

How changing flux creates an emf

Physics grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to calculate magnetic flux, apply Faraday's and Lenz's laws, and analyse moving conductors and rotating coils. They begin with one-step substitutions and finish with terminal speed, heating and measurement problems.

They suit A Level, IB Physics, CBSE Class 12 and WAEC senior students. Use $g = 9.81 \text{ N/kg}$ where needed.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB D.4

Problem 1 Flux through a coil (easy)

Wanjiru in Nairobi holds a coil of area 0.020 m^2 facing a 0.30 T field, with the coil's normal along the field.

1. Calculate the magnetic flux through the coil.

Problem 2 Tilted coil (easy)

A coil of area 0.040 m^2 is in a 0.50 T field. The normal to the coil makes an angle of 60° with the field.

1. Calculate the flux through the coil.

Problem 3 Single loop emf (easy)

The flux through a single loop falls from 8.0 mWb to 2.0 mWb in 0.30 s .

1. Calculate the average emf induced.

Problem 4 More turns (easy)

The same change of flux in problem 3 happens through a coil of 150 turns.

1. Calculate the induced emf.
2. State how the emf depends on the number of turns.

Problem 5 Aircraft wing (easy)

An airliner with a wingspan of 35 m flies horizontally at 250 m/s . The vertical component of Earth's field is $4.0 \times 10^{-5} \text{ T}$.

1. Calculate the emf between the wing tips.

Problem 6 Which pole forms? (easy)

The north pole of a magnet is pushed towards one end of a coil.

1. State the polarity that forms on the end of the coil nearest the magnet.
2. Explain your answer using Lenz's law.

Problem 7 Unit conversion (easy)

A rectangular coil measures 12 cm by 8.0 cm and faces a field of 35 mT.

1. Convert its area to m^2 .
2. Convert the field to tesla.
3. Calculate the flux in μWb .

Problem 8 Coil in a fading field (medium)

Chiamaka in Lagos switches off an electromagnet. The field through a 500-turn coil of area $4.0 \times 10^{-3} \text{ m}^2$ falls steadily from 0.60 T to 0 in 0.20 s. The coil resistance is 25Ω and its ends are joined.

1. Calculate the average emf.
2. Calculate the current.

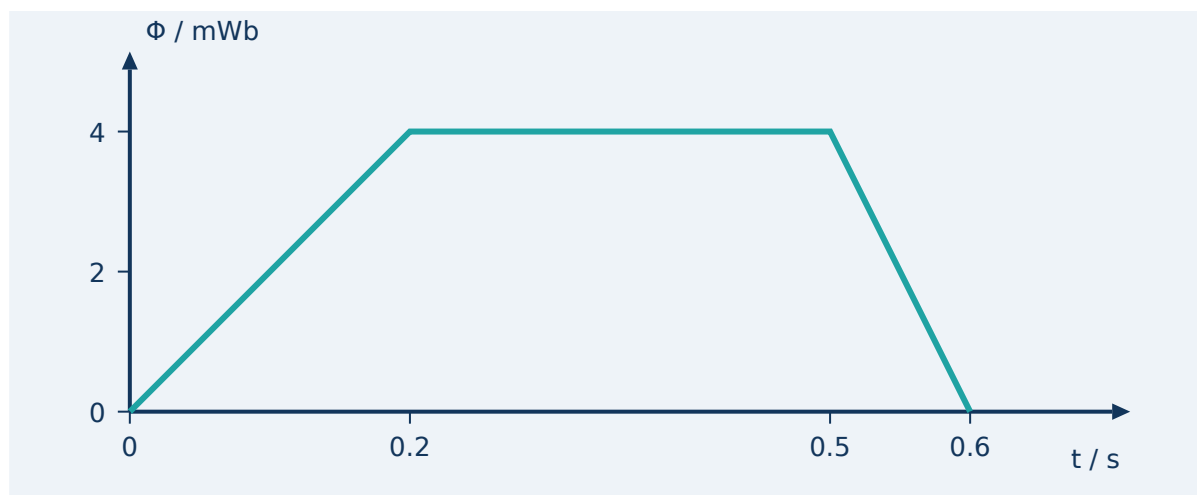
Problem 9 Sliding bar and force (medium)

A bar of length 0.40 m slides at 2.5 m/s along rails in a 0.50 T field. The total resistance of the circuit is 0.50Ω .

