Practice Problems for Exam 1

Displacement and Distance

1. While standing in your backyard, you notice an injured bird 13 m directly north of you. You run over and pick it up and then run directly south 22 meters to your house to take care of the bird. What is your total distance traveled? Your total displacement?

2. You're driving an old truck along a straight road north for 6 km at 60 km/hr at which point the truck runs out of gas and stops. You get out of the truck and walk due east to a gas station 8 km away to buy gas for the truck. What is your overall displacement from the beginning of the drive to your arrival at the gas station?

Velocity and Speed

1. What is the average speed of a sprinter who runs the 100-m dash in 10 seconds? What would be the time for 1500 m at this pace?

2. At an average speed of 15 km/hr, how many meters will a bicyclist travel in 5 hours?

3. The distance from San Francisco to Los Angeles is 600 km. How fast in km/hr must you drive to make the trip in 6 hours? (Assume you drive in a straight line.)

4. If you are driving 90 km/hr and you look to the side for 2.0 s, how many meters do you travel during this inattentive period?

5. You plan on driving from your home to a friend's house 15 km away, however you forget exactly where your friend lives and travel 5 km past your destination. You turn around and travel back the way you came to arrive at your friend's house. Your total travel time is 30 minutes.

   a. What is your average speed?

   b. What is your average velocity?

Acceleration

1. What is the acceleration of a car that travels on a straight road from 0 to +24 m/s (approximately 50 miles/hr) in 8 seconds?

2. A car traveling at +15 m/s comes to a complete stop in 5 seconds. What was its constant acceleration while braking?

3. A chipmunk, starting from rest, begins sprinting across a grassy lawn with an acceleration of +1.5 m/s^2. How long will it take the chipmunk to travel 30 meters?

4. A horse accelerates at a rate of +3 m/s^2. What will be its velocity after 3 seconds if it starts from rest? How far will it have traveled?

5. A stone is dropped from a cliff and is seen to hit the ground 5 seconds later. How high was the cliff?

6. For how long does an object dropped from a high tower have to fall before it reaches a speed of 25 m/s?

2-D Motion

1. You want to throw a ball horizontally out of an apartment window 80 m above the ground and get it into a swimming pool that is 20 m out from the bottom of the apartment. How fast do you have to throw it to reach the edge of the pool closest to you?

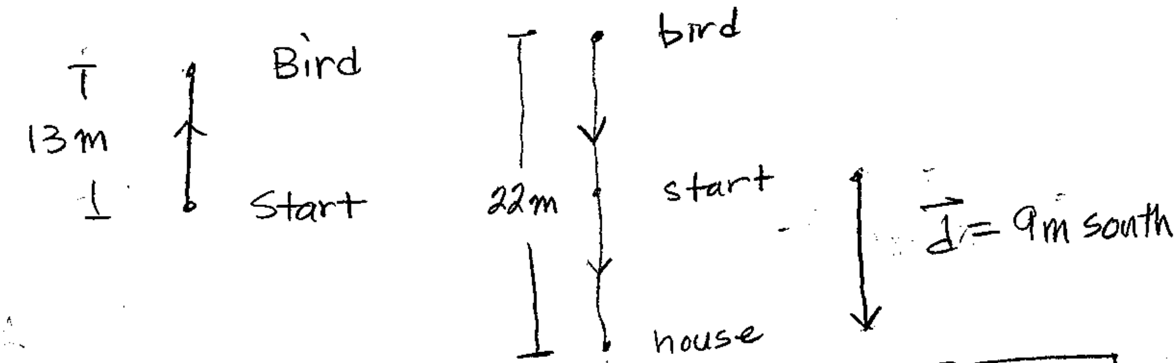
2. Calculate a person's "hang-time" if he moves horizontally 3 m during a 1.25 m high jump (assume that the person is inflexible). How would it change if he moves 6 m during the jump?

3. A boy in a tree with a slingshot fires a stone horizontally at a bird 10 m away. He is disappointed to find that the stone misses, 2.5 m below the bird. How fast does his slingshot fire the stone?

Solutions

Displacement and Distance

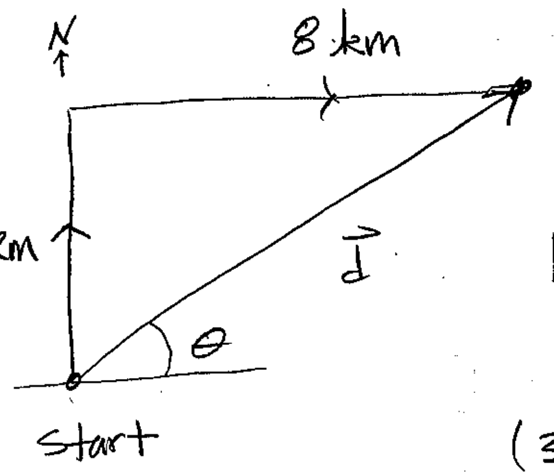
1.



