$$B\prime = rac{mv}{qR}$$

$$\frac{1}{2} mv^2 = eV$$
 or $v = \sqrt{\frac{1}{2}}$

$$v=\sqrt{rac{2eV}{m}}$$

$$rac{E}{B} = \sqrt{rac{2eV}{m}}$$

$$rac{e}{m}=rac{E^2}{2VB^2}$$

Physics 1C Equations Page 1

Fundamental Constants

 $c=\mathrm{\ speed\ of\ light}=3.00\times10^8\mathrm{\ ms^{-1}}$

 $k=\,$ Coulomb's constant $=8.9876\times 10^9\,\,{\rm Nm^2}C^{-2}$

 $\epsilon_o =$ permittivity of free space = $8.85\,\times\,10^{-12}$ $N^{-1}C^2m^{-2}$ (m/F)

 μ_o = permeability of free space = $4\pi \times 10^{-7}$ H/m

 $\overrightarrow{F} = q\overrightarrow{v} \times \overrightarrow{B} = \text{magnetic force on charged particle}$

 $\overrightarrow{F} = \overrightarrow{l} \times \overrightarrow{B}$ magnetic force on a conductor

 $||F|| = ||q||vBsin(\phi) = \text{magnitude of Magnetic Force}$

 \bigotimes = into page

○ = out of page

 $\tau = IBAsin(\phi) = \text{magnitude}$ of magnetic torque

 $\overrightarrow{\tau} = \overrightarrow{\mu} \times \overrightarrow{B} = \text{magnetic}$ torque

 $\overrightarrow{\mu} = IA = \text{magnetic}$ dipole moment

 $U = -\overrightarrow{\mu} \cdot \overrightarrow{B} = -\mu B cos(\phi) = \text{potential}$ energy of magnetic moment

Chapter 28

Magnetic Fields -

 $\vec{B}=\frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}=$ magnetic field due to a point charge with constant velocity

 $d\vec{B}=\frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\hat{r}}{r^2}=$ magnetic field due to an infinitesimal current element (Biot Savart)

 $B = \frac{\mu_0 I}{2\pi r}$ magnetic field near a long straight current carrying conductor

 $\frac{F}{L}=\frac{\mu_0 H'}{2\pi r}$ force between two long straight parallel current carrying conductors

 $\oint \vec{B} \cdot d\vec{A} = 0$ magnetic flux through any closed surface

B fields

 $B = \frac{\mu_0 I}{2\pi r}$ magnetic field distance r from conductor

 $B = \mu_0 nI$ Inside a solenoid, closely wound with n turns per unit length

B = 0 outside a solenoid

Chapter 29 Part B

Lenz's Law

The direction of any magnetic induction effect is such as to oppose the cause of the effect.

induced Electric Fields

 $\mathcal{E} = \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$

Displacement Current -

 $i_D = \epsilon \frac{d\Phi_E}{dt}$ displacement current

Maxwell's equations

 $\oint \vec{E} \cdot d\vec{a} = \frac{Q_{encl}}{\epsilon_0}$

 $\oint \vec{B} \cdot \vec{dA} = 0$ magnetic flux through any closed surface

 $\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$ Faraday's Law

 $\oint \vec{B} \cdot d\vec{l} = \mu_0 (i_C + \epsilon_0 \frac{d\Phi_E}{dt})_{encl}$ Ampere's Law including Displacement Current

