Past-paper walk-through

Polarisation ▪ 7.5

eXercise

Questions in this set

- 9702/11 N25 Q26 ▪ 1 mark
- 9702/14 N25 Q28 ▪ 1 mark
- 9702/11 J25 Q28 ▪ 1 mark
- 9702/12 J25 Q27 ▪ 1 mark
- 9702/13 J25 Q25 ▪ 1 mark
- 9702/14 J25 Q24 ▪ 1 mark
- 9702/23 J25 Q5 ▪ 8 marks
- 9702/12 M25 Q26 ▪ 1 mark

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 26

9702/11 N25 ▪ Q26 ▪ 1 mark

Two polarising filters are placed next to each other so that their planes are parallel.
The first polarising filter has its transmission axis at an angle of $50°$ to the vertical.
The second polarising filter has its transmission axis at an angle of $20°$ to the vertical.
The angle between the transmission axes of the two polarising filters is $30°$.
A beam of vertically polarised light of intensity 8.0 W m^{-2} is incident normally on the first polarising filter.
What is the intensity of the light that is transmitted from the second polarising filter? **[1]**

A zero

B 2.5 W m^{-2}

C 2.9 W m^{-2}

Question 26

D $6.0\ \mathrm{W\,m^{-2}}$

Solution 26

A zero

B $2.5\ \mathrm{W\,m^{-2}}$ ✓

C $2.9\ \mathrm{W\,m^{-2}}$

D $6.0\ \mathrm{W\,m^{-2}}$

Why

- The light reaches the first filter polarised vertically, at $50°$ to its axis: $8.0 \cos^2 50° = 3.3$ W m^{-2}.
- It leaves polarised along that first axis, so for the second filter the angle is the $30°$ between the two axes.
- $3.3 \times \cos^2 30° = 3.3 \times 0.75 = 2.5$ W m^{-2}.

Question 28

9702/14 N25 ▪ Q28 ▪ 1 mark

What may be observed with light waves but **not** with sound waves? **[1]**

A diffraction

B interference

C polarisation

D reflection

Solution 28

A diffraction

B interference

C polarisation ✓

D reflection

Why

- Light is transverse and sound is longitudinal.
- Only a transverse wave can be polarised, since only it has a plane of oscillation to restrict.
- Diffraction, interference and reflection are all shown by both.

Question 28

9702/11 J25 ▪ Q28 ▪ 1 mark

Which group contains only waves that can be polarised? **[1]**

- **A** infrared waves, radio waves, sound waves
- **B** visible light waves, microwaves, radio waves
- **C** visible light waves, radio waves, sound waves
- **D** microwaves, visible light waves, sound waves

Solution 28

- **A** infrared waves, radio waves, sound waves
- **B** visible light waves, microwaves, radio waves ✓
- **C** visible light waves, radio waves, sound waves
- **D** microwaves, visible light waves, sound waves

Why

- Only transverse waves can be polarised.
- Sound is longitudinal, so any group containing it is ruled out – that removes A, C and D.
- Visible light, microwaves and radio waves are all electromagnetic, and therefore transverse.

Question 27

9702/12 J25 ▪ Q27 ▪ 1 mark

Vertically polarised light of intensity I_0 is incident normally on a polarising filter.
The transmission axis of the filter is at an angle θ to the plane of polarisation of the light.
The intensity of the light after passing through the filter is $\frac{I_0}{3}$.
What is θ? **[1]**

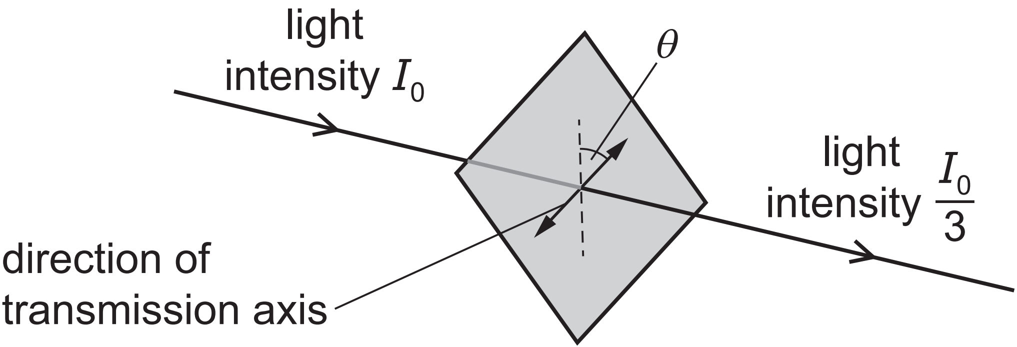
A $8.4°$

B $55°$

C $71°$

D $84°$

Question 27



light
intensity I_0
θ
light
intensity $\frac{I_0}{3}$
direction of
transmission axis

Solution 27

A $8.4°$

B $55°$ ✓

C $71°$

D $84°$

Why

- Malus's law: $I = I_0 \cos^2\theta$, and here $I = I_0/3$.
- So $\cos^2\theta = 1/3$ and $\cos\theta = 0.577$.
- $\theta = 54.7°$, which rounds to $55°$.

