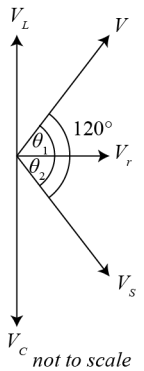


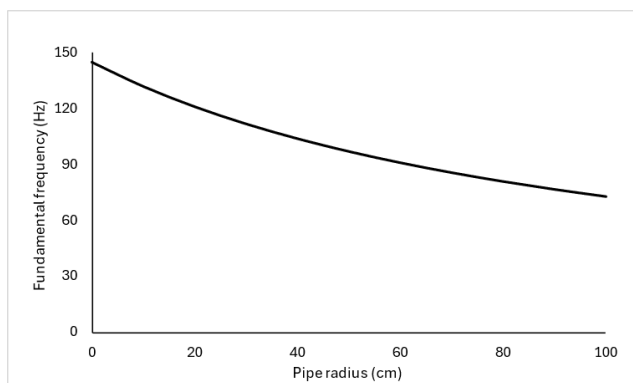
**Assessment Schedule – 2025****Scholarship Physics (93103)****Evidence Statement**

| Q          | Evidence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1–4 marks                                                                                                                                                                                                                      | 5–6 marks                                                                                                                                                          | 7–8 marks                                                                                                                              |
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| ONE<br>(a) | <p>Circuit 2 / series produces 3 times the voltage of a single cell, so the current in the circuit is also 3 times larger, as <math>R</math> is constant. As both <math>V</math> and <math>I</math> have tripled, the total power output of circuit 2 / series is 9 times higher than circuit 1 / single cell.</p> <p>Circuit 3 / parallel produces the same voltage as a single cell, so will have the same current, as both <math>V</math> and <math>R</math> are the same. As both <math>V</math> and <math>I</math> are the same, the total power output of circuit 3 / parallel is the same as circuit 1 / single cell.</p> <p><i>Circuit 3 will however provide this power for 3 times as long as circuit 1.</i></p> | <p>Thorough understanding of these applications of physics.</p> <p>OR</p> <p>Partially correct mathematical solution to the given problems.</p> <p>AND / OR</p> <p>Partial understanding of these applications of physics.</p> | <p>(Partially) correct mathematical solution to the given problems.</p> <p>AND / OR</p> <p>Reasonably thorough understanding of these applications of physics.</p> | <p>Correct mathematical solution to the given problems.</p> <p>AND</p> <p>Thorough understanding of these applications of physics.</p> |
| (b)(i)     | $I = \frac{\varepsilon}{R_{\text{total}}} = \frac{\varepsilon}{R + r}$ $V_R = IR = \frac{\varepsilon R}{R + r}$ $P = IV_R = \frac{\varepsilon}{R + r} \times \frac{\varepsilon R}{R + r} = \frac{\varepsilon^2 R}{(R + r)^2}$ <p>OR</p> $P = I^2 R = \left( \frac{\varepsilon}{R + r} \right)^2 \times R = \frac{\varepsilon^2 R}{(R + r)^2}$                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                |                                                                                                                                                                    |                                                                                                                                        |
| (ii)       | <p>At extremely high values of <math>R</math>:</p> <p><math>R \rightarrow \infty, V_R \rightarrow \varepsilon</math>, and <math>I \rightarrow 0</math>. <math>V_R</math> tends towards a finite fixed value and <math>I \rightarrow 0</math>, so <math>P_R = IV_R \rightarrow 0</math></p> <p>At extremely low values of <math>R</math>:</p> <p><math>R \rightarrow 0, V_R \rightarrow 0</math>, and <math>I \rightarrow \frac{\varepsilon}{R}</math>. <math>I</math> tends towards a finite fixed value and <math>V_R \rightarrow 0</math>, so <math>P_R = IV_R \rightarrow 0</math></p>                                                                                                                                  |                                                                                                                                                                                                                                |                                                                                                                                                                    |                                                                                                                                        |
| (c)        |  <p><math>V_r = Ir = 2.20 \times 10^{-2} \times 72.0 = 1.58 \text{ V}</math></p> $\theta_1 = \cos^{-1} \left( \frac{1.58}{4.20} \right) = 67.9^\circ$ $\theta_2 = 120 - 67.9 = 52.1^\circ$ $V_s = \frac{V_r}{\cos \theta_2} = \frac{1.58}{\cos 52.1^\circ} = 2.57 \text{ V}$                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                |                                                                                                                                                                    |                                                                                                                                        |

