Lesson 3: Motion diagrams & Force diagrams

3.1 Observe and Represent

Consider the following experiment: You have a bowling ball and a board (or anything that rolls easily, a billiard ball or a low friction cart on a track). You place the ball on the floor and push it with the board continuously trying to exert **a constant** force.

a) Sketch the situation.

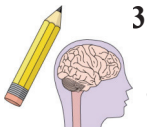
b) Perform the experiment; then describe the motion of the ball in words.

c) List all of the objects interacting with the bowling ball while it is being pushed.

d) Draw a motion diagram for the ball. Indicate the direction of the $\Delta\vec{v}$ arrow.

e) Draw three force diagrams for the ball as it is rolling on the floor. Place these diagrams under the motion diagram showing for what clock readings you created them. Does your picture make sense to you?

a) Observe experiment in http://paer.rutgers.edu/pt3/experiment.php?topicid=2&exptid=170 What is happening to Eugenia's speed? Draw a motion diagram and then 3 consecutive force diagrams for every instant when she drops a beanbag. Then draw a force diagram for Eugenia. Compare the direction of the $\Delta\vec{v}$ arrow on the motion diagram to the direction of the unbalanced force on the force diagrams

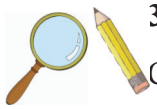


3.2 Represent and Reason

a) Look at the force diagrams you drew in 3.1 (in for both experiments). Are the force arrows changing as the ball rolls on the floor? Are there any forces that are balanced? If so, please indicate which and explain why you think so.

b) Indicate if there is an unbalanced force exerted on the ball on each diagram. Indicate the direction of the unbalanced force with an arrow.

c) Indicate the direction of the velocity change arrow ($\Delta\vec{v}$) on the motion diagram for the instances matching the force diagrams.



3.3 Observe and Represent

Consider this new experiment: You push the ball to start it moving. Once it is already rolling, you lightly push the front of the *moving* bowling ball continuously with a board in the direction **opposite** to the direction of motion. Try to exert **a constant** force. Make sure you do not push so hard that the ball stops very quickly. The slower the process occurs, the easier it will be for you to analyze it.

a) Sketch the situation.

b) Perform the experiment and describe the motion of the ball in words.

c) List all of the objects interacting with the bowling ball while it is being pushed in the direction opposite to its motion.

d) Draw a motion diagram for the entire time that the ball is in motion.

e) Draw three force diagrams for the ball as it is in motion; place those diagrams under the motion diagram for the relevant clock readings.

f) Examine your force diagrams. Do they change as the ball slows down? Indicate which forces are balanced and which forces are unbalanced. How do you know? Draw an arrow to show the direction of the unbalanced force.

g) Indicate the direction of the change in velocity arrow on the motion diagram for each of the clock readings for which you drew force diagrams.

a) Observe the experiment in http://paer.rutgers.edu/pt3/experiment.php?topicid=2&exptid=43 . Draw a motion diagram for the ball, as it is moving upward and the force diagram for the three instances on the motion diagram. Compare the direction of the $\Delta\vec{v}$ arrow on the motion diagram to the direction of the unbalanced force on the force diagram.

3.4 Represent and Reason

Place a bowling ball on a tilted surface and let it roll down on a very smooth floor. Observe the ball rolling on the floor. Does its velocity change? If the floor is smooth the ball should not slow down.

a) Draw a motion diagram for the ball. What is the direction of the velocity change?

b) Draw force diagrams for the ball for three different clock readings. Are the diagrams the same or different? What is the direction of the unbalanced force?

c) If the floor is infinitely long, how long will the ball move before it stops? Should it ever stop?

a) Use the outcome in the experiment in http://paer.rutgers.edu/pt3/experiment.php?topicid=2&exptid=169 to compare Eugenia's motion to the motion of the bowling ball. Are they similar? Different? How do you know?

3.5 Find a Pattern

Consider the experiments you performed in activities 3.1 - 3.4. Examine the force and motion diagrams for each experiment.

a) Is there a pattern in the directions of the *unbalanced forces* that other objects exert on the ball and in the *directions of the* $\vec{v}$ *arrows* on the motion diagrams for the ball?

b) Is there a pattern in the directions of the *unbalanced forces* that other objects exert on the ball and the *directions of the* $\Delta\vec{v}$ *arrows* in the motion diagrams?

c) Use the pattern that you found to formulate a statement relating the force diagram to the motion diagram.

d) How do you understand the difference between the words "motion" and "change in motion"? Give an example.

e) Do you think the net force exerted on an object causes motion or change in motion?

f) Who was the observer recording the velocity changes for the object in the above activities? Would there be observers for whom the statement relating the force diagram to the motion diagram would not be true?

