

أوراق مراجعة الوحدة التاسعة Induction Electromagnetic الحث الكهرومغناطيسي منهج انسابير



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف الثاني عشر المتقدم ← فيزياء ← الفصل الثالث ← ملفات متنوعة ← الملف

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المزيد من مادة
فيزياء:

إعداد: كمال الكركي

التواصل الاجتماعي بحسب الصف الثاني عشر المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف الثاني عشر المتقدم والمادة فيزياء في الفصل الثالث

أسئلة في الوحدة التاسعة الحث الكهرومغناطيسي

1

أوراق عمل مراجعة الوحدة التاسعة القسم الثاني (الدرس الثالث قانون لينز)

2

أوراق عمل مراجعة الوحدة التاسعة القسم الأول (الدرسين الأول والثاني)

3

مراجعة الوحدة التاسعة Induction Electromagnetic الحث الكهرومغناطيسي منهج انسابير

4

عشر أسئلة محلولة في الإمسات question 10 Physics Compass EmSAT

5

PHYSICS MADE EASY

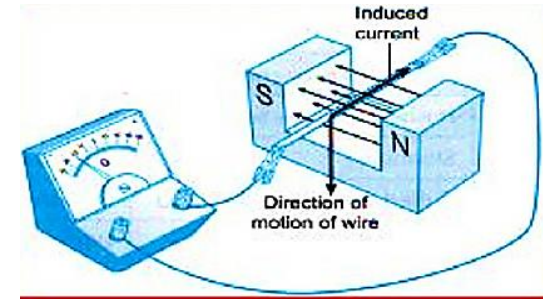
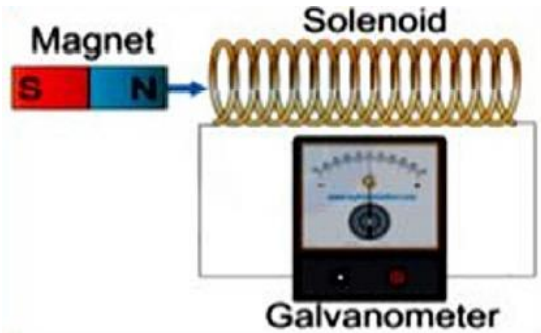
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-12Advance -physics-2025
الفيزياء للثاني عشر متقدم -2025



Academic Year 2024/2025 – Term 3

Ch 9- Electromagnetic Induction

أسم الطالب:

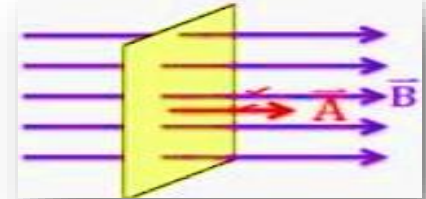
الأستاذ: كمال الكركي

كمال الكركي 0508193273

9-1 Faraday's Experiments

- **Oersted** discovered that the electric current is generating a magnetic field
- **Faraday** concluded, , that an electric current can be generated by moving a wire in a magnetic field
- The scientist **Henry** concluded in the same year that a change in the magnetic field can generate an electrical current

[Faraday's Electromagnetic Lab - Faraday's Law | Magnetic Field | Magnets - PhET Interactive Simulations \(colorado.edu\)](#)



***magnetic flux:** Magnetic flux is the number of magnetic field lines passing through a certain area.

***According to faraday's experiments, how an induced current can produce in a wire loop?**

By changing the magnetic flux through the loop.

***How we can change the magnetic flux through the loop?**

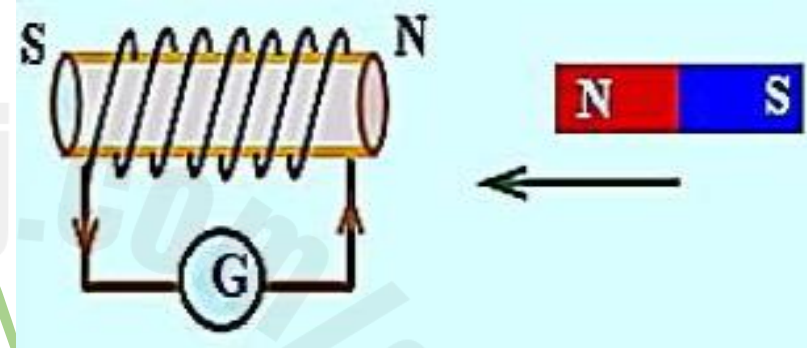
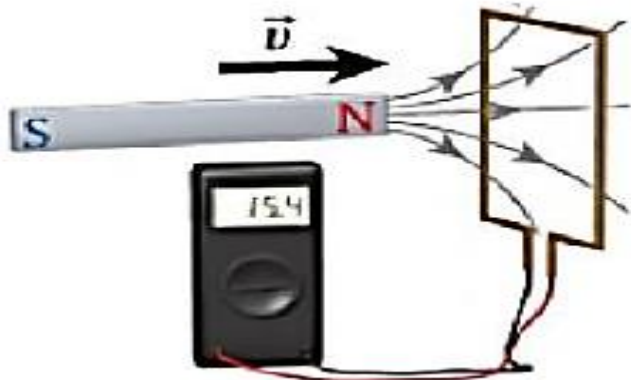
1.Changing the magnitude of the magnetic field.

2.Changing the area of the loop.

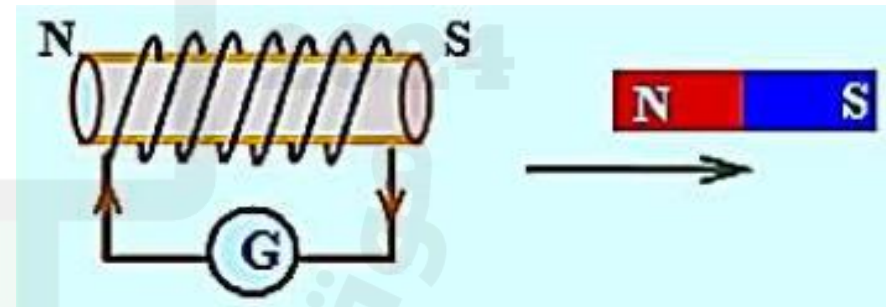
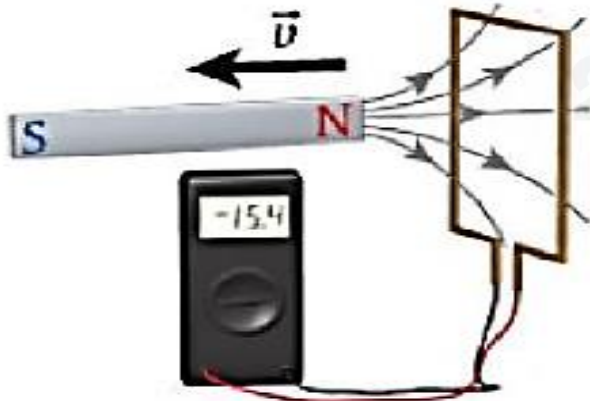
3.changing the angle that loop makes with respect to the magnetic field

According to the previous that you watch, determine the direction of the induced current in the wire loop in each of the following cases.

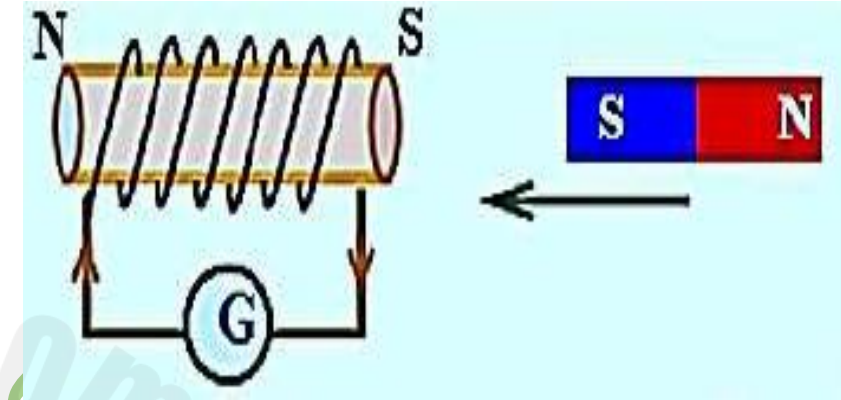
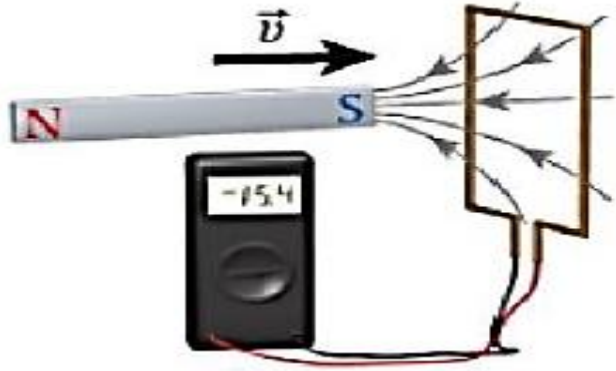
1.



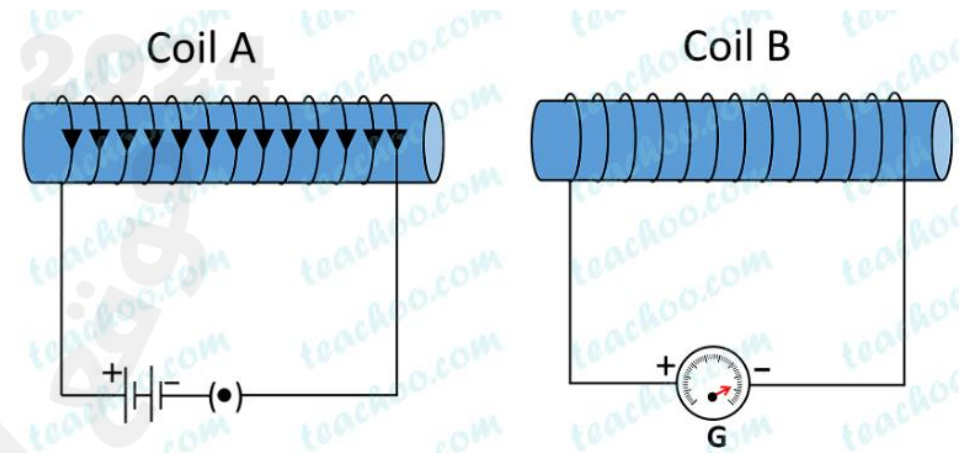
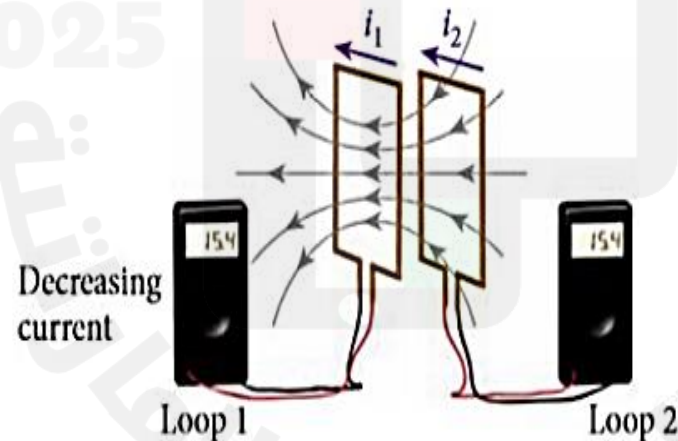
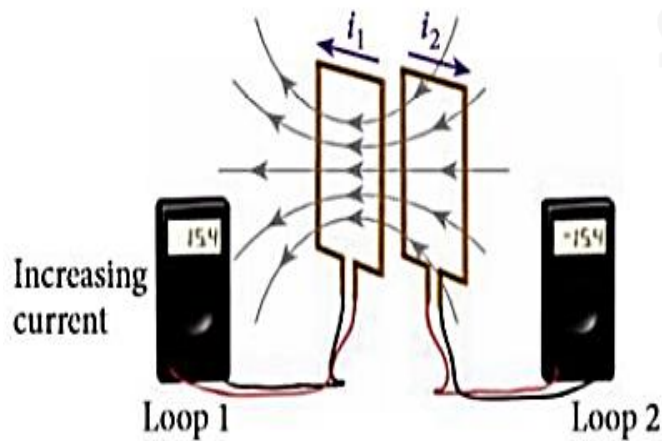
2.



3.



By using two conducting loops as shown in the figure If a **constant current** is flowing through loop 1, **no current is induced in loop 2**. If the **current in loop 1 is increased**, a **current is induced in loop 2 in the opposite direction** If the current in loop 1 is decreased, a current is induced in loop 2 in the same direction



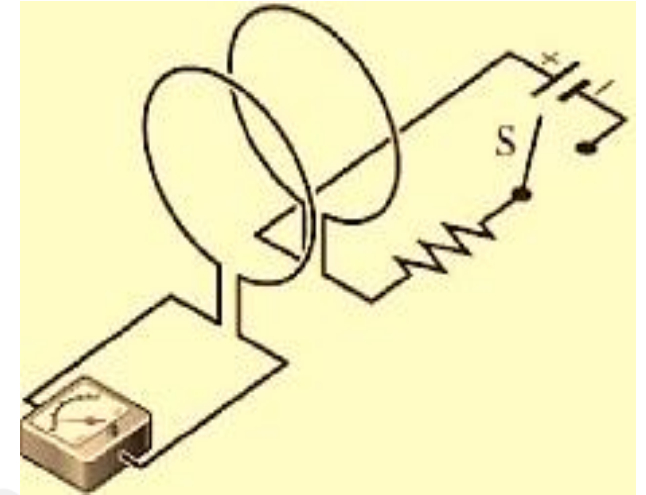
Concept Check 9.1

The four figures show a bar magnet, and a low-voltage light bulb connected to the ends of a conducting loop. The plane of the loop is perpendicular to the dotted line. In case 1, the loop is stationary, and the magnet is moving away from the loop. In case 2, the magnet is stationary, and the loop is moving toward the magnet. In case 3, both the magnet and loop are stationary, but the area of the loop is increasing. In case 4, the magnet is stationary, and the loop is rotating about its center. In which of these situations will the light bulb be burning?

