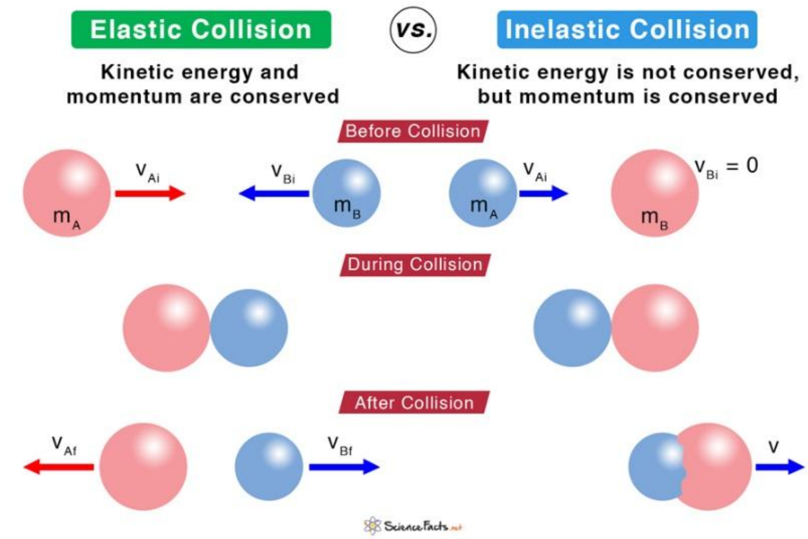
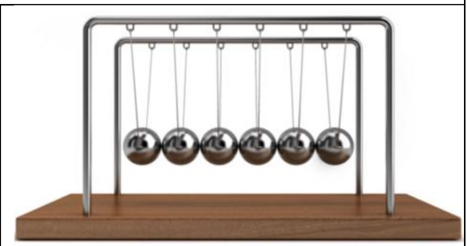
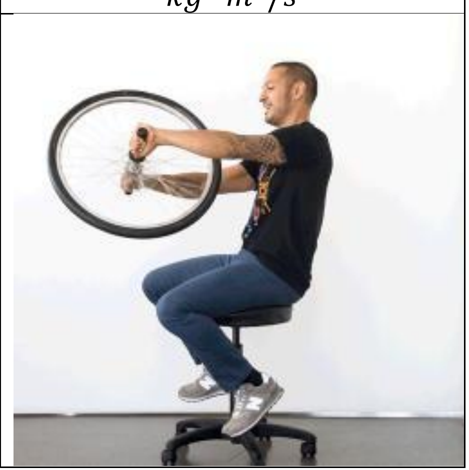
Harold's High School Physics 2nd Semester
Cheat Sheet

17 February 2026

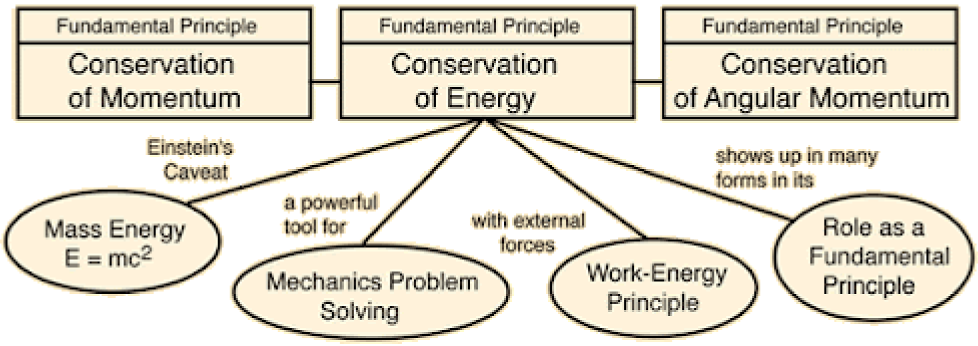
Chapter 9: Momentum and Its Conservation

