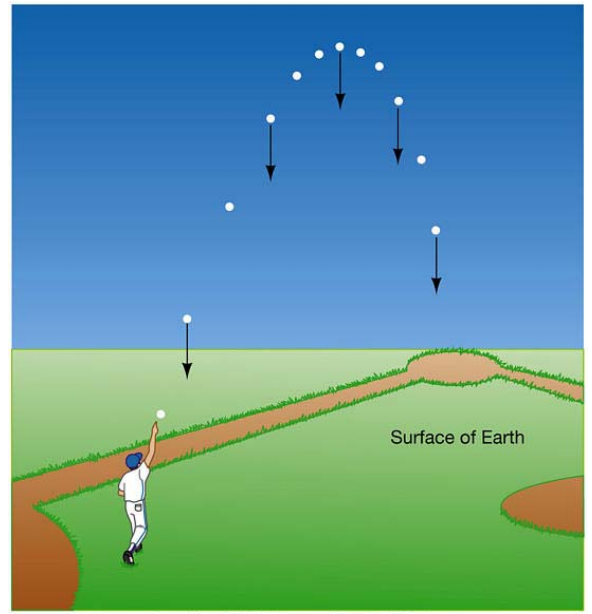
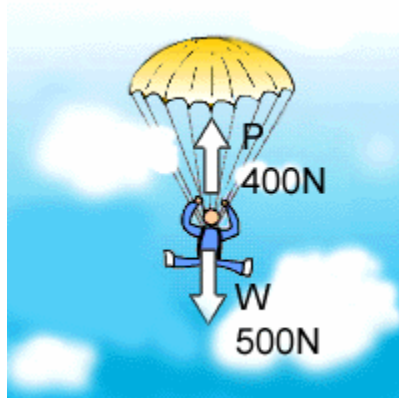


Forces and Motion



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Unit Overview

I. Unit Description

The following unit is centered on the topic of force and motion. The unit is to be taught through a series of hands on activities that allow the students to face many common preconceptions. Built into this unit are various assessment tools that teachers can use to alter the unit based upon the students need. These assessment tools include a pre and post test, as well as a final performance task. The activities in this unit cover the following topics:

- What is a force
- How forces are exerted
- Balanced and Unbalanced forces
- Force and motion graphs
- Relationships between force, acceleration, and mass

The activities themselves are student rather than teacher oriented. Instead of listening to lectures and taking notes students work through the activities developing their own understanding of the concepts through small group and class discussions. Because of this inquiry approach to learning the teacher becomes more of a guide helping to point the students in the right direction but not telling them how to get there.

II. Unit Rationale

“Nothing in the universe is at rest. Motion is as essential to understanding the physical world as matter and energy are.” (Project 2061) It is because of this fact we believe that it is essential that students learn and experience how motion is created and the forces that are behind it. A majority of common pre-conceptions that students have are formed on the subject of forces and are one of the major stumbling blocks for a large number of first year physics students.

Because students often struggle with the concept of force and motion this unit allows students to work through their preconceptions by facing them head on. The activities that are in this unit are all hands on and ask for students to make predictions and then to test their predictions. In teaching forces and motion in this manner students get to see that their preconceptions often lead to predictions that are incorrect. Therefore, when they see that the outcomes of experiments do not meet their expected results they have to examine their way of thinking and come up with new logical explanations that can explain what happened. This allows the students to develop a new way of thinking in a way that is hands on and relevant.

III. Audience

This unit is designed to be taught to first year physics students in class periods of 60 minutes. Ideally this would be in an introductory physics class where this is the students first exposure to physics.

