Edexcel GCSE Physics

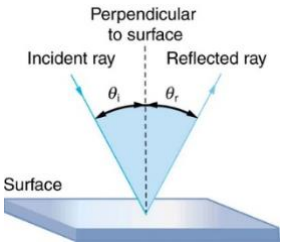
Topic 5: Light and the Electromagnetic Spectrum

Notes

(Content in bold is for Higher Tier only)

Ray Diagrams (Physics only)

- Arrows show direction of light travelling
- The normal is an (imaginary) dashed line which is perpendicular to the surface, and from which all angles are measured from
- Incident Angle is the angle of the entering ray
- Reflected Angle is the angle of the exiting ray

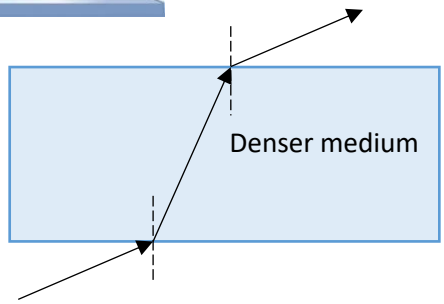


Reflection (Physics only)

- Incident angle = reflection angle
- Angles are **always** measured from normal

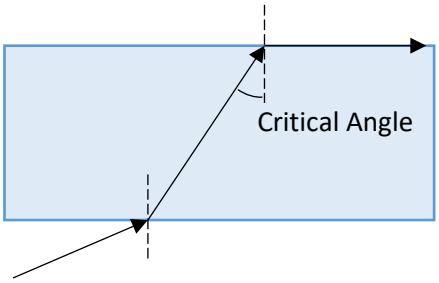
Refraction (Physics only)

- If entering a denser material, it bends towards the normal
- If entering a less dense material, it bends away from normal



Total Internal Reflection (TIR) (Physics only)

- This occurs when the light is passing from a denser medium into a less dense medium (glass to air)
- If the angle of incidence is equal to the critical angle, the refracted ray will pass along the boundary and not exit the medium
    - The critical angle is a unique angle for each two media (the critical angle for glass-air is different to glass-water)
- For larger angles, the light internally reflects (following the above law of reflection) back into the glass



Summary for glass to air (Physics only)

- If angle LESS than critical angle, light refracts away from normal
- If angle EQUAL to critical angle, light passes along boundary
- If angle MORE than critical angle, light reflects

Specular Reflection (Physics only)

- Mirror reflection, following law of reflection, for a smooth surface (all light incident at the same angle all exit at the same angle)

Diffuse Reflection (Physics only)

- Light hitting a rough surface – incident ray is reflected at many angles rather than just one angle

Colour (Physics only)

- Each colour is just a certain wavelength in visible light
- All the colours together make up white light

Opaque Material (Physics only)

- Objects appear to have a certain colour (e.g. 'green'), as out of the incident white light only that certain colour light (green light) is reflected, all other colours are absorbed

Colour Filters (Physics only)

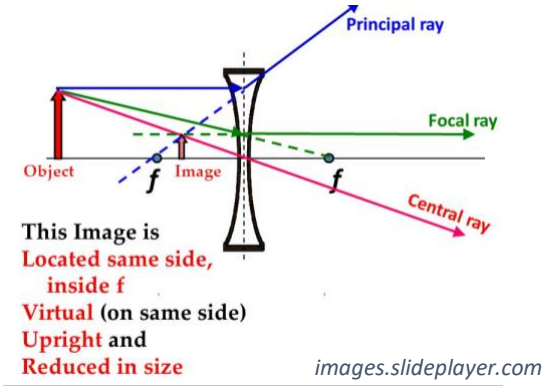
- All other colours are absorbed, and only a certain colour is allowed to pass through - so only a certain wavelength is transmitted through the filter

Lenses (Physics only)

- Focal Length is the distance between the lens and the focal point
- Focal Point is the point where all horizontal rays meet after passing through the lens
- Power of the lens is the inverse of the focal length
    - Shorter focal length, greater power
    - Thicker lens means shorter focal length, so greater power

Concave Lenses (Physics only)

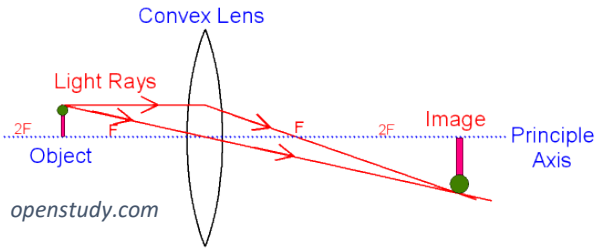
- "Caves" inward
- Thinner at centre than at edges
- Spreads light outwards
- Light appears to have come from the focal point
    - Draw horizontal ray from top of object to lens
    - Draw a faint line from focal point to point where the ray hits the lens
    - The ray exits the lens along the same direction as the faint line (shown by blue line)



