PHYS 2300 and 2305: General Physics I and II Formulas

Chapter 1

Trig Formulas

$\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}}$	$\theta = \sin^{-1}\left(\frac{\text{Opposite}}{\text{Hypotenuse}}\right)$
$\cos\theta = \frac{\text{Adjacent}}{\text{Hypotenuse}}$	$\theta = \cos^{-1}\left(\frac{\text{Adjacent}}{\text{Hypotenuse}}\right)$
$\tan\theta = \frac{\text{Oppostie}}{\text{Adjacent}}$	$\theta = \tan^{-1}\left(\frac{\text{Oppostie}}{\text{Adjacent}}\right)$
$a^2 = b^2 + c^2$	

Vectors

Vector Addition by Components	$\vec{A} + \vec{B} = \vec{C}$ Where $\overrightarrow{C_x} = \overrightarrow{A_x} + \overrightarrow{B_x}$ $\overrightarrow{C_y} = \overrightarrow{A_y} + \overrightarrow{B_y}$ Then to find $\vec{C}$ use $c^2 = a^2 + b^2$

Chapter 2

Velocity

Average Velocity	$\bar{v} = \frac{displacement}{time} = \frac{\Delta\bar{x}}{\Delta t}$ or $\bar{v} = \frac{\Delta\bar{d}}{\Delta t}$	2.2
Average Speed	$average\ speed = \frac{distance}{time}$	2.1
Instantaneous Velocity	$v = \lim_{\Delta t\to 0}\frac{\Delta\bar{x}}{\Delta t}$	2.3

Acceleration

Average Acceleration	$\bar{a} = \frac{\Delta v}{\Delta t}$	2.4
Instantaneous Acceleration	$a = \lim_{\Delta t\to 0}\frac{\Delta\bar{v}}{\Delta t}$	2.5

Motion of a particle with constant acceleration

$v = v_0 + at$	2.4
$x = \frac{1}{2}(v_0 + v)t$ or $d = \frac{1}{2}(v_0 + v)t$	2.7
$x = v_0 t + \frac{1}{2}at^2$ Or $d = v_0 t + \frac{1}{2}at^2$	2.8
$v^2 = v_0^2 + 2ax$ or $v^2 = v_0^2 + 2ad$	2.9

Chapter 3

Average Velocity/Acceleration

Average Velocity	$\bar{v} = \frac{\Delta\bar{x}}{\Delta t}$ *or* $\bar{v} = \frac{\Delta\bar{d}}{\Delta t}$	2.2
Average Acceleration	$\bar{a} = \frac{\Delta v}{\Delta t}$	2.4

Projectile Motion

X direction	*Y direction*	
$v_x = v_{0x} + a_x t$	$v_y = v_{0y} + a_y t$ $or\ v_y = v_{0y} + gt$	3.3
$x = \frac{1}{2}(v_{0x} + v_x)t$ or $d = \frac{1}{2}(v_{0x} + v_x)t$	$y = \frac{1}{2}(v_{0y} + v_y)t$ or $h = \frac{1}{2}(v_{0y} + v_y)t$	3.4
$x = v_{0x}t + \frac{1}{2}a_x t^2$ or $d = v_{0x}t + \frac{1}{2}a_x t^2$	$y = v_{0y}t + \frac{1}{2}a_y t^2$ or $h = v_{0y}t + \frac{1}{2}gt^2$	3.5
$v_x^2 = v_{ox}^2 + 2a_x x$ or $v_x^2 = v_{ox}^2 + 2a_x d$	$v_y^2 = v_{oy}^2 + 2a_y y$ or $v_y^2 = v_{oy}^2 + 2gh$	3.6

Relative Motion	$\overrightarrow{v_{AC}} = \overrightarrow{v_{AB}} + \overrightarrow{v_{BC}}$ $\overrightarrow{v_{AB}} = -\overrightarrow{v_{BA}}$

Chapter 4

Newton's Second Law

General	$\Sigma\vec{F} = m\vec{a}$	4.1
Component form	$\Sigma F_x = ma_x$ $\Sigma F_y = ma_y$	4.2

Gravitational Force

Gravitational Force	$F = G\frac{m_1 m_2}{r^2}$	4.3
Weight	W=mg Where $g = G\frac{m_1}{r^2}$	