IV. Unit Calendar

Day 1	Day 2	Day 3	Day 4	Day 5
Pre-test Lesson: Intro to Forces - Demo: Laser on Table - What are they? - How are they exerted?	Lesson / Activity: -Keeping objects at Rest	Lesson / Activity: -Force-Motion Graphs	Lesson / Activity: -Force and Mass	Lesson / Activity: -Combining Forces Post-Test
Day 6	Days 7-8	Day 9		
Lesson / Activity: -Math behind it	Final Investigation - Performance Task	Presentations on performance task		

Final Grade Breakdown

- Pre Tests : 10%
- Homework Checks : 20% (10% each)
- Lab Reports : 40% (20% each)
- Unit Test/Projects: 30%
- Total: 100%

Final Grade Scale

Grade:	A	A-	B+	B	B-	C+	C	C-	D	F
%:	94+	93.9-89	88.9-86	85.9-83	82.9-80	79.9-76	75.9-73	72.9-70	69.9-60	59.9-

V. Standards

This unit has been designed to take into account the standards set forth by the National Science Teacher Association, Project 2061, and the state of Washington.

Benchmarks on Motion:

Benchmark 4F pages 87-92

- The change in motion of an object is proportional to the applied force and inversely proportional to the mass.
- Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.
- An unbalanced force acting on an object changes its speed or direction of motion, or both.
- Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have.

NSES standards:

Grades 9-12, Standard B, pages 177-180

“Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.”

ATLAS:

Laws of Motion, pages 62-63

EALR's

1. SYSTEMS: The student knows and applies scientific concepts and principles to understand the properties, structures, and changes in physical, earth/space, and living systems.

1.1. Properties: Understand how properties are used to identify, describe, and categorize substances, materials, and objects, and how characteristics are used to categorize living things.

GLE 1.1.2: Apply an understanding of direction, speed, and acceleration when describing the linear motion of objects.

1.3. Changes: Understand how interactions within and among systems cause changes in matter and energy.

GLE 1.3.1: Understand forces in terms of strength and direction.

GLE 1.3.2: Understand that forces can change the motion of common objects.

2. INQUIRY: The student knows and applies the skills, processes, and nature of scientific inquiry.

- 2.1. Investigating Systems: Develop the knowledge and skills necessary to do scientific inquiry.
- 2.2. Nature of Science: Understand the nature of scientific inquiry.

3. APPLICATION: The student knows and applies science concepts and skills to develop solutions to human problems in societal contexts.

- 3.1. Designing Solutions: Apply knowledge and skills of science and technology to design solutions to human problems.

VI. Pre-Assessment

- a. Pre-Conceptions:** This unit is also designed to address the following preconceptions that students have about force and motion. It is the goal that through this unit students will have a chance to face these preconceptions and thus change their thinking and develop new scientifically sound arguments for how the world works.

Children Ideas in Science:

- I) Constant motion requires constant Force
- II) If a body is not moving there is no force acting on it
- III) If a body is moving there is a force acting on it in the direction of motion

ATLAS:

- I) Forces are a property of an object
- II) Active objects like hands exert forces where as passive objects like tables do not.

<http://www.darylsience.com/Misconceptions.htm>:

- I) Acceleration always occurs in the same direction as motion.
- II) Friction always hinders motion, thus reducing friction is always desired.
- III) Large objects exert a greater force than smaller objects

<http://amasci.com/miscon/opphys.html>:

- I) If an object has a speed of zero (even instantaneously), it has no acceleration.

b. Pre-Assessment

At the beginning of Day 1, students will be given a Pretest to assess their current understandings and knowledge of the unit. This will allow the students to see what thoughts they have on the topic and will help them focus on the lessons in the unit. The Pretest will also allow the teacher an opportunity to see where the students stand and to make adjustments to the unit to better address the students skill levels. See Day 1 Lesson Plan for a copy of the Pretest.

VIII. Post Assessments

This unit contains two assessment activities. The first is a test which will assess whether or not the students have overcome their preconceptions. The test consists of short answers, and a few multiple choice questions. Through this test the teacher will be able to assess whether or not the goals of the unit have been met and whether or not students are making advances in physics understanding.

The second assessment is a performance task which will test the students' ability to design and carry out a physics experiment based on force and motion. It is no longer enough just to memorize facts and equations. Students need to be able to use their knowledge to explain and explore real life situations. Without this connection students will not see the relevance of physics, or any other subject. That is why we have developed a performance task that allows the students to put their knowledge into action. Students will see that the knowledge they have gained can be put to use and the teacher will be able to assess whether or not the students have gained an adequate understanding of force and motion.

