Phys132 - Fund. Physics 2 - Spring 2007 Equation Sheet

1 Constants

Magnitude of electron charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$	Electron mass	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
Coulomb constant	$k = 8.99 \times 10^{9}\,\mathrm{N \cdot m^2/C^2}$	Proton mass	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
Speed of light	$c = 3.00 \times 10^{8}\,\mathrm{m/s}$	Gravitational Acceleration	$g = 9.81\,\mathrm{m/s^2}$
Permittivity of a vacuum	$\epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2/\left(N \cdot m^2\right)}$	Gravitational Constant	$G = 6.67 \times 10^{-11}\,\mathrm{N \cdot m^2/kg^2}$
Length of a year:	$1\,\mathrm{yr} = 365.24\,\mathrm{days} = 8766\,\mathrm{hr}$	Boltzman Constant	$k_B = 1.38 \times 10^{-23}\,\mathrm{J/K}$
Specific Heat Ratio for Air:	$\gamma_{\mathrm{air}} = 1.4$	Mass of Air Molecules	$m_{\mathrm{air}} = 4.80 \times 10^{-26}\,\mathrm{kg}$

2 Math and Physics 1 Equations

Trigonometry

$\sin\theta = \mathrm{opp/hyp}$

$\cos\theta = \mathrm{adj/hyp}$

$\tan\theta = \mathrm{opp/adj}$

$\sin^2\theta + \cos^2\theta = 1$

Vector Components

$F_x = F\cos\theta$

$F_y = F\sin\theta$

$F = \sqrt{F_x^2 + F_y^2}$

$\tan\theta = F_y/F_x$

Mechanics

$\vec{F} = m\vec{a}$

$F = ma$

$W = mg$

Constant Acceleration

$x = v_{0x}t + \frac{1}{2}a_x t^2$

Circular Motion

$a = v_\perp^2/r$

Energy

$\mathrm{KE} = \frac{1}{2}mv^2$

$\mathrm{GPE} = mgh$

$W = \Delta\mathrm{KE} = -\Delta\mathrm{PE}$

$\Delta\mathrm{KE} + \Delta\mathrm{PE} = 0$

SI Prefixes

$G = 10^9$

$M = 10^6$

$k = 10^3$

$c = 10^{-2}$

$m = 10^{-3}$

$\mu = 10^{-6}$

$n = 10^{-9}$

Geometry

$A_{\mathrm{circle}} = \pi r^2$

$C_{\mathrm{circle}} = \pi d = 2\pi r$

$A_{\mathrm{sphere}} = 4\pi r^2$

$V_{\mathrm{sphere}} = \frac{4}{3}\pi r^3$

3 Quantities and Units

Quantity	Symbol	Units	Quantity	Symbol	Units	Quantity	Symbol	Units
Charge	q, Q	C	Elec Potential	V, ΔV	$\mathrm{V} = \frac{\mathrm{J}}{\mathrm{C}}$	Energy	KE,W,PE	J
Force	$\vec{F}$	N	Surface Charge	σ	$\mathrm{C/m^2}$	Distance	x,y,R	m
E-Field	$\vec{E}$	$\frac{\mathrm{N}}{\mathrm{C}} = \frac{\mathrm{V}}{\mathrm{m}}$	Dielectric Constant	κ	(none)	Angle	θ	rad=(none)
Flux	Φ	$\frac{\mathrm{N \cdot m^2}}{\mathrm{C}}$	Capacitance	C	$\mathrm{F} = \frac{\mathrm{C}}{\mathrm{V}}$	Angle	θ	°
Speed	v	m/s	Velocity	$\vec{v}$	m/s	Acceleration	a	$\mathrm{m/s^2}$

Note, when there is no unit, like for the dielectric constant κ, you don't write any unit.

