Inspire Physics – Grade 10 – Advanced. Academic Year: 2022 - 2023 . . . Term 3
End of Term 3 Questions and Answers.

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(LO): Learning Objective

PART ONE & TWO – Multiple Choice Questions

LO – 1: Define magnetic fields. and identify its SI unit as tesla. Page 249

Magnetic field are fields that exist in space where magnets would experience a force. They are vector quantities because they have magnitude and direction.

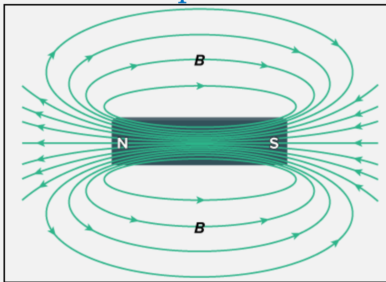

Figure 7. Magnetic field lines can be visualized as lines leaving the north pole of a magnet, entering the south pole, and passing through the magnet, forming closed loops. Magnetic field lines are traditionally represented by the letter B.

The strength of the magnetic field (B) is measured in tesla (T).

$$F = qvB\sin\theta \quad \Longrightarrow \quad B = \frac{F}{qv\sin\theta} \quad \Longrightarrow \quad T = \frac{N}{C.\left(\frac{m}{s}\right)} \quad \Longrightarrow T = \frac{N\,.\,s}{C.\,m}$$

$T = \frac{N\,.\,s}{C.\,m} = \frac{\frac{N.\,s}{s}}{\left(\frac{C}{s}\right).\,m} = \frac{N}{A.\,m}$	$T = \frac{N}{A.\,m} \times \frac{m}{m} = \frac{J}{A.\,m^2}$
$T = \frac{N}{A.\,m} = \frac{kg.\frac{m}{s^2}}{A.\,m} = \frac{kg}{A.\,s^2}$	$T = \frac{kg}{A.\,s^2} = \frac{kg}{\left(\frac{C}{s}\right).\,s^2} = \frac{kg}{C.\,s}$
$T = \frac{J}{A.\,m^2} = \frac{J}{\left(\frac{C}{s}\right)\,.\,m^2} = \frac{J.\,s}{C.\,m^2} = \frac{\left(\frac{J}{C}\right).\,s}{m^2} = \frac{V.\,s}{m^2}$	

Weber (Wb) is the unit of the magnetic flux (Φ) , where ($\Phi = B\,A\cos\theta$), so the unit of weber is equivalent to ($T\,.\,m^2$) $Wb = T\,.\,m^2 \quad \Longrightarrow \quad T = \frac{Wb}{m^2}$	Henry (H) is the SI units of the mutual inductance. One Henry is equal to one weber per ampere. ($1\,H = 1\,Wb/A$) $H = \frac{Wb}{A} = \frac{T\,.\,m^2}{A} \quad \Longrightarrow \quad T = \frac{H.\,A}{m^2}$

LO – 2: Draw the magnetic field lines inside and around a solenoid carrying current and identify its poles. Page 252

<table>
<tr>
<td>Figure 11. You can model the direction of the magnetic field around a loop of current-carrying wire and around a solenoid.

⊗ : away from you, or into the page.
⊙ : Toward you, or out of the page.</td>
<td>Figure 12. Imagine you are holding the solenoid with your right hand. Your thumb will point toward the solenoid’s north pole when your curl fingers in the direction of the conventional current.</td>
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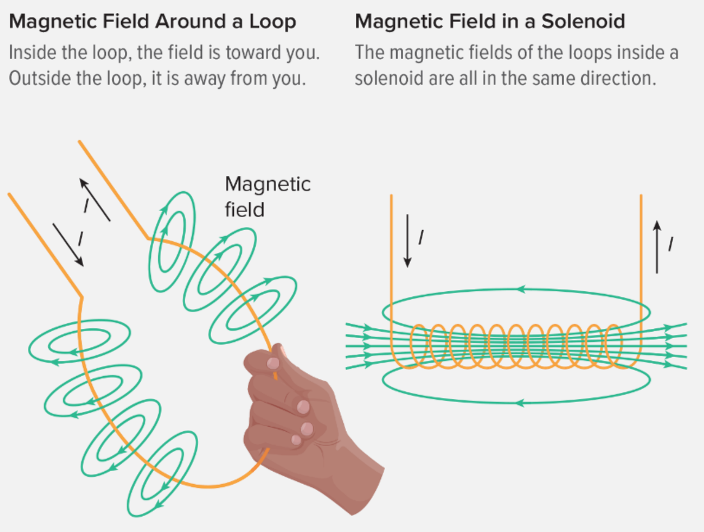
<td>
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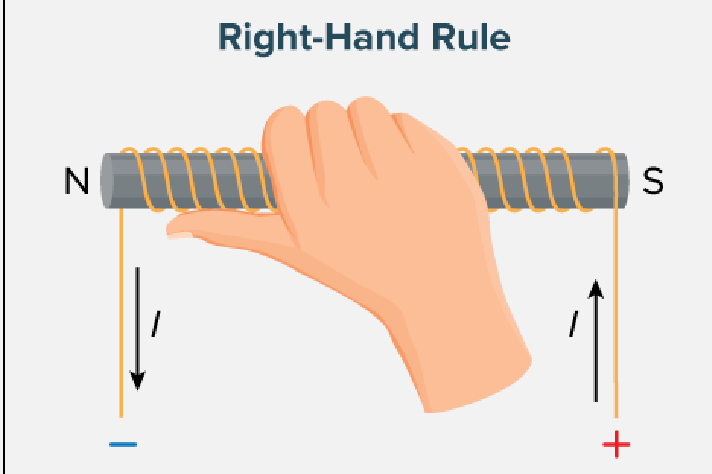
<td>
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Solenoid: A long coil of wire with many spirals loops that is attached to a circuit; fields from each loop add to the fields of the other loop, creating a greater total field strength.

LO – 3: Apply the equation [$EMF = BLvSin(\Theta)$] to determine the magnitude of induced emf for a wire moving through a magnetic field. Page 273.

Q I, P 275: straight wire, 0.5 m long, is moved straight up at a speed of 20 m/s through a 0.4-T magnetic field pointed in the horizontal direction.
a. What EMF is induced in the wire?
b. The wire is part of a circuit of total resistance of 6.0 Ω. What is the current in the circuit?
Solution:

$$EMF = BLv\sin\theta \qquad \Longrightarrow \qquad EMF = (0.4)(0.5)(20)\sin 90° = 4\ V$$

$$I = \frac{EMF}{R} \qquad \Longrightarrow \qquad I = \frac{4}{6} = 0.7\ A$$

Q 2, P 275: A straight wire, 25 m long, is mounted on an airplane flying at 125 m/s. The wire moves in a perpendicular direction through Earth’s magnetic field ($B = 5.0\ \times 10^{-5}\ T$). What EMF is induced in the wire?

$$EMF = BLv\,sin\,\theta \qquad \Longrightarrow \qquad EMF = (5.0\ \times 10^{-5})(25)(125)\,sin\,90° = 0.15625\ V\ \ \approx 0.16\ V$$

Q 3, P 275: A straight wire segment in a circuit is 30.0 m long and moves at 2.0 m/s perpendicular to a magnetic field.
a. A 6.0 V EMF is induced. What is the magnetic field?
b. The total resistance of the circuit is 5.0 Ω. What is the current?

$$EMF = BLv\sin\theta \qquad \Longrightarrow \quad B = \frac{EMF}{Lv\sin\theta} = \frac{6.0}{(30.0)(2.0)\sin 90°} = 0.10\ T$$

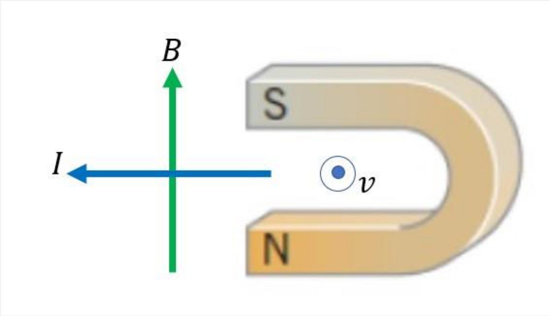
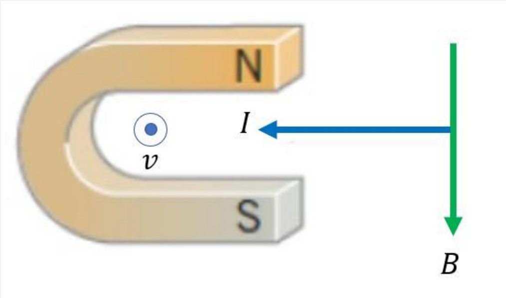
$$I = \frac{EMF}{R} \qquad \Longrightarrow \quad I = \frac{6.0}{5.0} = 1.2\ A$$

Q 4, P 275: A horseshoe magnet is mounted so that the magnetic field lines are vertical. You pass a straight wire between the poles and pull it toward you, the current through the wire is from right to left. Which is the magnet's north pole? Explain?