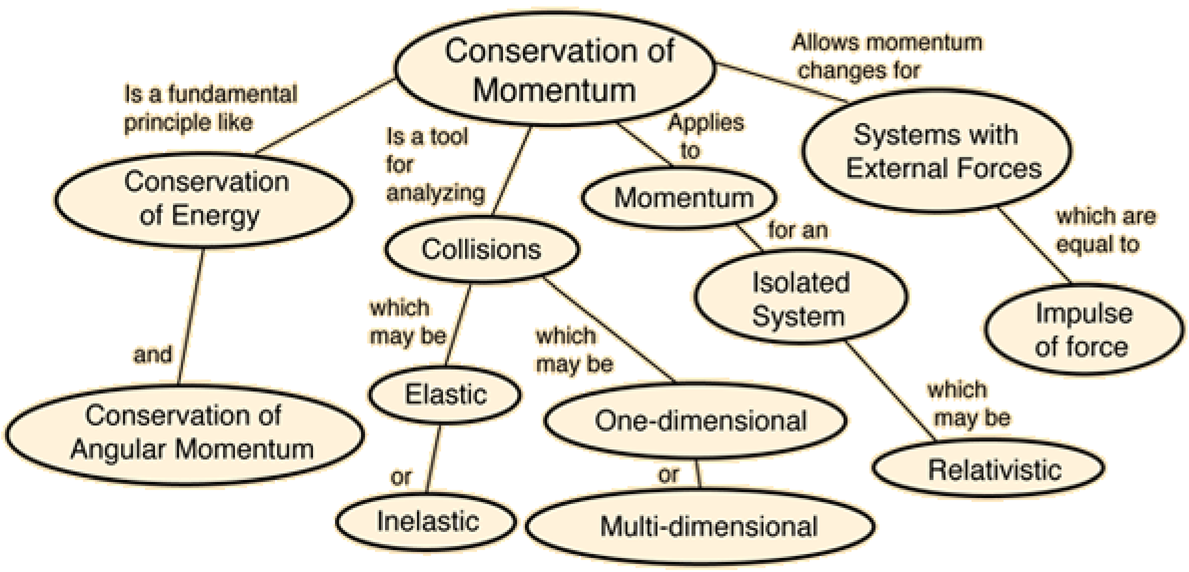
Term	Equations & Descriptions
Momentum	The mass of an object times its velocity.
Law of Momentum Conservation	When the net external force on a system is zero, the total momentum cannot change.
Elastic Collision	A collision in which the total energy of the colliding objects does not change.
Inelastic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

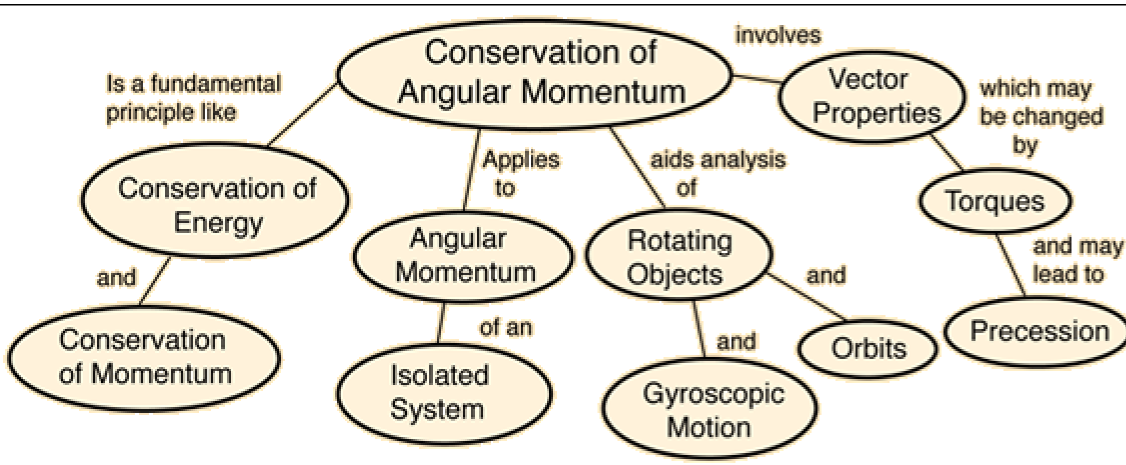
Momentum (Linear Momentum)		
Momentum	$\boldsymbol{p} = m\boldsymbol{v}$	$kg \cdot m/s$
Impulse	$\Delta\boldsymbol{p} = \boldsymbol{F} \cdot \Delta t$ $\Delta\boldsymbol{p} = \boldsymbol{p}_{final} - \boldsymbol{p}_{initial}$	$N \cdot s$ or $kg \cdot m/s$ The change in momentum.
Collision Types		
Newton's Cradle	Example of an elastic collision	

Angular Momentum		
Angular Momentum	$\boldsymbol{L} = mv\boldsymbol{r}$	$kg \cdot m^2/s$
Spinning Tire	A spinning bicycle tire requires effort to tilt since it has angular momentum ($\boldsymbol{L}$). You must apply a torque ($\boldsymbol{\tau}$) to change the angular momentum.	

