Uses of the generator effect

4.7.3.2 · Magnetism and electromagnetism · revision notes

Generators use the generator effect: a coil rotating in a magnetic field (or a magnet rotating near a coil) induces a potential difference. An alternator produces a.c. and a dynamo produces d.c. You need to explain how each works, and draw and interpret graphs of the induced potential difference against time. GCSE Physics only, Higher tier only.

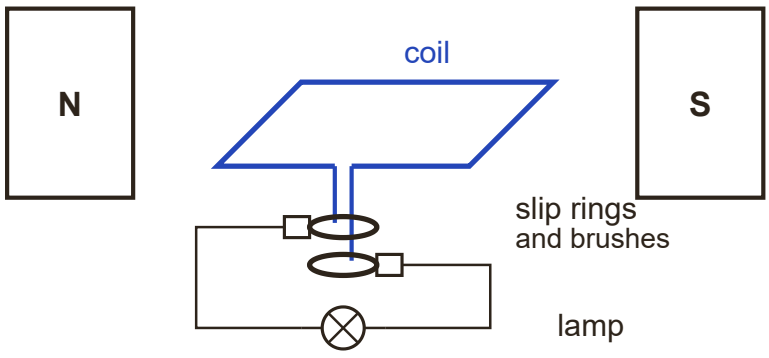
Key facts

- Alternator → a.c.; uses slip rings
- Rotating coil in a magnetic field → induced pd (generator effect)
- Alternator graph: wave above and below zero. Dynamo graph: humps on one side of zero
- Stronger field or more turns → higher peak, same frequency
- Dynamo → d.c.; uses a split-ring commutator
- The pd induced in the coil reverses every half turn
- Faster rotation → higher peak and higher frequency (shorter period)
- 1 turn = 1 complete a.c. cycle = 2 dynamo humps

Notes

How a generator works

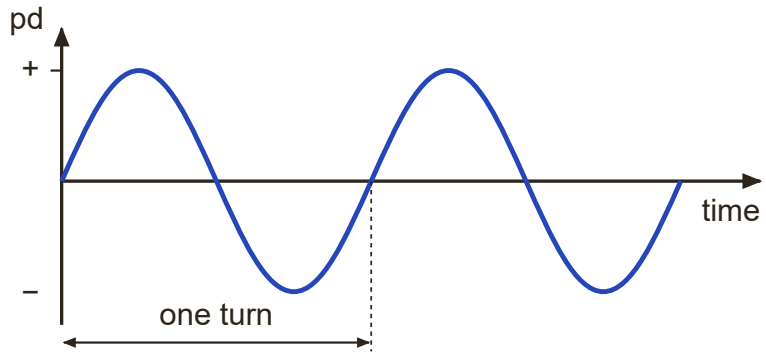
- A coil rotates in a magnetic field (or a magnet rotates near a coil). The sides of the coil move through the field lines, so a **pd is induced**: the generator effect. In a complete circuit, a current is induced.
- As the coil turns, each side moves up through the field and then down through it, so the pd induced in the coil **reverses every half turn**.
- **Brushes** press against rings on the axle to connect the spinning coil to the outside circuit.



Alternator: each slip ring always touches the same brush, so the output is a.c.

Alternator: a.c.

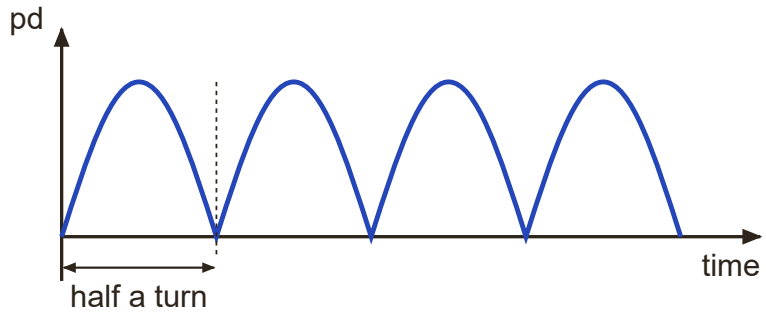
- An **alternator** has two **slip rings**, one joined to each end of the coil. Each ring always touches the same brush, giving a continuous contact without the wires twisting.
- So the output reverses every half turn, just like the pd in the coil. It is an **alternating** pd, and it drives an **alternating current (a.c.)**.
- Graph of pd against time: a smooth wave, going positive then negative.