Question 25

9702/13 J25 ▪ Q25 ▪ 1 mark

25 Which phenomenon is only associated with transverse waves?

A diffraction

B interference

C polarisation

D reflection

Solution 25

Answer: **C**

Why

- Polarisation means confining the oscillation to a single plane.
- That only has meaning when the oscillation is perpendicular to the direction of travel.
- Diffraction, interference and reflection all occur for longitudinal waves too.

Question 24

9702/14 J25 ▪ Q24 ▪ 1 mark

24 A horizontal beam of light is incident normally on a polarising filter. The incident light is vertically polarised and has an intensity of $24\,\mathrm{W\,m^{-2}}$. The direction of the transmission axis of the filter is at an angle of 30° to the vertical.

What is the intensity of the light in the transmitted beam?

A $18\,\mathrm{W\,m^{-2}}$ **B** $21\,\mathrm{W\,m^{-2}}$ **C** $28\,\mathrm{W\,m^{-2}}$ **D** $32\,\mathrm{W\,m^{-2}}$

Solution 24

Answer: **A**

Why

- Malus's law: $I = I_0 \cos^2 \theta$, with $\theta = 30^\circ$ between the polarisation and the axis.
- $\cos^2 30^\circ = 0.75$.
- $I = 24 \times 0.75 = 18$ W m^{-2}; using $\sin$ instead would give only 6 W m^{-2}.

Question 5

9702/23 J25 ▪ Q5 ▪ 8 marks

5 **(a)** State why sound waves **cannot** be polarised.

Question 5

(b) A plane-polarised light wave is incident on a polarising filter as shown in Fig. 5.1.

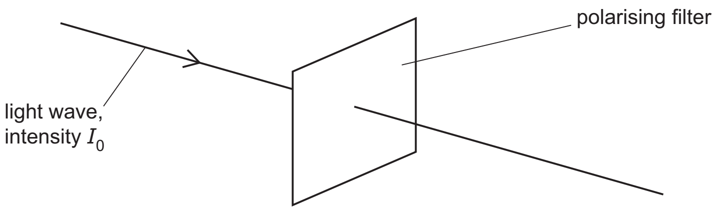


Fig. 5.1

The intensity of the light incident on the filter is I_0.

The light is incident normally on the filter and the transmission axis of the filter is initially perpendicular to the plane of polarisation of the light.

Question 5

The filter is now rotated through 360° about the direction of travel of the light wave.

(i) On Fig. 5.2, sketch the variation of the intensity I of the transmitted light with the angle of rotation α as the filter is rotated through 360° from its initial position.

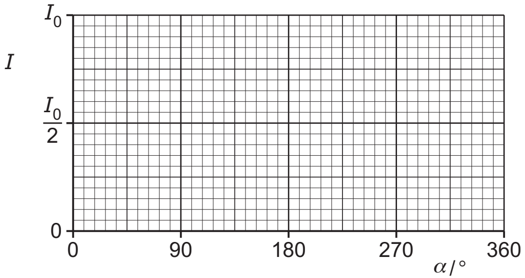


Fig. 5.2

[3]

Question 5

(ii) The amplitude of the incident light wave is A_0 when the intensity of the wave is I_0.

Use Malus's law to determine, in terms of A_0, the amplitude of the transmitted wave when $\alpha = 20°$.

Question 5

[Total: 8]

Solution 5

(a)

Mark scheme

- sound waves are longitudinal / not transverse (and only transverse waves can be polarised)

Solution 5

(b)(i)

Mark scheme

- A periodic curve of at least one period with minimum 0 and maximum I0
- Smooth continuous sin2α curve
- Peaks at 90° and 270° and troughs at 0, 180° and 360°

Solution 5

(b)(ii) Worked steps

Malus's law needs the angle **between the two planes of polarisation**, which is not always the angle the question names.

- $I = I_0 \cos^2\theta$, where θ is that angle.
- Here the filter is set at $20°$, so the planes are $90 - 20 = 70°$ apart.
- $I = I_0 \cos^2 70°$
- $I = 0.12\, I_0$

Sanity check: at $70°$ the axes are nearly perpendicular, so only a little light gets through — 12% is the right order. Using $20°$ instead would give $0.88\, I_0$, which is the same calculation with the angle read off the wrong pair of lines. **Mark scheme**

Solution 5

- I $\propto$ **A2**
- I $=$ I0 cos2 θ
- At $\alpha = 20°$ the angle between the planes of polarisation of light and filter is 70° (or 110°)
- I $=$ I0 cos2 70 or I $=$ I0 cos2 110
- (I $=$ 0.12 I0)
- amplitude $=$ 0.34 **A0**
- 9702/23
- May/June 2025

Question 26

9702/12 M25 ▪ Q26 ▪ 1 mark

26 A polarised beam of light with intensity I is incident normally on a polarising filter.

The transmitted light has intensity I.

The filter is rotated about the normal axis through an angle θ.

The transmitted light has intensity $0.75I$.

What is the angle θ?

A 30° **B** 42° **C** 49° **D** 60°

Solution 26

Answer: **A**

Why

- Malus's law: the transmitted intensity is $I\cos^2\theta$.
- Here $\cos^2\theta = 0.75$, so $\cos\theta = 0.866$.
- That gives $\theta = 30°$.