- It is used to spread out light further
    - E.g. they are used to correct short-sightedness
    - As light is focused in front of the retina, so needs to be spread out slightly to be able to be focused onto retina

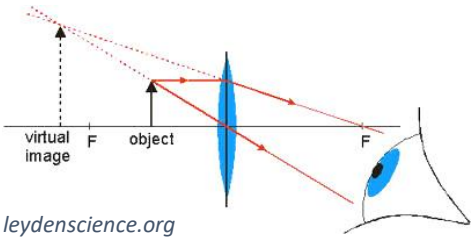
Convex Lenses (Physics only)

- Fatter at centre
- Focuses light inwards
- Horizontal rays focus onto focal point
- They are used for magnifying glasses, binoculars and to correct long-sightedness, as it focuses the rays closer



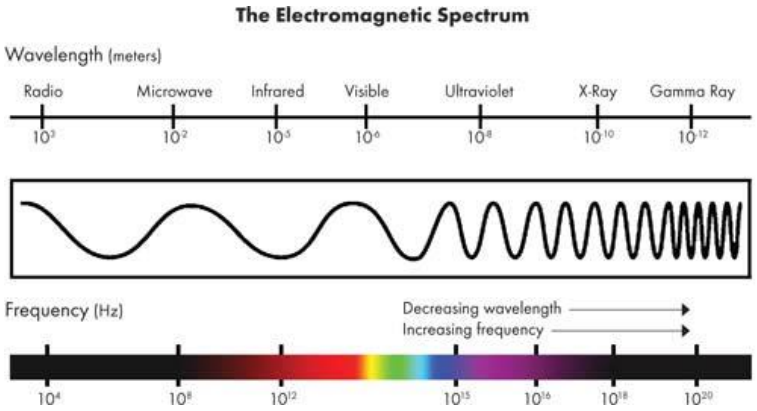
Images (Physics only)

- A Real image is an image produced at the opposite side of the lens to the object
    - The above image for a convex lens is a real image
- Virtual images appear to come from the same side of the lens to the object
    - This is if the object lies closer to the lens than the focal point (F)



EM Waves

- All electromagnetic waves transfer energy from source to observer
    - The waves contain energy, for example microwaves which transfers energy from source to food
- They are transverse waves
- They all travel at the same speed in a vacuum



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Need to learn the main groups, and in which order (for increasing wavelength or frequency)

- EM waves do not need particles to move
- In space, all waves have the same velocity (speed of light)
- They can transfer energy from a source to absorber
    - Microwave source to food
    - Sun emits energy to Earth
- Our eyes can only detect visible light
- Materials interact with EM waves differently depending on the wavelength
    - Glass can transmit visible light, reflect/absorb UV and IR

Relationships

- **As speed is constant for all EM waves in a vacuum**
- **As wavelength decreases, frequency must increase**
- **As frequency increases, energy of the wave increases**

All Bodies emit radiation

- The higher the temperature, the more intense (and more wavelengths) will be emitted

Temperature

- **It must radiate the same average power that it absorbs to remain at a constant temperature**
- **If It absorbs more power than it emits –the temperature will increase**
- **If it absorbs less power than it emits – the temperature will decrease**
- **Temperature of the earth – this is maintained by the amount of energy received and emitted from the sun**
    - **Short-wavelength Infra-red radiation from the sun reaches the Earth**
    - **Some is reflected by the atmosphere, most reaches the surface**
    - **The energy is absorbed and re-emitted as longer-length IR radiation**
    - **This is mostly absorbed by the atmosphere (greenhouse gases, CO_2 etc.) and keeps the Earth warm**

Danger of the EM spectrum

- Higher frequency EM waves have more energy, so exposure can transfer too much energy to cells, causing them to mutate and potentially damage them/causing cancer
- Microwaves - Internal heating of body cells
- Infra-Red - Skin burns
- UV - Damage to surface cells and eyes, leading to skin cancer
- X-ray/Gamma - Mutation or damage to cells in the body

Uses of the EM spectrum,

- Radio - Communications, satellite transmission.
    - ***They can be produced by oscillations in electrical circuits, or they can induce oscillations in electrical circuits***
- Microwave - Cooking, communication
- IR - Cooking, thermal imaging, short range communication, optical fibres
- Visible - Vision, photography, illumination
- UV - Security marking, fluorescent lamps, disinfecting water
- X-ray - Observing internal structure of objects, airport/medical scanners
- Gamma - Sterilising food/medical equipment, treating cancer

Change in Atoms and Nuclei:

- Generate radiations over a wide frequency range
- Be caused by absorption of a range of radiation