G=Universal Gravitational Constant =$6.67x10^{-11}\ Nm^2/kg^2$

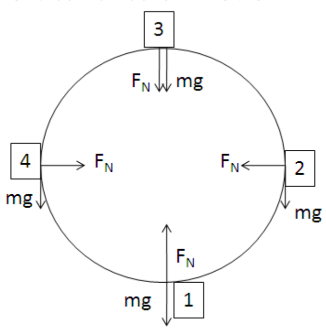
Friction

Static Friction (maximum)	$f_s{}^{max} = \mu_s F_N$	4.7
Kinetic Frictional	$f_k = \mu_k F_N$	4.8

Chapter 5

Speed	$v = \frac{2\pi r}{T}$	5.1
Centripetal Acceleration	$a_c = \frac{v^2}{r}$	5.2
Centripetal Force	$F_c = \frac{mv^2}{r}$	5.3
Banked Curve	$tan\theta = \frac{v^2}{rg}$	5.4
Satellites in circular orbits	$v = \sqrt{\frac{GM_E}{r}}$ $T = \frac{2\pi r^{3/2}}{\sqrt{GM_E}}$	5.5 5.6

NOTE:
M_E mass of earth = 5.98×10^{24}kg
r_E radius of earth 6.38×10^6m
G=6.67×10^{-11} N·m²/kg²

Vertical Circular Motion 	1) $F_c = F_N - mg = \frac{mv^2}{r}$ 2) $F_c = F_N = \frac{mv^2}{r}$ 3) $F_c = F_N + mg = \frac{mv^2}{r}$ 4) $F_c = F_N = \frac{mv^2}{r}$	Fig. 5.20

Chapter 6

Work done by constant Force	$W = (Fcos\theta)s$ or $W = (Fcos\theta)d$	6.1
Kinetic Energy	$KE = \frac{1}{2}mv^2$	6.2
Work-Energy Theorem	$W = KE_f - KE_0$ $= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$ $= \frac{1}{2}m(v_f^2 - v_0^2)$	6.3
Work done by gravity	$W_{gravity} = mg(h_0 - h_f)$	6.4
Gravitational Potential Energy	$PE = mgh$	6.5
Alternative Work-Energy Theorem	$W_{nc} = E_f - E_0$ $= (KE_f + PE_f) - (KE_0 + PE_0)$	6.8
When $W_{nc} = 0$	$E_f = E_0$ or $(KE_f + PE_f) = (KE_0 + PE_0)$	
Power	$P = \frac{W}{t} = \frac{\Delta E}{t} = Fv$	6.10 6.11
Work done by a variable Force	Area under the curve of a $Fcos\theta$ vs. s graph	

- Conservative Forces: force of gravity, spring force
- Non-conservative forces: friction, air resistance

Chapter 7

Impulse and Momentum

Impulse	$J = \bar{F}\Delta t$	7.1
Linear Momentum, p	*p=mv*	7.2
Impulse-Momentum Theorem	$\left(\sum \bar{F}\right)\Delta t = mv_f - mv_0 = m\Delta v$ Or J=Δp	7.4

Collision

Final Velocity of 2 objects in a head-on collision where one object is initially at rest 1: moving object 2: object at rest	$v_{f1} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{01}$ $v_{f2} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{01}$	7.8
Conservation of Linear Momentum (in 1D)	$\vec{P}_0 = \vec{P}_f$ $\vec{P}_0 = \vec{P}_f - \vec{P}_0 = 0$	7.7
Elastic Collision	$m_1 v_{01} + m_2 v_{02} = m_1 v_{f1} + m_2 v_{f2}$	7.7b
Inelastic Collision	$m_1 v_{01} + m_2 v_{02} = (m_1 + m_2) v_f$	
Conservation of Linear Momentum (in 2D)	$m_1 v_{01x} + m_2 v_{02x} = m_1 v_{f1x} + m_2 v_{f2x}$ $m_1 v_{01y} + m_2 v_{02y} = m_1 v_{f1y} + m_2 v_{f2y}$	7.9

Center of Mass

Center of mass location	$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$	7.10
Center of mass velocity	$v_{cm} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$	7.11