The north pole is at the bottom.

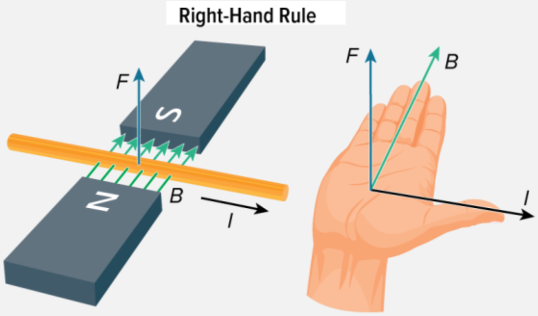
Two possible scenarios need to be examined, under the conditions of the magnetic field (B) directed vertically, and the current (I) from right to left.

The right – hand rule:
The four fingers point to the direction of (B)
The thumb points to the direction of motion (v)
The perpendicular on the palm of the right hand indicates to the direction of induced current (I)

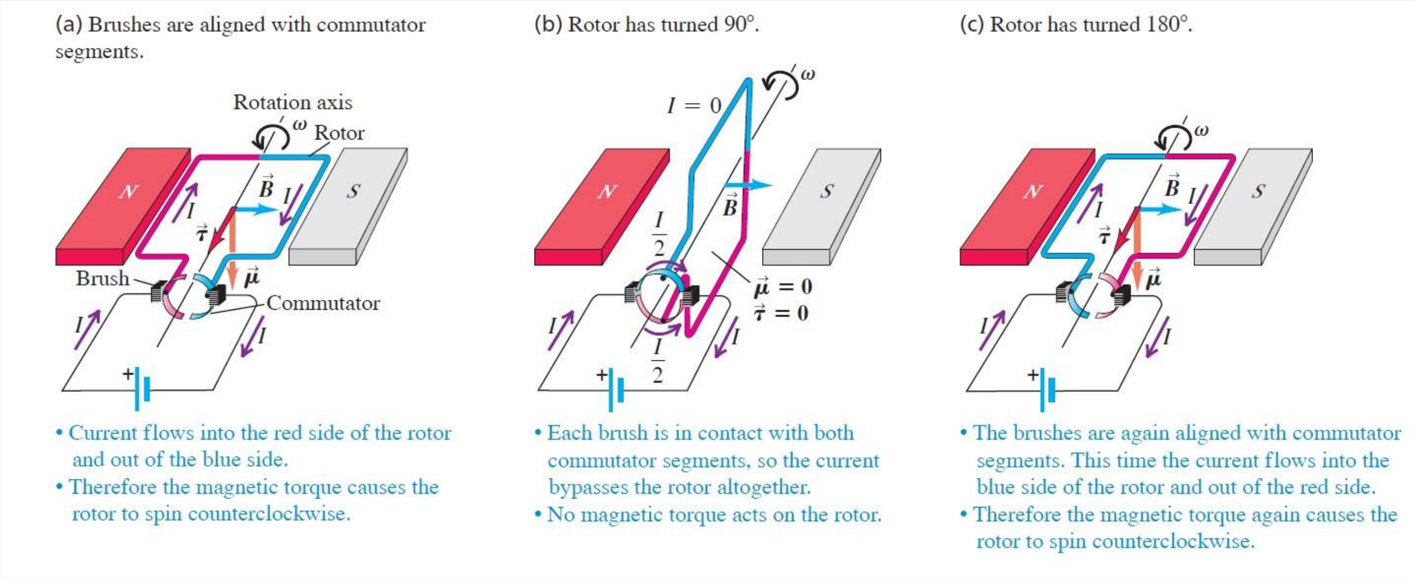
Match the right – hand rule.	Contradicts the right – hand rule.
	

LO – 4: Indicate the direction of magnetic forces on a current-carrying rectangular loop of wire in a magnetic field and determine how the loop will tend to rotate as a consequence of these forces. Page 254.

$$F = ILB\sin\theta$$



The magnetic force always acts on only two side of the rectangular loop, ($For\ \theta = 90°\ and\ \theta = 270°$), where θ is the angle between B and I. These two forces cause a net torque on the loop that will rotate the loop.
Note: ($For\ \theta = 0°\ \ and\ \theta = 180°$), the force is zero.



LO – 5: Conduct an experiment to measure potential differences, currents, and resistances in electric circuits and describe their relationships in series and parallel circuits. Page 222.

Q 1, P 222: Three 22 Ω resistors are connected in series across a 125 V generator. What is the equivalent resistance of the circuit? What is the current in the circuit?

$$R_{eq} = R_1 + R_2 + R_3 \qquad \Longrightarrow \quad R_{eq} = 22 + 22 + 22 = 66\ \Omega$$

$$I = \frac{V}{R_{eq}} \qquad \Longrightarrow \qquad I = \frac{125}{66} = 1.9\ A$$

Q 2, P 222: A 12 Ω, a 15 Ω $and\ a$ 5 Ω resistors are connected in a series circuit with a 75 V battery. What is the equivalent resistance of the circuit? What is the current in the circuit?

$$R_{eq} = R_1 + R_2 + R_3 \qquad \Longrightarrow \quad R_{eq} = 12 + 15 + 5 = 32\ \Omega$$

$$I = \frac{V}{R_{eq}} \qquad \Longrightarrow \qquad I = \frac{75}{32} = 2.3\ A$$

Q 3, P 222: A string of lights has ten identical bulbs with equal resistances connected in series. When the string of lights is connected to a 117 V outlet, the current through the bulbs is 0.06 A. What is the resistance of each bulb?

$$I = \frac{V}{R_{eq}} \qquad \Longrightarrow \qquad R_{eq} = \frac{V}{I} \qquad \Longrightarrow \qquad R_{eq} = \frac{117}{0.06} = 1950\ \Omega$$

$$R_{eq} = R_1 + R_2 + R_3 + \cdots + R_{10} \qquad \Longrightarrow \quad R_{eq} = (10)\ \mathrm{R} \qquad \Longrightarrow \qquad \mathrm{R} = \frac{R_{eq}}{10} = \frac{1950}{10} = 195\ \Omega$$

Q 4, P 222: A 9-V battery is in a circuit with three resistors connected in series.
a. If the resistance of one of the resistors increases, how will the equivalent resistance change?
b. What will happen to the current?
c. Will there be any change in the battery voltage?

$R_{eq} = R_1 + R_2 + R_3$, Increasing the resistance of any of the resistors will increase the equivalent resistance.

$I = \frac{V}{R_{eq}}$, as R_{eq} increase the current (I) will be decreasing. I *and* R_{eq} are inversely proportional

Not any change on the battery voltage will happen, as it doesn't depend on R_{eq}.

Q 5, P 222: Calculate the potential differences across three resistors, $12\ \Omega$, *a* $15\ \Omega$ *and a* $5\ \Omega$, that are connected in series with a 75 V battery. Verify that the sum of their potential differences equals to the potential difference across the battery.

