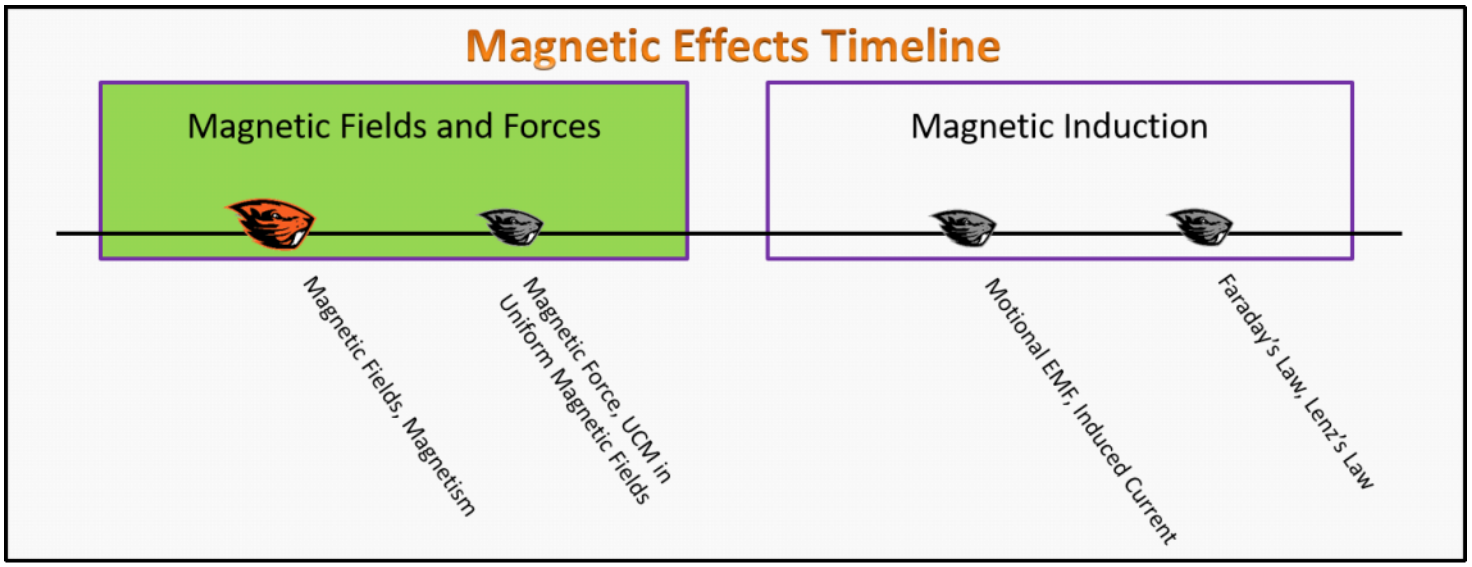
Magnetic Induction
Foundation Stage (MI.L1.2)

Lecture 1
Motional EMF, Induced Currents



Key Equations

$\Phi_B = \vec{B} \cdot \vec{A}$	$\varepsilon = -\frac{\Delta \Phi_B}{\Delta t}$

Questions

Act I: Motional EMF

MI.L1.2-02:

Problem Statement: A metal rod is traveling through a magnetic field, as shown in the diagram. Excited electrons within the metal rod are free to move towards point a or point b.

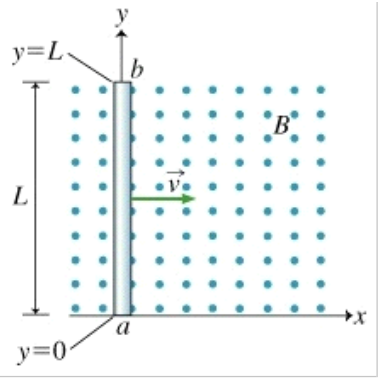
(a) What point, a or b, has a higher electric potential?

(1) a

(2) b

(3) neither, both are at a high potential

(4) neither, both are at a low potential



(b) The electric potential difference $\left|\Delta \boldsymbol{V_{ab}}\right|$ will continue to build until the electric force is equal to the magnetic force. Which of the following expressions describes the electric field strength in terms of given variables?