Copies of both the test and performance task can be found in Day 5 Lesson Plan.

VII. Lesson Plans

The lessons plans for the first 5 days of the unit are provided on the following pages.

Intro to Forces (Day 1)

Objectives:

- 1) Students will be able to recognize that everything has the ability to exert a force.
- 2) Students will be able to show forces acting on an object using a Free Body Diagram (FBD).

Materials needed for the Lesson:

30 copies of Pre-Test
Laser Pointer
Spring
Heavy Book
Whiteboard

Source of lessons:

Pretest: Constructing Physics Understanding (CPU), Summer 1998, Motion and Force
Activity II-E: Connections between Force and Motion.

Preconceptions Addressed:

- I) If a body is not moving there is no force acting on it.
- II) Active objects like hands exert forces where as passive objects like tables do not.

Lesson procedure:

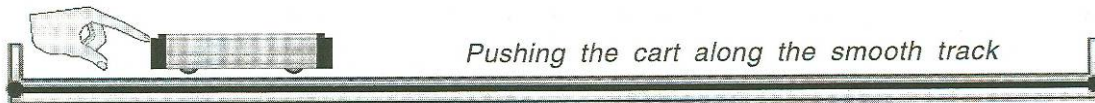
<u>Timeline</u>	<u>Teachers Role</u>	<u>Students Role</u>	<u>Teacher notes</u>
< 2 mins	Explain to the students that they will be taking a pretest that allows them to record their initial ideas about the upcoming unit. The test is not graded on correctness....		
15-20 mins	Hand out pretest and monitor for questions. Take attendance.	Take the pretest and ask questions if needed.	
5 mins	Slam book on table to end pretest and ask question, "Describe the forces acting on the book."	Students will participate in the discussion and answer questions when appropriate.	
10 mins	Begin discussion to get students to realize that all objects can exert a force. Talk about how the table is not just "in the way" of the book but that it is exerting a force on the book. Do the demo with the book on the spring and discuss how the spring is different and alike when compared to the table.	Participate in the discussion. Pay attention to the demo.	It will be expect that students will have difficulty with the concept that a table can exert a force. Thus the teacher will need to be prepared to do the demo with a spring.
10 mins	Do the final demo with a table and laser showing that the table does indeed flex and exert a force on the book.	Participate in the discussion. Pay attention to the demo.	This demo is necessary because a majority of the students will not see the connection between the table and spring.
5 mins	Go over a FBD of the book on the table. Explain that the length of the arrow is proportional to the strength of the force.	Take notes on FBD	
< 5 mins	Give them their exit slip instructions to draw a FBD of all the forces acting on a student sitting on their chair and explain why they included each force they have drawn.	Complete the exit slip by drawing a FBD and explaining each of the force they have included.	Review exit slips to check for students understanding of the lesson.

Name: _____

Pretest

- 1) To the best of your ability define the concept of a Force. What is it? How is it exerted? And any other information you want to include.

Imagine the following situation: Examine the diagram as it will be used to answer the following questions.



- 2) What do you have to do to make the cart move at a **constant** speed? In the space below explain your choice. Assume negligible friction.
 - a) Give it a push from behind and immediately let go.
 - b) Maintain a constant push.
 - c) Continually increase the strength of the push.
 - d) Continually decrease the strength of the push.
 - e) Something else, you describe it.

Explain:

3) Instead of maintain a constant speed you now want to continuously increase the carts speed. What do you have to do to make this happen?

- a) Give it a push from behind and immediately let go.
- b) Maintain a constant push.
- c) Continually increase the strength of the push.
- d) Continually decrease the strength of the push.
- e) Something else, you describe it.

Explain:

Imagine the following situation: Examine the diagram as it will be used to answer the following questions.



4)What do you have to do to make the chair move at a **constant** speed? In the space provided explain your choice.

