Prefixes

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

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$c = 299792458$ m/s (speed of light)
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (Gravitational constant)
$R_E = 6380$ km (mean radius of Earth)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units and Conversions

1 inch = 1 in = 2.54 cm (exactly)
1 mile = 5280 ft
1 m/s = 3.6 km/hour
1 acre = 43560 ft^2 = (1 mile)^2/640
1 foot = 1 ft = 12 in = 30.48 cm (exactly)
1 mile = 1609.344 m = 1.609344 km
1 ft/s = 0.6818 mile/hour
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 ± error, the percent error $= \frac{\text{error}}{\text{value}} \times 100$ %.

Chapter 2 Equations

Motion:

$\bar{v} = \frac{\Delta x}{\Delta t}$, $\Delta x = x - x_0$, slope of $x(t)$ curve = $v(t)$.
$\bar{a} = \frac{\Delta v}{\Delta t}$, $\Delta v = v - v_0$, slope of $v(t)$ curve = $a(t)$.

For constant acceleration in one-dimension:

$$\bar{v} = \tfrac{1}{2}(v_0 + v),\quad v = v_0 + at,\quad x = x_0 + v_0 t + \tfrac{1}{2}at^2,\quad v^2 = v_0^2 + 2a(x - x_0).$$

For free fall on Earth, using an upward y-axis, with $g = 9.80$ m/s^2 downward:

$$\bar{v}_y = \tfrac{1}{2}(v_{y0} + v_y),\quad v_y = v_{y0} - gt,\quad y = y_0 + v_{y0}t - \tfrac{1}{2}gt^2,\quad v_y^2 = v_{y0}^2 - 2g\Delta y.$$

Chapter 3 Equations

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{V_y}{V_x}$. θ is the angle from $\vec{V}$ 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

$a_x = 0$, $v_x = v_{x0}$, $x = x_0 + v_{x0}t$. For a horizontal x-axis.
$a_y = -g$, $v_y = v_{y0} - gt$, $y = y_0 + v_{y0}t - \frac{1}{2}gt^2$. For an upward y-axis.
$R = \frac{v_0^2}{g}\sin 2\theta_0$, (For level ground only.)

Relative Motion

$\vec{V}_{\text{BS}} = \vec{V}_{\text{BW}} + \vec{V}_{\text{WS}}$, 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:
$\vec{F}_{\text{net}} = m\vec{a}$, means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$. $\vec{F}_{\text{net}} = \sum \vec{F}_i$, sum over all forces on a mass.

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

Gravitational force near Earth:
$F_G = mg$, downward.

Chapter 5 Equations

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

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

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

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

Chapter 6 Equations

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

Conservation or Transformation of Energy:

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

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

Power:
$P_{\text{ave}} = \frac{W}{t}$, or use $P_{\text{ave}} = \frac{\text{energy}}{\text{time}}$.