Physics 7B

DLM 1 Overview

Unit 4: Momentum and Force

Model/Approach: Galilean Space-Time Model

CG 4.1 Using Vectors to represent Force, Velocity, and Other Vector Quantities

Act-4.1.1 Working with Position and Displacement Vectors **(~60 min)**

Learning Goals:

- Practice drawing vectors and adding and subtracting them using the tail-to-head method.
- Understand the difference between distance and displacement
- Understand the difference between displacement and position vectors and how one arises from the other.
- Understand that the displacement vector does not depend on the choice of coordinate system.
- Understand the relationship between the displacement vector and the average velocity vector.

Act-4.1.2 Using Vectors to Represent the Motion of a Weight Moving in a Circle **(~60 min)**

Learning Goals:

- Practice carefully observing motion and representing this motion using vectors.
- Practice using perpendicular components to represent a vector.
- Understand that a vector does not depend on the perpendicular axes chosen to define the components.
- Practice finding components using the graphical method.

Start discussing FNTs **(~20 min)**

Announcements

- **Buy your Physics 7B Course Notes** and your "clicker" (student response system) at the **MU Bookstore**. Before the next DL, **read** Unit 4 through page 25 and Summary and Review pages 107-111.
- Quizzes will be in lecture. Quizzes are closed book and closed notes. You will occasionally need a calculator, so always bring one with you.
- Be sure to check the Physics 7B webpage periodically. (http://physics7.ucdavis.edu/). Check often for new information and material. The FNTs should be available at this site as well as various announcements and all office hours.

Working with Position and Displacement Vectors

Make sure everyone in your group fully understands the ideas behind each question or part in these activities before going on to the next part.

Phenomenon: You are in a strange city that has streets that are laid out in a perfectly square grid. Your job will be to move around to several locations as instructed and record your progress.

All members of your group must now get up, go to the board, and work together on the responses to the following:

1) Make a drawing on the board showing the streets in the central city. (This should be a square grid with at least 10 streets going in each direction.) Decide as a group how you are going to label the streets and use your labeling system. Make sure your diagram is large enough for everyone in the room to clearly see it.

2) Near one of the edges of the diagram, label a street corner "o" for origin. Your origin should be different than any other group. Imagine you are standing at this point. Now imagine walking toward the center of the diagram, making several 90˚ turns as you walk. Using the labeled origin, draw a position vector on your diagram that shows where you ended up. Label this vector $\mathbf{R}_i$ (i stands for initial)

a) Determine the length of your position vector (you might need the Pythagorean Theorem for this). How you can describe the direction of the position vector? What units does it have?

Whole Class Sharing

b) Continuing from your location above, now imagine walking a distance equal to three blocks in a direction in space that is straight up (on the board). Show the *position vector* for this new location. Remember, *position vectors start at the origin*. Label this vector $\mathbf{R}_f$. Look around the room and check to see if you are doing what other groups are doing.

c) Off to the side of your diagram, **graphically add** a new vector labeled with the symbol $\Delta\mathbf{R}$ to the initial position vector, so that the sum is the final position vector using the tail-to-head method as shown on page 7 of the Course Notes. (Make sure you draw these vectors with the same length and direction that they have on your drawing). $\Delta\mathbf{R}$ is called the "displacement" vector. What does it physically represent? Transfer your displacement vector to your street diagram.

d) Write a vector addition equation from part c) near your diagram. It should have the form $\mathbf{A} + \mathbf{B} = \mathbf{C}$. Which vectors are **A** and **B**, and which is **C**? Does $\mathbf{B} + \mathbf{A}$ also equal **C**? Show this.

e) What are the differences between position vectors and displacement vectors? Is this the distance you walked along your path represented by any of these vectors? *Write this on the board* and be prepared to share with the whole class.

Whole Class Sharing

f) Suppose you walked the three blocks up in 60 seconds. Draw the *average velocity* vector for this situation. What is the "length" of this vector? Include the units. Draw another velocity vector for a situation where you took 180 seconds to walk the three blocks. Which arrow is longer? Why?

g) If you now walked back to your starting point "o" and assuming the total journey took eight hours what is your average velocity for the entire trip?

Whole Class Sharing

3) Look around the room at the different street diagrams. What is the same in each one? What is different?