Chapter 29 Part A

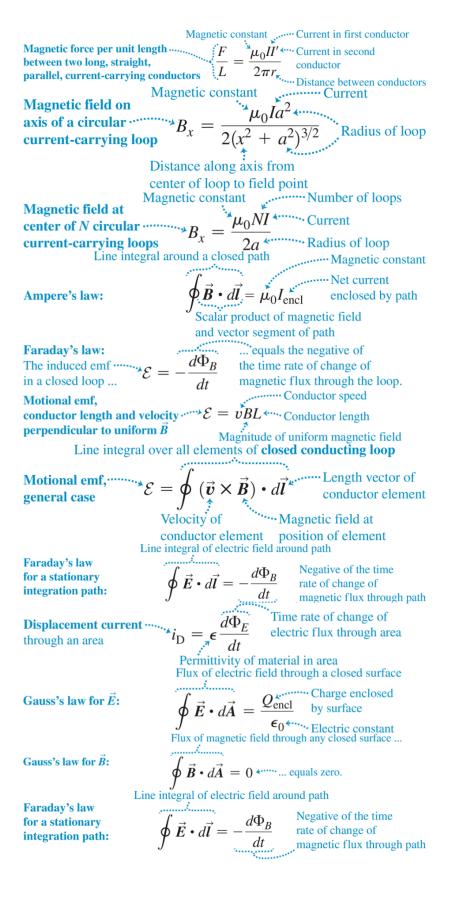
Faraday Induction

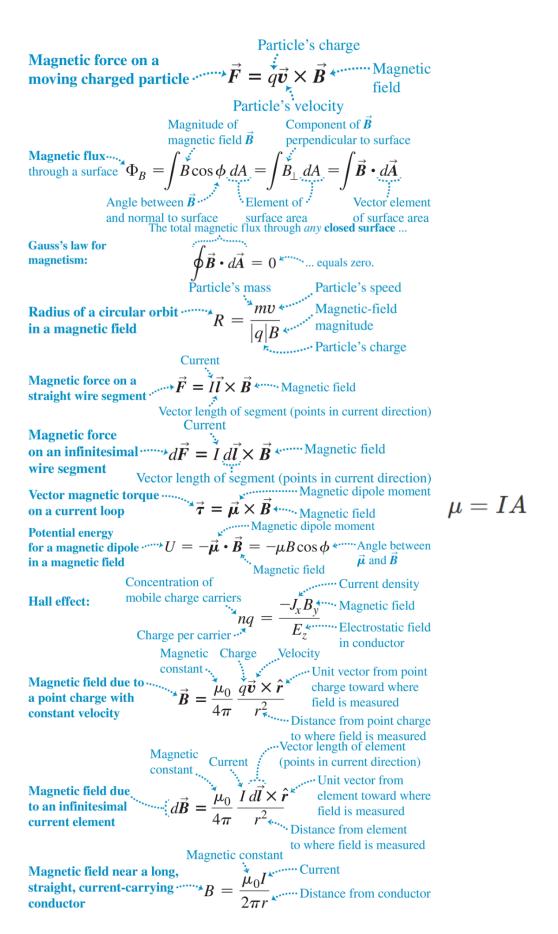
 $\Phi_B = \int \vec{B} \cdot d\vec{A} = \int B \, dA \, \cos(\phi)$

 $\mathcal{E} = \frac{-d\Phi_B}{dt}$

Motional EMF

 $\mathcal{E} = vBL$ where v is conductor speed, L is length and B is the magnitude of the uniform magnetic field $\mathcal{E} = \Phi(\vec{v} \times \vec{B}) \cdot \vec{dl}$





Physics 1C Equations Page 2

Chapter 30 Part A

Mutually Induced EMFS -

 $\mathcal{E}_1 = -M \frac{di_2}{dt}$ Induced EMF in coil 1

 $\mathcal{E}_2 = -M \frac{di_1}{dt}$ Induced EMF in coil 2

- Mutual Inductance -

 $M_{21} = \frac{N_2 \Phi_{B2}}{i_1}$

a change in current i_1 in coil 1 induces an emf in coil 2 proportional to rate of change of i_1

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

Self Inductance -

 $\mathcal{E} = -L \frac{di}{dt}$

The self induced emf in a circuit is proportional to the inductance of the circuit multipled by the rate of change of current in the circuit.

