1. Waves emitted from sources X and Y have equal wavelengths and are initially in phase. The waves interfere destructively at point P, where the path difference is 0.60m.

   ![Wave interference diagram]

   What is a possible value for the wavelength of the waves?
   A. 0.20 m  
   B. 0.30 m  
   C. 0.40 m  
   D. 0.60 m

2. The intensity of radiation from a star at the surface of one of its planets is $I$. The distance between the star and the planet is $d$. What is the intensity at the surface of another planet which is a distance $\frac{d}{4}$ from the star?
   A. $4I$  
   B. $8I$  
   C. $16I$  
   D. $64I$

3. Progressive (travelling) waves $S$ and $T$ have the same frequency and are in the same medium. $S$ has amplitude 2.0 m and $T$ has amplitude 4.0 m. What is the ratio of the intensity of $T$ to the intensity of $S$?
   A. $\frac{1}{4}$  
   B. $\frac{1}{2}$  
   C. 2  
   D. 4
4. P and Q are two points on a standing wave. R and S are two points on a progressive (travelling) wave.

Which of the following gives the relationship between the amplitudes of each pair of points?

<table>
<thead>
<tr>
<th>Points P and Q</th>
<th>Points R and S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. same amplitude</td>
<td>same amplitude</td>
</tr>
<tr>
<td>B. different amplitude</td>
<td>same amplitude</td>
</tr>
<tr>
<td>C. same amplitude</td>
<td>different amplitude</td>
</tr>
<tr>
<td>D. different amplitude</td>
<td>different amplitude</td>
</tr>
</tbody>
</table>

5. Unpolarized light is incident on the surface of a transparent medium. The reflected light is completely plane polarized. The refracted light will be
   A. unpolarized.
   B. partially plane polarized.
   C. completely plane polarized at right angles to the reflected light.
   D. completely plane polarized parallel to the reflected light.

6. What region of the electromagnetic spectrum includes waves of wavelength $5 \times 10^{-8}$ m?
   A. X-ray
   B. Ultraviolet
   C. Infrared
   D. Microwave
7. A ray of light travels from a vacuum into glass as shown below.

In glass, light has speed \( v \). In a vacuum, light has speed \( c \). Which of the following gives the refractive index of glass?

A. \( \frac{c}{v} \)
B. \( \frac{v}{c} \)
C. \( \frac{\sin\theta}{\sin\theta_v} \)
D. \( \frac{\sin\theta_v}{\sin\theta} \)

8. A pendulum swings back and forth in a circular arc between X and Y.

The pendulum bob is

A. always in equilibrium.
B. only in equilibrium at X and Y.
C. in equilibrium as it passes through the central position.
D. never in equilibrium.
A wave pulse is travelling along a dense thick rope which is connected to a less dense thin rope.

Which of the following is correct regarding the reflected and transmitted wave pulses after the wave pulse reaches the connection of the two ropes?

<table>
<thead>
<tr>
<th>Reflected pulse</th>
<th>Transmitted pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. inverted</td>
<td>inverted</td>
</tr>
<tr>
<td>B. not inverted</td>
<td>inverted</td>
</tr>
<tr>
<td>C. inverted</td>
<td>not inverted</td>
</tr>
<tr>
<td>D. not inverted</td>
<td>not inverted</td>
</tr>
</tbody>
</table>

Which of the following is correct regarding the reflected and transmitted wave pulses after the wave pulse reaches the connection of the two ropes?
10. Two wave pulses travel along a string towards each other. The diagram shows their positions at a moment in time. Which of the following shows a possible configuration of the pulses at a later time?

A.  

B.  

C.  

D.  

11. A transverse standing wave is established on a string. Consider the following phase differences.

I. 0°
II. 90°
III. 180°

Which of the following gives all the possible phase differences between the oscillations of any two particles in the standing wave?

A. I only
B. I and III only
C. II and III only
D. I, II and III
12. A beam of unpolarized light is incident on the surface of a liquid and is partially reflected and partially refracted as shown below. [1 mark]

The reflected light is completely horizontally polarized. Which of the following is the refractive index of the liquid?