Discuss in your group how you would summarize the meaning of everything you did in this activity. Be prepared to share with the whole class. How is this information useful for describing motion?

Using Vectors to Represent the Motion of a Mass Moving in a Circle

Make sure everyone in your group fully understands the ideas behind each question or part in these activities before going on to the next part.

Phenomenon: You are going to swing a ball in a circle and represent its velocity several different ways using vectors.

1) a) Get the ball swinging in a *large* horizontal *circle*, going *clockwise* when viewed from above. Imagine looking down on the weight. Pick a direction in space that you will identify as the “12 o’clock” position. Using a coordinate system that has the x-axis running from the 9 to the 3 o’clock position draw x and y-axes and draw the circular path of the weight on the board.

b) Draw a position vector identifying the position of the weight when it is in the 4 o’clock position. Show the x and y components of this vector on your diagram. Discuss in your group how to do this. Be prepared to share with the whole class.

c) Draw another position vector when the weight is in the 5 o’clock position. To the side of your diagram, graphically subtract the position vectors **as accurately as possible** to find the displacement vector, label it $\Delta\mathbf{r}$. Write an English sentence explaining the meaning of the delta.

Quick Whole Class Sharing

2) a) Describe in words the **velocity** of the ball as it moves in its circle. Be prepared to share.

b) What is an instantaneous velocity vector? How is it different from a position vector? Does it always point in the same direction? If you are having trouble answering these questions, apply them to a specific situation (e.g. driving northwest on I-5 at 65 mph and then curving toward the north).

3) a) Imagine that you are sitting on the ball and “driving” it in a circle. Which way are you moving when you are at the 4 o’clock position? Draw a velocity vector (put the tail of the vector at the weight’s location) showing the velocity of the weight at the 4 o’clock position. Show x and y components of this vector on your diagram. Discuss in your group how you do this.

b) Looking at the vectors you have drawn, is a position vector or a displacement vector more closely related to a velocity vector? Make sure this agrees with your knowledge of the definition of velocity.

c) Which vectors on your diagram would be different if you changed the origin?

Whole Class Sharing

4) Draw the velocity vector for the weight at the 6 o’clock position. Off to the side, graphically determine the change in velocity, $\Delta\mathbf{v}$, between the 4 o’clock position and the 6 o’clock position.

5) a) Find the x and y components of the 6 o’clock velocity vector.

b) Find the x and y components of the vector $\Delta\mathbf{v}$.

6) How can you use the x and y components of the 4 o’clock and the 6 o’clock positions to get the change in velocity, $\Delta\mathbf{v}$? Summarize your method and be prepared to share it with the class.

Whole Class Discussion

Physics 7B **Exit Handout** **DLM 01**

FNTs: (*We won't be covering these in detail so come with questions*).

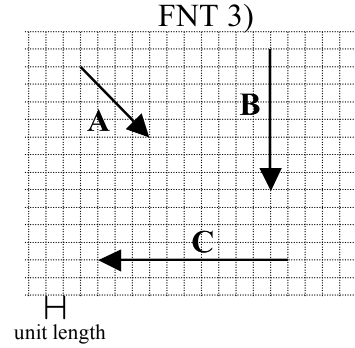
1) Three force vectors are added together. One has a magnitude of 9 N, the second one a magnitude of 18 N, and the third a magnitude of 15 N. What can we conclude about the *magnitude* of the net force vector? Explain.

I. It *must* equal 42 N.
II. It cannot be 0 N.
III. Anything from –42 N to +42 N.
IV. It can be anything from 0 N to 42 N.
V. None of the above can be concluded.

2) Alice, Bob and Chuck are three friends standing around talking. We know that Alice is standing 9 m away from Bob, and that Bob is standing 3 m away from Chuck. Let $\mathbf{\Delta R_{AB}}$ be the vector that starts at Alice and ends at Bob, and $\mathbf{\Delta R_{BC}}$ be the vector that starts at Bob and ends at Chuck.

(a) Write an equation to find the displacement between Alice and Chuck.
(b) What is the furthest Chuck can be from Alice, given the information in the question? What is the closest they can be?
(c) Draw a picture where Chuck is neither as close as he can be or as far as he can be from Alice. Draw and label the vectors $\mathbf{\Delta R_{AB}}$ and $\mathbf{\Delta R_{BC}}$.

