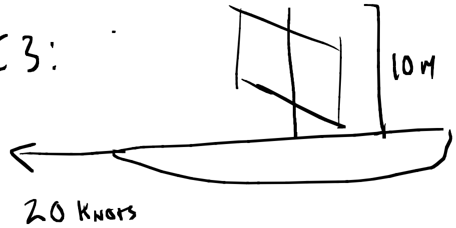
Homework 3 - Solutions

Note Title 1/3/2006

C3:



$$\frac{20 \text{ KNOTS}}{} \left| \frac{.514\ m/s}{\text{KNOT}} \right| = 10.3\ m/s$$

UNDER GRAVITY, IT TAKES

$x = 10 - gt^2 = 0$

$t = 1,\ g \sim 10\ m/s^2$

1 SECOND TO HIT THE DECK.

THE DECK MOVES ACCORDING TO

$x = v_0 t = (1s) \cdot (10.3\ m/s)$

$= 10.3\ m.$

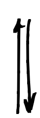
THE WRENCH HITS THE DECK AT 10.3 METERS FROM THE POLE.

C12) A CHANGE IN DIRECTION IS A CHANGE IN VELOCITY.

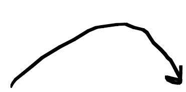
THE CORRECT STATEMENT IS

"THE RACING CAR ROUNDS THE CORNER AT A CONSTANT SPEED OF 90 mph".

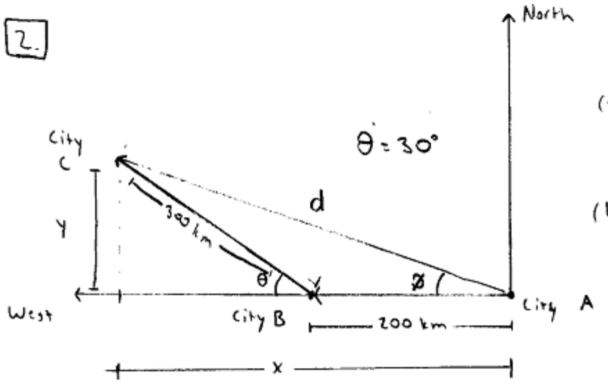
C19) a.) STRAIGHT UP.



b.) NOT STRAIGHT UP



2.



(a) In a straight line distance, what is the distance from A to C?

(b) Relative to A, what direction is C?

(a) We construct a right triangle, and can see that the distance from A to C, let's call it d, satisfies the relation

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

$x =$ (distance from A to B) + (horizontal component of distance from B to C)

$= (200\,km) + (300\,km)\cos\theta = 200\,km + 260\,km = 460\,km$

$y =$ (vertical component of distance from B to C)

$= (300\,km)\sin\theta = 150\,km$

then $d^2 = (460\,km)^2 + (150\,km)^2 = 234100\,km^2 \Rightarrow \boxed{d = 484\,km}$

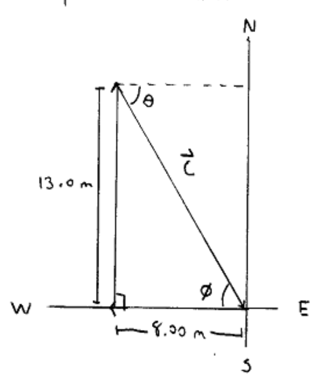
(b) We can specify the direction of C relative to A by the angle ϕ.

Notice $\tan\phi = \dfrac{y}{x} \Rightarrow \phi = \tan^{-1}\left(\dfrac{y}{x}\right) = \tan^{-1}\left(\dfrac{150}{460}\right) = 18.1°$

the we see that City C is 18.1° north of west relative to City A.

(2)

3. The "graphical method" just means that we're going to draw a scaled picture of the situation.



By making measurements on the picture, we can see that

$|\vec{c}|$ is about 15 m, and $\theta \approx 58°$ south of east

However, we can also solve this situation algebraically. The motion of the man gives us that

$$|\vec{c}|^2 = (13.0\,m)^2 + (8.00\,m)^2 = 233\,m^2 \Rightarrow \boxed{|\vec{c}| \approx 15.3\,m \approx 15\,m}$$

furthermore, basic geometry tells us that $\theta = \phi$

Then

$$\tan\phi = \left(\frac{13.0\,m}{8.00\,m}\right) \Rightarrow \theta = \phi = \tan^{-1}\left(\frac{13.0\,m}{8.00\,m}\right) = \boxed{58.4° \text{ south of east} = \theta}$$