- a) case 1
- b) cases 1 and 2
- c) cases 1, 2, and 3
- d) cases 1, 2, and 4
- e) All cases



Determine the direction of the current in the two loops at the moment the circuit is closed only



Determine the direction of the induced current in the wire loop

- A. Clockwise
- B. Counter clockwise
- C. Right
- D. Left



9.2 Faraday's Law of Induction

Faraday's Law of Induction states: A potential difference is induced in a loop when the number of magnetic field lines passing through the loop changes with time.

The rate of change of the magnetic field lines determines the induced potential difference.

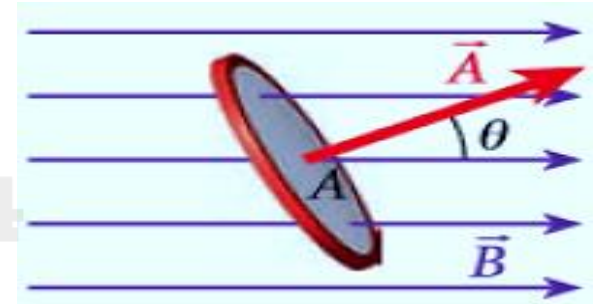
Magnetic flux is defined as the surface integral of the magnetic field passing through a differential element of area

$$\Phi_B = B \cdot A \cdot \cos \theta$$

Where B is the magnitude of the constant magnetic field

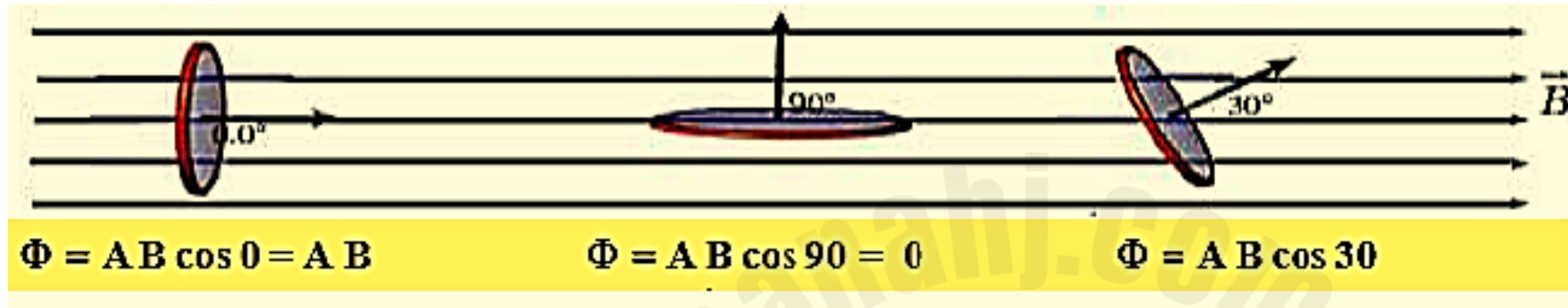
A is the area of the loop

θ is the angle between the surface normal vector to the plane of the loop



if the magnetic field is **perpendicular** to the plane of the loop, $\theta = 0^\circ$ and $\phi_B = BA$.

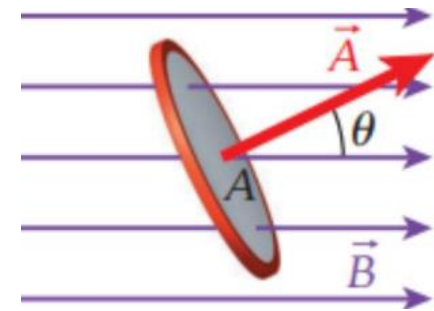
If the magnetic field is **parallel** to the plane of the loop, $\theta = 90^\circ$ and $\phi_B = 0$.



The unit of magnetic flux is $[\Phi] = [B][A] = T \cdot m^2$. This unit has received a special name, the **weber** (Wb):

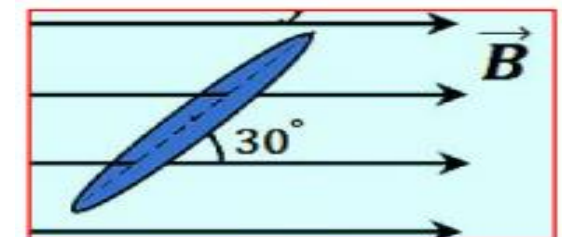
Depending on the shape, at what angle θ will the magnitude of the magnetic flux will be $(0.5AB)$?

- A. 90° B. 60° C. 0° D. 30°



the circular loop in the figure has a radius 50.0cm, and makes an angle of 30° with 4.0 T magnetic field . what is the flux through the loop?

- A. 2.7 Wb B. 1.6 Wb
C. 0.027 Wb D. 0.016 Wb



Faraday's Law of Induction is thus expressed by the equation

$$\Delta V_{ind} = -\frac{d\Phi_B}{dt}$$

ΔV_{ind} : induced potential difference (called also the induced electromotive force **emf**)

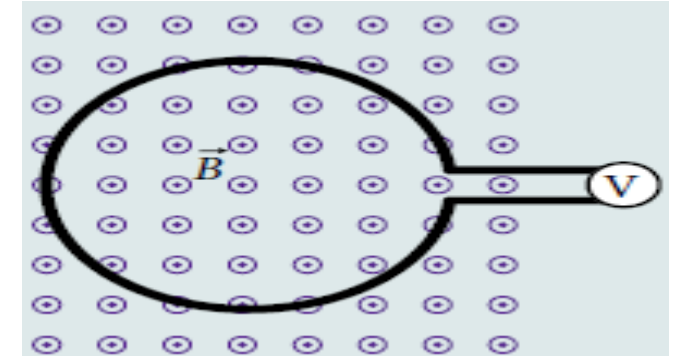
The **negative sign** in equation is necessary because the induced potential difference establishes an induced current whose magnetic field tends to oppose the flux change---- **Lenz's Law**

The magnetic flux **can be changed** of one of the factors of the equation $\Phi_B = B \cdot A \cdot \cos \theta$

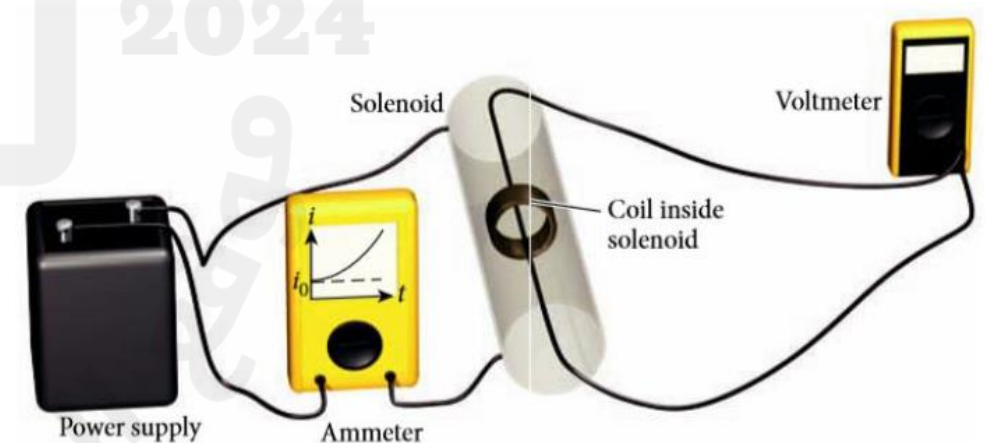
induction in a Flat loop inside a Magnetic Field

1. If the magnetic field is varying only ((A, θ) are constant) $\Delta V_{ind} = -A \cos \theta \frac{dB}{dt}$
2. If the Area is varying only ((B, θ) are constant) $\Delta V_{ind} = -B \cos \theta \frac{dA}{dt}$
3. If the Angle is varying only ((A, B) are constant) $\Delta V_{ind} = \omega AB \sin \theta$

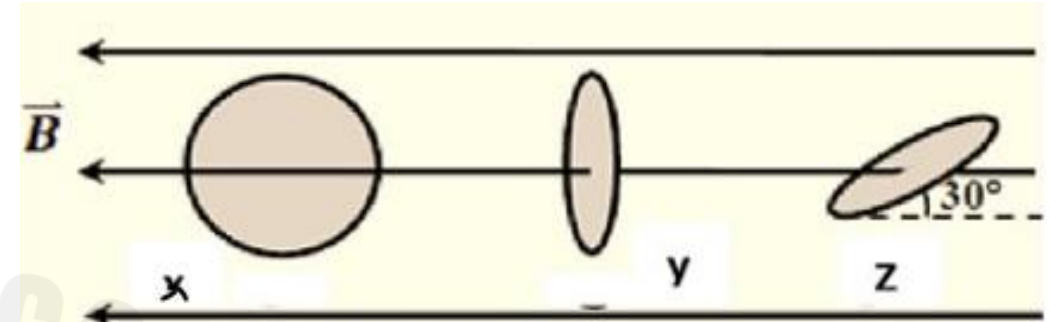
Q) The plane of the circular loop shown in the figure is perpendicular to a magnetic field with ($B=0.5\text{T}$)
The magnetic field goes to zero at a constant rate in (0.250 s). The induced voltage in the loop is ($\Delta V_{\text{ind}}=1.24\text{ V}$)
during that time. **What is the radius of the loop?**



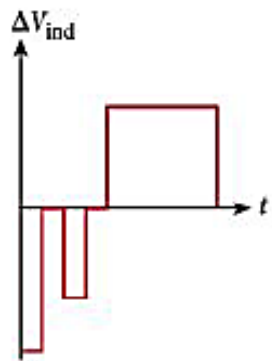
Q) A current of 600 mA is flowing in an ideal solenoid, resulting in a magnetic field of 0.025 T. Then the current increases with time, t , according to: $i(t)=i_0(1+2.4 t^2)$
If a circular coil of radius 3.4 cm with $N = 200$ windings is located inside the solenoid with its normal vector parallel to the magnetic field as shown in the figure, what is the induced potential difference in the coil at $t = 2.0\text{ s}$?



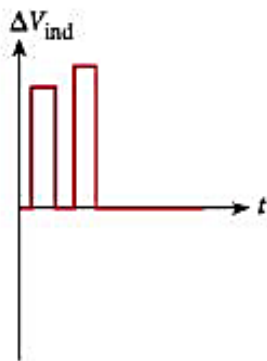
In the beside figure symmetry copper loops X,Y,Z which one have the highest magnetic flux



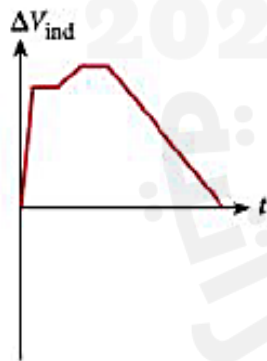
A power supply is connected to loop 1 and an ammeter as shown in the figure. Loop 2 is close to loop 1 and is connected to a voltmeter. A graph of the current i through loop 1 as a function of time, t , is also shown in the figure. Which graph best describes the induced potential difference, ΔV_{ind} , in loop 2 as a function of time, t ?



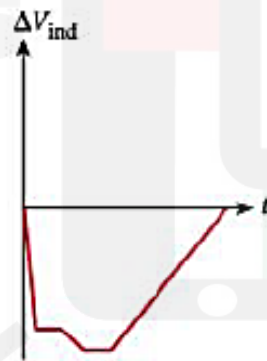
Graph 1



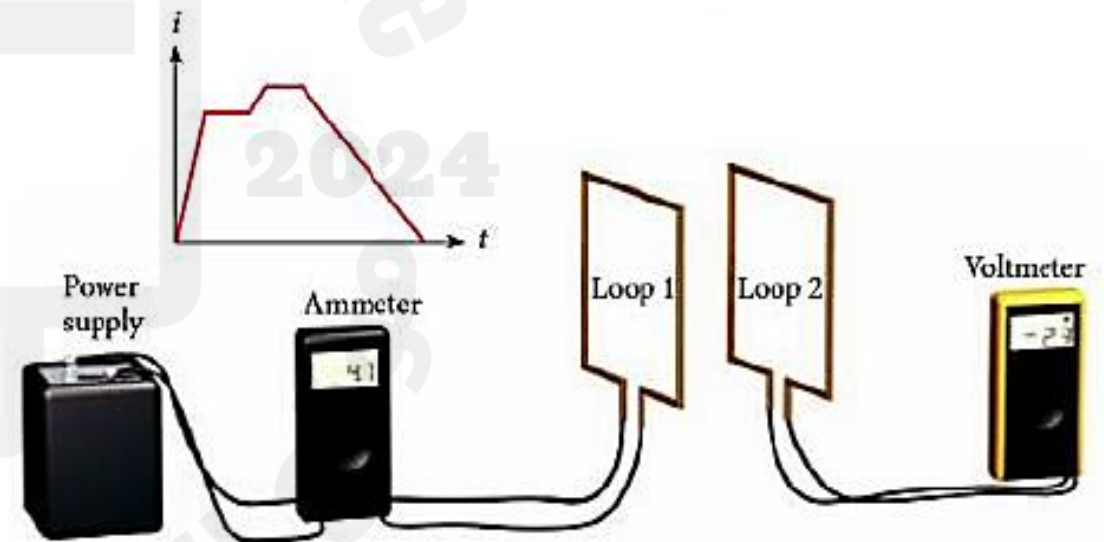
Graph 2



Graph 3

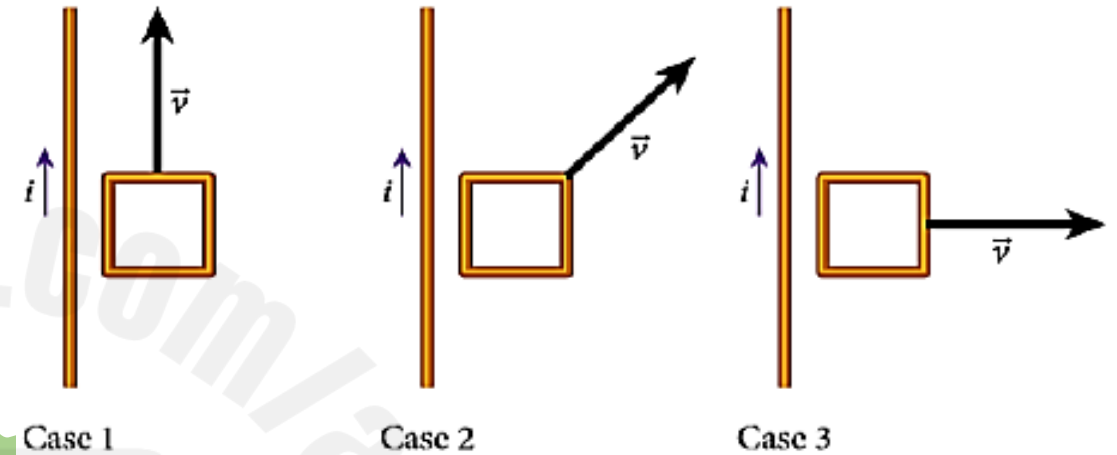


Graph 4



A long wire carries a current, i , as shown in the figure. A square loop moves in the same plane as the wire as indicated. In which cases will the loop have an induced current?