Alternator output: a.c. The pd reverses every half turn.

Dynamo: d.c.

- A **dynamo** has a **split-ring commutator** instead of slip rings.
- Every half turn, just as the pd in the coil reverses, the commutator swaps the connections to the brushes.
- So the output is always in the same direction: **direct current (d.c.)**. Its size still goes up and down.
- Graph: a series of humps, all on the same side of the time axis, falling to zero between each hump.



Dynamo output: d.c. It changes size but never changes direction.

Reading the graphs Grade 8+ only

- One complete wave of the alternator graph = one full turn of the coil. One dynamo hump = half a turn.
- Faster rotation: a higher peak pd **and** a shorter time for each cycle (a higher frequency).
- Stronger magnet or more turns: a higher peak pd, but the time for each cycle stays the same.
- The pd is biggest when the plane of the coil is parallel to the field lines (the sides cut through the field lines fastest). It is zero when the plane of the coil is at right angles to the field lines (the sides move along the field lines). Grade 9+ only

How to answer each type of question

Explain the difference between an alternator and a dynamo

3 to 4 marks | Grade 7

1. Say the pd induced in the coil reverses every half turn in both.
2. Alternator: slip rings keep each end of the coil on the same brush, so the output alternates.
3. Dynamo: the split-ring commutator swaps the connections every half turn, so the output is always in one direction.

Example. Explain why an alternator produces an alternating current but a dynamo produces a direct current. [4 marks]

Model answer. In both, the pd induced in the rotating coil reverses every half turn (1). An alternator has slip rings, so each end of the coil stays connected to the same brush and the output reverses too (a.c.) (1). A dynamo has a split-ring commutator (1), which swaps the connections every half turn, so the output is always in the same direction (d.c.) (1).

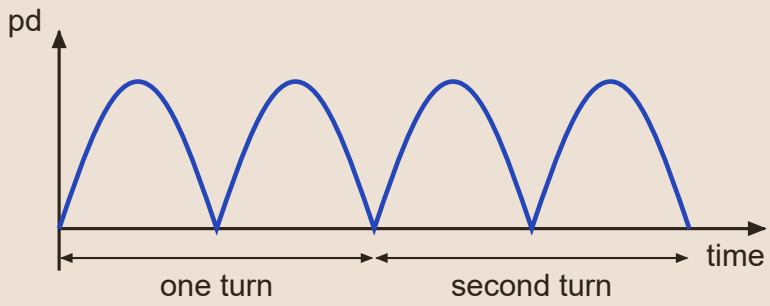
Sketch the graph of pd against time

2 to 3 marks | Grade 6

1. Label the axes: potential difference (up) and time (along).
2. Alternator: a smooth wave above and below zero. Dynamo: humps all on one side, touching zero between them.
3. Keep every peak the same height, and draw the right number of cycles or humps.

Example. A dynamo turns at a steady speed. Sketch a graph of its output pd against time for two complete turns of the coil. [2 marks]

Model answer.



Two complete turns: four humps, all the same height, all above the axis.

Four humps, all on the same side of the time axis (1). All the humps are the same height, and the pd falls to zero between them (1).

