

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.

Math:

$$\vec{u} \cdot \vec{v} = u_x v_x + u_y v_y = |\vec{u}| |\vec{v}| \cos \phi$$

$$\lim_{x \rightarrow 0} (1+x)^n \simeq 1 + nx$$

Physical Constants:

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

$$\hbar = 1.05 \times 10^{-34} \text{ J} \cdot \text{s}$$

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

Earth-specific constants:

$$g = 9.8 \text{ m/s}^2 \simeq 10 \text{ m/s}^2$$

$$M_{\oplus} = 6 \times 10^{24} \text{ kg}$$

$$R_{\oplus} = 6.4 \times 10^6 \text{ m}$$

$$\text{year} = 3.15 \times 10^7 \text{ s}$$

Units:

$$1\text{N} = \text{kg m/s}^2$$

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

Fundamental Physical Definitions:

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

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

Projectile Motion

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2$$

$$\vec{v} = \vec{v}_0 + \vec{a} t$$

From Newton's Laws (in relativity):

$$\gamma \equiv \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$\vec{p} = m\vec{v}\gamma$$

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

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

For a single timestep:

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

$$\Delta\vec{r} = \vec{v}\Delta t$$

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:

$$\vec{F}_{1,g} = \frac{Gm_1 m_2}{r^2} \hat{r}_{12}$$

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:

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

$$E = mc^2\gamma$$

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

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

$$K = mc^2(\gamma - 1)$$

$$K_{NR} \simeq \frac{1}{2}mv^2$$

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:

$$U_g = mgy$$