33. The ground speed is the magnitude of the horizontal component of velocity.
$v_g = (120 \text{ mi/h}) \cos 20° = \boxed{113 \text{ mi/h}}$.

$\boxed{36}$. (a) $A = \sqrt{A_x^2 + A_y^2}$ and $\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$. If A_x and A_y doubles,

$$A' = \sqrt{(2A_x)^2 + (2A_y)^2} = \sqrt{4(A_x)^2 + 4(A_y)^2} = 2\sqrt{A_x^2 + A_y^2} = 2A,$$

$$\theta' = \tan^{-1}\left(\frac{2A_y}{2A_x}\right) = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \theta.$$

So the answer is $\boxed{\text{(1) vector's magnitude doubles, but direction remains unchanged}}$.

(b) The magnitude triples, but the direction remains unchanged. So it is $\boxed{30 \text{ m at } 45°}$.

$\boxed{40}$. $A_x = 5.0$ m/s, $A_y = 0$.
$B_x = (10 \text{ m/s}) \cos 60° = 5.0$ m/s, $B_y = (10.0 \text{ m/s}) \sin 60° = 8.66$ m/s.
$C_x = -(15 \text{ m/s}) \cos 30° = -13.0$ m/s, $C_y = (15 \text{ m/s}) \sin 30° = 7.5$ m/s.
$(A + B + C)_x = 5.0 \text{ m/s} + 5.0 \text{ m/s} + (-13.0 \text{ m/s}) = -3.0$ m/s,
$(A + B + C)_y = 0 + 8.66 \text{ m/s} + 7.5 \text{ m/s} = 16$ m/s.

$$A + B + C = \sqrt{(-3.0 \text{ m/s})^2 + (16 \text{ m/s})^2} = \boxed{16 \text{ m/s}},$$

$$\theta = \tan^{-1}\left(\frac{16 \text{ m/s}}{3.0 \text{ m/s}}\right) = \boxed{79° \text{ above the } -x\text{-axis}}.$$

41. From Exercise 3.40:
$(A - B - C)_x = 5.0 \text{ m/s} - 5.0 \text{ m/s} - (-13.0 \text{ m/s}) = 13$ m/s,
$(A - B - C)_y = 0 - 8.66 \text{ m/s} - 7.5 \text{ m/s} = -16$ m/s.

So $A - B - C = \sqrt{(13 \text{ m/s})^2 + (-16 \text{ m/s})^2} = \boxed{21 \text{ m/s}}$,

$$\theta = \tan^{-1}\left(\frac{16 \text{ m/s}}{13 \text{ m/s}}\right) = \boxed{51° \text{ below the } +x\text{-axis}}$$

52. (a) Since $F_{2x} = F_{1x}$, or $F_2 \cos 45° = F_1 \cos 45°$. The answer is $\boxed{(2)\ F_2 = F_1}$.
(b) $F_{1y} + F_{2y} = F_1 \sin 45° + F_2 \sin 45° = 2F_1 \sin 45° = 2(100 \text{ N}) \sin 45° = 141$ N.
$\Sigma F_y = 141 \text{ N} - 100 \text{ N} - F_3 = 0$. So $F_3 = \boxed{41 \text{ N down}}$

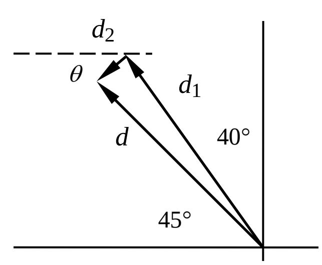
$\boxed{53}$. (a) $(10.5 \text{ m}) \cos 45° = 7.42$ m, $(10.5 \text{ m}) \cos 40° = 8.04$ m, $(10.5 \text{ m}) \sin 40° = 6.75$ m.

The desired displacement is $\vec{\mathbf{d}} = (-7.42 \text{ m})\,\hat{\mathbf{x}} + (7.42 \text{ m})\,\hat{\mathbf{y}}$.
The first shot is $\vec{\mathbf{d}}_1 = (-6.75 \text{ m})\,\hat{\mathbf{x}} + (8.04 \text{ m})\,\hat{\mathbf{y}}$.
The second shot should be $\vec{\mathbf{d}}_2 = \vec{\mathbf{d}} - \vec{\mathbf{d}}_1 = (-0.67 \text{ m})\,\hat{\mathbf{x}} + (-0.62 \text{ m})\,\hat{\mathbf{y}}$.

$$\theta = \tan^{-1}\left(\frac{0.62}{0.67}\right) = \boxed{42.8° \text{ south of west}}$$

(b) $d_2 = \sqrt{(-0.67 \text{ m})^2 + (-0.62 \text{ m})^2} = \boxed{0.91 \text{ m}}$.

(c) The reason is due to the fact that the ball $\boxed{\text{might travel in a curve}}$.



62. Given: $v_{xo} = 1.5 \times 10^6$ m/s, $v_{yo} = 0$, $x = 0.35$ m. Find: y. (Take both x_o and y_o as 0.)
First find the time of flight from the horizontal motion.

