

Magnets, motors, generators and transformers

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer shows the formula, the substitution and the result with its unit, with final results in bold. Direction answers name the rule used. Keep intermediate values unrounded and round only the last step, as examiners expect.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS2-5, GCSE P7

Problem 1 Attract or repel?

1. **Attract** (unlike poles).
2. **Repel** (like poles).
3. **Repel** (like poles).
4. **Attract:** a magnet induces magnetism in iron, and the nearer pole of the nail becomes the opposite pole.

Problem 2 Field line facts

1. From the **north pole to the south pole**.
2. At the **poles**, where the lines are closest together.
3. It turns to line up with the field, its north end pointing along the field line.
4. **Tesla (T)**.

Problem 3 Force on a wire

1. $F = B I L = 0.50 \times 2.0 \times 0.10 = \mathbf{0.10 \text{ N}}$.
2. **0 N:** the wire does not cut across the field.
3. Force is proportional to current: **0.20 N**.

Problem 4 Unit conversions

1. $25 \div 100 = \mathbf{0.25 \text{ m}}$.
2. $250 \div 1000 = \mathbf{0.25 \text{ T}}$.
3. $40 \div 1000 = \mathbf{0.040 \text{ A}}$.
4. $T = 1 \div f = 1 \div 50 = 0.020 \text{ s} = \mathbf{20 \text{ ms}}$.

Problem 5 Stronger electromagnet

1. Increase the **current**, use **more turns**, and use a **soft iron core**.
2. Soft iron is magnetised easily and loses its magnetism when the current stops. Steel would stay magnetised.

3. It can be **switched off** (and its strength can be varied by changing the current).

Problem 6 Transformer output

1. $V_s = V_p \times N_s \div N_p = 230 \times 50 \div 1000 = \mathbf{11.5\ V}$.
2. **Step-down**, because the secondary has fewer turns.
3. $N_s = N_p \times V_s \div V_p = 1000 \times 46 \div 230 = \mathbf{200\ turns}$.

Problem 7 Making more voltage

1. Turn the wheel **faster**, use a **stronger magnet**, or use a coil with **more turns**.
2. The coil or magnet turns, so each half turn the wire cuts the field in the opposite direction and the voltage reverses.
3. **Nothing**: with no relative movement the field does not change.

Problem 8 Finding the current

1. $I = F \div (B L) = 0.36 \div (0.30 \times 0.20) = 0.36 \div 0.060 = \mathbf{6.0\ A}$.
2. $B = F \div (I L) = 0.36 \div (3.0 \times 0.20) = \mathbf{0.60\ T}$.

Problem 9 Direction of the force

1. The field points right and the current goes into the page, so the force is **downwards**.
2. Reversing the current reverses the force: **upwards**.
3. Reversing both leaves the force unchanged: **downwards**.
4. **Fleming's left-hand rule**.

Problem 10 Phone charger transformer

1. $N_s = 2300 \times 9.0 \div 230 = \mathbf{90\ turns}$.
2. $P = V I = 9.0 \times 1.5 = \mathbf{13.5\ W}$.
3. $I_p = P \div V_p = 13.5 \div 230 = \mathbf{0.059\ A}$.

Problem 11 Reading a dynamo graph

1. The peak is **6.0 V**.
2. One full cycle takes 40 ms, so the period is **40 ms** = 0.040 s. $f = 1 \div 0.040 = \mathbf{25\ Hz}$.
3. The curve is at its peak a quarter of a period after the start: **6.0 V**.
4. The peak becomes 12 V and the period halves to 20 ms, so the frequency doubles to **50 Hz**.

Problem 12 Why alternating?

1. A battery gives a steady current and a steady field, so the field through the secondary coil does not change and **no voltage is induced**.

2. The flick occurs when the switch is closed: the field grows from zero, which is a change that induces a brief voltage.
3. The iron core guides and strengthens the changing field so almost all of it passes through the secondary coil.

