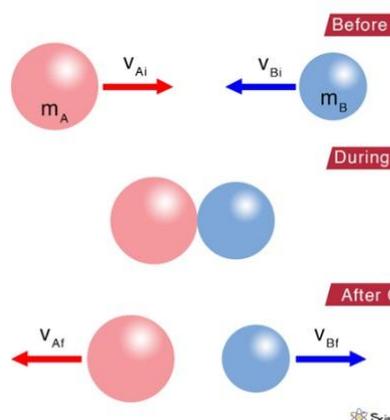
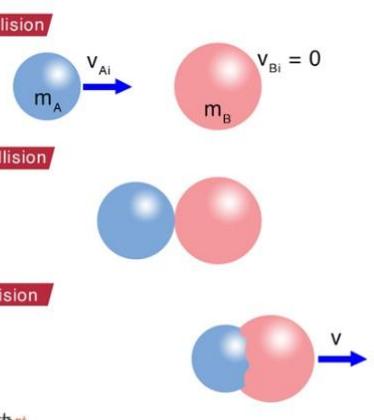
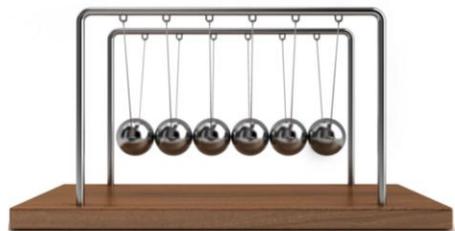


**Harold's High School Physics 2<sup>nd</sup> Semester**  
**Cheat Sheet**  
17 February 2026

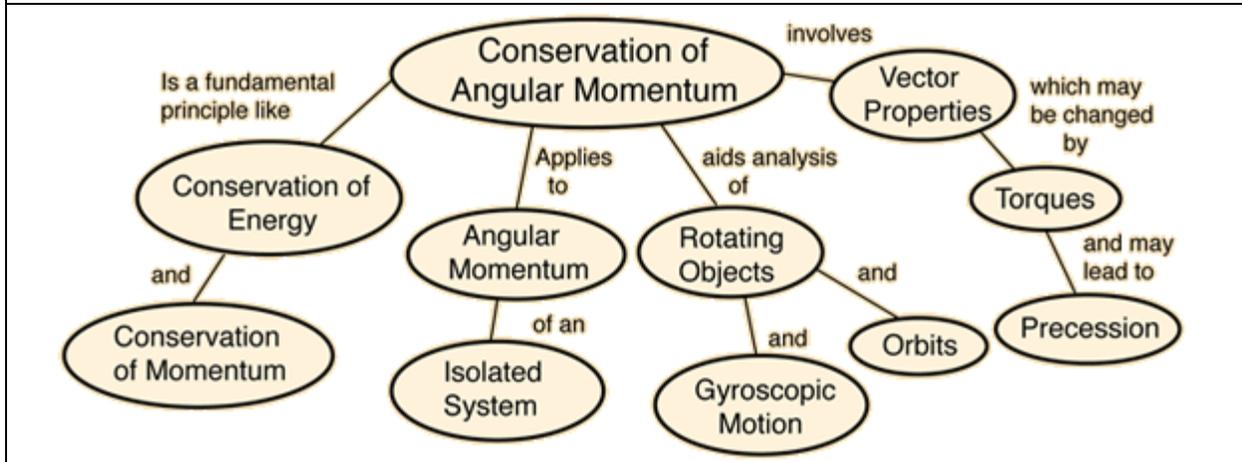
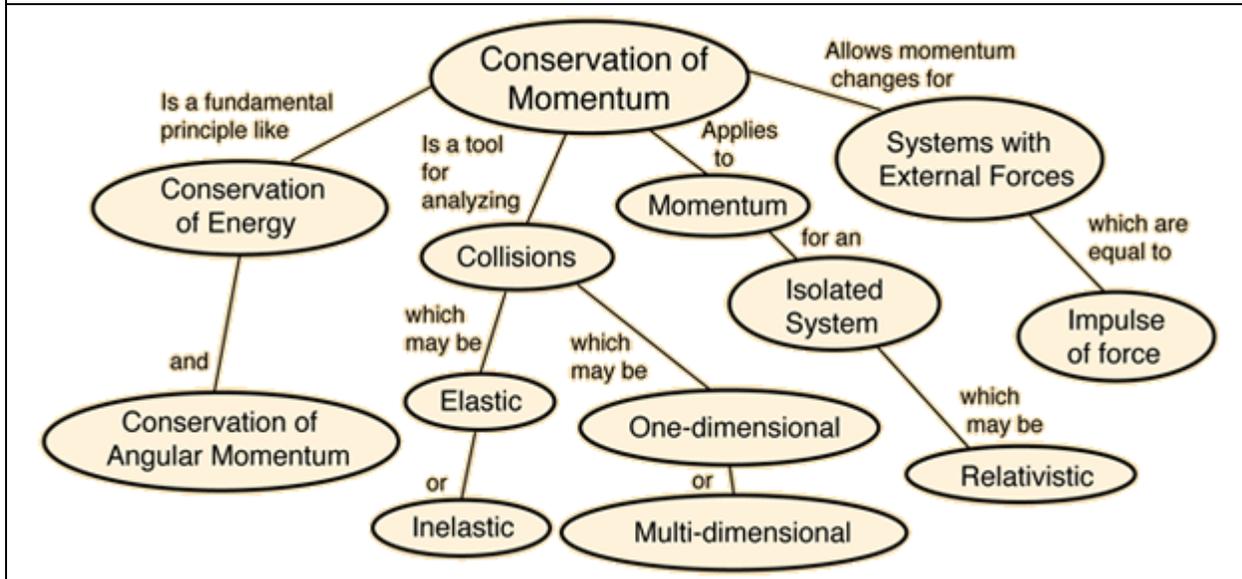
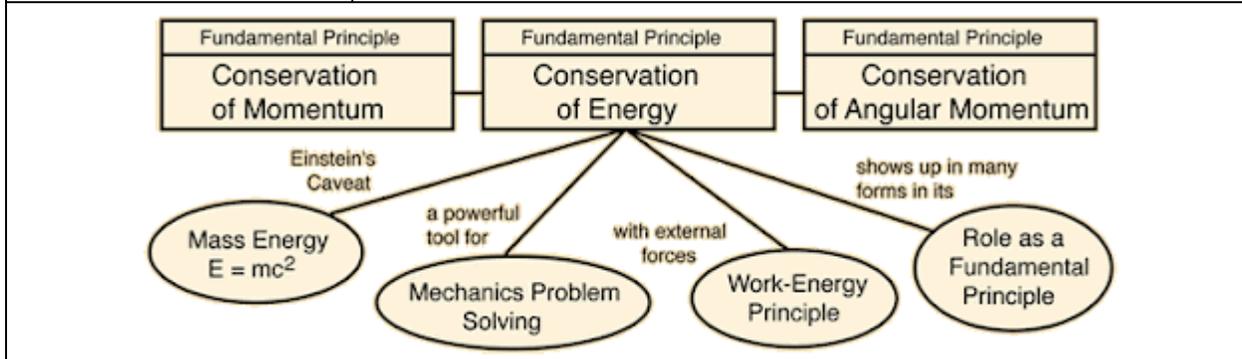
**Chapter 9: Momentum and Its Conservation**