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| (d) | <p>When an AC LCR circuit is <b><i>near resonance</i></b></p> <p><math>V_R \approx V_S</math> and <math>I = \frac{V_S}{R}</math>.</p> <p>As <math>I</math> is the same everywhere in the series circuit, if <b><math>X_C</math> and <math>X_L</math> are both <math>&gt; R</math></b>, then <math>V_C = IX_C</math> and <math>V_L = IX_L</math> will both exceed <math>V_S</math>.</p> <p>Under these conditions energy is alternately being transferred from the discharging capacitor to the magnetic field in the inductor, then from the inductor back to the charging capacitor. Energy from the power supply is replacing heat energy dissipated due to resistance.</p> |  |  |  |
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| Q          | Evidence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1–4 marks                                                                                                                                                                                                          | 5–6 marks                                                                                                                                                    | 7–8 marks                                                                                                                        |
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| TWO<br>(a) | <ul style="list-style-type: none"> <li>• <b>Shorten the length of the string:</b> This shortens the wavelength of the standing wave. The tension and lineal density of the string do not change. This results in the oscillation of the string having the same acceleration back towards equilibrium, so the same wave propagation speed.<br/>As <math>f = \frac{v}{\lambda}</math>, a constant wave speed and shorter wavelength result in a higher frequency.</li> <li>• <b>Increase tension / use a more rigid bent stick:</b> Increasing tension increases the restoring force of the string oscillation. The same lineal density and increased restoring force makes the acceleration towards equilibrium larger, which increases the speed of the wave in the string. The length of the string remains constant.<br/>As <math>f = \frac{v}{\lambda}</math>, an increased wave speed and constant wavelength result in a higher frequency.</li> <li>• <b>Use a lighter / thinner string:</b> The tension in the string remains constant, so the restoring force towards equilibrium is the same. Decreasing string weight / lineal density means the same force acts on a smaller mass, increasing the acceleration of the string towards equilibrium. The speed of the wave in the string increases. The length of the string remains constant.<br/>As <math>f = \frac{v}{\lambda}</math>, an increased wave speed and constant wavelength results in a higher frequency.</li> </ul> | <p>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.</p> | <p>(Partially) correct mathematical solution to the given problems.<br/>AND / OR<br/>Reasonably thorough understanding of these applications of physics.</p> | <p>Correct mathematical solution to the given problems.<br/>AND<br/>Thorough understanding of these applications of physics.</p> |
| (b)        | <p>When a compression / high pressure reaches an open end of a pipe, the relatively higher pressure inside the pipe (compared to atmospheric pressure) pushes air out of the open end of the pipe. This causes the pressure in the open end of the pipe to drop below atmospheric pressure, causing a rarefaction to travel in the opposite direction back down the pipe. As the incident and reflected pressure waves are in opposite phase, a pressure node is formed at the open end of the pipe. Pressure standing waves and displacement standing waves are always in opposite phase, so the pressure node at the open end is a displacement antinode.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                    |                                                                                                                                                              |                                                                                                                                  |
| (c)        | <p>Use y-intercept (<math>f = 145</math> Hz) to determine <math>L</math> (no end correction needed for <math>r = 0</math>):</p> $L = \frac{\lambda}{2} = \frac{v}{2f} = \frac{343}{2 \times 145} = 1.18 \text{ m}$ <p>Use another point on the graph and calculated length to determine <math>k</math>:</p> <p>e.g. Use point <math>r = 9.0 \text{ cm} = 0.090 \text{ m}</math>, <math>f = 133.0 \text{ Hz}</math>.</p> <p>Effective pipe length <math>L' = L + 2e = L + 2kr</math> (<math>2e</math> as end correction must be applied at both ends of an open-open pipe)</p> $v = f\lambda = 2fL' = 2f(L + 2kr)$ $k = \frac{\left(\frac{v}{2f} - L\right)}{2r} = \frac{\left(\frac{343}{2 \times 133.0} - 1.18\right)}{2 \times 0.090} = 0.61$ <p>Or uses two different points, and solves simultaneously for same results.</p> <p>Calculated values vary, depending on point(s) chosen.</p> <p>Accept <math>L = 1.18 \pm 0.01 \text{ m}</math> and <math>k = 0.61 \pm 0.03</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                    |                                                                                                                                                              |                                                                                                                                  |

(d)



As  $r$  increases, the end correction also becomes larger, making the effective length of the pipe  $L'$  larger. As  $L'$  increases and  $v$  is constant,  $f$  will decrease. As  $L' \rightarrow \infty$ ,  $f \rightarrow 0$ , but never reaches 0, so the trend has an asymptote at  $f = 0$ .