$R_{eq} = R_1 + R_2 + R_3 \qquad \Longrightarrow \quad R_{eq} = 12 + 15 + 5 = 32\ \Omega$

$$I = \frac{V}{R_{eq}} \qquad \Longrightarrow \qquad I = \frac{75}{32} = 2.3\ A$$

$V_1 = I\,R_1$ $V_1 = \left(\frac{75}{32}\right)(12)$ $V_1 = 28.125\ V$	$V_2 = I\,R_2$ $V_2 = \left(\frac{75}{32}\right)(15)$ $V_2 = 35.15625\ V$	$V_3 = I\,R_3$ $V_3 = \left(\frac{75}{32}\right)(5)$ $V_3 = 11.71875\ V$	$28.125 + 35.15625 + 11.71875 = 75\ V$ Energy is conserved. Remember: the potential difference is the amount of energy per unit of charge.

LO – 6: Relate the effective current and effective potential difference to their maximum values in an AC circuit. Page 273.

EFFECTIVE CURRENT.	EFFECTIVE POTENTIAL DIFFERENCE.
Effective current is equal to $\frac{\sqrt{2}}{2}$ times the maximum current. $I_{eff} = \left(\frac{\sqrt{2}}{2}\right) I_{max} = 0.707\ I_{max}$	Effective potential difference is equal to $\frac{\sqrt{2}}{2}$ times the maximum potential difference. $V_{eff} = \left(\frac{\sqrt{2}}{2}\right) V_{max} = 0.707\ V_{max}$

Q 5, P 279: A generator develops a maximum potential difference of 170 V.
a. What is the effective potential difference?
b. A 60-W lightbulb is placed across the generator with an I_{max} of 0.70 A. What is the effective current through the bulb?
c. What is the resistance of the lightbulb when it is working?

a	b	c
$V_{eff} = \left(\frac{\sqrt{2}}{2}\right) V_{max}$ $V_{eff} = \left(\frac{\sqrt{2}}{2}\right) (170)$ $V_{eff} = 120\ V$	$I_{eff} = \left(\frac{\sqrt{2}}{2}\right) I_{max}$ $I_{eff} = \left(\frac{\sqrt{2}}{2}\right) (0.70)$ $I_{eff} = 0.49\ A$	$R = \frac{V_{eff}}{I_{eff}}$ $R = \frac{120.2}{0.50}$ $R = 2.4 \times 10^2\ \Omega$

Note that: $\left(R = \frac{V_{max}}{I_{max}}\right)$ is the same as $\left(R = \frac{V_{eff}}{I_{eff}}\right)$

$$\frac{V_{eff}}{I_{eff}} = \frac{\left(\left(\frac{\sqrt{2}}{2}\right) V_{max}\right)}{\left(\left(\frac{\sqrt{2}}{2}\right) I_{max}\right)} = \frac{V_{max}}{I_{max}}$$

Q 6, P 279: The RMS voltage of an AC household outlet is 117 V. What is the maximum potential difference across a lamp connected to the outlet? If the RMS current through the lamp is 5.5 A, what is the maximum current in the lamp?

V_{max}	I_{max}
$V_{eff} = \left(\frac{\sqrt{2}}{2}\right) V_{max}$ $117 = \left(\frac{\sqrt{2}}{2}\right) (V_{max})$ $V_{max} = \left(\frac{2}{\sqrt{2}}\right)(117)$ $V_{max} = 165\ V$	$I_{eff} = \left(\frac{\sqrt{2}}{2}\right) I_{max}$ $5.5 = \left(\frac{\sqrt{2}}{2}\right) (I_{max})$ $I_{max} = \left(\frac{2}{\sqrt{2}}\right)(5.5)$ $I_{max} = 7.78\ A$

Q 7, P 279: If the average power used over time by an electric light is 75 W, what is the peak power?

$\bar{P}$ is the average power, and P_{peak} is the peak power.

$$\bar{P} = \frac{1}{2} P_{max} \quad \Longrightarrow \quad 75 = \frac{1}{2} P_{max} \quad \Longrightarrow \quad P_{max} = 150\, W$$

Derivation:

$$\bar{P} = I_{eff} V_{eff}$$

$$\bar{P} = \left(\frac{\sqrt{2}}{2}\right) I_{max} \left(\frac{\sqrt{2}}{2}\right) V_{max}$$

$$\bar{P} = \frac{1}{2} I_{max} V_{max}$$

$$\bar{P} = \frac{1}{2} P_{max}$$

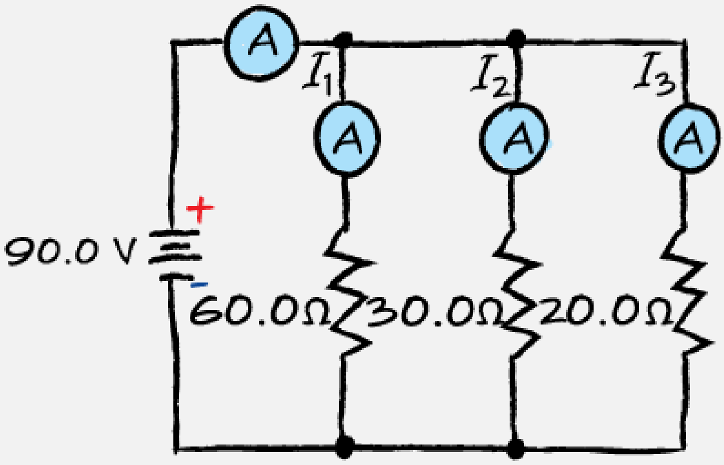
Q 8, P 279: An AC generator delivers a peak voltage of 425 V.
a. What is the V_{eff} in a circuit connected to the generator?
b. The resistance is $5.0 \times 10^2\ \Omega$. What is the effective current?

V_{eff}	I_{eff}
$V_{eff} = \left(\frac{\sqrt{2}}{2}\right) V_{max}$ $V_{eff} = \left(\frac{\sqrt{2}}{2}\right) (425)$ $V_{eff} = 3.01 \times 10^2\ V$	$I_{eff} = \frac{V_{eff}}{R}$ $I_{eff} = \frac{3.01 \times 10^2}{5.0 \times 10^2}$ $I_{eff} = 0.60\,1\ A$

LO – 7: Explain the characteristics of a parallel circuit. Pages 226 – 228.

Example 3, P 228.

Three resistors, $60.0\ \Omega, 30.0\ \Omega$ *and* $20.0\ \Omega$ are connected in parallel across a 90.0 V battery.
a. Find the current through each branch of the circuit.
b. Find the equivalent resistance of the circuit.
c. Find the current through the battery.



Solutions: The three resistors are connected in parallel, so the voltage across each of them is the same.

$I_1 = \frac{V}{R_1}$ $I_1 = \frac{90.0}{60.0}$ $I_1 = 1.50\ A$	$I_2 = \frac{V}{R_2}$ $I_2 = \frac{90.0}{30.0}$ $I_2 = 3.00\ A$	$I_3 = \frac{V}{R_3}$ $I_3 = \frac{90.0}{20.0}$ $I_3 = 4.50\ A$

The equivalent resistance:	The total current	
$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$ $R_{eq} = \left(\frac{1}{60.0} + \frac{1}{30.0} + \frac{1}{20.0}\right)^{-1} = 10.0\ \Omega$	$I = \frac{V}{R_{eq}}$ $I = \frac{90.0}{10.0}$ $I = 9.00\ A$	OR. $I = I_1 + I_2 + I_3$ $I = 1.50 + 3.00 + 4.50$ $I = 9.00\ A$ Charge is conserved.

Question 14, P 229.
You connect three 15.0 Ω resistors in parallel across a 30.0 V battery.
a. What is the equivalent resistance of the parallel circuit.
b. What is the current through the entire circuit.
c. what is the current through each branch of the circuit.

Note: the three resistances are equal, so the current will split equally between them at the junction point.

