Waves Questions MS

1. Single wavelength/frequency (1)
Waves in antiphase superimpose giving complete or partial cancellation (1)

\[ f = \frac{c}{\lambda} = \frac{3 \times 10^8 \text{ m s}^{-1}}{780 \times 10^{-9} \text{ m}} = 3.85 \times 10^4 \text{ Hz} \] (1)

\[ n = \frac{\nu_{\text{air}}}{\nu_{\text{plastic}}} \]
\[ \nu_{\text{plastic}} = \frac{3 \times 10^8 \text{ m s}^{-1}}{1.55} = 1.94 \times 10^8 \text{ m s}^{-1} \] (1)

\[ \lambda = \frac{\nu}{f} = \frac{1.94 \times 10^8 \text{ m s}^{-1}}{3.85 \times 10^{14} \text{ Hz}} = 5.04 \times 10^{-7} \text{ m} \] (1)

Path difference between two sets of waves = 2 × ridge height (1)

\[ = 2 \times 125 \text{ nm} = 250 \text{ nm or approx.} \frac{\lambda}{2} \] (1)

Waves are in antiphase when they combine and produce small amplitude (1)

No. Path difference is now \( \approx \lambda \) so waves from ridge and valley almost in phase when they recombine (1)

The pattern of ridges and valleys will not give an on/off signal (1)

[‘No’ must have an attempt at an explanation for a mark] 2

2. Calculate \( \nu \) or \( \nu^2 \) and \( t \) and plots correct (1)(1)(1)

<table>
<thead>
<tr>
<th>( M/\text{kg} )</th>
<th>( f/\text{Hz} )</th>
<th>( \lambda/\text{m} )</th>
<th>( \nu/\text{ms}^{-1} )</th>
<th>( \nu^2/\text{m}^2 \text{ s}^{-2} )</th>
<th>( T/\text{N} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.16</td>
<td>30.6</td>
<td>0.37</td>
<td>12.3</td>
<td>151</td>
<td>1.96</td>
</tr>
<tr>
<td>0.20</td>
<td>30.0</td>
<td>0.41</td>
<td>11.3</td>
<td>128</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Best fit line (1)

Yes (1)

Best fit line through origin is near all plots (1)

Large \( \Delta \) drawn (1)

Gradient = \( \frac{160}{2.01} = 79.6 \) (1)

\[ \mu = \frac{1}{\text{Gradient}} = 0.0126 \text{ kg m}^{-1} \text{ (accept 0.12 – 0.013)} \] (1)
3. Polarised – vibrations of transverse wave in 1 plane only (or E or B field)
   Non-polarised – vibrations can be in any plane perpendicular to direction
   of travel \( \text{(1)} \)
   No light \( \text{(1)} \)
   Align sunglasses so that axis allows absorption of polarised light \( \text{(1)} \)

\[
r + 90^\circ + \theta = 180^\circ \quad \text{(on straight line)}
\]
\[
r = 180 - 90 - \theta = 90 - \theta \quad \text{(1)}
\]
\[
\mu = \frac{\sin \theta}{\sin r} = \frac{\sin \theta}{\sin (90 - \theta)}
\]
\[
1.33 = \frac{\sin \theta}{\cos \theta} = \tan \theta
\]
\[
\theta = \tan^{-1} 1.33
\]
\[
= 53^\circ \quad \text{(1)}
\]

4. Explanation of words:
   
   **Coherent**
   
   Same frequency and constant phase relationship \( \text{(1)} \)
   
   **Standing wave**
   
   Any two points from:
   
   Superposition/interference
   
   Two (or more) wavetrains passing through each other
   
   Having equal \( A, f, \lambda \)
   
   + system of nodes and antinodes \( \text{(1)} \) \( \text{(1)} \)

   Position of one antinode marked on diagram
   
   Correctly marked \( A \) (in centre of rings – hot zone) \( \text{(1)} \)

