Formula Sheet for Physics 132

$nano = n = 10^{-9}$
$K = 8.99 \cdot 10^9 \frac{Nm^2}{C^2}$
elementary charge $e = 1.6 \times 10^{-19} C$
mass of an electron $m_e = 9.1 \times 10^{-31} kg$, $q_{electron} = -e$,
mass of a proton $m_p = 1.67 \times 10^{-27} kg$, $q_{proton} = e$
mass of a neutron $m_n = 1.68 \times 10^{-27} kg$
permittivity constant $\varepsilon_0 = 8.85 \cdot 10^{-12} \frac{C^2}{Nm^2} = 8.85 \cdot 10^{-12} \frac{F}{m}$, pronounced 'epsilon-naught'
acceleration due to gravity on Earth's surface: $g = 9.8 \frac{m}{s^2}$

Coulomb's Law: $F_{1\,on\,2} = F_{2\,on\,1} = \frac{K|q_1||q_2|}{r^2}$; the force is repulsive for like charges, attractive for unlike charges

Electric field $\vec{E} = \vec{F}_{on\,q}/q$
Electric field of a point charge: $\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}$ with the unit vector $\hat{r}$ in the direction pointing from the point charge to the location where the electric field is calculated.
electric flux through a flat area A with constant electric field: $\Phi_e = \vec{E} \cdot \vec{A}$
electric flux through a Gaussian surface: $\Phi_e = \oint \vec{E} \cdot d\vec{A}$
Gauss' Law: $\Phi_e = \frac{Q_{in}}{\varepsilon_0}$

electron current: i = rate of electron flow, $N_e = i\Delta t$
conventional current I = rate of charge flow $= ei$, $Q = I\Delta t$
current density $J = I/A = \sigma E = nev_d$ with σ = conductivity
drift speed $v_d = \frac{e\tau}{m} E$, with τ mean time between collisions, m mass of charge carriers
$i = nAv_d$ where n is the electron density
conductivity $\sigma = \frac{ne^2\tau}{m}$
resistivity $\rho = 1/\sigma$

electric potential energy of two point charges: $U = k\frac{q_1 q_2}{r}$
change in electric potential energy of a point charge inside a parallel plate capacitor: $\Delta U = -qE\Delta s$
electric potential $V = U/q$
electric potential of a point charge q, a distance r away: $V = k\frac{q}{r}$
electric potential of a charge Q on a sphere of radius R: same as the potential for a point charge if $r \geq R$
$\Delta V = V(s_f) - V(s_i) = -\int_{s_i}^{s_f} E_s ds$
$E_s = -\frac{dV}{ds}$
loop rule $\Sigma(\Delta V)_i = 0$ for a closed path
wires: $E_{wire} = \frac{\Delta V_{wire}}{L}$
current in a wire $I = \frac{\Delta V}{R}$ where $R = \frac{\rho L}{A}$ is the wire's resistance
capacitors: capacitance $C = \frac{Q}{\Delta V}$
energy stored in a capacitor $U_C = \frac{1}{2} C(\Delta V_C)^2$
series capacitors: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$
parallel capacitors $C_{eq} = C_1 + C_2 + C_3 + \ldots$

parallel plate capacitor: $C = \epsilon_0 \dfrac{A}{d}$

resistors:

current through a resistor with potential difference ΔV across the resistor: $I = \dfrac{\Delta V}{R}$

power dissipated $P = I \Delta V$

series connection: $R_{eq} = R_1 + R_2 + R_3 + \dots$

parallel connection: $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + \dots$

junction rule: the sum of the currents entering any junction must be equal to the sum of the currents leaving that junction.

loop rule: the algebraic sum of the changes in potential encountered in a complete traversal of any loop of a circuit must be zero.