The total distance is $\boxed{\Delta d = 13\text{m} + 22\text{m} = 35\text{m}}$

The total displacement is $\boxed{\vec{d} = 9\text{m south}}$

2.



$$|\vec{d}| = \sqrt{6^2 + 8^2}\ \text{km} = 10\text{km}$$

$$\theta = \tan^{-1}\left(\frac{6}{8}\right) = 36.9^\circ$$

(3-4-5 triangle)

We must specify the direction. $\vec{d}$ makes an angle of 36.9° North of East or, equivalenty, $\vec{d}$ makes angle of 53.1° East of North. Either answer is correct.

Solutions

Velocity and Speed

1. $v = \frac{\Delta d}{\Delta t} = \frac{100\,m}{10\,s} = \boxed{10\,\frac{m}{s}}$

At the same pace, it would take

$$\Delta t = \frac{1500\,m}{10\,\frac{m}{s}} = \boxed{150\,s}$$

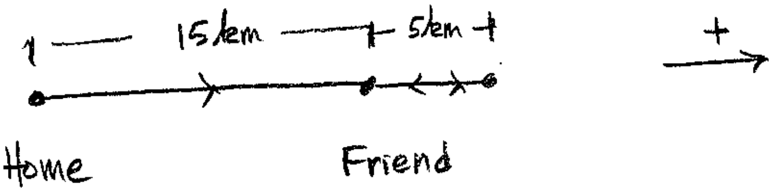
to run 1500 m.

2. $\Delta d = v\,\Delta t = 15\,\frac{km}{hr} \cdot 5\,hr = \boxed{75\,km}$

3. $v = \frac{\Delta d}{\Delta t} = \frac{600\,km}{6\,hr} = \boxed{100\,\frac{km}{hr}}$

4. $\Delta d = v\,\Delta t = 90\,\frac{km}{hr} \cdot 2.0\,s \cdot \frac{1\,hr}{3600\,s} \cdot \frac{1000\,m}{1\,km} = \boxed{50\,m}$

5.



a) $v = \frac{\Delta d}{\Delta t} = \frac{(15+5+5)\,km}{30\,min} \cdot \frac{60\,min}{1\,hr} = \boxed{50\,\frac{km}{hr}}$

b) $\vec{v} = \frac{\vec{d}}{\Delta t} = \frac{+15\,km}{30\,min} \cdot \frac{60\,min}{1\,hr} = \boxed{+30\,\frac{km}{hr}}$

(the direction is given by the sign
$+ = \rightarrow$
$- = \leftarrow$)

Solutions

Acceleration

1. $\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t} = \dfrac{+24\frac{m}{s} - 0}{8s} = \boxed{+3\frac{m}{s^2}}$

2. $\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t} = \dfrac{0 - (+15\frac{m}{s})}{5s} = \boxed{-3\frac{m}{s^2}}$

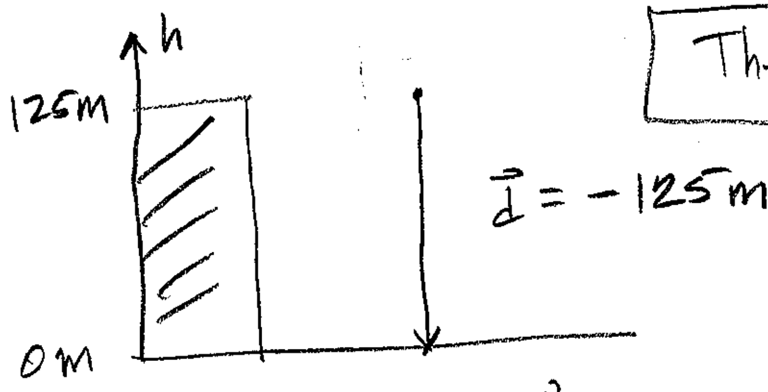
3. $\vec{d} = +30m = \cancel{\vec{v}_i}^{\,0} \Delta t + \dfrac{\vec{a}}{2}(\Delta t)^2 = \dfrac{+1.5\, m/s^2}{2}(\Delta t)^2$

$\Rightarrow (\Delta t)^2 = \dfrac{+30m}{+\frac{3}{4}\frac{m}{s^2}} = 40s^2 \Rightarrow \boxed{\begin{array}{l}\Delta t = \sqrt{40}\ s \\ \approx 6.32s\end{array}}$

