Physics 172 – Recitation 01

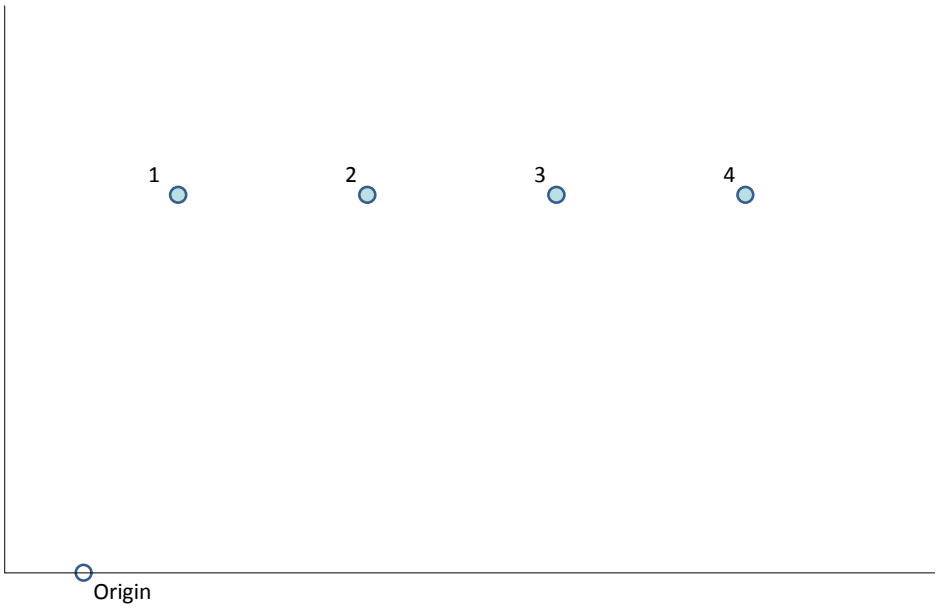
Spring 2012

Newton's First Law of Motion and Using Vectors to Represent the Changing 3D World

You will find more information about the topics of today's problems in chapter 1, sections 1.1 through 1.6, of the text. This was the reading assignment for the first lecture.

Make sure that you discuss and agree on the solutions of these problems with the others in your recitation work group (and with your TA!). The problems you encounter later this semester may seem more difficult because they involve more complicated physical situations, but we will learn how to use the ideas and methods you use to solve today's problems in order to solve those later ones too.

Problem 1. A child carries an empty cup balanced on her open, outstretched hand to give to her mother. The figure below shows the cup's position at a sequence of equally spaced times t_1, t_2, t_3 and t_4. The horizontal line represents the level floor in the child's room; the vertical one represents a wall.



Transfer a sketch of this drawing to your white board, and work with your partners to answer these questions.

a) Is the cup interacting with any objects in its surroundings? If not, explain how you know it is not. If so, say which objects it is interacting with and explain how you know.

b) If you choose an origin for a coordinate system, you can use a position vector $\vec{r}$ to represent the cup's position at any given time. Using the origin shown in the figure, draw arrows representing the cup's positions $\vec{r}_1$, $\vec{r}_2$, $\vec{r}_3$ and $\vec{r}_4$ at times t_1, t_2, t_3 and t_4.

c) The cup's displacement from its position at one time to another position at a later time is also a vector.

The cup's new position vector at the later time is the cup's old position vector at the earlier time plus the displacement vector from that old position to its new position at the later time.

Draw the arrow representing the cup's displacement vector during the time interval from t_1 to t_2. Explain clearly how the result of adding this displacement vector to the cup's initial position vector $\vec{r}_1$ gives the cup's final position vector $\vec{r}_2$ (initial and final positions for the time interval t_1 to t_2).

[Checkpoint 1]

d) Often, we will use the symbol Δ to help us represent changes in a quantity, such as the change in the position of the child's cup discussed above. For the time interval t_1 to t_2 the change in time is $\Delta t_{21} \equiv t_2 - t_1$, the final or later time minus the initial or earlier time. Similarly, the displacement vector representing the change in the cup's position during this time interval is $\Delta\vec{r}_{21} \equiv \vec{r}_2 - \vec{r}_1$, the cup's final position vector minus its initial position vector. Explain clearly how this definition is consistent with your answer to c).

e) Draw the arrows representing the cup's displacements $\Delta\vec{r}_{32}$ and $\Delta\vec{r}_{43}$. How do they compare to $\Delta\vec{r}_{21}$? [Notice that you can shift vectors like these around to compare them as long as you do not change their length or direction when you move them]. Explain how your answer relates to your discussion in part a) of direct and/or indirect evidence that the cup is interacting with objects in its surroundings.