Term	Equations & Descriptions
<b>Momentum</b>	The mass of an object times its velocity.
<b>Law of Momentum Conservation</b>	When the net external force on a system is zero, the total momentum cannot change.
<b>Elastic Collision</b>	A collision in which the total energy of the colliding objects does not change.
<b>Inelastic Collision</b>	A collision in which the total energy of the colliding objects is <u>lower</u> after the collision.
<b>Law of Angular Momentum Conservation</b>	When the net external torque on a system is zero, the total angular momentum cannot change.

Momentum (Linear Momentum)		
<b>Momentum</b>	$p = mv$	$kg \cdot m/s$
<b>Impulse</b>	$\Delta p = F \cdot \Delta t$ $\Delta p = p_{final} - p_{initial}$	$N \cdot s$ or $kg \cdot m/s$ The change in momentum.
<b>Collision Types</b>	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><b>Elastic Collision</b></p> <p>Kinetic energy and momentum are conserved</p>  </div> <div style="text-align: center;"> <p><b>Inelastic Collision</b></p> <p>Kinetic energy is not conserved, but momentum is conserved</p>  </div> </div> <p style="text-align: center; font-size: small;">ScienceFacts.net</p>	
<b>Newton's Cradle</b>	Example of an elastic collision	

Angular Momentum		
<b>Angular Momentum</b>	$L = mvr$	$kg \cdot m^2/s$
<b>Spinning Tire</b>	<p>A spinning bicycle tire requires effort to tilt since it has angular momentum (<math>L</math>).</p> <p>You must apply a torque (<math>\tau</math>) to change the angular momentum.</p>	