3.12 $+x = \text{eastward}$, $+y = \text{northward}$

$$\Sigma x = 250 \text{ m} + (125 \text{ m})\cos 30.0° = 358 \text{ m}$$

$$\Sigma y = 75.0 \text{ m} + (125 \text{ m})\sin 30.0° - 150 \text{ m} = -12.5 \text{ m}$$

$$d = \sqrt{(\Sigma x)^2 + (\Sigma y)^2} = \sqrt{(358 \text{ m})^2 + (-12.5 \text{ m})^2} = 358 \text{ m}$$

$$\theta = \tan^{-1}\left(\frac{\Sigma y}{\Sigma x}\right) = \tan^{-1}\left(-\frac{12.5}{358}\right) = -2.00° \quad \boxed{d = 358 \text{ m at } 2.00° \text{ S of E}}$$

3.15 After 3.00 h moving at 41.0 km/h, the hurricane is 123 km at 60.0° N of W from the island. In the next 1.50 h, it travels 37.5 km due north. The components of these two displacements are:

Displacement	x-component (eastward)	y-component (northward)
123 km	-61.5 km	+107 km
37.5 km	0	+37.5 km
Resultant	-61.5 km	144 km

Therefore, the eye of the hurricane is now

$$R = \sqrt{(-61.5 \text{ km})^2 + (144 \text{ km})^2} = \boxed{157 \text{ km from the island}}.$$

3.18 (a) $F_1 = 120 \text{ N}$ $\quad F_{1x} = 60.0 \text{ N}$ $\quad F_{1y} = 104 \text{ N}$

$F_2 = 80.0 \text{ N}$ $\quad F_{2x} = -20.7 \text{ N}$ $\quad F_{2y} = 77.3 \text{ N}$

$$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(39.3 \text{ N})^2 + (181 \text{ N})^2} = 185 \text{ N}$$

and $\theta = \tan^{-1}\left(\frac{181 \text{ N}}{39.3 \text{ N}}\right) = \tan^{-1}(4.61) = 77.8°$

The resultant is $\mathbf{R} = \boxed{185 \text{ N at } 77.8° \text{ from the x-axis}}$.

(b) To have zero net force on the mule, the resultant above must be cancelled by a force equal in magnitude and oppositely directed. Thus, the required force is $\boxed{185 \text{ N at } 258° \text{ from the x-axis}}$.

3.23 The constant horizontal speed of the falcon is

$$v_x = 200 \frac{\text{mi}}{\text{h}}\left(\frac{0.447 \text{ m/s}}{1 \text{ mi/h}}\right) = 89.4 \text{ m/s}.$$

The time required to travel 100 m horizontally is $t = \frac{\Delta x}{v_x} = \frac{100 \text{ m}}{89.4 \text{ m/s}} = 1.12 \text{ s}$. The vertical displacement during this time is

$$\Delta y = v_{iy}t + \frac{1}{2}a_y t^2 = 0 + \frac{1}{2}(-9.80 \text{ m/s}^2)(1.12 \text{ s})^2 = -6.13 \text{ m},$$

or the falcon has a vertical fall of $\boxed{6.13 \text{ m}}$.

3.25 At the maximum height $v_y = 0$, and the time to reach this height is found from

$v_y = v_{iy} + a_y t$ as $t = \dfrac{v_y - v_{iy}}{a_y} = \dfrac{0 - v_{iy}}{-g} = \dfrac{v_{iy}}{g}$.

The vertical displacement that has occurred during this time is

$$(\Delta y)_{max} = \bar{v}_y t = \left(\frac{v_y + v_{iy}}{2}\right)t = \left(\frac{0 + v_{iy}}{2}\right)\left(\frac{v_{iy}}{g}\right) = \frac{v_{iy}^2}{2g}.$$

