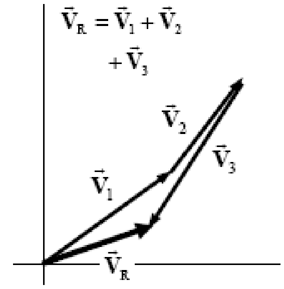
4. The vectors for the problem are drawn approximately to scale. The resultant has a length of $\boxed{17.5\,\text{m}}$ and a direction $\boxed{19^\circ}$ north of east. If calculations are done, the actual resultant should be 17 m at 23° north of east.

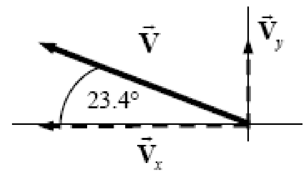


5. (*a*) See the accompanying diagram

(*b*) $V_x = -24.8\cos 23.4^\circ = \boxed{-22.8\text{ units}}$ $V_y = 24.8\sin 23.4^\circ = \boxed{9.85\text{ units}}$

(*c*) $V = \sqrt{V_x^2 + V_y^2} = \sqrt{(-22.8)^2 + (9.85)^2} = \boxed{24.8\text{ units}}$

$\theta = \tan^{-1}\dfrac{9.85}{22.8} = \boxed{23.4^\circ\text{above the } -x\text{ axis}}$



7. (*a*) $v_{\text{north}} = (835\,\text{km/h})(\cos 41.5^\circ) = \boxed{625\,\text{km/h}}$ $v_{\text{west}} = (835\,\text{km/h})(\sin 41.5^\circ) = \boxed{553\,\text{km/h}}$

(*b*) $\Delta d_{\text{north}} = v_{\text{north}}t = (625\text{ km/h})(2.50\text{ h}) = \boxed{1560\text{ km}}$

$\Delta d_{\text{west}} = v_{\text{west}}t = (553\text{ km/h})(2.50\text{ h}) = \boxed{1380\text{ km}}$

10. $A_x = 44.0\cos 28.0^\circ = 38.85$ $A_y = 44.0\sin 28.0^\circ = 20.66$

$B_x = -26.5\cos 56.0^\circ = -14.82$ $B_y = 26.5\sin 56.0^\circ = 21.97$

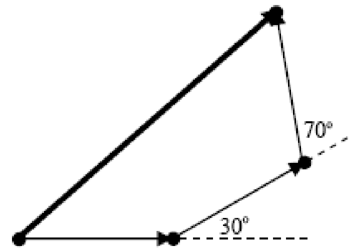
$C_x = 31.0\cos 270^\circ = 0.0$ $C_y = 31.0\sin 270^\circ = -31.0$

(*a*) $(\vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}})_x = 38.85 + (-14.82) + 0.0 = 24.03 = \boxed{24.0}$

$(\vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}})_y = 20.66 + 21.97 + (-31.0) = 11.63 = \boxed{11.6}$

(*b*) $|\vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}}| = \sqrt{(24.03)^2 + (11.63)^2} = \boxed{26.7}$ $\theta = \tan^{-1}\dfrac{11.63}{24.03} = \boxed{25.8^\circ}$

23. The three displacements for the ant are shown in the diagram, along with the net displacement. In x and y components, they are $+10.0\,\text{cm}\,\hat{\mathbf{i}}$, $\left(10.0\cos 30.0^\circ\,\hat{\mathbf{i}} + 10.0\sin 30.0^\circ\,\hat{\mathbf{j}}\right)\text{cm}$, , and $\left(10.0\cos 100^\circ\,\hat{\mathbf{i}} + 10.0\sin 100^\circ\,\hat{\mathbf{j}}\right)\text{cm}$. To find the average velocity, divide the net displacement by the elapsed time.



(*a*) $\Delta\vec{\mathbf{r}} = +10.0\,\text{cm}\,\hat{\mathbf{i}} + \left(10.0\cos 30.0^\circ\hat{\mathbf{i}} + 10.0\sin 30.0^\circ\hat{\mathbf{j}}\right)\text{cm}$

$$+\left(10.0\cos 100^\circ\,\hat{\mathbf{i}} + 10.0\sin 100^\circ\,\hat{\mathbf{j}}\right)\text{cm} = \left(16.92\,\hat{\mathbf{i}} + 14.85\,\hat{\mathbf{j}}\right)\text{cm}$$

$$\vec{\mathbf{v}}_{\text{avg}} = \frac{\Delta\vec{\mathbf{r}}}{\Delta t} = \frac{\left(16.92\,\hat{\mathbf{i}} + 14.85\,\hat{\mathbf{j}}\right)\text{cm}}{2.00\,\text{s} + 1.80\,\text{s} + 1.55\,\text{s}} = \boxed{\left(3.16\,\hat{\mathbf{i}} + 2.78\hat{\mathbf{j}}\right)\text{cm/s}}$$

