

LINEAR KINEMATICS (pp. 87-8)

$$v_f = v_i + at$$

$$s_f = s_i + v_i t + \frac{1}{2} at^2$$

$$v_f^2 = v_i^2 + 2a(s_f - s_i)$$

$$s_f = s_i + \frac{1}{2}(v_i + v_f)t$$

1. (a)

$$0 \text{ to } 40 \text{ m: } a = \frac{v_f^2 - v_i^2}{2(s_f - s_i)}$$

$$a = \frac{9^2 - 0}{2(40 - 0)} = \frac{9^2}{2(40)}$$

$$= \frac{81}{80} = 1.0125 \text{ m/s}^2$$

$$40 \text{ to } 70 \text{ m: } a = 0 \text{ m/s}^2$$

$$70 \text{ to } 100 \text{ m: } s_f = s_i + vt + \frac{1}{2} at^2$$

$$100 = 70 + 9(4) + \frac{1}{2} a(4)^2$$

$$a = 2 \frac{(30 - 36)}{16} = -0.750 \text{ m/s}^2$$

(b)

$$t_{0-40} = \frac{v_f - v_i}{a} = \frac{9 - 0}{1.0125} = 8.89 \text{ s}$$

$$t_{40-70} = \frac{70 - 40}{9} = 3.33 \text{ s}$$

$$t_{70-100} = 4.00 \text{ s}$$

$$t_{\text{total}} = 8.89 + 3.33 + 4 = 16.22 \text{ s}$$

(c)

$$s_f = 0 + 0 + \frac{1}{2} \left(\frac{81}{80} \right) 5^2 = 12.66 \text{ m}$$

(d)

$$v_{100} = 9 - \left(\frac{3}{4} \right) 4 = 6.00 \text{ m/s}$$

3. (a)

$$v_f^2 = \pm \sqrt{3.5^2 + 2(0.005)(25 - 0)}$$

$$= \pm 3.536 \text{ m/s}$$

$$t = \frac{v_f - v_i}{a} = \frac{+3.536 - 3.50}{0.005} = 7.11 \text{ s}$$

(b)

$$s_f = s_i + v_i t + \frac{1}{2} at^2$$

$$= 0 + 3.5 \times 10^2 + \frac{1}{2} (0.005) 10^2$$

$$= 35 + 0.25 = 35.3 \text{ m}$$

5. (a)

$$t = \frac{v_f - v_i}{a} = \frac{0 - 2.20}{-0.300} = 7.33 \text{ s}$$

(b)

$$s_f = s_i + v_i (7.333) + \frac{1}{2} at^2$$

$$= 0 + 2.20(7.333) + \frac{1}{2} (-0.3)(7.33)^2 = 8.07 \text{ m}$$

7.

$$v = 150 \text{ km/h} \div 3.6 = 41.67 \text{ m/s}$$

1st catcher :

$$a = \frac{v_f^2 - v_i^2}{2(s_f - s_i)} = \frac{0 - 41.67^2}{2(0.300 - 0)}$$

$$= -2894$$

$$t = \frac{v_f - v_i}{a} = \frac{0 - 41.67}{-2894}$$

$$= 0.01440 \text{ s} = 14.40 \text{ ms}$$

2nd catcher :

$$a = \frac{v_f^2 - v_i^2}{2(s_f - s_i)} = \frac{0 - 41.67^2}{2(0.500 - 0)}$$

$$= -1736$$

$$t = \frac{v_f - v_i}{a} = \frac{0 - 41.67}{-1736}$$

$$= 0.0240 \text{ s} = 24.0 \text{ ms}$$

The difference in the accelerations is 1158 m/s^2 . The difference in the times is 9.60 ms .

9.

$$s = \sqrt{12.00^2 + \left(\frac{7.32}{2}\right)^2} = 12.546 \text{ m}$$

$$v = s/t = 12.546/1.500 = 8.36 \text{ m/s}$$

Ball speed must be greater than 8.36 m/s.

11. (a)

$$v = \frac{s}{t} = \frac{100 \text{ m}}{4 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} = 0.417 \text{ m/s}$$

(b)

$$s_{\text{down river}} = v_{\text{current}} t = 4.00 \frac{\text{km}}{\text{h}} \times \frac{1 \text{ h}}{60 \text{ min}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times 4.00 \text{ min} = 266.7 \text{ m}$$

$$s_{\text{total}} = \sqrt{266.7^2 + 100.0^2} = 285 \text{ m}$$

(c)

$$v = s_{\text{total}} / t = 284.8 / (4.00 \times 60.0) = 1.187 \text{ m/s}$$

13.

$$0 = v_i^2 + 2a(s_f - s_i)$$

$$v_i^2 = -2a(s_f - s_i) = -2(-2.00)(6.00 - 0)$$

$$v_i = \pm\sqrt{24.0} = \pm 4.90$$

The initial velocity must be 4.90 m/s.