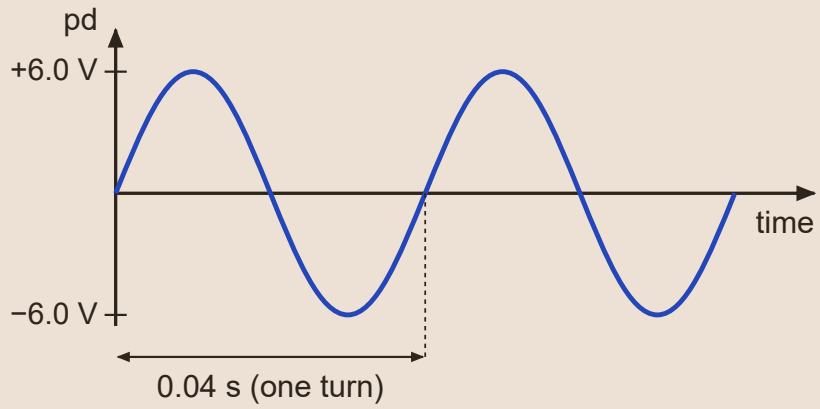
Interpret the graph and predict changes

3 to 5 marks | **Grade 8**

1. One complete a.c. cycle is one turn: find the time for one turn from the graph or from the turns per second.
2. Faster: taller peaks and shorter cycles.
3. Stronger magnet or more turns: taller peaks only.

Example. The coil of an alternator turns 25 times per second. The peak output pd is 6.0 V.
(a) Calculate the time for one complete turn of the coil. [1 mark]
(b) Describe the graph of output pd against time. [2 marks]
(c) The coil is made to turn twice as fast. Describe two ways in which the graph changes. [2 marks]

Model answer.



One full cycle every 0.04 s, peaks at +6.0 V and −6.0 V.

(a) 1 ÷ 25 = 0.04 s (1)

(b) A wave that goes up to +6.0 V and down to −6.0 V (1), with one complete cycle every 0.04 s (1).

(c) The peak pd is higher (1). Each cycle takes half the time / there are twice as many cycles each second (1).

Explain the pd at a particular coil position

2 marks | **Grade 9**

1. Work out how the sides of the coil are moving compared with the field lines at that moment.
2. Moving across the field lines at right angles: biggest pd. Moving along the field lines: zero pd.

Example. Explain why the induced pd is zero at the moment when the plane of the coil is at right angles to the magnetic field. [2 marks]

Model answer. At that moment the sides of the coil are moving along (parallel to) the field lines (1), so they are not cutting through the field lines and no pd is induced (1).

Don’t lose marks

- Swapping slip rings and the split-ring commutator.
- Drawing some dynamo humps below the axis, or not bringing the pd back to zero between humps.

- ✗ Saying faster rotation only changes the peak pd: it also shortens the time for each cycle.
- ✗ Saying a dynamo gives a steady pd: its output is d.c. but it still varies in size.
- ✗ Writing just 'rings': name them, 'slip rings' or 'split-ring commutator'.

More tips

Memory tricks

- Alternator makes A.c.; Dynamo makes D.c.
- A split-ring commutator is in both the motor and the dynamo, and in both it swaps the connections every half turn. Slip rings never swap.
- Faster rotation = taller and narrower waves. Stronger magnet or more turns = taller only.

Exam technique

- When you sketch a graph, label the axes (potential difference and time) and keep the peaks the same height.
- When a graph is given, count the cycles over a time interval to find the time for one turn.
- In 'explain' questions, say what the rings or commutator do to the connections and when (every half turn).

What each grade needs

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

Grade 5 — **State what an alternator and a dynamo produce**
An alternator generates alternating current (a.c.); a dynamo generates direct current (d.c.).

Grade 5 — **Explain why a rotating coil induces a pd**
The sides of the coil move through (cut) the magnetic field lines, so a pd is induced.

Grade 6 — **Describe the job of slip rings**
Each end of the coil stays connected to the same brush, so the output pd alternates as the coil turns.

Grade 7 — **Describe the job of a dynamo's commutator**
It swaps the connections every half turn, so the output pd is always in the same direction.

Grade 7 — **Sketch pd–time graphs for both generators**
Alternator: a wave going above and below zero. Dynamo: humps that are all on the same side of zero.

Grade 8 — **Predict graph changes for faster rotation**
Faster rotation gives a higher peak pd and a shorter time for each cycle (a higher frequency).

Grade 9 — **Link the coil's position to the induced pd**
The pd is biggest when the plane of the coil is parallel to the field and zero when it is at right angles to the field.

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