- a) Give it a push from behind and immediately let go.
- b) Maintain a constant push.
- c) Continually increase the strength of the push.
- d) Continually decrease the strength of the push.
- e) Something else, you describe it.

Explain:

5) Instead of maintain a constant speed you now want to continuously increase the chairs speed. What do you have to do to make this happen?

- a) Give it a push from behind and immediately let go.
- b) Maintain a constant push.
- c) Continually increase the strength of the push.
- d) Continually decrease the strength of the push.
- e) Something else, you describe it.

Explain:

Resting (Day 2)

Objectives:

- 3) Students will be able to recognize that objects at rest still have forces applied to them.
- 4) Students will be able to show forces acting on an object using a Free Body Diagram (FBD).

Materials needed for the Lesson:

30 copies of Resting Activity
Spring Scales
Force Meters attached to computer
Wooden Blocks
Heavy Book
Whiteboard

Source of lessons:

Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity
II-E: Connections between Force and Motion.

Lesson procedure:

<u>Timeline</u>	<u>Teachers Role</u>	<u>Students Role</u>	<u>Teacher notes</u>
< 2 mins	Explain to the students that they will be doing an activity that allows them to investigate objects at rest. The activity will be collected at the end of the period.	Get into their seats and get ready to begin class. They can pose any lingering questions from the previous day.	
10 mins	Re-visit the book demo from yesterday. Pose, “There are forces acting on the book, so why isn’t it moving?”	Participate in discussion.	Beware of misconceptions dealing with “force = motion”.
5 mins	Introduce them to the activity for the day. Then handout activity packets.	Students will get into their lab groups of 3.	Might need to explain proper use of spring scale.
30 mins	Float around room monitoring the groups while they complete the activity. If groups are stuck, try to guide in right direction without giving them the answers.	The students will follow the activity packet. They will record everything in the packet.	Make sure everyone in the group is participating. Keep an eye out for off-task behavior.
5 mins	Lead discussion on the day’s activity and findings. -Were students surprised by the activity? -Do forces always result in motion? -Balanced vs UnBalanced	Participate in the discussion. Be respectful to others when they are talking.	Keep discussion relevant.

6) Setup this situation with the block. What did you observe about the forces? Why did this happen? Draw a FBD for the block in this situation.

7) Attach spring scales to opposite sides of the wooden block. One group member will pull on each of the spring scales in an effort to not move the block. What is true about the force exerted on each scale? Draw a FBD

8) Now imagine that the third group member joins with one of the two, who are already pulling. In order for the block to stay at rest, what must happen to:

a. The force exerted by the lone student.

b. The force exerted by the joined student.

9) Setup this situation with the block. What did you observe about the forces? Why did this happen? Draw a FBD for the block in this situation.

10) Use your data to formulate a general statement (idea) which tells how the strengths and directions of the forces acting on an object must be related if the object at rest is to remain at rest.

11) You overhear two students, Marcia and Fernando, having a heated discussion about what they expect would happen when several different forces are acting simultaneously on an object:

Marcia: "The strongest force is all that counts. It dominates the others. When several forces act on an object, the object will be influenced only by the strongest force."

Fernando: "No, you cannot ignore the other forces. They all have an influence. What you have to do is simply add the strengths of all the individual forces to come up with the total force."

Do you agree with Marcia, Fernando, with both, or neither? Explain your reasoning.

Forces & Motion (Day 3)

Objectives:

- 5) Students will be able to analyze the effect force has on motion.
- 6) Student will be able to relate graphical representations of speed, acceleration, and force.
- 7) Students will be able to show forces acting on an object using a Free Body Diagram (FBD).

Materials needed for the Lesson:

30 copies of Forces & Motion Activity
Carts
Tracks for carts
Motion detector

Source of lessons:

Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity
II-E: Connections between Force and Motion.
PET, 2005, Activity 2: Motion and Energy.

Preconceptions Addressed:

- III) If a body is in motion there is a force acting on it in the direction of motion.
- IV) Forces are a property of an object.
- V) Forces can be stored and used up later.

