Motion in Two Dimensions

Pre-Class Questions

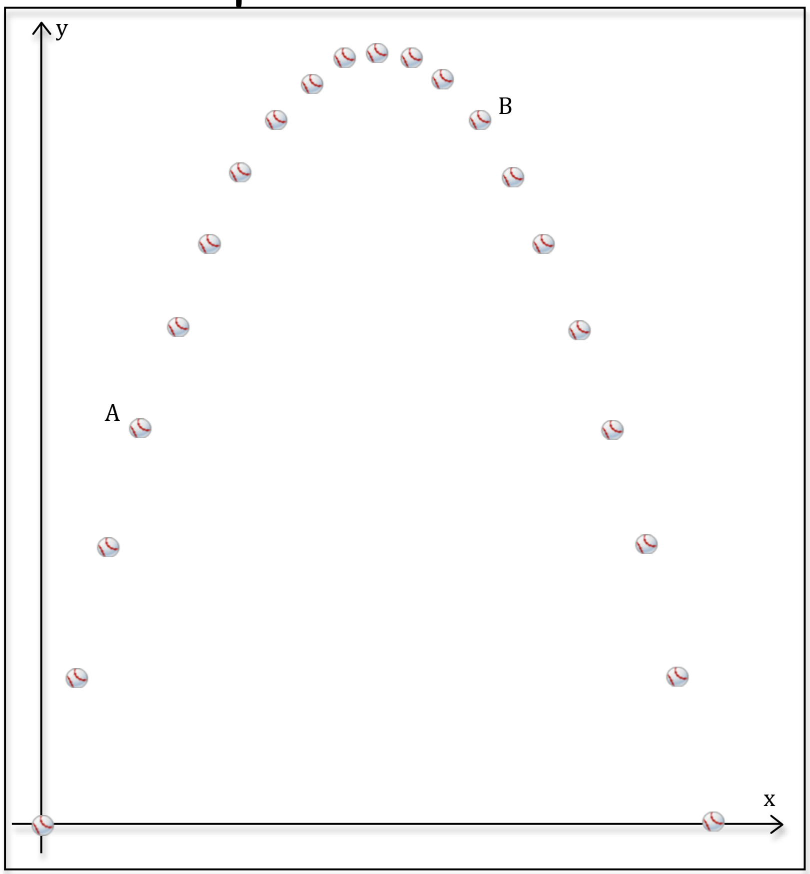
Problem Set (due next time)
Ch 3 – 1, 3, 4, 5ab

Lecture Outline

1. Going from One to Two Dimensions
2. Position and Displacement Vectors
3. Displacement and Velocity Vectors
4. Velocity and Acceleration Vectors

Quantity	Definition	Mathematically
Position	The location of an object with respect to a coordinate system.	$\vec{r}$
Displacement	A change in position.	$\Delta\vec{r} \equiv \vec{r}_f - \vec{r}_i$ or $\Delta x \equiv x_f - x_i$ and $\Delta y \equiv y_f - y_i$
Average Velocity	The average rate of displacement.	$\vec{v} \equiv \frac{\Delta\vec{r}}{\Delta t}$ or $v_x = \frac{\Delta x}{\Delta t}$ and $v_y = \frac{\Delta y}{\Delta t}$
Speed	The magnitude of the velocity vector.	$\mathrm{v} \equiv \lvert\vec{\mathrm{v}}\rvert = \sqrt{\mathrm{v}_x^2 + \mathrm{v}_y^2}$
Average Acceleration	The rate of change of velocity.	$\vec{a} \equiv \frac{\Delta\vec{v}}{\Delta t}$ or $a_x = \frac{\Delta v_x}{\Delta t}$ and $a_y = \frac{\Delta v_y}{\Delta t}$

Position and Displacement

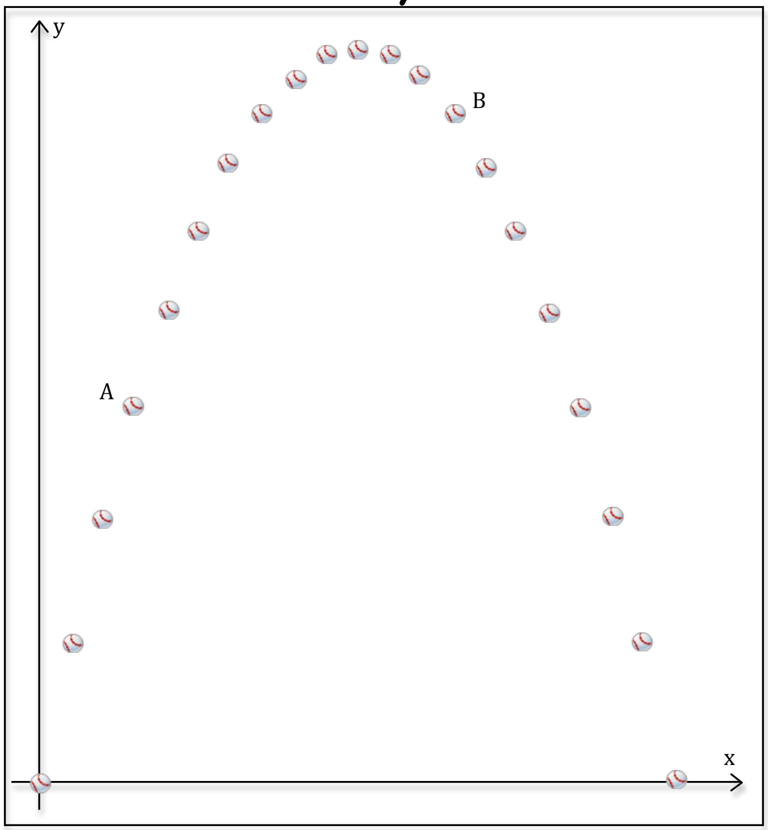


Using the coordinates shown:

1. Draw the position vector for the ball when it is at A. Label it $\vec{r}_A$.
2. Draw the position vector for the ball when it is at B. Label it $\vec{r}_B$.
3. Draw the displacement vector between A and B. Label it $\Delta\vec{r}$.
4. Explain why you know that $\vec{r}_A + \Delta\vec{r} = \vec{r}_B$. Solve for $\Delta\vec{r}$.

