7.3 Generator effect and transformers

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS transformer

Objective

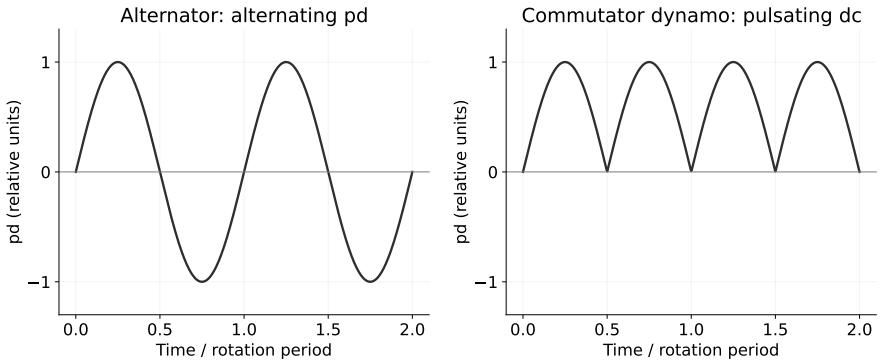
State the generator-effect conditions, explain alternators and dynamos with their graphs, and use both transformer equations. Physics only, HT. Original questions for spec statement 4.7.3.

1 Key knowledge and worked examples

Generator effect: a potential difference is induced when a conductor **cuts magnetic field lines**, or the field linking it **changes**; a complete circuit carries the induced current.

- The **induced current's field opposes the change** that made it.
- Bigger induced pd: **faster** motion, **stronger** field, **more turns**. Reversed direction: reversed movement or reversed polarity.

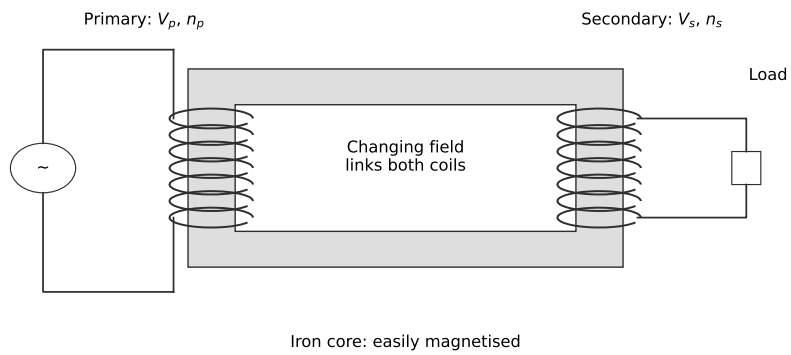
Device	Output graph
alternator (ac)	sine-like, crossing zero every half-turn
dynamo (dc, commutator)	pulsating output on one side of zero



Both repeat with the rotation; only the alternator reverses.

Microphone: sound pressure variations move a coil in a field, inducing a varying potential difference; a varying current flows in a complete circuit.

Transformer : primary and secondary coils on an **iron core** (easily magnetised). Alternating current in the primary makes a **changing field**; the changing field **induces an alternating pd** in the secondary.



Step-up: $V_s > V_p$. *Step-down:* $V_s < V_p$.

$$\frac{V_p}{V_s} = \frac{n_p}{n_s} \qquad V_s I_s = V_p I_p \text{ (100\% efficient)}$$

Worked example. 345 primary turns, 6000 secondary, input 230 V.

$$V_s = V_p \times \frac{n_s}{n_p} = 230 \times \frac{6000}{345} = 4000 \text{ V (step-up)}$$

Worked example (current). Assume 100% efficiency; output is 50 mA at 4000 V.

- Power out: $P = V_s I_s = 4000 \times 0.050 = 200$ W.
- Input current: $I_p = P/V_p = 200/230 = 0.87$ A.

Grid link: at the same transferred power, stepping up pd cuts current; with unchanged cable resistance, $P_{\text{loss}} = I^2 R$ decreases (topic 2.7).

2 Practice

2.1 State two ways to produce a changing magnetic field linkage and induce a potential difference in a conductor. [2]

2.2 A transformer has 100 primary and 500 secondary turns; input 12 V. Calculate the output pd. [2]

2.3 State why a transformer's core is iron. [1]

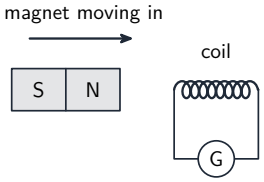
3 Exam-style questions

3.1 A magnet is pushed into a coil connected to a sensitive meter.

(a) Explain why the meter deflects. [2]

(b) State two changes that increase the deflection. [2]

(c) The magnet is pulled out faster. State what happens to the induced pd's size and direction, and explain using the opposing field. [3]



3.2 A transformer steps 230 V down to 11.5 V for a doorbell; the primary has 2000 turns.

(a) Calculate the secondary turns. [3]

(b) The bell draws 0.50 A. Calculate the primary current (assume 100% efficiency). [3]

(c) Explain why the transformer only works with alternating current. [2]

3.3 A bicycle generator uses a rotating coil and slip rings, with no split-ring commutator: it is an alternator. At its stated operating point it powers a 6.0 V, 3.0 W lamp. The system is unregulated.

(a) Sketch the pd–time graph for one full rotation and name the output type. [2]

(b) Calculate the lamp's current. [2]

(c) Starting below the lamp's maximum rating, the rider pedals faster with the same connected lamp and no regulation. Describe the output graph and expected initial brightness change. [3]

Solutions

2.1 The conductor cuts magnetic field lines, or the field linking it changes.

2.2

$$V_s = V_p \times \frac{n_s}{n_p} = 12 \times \frac{500}{100} = \mathbf{60}\ \text{V}$$

(equation C1, answer A1)

2.3 Iron is easily magnetised, so the changing primary field is carried strongly to the secondary coil.

3.1 (a) The magnet moving into the coil changes the magnetic field around the coil; the changing field induces a pd, driving a current through the meter. **3.1** (b) Any two: move the magnet faster; use a stronger magnet; more turns on the coil. **3.1** (c) The pd is larger (faster change) and reversed in direction (the flux through the coil now decreases instead of increasing); the induced current's own field opposes the change – reinforcing the field while the magnet leaves, opposing it while the magnet enters.

3.2 (a)

$$n_s = n_p \times \frac{V_s}{V_p} = 2000 \times \frac{11.5}{230} = \mathbf{100}\ \text{turns}$$

(equation C1, substitution C1, answer A1) **3.2** (b) Power out: $P = V_s I_s = 11.5 \times 0.50 = 5.75$ W (C1); input current:

$$I_p = \frac{P}{V_p} = \frac{5.75}{230} = \mathbf{0.025}\ \text{A}$$

(C1, A1) **3.2** (c) A transformer needs a **changing** field in the core; alternating current continually changes the primary's field, inducing a pd in the secondary – steady direct current gives a steady field and no sustained secondary pd. Switching on or off can briefly induce a pd.

3.3 (a) A sine-like curve crossing zero once per half rotation; ac output. **3.3** (b)

$$I = \frac{P}{V} = \frac{3.0}{6.0} = \mathbf{0.50}\ \text{A}$$

(C1, A1) **3.3** (c) In this stated alternator, the peaks come more frequently (higher frequency) and the peaks are higher (faster rotation, larger induced pd); the lamp is brighter because more energy is transferred per second.