



Unit 11 • Electricity and Magnetism: currents, fields and motors

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. direct current
2. alternating current
3. frequency
4. rectifier
5. magnetic effect
6. Oersted
7. solenoid
8. electromagnet

K • 4

Each carries 0.5 mark.

2 Label the diagram

1. force up
2. coil
3. split-ring commutator
4. brush
5. battery
6. force down

K • 3

Each carries 0.5 mark.

3 Multiple choice

- i. c. dynamo

K • 1

A dynamo makes a.c. by spinning a magnet beside a coil. Cells and solar panels give d.c.

- ii. b. Hans Christian Oersted

K • 1

Oersted saw a compass needle move near a current in 1820. Faraday discovered electromagnetic induction (1831); Maxwell gave the right-hand rules; Fleming gave the left- and right-hand rules for motors and generators.

- iii. a. anticlockwise

U • 1

Point your right thumb upwards: your fingers curl anticlockwise seen from above.

- iv. c. The brightness of the lamp fluctuates if the current produced by A is used.

A • 1

The dynamo's output depends on how fast the wheel turns, so its lamp gets brighter and dimmer as the bicycle speeds up and slows down. The torch's battery gives steady d.c., which never changes direction.

- v. d. reversing the direction of the current

U • 1

Reversing the current swaps the north and south poles, but the field is just as strong. The other three all make the field stronger.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ 50 Hz.

- b. MARKING SCHEME

K • 1

✓ Zero (it never changes direction).

- c. MARKING SCHEME

U • 1

✓ It can be switched on and off, or its strength can be changed.



5 Short answers

a. MARKING SCHEME

U · 2

- ✓ Any one difference, e.g. a.c. changes direction again and again; d.c. flows in one direction only.
- ✓ Any second difference, e.g. a.c. has a frequency (50 Hz in Nepal), d.c. has none; or a.c. comes from generators and dynamos, d.c. from cells and solar panels; or a.c. voltage can be changed by a transformer.

b. MARKING SCHEME

U · 2

- ✓ A solar panel gives d.c. at a low voltage.
- ✓ A ceiling fan has an a.c. motor made for about 230 V, which needs a current that keeps reversing, so it doesn't turn.

c. MARKING SCHEME

K · 2

- ✓ i. Grip the straight wire in the right hand with the thumb along the current: the curled fingers show the direction of the field lines.
- ✓ ii. Hold the solenoid in the right hand with the fingers curled along the current in its turns: the thumb points to its north pole.

d. MARKING SCHEME

U · 2

- ✓ The bell needs a magnet that can be switched on and off again and again; an electromagnet attracts the iron arm only while current flows.
- ✓ When the arm moves, it breaks the circuit, the magnetism goes, the arm springs back and closes it again, so the hammer strikes the gong again and again.

6 Long answer

ANSWER

U · 4

- i. When a current-carrying wire is placed in a magnetic field, a force acts on it and it moves: this is the motor effect.
- ii. The current flows one way along side AB of the coil and the opposite way along side CD, so one side is pushed up and the other down, and the coil turns.
- iii. It reverses the current in the coil every half turn, so the forces keep turning the coil the same way.
- iv. Any two: more turns in the coil, a larger coil, a stronger magnet, a soft iron core, a larger current.

MARKING SCHEME

- ✓ i. A current-carrying conductor in a magnetic field feels a force and moves.
- ✓ ii. The two sides carry current in opposite directions, so one is pushed up and the other down, and the coil turns.
- ✓ iii. The commutator reverses the current every half turn, so the coil keeps turning the same way.
- ✓ iv. Any two: more turns, larger coil, stronger magnet, soft iron core, larger current.

7 Numerical problems

a. ANSWER

A · 2

Time for one cycle = $1 \div 50 \text{ Hz} = 0.02 \text{ s}$. The current changes direction twice in each cycle, so $2 \times 50 = 100$ times a second.

MARKING SCHEME

- ✓ One cycle = $1 \div 50 = 0.02 \text{ s}$.
- ✓ It changes direction $2 \times 50 = 100$ times a second.



b. ANSWER

A • 2

In one second: $2 \times 60 = 120$ times. In one minute: $120 \times 60 = 7,200$ times.

MARKING SCHEME

- ✓ $2 \times 60 = 120$ changes of direction in one second.
- ✓ $120 \times 60 = 7,200$ in one minute.

8 Think**ANSWER**

HA • 2

- i. It turns towards the west: reversing the current reverses the magnetic field it makes.
(ii) It swings back to point north: with no current there is no field from the wire, and only the Earth's field acts on it.

MARKING SCHEME

- ✓ i. It turns the other way (towards the west), because reversing the current reverses its magnetic field.
- ✓ ii. It swings back to north, because with no current the wire makes no field and only the Earth's field acts.

9 Activity: Find the poles of a coil

(not marked)

WHAT STUDENTS SHOULD FIND

Each end of the coil attracts the opposite pole of the needle: if the right end pulls the needle's south pole, it is a north pole, and the left end is a south pole. Swapping the battery reverses the current, and both poles of the coil swap. The coil behaves like a bar magnet, but only while the current flows.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	13	13	5	2	33





Unit 11 • Electricity and Magnetism: induction, generators and transformers

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. flux
2. electromagnetic induction
3. Faraday
4. slip rings
5. transformer
6. mutual induction
7. step-up
8. lamination

K • 4

Each carries 0.5 mark.

