Chapter Four: Motion in Two Dimensions

SOLUTIONS TO PROBLEMS

P4.17 (a) $x_f = v_{xi} t = 8.00 \cos 20.0°(3.00) = \boxed{22.6 \text{ m}}$

(b) Taking y positive downwards,

$$y_f = v_{yi} t + \frac{1}{2} g t^2$$

$$y_f = 8.00 \sin 20.0°(3.00) + \frac{1}{2}(9.80)(3.00)^2 = \boxed{52.3 \text{ m}}.$$

(c) $10.0 = 8.00(\sin 20.0°)t + \frac{1}{2}(9.80)t^2$

$4.90t^2 + 2.74t - 10.0 = 0$

$$t = \frac{-2.74 \pm \sqrt{(2.74)^2 + 196}}{9.80} = \boxed{1.18 \text{ s}}$$

P4.29 $r = 0.500 \text{ m}$;

$$v_t = \frac{2\pi r}{T} = \frac{2\pi(0.500 \text{ m})}{\frac{60.0 \text{ s}}{200 \text{ rev}}} = 10.47 \text{ m/s} = \boxed{10.5 \text{ m/s}}$$

$$a = \frac{v^2}{R} = \frac{(10.47)^2}{0.5} = \boxed{219 \text{ m/s}^2 \text{ inward}}$$

P4.34 (a) $a_t = \boxed{0.600 \text{ m/s}^2}$

(b) $a_r = \frac{v^2}{r} = \frac{(4.00 \text{ m/s})^2}{20.0 \text{ m}} = \boxed{0.800 \text{ m/s}^2}$

(c) $a = \sqrt{a_t^2 + a_r^2} = \boxed{1.00 \text{ m/s}^2}$

$\theta = \tan^{-1}\frac{a_r}{a_t} = \boxed{53.1° \text{ inward from path}}$

P4.38 (a)

$$\mathbf{v}_H = 0 + \mathbf{a}_H t = (3.00\hat{\mathbf{i}} - 2.00\hat{\mathbf{j}}) \text{ m/s}^2 (5.00 \text{ s})$$

$$\mathbf{v}_H = (15.0\hat{\mathbf{i}} - 10.0\hat{\mathbf{j}}) \text{ m/s}$$

$$\mathbf{v}_J = 0 + \mathbf{a}_j t = (1.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}}) \text{ m/s}^2 (5.00 \text{ s})$$

$$\mathbf{v}_J = (5.00\hat{\mathbf{i}} + 15.0\hat{\mathbf{j}}) \text{ m/s}$$

$$\mathbf{v}_{HJ} = v_H - v_J = (15.0\hat{\mathbf{i}} - 10.0\hat{\mathbf{j}} - 5.00\hat{\mathbf{i}} - 15.0\hat{\mathbf{j}}) \text{ m/s}$$

$$\mathbf{v}_{HJ} = (10.0\hat{\mathbf{i}} - 25.0\hat{\mathbf{j}}) \text{ m/s}$$

$$|\mathbf{v}_{HJ}| = \sqrt{(10.0)^2 + (25.0)^2} \text{ m/s} = \boxed{26.9 \text{ m/s}}$$

P4.50 (a) $y_f = (\tan\theta_i)(x_f) - \dfrac{g}{2v_i^2\cos^2\theta_i}x_f^2$

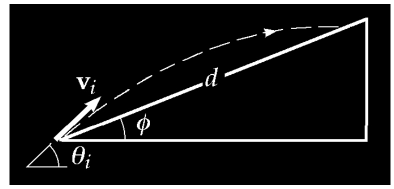

FIG. P4.50

Setting $x_f = d\cos\phi$, and $y_f = d\sin\phi$, we have

$$d\sin\phi = (\tan\theta_i)(d\cos\phi) - \frac{g}{2v_i^2\cos^2\theta_i}(d\cos\phi)^2.$$

Solving for d yields, $d = \dfrac{2v_i^2\cos\theta_i\left[\sin\theta_i\cos\phi - \sin\phi\cos\theta_i\right]}{g\cos^2\phi}$

or $d = \boxed{\dfrac{2v_i^2\cos\theta_i\sin(\theta_i-\phi)}{g\cos^2\phi}}$.

(b) Setting $\dfrac{dd}{d\theta_i} = 0$ leads to $\boxed{\theta_i = 45° + \dfrac{\phi}{2}}$ and $\boxed{d_{\max} = \dfrac{v_i^2(1-\sin\phi)}{g\cos^2\phi}}$.

