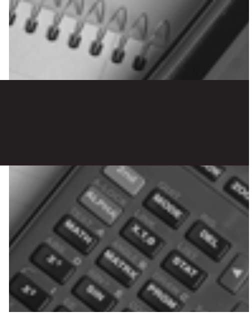

Two-Dimensional Motion and Vectors

Additional Practice A

Givens | *Solutions*

1. $\Delta t_x = 7.95$ s

$\Delta y = 161$ m

$d = 226$ m

$$d^2 = \Delta x^2 + \Delta y^2$$

$$\Delta x = \sqrt{d^2 - \Delta y^2} = \sqrt{(226\text{ m})^2 - (161\text{ m})^2} = \sqrt{5.11 \times 10^4\text{ m}^2 - 2.59 \times 10^4\text{ m}^2}$$

$$\Delta x = \sqrt{2.52 \times 10^4\text{ m}^2} = 159\text{ m}$$

$$\Delta x = \boxed{159\text{ m}}$$

$$v = \frac{\Delta x}{\Delta t_x} = \frac{159\text{ m}}{7.95\text{ s}} = \boxed{20.0\text{ m/s}}$$

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2. $d_1 = 5.0$ km

$\theta_1 = 11.5°$

$d^2 = 1.0$ km

$\theta_2 = -90.0°$

$$\Delta x_{tot} = d_1(\cos\theta_1) + d_2(\cos\theta_2) = (5.0\text{ km})(\cos 11.5°) + (1.0\text{ km})[\cos(-90.0°)]$$

$$\Delta x_{tot} = 4.9\text{ km}$$

$$\Delta y_{tot} = d_1(\sin\theta_1) + d_2(\sin\theta_2) = (5.0\text{ km})(\sin 11.5°) + (1.0\text{ km})[\sin(-90.0°)]$$
$$= 1.0\text{ km} - 1.0\text{ km}$$

$$\Delta y_{tot} = 0.0\text{ km}$$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(4.9\text{ km})^2 + (0.0\text{ km})^2}$$

$$d = \boxed{4.9\text{ km}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{0.0\text{ km}}{4.9\text{ km}}\right) = \boxed{0.0°\text{, or due east}}$$

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3. $\Delta x = 5$ jumps

1 jump = 8.0 m

$d = 68$ m

$$d^2 = \Delta x^2 + \Delta y^2$$

$$\Delta y = \sqrt{d^2 - \Delta x^2} = \sqrt{(68\text{ m})^2 - [(5)(8.0\text{ m})]^2} = \sqrt{4.6 \times 10^3\text{ m}^2 - 1.6 \times 10^3\text{ m}^2}$$

$$\Delta y = \sqrt{3.0 \times 10^3\text{ m}} = 55\text{ m}$$

$$\text{number of jumps northward} = \frac{55\text{ m}}{8.0\text{ m/jump}} = 6.9\text{ jumps} = \boxed{7\text{ jumps}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta x}{\Delta y}\right) = \tan^{-1}\left[\frac{(5)(8.0\text{ m})}{55\text{ m}}\right] = \boxed{36°\text{ west of north}}$$

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4. $\Delta x = 25.2$ km

$\Delta y = 21.3$ km

$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(25.2\text{ km})^2 + (21.3\text{ km})^2}$$

$$d = \sqrt{635\text{ km}^2 + 454\text{ km}^2} = \sqrt{1089\text{ km}^2}$$

$$d = \boxed{33.00\text{ km}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{21.3\text{ km}}{25.2\text{ km}}\right)$$

