Prefixes
*a* = 10^{-18}, *f* = 10^{-15}, *p* = 10^{-12}, *n* = 10^{-9}, *µ* = 10^{-6}, *m* = 10^{-3}, *c* = 10^{-2}, *k* = 10^{3}, *M* = 10^{6}, *G* = 10^{9}, *T* = 10^{12}, *P* = 10^{15}

Physical Constants

\[
g = 9.80 \text{ m/s}^2 \quad \text{(gravitational acceleration)} \quad G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \quad \text{(Gravitational constant)}
\]

\[
M_E = 5.98 \times 10^{24} \text{ kg} \quad \text{(mass of Earth)} \quad R_E = 6380 \text{ km} \quad \text{(mean radius of Earth)}
\]

\[
m_e = 9.11 \times 10^{-31} \text{ kg} \quad \text{(electron mass)} \quad m_p = 1.67 \times 10^{-27} \text{ kg} \quad \text{(proton mass)}
\]

\[
c = 299792458 \text{ m/s} \quad \text{(speed of light)}
\]

Units and Conversions

1 inch = 1 in = 2.54 cm (exactly) \quad 1 foot = 1 ft = 12 in = 30.48 cm (exactly)
1 mile = 5280 ft \quad 1 mile = 1609.344 m = 1.609344 km
1 m/s = 3.6 km/hour \quad 1 ft/s = 0.6818 mile/hour
1 acre = 43560 ft^2 = (1 mile)^2/640 \quad 1 hectare = 10^4 m^2

Trig summary

\[
\sin \theta = \frac{\text{(opp)}}{\text{(hyp)}}, \quad \cos \theta = \frac{\text{(adj)}}{\text{(hyp)}}, \quad \tan \theta = \frac{\text{(opp)}}{\text{(adj)}}, \quad (\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2.
\]

\[
\sin \theta = \sin(180^\circ - \theta), \quad \cos \theta = \cos(-\theta), \quad \tan \theta = \tan(180^\circ + \theta), \quad \sin^2 \theta + \cos^2 \theta = 1.
\]

Chapter 1 Equations

Percent error:
If a measurement = value \pm error, \quad the percent error = \frac{\text{error}}{\text{value}} \times 100 \%

Chapter 2 Equations

Motion:
\[
\frac{\Delta \vec{v}}{\Delta t}, \quad \Delta x = x - x_0, \quad \text{slope of } x(t) \text{ curve} = v(t).
\]

\[
\frac{\Delta \vec{a}}{\Delta t}, \quad \Delta v = v - v_0, \quad \text{slope of } v(t) \text{ curve} = a(t).
\]

For constant acceleration in one-dimension:
\[
\vec{v} = \frac{1}{2}(v_0 + v), \quad v = v_0 + at, \quad x = x_0 + v_0t + \frac{1}{2}at^2, \quad v^2 = v_0^2 + 2a(x - x_0).
\]

For free fall on Earth, using an upward y-axis, with *g* = 9.80 m/s^2 downward:
\[
\vec{v}_y = \frac{1}{2}(v_{y0} + v_y), \quad v_y = v_{y0} - gt, \quad y = y_0 + v_{y0}t - \frac{1}{2}gt^2, \quad v_y^2 = v_{y0}^2 - 2g\Delta y.
\]

Chapter 3 Equations

Vectors
Written \( \vec{V} \) or \( \mathbf{V} \), described by magnitude=V, direction=\( \theta \) or by components \( (V_x, V_y) \).

\[
V_x = V \cos \theta, \quad V_y = V \sin \theta,
\]

\[
V = \sqrt{V_x^2 + V_y^2}, \quad \tan \theta = \frac{V_y}{V_x}, \quad \theta \text{ is the angle from } \vec{V} \text{ to x-axis.}
\]

Addition: \( \mathbf{A} + \mathbf{B} \), head to tail. Subtraction: \( \mathbf{A} - \mathbf{B} \) is \( \mathbf{A} + (-\mathbf{B}) \), \( -\mathbf{B} \) is \( \mathbf{B} \) reversed.

Projectiles
\[
a_x = 0, \quad v_x = v_{x0}, \quad x = x_0 + v_{x0}t. \quad \text{For a horizontal } x\text{-axis.}
\]

\[
a_y = -g, \quad v_y = v_{y0} - gt, \quad y = y_0 + v_{y0}t - \frac{1}{2}gt^2. \quad \text{For an upward } y\text{-axis.}
\]

\[
R = \frac{v_{x0}^2}{g} \sin 2\theta_0, \quad \text{(For level ground only.)}
\]

Relative Motion
\[
\vec{V}_{BS} = \vec{V}_{BW} + \vec{V}_{WS}, \quad \text{B=Boat, S=Shore, W=Water.}
\]

BS means "boat relative to shore", etc.

Must be applied as a vector equation!
Chapter 4 Equations

Newton’s Second Law:
\[ \vec{F}_{\text{net}} = \vec{m}\ddot{a}, \text{ means } \Sigma F_x = ma_x \text{ and } \Sigma F_y = ma_y. \]
\[ \vec{F}_{\text{net}} = \sum \vec{F}_i, \text{ sum over all forces on a mass}. \]

Friction (magnitude):
\[ f_s \leq \mu_s N \quad \text{or} \quad F_{\text{fr}} \leq \mu_s F_N \quad \text{(static friction)}.
\[ f_k = \mu_k N \quad \text{or} \quad F_{\text{fr}} = \mu_k F_N. \quad \text{(kinetic or sliding friction)}\]

Gravitational force near Earth:
\[ F_G = mg, \text{ downward}. \]

Chapter 5 Equations

Centripetal Acceleration:
\[ a_R = \frac{v^2}{r}, \text{ towards the center of the circle}. \]

Circular motion:
\[ \text{speed } v = \frac{2\pi r}{T} = 2\pi f, \text{ frequency } f = \frac{1}{T}, \text{ where } T \text{ is the period of one revolution}. \]

Gravitation:
\[ F = G\frac{m_1 m_2}{r^2}; \quad g = \frac{GM}{r^2}, \quad \text{where } G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2; \]

Orbits:
\[ \frac{v^2}{r} = g = \frac{GM}{r^2}; \quad v = \sqrt{\frac{GM}{r}}. \quad \text{centripetal acceleration = free fall acceleration}. \]

Chapter 6 Equations

Work & Kinetic & Potential Energies:
\[ W = Fd \cos \theta, \quad KE = \frac{1}{2}mv^2, \quad \text{PE}_{\text{gravity}} = mgy, \quad \text{PE}_{\text{spring}} = \frac{1}{2}kx^2. \quad \theta = \text{angle btwn } \vec{F} \text{ and } \vec{d}. \]

Conservation or Transformation of Energy:

**Work-KE theorem:**
\[ \Delta KE = W_{\text{net}} = \text{work of all forces}. \]

**General energy-conservation law:**
\[ \Delta KE + \Delta \text{PE} = W_{\text{NC}} = \text{work of non-conservative forces}. \]

Power:
\[ P_{\text{ave}} = \frac{W}{T}, \quad \text{or use } P_{\text{ave}} = \frac{\text{energy}}{\text{time}}. \]