- A. Cases 1 and 2
- B. Cases 1 and 3
- C. Cases 2 and 3
- D. All the loops will have an induced current.

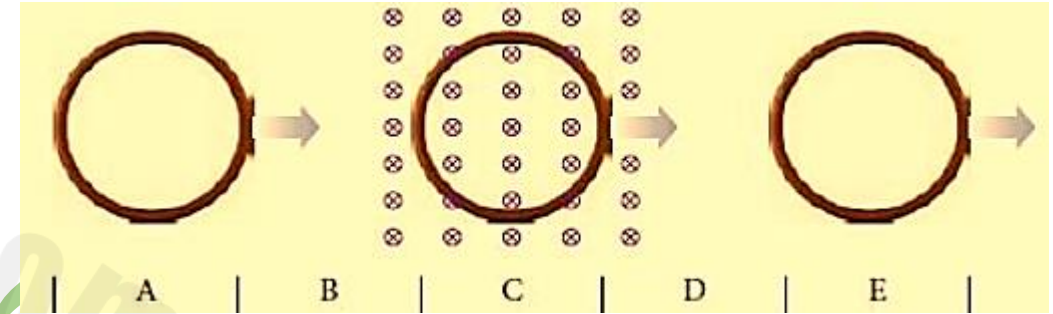


A solenoid with 200 turns and a cross-sectional area of 60 cm^2 has a magnetic field of 0.60 T along its axis. If the field is confined within the solenoid and changes at a rate of 0.20 T/s, the magnitude of the induced potential difference in the solenoid will be:

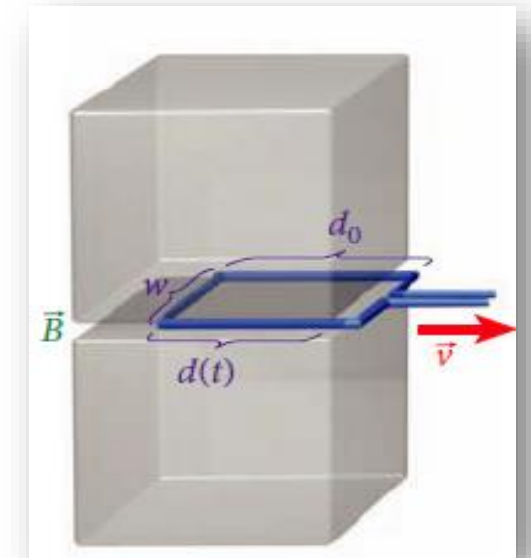
- A. 0.0020 V.
- B. 0.02 V.
- C. 0.24 V.
- D. 0.001 V.

A conducting ring is moving from left to right through a uniform magnetic field, as shown in the figure. In which regions is there an induced current in the ring?

- a) Regions B and D b) regions B, C, and D c) region C d) regions A

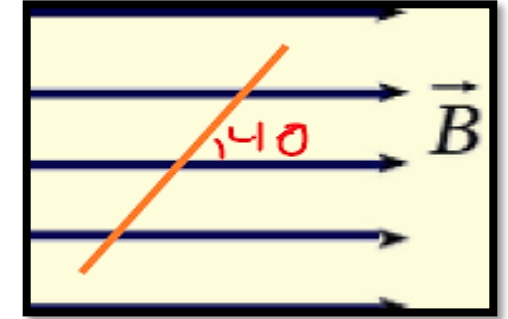


A rectangular wire loop of width $w = 3.1 \text{ cm}$ and depth $d_0 = 4.8 \text{ cm}$ is pulled out of the gap between two permanent magnets. A magnetic field of magnitude $B = 0.073 \text{ T}$ is present throughout the gap as shown in the figure. If the loop is removed at a constant speed of 1.6 cm/s , what is the induced voltage in the loop as a function of time?

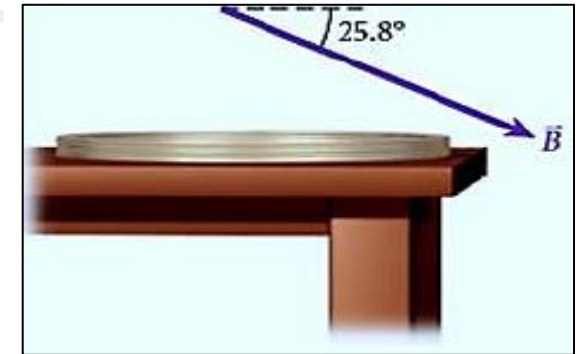


An 8-turn coil has square loops measuring ($L = 0.100 \text{ m}$) along a side and a resistance of $R = 2.00 \, \Omega$. It is placed in a magnetic field that makes an angle of (40.0°) with the plane of each loop. The magnitude of this field varies with time according to $B(t) = 2.4 t^3$, where t is measured in seconds and B in Tesla.

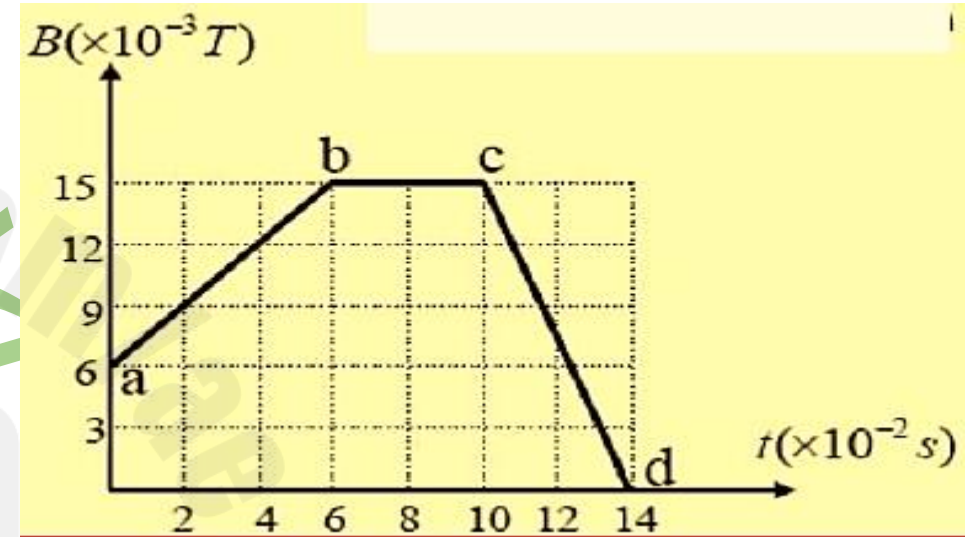
What is the induced current in the coil at $t = 2.00 \text{ s}$?



A circular coil of wire with (20 turns) and a radius of ($r = 40.0 \text{ cm}$) is laying flat on a horizontal table as shown in the figure. There is a uniform magnetic field extending over the entire table with a magnitude of ($B = 5.00 \text{ T}$) and directed to the north and downward, making an (angle of 25.8° with the horizontal). What is the magnitude of the magnetic flux through the coil?



A coil of (2000 turns), its area (0.2 m^2), and its level perpendicular to a variable magnetic field according to the graph shown in the figure. **Calculate the potential difference induced in the coil at each stage of the change**



9-3 Lenz's law

The Lenz law states that:

the direction of the induced current reflects the magnetic field caused by the change in the magnetic field that caused it

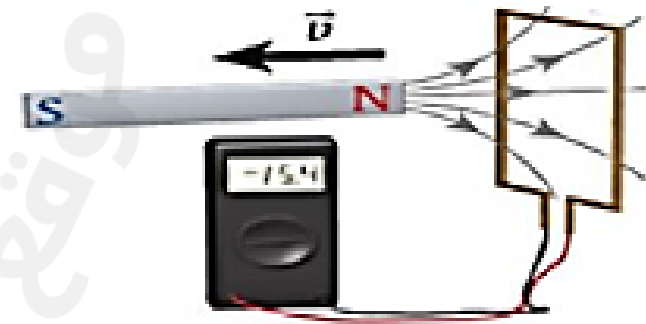
Or

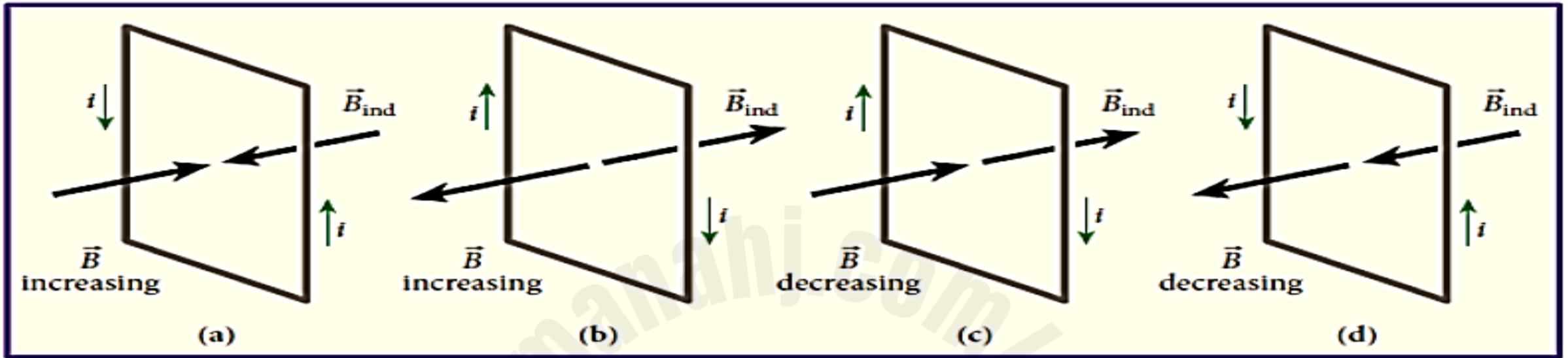
The direction of the induced current in a loop creates a magnetic field that resists the change of flow

- When the flux increases: a similar pole is created (or (Bind) induced field created at the opposite direction of the original field) (Repel)
- When the flux decreases: unlike pole is created (or (Bind) induced field created at the same direction of the original field) (Attract)

Determine the direction of the induced current in the wire loop

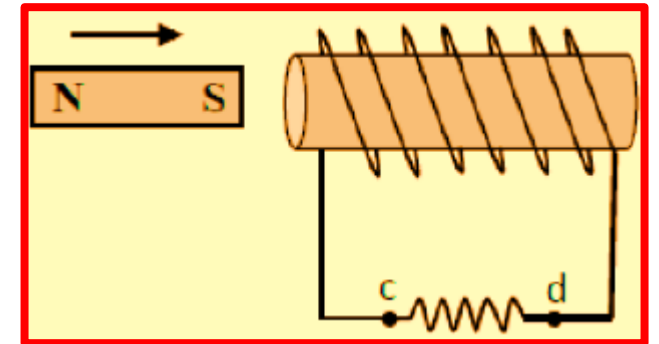
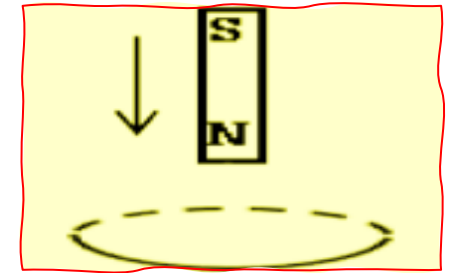
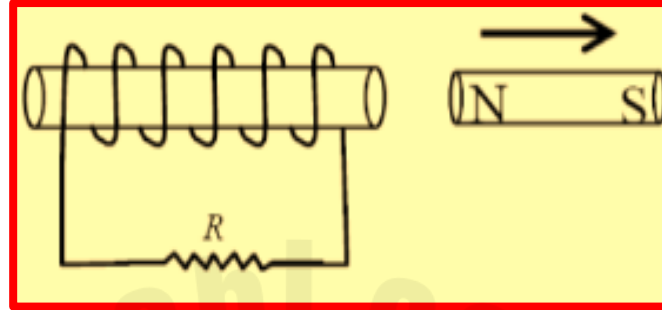
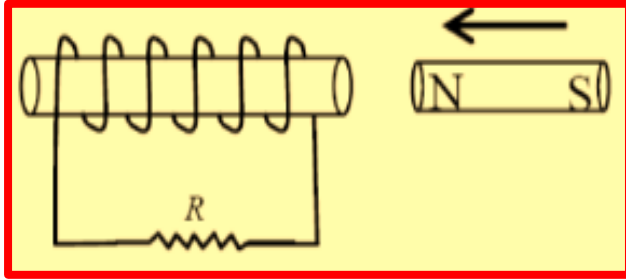
- A. Clockwise
- B. Counter clockwise
- C. Right
- D. Left





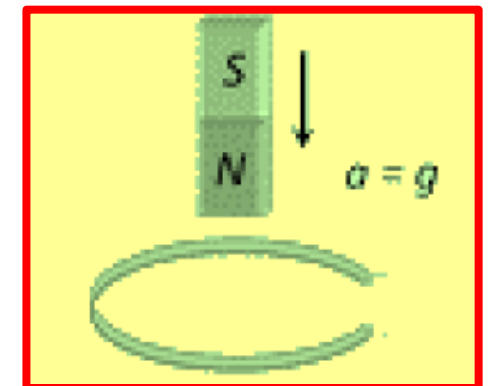
- a) An increasing magnetic field pointing to the right induces a current that creates a magnetic field pointing to the left. **direction of current is counterclockwise**
- b) An increasing magnetic field pointing to the left induces a current that creates a magnetic field pointing to the right. **direction of current is clockwise**
- c) A decreasing magnetic field pointing to the right induces a current that creates a magnetic field pointing to the right. **direction of current is clockwise**
- d) A decreasing magnetic field pointing to the left induces a current that creates a magnetic field pointing to the left. **direction of current is counterclockwise**

In each of the following cases, determine the direction of the induced current in the coil and resistor (R)



Q) A copper ring is held horizontally, and a bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet while it is passing through the ring is **g**.

