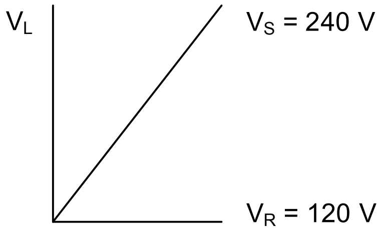
Assessment Schedule – 2010

Scholarship Physics (93103)

Evidence Statement

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)	The fusion of low mass nuclei and the fission of large mass nuclei both produce products that have less mass than the starting mass. The mass loss in both cases is released as energy.	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)	Fusion is the joining of low mass nuclei to produce a heavier nucleus. The nuclei are positively charged and have strong electrostatic repulsion. For the strong nuclear force to operate and unite the reactant nuclei, they must approach to within 10^{-15} m. To overcome the force of repulsion at this distance requires very high kinetic energy (temperature), which has proven hard to produce and hard to keep confined without melting the surroundings.			
(c)(i) (ii)	The negative radiation is Beta radiation – electrons resulting from the decay of neutrons $n \rightarrow p + e$. At short range, 10^{-15} m, the strong force of attraction between protons overwhelms the force of electrostatic repulsion. So most small nuclei are stable.			
(d)	Energy released $= 4 \times 10^9 \,.(3 \times 10^8)^2 = 3.6 \times 10^{26}$ J s^{-1} Area spread over $= 4 \times \pi \,.(1.50 \times 10^{11})^2 = 2.83 \times 10^{23}$ m^2 That is 1.3×10^3 W m^{-2} 10^9 W will need $\dfrac{10^9}{1.3 \times 10^3} = 7.7 \times 10^5$ m^2 (not far short of 1 square km) Some possible assumptions are: a) 100% efficiency b) normal incidence (overhead sun) c) no absorption, reflection from the atmosphere.			

TWO (a)	The current through the bulb is 75 / 120 A. The resistance of the bulb is $\frac{120}{75} \times 120 = 192\ \Omega$ The resistance R, in series with the bulb, must have the same voltage drop of 120 V (to achieve an overall circuit PD of 240 V) and the same current. So R must be the same as the bulb, 192 Ω. Power = $\frac{V^2}{R} = \frac{240^2}{384}$ = 150 W	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 voltage across the bulb must be 120 V. The source voltage of 240 V will lag the inductor voltage.  $V_L = \sqrt{(V_S^2 - V_R^2)} = 207.8$ V Since the current through the bulb and the inductor must be the same, X_L the reactance of the inductor = $\frac{V_L}{I} = \frac{207.8}{120} \times 192 = 332.5\,\Omega$ $X_L = \omega . L$ $L = \frac{332.5}{100\pi}$ = 1.06 H The inductor draws no power so the power drawn from the supply is just the power dissipated by the bulb, which is 75 W.			
(c)(i)	B_1 will light up at full brightness immediately. B_2 will slowly come to full brightness as the induced back emf reduces as the rate of change in current reduces.			
(ii)	The stored energy in the magnetic field of the inductor will drive a current through both B_1 and B_2. Both bulbs will glow briefly, equally brightly.			
(d)(i)	The non-ideal inductor does have a resistance, which would result in reduced maximum current to the bulb B_2, and so reduced brightness, relative to B_1.			
(d)(ii)	The stored energy in the magnetic field of the inductor will drive a current through B_1 and B_2 and through the resistance of the (non-ideal) conductor. Both bulbs will glow briefly, equally brightly but not as bright as c(ii).			