$$\theta = \boxed{42.6°\text{ south of east}}$$

Givens	Solutions
5. $\Delta y = -483$ m $\Delta x = 225$ m	$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-483}{225\text{ m}}\right) = -65.0° = \boxed{65.0° \text{ below the waters surface}}$ $d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(225\text{ m})^2 + (-483\text{ m})^2}$ $d = \sqrt{5.06 \times 10^4\text{ m}^2 + 2.33 \times 10^5\text{ m}^2} = \sqrt{2.84 \times 10^5\text{ m}^2}$ $d = \boxed{533\text{ m}}$
6. $v = 15.0$ m/s $\Delta t_x = 8.0$ s $d = 180.0$ m	$d^2 = \Delta x^2 + \Delta y^2 = (v\Delta t_x)^2 + (v\Delta t_y)^2$ $d^2 = v^2(\Delta t_x{}^2 + \Delta t_y{}^2)$ $\Delta t_y = \sqrt{\left(\frac{d}{v}\right)^2 - \Delta t_x{}^2} = \sqrt{\left(\frac{180.0\text{ m}}{15.0\text{ m/s}}\right)^2 - (8.0\text{ s})^2} = \sqrt{144\text{ s}^2 - 64\text{ s}^2} = \sqrt{8.0 \times 10^1\text{ s}^2}$ $\Delta t_y = \boxed{8.9\text{ s}}$
7. $v = 8.00$ km/h $\Delta t_x = 15.0$ min $\Delta t_y = 22.0$ min	$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(v\Delta t_x)^2 + (v\Delta t_y)^2}$ $= v\sqrt{\Delta t_x{}^2 + \Delta t_y{}^2}$ $d = (8.00\text{ km/h})\left(\frac{1\text{ h}}{60\text{ min}}\right)\sqrt{(15.0\text{ min})^2 + (22.0\text{ min})^2}$ $d = (8.00\text{ km/h})\left(\frac{1\text{ h}}{60\text{ min}}\right)\sqrt{225\text{ min}^2 + 484\text{ min}^2}$ $d = \left(\frac{8.00\text{ km}}{60\text{ min}}\right)\sqrt{709\text{ min}^2} = \boxed{3.55\text{ km}}$ $\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{v\Delta t_y}{v\Delta t_x}\right) = \tan^{-1}\left(\frac{\Delta t_y}{\Delta t_x}\right) = \tan^{-1}\left(\frac{22.0\text{ min}}{15.0\text{ min}}\right)$ $\theta = \boxed{55.7° \text{ north of east}}$

Additional Practice B

Givens	Solutions
1. $d = (5)(33.0\text{ cm})$ $\Delta y = 88.0$ cm	$\theta = \sin^{-1}\left(\frac{\Delta y}{d}\right) = \sin^{-1}\left[\frac{88.0\text{ cm}}{(5)(33.0\text{ cm})}\right] = \boxed{32.2° \text{ north of west}}$ $\Delta x = d(\cos\theta) = (5)(33.0\text{ cm})(\cos 32.2°) = \boxed{1.40 \times 10^2\text{ cm to the west}}$
2. $\theta = 60.0°$ $d = 10.0$ m	$\Delta x = d(\cos\theta) = (10.0\text{ m})(\cos 60.0°) = \boxed{5.00\text{ m}}$ $\Delta y = d(\sin\theta) = (10.0\text{ m})(\sin 60.0°) = \boxed{8.66\text{ m}}$
3. $d = 10.3$ m $\Delta y = -6.10$ m	Finding the angle between d and the x-axis yields, $\theta_1 = \sin^{-1}\left(\frac{\Delta y}{\text{d}}\right) = \sin^{-1}\left(\frac{-6.10\text{ m}}{10.3\text{ m}}\right) = -36.3°$ The angle between d and the negative y-axis is therefore, $\theta = -90.0 - (-36.3°) = -53.7°$ $\theta = \boxed{53.7° \text{ on either side of the negative } y\text{-axis}}$ $d^2 + \Delta x^2 + \Delta_y{}^2$ $\Delta x = \sqrt{d^2 - \Delta y^2} = \sqrt{(10.3\text{ m})^2 - (-6.10\text{ m})^2} = \sqrt{106\text{ m}^2 - 37.2\text{ m}^2} = \sqrt{69\text{ m}^2}$ $\Delta x = \boxed{\pm 8.3\text{ m}}$

