SCIENCE ACTIVITY UNIT – DOUGLAS KOLODNY

UNIT INTRODUCTION: This purpose of this unit is to have students explore the concepts of force and motion. The key concepts covered will be speed, velocity, distance vs. time graphing techniques, gravity, potential energy, kinetic energy. The goal is to create a unit which is student centered, project-based and placed the teacher in a more facilitative rather than "teaching" role. The material in the unit is a conglomerate of original work, curriculum from the ARIES Series created at the Harvard-Smithsonian Center for Astrophysics, the FOSS Series created by Delta Education, the National Science Education Standards, Physics: A World View by Kirkpatrick & Wheeler (reference for factual information) and the Massachusetts Department of Education Science and Technology/Engineering Curriculum Frameworks.

BRIEF DESCRIPTION OF STUDENT TO BE TAUGHT: 7TH grade science students, all ability levels, with inclusion. A class size of 20 students to allow groups of four students in each group. The inclusion students include those with learning disabilities, behavioral issues, or a combination of both. The students with IEP's are limited to one per group with a Teachers Aid always present in the classroom. Lesson #4 was taught to four separate classes (four block team) over a two day period at JFK Middle School in Hudson, MA.

Lesson #1 Galileo's "thought" experiment – all objects fall at the same rate

Brief Description of Group to be taught:

- 7th grade
- Four blocks of 20 students per block – 80 students total
- Each block will be in five groups of four students
- Inclusive classroom – students of all levels will be intermixed in the groups
- Two of the blocks have no students on IEP's and two blocks have two to three students on IEP's (learning disabilities, behavioral issues, or a combination of both.)
- If possible there will be no more than one IEP student per group

Relationship of this Lesson to the unit:

- This is the first lesson in the Force and Motion Unit.

Massachusetts Curriculum Frameworks:
Grades 6-8 Physical Science

- Learning Standard 11: Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.

Concepts:

- Students will be exposed to the concept that all objects will fall at the same rate and thus hit the ground at the same time when dropped from the same height at the same time.
- Students will be exposed to the concept of gravity.

Processes:

- Observing
- Measuring

Science Habit of Mind:

- Open minded, willing to change mind in the face of reliable evidence, and respect another's point of view.

Other Subject Area Objectives:

- Mathematics – Using numbers, Measuring

Session Length:

- One 90 minute class period

Materials needed: (Per group of 4)

- ❑ Meter Stick
- ❑ Racquetball (round hollow rubber sphere)
- ❑ Students Science Journals – for recording observations
- ❑ Pencil
- ❑ Stopwatch
- ❑ Baseball (solid core hardball traditionally used in professional baseball)
- ❑ Scale
- ❑ Calculators

TIME	PROCEDURE	CONCEPT
9 to 9:05	Introduction: Ask class, by raising their hands, who has gone apple picking? Ask what they see when they look at an apple tree? Answers I hope to get are apples in the tree and apples on the ground. Ask students to think about how apples got on the ground.	
9:05 to 9:45	Have students break into groups of four. Have each group count off one to four and then the teacher will assign each number as a getter, starter, recorder or reporter/observer. Explain the role of each student to the class – getter (gets all materials for the group), recorder (reminds all group members to write down their data, ideas, or questions – this may be done by one student as long as at the end of class each student gets to copy the notes of the recorder), starter (ensures that each team member stays on task), and reporter (will share the team's findings with the rest of the class). Explain to students that they will be provided with the materials (listed under materials above). Each ball will be in a plastic cup. Explain to students that the balls must remain in the cups unless being used in the activity. Point out the need for trust and that each student should be participating and every team member's ideas taken seriously. Explain that each group taken together represents a community of scientists attempting to make discoveries utilizing the material provided in the classroom. • Have getters get materials. Ask the individual participants to make a prediction first about what will happen and then why they think it will happen**. (**"**If, then**" statements) Have each group member share with others in their group their "if, then" statements and as a group test their predictions. • Groups will work with the materials provided. Each group will attempt different experiments depending on their view of what the purpose of the activity is. • The teacher will walk around classroom and observe, but not make any comments. The teacher will only answer questions asked by the students. The teacher will not tell the groups what to do and not tell them if what they	Roles and groups. Community of learners Concept or skill or habit of mind