Example 1: A baseball is tossed into the air. After 0.30s it is at the position (2.2m, 2.5m). After 1.3s it is at the position (9.6m, 4.5m). (a)Draw these two position vectors and (b) the displacement vector. (c)Find the magnitude and direction of the displacement vector.

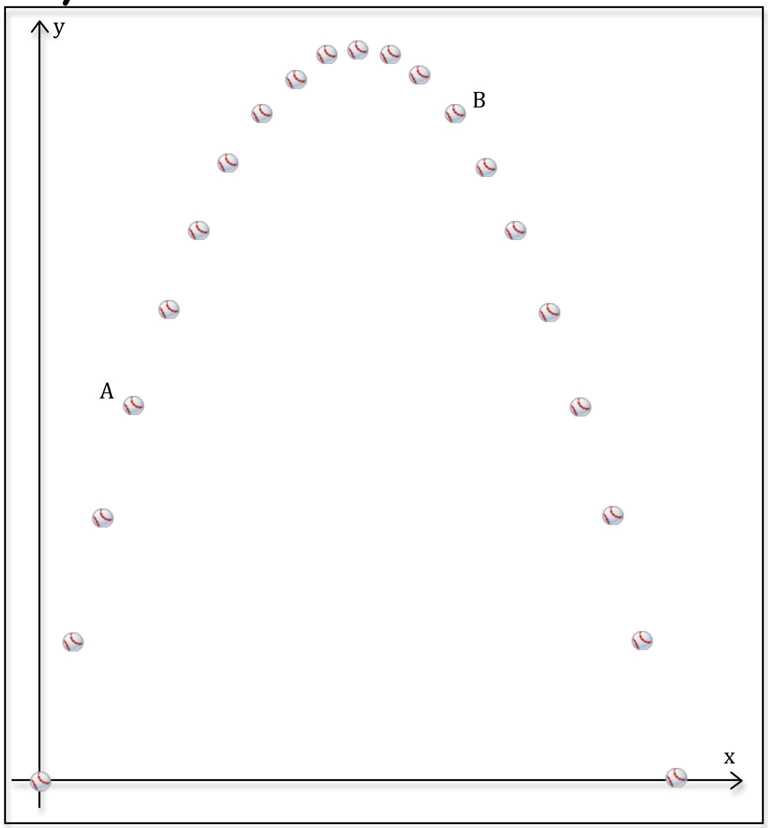
Displacement and Velocity



1. Draw the displacement vector for the ball from one image before A to one image after A. Label it $\Delta\vec{r}_A$.
2. Draw the displacement vector for the ball from one image before B to one image after B. Label it $\Delta\vec{r}_B$.
3. Explain why the velocity vector at A must point in the direction of the displacement vector at A (This is also true at B).
4. Sketch the velocity vectors at A and B.

Example 2:The position vector of the ball at 0.20s has the components (1.47m, 1.76m) and the position vector at 0.40s is given (2.94m, 3.14m). During this interval, find (a)the components of the average velocity vector, (b)the average speed of the ball, and (c)the direction of the average velocity vector.

Velocity and Acceleration



1. Draw the velocity vector for the ball at A. Label it $\vec{v}_A$.
2. Draw the velocity vector for the ball at B. Label it $\vec{v}_B$.
3. Redraw the two velocity vectors with their tails at the origin.
4. Draw the change in velocity vector. Label it $\Delta\vec{v}$.
5. Explain why $\Delta\vec{v}$ must point in the direction of the acceleration vector.
6. Explain why the acceleration vector points directly downward.

Example 3: At $t = 0.30s$ a baseball has a velocity of (7.35m/s, 6.86m/s). At $t = 1.3s$ its velocity is (7.35m/s, -2.94m/s). Find the magnitude and direction of the average acceleration vector.

Example 4:The second hand on a clock is 10.0cm long. Find (a)the speed of the tip of a second hand and (b)the direction of the instantaneous acceleration of the tip of a second hand.

Lecture 06 - Summary

Quantity	Definition	Mathematically
Position	The location of an object with respect to a coordinate system.	$\vec{r}$
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Average Velocity	The average rate of displacement.	$\vec{v} \equiv \frac{\Delta\vec{r}}{\Delta t}$ or $v_x = \frac{\Delta x}{\Delta t}$ and $v_y = \frac{\Delta y}{\Delta t}$
Speed	The magnitude of the velocity vector.	$\mathrm{v} \equiv \lvert\vec{\mathrm{v}}\rvert = \sqrt{\mathrm{v}_\mathrm{x}^2 + \mathrm{v}_\mathrm{y}^2}$
Average Acceleration	The rate of change of velocity.	$\vec{\mathrm{a}} \equiv \frac{\Delta\vec{\mathrm{v}}}{\Delta \mathrm{t}}$ or $a_x = \frac{\Delta v_x}{\Delta t}$ and $a_y = \frac{\Delta v_y}{\Delta t}$