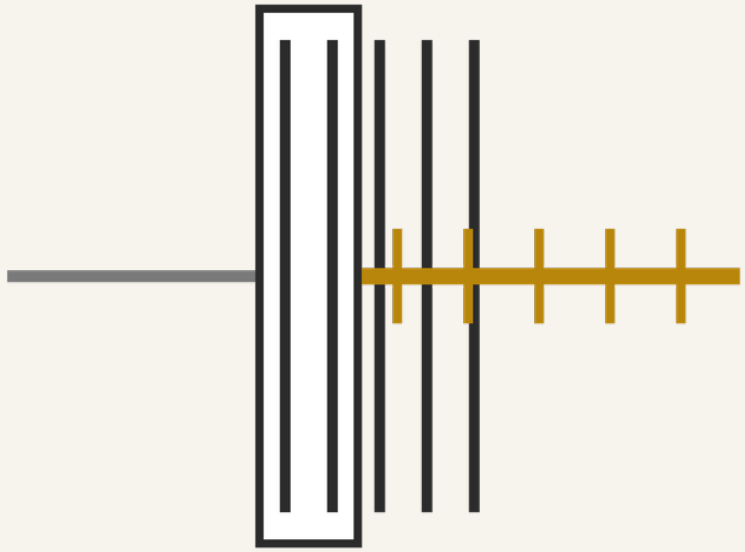
QUANTA AND WAVES · 2.5 POLARISATION

Polarisation

One direction of vibration only — and a reflected ray that picks it out for free.



Advanced Higher Physics

LEARNING INTENTION

To describe plane-polarised light and how polarisers and analysers act on it, and to derive and use the relationship for Brewster's angle.

By the end of this topic…

1. I can state what is meant by a plane-polarised wave.
2. I can describe the effect of polarisers and analysers on light.
3. I can describe how reflection at Brewster's angle produces plane-polarised light.
4. I can derive $n = \tan i_p$.
5. I can use $n = \tan i_p$ to solve problems.

PERIOD 1 · POLARISERS AND ANALYSERS

Picking out one direction

Light is a transverse wave — polarisation is what that actually buys you.

Plane-polarised light

JOTTER NOTES

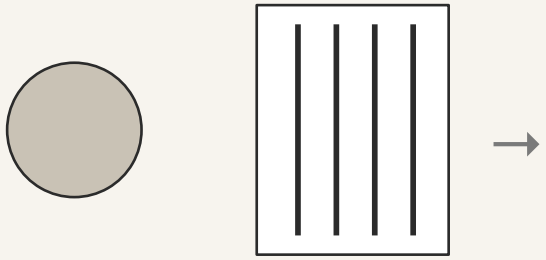
MANDATORY DEFINITION — asked word for word

The electric vector of light oscillates in a single plane.

Asked 2018 and other diets.

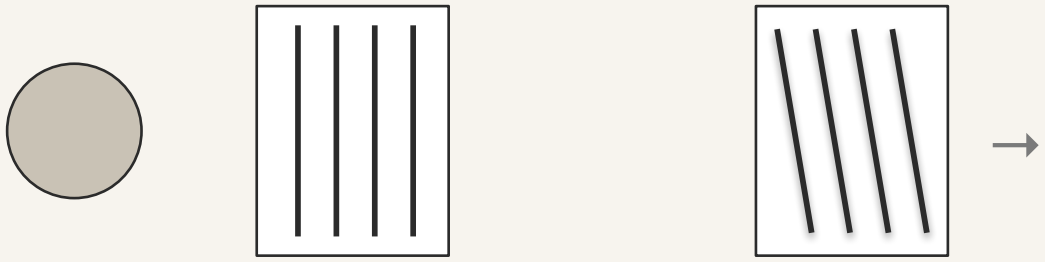
Marking instructions do NOT accept "travels in a single plane/direction" or "oscillates in one direction" — it must be the electric vector, and it must be a plane.

Polarisers and analysers



Unpolarised light vibrates in every plane. A polariser only lets through the component vibrating in one plane — the output is plane-polarised.
A second polarising filter used to test the light is called an analyser.

