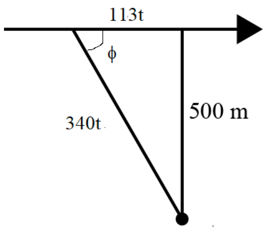
Assessment Schedule – 2017

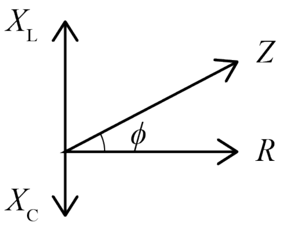
Scholarship Physics (93103)

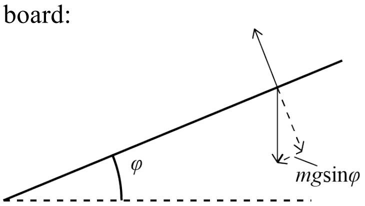
Evidence Statement

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)(i)	Due to the motion of the source, there are compressions and stretching of wavelengths while the velocity remains constant. This leads to a change in frequency. The instantaneous change in frequency means that the plane has been assumed to pass directly through the observer.	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.
(ii)	$f_a' = \frac{f\,v_w}{v_w - v_s}$ $1500 = \frac{1000 \times 340}{340 - v_s}$ $f_b' = \frac{f\,v_w}{v_w + v_s}$ $750 = \frac{1000 \times 340}{340 + v_s}$ Substituting gives $=113.333 \text{ m s}^{-1}$			
(b)	 Component of the plane's velocity at emission point towards observer = $v\cos\phi = 113 \times \frac{113}{340}$ = 37.78 m s^{-1} $f' = \frac{f\,v_w}{v_w - v_s} = 1 \times 10^3 \frac{340}{(340 - 37.78)} = 1.125 \times 10^3 \text{ Hz}$			
(c)	Vertical force on plane (after the drop) = 4000 g – 3000g = 1000 g Vertical acceleration of plane = $\frac{F}{m} = \frac{1000g}{3000} = \frac{1}{3}g$ Vertical distance moved by plane in 1.5 s = ½ at^2 = 0.5 × 0.33 × 9.81 × 1.5^2 = 3.68 m Vertical distance fallen by pod = 0.5 × 9.81 × 1.5^2 = 11.036 m Vertical separation = 14.72 m.			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
TWO (a)	GPE lost = KE gained $mgh = \frac{1}{2} mv^2$ $v^2 = 2gh$ Speed of 1 kg mass at collision $= \sqrt{2gh} = 2\sqrt{9.81}$ m s^{-1} Speed of platform and ball after collision using conservation of momentum $mv = 3mV$ (V = speed after collision) $V = \frac{v}{3} = \frac{2\sqrt{9.81}}{3}$ KE after $= \frac{1}{2} mV^2 = \frac{1}{2} \frac{3 \times 4 \times 9.81}{9} = \frac{2}{3} g$ J Total initial energy was $mgh = 1 \times 2 \times 9.81 = 2g$ J Missing energy = Heat radiated $= 2g - (\frac{2}{3})g = \frac{4}{3}$ g $=13.1$ J	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)	x = initial compression due to platform $= \frac{mg}{k} = \frac{2 \times 9.81}{100} = 0.1962$ m y = extra compression due to addition of the falling 1kg mass. KE + Initial EPE + loss of GPE = Final EPE $\frac{1}{2} mv^2 + \frac{1}{2}kx^2 + mgy = \frac{1}{2}k(x + y)^2$ $\frac{1}{2} \times 3 \times \left(\frac{2\sqrt{9.81}}{3} \right)^2 + \frac{1}{2} \times 100 \times 0.1962^2 + 3 \times 9.81y$ $= 50(0.1962^2 + 0.3924y + y^2)$ $6.54 + 1.924722 + 29.43y = 1.924722 + 19.62y + 50y^2$ $50y^2 - 9.81y - 6.54 = 0$ $y = \frac{9.81 \pm \sqrt{9.81^2 - (4 \times 50 \times -6.54)}}{2 \times 50}$ $= \frac{9.81 \pm \sqrt{1404.236}}{100} = \frac{47.28}{100}$ (ignore negative root) Extra compression $= y = 0.4728$ m			
(c)	New equilibrium point is compression of 29.43 cm. Max displacement from unstretched length = 66.90 cm Amplitude to 37.47 cm			
(d)	By comparing the total energy at the bottom of the motion with the total energy at the top of the motion. Energy stored at base $= \frac{1}{2}k(x + y)^2$ $= 0.5 \times 100 \times (0.4728 + 0.1962)^2 = 22.378$ J Energy stored at top $= mg\Delta h + \frac{1}{2}$ k 0.0804^2 $= 3 \times 9.81 \times (2 \times 0.3747) + 0.5 \times 100 \times 0.0804^2$ $= 22.0548 + 0.3232 = 22.378$ J			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
THREE (a)	hf = work function + E_k $E_k = 1.31 \times 1.60 \times 10^{-19}$ J $= 2.096 \times 10^{-19}$ J $hf = \dfrac{6.63\times10^{-34}\times3\times10^{8}}{375\times10^{-9}} = 5.304\times10^{-19}$ J work function $= 3.208 \times 10^{-19}$ J	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)	Diameter of the beam $= 3.80 \times 10^{8} \times 1.65 \times 10^{-3}$ m Area illuminated $= \pi r^2 = 3.09 \times 10^{11}$ m^2 Energy of a single photon = $hf = \dfrac{hc}{\lambda} = 3.42\times10^{-19}$ J The number of photons per second = $\dfrac{0.45\times10^{-3}}{3.42\times10^{-19}} = 1.31\times10^{15}$ The number of photons s^{-1} m^{-2} = $\dfrac{1.31\times10^{15}}{3.09\times10^{11}} = 4260$			
(c)	Conservation of momentum states that: $\dfrac{h}{\lambda_1} = -\dfrac{h}{\lambda_2} + m_e v$ Conservation of energy states that: $hf_1 = hf_2 + \dfrac{1}{2}m_e v^2$ and since $c = f\lambda$ $\dfrac{h}{\lambda_1} = \dfrac{h}{\lambda_2} + \dfrac{1}{2c}m_e v^2$ Finally $\dfrac{2hc}{\lambda_1} = \dfrac{1}{2}m_e v^2 + m_e vc$ For 4.00 keV electrons the kinetic energy $= 6.4 \times 10^{-16}$ J Using $E_k = \frac{1}{2}mv^2$ gives $v = 3.7484 \times 10^{7}$ m s^{-1} $\dfrac{2hc}{\lambda_1} = 6.4 \times 10^{-16} + 1.0244 \times 10^{-14} = 1.088 \times 10^{-14}$ The final wavelength $= 3.65 \times 10^{-11}$ m			
(d)	Each electron comes with its own proton. The 1 gram of hydrogen is almost entirely single protons, so there are about as many electrons as there are protons. In all the other light elements, half the mass is composed of neutrons so half the mass is protons, meaning half the number of electrons in the 1 gram mass. The number of electrons is only approximately half because both hydrogen and the light elements have isotopes with differing numbers of neutrons which usually serve to reduce the number of protons (and hence the number of electrons) in any given mass. (But not in the case of He3).			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
FOUR (a)(i)	The phase angle is the same for phasor diagram involving reactances and resistances as below.  The triangle formed with $\tan\phi = \frac{X_L - X_C}{R}$	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.
(ii)	C increases; this reduces the capacitive reactance as X is proportional to 1/C, but increases the overall reactance because X_L is constant so X_L-X_c is larger, so from the above diagram the angle must increase.			
(b)(i)	$V_s = IX = 1.5 \times X$ with $V_s = 185$ V So net $X = 123.33$ ohms R = $\frac{123.33}{\tan 30°}$ = 213.6 ohms.			
(ii)	Capacitance has doubled, as they are in parallel. The reactance (capacitive) has halved. Since it leads the current $X_L > X_C$. The overall value is tan 15° × 213.6 = 57.2			
(iii)	$\frac{1}{\omega C} - \omega L = 123.3$ $\omega L - \frac{1}{2\omega C} = 57.2$ Solving these simultaneously gives: $C = 7.91 \times 10^{-6}$ F $L = 0.679$ H			

