Assessment Schedule – 2009

Scholarship Physics (93103)

Evidence Statement

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)	The values of angular momentum for the hydrogen electron are discrete, which means that the electron can only have discrete values of position or energy. When electrons transition from one energy level value to another, they do not go through all the values in between, which means that the accelerating electron in its orbit does not radiate electromagnetic energy. When the electron transitions from one energy level to another, it either emits or absorbs electromagnetic radiation of a frequency that depends on the size of the energy jump. This means that there will be emission and absorption spectra from the H atom.	Shows some understanding of the underlying physics. AND / OR (Partially) correct mathematical solution to given problem.	A reasonable understanding of the underlying physics. AND (Partially) correct mathematical solution to given problem.	Thorough understanding of the underlying physics. AND Correct mathematical solution to the given problem.
(b)	The attraction is due to the magnetic fields, caused by the movement of electrons in the wires. And currents in wires do not change the charge within the wire (effectively Kirchhoff's current law) – the moving electrons do not increase (or decrease) the number of charges within the wire.			
(c)	The charged rod attracts opposite charges within the metal sphere, and repels like charges. The attracted charges are closer to the original charge than are the repelled charges, and so the attracted charges experience a larger force than the repelled charges, meaning that there is an overall (net) force of attraction. If the sphere is earthed, the repelled charges will leak away to earth (or be neutralised by charge flow from the Earth), while the attracted charges are locked in place by the rod. The net force of attraction is now increased because there is no longer a repulsion component.			
(d)	Needs $\varepsilon_0 = 8.854 \times 10^{-12}$ Take 1 square meter of capacitor. $C = \varepsilon_0 \frac{A}{d} = 8.8954 \times 10^{-9}$ F $Q = CV = 8.8954 \times 10^{-6}$ C Number of electrons in this amount of charge = 5.560×10^{13} In 1 sq m this number of electrons will each occupy an area of $\frac{1}{5.560 \times 10^{13}} = 1.80 \times 10^{-14}$ m^2 The distance between each electron will be approximately $\sqrt{\text{Area}} = 1.34 \times 10^{-7}$ m This separation is independent of the area of the capacitor.			

<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>An RMS value is required because AC is a varying quantity.</td><td rowspan="5">Thorough understanding of this application of physics.

OR

Partially correct mathematical solution to the given problems.

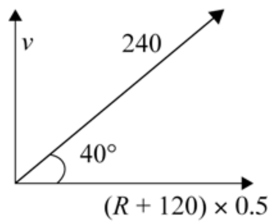
AND / OR

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 this application of physics.</td><td rowspan="5">Correct mathematical solution to the given problems.

AND

Thorough understanding of this application of physics.</td></tr>
<tr><td>(b)</td><td>AC power is the product of (instantaneous) voltage and current, and is continuously changing. The maximum or peak power is the product of peak voltage and peak current. However this value is the maximum. The average power is half this value. (Reason: the power vs time graph is symmetric and never negative if the current and voltage are in phase.) Therefore RMS power is peak voltage and peak current multiplied together, but to ensure their product (the power) is half the peak power, the current needs to be $\frac{I_{\text{peak}}}{\sqrt{2}}$ and the voltage $\frac{V_{\text{peak}}}{\sqrt{2}}$ so their product is $\frac{I_{\text{peak}}V_{\text{peak}}}{2}$.</td></tr>
<tr><td>(c)(i)</td><td>

$(R + 120) \times 0.5 = 240\cos 40$
$R_{\text{tot}} = 367.7\ \Omega$
So $R = 247.7\ \Omega = 250\ \Omega$</td></tr>
<tr><td>(c)(ii)</td><td>RMS power supplied = 240 × 0.5 = 120 W
Total power dissipated by the motor's resistance and the load resistor is given by I_2 (120 + r)
$= (247.7 + 120) \times 0.5^2 = 91.9$ W
The difference in the power supplied and power dissipated is stored in the inductor and then returned to the supplier.</td></tr>
<tr><td>(d)</td><td>Add a suitable capacitor to bring the circuit into resonance.</td></tr>
</table>