(1) $\left|\vec{\boldsymbol{E}}\right| = |\vec{\boldsymbol{v}}|\left|\vec{\boldsymbol{B}}\right|$

(2) $\left|\vec{\boldsymbol{E}}\right| = \boldsymbol{q}|\vec{\boldsymbol{v}}|\left|\vec{\boldsymbol{B}}\right|$

(3) $\left|\vec{\boldsymbol{E}}\right| = \frac{\boldsymbol{1}}{\boldsymbol{q^2}}|\vec{\boldsymbol{v}}|\left|\vec{\boldsymbol{B}}\right|$

(4) $\left|\vec{\boldsymbol{E}}\right| = \boldsymbol{q^2}|\vec{\boldsymbol{v}}|\left|\vec{\boldsymbol{B}}\right|$

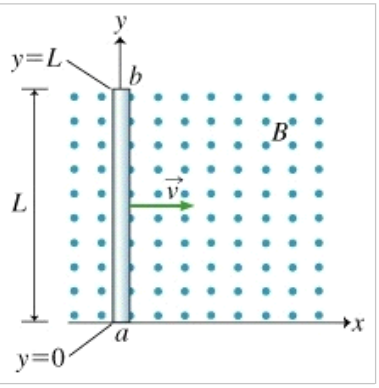
(c) Given the relationship between electric field and electric potential ($\boldsymbol{E_x} = -\frac{\Delta \boldsymbol{V}}{\Delta \boldsymbol{x}}$), which of the following expressions describes the magnitude of the electric potential difference between points a and b?

(1) $\left|\Delta \boldsymbol{V_{ab}}\right| = |\vec{\boldsymbol{v}}|\left|\vec{\boldsymbol{B}}\right|\boldsymbol{L}$

(2) $\left|\Delta \boldsymbol{V_{ab}}\right| = \frac{|\vec{\boldsymbol{v}}|\left|\vec{\boldsymbol{B}}\right|}{\boldsymbol{L}}$

(3) $\left|\Delta \boldsymbol{V_{ab}}\right| = \frac{|\vec{\boldsymbol{v}}|^{\boldsymbol{2}}\left|\vec{\boldsymbol{B}}\right|}{\boldsymbol{L}}$

(4) $\left|\Delta \boldsymbol{V_{ab}}\right| = |\vec{\boldsymbol{v}}|^{\boldsymbol{2}}\left|\vec{\boldsymbol{B}}\right|\boldsymbol{L}$



Act II: Flux and Faraday's Law

MI.L1.2-03:

Problem Statement: A circular loop with area 2.00 m^2 , has a uniform magnetic field of 0.02 T going through it at an angle of $\varphi = 60.0°$ with respect to the plane of the loop.

(a) What is the magnetic flux through the loop?

(b) Which of the following actions will result in an induced current in the loop?

(1) rotate the coil
(2) decrease the magnetic field
(3) increase the magnetic field
(4) nothing, current is already induced in the coil
(5) move the coil forward and backward
(6) increase the radius of the loop
(7) decrease the radius of the loop

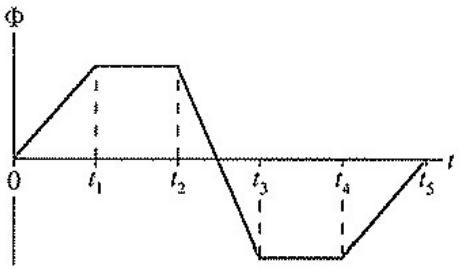
MI.L1.2-04:

Problem Statement: The magnetic flux passing through a coil of wire varies as shown in the

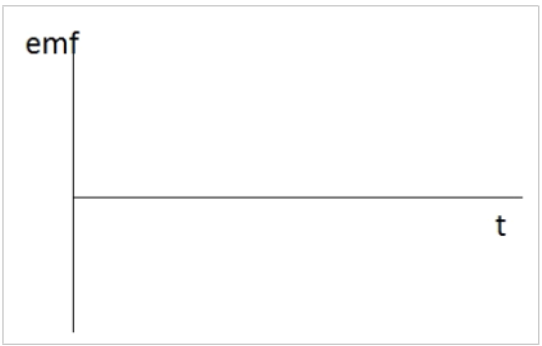
plot.

(a) During which time interval(s) will an induced current be present in the coil?