	are doing is the right thing to do. • If the students are on task, they will do the following: 1. Getter will get the materials. 2. One student will hold the two balls, one in each hand at a specific distance from the floor – as measured by the meter stick. 3. One student will hold the ruler vertical to the floor. 4. One student will be the timer as the balls drop to the floor. 5. One student will record what is happening. 6. The student with the stop watch will say drop and start the timer. 7. The student with the stop watch will then stop the timer when the balls hit the floor. 8. The students may observe that one ball lands first and stop the watch at that time. There will be many variations in different groups. 9. Students will discuss their observations and see if the group can come to a consensus on what has occurred and what the purpose of the activity is. 10. Each group comes up with questions they were trying to answer and what answers they found.	
9:45 to 10:15	• Reporters share each group's ideas with the class. • Teacher will facilitate a discussion regarding what each group found and what turned out different than they expected. • Have reporters share their questions and answers with the class. Teacher will write them on the board. • Have students come up with reasons why the results came out as they did. For example, why did both balls land at the same time?	Misconceptions Having students be overt about describing their reasoning for their decision
10:15 to 10:25	Teacher will spend next ten minutes discussing the concepts. Explain that there are factors that may have prevented the balls from landing. If not already discussed by students, ask students what these factors may be. Explain to students that the experimental result was verified in 1971 when an Apollo 15 astronaut dropped a feather and a hammer simultaneously from the same height above the Moon's. Explain that on the moon the factors that are present that corrupt the experiment are not present on the surface of the moon (no atmosphere). Hand out worksheet for Lesson #1 for the students to hand at the beginning of the next class.	
10:25 to 10:30	Have students clean up the room in an orderly fashion. Remind the students that the tables and floors must be clean so that the next class will have a clean work environment or the janitor will not have to do more than vacuum and wipe down tables after school.	

Assessment

	Novice	Competent	Expert
Process Skill	Will not carefully document observations and will not question what is occurring and why.	Will document observations, but will not be curious about different methods of experimentation. Will understand that there may be reasons why the balls fall at different rates.	Will carefully document observations and create charts of different distances and record the times at different distances. Will try other objects, such as a book and a ball instead of simply two balls.
Habit of Mind	Not working as group of four and dismissing opinions of some group members.	Will work as group and listen to each others ideas.	Will work as group and listen to each others ideas and a member of the group will explore what the other groups are doing.
Concept	Will not understand that the two objects fall at the same time when intervening factors are removed. If their balls do not land at same time, will believe that heavier objects hit floor first.	Will accept the notion that all objects will land at the same time but not understand why?	Will accept the notion that all objects will land at the same time and understand why.

FORCE AND MOTION UNIT

Lesson #1 Worksheet

Name:
Date:

1. Free fall near the surface of the moon can be described as motion with a constant_____.

2. If we ignore air resistance, acceleration during free fall is constant. How do you suppose the acceleration would change if we do not ignore air resistance? Why?

3. A penny and a feather are placed inside a long cylinder and the air is removed. The cylinder is placed so that the cylinder is vertical to the ground and the penny and feather are at the top of the cylinder. Which hits the bottom of the cylinder first – the penny or feather? Why?

4. What happens to the acceleration of a ball in free fall if its mass is doubled? Why?

Lesson #2 Gravity

Brief Description of Group to be taught:

- 7th grade
- Four blocks of 20 students per block – 80 students total
- Each block will be in five groups of four students
- Inclusive classroom – students of all levels will be intermixed in the groups
- Two of the blocks have no students on IEP's and two blocks have two to three students on IEP's (learning disabilities, behavioral issues, or a combination of both.)
- If possible there will be no more than one IEP student per group

Relationship of this Lesson to the unit:

- This is the second lesson in the Force and Motion Unit.

Massachusetts Curriculum Frameworks:
Grades 6-8 Physical Science

- Learning Standard 12: Graph and interpret distance vs. time graphs for constant speed.

Concepts:

- Students will be further exploring the concept of gravity and Galileo's "thought" experiment to understand that all objects will fall at the same rate and thus hit the ground at the same time when dropped from the same height at the same time.

Processes:

- Using space/time relationships
- Using numbers
- Measuring

Science Habit of Mind:

- Open-minded, willing to change your mind in the face of reliable evidence, and respect another's point of view.