The equivalent resistance:	The total current	The current through each branch.
$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$ $R_{eq} = \left(\frac{1}{15.0} + \frac{1}{15.0} + \frac{1}{15.0}\right)^{-1} = 5.0\ \Omega$	$I = \frac{V}{R_{eq}}$ $I = \frac{30.0}{5.0}$ $I = 6.00\ A$	$I_{each} = \frac{I_{total}}{3}$ $I_{each} = \frac{6.00}{3}$ $I_{each} = 2.00\ A$

Question 15, P 229.

Suppose you replace one of the 15.0 Ω resistors in the previous problem with a 10.0 Ω resistors.

a. How does the equivalent resistance change?
b. How does the current through the entire circuit change?
c. How does the current through one of the 15.0 Ω resistors change?

The equivalent resistance:	The total current	The current through one of the 15.0 Ω resistors.
$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$ $R_{eq} = \left(\frac{1}{15.0} + \frac{1}{15.0} + \frac{1}{10.0}\right)^{-1} = \frac{30}{7} = 4.29\ \Omega$	$I = \frac{V}{R_{eq}}$ $I = \frac{30.0}{4.29}$ $I = 7.00\ A$	$I_{15\Omega} = \frac{V}{15}$ $I_{15\Omega} = \frac{30.0}{15.0}$ $I_{15\Omega} = 2.00\ A$

The equivalent resistance reduced by 0.71 Ω
The entire current increased by 1.00 A
The current through each of the two 15.0 Ω resistors will stay the same.

The amount of drop in the equivalent resistance was related to the amount of increase in the total current. $\Delta V = I\ R$, Ohm's Law, I and R are inversely proportional to keep the potential difference constant through the parts of the circuit.

Question 16, P 229.

You connect a 120.0 Ω resistor, a 60.0 Ω resistor, and a 40.0 Ω resistor in parallel across a 12.0 V battery.

a. What is the equivalent resistance of the parallel circuit.
b. What is the current through the entire circuit.
c. what is the current through each branch of the circuit.

The equivalent resistance:	The total current
$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$ $R_{eq} = \left(\frac{1}{120.0} + \frac{1}{60.0} + \frac{1}{40.0}\right)^{-1} = 20.0\ \Omega$	$I = \frac{V}{R_{eq}}$ $I = \frac{12.0}{20.0}$ $I = 0.600\ A$

The current through each branch			Charge is conserved
$I_1 = \frac{V}{R_1}$ $I_1 = \frac{12.0}{120.0}$ $I_1 = 0.100\ A$	$I_2 = \frac{V}{R_2}$ $I_2 = \frac{12.0}{60.0}$ $I_2 = 0.200\ A$	$I_3 = \frac{V}{R_3}$ $I_3 = \frac{12.0}{40.0}$ $I_3 = 0.300\ A$	$I = I_1 + I_2 + I_3$ $I = 0.100 + 0.200 + 0.300$ $I = 0.600\ A$

Question 17, P 229.

You are trying to reduce the resistance in a branch of a circuit from 150 Ω to 93 Ω. You add a resistor to this branch of the circuit to make this change. What value of resistance should you use, and how should you connect this resistor?

The parallel connection has the feature of reducing the resistance.

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

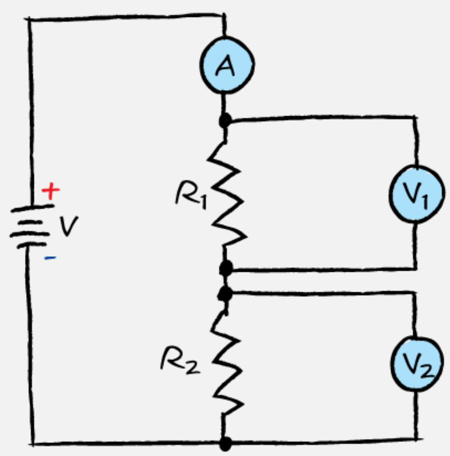
$$93 = \left(\frac{1}{150} + \frac{1}{R_2}\right)^{-1} \qquad \Longrightarrow \quad R_2 = \frac{4650}{19} = 240\ \Omega$$

LO – 8: Explain the characteristics of a series circuit. Pages 221 – 225.

Example 1, P 224.

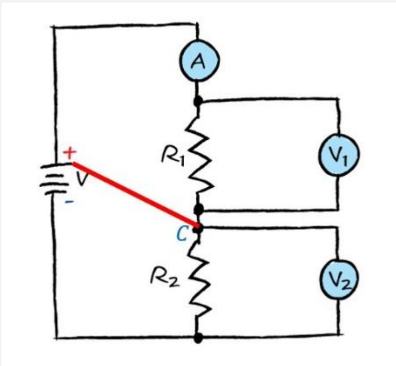
Two resistors, $47\ \Omega$ *and* $82\ \Omega$ are connected in series across a 45 V battery.

a. What is the current in the circuit?
b. What is the potential difference across each resistor?
c. If you replace the $47\ \Omega$ resistor with a $39\ \Omega$ resistor, will the current increase, decrease, or remain the same?
d. What is the new potential difference across the $82\ \Omega$ resistor?

a	b		
$R_{eq} = R_1 + R_2$ $R_{eq} = 47 + 82$ $R_{eq} = 129\ \Omega$ $I = \frac{V}{R_{eq}}$ $I = \frac{45}{129}$ $I = 0.35\ A$	$V_1 = I\ R_1$ $V_1 = \left(\frac{45}{129}\right)(47)$ $V_1 = \frac{705}{43} = 16\ V$	$V_2 = I\ R_2$ $V_2 = \left(\frac{45}{129}\right)(82)$ $V_2 = \frac{1230}{43} = 29\ V$	

C: replacing the 47 Ω resistor with a 39 Ω resistor	D: the new potential difference across the 82 Ω resistor.
$R_{eq} = R_1 + R_2$ $R_{eq} = 39 + 82$ $R_{eq} = 121\ \Omega$ $I = \frac{V}{R_{eq}}$ $I = \frac{45}{121}$ $I = 0.37\ A$ The current will increase.	$V_2 = I\ R_2$ $V_2 = \left(\frac{45}{121}\right)(82)$ $V_2 = \frac{3690}{121} = 30\ V$ the new potential difference across the 39 Ω resistor. $V_1 = I\ R_1$ $V_1 = \left(\frac{45}{121}\right)(39)$ $V_1 = \frac{1755}{121} = 15\ V$

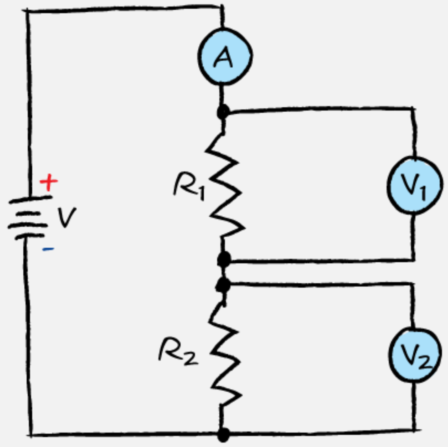
Question 6, P 225.
The circuit shown in Example 1 is producing these symptoms: the ammeter reads 0 A, ΔV_1 reads 0 V, and ΔV_2 reads 45 V. What has happened?

The positive terminal of the battery has been connected to the point C, so no current will pass through the resistance (R_1), and that explain why both ammeter and voltmeter of (R_1) reads zeros values. The current will flow throughout the least amount resistance path (the red wire), which is known as short circuit. The total potential difference of the battery will be measured only around the other resistance (R_2).	

Question 7, P 225.

