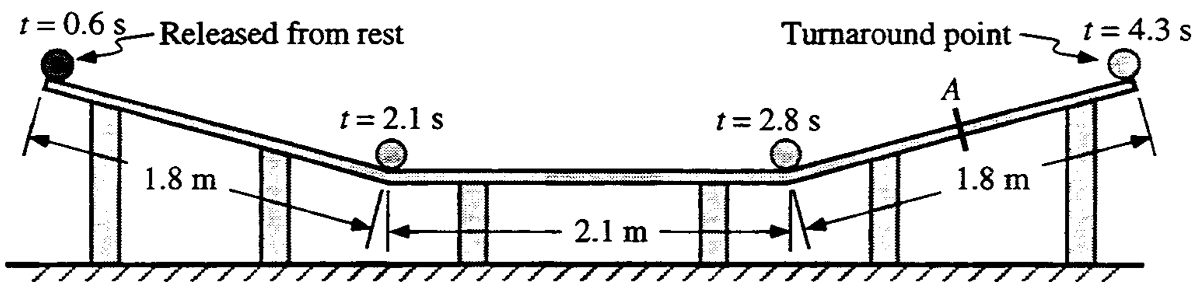
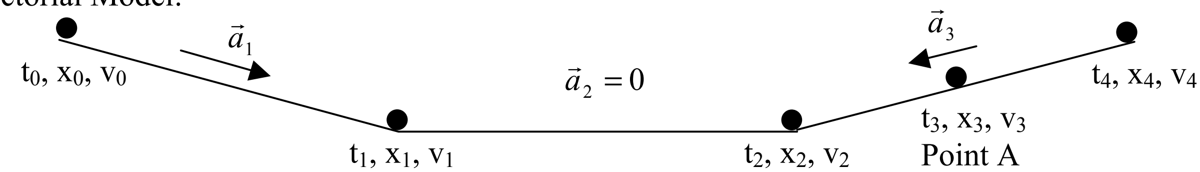
Physics 2048 Test 1 Dr. Jeff Saul
Fall 2001

Problem 1 (Short Answer: 20 points) Make a motion diagram and a pictorial model for the following problem, but DO NOT SOLVE IT

Find the velocity and acceleration of the ball at point A. Assume friction is negligible.



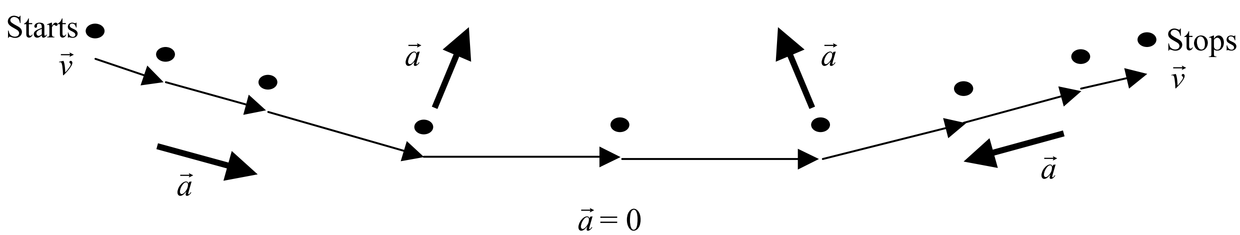
Pictorial Model:



Known values:
$t_0 = 0.6$ s $x_0 = 0$ m
$v_0 = v_4 = 0$ m/s
$t_1 = 2.1$ s $x_1 = 1.8$ m
$t_2 = 2.8$ s $x_2 = 2.1$ m
$v_1 = v_2 = v_{max}$
$t_4 = 4.3$ s $x_4 = 1.8$ m

Desired unknowns: v_3, a_3
Also need v_1

Motion Diagram:



Problem 2 (Estimation Problem: 15 points)

Estimate the weight of the air (in pounds) in our classroom. The density of air is 1.20 kg/m^3.