RC circuits:

discharging the capacitor: resistance R and capacitance C in series

$q = q_0 \exp[-t/RC]$

time constant$\tau = RC$

Magnetism

magnetic field $\vec{B}$, unit: $1T = tesla = \frac{N}{Am}$

Biot - Savart Law $d\vec{B} = \dfrac{\mu_0}{4\pi} \dfrac{q\,\vec{v} \times \hat{r}}{r^2}$; permeability constant: $\mu_0 = 4\pi \cdot 10^{-7} \frac{Tm}{A}$

magnetic field due to a long straight wire with current i, a distance r away: $B = \dfrac{\mu_0}{2\pi} \dfrac{I}{r}$

Ampere's Law $\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{through}$

Dynamics

Newton's Second Law: $\sum \vec{F} = m\vec{a}$

Newton's Third Law: $\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$

force of **gravity** on earth's surface: $|\vec{F}_g| = mg$, $g = 9.8 \frac{m}{s^2}$, $|\vec{F}_g|$ is also called weight

uniform circular motion - centripetal acceleration: $a = \dfrac{v^2}{r}$

Gravitational force between two masses: $F = G\dfrac{m\,M}{r^2}$, $G = 6.67 \cdot 10^{-11} \frac{Nm^2}{kg^2}$

Geometry: area of a circle of radius r: $A = \pi r^2$ circumference of a circle of radius r: $C = 2\pi r$

surface area of a sphere of radius r: $S = 4\pi r^2$ volume of a sphere of radius r: $V = \frac{4}{3}\pi r^3$

angle in radians: $\theta = s/r$ with arclength s and radius r

Quadratic equation: $ax^2 + bx + c = 0, \; x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Unit vectors: $\hat{i}$ in x-direction $\hat{j}$ in y-direction $\hat{k}$ in z-direction

Dot Product (or Scalar Product) of two vectors: $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z = ab\cos\theta$, θ angle between the two vectors

Cross product of two vectors: $\vec{a} \times \vec{b} = \vec{c}$, magnitude $|\vec{a} \times \vec{b}| = ab\sin\phi$, ϕ angle between the two vectors; direction from right hand rule: point thumb in the direction of $\vec{a}$, index finger in the direction of $\vec{b}$, then your middle finger will point in the direction of $\vec{c}$

$\hat{i} \times \hat{j} = \hat{k}, \;\; \hat{k} \times \hat{i} = \hat{j}, \;\; \hat{j} \times \hat{k} = \hat{i}$

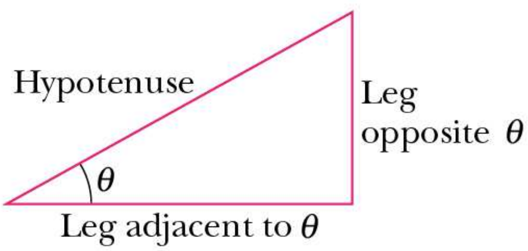
$\vec{a} \times \vec{b} = -\vec{b} \times \vec{a}$

Trig and right triangle:

$$\sin\theta = \frac{\text{leg opposite } \theta}{\text{hypotenuse}}$$

$$\cos\theta = \frac{\text{leg adjacent to } \theta}{\text{hypotenuse}}$$

$$\tan\theta = \frac{\text{leg opposite } \theta}{\text{leg adjacent to } \theta}$$



Theorem of **Pythagoras**: $(\text{leg adjacent})^2 + (\text{leg opposite})^2 = (\text{hypotenuse})^2$

physical quantity	symbol	SI unit	abbreviation for unit
displacement, distance	$\vec{r}, x, y, ...$	meter	m
velocity	$\vec{v},\ v_s$	meter/second	$\frac{m}{s}$
acceleration	$\vec{a}, a_s$	meter/second/second	$\frac{m}{s^2}$
mass	m	kilogram	kg
force	F	Newton	$N = \frac{kgm}{s^2}$
energy, work	E, U, K, W	Joule	$J = Nm$
power	P	Watt	$W = \frac{J}{s}$
electric charge	Q	Coulomb	C
electric field	$\vec{E}$	Newton/Coulomb	$\frac{N}{C} = \frac{V}{m}$
electric current	I	Ampere	$A = \frac{C}{s}$
current density	$\vec{J}$	Ampere/meter squared	$\frac{A}{m^2}$
resistance	R	Ohm	$\Omega = \frac{V}{A}$
conductivity	σ	1/Ohm-meters	$1/(\Omega m)$
resistivity	ρ	Ohm-meters	Ωm
electric potential, voltage	V	Volt	V
capacitance	C	Farad	$F = \frac{C}{V}$
magnetic field	$\vec{B}$	Tesla	$1T = \frac{N}{Am}$