Generating and distributing electricity

OxfordAQA International GCSE Physics 9203, topic 3.6 (all P): generator effect, the grid, transformers, motor effect, kWh

Move a magnet, move a current

Generator, grid, home: one chain of coils and cables.

- OxfordAQA International GCSE Physics 9203, topic 3.6.
- The whole topic is Paper 2 (P).

The generator effect

> Motion through a field, or a changing field, induces a p.d.

- A still magnet in a still coil induces nothing.
- The induced current's field opposes the change.

A bigger induced p.d.

> Faster, stronger, more turns, bigger area.

- Any one of these raises the p.d.
- Power stations spin coils between magnets.

Alternator and dynamo

Same spinning coil, different connections: a.c. or d.c.

- Alternator: a.c., the sign flips.
- Dynamo: d.c., humps one way.

The national grid

> Transmit at high voltage, use at low voltage.

- Step up before the lines, step down after.
- Switch-mode transformers: small, light chargers.

Why high voltage?

> High voltage means low current, so the cables waste little energy.

- Same power: $P = IV$.
- Less current, far less heating in the cables.

Inside a transformer

More secondary turns, higher secondary p.d.

- It needs a.c.: only a changing current changes the field.
- 100% efficient: $V_p I_p = V_s I_s$.

Worked: a step-down transformer

1. **Turns** $n_s = 2000 \times 11.5/230 = 100$
2. **Power** $V_p I_p = V_s I_s$
3. **Current** $I_p = 11.5 \times 2.0/230 = 0.10$ A

Decision

100 turns; 0.10 A in, 2.0 A out.

Reading a mains trace

One cycle, 20 ms: the mains frequency is 50 Hz.

- Cells give d.c.; mains is a.c.
- f = 1 / T, with T in seconds.

Safety in the home

Earth wire

fault current to earth

casing stays safe

Fuse or breaker

excess current cuts the live wire

breaker: trips, resettable

The motor effect

A current across a field feels a force.

- No force when the wire is parallel to the field.
- Stronger field, bigger current: bigger force.

Fleming's left-hand rule

> First finger Field, seCond finger Current, thuMb Motion.

- Three fingers at right angles.
- A coil in a field rotates: the electric motor.

Power and the fuse

1. **Data** $P = 1100$ W, $V = 230$ V
2. **Current** $I = P/V = 1100/230 \approx 4.8$ A
3. **Fuse** next rating above: 5 A (or 13 A)

Decision

4.8 A: fit a 5 A **fuse**, never a 3 A.

Kilowatt-hours and the bill

1. **Meter** $12\,465 - 12\,345 = 120$ kWh
2. **Bill** $120 \times 0.9 = 108$
3. **Heater** 1.5 kW $\times 0.5$ h $= 0.75$ kWh

Decision

The bill is energy in kWh times the price per unit.

Common mistakes

Mistake	Fix
transformer on d.c.	needs a.c.: a changing field
high voltage travels faster	low current, less heating
watts and seconds for kWh	kW and hours
motor force biggest when parallel	zero then; biggest at 90°

Check yourself

Question	**Answer**
200 : 3000 turns on 12 V a.c.?	180 V
Current: 230 V, 2.3 kW heater?	10 A, 13 A **fuse**
1.5 kW kettle for 20 min?	0.5 kWh
Why transmit at high voltage?	low current, less heating