Assessment Schedule – 2011

Scholarship Physics (93103)

Evidence Statement

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)	Kinetic energy $E_K = \frac{1}{2}mv^2$ $\Rightarrow E_K = \frac{p^2}{2m}$ $p = \sqrt{2mE}$ $\lambda = \frac{h}{p}$ $\therefore \lambda = \frac{h}{\sqrt{2mE}}$	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)(i) (ii)	The intensity maxima and minima occur when the path difference from the two slits is an integral or half integral number of wavelengths, respectively. For intensity maxima: $\therefore d\sin\theta = n\lambda = \frac{nh}{p} = \frac{nh}{\sqrt{2mE}}$ For intensity minima: $\therefore d\sin\theta = \left(n - \frac{1}{2}\right)\lambda = \frac{\left(n - \frac{1}{2}\right)h}{p} = \frac{\left(n - \frac{1}{2}\right)h}{\sqrt{2mE}}$			
(c)	The fringes of intensity maxima are poorly defined because their positions depend on the wavelength. A spread of energies implies a spread of wavelengths which implies a spread of positions.			
(d)	For order 1, the extreme (outer) angle (ϕ_1) is given by $\sin\phi_1 = \frac{h}{d\sqrt{2m(E - \Delta E)}}$ For order 2, the extreme (inner) angle (ϕ_2) is given by $\sin\phi_2 = \frac{2h}{d\sqrt{2m(E + \Delta E)}}$ At overlap, $\sin\phi_1 = \sin\phi_2$ $\frac{h}{d\sqrt{2m(E - \Delta E)}} = \frac{2h}{d\sqrt{2m(E + \Delta E)}}$ $\sqrt{2m(E + \Delta E)} = 2\sqrt{2m(E - \Delta E)}$ $2m(E + \Delta E) = 8m(E - \Delta E)$ $E + \Delta E = 4E - 4\Delta E$ $5\Delta E = 3E$ $\Delta E = \frac{3E}{5}$ $\Delta E \leq \frac{3E}{5}$			

<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>TWO
(a)</td><td>Surrounded on all sides by equal quantities of mass all the gravitational forces will balance and sum to zero.</td><td rowspan="4">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="4">(Partially) correct mathematical solution to the given problems.

AND/OR

Reasonably thorough understanding of these applications of physics.</td><td rowspan="4">Correct mathematical solution to the given problems.

AND

Thorough understanding of these applications of physics.</td></tr>
<tr><td>(b)</td><td>$mg = \frac{GMm}{r^2}$
$M = \rho V = \rho \frac{4}{3}\pi r^3$
$g = G\rho \frac{4}{3}\pi r$</td></tr>
<tr><td>(c)</td><td>The gravitational attraction from a point mass decreases according to $1/r^2$, where r is the distance from the point mass.
The Earth can be regarded as a point mass, with all of its mass in the centre.</td></tr>
<tr><td>(d)</td><td>The Earth has not got uniform density. The outer layers of low density material do not produce the expected fall off in field strength as we descend because we are simultaneously approaching the core region of much higher density. The two effects cancel out, producing a region of uniform field strength. The core region is of uniform density.</td></tr>
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Question	Evidence	1-4 marks	5-6 marks	7-8 marks
THREE (a)	As the particles are oscillating under simple harmonic motion (SHM), the pressure will also oscillate from positive to negative. This leads to two readings existing for each position.	Shows some understanding of the underlying physics.	A reasonable understanding of the underlying physics.	Thorough understanding of the underlying physics.
(b)	The air particles at the reed end of the clarinet are against the end wall. They are unable to move. This is a displacement node.			
(c)	The clarinet is a tube which is open at one end and closed at the other. Therefore its (fundamental) frequency can only have odd harmonics. As overblowing is defined as a doubling of the frequency, it is not possible to double the first harmonic frequency (by overblowing the fundamental). The flute is modelled as a tube opened at both ends and so can resonate at both even and odd harmonics. Therefore it is possible to double the fundamental frequency by overblowing.			
(d)	The heating of the air leads to an increase in the sound velocity which, since the wavelength is fixed, gives rise to an increase in the frequency.			
(e)	For a standing wave to form, two waves must interact. This requires in an open pipe for there to be a reflection at the open end. This occurs by a change in impedance at the end of the pipe. This can also be considered a change in pressure – where the outside pressure (atmospheric) does not change but the wave effectively leaves a "pocket" or "vacuum" for the outside air to be able to fill, and the wave can then change direction and reflect. Another way to see this reflection is to consider the collision of the air molecules.			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
4(a)	$C = 2.8 \times 3.0 \times 10^{-6} = 8.4\ \mu\text{F}$ Assumption: The wax completely fills the distance between the plates.	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 dielectric material is polarised by the electric field between the plates. There is now an electric field inside the dielectric, which opposes (weakens) the field between the plates. Reduced field strength, with the same amount of charge stored, means reduced voltage (assuming not connected to battery) and therefore the capacitance has increased. ($C = Q / V$) If capacitor is connected to the battery the voltage is fixed but the capacitance still increases as more charge is able to 'fit in'.			
(c)	At distance d_1 the energy stored in the capacitor is $E = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\varepsilon_0 A V^2}{d_1}$ as the capacitance is $C = \frac{\varepsilon_0 A}{d_1}$. As the distance between plates increases from d_1 to d_2, the capacitance changes to $C = \frac{\varepsilon_0 A}{d_2}$ and the energy stored is now $\frac{1}{2}\frac{\varepsilon_0 A V^2}{d_2}$. $\Delta E = \frac{V^2 \varepsilon_0 A}{2}\left(\frac{1}{d_1} - \frac{1}{d_2}\right) = \frac{V^2 \varepsilon_0 A}{2}\left(\frac{d_2 - d_1}{d_1 d_2}\right)$			
(d)	As the capacitor is still connected to the battery, the voltage across the capacitor must remain constant at V. As the capacitance decreases as the distance between the two plates increases $C \propto \frac{1}{d}$, the energy stored in the capacitor must decrease (as $E = \frac{1}{2}CV^2$).The amount of charge on the plates must also decrease by ΔQ (as $Q = VC$). The "lost" charge is driven back through the battery to the opposite capacitor plate by the work done to separate the plates and the potential energy removed from the capacitor. This missing energy is converted into heat of the connecting wires and into potential energy stored in the battery.			
(e)	The plates, being oppositely charged, attract each other. In separating them, they have to be dragged apart. Work must be done and this energy is stored as electric potential energy in the field between the plates. We express this by talking of an increase in the voltage between the plates. $C = \frac{\varepsilon A}{d}$ so as d increases, C reduces.Energy $= \frac{Q^2}{C_2} - \frac{1}{2}\frac{Q^2}{C_1}$. Q is constant so as C decreases, the energy must increase – work is being done to drag the plates apart. Work done $= \frac{1}{2}\frac{Q^2}{C_2} - \frac{1}{2}\frac{Q^2}{C_1}$ $\frac{1}{2}Q^2\left(\frac{1}{C_2} - \frac{1}{C_1}\right) = \frac{Q^2(d_2 - d_1)}{2\varepsilon A}$			