3.6 Test the Pattern

a) Design 2 different experiments whose outcome you can predict using the statement you formulated in activity 3.5 (c).

Need Some Help?

The statement you are testing is the rule or pattern you noticed between the direction of the unbalanced force on the force diagram and the direction of the $\Delta\vec{v}$ arrow on the motion diagram for the same object. The experiment you design should try to "rule out" the pattern, not to "prove" it.

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b) Write predictions for the outcome of each experiment based on the pattern you noticed.

c) Perform the experiment and record the outcome. How did your prediction compare to the outcome? Did you succeed in the disproving the pattern? Explain your judgment.

Homework

3.7 Test the Pattern

You have a medicine ball. When you place it on a bathroom scale, the scale reads 6 pounds (a unit of force in a the British system). Imagine that a friend drops a medicine ball, and it falls straight down on a bathroom scale.

a) Draw a force diagram for the ball when it sits on the scale at rest. Draw a motion diagram for the ball.

b) Draw a motion diagram for the ball when it just touches the scale but is not yet stopped.

c) Draw a force diagram to match the motion diagram.

Assume that the scale reads the force that the scale exerts on the ball. Make a prediction about the reading of the scale as it stops the falling ball using the pattern between the motion diagram and the force diagram you formulated and tested during the lesson.

d) After you made the prediction, watch the videos. Make sure that in the second clip, you move frame by frame.

http://paer.rutgers.edu/pt3/movies/medballdrop1.mov then
http://paer.rutgers.edu/pt3/movies/medballdrop2.mov.

e) What judgment can you make about the pattern you formulated?

3.8 Represent and Reason

a) Draw a motion diagram for a book sliding on a table coming to a stop. Draw a force diagram for the book. Are the force diagram and motion diagram consistent with each other? Explain.

b) You are holding a birthday balloon filled with helium. Draw motion and force diagrams for the balloon. Are the force diagram and motion diagram consistent with each other? Explain.

c) You are holding a birthday balloon filled with helium and then let it go. Draw motion and force diagrams for the balloon the moment you let it go. Are the diagrams consistent with each other? Explain.

d) The balloon reaches the ceiling. Draw motion and force diagrams for the balloon the moment the top of it touches the ceiling. Check the consistency of your representations. Can you represent the balloon as a particle in this case? Explain.

e) A matchbox slides down a steep incline. Draw a motion diagram and a force diagram for the matchbox as it slides down the incline. Check the consistency of your representations.

3.9 Pose a Problem

Consider the scenario: You are playing ice hockey.

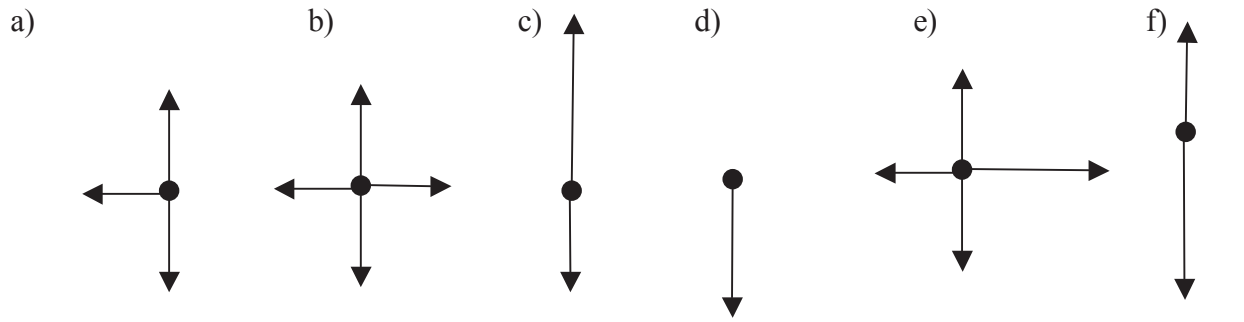
Pose a problem similar to the two activities above. Then solve your problem.

3.10 Reason

Below you have descriptions of processes, unlabeled motion diagrams, and unlabeled force diagrams. Label the force diagrams and motion diagrams and match the diagrams so all three describe the same motion.

Words: (a) a book sliding on a table top to a stop; (b) a book dragged on the tabletop at constant speed; (c) an object thrown upward on its way up; (d) and object thrown upward at the top of its flight; (d) a car skidding to a stop. Notice that some force diagrams are extra – they do not match any word descriptions.

Force diagrams



Motion diagrams