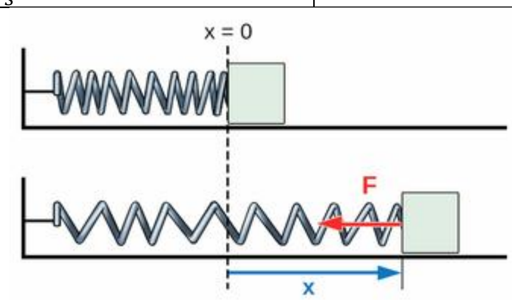
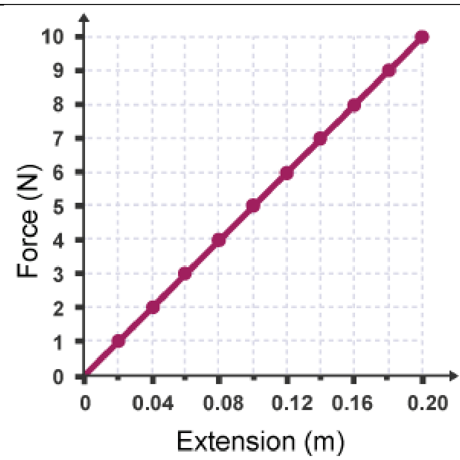
Conservation Laws		
Conservation of Linear Momentum: $\boldsymbol{p}_i = \boldsymbol{p}_f$	*Conservation of Energy:* $\boldsymbol{E}_i = \boldsymbol{E}_f$	*Conservation of Angular Momentum:* $\boldsymbol{L}_i = \boldsymbol{L}_f$
Conservation of Energy	The capacity for doing work. *"Energy can neither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

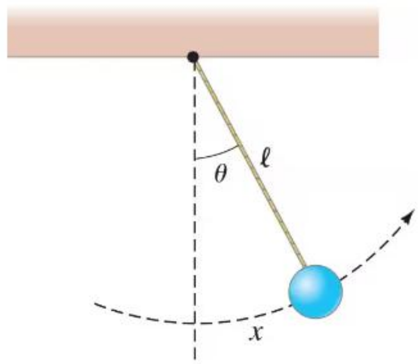
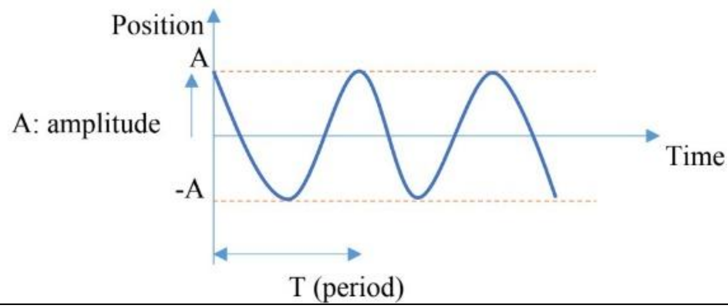
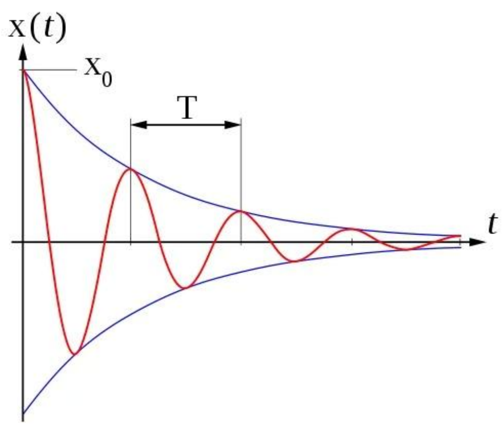