Lesson procedure:

<u>Timeline</u>	<u>Teachers Role</u>	<u>Students Role</u>	<u>Teacher notes</u>
< 2 mins	Explain to the students that they will be investigating the effects of forces on an object's motion. The activity will be collected at the end of the period.	Get into their seats and get ready to begin class. They can pose any lingering questions from the previous day.	
5 mins	Introduce them to the activity for the day. Then handout activity packets.	Students will get into their lab groups of 3.	Might need to explain proper use of motion detectors or troubleshoot problems with motion detectors.
40 mins	Float around room monitoring the groups while they complete the activity. If groups are stuck, try to guide in right direction without giving them the answers.	The students will follow the activity packet. They will record everything in the packet. They will attach tables and/or graphs made on the computer.	Make sure everyone in the group is participating. Keep an eye out for off-task behavior.
5 mins	Lead discussion on the day's activity and findings. -Were students surprised by the activity? - After object is released from a push/pull does the force of the push/pull continue to affect the object? - I thought that forces always acted in the direction of motion, so why didn't the cart reverse direction when I applied a backward tap? - Looking at the speed vs time graphs, after you let the cart go, why do you think it lost speed?	Participate in the discussion. Be respectful to others when they are talking.	Keep discussion relevant.

Name: _____

Force & Motion Activity

In the last activity you explored the conditions necessary to keep an object at rest. In this activity you will begin to explore how a force influences the motion of an object.

- 12) Set up the cart and track. The cart and track are designed to allow the cart to move along the track with very little resistance. Try giving the cart a **brief, moderately strong push** with your finger, so that after it leaves your finger it will travel along the track without noticeably speeding up or slowing down. (If it does not do that, try leveling the track.)
- 13) For the situation described above, sketch what you think the speed-time graph would look like. Indicate on the graph the point where you released the cart.

- 14) Now open the Force-Motion file on the desktop to access the motion detector. Reproduce the situation from Step 1, recording the speed with the motion detector. Sketch the graph below.

- 15) Now predict by sketching a separate speed-time graph for each of the following cases. For every graph, indicate the region(s) in which a finger is in contact with the cart.
 - 1) Starting at one end of the track, gently tap the cart to start it moving. Let it travel a short distance then tap it gently again. Let it travel some more and give it one final gentle tap.

Force and Mass (Day 4)

Objectives:

- 8) Students will be able to state the relationship between force and mass.
- 9) Students will be able to state how mass affects acceleration.
- 10) Students will be able to show forces acting on an object using a Free Body Diagram (FBD).

Materials needed for the Lesson:

30 copies of Force and Mass activity
Carts
Tracks for carts
Fans that can attach to the carts
Heavy Blocks
Motion Detectors

Source of lessons:

Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity
II-D4: Affects of Force and Mass.

Lesson procedure:

<u>Timeline</u>	<u>Teachers Role</u>	<u>Students Role</u>	<u>Teacher notes</u>
< 2 mins	Explain to the students that they will be investigating the relationship between force, mass and acceleration. Use this time to answer any lingering questions.	Get into their seats and get ready to begin class. They can pose any lingering questions from the previous day.	
5 mins	Introduce them to the activity for the day. Restate the safety issues with the fans. Do not leave the fans on for extended periods of time.	Students will get into their lab groups of 3 and gather the materials needed for the days activity.	Might need to explain proper use of the fans.
30 mins	Float around room monitoring the groups while they complete the activity. If groups are stuck, try to guide in right direction without giving them the answers.	The students will follow the activity packet. They will record everything in the packet. If they don't get to the paragraph at the end this is homework.	Make sure everyone in the group is participating. Keep an eye out for off-task behavior, especially with the fans. Fans do have the chance of injuring a student so have band-aides in the classroom.
15 mins	At this point it is advantageous to lead a discussion with the class about the concepts and ideas they have developed over the past 4 days since the next activities depend on their understanding of the previous material..	Participate in the discussion. Share question they may have or anything they are still confused about. Listen to other students ideas and be willing to ask questions or critique these ideas.	Use this discussion as a way to assess student understanding thus far. If students are stuck try to bring in the activities they have been doing to help them wade through the confusions. Remind them that if they didn't finish the paragraph at the end of the activity that it is homework.