Other Subject Area Objectives:

- Mathematics – Using numbers, measuring, graphing

Session Length:

- One 90 minute class period

Materials needed: (Per group of 4)

- ❑ Meter Stick
- ❑ Racquetball (round hollow rubber sphere)
- ❑ Students Science Journals – for recording observations
- ❑ Pencil
- ❑ Stopwatch
- ❑ Baseball (solid core hardball traditionally used in professional baseball)
- ❑ Graph paper
- ❑ Calculators

TIME	PROCEDURE	CONCEPT

9 to 9:15	Introduction: Ask class, by raising their hands, what will happen if I hold a ball (one baseball and one racquetball) in each hand, the same distance from the floor and then drop them at the same time? Explain to students that today we will be doing an experiment similar to the one we did last time we had class. Teacher will introduce to students that the experiment conducted was first discovered by Galileo in the 17th century and verified in 1971 by the Apollo 15 astronaut. Ask the class, by raising hands, to answer why it took a trip to the moon to verify Galileo's results? Explain to class that for this class the recorder will be recording the distance the ball travels and the time it takes to reach the floor. Then the ball will be dropped but this time the timer will be stopped at different distances from the floor. Teacher will explain that the students will be creating distance vs. time graphs. Teacher will explain that only pencils will be used so that errors can be corrected without having to start over.	
9:15 to 9:45	Have students break into groups of four. Have each group count off one to four and then the teacher will assign each number as a getter, starter, recorder or reporter/observer. Explain the role of each student to the class – getter (gets all materials for the group), recorder (reminds all group members to write down their data, ideas, or questions – this may be done by one student as long as at the end of class each student gets to copy the notes of the recorder), starter (ensures that each team member stays on task), and reporter (will share the team's findings with the rest of the class). Explain to students that they will be provided with the materials (listed under materials above). Each ball will be in a plastic cup. Explain to students that the balls must remain in the cups unless being used in the activity. Point out the need for trust and that each student should be participating and every team member's ideas taken seriously. Explain that each group taken together represents a community of scientists attempting to make discoveries utilizing the material provided in the classroom. • Have getters get materials. Ask the individual participants to make a prediction of what the graphs will look like. Have each group member share with others in their group their graphs and as a group test their predictions. • Groups will work with the materials provided. The teacher will walk around classroom and observe, but not make any comments. The teacher will only answer questions asked by the students. The teacher will not tell the groups what to do will not tell them if what they are doing is the right thing to do. • If the students are on task, they will do the following: 11. Getter will get the materials. 12. One student will hold a ball a specific distance from the floor – as measured by the meter stick. Some groups may think they have to drop both balls at the same time for this activity. 13. One student will hold the ruler vertical to the floor. 14. One student will be the timer as the ball drops to the floor. 15. One student will record what is happening. 16. The student with the stop watch will say drop and start the timer. 17. The student with the stop watch will then stop the timer when the ball hits the floor. 18. Students will record their observations and see if the group can come to a consensus on what the graph looks like and compare to their predictions.	Roles and groups. Community of learners Concept or skill or habit of mind
9:45 to 10:15	• Reporters share each group's graphs with the class. • Teacher will facilitate a discussion regarding what each group found and	Misconceptions

	what turned out different than they expected. • Have students come up with reasons why the results came out as they did.	Having students be overt about describing their reasoning for their decision
10:15 to 10:25	Teacher will spend next ten minutes discussing graphing. Teacher will explain that there is an x and y axis and that they must be labeled properly. There also must be a title at the top of the graph and that each segment on the x or y axis must be identified. The teacher will also discuss best fit lines. The teacher will inform the class that for homework they must finish the graphs so that they follow the rules about graphing discussed at the beginning of class. Graph due at next class.	
10:25 to 10:30	Have students clean up the room in an orderly fashion. Remind the students that the tables and floors must be clean so that the next class will have a clean work environment or the janitor will not have to do more than vacuum and wipe down tables after school.	

Assessment

	Novice	**Competent**	**Expert**
Process Skill	Will not carefully document observations and will not properly graph results.	Will carefully document observations, but will not draw a best fit line properly.	Will carefully document observations and will properly create graph with best fit line. Will understand why use best fit line instead of connecting the dots.
Habit of Mind	Not working as group of four and dismissing opinions of some group members.	Will work as group and listen to each others ideas.	Will work as group and listen to each others ideas and a member of the group will explore what the other groups are doing.
Concept	Will not understand why the dots do not form straight line and rather than redo experiment utilize results achieved.	Will understand why the dots do not form straight line and redo experiment.	Will understand why the dots do not form straight line and before redoing experiment try to determine what caused the problems.

Lesson #3 Speed (FOSS Force and Motion Course Matrix #2-Middle School)

Brief Description of Group to be taught:

- 7th grade
- Four blocks of 20 students per block – 80 students total
- Each block will be in five groups of four students
- Inclusive classroom – students of all levels will be intermixed in the groups
- Two of the blocks have no students on IEP's and two blocks have two to three students on IEP's (learning disabilities, behavioral issues, or a combination of both.)
- If possible there will be no more than one IEP student per group

Relationship of this Lesson to the unit:

- This is the third lesson in the Force and Motion Unit.

