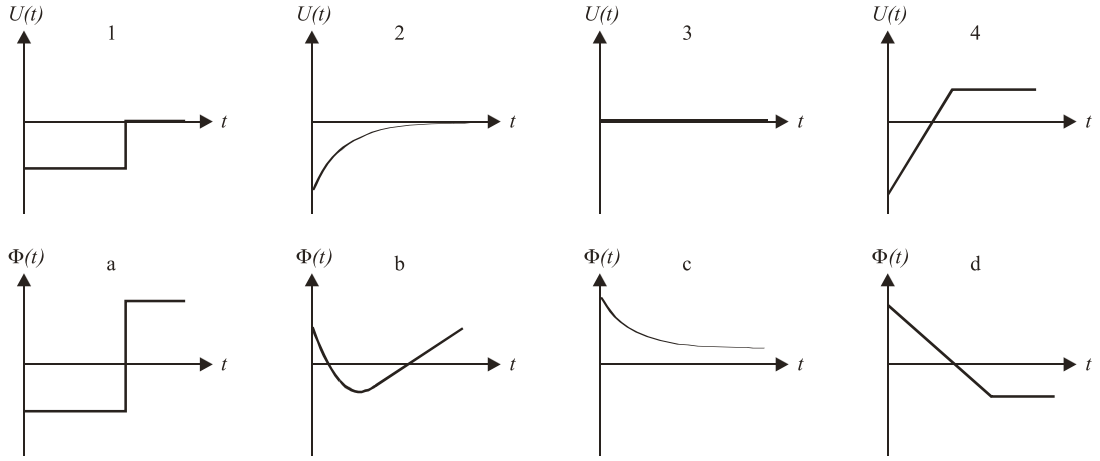
Induced Electromotive Force

Basic Problems

1. A voltmeter is connected between two rails (gauge of the track: 143.5 cm). The vertical component of the earth's magnetic field at this place has a magnitude of 43 μT.
   a) Calculate the voltage measured by the meter when a train approaches at 210 km/h.
   b) What is the reading of a voltmeter connected to one of the train's axles?

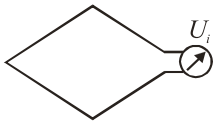
2. Match the induced voltage diagrams (1 to 4) and the corresponding magnetic fluxes (a to e):



3. The generator in a power station produces an emf with frequency 16 ⅔ Hz and amplitude 12 kV. The coil with an area of 7.3 m² rotates in a magnetic field of magnitude 460 mT. Calculate the number of turns.

4. The loop of wire in the figure below has a length (from left to right) of 50 cm. It is moved to the left at constant speed through a 1 m long area with a homogeneous magnetic field perpendicular to the plane of the loop. Sketch the induced voltage in the loop vs. time until the loop has completely left the magnetic field.

   Draw the diagram for a situation where the magnetic field only covers a 25 cm long region.



5. A quadratic loop of wire with sides 5.2 cm long is placed perpendicularly to the field lines of a homogeneous magnetic field of magnitude 140 mT. While the loop's area is halved, an average voltage of 1.8 mV is measured between its ends. How long does the deformation take?

6. A generator coil rotates in an exponentially decreasing magnetic field. Derive a formal expression for the emf induced in the coil. Explain the physical meaning of the parameters in your expression.

7. The magnetic field in a solenoid linearly decreases from 320 mT to 140 mT in 3.8 ms. A circular loop of wire with radius 4.5 cm is placed perpendicularly to the field lines. Calculate the magnitude of the emf induced in the loop.

Additional Problems

8. A semi-circular loop of wire with radius 25 cm rotates with a frequency of 0.3 Hz. During the second half of every revolution it passes through a homogeneous magnetic field with magnitude 250 mT pointing perpendicularly to the loop's plane. Draw a quantitatively correct diagram for the induced emf vs. time over two complete revolutions.

9. The 6.2 m long rotor blades of a helicopter turn at 9.1 rotations per second. At this point the vertical component of the earth's magnetic field has a magnitude of 58 μT. Calculate the induced emf between the rotor axis and the end of a blade.

10. Describe a situation in which a hyperbolic voltage signal is induced in a coil.

Numerical Solutions: 1. 3.6 mV; 2. 1d, 2c, 3a, 4b; 3. 34; 5. 0.11 s; 7. 0.30 V; 9. 64 mV