4 Physics 2 Equations

Total charge of a number of charges: $q = Ne \Leftrightarrow N = \frac{q}{e}$

Strength of the electric force: $F = k\frac{|q_1|\,|q_2|}{r^2}$

Force in an electric field: $\vec{F} = q\vec{E}$ or $\vec{E} = \frac{\vec{F}}{q}$

Electric field of a point charge: $E = k\frac{|q|}{r^2}$

Electric field inside a capacitor: $E = \frac{q}{\epsilon_0 A} = \frac{\sigma}{\epsilon_0}$

Gauss's Law (general): $\Phi_{\mathrm{E}} = \frac{Q_{\mathrm{enc}}}{\epsilon_0}$

Gauss's Law (sphere): $\Phi_{\mathrm{E}} = EA = E\left(4\pi R^2\right) = \frac{Q_{\mathrm{enc}}}{\epsilon_0}$

Surface Charge: $q = \sigma A$ or $\sigma = \frac{q}{A}$

Volume Charge: $q = \rho V$ or $\rho = \frac{q}{V}$

Electric Potential: $V = \frac{\mathrm{EPE}}{q_0}$

Electric Potential Change: $\Delta V = \frac{\Delta\mathrm{EPE}}{q_0}$

Field vs. Potential $\Delta V = E_{\mathrm{ave}}d \quad E_{\mathrm{ave}} = \frac{\Delta V}{d}$

Effet of Dielectric: $E = E_0/\kappa$

Dielectric Capacitor: $C = \kappa C_0 = \frac{\kappa\epsilon_0 A}{d}$

Electric Potential of Point Charge: $V = k\frac{q}{R}$

Electric Potential of Empty Capacitor: $V = Ed = \frac{q}{\epsilon_0 A}d$

Air-filled Capacitor: $q = \left(\frac{\epsilon_0 A}{d}\right)V \quad C = \frac{\epsilon_0 A}{d}$

Any Capacitor: $q = CV \quad V = q/C$

Energy of Capacitor: $E_{\mathrm{cap}} = q\left(\frac{1}{2}V\right) = \frac{1}{2}CV^2$

4.1 Electricity (Chapter 20)

Quantity	Symbol	Units
Current	I	$\mathrm{A} = \mathrm{C/s}$
Voltage	V	$\mathrm{V} = \mathrm{J/C}$
Resistance	R	$\Omega = \mathrm{V/A} = \frac{\mathrm{J}\cdot\mathrm{s}}{\mathrm{C}^2}$

Quantity	Symbol	Units
Resistivity	ρ	$\Omega\cdot\mathrm{m}$
Power	P	$\mathrm{W} = \frac{\mathrm{J}}{\mathrm{s}} = \mathrm{VA}$

Electric Current:	$I = \frac{Q}{\Delta t}$ $\quad Q = I\Delta t$	Ohm's Law:	$V = IR$ $\quad I = \frac{V}{R}$ $\quad R = \frac{V}{I}$
Power:	$P = IV = I^2R = \frac{V^2}{R}$	Internal Resistance:	$V_{\text{terminal}} = V_{\mathcal{EMF}} - IR_{\text{int}}$
Energy:	$\text{Energy} = P\Delta t$	Resistivity:	$R = \rho\frac{L}{A}$
Series Resistors:	$R_{\text{S}} = R_1 + R_2 + ...$	Parallel Resistors:	$\frac{1}{R_{\text{P}}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$
Series Voltage:	$V_{\text{tot}} = V_1 + V_2 + ...$	Parallel Voltage:	$V_{\text{eq}} = V_1 = V_2 = ...$
Series Current:	$I_{\text{eq}} = I_1 = I_2 = ...$	Parallel Current:	$I_{\text{tot}} = I_1 + I_2 + ...$
Kirchoff's Junction Law:	$\sum I_{\text{in}} = \sum I_{\text{out}}$	Kirchoff's Loop Law:	$\sum V_{\text{Rises}} = \sum V_{\text{Drops}}$
RMS Voltage/Current:	$V_{\text{RMS}} = \frac{V_{\max}}{\sqrt{2}}$	AC Power:	$P_{\text{ave}} = V_{\text{RMS}}\, I_{\text{RMS}} = \frac{P_{\max}}{2}$
Series Capacitors:	$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + ...$	Parallel Capacitors:	$C_P = C_1 + C_2 + ...$
Charge of Capacitor:	$Q = CV$ $\quad V = \frac{Q}{C}$	Energy of Capacitor:	$E_{\text{cap}} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
RC Time Constant:	$\tau = RC$	RC Current:	$I = I_0 e^{-t/\tau}$
RC Charge (charging):	$q\left(t\right) = q_f\left(1 - e^{-t/\tau}\right)$	RC Charge (discharging):	$q\left(t\right) = q_i e^{-t/\tau}$

Applying Kirchoff's Rules:

1. Draw a current for each branch of the circuit.
2. Mark each resistor with + and – signs to indicate the potential that pushes the current through the resistor.
3. Apply the junction and loop rules until enough equations are available.
4. Solve for the currents.