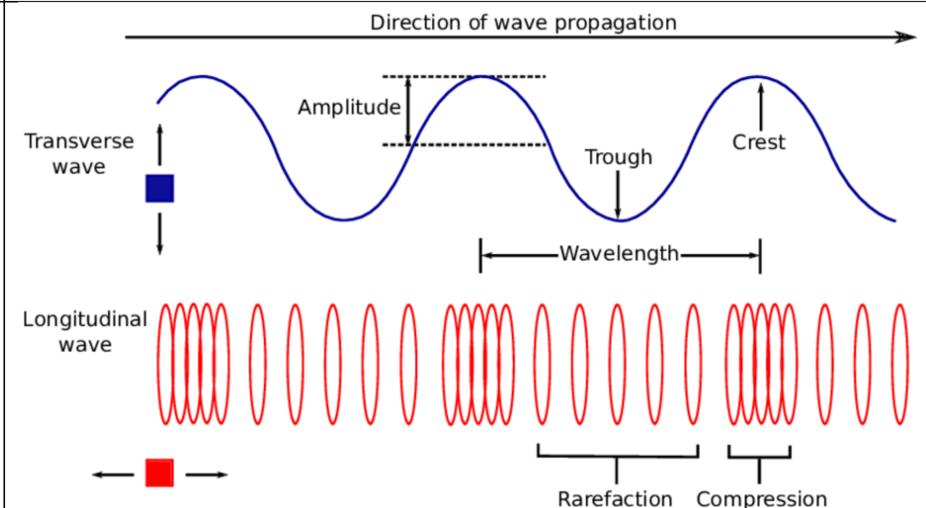
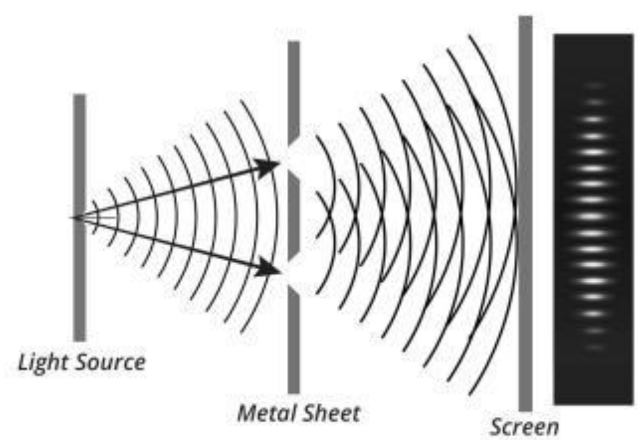


Chapter 10: Periodic Motion

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

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	*"**L**ife is **G**ood, if you are a **M**on**K**ey."* $T_p = 2\pi\sqrt{\frac{\ell}{g}}$ and $T_s = 2\pi\sqrt{\frac{m}{k}}$	

Chapter 11: Sound and Light

<table>
<tr><th>Term</th><th colspan="2">Equations & Descriptions</th></tr>
<tr><td>Oscillations</td><td colspan="2">Regular variation in magnitude around a central point.</td></tr>
<tr><td>Wavelength</td><td colspan="2">The distance between two crests or two troughs of a wave.</td></tr>
<tr><td>Transverse Wave</td><td colspan="2">A wave whose oscillation is perpendicular to its translational motion.</td></tr>
<tr><td>Longitudinal Wave</td><td colspan="2">A wave whose oscillation is parallel to its translational motion.</td></tr>
<tr><td></td><td colspan="2">
</td></tr>
<tr><td>Doppler Effect</td><td colspan="2">A change in the observed frequency of a wave caused by the motion of the wave's source and/or the observer.</td></tr>
<tr><td colspan="3">Sound</td></tr>
<tr><td>Sonic Waves</td><td colspan="2">Waves that the <u>typical</u> person can hear, with frequencies of 20 Hz – 20,000 Hz.</td></tr>
<tr><td>Ultrasonic Waves</td><td colspan="2">Waves with frequency greater than 20,000 Hz. $(f > 20\ kHz)$</td></tr>
<tr><td>Infrasonic Waves</td><td colspan="2">Waves with frequency lower than 20 Hz. $(f < 20\ Hz)$</td></tr>
<tr><td>Timbre</td><td colspan="2">The character of a sound that is not based on the <u>frequency</u> or <u>amplitude</u> of the main sound wave. Examples:
• air vs. bone conduction
• flute vs. violin</td></tr>
<tr><td>Wave-Particle Duality</td><td colspan="2">The concept that light, as well as many subatomic particles, have the properties of both particles and waves.

</td></tr>
<tr><td>Frequency</td><td>$f = \frac{v}{\lambda}$</td><td>Frequency and wavelength are inversely proportional; when one increases, the other decreases.</td></tr>
</table>

<table>
<tr><td>Medium</td><td>A wave oscillates a medium so that energy can move from one place to another.</td></tr>
<tr><td>Sound Volume & Frequency</td><td>

The higher the <u>amplitude</u> of a sound wave, the higher the <u>volume</u> of the sound.
The higher the <u>frequency</u> of a sound wave, the higher the <u>pitch</u> of the sound.
</td></tr>
<tr><td rowspan="2">Speed of Sound</td><td>