Problem 13 Electromagnet data

1. The number of clips **increases roughly in proportion** to the number of turns, about 0.45 clips per turn.
2. $50 \times 0.45 = 22.5$, so about **22 to 23 clips**.
3. The **current** and the **core material** (also the size of the paper clips and the battery).

Problem 14 How much can the force lift?

1. $F = B I L = 0.080 \times 3.5 \times 0.12 = \mathbf{0.034\ N}$ (0.0336 N).
2. $m = F \div g = 0.0336 \div 9.8 = 0.00343\ \text{kg} = \mathbf{3.4\ g}$.
3. Doubling I doubles F to 0.0672 N: $m = 0.0672 \div 9.8 = 0.00686\ \text{kg} = \mathbf{6.9\ g}$.

Problem 15 Motor against generator

1. Motor: **electrical to kinetic**. Generator: **kinetic to electrical**.
2. Both have a coil that can turn between the poles of a magnet.
3. The **motor** uses a split-ring commutator to reverse the current every half turn so the turning effect keeps the same direction. The **generator** uses slip rings so that the alternating voltage is delivered unchanged.

Problem 16 Transformer efficiency

1. $N_s \div N_p = V_s \div V_p = 240 \div 12 = \mathbf{20}$.
2. $I_s = P \div V = 60 \div 240 = \mathbf{0.25\ A}$.
3. Input power = $60 \div 0.92 = \mathbf{65\ W}$ (65.2 W).
4. $I_p = 65.2 \div 12 = \mathbf{5.4\ A}$.
5. About 5.2 W is lost as **heat** in the coils (resistance) and in the core (eddy currents).

Problem 17 Lamp on a transformer

1. $V_s = 24 \times 2000 \div 400 = \mathbf{120\ V}$.
2. **Step-up**, since N_s is larger than N_p .
3. $I_s = P \div V = 60 \div 120 = \mathbf{0.50\ A}$.
4. $V_p I_p = 60\ \text{W}$, so $I_p = 60 \div 24 = \mathbf{2.5\ A}$.
5. $I_p \div I_s = 2.5 \div 0.50 = 5.0$ and $N_s \div N_p = 2000 \div 400 = 5.0$, **so they are equal**.

Problem 18 Spot the errors

1. Power cannot increase. In an ideal transformer the output power **equals** the input power,

and in a real one it is smaller because of heating losses.

2. A magnet at rest causes no change of field, so **no voltage** is induced. Voltage appears only while the magnet or the field moves.

3. A wire parallel to the field cuts no field lines, so the force is **zero**. The force is greatest at right angles.

Problem 19 Turning effect of a coil

1. $F = N B I L = 50 \times 0.40 \times 1.2 \times 0.060 = \mathbf{1.44 \text{ N}}$.

2. It points in the **opposite direction**, since the current runs the other way in the field.

3. Moment = $F \times \text{distance} = 1.44 \times 0.040 = \mathbf{0.058 \text{ N m}}$ (0.0576 N m).

4. **Zero**, because the two forces then act along the same line.

5. The commutator reverses the current every half turn so that each side is pushed the same way round and the coil keeps spinning instead of stopping.

Problem 20 Magnet in a copper tube

1. $t = \sqrt{2h \div g} = \sqrt{2 \times 0.50 \div 9.8} = \sqrt{0.102} = \mathbf{0.32 \text{ s}}$.

2. $t = 0.50 \div 0.25 = \mathbf{2.0 \text{ s}}$.

3. The moving magnet changes the field through the copper, inducing circulating currents. By Lenz's law these produce a field that opposes the motion, so there is an upward force and the magnet falls slowly.

4. $\Delta E = m g h = 0.040 \times 9.8 \times 0.50 = \mathbf{0.20 \text{ J}}$ (0.196 J).

5. $P = 0.196 \div 2.0 = \mathbf{0.098 \text{ W}}$, transferred as heat in the tube.