Adapting PER Strategies for Middle-School Science Classes

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Supported in part by a grant from Mary Lou Fulton Teachers College

Classroom Context: 5th-8th grade

- All middle-school students from ASU Preparatory Academy (on-campus charter school) attended weekly science classes taught by DEM, August 2010-June 2011
- Grades 7/8 clustered, ~55 students divided into two classes, one hour each per week
- Grades 5/6 clustered, ~90 students divided into three classes, one hour each per week

Additional Context

- Generally one instructor, sometimes helped by graduate student aide
- Homework assigned and corrected most weeks; occasional quizzes (graded only for 7/8th grade)
- In 2009-2010, DEM had taught many of the same students ~1 hour/week, focused on properties of matter, motion, and batteries and bulbs
- Many of the same activities being taught during same semester to preservice elementary teachers

Topics Covered

- **Grades 7/8:** Major focus on motion and force (to prepare for Arizona 8th-grade science test); also did solar system astronomy, electromagnetism, some review of properties of matter, energy concepts, some chemistry

- **Grades 5/6:** solar system astronomy, optics, motion and force, energy concepts, electromagnetism, some biology

General Observations

- A lot of hands-on instructor assistance is needed to keep kids on task and on track;
- Logistics of handling supplies and maintaining equipment is a major concern;
- Written worksheets can be used if they are carefully edited and accompanied by frequent check-ins by the instructor.

General Impressions of Student Reactions to Activities

- *College students:* burdensome tasks that had to be gotten through
- *7th/8th graders:* Time to socialize with each other; moderate engagement
- *5th/6th graders:* Playtime: fun and high engagement

Motion and Force with 7/8th Graders

- Approximately 10-15 hours of activities, beginning with graph paper and stopwatches, moving on to dynamics carts and tracks, fan carts, motion sensors and GLX's (hand-held graphing computers).
- Many of the students had previous experience using GLX for position/time and velocity/time graphs.
- *Typical sequence:* explore with equipment; predict graphs for various motions; carry out series of experiments; describe and report results; explain and generalize.

Goals Tuned to Arizona 8th-Grade Science Standard

- Describe the various effects forces can have on an object (e.g., cause motion, halt motion, change direction of motion, cause deformation).

- Describe how the acceleration of a body is dependent on its mass and the net applied force (Newton's 2nd Law of Motion).

- Create a graph devised from measurements of moving objects and their interactions, including:
  - position-time graphs
  - velocity-time graphs

Quiz Taken from Arizona 8th Grade Sample Test

1 A ball was attached to the end of a string and spun in a circle as shown in Figure 1 below. The ball moved in a counter-clockwise direction when seen from above as shown in Figure 2.

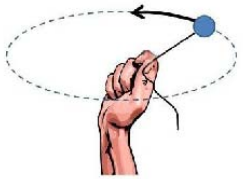


Figure 1 (view from side)

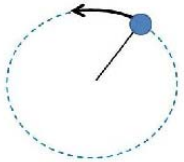
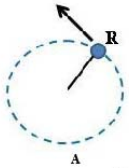
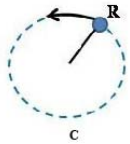


Figure 2 (view from above)

After several spins, the string was released when the ball was at point R. Which diagram shows the direction that the ball would fly the instant the string was released?



A



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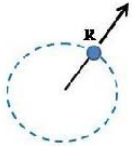

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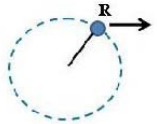


D

Name_____

7/8 Science Quiz #2, February 28, 2011: WRITE EXPLANATIONS FOR #2 AND #3

1 A ball was attached to the end of a string and spun in a circle as shown in Figure 1 below. The ball moved in a counter-clockwise direction when seen from above as shown in Figure 2.

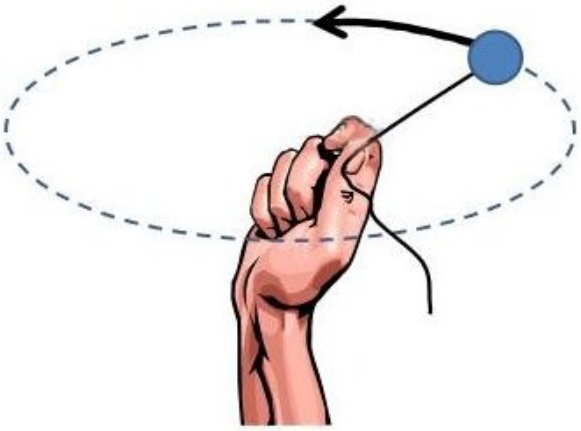


Figure 1 (view from side)

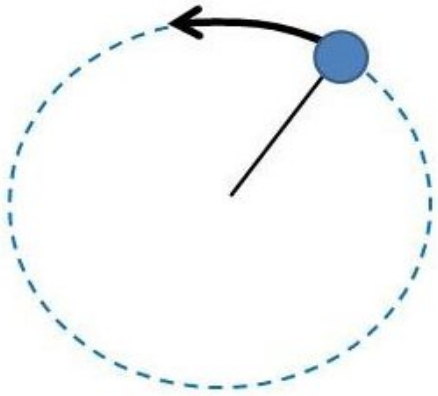
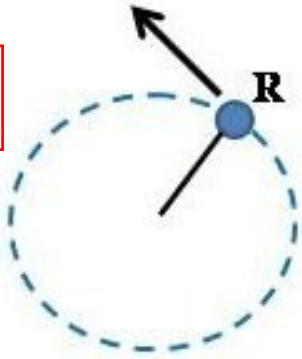


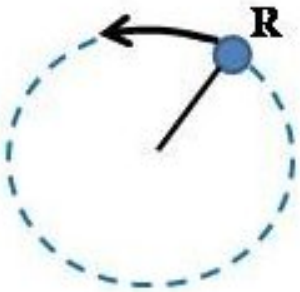
Figure 2 (view from above)

After several spins, the string was released when the ball was at point R. Which diagram shows the direction that the ball would fly the instant the string was released?