Name: _____

Force & Motion Activity

In the previous activities we have seen that an object accelerates when there is unbalanced force acting on it. In the first part of this activity you simply to experiment with the fans and carts in order to propose an idea for how the **acceleration** of an object is affected by the **strength** of the unbalanced force, and the **mass** of the object.

1) Describe your experiments and your observations below. State what you believe to be the relationship between acceleration, unbalanced force, and mass.

2) Give an empty cart a shove and notice how much effort is involved. Next place two heavy blocks on the cart and give it a shove. How does the effort differ between the two situations?

Why do you think there is a difference?

3) All objects have a tendency to resist motion. This resistance to changing its motion is usually called **Inertia**. Objects with greater inertia have a greater resistance to motion. In the case of the two cart situations above which set up has the greatest inertia and why?

4) From the above activity what can you say about the effect of mass on the acceleration of an object assuming that the unbalanced force is kept the same? Explain your answer in terms of **Inertia**.

5) For the next activity you will need to pair up with another group. Place a cart and fan on one track. On the other track place two carts on top of each other and place the fan on the top cart.

Suppose you were to turn on the fans and give each set up an equally strong push in the opposite direction that the fan is blowing. Which set up do you predict will slow down quicker and why? Also, draw a speed vs. time graph for each situation.

6) Set up and test your predictions. Was your prediction correct? Use a motion detector to record the speed vs. time graphs for the two situations. If your predictions do not match your observations how can you make sense of the results?

7) From this activity you should have seen a relationship between mass, inertia and an unbalanced force. Explain this relationship in a one paragraph summary. Be sure to use evidence from this activity to support your conclusions.

Combining Forces (Day 5)

Objectives:

- 11) Students will be able to state how individual forces combine to create the net Force on an object.

Materials needed for the Lesson:

30 copies of Combining Forces activity
Blocks of wood
Spring scales

Source of lessons:

Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity
II-D6: The Effects of Combining Forces.

Preconceptions addressed:

- IV) Only the largest force matters. It dominates the situation.
- V) Large objects exert a greater force than smaller objects

Lesson procedure:

<u>Timeline</u>	<u>Teachers Role</u>	<u>Students Role</u>	<u>Teacher notes</u>
< 2 mins	Explain to the students that they will be investigating how individual forces combine in order to create a net force on an object.	Get into their seats and get ready to begin class. They can pose any lingering questions from the previous day.	
40 mins	Float around room monitoring the groups while they complete the activity. If groups are stuck, try to guide in right direction without giving them the answers.	The students will follow the activity packet. They will record everything in the packet. When they have designed their own experiment get the attention of an instructor.	Make sure everyone in the group is participating. Keep an eye out for off-task behavior. Be sure to check in with the groups when they design their own experiment.
10 mins	Be sure to explain to students that they have homework to do and that it is due the next day. Ask students to share the rule they have developed for how forces combine and if they have any questions about the activity.	Participate in the discussion. Share the rule they developed for how forces combine. Be willing to defend their rule by using evidence from today activity.	Use this discussion as a way to assess whether students met the goal of the activity. Hand out the homework and write in on the board for added emphasis.

9) Set up and test your prediction. Did your prediction agree with the outcome? If not explain what incorrect assumption you made.

Post Test

Name: _____

Two students have just finished watching a hockey game when one student says to the other:

“I learned in science that as long as I push a hockey puck across the ice with a constant force, then the puck will continually speed up. However, last weekend I was playing roller blade hockey in a parking lot with some friends. One of the players passed the puck to me. When the puck slid past I started applying a constant force with my stick as I moved towards the goal. But, the puck didn’t speed up. Its speed just stayed constant the whole time I was pushing it. I guess science doesn’t really apply in the real world.”

