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Magnetic Fields, Voltage, and Currents Problems (Practice Questions)

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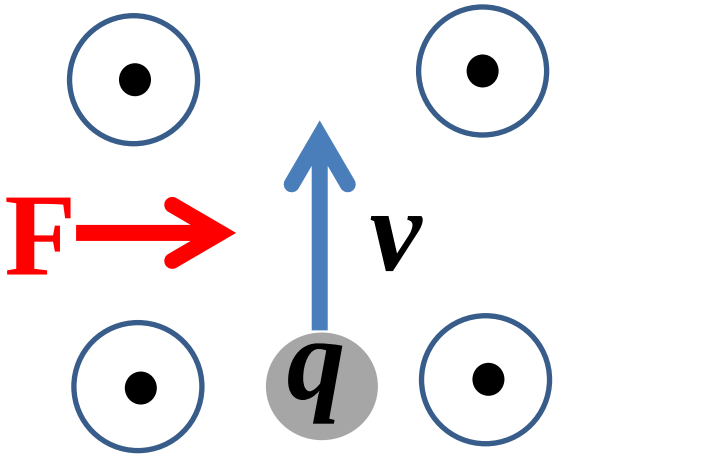
Magnetism

Force on a Moving Charge in Magnetic Field

Basic principle for voltage generation in a conductor or a close loop conductor



B=2 Tesla

In the magnetic field shown in the picture, what is the magnitude & direction of force on the charge 3 C moving at velocity of 100 m/s in the north direction.

Magnitude of force F=q(vXB)

= 3*(100*2)=600 N

From the right hand screw rule, the direction of the force F is in the RIGHT or in the EAST

Force on a moving charge in magnetic field

In the figure 1, a point charge +q C is moving at a velocity of V m/s towards NORTH. Magnetic field (B) direction is shown. What is the direction of the force on the charge:

(a) East (b) West, (c) North, (d) South

In the figure 1, a point charge +q C is moving at a velocity of V m/s towards SOUTH. Magnetic field (B) direction is shown. What is the direction of the force on the charge:

(a) East (b) West, (c) North, (d) South

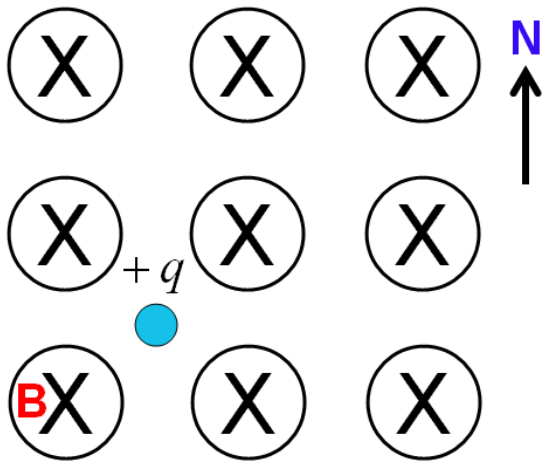


Figure 1

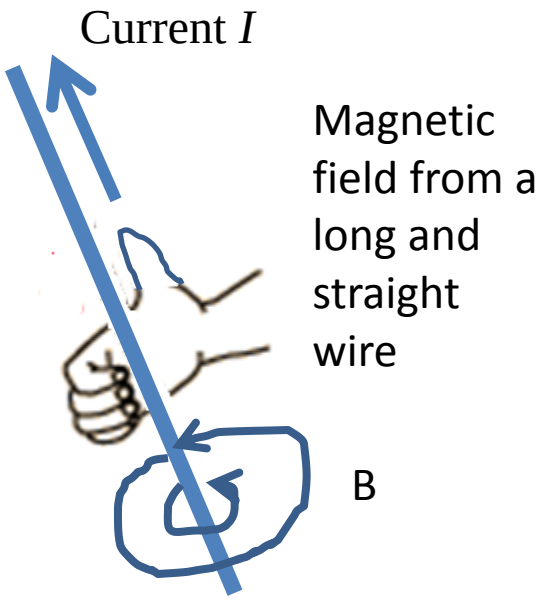
In the figure 1, a point charge +q C is moving at a velocity of V m/s towards EAST. Magnetic field (B) direction is shown. What is the direction of the force on the charge:

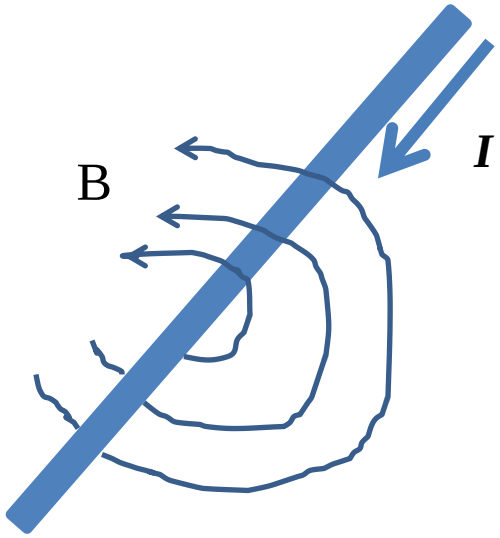
(a) East (b) West, (c) North, (d) South

In the figure 1, a point charge +q C is moving at a velocity of V m/s towards WEST. Magnetic field (B) direction is shown. What is the direction of the force on the charge:

(a) East (b) West, (c) North, (d) South

Ampere's Law

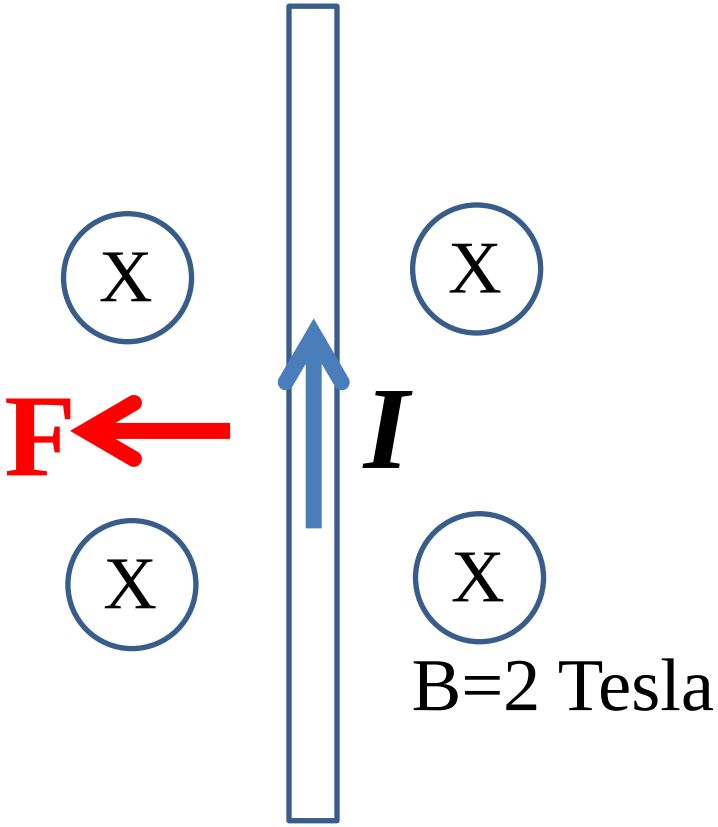




What is the magnetic field at 5 cm far from a long straight conductor which carries 10 A current.

Solution: $B=I/(2\pi r) = 31.84$ A/m

Force on a Current Carrying Conductor in Magnetic Field



In the magnetic field shown in the picture, what is the magnitude & direction of force on the 3 m conductor carrying current I=2 A

Magnitude of force F=I(LXB)

= 2*(3*2)=12 N

From the right hand screw rule, the direction of the force F is in the LEFT or in the WEST

Voltage & Current in a Conductor Moving in Magnetic Field

1. Conductor AB is falling down in Fig 1. What is the voltage V_{AB}

Answer: zero voltage [Think why]

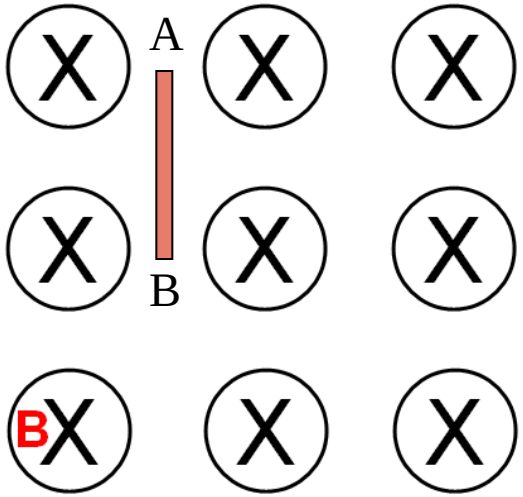


Fig. 1

2. Conductor AB (=2m) is falling down in the magnetic field (0.1 mT) as indicated in the Fig.2. What is V_{AB} when its velocity is 20m/s? What is the direction of current?