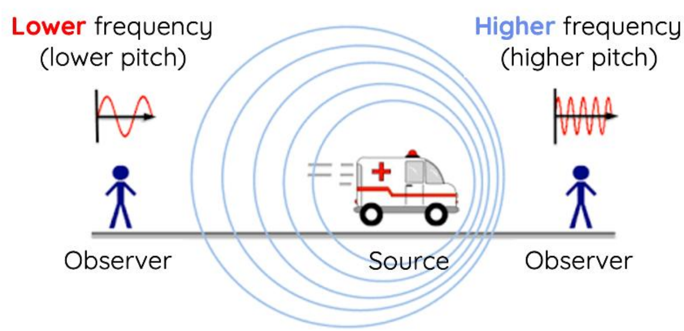
$$v_{sound} = (331.3 + 0.606 \cdot T_C)\frac{m}{s}$$

Where T_C is the temperature in Celsius.</td></tr>
<tr><td>

The speed of sound increases with increasing elasticity and <u>decreasing density</u>.
In general, it travels faster in <u>solids</u>, slower in <u>liquids</u>, and slowest in <u>gases</u>.
For solids and gases, the lower the density, the faster the speed of sound.

<table>
<tr><th>Physical State</th><th>Medium</th><th>Velocity (m/s)</th><th>Velocity (mph)</th></tr>
<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>
</table></td></tr>
<tr><td rowspan="4">Doppler Effect (Sound)</td><td>

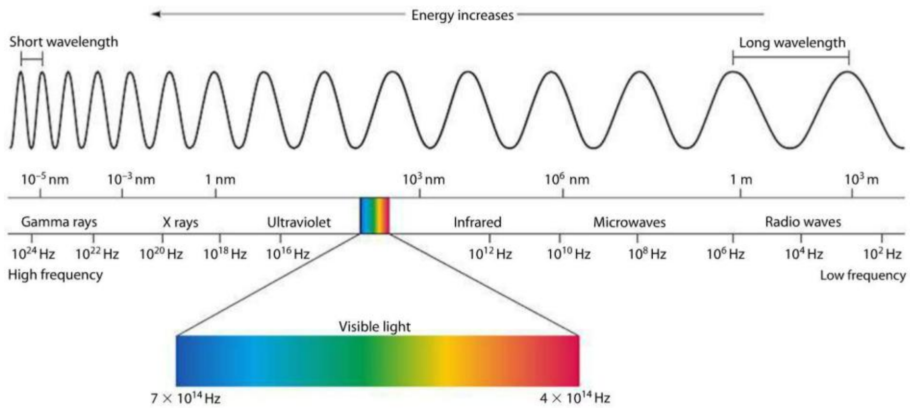
$$f_{observed} = \left(\frac{v_{sound} \pm v_{observer}}{v_{sound} \pm v_{source}}\right) \cdot f_{stationary}$$

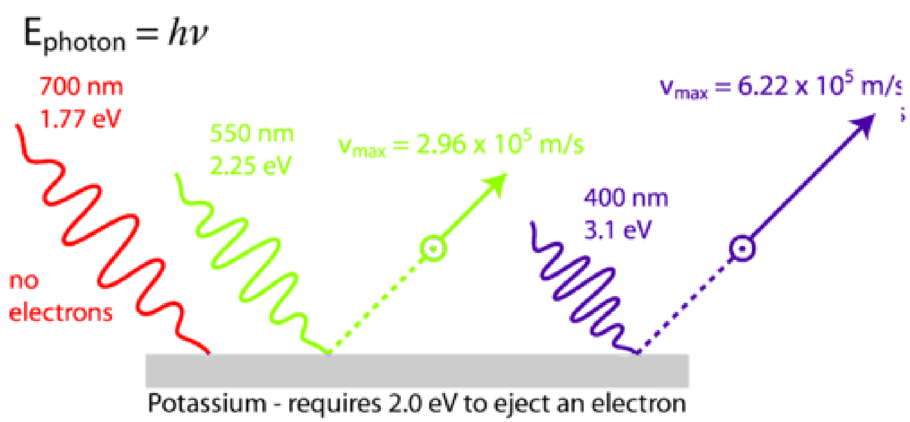

</td></tr>
<tr><td>

When a <u>source</u> of sound is moving, the frequency in front of the source is higher than the frequency behind the source.
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.
</td></tr>
<tr><td>

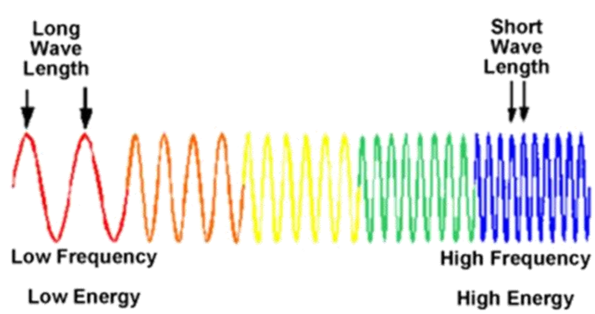
<u>Add</u> $v_{obserer}$ when the observer is moving <u>towards</u> the source.
<u>Subtract</u> it when the observer is moving <u>away</u> from the source.
</td></tr>
<tr><td>

<u>Subtract</u> v_{source} when the source is moving <u>towards</u> the observer.
<u>Add</u> it when the source is moving <u>away</u> from the observer.
</td></tr>
</table>

<table>
<tr><th colspan="2">Light</th></tr>
<tr><td>Electromagnetic Spectrum</td><td>The prefix “nano” is abbreviated with “n” and means 10^{-9}.