Chapter 8

Angular displacement	$\Delta\theta = \theta - \theta_0$ $\theta = \frac{s}{r}$	8.1
Average angular velocity	$\bar{\omega} = \frac{\Delta\theta}{\Delta t}$	8.2
Average angular acceleration	$\bar{\alpha} = \frac{\Delta\omega}{\Delta t}$	8.4

Motion of a particle with constant acceleration

$\omega = \omega_0 + \alpha t$	8.4
$\theta = \frac{1}{2}(\omega + \omega_0)t$	8.6
$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$	8.7
$\omega^2 = \omega_0^2 + 2\alpha\theta$	8.8

Relationship between angular variables and tangential variables (t subscript)	$v_T = r\omega$ $a_T = r\alpha$	8.9 8.10
When no slipping	$v = v_T = r\omega$ $a = a_T = r\alpha$	8.12 8.13
Centripetal acceleration	$a_c = r\omega^2$	8.11

Chapter 9

Torque and Inertia

Torque $\boldsymbol{\tau}$	$\tau = F\ell$	9.1
When at Equilibrium	$\sum \tau = 0$	9.2
Moment of Inertia	$I = \sum mr^2$	9.6
Newton's Second Law for a rigid body rotating about a Fixed axis	$\sum \tau = I\alpha$	9.7

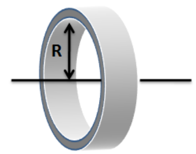
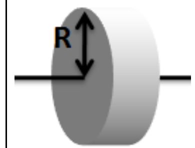
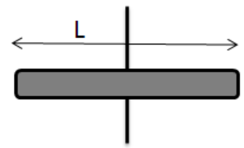
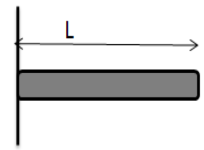
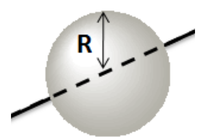
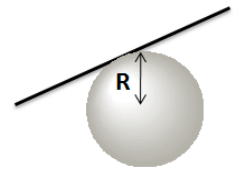
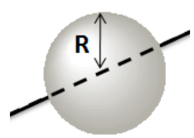
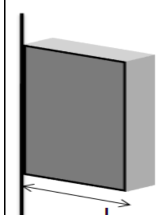
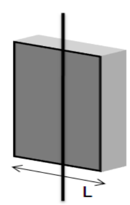
Work, Energy

Rotational work	$W_R = \tau\theta$	9.8
Rotational Kinetic Energy	$KE_R = \frac{1}{2}I\omega^2$	9.9

Angular Momentum	$L = I\omega$	9.1
Center of Gravity	$x_{cg} = \frac{W_1x_1 + W_1x_1 + \cdots}{W_1 + W_2 + \cdots}$	9.2

See reverse side for moments of Inertia I for various rigid objects of Mass M

Moments of Inertia I for various rigid objects of Mass M

Thin walled hollow cylinder or hoop  $I = MR^2$	Solid cylinder or disk  $I = \frac{1}{2}MR^2$
Thin rod, axis perpendicular to rod and passing though center  $I = \frac{1}{12}ML^2$	Thin rod, axis perpendicular to rod and passing though end  $I = \frac{1}{3}ML^2$
Solid Sphere, axis through center  $I = \frac{2}{5}MR^2$	Solid Sphere, axis tangent to surface  $I = \frac{7}{5}MR^2$
Thin Walled spherical shell, axis through center  $I = \frac{2}{3}MR^2$	Thin Rectangular sheet, axis along one edge  $I = \frac{1}{3}ML^2$
Thin Rectangular sheet, axis parallel to sheet and passing though center of the other edge  $I = \frac{1}{12}ML^2$	

Chapter 10

Force Applied	$F_x^{applied} = kx$	10.1
Hooke's Law	$F_x = -kx$	10.2
Frequency cycles per time	$f = \frac{1}{T}$	10.5
Angular frequency	$\omega = 2\pi f = {}^{2\pi}/_{T}$	10.6
Maximum Velocity Simple Harmonic Motion	$v_{max} = A\omega$	10.8
Maximum Acceleration Simple Harmonic Motion	$a_{max} = A\omega^2$	10.11
Angular frequency of simple harmonic motion	$\omega = \sqrt{{}^{k}/_{m}}$	10.11
Elastic potential energy	$PE_{elastic} = \frac{1}{2}kx^2$	10.13

Simple Pendulum (10.16)

