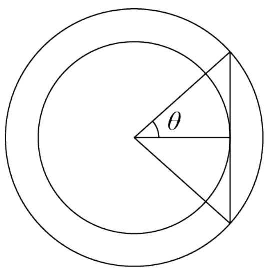
Assessment Schedule – 2016

Scholarship Physics (93103)

Evidence Statement

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)	The magnetic force on the roller is up the rails (to the left). The gravity force component must be equal and opposite to the magnetic force component. $F_g = mg\sin\phi = F_m = B\cos\phi \times IL$	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 moving conductor (the roller) will have a potential difference (pd) induced between its ends by the movement through the magnetic field. This pd will drive a current around the circuit. (This is why a resistor needs to be connected.) The current will produce a magnetic field around the roller, which will react against the permanent magnetic field, causing the roller to slow down. Slowing down will reduce the induced voltage, therefore reduce the current, therefore reduce the retarding force. Once the retarding force (initially larger than the gravity component) becomes equal to the accelerating component of the gravity force on the roller, with no net force now acting on the roller, it will continue moving at some small constant velocity.			
(c)	$V = B\cos\phi \times v \times L$ $I = \frac{V}{R}$ $I = \frac{B\cos\phi \times v \times L}{R}$ At constant velocity $mg\sin\phi = B\cos\phi \times I \times L$ (from part(a)) $mg\sin\phi = B^2\cos^2\phi \times L^2 \times \frac{v}{R}$ $v = \frac{R \times m \times g\tan\phi}{B^2\cos\phi \times L^2}$			
(d)	The movement of the roller will depend on the phase state of the supply when the power is turned on. If the voltage is rising from zero to its peak, the roller will move in a series of jerks in one direction (if the frequency is high enough, the movement will appear to be continuous). If the voltage is decreasing from zero towards its negative maximum, then the roller will move in the opposite direction. And if the voltage is falling from its peak value (or rising from its negative maximum), then the roller will vibrate in place.			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
TWO (a)	$f = \text{s}^{-1} \quad r = \text{m} \quad v_\text{w} = \text{m s}^{-1}$ $\text{St} = \frac{fr}{v_\text{w}} = \frac{\text{s}^{-1}\text{ m}}{\text{m s}^{-1}} = 1$ (dimensionless)	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)	If the tension increases, then effectively a mass element in the wire will experience a greater acceleration leading to a greater velocity. If the mass / length is lower, then the acceleration experienced will also be greater leading to a greater velocity. Overall the velocity will be proportional to the tension and inversely proportional to the mass / length.			
(c)	$T = \frac{175 \times 9.81}{2} = 858\text{ N}$ $\text{St} = \frac{fr}{v_\text{w}} \Rightarrow r = 10^{-2}\text{ m}$ $\mu = \pi \times (10^{-2})^2 \times 1 \times 8 \times 10^3 = 2.51\text{ kg m}^{-1}$ $v = \sqrt{\frac{858}{2.51}} = 18.48 = 18\text{ m s}^{-1}$			
(d)(i)	$T_1 + T_2 = 175 \times \text{g} = 1716.75\text{ N}$ $4\ T_1 = 2 \times 100 \times \text{g} + 3 \times 75 \times \text{g}$ $T_1 = \frac{4169.25}{4} = 1042\text{ N}$ $T_2 = 674.4375\text{ N}$ $v_1 = \sqrt{\frac{T_1}{\mu}} = 20.365\text{ m s}^{-1}$ $v_2 = \sqrt{\frac{T_2}{\mu}} = 16.381\text{ m s}^{-1}$ Wavelength 1 $= \frac{v_1}{200} = 10.18$ cm Wavelength 2 $= \frac{v_2}{200} = 8.19$ cm			
(d)(ii)	Beats require slightly different frequencies. If the wind is to produce the frequency, then the wires have the same radius then this will not result. So one possibility is to slightly alter the radius of one of the wires.			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
THREE (a)	The sensation of weight comes from a reaction force. Satellites are in constant free-fall around the object they are orbiting. In this situation the reaction force is zero, so the satellite appears weightless.	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)	$\frac{mv^2}{r} = \frac{GMm}{r^2}$ In this case $r = R + h$, where R = radius of the Earth and h is altitude of satellite. Rearranging gives $\frac{4\pi^2(R+h)^2}{T^2} = \frac{GM}{R+h}$ Rearranging gives $h = \sqrt[3]{\frac{GMT^2}{4\pi^2}} - R$ Substituting gives h = 1690 km			
(c)	Angular velocity of the Earth = $\frac{2\pi}{24 \times 60 \times 60}$ Angular velocity of the satellite = $\frac{2\pi}{2 \times 60 \times 60}$ Angular velocity of the satellite relative to the Earth $= \frac{2\pi}{2 \times 60 \times 60}\left[1 - \frac{1}{12}\right]$ $= 8 \times 10^{-4}$ rad s^{-1}			
(d)	 R = radius of Earth h = altitude of the satellite $\cos\theta = \frac{R}{R+h}$ $2\theta = 75.6°$			
(e)	As the satellite's orbital radius gets larger, the Earth's gravitational field strength decreases until it becomes smaller than other celestial bodies, and so the satellite will no longer orbit the Earth. So this limits the maximum period. The minimum period is determined by when the satellite enters the Earth's atmosphere.			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
FOUR (a)	$\Delta u = 226.025410 - 226.020181 = 0.005229$ u $\Delta m = 0.005229 \times 1.66 \times 10^{-27} = 0.00868014 \times 10^{-27}$ kg $E = \Delta mc^2 = 8.68014 \times 10^{-30} \times 9 \times 10^{16} = 7.812 \times 10^{-13}$ J $E = \frac{7.812 \times 10^{-13}}{1.60 \times 10^{-19}} = 4.88$ MeV	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)	Conservation of momentum results in the alpha particle having velocity of $\frac{M_{\text{Rn}}}{M_{\text{alpha}}} V_{\text{Rn}}$ $\frac{222.017578}{4.002603} = 55.4682985 \times V_{\text{Rn}}$ Conservation of Energy gives $\Delta E = KE_{\text{Rn}} + KE_{\text{alpha}} = ½\, M_{\text{Rn}}\, V_{\text{Rn}}^2 + ½\, M_{\text{alpha}}\, V_{\text{alpha}}^2$ $\Delta E = \frac{1}{2} M_{\text{Rn}} V_{\text{Rn}}^2 + \frac{1}{2} M_{\text{alpha}} \left(\frac{M_{\text{Rn}}}{M_{\text{alpha}}} V_{\text{Rn}} \right)^2$ $\Delta E = \frac{1}{2} M_{\text{Rn}} V_{\text{Rn}}^2 \left(1 + \frac{M_{\text{Rn}}}{M_{\text{alpha}}} \right)$ $\frac{1}{2} M_{\text{Rn}} V_{\text{Rn}}^2 = KE_{\text{Rn}} = \frac{\Delta E}{56.4682985} = 0.08646584$ MeV $KE_{\text{alpha}} = \Delta E - KE_{\text{Rn}} = 4.88257875 - 0.08646584$ $= 4.79611291$ MeV The lighter particle carries most of the KE because it has the higher velocity after the decay and the velocity term in KE is squared, therefore more than making up for the lower mass component.			
(c)	Every decay should liberate the exact same amount of energy, which should be carried away as the kinetic energy of the reaction products, shared in a similar way to the calculation in part (a) (if there were no neutrino then for beta decay you would expect the electron, being the lighter particle, to carry almost all of the energy). The fact that there is a distribution in beta energy implies that some other particle has the missing energy.			
(d)	The deuteron requires an input of energy to separate the proton and neutron. This added energy manifests itself as an increase in mass. The rocket uses internal energy to eject some mass at high speed in order to gain gravitational potential energy and kinetic energy for the remaining part of the rocket. Considering the Earth and the rocket as a single system, energy is conserved.			