THREE (a)	Charge will move from C_1 to C_2 (due to the mutual repulsion of the excess charges on C_1). The voltage across C_1 will fall, while that across C_2 will rise until the two potential differences are equal. At that point, charge movement will cease, as the forces on the charges are balanced.	Shows some understanding of the underlying physics. AND/OR	A reasonable understanding of the underlying physics. AND	Thorough understanding of the underlying physics. AND
(b)	$Q_{1F} = C_1 V$ $Q_{2F} = C_2 V$ $Q = Q_{1F} + Q_{2F}$ $Q_{1F} = \frac{C_1 Q_{2F}}{C_2} = \frac{C_1 Q_{2F} p}{C_1} = Q_{2F} p$ $Q_{1F}(p+1) = pQ$ $Q_{2F} = \frac{C_2 Q_{1f}}{C_1} = \frac{(Q - Q_{2f})}{p}$ $Q_{2F} \frac{(p+1)}{p} = \frac{Q}{p}$	(Partially) correct mathematical solution to given problem.	(Partially) correct mathematical solution to given problem.	Correct mathematical solution to the given problem.
(c)	If p tends towards zero, then C_2 is very large (tending towards ∞) and will act as a short circuit (a very large charge sink). All the charge will flow to it and none of the charge will remain on C_1. As shown by the equations (taking the limit below): $Q_{1F} = Q\frac{p}{p+1}$ tends towards 0 when $p \to 0$ and $Q_{2F} = \frac{Q(1)}{p+1}$ tends towards Q when $p \to 0$ If p tends towards ∞, then C_2 is very small (tending toward zero) and will act as a break in the circuit, so no charge will move. $Q_{1F} = \frac{Q(p)}{p+1}$ tends towards Q when $p \to \infty$ $Q_{2F} = \frac{Q(1)}{p+1}$ tends towards 0 when $p \to \infty$			
(d)	Original energy $E_0 = \frac{Q^2}{2C_1}$ Final capacitance = $C_1 + C_2 = C_1 + \frac{C_1}{p} = C_1\frac{(p+1)}{p}$ Q is conserved so Final energy $E_F = \frac{Q^2 \times p}{C_1(p+1)} = E_0 \frac{p}{p+1}$ The energy change does not depend on the resistance in the circuit, only on the relative sizes (given by the value of "p") of the capacitances. The resistor provides the mechanism for the energy dissipation.			

FOUR (a)	$d \sin\theta = n\lambda$ $d = \dfrac{587.563 \times 10^{-9}}{\sin 20.6426}$ $d = 1.66 \times 10^{-6}$ m Number of lines per cm = 6 000	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 stellar wavelength is longer than the lab wavelength. Sources moving away from an observer have the wavelength of any emitted radiation increased; we say "red shifted" (since red is the largest observable visible wavelength). So the two wavelengths are different because the stellar source is moving radially away from the Earth.			
(c)	$f' = f\left(\dfrac{v_w}{v_w + v_s}\right)$ $\dfrac{f'}{c} = \dfrac{f}{c}\left(\dfrac{v_w}{v_w + v_s}\right) \Rightarrow \dfrac{1}{\lambda'} = \dfrac{1}{\lambda}\left(\dfrac{v_w}{v_w + v_s}\right)$ $\Rightarrow \lambda' = \lambda\left(\dfrac{v_w + v_s}{v_w}\right)$ $\Delta\lambda = \lambda' - \lambda = \lambda\left(\dfrac{v_w + v_s}{v_w} - 1\right) = \lambda\left(\dfrac{v_s}{v_w}\right)$ $\dfrac{\Delta\lambda}{\lambda} = \dfrac{v_s}{v_w} = \dfrac{v_s}{c}$			
(d)	A reasonable approximation would be to find the average wavelength from the star $0.5 \times (587.67 + 587.60)$ nm = 587.635 gives $\Delta\lambda = 0.072$ nm $\dfrac{v_{\text{source}}}{\text{c}} = \dfrac{\Delta\lambda}{\lambda} = \dfrac{0.072 \times 10^{-9}}{587.563 \times 10^{-9}}$ $\Rightarrow v_{\text{source}} = 36.7\ \text{km s}^{-1}$ Assumption(s): The source is going directly (radially) away from the Earth. Otherwise the answer given would be the radial component of the helium source's velocity. Relativistic effects can be ignored.			
(e)	Possible mechanisms include but are not limited to: • Doppler broadening, due to thermal motion of the emitting atoms. Becomes larger at higher temperatures (greater atomic velocities). • Doppler broadening, due to stellar rotation. • Broadening caused by energy level shifts due to pressure, electric fields, magnetic fields.			

