Phys2020 Final Exam Review

- **Topics from PHYS2010**: algebra, trig, units, acceleration vs. velocity, vectors, $F_{net} = ma$ problems, free-body diagrams, conservation of energy

- **Charges and E-fields**

  Coulomb's Law: $F = \frac{k Q_1 Q_2}{r^2}$, \quad $\vec{E} \equiv \frac{\vec{F}_{\text{eq}}}{q}$ \quad $\Rightarrow$ \quad $|\vec{E}| = \frac{k |Q|}{r^2}$

  $\vec{E}_{\text{tot}} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \ldots$ \quad (vector addition)

  Induced charge and polarization

- **Voltage and PE**

  Definition of voltage: $\Delta P E_{\text{of } q} = q \cdot \Delta V \Rightarrow |\Delta V| = |E \Delta x|$

  Voltage due to a point charge $Q$: $V = \frac{kQ}{r}$

  Voltage due to many charges: $V_{\text{tot}} = V_1 + V_2 + V_3 + ..$

  Energy in units of eV

- **Capacitance**

  Definition: $C \equiv \frac{Q}{V}$, parallel plates: $C = \frac{\varepsilon_0 A}{d}$, energy $= U = \frac{1}{2} Q V = \frac{1}{2} C V^2 = \frac{1}{2} \frac{Q^2}{C}$

- **Current, Ohm's Law, Circuits**

  $I = \frac{\Delta Q}{\Delta t}$, \quad $\Delta V = I \cdot R$ \quad $R = \frac{\rho L}{A}$, \quad power $P = \frac{\Delta W}{\Delta t} = I V = I^2 R = \frac{V^2}{R}$

  Circuits, Kirchhoff's Laws, resistors in parallel and series, AC vs. DC

  Batteries provide constant voltage, NOT constant current
• **Magnetic Fields**

\[ F_{\text{on q}} = |q|v B \sin \theta = |q|v \pm B \]  
\[ F_{\text{on wire}} = I L B \sin \theta \quad \text{if } L \perp B \]

B-field due to long straight wire:  
\[ B = \frac{\mu_0 I}{2\pi r} \]

Circular motion of charge q in a B-field.

• **Faraday's Law**

magnetic flux \( \Phi = B \cdot A \)  
\[ \mathcal{E}_{(N \text{ loops})} = -N \frac{\Delta \Phi}{\Delta t} \]

Lenz's Law: \( I_{\text{induced}} \) creates \( B_{\text{induced}} \) in direction that opposes change in flux.

Transformers

• **EM Waves**

\[ c = \lambda f \]  
intensity = power / area

• **Ray Optics**

MIRRORS, Snell's Law, internal reflection

Lenses, ray tracing,  
\[ \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \]

Camera and eye
- **Wave Optics**

  If sources are in synch, then ..
  
  constructive interference when \( p.d. = 0, \lambda, 2\lambda, \ldots \)
  
  destructive interference when \( p.d. = \frac{1}{2}\lambda, \frac{3}{2}\lambda, \frac{5}{2}\lambda, \ldots \)

  Single-slit, double-slit, diffraction grating

- **Modern Physics**

  Atoms have quantized energy levels:

  change in energy of atom \( \Delta E = \) energy of photon \( E_\gamma \) absorbed or emitted.

  photon energy \( = E_\gamma = h f = h c/\lambda \)

- **Special Relativity**

  c is constant for all observers \( \Rightarrow \)

  simultaneity is not absolute, time dilation, length contraction, gamma-factor,

  rest energy \( E_o = m_o c^2 \), total energy = rest energy + KE = \( \gamma m_o c^2 \)