</td></tr>
<tr><td>Photoelectric Effect</td><td>$$KE_{e\_max} = h \cdot f - \phi$$
KE_{e_max} (Max. electronic kinetic energy)
$h = 6.63 \times 10^{-34}\ J \cdot s$ (Planck’s constant)
ϕ (Work function) expressed in eV(electron-volt).

If $h < 0$, then the electron cannot leave the metal when struck by a photon.

</td></tr>
<tr><td>Electron-Volt</td><td>$$1\ eV = 1.602\ \times 10^{-19}\ J$$</td></tr>
<tr><td>Doppler Effect (Light)</td><td>

Blueshift: <u>Higher</u> frequency, so the star is moving <u>towards</u> the earth.
Redshift: <u>Lower</u> frequency, so the star is moving <u>away</u> from the earth.

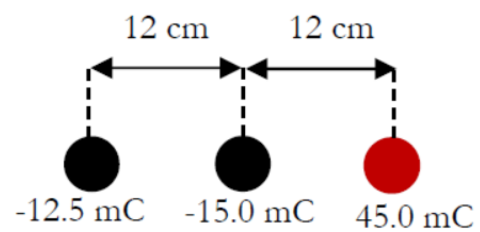
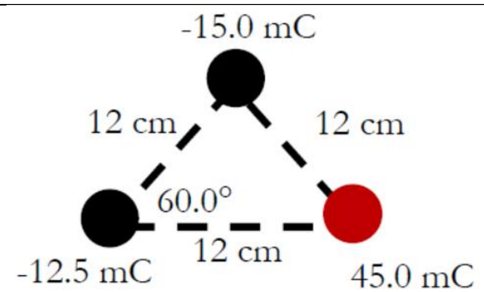
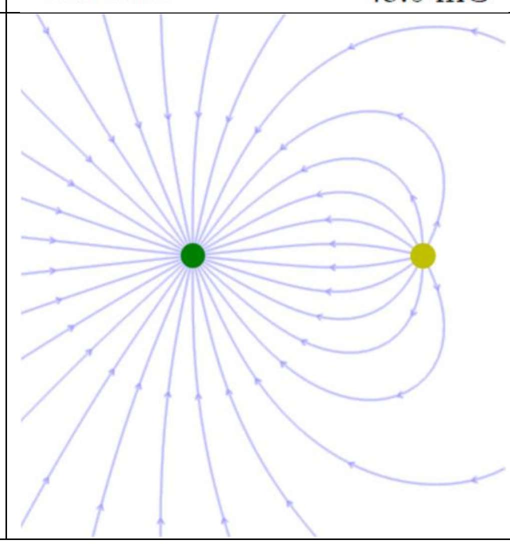

</td></tr>
</table>

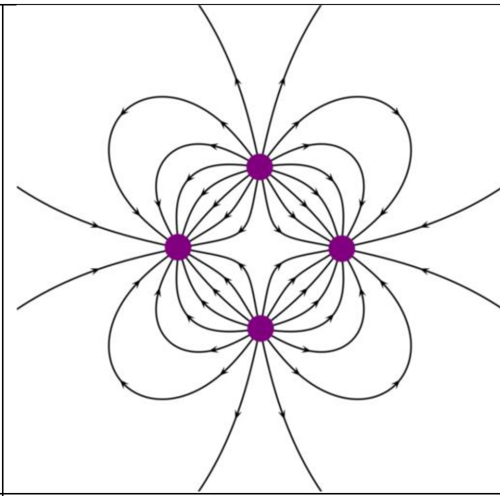
Chapter 12: Optics

Term	Equations & Descriptions
Law of Reflection	
Virtual Image	
Real Image	
Refraction	
Spherical Aberration	
Chromatic Aberration	