PROJECTILE MOTION (pp. 94-5)

$$\begin{aligned}
 v_{fy} &= v_{iy} - gt \\
 s_{fy} &= s_{iy} - gt \\
 v_{fy}^2 &= v_{iy}^2 - 2g(s_{fy} - s_{iy}) \\
 s_{fy} &= s_{iy} + \frac{1}{2}(v_{iy} + v_{fy})t
 \end{aligned}$$

1. (a)

$$90 \frac{\text{km}}{\text{h}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 25.0 \text{ m/s}$$

$$v_x = v \cos \theta = 25 \cos 5^\circ = 24.90 \text{ m/s}$$

$$v_y = v \sin \theta = 25 \sin 5^\circ = 2.179 \text{ m/s}$$

(b)

$$s_{fx} = s_{ix} - v_x t$$

$$t = \frac{10 - 0}{24.9} = 0.402 \text{ s}$$

(c)

$$v_{fy}^2 = v_{iy}^2 - 2g(s_{fy} - s_{iy})$$

$$s_{fy} = \frac{v_{fy}^2 - v_{iy}^2}{-2g} + s_{iy}$$

$$= \frac{0 - (2.179)^2}{-2(9.81)} + 0 = 0.242 \text{ m} = 24.2 \text{ cm}$$

(d)

$$v_x = \frac{10 - 0}{0.350} = 28.6 \text{ m/s}$$

3. (a)

$$v_{fy}^2 = v_{iy}^2 - 2g(s_{fy} - s_{iy})$$

$$v_{fy} = \pm \sqrt{0 - 2(9.81)(-20 - 0)}$$

$$= \pm \sqrt{392.4} = \pm 19.81 \text{ m/s}$$

$$v_f = -19.81 \text{ m/s}^2$$

(b)

$$t = \frac{v_f - v_i}{-g} = \frac{-19.81 - 0}{-9.81} = 2.02 \text{ s}$$

(c)

$$s_{ix} = s_{ix} - v_x t = 0 + 2(2.02) = 4.04 \text{ m}$$

5. (a)

$$\begin{aligned}
 s_{fy} &= s_{iy} + \frac{v_{fy}^2 - v_{iy}^2}{-2g} \\
 &= 0 + \frac{0 + v_{iy}^2}{+2g} = \frac{6.00^2}{2(9.81)} = 1.835 \text{ m}
 \end{aligned}$$

(b)

$$t = \frac{v_f - v_i}{-g}$$

$$v_f^2 = v_i^2 - 2g(s_f - s_i)$$

$$= 6^2 - 2(9.81)(0 - 10)$$

$$v_f = \pm \sqrt{232.2} = \pm 15.24 \text{ m/s}$$

select the negative velocity

$$t = \frac{-15.24 - 6}{-9.81} = 2.16 \text{ s}$$

(c)

$$s_x = v_x t = 0.500(2.16) = 1.082 \text{ m}$$

7.

θ	v_x	v_y	y_{max}	x_{max}	time
30°	8.66	5.00	1.270	8.83	1.019
45°	7.07	7.07	2.55	10.19	1.442
60°	5.00	8.66	3.82	8.83	1.765

9.

$$v_{fy}^2 = 0 - 2g(1.0 - 1.5) = 9.81$$

$$v_{fy} = \pm \sqrt{9.81} = -3.13$$

$$t = \frac{v_f - v_i}{-g} = \frac{-3.13 - 0}{-9.81} = 0.319 \text{ s}$$

$$v_x = \frac{10}{0.319} = 31.3 \text{ m/s}$$

11.

$$v_f^2 = 0 - 2(9.81)(-0.795)$$

$$v_f = -3.94 \text{ m/s}$$

$$t = \frac{v_f}{g} = 0.4026$$

$$v_{fps} = \frac{12}{0.4206} = 29.8 \text{ fps}$$

ANGULAR KINEMATICS (p. 99)

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

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

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

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

1. (a)

$$\alpha = \frac{\omega_f - \omega_i}{t} = \frac{5 - 2}{2} = 1.500 \text{ r/s}^2$$

$$= 3 \text{ rad/s} = 9.42 \text{ rad/s}^2$$

(b)

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

$$= 0 + 2(2) + \frac{1}{2}(1.5)2^2 = 7.00 \text{ revolutions}$$

3.

$$\theta = 0 + 0 + \frac{1}{2}(0.35)36^2$$

$$= 227 \text{ revolutions}$$

5.