Angular Frequency $\omega = \sqrt{\frac{g}{L}}$	*Time Period* $T = 2\pi\sqrt{\frac{L}{g}}$	*Length* $L = \frac{T^2 g}{4\pi^2}$

Physical pendulum (10.15)

Angular Frequency $\omega = \sqrt{\frac{mgL}{I}}$	*Time Period* $T = 2\pi\sqrt{\frac{I}{mgL}}$

Elastic deformation -stretch and compression (10.17)

Perpendicular to Area (A)

Y = constant called Young's modulus

Force $F = Y\left(\frac{\Delta L}{L_0}\right)A$	**Change in Length** $\Delta L = \frac{FL_0}{YA}$

Shear Deformation (change in shape)

Parallel to Area (A)

S = constant called the shear modulus

Force $F = S\left(\frac{\Delta X}{L_0}\right)A$	**Change in Length** $\Delta X = \frac{FL_0}{SA}$

Pressure (related to Volume deformation)

$P = \frac{F}{A}$	10.19

change ΔP in pressure needed to change the volume

B = constant known as the bulk modulus

When the volume decreases, ΔV is negative

$\Delta P = -B\left(\frac{\Delta V}{V_o}\right)$	10.20

Chapter 11

Density	$\rho = \frac{m}{V}$	11.1
Pressure	$P = \frac{F}{A}$	11.3
Specific Gravity	$= \frac{Density\ of\ substance}{1.000 \times 10^3\ kg/m^3}$	11.2
Pressure and depth in a static Fluid P_1 is higher than P_2	$P_2 = P_1 + \rho gh$	10.4
Gauge Pressure	ρgh	
Archimedes' principle	$F_B = W_{fluid}$	11.6
Mass Flow Rate	$Mass\ flow\ rate = \rho Av$	11.7
Volume flow rate	$Q = Av = \frac{V}{t}$	
Bernoulli's Equation	$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$	11.11
Equation of continuity	$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$	11.8
equation of continuity ($\rho_1 = \rho_2$)	$A_1 v_1 = A_2 v_2$	
Force to move Viscous Layer with constant velocity	$F = \frac{\eta A v}{y}$	11.13
Poiseuille's law	$Q = \frac{\pi R^4 (P_2 - P_1)}{8\eta L}$	11.14
Force and Area if Pressure same	$F_1/A_1 = F_2/A_2\ or\ F_2 = F_1\left(\frac{A_2}{A_1}\right)$	

Chapter 12

Temperature Scales

Fahrenheit to Celsius		$C = \frac{5}{9}(F - 32)$	
Celsius to Fahrenheit		$F = \frac{9}{5}C + 32$	
Celsius to Kelvin		K=C+273.15 or $T = T_c + 273.15$	12.1

Thermal Expansion

Linear Thermal Expansion	$\Delta L = \alpha L_o \Delta T$	12.2
Volume Thermal Expansion	$\Delta V = \beta V_0 \Delta T$	12.3

Heat and Power

Heat and temperature change	$\Delta Q = cm\Delta T$	12.4
Heat and phase change	$Q = mL$	12.5

% Relative Humidity	$\frac{Partial\ P_{water\ vapot}}{Equilibrum\ P_{water\ vapot}\ @\ temp}$	12.6

Chapter 13

Heat and Power

Power	P=Q/t	
Heat Conducted	$Q = \frac{(kA\Delta T)t}{L}$	13.1
Radiant energy e emissivity $\sigma = 5.67\text{x}10^{-8}$ J/(s*m^2*K^4) T temp in *Kelvins* A surface area	$Q = e\sigma T^4 At$	
Net radiant Power T object Temp in kelvins T_o environment temp in *Kelvins*	$P_{net} = e\sigma A(T^4 - T_0^4)$	13.3

Table 13.1 Thermal Conductivities[a] of Selected Materials

Substance	Thermal Conductivity, $k\,[\mathrm{J}/(\mathrm{s}\cdot\mathrm{m}\cdot\mathrm{C}^\circ)]$
Metals	
Aluminum	240
Brass	110
Copper	390
Iron	79
Lead	35
Silver	420
Steel (stainless)	14
Gases	
Air	0.0256
Hydrogen (H_2)	0.180
Nitrogen (N_2)	0.0258
Oxygen (O_2)	0.0265
Other Materials	
Asbestos	0.090
Body fat	0.20
Concrete	1.1
Diamond	2450
Glass	0.80
Goose down	0.025
Ice ($0\ {}^\circ\mathrm{C}$)	2.2
Styrofoam	0.010
Water	0.60
Wood (oak)	0.15
Wool	0.040

[a] Except as noted, the values pertain to temperatures near $20\ {}^\circ\mathrm{C}$.