<u>*Given:*</u>

Density of air = 1.20 kg/m^3

<u>*Find:*</u>

The weight of the volume of the air in this room
Steps:
a. Find the volume of the room
b. Assuming entire volume of room is filled with air, multiply volume by density of air to find mass in kg
c. Convert to lbs.

<u>*Estimating the volume of the classroom:*</u>

- *Make use of the ceiling tiles which are 2' x 4' to determine the floor/ceiling area (this is a standard size that can help you determine room sizes in the future).*
  *Length of room L = (# of tile lengths * a tile length) = 9 lengths * 4 feet/length = 36 feet*
  *Width of room W = (# of tile widths * a tile width) = 15 widths * 2 feet/width = 30 feet*
- *The room is half again as tall as Dr. Saul who is 68 inches tall. So the room height H,*
  *H = 3/2 * 68 inches = 102 inches * 1 foot/12 inches = 8.5 feet (actual height 8 feet).*
- *Volume V = L * W * H = (36 feet) * (30 feet) * (8.5 feet) = 9,180 ft.^{3}*

  *Volume = 9,180 ft.^{3} * (12 inches/ft.)^3 * (2.54 cm/in)^3 * (1 m/ 100 cm)^3 = 260 m^3*

<u>*Determine the mass of the air*</u>

- *Density = mass/ volume => mass = density * volume*
  *m = (1.20 kg/m^3) * 260 m^3 = 312 kg*

<u>*Unit conversion*</u>

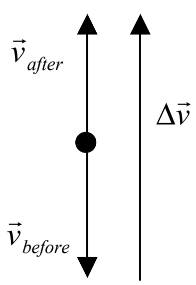
- *Weight = m * conversion = (312 kg) * (2.2 lb. / kg) = 700 lb (to 1 significant figure)*

Problem 3 (Essay 10 points)
You may use diagrams and equations but no calculations in your response for this problem.
USE WHAT YOU'VE LEARNED FROM CLASS SO FAR TO GIVE A CONVINCING EXPLANATION OF YOUR ANSWER.

Jay falls out of a tree and lands on a trampoline. The trampoline sags 3 feet before launching Jay back in the air. At the very bottom, where the sag is the greatest, is Jay's acceleration upward, downward, or zero.

When the trampoline's sag is a maximum, Jay's acceleration is upward.

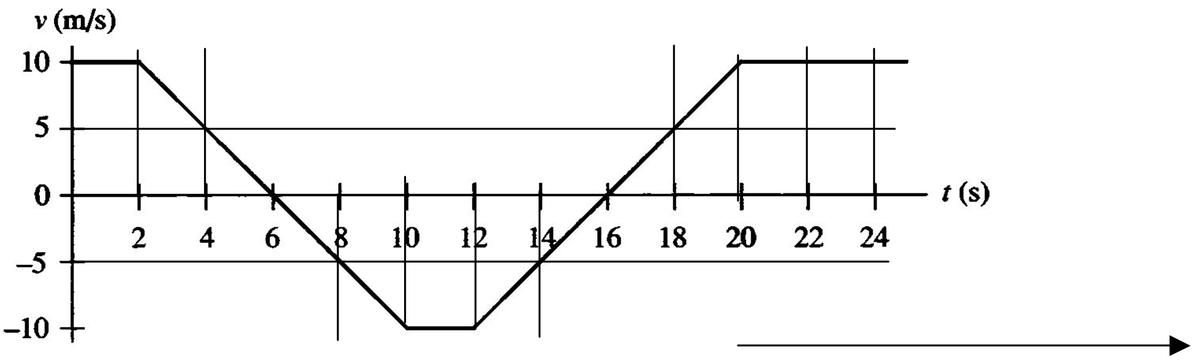
EXPLANATION: As Jay lands on the trampoline, the trampoline caused him to first slow down to a stop. Then the trampoline causes Jay to speed up as it throws him up in air. So right before Jay comes to a stop he is moving downward. Immediately afterward, he is moving upward. Thus the change in velocity and therefore the change in velocity and acceleration vectors point upward.Recall that the acceleration vector always points in the direction of the change in velocity vector.



