range = Horizontal speed $\times$ time Range $= v\cos\phi\dfrac{v\sin\phi + \sqrt{v^2\sin^2\phi + 4g}}{g}$			

<table>
<tr><th>Q</th><th>Evidence</th><th>1-4 marks</th><th>5-6 marks</th><th>7-8 marks</th></tr>
<tr><td>FOUR
(a)(i)</td><td>Current cannot build instantaneously in inductor, so initial current is just through resistor arm: $I = \frac{V}{R}$.</td><td rowspan="5">Thorough understanding of these applications of physics.

OR

Partially correct mathematical solution to the given problems.

AND / OR

Partial understanding of these applications of physics.</td><td rowspan="5">(Partially) correct mathematical solution to the given problems.

AND / OR

Reasonably thorough understanding of these applications of physics.</td><td rowspan="5">Correct mathematical solution to the given problems.

AND

Thorough understanding of these applications of physics.</td></tr>
<tr><td>(a)(ii)</td><td>After a long time, the current reaches a steady state and the inductor voltage is zero, so the total impedance seen by the voltage source is just the two parallel resistors, with total resistance $\frac{R}{2}$. Thus $I = \frac{2V}{R}$.</td></tr>
<tr><td>(b)(i)</td><td>Electric potential energy stored in the capacitor converts by way of moving charges (a current) into the magnetic field energy. This field energy then converts into more current, driving charge onto the plates of the capacitor so that the plates now restore EPE. Then the process reverses itself.</td></tr>
<tr><td>(b)(ii)</td><td>After ¼ of a cycle (when $t = 1.57$ s), there is no charge separation on the capacitor plates, and so no work (positive or negative) need be done in moving the plates closer.</td></tr>
<tr><td>(c)</td><td>The copper feels a changing magnetic field as it enters the field region, so eddy currents are induced. Their direction of flow is such that they create a field of their own that interacts with the applied field, slowing the copper. The energy is lost to heat – the copper has finite resistance so the eddy currents are dissipative.</td></tr>
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FIVE (a)	Velocity unit is m s^{-1} Tension is N = kg m s^{-2} μ is kg m^{-1} Dividing T by μ we get $m^2\,s^{-2}$.Then taking square root we get the desired result.	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND/OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(b)	**String 1:** $v_1 = \sqrt{\frac{T_1}{\mu_1}} = \sqrt{\frac{m_1 g}{\mu_1}}$ $\lambda_1 = 2L \quad v_1 = \lambda_1 f_1$ $2Lf_1 = \sqrt{\frac{m_1 g}{\mu_1}}$ **String 2:** $\lambda_2 = \frac{2}{3}L$ The linear mass density is four times as much as for the first string (twice the diameter, so 4× as much mass per metre). $v_2 = \sqrt{\frac{T_2}{\mu_2}} = \sqrt{\frac{m_2 g}{4\mu_1}} = \sqrt{\frac{m_1 g}{4\mu_1}} = \frac{1}{2}v_1$ $\frac{1}{2}\sqrt{\frac{m_1 g}{\mu_1}} = \frac{2}{3}Lf_2$ Combining expressions: $\frac{2}{3}Lf_2 = \frac{1}{2}2Lf_1$ $\Rightarrow f_2 = \frac{3}{2}\frac{1}{2}2f_1 = \frac{3}{2}\times 200\text{ Hz}$ $f_2 = 300\text{ Hz}$			
(c)	The tension is the same as for having one end of the string stuck to a wall. Frequency of the *n*th harmonic = n × frequency of first harmonic Fifth harmonic = 5 × 200 = 1000 Hz			
(d)	The modulation is due to beats, so $f_1 - f_2 = 4.5$ Hz (or $f_2 - f_1 = 4.5$ Hz) The wavelength of the waves forming the standing wave pattern on string 1 obeys $\frac{(n_1-1)\lambda_1}{2} = L_1$ The wave velocity is given by $v_1 = \lambda_1 f_1 = \frac{2L_1}{n_1 - 1}\times f_1$ Similarly, for the second string we have $\lambda_2 = \frac{2L_2}{n_2 - 1} = \frac{2L_2}{n_1}$ (the question says $n_2 = n_1 + 1$) $v_2 = \lambda_2 f_2 = \frac{2L_2}{n_1}\times f_2$ We also know that $v_1 = v_2$ (equivalent medium, same tension) Thus $\frac{2L_1}{n_1-1}\times f_1 = \frac{2L_2}{n_1}\times f_2$ Insert $L_1 = 1.00$ m, and $L_2 = 1.18$ m. Plugging these in along with $f_1 = 400$ Hz and $f_2 = 395.5$ Hz, we find that $n_1 = 7$, i.e., 7 nodes.			