Chapter 14

Molecular Mass, Moles, and Avogadro's Number

Atomic Mass Unit	$1\,u = 1.6605 \times 10^{-27}\,kg$
Avogadro's Number	$N_A = 6.022 \times 10^{23}\,mol^{-1}$
Number of Moles, n N number of particles (atoms or molecules)	$n = \frac{N}{N_A}$
Number of Moles, n m sample mass (g) mass per mole: g/mol	$n = \frac{m}{mass\ per\ mole}$
Mass of a particle	$m_{particle} = \frac{mass\ per\ mole}{N_A}$
Density	$\rho = \frac{n \cdot mass\ per\ mole}{V}$

Ideal Gas Law

Ideal Gas law n number of moles R Universal gas constant =8.31 J/(mol *K) T temp kelvins	$PV = nRT$	14.1
Ideal Gas Law (alternative form) N number of particles k Boltzmann's constant (1.38x10^{-23} J K^{-1})	$PV = NkT$	14.2

Boyle's and Charles' Laws

Boyle's law (when n and T are constant)	$P_iV_i = P_fV_f$	14.3
Charles' law (n and P are constant)	$\frac{V_i}{T_i} = \frac{V_f}{T_f}$	14.4

Energy

Average Kinetic Energy for a molecule	$\overline{KE} = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$	14.6
Internal Energy	$U = \frac{3}{2}nRT$	14.7

Diffusion

Fick's law of diffusion D Diffusion constant ΔC is the solute concentration difference between the ends of the channel (same as density)	$m = \frac{DA\Delta Ct}{L}$	14.8

Chapter 15

First Law of Thermodynamics

First Law	$\Delta U = U_f - U_0 = Q - W$	15.1
Note: ΔU Change in Internal Energy **Q** (heat) is positive when the system gains heat and negative when it loses heat. **W** (work) is positive when work is done by the system and negative when work is done on the system.		
Monatomic Ideal Gas Internal Energy *R=8.31 J/(mol K)	$U = \frac{3}{2}nRT$	12.5

Applications of First Law

Process	*Work Done*	*First Law*
Isobaric (constant pressure)	$W = P(V_f - V_i)$ (Eq 15.2)	$\Delta U = Q - P(V_f - V_i)$ $(Q = \frac{5}{2}nR\Delta T)$
Isochoric (constant volume)	W=0 J	$\Delta U = Q - 0J$ $(Q = \frac{3}{2}nR\Delta T)$
Isothermal (constant temp)	$W = nRTln(\frac{V_f}{V_i})$ (Eq. 15.3)	$0J = Q - nRTln(\frac{V_f}{V_i})$
Adiabatic (no heat flow)	$W = \frac{3}{2}nR(T_i - T_f)$ (15.4)	$\Delta U = 0J - \frac{3}{2}nR(T_i - T_f)$

Adiabatic expansion/compression of an ideal gas	$P_0V_0^\gamma = P_fV_f^\gamma$	15.5
Heat with known number of moles	$Q = Cn\Delta T$	15.6
molar specific heat	$C_p = \frac{5}{2}R$ $C_v = \frac{3}{2}R$	15.7 15.8

Heat Engines

The efficiency e of a heat engine	$e = \frac{Work\ done}{Input\ heat} = \frac{\|W\|}{\|Q_H\|} = 1 - \frac{\|Q_c\|}{\|Q_H\|}$	15.11 15.13
Conservation of energy requires	$\|Q_H\| = \|W\| + \|Q_c\|$	15.12

Carnot Engine

For a Carnot engine	$\frac{\|Q_C\|}{\|Q_H\|} = \frac{\|T_C\|}{\|T_H\|}$	14.14
Efficiency e for a Carnot engine	$e_{carnot} = 1 - \frac{T_C}{T_H}$	15.15

Coefficient of Performance (COP)