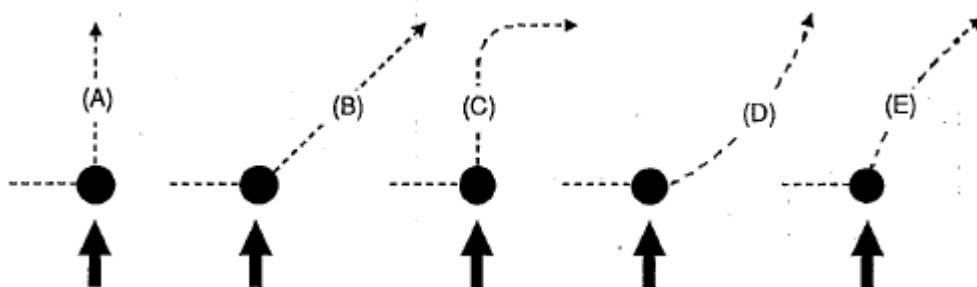
1) Can you help the student solve this dilemma? Write your explanation in the space below.

Use the statement and diagram below to answer the next four questions:

The diagram depicts a hockey puck sliding with a constant velocity, from point a to point b along a frictionless horizontal surface. When the puck reaches point b; it is instantaneously hit by a player in the direction of the heavy arrow.



2) Along which of the paths below will the hockey puck move after being hit?



- 3) The speed of the puck just after being hit is
 - a. Equal to the speed it had before being hit.
 - b. Equal to the speed it acquires from the hit.
 - c. Equal to the sum of the speeds (speed before hit + speed from hit).
 - d. Smaller than either speed before hit or speed from hit.

- 4) Along the frictionless path you have chosen, how does the speed of the puck vary after the hit?
 - a. No change.
 - b. Continuously increasing
 - c. Continuously decreasing
 - d. Increase for awhile and then decreasing
 - e. Constant for awhile then decreasing.

- 5) The main forces acting, after the hit on the puck along the path are:
 - a. The downward force due to gravity and the effect of air pressure.
 - b. The downward force of gravity and the horizontal force of momentum in the direction of motion.
 - c. The downward force of gravity, the upward force exerted by the surface and the horizontal force acting on the puck in the direction of motion.
 - d. The downward force of gravity and the upward force exerted on the puck by the surface.

Performance Task Blueprint

What understandings/goals will be assessed through this task?

Through this task, students will show their understanding of how forces act on and create motion in everyday situations. This task is designed to allow students to explore how physics works in situations outside of a lab. Students will also be given the opportunity to practice the scientific method when designing, carrying out, and analyzing an experiment of their choice.

What criteria are implied in the standard(s)/understanding(s) regardless of the task specifics? What qualities must student work demonstrate to signify that standards were met?

Use of the Scientific method
Detailed and accurate recording of data
Use of past physics knowledge to strengthen and support evidence of findings

Through what authentic performance task will students demonstrate understanding?

You are an alien from Zordon who has been sent by the great and powerful Oz, to investigate the motion of objects on the planet Earth. Oz wants to know whether or not the physics of Earth are the same as on Zordon. Therefore, it is up to you and your accomplice to investigate the motion of an object or objects of your choice. It is your job to write up a report with your findings describing the forces at work and how they are affecting the motion of that object. But beware; Oz is a very detailed ruler. He will want complete explanations, graphs, diagrams, step by step explanations of your experiment and any other important findings in the report. Finally, he has requested a conference to be held for each exploring team to share their findings with the whole community of Zordon.

What student products/performances will provide evidence of desired understandings?

1. Detailed explanation of the experiment
2. Graphs showing the acceleration, and speed of the object under various forces
3. Data tables
4. Explanations of all the forces acting on the object and how they affect the motion of the object.
5. A report containing all of the above information.

By what criteria will student products/performances be evaluated?

A rubric which will be handed out to the class before the start of the task. The rubric will assess the students in the following areas:

- Explanation of the experiment
- Ability to identify and explain how the forces affect motion
- Graphs of acceleration and speed showing the affects of various forces
- Appearance of the report
- Presentation