Conservation Laws		
Conservation of Linear Momentum: $\mathbf{p}_i = \mathbf{p}_f$	Conservation of Energy: $E_i = E_f$	Conservation of Angular Momentum: $\mathbf{L}_i = \mathbf{L}_f$
Conservation of Energy	The capacity for doing work. "Energy can neither be created nor destroyed".	
Conservation of Momentum	When the net external force is zero: $\mathbf{p}_{before} = \mathbf{p}_{after}$	
Conservation of Angular Momentum	When the sum of the torques is zero: $\mathbf{L}_{before} = \mathbf{L}_{after}$	



## Chapter 10: Periodic Motion

Term	Equations and Descriptions	
<b>Periodic Motion</b>	Motion that repeats itself in equal intervals of time.	
<b>Hooke's Law</b>	The restoring force exerted by an elastic object is directly proportional to the distance it is displaced from its equilibrium position.	
<b>Amplitude</b>	The maximum extent of a periodic motion, defined from the equilibrium position.	
<b>Simple Harmonic Motion</b>	Periodic motion produced by a restoring force that is directly proportional to the distance from the equilibrium position.	
<b>Damped Harmonic Motion</b>	Periodic motion whose amplitude decreases over time.	
<b>Spring</b>		
<b>Spring Force</b>	$F_s = -k \cdot \Delta x$	N
<b>Equilibrium</b>		
<b>Spring Force Graph</b>		Linear $y = mx + b$ $F = kx + 0$
<b>Spring Period</b>	$T_s = 2\pi \sqrt{\frac{m}{k}}$	s
	The period of a mass / spring system depends on $\pi$ because it is a one-dimensional projection of uniform circular motion.	
<b>Max. Spring PE</b>	At the amplitude of a mass / spring system's motion, the restoring force is the greatest, and the speed of the mass is zero.	
<b>Max. Spring KE</b>	At the equilibrium position of a mass / spring system's motion, the restoring force zero, and the speed of the mass is at its maximum value.	
<b>Spring Energy</b>	$PE_s = \frac{1}{2}k\Delta x^2$	$KE_s = \frac{1}{2}mv^2$
	$TE_s = \frac{1}{2}kA^2$	A is amplitude in $x(t) = A \cos(2\pi ft + \phi)$

Pendulum		
Simple Pendulum		
Small Displacement Simplification	A simple pendulum will exhibit simple harmonic motion if the angle that represents its amplitude is small. That is because the restoring force is directly proportional to the displacement only when $\sin \theta \approx \theta$ .	
Pendulum Period	$T_p = 2\pi \sqrt{\frac{\ell}{g}}$	s
Simple Harmonic Motion		
Damped Harmonic Motion		
Mnemonic	<p><i>"Life is <b>Good</b>, if you are a <b>MonKey</b>."</i></p> $T_p = 2\pi \sqrt{\frac{\ell}{g}} \text{ and } T_s = 2\pi \sqrt{\frac{m}{k}}$	

## Chapter 11: Sound and Light

Term	Equations & Descriptions	
<b>Oscillations</b>	Regular variation in magnitude around a central point.	
<b>Wavelength</b>	The distance between two crests or two troughs of a wave.	
<b>Transverse Wave</b>	A wave whose oscillation is perpendicular to its translational motion.	
<b>Longitudinal Wave</b>	A wave whose oscillation is parallel to its translational motion.	
<b>Doppler Effect</b>	A change in the observed frequency of a wave caused by the motion of the wave's source and/or the observer.	
<b>Sound</b>		
<b>Sonic Waves</b>	Waves that the <u>typical</u> person can hear, with frequencies of 20 Hz – 20,000 Hz.	
<b>Ultrasonic Waves</b>	Waves with frequency greater than 20,000 Hz. ( $f > 20 \text{ kHz}$ )	
<b>Infrasonic Waves</b>	Waves with frequency lower than 20 Hz. ( $f < 20 \text{ Hz}$ )	
<b>Timbre</b>	The character of a sound that is not based on the <u>frequency</u> or <u>amplitude</u> of the main sound wave. Examples: <ul style="list-style-type: none"> <li>• air vs. bone conduction</li> <li>• flute vs. violin</li> </ul>	
<b>Wave-Particle Duality</b>	The concept that light, as well as many subatomic particles, have the properties of both particles and waves.	
<b>Frequency</b>	$f = \frac{v}{\lambda}$	Frequency and wavelength are inversely proportional; when one increases, the other decreases.