COP of a refrigerator or an air conditioner	$COP = \frac{\|Q_c\|}{\|W\|} = \frac{1}{\frac{T_H}{T_C} - 1}$	
COP of a heat pump	$COP = \frac{\|Q_H\|}{\|W\|}$	15.17

Entropy

change in entropy ΔS	$\Delta S = \left(\frac{Q}{T}\right)_R$	15.18
change in entropy $\Delta \boldsymbol{S_{universal}}$	$\Delta S_{universal} = \Delta S_{system} + \Delta S_{surroundings}$ $= \Delta S_{cold} + \Delta S_{Hot}$	
Energy unavailable for doing work	$W_{unavailable} = T_0 \Delta S_{universe}$	15.19

Chapter 16

Waves

Speed of a Wavelength	$v = f\lambda = \frac{\lambda}{T}$	16.1
Speed of a wave on a string	$v = \sqrt{\frac{F}{m/L}}$	16.2
description +x direction	$y = Asin(2\pi ft - \frac{2\pi x}{\lambda})$	16.3
description -x direction	$y = Asin(2\pi ft + \frac{2\pi x}{\lambda})$	16.4

Speed of Sound

Speed of Sound in a Gas k= 1.38×10^{-23}	$v = \sqrt{\frac{\gamma kT}{m}}$	16.5
Speed of sound in a liquid	$v = \sqrt{\frac{B_{ad}}{\rho}}$	16.6
Speed of sound in solid bar	$v = \sqrt{\frac{Y}{\rho}}$	16.7

Sound Intensity

Intensity	$I = \frac{P}{A}$	16.8
Intensity -uniform in all directions	$I = \frac{P}{4\pi r^2}$	16.9
Intensity level in decibels I0 =1x10-12W/m2	$\beta = (10dB)\log\left(\frac{I}{I_o}\right)$	16.10

Doppler Effect

Source Moving toward stationary observer	$f_o = f_s\left(\frac{1}{1 - \frac{v_s}{v}}\right)$	16.15
Source Moving away from stationary observer	$f_o = f_s\left(\frac{1}{1 + \frac{v_s}{v}}\right)$	16.15
Observer moving toward stationary source	$f_o = f_s\left(1 + \frac{v_o}{v}\right)$	16.15
Observer moving away from stationary source	$f_o = f_s\left(1 - \frac{v_o}{v}\right)$	16.15

Chapter 17

Constructive and Destructive Interference

Constructive 2 waves in Phase	Difference in path lengths is zero or an integer (0,1,2,3…)
Destructive 2 waves in Phase	Difference in path lengths is a half- integer (0.5,1.5,2.5,…)
Constructive 2 waves out of Phase	Difference in path lengths is a half- integer (0.5,1.5,2.5,…)
Destructive 2 waves out of Phase	Difference in path lengths is zero or an integer (0,1,2,3…)

Diffraction

Single Slit –first minimum	$sin\theta = \frac{\lambda}{D}$	17.1
Circular Opening –first minimum	$sin\theta = 1.22\frac{\lambda}{D}$	17.2

beats	$f_{beat} = f_1 - f_2$	17.46

Standing Waves

Transverse Natural frequency Fixed at both ends	$f_n = n\left(\frac{v}{2L}\right)$ for n=1,2,…	17.3
Longitudinal Natural frequency open at both ends	$f_n = n\left(\frac{v}{2L}\right)$ for n=1,2,…	17.4
Longitudinal Natural frequency open at one end	$f_n = n\left(\frac{v}{4L}\right)$ for n=1,3,5,…	17.5

Chapter 18

Formulas

Number of electrons/protons	$\# = \frac{q}{e}$	
Coulombs law: F=force Where one exerts on two	$F = \frac{k\|q_1\|\|q_2\|}{r^2}$	18.1
Electric Field	$\vec{E} = \frac{\vec{F}}{q_0}$	18.2
Magnitude of Electric Field	$E = \frac{k\|q\|}{r^2}$	18.3
Magnitude of Electric Field for a parallel plate capacitor	$E = \frac{q}{\epsilon_0 A} = \frac{\sigma}{\epsilon_0}$	18.4
Electric Flux	$\Phi_E = \sum(E\cos\phi)\Delta A = \frac{Q}{\epsilon_0}$	18.6,7