A. \( \tan 40^\circ \)
B. \( \tan 50^\circ \)
C. \( \frac{\sin 60^\circ}{\sin 50^\circ} \)
D. \( \frac{\sin 60^\circ}{\cos 50^\circ} \)

13. The diagrams show the variation with time \( t \) of the displacement \( y \) of a particle of a medium through which a wave travels. Which diagram correctly shows the period \( T \) and amplitude \( A \) of the wave? [1 mark]

A. ![Diagram A]
B. ![Diagram B]
C. ![Diagram C]
D. ![Diagram D]
Unpolarized light is incident on a polarizer. The light transmitted by the first polarizer is then incident on a second polarizer. The polarizing axis of the second polarizer is at 60º to that of the first polarizer.

The intensity emerging from the second polarizer is $I_f$.

Which of the following correctly gives the intensity incident on the first polarizer?

A. $\frac{I_f}{4}$
B. $\frac{I_f}{8}$
C. $4I_f$
D. $8I_f$

For a body undergoing simple harmonic motion the velocity and acceleration are

A. always in the same direction.
B. always in opposite directions.
C. in the same direction for a quarter of the period.
D. in the same direction for half the period.

Which of the following correctly relates the direction of oscillation of the particles in a medium to the direction of energy propagation for transverse and longitudinal waves?

<table>
<thead>
<tr>
<th>Transverse wave</th>
<th>Longitudinal wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. perpendicular</td>
<td>perpendicular</td>
</tr>
<tr>
<td>B. perpendicular</td>
<td>parallel</td>
</tr>
<tr>
<td>C. parallel</td>
<td>perpendicular</td>
</tr>
<tr>
<td>D. parallel</td>
<td>parallel</td>
</tr>
</tbody>
</table>
17. Two identical waves of wavelength $\lambda$ leave two sources in phase. The waves meet and superpose after travelling different distances. Which path difference will result in destructive interference?

A. $\frac{\lambda}{4}$
B. $\frac{\lambda}{2}$
C. $\frac{3\lambda}{4}$
D. $\lambda$

18. The diagrams show four different organ pipes drawn to scale. Standing waves in the fundamental (first harmonic) mode are set up inside each pipe. Which pipe produces a fundamental note with the lowest frequency?

A. 

B. 

C. 

D. 

19. Two polarizing filters are set up so the transmitted light is at a maximum intensity.

Through which angle should polarizer 2 be rotated so that no light is transmitted?

A. 45°
B. 60°
C. 90°
D. 180°
20. Light of wavelength 600 nm travels from air to glass at normal incidence. The refractive index of the glass is 1.5. The speed of light in air is \( c \). Which of the following correctly identifies the speed of the waves and their wavelength in the glass?

<table>
<thead>
<tr>
<th>Speed</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ( \frac{2c}{3} )</td>
<td>900 nm</td>
</tr>
<tr>
<td>B. ( c )</td>
<td>900 nm</td>
</tr>
<tr>
<td>C. ( c )</td>
<td>400 nm</td>
</tr>
<tr>
<td>D. ( \frac{2c}{3} )</td>
<td>400 nm</td>
</tr>
</tbody>
</table>

21. Which of the following correctly describes the direction of a ray drawn relative to a wavefront for longitudinal and transverse waves? [1 mark]

<table>
<thead>
<tr>
<th>Longitudinal wave</th>
<th>Transverse wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. parallel</td>
<td>parallel</td>
</tr>
<tr>
<td>B. parallel</td>
<td>perpendicular</td>
</tr>
<tr>
<td>C. perpendicular</td>
<td>parallel</td>
</tr>
<tr>
<td>D. perpendicular</td>
<td>perpendicular</td>
</tr>
</tbody>
</table>

22. Gas particles are equally spaced along a straight line. A sound wave passes through the gas. The positions of the gas particles at one instant are shown below.

Which of the distances shown is equal to the wavelength of the wave?
23. A point source of sound is placed behind a soundproof barrier as shown in the diagram. From where Euan is standing he can hear the sound. Which of the following best explains this observation?

A. Diffraction  
B. Interference  
C. Polarization  
D. Refraction

24. A standing wave of frequency $f$ is established in air in a pipe open at one end, as shown. Which of the following is the frequency of the next highest harmonic?

A. $\frac{f}{2}$  
B. $\frac{f}{3}$  
C. $2f$  
D. $3f$
25. Unpolarized light of intensity $I_0$ is transmitted through a polarizer which has a transmission axis at an angle $\theta$ to the vertical. The light is then incident on a second polarizer with a transmission axis at an angle $\phi$ to the transmission axis of the first polarizer, as shown below.