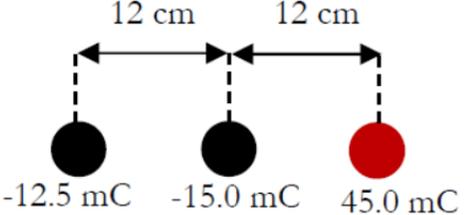
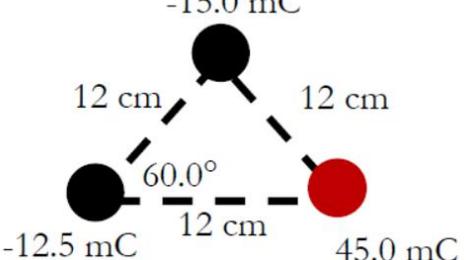
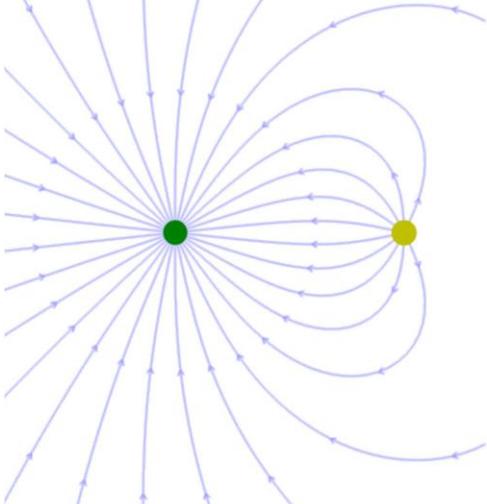
<b>Medium</b>	A wave oscillates a medium so that energy can move from one place to another.																						
<b>Sound Volume &amp; Frequency</b>	<ul style="list-style-type: none"> <li>The higher the <u>amplitude</u> of a sound wave, the higher the <u>volume</u> of the sound.</li> <li>The higher the <u>frequency</u> of a sound wave, the higher the <u>pitch</u> of the sound.</li> </ul>																						
<b>Speed of Sound</b>	$v_{\text{sound}} = (331.3 + 0.606 \cdot T_C) \frac{m}{s}$ <p>Where <math>T_C</math> is the temperature in Celsius.</p> <ul style="list-style-type: none"> <li>The speed of sound increases with increasing elasticity and <u>decreasing density</u>.</li> <li>In general, it travels faster in <u>solids</u>, slower in <u>liquids</u>, and slowest in <u>gases</u>.</li> <li>For solids and gases, the lower the density, the faster the speed of sound.</li> </ul> <table border="1"> <thead> <tr> <th>Physical State</th> <th>Medium</th> <th>Velocity (m/s)</th> <th>Velocity (mph)</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Gas</td> <td>Air (0°C)</td> <td>331</td> <td>740</td> </tr> <tr> <td>Air (25°C)</td> <td>346</td> <td>774</td> </tr> <tr> <td>Helium (0°C)</td> <td>972</td> <td>2,174</td> </tr> <tr> <td>Liquid</td> <td>Water (25°C)</td> <td>1,490</td> <td>3,333</td> </tr> <tr> <td>Solid</td> <td>Iron</td> <td>5,130</td> <td>11,472</td> </tr> </tbody> </table>	Physical State	Medium	Velocity (m/s)	Velocity (mph)	Gas	Air (0°C)	331	740	Air (25°C)	346	774	Helium (0°C)	972	2,174	Liquid	Water (25°C)	1,490	3,333	Solid	Iron	5,130	11,472
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<b>Doppler Effect (Sound)</b>	$f_{\text{observed}} = \left( \frac{v_{\text{sound}} \pm v_{\text{observer}}}{v_{\text{sound}} \pm v_{\text{source}}} \right) \cdot f_{\text{stationary}}$ <ul style="list-style-type: none"> <li>When a <u>source</u> of sound is moving, the frequency in front of the source is higher than the frequency behind the source.</li> <li>When the <u>observer</u> is moving, the frequency is higher as the observer moves towards the source, and it is lower as the observer moves away from the source.</li> <li><u>Add</u> <math>v_{\text{observer}}</math> when the observer is moving <u>towards</u> the source.</li> <li><u>Subtract</u> it when the observer is moving <u>away</u> from the source.</li> <li><u>Subtract</u> <math>v_{\text{source}}</math> when the source is moving <u>towards</u> the observer.</li> <li><u>Add</u> it when the source is moving <u>away</u> from the observer.</li> </ul>																						

