

EM waves: refraction and absorption

4.6.2.2 · Waves · revision notes

How to draw ray diagrams for refraction, and the required practical on the infrared radiation emitted and absorbed by different surfaces.

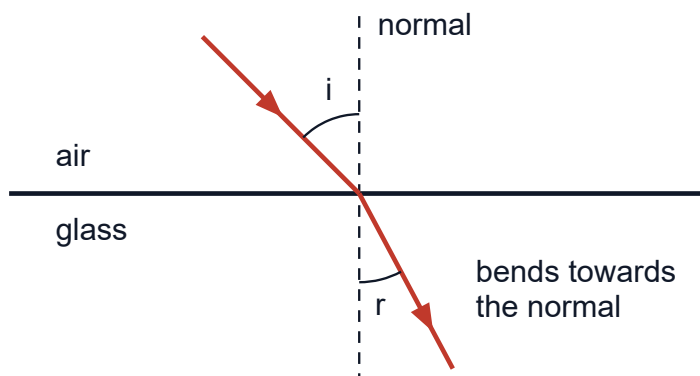
Key facts

- Refraction = change of direction at a boundary
- Slows down → bends towards the normal; speeds up → bends away from the normal
- Along the normal: no change in direction
- Angles are measured from the normal
- Matt black: best emitter and absorber of infrared; shiny silver: worst

Notes

Refraction and ray diagrams

- **Refraction** is the change in direction of a wave when it crosses a boundary between two media at an angle.
- Light slows down when it passes from air into glass, water or Perspex, and bends **towards the normal**. When it speeds up (e.g. from glass into air) it bends **away from the normal**.

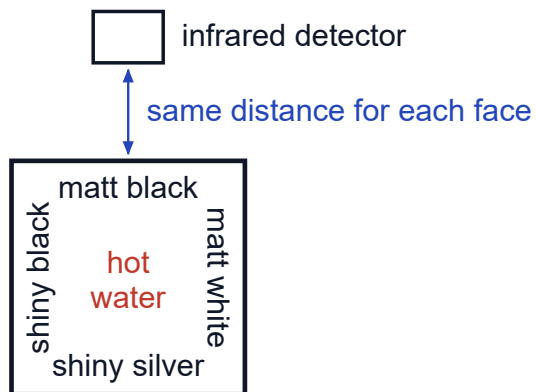


Light slows down in glass and bends towards the normal (r is smaller than i).

- A ray that meets the boundary along the normal does not change direction.
- In a ray diagram, draw the normal (dashed) where the ray meets the boundary, and measure the angles of incidence and refraction from the normal.
- For a rectangular glass block, the ray that comes out is parallel to the ray that went in, but shifted sideways.

Required practical: infrared and different surfaces

- Fill a Leslie cube (a metal cube whose faces are, for example, matt black, shiny black, matt white and shiny silver) with hot water, so every face is at the same temperature.
- Hold an infrared detector the same distance from each face in turn and record the readings.



Leslie cube: all faces are at the same temperature; only the surface changes.

- Result: the matt black face emits the most infrared and the shiny silver face the least.
- Matt black surfaces are also the best absorbers of infrared, and shiny surfaces the worst, because shiny surfaces reflect most of it.

How to answer each type of question

Draw or describe a refraction ray diagram

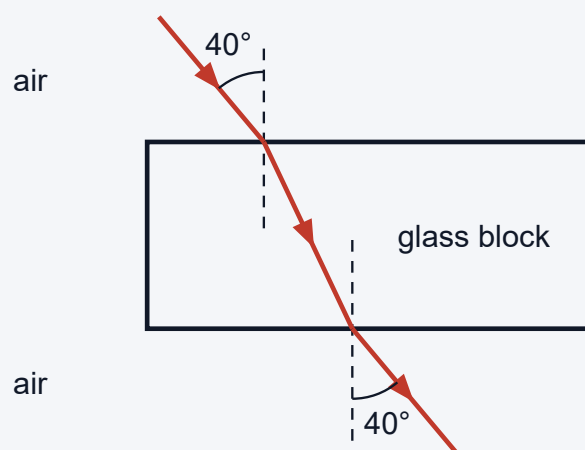
2 to 3 marks

Grade 5

1. Draw the normal where the ray meets the boundary.
2. Decide whether the wave speeds up or slows down.
3. Bend the ray towards the normal if it slows down, away if it speeds up.

Example. A ray of light passes from air into a rectangular glass block at an angle of incidence of 40° . Describe the path of the ray as it enters and then leaves the block.

Model answer.



Towards the normal going in, away from the normal coming out; the ray leaves parallel to the one that went in.

As it enters the glass the ray bends towards the normal, so the angle of refraction is less than 40° (1). As it leaves the block into air it bends away from the normal (1). The ray leaving the block is parallel to the ray that entered it (1).

Explain why a variable must be controlled

2 marks

Grade 5

1. Say how the variable would affect the reading.
2. Say that controlling it means only the type of surface affects the result (a fair test).

Example. Suggest why the infrared detector must be the same distance from each face of the Leslie cube.

Model answer. The reading depends on the distance: more infrared reaches the detector when it is closer to the surface (1). Keeping the distance the same means only the type of surface affects the reading (1).

Don't lose marks

- ✗ Measuring angles from the boundary instead of from the normal.
- ✗ Saying a ray along the normal bends. It does not change direction.
- ✗ In the practical, not keeping the distance between the detector and each face the same.
- ✗ Saying shiny surfaces are good absorbers. Shiny surfaces reflect most of the infrared.

More tips

Memory tricks

- FAST: Faster → Away from the normal; Slower → Towards the normal.
- Infrared practical in two words: matt black wins (best emitter and best absorber).

Exam technique

- Use a ruler and a sharp pencil for ray diagrams, and draw the normal as a dashed line.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 5

Draw a ray diagram for refraction

Draw the normal; a ray that slows down (e.g. air into glass) bends towards the normal.

Grade 5

State which surfaces emit and absorb infrared best

Matt black surfaces are the best emitters and absorbers of infrared; shiny silver surfaces are the worst.

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