

EQUATIONS¹

Chapter 2

$$\underline{R} = \underline{A} + \underline{B} = \underline{B} + \underline{A}$$

$$\begin{aligned} \underline{R} &= \underline{A} + \underline{B} + \underline{C} = \underline{B} + \underline{C} + \underline{A} \\ &= \underline{C} + \underline{A} + \underline{B} = \dots \end{aligned}$$

$$A_x = A \sin \theta$$

$$A_y = A \cos \theta$$

$$A = \sqrt{A_x^2 + A_y^2} \quad \text{and} \quad \theta = \tan^{-1} \frac{A_y}{A_x}$$

Chapter 3

$$\text{weight} = mg$$

$$\underline{W} = -(mg) \underline{j}$$

$$\underline{F} = (F_x, F_y)$$

$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$

$$\underline{F} = F_x \underline{i} + F_y \underline{j}$$

$$\underline{F} = \underline{F}_1 + \underline{F}_2 + \underline{F}_3 + \dots$$

$$= (F_x, F_y, F_z)$$

$$F_x = F_{1_x} + F_{2_x} + F_{3_x} + \dots$$

$$F_y = F_{1_y} + F_{2_y} + F_{3_y} + \dots$$

$$F_z = F_{1_z} + F_{2_z} + F_{3_z} + \dots$$

$$\Sigma \underline{F} = \underline{0}$$

$$\Sigma M = 0$$

$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

$$\Sigma M_z = 0$$

Chapter 4.

$$F_{static} = \mu_{static} F_{normal}$$

$$F_{kinetic} = \mu_{kinetic} F_{normal}$$

$$\mu_{static} = \tan \theta_{static}$$

$$\mu_{kinetic} = \tan \theta_{kinetic}$$

Chapter 5

$$\overline{\text{speed}} = \frac{\text{distance}}{\text{time}}$$

$$\bar{v} = \frac{\Delta s}{\Delta t} = \frac{s_f - s_i}{\Delta t}$$

$$v = \lim_{\Delta t \rightarrow 0} \frac{\Delta s}{\Delta t}$$

$$= \frac{ds}{dt} = \dot{s}$$

$$\bar{v} = \sqrt{\bar{v}_x^2 + \bar{v}_y^2}$$

$$\theta_v = \tan^{-1} \left(\frac{\bar{v}_y}{\bar{v}_x} \right)$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

$$a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$$

$$= \dot{v} = \ddot{s}$$

¹ The subscripts “i” and “f” refer to initial and final intervals of time.

$$\begin{aligned}v_f &= v_i + at \\s_f &= s_i + v_i t + \frac{1}{2}at^2 \\v_f^2 &= v_i^2 + 2a(s_f - s_i) \\s_f &= s_i + \frac{1}{2}(v_i + v_f)t\end{aligned}$$

$$\begin{aligned}s_{f_x} &= s_{i_x} + v_{i_x} t \\v_{f_y} &= v_{i_y} - gt \\s_{f_y} &= s_{i_y} + v_{i_y} t - \frac{1}{2}gt^2 \\v_{f_y}^2 &= v_{i_y}^2 - 2g(s_{f_y} - s_{i_y}) \\s_{f_y} &= s_{i_y} + \frac{1}{2}(v_{i_y} + v_{f_y})t\end{aligned}$$

$$\begin{aligned}\bar{\omega} &= \frac{\theta_f - \theta_i}{\Delta t} \\ \omega &= \frac{d\theta}{dt} = \dot{\theta}\end{aligned}$$

$$\theta = \frac{s}{r} \text{ radians}$$

$$\pi \text{ radians} = 180 \text{ degrees}$$

$$1 \text{ radian} = \frac{180 \text{ degrees}}{\pi} \approx 57.3 \text{ degrees}$$

$$\bar{\alpha} = \frac{\omega_f - \omega_i}{\Delta t}$$

$$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2} = \dot{\omega} = \ddot{\theta}$$