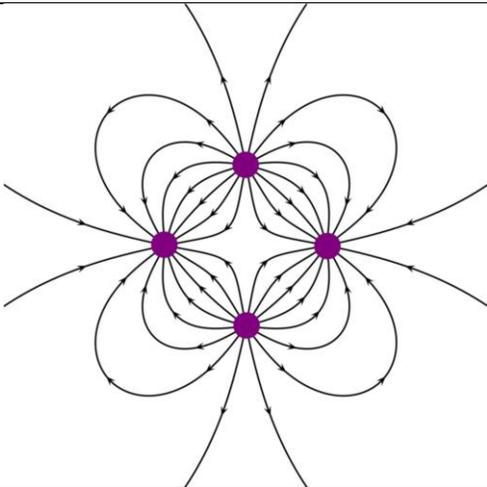
<b>Light</b>	
<b>Electromagnetic Spectrum</b>	<p>The prefix “nano” is abbreviated with “n” and means <math>10^{-9}</math>.</p> <p>Short wavelength <span style="float: right;">Long wavelength</span></p> <p style="text-align: center;">← Energy increases →</p> <p>10<sup>-5</sup> nm   10<sup>-3</sup> nm   1 nm   10<sup>3</sup> nm   10<sup>6</sup> nm   1 m   10<sup>3</sup> m</p> <p>Gamma rays   X rays   Ultraviolet   Infrared   Microwaves   Radio waves</p> <p>10<sup>24</sup> Hz   10<sup>22</sup> Hz   10<sup>20</sup> Hz   10<sup>18</sup> Hz   10<sup>16</sup> Hz   10<sup>12</sup> Hz   10<sup>10</sup> Hz   10<sup>8</sup> Hz   10<sup>6</sup> Hz   10<sup>4</sup> Hz   10<sup>2</sup> Hz</p> <p>High frequency <span style="float: right;">Low frequency</span></p> <p style="text-align: center;">Visible light</p> <p style="text-align: center;">7 × 10<sup>14</sup> Hz <span style="float: right;">4 × 10<sup>14</sup> Hz</span></p>
<b>Photoelectric Effect</b>	$KE_{e\_max} = h \cdot f - \phi$ <p><math>KE_{e\_max}</math> (Max. electronic kinetic energy)  <math>h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}</math> (Planck's constant)  <math>\phi</math> (Work function) expressed in eV (electron-volt).</p> <p>If <math>h &lt; 0</math>, then the electron cannot leave the metal when struck by a photon.</p> <p><math>E_{\text{photon}} = h\nu</math></p> <p>700 nm   1.77 eV   no electrons</p> <p>550 nm   2.25 eV   <math>v_{\text{max}} = 2.96 \times 10^5 \text{ m/s}</math></p> <p>400 nm   3.1 eV   <math>v_{\text{max}} = 6.22 \times 10^5 \text{ m/s}</math></p> <p>Potassium - requires 2.0 eV to eject an electron</p>
<b>Electron-Volt</b>	$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$
<b>Doppler Effect (Light)</b>	<ul style="list-style-type: none"> <li><b>Blueshift:</b> <u>Higher</u> frequency, so the star is moving <u>towards</u> the earth.</li> <li><b>Redshift:</b> <u>Lower</u> frequency, so the star is moving <u>away</u> from the earth.</li> </ul> <p>Long Wave Length   Short Wave Length</p> <p>Low Frequency   High Frequency</p> <p>Low Energy   High Energy</p>