Massachusetts Curriculum Frameworks:
Grades 6-8 Physical Science

- Learning Standard 11: Explain and give examples of how motion of an object can be described by its position, direction of motion, and speed.

Concepts:

- Students will learn that speed is the rate at which an object changes position. They gather data from cars rolling down ramps and representations of moving vehicles to investigate and solve speed problems. They will create and analyze distance vs. time graphs. Students will learn that speed is the rate of change of position of an object. $v=d/\Delta t$

Processes:

- Using space/time relationships
- Using numbers
- Measuring
- Observing

Science Habit of Mind:

- Respect for Evidence: A desire for accuracy and precision in observation and measurement; Valuing and practicing the use of data, evidence, and reason in the construction of explanations; Valuing and practicing accuracy and precision in explanation.

Other Subject Area Objectives:

- Mathematics – to solve problems involving unknown quantities.

Session Length:

- Two 90 minute class periods

Materials needed: (Per group of 4)

- ❑ Meter Stick
- ❑ Cars (provided in FOSS kit)
- ❑ Long flat wide plastic strips to use as track (provided in FOSS kit)
- ❑ Students Science Journals – for recording observations
- ❑ Pencil
- ❑ Stopwatch

- ❑ Calculators
- ❑ Graph paper
- ❑ Textbooks or other thick books such as dictionaries

TIME	PROCEDURE	CONCEPT
9 to 9:30	Introduction: Hand back the Lesson #1 worksheet and ask the students to take out their graphs. Go over answers to worksheet by asking for students to raise their hands and provide their answers to the questions. Have the starter from each group, one at a time, discuss their graphs and show their results with all details. Ask class, by raising their hands, to comment on each graph presented as they are presented. Before proceeding to next part of unit make sure that the students understand the concepts presented so far and have a full understanding of what is expected of the students when they create distance vs. time graphs.	Community of learners Roles and groups.
9:30 to 10:25	Have students break into groups of four. Have each group count off one to four and then the teacher will assign each number as a getter, starter, recorder or reporter/observer. Explain the role of each student to the class – getter (gets all materials for the group), recorder (reminds all group members to write down their data, ideas, or questions – this may be done by one student as long as at the end of class each student gets to copy the notes of the recorder), starter (ensures that each team member stays on task), and reporter (will share the team's findings with the rest of the class). Explain to students that they will be provided with the materials (listed under materials above). Each ball will be in a plastic cup. Explain to students that the balls must remain in the cups unless being used in the activity. Point out the need for trust and that each student should be participating and every team member's ideas taken seriously. Explain that each group taken together represents a community of scientists attempting to make discoveries utilizing the material provided in the classroom. • Have getters get materials. Ask the individual participants to make a prediction first about what will happen and then why they think it will happen**. ("If, then"** statements) Have each group member share with others in their group their "if, then" statements and as a group test their predictions. • Groups will work with the materials provided. Each group will attempt different experiments depending on their view of what the purpose of the activity is. • The teacher will walk around classroom and observe, but not make any comments. The teacher will only answer questions asked by the students. The teacher will not tell the groups what to do and not tell them if what they are doing is the right thing to do. • If the students are on task, they will do the following: 19. Getter will get the materials. 20. Each group will put a book under the track and one end and have the other end sitting on the table. 21. Each group will place the meter stick along the side of the track. 22. Each group will place the car at the end of the track with the book under it. 23. One student will be the timer and will tell the student holding the car when to let go. 24. The student with the timer will stop the timer when the car reaches the end of the track. 25. Each team will record the distance traveled and the time it took.	

	26. Each team will then repeat this but this time recording how long it takes for the car to reach various points on the slope. 27. Each group will repeat these steps using more and more books at one end. 28. Each group will them create graphs of their results. 29. Each group will discuss if their predictions were correct and why.	
10:25 to 10:30	Have students clean up the room in an orderly fashion. Remind the students that the tables and floors must be clean so that the next class will have a clean work environment or the janitor will not have to do more than vacuum and wipe down tables after school.	
9:00 to 10:00	Teacher will start class by asking students to get back into their groups from last class. The students will then count off from one to four and the teacher will assign a task for each number - getter, starter, reporter/observer, recorder. Teacher will then ask that the recorder from each group, one at a time, present their graphs. The class will then comment on each groups results.	
10:00 to 10:25	After groups have shared their results, the teacher will write the following questions on the board, one at a time, discussing each one as they are being written down: 1. Do you think all the strategies were equally effective? 2. Did each strategy get the same results? Why or why not? 3. Can you think of a way to make your measurements more accurate? 4. Can you think of anything we might add to the track setup to help everyone know when to start and stop timing? Teacher will select a student to record the students' ideas and affirm their efforts in creative problem solving.	
10:25 to 10:30	Teacher hands out Activity #3 Worksheet and tells students that they will be collected at the beginning of the next class.	