In answering this question, it is important to consider the motion both before and after the point where the trampoline's sag is greatest, even though Jay's velocity is zero at that point. You need to do this to distinguish Jay's motion from an object coming to a stop and staying stopped. At the instant the object stops, v and a are both zero and the object stays stopped. For example, at the point where a car comes to a complete stop on level ground, velocity and acceleration are both zero. The car remains at rest until something causes it to accelerate.

Problem 4 (10 points)

The graph below is velocity verses time graph for a particle having an initial position $x_0 = x\ (t = 0) = 0$. At what time or times is the particle located at x = 35 m? Work directly from the graph, using the graphical relationship between velocity and position, and not from any kinematics formulas.



*Each box represents an area = 5 m/s * 2 s = 10 m => each box represents a displacement of 10 m*
At t = 0 the particle is at x = 0 m

Time interval	*# of boxes*	*Displacement*	*Position at the end of the time interval (**x = 35 m)*
0 s to 2 s	*2 boxes*	*2 boxes * 10 m/box = 20 m*	*x = 20 m*
2 s to 4 s	*1.5 boxes*	*1.5 boxes * 10 m/box = 15 m*	*x = 20 m + 15 m = 35 m ***
4 s to 6 s	*0.5 boxes*	*0.5 boxes * 10 m/box = 5 m*	*x = 35 m + 5 m = 40 m*
6 s to 8 s	*- 0.5 boxes*	*- 0.5 boxes * 10 m/box = -5 m*	*x = 40 m + (-5 m) = 35 m ***
8 s to 10 s	*- 1.5 boxes*	*- 1.5 boxes * 10 m/box = -15 m*	*x = 35 m + (-15 m) = 20 m*
10 s to 12 s	*-2 boxes*	*- 2 boxes * 10 m/box = -20 m*	*x = 20 m + (-20 m) = 0 m*
12 s to 14 s	*-1.5 boxes*	*-1.5 boxes * 10 m/box = -15 m*	*x = 0 m + (-15 m) = -15 m*
14 s to 16 s	*- 0.5 boxes*	*- 0.5 boxes * 10 m/box = -5 m*	*x = -15 m + (-5 m) = -20 m*
16 s to 18 s	*0.5 boxes*	*0.5 boxes * 10 m/box = 5 m*	*x = -20 m + 5 m = -15 m*
18 s to 20 s	*1.5 boxes*	*1.5 boxes * 10 m/box = 15 m*	*x = -15 m + 15 m = 0 m*
20 s to 22 s	*2 boxes*	*2 boxes * 10 m/box = 20 m*	*x = 0 m + 20 m = 20 m*
22 s to 24 s	*2 boxes*	*2 boxes * 10 m/box = 20 m*	*x = 20 m + 20 m = 40 m*

In the last time interval (22s < t < 24s), the particle clearly passes x = 35 m during this interval.
Since velocity is constant, position is changing at a constant rate

Since x = 35 m represents ¾ of the displacement during this time interval
It will happen ¾ of the way through the time interval at t = 23.5 s

So x = 35 m at t = 4 s, 8 s, and 23.5 s

v_1=30.0 km/hr W *v_2 = 40.0 km NW*

Δt_1 = 4 hrs *Δt_2 = 2 hrs*

make Grand Bahama Island the origin of our coordinate system with East being the + x direction and North being the + y direction (see diagram below). Use constant velocity motion and addition of vectors

Problem 5 (20 points)

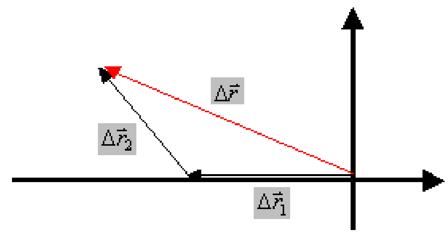
Several years ago, at 8 AM the eye of hurricane Floyd passed over Grand Bahama Island heading due west at a speed of 30.0 km/h. Four hours later, the course of hurricane Floyd shifted to Northwest towards the Florida coast and its speed increased to 40.0 km/h. Floyd continued on this course at this speed for two hours before turning due north again.