Suppose the circuit shown in Example 1 has these values: $R_1 = 225\ \Omega$, $R_2 = 290\ \Omega$, and $\Delta V_1 = 17\ V$. No other information is available.

a. What is the current in the circuit?
b. What is the potential difference across the battery?
c. What is the total power used in the circuit, and what is the power used in each resistor?
d. Does the sum of the power used in each resistor in the circuit equal the total power used in the circuit? Explain?



a	b	c	d
$R_{eq} = R_1 + R_2$ $R_{eq} = 225 + 290$ $R_{eq} = 515\ \Omega$ $I = \frac{V}{R_{eq}}$ $I = \frac{V}{515}$ $I = \frac{\left(\frac{1751}{45}\right)}{515}$ $I = \frac{17}{225} = 0.076\ A$	$V_1 = I\ R_1$ $17 = \left(\frac{V}{515}\right)(225)$ $V = \frac{1751}{45} = 38.9\ V$ So, $V_2 = V - V_1$ $V_2 = \frac{1751}{45} - 17$ $V_2 = \frac{986}{45} = 21.9\ V$	$P = \frac{V^2}{R}$ $P_{total} = \frac{38.9^2}{515}$ $P_{total} = 2.94\ W$ $P_1 = \frac{V_1^2}{R_1}$ $P_1 = \frac{17^2}{225} = 1.28\ W$ $P_2 = \frac{21.9^2}{290} = 1.66\ W$	Yes. The law of conservation of energy states that energy cannot be created or destroyed, therefore the rate at which energy is converted, or power dissipated, will equal the sum of all parts.

Question 8, P 225.

Holiday light often are connected in series and use special lamps that short out when the voltage across a lamp increases to the line voltage. Explain why. Also explain why these light sets might blow their fuses after many bulbs have failed.

If not for the shorting mechanism, the entire set would go out when one lamp burns out. After several lamps fail and then short, the reduced total resistance of the remaining working lamps results in an increased current sufficient to blow the fuse.

Question 9, P 225.
The circuit in Example 1 has unequal resistors. Explain why the resistor with the lower resistance will operate at a lower temperature.
The resistor with the lower resistance will dissipate less power, and thus will be cooler.
($P = I^2 R$) indicates that in the series connection, the power (P) and the resistance R are directly proportional.

Question 10, P 225.
A series circuit is made up of 12 V battery and three resistors. The potential difference across one resistor is 1.2 V, and the potential difference across another resistor is 3.3 V. What is the voltage across the third resistor?
$V = V_1 + V_2 + V_3 \quad \Longrightarrow \quad 12 = 1.2 + 3.3 + V_3 \quad \Longrightarrow \quad V_3 = 7.5\,V$

LO – 9: State and apply Kirchhoff's loop rule and relate it to the conservation of energy.
Page 229.
A loop is any closed conducting path.
Kirchhoff's loop rule state that the sum of increases in electric potential around a loop in an electric circuit equals the sum of decreases in electric potential around that loop.

$$\Sigma \text{ increases in electric potential} = \Sigma \text{ decreases in electric potential}$$

The principle of conservation of energy is inevitably embedded in Kirchhoff's loop rule, as the electric potential defined as the amount of energy per unit of charge.

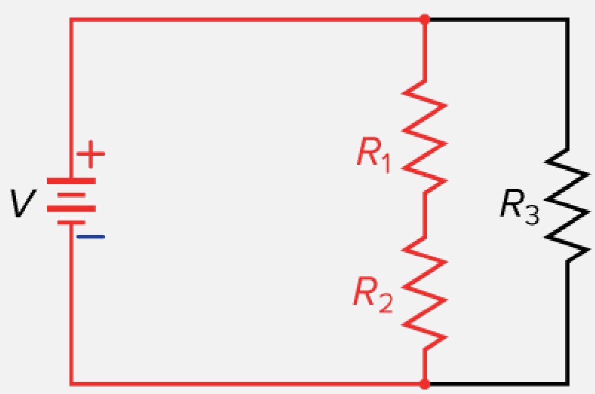
Electric potential = Energy per Coulomb

Practice: Figure 8, Page 229.

If electric potential increases by 9 V as charge travels through the battery, and electric potential drops by 5 V as this charge travels through resistor (1), then and because the increases in electric potential around a loop must equal the decreases in electric potential around that loop.

The electric potential across resistor (2) must be ($9\,V - 5\,V = 4\,V$).

Note that resistor (3) does not affect the answer. Because resistor (3) is NOT a part of the loop that includes the battery, resistor (1), and resistor (2).



LO – 10: Define magnetic flux. Page 250.

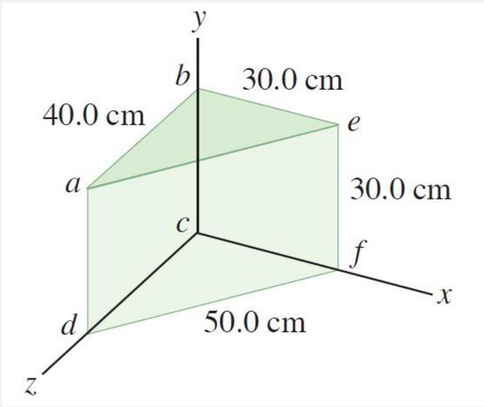
Magnetic flux (**Φ**) is the number of magnetic fields lines (***B***) that passes through a perpendicular surface (***A***).

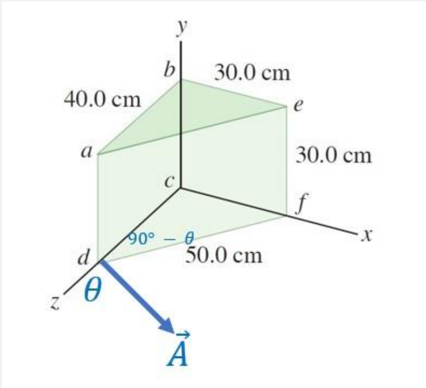
$(\Phi = B\ A \cos\theta)$, where the angle (θ) is the angle between (***B***) and (***A***).

The direction of area vector is always perpendicular to it. For open surfaces, we have to arbitrarily choose between two perpendiculars, but for closed surfaces, we choose the outward direction as our standard.

The SI unit of magnetic flux is weber (Wb), where ($1\, Wb = 1\, T\, .\, m^2$)

Practice Question:

Given that: $B = 0.128\, T$, and it is directed along the positive z – axis. 1. Find the magnetic flux through the surface adfe. 2. Find the magnetic flux through the surface bcfe	

a	b	
Solution: $\cos\theta = \sin(90° - \theta)$ $\cos\theta = \frac{30.0\, cm}{50.0\, cm} = 0.60$ $\Phi = B\ A \cos\theta$ $\Phi = (0.128)(0.50 \times 0.30)\ (0.60)$ $\Phi = 0.01152\, Wb$	Solution: $\Phi = B\ A \cos\theta$ $\Phi = (0.128)(0.3^2)\ (\cos 180\,°)$ $\Phi = -0.01152\, Wb$	

The magnetic flux through each of abcd, abe, dcf are all zeros due to the fact that these surfaces are parallel to the magnetic field.

$\Phi_{total} = 0.01152 + (-0.01152) + 0 + 0 + 0 = zero.$

The magnetic flux through any three – dimensional surface area must be zero.
The number of B lines entering the surface must equal the number of B lines leaving that surface. Magnetic field lines are conserved.

LO – 11: Apply the equation F=BILSin(θ)to calculate the magnitude of the force on a straight segment of a current-carrying wire placed in a uniform magnetic field. Page 255.

Question 21, P 256.
A wire that is 75 cm long, carrying a current of 6.0 A, is at right angles to a uniform magnetic field. The magnitude of the force acting on the wire is 0.60 N. What is the strength of the magnetic field?

$F = BIL \sin\theta$

$$0.60 = (B)\,(6.0)\,(0.75)\sin 90° \quad \Longrightarrow \quad B = \frac{0.60}{(6.0)\,(0.75)\sin 90°} = \frac{2}{15} = 0.13\ T$$

Question 22, P 256.
A 40.0-cm-long copper wire carries a current of 6.0 A and weighs 0.35 N. A certain magnetic field is strong enough to balance the force of gravity on the wire. What is the strength of the magnetic field?

The two forces are balanced, so they are equal in magnitudes and opposite in directions.

