Formula Sheet for LSU Physics 2113, Second Exam, Fall '16

- **Constants, definitions:**

$g = 9.8\,\frac{\text{m}}{\text{s}^2}$
$G = 6.67 \times 10^{-11}\,\text{m}^3/(\text{kg}\cdot\text{s}^2)$
$c = 3.00 \times 10^{8}\,\text{m/s}$
$e = 1.602 \times 10^{-19}\,\text{C}$
$1\,\text{eV} = e\,(1\text{V}) = 1.60\times10^{-19}\,\text{J}$
$m_p = 1.67 \times 10^{-27}\,\text{kg}$
$m_e = 9.11 \times 10^{-31}\,\text{kg}$
dipole moment: $\vec{p} = q\vec{d}$

$\varepsilon_o = 8.85 \times 10^{-12}\,\frac{\text{C}^2}{\text{Nm}^2}$
$R_{Earth} = 6.37 \times 10^{6}\,\text{m}$
$M_{Earth} = 5.98 \times 10^{24}\,\text{kg}$
$R_{Moon} = 1.74 \times 10^{6}\,\text{m}$
$M_{Moon} = 7.36 \times 10^{22}\,\text{kg}$
$M_{Sun} = 1.99 \times 10^{30}\,\text{kg}$
Earth-Sun distance = 1.50×10^{11} m
Earth-Moon distance = 3.82×10^{8} m

$k = \frac{1}{4\pi\varepsilon_o} = 8.99 \times 10^{9}\,\frac{\text{Nm}^2}{\text{C}^2}$
Area of a cylinder: $A = 2\pi r\ell$
Volume of a cylinder: $V = \pi r^2 \ell$
Volume element: $dV = 2\pi \ell r dr$
Area of a circle: $A = \pi r^2$
Area element: $dA = 2\pi r dr$
Area of a sphere: $A = 4\pi r^2$
Volume of a sphere: $V = \frac{4}{3}\pi r^3$
Volume element: $dV = 4\pi r^2 dr$

Uniform charge densities: $\lambda = \frac{Q}{L}$, $\sigma = \frac{Q}{A}$, $\rho = \frac{Q}{V}$

- **Kinematics (constant acceleration):**

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

- **Circular motion:**

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

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

$K = \frac{1}{2}mv^2 \qquad \vec{F}_{\text{net}} = m\vec{a} \qquad E_{\text{mech}} = K + U$
$W = -\Delta U$ (by field) $\quad W_{ext} = \Delta U = -W$ (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): $a_g = \frac{GM}{r^2}$

Law of periods: $T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$, Potential Energy: $U_g = -G\frac{m_1 m_2}{r_{12}}$

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

- **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: $|\vec{E}| = k\frac{|\,q\,|}{r^2}$, An infinite line charge: $|\vec{E}| = \frac{2k\lambda}{r}$

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

At the center of uniformly charged arc of angle ϕ: $|\vec{E}| = \frac{\lambda \sin(\phi/2)}{2\pi\varepsilon_0 R}$

Along the line through the center of uniformly charged disk: $|\vec{E}| = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{\sqrt{z^2 + R^2}}\right)$

Of an infinite non-conducting plane: $E = \frac{\sigma}{2\varepsilon_o}$

An infinite conducting plane or close to the conducting surface: $E = \frac{\sigma}{\varepsilon_o}$

Torque on a dipole in an $\vec{E}$ field: $\vec{\tau} = \vec{p} \times \vec{E}$, **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:** $\varepsilon_o \oint \vec{E}\cdot d\vec{A} = q_{enc}$

- **Electric potential, potential energy, and work:**

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

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

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

  Electric potential energy: $\Delta U = q\Delta V = -W_{\text{field}}$, $\Delta U = W_{ext}$ (if objects are initially and finally at rest)

  Potential energy of two point charges: $U_{12} = W_{\text{ext}} = q_2V_1 = q_1V_2 = k\dfrac{q_1q_2}{r_{12}}$

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

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

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

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