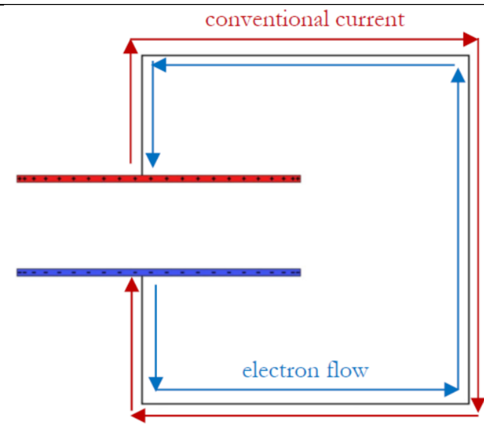
Medium	Index of Refraction
air	1.0003
water	1.333
ethanol	1.361
ice	1.309
glass, crown	1.52
glass, flint	1.66
fused quartz	1.458
diamond	2.419

Chapter 13: The Electrostatic Force

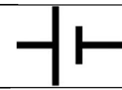
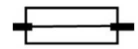
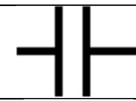
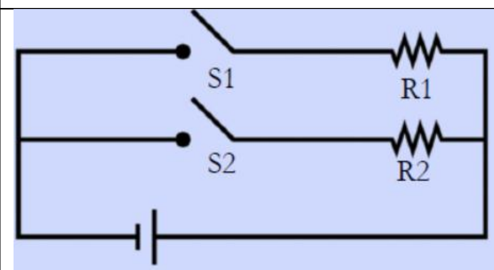
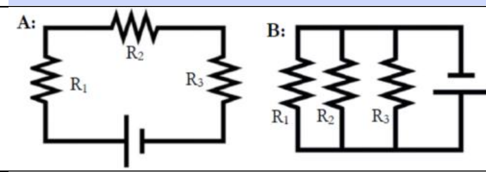
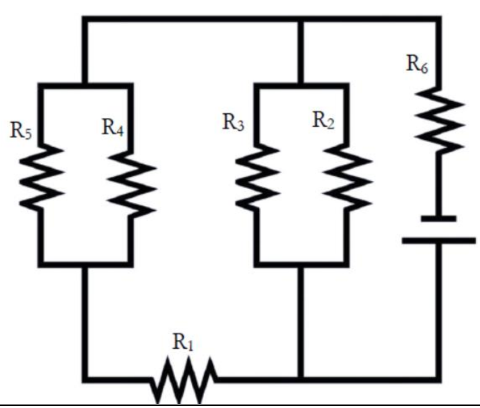
Term	Equations & Descriptions	
Electrostatic Force		
Triboelectric Charging		
Charging by Conduction		
Charging by Induction		
Conductor		
Insulator		
		
		
		

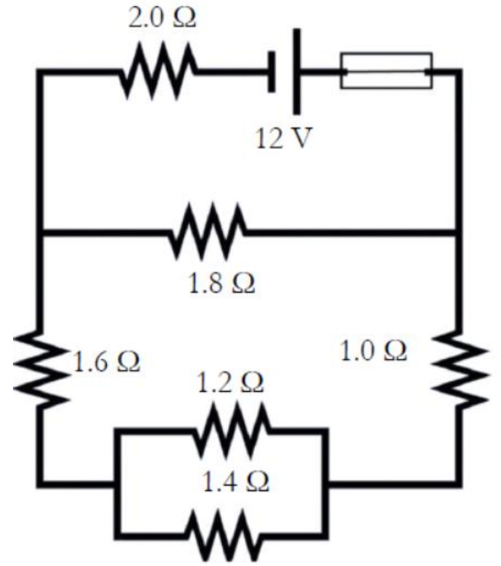
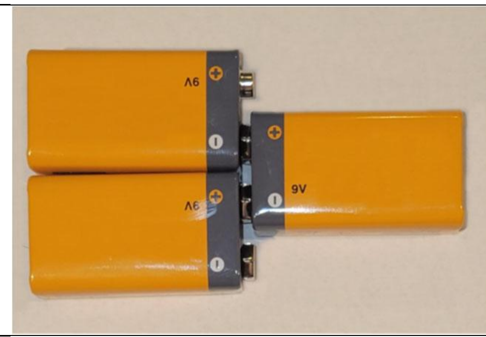
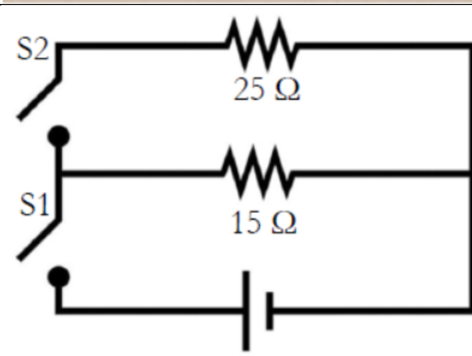
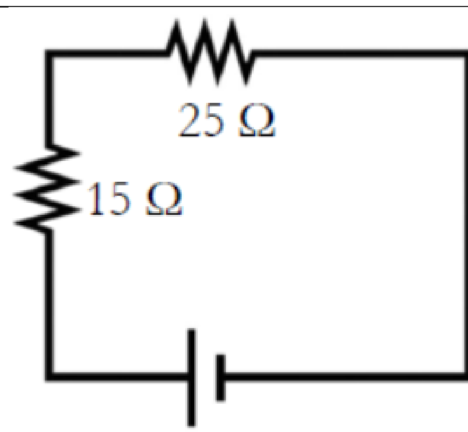
		