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
THREE (a)	GPE goes to KE – specify that the arm must be massless, otherwise there is rotational KE in the rotating beam.	Thorough understanding of this application of physics. OR Partially correct mathematical solution to the given problems AND / OR Partial understanding of this application of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of this application of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of this application of physics.
(b)	$R = \frac{2v^2 \sin\alpha\cos\alpha}{\mathrm{g}}$ v = velocity of projectile at release α = angle of v to the horizontal (at release) At max range $\alpha = 45^{\circ}$ so $\sin\alpha\cos\alpha = 0.5$ And $\frac{1}{2}mv^2 = \mathrm{Mg}h$ (All of the GPE is converted to KE) So $v^2 = \frac{2\mathrm{Mg}h}{\mathrm{m}}$ and $R = \frac{2 \times 2\mathrm{Mg}h \times 0.5}{\mathrm{mg}}$ $R = \frac{2\mathrm{M}h}{m}$			
(c)	When the falling weight is dropped it swings BACKWARDS, so the trebuchet frame "wants" to go forward – centre of mass tries to stay in the same position; or conservation of momentum in a closed system. So yes, put it on wheels so it can roll forward and give the projectile some additional KE.			
(d)	It would be the same (100 m). • Equation for maximum range is independent of g. • Force supplied by the falling counterweight is only 1/6 that supplied on the Earth but once launched the projectile is only subject to 1/6 of the force returning it to the ground. These two factors exactly cancel each other.			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
FOUR (a)	The ball will stay in contact with the track, rolling back and forth. (No need to be concerned about rotation. Rotational energy will limit the maximum velocity reached by the ball but it is all returned to GPE as the ball rolls uphill.)	Shows some understanding of the underlying physics. AND / OR (partially) correct mathematical solution to given problem.	A reasonable understanding of the underlying physics. AND (partially) correct mathematical solution to given problem.	Thorough understanding of the underlying physics. AND Correct mathematical solution to the given problem.
(b)	mgh is the total energy At the top of the circle, $\text{total energy} = mg2R + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ To "just" make the loop, the required centripetal force must be entirely supplied by the gravity force on the ball (meaning that the track reaction force is zero) $mg = \frac{mv^2}{R}$ therefore $v^2 = gR$ also $\omega = \frac{v}{r}$ and I (for a solid sphere) $= \frac{2}{5}mr^2$ So $mgh = mg2R + \frac{1}{2}mgR + \frac{1}{2} \times \frac{2}{5}mgR$ $h = 2.7R$ for the ball to just complete the loop.			
(c)	The ball will leave the rail when the rail reaction is zero. This happens when the centripetal force needed to travel around the loop is totally supplied by the component of the gravity force directed towards the centre of the motion. when $mg\sin\theta = \frac{mv^2}{R}$ ie $v^2 = gR\sin\theta$			
(d)	The height of oscillation would be the same due to conservation of energy but the block would have shorter period because with no energy going into rotation it would have a greater maximum velocity.			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
FIVE (a)	Diffraction: A slit about the same size as the wavelength is needed to get maximum diffraction. Interference: If the slits are close enough for the diffracted waves to overlap, then they will interfere. d should be more than the wavelength. The waves should have the same frequency, amplitude and phase difference (coherence).	Shows some understanding of the underlying physics And/or (partially) correct mathematical solution to given problem	A reasonable understanding of the underlying physics And (partially) correct mathematical solution to given problem	Thorough understanding of the underlying physics And Correct mathematical solution to the given problem
(b)	$n\lambda = \frac{dx}{L}$ is based on the assumption that $\tan\theta$ is of the order of $\sin\theta$ which is true only for small but not for large angles. $n\lambda = d\sin\theta$ is valid for angles up to 90 degrees. Both these are derived on the basis that $L >> d$.			
(c)	$x << L$ therefore $(2-0.5)\lambda = \frac{dx}{L}$ $d = 2 \times 10^{-5}$ m $L = 1.20$ m $\lambda = 632 \times 10^{-9}$ m $x = 5.69$ cm			
(d)	$n\lambda = d\sin\theta = 1380$nm from data given. Therefore n and λ are (for red) $n = 2$ and $\lambda = 690$ nm For blue / violet $n = 3$ and $\lambda = 460$ nm For realistic values, $n\lambda$ must be less than sin90 = 3333 nm. The only other pair of integers which are in the ratio $3m : 2m$ with m less than $\frac{3333}{1380}$ (= 2.4) is 6 : 4. Therefore there is only one more pattern in the range 0 to 90 given by $\sin\theta = \frac{6 \times 460}{3333}$ $\theta = 55.9°$ Yes. Only one at 55.90°.			

Question	**Evidence**	**1-4 marks**	**5-6 marks**	**7-8 marks**
SIX (a)	Gravitational energy transferred = $mgh + mgb$ Energy transferred to body (elastic, heat) = Fb (Average force × resulting movement of the C of M.) If these two are the same (ie if there is no “give” in the ground) then $Fb = mgh + mgb$ or $f = mg(1 + \frac{h}{b})$ Can also be done by calculating the deceleration ($a = \frac{gh}{b}$) and summing forces in the vertical plane.	Partially correct mathematical solution to the given problems. AND / OR Partial discussion of the underlying physics of this application.	(Partially) correct mathematical solution to the given problems. AND Reasonably thorough discussion of the underlying physics of this application.	Thorough discussion of the underlying physics of this application. AND Correct mathematical solution to the given problems.
(b)	$Fd = \Delta E \qquad F = mg\frac{h+b}{b}$ $h = 3$ m , $b = 0.5$ m gives $F = 7mg$ And its only the average force - we are assuming constant acceleration for the duration of the stop and since the acceleration has to begin and end at zero and take some time to reach its maximum value, the maximum value must be larger than the $7mg$ calculated.			
(c)	$b = v_{av} \times t = \frac{vt}{2}$ $v = (2gh)^{0.5}$ (due to conservation of energy) $t = \frac{2b}{(2gh)^{0.5}} = b\left(\frac{2}{gh}\right)^{0.5}$ Effectively the distance b is increased as the snow sinks a bit on landing. Assuming b increases by 10 cm this will make $F = 6mg$. This is a significant reduction.			
(d)	The force normal to the surface will reduce as θ gets larger and $\cos\theta$ gets closer to zero. As the slope gets steeper the force normal to the surface will reduce.			
(e)	The answer wanted is a diagram showing the slope to be a parabola – the slope will match the freefall path of the snowboarder and so no force will be exerted at the time of (grazing) contact. However it should be noted that forces will have to be exerted at some time when the slope changes its profile (or else the projectile keeps going down forever).			