ANSWERS TO EVEN PROBLEMS

P4.2 (a) \( \vec{r} = 18.0t\hat{i} + (4.00 - 4.90t^2)\hat{j} \)  
(b) \( \vec{v} = 18.0\hat{i} + (4.00 - 9.80t)\hat{j} \)  
(c) \( \vec{a} = (-9.80 \text{ m/s}^2)\hat{j} \)
(d) \( (54.0 \text{ m})\hat{i} - (32.1 \text{ m})\hat{j} \)  
(e) \( (18.0 \text{ m/s})\hat{i} - (25.4 \text{ m/s})\hat{j} \)  
(f) \( (-9.80 \text{ m/s}^2)\hat{j} \)

P4.4 (a) \( \vec{v} = (-5.00\omega\hat{i} + 0\hat{j}) \text{ m/s} \);  
\( \vec{a} = (0\hat{i} + 5.00\omega^2\hat{j}) \text{ m/s}^2 \)
(b) \( \vec{r} = 4.00 \text{ m }\hat{j} + 5.00 \text{ m}(-\sin \omega t\hat{i} - \cos \omega t\hat{j}) \);  
\( \vec{v} = 5.00 \text{ m }\omega(-\cos \omega t\hat{i} + \sin \omega t\hat{j}) \);  
\( \vec{a} = 5.00 \text{ m }\omega^2(\sin \omega t\hat{i} + \cos \omega t\hat{j}) \)
(c) a circle of radius 5.00 m centered at (0, 4.00 m)

P4.6 (a) \( \vec{v} = -12.0\hat{j} \text{ m/s} \);  
\( \vec{a} = -12.0\hat{j} \text{ m/s}^2 \)  
(b) \( \vec{r} = (3.00\hat{i} - 6.00\hat{j}) \text{ m} \);  
\( \vec{v} = -12.0\hat{j} \text{ m/s} \)

P4.8 (a) \( \vec{r} = (5.00\hat{i} + 1.50t^2\hat{j}) \text{ m} \);  
\( \vec{v} = (5.00\hat{i} + 3.00t\hat{j}) \text{ m/s} \)  
(b) \( \vec{r} = (10.0\hat{i} + 6.00\hat{j}) \text{ m} \);  
7.81 m/s

P4.10 (a) \( d\sqrt{\frac{g}{2h}} \) horizontally  
(b) \( \tan^{-1}\left(\frac{2h}{d}\right) \) below the horizontal

P4.12 (a) 76.0°  
(b) the same on every planet. Mathematically, this is because the acceleration of gravity divides out of the answer.  
(c) \( \frac{17d}{8} \)

P4.14 \( \tan \theta = \frac{gd^2}{(2v_i^2 \cos^2 \theta)} \)

P4.16 (a) Yes. (b) \( (1.70 \text{ m/s})/\sqrt{12} = 0.491 \text{ m/s} \)

P4.18 33.5° below the horizontal

P4.20 (a) 0.852 s; (b) 3.29 m/s; (c) 4.03 m/s;  
(d) 50.8°; (e) 1.12 s

P4.22 (a) \( \vec{r} = 0\hat{i} + 0.840 \text{ m }\hat{j} \)  
(b) 11.2 m/s at 18.5°  
(c) 8.94 m  
(d) The free-fall trajectory of the athlete is a section around the vertex of a parabola opening downward, everywhere close to horizontal and 48 cm lower on the landing side than on the takeoff side.

P4.24 0.0337 m/s² toward the center of the Earth
P4.26 0.281 rev/s

P4.28 (a) Yes. The particle can be either speeding up or slowing down, with a tangential component of acceleration of magnitude $\sqrt{6^2 - 4.5^2} = 3.97 \text{ m/s}^2$. (b) No. The magnitude of the acceleration cannot be less than $v^2/r = 4.5 \text{ m/s}^2$.

P4.30 (a) see the solution (b) 29.7 m/s$^2$ (c) 6.67 m/s at 36.9° above the horizontal

P4.32 4.55°

P4.34 (a) 26.9 m/s (b) 67.3 m (c) $(2.00\hat{i} - 5.00\hat{j})$ m/s$^2$

P4.36 18.0 s

P4.38 (a) $0^\circ$ (b) 8.25 m/s (c) The can traverses a straight line segment upward and then downward (d) A symmetric section of a parabola opening downward; 12.6 m/s north at 41.0° above the horizontal.

P4.40 (a) 10.1 m/s$^2$ at 14.3° south from the vertical (b) 9.80 m/s$^2$ vertically downward (c) The bolt moves on a parabola with its axis downward and tilting to the south. It lands south of the point directly below its starting point. (d) The bolt moves on a parabola with a vertical axis.

P4.42 (a) 101 m/s (b) $3.27 \times 10^4$ ft (c) 20.6 s (d) 180 m/s

P4.44 (a) 2.69 m (b) The angle could be either positive or negative. The horizontal bounce sends the ball 2.69 m behind the player. To shorten this distance, the bird wants to reduce the horizontal velocity component of the ball. It can do this either by sending the ball upward or downward relative to the horizontal.

P4.46 $2v_0t\cos\theta$

P4.48 (a) 1.69 km/s; (b) $6.47 \times 10^3$ s

P4.50 (a) $x = v_0\left(0.1643 + 0.002 \cdot 299 v_0^2\right)^{1/2} + 0.047 \cdot 98 v_0^2$ where $x$ is in meters and $v_0$ is in meters per second, (b) 0.410 m (c) 961 m (d) $x \approx 0.405 \cdot v_0$ (e) $x \approx 0.095 \cdot 9 \cdot v_0^2$ (f) The graph of $x$ versus $v_0$ starts from the origin as a straight line with slope 0.405 s. Then it curves upward above this tangent line, getting closer and closer to the parabola $x = (0.095 \cdot 9 \text{ s/m}) v_0^2$.

P4.52 (18.8 m; –17.3 m)
P4.54  (a) $\sqrt{gR}$; (b) $(\sqrt{2} - 1)R$

P4.56  (a) 22.9 m/s  (b) 360 m from the base of the cliff  (c) $\mathbf{v} = (114 \hat{i} - 44.3 \hat{j})$ m/s

P4.58  Imagine you have a sick child and are shaking down the mercury in an old fever thermometer. Starting with your hand at the level of your shoulder, move your hand down as fast as you can and snap it around an arc at the bottom. $\sim 10^2$ m/s$^2 \sim 10$ g

P4.60  4.00 km/h

P4.62  see the solution