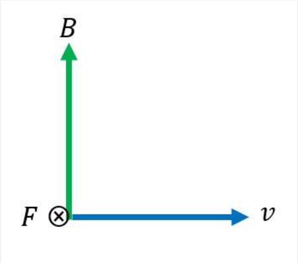
$$0.35 = BIL \sin\theta \quad \Longrightarrow \quad 0.35 = (B)\,(6.0)\,(0.40)\sin 90°$$

$$B = \frac{0.35}{(6.0)\,(0.40)\sin 90°} = \frac{7}{48} = 0.15\ T$$

Note that the weight is always directed vertically downward, so the magnetic force must be upward.

LO – 12: Apply the right-hand rule to determine the direction of the force acting on a charged particle moving in a magnetic field. Page 258.

Question 25, P 260.
In what direction is the force on an electron if that electron is moving east through a magnetic field that points north?

Use your left-hand as the electron has a negative charge. The force will be directed downward if v – B exists in horizontal plane. Into the page if v – B exists in vertical plane.	

Question 26, P 260.
What are the magnitude and direction of the force acting on the proton shown in Figure 27.

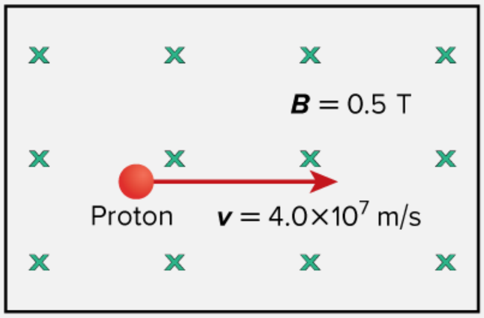
Use your right-hand as the proton has a positive charge.

F will be directed upward.

$F = qvB \sin\theta$

$F = (1.6 \times 10^{-19})(4.0 \times 10^{7})(0.5) \sin 90°$

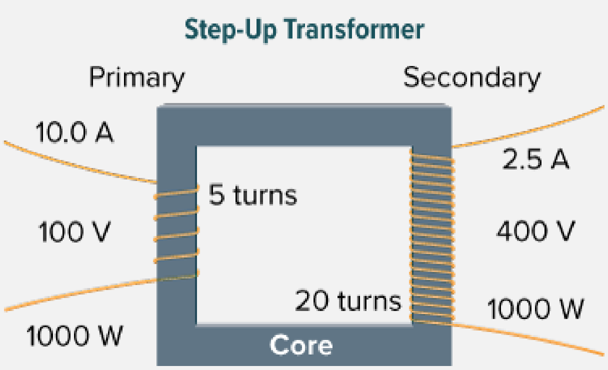
$F = 3.2 \times 10^{-12}\ N$

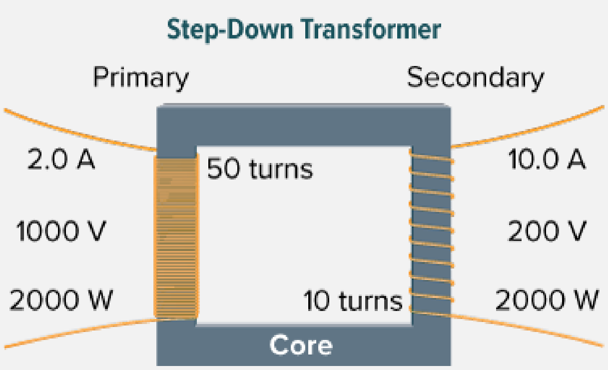


LO – 13: Calculate the equivalent resistance of a parallel circuit. Page 226 - 228.
All covered, solved and explained in LO – 7.

LO – 14: Define a transformer and mutual inductance. Page 284.

Transformer is a device that can decrease or increase the voltage in AC circuits with relatively little energy loss.





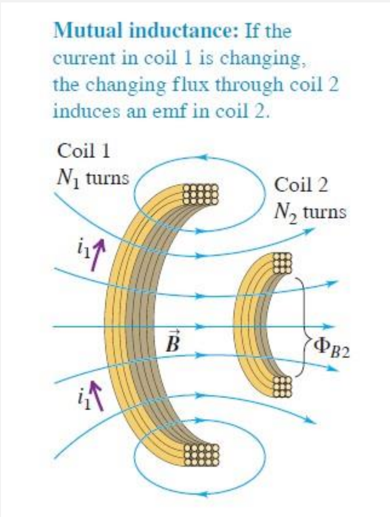
Step-Up Transformer	Step-Down Transformer
$V_p < V_s$	$V_p > V_s$
$I_p > I_s$	$I_p < I_s$
$N_p < N_s$	$N_p > N_s$

Transformer's equation: $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

Ideal transformer equation
Input power = output power

$$I_p V_p = I_s V_s$$

Mutual inductance: effect in which a changing current in a coil creates a changing magnetic field that induces a varying EMF in a second coil.



Mutually induced emfs:

$$\mathcal{E}_2 = -M\frac{di_1}{dt} \quad \text{and} \quad \mathcal{E}_1 = -M\frac{di_2}{dt}$$

Induced emf in coil 2; Rate of change of current in coil 1; Induced emf in coil 1; Rate of change of current in coil 2; Mutual inductance of coils 1 and 2

Mutual inductance of coils 1 and 2

$$M = \frac{N_2\Phi_{B2}}{i_1} = \frac{N_1\Phi_{B1}}{i_2}$$

Turns in coil 2; Magnetic flux through each turn of coil 2; Turns in coil 1; Magnetic flux through each turn of coil 1; Current in coil 1 (causes flux through coil 2); Current in coil 2 (causes flux through coil 1)

Self-inductance: the property of a wire, either straight or in a coil, to create an induced EMF that opposes the change in the potential difference across the wire.

Self-inductance (or **inductance**) of a coil

$$L = \frac{N\Phi_B}{i}$$

Number of turns in coil; Flux due to current through each turn of coil; Current in coil

LO – 15: Explore experimentally the relationship between electric current and magnetic field and the factors that affect the strength of an electromagnet. Page 251.

Electromagnet is a type of magnet whose magnetic field is produced by electric current.

1. When a current is turned on in a solenoid, each loop produces its own magnetic field. The fields are all in same directions.
2. The strength of the magnetic field in a solenoid is proportional to the current in the solenoid's loop.
3. The strength of the magnetic field in a solenoid is proportional to the number and spacing of loops.
4. Finally, the magnetic field strength in a solenoid can be increased by placing an iron-containing rod inside. Because the solenoid's field produces a temporary magnetic field in the iron.

Question 5, P 253.
How does the strength of a magnetic field, 1 cm from a current carrying wire, compare with each of the following?
a. the strength of the field that is 2 cm from the wire
b. the strength of the field that is 3 cm from the wire

The strength of a magnetic field of a current carrying wire is directly proportional to the distance, So:

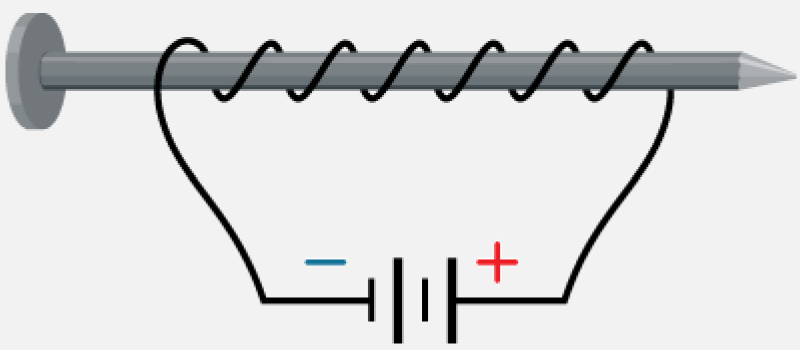
a. The strength of a magnetic field, 1 cm from a current carrying wire is twice as strong as the strength of the field that is 2 cm from the wire.

b. The strength of a magnetic field, 1 cm from a current carrying wire is three times as strong as the strength of the field that is 3 cm from the wire

Question 6, P 253.
A long, straight, current-carrying wire lies in a north-south direction.
a. The north pole of a compass needle placed above this wire points toward the east. In what direction is the current?
b. If a compass were put underneath the wire, in which direction would the compass needle point?

a. Applying the right-hand rule: the four fingers to east, the thumb will be directed from south to north.
b. West.