II

Givens	*Solutions*
4. $d = (8)(4.5 \text{ m})$ $\theta = 35°$	$\Delta x = d(\cos\theta) = (8)(4.5 \text{ m})(\cos 35°) = \boxed{29 \text{ m}}$ $\Delta y = d(\sin\theta) = (8)(4.5 \text{ m})(\sin 35°) = \boxed{21 \text{ m}}$
5. $v = 347$ km/h $\theta = 15.0°$	$v_x = v(\cos\theta) = (347 \text{ km/h})(\cos 15.0°) = \boxed{335 \text{ km/h}}$ $v_y = v(\sin\theta) = (347 \text{ km/h})(\sin 15.0°) = \boxed{89.8 \text{ km/h}}$
6. $v = 372$ km/h $\Delta t = 8.7$ s $\theta = 60.0°$	$d = v\Delta t = (372 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})(8.7 \text{ s}) = 9.0 \times 10^2 \text{ m}$ $\Delta x = d(\cos\theta) = (9.0 \times 10^2 \text{ m})(\cos 60.0°) = \boxed{450 \text{ m east}}$ $\Delta y = d(\sin\theta) = (9.0 \times 10^2 \text{ m})(\sin 60.0°) = \boxed{780 \text{ m north}}$
7. $d = 14\,890$ km $\theta = 25.0°$ $\Delta t = 18.5$ h	$v_{avg} = \frac{d}{\Delta t} = \frac{1.489 \times 10^4 \text{ km}}{18.45 \text{ h}} = \boxed{805 \text{ km/h}}$ $v_x = v_{avg}(\cos\theta) = (805 \text{ km/h})(\cos 25.0°) = \boxed{730 \text{ km/h east}}$ $v_y = v_{avg}(\sin\theta) = (805 \text{ km/h})(\sin 25.0°) = \boxed{340 \text{ km/h south}}$
8. $v_i = 6.0 \times 10^2$ km/h $v_f = 2.3 \times 10^3$ km/h $\Delta t = 120$ s $\theta = 35°$ with respect to horizontal	$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$ $a = \frac{(2.3 \times 10^3 \text{ km/h} - 6.0 \times 10^2 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})}{1.2 \times 10^2 \text{ s}}$ $a = \frac{(1.7 \times 10^3 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})}{1.2 \times 10^2 \text{ s}}$ $a = 3.9 \text{ m/s}^2$ $a_x = a(\cos\theta) = (3.9 \text{ m/s}^2)(\cos 35°) = \boxed{3.2 \text{ m/s}^2 \text{ horizontally}}$ $a_y = a(\sin\theta) = (3.9 \text{ m/s}^2)(\sin 35°) = \boxed{2.2 \text{ m/s}^2 \text{ vertically}}$

II

Additional Practice C

1. $\Delta x_1 = 250.0$ m $d_2 = 125.0$ m $\theta_2 = 120.0°$	$\Delta x_2 = d_2(\cos\theta_2) = (125.0 \text{ m})(\cos 120.0°) = -62.50 \text{ m}$ $\Delta y_2 = d_2(\sin\theta_2) = (125.0 \text{ m})(\sin 120.0°) = 108.3 \text{ m}$ $\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 250.0 \text{ m} - 62.50 \text{ m} = 187.5 \text{ m}$ $\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 0 \text{ m} + 108.3 \text{ m} = 108.3 \text{ m}$ $d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(187.5 \text{ m})^2 + (108.3 \text{ m})^2}$ $d = \sqrt{3.516 \times 10^4 \text{ m}^2 + 1.173 \times 10^4 \text{ m}^2} = \sqrt{4.689 \times 10^4 \text{ m}^2}$ $d = \boxed{216.5 \text{ m}}$ $\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{108.3 \text{ m}}{187.5 \text{ m}}\right) = \boxed{30.01° \text{ north of east}}$

Givens | *Solutions*

2. $v = 3.53 \times 10^3$ km/h

$\Delta t_1 = 20.0$ s

$\Delta t_2 = 10.0$ s

$\theta_1 = 15.0°$

$\theta_2 = 35.0°$

$$\Delta x_1 = v\Delta t_1(\cos\theta_1)$$

$$\Delta x_1 = (3.53 \times 10^3 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})(20.0 \text{ s})(\cos 15.0°) = 1.89 \times 10^4 \text{ m}$$

$$\Delta y_1 = v\Delta t_1(\sin\theta_1)$$

$$\Delta y_1 = (3.53 \times 10^3 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})(20.0 \text{ s})(\sin 15.0°) = 5.08 \times 10^3 \text{ m}$$

$$\Delta x_2 = v\Delta t_2(\cos\theta_2)$$

$$\Delta x_2 = (3.53 \times 10^3 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})(10.0 \text{ s})(\cos 35.0°) = 8.03 \times 10^3 \text{ m}$$

$$\Delta y_2 = v\Delta t_2(\sin\theta_2)$$

$$\Delta y_2 = (3.53 \times 10^3 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km})(10.0 \text{ s})(\sin 35.0°) = 5.62 \times 10^3 \text{ m}$$

$$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 5.08 \times 10^3 \text{ m} + 5.62 \times 10^3 \text{ m} = \boxed{1.07 \times 10^4 \text{ m}}$$

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 1.89 \times 10^4 \text{ m} + 8.03 \times 10^3 \text{ m} = \boxed{2.69 \times 10^4 \text{ m}}$$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(2.69 \times 10^4 \text{ m})^2 + (1.07 \times 10^4 \text{ m})^2}$$

$$d = \sqrt{7.24 \times 10^8 \text{ m}^2 + 1.11 \times 10^8 \text{ m}^2} = \sqrt{8.35 \times 10^8 \text{ m}}$$

$$d = \boxed{2.89 \times 10^4 \text{ m}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{1.07 \times 10^4 \text{ m}}{2.69 \times 10^4 \text{ m}}\right)$$

$$\theta = \boxed{21.7° \text{ above the horizontal}}$$

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3. $\Delta x_1 + \Delta x_2 = 2.00 \times 10^2$ m