<table>
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<tr><td>FIVE
(a)</td><td>At large angles (> 10º) there is no longer a linear relationship between the displacement and the restoring force.</td><td rowspan="4">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="4">(Partially) correct mathematical solution to the given problems.

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<tr><td>(b)</td><td>$F_{NET} = F_{TENSION} - F_{GRAVITY}$
At the bottom, Tension = $Mg + \frac{Mv^2}{r}$
Height energy lost = Mgr = KE gained = $\frac{Mv^2}{2}$
Therefore $2gr = v^2$
Tension = $Mg + \frac{2Mgr}{r} = 3Mg$</td></tr>
<tr><td>(c)</td><td>$T = mg\sin\theta + \frac{mv^2}{r}$
Height lost is $r \sin \theta$
Energy lost $= mgr\sin\theta = \frac{1}{2}mv^2$
So centripetal force $\left(\frac{mv^2}{r}\right) = 2mg\sin\theta$

Gives $T = 2\,m\,g$ = $2mg \sin \theta$ {the centripetal component} + $mg \sin \theta$ {the weight component}

Cancel and get $\sin \theta = 2/3$

$\theta = 41.8°$</td></tr>
<tr><td>(d)</td><td>The positive bob will induce a negative charge on the metal plate. This will increase the downward force acting on the bob. The net effect of this is that the restoring force is increased. This leads to a reduction in the period.</td></tr>
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Question	Evidence	1-4 marks	5-6 marks	7-8 marks
SIX (a)	As the 2 g red puck approaches, electrostatic repulsion will cause it to slow down and the 4 g blue puck to start moving. The 4 g will accelerate in the original direction and the 2 g will stop and recoil in the opposite direction.	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)	At closest approach, the relative velocity of the pucks must be zero. So both will have the same velocity with respect to the track. Conservation of momentum $m_{2g}v_{2g} = (m_{2g} + m_{4g})v_c$ $v_c = 42 / 6 = 7 \text{ m s}^{-1}$			
(c)	At 10 m, the electrostatic potential energy is $\frac{kQQ}{r} = 9\times10^{9}\times\frac{(1.5\times10^{-6})^2}{10} = 2.02\times10^{-3}$ J Kinetic energy is $\frac{1}{2}\times2\times10^{-3}\times21^2 = 441\times10^{-3}$ J			
(d)	Total energy is conserved. Original KE = KE_{2g} at closest + KE_{4g} at closest + electric potential energy $\frac{1}{2}\times2\times10^{-3}\times21^2 = \left(\frac{1}{2}\times2\times10^{-3}\times7^2\right) + \left(\frac{1}{2}\times4\times10^{-3}\times7^2\right) + \frac{1.5\times10^{-6}\times1.5\times10^{-6}\times9\times10^{9}}{d}$ $(441-49-98)\times10^{-3} = 0.294 = \frac{0.02025}{d}$ $d = 0.069\,\text{m}$			
(e)	The collision is elastic $2\times21 = 2v_R + 4v_B$ (conservation of momentum) $\frac{1}{2}\times2\times21^2 = \frac{1}{2}\times2\times v_R^2 + \frac{1}{2}\times4\times v_B^2$ (conservation of kinetic energy) (and taking the original electric PE as zero) From 1st equation: $2v_R = 2\times21 - 4v_B \Rightarrow 4v_R^2 = (2\times21 - 4v_B)^2$ Using 2nd: $2\times21^2 = \frac{(2\times21-4v_B)^2}{2} + 8v_B^2$ $2\times2\times21^2 = (2\times21)^2 - 336v_B + 16v_B^2 + 8v_B^2$ $336v_B = 24v_B^2$ $v_{Blue} = 14\,\text{m s}^{-1}$ $v_{Red} = -7\,\text{m s}^{-1}$			