Prefixes

z=10^{-21},	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},	E=10^{18},	Z=10^{21}
zepto,	atto,	femto,	pico,	nano,	micro,	milli,	centi,	kilo,	mega,	giga,	tera,	peta,	exa,	zeta.

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration) — $G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (gravitational constant)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth) — $R_E = 6380$ km (mean radius of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass) — $m_p = 1.67 \times 10^{-27}$ kg (proton mass)
$c = 299,792,458$ m/s (speed of light) — 1 amu = 1 u = $1.6605402 \times 10^{-27}$ kg (atomic mass unit)

Units & Conversions

1 inch = 1 in = 2.54 cm — 1 foot = 1 ft = 12 in = 0.3048 m
1 mile = 5280 ft =1760 yards — 1 mile = 1609.344 m = 1.609344 km
1 m/s = 3.6 km/hour — 88 ft/s = 60 mile/hour
1 acre = (1 mile)^2/640 = 43 560 ft^2 — 1 hectare = (100 m)^2 = 10^4 m^2
1 lb = 4.45 N — 1 N = 0.225 lb — 1 J = 1 joule = 1 N·m

Algebra

Quadratic equations: $ax^2 + bx + c = 0$, solved by $x = \left(-b \pm \sqrt{b^2 - 4ac}\right)/(2a)$.

Geometry

Triangles: $A = \frac{1}{2}bh$, Circles; $C = 2\pi r$, $A = \pi r^2$, arc $= s = r\theta$. Spheres: $A = 4\pi r^2$, $V = \frac{4\pi}{3}r^3$

Trigonometry

$\sin\theta = \text{(opp)/(hyp)}$, $\cos\theta = \text{(adj)/(hyp)}$, $\tan\theta = \text{(opp)/(adj)}$, $\text{(opp)}^2 + \text{(adj)}^2 = \text{(hyp)}^2$.
$\sin^2\theta + \cos^2\theta = 1$, $a^2 + b^2 - 2ab\cos\gamma = c^2$, $\frac{\sin\alpha}{a} = \frac{\sin\beta}{b} = \frac{\sin\gamma}{c}$, $\alpha + \beta + \gamma = 180^\circ = \pi$ rad.

Chapter 1 - Units, measurements, errors or uncertainties

Unit conversions:	value = # (old units),	(old units) $\times \left(\frac{\text{new units}}{\text{old units}}\right)$ = (new units).
Significant figures:	$\div$ or $\times$, use the least no. of sig. figs.,	+ or −, drop the insignificant *digits*.
Sig. figs. "1" rule:	if 1st digit=1, keep 1 extra digit,	$\longleftarrow$ for division or multiplication only.
Measurements:	measurement = $x \pm \delta x$,	x = observed value, δx = error or uncertainty.
Percent error:	measurement = value ± error,	percent error = (error / value)×100%.
Combining errors:	$\div$ or $\times$, add the % errors,	+ or −, $\delta x = \sqrt{(\delta x_1)^2 + (\delta x_2)^2 + ...}$.

Chapter 2 - Vectors - Magnitude & Direction

2D Vectors:	$\vec{\mathbf{a}} = a_x\hat{\mathbf{i}} + a_y\hat{\mathbf{j}}$	magnitude = $a = \sqrt{a_x^2 + a_y^2}$	direction $\rightarrow \tan\theta = a_y/a_x$
Components:	$a_x = a\cos\theta$	$a_y = a\sin\theta$	θ=angle to $+x$-axis.
Addition:	$\vec{\mathbf{a}} + \vec{\mathbf{b}}$, head to tail.	Subtraction: $\vec{\mathbf{a}} - \vec{\mathbf{b}}$ is $\vec{\mathbf{a}} + (-\vec{\mathbf{b}})$	$-\vec{\mathbf{b}}$ is $\vec{\mathbf{b}}$ reversed.
Scalar product:	$\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = ab\cos\phi$	$\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = a_xb_x + a_yb_y + a_zb_z$	$\hat{\mathbf{i}} \cdot \hat{\mathbf{i}} = 1$, $\hat{\mathbf{i}} \cdot \hat{\mathbf{j}} = 0$, etc.
Cross product:	$\lvert\vec{\mathbf{a}} \times \vec{\mathbf{b}}\rvert = ab\sin\phi$	$\hat{\mathbf{i}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}}$, etc.	$\hat{\mathbf{i}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}} \times \hat{\mathbf{k}} = 0$

Chapter 3 - 1D Kinematics - Straight-line motion

Velocity:	$v_{\text{avg}} = \Delta x/\Delta t$	$\Delta x = x - x_0$	$v(t) = \frac{dx}{dt}$= slope of $x(t)$
Acceleration:	$a_{\text{avg}} = \Delta v/\Delta t$	$\Delta v = v - v_0$	$a(t) = \frac{dv}{dt}$= slope of $v(t)$
Integrals = areas:	$x(t) = x_0 + \int_0^t v(t')dt'$,	$v(t) = v_0 + \int_0^t a(t')dt'$.	
Constant acceleration:	$v = v_0 + at$,	$v_{\text{avg}} = \frac{1}{2}(v_0 + v)$,	$\Delta x = v_{\text{avg}}\Delta t$.
	$x = x_0 + v_0t + \frac{1}{2}at^2$,	$x = x_0 + v_{\text{avg}}t$,	$v^2 = v_0^2 + 2a\Delta x$.
	(position from acceleration)	(using average velocity)	(timeless equation)
Free fall ($+y$-axis is up):	$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$,	$v_y = v_{0y} - gt$,	$v_y^2 = v_{0y}^2 - 2g\Delta y$.