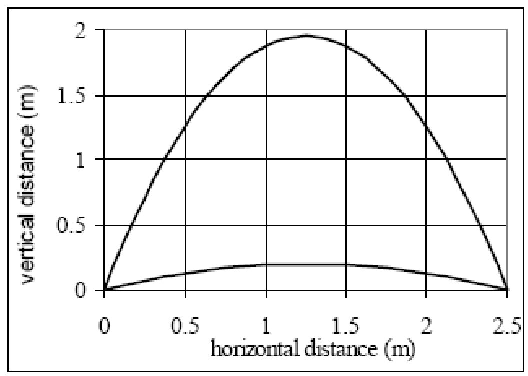
(*b*) $\left|\vec{\mathbf{v}}_{\text{avg}}\right| = \sqrt{\left(3.16\,\text{cm/s}\right)^2 + \left(2.78\,\text{cm/s}\right)^2} = \boxed{4.21\,\text{cm/s}}$ $\quad\theta = \tan^{-1}\frac{v_y}{v_x} = \tan^{-1}\frac{2.78}{3.16} = \boxed{41.3^\circ}$

31. Apply the range formula from Example 3-10.

$$R = \frac{v_0^2 \sin 2\theta_0}{g} \quad\rightarrow$$

$$\sin 2\theta_0 = \frac{Rg}{v_0^2} = \frac{\left(2.5\text{ m}\right)\left(9.80\,\text{m/s}^2\right)}{\left(6.5\,\text{m/s}\right)^2} = 0.5799$$

$$2\theta_0 = \sin^{-1} 0.5799 \quad\rightarrow\quad \theta_0 = \boxed{18^\circ, 72^\circ}$$



There are two angles because each angle gives the same range. If one angle is $\theta = 45^\circ + \delta$, then $\theta = 45^\circ - \delta$ is also a solution. The two paths are shown in the graph.

46. Choose the origin to be at ground level, under the place where the projectile is launched, and upwards to be the positive y direction. For the projectile, $v_0 = 65.0\,\text{m/s}$, $\theta_0 = 35.0°$, $a_y = -g$, $y_0 = 115\,\text{m}$, and $v_{y0} = v_0 \sin\theta_0$.

(*a*) The time taken to reach the ground is found from Eq. 2-12b, with a final height of 0.

$$y = y_0 + v_{y0}t + \tfrac{1}{2}a_y t^2 \quad \rightarrow \quad 0 = y_0 + v_0 \sin\theta_0 t - \tfrac{1}{2}gt^2 \quad \rightarrow$$

$$t = \frac{-v_0 \sin\theta_0 \pm \sqrt{v_0^2 \sin^2\theta_0 - 4\left(-\tfrac{1}{2}g\right)y_0}}{2\left(-\tfrac{1}{2}g\right)} = 9.964\,\text{s}\,,\ -2.3655\,\text{s} = \boxed{9.96\,\text{s}}$$

Choose the positive time since the projectile was launched at time $t = 0$.

(*b*) The horizontal range is found from the horizontal motion at constant velocity.

$$\Delta x = v_x t = \left(v_0 \cos\theta_0\right)t = \left(65.0\,\text{m/s}\right)\left(\cos 35.0°\right)\left(9.964\,\text{s}\right) = \boxed{531\,\text{m}}$$

(*c*) At the instant just before the particle reaches the ground, the horizontal component of its velocity is the constant $v_x = v_0 \cos\theta_0 = \left(65.0\,\text{m/s}\right)\cos 35.0° = \boxed{53.2\,\text{m/s}}$. The vertical component is found from Eq. 2-12a.

$$v_y = v_{y0} + at = v_0 \sin\theta_0 - gt = \left(65.0\,\text{m/s}\right)\sin 35.0° - \left(9.80\,\text{m/s}^2\right)\left(9.964\,\text{s}\right)$$

$$= \boxed{-60.4\,\text{m/s}}$$

(*d*) The magnitude of the velocity is found from the x and y components calculated in part (*c*) above.

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{\left(53.2\,\text{m/s}\right)^2 + \left(-60.4\,\text{m/s}\right)^2} = \boxed{80.5\,\text{m/s}}$$

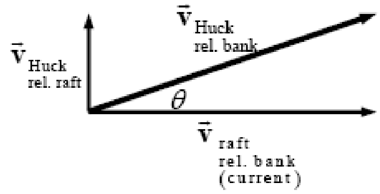
(*e*) The direction of the velocity is $\theta = \tan^{-1}\dfrac{v_y}{v_x} = \tan^{-1}\dfrac{-60.4}{53.2} = -48.6°$, and so the object is moving $\boxed{48.6° \text{ below the horizon}}$.

