## Assessment Schedule – 2020

## Scholarship Physics (93103)

### Evidence Statement

| Q | Evidence | 1–4<br>Below Schol | 5–6<br>Scholarship | 7–8<br>Outstanding |
|---|---|---|---|---|
| ONE (a) | Conditions: $X_L = X_C$ or $Z = R$ or $Z = \text{min}$<br>Measured: $I = \text{max}$ or $V_C = V_L$ or $V_R = V_S$ | Thorough understanding of these applications of physics.<br>OR<br>Partially correct mathematical solution to the given problems.<br>AND / OR<br>Partial understanding of these applications of physics. | (Partially) correct mathematical solution to the given problems.<br>AND / OR<br>Reasonably thorough understanding of these applications of physics. | Correct mathematical solution to the given problems.<br>AND<br>Thorough understanding of these applications of physics. |
| (b) | If the reactance of the capacitor and the reactance of the inductor are larger than the resistance then, as $V = IX$, and all three are in series so have the same current, $V_C$ and $V_L$ will both exceed the supply voltage. At resonance, the power supply is only making up for heat losses due to resistance in the circuit. | | | |
| (c) | The overall impedance of the circuit is determined, not by the capacitor reactance or the inductor reactance directly, but by the difference between them, and the resistance. For a given resistance, the difference in capacitor and inductor reactance will cause a given circuit impedance. This can occur when $X_L > X_C$ ($f >$ resonant frequency) or when $X_C > X_L$ ($f <$ resonant frequency). | | | |
| (d) | $Z = \frac{V_S}{I} = \frac{6.50}{0.400} = 16.25\ \Omega$<br>$X_L - X_C = \sqrt{Z^2 - R^2} = \sqrt{16.25^2 - 12.0^2} = \pm 10.96\ \Omega$<br>$X_L - X_C = 10.96$ when $X_L > X_C$, which occurs at $f > f_{res}$,<br>so at 199 Hz ($\omega = 1250$ rad s$^{-1}$), and<br>$X_C - X_L = 10.96$ when $X_C > X_L$, which occurs at $f < f_{res}$,<br>so at 134 Hz ($\omega = 842$ rad s$^{-1}$)<br>$\omega L - \frac{1}{\omega C} = 10.96$ at $\omega = 1250$ rad s$^{-1}$<br>AND $\frac{1}{\omega C} - \omega L = 10.96$ at $\omega = 842$ rad s$^{-1}$<br>$1250L - \frac{1}{1250C} = 10.96$<br>AND $\frac{1}{842C} - 842L = 10.96$<br>$L = \frac{10.96 + \frac{1}{1250C}}{1250}$<br>AND $L = \frac{\frac{1}{842C} - 10.96}{842}$<br>Equate these terms and solve for $C$… much algebra later…<br>$C = 3.54 \times 10^{-5}$ F<br>Substitute this value back into either expression for $L$…<br>$L = 2.68 \times 10^{-2}$ H | | | |

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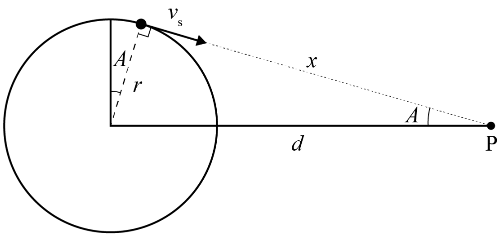
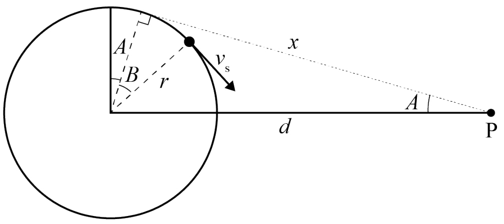
| TWO (a)(i) | The ± symbol accounts for the movement of the source being towards or away from the observer.<br>When +, the movement is away from the observer, and – means the source is approaching the observer. | Thorough understanding of these applications of physics.<br>OR<br>Partially correct mathematical solution to the given problems.<br>AND / OR<br>Partial understanding of these applications of physics. | (Partially) correct mathematical solution to the given problems.<br>AND / OR<br>Reasonably thorough understanding of these applications of physics. | Correct mathematical solution to the given problems.<br>AND<br>Thorough understanding of these applications of physics. |
| (ii) | The velocity of the source should be constant and directly towards the observer. | | | |
| (b) | <br><br>Sound of max frequency is emitted when $v_s$ is directly towards the observer. At this point the angle $A$ is given by:<br>$A = \sin^{-1}\frac{r}{d}$<br><br><br>As the sound travels from where it was emitted to point P, the source will move through an additional angle $B$.<br>$B = \omega t = \frac{v_s}{r} \times \frac{x}{v_w} = \frac{v_s}{r} \times \frac{\sqrt{d^2 - r^2}}{v_w} = \frac{v_s\sqrt{d^2 - r^2}}{v_w r}$<br>The total angle $\theta$ is then given by:<br>$\theta = B + A$<br>$\therefore \theta = \frac{v_s\sqrt{d^2 - r^2}}{v_w r} + \sin^{-1}\frac{r}{d}$ | | | |

