10.7: Motors and Meters

Learning Objectives

- Describe how motors and meters work in terms of force on a current loop.

Motors are the most common application of magnetic force on current-carrying wires. Motors have loops of wire in a magnetic field. When current is passed through the loops, the magnetic field exerts force on the loops, which rotates a shaft. Electrical energy is converted to mechanical work in the process. (See Figure $10.7.1$)

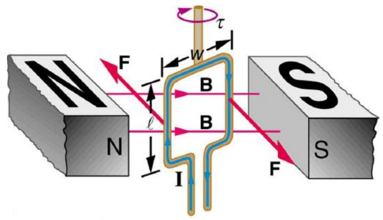

Figure 10.7.1: Force on a current loop. A current-carrying loop of wire attached to a vertically rotating shaft feels magnetic forces that produce a clockwise rotation as viewed from above.

As the coil rotates, the force decreases to zero at $\theta = 0$. The force then *reverses* its direction once the coil rotates past $\theta = 0$. This means that, unless we do something, the coil will oscillate back and forth about equilibrium at $\theta = 0$. To get the coil to continue rotating in the same direction, we can reverse the current as it passes through $\theta = 0$ with automatic switches called *brushes*. (See Figure $10.7.2$)

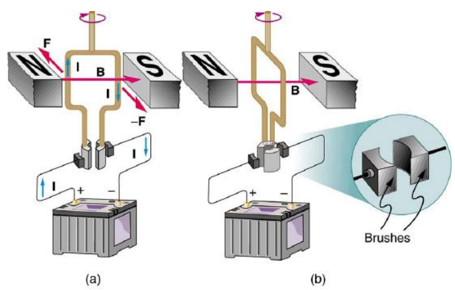

Figure 10.7.2: (a) As the momentum of the coil carries it through $\theta = 0$, the brushes reverse the current to keep the motion clockwise. (b) The coil will rotate continuously in the clockwise direction, with the current reversing each half revolution to maintain the motion.

Meters, such as those in analog fuel gauges on a car, are another common application of magnetic force on a current-carrying loop. Figure $10.7.3$ shows that a meter is very similar in construction to a motor. The meter in the figure has its magnets shaped to limit the effect of θ by making B perpendicular to the loop over a large angular range. A linear spring exerts a counter-force that balances the current-produced force. This makes the needle deflection proportional to I. If an exact proportionality cannot be achieved, the gauge reading can be calibrated. To produce a galvanometer for use in analog voltmeters and ammeters that have a low resistance and respond to small currents, we use a large loop area A, high magnetic field B, and low-resistance coils.

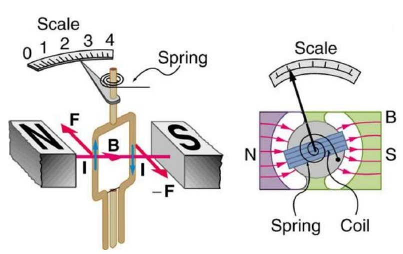

Figure 10.7.3: Meters are very similar to motors but only rotate through a part of a revolution. The magnetic poles of this meter are shaped to keep the component of B perpendicular to the loop constant, so that the force does not depend on θ and the deflection against the return spring is proportional only to the current I.

Glossary

motor

loop of wire in a magnetic field; when current is passed through the loops, the magnetic field exerts force on the loops, which rotates a shaft; electrical energy is converted to mechanical work in the process

meter

common application of magnetic force on a current-carrying loop that is very similar in construction to a motor; by design, the force is proportional to I and not θ, so the needle deflection is proportional to the current

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