- A) Equal to that due to gravity
- B) Less than that due to gravity
- C) More than that due to gravity
- D) Depends on the diameter of the ring and the length of the magnet



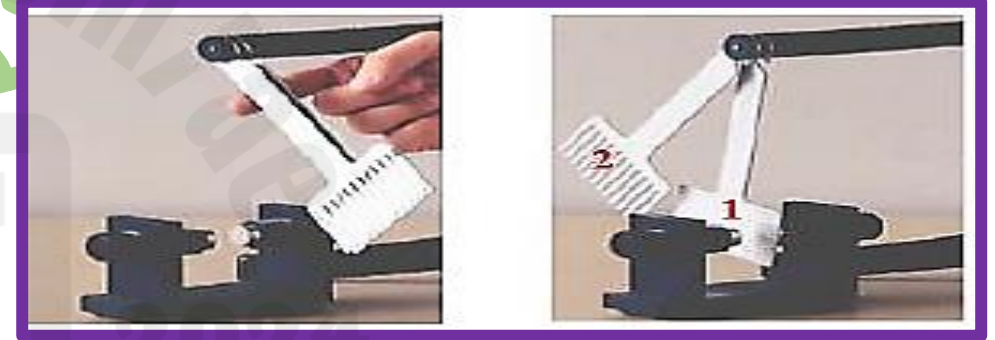
- . The direction of induced (ΔV_{ind}) during electromagnetic induction is given by:
- A) Faraday's law B) Lenz's law C) Maxwell's law D) Ampere's law

Eddy Currents

are induced currents in a conductor moving relative to a magnetic field. They produce a magnetic field in the direction opposite to that which induced the currents

تيارات الدوامية : هي تيارات مستحثه في موصل تتحرك بالنسبة إلى مجال مغناطيسي. إنها تنتج حقلا مغناطيسيا في الاتجاه المعاكس الذي تسبب في التيارات

As the pendulum with the solid plate (1) enters the magnetic field between the magnets, these currents produce induced magnetic fields opposing the external field that created the currents. These induced magnetic fields interact with the external magnetic field (via their spatial gradients) to stop the pendulum



Larger induced currents produce larger induced magnetic fields and thus lead to more rapid deceleration of the pendulum. In the slotted plate (2), the induced eddy currents are broken up by the slots, and the slotted plate passes through the magnetic field, only slowing slightly

Metal Detector: Uses: in airports, to detect the metals

- A metal detector has a transmitter coil and a receiver coil
- A metal detector works by using electromagnetic induction, often called *pulse induction*
- An alternating current is applied to the transmitter coil, which then produces an alternating magnetic field
- As the magnetic field of the transmitter coil increases and decreases, it induces a current in the receiving coil that tends to counteract the change in the magnetic flux produced by the transmitter coil
- When a metal object passes between the two coils, a current in the metal body is induced as **Eddy Currents**

Eddy currents are **used** in:

- A) Induction furnace B) Electromagnetic brakes C) Speedometers D) All of these

How eddy current can be **produced in some devices** :

- A. By placing it under changing of electric field
B. By changing the magnetic field
C. By placing it under uniform magnetic field

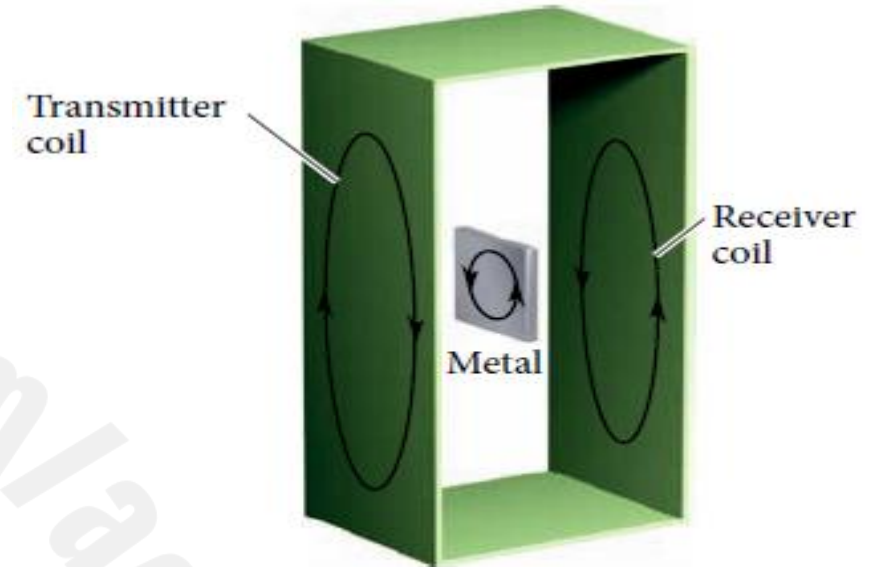


FIGURE 29.12 Schematic diagram of an airport metal detector.

Induced Potential Difference on a Wire Moving in a Magnetic Field

$$\vec{F}_B = \vec{F}_E$$

$$evB = eE$$

$$vB = E$$

$$\Delta V_{ind} = El$$

$$\Delta V_{ind} = v l B$$

\vec{E} : electric field

l : wire length

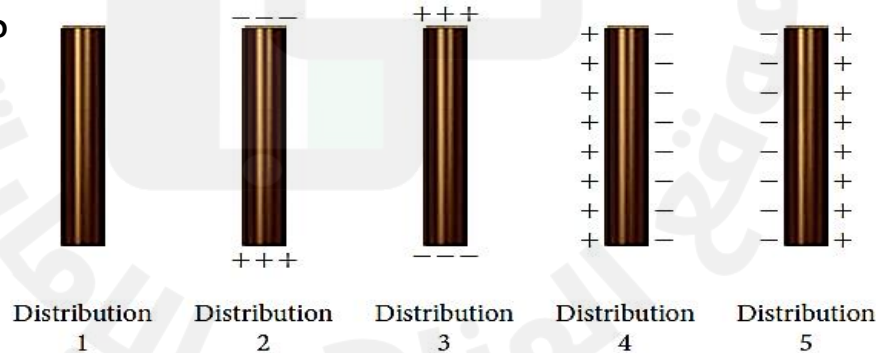
<https://www.youtube.com/watch?v=GR44Ajut3hU>

$$\Delta V_{ind} = BLv \sin \theta$$

$$I = \frac{EMF}{R} = \frac{V}{R}$$

Q) A metal bar is moving with constant velocity \vec{v} through a uniform magnetic field pointing into the page, as shown in the figure. **Which of the following most** accurately represents the charge distribution on the surface of the metal bar?

- a) distribution 1
- b) distribution 2
- c) distribution 3
- d) distribution 4
- e) distribution 5



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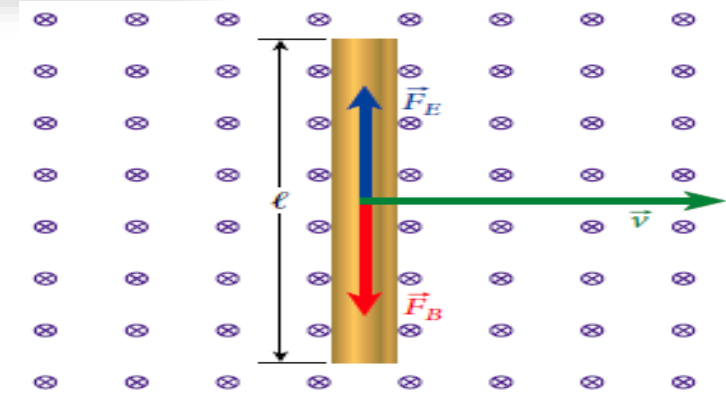
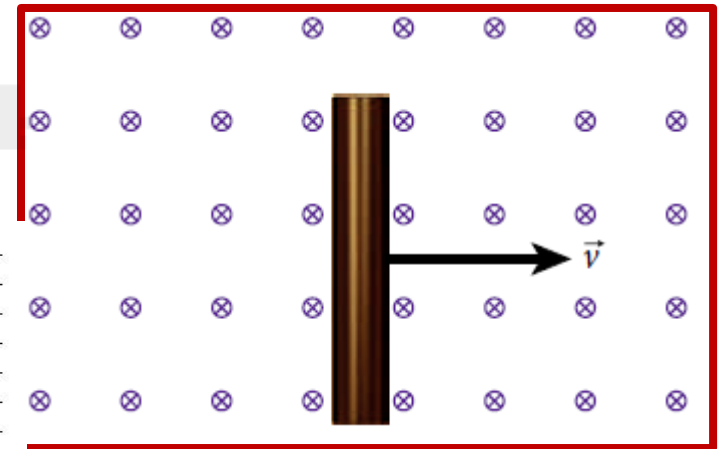
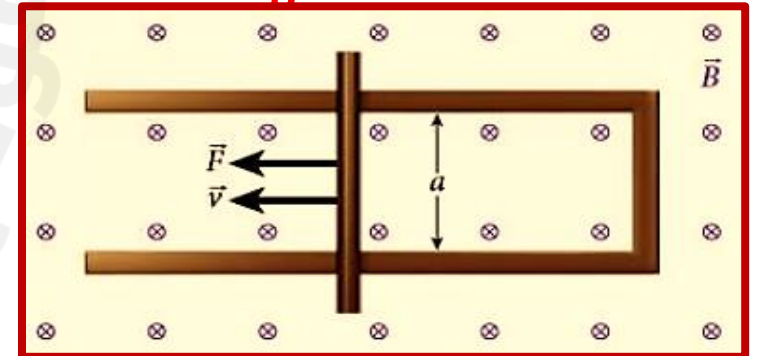


FIGURE 29.13 A moving conductor in a constant magnetic field. The magnetic and electric forces on the conduction electrons are shown.



Q) In 1996, the Space Shuttle Columbia deployed a tethered satellite on a wire out to a distance of 20 km, The wire was oriented perpendicular to the Earth's magnetic field at that point, and the magnitude of the field was ($B = 5.1 \times 10^{-5} \text{ T}$). Columbia was traveling at a speed of (7.6 km/s). **What was the potential difference induced between the ends of the wire?**

Q) A conducting rod is pulled horizontally by a constant force of magnitude, ($F = 5.00 \text{ N}$), along a set of conducting rails separated by a distance ($a = 0.500 \text{ m}$) (Figure). The two rails are connected, and no friction occurs between the rod and the rails. A uniform magnetic field with magnitude ($B = 0.500 \text{ T}$) is directed into the page. The rod moves at constant speed, ($v = 5.00 \text{ m/s}$). **What is the magnitude of the induced potential difference in the loop created by the connected rails and the moving rod?**



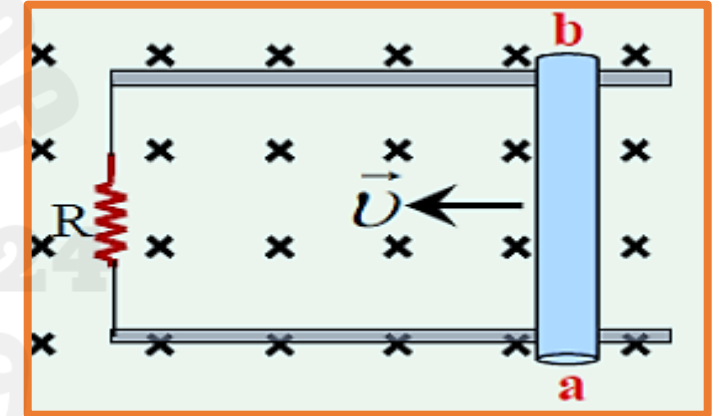
Calculate the potential difference induced between the tips of the wings of a Boeing 747-400 with a wingspan of 64.67 m in level flight at a speed of 913 km/h. Assume that the downward component of the Earth's magnetic field is $B = 5 \times 10^{-5} \text{ T}$.

- a) 0.821 V b) 2.95 V c) 10.4 V d) 30.1 V e) 225 V

The opposite figure shows a conductor(a, b) of length 0.3 m that slides to the left on two wires without friction at a constant speed of 0.3m / s vertically on a regular magnetic field in which an induced electric force is generated its amount 0.2V,**Answer the following:**

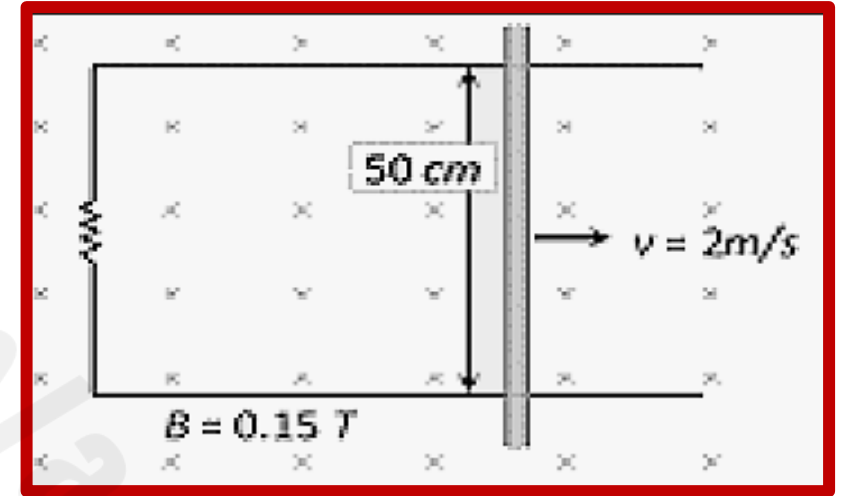
1-**The amount of intensity of the magnetic field** in which the conductor moves

2-**The intensity of the induced current through** the resistance R (4 Ω) and determine the direction of the current on the resistance .