Chapter 4 - 2D and 3D Motion - Vector displacement, velocity, acceleration

Position:	$\vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$	$\vec{\mathbf{r}} = (x, y, z)$	$\Delta\vec{\mathbf{r}} = (\Delta x, \Delta y, \Delta z)$
Velocity:	$\vec{\mathbf{v}}_{\text{avg}} = \Delta\vec{\mathbf{r}}/\Delta t$	$\vec{\mathbf{v}} = d\vec{\mathbf{r}}/dt$	$\Delta\vec{\mathbf{r}} = \vec{\mathbf{r}} - \vec{\mathbf{r}}_0$
Acceleration:	$\vec{\mathbf{a}}_{\text{avg}} = \Delta\vec{\mathbf{v}}/\Delta t$	$\vec{\mathbf{a}} = d\vec{\mathbf{v}}/dt$	$\Delta\vec{\mathbf{v}} = \vec{\mathbf{v}} - \vec{\mathbf{v}}_0$
Projectiles:	$a_x = 0$	$v_x = v_{0x}$	$x = x_0 + v_{0x}t$
(+y-axis is up)	$a_y = -g$	$v_y = v_{0y} - gt$	$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$
Range:	$R = (v_0^2/g)\sin(2\theta_0)$	← (range on level ground only)	
Relative Motion:	$\vec{\mathbf{v}}_{\text{BS}} = \vec{\mathbf{v}}_{\text{BW}} + \vec{\mathbf{v}}_{\text{WS}}$	B=Boat, S=Shore, W=Water.	BS is "boat relative to shore", etc.
Circular motion:	$a_c = v^2/r = \omega^2 r$	$v = 2\pi r/T = \omega r$	$\omega = 2\pi/T$, T=period of 1 rev.

Chapter 5 - Newton's laws and forces

Newton's 1st Law:	$\vec{a} = d\vec{v}/dt = 0$ unless $\vec{F}_{\text{net}} \neq 0$	$\vec{F}_{\text{net}} = \sum \vec{F}_i$ = sum of all forces on a mass.
Newton's 2nd Law:	$\vec{F}_{\text{net}} = m\vec{a}$	$F_{\text{net},x} = ma_x,\ F_{\text{net},y} = ma_y,\ F_{\text{net},z} = ma_z$
Newton's 3rd Law:	$\vec{F}_{AB} = -\vec{F}_{BA}$	Forces exist in action-reaction pairs.
Gravitational force near Earth:	$F_g = mg$, downward.	Apparent weight is force measured by a scales.
Gravity components on inclines:	$F_{g,\parallel} = mg\sin\theta,\ F_{g,\perp} = mg\cos\theta$	← for incline at angle θ to horizontal.
Spring force:	$F_s = -kx$	x is the displacement from equilibrium.

Chapter 6 - Friction, circular motion

Static friction (object is stuck):	$f_s \leq \mu_s N$	Can balance other forces in any direction.
Kinetic friction (object sliding):	$f_k = \mu_k N$	Acts **against** the relative motion of surfaces.
Centripetal acceleration:	$a_c = v^2/r$	Points towards the center of the circle.
Centripetal force:	$F_{\text{net,inward}} = ma_c$	"Centripetal force" is the **sum** of forces inward.
Rates of circular motion:	$v = 2\pi r/T = 2\pi r f$	frequency $f = 1/T$, T=period of one revolution.

Chapter 7 - Work and kinetic energy

Work done by a force:	$dW = \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}} = F\ dr\ \cos\theta$	$W_{AB} = \int_A^B \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}$ (along the path $A \to B$)
Work of a constant force:	$W = \vec{\mathbf{F}} \cdot \Delta\vec{\mathbf{r}}$	$\Delta\mathbf{r} = \vec{\mathbf{r}}_B - \vec{\mathbf{r}}_A$ = displacement.
Work done by gravity:	$W_{\text{g}} = -mg\Delta y$	$\Delta y = y_B - y_A$ (final minus initial height)
Work done by a spring:	$W_s = -\frac{1}{2}k(x_B^2 - x_A^2)$	B=final stretch, A =initial stretch.
Work done by friction:	Use formula for constant force.	Friction's work can be positive or negative!!
Work-KE theorem:	$\Delta\text{KE} = W_{\text{net}}$ = all works on m.	$\text{KE} = \frac{1}{2}mv^2$, $\Delta\text{KE} = \frac{1}{2}m(v_B^2 - v_A^2)$
Instantaneous power:	$P = dW/dt$	← the rate of doing work by some force.
When $\vec{\mathbf{F}}$ acts on m:	$P = \vec{\mathbf{F}} \cdot \vec{\mathbf{v}}$	← instantaneous power only due to $\vec{\mathbf{F}}$
Average power:	$P_{\text{ave}} = \Delta W/\Delta t$	← average over time interval Δt.

Chapter 8 - Potential energy and Conservation of energy

Potential energy:	$\Delta U = U_B - U_A = -W_{A\to B}$,	$W_{A\to B}$ = work done by a conservative force.
PE for gravity:	$\Delta U = mg\Delta y$,	$U(y) = mgy+$ constant.
PE for springs:	$\Delta U = \frac{1}{2}k(x_B^2 - x_A^2)$,	$U(x) = \frac{1}{2}kx^2$ + constant.
Force from potential:	$F_x = -dU/dx$,	← the force component along x-axis.
Conservative system:	$\Delta E_{\text{mec}} = 0$,	$E_{\text{mec}} = K + U$ only.
Non-conservative system:	$\Delta E_{\text{mec}} = W_{\text{nc}}$,	W_{nc} = work of nonconservative forces.
Isolated system:	$\Delta E_{\text{total}} = 0$,	$E_{\text{total}} = E_{\text{mec}} + E_{\text{thermal}} + E_{\text{other}}$. (nothing is left out of energy accounting).