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| (c) | So, for the same relative speed, a stationary observer with an approaching source will experience a higher frequency than an observer approaching a stationary source.<br><br>Consider the case when $v_o \rightarrow v_w$ for both approaching source and approaching observer.<br>For an approaching source:<br>$f' = \frac{f v_w}{v_w - v_s} \approx \frac{f v_w}{v_w - v_w} = \frac{f v_w}{0} \rightarrow \infty$<br>If the source moves forwards at the speed of sound, each consecutive wavefront is emitted on top of the previous one, so the wavelength tends towards 0, and because the wave speed is constant, the apparent frequency then tends towards ∞.<br>For an approaching observer:<br>$f' = \frac{f(v_w + v_o)}{v_w} \approx f' = \frac{f(v_w + v_w)}{v_w} = \frac{2 f v_w}{v_w} \rightarrow 2f$<br>If the observer moves towards the source at the speed of sound, the effective speed of the wave is doubled, while the wavelength stays constant, so the apparent frequency will be double the emitted frequency. | | | |

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| THREE<br>(a)(i) | Kinetic energy is conserved:<br>$\frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2$<br>that is: $v^2 = v_1^2 + v_2^2$<br>Momentum is conserved:<br>$mv = mv_1 + mv_2$<br>that is: $v = v_1 + v_2$<br>These two equations can only be satisfied if one final velocity = $v$, and the other = 0. If $v_1$ and $v_2$ are both non-zero, both must be less than $v$, and the sum of the squares will be less than $v^2$. | Thorough understanding of these applications of physics.<br>OR<br>Partially correct mathematical solution to the given problems.<br>AND / OR<br>Partial understanding of these applications of physics. | (Partially) correct mathematical solution to the given problems.<br>AND / OR<br>Reasonably thorough understanding of these applications of physics. | Correct mathematical solution to the given problems.<br>AND<br>Thorough understanding of these applications of physics. |
| (ii) | $v^2 = v_1^2 + nv_3^2$ that is $1 = v_1^2 + nv_3^2$ (because $v = 1$)<br>$v = v_1 + nv_3$ that is $1 = v_1 + nv_3$ or $\frac{1-v_1}{n} = v_3$<br>(because $v = 1$)<br>So, substituting the second equation above into the first equation:<br>$1 = v_1^2 + n\left(\frac{1-v_1}{n}\right)^2 = v_1^2 + \frac{(1-v_1)^2}{n} = v_1^2\left(1+\frac{1}{n}\right) + \frac{1}{n} - \frac{2v_1}{n}$<br>That is: $v_1^2\left(1+\frac{1}{n}\right) - 1\left(1-\frac{1}{n}\right) - \frac{2v_1}{n} = 0$<br>$v_1^2\frac{n+1}{n} - \frac{2v_1}{n} - \frac{n-1}{n} = 0$<br>$v_1^2(n+1) - 2v_1 - (n-1) = 0$<br>This can be written as: $\left[(n+1)v_1 + (n-1)\right]\left[v_1 - 1\right] = 0$<br>so either $v_1 = 1$ or $(n+1)v_1 + (n-1) = 0$<br>that is $v_1 = \frac{1-n}{1+n}$<br>and hence $v_3 = \frac{1-v_1}{n} = \frac{(1+n)-(1-n)}{\frac{n+1}{n}} = \frac{\left(\frac{2n}{n+1}\right)}{n} = \frac{2}{n+1}$ | | | |