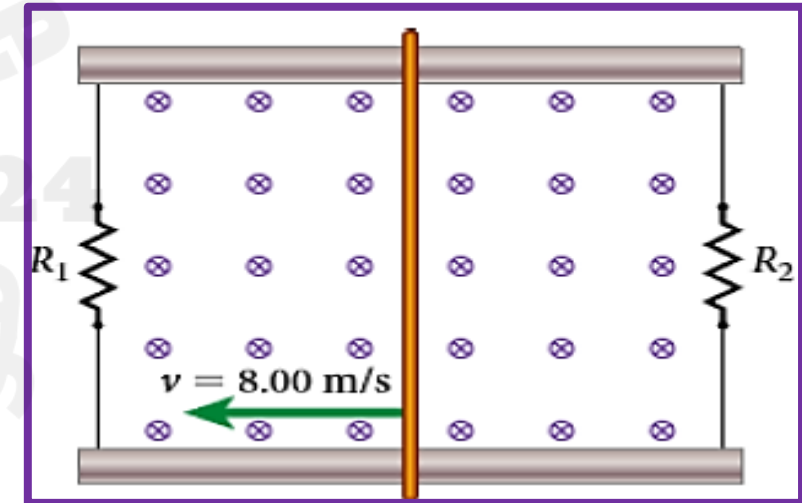
As shown in the figure a metal rod makes contact and complete the circuit. The circuit is perpendicular to the magnetic field with $B=0.15\text{T}$. If the resistance is 3Ω , force needed to move the rod as indicated with a constant speed of 2m/s is:

- A) $3.75 \times 10^{-3}\text{N}$
- B) $3.75 \times 10^{-2}\text{N}$
- C) $3.75 \times 10^2\text{N}$
- D) $3.75 \times 10^{-4}\text{N}$



Q 9.75) A conducting rod of length 50.0 cm slides over two parallel metal bars placed in a magnetic field with a magnitude of 1000 G , as shown in the figure. The ends of the rods are connected by two resistors, $R_1 = 100\Omega$ and $R_2 = 200\Omega$ the conducting rod moves with a constant speed of 8.00 m/s .

- A. What are the currents flowing through the two resistors?
- B. What power is delivered to the resistors?
- C. What force is needed to keep the rod moving with constant velocity?



9-4 Generators and Motors

An electric generator.: A device that produces electric current from mechanical motion

An electric motor: A device that produces mechanical motion from electric current

A simple generator consists of: a loop forced to rotate in a fixed magnetic field

Its parts:

- 1- A magnetic pole to generate the uniform field
- 2- Coil in the form of a rectangular with iron core to increase the magnetic field
- 3- Two metal rings (slip rings) rotate with the coil ring continuously
- 4- Two brushes of graphite, each touching one of rings Slip

Working principle: **electromagnetic induction**

$$\Delta V_{ind} = NAB\omega \sin \theta$$

$$\theta = \omega$$

$$\omega = 2\pi f$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

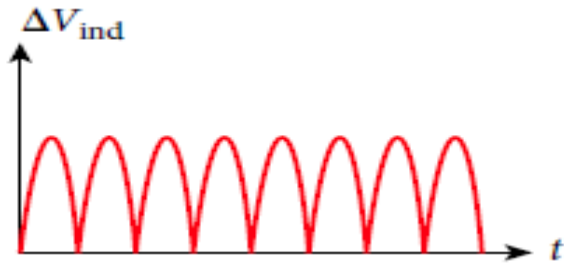
$$\Delta V_{ind} = NAB\omega \sin \omega t$$

$$\Delta V_{ind} = NAB\omega \sin(2\pi ft)$$

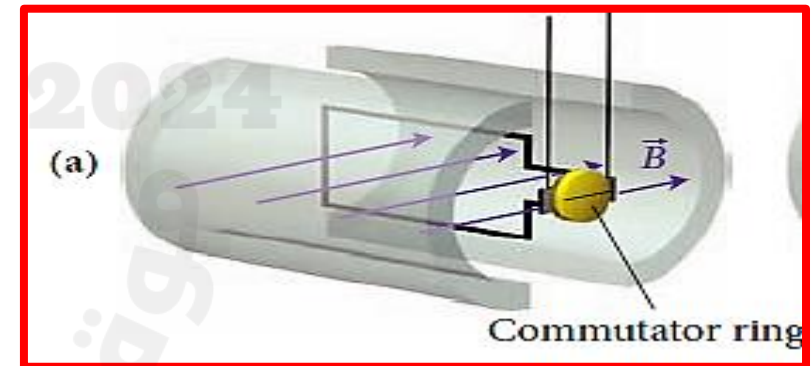
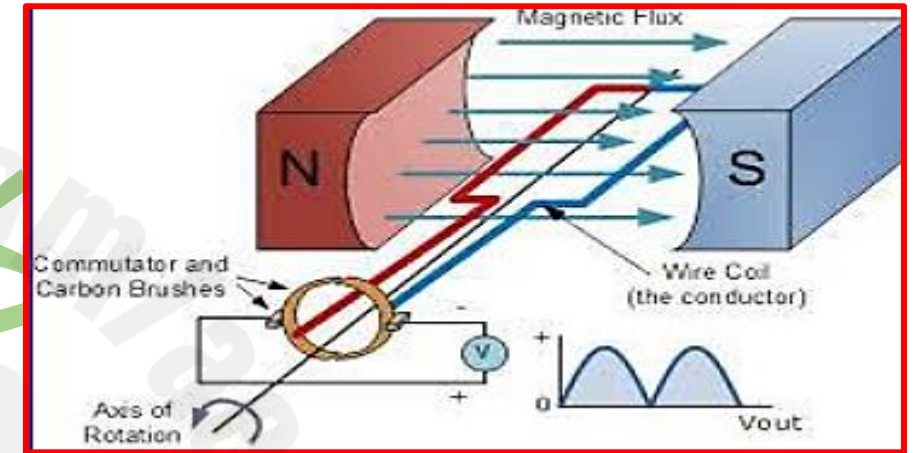
Generators are two types:.

1- Direct-current generator

- The rotating loop is connected to an external circuit through a split commutator ring
- As the loop turns, the connection is reversed twice per revolution
- the induced potential difference always has the same sign

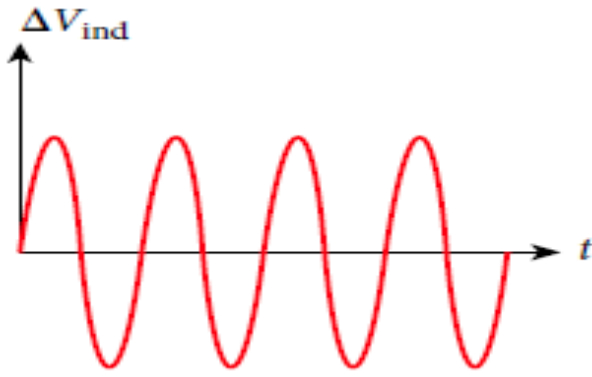


(a) A simple direct-current (DC) generator/motor

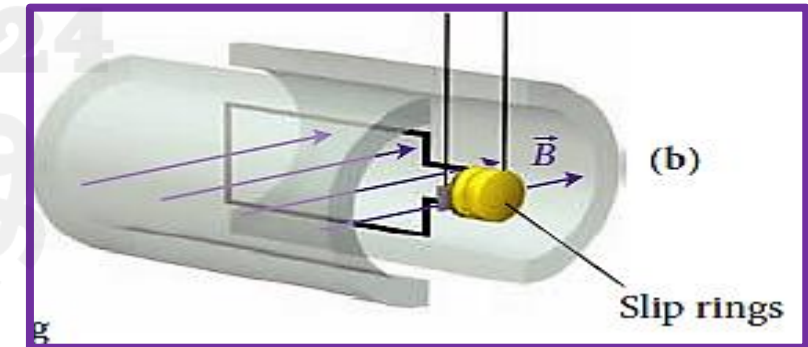
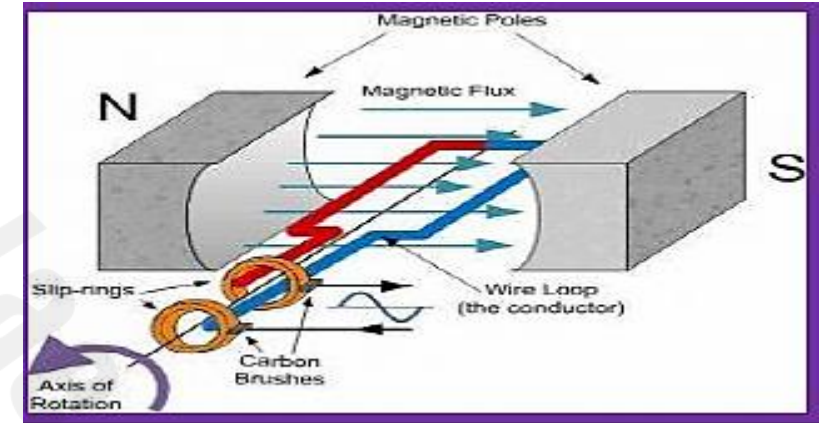


2- An alternating current generator

- An alternating current is a current that varies in time between positive and negative values,
- Each end of the loop is connected to the external circuit through its own solid slip ring.
- the generator produces an induced potential difference that varies from positive to negative and back

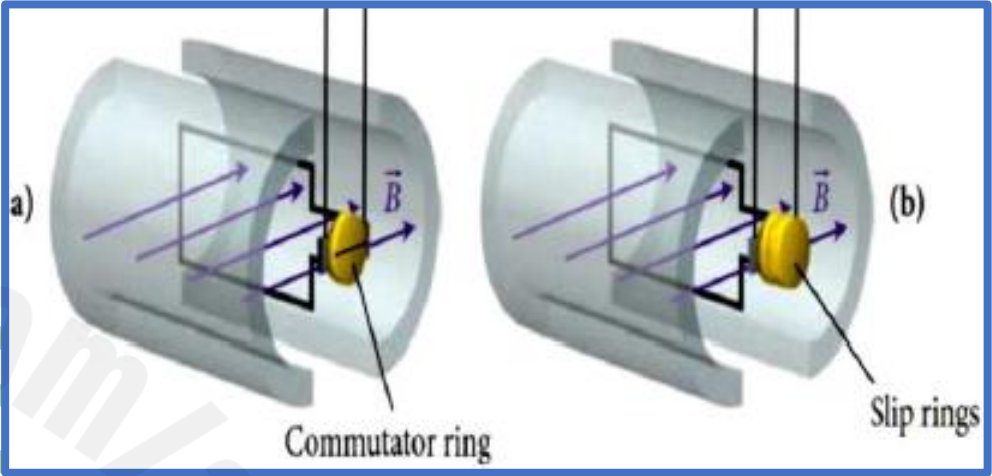


A simple alternating-current (AC) generator/motor



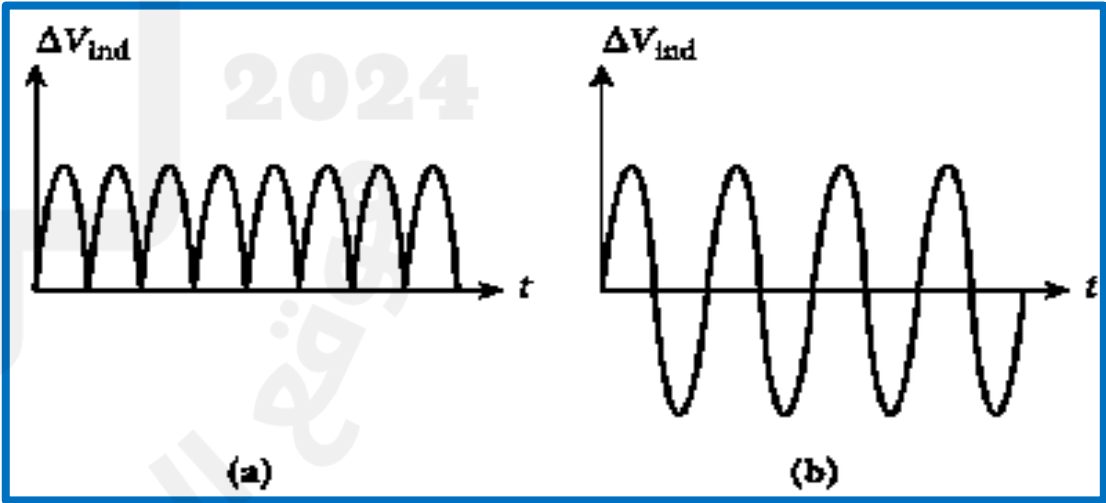
The figures (a) and (b) below shows two types of simple generators. Which of the below identifies the correct generator type?

	Figure (a)	Figure (b)
A	DC generator	AC generator
B	DC generator	DC generator
C	AC generator	DC generator
D	AC generator	AC generator



The figures (a) and (b) below shows the output from two generator coils.

	Figure (a)	Figure (b)
A	Direct current	Alternating current
B	Direct current	Direct current
C	Alternating current	Direct current
D	Alternating current	Alternating current



Q) An AC generator consists of 12 turns of wire, each of area $A = 0.06 \text{ m}^2$, and the total resistance of the wire is 8Ω . The loop rotates in a 0.4 T magnetic field at a constant frequency of 60.0 Hz .