| Q            | Evidence                                                                                                                                                                                                                                                                                                                                                              | 1–4 marks                                                                                                                             | 5–6 marks                                                                       | 7–8 marks                                                   |
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| THREE<br>(a) | The electric force must be towards the centre of the hemispheres to enable circular motion. Since the electron's charge is negative, this requires an electric field that points radially outwards, so the inner hemisphere is positive and the outer one negative. The positive plate has the higher voltage, so $V_1 > V_2$ . The potential difference is negative. | Thorough understanding of these applications of physics.<br>OR                                                                        | (Partially) correct mathematical solution to the given problems.                | Correct mathematical solution to the given problems.<br>AND |
| (b)(i)       | $F_c = Eq = \frac{V}{d}q = \frac{mv^2}{R_{\text{mid}}}$ $E_k = \frac{1}{2}mv^2 = \frac{VqR_{\text{mid}}}{2d}$ $E_k = \frac{60.0 \times 1.60 \times 10^{-19} \times 0.300}{2 \times 0.050} = 2.88 \times 10^{-17} \text{ J}$ $E_k = \frac{2.88 \times 10^{-17}}{1.60 \times 10^{-19}} = 180 \text{ eV}$                                                                | Partially correct mathematical solution to the given problems.<br>AND / OR<br>Partial understanding of these applications of physics. | AND / OR<br>Reasonably thorough understanding of these applications of physics. | Thorough understanding of these applications of physics.    |
| (ii)         | Energy input (energy of the photon)<br>= kinetic energy left + energy to remove electron<br>$E_{\text{photon}} = \frac{hc}{\lambda} = 2.39 \times 10^{-16} \text{ J} = 1498 \text{ eV}$ $E_{\text{remove}} = 1498 - 180 = 1318 = 1320 \text{ eV (3 s.f.)}$ $(= 2.396 \times 10^{-16} - 2.88 \times 10^{-17} = 2.11 \times 10^{-16} \text{ J})$                        |                                                                                                                                       |                                                                                 |                                                             |
| (c)          | If the sample is not connected to ground, it will become positively charged as electrons are photo-emitted. This will increase the attraction of the electrons to the sample, and more energy will be needed to remove the electrons, so the kinetic energy of the emitted electrons will decrease (assuming fixed photon energy).                                    |                                                                                                                                       |                                                                                 |                                                             |
| (d)          | The fact that three narrow peaks are observed implies that the electrons in the material have discrete, quantised energy levels (these correspond to the quantised energy levels in the Bohr model).                                                                                                                                                                  |                                                                                                                                       |                                                                                 |                                                             |

| Question       | Evidence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1–4 marks                                                                                                                        | 5–6 marks                                                                                                                                           | 7–8 marks                                                                                                               |
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| FOUR<br>(a)(i) | Horizontal: $F_T = \sin \theta = ma$<br>Vertical: $F_T \cos \theta = mg$<br>Combining: $F_T = \frac{ma}{\sin \theta} = \frac{mg}{\cos \theta}$<br>$a = \frac{g \sin \theta}{\cos \theta} = g \tan \theta \approx g \sin \theta$ (assuming small $\theta$ )<br>$a = \frac{gx}{L}$<br>As $a$ is in the opposite direction to $x$ , $a = -\frac{gx}{L}$                                                                                                                                                                            | Thorough understanding of these applications of physics.<br>OR<br>Partially correct mathematical solution to the given problems. | (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 expression shows that acceleration is proportional to displacement and towards equilibrium ( $a \propto -x$ ), so is SHM.                                                                                                                                                                                                                                                                                                                                                                                                   | AND / OR<br>Partial understanding of these applications of physics.                                                              |                                                                                                                                                     |                                                                                                                         |
| (b)            | When the masses oscillate in phase, the spring is neither stretched nor compressed, so there are no additional forces on each pendulum, and the period will be the same as that of a simple pendulum.<br>$T = 2\pi \sqrt{\frac{L}{g}} = 2\pi \sqrt{\frac{0.560}{9.81}} = 1.50 \text{ s}$                                                                                                                                                                                                                                        |                                                                                                                                  |                                                                                                                                                     |                                                                                                                         |
| (c)            | Restoring force from tension:<br>$F_T = mg \tan \theta \approx -\frac{mgx}{L}$<br>Restoring force from spring:<br>$F_S = -2kx$ (extended by $x$ at both ends)<br>$F_{\text{net}} = F_T + F_S = -\frac{mgx}{L} - 2kx = -x\left(\frac{mg}{L} + 2k\right)$<br>$a = \frac{F_{\text{net}}}{m} = -x\left(\frac{g}{L} + \frac{2k}{m}\right)$<br>$a = -\omega^2 x = -x\left(\frac{g}{L} + \frac{2k}{m}\right)$<br>$\omega = \frac{2\pi}{t} = \sqrt{\frac{g}{L} + \frac{2k}{m}}$<br>$T = \frac{2\pi}{\sqrt{\frac{g}{L} + \frac{2k}{m}}}$ |                                                                                                                                  |                                                                                                                                                     |                                                                                                                         |
| (d)            | The extended spring exerts force on both masses.<br>As the masses move, this does work on both masses, gradually transferring energy from mass 2 to mass 1. This increases the amplitude of the oscillation of mass 2 and decreases the amplitude of the oscillation of mass 1.<br>Eventually the oscillation of mass 2 stops when all the energy has been transferred to mass 1. The process is then reversed, and the energy is transferred back to mass 2.                                                                   |                                                                                                                                  |                                                                                                                                                     |                                                                                                                         |

**Cut Scores**

| Scholarship | Outstanding Scholarship |
|-------------|-------------------------|
| 17 – 27     | 28– 32                  |