Assessment Schedule – 2013

Scholarship Physics (93103)

Evidence Statement

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)	*Photoelectric effect.* Electrons in the conduction band of metals do not require large amounts of energy to escape from the host atom. Light consists of photons – energy packets whose energy is directly proportional to the frequency of the photons. If the energy needed to release an electron is less than the energy carried by a photon, then when the photon interacts with the electron, the photon can be absorbed by the electron which gains all the photon's energy, converting some of that energy into potential energy in the act of leaving the atom and the rest (if there is any) into KE. Single electrons can be released by single photons, showing that light (and therefore energy) is quantised – exists in distinct packets. *Hydrogen spectrum.* The electron associated with a single proton (forming a hydrogen atom) has a restricted set of possible energy values. We say the energy held by the electron is quantised because when the electron changes from large PE to less PE, the energy change is released as an electromagnetic photon and these photons always have precise values, forming the hydrogen emission spectrum. The quantisation of energy would be the link between these phenomena.	Some understanding of these applications of physics.	Reasonably thorough understanding of these applications of physics.	Thorough understanding of these applications of physics.
(b)	The fusion of deuterium to helium will release about 6 MeV per nucleon. The fission of U to Fe (the largest possible fission energy gap) will release about 1 MeV per nucleon. Fusion releases more energy per nucleon than fission, but fission processes involve more nucleons, and so can release greater total amounts of energy per fission reaction than a fusion reaction will release.			
(c)	The atoms of the intervening hydrogen interact with photons that have frequencies that deliver exactly the correct energy. The electrons of hydrogen atoms can accept only specific amounts of energy in the process of becoming excited. Only photons of specific frequency will carry these precise energy amounts, and it is these photons that will be absorbed (and "used" to excite electrons) in the passage of the radiation through the hydrogen. The emerging light will therefore be missing just those frequencies that can excite hydrogen electrons. The missing frequencies will show up as dark lines in the spectrum of the light. The excited electrons will soon reradiate the missing photons, but the re-radiation will be in a random direction and so not many of the reradiated photons will travel in the direction of the original beam.			