1- Find the maximum induced emf

2- What is the maximum induced current

An AC power supply voltage as $V_{emf} = 120 \sin(2\pi 60t)$

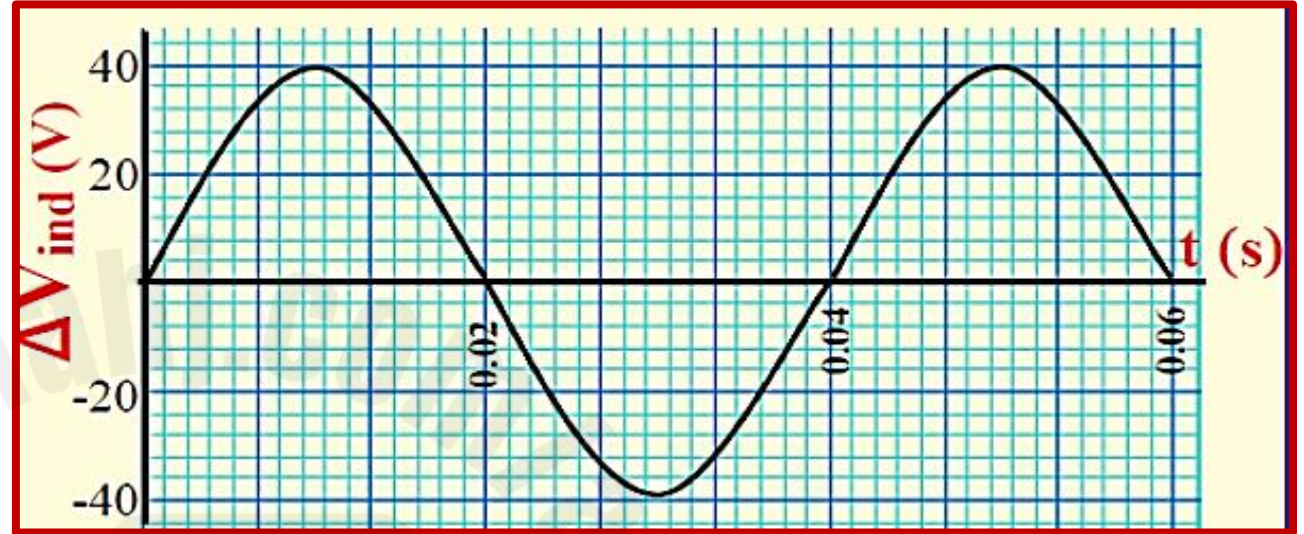
Where t is measured in second and V is measured in volt, the power supply is connected to 10Ω :

1. What is the maximum induced current

2. What is the max power dissipated in the resistor

The next diagram shows the relationship between the induced electromotive force (emf) in a generator his number of rolls is 1200 rolls and a section area of 0.04 m^2

Find The intensity of the uniform magnetic field in which the generator coil is rotated



Q(9-44) A motor has a single loop inside a magnetic field of magnitude 0.87 T. If the area of the loop is $300. \text{ cm}^2$, find the maximum angular speed possible for this motor when connected to a source of emf providing 170 V

9-5 Induced Electric Field

Faraday's Law of Induction states that a changing magnetic flux produces an induced potential difference, which can lead to an induced current.

A positive charge q moving in a circular path with radius r in an electric field, \vec{E}

$$E = \frac{\Delta V_{ind}}{2\pi r}$$

Induced potential difference may also be expressed in another way :

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$

The general equation that is used to calculate the **induced electric field** is.

A	$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$	B	$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$
C	$E = \frac{\Delta V_{ind}}{\pi r}$	D	$E = \frac{\Delta V_{ind}}{r}$

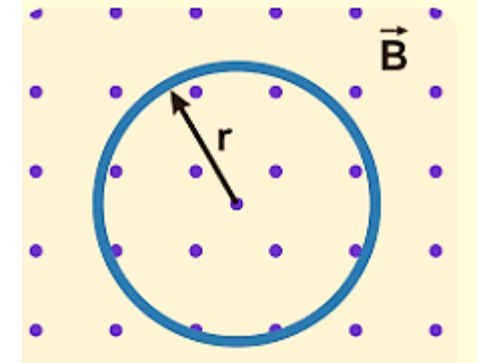
positive charge moving in a circular path in an electric field, the induced potential difference can be expressed as ($\Delta V_{\text{ind}} = 2\pi x E$). What does x represent?

- A. The magnitude of the charge
- B. The radius of the circular path
- C. Induced electric field
- D. Induced current.

A loop with radius (2cm) is put inside magnetic field, which is increasing as equation $B = 4t^3$

1. Calculate the induced electric field in the loop at $t = 1.1\text{s}$

2. Determine the induced current direction



9-6 Inductance of a Solenoid

The amount of magnetic field inside the coil is calculated near its axis using the relationship:

$$B = \mu_0 n i \quad n: \text{is the number of turns} \quad L: \text{File length} \quad n = \frac{N}{L}$$

$$B = \frac{\mu_0 N i}{L}$$

The magnetic flux is proportional to the current in the inner part of the coil depending on the relationship:

$$N \Phi_B = L i \quad L: \text{inductance. The unit of inductance is the henry (H),}$$

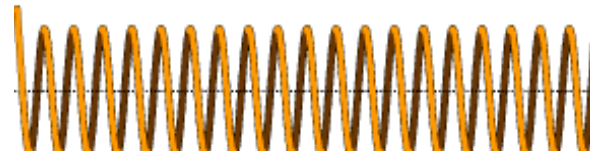
$$L = \frac{N \Phi_B}{i} = \frac{(n l) (\mu_0 n i) A}{i} = (\mu_0 n^2 l A)$$

$$L = \mu_0 n^2 l A = \mu_0 \frac{N^2}{l^2} \times l A = \mu_0 \frac{N^2 A}{l}$$

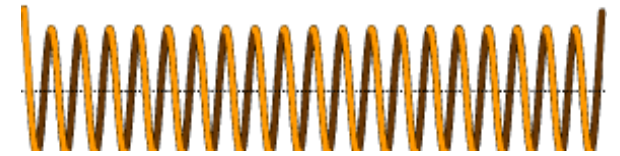
Solenoid coil of 10 cm length and section area of 30 cm^2 . his number of rolls is 200 rolls It is upset from the air and passed through a 3 A electric current **Calculate the magnetic flux** that passes the coil section .

Calculate the inductance of an air-core solenoid containing 200 turns if the length of the solenoid is 20 cm and its cross-sectional area is 3 cm^2 .

In the figure you can see two identical solenoids, through each of them a current flows, but: $i_1 > i_2$
In which solenoid the magnetic flux is stronger?



Solenoid 1



Solenoid 2

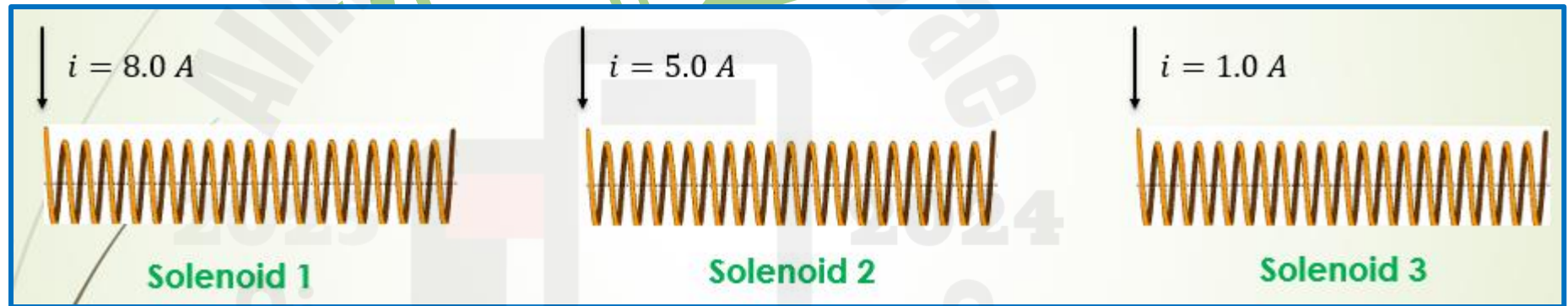
Which of the following identical solenoid has the highest inductance?

A- solenoid 1

B- solenoid 2

C- solenoid 3

D- All of them has the same inductance

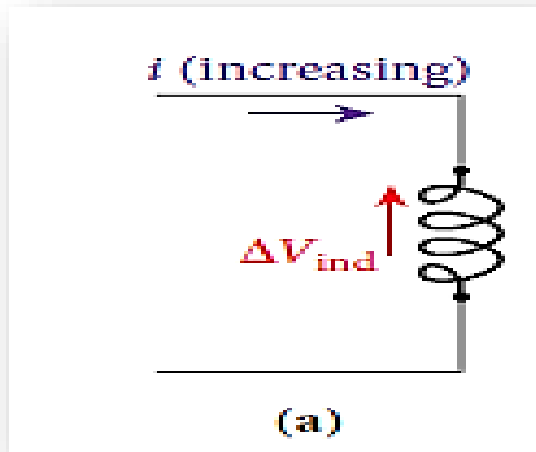


9-7 Self-Induction and Mutual Induction

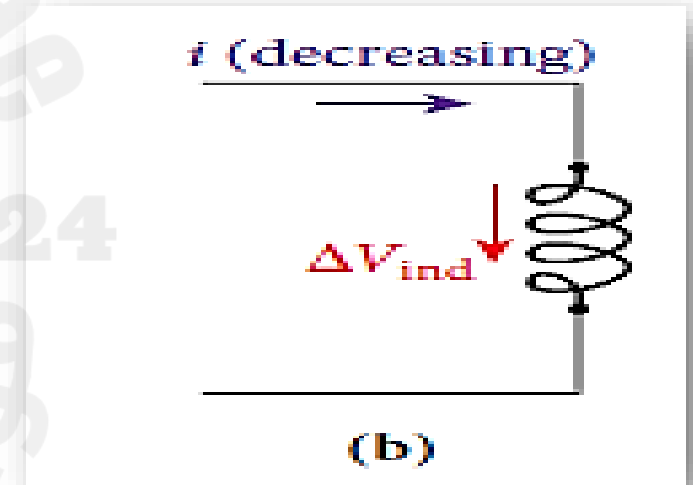
self-induction: “The changing current in the first coil also induces a potential difference in that coil, and thus the magnetic field from that coil also changes.

According to Faraday’s Law of Induction the self-induced potential difference for any inductor is given by

$$\Delta V_{ind,L} = -\frac{d(N\Phi_B)}{dt} = -\frac{d(Li)}{dt} = -L\frac{di}{dt}$$



Self-induced potential difference in an inductor when the current is increasing



Self-induced potential difference in an inductor when the current is decreasing

The negative sign in equation provides the clue that the induced potential difference always opposes any change in current

$$V_{\text{ind},L} = - N \frac{d \Phi_B}{dt} = - L \frac{di}{dt}$$

L Self inductance and the unit of **L** $\frac{V \cdot s}{A} = H$

. The back (ΔV_{ind}) induced in a coil, when current changes from 1 ampere to zero in one milli-second, is 4 V, the self-inductance of the coil is:

A) 1 H

B) 4 H

C) 10^{-3} H

D) 4×10^{-3} H

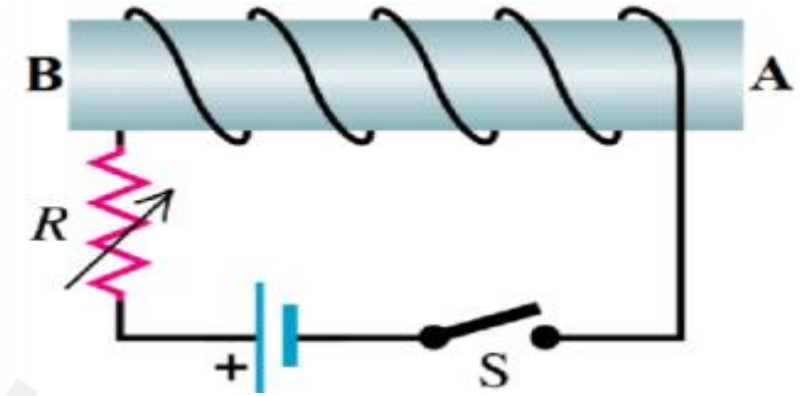
Q) A-Calculate the inductance of an air-core solenoid containing 200 turns if the length of the solenoid is 20 cm and its cross-sectional area is 4.00 cm^2 .

B-Calculate the self-induced emf in the solenoid if the current it carries is decreasing from 0.3 A to zero in 0.2s.

Q) In the beside figure determine the induced current if :

A. Switch is closed

B. Resistance is increased



A 5.6 mH inductor is connected to a current source. What is the magnitude of the voltage in the inductor at time $t=4.0 \text{ s}$ if the current is $I(t)=10.0+9.0t-3.0 t^2$?

