Reflection of waves

4.6.1.3 · Waves · revision notes

What can happen when a wave meets a boundary between two materials: it can be reflected, absorbed or transmitted. You need to draw ray diagrams for reflection and know the required practical on the reflection and refraction of light. GCSE Physics only, not in Combined Science.

Key facts

- At a boundary a wave can be reflected, absorbed or transmitted
- Angle of incidence = angle of reflection
- Absorbed wave energy is transferred to the material (often heating it)
- Practical: ray box with slit, mirror, glass or Perspex block, protractor, ruler, sharp pencil, paper
- Normal = line at 90° to the surface where the ray hits
- All angles are measured from the normal
- Refraction = change of direction of a transmitted wave at a boundary

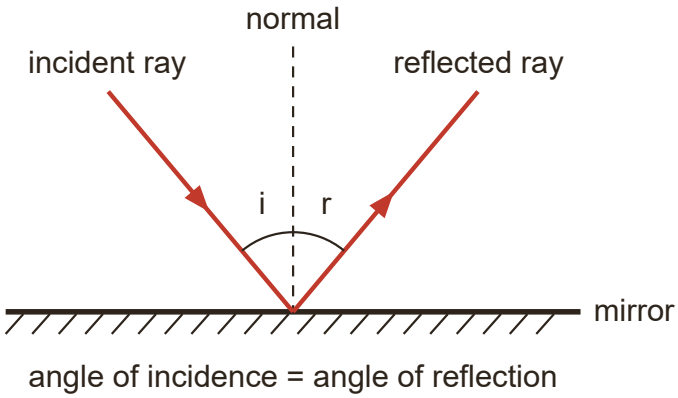
Notes

Waves at a boundary

- When a wave meets a boundary between two different materials it can be **reflected** (bounce back), **absorbed** (its energy is taken in by the material) or **transmitted** (it passes through and carries on).
- Usually some of each happens. What happens depends on the materials.
- What happens also depends on the wavelength of the wave. Grade 6+ only
- Absorbed energy is transferred to the material, often heating it.
- A transmitted wave may change direction as it enters the new material. This is **refraction**.
- Examples: a mirror reflects most of the light that hits it, clear glass transmits most light, and black card absorbs most light. Hard, smooth walls reflect sound (echoes), while soft materials such as curtains and foam absorb it.

The law of reflection

- The **normal** is a line at 90° to the surface at the point where the ray hits it. Draw it as a dashed line.
- **Angle of incidence = angle of reflection.** Both angles are measured between the ray and the normal, not the surface.



Both angles are measured from the normal, not from the mirror.

- To draw a reflection: draw the normal, measure the angle of incidence with a protractor, then draw the reflected ray on the other side of the normal at the same angle. Put arrows on both rays.
- A ray that hits a surface along the normal (angle of incidence 0°) reflects straight back along the same line.

Required practical: reflection and refraction of light

- Use a **ray box** with a slit to make a narrow ray of light, and work in a darkened room so the ray is easy to see.
- Reflection: stand a plane mirror (or another surface) on paper and draw the normal. Shine the ray at the point where the normal meets the mirror, mark the incident and reflected rays with crosses, join them with a ruler and measure both angles with a protractor. Repeat for several angles of incidence and for different surfaces.
- Refraction: draw round a glass or Perspex block and draw a normal at 90° to one side. Shine the ray in where the normal meets the block, and mark the rays going in and coming out with crosses.
- Remove the block, join the point where the ray entered to the point where it left, and measure the angles of incidence and refraction from the normal. Repeat for several angles of incidence and for blocks of different materials.
- Expected results: the angle of reflection equals the angle of incidence. From air into glass, the angle of refraction is smaller than the angle of incidence.
- Smooth, shiny surfaces give one clear reflected ray. Rough or dull surfaces give a weak reflected ray that is spread out.

How to answer each type of question

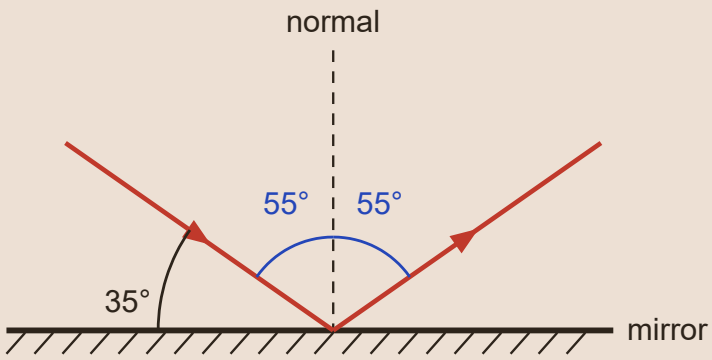
Draw or use a ray diagram for reflection

2 to 3 marks | Grade 5

1. Draw the normal (dashed) at 90° to the surface where the ray hits.
2. Measure the angle of incidence from the normal. If you are given the angle to the surface, subtract it from 90°.
3. Draw the reflected ray at the same angle on the other side of the normal, with an arrow.

