



Unit 3 Chapter 8: Magnetic fields

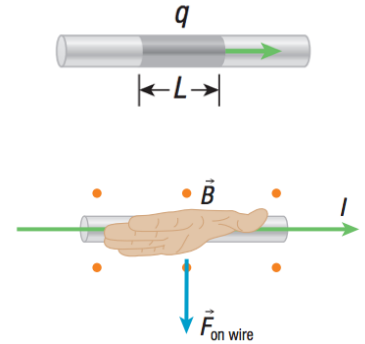
Lesson 3.9: Magnetic Force on a Current-Carrying Conductor (8.3)

$\therefore F_{\text{single charge}} = qvB\sin\theta$ and, $v = \frac{L}{\Delta t}$ (how fast the electron passes over a certain segment, L , of the wire)

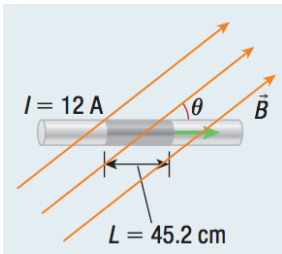
$$\therefore F_{\text{current (collection of charge)}} = q \frac{L}{\Delta t} B\sin\theta = \frac{q}{\Delta t} LB\sin\theta,$$

where $\frac{q}{\Delta t}$ is current, I , how many charges pass through a wire within certain time period.

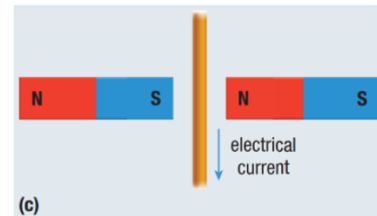
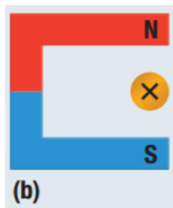
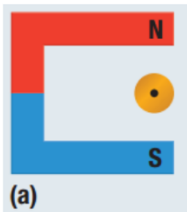
Hence, $F_{\text{on wire}} = ILB\sin\theta$



Example 1: A piece of wire 45.2 m has a current of 12 A. The wire moves through a uniform magnetic field with a strength of 0.30 T. Calculate the magnitude of the magnetic force on the wire when the angle between the magnetic field and the wire is 45 degrees.



Example 2: Draw the magnetic field lines of both the magnet and the conductor. Then determine the direction of the force on the conductor.

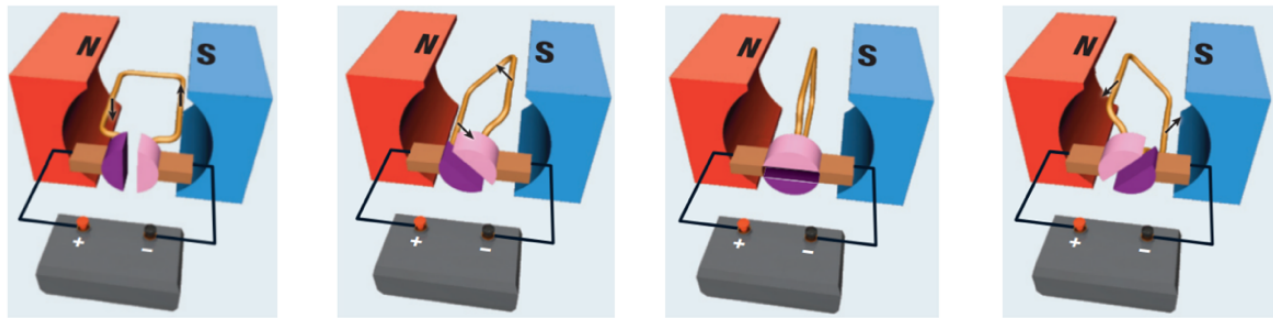
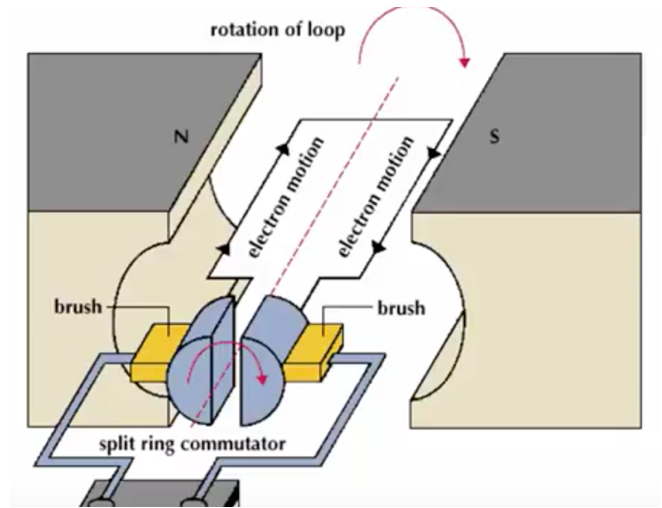
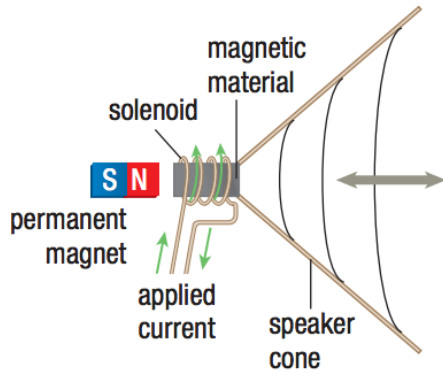


Example 3: Current with opposite direction going through 2 wires that are placed side by side, will they stay stationary or repel or attract? How about 2 wires with same conventional current?