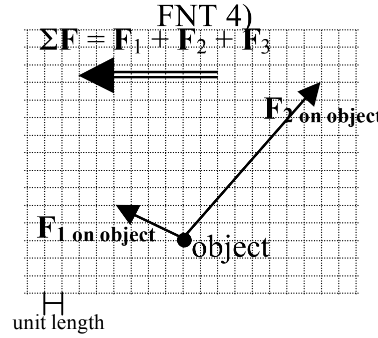
FNT 3)



3) Using a piece of graph paper carry out the operations listed below again on the vectors shown to the upper right. Label all vectors.

(a) $\Sigma\mathbf{F} = \mathbf{A} + \mathbf{B}$.
(b) $\Sigma\mathbf{F} = \mathbf{B} + \mathbf{A}$.
(c) $\Delta\mathbf{p} = \mathbf{A} - \mathbf{B}$.
(d) $\Sigma\mathbf{F} = \mathbf{A} + \mathbf{B} + \mathbf{C}$.
(e) $-\Delta\mathbf{p} = \mathbf{B} - \mathbf{A}$.

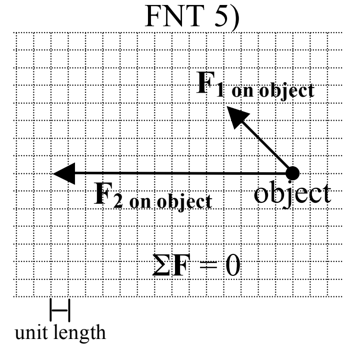
FNT 4)



4) Vectors $\mathbf{F}_{1\text{ on object}}$, $\mathbf{F}_{2\text{ on object}}$, and $\mathbf{F}_{3\text{ on object}}$ are all exerted on an object, adding together to form a net force vector, $\Sigma\mathbf{F}$, as shown in the second graph to the right. However, only vectors $\mathbf{F}_{1\text{ on object}}$, $\mathbf{F}_{2\text{ on object}}$, and $\Sigma\mathbf{F}$ are known. On a separate piece of graph paper, use the properties of vector addition to graphically determine the vector $\mathbf{F}_{3\text{ on object}}$.

5) Vectors $\mathbf{F}_{1\text{ on object}}$, $\mathbf{F}_{2\text{ on object}}$, $\mathbf{F}_{3\text{ on object}}$, and $\mathbf{F}_{4\text{ on object}}$ are all exerted on an object, adding together to form a net force vector $\Sigma\mathbf{F} = 0$, as shown to the right. However, only vectors $\mathbf{F}_{1\text{ on object}}$, $\mathbf{F}_{2\text{ on object}}$, and $\Sigma\mathbf{F}$ (which is zero) are known. It is known that $\mathbf{F}_{3\text{ on object}}$ is completely vertical, and $\mathbf{F}_{4\text{ on object}}$ is completely horizontal. On a separate piece of graph paper, use the properties of vector addition to determine the magnitudes of the vertical vector $\mathbf{F}_{3\text{ on object}}$, and the horizontal vector $\mathbf{F}_{4\text{ on object}}$.

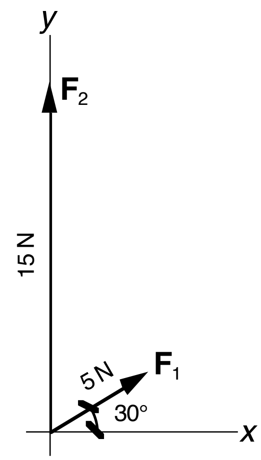
FNT 5)



Exit Handout

6) Two force vectors ($\mathbf{F}_1$ and $\mathbf{F}_2$, as shown to the right) act on a 2 kg object that has an initial velocity $\mathbf{v}_i$ of 3 m/s in the $+x$ direction.

(a) Find the x and y components of the net force (use trigonometry).
(b) Find the magnitude and direction of the net force.



7) Two rolling carts are moving toward each other at the **same speed**. Cart 1 has a mass, m_1 = 200 g and cart 2 has a mass, m_2 = 400 g.

(a) Draw a velocity vector, **v**, for each cart.
(b) Momentum, **p**, is a vector defined as **p** = m**v**. Draw a momentum vector for each cart.
(c) Add the two momentum vectors together to find the total momentum, $\mathbf{p}_{total} = \mathbf{p}_1 + \mathbf{p}_2$.