Example. A ray of light hits a plane mirror. The angle between the ray and the **surface of the mirror** is 35°.
(a) Calculate the angle of incidence.
(b) State the angle of reflection.

Model answer.



The normal is at 90° to the mirror, so i = 90° − 35° = 55°, and r = i.

(a) The normal is at 90° to the mirror, so angle of incidence = 90° − 35° (1) = 55° (1)
(b) 55° (1)

Describe what happens when waves meet different materials

2 to 3 marks | Grade 6

1. Use the three key words: reflected, absorbed, transmitted.
2. Say what happens to **most** of the wave for each material.
3. If energy is absorbed, say what it does (e.g. heats the material).

Example. A student shines light at a mirror, a sheet of clear glass and a piece of black card. Describe what happens to most of the light at each object.

Model answer.

Mirror: most of the light is reflected (1).
Clear glass: most of the light is transmitted (1).
Black card: most of the light is absorbed, and its energy heats the card (1).

Describe the method for the reflection practical 4 marks **Grade 5**

1. Say how you set up the mirror and draw the normal.
2. Say how you make and aim a narrow ray (ray box and slit).
3. Say how you record the rays (crosses, joined with a ruler) and measure the angles (protractor, from the normal).
4. Say what you repeat: several angles of incidence.

Example. Describe how a student could test whether the angle of reflection is always equal to the angle of incidence for a plane mirror.

Model answer. Stand the mirror on a sheet of paper and draw a normal at 90° to the mirror (1). Use a ray box with a slit to shine a narrow ray at the point where the normal meets the mirror (1). Mark the incident and reflected rays with crosses and join them with a ruler (1). Measure the angles of incidence and reflection from the normal with a protractor, and repeat for several different angles of incidence (1).

Suggest how to improve the accuracy of the practical 2 marks **Grade 5**

1. Say what the change is.
2. Say why it helps: it makes the ray easier to see or to mark, so the angles are more accurate.

Example. Suggest why the student does the investigation in a darkened room and uses a narrow ray of light.

Model answer. The ray is easier to see in a darkened room (1). A narrow ray makes it easier to mark the centre of the ray, so the angles are measured more accurately (1).

Don’t lose marks

- Measuring angles from the surface instead of from the normal.
- Forgetting arrows on rays, or drawing the normal as a solid line that looks like another ray.
- Saying absorbed waves 'disappear'. Their energy is transferred to the material.
- Joining the crosses freehand or using a blunt pencil, which makes the measured angles inaccurate.
- Recording angles to 0.1° when the protractor's resolution is 1°: the readings cannot be that precise.

More tips

Memory tricks

- 'i = r': the angle of incidence equals the angle of reflection, measured from the normal, never from the surface.
- Given the angle to the surface? Take it away from 90° to get the angle to the normal.
- RAT: at a boundary a wave can be Reflected, Absorbed or Transmitted.

Exam technique

- Use a ruler and a sharp pencil for ray diagrams: examiners check that your angles are accurate.
- In method questions, say what you measure the angles from (the normal) and what with (a protractor).
- Say 'most' of the light is reflected, transmitted or absorbed: at real boundaries some of each usually happens.

What each grade needs

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

Grade 3

State what can happen at a boundary

A wave can be reflected, absorbed or transmitted when it meets a boundary between two different materials.

Grade 4

State the law of reflection

The angle of incidence equals the angle of reflection, both measured from the normal.

Grade 5

Draw a ray diagram for reflection

Draw the normal at 90° to the surface, then the reflected ray at an equal angle on the other side, with arrows on both rays.

Grade 5

State what happens to absorbed wave energy

When a wave is absorbed, its energy is transferred to the material, usually heating it.

Grade 5

Describe the reflection and refraction practical

Use a ray box, a mirror or glass block, paper and a protractor to measure angles for several angles of incidence.

Grade 5

Improve angle accuracy in the ray box practical

Use a narrow ray in a darkened room, mark the ray with crosses far apart, and measure every angle from the normal.

Grade 6

Describe reflection, absorption and transmission for materials

E.g. a mirror reflects most light, black card absorbs most light and clear glass transmits most light.

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