A. 11 mV

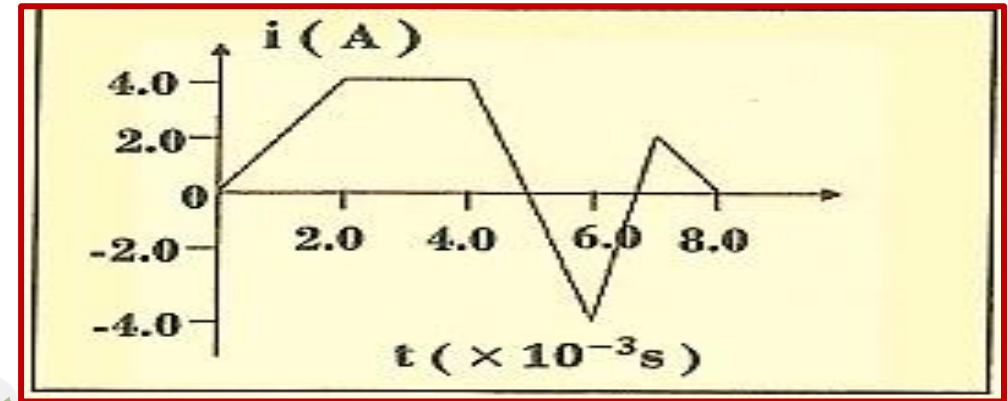
B. 22 Mv

C. 84 mV

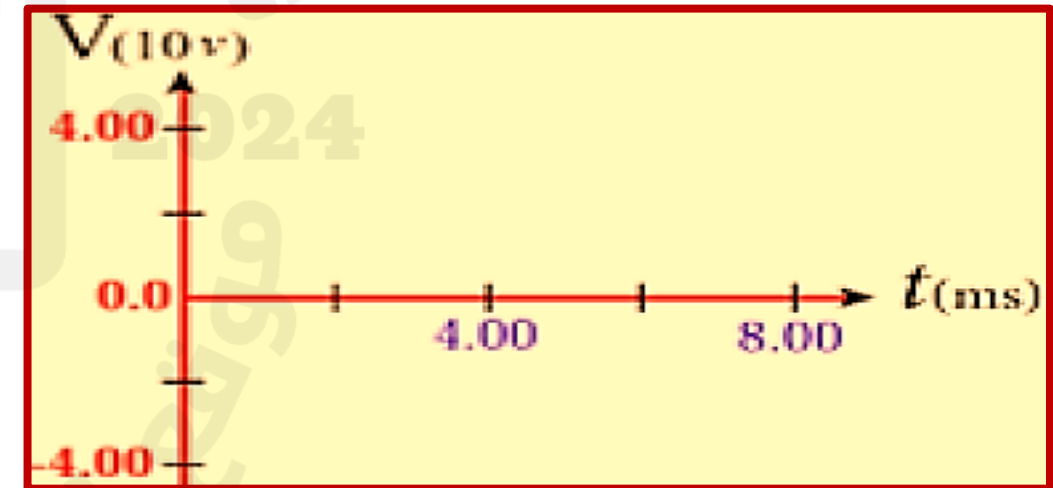
D. 58 mV

Q) The figure shows the current through a ($L=10.0\text{-mH}$) inductor over a time interval of ($\Delta t= 8.00\text{ ms}$)

A. Calculate the ΔV_{ind} (from $i=0\text{ A}$ to $i=4\text{ A}$)



B. Draw a graph showing the self-induced potential difference, ΔV_{ind} , for the inductor over the same interval



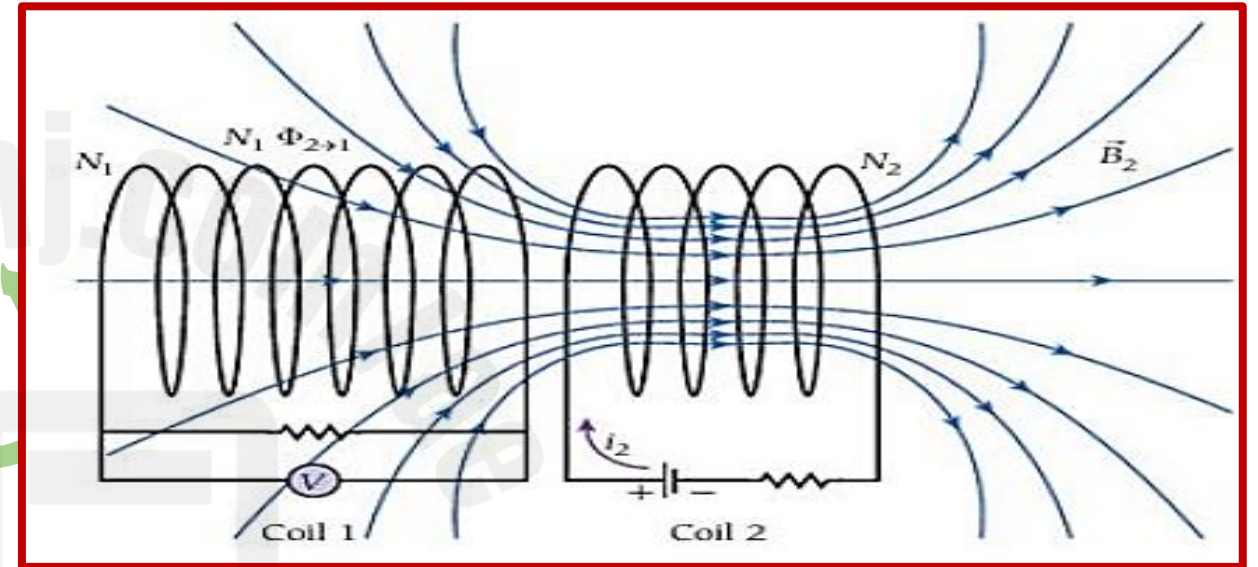
Mutual Induction

It occurs between two coils close to each other Changing the current in the first coil also induces a potential difference in the second coil.

$$\Delta V_{\text{ind},2} = -M \frac{di_1}{dt} = -N_2 \frac{d\Phi_{1 \rightarrow 2}}{dt}$$

$$\Delta V_{\text{ind},1} = -M \frac{di_2}{dt} = -N_1 \frac{d\Phi_{2 \rightarrow 1}}{dt}$$

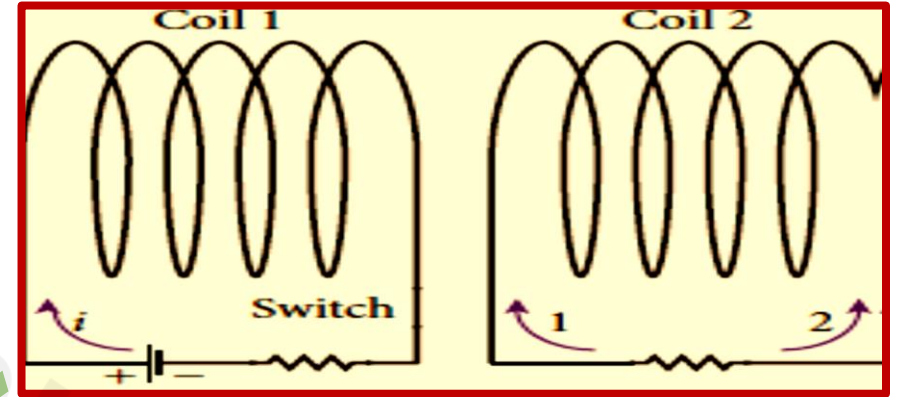
$$M = \frac{NBA}{i} = \frac{N(\mu_0 ni)(\pi r_1^2)}{i} = N\pi\mu_0 nr_1^2.$$



Where **M** is the **mutual inductance** between the two coils. The SI unit of mutual inductance is the **henry(H)**

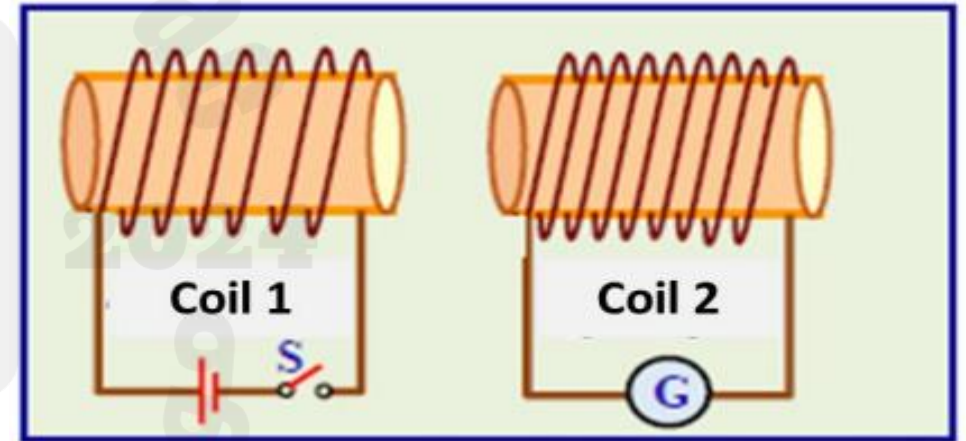
Two identical coils are shown in the figure. Coil 1 has a current i flowing in the direction shown. When the switch in the circuit containing coil 1 is opened, **what happens in coil 2?**

- a) A current is induced in coil 2 that flows in direction 1.
- b) A current is induced in coil 2 that flows in direction 2.
- c) No current is induced in coil 2.



Q) Two coils placed near each other. mutual inductance $M=1.5\text{ H}$, if the current in circuit 1 increased from 5 A to 25 A during 0.05 s .

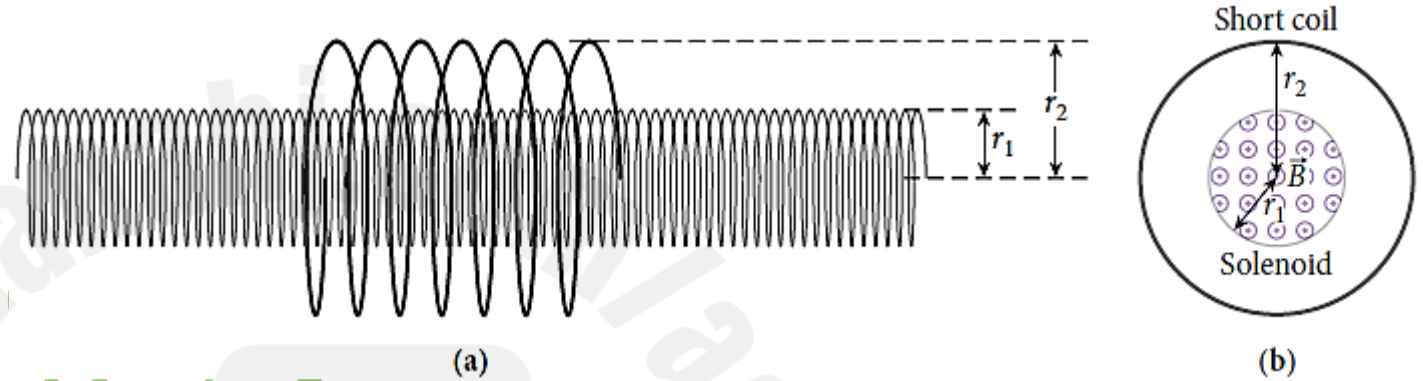
A) Calculate the induced potential difference in circuit 2



B) use Lenz law to determine the direction of the induced current in circuit 2. if the switch is closed

A long solenoid with a circular cross section of radius $r_1 = 2.80$ cm and $n = 290$ turns/cm is inside and coaxial with a short coil that has a circular cross section of radius $r_2 = 4.90$ cm and $N = 31$ turns (Figure). The current in the solenoid is increased at a constant rate from zero to $i = 2.20$ A over a time interval of 48.0 ms.

What is the potential difference induced in the short coil while the current is changing?



9.9 Energy and energy Density of a Magnetic Field

We can think of an inductor as a device that can store energy in a magnetic field

$$P = V_{emf} i = L \left(\frac{di}{dt} \right) i$$

Now let's consider an ideal solenoid with length l , cross-sectional area A , and n turns per unit length, carrying current i . The energy stored in the magnetic field of the solenoid using is

$$U_B = \frac{1}{2} L i^2$$

$$L = (\mu_0 n^2 l A)$$

Self study

Since $B = \mu_0 n i$ for a solenoid, the energy density of the magnetic field of a solenoid can be expressed as

$$u_B = \frac{1}{2\mu_0} B^2.$$

Energy density stored in the coil ($u_B = \left(\frac{U_B}{V} \right)$)

Q) Consider a long solenoid with a circular cross section of radius ($r = 8.10 \text{ cm}$) and ($n = 2.0 \times 10^4 \text{ turns/m}$). The solenoid has length ($l = 0.540 \text{ m}$) and is carrying a current of magnitude ($i = 4.04 \times 10^{-3} \text{ A}$).

How much energy is stored in the magnetic field of the solenoid?

Q) Solenoid passes through it a constant electric current creating a magnetic field of strength of 0.45 T , if it is 6.2 cm diameter of section and length of solenoid 26 cm Find the following:

1- Energy stored in the coil

2- Energy density stored in the coil

9:8 RL CIRCUIT

Charging a capacitor

$$q = CV_{\text{emf}} \left(1 - e^{-t/\tau_{\text{RC}}} \right)$$

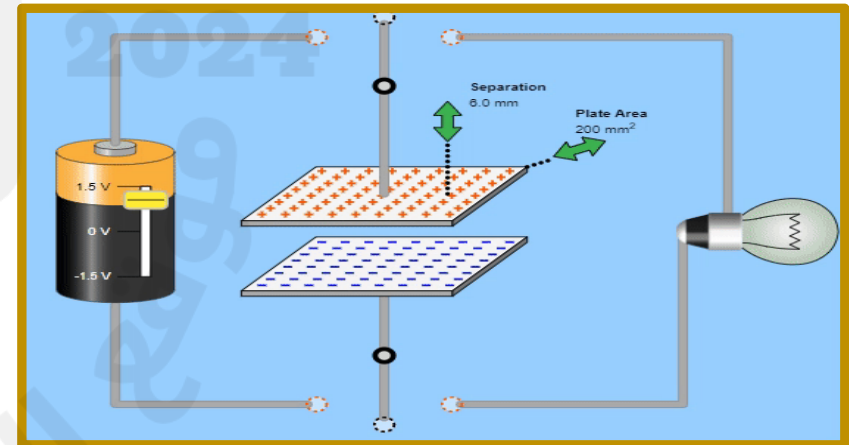
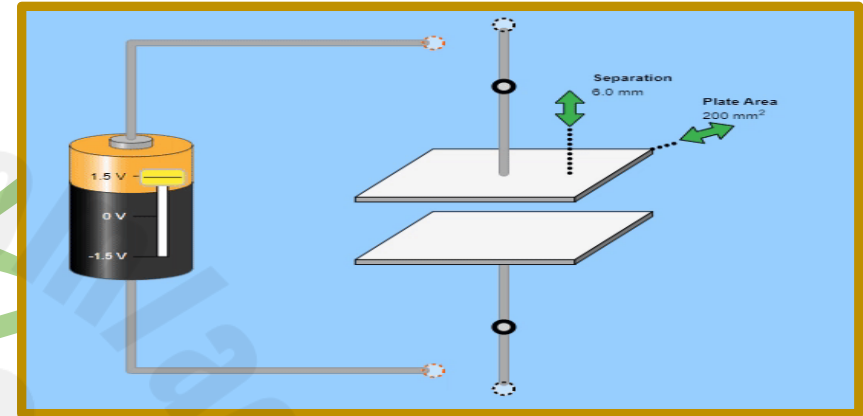
$$\tau = RC$$

