Visible light

4.6.2.6 · Waves · revision notes

How colours relate to wavelength and frequency, the difference between specular and diffuse reflection, and how filters and the reflection or absorption of different wavelengths give objects their colour. GCSE Physics only, not in Combined Science.

Key facts

- Visible spectrum: red, orange, yellow, green, blue, indigo, violet
- Specular reflection: smooth surface, single direction
- Opaque object's colour = the wavelengths it reflects most strongly
- Colour filter: transmits its own colour, absorbs the others
- Red: longest wavelength, lowest frequency; violet: shortest wavelength, highest frequency
- Diffuse reflection: rough surface, light scattered
- White: reflects all wavelengths equally; black: absorbs all wavelengths
- Transparent: transmits light clearly; translucent: transmits but scatters; opaque: transmits none

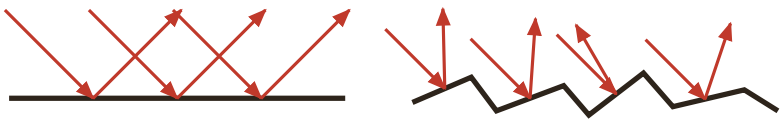
Notes

The visible spectrum

- Visible light is the part of the EM spectrum our eyes detect. White light is a mixture of all the colours.
- Each colour has its own **narrow band** of wavelengths and frequencies.
- In order: red, orange, yellow, green, blue, indigo, violet. Red has the longest wavelength and lowest frequency; violet has the shortest wavelength and highest frequency.

Specular and diffuse reflection

- **Specular reflection**: reflection from a smooth surface in a **single direction**, e.g. a mirror. You see a clear image.
- **Diffuse reflection**: reflection from a rough surface, which **scatters** the light in many directions, e.g. paper. No clear image forms.
- The law of reflection still works at every point. On a rough surface the normals point in different directions, so the reflected rays spread out.



specular: smooth surface
one direction

diffuse: rough surface
scattered in many directions

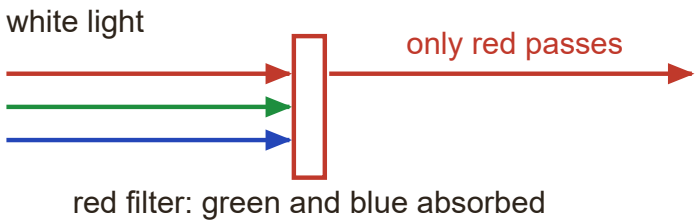
Each ray obeys i = r, but on a rough surface the normals point different ways.

Transparent, translucent and opaque

- **Transparent** objects, such as clear glass, transmit light straight through, so you can see clearly through them.
- **Translucent** objects, such as frosted glass, transmit light but scatter it, so you cannot see clearly through them.
- **Opaque** objects do not transmit light: they reflect or absorb it.

Colour and filters

- The colour of an **opaque** object depends on which wavelengths it reflects most strongly. Wavelengths that are not reflected are absorbed.
- In white light, a red object reflects red and absorbs the other colours. A white object reflects all wavelengths equally; a black object absorbs all wavelengths.
- In coloured light the colour can change: a red object lit by blue light looks black, because it absorbs the blue and there is no red light to reflect.
- A **colour filter** transmits certain wavelengths (its own colour) and absorbs the rest. A red filter lets only red light through.



A red filter transmits red and absorbs the other colours (only three colours drawn).

- To work out the colour you see, follow the light: which colours reach the object, which it reflects, and which get through any filter to your eye. If no light reaches your eye, the object looks black.

How to answer each type of question

Explain why an object looks a certain colour — 2 marks — **Grade 4**

1. Say which colour (wavelengths) the object reflects.
2. Say that it absorbs the other colours.

Example. Explain why a green leaf looks green in white light.

Model answer. The leaf reflects green light (1). It absorbs the other colours (wavelengths) in white light (1).

Explain specular and diffuse reflection — 2 to 3 marks — **Grade 5**

1. Link each surface to smooth or rough.
2. Say how the light is reflected: in a single direction, or scattered.
3. Link this to whether a clear image forms.

Example. Explain why you can see your reflection in a mirror but not in a sheet of white paper.

Model answer. A mirror has a smooth surface, so light is reflected in a single direction (specular reflection) (1). Paper has a rough surface, so light is scattered in many directions (diffuse reflection) (1). So only the mirror forms a clear image (1).

Compare transparent and translucent materials

2 marks **Grade 5**

1. Say that both transmit light.
2. Say that one lets light straight through and the other scatters it.

Example. A bathroom window is made of frosted glass instead of clear glass.
Describe the difference between frosted glass and clear glass in terms of what happens to light.

Model answer. Both transmit light (1). Clear glass is transparent, so light passes straight through and you can see clearly through it, but frosted glass is translucent, so it scatters the light and you cannot see clearly through it (1).

Predict and explain colours seen through a filter

4 marks **Grade 5**

1. List the colours reflected by each part of the object.
2. Decide which of those colours the filter transmits.
3. If none get through, that part looks black. Explain each answer.

Example. A white shirt with a blue logo is lit by white light and viewed through a red filter.
What colour does (a) the shirt and (b) the logo appear? Explain your answers.

Model answer.

(a) Red (1). The white shirt reflects all colours, but the filter only transmits the red light (1).
(b) Black (1). The logo reflects only blue light, which the red filter absorbs, so no light from the logo reaches the eye (1).

Don’t lose marks

- Saying a red object 'absorbs red'. It reflects red and absorbs the other colours.
- Saying a filter 'adds colour' or 'turns light red'. A filter only absorbs colours; it cannot add any.
- Mixing up translucent (scatters light) and transparent (clear view through).
- Saying diffuse reflection does not obey the law of reflection. It does, at every point.

More tips

Memory tricks

- ROY G BIV: red, orange, yellow, green, blue, indigo, violet, from longest to shortest wavelength.
- Specular = Smooth = Single direction (three S's).
- Filters are one-colour gates: only their own colour gets through.
- Black means no light reaches your eye; white means all colours reach your eye.

Exam technique

- Use the words reflect, absorb and transmit, and name the colours (or wavelengths) each time.
- In filter questions, work step by step: light source → object → filter → eye.
- When explaining a colour, say what happens to the colour you see and to all the other colours.

What each grade needs

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

Grade 3 — **Order the colours of the visible spectrum**
Red, orange, yellow, green, blue, indigo, violet; red has the longest wavelength.

Grade 4 — **State why an object looks a colour**
An opaque object reflects the wavelengths of its colour most strongly and absorbs the others.

Grade 4 — **Explain why objects look white or black**
White objects reflect all wavelengths equally; black objects absorb all wavelengths.

Grade 5 — **Describe specular and diffuse reflection**
Specular: from a smooth surface in a single direction. Diffuse: from a rough surface, scattered in many directions.

Grade 5 — **Explain how a colour filter works**
A filter transmits certain wavelengths (its own colour) and absorbs the others.

Grade 5 — **Distinguish transparent, translucent and opaque**
Transparent and translucent objects transmit light (translucent ones scatter it); opaque objects do not.

Grade 5 — **Predict colours seen through filters**
E.g. a blue object seen through a red filter looks black, because no light from it gets through.

Grade 5 — **Explain colours using absorption, transmission and reflection**
Follow the light from source to object to filter to eye, saying which wavelengths are reflected, absorbed or transmitted at each stage.

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