$\Delta y_1 + \Delta y_2 = 0$

$\theta_1 = 30.0°$

$\theta_2 = -45.0°$

$v = 11.6$ km/h

$$\Delta y_1 = d_1(\sin\theta_1) = -\Delta y_2 = -d_2(\sin\theta_2)$$

$$d_1 = -d_2\left(\frac{\sin\theta_2}{\sin\theta_1}\right) = -d_2\left[\frac{\sin(-45.0°)}{\sin 30.0°}\right] = 1.41d_2$$

$$\Delta x_1 = d_1(\cos\theta_1) = (1.41d_2)(\cos 30.0°) = 1.22d_2$$

$$\Delta x_2 = d_2(\cos\theta_2) = d_2[\cos(-45.0°)] = 0.707d_2$$

$$\Delta x_1 + \Delta x_2 = d_2(1.22 + 0.707) = 1.93d_2 = 2.00 \times 10^2 \text{ m}$$

$$d_2 = \boxed{104 \text{ m}}$$

$$d_1 = (1.41)d_2 = (1.41)(104 \text{ m}) = \boxed{147 \text{ m}}$$

$$v = 11.6 \text{ km/h} = (11.6 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(10^3 \text{ m/km}) = 3.22 \text{ m/s}$$

$$\Delta t_1 = \frac{d_1}{v} = \left(\frac{147 \text{ m}}{3.22 \text{ m/s}}\right) = 45.7 \text{ s}$$

$$\Delta t_2 = \frac{d_2}{v} = \left(\frac{104 \text{ m}}{3.22 \text{ m/s}}\right) = 32.3 \text{ s}$$

$$\Delta t_{tot} = \Delta t_1 + \Delta t_2 = 45.7 \text{ s} + 32.3 \text{ s} = \boxed{78.0 \text{ s}}$$

II

Givens	Solutions

Givens *Solutions*

4. $v = 925$ km/h

$\Delta t_1 = 1.50$ h

$\Delta t_2 = 2.00$ h

$\theta_2 = 135°$

$d_1 = v\Delta t_1 = (925 \text{ km/h})(10^3 \text{ m/km})(1.50 \text{ h}) = 1.39 \times 10^6 \text{ m}$

$d_2 = v\Delta t_2 = (925 \text{ km/h})(10^3 \text{ m/km})(2.00 \text{ h}) = 1.85 \times 10^6 \text{ m}$

$\Delta x_1 = d_1 = 1.39 \times 10^6 \text{ m}$

$\Delta y_1 = 0 \text{ m}$

$\Delta x_2 = d_2(\cos \theta_2) = (1.85 \times 10^6 \text{ m})(\cos 135°) = -1.31 \times 10^6 \text{ m}$

$\Delta y_2 = d_2(\sin \theta_2) = (1.85 \times 10^6 \text{ m})(\sin 135°) = 1.31 \times 10^6 \text{ m}$

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 1.39 \times 10^6 \text{ m} + (-1.31 \times 10^6 \text{ m}) = 0.08 \times 10^6 \text{ m}$

$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 0 \text{ m} + 1.31 \times 10^6 \text{ m} = 1.31 \times 10^6 \text{ m}$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(0.08 \times 10^6 \text{ m})^2 + (1.31 \times 10^6 \text{ m})^2}$$

$$d = \sqrt{6 \times 10^9 \text{ m}^2 + 1.72 \times 10^{12} \text{ m}^2} = \sqrt{1.73 \times 10^{12} \text{ m}^2}$$

$$d = \boxed{1.32 \times 10^6 \text{ m} = 1.32 \times 10^3 \text{ km}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{1.31 \times 10^6 \text{ m}}{0.08 \times 10^6 \text{ m}}\right) = 86.5° = 90.0° - 3.5°$$

$$\theta = \boxed{3.5° \text{ east of north}}$$

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5. $v = 57.2$ km/h

$\Delta t_1 = 2.50$ h

$\Delta t_2 = 1.50$ h

$\theta_2 = 30.0°$

$d_1 = v\Delta t_1 = (57.2 \text{ km/h})(2.50 \text{ h}) = 143 \text{ km}$

$d_2 = v\Delta t_2 = (57.2 \text{ km/h})(1.50 \text{ h}) = 85.8 \text{ km}$

$\Delta_{tot} = d_1 + d_2(\cos \theta_2) = 143 \text{ km} + (85.8 \text{ km})(\cos 30.0°) = 143 \text{ km} + 74.3 \text{ km} = 217 \text{ km}$