4. $\vec{v}_f = \cancel{\vec{v}_i}^{\,0} + \vec{a}\Delta t = +3\frac{m}{s^2}\ 3s = \boxed{+9\frac{m}{s}}$

$\vec{d} = \cancel{\vec{v}_i}^{\,0}\Delta t + \dfrac{\vec{a}}{2}(\Delta t)^2 = +\dfrac{3}{2}\dfrac{m}{s^2}(3s)^2 = \boxed{+13.5\, m}$

5. $\vec{d} = \cancel{\vec{v}_i}^{\,0}\Delta t + \dfrac{\vec{a}}{2}(\Delta t)^2 = -\dfrac{10}{2}\dfrac{m}{s^2}(5s)^2 = -125m$



$\boxed{\text{The cliff is 125m high}}$

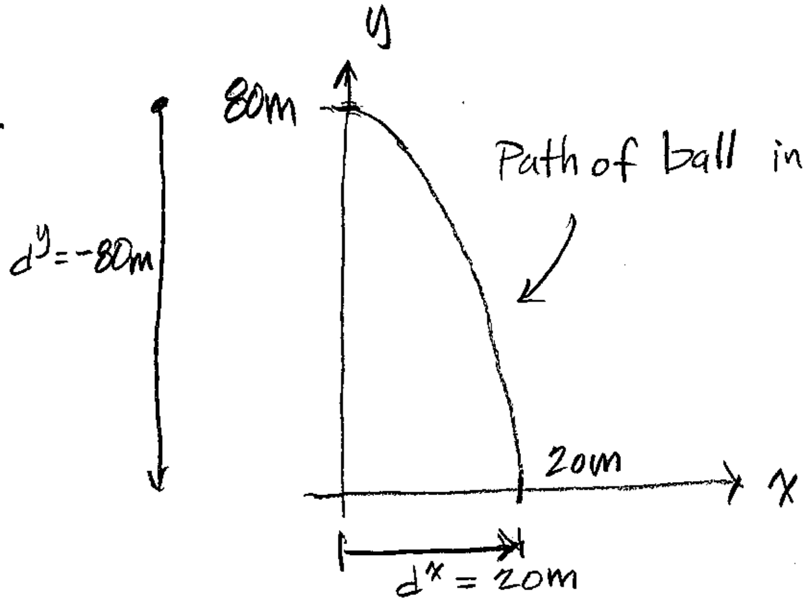
6. $\vec{v}_f = -25\frac{m}{s} = \cancel{\vec{v}_i}^{\,0} + \vec{a}\Delta t = -10\frac{m}{s^2}\Delta t$

$\Rightarrow \Delta t = \dfrac{-25\frac{m}{s}}{-10\frac{m}{s^2}} = \boxed{2.5s}$

Solutions

2-D Motion

1



$$\vec{d} = \vec{v}_i \Delta t + \frac{\vec{a}}{2}(\Delta t)^2 \Rightarrow \text{2 independent equations.}$$

x: $d^x = v_i^x \Delta t + \cancel{\frac{a^x}{2}}^{\,0} (\Delta t)^2 = v_i^x \Delta t = +20m$

y: $d^y = \cancel{v_i^y}^{\,0} \Delta t + \frac{a^y}{2}(\Delta t)^2 = \frac{-10}{2}\frac{m}{s^2}(\Delta t)^2 = -80m$

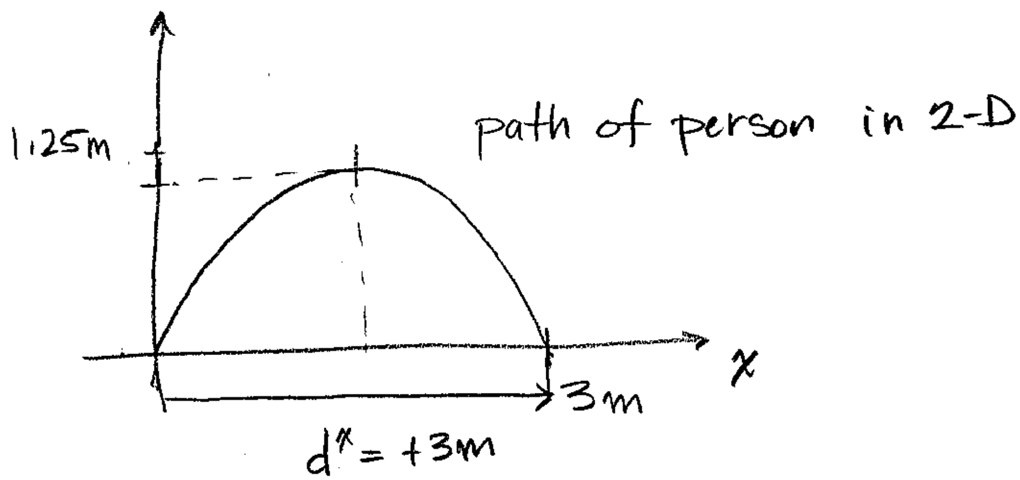
Two equations and two unknowns: v_i^x and Δt.