The intensity of the light that emerges from the second polarizer is $I$. What is the ratio $\frac{I}{I_0}$?

A. 0.25  
B. $0.5 \cos^2 (\theta + \phi)$  
C. $0.5 \cos^2 \phi$  
D. $\cos \theta \cos \phi$

26. The air in a pipe, of length $l$ and open at both ends, vibrates with a fundamental frequency $f$. What is the fundamental frequency of a pipe of length $1.5l$ and closed at one end?

A. $\frac{f}{3}$  
B. $\frac{2f}{3}$  
C. $\frac{3f}{2}$  
D. $3f$
Unpolarized light of intensity $I_0$ is incident on a polarizer with a vertical transmission axis. The transmitted light is incident on a sheet of material $X$. After transmission through $X$ the intensity of the light is $\frac{I_0}{2}$.

It is suggested that $X$ could be

I. a polarizer with vertical transmission axis
II. a polarizer with horizontal transmission axis
III. non polarizing glass.

Which of the above suggestions is/are correct?

A. I and III only
B. I only
C. II only
D. II and III only

A high solid wall separates two gardens $X$ and $Y$. Music from a loudspeaker in $X$ can be heard in $Y$ even though $X$ cannot be seen from $Y$. The music can be heard in $Y$ due to

A. absorption.
B. diffraction.
C. reflection.
D. refraction.
29. A string is made to vibrate at its third harmonic. The diagram shows two points P and Q at a particular instant in time.

![Diagram of a string with points P and Q](image)

Which of the following compares the period of vibration of P and Q and the average speed of P and Q?

<table>
<thead>
<tr>
<th>Period of vibration of P and Q</th>
<th>Average speed of P and Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. same</td>
<td>same</td>
</tr>
<tr>
<td>B. same</td>
<td>different</td>
</tr>
<tr>
<td>C. different</td>
<td>same</td>
</tr>
<tr>
<td>D. different</td>
<td>different</td>
</tr>
</tbody>
</table>

30. A wave of period 5.0 m s travels through a medium. The graph shows the variation with distance \( d \) of the displacement \( x \) of points in the medium.

![Graph showing variation of displacement with distance](image)

What is the average speed of a point in the medium during one full oscillation?

A. 0 m s\(^{-1}\)
B. 4.0 m s\(^{-1}\)
C. 16 m s\(^{-1}\)
D. 400 m s\(^{-1}\)
A body undergoes simple harmonic motion. Which graph correctly shows the variation with displacement $x$ of the velocity $v$ of the body?

A. ![Graph A](image)
B. ![Graph B](image)
C. ![Graph C](image)
D. ![Graph D](image)

The speed of a wave in medium X is greater than the speed of the wave in medium Y. Which diagram shows the correct refraction of the wavefronts at the boundary between X and Y?

A. ![Diagram A](image)
B. ![Diagram B](image)
C. ![Diagram C](image)
D. ![Diagram D](image)
Two loudspeakers, $L_1$ and $L_2$, emit identical sound waves.

The waves leaving $L_1$ and $L_2$ are in phase and are observed at points P and Q.

The wavelength of the sound is 0.60 m. The distances of points P and Q from the loudspeakers are shown in the diagram.

Which of the following is true about the intensity of the sound at P and the intensity of the sound at Q?

<table>
<thead>
<tr>
<th></th>
<th>Intensity at P</th>
<th>Intensity at Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>maximum</td>
<td>maximum</td>
</tr>
<tr>
<td>B.</td>
<td>maximum</td>
<td>minimum</td>
</tr>
<tr>
<td>C.</td>
<td>minimum</td>
<td>maximum</td>
</tr>
<tr>
<td>D.</td>
<td>minimum</td>
<td>minimum</td>
</tr>
</tbody>
</table>
34. The diagram shows, at a particular instant in time, part of a rope along which a wave is travelling. The wave is travelling from left to right. Which arrow shows the direction of motion of the rope at the point shown?
   A. W
   B. X
   C. Y
   D. Z

35. The diagram shows the fundamental (first harmonic) of a standing (stationary) sound wave in a pipe open at one end. At any instant, all the molecules of air in the pipe oscillate with the same
   A. phase.
   B. amplitude.
   C. velocity.
   D. acceleration.
Monochromatic coherent light is incident on a narrow rectangular slit. The diffracted light is observed on a distant screen. The graph below shows how the intensity of the light varies with position on the screen.