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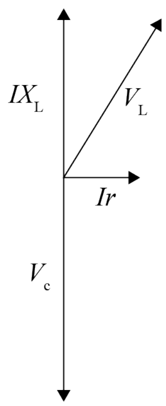
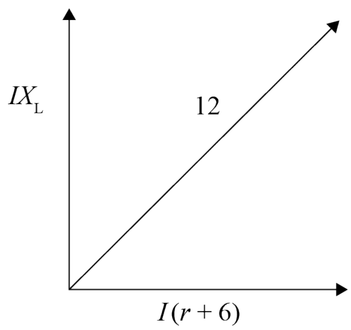
TWO (a)	At resonance $V_L = -V_C$ and so cancel each other. $V_O = V_R$ $I_{max} = \frac{V_R}{R} = \frac{25}{10} = 2.5\text{ A}$ $V_L = IX_L = I2\pi fL = 2.5 \times 2 \times \pi \times 500 \times 1.013 \times 10^{-2}$ $= 79.56 = 79.6\text{ V}$ $V_c = IX_c = \frac{I}{2\pi fC} = \frac{2.5}{2 \times \pi \times 500 \times 10^{-5}} = 79.58 = 79.6\text{ V}$ In the inductor, the maximum voltage depends on the rate of change of current which is large for a high frequency and so the max induced voltage is larger than the source voltage. For the capacitor, the max voltage depends on the max stored charge, which might be larger than the straight source voltage can drive onto the plates because the high frequency causes excess charge to surge onto the plates, driving up the voltage that is going to stop any more charge arriving.	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)	He substituted into the equation for resonant frequency: $50 = \frac{1}{2\pi\sqrt{L \times 219 \times 10^{-6}}}$ $L = \frac{1}{4\pi^2 \times 2.5 \times 10^3 \times 219 \times 10^{-6}}$ $L = \frac{1}{21.6} = 46.3\text{ mH}$ He has assumed that equal voltages across the components means the circuit is at resonance. He has forgotten that the inductance will have some resistance which must be taken into account in the calculation.			
(c)	Using Ali's results 			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
	$V_c = V_{\text{L and r}} = V_L$ see diagram $IX_c = V_L = I\sqrt{X_L^2 + r^2}$ $\frac{1}{2\pi fC} = \sqrt{X_L^2 + r^2}$ or $\frac{1}{4\pi^2 f^2 C^2} = X_L^2 + r^2$ or $X_L^2 + r^2 = 211.25745$...........(1) Using Sue's results  $12^2 = I^2\left[\left(X_L^2 + (r+6)^2\right)\right]$ where $I = 0.657\text{A}$ $144 = 0.657^2\left[X_L^2 + r^2 + 12r + 36\right]$............(2) Substituting (1) into (2) gives $r = 7.195578\ \Omega$ from which $X_L = 12.628583\,\Omega$ and $L = 40.2\,\text{mH}$			
(d)	$\frac{1}{\omega C} = 5$ $\omega L = 28$ $\frac{L}{C} = 5 \times 28 = 140$ $L = 140\ C$ $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{140C^2}}$ $1460 \times 2\pi \times 11.8C = 1$ $C = 9.2\ \mu\text{F}$ $L = 1.30\ \text{mH}$			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
THREE (a)	The fringes from the grating would be brighter and sharper. The fringes will be brighter, having contributions from every slit in the grating. The fringes will be sharper because the destructive interference between the bright fringes will be greater (than in the double slit case). The fringes will have the same separation in both cases.	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)	The separation of the fringes will become smaller. The wavelength of the light will reduce, as its velocity has decreased while the frequency has remained constant. With reduced wavelength, a smaller displacement is needed for the interfering waves to find positions of constructive interference.			
(c)	The light through the top slit is slowed down for a while and so is out of phase with the bottom slit light when at the original position of the central maximum. The position on the screen where the two rays will be in phase must have the bottom slit light move through more phases (travel further) to realign the phases. This happens at some position up the screen.			
(d)	The ray from the uncovered slit must travel an extra 5λ to compensate for the extra phase difference introduced by the thin film. That extra pd is the number of wavelengths travelled through the material – the number of wavelengths travelled through the same distance in air. $\frac{t}{\lambda_m} - \frac{t}{\lambda_a} = 5$ $\lambda_m = \frac{\lambda_a}{n}$ $1.6t - t = 5\lambda_a$ $t = \frac{5}{0.6} \times 500 \times 10^{-9} = 4.17 \times 10^{-6}$ m *t* is the distance travelled; therefore the thickness of the slice will be $\leq t$.			
(e)	With monochromatic light, the zero order fringe is not obviously different from other fringes. With white light rather than monochromatic, the zero order fringe will be obviously white while the others will be variously coloured. There will be a white central maximum flanked by overlapping coloured fringes.			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
FOUR (a)	$v^2 = \text{m}^2\,\text{s}^{-2}$ $g\,\lambda = \text{m s}^{-2}\,\text{m} = \text{m}^2\,\text{s}^{-2}$ (and 2π is dimensionless) $2\,\pi\,\gamma = \text{kg m s}^{-2}\,\text{m}^{-1} = \text{kg s}^{-2}$ $\lambda\,\rho = \text{m kg m}^{-3} = \text{kg m}^{-2}$ $\frac{2\pi\gamma}{\lambda\rho} = \frac{\text{kg s}^{-2}}{\text{kg m}^{-2}} = \text{m}^2\,\text{s}^{-2}$ All terms have the same dimensions.	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)	$v^2 = \frac{9.8\times 10}{2\pi} + \frac{2\pi\times 7.2\times 10^{-2}}{10\times 10^3}$ $v^2 = 15.597 + 4.5\times 10^{-5} = 15.597045$ $v = 3.95\ \text{m s}^{-1}$			
(c)	$f = \frac{v}{\lambda} = \frac{3.95}{10} = 0.395\ \text{Hz}$ $v_{\text{max}} = 2\pi f \times A = 2\pi \times 0.395 \times 0.2 = 0.496\ \text{m s}^{-1}$			
(d)	$f = \frac{C}{\lambda} = \frac{15.3-8}{150} = 0.049\ \text{Hz}$			
(e)	The ship does not want its natural pitch frequency to be the same as the frequency with which the waves are moving the ship. Such a resonance will produce increasing amplitudes in the ship's rise and fall and will strain the structure of the vessel and become more uncomfortable for the passengers. The ship has to avoid frequency 0.125 Hz (1/8 Hz). Speed to avoid is given by: $0.125 = \frac{V_{\text{ship}} \pm C_{\text{water}}}{75}$ $V_{\text{ship}} = 9.375 \pm 10.8 = -1.425\ \text{m s}^{-1}$ or $20.2\ \text{m s}^{-1}$			