Important Numbers

$k = 8.99 \times 10^9\ N \cdot m^2/C^2$
Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}\ \frac{C^2}{N \cdot m^2}$
Magnitude of charge on electron (-e) or proton (+e) $e = 1.6 \times 10^{-19}$ C (a lot of time q_0)
Mass of Electron $9.11 \times 10^{-31}\ kg$
Mass of Proton $1.673 \times 10^{-27}\ kg$
Mass of Neutron $1.675 \times 10^{-27}\ kg$

Chapter 19

Work and Electric Potential Energy	$W_{AB} = EPE_A - EPE_B$	19.1
Electric Potential	$V = \frac{EPE}{q_0} = \frac{kq}{r}$	19.3,6
Electric Potential Difference Charge moves from A to B	$V_A - V_B = \frac{EPE_B}{q_0} - \frac{EPE_A}{q_0} = \frac{-W_{AB}}{q_0}$	19.4
Electric Potential Difference Charge moves from B to A	$V_B - V_A = \frac{W_{AB}}{q_0}$	
Total Energy	$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + mgh + \frac{1}{2}kx^2 + EPE$	
Electric field	$E = -\frac{\Delta V}{\Delta s}$	19.7a
Charge on each plate of a capacitor	$q = CV$	
Dielectric constant (E's are electric fields without and with a dielectric)	$\kappa = \frac{E_o}{E}$	
Capacitance of a parallel plate capacitor	$C = \frac{\kappa\epsilon_0 A}{d}$	
Electric Potential Energy Stored in a capacitor	$Energy = \frac{1}{2}qV = \frac{1}{2}CV^2 = \frac{q^2}{2C}$	19.11
Energy Density	$\text{Energy Density} = \frac{Energy}{Volume} = \frac{1}{2}\kappa\epsilon_0 E^2$	19.12

Chapter 20

Current (if electric current is constant)	$I = \frac{\Delta q}{\Delta t}$	20.1
Ohms Law	$V = IR \ or \ R = \frac{V}{I} \ or \ I = \frac{V}{R}$	20.2
Resistance with length L, cross-sectional area A	$R = \rho\frac{L}{A}$	20.3
Resistance and Resistivity (T temp)	$\rho = \rho_0[1 + \alpha(T - T_0)]$ $R = R_0[1 + \alpha(T - T_0)]$	20.4,5
Electric Power	$P = IV, \ P = I^2R, \ P = \frac{V^2}{R}$	20.6
AC Circuits	$V = V_0\sin(2\pi ft)$ $I = I_0\sin(2\pi ft)$	20.7,8
RMS Formulas with Current and Voltage	$I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$	20.12 20.13
Average Power	$\bar{P} = I_{rms}V_{rms}$ $\bar{P} = I_{rms}^2 R$ $\bar{P} = \frac{V_{rms}^2}{R}$	20.15
Series (I is the same)	$R_s = R_1 + R_2 + R_3 + \cdots$ $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$	20.16 20.19
Parallel (V is the same)	$\frac{1}{R_s} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$ $C_p = C_1 + C_2 + C_3 + \cdots$	20.17 20.18
RC circuits	$q = q_0[1 - e^{\frac{-t}{RC}}]$ (charging) $\tau = RC$ $q = q_0 e^{\frac{-t}{RC}}$ (discharging)	20.20 20.21 20.22

Chapter 21

Magnitude of magnetic Field $\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A$	$B = \dfrac{F}{\lvert q_0\rvert v \sin\theta}$ $B = \dfrac{\mu_0 I}{2\pi r}$ $B = N\dfrac{\mu_0 I}{2R}$ $B = \mu_0 n I$	21.1 21.5 21.6 21.7
Radius of circular path of particle caused by F	$r = \dfrac{mv}{\lvert q\rvert B}$	21.2
Relationship between Mass and B	$m = \left(\dfrac{er^2}{2V}\right)^2 B^2$	
Force on a current in a magnetic field	$F = ILBsin\theta$	21.3
Torque on a current-carrying coil	$\tau = NIABsin\phi$ ϕ is the angle between direction of B and the normal plane	21.4
Ampere's Law	$\sum B_{\|\|}\Delta l = \mu_0 I$	21.8

RHR 1: Fingers point along the direction of $\vec{B}$ and the thumb points along the velocity $\vec{v}$ The palm of the hand then faces in the direction of $\vec{F}$ that acts on a positive charge.