$\Delta y_{tot} = d_2(\sin \theta_2) = (85.8 \text{ km})(\sin 30.0°) = 42.9 \text{ km}$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(217 \text{ km})^2 + (42.9 \text{ km})}$$

$$d = \sqrt{4.71 \times 10^4 \text{ km}^2 + 1.84 \times 10^3 \text{ km}^2} = \sqrt{4.89 \times 10^4 \text{ km}^2}$$

$$d = \boxed{221 \text{ km}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{42.9 \text{ km}}{217 \text{ km}}\right) = \boxed{11.2° \text{ north of east}}$$

Additional Practice D

1. $v_x = 9.37$ m/s

$\Delta y = -2.00$ m

$a_y = -g = -9.81 \text{ m/s}^2$

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \frac{\Delta x}{v_x}$$

$$\Delta x = v_x\sqrt{\frac{2\Delta y}{a_y}} = (9.37 \text{ m/s})\sqrt{\frac{(2)(-2.00 \text{ m})}{(-9.81 \text{ m/s}^2)}} = 5.98 \text{ m}$$

$\boxed{\text{The river is 5.98 m wide.}}$

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2. $\Delta x = 7.32$ km

$\Delta y = -8848$ m

$a_y = -g = -9.81 \text{ m/s}^2$

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \frac{\Delta x}{v_x}$$

$$v_x = \sqrt{\frac{a_y}{2\Delta y}}\Delta x = \sqrt{\frac{(-9.81 \text{ m/s}^2)}{(2)(-8\,848 \text{ m})}}(7.32 \times 10^3 \text{ m}) = \boxed{172 \text{ m/s}}$$

No. The arrow must have a horizontal speed of 172 m/s, which is much greater than 100 m/s.

II

Givens | *Solutions*

3. $\Delta x = 471 \text{ m}$

$v_i = 80.0 \text{ m/s}$

$a_y = -g = -9.81 \text{ m/s}^2$

$$\Delta t = \frac{\Delta x}{v_x}$$

$$\Delta y = \frac{1}{2}a_y(\Delta t)^2 = \frac{a_y(\Delta x)^2}{2v_x^2} = \frac{(-9.81 \text{ m/s}^2)(471 \text{ m})^2}{(2)(80.0 \text{ m/s})^2} = -1.70 \times 10^2 \text{ m}$$

$\boxed{\text{The cliff is } 1.70 \times 10^2 \text{ m high.}}$

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4. $v_x = 372 \text{ km/h}$

$\Delta x = 40.0 \text{ m}$

$a_y = -g = -9.81 \text{ m/s}^2$

$$\Delta t = \frac{\Delta x}{v_x}$$

$$\Delta y = \frac{1}{2}a_y(\Delta t)^2 = \frac{a_y(\Delta x)^2}{2v_x^2} = \frac{(-9.81 \text{ m/s}^2)(40.0 \text{ m})^2}{(2)\left[(372 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)\right]^2}$$

$$\Delta y = -0.735 \text{ m}$$

$\boxed{\text{The ramp is 0.735 m above the ground.}}$

---

5. $\Delta x = 25 \text{ m}$

$v_x = 15 \text{ m/s}$

$a_y = -g = -9.81 \text{ m/s}^2$

$h = 25 \text{ m}$

$$\Delta t = \frac{\Delta x}{v_x}$$

$$\Delta y = \frac{1}{2}a_y(\Delta t)^2 = \frac{a_y(\Delta x)^2}{2v_x^2} = \frac{(-9.81 \text{ m/s}^2)(25 \text{ m})^2}{(2)(15 \text{ m/s})^2}$$

$$\Delta y = h - h' = -14 \text{ m}$$

$$h' = h - \Delta y = 25 \text{ m} - (-14 \text{ m})$$

$$= \boxed{39 \text{ m}}$$

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6. $\ell = 420 \text{ m}$

$\Delta y = \frac{-\ell}{2}$

$\Delta x = \ell$

$a_y = -g = -9.81 \text{ m/s}^2$

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \frac{\Delta x}{v_x}$$

$$v_x = \sqrt{\frac{a_y}{2\Delta y}}\Delta x = \sqrt{\frac{(-9.81 \text{ m/s}^2)}{(2)(-2\ 10 \text{m})}}(420 \text{ m}) = \boxed{64 \text{ m/s}}$$