τ_{RC} = time constant of the circuit,

$$q(t) = CV_{\text{emf}} (1 - e^{-t/RC})$$

Discharging a capacitor

$$q(t) = q_{\text{max}} e^{-t/RC}$$



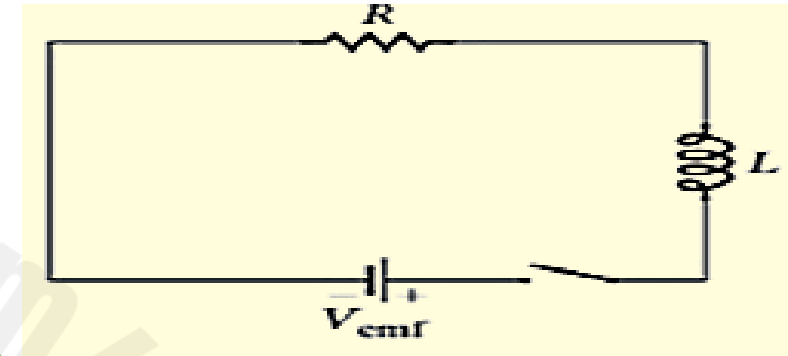
RL Circuit: A circuit in which a source of emf is connected to a resistor and an inductor in series **RL circuits can be used as timers like** radio wave transmitters, oscillator circuits, amplifiers, filtering circuits, When the switch is closed the **current would increase** , with the time the current will decreased until steady

$$V_{\text{emf}} - iR - L \frac{di}{dt} = 0.$$

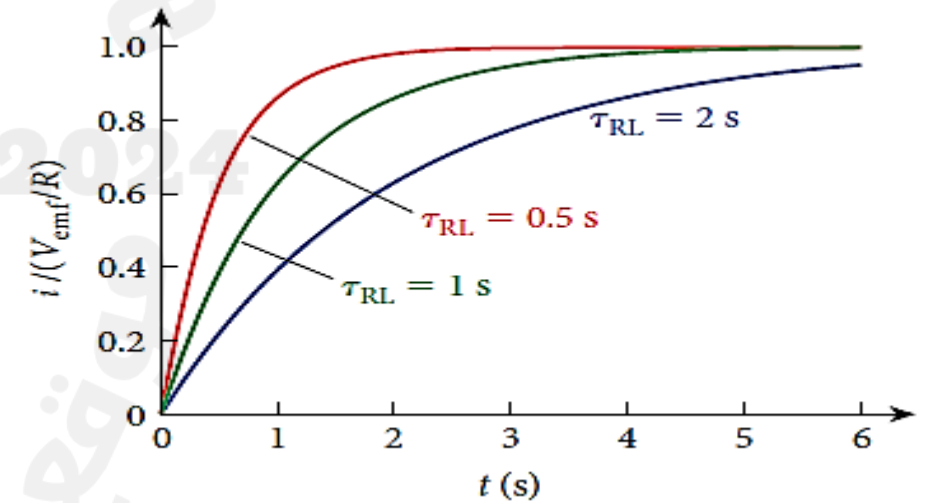
$$i_t = i_{\text{max}} (1 - e^{-t/\tau})$$

$$i_{\text{max}} = \frac{V_{\text{emf}}}{R}$$

$$\tau_{\text{RL}} = \frac{L}{R}$$



When the switch is closed $t = 0$ $i = 0$, **At** $t = \infty$ $i = i_{\text{max}}$



When we removed the battery
The current will decrease until it reached to zero

$$L \frac{di}{dt} + iR = 0.$$

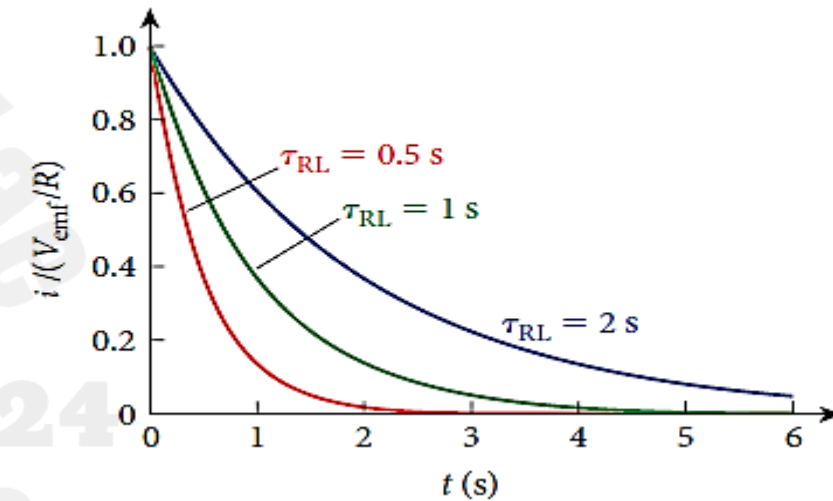
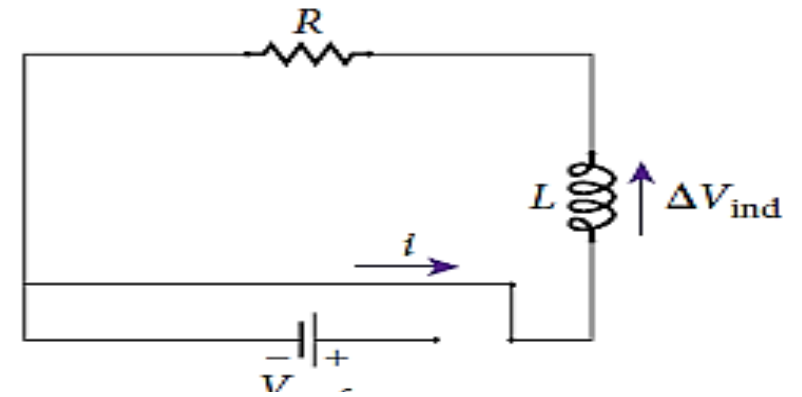
$$V_{\text{emf}} = 0$$

$$i(t) = i_0 e^{-t/\tau_{\text{RL}}}.$$

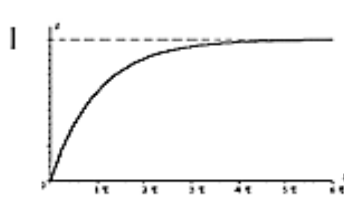
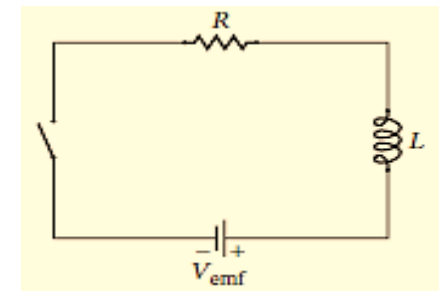
equation below. What does **x** represent in RL circuit?

$$x = \frac{V_{\text{emf}}^2}{R} (1 - e^{-t/\tau_{\text{RL}}})$$

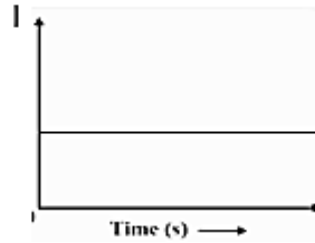
- A. The power
- B. The work done
- C. The resistance
- D. The inductance



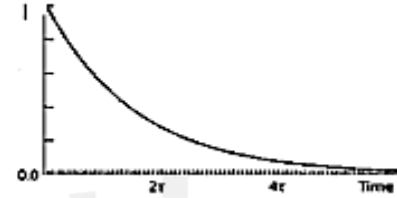
In the figure beside , when the switch is closed which graph represent the current flowing with time :



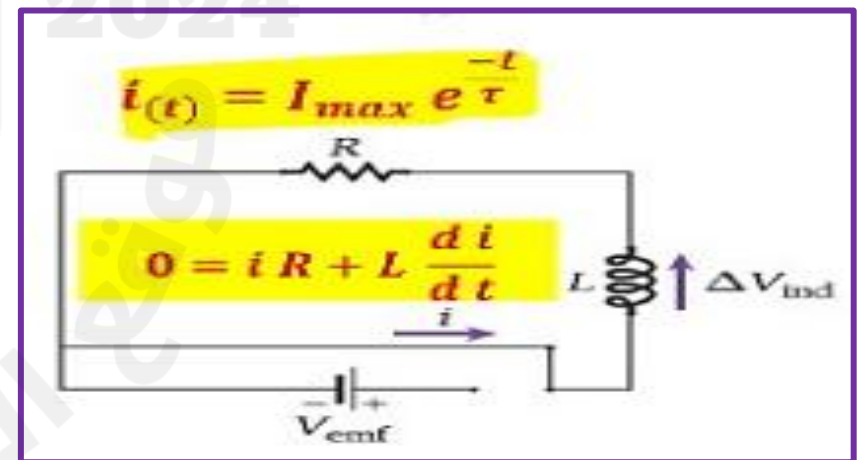
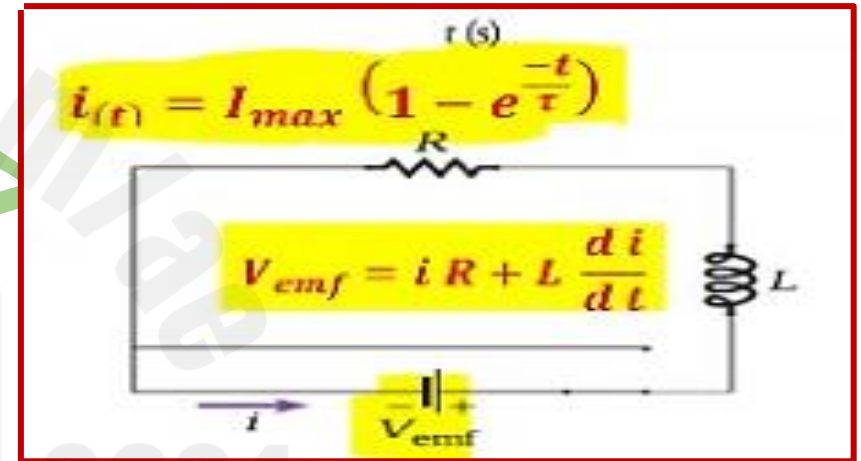
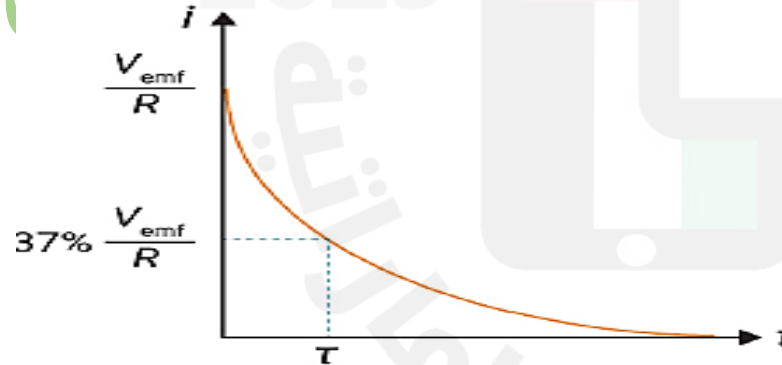
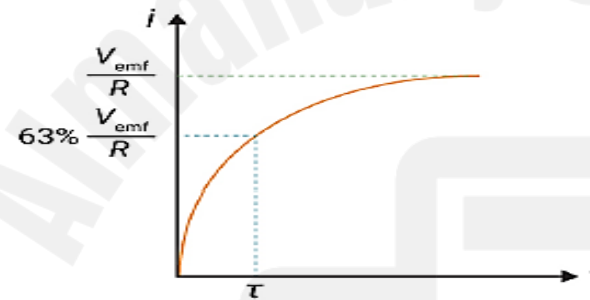
A.



B.

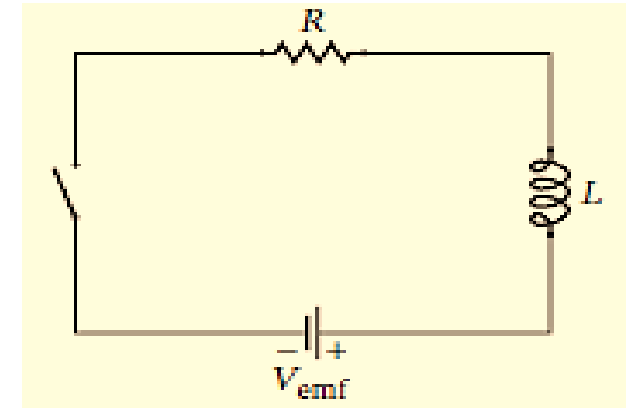


C.



Consider the RL circuit shown in the figure. When the switch is closed, the current in the circuit increases exponentially to the value $i = V_{\text{emf}}/R$. If the inductor in this circuit is replaced with an inductor having three times the number of turns per unit length, the time required to reach a current of magnitude $0.9i$

- a) increases.
- b) decreases.
- c) stays the same.



Q49) Consider an RL circuit with resistance $R = 1.00 \text{ M}\Omega$ and inductance $L = 1.00 \text{ H}$, which is powered by a 10.0-V battery.

- a) What is the time constant of the circuit?
- b) If the switch is closed at time $t = 0$ what is the current just after that time? After $t = 2.00 \mu\text{s}$?

When has a **long time** passed?

9.50) In the circuit in the figure, $R = 120. \Omega$, $L = 3.00 \text{ H}$, and $V_{\text{emf}} = 40.0 \text{ V}$. After the switch is closed, how long will it take the current in the inductor to reach $300. \text{ mA}$?

9.51) The current is increasing at a rate of 3.60 A/s in an RL circuit with $R = 3.25 \Omega$ and $L = 440. \text{ mH}$. What is the potential difference across the circuit at the moment when the current in the circuit is 3.00 A ?

9.58) An emf of 20.0 V is applied to a coil with an inductance of 40.0 mH and a resistance of 0.500Ω .

- a) Determine the energy stored in the magnetic field when the current reaches $1/4$ of its maximum value.
- b) How long does it take for the current to reach this value?

9.53)In the circuit in the figure, a battery supplies $V_{emf} = 18.0 \text{ V}$ and $R_1 = 6.00 \Omega$, $R_2 = 6.00 \Omega$, and $L = 5.00 \text{ H}$. Calculate each of the following a long time after the switch is closed:

- a) the current flowing out of the battery
- b) the current through R_1
- c) the current through R_2
- d) the potential difference across R_1
- e) the potential difference across R_2
- f) the potential difference across L

