LINEAR KINEMATICS (pp. 87-8)

$$v_f = v_i + at$$
$$s_f = s_i + v_i t + \tfrac{1}{2}at^2$$
$$v_f^2 = v_i^2 + 2a(s_f - s_i)$$
$$s_f = s_i + \tfrac{1}{2}(v_i + v_f)t$$

1. (a)

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

$$a = \frac{9^2 - 0}{2(40-0)} = \frac{9^2}{2(40)}$$
$$= \frac{81}{80} = 1.0125 \text{ m/s}^2$$

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

70 to 100 m: $s_f = s_i + vt + ½at^2$

$$100 = 70 + 9(4) + \frac{1}{2}a(4)^2$$
$$a = 2\frac{(30-36)}{16} = -0.750 \text{ m/s}^2$$

(b)

$$t_{0-40} = \frac{v_f - v_i}{a} = \frac{9-0}{1.0125} = 8.89 \text{ s}$$
$$t_{40-70} = \frac{70-40}{9} = 3.33 \text{ s}$$
$$t_{70-100} = 4.00 \text{ s}$$
$$t_{total} = 8.89 + 3.33 + 4 = 16.22 \text{ s}$$

(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)

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

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)

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

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

(c)

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

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)

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

1. (a)

$$90\frac{km}{h} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ h}}{3600\text{ s}} = 25.0\text{ m/s}$$
$$v_x = v\cos\theta = 25\cos 5° = 24.90\text{ m/s}$$
$$v_y = v\sin\theta = 25\sin 5° = 2.179\text{ m/s}$$

(b)

$$s_{fx} = s_{ix} - v_x t$$
$$t = \frac{10-0}{24.9} = 0.402s$$

(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)

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

5. (a)

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

(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)

$$\omega_f = \omega_i + \alpha t$$
$$\theta_f = \theta_i + \omega_i t + \tfrac{1}{2}\alpha t^2$$
$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$$
$$\theta_f = \theta_i + \tfrac{1}{2}(\omega_i + \omega_f)t$$

1. (a)

$$\alpha = \frac{\omega_f - \omega_i}{t} = \frac{5-2}{2} = 1.500 \text{ r/s}^2$$
$$= 3\pi \text{ rad/s}^2 = 9.42 \text{ rad/s}^2$$

(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.

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

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)

$$a_t = r\alpha = 0.75(150) = 117.5$$
$$a_r = r\omega^2 = 0.75(15)^2 = 168.75$$
$$a = \sqrt{a_t{}^2 + a_r{}^2} = \sqrt{117.5^2 + 168.75^2}$$
$$= 203 \text{ m/s}^2$$

3. (a)

$$v_t = r\omega = 0.900\left(573\frac{\text{deg}}{s}\right) \times \frac{\pi \text{ rad}}{180 \text{ deg}}$$
$$= 9.00 \text{ m/s}$$

(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)

$$v_{tfeet} = r\omega = 2.30(10) = 23.0 \text{ m/s}$$
$$v_{tcg} = r\omega = 1.30(10) = 13.00 \text{ m/s}$$

(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)

$$a_{r\ feet} = r\omega^2 = 2.30(10.00)^2$$
$$= 230 \text{ m/s}^2$$

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.

$$\omega = 65\frac{\text{r}}{\text{min}} \times \frac{2\pi \text{ rad}}{1 \text{ r}} \times \frac{1 \text{ min}}{60 \text{ s}}$$
$$= 6.81 \text{ rad/s}$$
$$v_{rim} = r\omega = 0.330(6.81) = 2.25 \text{ m/s}$$
$$v_{pushwheel} = r\omega = 0.100(6.81)$$
$$= 0.681 \text{ m/s}$$