This test covers one-dimensional kinematics, including speed, velocity, acceleration, motion graphs, with some problems requiring a knowledge of basic calculus.

Part I. Multiple Choice

1. A rock is released from rest from the top of a very high cliff, and accelerates downward at **g**. Approximately how far does the rock travel in the first 7 seconds of its free-fall? (Assume no air friction.)
   a. 35 m
   b. 70 m
   c. 180 m
   d. 245 m
   e. 490 m

2. A projectile is fired horizontally from a height of 20 meters above the ground, with an initial velocity of 7.0 m/s. How far does the projectile travel horizontally before it reaches the ground?
   a. 7m
   b. 14m
   c. 140m
   d. 3.5m
   e. 20m

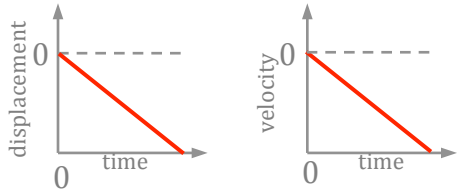
3. An object is launched into the air at an angle less than 90° above the surface of the earth. Air resistance is negligible. At the highest point in its path of motion, which of the following statements is true?
   a. It has no vertical velocity and no vertical acceleration.
   b. It has no horizontal velocity and no vertical acceleration.
   c. It has vertical velocity and no horizontal acceleration.
   d. It has horizontal velocity and no vertical acceleration.
   e. It has no vertical velocity and no horizontal acceleration.

4. A particle begins from rest at a point +10 meters from the origin at time $t = 0$, and begins accelerating at a constant 2 m/s^2 in the negative direction. At time $t = 4$ seconds, the particle has reached a certain speed; it stops accelerating, and continues traveling with that same speed until $t = 7$ seconds. What is its position relative to the origin at $t = 7$ seconds?
   a. -6 meters
   b. -30 meters
   c. -8 meters
   d. -40 meters
   e. -59 meters

5. An object moving along the x-axis has its position given by the equation $x = 2.0t^2 - 3.0t + 4$, with x in meters and t in seconds. What is the acceleration of the object at time $t = 4.0$s?
   a. 24 m/s^2
   b. 46 m/s^2
   c. 13 m/s^2
   d. 16 m/s^2
   e. 4.0 m/s^2

6. A mass is dropped from a height *h* above the ground, and freely falls under the influence of gravity. Which graphs here correctly describe the displacement and velocity of the object during the time the object is falling? Consider the "up" direction to be positive.

a.



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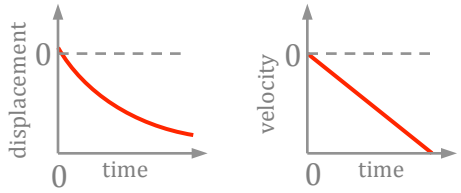

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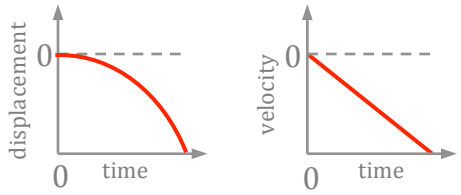
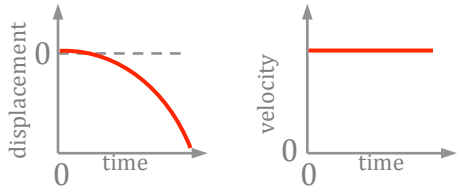
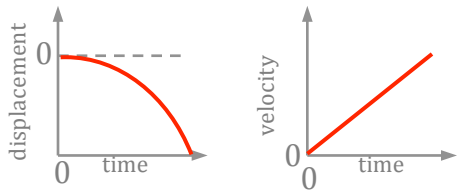


d.



e.