A. How far from Grand Bahama was hurricane Floyd 6 hours after it passes over the island?

The hurricane makes two constant velocity motions:

$\Delta\vec{r}_1$ from going West at 30.0 km/hr for 4 hrs &

$\Delta\vec{r}_2$ from going NW at 40.0 km/hr for 2 hrs



The hurricane's displacement $\Delta\vec{r} = \Delta\vec{r}_1 + \Delta\vec{r}_2$

$\Delta\vec{r} = |\Delta\vec{r}_1|(-\cos\phi\,\hat{i} + \sin\phi\,\hat{j}) + |\Delta\vec{r}_2|(-\cos\alpha\,\hat{i} + \sin\alpha\,\hat{j})$ where

$\phi = 0°$ *is the angle between* $\Delta\vec{r}_1$ *& the –x axis,* $\alpha = 45°$ *is the angle between* $\Delta\vec{r}_2$ *and the –x axis,*

$|\Delta\vec{r}_1| = v_1\,\Delta t_1 =$ *(30.0 km/hr) (4 hrs) = 120 km* $|\Delta\vec{r}_2| = v_2\Delta t_2 =$ *(40.0 km/hr) (2h) = 80 km*

$$\Delta\vec{r} = \left(-|\Delta\vec{r}_1|\cos\phi\,\hat{i} + 0\hat{j}\right) + (-|\Delta\vec{r}_2|\cos\alpha\,\hat{i} + |\Delta\vec{r}_2|\sin\alpha\,\hat{j}) = (-|\Delta\vec{r}_1|\cos\phi - |\Delta\vec{r}_2|\cos\alpha)\hat{i} + |\Delta\vec{r}_2|\sin\alpha\,\hat{j}$$

$$\Delta\vec{r} = [-(120\,km)\ \cos 0° - 80\,km\ \cos 45°]\,\hat{i} + 80\,km \sin 45°\,\hat{j} = -176.6\,km\,\hat{i} + 56.57\,km\,\hat{j}$$

$|\Delta\vec{r}| = \sqrt{(-176.6\,km)^2 + (56.57km)^2}$ *= 185 km (185.4 km)*

B. What was Floyd's average speed during this time?

Average Speed = distance / time = (d1 + d2) / (Dt1 + Dt2) = (120 km + 80 km) / (4 hrs + 2 hrs)

Average Speed = 200 km / 6 hrs = 33.3 km / hr

C. What was Floyd's average velocity during this time?

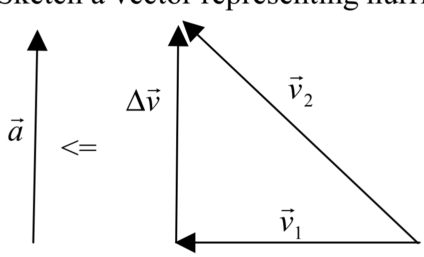
Average velocity $<\vec{v}>=$ *displacement/time =* $\Delta\vec{r} / \Delta t$

$|\langle\vec{v}\rangle| = |\Delta\vec{r} / \Delta t| = |\Delta\vec{r}| / (\Delta t_1 + \Delta t_2) =$ *(185.4 km) / (4 hrs + 2 hrs) = 30.9 km / hr*

direction: $\vartheta = \arctan\dfrac{|\Delta\vec{r}_y|}{|\Delta\vec{r}_x|} = \arctan\left(\dfrac{56.56\,km}{176.6\,km}\right) = 17.8°$

alternatively, $<\vec{v}> = \Delta\vec{r} / \Delta t = (-176.6\,km\,\hat{i} + 56.57\,km\,\hat{j}) / (4\,hrs + 2\,hrs) = -29.4\,km\,\hat{i} + 9.43\,km\,\hat{j}$

D. Sketch a vector representing hurricane Floyd's average acceleration during this time.



Since Delta v is proportional to the average acceleration, Delta v vector points in the direction of the acceleration. Recall that $\vec{a} = \Delta\vec{v} / \Delta t = (\vec{v}_f - \vec{v}_i) / \Delta t$