   Wavelength demonstration:
   
   \[
   \lambda = \frac{c}{f} = \frac{3 \times 10^8}{2.45 \times 10^9} \text{ m}
   \]
   
   \[
   = 12.2 \text{ cm} \quad \text{(1)}
   \]

   Path difference:
   
   \[
   (22.1 + 14) - (20 + 10) \text{ cm}
   \]
   
   \[
   = 6.1 \text{ cm} \quad \text{(1)}
   \]

   Explanation:
   
   \[
   6.1 \text{ cm} = \frac{1}{2} \times \lambda \quad \text{(1)}
   \]
   
   Waves at \( X \) in antiphase/ destructive interference \( \text{(1)} \)
   
   \( \rightarrow \) node \( \text{(1)} \)

   Explanation of how two separate microwave frequencies overcomes uneven heating problem:
   
   Different wavelengths \( \text{(1)} \)
   
   So a path difference which gives destructive interference at
   one wavelength may not do so at another \( \text{(1)} \)
5. \( w \mu_h = 1.0 \)

**Eye diagram:**
Both rays bend inwards on entering spherical lens (1)
Then inwards again on leaving spherical lens to cross at retina (1)

**Explanation:**
Object distance reduced, so image distance must be increased (1)
so lens must move away from the retina (1)

Use of \( \frac{1}{u} + \frac{1}{v} = \frac{1}{f} \) to explain

OR good use of diagrams for maximum marks (1)

**Lake diagram**
Ray of light drawn from person, refracting in correct direction at water surface (1)
Ray drawn from below fish, reflecting at water surface [angles approximately correct] (1)
Arrows on both rays towards fish (1)

**Critical angle calculation:**
\[
\sin C = \frac{1}{\mu_w} (1)
\]

\[
= \frac{1}{1.33}
\]
\[
\therefore C = 49^\circ (1)
\]

6. **Physics principles**
Requires 9 V battery:
Battery required for electronic circuitry / microphone / speaker (1)

**Rubberized foam ear cups:**
Air filled material / material has large surface area (1)
Air molecules collide frequently with material (1)
Foam deforms plastically/collisions are inelastic (1)
Sound converted to heat in material (1)

**Active noise attenuation:**
Noise picked up by microphone (1)
Feedback signal inverted / 180° out of phase with noise / antiphase (1)
Amplified [OR amplitude adjusted] and fed to earphones / speaker (1)
Sound generated cancels/superimposes/minimum noise (1)
Diagrams of superposing waves showing (approx.) cancellation (1)
Amplifier gain automatically adjusted if noise remains (1)
Device only works over frequency range 20 – 800 Hz (1)
Where does the energy go?
Some places will have constructive interference (1)
More intense noise (1)
Some noise dissipated as heat in air / foam (1)
increased kinetic energy of air [OR foam] molecules (1)  Max 2

7. Explanation of pressure nodes or antinodes
Pressure constant (1)
Node as a result (1)  2
Relationship between length and wavelength
\( l = \lambda / 2 \) or \( \lambda = 2l \) (1)  1
Calculation of fundamental frequency
\( \lambda = 2 \times 0.28 \text{ m} = 0.56 \text{ m} \) [ecf for relationship above] (1)
\( v = f \lambda \) (1)
\( f = \frac{v}{\lambda} = \frac{330 \text{ m s}^{-1}}{0.56 \text{ m}} \)
= 590 Hz (1)  3
Calculation of time period
\( T = \frac{1}{f} \) (1)
\( T = \frac{1}{590 \text{ Hz}} \) [ecf]
= 0.0017 s (1)  2
State another frequency and explain choice
e.g. 590 Hz \( \times 2 = 1180 \text{ Hz} \) (or other multiple) (1)
multiple of \( f_0 \) or correct reference to changed wavelength (1)
diagram or description, e.g. N A N A N, of new pattern [ecf for A & N] (1)  3