Solve for Δt first using the y equation

$$(\Delta t)^2 = \frac{-80m}{-5\frac{m}{s^2}} = 16s^2 \Rightarrow \boxed{\Delta t = 4s}$$

Now, plug $\Delta t = 4s$ into the x equation and solve for $v_i^x = \frac{+20m}{4s} = \boxed{+5\frac{m}{s}}$

2.



To find the time the person is in the air, we only need one equation: the y displacement equation. Since it takes just as much time to <u>rise</u> to 1.25m as it takes to <u>fall</u> to fall from 1.25 m, we'll find the time to <u>fall</u> and then multiply by 2 to get the total time in the air.

(y velocity is zero at peak)

$$d^y = -1.25m = \cancel{v_i^y}^{\,0} \Delta t_f + \frac{a^y}{2}(\Delta t_f)^2 = -\frac{10}{2}\frac{m}{s^2}(\Delta t_f)^2$$

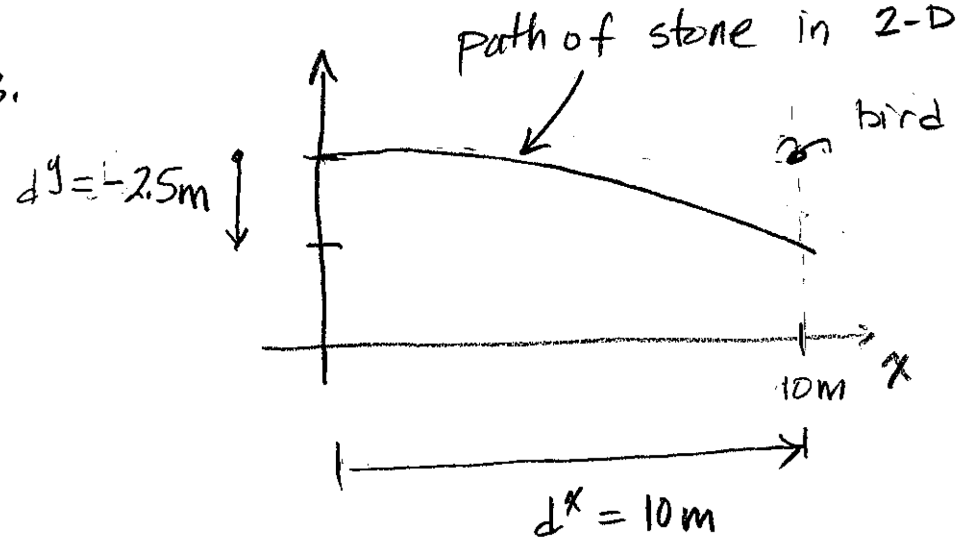
$$\Rightarrow (\Delta t_f)^2 = \frac{-1.25m}{-5\frac{m}{s^2}} = \frac{1}{4}s^2 \Rightarrow \boxed{\Delta t_f = \frac{1}{2}s}$$

so the total time in the air is $\Delta t = 2\Delta t_f$

$$\Delta t = 2 \cdot \frac{1}{2} s = \boxed{1s}$$

Note: This does not depend at all on the x displacement!

3.



$$d^x = 10\,m = v_i^x\,\Delta t + \frac{\cancel{a^x}^{\,0}}{2}(\Delta t)^2 = v_i^x\,\Delta t$$

$$d^y = -2.5m = \cancel{v_i^y}^{\,0}\,\Delta t + \frac{a^y}{2}(\Delta t)^2 = \frac{-10}{2}\frac{m}{s^2}(\Delta t)^2$$

Two equations and two unknowns, v_i^x and Δt.

Find Δt using the y equation:

$$(\Delta t)^2 = \frac{-2.5m}{-5\,\frac{m}{s^2}} = \frac{1}{2}s^2 \Rightarrow \boxed{\Delta t = \frac{1}{\sqrt{2}}\,s}$$

Now, plug $\Delta t = \frac{1}{\sqrt{2}}s$ into the x equation and

Solve for $v_i^x = \dfrac{10\,m}{\frac{1}{\sqrt{2}}\,s} = \sqrt{2}\cdot 10 s \cong \boxed{14.1\ s}$