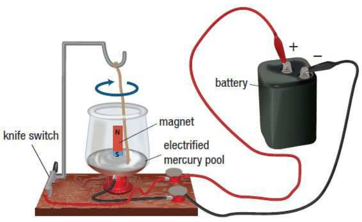
SPH3U UNIVERSITY PHYSICS

ELECTRICITY & MAGNETISM

- The Motor Principle (P.563-566)

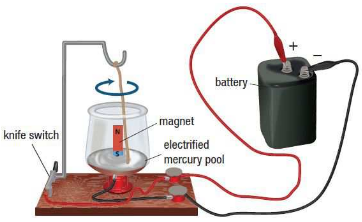
Faraday's Motor

In 1821, following Oersted's discovery of electromagnetism, English physicist Michael Faraday set out to prove that, as a wire carrying electric current could cause a magnetized compass needle to move, so in reverse a magnet could cause a current-carrying wire to move.



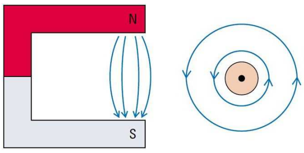
Faraday's Motor

Suspending a piece of copper wire above a bowl of mercury in which he had fixed a magnet upright, Faraday connected the wire to a battery, and the wire began to rotate. This was the first electric motor!



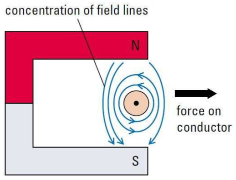
Faraday's Motor

The copper wire in Faraday's motor moved because the magnetic field in the copper wire interacted with the magnetic field of the permanent bar magnet. Faraday determined that the magnetic field of the permanent magnet exerted a force on the current-carrying conductor.



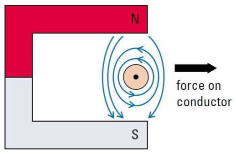
Motor Principle

Where the two interacting magnetic field lines are pointed in the same they tend to reinforce each other, producing a strong magnetic field. Where the two interacting field lines are pointed in opposite directions, they tend to cancel each other, producing a weaker field. This difference in field strength results in a force to the right on the conductor.



Motor Principle

The movement of a current-carrying conductor in an external magnetic field is described by the motor principle. The ***motor principle*** *states that a current-carrying conductor that cuts across external magnetic field lines experiences a force perpendicular to both the magnetic field and the direction of the electric current.*



Motor Principle

A more detailed investigation of the motor principle shows:

1. *The magnitude of the force depends on (a) the magnitude of both (i) the external magnetic field and (ii) the electric current, and (b) the angle between the conductor and the magnetic field it cuts across.*
2. *The direction of the force depends on the direction of both (i) the external magnetic field and (ii) the electric current.*

Motor Principle

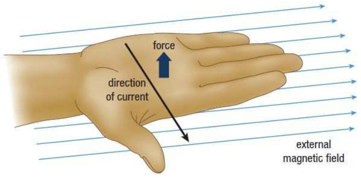
MOTOR PRINCIPLE

- a current-carrying conductor that cuts across external magnetic field lines experiences a force perpendicular to both the magnetic field and the direction of the electric current
- the magnitude of the force depends on:
  - the magnitude of the external magnetic field
  - the magnitude of the electric current
  - the angle between the conductor and the magnetic field
- the direction of the force depends on the direction of:
  - the external magnetic field
  - the electric current

NOTE!
Conductors parallel to the magnetic field experience no force!

Right-Hand Rule for the Motor Principle

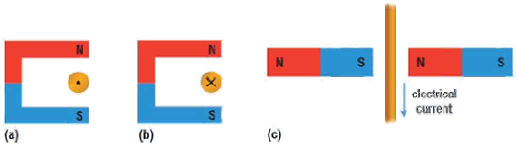
A third right-hand rule can be used as a tool to determine the direction of force acting on a current-carrying conductor. This time your hand is held flat with your thumb at a right angle to your fingers. The ***right-hand rule for the motor principle*** *states that if the fingers of your open right hand point in the direction of the external magnetic field and your thumb points in the direction of the conventional current, then your palm faces in the direction of the force on the conductor.*



Right-Hand Rule for the Motor Principle

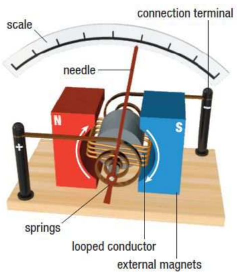
PRACTICE

1. Copy each diagram into your notebook, and draw the magnetic field lines of both the magnet and the conductor. Then determine the direction of the force on the conductor.



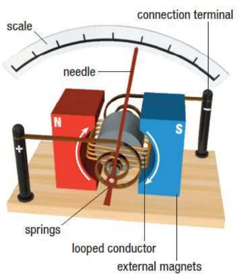
Application of the Motor Principle – Meters

One of the first practical uses of the motor principle was the development of meters for measuring electrical quantities. The galvanometer, shown to the right, is a sensitive meter for measuring current.



Application of the Motor Principle – Meters

Looking at the cross-sectional view, we see the current is directed into the page on the right side and out of the page on the left side. Using the right-hand rule for the motor principle, we see that the loop is forced down on the right side and up on the left side. This causes the needle to rotate toward the right side of the scale.

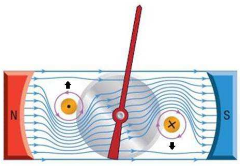


Application of the Motor Principle – Meters

PRACTICE

2. How would increasing the number of loops in the looped conductor of a galvanometer affect its operation?

   it would make it more sensitive to varying current flow

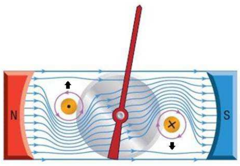


Application of the Motor Principle – Meters

PRACTICE

3. Would the needle move in the same direction if the leads connected to the galvanometer were reversed? Explain.

   no – change the current – change the direction of the magnetic field - changes the direction of the force



Application of the Motor Principle – Motors

As its name suggests, the "motor principle" is also the basis of operation of all electric motors, from the tiny ones used in toys to the massive ones used to propel electric commuter trains.

✔ Check Your Learning

TEXTBOOK
P.566 Q.1-3