<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>$x_{\text{com}} = 0$
$y_{\text{com}} = \frac{2m \times 0 + 3m \times k}{m + 2m + m + m} = \frac{3mk}{5m}$
$\Rightarrow (x, y)_{\text{com}} = \left(0, \frac{3k}{5}\right)$</td><td rowspan="4">Thorough understanding of these applications of physics.
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<tr><td>(b)</td><td>$I = (m_1 + m_3)\left(-\frac{3k}{5}\right)^2 + (m_2 + m_4)\left(k - \frac{3k}{5}\right)^2$
$I = 2m\left(-\frac{3k}{5}\right)^2 + 3m\left(\frac{2k}{5}\right)^2$
$I = \frac{6}{5}mk^2$</td></tr>
<tr><td>(c)</td><td>First calculate the initial angular momentum about the centre of mass.
$L_{\text{i}} = L_3 + L_4$
$L_{\text{i}} = m_3\left(\frac{3k}{5}\right)v + m_4\left(k - \frac{3k}{5}\right)(2v)$
$L_{\text{i}} = mv\left[\left(\frac{3k}{5}\right) + 2\left(\frac{2k}{5}\right)\right]$
$L_{\text{i}} = \frac{7}{5}mvk$
Now use conservation of angular momentum and the moment of inertia from (b):
$L_{\text{f}} = L_{\text{i}}$
$I\omega = \frac{7}{5}mvk \quad and \quad I = \frac{6}{5}mk^2$
$\therefore \omega = \frac{7v}{6k}$</td></tr>
<tr><td>(d)</td><td>In 0.5 seconds the object has rotated by
$\theta = \omega t = \frac{7v}{6k} \times 0.5 = 1.17 \text{ rad } (66.845°)$
The mass ($m_2 + m_4$) is thus located at coordinates
$(x', y') = \frac{2k}{5}(-\sin\phi, \cos\phi) = (-0.3678, 0.1573)$
measured relative to the centre of mass. The centre of mass itself moves. Calculate its location using conservation of momentum:
$m_3 v - m_4 2v = 5mv_{\text{f}}$ and $mv - 2mv = 5mv_{\text{f}}$
$v_{\text{f}} = -\frac{v}{5} = -0.4 \text{ m s}^{-1}$
So after 0.5 seconds the centre of mass has moved from its original location $\left(0, \frac{3k}{5}\right) = (0, 0.6)$ to
$\left(v_{\text{f}}t, \frac{3k}{5}\right) = (-0.2, 0.6)$.
Thus, in the original coordinate frame the mass ($m_2 + m_4$) is located at $(-0.5678, 0.7573)$ metres.</td></tr>
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