Assessment

	Novice	Competent	Expert
Process Skill	Will not carefully document observations and will not properly graph results.	Will carefully document observations, but will not draw a best fit line properly.	Will carefully document observations and will properly create graph with best fit line. Will understand why use best fit line instead of connecting the dots.
Habit of Mind	Not working precisely so the results are accurate.	Working and observing results carefully so obtain results.	Working and observing results carefully so that obtain results accurately.
Concept	Does not understand that concept is to measure the speed of the car and the resultant acceleration as it moves down incline.	Understands that concept is to measure the speed of the car but not that it accelerates as it moves down incline.	Understands that concept is to measure the speed of the car and understands that it it accelerates as it moves down incline. Understands that the larger the incline the greater the acceleration.

Lesson #3 Worksheet

Name:
Date:

5. What does the shape of your graph tell you about the behavior of a car moving down an inclined track? Explain.

6. What effect does increasing the incline of the track have on the car? Explain.

7. How could you use a graph to predict what would happen if you started a car at a new point on the incline track? Explain.

8. What can you infer about how the speed of the car at the bottom of is affected by the starting point of the incline? Explain.

9. How do you think the motion of a falling object compares with the motion of a car rolling down an incline track? Explain.

<u>Lesson #4 Roller Coaster</u>

Brief Description of Group to be taught:

- 7th grade
- Four blocks of 20 students per block – 80 students total
- Each block will be in five groups of four students
- Inclusive classroom – students of all levels will be intermixed in the groups
- Two of the blocks have no students on IEP's and two blocks have two to three students on IEP's (learning disabilities, behavioral issues, or a combination of both.)
- If possible there will be no more than one IEP student per group

Relationship of this Lesson to the unit:

- This is the fourth lesson in the Force and Motion Unit.

Massachusetts Curriculum Frameworks:

Grades 6-8 Physical Science

- Learning Standard 13: Differentiate between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vise versa.

Grades 6-8 Technology/Engineering

- Identify and explain the steps of the engineering design process, i.e. identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

Concepts:

- Mechanical energy is associated with a moving mass or the potential action of a force being applied through a distance. The two forms of mechanical energy that are relevant to the understanding of how a roller coaster works are gravitational potential energy and kinetic energy. As the roller coaster glides down each hill, the gravitational potential energy is converted into kinetic energy and you and the car go faster and faster.

Processes:

- Modeling
- Experimenting

Science Habit of Mind:

- Look at a matter from many sides before drawing a conclusion. Do not jump to conclusions or decide on the basis of one observation; deliberate and examine until you are as sure as you can be.

Other Subject Area Objectives:

- Art – building a model of a roller coaster

Session Length:

- Two 90 minute class periods

Materials needed: (Per group of 4)

- ❑ Corrugated cardboard cut into strips
- ❑ Racquetball (hollow rubber ball)
- ❑ Masking Tape

- ❑ Students Science Journals – for recording observations
- ❑ Pencil
- ❑ Scissors
- ❑ Plastic cups of various sizes