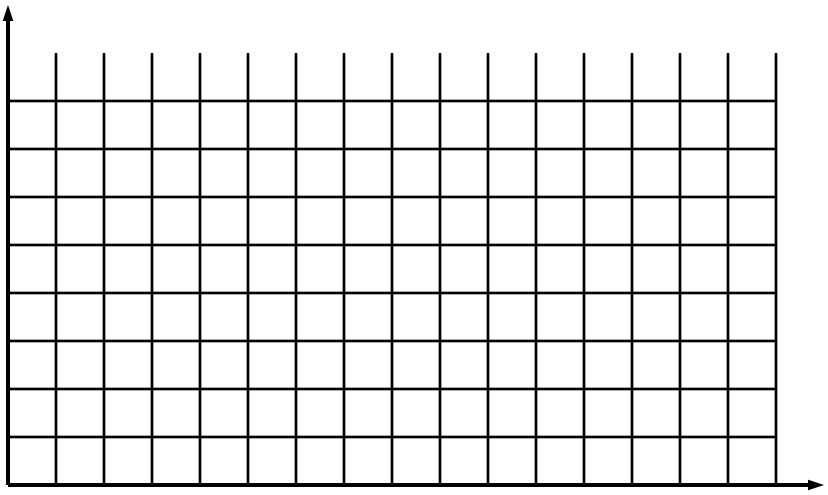


Part II. Free Response

7. A 50-gram superball is thrown horizontally in the negative-*x* direction against a brick wall so that it bounces directly back after hitting the wall. (The vertical motion of the ball during the throw is negligible.) The horizontal position of the ball's center of mass as a function of time is described in the data table below.

x-position relative to wall (centimeters)	25	20	15	10	6	3	2	3	6	10	14	18	22
t (milliseconds)	0	2	4	6	8	10	12	14	16	18	20	22	24

a. Draw a graph of the ball's position as a function of time.



b. Determine the ball's initial velocity before coming into contact with the wall?

c. Determine the ball's final velocity after bouncing off the wall?

d. What is the ball's average acceleration during the time period when the ball's velocity is changing, from 6 to 16 ms?

e. Use the graph to determine the ball's instantaneous velocity at time t = 10 ms. Explain briefly how you arrived at your answer.

8. A rocket, initially at rest, is fired vertically upward with an acceleration of 12.0 m/s^2. At an altitude of 1.00 km, the rocket engine cuts off. Air friction is negligible in this problem.

a. How fast is the rocket traveling when the engine cuts off?

b. What maximum height relative to the ground does the rocket reach before it begins falling back toward the earth?

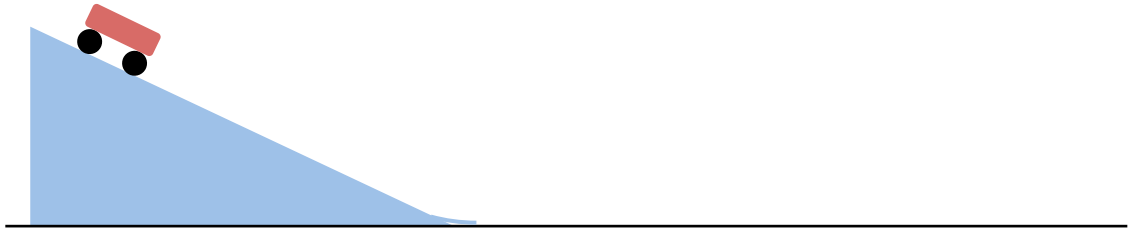
c. After free-falling, what is the rocket's velocity just before it hits the earth?

d. For what total amount of time was the rocket in the air (from initial launch to return to earth)?

9. A toy car with essentially frictionless wheels is to be released at the top of an inclined plane such that it will accelerate down the ramp until it reaches the bottom, after which it will continue to roll along the floor. You have been given the assignment of developing an experimental procedure and data tables that will allow you to measure the car's acceleration on the ramp and its velocity on the floor.

a. What materials commonly found in a science lab or classroom would you need to conduct this experiment? Explain what you would use each piece of equipment for. (Note that you do *not* have access to computers or computer-based measuring devices such as motion detectors, smart pulleys, or other probeware.)

b. What experimental procedure would you use to measure the car's acceleration down the ramp, and velocity along the floor? Describe your procedures as a series of ordered steps, use the diagram to identify what measurements you would make, and identify which equipment from part (a) you would use in your data collection.



c. Create appropriate data table(s) with clearly-labeled headers that you would use to record the data from your experiment.

d. Clearly describe how you will analyze the data you have collected for each part of the experiment (ramp and horizontal surface).