Rotating the analyser



- Plane-polarised light through a rotating analyser: brightness starts at a max, falls to a min at 90°, rises back to a max at 180°.
- Unpolarised light through a rotating analyser alone: brightness stays constant.

JOTTER NOTES

Polarisers and analysers

Plane-polarised light — the electric vector of light oscillates in a single plane.

Polariser — lets through only the component of light vibrating in one plane.

Analyser — a second polarising filter, used to test polarised light.

Rotating an analyser in plane-polarised light: brightness varies max → min (at 90°) → max (at 180°).

PERIOD 2 · BREWSTER'S ANGLE

Polarising light by reflection

One angle of incidence, and the reflected ray comes out fully polarised.

Polarisation by reflection

- Unpolarised light hits the surface of an insulator.
- At one particular angle of incidence — Brewster's angle, i_p — the reflected ray is fully plane-polarised.
- At Brewster's angle, the reflected ray and the refracted ray are at 90° to each other.

Deriving n = tan i_p (1 of 2)

JOTTER NOTES

MANDATORY DERIVATION — you must reproduce every line

$$i_p + r = 90°$$

Reflected and refracted rays are at 90°; angle of reflection = i_p.

$$r = 90° - i_p$$

Rearranging.

$$\sin i_p = n \sin r$$

Snell's law, air into the insulator.

Deriving n = tan i_p (2 of 2)

JOTTER NOTES

MANDATORY DERIVATION — you must reproduce every line

$$\sin i_p = n \sin (90° - i_p)$$

Substituting r.

$$\sin i_p = n \cos i_p$$

sin(90° − x) = cos x.

n = tan i_p

Worked example 1 — Brewster's angle for water

Calculate the Brewster angle for light reflected from water.

$n = 1.33$

$i_p = ?$

$n = \tan i_p$

$\tan i_p = 1.33$

$i_p = 53.1°$

Worked example 2 — Brewster's angle for Perspex

A teacher determines Brewster's angle for Perspex.

Calculate Brewster's angle for Perspex.

$n = 1.49$

$i_p = ?$

$n = \tan i_p$

$\tan i_p = 1.49$

$i_p = 56.1°$

JOTTER NOTES

Brewster's angle

At Brewster's angle i_p, unpolarised light reflected from an insulator is fully plane-polarised.

At i_p, the reflected and refracted rays are at 90°.

$$n = tan\ \ i_p$$

Task pointer

BrightRed Study Guide pp. 88–89.
Scholar — Quanta and Waves, Topic 9: Polarisation.

Homework: Scholar end-of-topic test

Polarisation in the exam

Asked every diet except 2017 and 2019

Diet	Question
2016	Q12
2018	Q12
2020	Q11
2022	Q13(a)
2023	Q12
2024	Q12
2025	Q12

Reading and homework

Scholar: Quanta and waves, Topic 9 — Polarisation

Read the topic, then sit the Scholar end-of-topic test.

Scholar — Quanta and Waves, Topic 9
Scholar — end-of-topic test (homework)
BrightRed Study Guide pp. 88-89
Past papers — every diet except '17, '19

Scholar

Check yourself

Can you do each of these without your notes?

1. State the definition of plane-polarised light, word for word.
2. Describe what a polariser does, and what an analyser is.
3. Describe how Brewster's angle produces a plane-polarised reflected ray.
4. Derive $n = \tan i_p$, showing every step.

Experiments you could try

Standard kit, or your own phone

- Two polarising filters: rotate one and watch the brightness change.
- Investigate the polarisation of microwaves with a transmitter, receiver and a wire-grid polariser.
- Reflect light off glass or Perspex and view it through an analyser as the angle of incidence is varied.
- Polarising sunglasses against a reflective surface: rotate the lens and watch the glare change.

Sources & credits

- Past-paper questions and marking instructions © Qualifications Scotland (SQA), reproduced for educational use.
- Notes, tests and homework: SCHOLAR Advanced Higher Physics, © Heriot-Watt University.
- Textbook: BrightRed Advanced Higher Physics Study Guide.
- All diagrams drawn for this deck; no images taken from the web.