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Reflecting Telescope:
It’s easier to make big mirrors than big lenses so reflecting telescopes can be larger and see more distant stars.
P1  Topic 1 Refracting telescope

Refracting Telescope:

Eyepiece lens magnifies the real image formed by the objective lens.

Refraction: A change in direction due to a change in speed passing from one material to another.
Topic 1 Real & virtual

Measuring the focal length:

If it can be projected it’s real, if not it’s virtual.

Magnification:
Up to the focal length, the greater the distance from the subject the greater the magnification.
P1  Topic 1 Transverse & Longitudinal

Transverse waves
(a)
(side-to-side)
(b)
(c)

Longitudinal waves
(push & pull)

Waves move energy & information (not matter)

s-waves
&
electromagnetic spectrum

sound &
p-waves

1.12  1.14
P1 Topic 1 Wave characteristics

Frequency \((f)\): The number of waves passing a point every second

Wavelength \((\lambda)\)

Amplitude \((A)\)
Galileo did not invent the telescope, nor did he prove the heliocentric model. He did, however, disprove the geocentric model!

Galileo observed stars (moons) apparently orbiting Jupiter (in the wrong direction) – this got him thinking that maybe the Earth wasn’t at the centre of everything.
Refraction: A change in direction due to a change in speed.

Normal

Incident (Incoming) ray

Reflected ray

AIR

GLASS

Refracted ray

Slower in shallow water (shorter wavelength)

To find 1, count 5, divide by 5

longer $\lambda$

shorter $\lambda$
P1  Topic 1 Formulae

wave speed = frequency \times wavelength

metres per second (m/s) = hertz (Hz) \times metres (m)

\[ v = f \times \lambda \]

wave speed = distance / time

metres per second (m/s) = metres (m) / seconds (s)

\[ v = \frac{x}{t} \]
Herschel’s discovery (IR)

Used blackened thermometers to measure the temperature of the colours.

Ritter’s discovery (UV)

Ritter found that UV light made silver chloride crystals darken more rapidly.

Both Herschel and Ritter split light into its constituent colours using a prism. Herschel measured the temperature of each colour whilst Ritter saw how quickly silver chloride darkened.
Speed in a vacuum: 300,000,000 m/s

Transverse waves

<table>
<thead>
<tr>
<th>Microwave</th>
<th>Visible Light</th>
<th>X-Ray</th>
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</thead>
<tbody>
<tr>
<td>Radio</td>
<td>Infrared</td>
<td>Ultraviolet</td>
</tr>
</tbody>
</table>

 Longer wavelength  
 Lower frequency  
 Less energy  
 Less damage / danger  

 Shorter wavelength  
 Higher frequency  
 More energy  
 More damage / danger
P1  Topic 2 Dangers of E.M. radiation

Microwaves:
Internal heating of water in body cells

Infrared:
Heat burns to cells on the surface of the skin.

X-rays and gamma rays:
Similar dangers, both cause mutation of cells or damage to DNA inside the body

UV:
Damage to surface cells and eyes, leading to skin cancer and cataracts. (UV is not ionising)

The higher the frequency, the greater the energy, the greater the danger, the more damage is done.
**P1 Topic 2 Uses of E.M. radiation**

**Radio waves:**
Broadcasting, communications & satellite transmissions

**Microwaves:**
Cooking, communications & satellite transmissions

**X-ray & gamma:**
Airport security, medical x-rays, sterilising food and equipment, cancer detection and treatment

**Infrared:**
Cooking, thermal imaging, optic fibres, TV remote controls, security.

**Visible light:**
Vision, photography

**UV:**
Killing bacteria, sterilising water and detecting forged bank notes.

**Special ink absorbs energy from UV**

The UV radiation absorbed is re-emitted as visible light.

It fluoresces
Ionising radiation is emitted randomly all the time from a radioactive source. Alpha, beta particles and gamma waves all transfer energy.
Our solar system is part of a collection of billions of other stars in a galaxy called the Milky Way.

It takes light 400 years to travel to our nearest star.

The Milky Way is just one of billions of galaxies in the universe.
Telescopes in space (outside of the Earth’s atmosphere) can pick up a wider spectrum including gamma and x-rays (not just light and radio waves) and are not affected by clouds, atmospheric or light pollution.

Modern telescopes (like NASA’s Hubble Spitzer, Plank and Kepler telescopes) have better optics and use computers to see fainter, more distant objects.
Stars form from stellar dust and gas (Nebula) which is pulled together by gravity. Under pressure and with plenty of collisions, kinetic energy is converted to thermal energy. Eventually it gets hot enough for fusion to start and Hydrogen is converted into Helium.
Red Shift is an observed change in wavelength where waves appear longer because they are coming from something moving away from the observer. The light is shifted to the red end of the spectrum.

Red Shift is evidence of an expanding Universe. It indicates that everything is moving away from the centre of the Universe. A greater shift indicates stars that are further away and moving faster.

CMB: (Cosmic Microwave Background) Radiation left over from the early stages of the Universe is evidence of a single event (Big Bang) only.