## Chapter 12: Optics

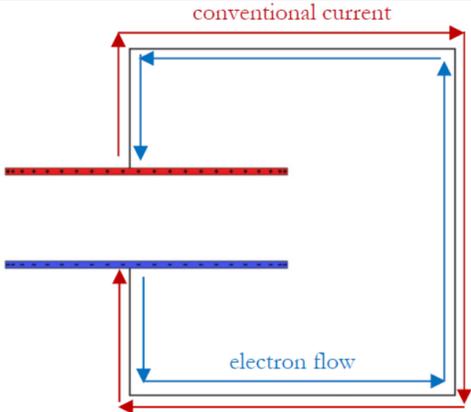
Term	Equations & Descriptions																			
Law of Reflection																				
Virtual Image																				
Real Image																				
Refraction																				
Spherical Aberration																				
Chromatic Aberration																				
		<table border="1"> <thead> <tr> <th data-bbox="932 548 1195 625">Medium</th> <th data-bbox="1195 548 1419 625">Index of Refraction</th> </tr> </thead> <tbody> <tr> <td data-bbox="932 625 1195 669">air</td> <td data-bbox="1195 625 1419 669">1.0003</td> </tr> <tr> <td data-bbox="932 669 1195 714">water</td> <td data-bbox="1195 669 1419 714">1.333</td> </tr> <tr> <td data-bbox="932 714 1195 758">ethanol</td> <td data-bbox="1195 714 1419 758">1.361</td> </tr> <tr> <td data-bbox="932 758 1195 802">ice</td> <td data-bbox="1195 758 1419 802">1.309</td> </tr> <tr> <td data-bbox="932 802 1195 846">glass, crown</td> <td data-bbox="1195 802 1419 846">1.52</td> </tr> <tr> <td data-bbox="932 846 1195 890">glass, flint</td> <td data-bbox="1195 846 1419 890">1.66</td> </tr> <tr> <td data-bbox="932 890 1195 934">fused quartz</td> <td data-bbox="1195 890 1419 934">1.458</td> </tr> <tr> <td data-bbox="932 934 1195 978">diamond</td> <td data-bbox="1195 934 1419 978">2.419</td> </tr> </tbody> </table>	Medium	Index of Refraction	air	1.0003	water	1.333	ethanol	1.361	ice	1.309	glass, crown	1.52	glass, flint	1.66	fused quartz	1.458	diamond	2.419
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## Chapter 13: The Electrostatic Force

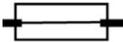
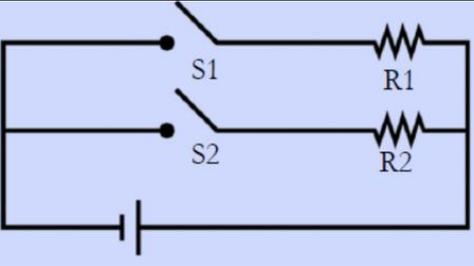
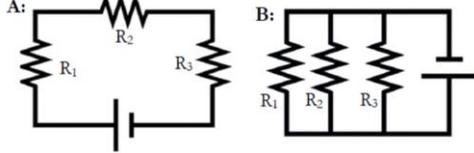
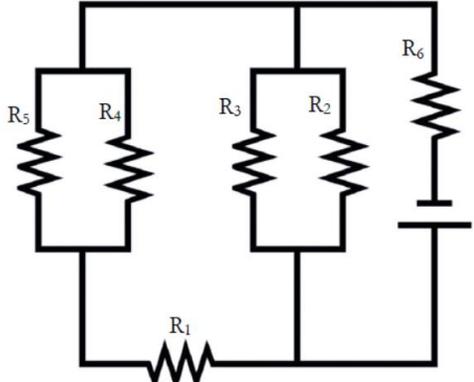
Term	Equations & Descriptions	
Electrostatic Force		
Triboelectric Charging		
Charging by Conduction		
Charging by Induction		
Conductor		
Insulator		
		
		
		

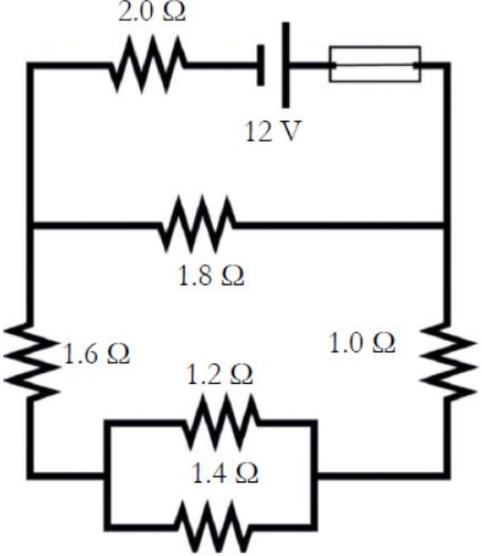
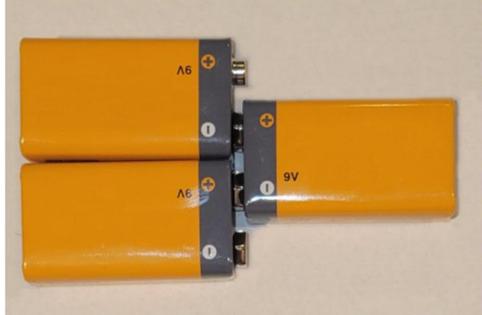
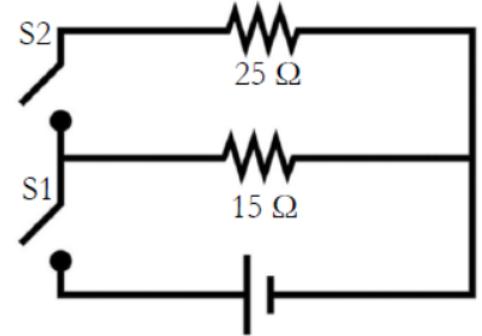
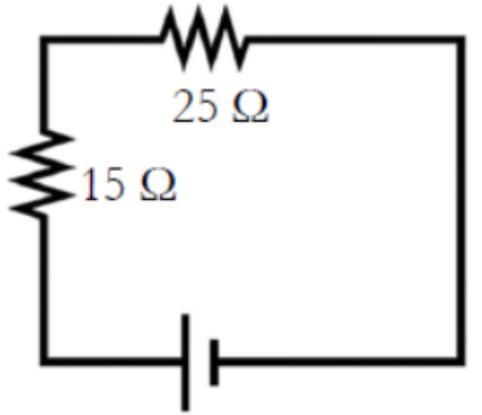
		