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7. $\Delta y = -2.45 \text{ m}$

$v = 12.0 \text{ m/s}$

$a_y = -g = -9.81 \text{ m/s}^2$

$$v_y^2 = 2a_y\Delta y$$

$$v^2 = v_x^2 + v_y^2 = v_x^2 + 2a_y\Delta y$$

$$v_x = \sqrt{v^2 - 2a_y\Delta y} = \sqrt{(12.0 \text{ m/s})^2 - (2)(-9.81 \text{ m/s}^2)(-2.45 \text{ m})}$$

$$v_x = \sqrt{144 \text{ m}^2/\text{s}^2 - 48.1 \text{ m}^2/\text{s}^2}$$

$$= \sqrt{96 \text{ m}^2/\text{s}^2}$$

$$v_x = \boxed{9.8 \text{ m/s}}$$

Givens	Solutions
8. $\Delta y = -1.95$ m	$v_y^2 = 2a_y \Delta y$
$v_x = 3.0$ m/s	$v = \sqrt{v_x^2 + v_y^2} = \sqrt{v_x^2 + 2a_y\Delta y}$
$a_y = -g = -9.81$ m/s^2	$v = \sqrt{(3.0 \text{ m/s})^2 + (2)(-9.81 \text{ m/s}^2)(-1.95 \text{ m})}$
	$v = \sqrt{9.0 \text{ m}^2/\text{s}^2 + 38.3 \text{ m}^2/\text{s}^2} = \sqrt{47.3 \text{ m}^2/\text{s}^2} = \boxed{6.88 \text{ m/s}}$
	$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{\sqrt{2a_y\Delta y}}{v_x}\right) = \tan^{-1}\left(\frac{\sqrt{(2)(-9.81 \text{ m/s}^2)(-1.95 \text{ m})}}{3.0 \text{ m/s}}\right)$
	$\theta = \boxed{64° \text{ below the horizontal}}$

Additional Practice E

1. $\Delta x = 201.24$ m

$\theta = 35.0°$

$a_y = -g = -9.81$ m/s^2

$$\Delta y = v_i(\sin\theta)\Delta t + \frac{1}{2}a_y(\Delta t)^2 = v_i(\sin\theta) + \frac{1}{2}a_y\Delta t = 0$$

$$\Delta x = v_i(\cos\theta)\Delta t$$

$$\Delta t = \frac{\Delta x}{v_i(\cos\theta)}$$

$$v_i(\sin\theta) = -\frac{1}{2}a_y\left[\frac{\Delta x}{v_i(\cos\theta)}\right]$$

$$v_i = \sqrt{\frac{-a_y\Delta x}{2(\sin\theta)(\cos\theta)}} = \sqrt{\frac{-(-9.81 \text{ m/s}^2)(201.24 \text{ m})}{(2)(\sin 35.0°)(\cos 35.0°)}}$$

$$v_i = \boxed{45.8 \text{ m/s}}$$

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2. $\Delta x = 9.50 \times 10^2$ m

$\theta = 45.0°$

$a_y = -g = -9.81$ m/s^2

Using the derivation shown in problem 1,

$$v_i = \sqrt{\frac{-a_y\Delta x}{2(\sin\theta)(\cos\theta)}} = \sqrt{\frac{-(-9.81 \text{ m/s}^2)(9.50 \times 10^2 \text{ m})}{(2)(\sin 45.0°)(\cos 45.0°)}}$$

$$v_i = 96.5 \text{ m/s}$$

At the top of the arrow's flight:

$$v = v_x = v_i(\cos\theta) = (96.5 \text{ m/s})(\cos 45.0°) = \boxed{68.2 \text{ m/s}}$$

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3. $\Delta x = 27.5$ m

$\theta = 50.0°$

$a_y = -g = -9.81$ m/s^2

Using the derivation shown in problem 1,

$$v_i = \sqrt{\frac{-a_y\Delta x}{2(\sin\theta)(\cos\theta)}} = \sqrt{\frac{-(-9.81 \text{ m/s}^2)(27.5 \text{ m})}{(2)(\sin 50.0°)(\cos 50.0°)}}$$

$$v_i = \boxed{16.6 \text{ m/s}}$$

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4. $\Delta x = 44.0$ m

$\theta = 45.0°$

$a_y = -g = -9.81$ m/s^2

Using the derivation shown in problem 1,

a. $$v_i = \sqrt{\frac{-a_y\Delta x}{2(\sin\theta)(\cos\theta)}} = \sqrt{\frac{-(-9.81 \text{ m/s}^2)(44.0 \text{ m})}{(2)(\sin 45.0°)(\cos 45.0°)}}$$

$$v_i = \boxed{20.8 \text{ m/s}}$$

II

Givens	Solutions
	b. At maximum height, $v_{y,f} = 0$ m/s

$$v_{y,f}^2 = v_{y,i}^2 + 2a_y\Delta y_{max} = 0$$

$$y_{max} = \frac{-v_{y,i}^2}{2a_y} = \frac{-v_i^2(\sin\theta)^2}{2a_y} = \frac{-(20.8 \text{ m/s})^2(\sin 45.0°)^2}{(2)(-9.81 \text{ m/s}^2)} = 11.0 \text{ m}$$