Sound and Waves

Constants

Speed of light	$c = 3.00 \times 10^{8}\,\mathrm{m/s}$	Typical speed of sound:	$v = 343\,\mathrm{m/s}$
Length of a year:	$1\,\mathrm{yr} = 365.24\,\mathrm{days} = 8766\,\mathrm{hr}$	Boltzman Constant	$k_B = 1.38 \times 10^{-23}\,\mathrm{J/K}$
Specific Heat Ratio for Air:	$\gamma_{\text{air}} = 1.4$	Mass of Air Molecules	$m_{\text{air}} = 4.80 \times 10^{-26}\,\mathrm{kg}$

Quantities

Quantity	Symbol	Units	Quantity	Symbol	Units	Quantity	Symbol	Units
Period	T	s	Frequency	f	$\frac{\text{Cycles}}{\text{s}} = \text{Hz}$	Wavelength	λ	m
Speed	v	m/s	Amplitude	A	(various)	Phase	ϕ	rad
Power	P	$\mathrm{W}=\frac{\mathrm{J}}{\mathrm{s}}$	Intensity	I	$\mathrm{W/m^2}$	Sound Level	β	dB
Temperature	T	K	Force	F	N	Energy		J
Length	L	m	Time	t	s			

Equations

Speed of a Wave:	$v = f\lambda$	Mathematical Oscillating Wave:	$y(x,t) = A\sin\left(2\pi f t - \frac{2\pi}{\lambda}x\right)$
Period vs. Frequency:	$f = \frac{1}{T}$	Phase:	$\frac{\phi}{2\pi} = \frac{x}{\lambda} = \frac{t}{T} = \text{Fraction of a cycle}$
Speed on String:	$v = \sqrt{\frac{F_T}{(m/L)}}$	Speed of Sound in a gas:	$v = \sqrt{\frac{\gamma k_B T}{m}}$
n^{th} Harmonic Frequencies:	$f_n = n f_1 = \frac{v}{\lambda_n}$	Wave on string (both ends fixed):	$\lambda_n = \frac{2L}{n}$ (n is integer)
Intensity:	$I = \frac{P}{A}$	Wave in a pipe (one end open):	$\lambda_n = \frac{4L}{n}$ (n is odd)
Point Source Intensity:	$I = \frac{P}{4\pi R^2}$	Wave in a pipe (both ends open):	$\lambda_n = \frac{2L}{n}$ (n is integer)
Decibels:	$\text{Factor} = \frac{I}{I_0} = 10^{\text{dB}/10}$	Doppler Effect (source moving toward):	$f_o = f_s\left(\frac{1}{1-\frac{v_s}{v}}\right)$
Decibels:	$\text{dB} = 10 \cdot \log(\text{Factor})$	Doppler Effect (observer moving toward):	$f_o = f_s\left(1+\frac{v_o}{v}\right)$
Beat Frequency:	$f_{\text{Beats}} = f_1 - f_2$	Full Doppler Effect	$f_o = f_s\left(\frac{1+v_o/v}{1-v_s/v}\right)$
Energy:	$\text{Energy} = P\Delta t$		

Sample decibel values

dB	Factor
3	2
5	3.2
7	5
10	10
20	100
Add	Multiply
Subtract	Divide

	Intensity	Sound Level
Threshold of Hearing	$10^{-12}\,\mathrm{W/m^2}$	0 dB
Whisper	$10^{-10}\,\mathrm{W/m^2}$	20 dB
Normal Conversation	$3.2 \times 10^{-6}\,\mathrm{W/m^2}$	65 dB
Loud Vehicle	$10^{-2}\,\mathrm{W/m^2}$	100 dB
Pain	1.0	120 dB