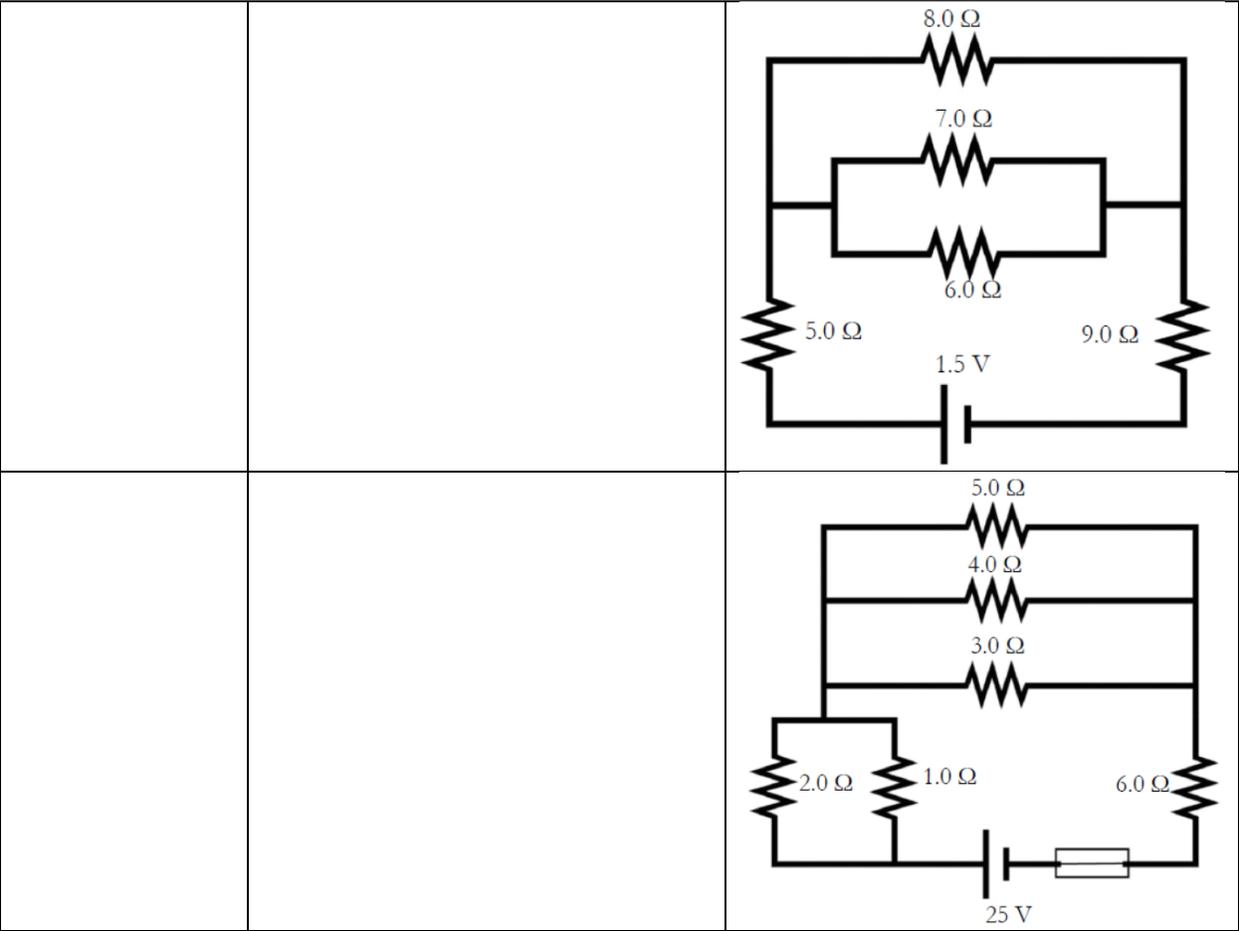
## Chapter 14: Electricity Has Potential!