FIVE (a)	For a horizontal displacement x: The force of compression from spring 2 is $-kx$. The force of extension from spring 1 is $-kx$. The total force on the mass is $-2kx$. This is a restoring force proportional to the displacement. The condition for SHM.	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.	Correct mathematical solution to the given problem. AND Thorough understanding of the underlying physics.
(b)	The springs are attached to supports, which are anchored to the ground. As the springs alter the momentum of the moving masses, they also alter the momentum of the supports (and the Earth). The system of the springs and oscillating masses is NOT a closed system and so the law of conservation of momentum does not apply. In the larger system, including the Earth, momentum is conserved.			
(c)(i)	Momentum is conserved so: $M.v_I = (M + m) \cdot v_F$ $v_F = \dfrac{M.v_1}{(M+m)}$ Initial energy $(E) = \frac{1}{2} M \cdot v_I^2$ Final energy $(F) = \frac{1}{2}(M + m) \cdot v_F^2$ Substitute for v_F $F = \dfrac{\frac{1}{2}(M+m).M^2.v_1^2}{(M+m)^2}$ Cancel $(M + m)$. Replace $\frac{1}{2} M \cdot v_I^2$ with E $F = \dfrac{M}{M+m}.E$ Final energy is a factor of $\dfrac{M}{(M+m)}$ of the initial Energy.			
(c)(ii)	There is no change in the energy of the system. All the initial energy is potential energy in the springs. This does not change when the mass is added. So the total energy stays the same.			
(d)	$F = \mu mg$ is the maximum frictional force on mass m. If ma (the accelerating force) is greater than the maximum frictional force, then the mass "m" will slip. So "a" must be less than or equal to μg a_{MAX} of the SHM $= A\omega^2$ $2kx = F = (M + m)a$ $a_{MAX} = \dfrac{2kA}{(M+m)}$ $\omega^2 = \dfrac{2k}{(M+m)}$ m will slip when $m\omega^2 A = \mu mg$ when $A = \mu g \dfrac{(M+m)}{2.k}$			

SIX (a)	$\frac{1}{2} mV^2 = \frac{1}{2} Mv^2$ $V = v\sqrt{\frac{M}{m}}$ Momentum small mass $= mv\sqrt{\frac{M}{m}}$ Momentum large mass = Mv vs cancel in the comparison $\sqrt{Mm} : M$ $\sqrt{m} : \sqrt{M}$ Large mass has the larger momentum by factor of $\sqrt{\frac{M}{m}}$	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.	Correct mathematical solution to the given problems. AND Thorough discussion of the underlying physics of this application.
(b)(i)	Centripetal force is supplied by tyre friction. It is static friction, because the tires are not moving into or away from the centre of the circle they are describing. If the car is going fast enough so that the static friction cannot supply the centripetal force needed to maintain a circular path, then the car will leave that path (move outwards relative to the road surface). (As soon as this happens, the available friction becomes kinetic friction and now the available centripetal force is far too low to maintain the circle. The car skids across the road.) The statement “There is more force taking you off the road” is incorrect. There is no force “taking you off the road”. In the absence of a force, the car will continue in a straight line (Newton’s First Law). The statement “There is less force keeping you on it” is inaccurate. A more accurate statement would be “There is insufficient force to keep you going round the bend”.			
(b)(ii)	Energy absorbed/converted = $\frac{1}{2} .m . 50^2$ units Energy started with = $\frac{1}{2} . m . 60^2$ units Remaining energy = 1100 ½ m units $V^2 = 1100$ $V = 33$ kph			
(c)	At constant velocity, the forces on the 10 kg must sum to zero. The 100 N gravity force must be balanced by a 100 N tension force. The tension is constant throughout the belt. The cylinder A is supported by two tensions = 200 N. The gravity force on the cylinder must = 200 N The mass that experiences a gravity force of 200 N would be 20 kg the mass of A.			