Magnetism

Constants

Magnitude of electron charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$	Electron mass	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
Coulomb constant	$k = 8.99 \times 10^{9}\,\mathrm{N \cdot m^2/C^2}$	Proton mass	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
Speed of light	$c = 3.00 \times 10^{8}\,\mathrm{m/s}$	Gravitational Acceleration	$g = 9.81\,\mathrm{m/s^2}$
Permittivity of a vacuum	$\epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2/\left(N \cdot m^2\right)}$	Permeability of vacuum	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{T \cdot m/A}$

Quantities

Quantity	Symbol	Units	Quantity	Symbol	Units	Quantity	Symbol	Units
Magnetic Field	$\vec{B}$	T	Force	$\vec{F}$	N	Current	I	$\mathrm{A} = C/s$
Charge	q	C	Velocity	$\vec{v}$	m/s	Angle	θ	rad or °
Length, Radius	L, r	m	Torque	τ	$\mathrm{N \cdot m}$	Mag. Flux	Φ	$\mathrm{T \cdot m^2}$
EMF, Voltage	$\mathcal{E}$, V	V	Energy		J	Energy Density		$\mathrm{J/m^3}$
Capacitance	C	F	Inductance	L	H	Angular Speed	ω	rad/s
Electric Field	$\vec{E}$	N/C = V/m						

Equations

Magnetic Force: $\vec{F} = q\vec{v} \otimes \vec{B} = F$ (dir by RHR)

Magnetic Force magnitude: $F = qvB\sin\theta_{vB} = qv_\perp B = qvB_\perp$

Force on straight current: $F = ILB\sin\theta_{vB} = IL_\perp B = ILB_\perp$

Circular Motion: $F = m\dfrac{v_\perp^2}{r} = qv_\perp B \qquad r = \dfrac{mv}{qB}$

Electric Force: $\vec{F} = q\vec{E} \qquad F = qE$

Velocity Selector: $E = vB$

Mass Spectrometer: $m = \left(\dfrac{qr^2}{2V}\right)B^2$

Torque on a motor coil: $\tau = NIAB\sin\phi$

Field of a straight current: $B = \dfrac{\mu_0 I}{2\pi r}$

Field of a loop (at center): $B = N\dfrac{\mu_0 I}{2R}$

Field of Solenoid: $B = \mu_0 nI$

Ampere's Law: $B_{\parallel,\,\mathrm{ave}}\ell = \mu_0 I_{\mathrm{enc}}$

EMF of a wire: $\mathcal{E} = vBL$

Magnetic Flux: $\Phi = BA\cos\phi$

Faraday's Law: $\mathcal{E} = -N\dfrac{\Delta\Phi}{\Delta t}$

EMF of generator: $\mathcal{E}_{\max} = NAB\omega \qquad \mathcal{E} = \mathcal{E}_{\max}\sin\omega t$

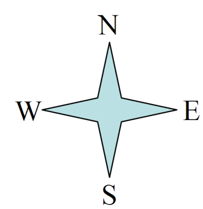
Inductor: $N\Phi = LI \qquad \mathcal{E} = -L\dfrac{\Delta I}{\Delta t}$

Current of Motor: $I = \dfrac{V - \mathcal{E}_{\mathrm{back}}}{R}$

Energy of Inductor $= \frac{1}{2}LI^2$ Energy Density $= \frac{1}{2\mu_0}B^2$

Transformer: $\dfrac{V_P}{V_S} = \dfrac{N_P}{N_S} \qquad \dfrac{I_S}{I_P} = \dfrac{N_P}{N_S}$

First Right-Hand Rule (Magnetic Force):



1. Point your fingers in the direction of the first vector ($\vec{v}$)
2. Curl your fingers in toward the second vector $\left(\vec{B}\right)$, and
3. Your thumb will point in the direction of the force on a positive charge.
   Don't forget to reverse the direction if q is negative.

Second Right-Hand Rule (Magnetic Field of a current):

1. Point your **thumb** in the direction of a **straight current**, and your fingers will curl around the current in the direction of the magnetic field.
2. **Curl your fingers** in the direction of a **loop current**, and your thumb will point in the direction of the magnetic field inside the loop.