The width of the slit is reduced.

Which graph shows how the intensity of light observed varies with position on the screen? The original diffraction pattern is shown with a dotted line.
37. Unpolarized light of intensity $I_0$ is incident on a polarizer that has a vertical transmission axis. The polarizer is rotated by an angle $\theta$ about the direction of the incident light. The intensity of the transmitted light is $I$. Which graph correctly shows the variation with the angle $\theta$ of the ratio $\frac{I}{I_0}$?

![Graphs A, B, C, D showing variations of $\frac{I}{I_0}$ with $\theta$.]

38. The lowest frequency emitted by an organ pipe that is open at both ends is $f$. What is the lowest frequency emitted by an organ pipe of the same length that is closed at one end? [1 mark]

A. $\frac{f}{4}$
B. $\frac{f}{2}$
C. $2f$
D. $4f$
A person wearing polarizing sunglasses stands at the edge of a pond in bright sunlight. The surface of the pond is flat and the line of sight of the person makes an angle \( \theta \) with the surface. The refractive index of the pond water is \( n \). What is the value of \( \theta \) for which the intensity of the sunlight reflected by the surface to the person’s eye is a minimum?

A. \( \tan^{-1}(n) \)
B. \( \cos^{-1}\left(\frac{1}{n}\right) \)
C. \( \cos^{-1}(n) \)
D. \( \tan^{-1}\left(\frac{1}{n}\right) \)

A transverse travelling wave has an amplitude \( x_0 \) and wavelength \( \lambda \). What is the minimum distance between a crest and a trough measured in the direction of energy propagation?

A. \( 2x_0 \)
B. \( x_0 \)
C. \( \lambda \)
D. \( \frac{\lambda}{2} \)

A wave on a string travels to the right as shown. The frequency of the wave is \( f \). At time \( t = 0 \), a small marker on the string is in the position shown.

What is the position of the marker at \( t = \frac{1}{4f} \)?

Electromagnetic waves

A. always obey an inverse square law.
B. are made up of electric and magnetic fields of constant amplitude.
C. always travel at the same speed in a vacuum.
D. are always polarized.
43. A wave pulse travels along a light string which is attached to a frictionless ring. The ring can move freely up and down a vertical rod. [1 mark]

What is the shape of the wave pulse after reflection?

A. 

B. 

C. 

D. 

44. A standing (stationary) wave is set up on a string at a particular frequency as shown. [1 mark]

How many nodes will be on the string if the frequency is doubled but nothing else is changed?

A. 2
B. 3
C. 7
D. 8

45. Electromagnetic waves pass through a slit in a metal plate with minimal diffraction. The slit has a width of 0.25 m. What is the wavelength of the waves? [1 mark]

A. Much less than 0.25 m
B. Between 0.10 m and 0.40 m
C. Equal to 0.25 m
D. Much greater than 0.25 m
46. Light is incident from air on the surface of a transparent medium.

When V is equal to the Brewster angle, which angle is equal to 90°?

A. \( V + W \)
B. \( W \) only
C. \( X + Y \)
D. \( Z \) only

47. An object performs simple harmonic motion (SHM) about a central point. The object has velocity \( v \) and acceleration \( a \) when it has displacement \( x \) from the point.

Which ratio is constant?

A. \( \frac{a}{v} \)
B. \( \frac{x}{v} \)
C. \( \frac{v}{x} \)
D. \( \frac{v}{x} \)

48. Which graph shows the variation with amplitude \( A \) of the intensity \( I \) for a wave?

A. 

\[
\begin{array}{c}
\text{A. } I \\
\end{array}
\]

B. 

\[
\begin{array}{c}
\text{B. } I \\
\end{array}
\]

C. 

\[
\begin{array}{c}
\text{C. } I \\
\end{array}
\]

D. 

\[
\begin{array}{c}
\text{D. } I \\
\end{array}
\]
Wave generators placed at position P and position Q produce water waves of wavelength 4.0 cm. Each generator, operating alone, produces a wave oscillating with amplitude $A$ at position R. Distances PR and QR are shown in the diagram below.

Both wave generators now operate together in phase. What is the amplitude of the oscillation of the resulting wave at R?