TIME	PROCEDURE	CONCEPT
9 to 9:10	Introduction: Teacher asks class to imagine that they are at the amusement park and it is summer. Show five minute roller coaster video of various types of roller coasters at different amusement parks.	.
9:10 to 9:15	Teacher explains that students will be designing and constructing roller coasters. Explain that it will not be a closed loop but a start and a finish point like in the picture. (Show picture of roller coaster with three hills that are all the same size.) Tell students that once the roller coaster reaches the top of the first hill that there is no motor or device moving the cars. The roller coaster is coasting until it gets to the end.	.
9:15 to 10:00	Break up class into groups of four students. Have each group count off one to four and then the teacher will assign each number as a getter, starter, recorder or reporter/observer. Explain the role of each student to the class – getter (gets all materials for the group), recorder (reminds all group members to write down their data, ideas, or questions – this may be done by one student as long as at the end of class each student gets to copy the notes of the recorder), starter (ensures that each team member stays on task), and reporter (will share the team's findings with the rest of the class). Discuss with students how their roller coasters will have to be constructed so that at the beginning (point to the top of first hill) they will let go of their ball and the object is for it to coast to the end (point to the end of the coaster) without any other assistance. Have each group design their roller coasters in groups. Have each student do it individually and then get together as a group. Have students consider the following when designing their roller coasters: - Can all the hills be the same height? If not, why? Can they get bigger or must they get smaller? How will you determine how big or how small the hills can be and still reach the end of the roller coaster? - Does the steepness of the hill count? Is it better to make the hills steep or not so steep? Why? - How curvy should the tops of the hills and the valleys be? Should you design sharp turns or smooth turns? Why?	Roles and groups.
10:00 to 10:30	Teacher will ask the reporter from each group to draw on the board what the group decided on for the design of their roller coaster. As each group reports their design, the entire class will discuss the designs of each group. The teacher will not make a determination as to which design will work, but will let the individual groups apply their designs in building their roller coasters. At the end of the class period the teacher will let the students know that they will have the first ten minutes of the next class to modify their designs if they would like to.	Community of learners
9:00 to 9:10	Teacher reminds class that they will be building roller coasters in class. Break up class into same group of four students as previous class. Have each group count off one to four and then the teacher will assign each number as a getter, starter, recorder or reporter/observer. Explain the role of each student to the	

	class – getter (gets all materials for the group), recorder (reminds all group members to write down their data, ideas, or questions – this may be done by one student as long as at the end of class each student gets to copy the notes of the recorder), starter (ensures that each team member stays on task), and reporter (will share the team's findings with the rest of the class). Discuss with students how their roller coasters will have to be constructed so that at the beginning (point to the top of first hill) they will let go of their ball and the object is for it to coast to the end (point to the end of the coaster) without any other assistance. Teacher explains that the class has until 9:10 to make any modifications to their roller coaster plans.	
9:10 to 10:00	Teacher will explain to class that they have 50 minutes to build their roller coasters. While the students are constructing their roller coasters teacher walks around the room to see what each group is building. Teacher observes but does not make any comments other than answering questions the students may have but does not tell students if what they are doing is right or wrong.	Concept or skill or habit of mind
10:00 to 10:05	Teacher explains that each group will now demonstrate their roller coasters. Teacher also emphasizes that this is not a competition and that if a group did not finish, that it is okay. The groups will demonstrate what they have completed.Once all groups have completed their roller coasters have each group do a quick demonstration of their roller coasters. 1. Have class come back together as one large group. 2. Hold tennis ball in hand with arm parallel to the ground. 3. Drop the tennis ball. 4. Ask students to describe what happened and why. 5. At this point teacher will facilitate discussion on the transfer of energy as the ball falls to the floor and as the roller coaster moves through its course.	

10:05 to 10:25	Have class come back together as one large group. Teacher asks class why the roller coasters worked the way they did? Students and teacher discussed different reasons why they performed the way they did. Teacher then holds arm straight out in front of him/her with ball in hand. Teacher asks the class why the ball is able to stay suspended in the air. The students will answer because the teacher is holding the ball. The teacher asks the students to predict what will happen if he/she opens his hand and releases the ball. The class will say that the ball will fall to the floor. Teacher lets go of the ball and it falls to the floor. Teacher asks the class if the ball had energy in it since the teacher simply let go of the ball and it fell to the floor. Some students will respond yes and some will respond no. The teacher then says, "if the ball had no energy how did it move?" The teacher will then facilitate a discussion on the transfer of energy as the ball falls to the floor and as the roller coaster moves through its course. The teacher discusses with the class that the energy that the energy that the ball has at the top of the roller coaster is called "potential energy" and since it is due to the pull of gravity, it is called "gravitational potential energy." The teacher then goes on to discuss the energy of motion which is called "kinetic energy" which will be confusing to the students. The students, when asked, will say that when the ball is at the end of the roller coaster or sitting on the floor it has no energy. The teacher has to try to explain that the potential energy is converted to kinetic energy so that the ball never loses energy, but instead has its energy converted from one type to another. Teacher gives students Lesson #4 Worksheet to complete and hand in at the beginning of the next class.	
10:25 to 10:30	Have students clean up the room in an orderly fashion. Remind the students that the tables and floors must be clean so that the next class will have a clean work environment or the janitor will not have to do more than vacuum and wipe down tables after school.	