Term	Equations & Descriptions	
Electric Potential		
Electron Volt		
Capacitor		
Capacitance		
Electric Permittivity ( $\epsilon$ )		
Ground (Electrical)		
Law of Charge Conservation		
Electric Current		
Electric Circuit		
		 <p>The diagram illustrates a capacitor with two parallel plates. The top plate is red and the bottom plate is blue. Red arrows indicate 'conventional current' flowing clockwise in a rectangular loop around the capacitor. Blue arrows indicate 'electron flow' flowing counter-clockwise in a rectangular loop around the capacitor. The current flows from the top plate to the right, then down, then left, and then up back to the top plate. Electron flow flows from the bottom plate to the right, then down, then left, and then up back to the bottom plate.</p>

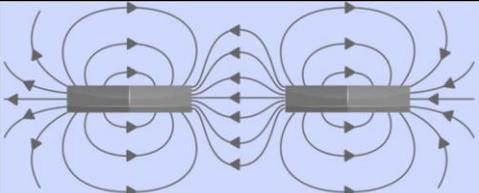
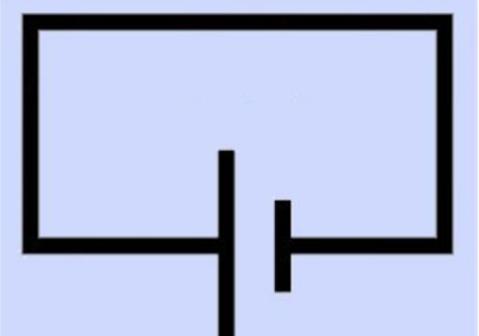
# Chapter 15: Electric Circuits

Term	Equations & Descriptions	
<b>Drift Velocity</b>		
<b>Resistor</b>		
<b>Battery</b> (Voltage source)		
<b>Fuse</b>		
<b>Capacitor</b>		
<b>Switch</b>		
		
		
		

		 <p>A circuit diagram featuring a 12 V battery at the top. A 2.0 Ω resistor is connected in series with the battery. Following this resistor, the circuit splits into two parallel branches. The upper branch contains a 1.8 Ω resistor. The lower branch contains a 1.6 Ω resistor in series with a parallel combination of a 1.2 Ω resistor and a 1.4 Ω resistor. After this parallel section, the circuit continues through a 1.0 Ω resistor before returning to the battery.</p>
		 <p>A photograph showing two AA batteries connected in series to a 9V battery. The AA batteries are labeled 'AA6' and the 9V battery is labeled '9V'. The positive terminals of the AA batteries are connected to the positive terminal of the 9V battery, and the negative terminals are connected to the negative terminal of the 9V battery.</p>
		 <p>A circuit diagram with a battery at the bottom. Two parallel branches are connected to the battery. The upper branch contains a switch labeled S2 in series with a 25 Ω resistor. The lower branch contains a switch labeled S1 in series with a 15 Ω resistor.</p>
		 <p>A simple series circuit diagram consisting of a battery at the bottom, a 15 Ω resistor on the left, and a 25 Ω resistor at the top, all connected in a single loop.</p>



## Chapter 16: Magnetism

Term	Equations & Descriptions	
Basic Law of Magnetism		
Magnetic Permeability ( $\mu$ )		
Right-Hand Rule		
Diamagnetic Substance		
Paramagnetic Substance		
Ferromagnetic Substance		
Faraday's Law of Magnetic Induction		
Electromotive Force		
Alternating Current		
Direct Current		
Rectifier		
Inverter		
Lenz's Law		
		 <p>A diagram showing two bar magnets placed horizontally with their north poles facing each other. Magnetic field lines are shown as curved arrows originating from the north poles and pointing towards the south poles, illustrating the repulsive force between like poles.</p>
		 <p>A schematic diagram of a rectangular circuit. It consists of a closed loop of wire with a battery symbol (two vertical lines of unequal length) connected to the bottom side of the loop.</p>

## Sources

These chapters and content are taken verbatim from the High School textbook:

- Dr. Jay L. Wile (2023). [Discovering Design with Physics](#), 1<sup>st</sup> Edition.

## Image Sources

- Dr. Carl Rod Nave (1998). HyperPhysics, Conservation of Energy. <http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html>