Both the Steady State Model (constant density / constant temperature) and the Big Bang Model (decreasing density / decreasing temperature) are supported by Red Shift.
Looking for life beyond Earth, scientists use radio telescopes, space probes, send landers to other planets to collect soil samples and even fly rockets through the tails of comets. They are looking for evidence of life, bacteria would do, and for the water that would be needed to support life.

Modern, more sensitive telescopes will see further as will those placed outside of the Earth’s atmosphere – these will also see a greater range of frequencies. Computers play a part too in analysing the data gathered.
Ultrasound – frequencies greater than 20,000 Hz

Communication between animals:

Sonar:
Knowing the speed of sound in water and the time taken for a signal to return it is possible to calculate the distance away of an object.

Foetal scanning:
Work in a similar way to sonar but use a computer to build a more complex picture.

distance = speed x time
Infrasound – frequencies less than 20 Hz
(A longitudinal sound wave)

Communication between animals

Detection of animal movements

Detecting volcanic eruptions and meteors
The mantle has all the properties of a solid whilst the outer core is liquid.

- **p & s - waves**
  - **p - waves**
  - Push-and-pull
  - Primary
  - (Longitudinal)

- **s - waves only**
  - **s - waves**
  - Slow
  - Side-to-side
  - Slow moving
  - Secondary
  - (Transverse)

Seismic waves are reflected and refracted at boundaries.
P1  Topic 4 Seismometer

Used to detect both s and p waves. From the chart it is possible to measure the s-p distance and calculate how far away an earthquake was.

Circles, representing distance, centre on each receiving station can be used to identify the earthquake location.
Energy / pressure / force builds up when the plates don’t slide and jolt / jerk / move suddenly when released. This sudden slip causes an earthquake.

The Earth’s crust consists of tectonic plates which float on molten magma. They move relative to each other as a result of convection currents in the molten rock which rise and pull the plates apart.
**P1**  Topic 5 Formulae

Voltage is an electrical pressure related to the energy transferred. Volts (V)

Power is the energy transferred per second. Watts (W)

Current is the rate of flow of charge(s) (electrons). Amps (I)

\[ P = I \times V \]
The magnet moves into the coil. A current is induced.

The magnet moves in the other direction. The current is reversed.

No movement = No current.

To generate a bigger current. You need:

- Stronger magnets
- Faster movement (frequency)
- Greater movement (amplitude)
- More coils of wire.
The coil of wire moving between the magnets generates / induces, an (alternating) current. This is a generator.

A similar process takes place in the large-scale generation of electricity by wind turbines or hydroelectric turbines. These or steam produced in coal, gas and nuclear plants are used to turn a turbine and then generator.
Transformers change alternating voltage:

Voltage changes in the ratio of the number of turns. 4x as many turns on the Secondary means 4x the voltage. Increasing voltage = **Step Up**, decreasing voltage = **Step Down**.

Changing current in the Primary results in changing magnetic field which induces a changing current in the Secondary.

Alternating current / voltage (ac): The displacement is above and below zero. (Generators and transformers)

Direct current / voltage (DC): Despite the same shape, the curve does not go below the zero. (Batteries and photocells)
High Voltage = Low Current
Low Current = Low Heating
Low Heating = Low energy Loss
Low energy loss = Increased Efficiency
% Efficiency:
(useful energy transferred by the device) x 100
(total energy supplied to the device)

\[
\text{Power} = \frac{\text{Energy used}}{\text{Time taken}}
\]

\[
P = \frac{E}{t}
\]

Power (watt, W)
energy used (joule, J)
time (second, s)

Energy from the mains supply is measured in kilowatt-hours

**Power is the “rate of transfer of energy”**

**Formula (given to you):**

\[
\% \text{ Efficiency} = \left( \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}} \right) \times 100
\]
P1 Topic 5 Energy efficiency

Energy saving lightbulbs produce the same brightness with less loss of energy through heat.

**Payback time:** You can get back the cost of adding new loft insulation in around 2 years and of adding extra insulation in around 6 years.

Low energy devices are better for the environment, they use less energy and indirectly produce less CO₂.

Energy saving devices will save money in the end. Payback times (the time to get the investment back) will vary.

You should expect to carry out calculations of cost-efficiency and payback times from data provided in an exam question.
P1  Topic 6 Forms of energy

- Light
- Nuclear
- Kinetic
- Chemical
- Elastic potential
- Gravitational potential
- Thermal
- Electrical

6.2
P1 Topic 6 Energy transfer

Heat Energy
Combustion in boiler, nuclear reaction

Kinetic Energy
Movement of steam molecules as they are heated and expand from high to low pressure.

Kinetic Energy
Movement of turbine and generator

Electrical Energy
Transferred to grid

Boiler

Condenser

Turbine

Generator

Transformer

Chemical Energy
Stored in fuel (coal, gas, nuclear)

Energy in Fuel
100 J

Heat Loss
20 J

Steam cools to water
40 J

Generator Losses
5 J

Electrical Energy
35 J

Energy Transfer Diagram
Black objects are good absorbers and radiators whilst silver is a poor absorber and radiator of thermal energy.

An electric heater will reach equilibrium when the electrical energy going in equals the thermal energy coming out.

The Law of Conservation of Energy: “Energy cannot be created or destroyed, it can only change form”