Applications: Loudspeakers and motors

<https://www.youtube.com/watch?v=1DqWMHyRhYg>

<https://www.youtube.com/watch?v=kyDo46J7JNA>



<https://www.youtube.com/watch?v=CWuIQ1ZSE3c>

Motors: We have seen that a current carrying wire perpendicular to a magnetic field will experience a force. Due to this, motors transform electrical energy into mechanical energy.

A simple DC (direct current) motor consists of:

- a loop of wire that passes through a magnetic field
- split ring (commutator) turns with the loop
- fixed metallic brushes connect the commutator to the battery

The commutator is important because...

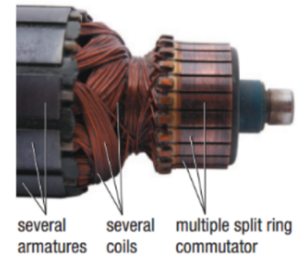
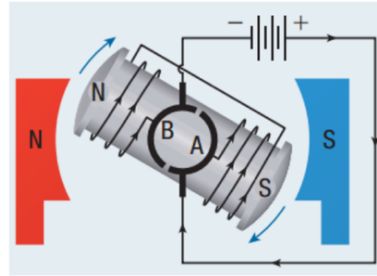
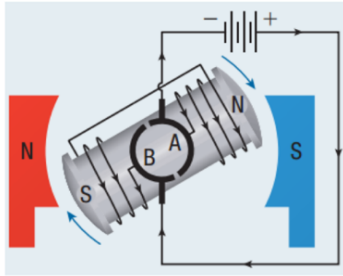
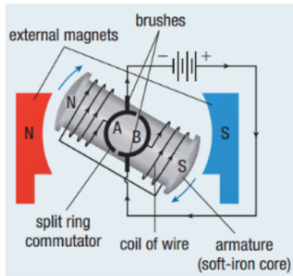
- **prevents** motor from getting **locked** in the vertical position
- it reverse the direction of the current every half-turn so that the motor **keep spinning** in the same direction

However the design of the DC motor shown above has some shortcomings. A motor with just loop will not be very strong. To improve, we can:

- increase the number of loops
- use electric-highly-conducted material such soft-iron core (armature)
- increase the current (not desirable choice because it will produce more thermal energy as a side effect)



Modern DC motors:



The current directed into split ring B, hence the charges go up the coil at the front of the coil and then exit from split ring A. Based on right hand-rule of solenoid, the South pole of armature repel the South pole of external magnet to cause a clockwise rotation.

Main problems:

1. As the coil rotates and lined up with the external magnetic field, the strength of the magnetic force on the coil weakens and motor slows down.
2. if the motor is turned off just as it reaches the split in the split ring commutator, it will not be able to rotate when the motor is turned on again because the circuit is incomplete.

Further improvement: put **several coils** into the motors and use a split ring commutator with **several splits**. This helps:

- the speed of the motor does not fluctuate as much
- a segment of the multiple split ring commutator is always in contact with the external circuit so that the motor does not need to be paused by hand to start it.

Applications: cars, trains, laptop fan for cooling, DVD/Blue-Ray drive, etc.

- Identify the parts labelled A, B, C, D, E, and F for the motor shown in **Figure 12**.
 - Determine which way the motor will spin. Explain your answer.
 - What effect will reversing the current have? K/U T/I C

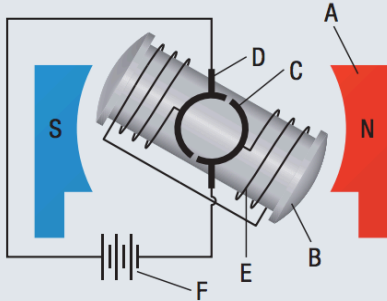


Figure 12

- Look at **Figure 13**. In which direction will the loop rotate? Explain your answer.
 - What is the purpose of the split ring commutator?

K/U T/I C

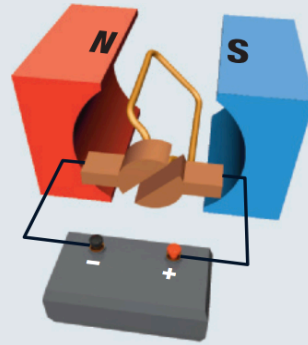


Figure 13

- What effect would each of the following changes have on a DC motor? Consider each of the changes separately. K/U

 - increasing the number of loops in the coil
 - using a plastic core instead of a soft-iron core
 - decreasing the current
 - reversing the polarity of the external magnets
 - reversing the polarity of the external magnets and reversing the direction of the current