1. Calculate the emf.
2. Calculate the current.
3. Calculate the force needed to keep the bar moving at constant speed.

Problem 10 Reading a flux graph (medium)

The graph shows the flux through a single loop over 0.6 s.



Flux through a single loop.

1. Calculate the emf during 0 to 0.2 s.
2. State the emf from 0.2 s to 0.5 s.
3. Calculate the emf from 0.5 s to 0.6 s and compare its direction with part 1.

Problem 11 Peak emf of a generator (medium)

A generator coil has 100 turns of area 0.020 m^2 and turns at 50 revolutions per second in a field of 0.15 T .

1. Calculate the angular speed in rad/s.
2. Calculate the peak emf.
3. Calculate the emf 2.0 ms after the coil passes the position of zero emf.

Problem 12 Bicycle dynamo (medium)

Bilal in Lahore measures a peak emf of 12 V from his bicycle dynamo when it turns at 8.0 Hz .

1. Predict the peak emf at 16 Hz .
2. Predict the frequency of the emf at 16 Hz .
3. Explain why the lamp is brighter at higher speed.

Problem 13 Magnet in a metal tube (medium)

A strong magnet dropped down a vertical copper tube takes much longer to emerge than a lump of non-magnetic metal of the same mass.

1. Explain why the magnet falls slowly.
2. State what happens to the lost gravitational energy.

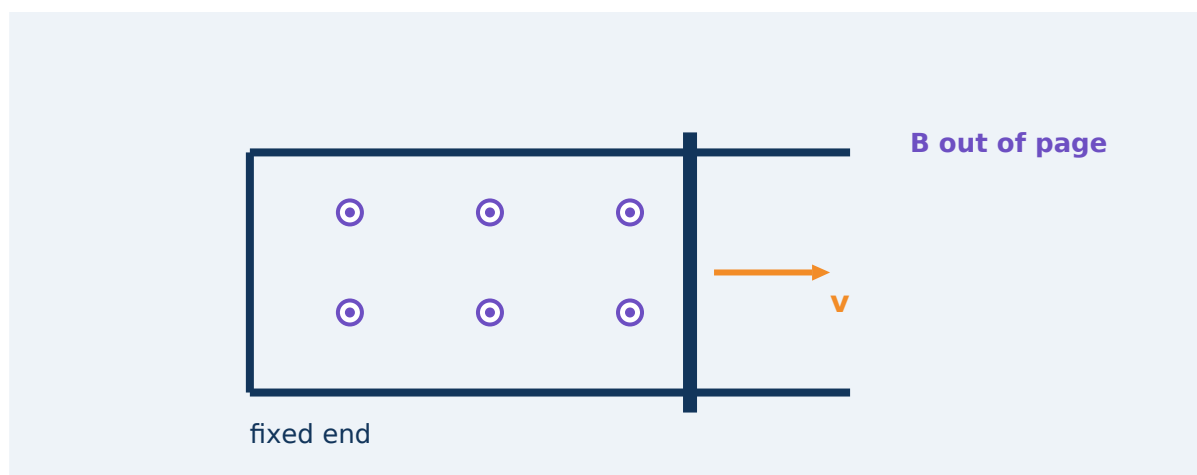
Problem 14 Pulling a coil faster (medium)

A coil is pulled out of a magnetic field at speed v and then at $2v$.

1. Compare the induced emfs.
2. Compare the forces needed.
3. Compare the power supplied.

Problem 15 Direction of induced current (medium)

Use the diagram of a rod sliding to the right on rails in a field out of the page.