The self inductance of a coil is defined to be the number of turns in the coil, multiplied by the flux due to current through each turn, divided by the current in the coil

Chapter 30 Part B

Magnetic Field Energy

 $U_L = \frac{1}{2}LI(t)^2$

An inductor with inductance L carrying current I has an energy U associated with the inductor's magnetic field. The magnetic energy desnity u (energy per unit volume) is proportional to the square of the magnetic field magnitude

 $u = \frac{B^2}{2\mu_0}$ (in a vacuuum) $U_C = \frac{1}{2} \frac{Q^2}{C}$

 ${\cal V}=IR$ Always True in General

 $P = I^2 R$

- LC circuits

 $\omega = \sqrt{\frac{1}{LC}}$ A circuit that contains inductance L and capacitance C undergoes electrical oscillations with angular frequency ω that depends on L and C

 $\omega'=\sqrt{\frac{1}{LC}-\frac{r^2}{4L^2}}$ A circuit containing inductance, resistance and capacitance undergoes oscillations that are damped with frequency ω'

Chapter 31

AC current

 $i = Icos(\omega t)$

 $I_{rms} = \frac{I}{\sqrt{2}}$

 $V_{rms} = \frac{V}{\sqrt{2}}$

- AC Circuits -

 $V_R = V_R cos(\omega t)$

Amplitude of Voltage across a resistor

Amplitude of Voltage across an inductor where $X_L =$

L leads current by 90 deg = $(\phi + 90 \text{ deg})$

 $V_C = IX_C$ Amplitude of Voltage across a capacitor where $X_C = \frac{1}{\omega C}$

C lags current by 90 deg = $(\phi - 90 \text{ deg})$

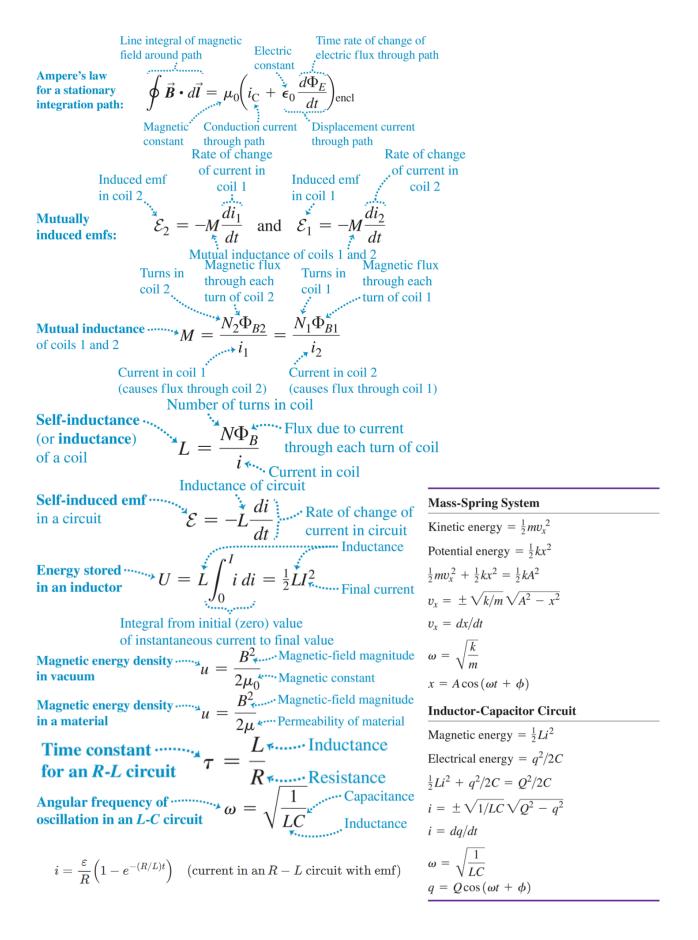
Impedance and the LRC series circuit

V = IZ

In a general AC circuit, the voltage and current amplitudes are related by the circuit impedance Z. In an LRC series, the values of these and the angular frequency ω determine Z and the phase angle of the voltage relative to the current.