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| (iii) | It is the same except it is colliding with a mass $\frac{1}{n}$ times as big, not $n$ times as big. So replace $n$ by $\frac{1}{n}$ to get. The velocity of $S_1$ is given by $v_1 = \frac{1-\frac{1}{n}}{1+\frac{1}{n}}$ m s$^{-1}$ and the velocity of $S_3$ is given by $v_3 = \frac{2}{1+\frac{1}{n}}$ m s$^{-}$<br>1 $v_1 = \frac{1-\frac{1}{n}}{1+\frac{1}{n}}$ m s$^{-1}$ $= \frac{\frac{(n-1)}{n}}{\frac{(n+1)}{n}}$ m s$^{-1}$ $= \frac{n-1}{n+1}$ m s$^{-1}$ and<br>$v_3 = \frac{2}{1+\frac{1}{n}}$ m s$^{-1}$ $= \frac{2}{\frac{(n+1)}{n}}$ m s$^{-1}$ $= \frac{2n}{n+1}$ m s$^{-1}$<br>But $S_1$ and $S_3$ have changed places ($S_3$ is now moving and $S_1$ is stationary), so need to alter the subscripts. That is:<br>$v_3 = \frac{n-1}{n+1}$ m s$^{-1}$<br>$v_1 = \frac{2n}{n+1}$ m s$^{-1}$ | | | |
| (b) | The velocity of the ball is given by the following equation from (a)(iii), for the case that the velocity of the bat is 1 m s$^{-1}$<br>$v_1 = \frac{2n}{n+1}$ m s$^{-1}$<br>But the velocity of the bat is $V$, so the velocity of the ball should be scaled by $V$:<br>$v_1 = \frac{2nV}{n+1}$ m s$^{-1}$<br>For large $n$, $v_1 = \frac{2nV}{n} = 2V$ m s$^{-1}$ | | | |
| (c)(i) | $0.5mv^2 = 0.5\times1.675\times10^{-27}\times v^2 = 2\times10^6\times1.602\times10^{-19}$<br>$v^2 = \frac{2\times10^6\times1.602\times10^{-19}}{0.5\times1.675\times10^{-27}} = 3.83\times10^{14}$<br>$v = 1.956\times10^7$ m s$^{-1}$<br>and repeat for 1 eV<br>$0.5mv^2 = 0.5\times1.675\times10^{-27}\times v^2 = 1.602\times10^{-19}$<br>$v = 1.383\times10^4$ m s$^{-1}$<br>Difference is $1.955\times10^7$ m s$^{-1}$ | | | |
| (ii) | Need similar mass, which will result in significant velocity reduction, but don't want something that will absorb the neutrons. | | | |

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|---|---|---|---|---|
| FOUR<br>(a) | Electrons will experience a force (downwards) at right angles to the motion resulting in charge separation. | Thorough understanding of these applications of physics.<br>OR<br>Partially correct mathematical solution to the given problems.<br>AND / OR<br>Partial understanding of these applications of physics. | (Partially) correct mathematical solution to the given problems.<br>AND / OR<br>Reasonably thorough understanding of these applications of physics. | Correct mathematical solution to the given problems.<br>AND<br>Thorough understanding of these applications of physics. |
| (b) | With no friction or other unbalanced force on the wire ($W_2$), it will continue sliding at constant velocity. | | | |
| (c) | A current flows from the positive rail $T_A$ through $T_B$ and around the loop.<br>This current produces a magnetic field which interacts with the permanent magnetic field. $W_2$ slows down while $W_1$ picks up speed,<br>As $W_2$ slows the induced emf reduces, the current reduces, the decelerating force reduces. As $W_1$ picks up speed a back emf is generated that tries to make $T_A$ positive. This double action continues until both sliders reach the same speed (v/2 from the conservation of momentum) at which point the induced emfs cancel out and there is no more current. | | | |
| (d) | Using conservation of momentum:<br>Initial momentum is $mv$ and since the two wires are identical, each must have equal amounts of momentum – they are moving in the same direction so the final speed of each wire is $\frac{v}{2}$, or the fact that both wires feel the same magnitude of force so their speeds will converge on their average value of $\frac{v}{2}$. | | | |
| (e) | Since $v$ has reduced to $\frac{v}{2}$, while the moving mass of sliders has doubled, the KE has been reduced by half. With the missing energy lost to ohmic heating in the resistances. | | | |

## Cut Scores

| Scholarship | Outstanding Scholarship |
|---|---|
| 17 – 24 | 25 – 32 |