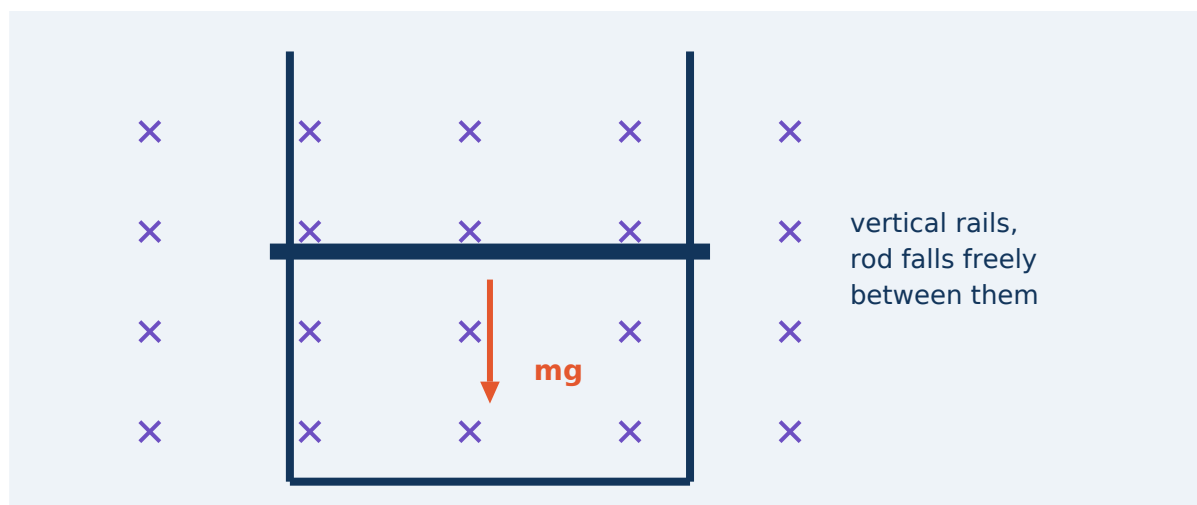


Rod moving to the right on rails in a field out of the page.

1. State whether the induced current in the loop is clockwise or anticlockwise.
2. State the direction of the magnetic force on the rod.

Problem 16 Terminal speed of a falling rod (hard)

A rod of mass 0.020 kg and length 0.30 m falls under gravity along smooth vertical rails joined at the bottom, in a horizontal field of 0.40 T . The circuit resistance is $0.50\ \Omega$.



Falling rod completing a circuit with the rails.

1. Show that the magnetic force is B^2L^2v/R .
2. Calculate the terminal speed.
3. Explain why the speed stops increasing.

Problem 17 Heating by induction (hard)

A rectangular loop 0.15 m by 0.20 m has resistance $0.30\ \Omega$ and lies perpendicular to a field that increases steadily at 0.50 T/s for 4.0 s .

1. Calculate the induced emf.
2. Calculate the current.
3. Calculate the thermal energy produced in the 4.0 s .

Problem 18 Spinning metal disc (hard)

A copper disc of radius 0.15 m rotates 10 times per second in a uniform field of 0.20 T perpendicular to the disc. One contact is at the centre and one at the rim.

1. Calculate the area swept by a radius in one second.
2. Calculate the emf between centre and rim.

Problem 19 Search coil measurement (hard)

A search coil of 60 turns and area 2.0 cm² is placed face-on to a field and flipped through 180° in 0.040 s. The average emf recorded is 0.45 V.

1. State the change in flux through one turn in terms of B and A.
2. Calculate the flux density.

Problem 20 Spot the error (hard)

A student writes: "A 30-turn coil of area 0.010 m² sees the field rise from 0.20 T to 0.60 T in 0.10 s. $\epsilon = 30 \times 0.010 \times 0.60 / 0.10 = 1.8 \text{ V}$."

1. Identify the mistake.
2. Calculate the correct emf.
3. State what quantity the student's 1.8 V would be correct for.