The brick's maximum height is 11.0 m.

c. $$y_{max} = \frac{-v_{y,i}^2}{2a_y} = \frac{-(20.8 \text{ m/s})^2}{(2)(-9.81 \text{ m/s}^2)} = 22.1 \text{ m}$$

The brick's maximum height is 22.1 m.

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5. $\Delta x = 76.5$ m

$\theta = 12.0°$

$a_y = -g = -9.81 \text{ m/s}^2$

At maximum height, $v_{y,f} = 0$ m/s.

$$v_{y,f}^2 = v_{y,i}^2 + 2a_y\Delta y_{max} = 0$$

$$y_{max} = \frac{-v_{y,i}^2}{2a_y} = \frac{-v_i^2(\sin\theta)^2}{2a_y}$$

Using the derivation for v_i^2 from problem 1,

$$\Delta y_{max} = \left[\frac{-a_y\Delta x}{2(\sin\theta)(\cos\theta)}\right]\frac{-(\sin\theta)^2}{2a_y} = \frac{\Delta x(\sin\theta)}{4(\cos\theta)} = \frac{\Delta x(\tan\theta)}{4}$$

$$\Delta y_{max} = \frac{(76.5 \text{ m})(\tan 12.0°)}{4} = 4.07 \text{ m}$$

---

6. $v_{runner} = 5.82$ m/s

$v_{i,ball} = 2v_{runner}$

In x-direction,

$$v_{i,ball}(\cos\theta) = 2v_{runner}(\cos\theta) = v_{runner}$$

$$2(\cos\theta) = 1$$

$$\theta = \cos^{-1}\left(\tfrac{1}{2}\right) = \boxed{60°}$$

---

7. $v_i = 8.42$ m/s

$\theta = 55.2°$

$\Delta t = 1.40$ s

$a_y = -g = -9.81 \text{ m/s}^2$

For first half of jump,

$$\Delta t_1 = \frac{1.40 \text{ s}}{2} = 0.700 \text{ s}$$

$$\Delta y = v_i(\sin\theta)\Delta t_1 + \tfrac{1}{2}a_y(\Delta t_1)^2 = (8.42 \text{ m/s})(\sin 55.2°)(0.700 \text{ s}) + \tfrac{1}{2}(-9.81 \text{ m/s}^2)(0.700 \text{ s})^2$$

$$\Delta y = 4.84 \text{ m} - 2.40 \text{ m} = 2.44 \text{ m}$$

The fence is 2.44 m high.

$$\Delta x = v_i(\cos\theta)\Delta t$$

$$\Delta x = (8.42 \text{ m/s})(\cos 55.2°)(1.40 \text{ s}) = \boxed{6.73 \text{ m}}$$

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8. $v_i = 2.2$ m/s

$\theta = 21°$

$\Delta t = 0.16$ s

$a_y = -g = -9.81 \text{ m/s}^2$

$$\Delta x = v_i(\cos\theta)\Delta t = (2.2 \text{ m/s})(\cos 21°)(0.16 \text{ s}) = \boxed{0.33 \text{ m}}$$

Maximum height is reached in a time interval of $\frac{\Delta t}{2}$

$$\Delta y_{max} = v_i(\sin\theta)\left(\frac{\Delta t}{2}\right) + \tfrac{1}{2}a_y\left(\frac{\Delta t}{2}\right)^2$$

$$\Delta y_{max} = (2.2 \text{ m/s})(\sin 21°)\left(\frac{0.16 \text{ s}}{2}\right) + \tfrac{1}{2}(-9.81 \text{ m/s}^2)\left(\frac{0.16 \text{ s}}{2}\right)^2$$

$$\Delta y_{max} = 6.3 \times 10^{-2} \text{ m} - 3.1 \times 10^{-2} \text{ m} = 3.2 \times 10^{-2} \text{ m} = 3.2 \text{ cm}$$

The flea's maximum height is 3.2 cm.