$$Z = \sqrt{R^2 + [\omega L - \frac{1}{\omega C}]^2}$$

$$tan(\phi) = \frac{\omega L - \frac{1}{\omega C}}{R}$$



Physics 1C Equations Page 3

Chapter 32

Maxwell's equations

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{encl}}{\epsilon_0}$$

 $\oint \vec{B} \cdot d\vec{A} = 0$ magnetic flux through any closed surface

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$
 Faraday's Law

 $\oint \vec{B} \cdot d\vec{l} = \mu_0 (i_C + \epsilon_0 \frac{d\Phi_E}{dt})_{encl} \text{ Ampere's Law including Displacement Current}$

- Field Magnitudes -

E=cBElectric Field Magnitude in terms of Magnetic Field Magnitude

 $B=\epsilon_0\mu_0cE$ Electromagnetic wave in a vacuum

Speed of light

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

— Sinusoidal Electromagnetic Waves —

 $\overrightarrow{E}(x,t) = \hat{j}E_{max}cos(kx - \omega t)$ For a wave traveling in the + x direction

If the wave is traveling in - x direction, replace $kx-\omega t$ by $kx+\omega t$.

If wave is traveling in y or z direction, use the right hand rule to find the direction of the $E_{max}cos(kx-\omega t)$ vector.

Chapter 32 Part B

Sinusoidal Electromagnetic Waves

 $\overrightarrow{B}(x,t) = \hat{k}B_{max}cos(kx - \omega t)$ For a wave traveling in the + x direction

If the wave is traveling in - x direction, replace $kx-\omega t$ by $kx+\omega t$.

If wave is traveling in y or z direction, use the right hand rule to find the direction of the $B_{max}cos(kx-\omega t)$ vector. $E_{max}=cB_{max}$

— Poynting Vector —

$$\overrightarrow{S} = \frac{1}{\mu_0} \overrightarrow{E} \times \overrightarrow{B}$$

$$I = S_{av} = \frac{E_{max}B_{max}}{2\mu_0} = \frac{E_{max}^2}{2\mu_0c} = \frac{1}{2}\sqrt{\frac{\epsilon_0}{\mu_0}}E_{max}^2 = \frac{1}{5}\epsilon_0cE_{max}^2$$

Radiation Pressure

 $\frac{1}{A}\frac{dp}{dt}=\frac{S}{c}=\frac{EB}{\mu_0c}$ flow rate of electromagnetic momentum

 $p_{rad} = \frac{I}{c}$ for a perfect absorber

 $p_{rad} = \frac{2I}{c}$ for a perfect reflector

Chapter 37

Time dilation

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{u^2}{c^2}}}$$

- Length contraction -

$$l = l_0 \sqrt{1 - \frac{u^2}{c^2}}$$

Lorentz Transformations

For observers where the relative velocity difference is along the ${\bf x}$ axis

$$x' = \frac{x - ut}{\sqrt{1 - \frac{u^2}{c^2}}}$$

$$y' = y$$

$$z' = z$$

$$t' = \frac{t - \frac{ux}{c^2}}{\sqrt{1 - \frac{u^2}{c^2}}}$$

For observers where the relative velocity difference is along the **x** axis

$$v'_{x} = \frac{v_{x} - u}{1 - \frac{uv_{z}}{2}}$$

$$v_x = \frac{v_x' + u}{1 + \frac{uv_x'}{2}}$$

Angular frequency of underdamped oscillations in an
$$L$$
- R - C series circuit

Inductance

Inductance

Capacitance

Instantaneous current

Inductance

Instantaneous current

Instant

Circuit Element	Amplitude Relationship	Circuit Quantity	Phase of v	
Resistor	$V_R = IR$	R	In phase with i	
Inductor	$V_L = IX_L$	$X_L = \omega L$	Leads i by 90°	
Capacitor	$V_C = IX_C$	$X_C = 1/\omega C$	Lags i by 90°	

Amplitude of voltage V = IZ Current amplitude across an ac circuit

$$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2}$$

Resistance Inductance Capacitance

L-R-C series circuit

$$Z = \sqrt{R^2 + \left[\omega L - \left(1/\omega C\right)\right]^2}$$
Phase angle of voltage Inductance Ind

frequency of an L-R-C series circuit

$$\omega_0 = \frac{1}{\sqrt{LC}}$$
Inductance Capacitance