Question 7, P 253.
A student makes a magnet by winding wire around a nail and connecting it to a battery, as shown in Figure 13. Which end of the nail - the pointed end or the head - is the north pole?

Curl the four fingers in direction of the current inside the solenoid, then the thumb will be directed to the right. So, the pointed end will be the north pole.	

Question 8, P 253.
You have a spool of wire, a glass rod, an iron rod, and an aluminum rod. Which rod should you use to make an electromagnet to pick up steel objects? Explain.
Use the iron rod. Iron would be attracted to a permanent magnet and take on properties of a magnet, whereas aluminum or glass would not. This effect would support the magnetic field in the wire coil and thus make the strongest electromagnet.

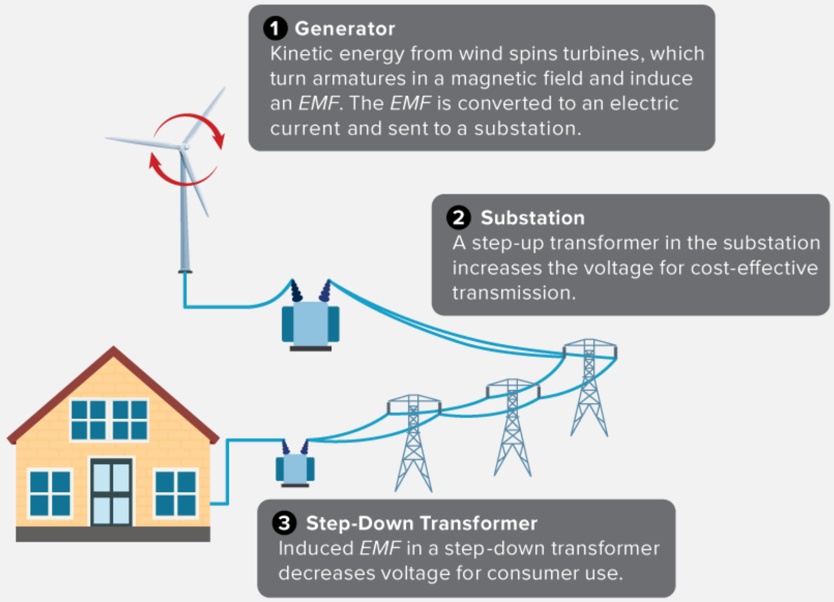
Question 9, P 253.
The electromagnet in the previous problem works well, but you would like to make the strength of the electromagnet adjustable by using a potentiometer as a variable resistor. Is this possible? Explain.
Yes, connect the potentiometer in series with the power supply and the coil. Adjusting the potentiometer for more resistance will decrease the current and the field strength.

LO – 16: Explain how transformers are used in the National Grid System to transmit power through long distances with minimal power losses. Page 287.

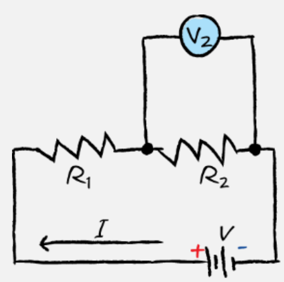
High potential differences reduce the current required in the transmission lines, keeping the wasteful energy transformations low.

1. Step-up transformers are used at power sources, where they can develop potential difference as high as 480,000 V.
2. When the energy reaches homes, step-down transformers reduce the potential difference to 120 V.
3. Electric devices at home deuce the potential difference to usable levels of a range of 3 V – 26 V.

Figure 16. Step-up transformers increase potential differences (voltages) in overhead power lines. Step-down transformers decrease potential differences for consumer use.



WRITTEN PART
LO – 17: Use the voltage divider circuit as a series circuit to calculate resistances and voltage drop across the components. Page 225.
All applications problems are solved in LO – 8.
Example 2. Page 225:
A 9.0 V battery and two resistors, 390 Ω *and* 470 Ω, are connected as a voltage divider. What is the potential difference across the 470 Ω resistor?

$R_{eq} = R_1 + R_2$ $R_{eq} = 390 + 470$ $R_{eq} = 860\ \Omega$	$I = \frac{V}{R_{eq}}$ $I = \frac{9.0}{860}\ A$	$V_2 = I\,R_2$ $V_2 = \left(\frac{9.0}{860}\right)(470)$ $V_2 = 4.9\ V$	

LO – 18: Apply the equation F=BILSin(θ)to calculate the magnitude of the force on a straight segment of a current-carrying wire placed in a uniform magnetic field. Page 256.

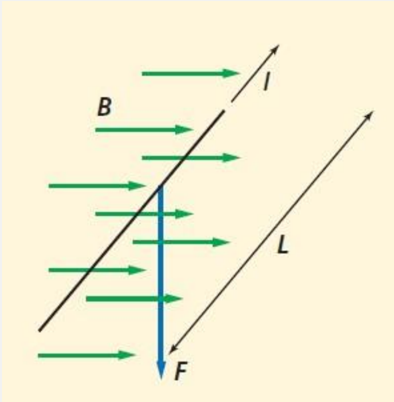
Example 1, Page 256.

A straight wire carrying a 5.0-A current is in a uniform magnetic field oriented at right angles to the wire. When 0.10 m of the wire is in the field, the force on the wire is 0.20 N. What is the strength of the magnetic field, B?

$$F = BIL\sin\theta$$

$$0.20 = (B)\,(5.0)\,(0.1)\sin 90°$$

$$B = \frac{0.20}{(5.0)\,(0.1)\sin 90°} = 0.40\ T$$



Question 19, P 256.

Explain the method you could use to determine the direction of force on a current-carrying wire at right angles to a magnetic field. Identify what must be known to use this method.
You would use the right-hand rule for the magnetic force on a wire. When you point the fingers of your right hand in the direction of the magnetic field and your thumb in the direction of the wire's conventional (positive) current, the palm of your hand will face in the direction of the force acting on the wire. To use this method, you would need to know the direction of the current and the direction of the field.

Question 20, P 256.

A wire that is 0.50 m long and carrying a current of 8.0 A is at right angles to a 0.40-T magnetic field. How strong is the force that acts on the wire?

$$F = BIL\sin\theta$$

$$F = (0.40)\,(8.0)\,(0.5)\sin 90° = 1.6\ N$$

Question 21, P 256.

A wire that is 75 cm long, carrying a current of 6.0 A, is at right angles to a uniform magnetic field. The magnitude of the force acting on the wire is 0.60 N. What is the strength of the magnetic field?

$$F = BIL\sin\theta$$

$$0.60 = (B)\,(6.0)\,(0.75)\sin 90° \quad \Longrightarrow \quad B = \frac{0.60}{(6.0)\,(0.75)\sin 90°} = \frac{2}{15} = 0.13\ T$$

Question 22, P 256.

A 40.0-cm-long copper wire carries a current of 6.0 A and weighs 0.35 N. A certain magnetic field is strong enough to balance the force of gravity on the wire. What is the strength of the magnetic field?

The two forces are balanced, so they are equal in magnitudes and opposite in directions.

$0.35 = BIL \sin\theta \qquad \Longrightarrow \qquad 0.35 = (B)\,(6.0)\,(0.40) \sin 90°$

$$B = \frac{0.35}{(6.0)\,(0.40)\sin 90°} = \frac{7}{48} = 0.15\ T$$

Note that the weight is always directed vertically downward, so the magnetic force must be upward.