(1) $t_0 - t_1$
(2) $t_1 - t_2$
(3) $t_2 - t_3$
(4) $t_3 - t_4$
(5) $t_4 - t_5$



(b) Sketch the induced emf in the loop as a function of time

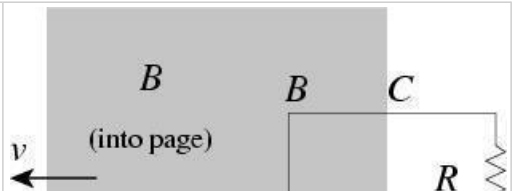


MI.L1.2-05:

Problem Statement: Consider the arrangement shown below. As the magnetic field is moved to the left, a current is induced through the stationary loop.

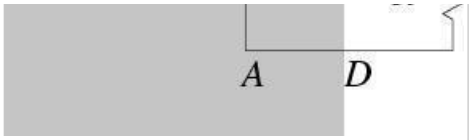
(a) The charges are put in motion by…

(1) a magnetic force on AB.
(2) a magnetic force on AB and BC.
(3) an electric force.



(4) a force that is partly magnetic and partly electric.

(5) a new kind of force.



(b) A person moves the loop to the right, a current is induced through the loop and the energy is dissipated in the resistor. The dissipated energy is supplied by…

(1) work by a magnetic force on AB.

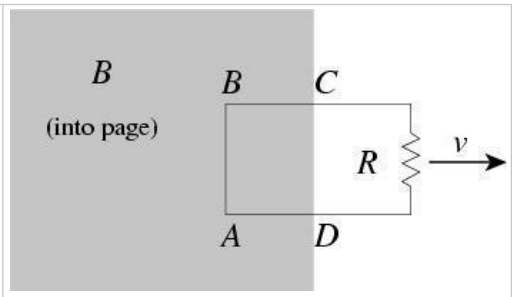
(2) work by a magnetic force on AD and BC.

(3) the person moving the loop.

(4) a decrease in magnetic field energy.

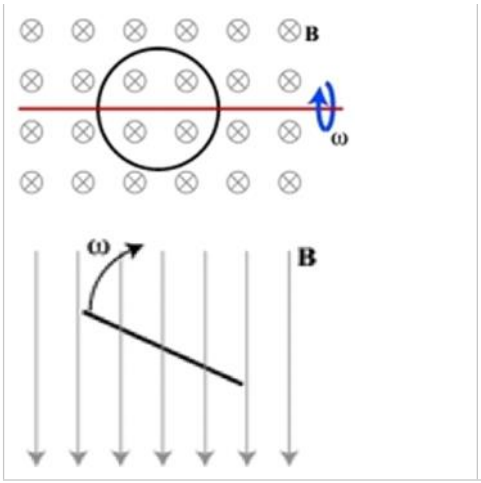
(5) a change in charge configuration.

(6) none of the above.



MI.L1.2-06:

Problem Statement: A metal loop with resistance R rotates in a magnetic field at constant angular velocity, as shown below. Which graph correctly depicts the dependence of the current in the loop on time?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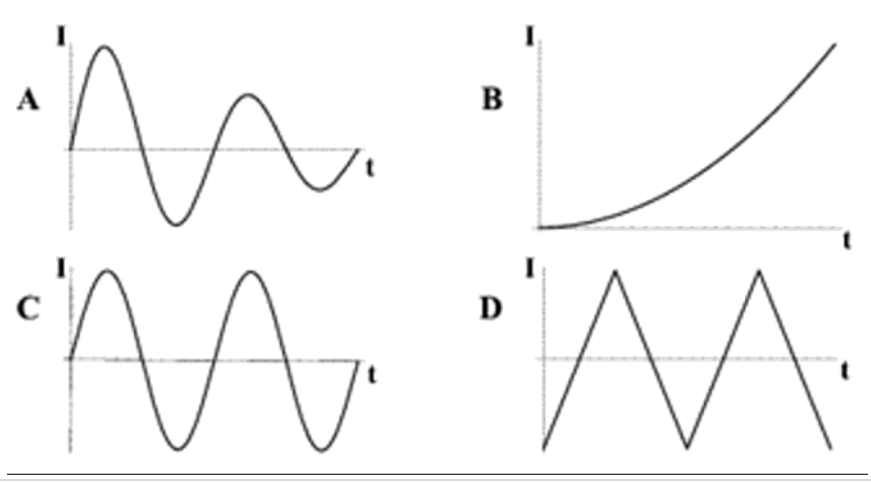
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