Chapter Five: The Laws of Motion

SOLUTIONS TO PROBLEMS

P5.6 (a) Let the x-axis be in the original direction of the molecule's motion.

$$v_f = v_i + at: \quad -670 \text{ m/s} = 670 \text{ m/s} + a\left(3.00\times10^{-13}\text{ s}\right)$$
$$a = \boxed{-4.47\times10^{15}\text{ m/s}^2}$$

(b) For the molecule, $\sum\mathbf{F} = m\mathbf{a}$. Its weight is negligible.

$$\mathbf{F}_{\text{wall on molecule}} = 4.68\times10^{-26}\text{ kg}\left(-4.47\times10^{15}\text{ m/s}^2\right) = -2.09\times10^{-10}\text{ N}$$
$$\vec{\mathbf{F}}_{\text{molecule on wall}} = \boxed{+2.09\times10^{-10}\text{ N}}$$

P5.16 $v_x = \dfrac{dx}{dt} = 10t$, $v_y = \dfrac{dy}{dt} = 9t^2$

$a_x = \dfrac{dv_x}{dt} = 10$, $a_y = \dfrac{dv_y}{dt} = 18t$

At $t = 2.00$ s, $a_x = 10.0 \text{ m/s}^2$, $a_y = 36.0 \text{ m/s}^2$

$$\sum F_x = ma_x: \; 3.00\text{ kg}\left(10.0\text{ m/s}^2\right) = 30.0\text{ N}$$
$$\sum F_y = ma_y: \; 3.00\text{ kg}\left(36.0\text{ m/s}^2\right) = 108\text{ N}$$

$$\sum F = \sqrt{F_x^2 + F_y^2} = \boxed{112\text{ N}}$$

P5.18 $T_3 = F_g$ (1)

$T_1 \sin\theta_1 + T_2 \sin\theta_2 = F_g$ (2)

$T_1 \cos\theta_1 = T_2 \cos\theta_2$ (3)

Eliminate T_2 and solve for T_1

$$T_1 = \frac{F_g \cos\theta_2}{(\sin\theta_1 \cos\theta_2 + \cos\theta_1 \sin\theta_2)} = \frac{F_g \cos\theta_2}{\sin(\theta_1 + \theta_2)}$$

$$T_3 = F_g = \boxed{325 \text{ N}}$$

$$T_1 = F_g\left(\frac{\cos 25.0°}{\sin 85.0°}\right) = \boxed{296 \text{ N}}$$

$$T_2 = T_1\left(\frac{\cos\theta_1}{\cos\theta_2}\right) = 296 \text{ N}\left(\frac{\cos 60.0°}{\cos 25.0°}\right) = \boxed{163 \text{ N}}$$

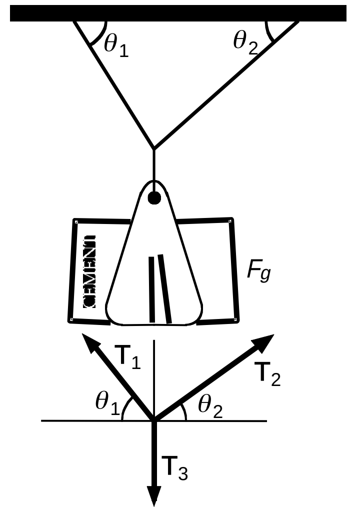

FIG. P5.18

P5.21 (a) Isolate either mass

$$T + mg = ma = 0$$
$$|T| = |mg|.$$

The scale reads the tension T,

so

$$T = mg = 5.00 \text{ kg}\left(9.80 \text{ m/s}^2\right) = \boxed{49.0 \text{ N}}.$$

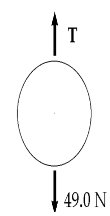

FIG. P5.21(a)

(b) Isolate the pulley

$$\mathbf{T}_2 + 2\mathbf{T}_1 = 0$$
$$T_2 = 2|T_1| = 2mg = \boxed{98.0 \text{ N}}.$$

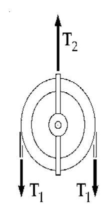

FIG. P5.21(b)

(c) $\sum \mathbf{F} = \mathbf{n} + \mathbf{T} + m\mathbf{g} = 0$

Take the component along the incline

$$\mathbf{n}_x + \mathbf{T}_x + m\mathbf{g}_x = 0$$

or

$$0 + T - mg \sin 30.0° = 0$$

$$T = mg \sin 30.0° = \frac{mg}{2} = \frac{5.00(9.80)}{2}$$
$$= \boxed{24.5 \text{ N}}.$$

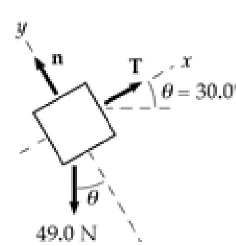

FIG. P5.21(c)

P5.40 $m_{\text{suitcase}} = 20.0\text{ kg}$, $F = 35.0\text{ N}$

$$\sum F_x = ma_x: \quad -20.0\text{ N} + F\cos\theta = 0$$
$$\sum F_y = ma_y: \quad +n + F\sin\theta - F_g = 0$$

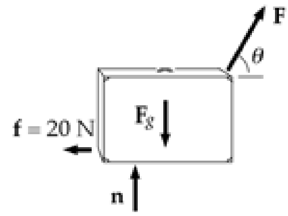

FIG. P5.40

(a) $F\cos\theta = 20.0\text{ N}$

$$\cos\theta = \frac{20.0\text{ N}}{35.0\text{ N}} = 0.571$$

$$\boxed{\theta = 55.2°}$$

(b) $n = F_g - F\sin\theta = [196 - 35.0(0.821)]\text{ N}$

$$\boxed{n = 167\text{ N}}$$