$$\omega_f = \omega_i + \alpha t$$

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$

$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$$

$$\theta_f = \theta_i + \frac{1}{2}(\omega_i + \omega_f)t$$

$$s = r\theta$$

$$s_{\text{circle}} = 2\pi r$$

$$v_{\text{transverse}} = r\omega$$

$$a_{\text{transverse}} = r\alpha$$

$$a_{\text{radial}} = r\omega^2$$

$$= v_{\text{transverse}} / r$$

$$a = \sqrt{a_{\text{radial}}^2 + a_{\text{transverse}}^2}$$

Chapter 6

$$\underline{R} = \Sigma \underline{F} = m\underline{a}$$

$$M_R = \Sigma M_{cg} = I_{cg}\alpha$$

$$\Sigma F_x = ma_x$$

$$\Sigma F_y = ma_y$$

$$\Sigma M_{z_{cg}} = I_{cg}\alpha$$

$$I = mk^2$$

$$I_a = mk_{cg}^2 + mr^2$$

Chapter 7

$$\int_{t_i}^{t_f} F dt = mv_f - mv_i$$

$$\text{impulse} = \overline{F}t = \int F dt$$

$$\text{momentum} = p = mv$$

$$\int_{t_i}^{t_f} M_R dt = I_{cg} \omega_f - I_{cg} \omega_i$$

$$\text{ang. impulse} = \int M_R dt$$

$$= \int (\underline{r} \times \underline{F}) dt$$

$$\text{ang. momentum} = L = I_{cg} \omega$$

Chapter 8

$$W = \text{work}$$

$$= \Delta E = E_f - E_i$$

$$= (mgy_f + \frac{1}{2}mv_f^2 + \frac{1}{2}I_{cg}\omega_f^2) -$$

$$(mgy_i + \frac{1}{2}mv_i^2 + \frac{1}{2}I_{cg}\omega_i^2)$$

$$E_{\text{potential}} = mgy$$

$$E_{\text{translational}} = \frac{1}{2}mv^2$$

$$E_{\text{rotational}} = \frac{1}{2}I\omega^2$$

$$E_{\text{total}} = E_{\text{potential}} +$$

$$E_{\text{translational}} +$$

$$E_{\text{rotational}}$$

$$W_{\text{force}} = \int_{s_i}^{s_f} F ds$$

$$= \overline{F}s \quad (F \text{ parallel to } s)$$

$$= Fs \cos \theta$$

$$W_{\text{moment}} = \int_{\theta_i}^{\theta_f} M d\theta$$

$$W_{\text{moment}} = \overline{M}\theta$$

$$= \int_{\theta_i}^{\theta_f} M d\theta$$

$$\overline{P} = \frac{\Delta E}{\Delta t}$$

$$P = \frac{dE}{dt}$$

$$= Fv \cos \theta$$

$$= \underline{F} \cdot \underline{v}$$

$$= F_x v_x + F_y v_y$$

$$P_{\text{moment}} = M\omega$$

$$= (rF \sin \theta)\omega$$

Chapter 9

$$\rho = \frac{m}{V}$$

$$p = \frac{F}{A}$$

$$F_{\text{buoyant}} = pA = \rho gV$$

$$F_{\text{vd}} = -6\pi r \eta v$$

$$F_{\text{fd}} = -\frac{1}{2}C_{\text{drag}}\rho A_{\text{normal}}v^2$$

$$v_{\text{terminal}} = \sqrt{\frac{2mg}{C_{\text{drag}}\rho A_{\text{normal}}}}$$

$$\begin{aligned} F_{\text{lift}} &= (p_2 - p_1)A_{\text{parallel}} \\ &= \frac{1}{2}C_{\text{lift}}\rho A_{\text{parallel}}v^2 \end{aligned}$$

Chapter 10

$$\text{stride rate} = 1 / \text{stride time}$$

$$\text{cadence} = 120 \times \text{stride rate}$$

$$\begin{aligned} \text{stride velocity} &= \text{stride length} / \text{stride time} \\ &= \text{stride length} \times \text{stride rate} \end{aligned}$$

$$\text{COP} - \text{COM} = -ka_{\text{COM}}$$

$$k = I / Wd$$