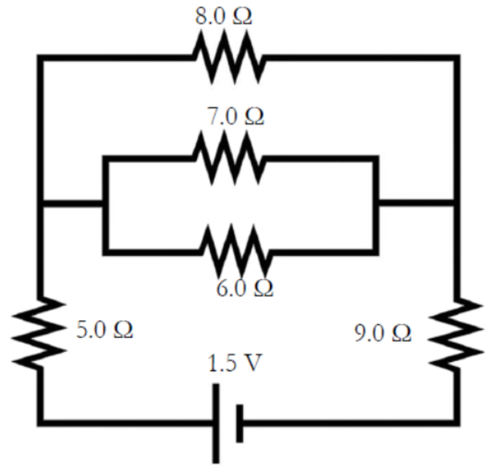
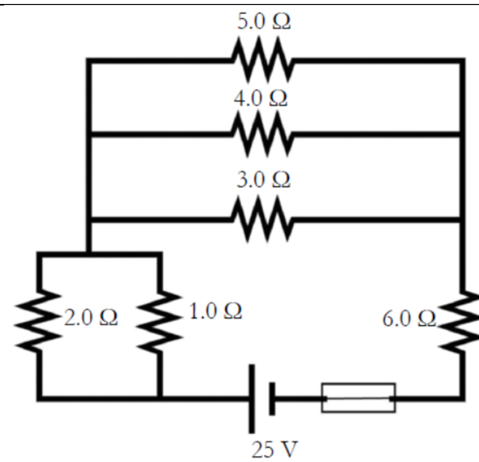
Chapter 14: Electricity Has Potential!

Term	Equations & Descriptions	
Electric Potential		
Electron Volt		
Capacitor		
Capacitance		
Electric Permittivity (ε)		
Ground (Electrical)		
Law of Charge Conservation		
Electric Current		
Electric Circuit		
		

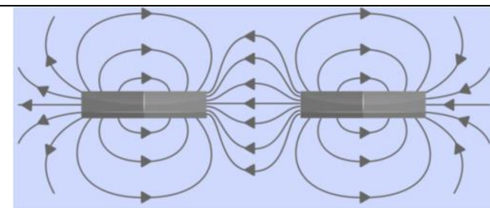
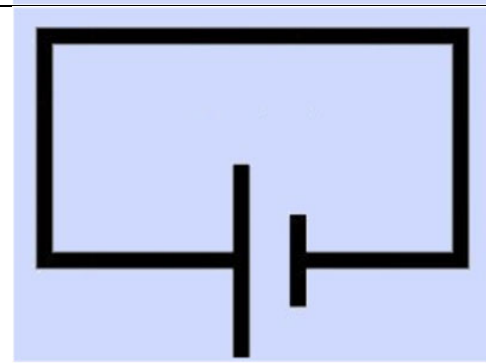
Chapter 15: Electric Circuits

Term	Equations & Descriptions	
Drift Velocity		
Resistor		
Battery (Voltage source)		
Fuse		
Capacitor		
Switch		
		
		
		

<table>
<tr><td></td><td></td><td>
</td></tr>
<tr><td></td><td></td><td>
</td></tr>
<tr><td></td><td></td><td>
</td></tr>
<tr><td></td><td></td><td>
</td></tr>
</table>

		 8.0 Ω 7.0 Ω 6.0 Ω 5.0 Ω 9.0 Ω 1.5 V
		 5.0 Ω 4.0 Ω 3.0 Ω 2.0 Ω 1.0 Ω 6.0 Ω 25 V

Chapter 16: Magnetism

Term	Equations & Descriptions	
Basic Law of Magnetism		
Magnetic Permeability (μ)		
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		
		
		

Sources

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

- Dr. Jay L. Wile (2023). Discovering Design with Physics, 1st Edition.

Image Sources

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