A. 0  
B. $A$  
C. $A^2$  
D. $2A$  

49. Wave generators placed at position P and position Q produce water waves of wavelength 4.0 cm. Each generator, operating alone, produces a wave oscillating with amplitude $A$ at position R. Distances PR and QR are shown in the diagram below.
50. A water wave entering a harbour passes suddenly from deep to shallow water. In deep water, the wave has frequency $f_1$ and speed $v_1$. In shallow water, the wave has frequency $f_2$ and speed $v_2$.

Which of the following compares the frequencies and speeds of the wave between deep water and shallow water?

<table>
<thead>
<tr>
<th>Frequencies</th>
<th>Wave speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_1 = f_2$</td>
<td>$v_1 &gt; v_2$</td>
</tr>
<tr>
<td>$f_1 = f_2$</td>
<td>$v_1 &lt; v_2$</td>
</tr>
<tr>
<td>$f_1 &gt; f_2$</td>
<td>$v_1 = v_2$</td>
</tr>
<tr>
<td>$f_1 &lt; f_2$</td>
<td>$v_1 &gt; v_2$</td>
</tr>
</tbody>
</table>

51. Two wave pulses move towards each other as shown in the diagram.

Which diagram shows a possible combination of the two pulses after a short time?
Wave generators placed at position P and position Q produce water waves of wavelength 4.0 cm. Each generator, operating alone, produces a wave oscillating with amplitude $A$ at position R. Distances PR and QR are shown in the diagram below.

Both wave generators now operate together in phase. What is the amplitude of the oscillation of the resulting wave at R?

A. 0  
B. $A$  
C. $A^2$  
D. $2A$
A standing (stationary) wave is set up on a stretched string. The diagram below shows the string at three different instants of time. P, Q and R are three points on the string.

Which of the following gives two points on the string that are in phase and two points on the string that are one wavelength apart?

<table>
<thead>
<tr>
<th>In phase</th>
<th>One wavelength apart</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. P and Q</td>
<td>P and R</td>
</tr>
<tr>
<td>B. P and R</td>
<td>P and R</td>
</tr>
<tr>
<td>C. P and Q</td>
<td>P and Q</td>
</tr>
<tr>
<td>D. P and R</td>
<td>P and Q</td>
</tr>
</tbody>
</table>

An unpolarized ray of light in air is incident on the surface of water. The reflected ray is completely polarized. Which of the following are separated by an angle of 90°?

A. The incident ray and the reflected ray  
B. The reflected ray and the refracted ray  
C. The refracted ray and the incident ray  
D. The refracted ray and the surface of the water
Two polarizers have polarizing axes that make an angle of 30˚ to each other. Unpolarized light of intensity \( I \) is incident on the first polarizer so that light of intensity \( I_2 \) emerges from the second polarizer, as shown below.

The cosine of 30˚ is \( \frac{\sqrt{3}}{2} \). What is the ratio \( \frac{I}{I_1} \)?

A. \( \frac{2}{3} \)  
B. \( \frac{2}{\sqrt{3}} \)  
C. \( \frac{4}{3} \)  
D. \( \frac{\sqrt{3}}{8} \)

A liquid in a U-tube is given an initial displacement and allowed to oscillate. The motion of the liquid is recorded using a motion sensor. Which graph shows the variation with time \( t \) of the velocity \( v \) of the liquid?

A. \[ \begin{array}{c}
\text{A.} \\
\text{v} \\
0 \\
0 \\
\text{t}
\end{array} \]  
B. \[ \begin{array}{c}
\text{B.} \\
\text{v} \\
0 \\
0 \\
\text{t}
\end{array} \]  
C. \[ \begin{array}{c}
\text{C.} \\
\text{v} \\
0 \\
0 \\
\text{t}
\end{array} \]  
D. \[ \begin{array}{c}
\text{D.} \\
\text{v} \\
0 \\
0 \\
\text{t}
\end{array} \]
57. A wave pulse is sent along a light string which is attached to a heavy rope as shown. The diagrams are not to scale.

Which diagram shows the shape of the string and the rope after a short time?

A.  

B.  

C.  

D.  

58. A standing sound wave is set up inside a narrow glass tube which has both ends open. The first harmonic frequency of the standing wave is 500Hz. What is the frequency of the sound wave if the length of the tube is halved and one end is closed?

A. 250 Hz  
B. 500 Hz  
C. 1000 Hz  
D. 2000 Hz