(*f*) The maximum height above the cliff top reached by the projectile will occur when the y-velocity is 0, and is found from Eq. 2-12c.

$$v_y^2 = v_{y0}^2 + 2a_y\left(y - y_0\right) \quad \rightarrow \quad 0 = v_0^2 \sin^2\theta_0 - 2gy_{max}$$

$$y_{max} = \frac{v_0^2 \sin^2\theta_0}{2g} = \frac{\left(65.0\,\text{m/s}\right)^2 \sin^2 35.0°}{2\left(9.80\,\text{m/s}^2\right)} = \boxed{70.9\,\text{m}}$$

58. Call the direction of the flow of the river the x direction, and the direction of Huck walking relative to the raft the y direction.



$$\vec{\mathbf{v}}_{\text{Huck rel. bank}} = \vec{\mathbf{v}}_{\text{Huck rel. raft}} + \vec{\mathbf{v}}_{\text{raft rel. bank}} = 0.70\hat{\mathbf{j}}\,\text{m/s} + 1.50\hat{\mathbf{i}}\,\text{m/s}$$

$$= \left(1.50\hat{\mathbf{i}} + 0.70\hat{\mathbf{j}}\right)\text{m/s}$$

Magnitude: $v_{\text{Huck rel. bank}} = \sqrt{1.50^2 + 0.70^2} = \boxed{1.66\,\text{m/s}}$

Direction: $\theta = \tan^{-1}\dfrac{0.70}{1.50} = \boxed{25°\text{relative to river}}$

61. The lifeguard will be carried downstream at the same rate as the child. Thus only the horizontal motion need be considered. To cover 45 meters horizontally at a rate of 2 m/s takes $\dfrac{45\,\text{m}}{2\,\text{m/s}} = 22.5\,\text{s} \approx \boxed{23\,\text{s}}$ for the lifeguard to reach the child. During this time they would both be moving downstream at 1.0 m/s, and so would travel $(1.0\,\text{m/s})(22.5\,\text{s}) = 22.5\text{m} \approx \boxed{23\,\text{m}}$ downstream.

63. (*a*) Call the upward direction positive for the vertical motion. Then the velocity of the ball relative to a person on the ground is the vector sum of the horizontal and vertical motions. The horizontal velocity is $v_x = 10.0\,\text{m/s}$ and the vertical velocity is $v_y = 5.0\,\text{m/s}$.

$$\vec{\mathbf{v}} = 10.0\,\text{m/s}\,\hat{\mathbf{i}} + 5.0\,\text{m/s}\,\hat{\mathbf{j}} \;\rightarrow\; v = \sqrt{(10.0\,\text{m/s})^2 + (5.0\,\text{m/s})^2} = \boxed{11.2\,\text{m/s}}$$

$$\theta = \tan^{-1}\frac{5.0\,\text{m/s}}{10.0\,\text{m/s}} = \boxed{27°\text{ above the horizontal}}$$

(*b*) The only change is the initial vertical velocity, and so $v_y = -5.0\,\text{m/s}$.

$$\vec{\mathbf{v}} = 10.0\,\text{m/s}\,\hat{\mathbf{i}} - 5.0\,\text{m/s}\,\hat{\mathbf{j}} \;\rightarrow\; v = \sqrt{(10.0\,\text{m/s})^2 + (-5.0\,\text{m/s})^2} = \boxed{11.2\,\text{m/s}}$$

$$\theta = \tan^{-1}\frac{-5.0\,\text{m/s}}{10.0\,\text{m/s}} = \boxed{27°\text{ below the horizontal}}$$

93. Find the time of flight from the vertical data, using Eq. 2-12b. Call the floor the $y = 0$ location, and choose upwards as positive.

$$y = y_0 + v_{0y}t + \tfrac{1}{2}a_y t^2 \quad \rightarrow \quad 3.05\,\text{m} = 2.4\,\text{m} + (12\,\text{m/s})\sin 35^\circ t + \tfrac{1}{2}(-9.80\,\text{m/s}^2)t^2$$

$$4.90t^2 - 6.883t + 0.65\,\text{m} = 0 \quad \rightarrow$$

$$t = \frac{6.883 \pm \sqrt{6.883^2 - 4(4.90)(0.65)}}{2(4.90)} = 1.303\,\text{s},\ 0.102\,\text{s}$$

(*a*) Use the larger time for the time of flight. The shorter time is the time for the ball to rise to the basket height on the way up, while the longer time is the time for the ball to be at the basket height on the way down.

$$x = v_x t = v_0(\cos 35^\circ)t = (12\,\text{m/s})(\cos 35^\circ)(1.303\,\text{s}) = 12.81\,\text{m} \approx \boxed{13\,\text{m}}$$

(*b*) The angle to the horizontal is determined by the components of the velocity.

$$v_x = v_0 \cos\theta_0 = 12\cos 35^\circ = 9.830\,\text{m/s}$$

$$v_y = v_{y0} + at = v_0\sin\theta_0 - gt = 12\sin 35^\circ - 9.80(1.303) = -5.886\,\text{m/s}$$

$$\theta = \tan^{-1}\frac{v_y}{v_x} = \tan^{-1}\frac{-5.886}{9.830} = -30.9^\circ \approx \boxed{-31^\circ}$$

The negative angle means it is below the horizontal.