78% CORRECT



A



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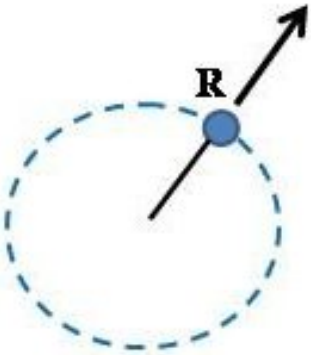

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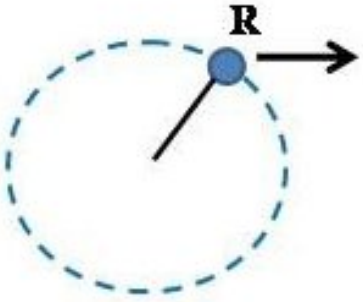
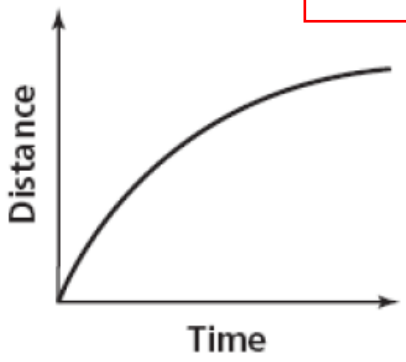


D

2. After a baseball is thrown up into the air, it will eventually fall back down to Earth. Which graph **best** demonstrates the relationship between time and distance from Earth as the baseball falls?

AMBIGUOUS WORDING!

A



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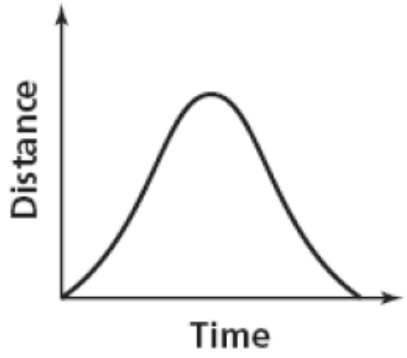

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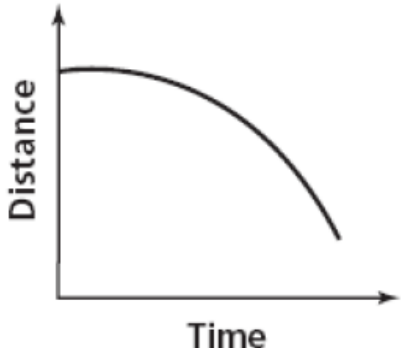

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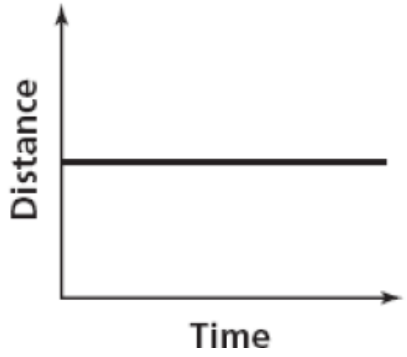

---> WRITE YOUR EXPLANATION HERE:

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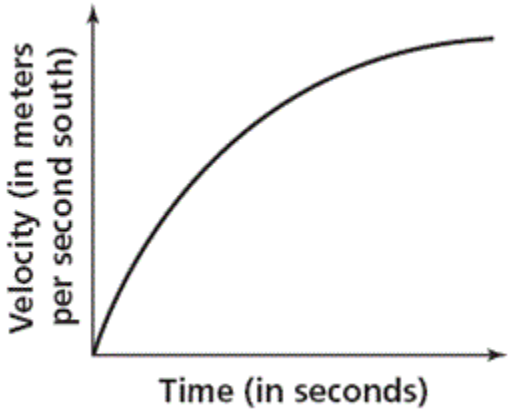
3. **Look at the velocity-time graph below.**



According to the graph, the acceleration of the object is

A. **constant.**
B. **decreasing.**
C. **increasing.**
D. **zero.**

----> WRITE YOUR EXPLANATION BELOW:

38% CORRECT

9% CORRECT WITH CORRECT EXPLANATION

Grade 7/8 Results for Mechanics Instruction

- Good and consistent performance on position/time graphs
- On velocity/time graphs, 40-50% qualitatively correct, 15-30% quantitatively correct
- On acceleration graphs and force questions, 15-30% correct, 10-20% correct with correct explanations.

➢ **Overall impressions: State science standards are unrealistic, at least regarding mechanics**

Summary

- For a college physics instructor, teaching young middle-schoolers is an enormously rewarding contrast to typically unenthusiastic college science classes.
- Gains in middle-school student understanding come slowly and unevenly, with much time and repetition required. But, progress is measurable.