PHYSICS 113: Contemporary Physics – Midterm Formula Sheet

Not every equation here will actually be needed on the exam, and some may be needed more than once. Process of elimination is not a terribly good strategy.

Physical Constants:

$$c = 3 \times 10^8 m/s$$

$$G = 6.67 \times 10^{-11} Nm^2/kg^2$$

Units:

$$1N = kg\ m/s^2$$

$$1J = 1Nm = 1kg\ m^2/s^2$$

Fundamental Physical Definitions:

$$\vec{v} = \frac{d\vec{r}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt}$$

From Newton's Laws (in relativity):

$$\vec{p} = \frac{m\vec{v}}{\sqrt{1 - v^2/c^2}}$$

$$\vec{v} = \frac{\vec{p}/m}{\sqrt{1 + \left(\frac{p}{mc}\right)^2}}$$

$$\vec{F}_{net} = \frac{d\vec{p}}{dt}$$

For a single timestep:

$$\Delta\vec{p} = \vec{F}_{net}\Delta t$$

$$\begin{aligned} \Delta\vec{r} &= \vec{v}\Delta t \\ &= \frac{\vec{p}/m}{\sqrt{1 + \left(\frac{p}{mc}\right)^2}}\Delta t \\ &\simeq \frac{\vec{p}}{m}\Delta t \end{aligned}$$

Springs:

$$F = -kx$$

Which has the solution:

$$x(t) = x_0 \cos(\omega_0 t)$$

where

$$\omega_0 = \sqrt{k/m}$$

Young's Modulus:

$$\frac{F}{A} = Y \times \frac{\Delta L}{L}$$

Pendulums:

$$\omega_0 = \sqrt{g/l}$$

The Force of Gravity:

$$\vec{F}_{1,g} = \frac{Gm_1m_2}{r^2}\hat{r}_{12}$$

Near the surface of the earth:

$$\vec{F}_g = -mg\hat{j}$$

Properties of a circular orbit:

$$\vec{a}_c = -\frac{v^2}{r}\hat{r}$$

$$v = \sqrt{\frac{GM}{r}}$$

Work:

$$W = \vec{F} \cdot \Delta\vec{r}$$

$$W_{ext} = \Delta E$$

Energy:

$$\frac{dE}{dt} = \vec{v} \cdot \frac{d\vec{p}}{dt}$$

$$E = \frac{mc^2}{\sqrt{1 - v^2/c^2}}$$

$$E = mc^2 + K + U$$

$$E^2 = (mc^2)^2 + (pc)^2$$

$$K \simeq \frac{p^2}{2m}$$

Potential Energy:

$$\frac{dU}{dx} = -F_x$$

For a Mass on a Spring:

$$U_s = \frac{1}{2}kx^2$$

Gravitational Potential Energy:

$$U_g = -\frac{Gm_1m_2}{r}$$

Near the Surface of the earth:

$$U_g = mgy$$