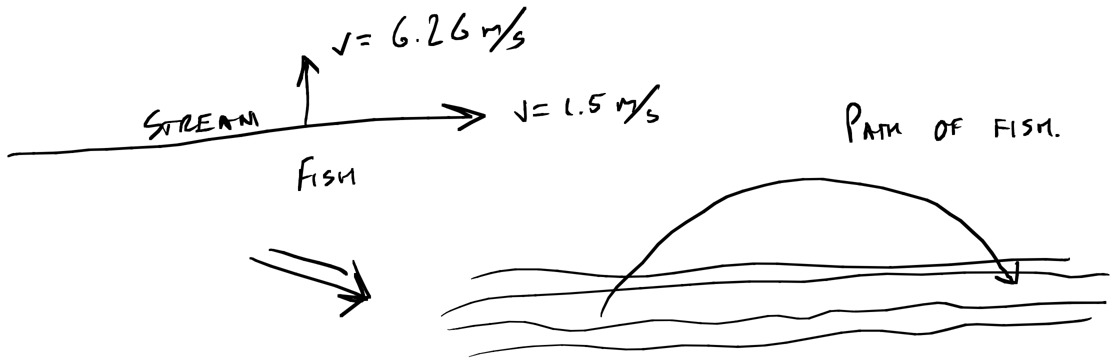
Thus, if $(\Delta y)_{max} = 12\text{ ft}\left(\dfrac{1\text{ m}}{3.281\text{ ft}}\right) = 3.7\text{ m}$, then

$$v_{iy} = \sqrt{2g(\Delta y)_{max}} = \sqrt{2(9.80\text{ m/s}^2)(3.7\text{ m})} = 8.5\text{ m/s},$$

and if the angle of projection is $\theta = 45°$, the launch speed is

$$v_i = \frac{v_{iy}}{\sin\theta} = \frac{8.5\text{ m/s}}{\sin 45°} = \boxed{12\text{ m/s}}.$$

3.37)



BECAUSE WE ALREADY HAVE THE COMPONENTS OF THE VELOCITY, WE DON'T HAVE TO WORRY ABOUT 2-D MOTION. ON THE Y-AXIS,

$$V_y = V_{oy} + a_y t \qquad (3.12a)$$

AT MAX. HEIGHT, $V_y = 0$

$$0 = 6.26\text{ m/s} - 9.8\text{ m/s}^2\,(t)$$

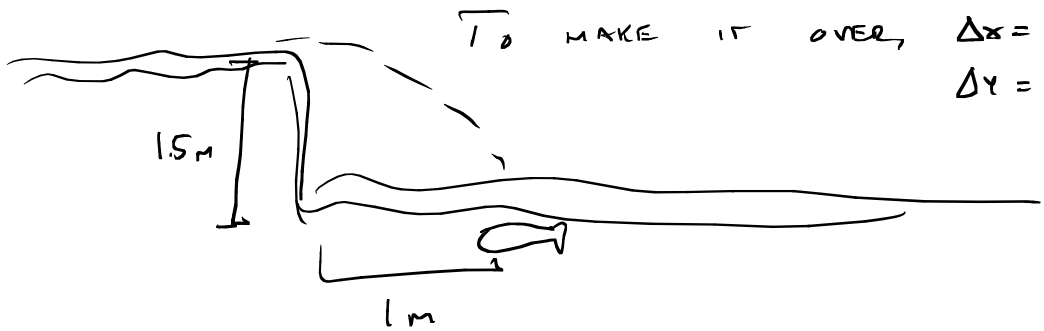
SOLVING FOR t,

$$t = .63 \text{ SECONDS.}$$

THE MAX. HEIGHT IS THEN

$$\Delta Y = 6.26\text{ m/s}\cdot(.635) - \tfrac{1}{2}(9.8)(.635)^2 = 1.99 \rightarrow 2.0\text{ m.}$$

40.)



To make it over, $\Delta x = 1\,m$
$\Delta y = 1.5\,m$.

(3.11b)

$\Delta x = V_{ox} t$

t is the time it takes the fish to reach the top of the trajectory.

$$0 = V_{oy} - gt \qquad t = \frac{V_{oy}}{g}$$

Thus,

$$\Delta x = 1\,m = \frac{V_{ox} V_{oy}}{g}.$$

$$\Delta y = V_{oy} t - \frac{1}{2} g t^2 \implies \frac{V_{oy}^2}{g} - \frac{1}{2} g \left(\frac{V_{oy}^2}{g^2}\right) = \frac{V_{oy}^2}{2g}$$

$$1.5\,m = \frac{V_{oy}^2}{2g}$$

Solving, $V_{oy} = 5.42\,m/s$ $\qquad 1\,m = \dfrac{V_{ox}(5.42\,m/s)}{9.8\,m/s}$

$V_{ox} = 1.4\,m/s$

Summing the vectors,

$\vec{V} = 5.7\,m/s$. The fish can make the jump.