2 Label the diagram

- | | | |
|--------------------|--------------------|-------|
| 1. N | 4. carbon brushes | K • 3 |
| 2. slip rings | 5. magnetic field | |
| 3. coil (armature) | 6. lamp (the load) | |

Each carries 0.5 mark.

3 Multiple choice

- i. b. mutual induction

K • 1

Mutual induction is a kind of electromagnetic induction: a changing current in one coil induces an e.m.f. in the other. “Electromagnetic induction” isn’t wrong, but “mutual induction” is the best answer because it names exactly what happens in a transformer, and it is the answer your exam expects.

- ii. d. $V_s/N_s = V_p/N_p$

U • 1

Each turn of wire gets the same share of the voltage, so voltage ÷ turns is the same for both coils: $V_s/N_s = V_p/N_p$, which is the same as $N_p/N_s = V_p/V_s$.

- iii. c. zero

U • 1

An e.m.f. is induced only while the flux **changes**. A still magnet gives a steady flux, so there is no induced current, however strong the magnet is.

- iv. b. the magnet spins faster, so the flux changes faster and a larger voltage is induced

A • 1

By Faraday’s law, the induced e.m.f. is proportional to the rate of change of flux. A faster wheel spins the magnet faster, so the e.m.f. is bigger. There is no battery in a dynamo.

- v. b. a microwave oven

K • 1

A microwave oven needs about 2,000 V from the 230 V supply. Chargers, doorbells and pole transformers all lower the voltage.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ Weber (Wb).

- b. MARKING SCHEME

K • 1

✓ Mechanical energy.



- c. MARKING SCHEME U · 1
✓ D.c. gives a steady flux, so no e.m.f. is induced in the secondary coil.

5 Short answers

- a. MARKING SCHEME K · 2
✓ When there is relative motion between a conductor and a magnet, an e.m.f. is induced in the conductor.
✓ Its size is directly proportional to the rate of change of the magnetic flux linked with the conductor.
- b. MARKING SCHEME U · 2
✓ The changing field induces currents (eddy currents) in the iron core itself, which heat it and waste energy.
✓ Thin iron sheets insulated from each other break up these currents, so less energy is lost.
- c. MARKING SCHEME U · 2
✓ Any one difference, e.g. a motor changes electrical energy into mechanical energy; a generator changes mechanical energy into electrical energy.
✓ Any second difference, e.g. a motor works on the motor effect; a generator on electromagnetic induction.

6 Long answer

ANSWER

U · 4

- The galvanometer needle moves a **little** to one side: a small current is induced, because the flux changes slowly.
- The needle moves **further** to the same side: the flux changes faster, so a larger e.m.f. is induced.
- The needle returns to **zero**: the flux doesn't change, so nothing is induced.
- The needle moves a large amount to the **opposite** side: the flux is decreasing quickly, so a large current flows in the opposite direction.

MARKING SCHEME

- ✓ i. The needle moves a little to one side: the flux changes slowly, so a small current is induced.
- ✓ ii. The needle moves further to the same side: the flux changes faster, so a larger e.m.f. is induced.
- ✓ iii. The needle stays at zero: the flux doesn't change, so nothing is induced.
- ✓ iv. The needle moves a lot to the opposite side: the flux decreases quickly, so a large current flows the other way.

7 Numerical problems

- a. ANSWER A · 2
 $N_p/N_s = V_p/V_s$, so $N_s = N_p \times V_s \div V_p = 550 \times 20 \div 220 = 50$ turns.
- MARKING SCHEME
✓ $N_p/N_s = V_p/V_s$, with $N_p = 550$, $V_p = 220$ V and $V_s = 20$ V put in.
✓ $N_s = 50$ turns.



b. ANSWER

A • 4

- $N_s = N_p \times V_s \div V_p = 1,200 \times 11 \div 220 = 60$ turns.
- Step-down: the secondary has fewer turns than the primary, and the output voltage is lower.
- Zero: d.c. gives a steady flux, so no e.m.f. is induced in the secondary.

MARKING SCHEME

- ✓ $N_p/N_s = V_p/V_s$, so $N_s = 1,200 \times 11 \div 220$.
- ✓ $N_s = 60$ turns.
- ✓ Step-down, because the secondary has fewer turns (the output voltage is lower).
- ✓ Zero output, because d.c. gives no change of flux, so nothing is induced.

8 Think**ANSWER**

HA • 2

For the same power ($P = VI$), a line at 100 times the voltage carries 1/100 of the current, and the heat wasted in the wires grows with the square of the current, so it wastes only 1/10,000 as much. At 230 V most of the electricity would be lost as heat on the way. Only a.c. can be stepped up and down like this, by transformers.

MARKING SCHEME

- ✓ For the same power ($P = VI$), a higher voltage needs a much smaller current, and the heat wasted in the wires grows with the square of the current.
- ✓ So little energy is lost on the long journey; only a.c. can be stepped up and down like this, by transformers.

9 Activity: Devices with transformers

(not marked)

WHAT STUDENTS SHOULD FIND

Typical labels: input 100–240 V a.c. for all; output about 5 V d.c. (phone, some 9 V or 12 V for fast charging), about 19–20 V d.c. (laptop), 12 V d.c. (router and set-top box). All step the voltage down, and their output is d.c., because a rectifier follows the transformer.

See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **Magnetic Braking** (exhibit): Drop the magnet down the metal tube: the currents it induces slow its fall.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	13	11	7	2	33