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

$$= 6 + 0.750(5) = 9.75 \text{ rad/s}$$

7.

$$\omega = \frac{3r}{0.89} = \frac{6\pi}{0.89} = 21.2 \text{ rad/s}$$

9.

$$\omega_{final} = \omega_{initial} + \alpha t = 5.60 + (-0.200)3.00 = 5.00 \text{ rad/s}$$

11.

$$t = \frac{\omega_{final} - \omega_{initial}}{\alpha} = \frac{0 - 20.0}{-1.500} = 13.33 \text{ s}$$

RELATIONSHIP between LINEAR and ANGULAR MEASURES (pp. 104-5)

$$v_t = r\omega$$

$$a_t = r\alpha$$

$$a_r = r\omega^2 = \frac{v_t^2}{r}$$

$$a = \sqrt{a_r^2 + a_t^2}$$

1. (a)

$$v_t = r\omega = 0.75(15) = 11.25 \text{ m/s}$$

(b)

$$a_t = r\alpha = 0.75(150) = 112.5$$

$$a_r = r\omega^2 = 0.75(15)^2 = 168.75$$

$$a = \sqrt{a_t^2 + a_r^2} = \sqrt{112.5^2 + 168.75^2}$$

$$= 203 \text{ m/s}^2$$

3. (a)

$$v_t = r\omega = 0.900 \left(573 \frac{\text{deg}}{\text{s}} \right) \times \frac{\pi \text{ rad}}{180 \text{ deg}}$$

$$= 9.00 \text{ m/s}$$

(b)

$$\alpha = \frac{\omega_f - \omega_i}{t} = \frac{10 - 0}{1.5} = 6.67 \text{ rad/s}^2$$

(c)

$$a_t = r\alpha = 0.9(10) = 9.00$$

$$a_r = r\omega^2 = 0.9(10)^2 = 90.0$$

$$a = \sqrt{a_t^2 + a_r^2} = \sqrt{9.00^2 + 90.0^2}$$

$$= 90.4 \text{ m/s}^2$$

5.

$$v_t = r\omega$$

$$= 0.75(10.00)$$

$$= 7.50 \text{ m/s}$$

$$a_r = r\omega^2 = 0.75(10)^2 = 75.0 \text{ m/s}^2$$

$$a_t = r\alpha = 0.75(2.00) = 1.500 \text{ m/s}^2$$

$$a = \sqrt{a_t^2 + a_r^2} = \sqrt{75^2 + 1.5^2}$$

$$= 75.0 \text{ m/s}^2$$

7. (a)

$$v_{feet} = r\omega = 2.30(10) = 23.0 \text{ m/s}$$

$$v_{cg} = r\omega = 1.30(10) = 13.00 \text{ m/s}$$

(b)

$$\omega = \frac{v}{r} = \frac{10 - 0}{2} = 5.00 \text{ rad/s}$$

(c)

$$s_{feet} = 2\pi r = 2\pi(2.30) = 14.45 \text{ m}$$

$$s_{cg} = 2\pi r = 2\pi(1.3) = 8.16 \text{ m}$$

$$= 14.45 - 8.16 = 6.29 \text{ m}$$

(d)

$$a_{r\text{ feet}} = r\omega^2 = 2.30(10.00)^2$$

$$= 230 \text{ m/s}^2$$

9. (a)

$$r_{total} = 1.00 + .70 = 1.700 \text{ m}$$

$$v_t = r\omega = 1.70(8.75) = 14.875 \text{ m/s}$$

$$v = r\omega; r = \frac{v}{\omega},$$

$$1.70 + r = \frac{v_t + 1.5}{\omega}$$

$$r = \frac{16.375}{8.75} - 1.7 = 0.1714 \text{ m}$$

(b)

$$a_r = r\omega^2 = 0.1714(8.75)^2$$

$$= 13.12 \text{ m/s}^2$$

11.

$$\omega = 65 \frac{\text{r}}{\text{min}} \times \frac{2\pi \text{ rad}}{1 \text{ r}} \times \frac{1 \text{ min}}{60 \text{ s}}$$

$$= 6.81 \text{ rad/s}$$

$$v_{rim} = r\omega = 0.330(6.81) = 2.25 \text{ m/s}$$

$$v_{pushwheel} = r\omega = 0.100(6.81)$$

$$= 0.681 \text{ m/s}$$