Question 23, P 256.
How much current will be required to produce a force of 0.38 N on a 10.0 cm length of wire at right angles to a 0.49-T field?
$F = BIL \sin\theta$

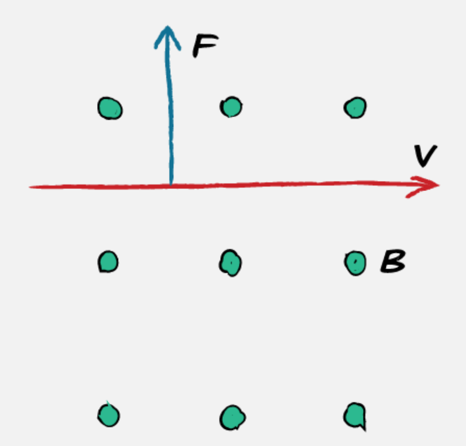
$0.38 = (0.49)\,(I)\,(0.10) \sin 90°$

$$I = \frac{0.38}{(0.49)\,(0.10)\sin 90°} = 7.8\ A$$

Question 24, P 256.
You are making your own loudspeaker. You make a 1 cm diameter coil with 20 loops of thin wire. You use hot glue to fasten the coil to an aluminum pie plate. The ends of the wire are connected to a plug that goes into the earphone jack on an MP3 music player. You have a bar magnet to produce a magnetic field. How would you orient the magnetic field to make the plate vibrate and produce sound?
One pole should be held as close to the coil as possible so that the field lines are perpendicular to both the wires and the direction of motion of the plate.

LO – 19: Apply the equation F=qvBSin(θ) to calculate the magnitude of the force acting on a charged particle moving in a magnetic field. Page 260.

Example 2, Page 260.
A beam of electrons travels at $3.0 \times 10^{6}\ m/s$ through a uniform magnetic field of $4.0 \times 10^{-2}\ T$ at right angles to the field. How strong is the force acting on each electron?

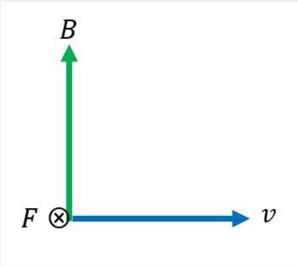
$F = qvB\sin\theta$ $F = (-1.602 \times 10^{-19})\,(3.0 \times 10^{6})\,(4.0 \times 10^{-2}) \sin 90°$ $F = -1.9 \times 10^{-14}\ N$	

Question 25, P 260.
In what direction is the force on an electron if that electron is moving east through a magnetic field that points north?

Use your left-hand as the electron has a negative charge.

The force will be directed downward if v – B exists in horizontal plane.

Into the page if v – B exists in vertical plane.



Question 26, P 260.
What are the magnitude and direction of the force acting on the proton shown in Figure 27.

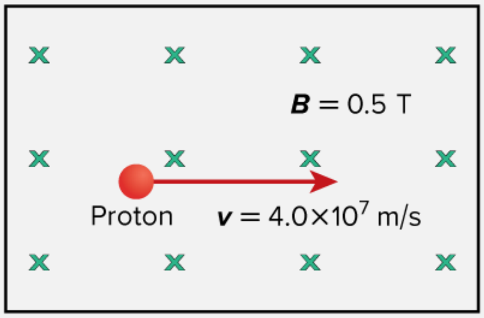
Use your right-hand as the proton has a positive charge.

F will be directed upward.

$F = qvB \sin\theta$

$F = (1.6 \times 10^{-19})(4.0 \times 10^{7})\,(0.5) \sin 90°$

$F = 3.2 \times 10^{-12}\ N$



Question 27, P 260.
A stream of doubly ionized particles (missing two electrons and thus carrying a net positive charge of two elementary charges) moves at a velocity of $3.0 \times 10^{4}\ m/s$ perpendicular to a magnetic field of $9.0 \times 10^{-2}\ T$. How large is the force acting on each ion?

$F = qvB \sin\theta$

$F = (2 \times 1.602 \times 10^{-19})\,(3.0 \times 10^{4})\,(9.0 \times 10^{-2}) \sin 90°$

$F = 8.6 \times 10^{-16}\ N$

Question 28, P 260.
Triply ionized particles in a beam carry a net positive charge of three elementary charge units. The beam enters a magnetic field of $4.0 \times 10^{-2}\ T$. The particles have a speed of $9.0 \times 10^{6}\ m/s$ and move at right angles to the field. How large is the magnitude of the force acting on each particle?

$F = qvB \sin\theta$

$F = (3 \times 1.602 \times 10^{-19})\,(9.0 \times 10^{6})\,(4.0 \times 10^{-2}) \sin 90°$

$F = 1.7 \times 10^{-13}\ N$

Question 29, P 260.
A singly ionized particle experiences a force of $4.1 \times 10^{-13}\ N$ when it travels at a right angle through a 0.61 T magnetic field. What is the particle's velocity?

$F = qvB \sin\theta$

$4.1 \times 10^{-13} = (1.602 \times 10^{-19})\,(v)\,(0.61) \sin 90°$

$$v = \frac{4.1 \times 10^{-13}}{(1.602 \times 10^{-19})\ (0.61) \sin 90°} = 4.2 \times 10^{6}\ m/s$$

Question 30, P 260.
Doubly ionized helium atoms (alpha particles) are traveling at right angles to a magnetic field at a speed of $4.0 \times 10^{4}\ m/s$. The force on each particle is $6.4 \times 10^{-16}\ N$. What is the magnetic field strength?

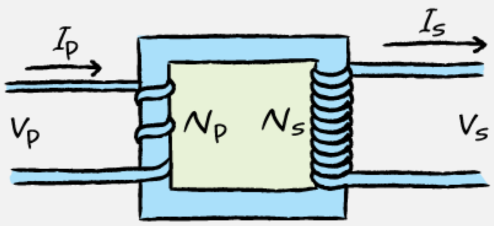
$F = qvB \sin\theta$

$6.4 \times 10^{-16} = (2 \times 1.602 \times 10^{-19})\,(4.0 \times 10^{4})\,(B) \sin 90°$

$$B = \frac{6.4 \times 10^{-16}}{(2 \times 1.602 \times 10^{-19})\ (4.0 \times 10^{4})\ \sin 90°} = 0.05\ T$$

LO – 20: Apply the ideal transformer equation to solve numerical problems. Page 286.

Example 2, Page 286.
A step-up transformer has a primary coil consisting of 200 turns and a secondary coil consisting of 3000 turns. The primary coil is supplied with an effective AC voltage of 90.0 V.
a. What is the voltage in the secondary circuit?
b. The current in the secondary circuit is 2.0 A. What is the current in the primary circuit?

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{90.0}{V_s} = \frac{200}{3000}$ $V_s = (90.0)\left(\frac{3000}{200}\right)$ $V_s = 1350\ V$	Assume an ideal transformer. $V_p I_p = V_s I_s$ $I_p = \frac{V_s I_s}{V_p}$ $I_s = \frac{(1350)(2.0)}{90.0} = 30.0\ A$	

Question 16, P 286.
A step-down transformer has 7500 turns on its primary coil and 125 turns on its secondary coil. The potential difference across the primary circuit is 7.2 kV. What is potential difference across the secondary circuit? If the current in the secondary circuit is 36 A, what is the current in the primary circuit?

V_s	I_p
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{7200}{V_s} = \frac{7500}{125}$ $V_s = (7200)\left(\frac{125}{7500}\right)$ $V_s = 120\ V$	Assume ideal transformer. $V_p I_p = V_s I_s$ $I_p = \frac{V_s I_s}{V_p}$ $I_s = \frac{(120)(36)}{7200} = 0.60\ A$

Question 17, P 286.
A step-up transformer has 300 turns on its primary coil and 90,000 turns on its secondary coil. The potential difference of the generator to which the primary circuit is attached is 60.0 V. The transformer is 95 percent efficient. What is the potential difference across the secondary circuit? The current in the secondary circuit is 0.50 A. What current is in the primary circuit?

V_s	I_p
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{60.0}{V_s} = \frac{300}{90000}$ $V_s = (60.0)\left(\frac{90000}{300}\right)$ $V_s = 18000\ V$	Efficiency is 0.95 $\text{Efficiency} = \frac{P_s}{P_p}$ $0.95 = \frac{V_s I_s}{V_p I_p}$ $I_p = \frac{V_s I_s}{(0.95)V_p} = \frac{(1.80\ \times 10^4)(0.50)}{(0.95)(60.0)} = 157.9\ A$

Part 3 – Question 21: Unpublished.
Part 3 – Question 22: Unpublished.

THE END