Assessment

	Novice	Competent	Expert
Process Skill	Does not carefully plan roller coaster and it therefore does not work. Does not keep trying.	Carefully plans roller coaster and as a result it works even if through trial and error, but does not understand why.	Carefully plans roller coaster and as a result it works even if through trial and error, and understands.
Habit of Mind	Does not take time to plan and make incorrect assumptions based on prior knowledge.	Takes time to plan but does not understand that each consecutive hill has to be smaller than previous.	Takes time to plan and understands that due to the physical properties of PE and KE, each successive hill must be smaller than previous hill.
Concept	Does not understand that even though no apparent force is being exerted on ball that it has no energy or that once the ball stops it must have run out of energy.	Understands that gravity is acting on the ball to make it move but is having difficulty understanding the concepts of PE vs. KE.	Understands that gravity is acting on the ball to make it move as well as the concepts of PE vs. KE.

FORCE AND MOTION UNIT

Lesson #4 Worksheet

Name:
Date:

1. Relate the principle of “conservation of energy” in an analysis of a roller coaster ride from start to finish. Include in your discussion the names of all relevant energy forms and where and when on the ride energy transformations are occurring.

2. Imagine that you are among the first group of passengers to test out a newly constructed roller coaster. The slide down the first hill is thrilling, but before you get to the top of the second hill, you start sliding backward and get trapped between the first two hills. Discuss what practicalities the designer forgot to include in transforming his creation from the idealized blueprint to the real world.

3. Some roller coasters feature an upside-down “loop.” Explain why these features are always placed at the beginning of the ride and never near the end.

4. It is all fun and games until somebody gets hurt. Imagine that you are designing the world's ultimate roller coaster. Describe the features you would incorporate into your design and explain what limits you would put on those features to prevent fun from becoming dangerous.

Lesson #5 Roller Coaster Software Simulation

Brief Description of Group to be taught:

- 7th grade
- Four blocks of 20 students per block – 80 students total
- Each block will be in five groups of four students
- Inclusive classroom – students of all levels will be intermixed in the groups
- Two of the blocks have no students on IEP's and two blocks have two to three students on IEP's (learning disabilities, behavioral issues, or a combination of both.)
- If possible there will be no more than one IEP student per group

Relationship of this Lesson to the unit:

- This is the fifth lesson in the Force and Motion Unit.

Massachusetts Curriculum Frameworks:
Grades 6-8 Physical Science

- Learning Standard 11: Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.

Concepts:

- Through the use of a software simulation of a roller coaster, students will use their prior knowledge of gravity, potential energy and kinetic energy to design a closed loop roller coaster that works and be able to explain why it works.

Processes:

- Identifying and controlling variables.

Science Habit of Mind:

- Open minded, willing to change mind in the face of reliable evidence, and respect another's point of view.

Other Subject Area Objectives:

- Technology – software simulation

Session Length:

- Two 90 minute class period

Materials needed: (Per group of 4)

- ❑ One computer per group with Ultimate Ride Coaster Deluxe installed
- ❑ Students Science Journals – Notes on kinetic and potential energy from previous class lessons
- ❑ Pencil

TIME	PROCEDURE	CONCEPT
9 to 9:15	Introduction: Teacher will review some of the challenges students had when constructing their cardboard roller- coasters. Prompt students with the following questions: 1. Why did your coasters have to start with a hill? It needs enough potential energy to carry it to the end of the ride.	

	2. Why are loops placed at the beginning of the ride rather than at the end? So there is enough energy to get the cars completely around the loop. 3. What provides the energy to the cars at the beginning of your coaster? Your arm as it lifts the ball. 4. What provides the energy to move the cars to the first hill on a real coaster? A motorized track Teacher will then explain that in the real world engineers use computer programs to design and test roller coasters. The students' task is to design a roller coaster. The track style and environment is their choice. They may also choose props if they like. They will be working in the same groups of four that they were in when they constructed the cardboard roller coaster. Today the students goal is to learn how to use the software.	
9:15 to 10:25	Have students break into groups of four. Have each group count off one to four and then the teacher will assign each number as a getter, starter, recorder or reporter/observer. Explain the role of each student to the class – getter (gets all materials for the group), recorder (reminds all group members to write down their data, ideas, or questions – this may be done by one student as long as at the end of class each student gets to copy the notes of the recorder), starter (ensures that each team member stays on task), and reporter (will share the team's findings with the rest of the class). Explain that each group taken together represents a community of scientists attempting to make discoveries utilizing the material provided in the classroom. 30. Students will work in their respective groups in learning how to use the roller coaster simulation software. The teacher will walk around classroom and observe, and provide any assistance students require in learning how to use the software correctly	Roles and groups. Community of learners Concept or skill or habit of mind
10:25 to 10:30	Have students logoff of the computers and make sure that the room is clean for the next class or the janitor so he/she will not have to do more than vacuum and wipe down tables after school.	
9:00 to 10:00	Students will get into teams, log onto their respective computers and begin designing their roller coasters. Teacher will walk around and provide any assistance required by students.	
10:00 to 10:25	Each group will demonstrate their roller coaster simulations and class will discuss the concepts involved in the successful roller coaster simulation. Teacher will hand out Lesson #5 worksheet which will be due by the next class. Teacher will hand out Student Self-Assessment and explain that the self-assessment is required to be completed and handed in, but it will not be graded	
10:25 to 10:30	Have students logoff of the computers and make sure that the room is clean for the next class or the janitor so he/she will not have to do more than vacuum and wipe down tables after school.	