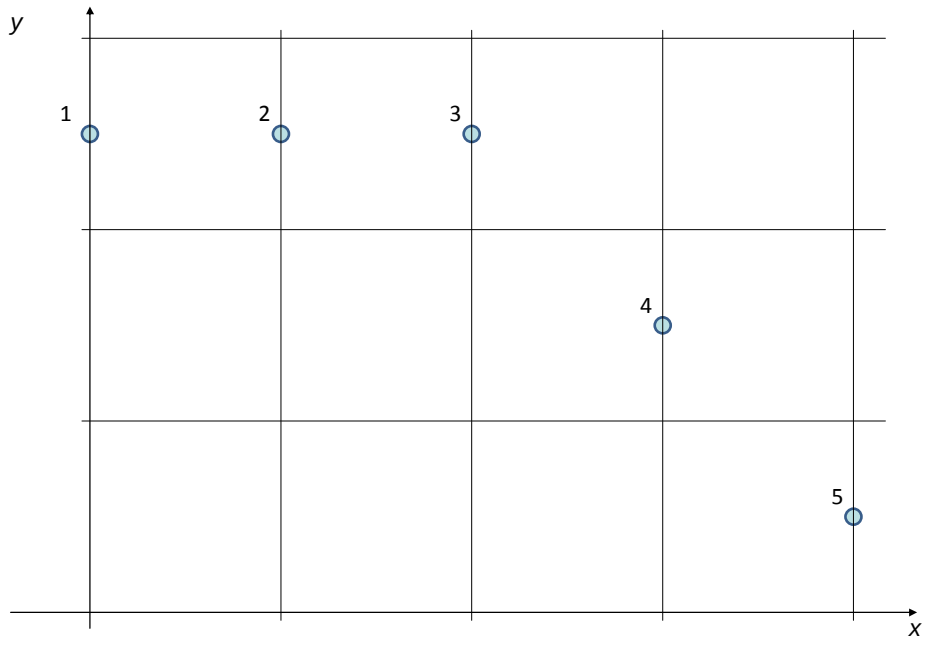
f) If, in addition to choosing an origin, you choose a set of coordinate axes for a coordinate system, you can use components to represent vectors like the position and displacement vectors of the child's cup. Using an *x* axis that runs along the floor to the right, a *y* axis that runs upward parallel to the wall and a *z* axis that points out of your whiteboard toward you, the components of the cup's position vectors at times t_1, t_2, t_3 and t_4 are $\vec{r}_1 = \langle 0.25, 1.0, 0.0 \rangle m$, $\vec{r}_2 = \langle 0.75, 1.0, 0.0 \rangle m$, $\vec{r}_3 = \langle 1.25, 1.0, 0.0 \rangle m$ and $\vec{r}_4 = \langle 1.75, 1.0, 0.0 \rangle m$. Draw the coordinate axes on your whiteboard diagram and explain how the components of $\vec{r}_2$ are related to the arrow you drew to represent it.

What are the components of the displacement vectors $\Delta\vec{r}_{21}$, $\Delta\vec{r}_{32}$ and $\Delta\vec{r}_{43}$ in this coordinate system? Explain how your answers here are consistent with your answer to the first part of e)?

[Checkpoint 2]

Problem 2. The figure on the next page shows positions of a hockey puck at a sequence of equally spaced times t_1, t_2, t_3, t_4 and t_5. In this case, you are looking down from above at the puck's position on the horizontal surface of the ice of a hockey rink. The positions of hockey players skating on the ice are not shown. The *x*-axis of the

coordinate system shown runs along the length of the rink, its *y* axis runs across the rink and its *z* axis points up toward you. The spacing between the gridlines shown is 2 meters.



a) Is there any <u>direct</u> evidence that the puck interacts with something in its surroundings during the time interval between t_1 and t_5? If so, be as specific as you can about when and where the interactions occur and about which objects in its surroundings the puck may have interacted with.

Is there <u>indirect</u> evidence in this situation that the puck is interacting with other objects in its surroundings? If so, what objects is it interacting with and how do you know?

b) What are the components of the puck's position vectors $\vec{r}_1$, $\vec{r}_2$, $\vec{r}_3$, $\vec{r}_4$ and $\vec{r}_5$ at times t_1, t_2, t_3, t_4 and t_5 in the coordinate system shown?

c) What are the components of the puck's displacement vectors $\Delta\vec{r}_{21}$, $\Delta\vec{r}_{32}$, $\Delta\vec{r}_{43}$ and $\Delta\vec{r}_{54}$? Explain how your answers are consistent with your answers to part a).

[Checkpoint 3]