$x = x_o + v_{xo}\,t$, ☞ $t = \dfrac{x}{v_{xo}} = \dfrac{0.35\text{ m}}{1.5 \times 10^6\text{ m/s}} = 2.33 \times 10^{-7}$ s.

$y = y_o + v_{yo}\,t - \frac{1}{2}gt^2 = 0 + 0 - (4.9\text{ m/s}^2)(2.33 \times 10^{-7}\text{ s})^2 = -2.7 \times 10^{-13}$ m.

So it falls $\boxed{2.7 \times 10^{-13}\text{ m}}$. This is a very small distance. Therefore the answer is $\boxed{\text{no}}$, the designer need not worry about gravitational effects.

$\boxed{67}$. (a) $\boxed{\text{(2) Ball B collides with ball A}}$ because they have the same horizontal velocity.

(b) $y = y_o + v_{yo}\,t - \frac{1}{2}gt^2 = 0 - \frac{1}{2}gt^2$, ☞ $t = \sqrt{-\dfrac{2\,y}{g}} = \sqrt{-\dfrac{2(-1.00\text{ m})}{9.80\text{ m/s}^2}} = 0.452$ s. (Take y_o as 0.)

$x = x_o + v_{xo}\,t = 0 + (0.25\text{ m/s})(0.452\text{ s}) = \boxed{0.11\text{ m}}$ for both. (Take both x_o as 0.)

70. $v_{xo} = v_o \cos\theta = (15.0\text{ m/s}) \cos 15.0° = 14.5$ m/s,
$v_{yo} = v_o \sin\theta = (15.0\text{ m/s}) \sin 15.0° = 3.88$ m/s.
(Take both x_o and y_o as 0.)

(a) At maximum height, $v_y = 0$. $v_y^2 = v_{yo}^2 - 2g(y - y_o)$, ☞ $y = \dfrac{(3.88\text{ m/s})^2}{2(9.80\text{ m/s}^2)} = \boxed{0.768\text{ m}}$.

(b) At impact, $y = 0$. $y = y_o + v_{yo}\,t - \frac{1}{2}gt^2$, ☞ $t = \dfrac{5.176\text{ m/s}}{\frac{1}{2}(9.80\text{ m/s}^2)} = 0.792$ s.

So $R = x = x_o + v_{xo}\,t = 0 + (14.5\text{ m/s})(0.792\text{ s}) = \boxed{11.5\text{ m}}$.

(c) Kick the ball harder to $\boxed{\text{increase } v_o \text{ and/or increase the angle}}$ so it is as close to 45° as possible.

76. At the maximum height, $y = R/2$ and $v_y = 0$. (Take $y_o = 0$.)

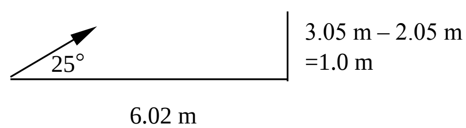
Use the result from Exercise 3.71, $R = \dfrac{v_o^2 \sin 2\theta}{g}$.

$v_y^2 = v_{yo}^2 - 2gy$, ☞ $0 = v_o^2 \sin^2\theta - 2gy_{max} = v_o^2 \sin^2\theta - 2g\dfrac{v_o^2 \sin 2\theta}{g} = v_o^2 \sin^2\theta - v_o^2 \sin 2\theta$.

So $v_o^2 \sin^2\theta = v_o^2 \sin 2\theta$ or $\sin^2\theta = 2 \sin\theta \cos\theta$.

Therefore $\sin\theta = 2\cos\theta$ or $\tan\theta = 2$. Thus $\theta = \boxed{63°}$.

84. (Take both x_o and y_o as 0.)



$x = x_o + v_{xo}\,t = (v_o \cos\theta)t$, ☞ $t = \dfrac{x}{v_{xo}} = \dfrac{x}{v_o \cos\theta}$,

$y = y_o + v_{yo}\,t - \frac{1}{2}gt^2 = v_o \sin\theta \times \dfrac{x}{v_o \cos\theta} - \frac{1}{2}g\left(\dfrac{x}{v_o \cos\theta}\right)^2 = x$

$\tan\theta - \dfrac{gx^2}{2v_o^2 \cos^2\theta}$.

So $v_o = \dfrac{x}{\cos\theta}\sqrt{\dfrac{g}{2(x\tan\theta - y)}} = \dfrac{6.02\text{ m}}{\cos 25°}\sqrt{\dfrac{9.80\text{ m/s}^2}{2[(6.02\text{ m}) \tan 25° - 1.0\text{ m}]}} = \boxed{10.9\text{ m/s}}$.

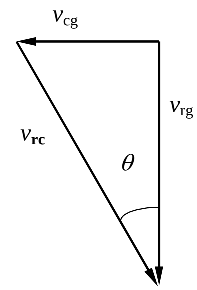
98. Use the following subscripts: b = boat, c = current, and w = water.
Upstream: $v_{bc} = 7.5$ m/s, $v_{cw} = -5.0$ m/s.
$v_{bw} = v_{bc} + v_{cw} = 7.5\text{ m/s} + (-5.0\text{ m/s}) = 2.5$ m/s.