Additional Practice F

Givens	Solutions
1. $\mathbf{v_{se}}$ = 126 km/h north $\mathbf{v_{gs}}$ = 40.0 km/h east	$v_{ge} = \sqrt{v_{gs}^2 + v_{se}^2} = \sqrt{(40.0 \text{ km/h})^2 + (126 \text{ km/h})^2}$ $v_{ge} = \sqrt{1.60 \times 10^3 \text{ km}^2/\text{h}^2 + 1.59 \times 10^4 \text{ km}^2/\text{h}^2}$ $v_{ge} = \sqrt{1.75 \times 10^4 \text{ km/h}} = \boxed{132 \text{ km/h}}$ $\theta = \tan^{-1}\left(\frac{v_{se}}{v_{gs}}\right) = \tan^{-1}\left(\frac{126 \text{ km/h}}{40.0 \text{ km/h}}\right) = \boxed{72.4° \text{ north of east}}$
2. $\mathbf{v_{we}} = -3.00 \times 10^2$ km/h $\mathbf{v_{pw}} = 4.50 \times 10^2$ km/h Δx = 250 km	$v_{pe} = v_{pw} + v_{we} = 4.50 \times 10^2 \text{ km/h} - 3.00 \times 10^2 \text{ km/h} = 1.50 \times 10^2 \text{ km/h}$ $\Delta t = \frac{\Delta x}{v_{pe}} = \frac{250 \text{ km}}{1.50 \times 10^2 \text{ km/h}} = \boxed{1.7 \text{ h}}$
3. $\mathbf{v_{tw}}$ = 9.0 m/s north $\mathbf{v_{wb}}$ = 3.0 m/s east Δt = 1.0 min	$\mathbf{v_{tb}} = \mathbf{v_{tw}} + \mathbf{v_{wb}}$ $v_{tb} = \sqrt{v_{tw}^2 + v_{wb}^2} = \sqrt{(9.0 \text{ m/s})^2 + (3.0 \text{ m/s})^2} = \sqrt{81 \text{ m}^2/\text{s}^2 + 9.0 \text{ m}^2/\text{s}^2}$ $v_{tb} = \sqrt{9.0 \times 10^1 \text{ m}^2/\text{s}^2}$ $v_{tb} = 9.5$ m/s $\Delta x = v_{tb}\Delta t = (9.5 \text{ m/s})(1.0 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = \boxed{570 \text{ m}}$ $\theta = \tan^{-1}\left(\frac{v_{wb}}{v_{tw}}\right) = \tan^{-1}\left(\frac{3.0 \text{ m/s}}{9.0 \text{ m/s}}\right) = \boxed{18° \text{ east of north}}$
4. $\mathbf{v_{sw}}$ = 40.0 km/h forward $\mathbf{v_{fw}}$ = 16.0 km/h forward Δx = 60.0 m	$\mathbf{v_{sf}} = \mathbf{v_{sw}} - \mathbf{v_{fw}}$ = 40.0 km/h − 16.0 km/h = 24.0 km/h toward fish $\Delta t = \frac{\Delta x}{v_{sf}} = \frac{60.0 \text{ m}}{(24.0 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)} = \boxed{9.00 \text{ s}}$
5. $\mathbf{v_{1E}}$ = 90.0 km/h $\mathbf{v_{2E}}$ = −90.0 km/h Δt = 40.0 s	$\mathbf{v_{12}} = \mathbf{v_{1E}} - \mathbf{v_{2E}}$ $v_{12} = 90.0 \text{ km/h} - (-90.0 \text{ km/h}) = 1.80 \times 10^2 \text{ km/h}$ $\Delta x = v_{12}\Delta t = (1.80 \times 10^2 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)(40.0 \text{ s}) = 2.00 \times 10^3 \text{ m} = 2.00 \text{ km}$ $\boxed{\text{The two geese are initially 2.00 km apart}}$
6. $\mathbf{v_{me}}$ = 18.0 km/h forward $\mathbf{V_{re}} = 0.333\ \mathbf{V_{me}}$ = 6.00 km/h forward Δx = 12.0 m	$\mathbf{v_{mr}} = \mathbf{v_{me}} - \mathbf{v_{re}}$ v_{mr} = 18.0 km/h − 6.0 km/h = 12.0 km/h $\Delta t = \frac{\Delta x}{v_{mr}} = \frac{12.0 \text{ m}}{(12.0 \text{ km/h})}\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)\left(\frac{1 \text{ km}}{10^3 \text{ m}}\right)$ $\Delta t = \boxed{3.60 \text{ s}}$

II