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
FIVE (a)i)	By considering the force due to gravity acting down the board:  So the vertical acceleration component is $g\sin\varphi$. At top the vertical velocity is zero. Setting $a = g\sin\varphi$ And showing that the initial vertical velocity is $v_0\sin\theta$. Then using the kinematic equation $v_f^2 = v_i^2 + 2ad$ Rearranging provides the result.	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.
(ii)	The horizontal component of velocity is $v_0\cos\theta$. The distance, d will be travelled in time Δt – given no forces are acting this is a constant velocity situation – $\Delta t = \frac{d}{v}$			
(iii)	$v + at = 0$ at top so $\Delta t = \frac{v_0 \sin\theta}{g\sin\varphi}$			
(b)	Using the results to the two previous questions it can be shown that $\frac{d}{v_0\cos\theta} = \frac{2v_0\sin\theta}{g\sin\varphi}$ Using the trig identity provided gives $v_0^2\sin 2\theta = gd\sin\varphi$ Simple rearrangement gives $\theta = \frac{1}{2}\sin^{-1}\left(\frac{gd\sin\varphi}{v_0^2}\right)$			
(c)	Initial energy $\frac{1}{2}I\omega_0^2 + \frac{1}{2}mv_0^2 = \frac{7}{10}mv_0^2$ Final energy at the top where v_f is the horizontal velocity (since it is unchanged) is $\frac{7}{10}mv_f^2 + mg\Delta y\sin\varphi$ $v_f = v_0\cos\theta$ Equate energies and rearrange gives $\frac{7}{10}mv_0^2(1-\cos^2\theta) = mg\Delta y\sin\varphi$ using trig identity gives $\frac{7}{10}mv_0^2(\sin^2\theta) = mg\Delta y\sin\varphi$ Therefore $\Delta y = \frac{7}{10}\frac{(v_0\sin\theta)^2}{g\sin\varphi}$			
(d)(i)	This will result in Δy tending to infinity – a simple consequence of Newton's first law.			
(d)(ii)	More energy input due to additional rotational component.			