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💧Unit 1
Fluids

- **Density**: $\rho = \frac{m}{V}$; if the density of an object is greater than the density of water, the object will sink in water
- **Pressure**: $P = \frac{F}{A}$, $Pabs = Patm + \rho gh$ where ρgh is the guage pressure
- **Archimedes' Principle**: the buoyant force on an object is equal to the weight of the displaced fluid ($F = \rho_{\square} V_o g$)
- **Fluid Flow Rate**: $Q = \frac{V}{t} = \frac{Al}{t}$
- **Continuity Equation**: if $Q_1 = Q_2$, then $A_1 v_1 = A_2 v_2$
- **Bernoulli's Principle**: $P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$
- Faster moving fluid is at a lower pressure
- **Pascal's Principle**: any pressure applied to a confined and incompressible fluid is transmitted throughout
- **Mechanical Advantage**: $\frac{F}{A}$

🔥Unit 2
Thermodynamics

- **Temperature Conversion**: $Tf = \frac{9}{5}Tc + 32℃$, $Tc = Tk - 273.15\,℃$
- **Kinetic Energy**: $KE = \frac{3}{2}kb\,T$; Internal energy is the sum of kinetic energies of all particles and the potential energies of all interactions
- **Ideal Gas Law**: $PV = nRT$
- $\Delta U = N\frac{3}{2}kb\,T$
- **First Law of Thermodynamics**: $Q = W + \Delta U$

	Q	W	ΔU
+	heat added	increase in V	temp increase
-	heat lost	decrease in V	temp decrease

- When +W, work is being done by the gas. When -W, work is being done to the gas
- $W = P\Delta V$
- **Second Law of Thermodynamics**: law of entropy, heat flows from hotter body to cooler body

⚡Unit 3
Electric Force, Field, & Potential

- **Coulomb Force**: $FE = \frac{kq_1q_2}{r^2}$
- **Electric Field**: $E = \frac{kQ}{r^2}$ (measured in $\frac{N}{C}$ or $\frac{V}{m}$).
- **Electric Potential**: $V = \frac{kQ}{r}$ for non-uniform fields, $V = Ed$ for uniform fields
- **Equipotential lines** are perpendicular to electric field lines. Equipotential lines represent locations where the voltage is the same. A metal surface is an equipotential surface since charge resides on the top of conductors.
- Charge only flows in the presence of electric fields. To generate an electric field, there must be a difference in electric potential. For example, the electric field is 0 inside of a conductor because there is no potential difference.
- Electric fields lines go from high potential to low potential. For example, they point away from positively charged particles.
- $W = q\Delta V$

💡Unit 4
Electric Circuits

- A battery doesn't create current, it creates a potential difference. Long side of the battery is high potential end.
- **Capacitance**: $C = k\varepsilon_0\frac{A}{d}$ (measured in F)
- **Charge on Capacitor**: $Q = CV$
- **Energy**: $EC = \frac{1}{2}CV^2$
- Capacitance and Resistance

Capacitance		Resistance	
Series	Parallel	Series	Parallel
$Q_{\square} = Q_1 = Q_2$	$Q_{\square} = Q_1 + Q_2$	$I_{\square} = I_1 = I_2$	$I_{\square} = I_1 + I_2$
$\frac{1}{C_{\square}} = \frac{1}{C_1} + \frac{1}{C_2}$	$C_{\square} = C_1 + C_2$	$Req = R_1 + R_2$	$\frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2}$
$V_{\square} = V_1 + V_2$	$V_{\square} = V_1 = V_2$	$V_{\square} = V_1 + V_2$	$V_{\square} = V_1 = V_2$

- **Ohm's Law**: $V = IR$
- **Kirchhoff's Laws**: $\Sigma I\ in = \Sigma I\ out$ (Loop Rule) and sum of all potential drops is 0 (Voltage Rule)
- Internal resistance of battery is r
- $P = IV$

🧲Unit 5
Magnetism & Electromagnetic Induction

- Earth's magnetic fields come from the convective currents of the core. Magnetic fields deflect the sun's rays making Earth habitable.
- Feromagnetic materials like iron and neodymium have the ability to make electron spins line up. Heating soft magnets (iron) unaligns spins and reduces magnetic field
- Magnetic field goes in concurrent circles around wire; direction is determined using RHR
- **Magnetic Field**: $B = \frac{\mu_0 I}{2\pi r}$ (measured in T)
- **Magnetic Force**: $FB = l(I \times B) = BIlsin\theta$ or $FB = q(v\times B) = qvBsin\theta$; determine the direction of force using RHR
- **Faraday's Law**: $\varepsilon = -N\frac{\Delta\phi}{\Delta t}$ where $\Phi = B.A$
- **Lenz's Law**: The direction of induced current will be to produce a field that counterracts the magnetic field
- **Motional emf**: $\varepsilon = Blv$

🔍Unit 6
Geometric & Physical Optics

- **Mirror and Lens Equation**: $\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i}$ where d_0 is always positive.

	Mirror	Lens
d_i	+ if image is in front of mirror (real) - if image is behind mirror (virtual)	+ if image behind lens - if image in front of lens
f	+ if concave mirror - if convex mirror	+ for convex lens (converging) - for concave lens (diverging)

- **Magnification**: $M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$
- Light that isn't refracted is reflected
- **Snell's Law**: $n_i sin\theta_i = n_r sin\theta_r$
- The critical angle is the angle at which total internal reflection occurs
- Thickness of $\frac{\lambda'}{2}$ for constructive interference; $\frac{\lambda'}{4}$ for destructive interference.
- $\lambda' = \frac{n\lambda}{n'}$ where $n = \frac{c}{v}$
- **Young's Double Slit Experiment Equation**: $\lambda \approx \frac{d\Delta x}{nL}$

⚛️ Unit 7
Quantum, Atomic, & Nuclear Physics

- $r = \frac{n^2h^2}{mkq^2} = n^2 a_o$
- $E_{\square} = -\frac{mk^2q^4}{2h^2n^2} = -\frac{z^2 w_o}{n^2}$ where $w_o = 13.6\,eV$ and z is the atomic number
- $E = \hbar f = \frac{hc}{\lambda}$ where ħ is Planck's constant
- Light can act as both a wave and a particle depending on the situation. An electron is called a photelectron if broken off by photon
- $E\varphi = \phi + K$ where ϕ is the incident photon energy
- **Stopping Potential**: voltage at which photoelectrons are prevented from reaching the anode
- **Work Function**: energy that it takes to break off a photoelectron; every metal has its own work function
- **Threshold Frequency**: minimum frequency needed to produce photoelectrons
- The slope of Stopping Potential v. Light Frequency is ħ
- **DeBroglie's Wavelength**: $\lambda = \frac{\hbar}{p}$

💯 FRQ Tips

- Start every FRQ by writing out all of the givens.
- Always write the original equation. For example, always write $\Sigma F = ma$ or $E = E'$ before solving.
- Always write units.
- Remember that the 3 most important things in every graph are the y-intercept, the slope, and the area under the curve.
- Keep all written explanations precise and concise.
- Be detailed when explaining experiment setups.
- Don't worry about rounding decimal answers. Two to three decimal places is typically recommended.
- If unable to find the answer to the first part of a problem, make up an answer and use that answer to solve all following parts to obtain as many points as possible.
- Stay calm and don't panic!