Assessment

	Novice	Competent	Expert
Process Skill	Is unable to work with simulation software so therefore can not complete assignment.	Is able to work with simulation software but has some difficulty with nuances of software.	Is able to master the software and therefore is able to create a working roller coaster as well as providing additional amenities to the simulation.
Habit of Mind	Not working as group of four and dismissing opinions of some group members.	Will work as group and listen to each others ideas.	Will work as group and listen to each others ideas and a member of the group will explore what the other groups are doing.
Concept	Does not have understanding of the concepts required to successful construct a successful simulation.	Has understanding of concepts enough that is able to create a successful simulation.	Fully understands concepts involved in roller coaster physics and therefore creates an entertaining simulation.

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Lesson #5 Worksheet

Name:
Date:

In the space below create a simple line diagram of your groups roller coaster. Label your coaster with the following:

1. Give each hill and loop a letter designation.
2. Label the height of each hill and loop.

Answer the questions in the space provided.

Roller Coaster Diagram

1. What is the greatest gravitational force experienced during a ride?

2. Where does this gravitational force occur on your coaster?

3. Describe the location of any chains or accelerators used in your design. Explain why you placed them where you did. If you did not use any chains or accelerators explain why these were not necessary.

4. Describe locations on your coaster where the cars have potential energy.

5. Where is potential energy the greatest?

6. Describe locations on your coaster where potential energy is transformed into kinetic energy.

7. Where is kinetic energy the greatest?

8. Explain in terms of kinetic and potential energy why the first hill must be the highest if chains and accelerators are not permitted on any other hill.

STUDENT SELF-ASSESSMENT

1. In which lessons did you learn the most? Why?

2. In general, which parts of the lessons did you like best: discussions, writing your own questions, building the models, using the things you built, using the software simulation, discussing the results, or writing what you learned? Explain why?

3. What did you like least? Explain why.

4. How do you rate yourself on the following: (10 = great, 1 = needs a lot of improvement)
    a. discussing ideas ____
    b. observing carefully ____
    c. making inferences from evidence ____
    d. recording events in sequence ____
    e. making predictions ____
    f. using tables to organize data ____
    g. drawing reasonable conclusions ____

5. What do you still want know more about?

6. Has your curiousity and interest in science increased? Why or why not?

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OBSERVATION CHART

Use the Observation Chart to assess a student's in-class work. You may wish to use the coding system below to describe the student's behavior.

Performance Codes: A = almost always
O = often
S = sometimes
N = never

Student's Name:
Date:

Performance Code	Student Performance
	1. Participates in class discussions
	2. Offers helpful comments on the ideas of others
	3. Pays attention to detail
	4. Demonstrates concern for validity of evidence
	5. Discerns inference from evidence
	6. Demonstrates curiosity
	7. Presents predictions, constructs hypotheses
	8. Records observations
	9. Collects and tabulates data carefully
	10. Records events in sequence
	11. Asks thoughtful questions
	12. Uses sketches as well as text
	13. Demonstrates reflection
	14.Demonstrates initiative in problem solving
	15. Reaches plausible conclusions
	16. Explains ideas

Additional Comments:
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4	The observations recorded during the procedures are complete and accurate. The writing and drawing of results show detail and accuracy in recording observations and show an understanding of the concepts that are developed through the lessons.
3	The observations recorded during the procedures are complete and usually accurate. The writing and drawing of the results include some accurate details and acceptable observations, but are missing some information or contain a few errors. Nevertheless, the student shows an understanding of most concepts.
2	The observations recorded during the procedures are incomplete or inaccurate. The writing and drawing of the results do not include enough accurate details and observations to consistently demonstrate that the student understands the concepts.
1	The details and observations recorded during the procedures are missing or so inaccurate that the student drew erroneous conclusions that show little understanding of the main concepts