Formula Sheet for LSU Physics 2113, Second Exam, Spring '15

- **Constants, definitions:**

$g = 9.8\,\frac{\mathrm{m}}{\mathrm{s}^2}$ $\quad R_{Earth} = 6.37 \times 10^6\,\mathrm{m}$ $\quad M_{Earth} = 5.98 \times 10^{24}\,\mathrm{kg}$

$G = 6.67 \times 10^{-11}\,\frac{\mathrm{m}^3}{\mathrm{kg}\cdot\mathrm{s}^2}$ $\quad R_{Moon} = 1.74 \times 10^6\,\mathrm{m}$ $\quad$ Earth-Sun distance $= 1.50\times10^{11}\,\mathrm{m}$

$M_{Sun} = 1.99 \times 10^{30}\,\mathrm{kg}$ $\quad M_{Moon} = 7.36 \times 10^{22}\,\mathrm{kg}$ $\quad$ Earth-Moon distance $= 3.82\times10^{8}\,\mathrm{m}$

$\epsilon_o = 8.85 \times 10^{-12}\,\frac{\mathrm{C}^2}{\mathrm{Nm}^2}$ $\quad k = \frac{1}{4\pi\epsilon_o} = 8.99\,\times 10^9\,\frac{\mathrm{Nm}^2}{\mathrm{C}^2}$ $\quad e = 1.60 \times 10^{-19}\,\mathrm{C}$

$c = 3.00 \times 10^8\,\mathrm{m/s}$ $\quad m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$ $\quad 1\ \mathrm{eV} = \mathrm{e}(1\mathrm{V}) = 1.60\times10^{-19}\,\mathrm{J}$

dipole moment: $\vec{p} = q\vec{d}$ $\quad m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$ $\quad$ charge densities: $\lambda = \frac{Q}{L},\ \ \sigma = \frac{Q}{A},\ \ \rho = \frac{Q}{V}$

Area of a circle: $A = \pi r^2$ $\quad$ Area of a sphere: $A = 4\pi r^2$ $\quad$ Volume of a sphere: $V = \frac{4}{3}\pi r^3$

Area of a cylinder: $A = 2\pi r\ell$ $\quad$ Volume of a cylinder: $V = \pi r^2 \ell$

- **Units:**

Joule = J = N·m

- **Kinematics (constant acceleration):**

$$v = v_o + at \qquad x - x_o = \tfrac{1}{2}(v_o + v)t \qquad x - x_o = v_o t + \tfrac{1}{2}at^2 \qquad v^2 = v_o^2 + 2a(x - x_o)$$

- **Circular motion:**

$$F_c = ma_c = \frac{mv^2}{r}, \quad T = \frac{2\pi r}{v}, \quad v = \omega r$$

- **General (work, def. of potential energy, kinetic energy):**

$K = \frac{1}{2}mv^2$ $\quad \vec{F}_{\mathrm{net}} = m\vec{a}$ $\quad E_{\mathrm{mech}} = K + U$

$W = -\Delta U$ (by field) $\quad W_{ext} = \Delta U$ (if objects are initially and finally at rest)

- **Gravity:**

Newton's law: $|\vec{F}| = G\frac{m_1 m_2}{r^2}$

Gravitational acceleration (planet of mass M): $a_g = \frac{GM}{r^2}$

Gravitational Field: $\vec{g} = -G\frac{M}{r^2}\hat{r} = -\frac{dV_g}{dr}$

Gravitational potential: $V_g = -\frac{GM}{r}$

Law of periods: $T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$

Potential Energy: $U = -G\frac{m_1 m_2}{r_{12}}$

Potential Energy of a System (more than 2 masses): $U = -\left(G\frac{m_1 m_2}{r_{12}} + G\frac{m_1 m_3}{r_{13}} + G\frac{m_2 m_3}{r_{23}} + \ldots\right)$

Gauss' law for gravity: $\oint_S \vec{g}\cdot d\vec{S} = -4\pi G M_{ins}$

- **Electrostatics:**

Coulomb's law: $|\vec{F}| = k\frac{|\,q_1\,||\,q_2\,|}{r^2}$

Force on a charge in an electric field: $\vec{F} = q\vec{E}$

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

Electric field of a dipole on axis, far away from dipole: $\vec{E} = \frac{2k\vec{p}}{z^3}$

Electric field of an infinite line charge: $|\vec{E}| = \frac{2k\lambda}{r}$

Electric field at the center of uniformly charged arc of angle ϕ: $|\vec{E}| = \frac{\lambda\sin(\phi/2)}{2\pi\epsilon_0 R}$

Torque on a dipole in an $\vec{E}$ field: $\vec{\tau} = \vec{p}\times\vec{E}$, $\quad$ Potential energy of a dipole in $\vec{E}$ field: $U = -\vec{p}\cdot\vec{E}$

- **Electric flux:** $\Phi = \int \vec{E} \cdot d\vec{A}$
- **Gauss' law:** $\epsilon_o \oint \vec{E} \cdot d\vec{A} = q_{enc}$
- **Electric field of an infinite non-conducting plane with a charge density** σ**:** $E = \frac{\sigma}{2\epsilon_o}$
- **Electric field of infinite conducting plane or close to the surface of a conductor:** $E = \frac{\sigma}{\epsilon_o}$
- **Electric potential, potential energy, and work:**

  $V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$ **In a uniform field:** $\Delta V = -\vec{E} \cdot \Delta\vec{s} = -Ed\cos\theta$

  $\vec{E} = -\vec{\bigtriangledown} V, \quad E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$

  Potential of a point charge q**:** $V = k\frac{q}{r}$ **Potential of** n **point charges:** $V = \sum_{i=1}^{n} V_i = k \sum_{i=1}^{n} \frac{q_i}{r_i}$

  Electric potential energy: $\Delta U = q\Delta V \quad \Delta U = -W_{\text{field}}$

  Potential energy of two point charges: $U_{12} = W_{\text{ext}} = q_2 V_1 = q_1 V_2 = k\frac{q_1 q_2}{r_{12}}$

- **Capacitance: definition:** $q = CV$

  Capacitor with a dielectric: $C = \kappa C_{air}$ **Parallel plate:** $C = \varepsilon_\circ \frac{A}{d}$

  Potential Energy in Cap: $U = \frac{q^2}{2C} = \frac{1}{2}qV = \frac{1}{2}CV^2$ **Energy density of electric field:** $u = \frac{1}{2}\kappa\varepsilon_o|\vec{E}|^2$

  Capacitors in parallel: $C_{eq} = \sum C_i$ **Capacitors in series:** $\frac{1}{C_{eq}} = \sum \frac{1}{C_i}$