RHR 2: Curl the fingers of the right hand into a half-circle. Point the thumb in the direction of the conventional current I, and the tips of the fingers will point in the direction of $\vec{B}$

Chapter 22

Motional emf	$\mathcal{E} = vBL$	22.1
Magnetic Flux	$\Phi = BAcos\phi$	22.2
Faraday's Law	$\mathcal{E} = -N\dfrac{\Delta\Phi}{\Delta t}$	22.3
Emf induced ion a rotating planar coil $\omega = 2\pi f$	$\mathcal{E} = NAB\omega\sin(\omega t) = \mathcal{E}_0\sin(\omega t)$	22.4
Current	$I = \dfrac{V - \mathcal{E}}{R}$	22.5
Mutual Inductance	$M = \dfrac{N_s\Phi_s}{I_p}$	22.6
Emf due to mutual inductance	$\mathcal{E}_s = -M\dfrac{\Delta I_p}{\Delta t}$	22.7
Self-Inductance	$L = \dfrac{N\Phi}{I}$	22.8
Emf due to self-inductance	$\mathcal{E}_s = -L\dfrac{\Delta I}{\Delta t}$	22.9
Energy stored in an inductor	$Energy = \dfrac{1}{2}LI^2$	22.10
Energy Density	$Energy\ Density = \dfrac{1}{2\mu_0}B^2$	22.11
Voltage and turns of primary and secondary coil	$\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$	22.12
Current and turns of primary and secondary coil	$\dfrac{I_s}{I_p} = \dfrac{N_p}{N_s}$	22.13
Power	Power=Energy*time	

Chapter 23

Rms Voltage across a capacitor	$V_{rms} = I_{rms}X_c$	23.1
Capacitive Reactance	$X_C = \frac{1}{2\pi fC}$	23.2
Rms Voltage across an inductor	$V_{rms} = I_{rms}X_L$	23.3
Inductive Reactance	$X_L = 2\pi fL$	23.4
Rms Voltage for circuit containing resistance, capacitance, and inductance	$V_{rms} = I_{rms}Z$	23.6
Impedance of a resistor, capacitor and inductor connected in a series	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	23.7
Tangent of the phase angle	$tan\phi = \frac{X_L - X_C}{R}$	23.8
Average Power	$\bar{P} = I_{rms}V_{rms}cos\phi$	23.9
Resonant frequency	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	23.10
Power Factor	$power\ factor = \frac{\mathrm{R}}{Z}$	

Chapter 24

Speed of Light	$c = 3.00 \times 10^8\ m/s$	
Speed of Light in a vacuum	$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}}$	24.1
Total energy density	$u = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2\mu_0}B^2$ $u = \varepsilon_0 E^2$ $u = \frac{1}{\mu_0}B^2$	24.2
Relationship between magnitudes Electric and magnetic field waves	$E = cB$	2.43
Rms for Electric Field	$E_{rms} = \frac{1}{\sqrt{2}}E_0$	
Rms for Magnetic Field	$B_{rms} = \frac{1}{\sqrt{2}}B_0$	
Intensity	$S = cU$	24.4
Doppler Effect in vacuum + come together - move apart	$f_o = f_s(1 \pm \frac{v_{rel}}{c})$	24.6
Marlus' Law	$\bar{S} = \bar{S}_0 cos^2\theta$	24.7

Chapter 25

Concave Mirror

Focal length Concave mirror	$f = \frac{1}{2}R$	25.1
Focal length Convex Mirror	$f = -\frac{1}{2}R$	25.2
Mirror Equation	$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$	25.3
Magnification Equation	$m = -\frac{d_i}{d_o}$ $m = \frac{h_i}{h_o}$	25.4

Plain Mirror

- Forms an upright virtual image
- Image located same distance behind the mirror as the object in front
- Heights of object and virtual image the same

Information for Spherical mirrors

Focal Length	+	Concave mirror
	-	Convex mirror
Object distance	+	Object in front (real)
	-	Object behind (virtual)
Image Distance	+	Image in front (real)
	-	Image behind (virtual)
Magnification (sign)	+	Image is upright
	-	Image is inverted
Magnification (magnitude)	>1	larger
	<1	smaller