So $t_{up} = \dfrac{500\text{ m}}{2.5\text{ m/s}} = 200$ s.

Downstream: $v_{bc} = 7.5$ m/s, $v_{cw} = 5.0$ m/s. $v_{bw} = v_{bc} + v_{cw} = 7.5\text{ m/s} + 5.0\text{ m/s} = 12.5$ m/s.

So $t_{down} = \dfrac{500\text{ m}}{12.5\text{ m/s}} = 40$ s.

Therefore $t = 200\text{ s} + 40\text{ s} = 240\text{ s} = \boxed{4.0\text{ min}}$.



102. (a) The relative velocity of the rain to that of the car is $\vec{\mathbf{v}}_{rc} = \vec{\mathbf{v}}_{rg} - \vec{\mathbf{v}}_{cg}$, where the subscripts r, c, and g stand for rain, car, and ground, respectively, and the symbol $\vec{\mathbf{v}}_{cg}$ denotes the relative velocity of the car to the ground, etc. It is clear in the vector diagram that $\mathbf{v}_{rc}$ is not vertical, but at an angle.

Since $\tan\theta = v_{cg}/v_{rg}$, the angle θ $\boxed{\text{also increases}}$ as the velocity of the car increases.

(b) $v_{cg} = v_{rg}\tan\theta = (10\text{ m/s})\tan 25° = \boxed{4.7\text{ m/s}}$.

111. (a) 6000 km/h = 167 m/s.
$v_{xo} = v_o\cos 75° = (166.7\text{ m/s})\cos 75° = 43.1\text{ m/s}$, $v_{yo} = v_o\sin 75° = (166.7\text{ m/s})\sin 75° = 161\text{ m/s}$.
$y = y_o + v_{yo}t - \frac{1}{2}gt^2$, ☞ $500\text{ m} = 4000\text{ m} + (161\text{ m/s})\,t - (4.90\text{ m/s}^2)\,t^2$.

Reducing to quadratic equation $4.9\,t^2 - 161\,t - 3500 = 0$.

Solving, $t = \boxed{47.8\text{ s}}$ and -14.9 s.

(b) At the maximum height $v_y = 0$.

$v_y^2 = v_{yo}^2 - 2g(y - y_o)$, ☞ $y = y_{max} = y_o + \dfrac{v_{yo}^2}{2g} = 4000\text{ m} + \dfrac{(161\text{ m/s})^2}{2(9.80\text{ m/s}^2)} = \boxed{5.32\times10^3\text{ m}}$.

(c) $v_x = v_{xo} = 43.1$ m/s,
$v_y = v_{yo} - gt = 161\text{ m/s} - (9.80\text{ m/s}^2)(47.8\text{ s}) = -307\text{ m/s}$.
So $v_y = \sqrt{(43.1\text{ m/s})^2 + (-307\text{ m/s})^2} = \boxed{310\text{ m/s}}$.

112. $\vec{\mathbf{v}}_A = (35\text{ m/s})\,\hat{\mathbf{x}}$,
$\vec{\mathbf{v}}_B = [(30\text{ m/s})\cos 10°]\,\hat{\mathbf{x}} + [(30\text{ m/s})\sin 10°]\,\hat{\mathbf{y}} = (29.5\text{ m/s})\,\hat{\mathbf{x}} + (5.21\text{ m/s})\,\hat{\mathbf{y}}$.
The velocity of car B relative to car A is
$\vec{\mathbf{v}}_B - \vec{\mathbf{v}}_A = (29.5\text{ m/s} - 35\text{ m/s})\,\hat{\mathbf{x}} + (5.21\text{ m/s})\,\hat{\mathbf{y}} = \boxed{(-5.5\text{ m/s})\,\hat{\mathbf{x}} + (5.2\text{ m/s})\,\hat{\mathbf{y}}}$.

(b) Time for car A to get to point ⊗: $t_A = \dfrac{d_A}{v_A} = \dfrac{350\text{ m}}{35\text{ m/s}} = 10\text{ s}$.

During that time car B will travel a distance of $d_B = v_B\,t = (30\text{ m/s})(10\text{ s}) = 300\text{ m}$.
Since the angled ramp is longer than the straight ramp, car B will not be at point ⊗ when car A is there.
Therefore they do *not* collide at point ⊗.

(c) The length of the 10° ramp is $d_B = \dfrac{350\text{ m}}{\cos 10°} = 355\text{ m}$.

So the time for car B to reach point ⊗ is $t_B = \dfrac{d_B}{v_B} = \dfrac{355\text{ m}}{30\text{ m/s}} = 11.8\text{ s}$.

During the 11.8 s, car A will travel a total distance of $(35\text{ m/s})(11.8\text{ s}) = 413\text{ m}$.
Therefore, when car B reaches point ⊗, car A will travel an extra distance of 413 m – 350 m = 63 m.
Thus, there is no collision.

Thus car A is $\boxed{63\text{ m}}$ ahead.