Answer: 4 mV & current direction is from A to B

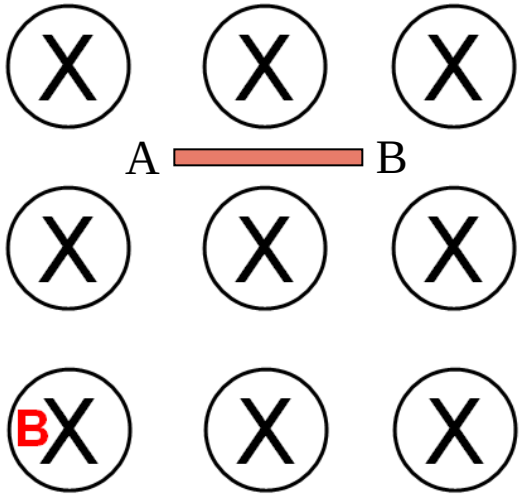
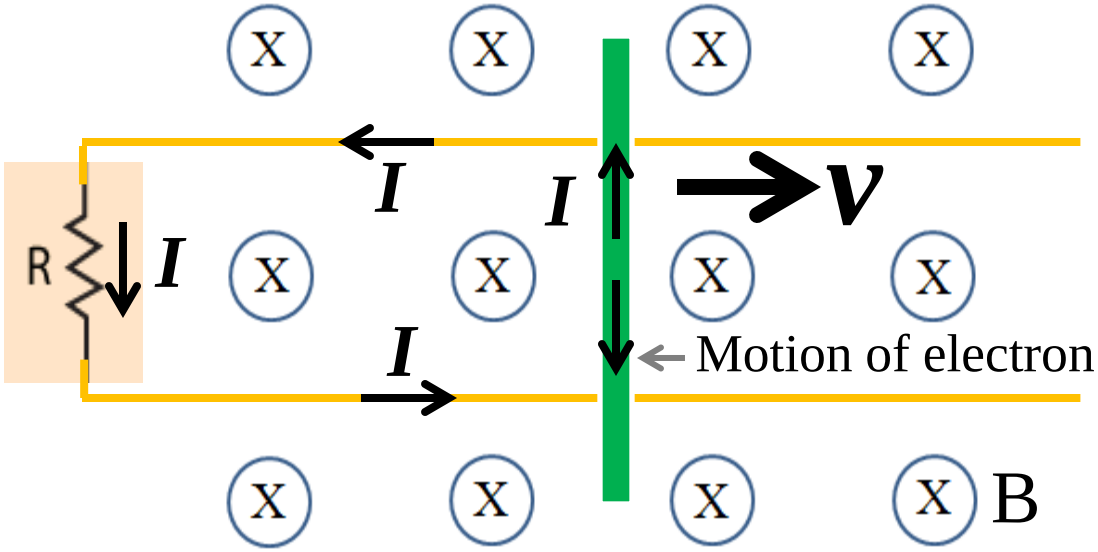


Fig. 2

3. A small bicycle generator has 150 turns of wire in a circular coil of radius 1.8 cm. The magnetic field is 0.2 T. If induced voltage amplitude is 4.2 V, what is the rotational speed in r.p.m ? [1300 rpm]

Several variables here, so several problems from here.

Voltage & Current in a Conductor Moving in Magnetic Field



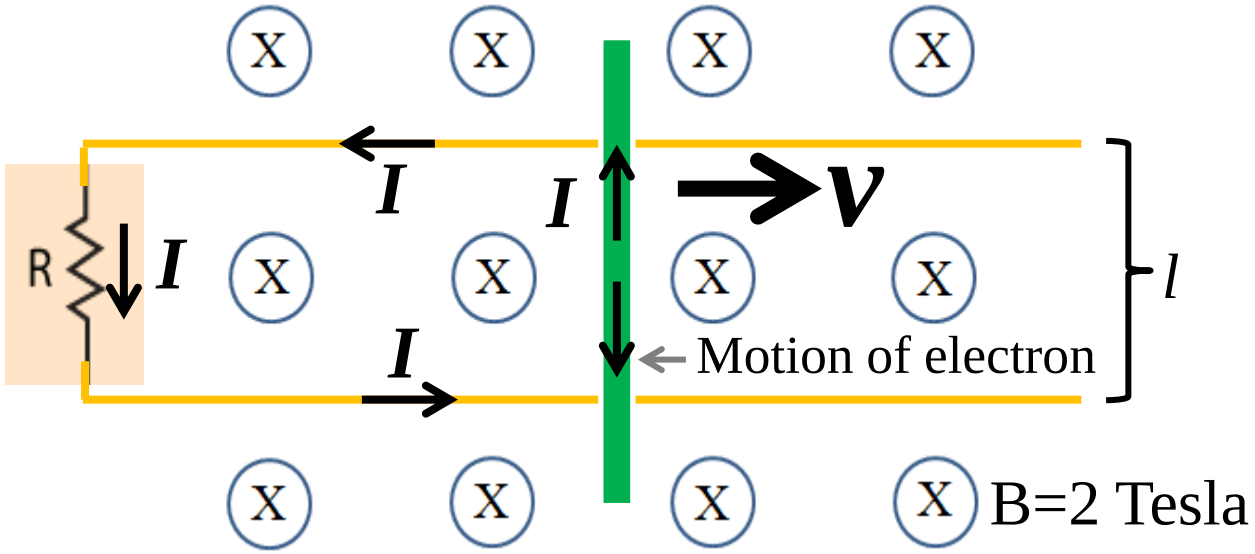
Try to understand the current direction in the moving conductor from the following equation:

$$F = -1.6 \times 10^{-19}(v \times B)$$

for one free valance electron in conductor.

In the test, direction of **B** or ***v*** will be given and you have to find the current direction in the closed loop circuit.

Voltage & Current in a Conductor Moving in Magnetic Field



$E = l(v \times B) = Blv$ Here l is conductor length

Current direction can be also found from this equation by applying right hand screw rule.

Problem: In the magnetic field shown in the picture, what is the magnitude of voltage and & direction of current in 4 m conductor which is moving in east direction at a velocity of 10m/s.

Solution: Magnitude of voltage E = *Blv*= 2Tesla*4m*10m/s=80Volts
Direction of current is in NORTH direction

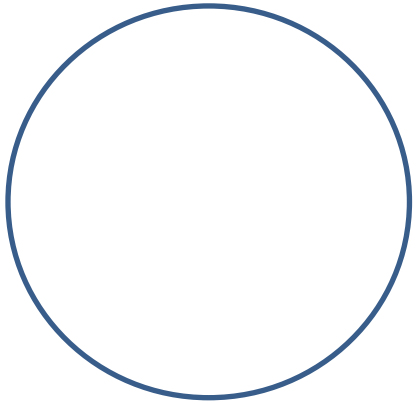
In the test, direction of **B** or ***v*** will be given and you have to find the current direction in the closed loop circuit.

Voltage in a Closed Loop Conductor in Magnetic Field
~ Faraday's Law ~

$$E = -N\frac{\Delta\phi}{\Delta t}$$

$$= -N\frac{BA}{\Delta t}$$

Here N=# of turns
$\Delta\phi$=Magnetic flux change in the loop
B=Magnetic field ***change*** in Tesla
Δt=Change in time



Problem: A 40 turn coil of wire of radius 3 cm is placed between the poles of an electromagnet. The field increases from 0.75 Tesla to 1.5 Tesla at a constant rate in a time interval of 225 s. What is the magnitude of induced voltage in the coil if the field is perpendicular to the plane of coil.

Solution: E = -NBA/ Δt
=-40*(1.5-0.75)*3.14*(0.03)^2/225
=-0.38mV
Magnitude of the induced voltage is 0.38 mV

Voltage Generation in Power Industry

In power industry, voltage is generated by rotating coils in fixed magnetic field as shown in the picture.

$E = \omega NBAsin(\omega t)$

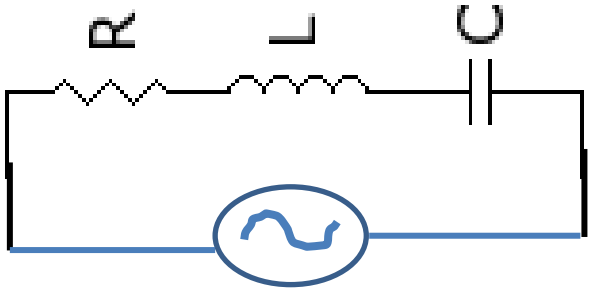
E= Voltage generated
ω=Rotational speed
N=# turns
B=Magnetic field
A= Area of loop

Problem: A small bicycle generator has 150 turns of wire in a circular coil of radius 1.8 cm. The magnetic field is 0.2 T. If induced voltage amplitude is 4.2 V, what is the rotational speed in r.p.m ? [137.5 rpm]

This problem is done in class. So see the note.

Several variables here, so several problems from here could be.

R-L-C Circuit Solution



In the following R-L-C circuit, R= 2 Ohms, L=0.02 H C= 0.001 F, and supply voltage is v=100sin(200t). Determine (a) total impedance of the circuit, (b) I_rms, (c) power loss in the resistor, (d) resonance frequency of the circuit, (e) power factor of the circuit, (f) whether current leading or lagging voltage

Answer: (a) Z=2.2361 Ohms, (b) I_rms=31.6223 A, (c) 1999.939 Watts, (d) 35.606 Hz, (e) 0.8944, (f) Current leads Voltage