<table>
<tr><th>Question</th><th>Evidence</th><th>1-4 marks</th><th>5-6 marks</th><th>7-8 marks</th></tr>
<tr><td>FIVE
(a)</td><td>The ladder’s mass is to be considered as zero. The centre of mass of the man and ladder system is therefore where the man is. As he climbs the ladder the horizontal position of the centre of mass must stay in its original position (at the foot of the ladder) because, on the frictionless ice, no unbalanced horizontal force can be exerted on the ladder / man system to move the centre of mass to the left. As the man climbs, moving left relative to the ladder, the ladder will move, relative to the ice, to the right so that the position of the centre of mass doesn’t move (except upwards).As the man climbs there is a component of the force he exerts acting to the right which moves the ladder to the right.</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>(b)</td><td>$mg = R_1 + R_2$
Taking moments about the top of the ladder
Each side can be treated separately (both sides must individually have zero net torque acting).
$R_2 \times L \sin\theta = T \times (L \cos\theta - d)$
$R_1 \times L \sin\theta = T \times (L\cos\theta - d) + mg \times (L\cos\theta - h) \tan\theta$
Add both
$L \sin\theta (R_1 + R_2) = 2T (L \cos\theta - d) + mg (L \cos\theta - h) \tan\theta$
Sub for $R_1 + R_2$
Rearrange $mg (L \sin\theta - L \cos\theta \tan\theta + h \tan\theta) = 2T (L \cos\theta - d)$
$\cos\theta \tan\theta = \sin\theta$ so $T = \dfrac{mgh\tan\theta}{2(L\cos\theta - d)}$</td></tr>
<tr><td>(c)(i)</td><td>$T = \dfrac{70 \times 9.81 \times 3 \times \cos 30° \times \tan 30°}{2(3\cos 30° - 2\cos 30°)}$
$T = 594\text{ N}$</td></tr>
<tr><td>(c)(ii)</td><td>x = length of tie bar
$2(L\cos\theta - d)\tan\theta = x$
$L\cos\theta - \dfrac{x}{2\tan\theta} = d$
$T = \dfrac{mgh\tan\theta}{2(L\cos\theta - (L\cos\theta - \dfrac{x}{2\tan\theta}))}$
$= \dfrac{mgh\tan\theta}{\dfrac{2x}{2\tan\theta}}$
$T = mgh\dfrac{\tan^2\theta}{x}$
The tension will increase as $\tan\theta$ is proportional to x.</td></tr>
<tr><td>(d)</td><td>To climb the ladder, the electrician must accelerate upwards. If this acceleration is large (so that they get to the top quickly), the reaction forces from the ground must be greater to supply the force needed for acceleration. The reaction forces will require an increased tension in the tie bar and a slow climb will keep the tension as low as possible, so hopefully the tie will not snap.</td></tr>
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