Exam Papers Practice

4.3 Wave Characteristics

Mark Schemes

Course	DP IB Physics
Section	4. Waves
Topic	4.3 Wave Characteristics
Difficulty	Medium

To be used by all students preparing for DP IB Physics HL
Students of other boards may also find this useful

1

The correct answer is **A** because

- 50% of unpolarised light will be transmitted through any given polariser
  - This is because light can be split into vertical and horizonal components at 90° to each other
  - The components of light in the direction of the polariser will pass through, but components of light at 90° will not
- Therefore, once the light has passed through the first polariser, the intensity is 50% of the original unpolarised light
- When we add a second polariser, it will only allow components of light at the correct polarisation to pass through:
  - When the axes of the first and second filters are aligned parallel, then all of the light which passes through by the first polariser will pass through the second
  - When the polarisers are at 90° to each other no light will pass through second polariser
  - By symmetry, 50% of the light will pass through the second polariser if it is rotated to 45°
- At 180° the polarisers are parallel and so 100% of light passes through
  - Since 225° = 180° + 45°, then the intensity of light is reduced by another 50%
  - Therefore 50% × 50% = 25% of the unpolarised light is transmitted through both filters

2

The correct answer is **B** because:

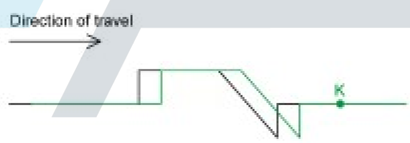
- Light reflecting from your left eye to the mirror will be polarised in the horizontal direction by the polariser in the left lens
- It retains this polarisation when it reflects from the mirror, remaining horizontally polarised

- None of this light can then pass through the vertical polariser in the right lens
    - Therefore, the left lens appears black to your right eye as no light can pass through
- Light from elsewhere has not been polarised before reaching the right lens and so will appear the same as before you shut your left eye
    - Therefore, the surroundings are still visible as before

3

The correct answer is **B** because:

- The wave formed along the rope is a transverse wave
    - The oscillations are perpendicular to the direction of travel
- Direction of travel is to the right, as shown in the diagram
- The particles can only oscillate in a vertical motion (up and down)
- The diagram below shows the wave an instant later, moving the wave to the right



- The particle K will move according to the form of the wave:
    - A sudden negative peak
    - A gradual increase to maximum
    - A high value of displacement
    - And a final sudden jump down
- Therefore the correct answer is **B**

A is incorrect as	the graph shows a long negative displacement with a positive peak, this is the opposite direction to what would happen to particle K
C is incorrect as	the graph shows a long positive displacement followed by a gradual decrease and a final negative peak which is the opposite order to what would happen to particle K

D is incorrect as	the graph shows a long negative displacement with a positive peak, this is the opposite direction to what would happen to particle K

4

The correct answer is **C** because:

- Intensity is proportional to the square of the amplitude:
  - $I \propto A^2$
- Therefore, since $I = I_0 \cos^2\theta$
  - $A \propto \sqrt{I}$
  - $A = \sqrt{I_0 \cos^2\theta}$
- $I_0 = A_0{}^2$
  - Therefore, $A = \sqrt{A_0{}^2 \cos^2\theta} = A_0 \cos\theta$
- Power, *P* is proportional to intensity, $P \propto I$
  - Therefore, $P \propto A^2$
- Since the received amplitude is given by $A_0{}^2 \cos^2\theta$
- Therefore the correct answer is **C**

5

The correct answer is **C** because:

- $I = I_0 \cos^2\theta$
- $\frac{I_0}{4} = I_0 \cos^2\theta$
- $\frac{1}{4} = \cos^2\theta$
- $\frac{1}{2} = \cos\theta$
- When $\cos\theta = \frac{1}{2}$, $\theta = 60°$
- Therefore the correct answer is **C**

6

The correct answer is **D** because:

- $I \propto A^2$ and $I \propto f^2$
- $I_2 \propto (2f)^2$
    - I_2 is increased by a factor of 4
- $I_2 \propto \left(\frac{1}{3}A\right)^2$
    - I_2 is decreased by a factor of 9
- Therefore the correct answer is **D**

7

The correct answer is **D** because:

- The light coming into the polariser initially is from the Sun
- This means the light is unpolarised
- If unpolarised light passes through a polariser then the amount transmitted, regardless of angle of the polariser, is 50%
- Therefore the ratio of $\frac{I_1}{I_0}$ is always 0.5
- This is answer **D**

A really common mistake is to forget that the incoming light is unpolarised - it is only when dealing with two polarisers that we see a changing value of light transmitted.

8

The correct answer is **C** because:

- All electromagnetic waves are transverse
- This means they can be polarised and follow Malus' Law which predicts the intensity of the polarised light
- All electromagnetic waves travel at the same speed, the speed of light, in a vacuum
    - Both of these statements are in row **C**

A is incorrect as	only those waves which are emitted from a point source and spreading out in a **spherical** pattern follow the inverse square law
B is incorrect as	amplitude can easily be changed, either by energy being transferred or through interference, for example
D is incorrect as	electromagnetic waves can be polarised but are not always, this depends on the orientation of polarisers

9

The correct answer is **A** because:

- Intensity is proportional to $\frac{1}{r^2}$
- Therefore the intensity of light at the second star is $\frac{0.25I_0}{(3r)^2}$
- Simplifying gives $\frac{I_0}{4\times(3r)^2} = \frac{I_0}{36}$
- This is answer **A**

10

The correct answer is **D** because:

- Incident light from the Sun is unpolarised
- On reflection from the surface of a pond this light becomes completely plane polarised
- This eliminates options **A** and **C**

- When refraction occurs, polarisation does not
- However, there will be less light in the same plane of vibration as the reflected light
- Therefore the refracted light is partially plane polarised
- This is answer **D**

This question requires you to think about the nature of the light remaining after the reflection has occurred, as well as knowing that reflection causes polarisation and refraction does not.