Hot Wheels Stopping Distance

A group of physics students are conducting a study using a Hot Wheels™ car. Their arrangement of equipment is shown in **Figure 1**. The car is placed on the track at an elevated position (**A**) and released from rest. The car rolls down the track to the ground and passes through a photogate timer. The photogate timer measures the time for the car to pass through it; this allows the students to calculate the speed.

Immediately after passing through the timer, the car hits a small box (**B**). The car lodges in the box and slides across the floor to a final stopping position (**C**). The students measure the initial height of the car ($\mathbf{h_A}$) and the photogate time (**t**) and calculate the speed ($\mathbf{v_B}$); see **Table 1**.

Figure 1

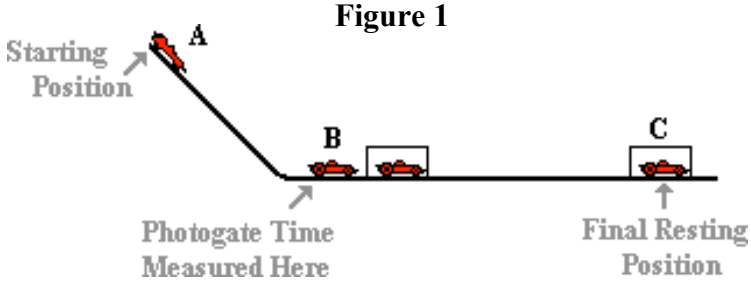
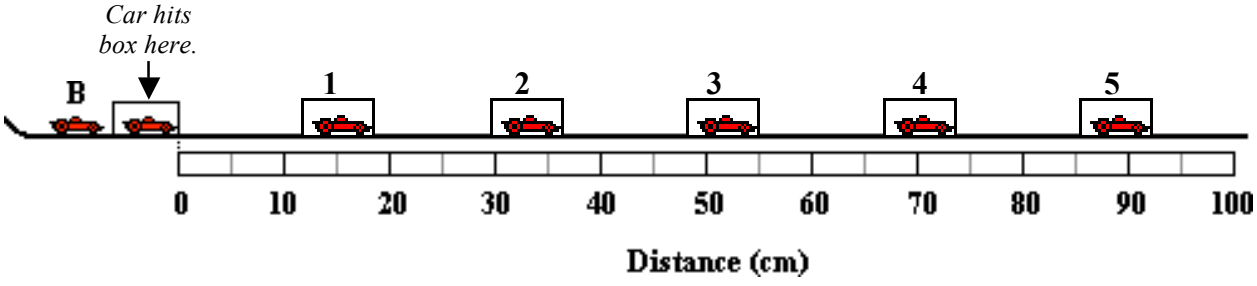


Table 1: Student Data

Trial	h_A (m)	Photogate Time (s)	v_B (m/s)
1	0.20	0.00904	1.77
2	0.40	0.00639	2.50
3	0.60	0.00522	3.07
4	0.80	0.00452	3.54
5	1.00	0.00404	3.96

The students place a meter stick along the floor so that they can measure the distance that the box and car skid before stopping ($\mathbf{d_{BC}}$). **Figure 2** shows the final positions of the box and car for the five trials that are performed; the final position for each trial is numbered. The divisions on the 1-meter stick are 5.0 centimeters (cm) apart; every 10 cm is labeled.

Figure 2 Final Position of Box and Car

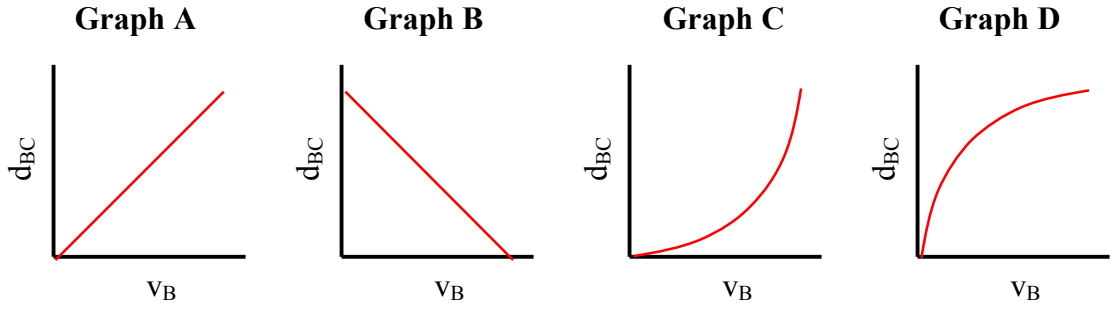


Questions:

1. What affect does increasing the height from which the car is released have upon the speed of the car at position B?
   a. Increasing the initial height causes the speed to increase.
   b. Increasing the initial height causes the speed to decrease.
   c. Increasing the initial height first decreases the speed and then increases it.
   d. Increasing the initial height has no affect upon the speed of the car at position B.

2. What affect does increasing the height from which the car is released have upon the distance that the box and car skid before stopping?
   a. Increasing the initial height causes the box and car to skid less distance.
   b. Increasing the initial height causes the box and car to skid a further distance.
   c. Increasing the initial height does not affect the distance the box and car skid.
   d. It is not possible to predict the affect that increasing height has upon the skid distance.

3. Which graph represents the relationship between the speed of the car at position B (v_B) and the distance that the box and car skids (d_{BC})?



4. Doubling the initial height of the car (h_A) causes the speed of the car at position B (v_B) to be ____.
   a. roughly one-half the value it has before the doubling
   b. roughly twice the value that it had before the doubling
   c. greater, but definitely not twice as great
   d. greater - approximately four times greater

5. Doubling the initial height of the car (h_A) causes the distance that the box and car skid to a stop (d_{BC}) to be ____.
   a. roughly one-half the value it has before the doubling
   b. roughly twice the value that it had before the doubling
   c. greater, but definitely not twice as great
   d. greater - approximately four times greater

6. What distance did the box and car slide before stopping in trial 4?
   a. 33 cm
   b. 68 cm
   c. 71 cm
   d. 74 cm

7. What distance will the box and car slide to a stop if the car hits the box while moving at 3.54 m/s?
   a. 2.2 cm
   b. 52 cm
   c. 67 cm
   d. 71 cm
   e. 74 cm

8. What distance will the box and car slide to a stop if the car is released from a height of 0.80 m?
   a. 30 cm
   b. 37 cm
   c. 67 cm
   d. 70 cm
   e. 74 cm

9. Predict the speed that the car would have at position B if the car were released from a height of 1.20 m?
   a. 4.35 m/s
   b. 4.69 m/s
   c. 5.73 m/s
   d. 6.14 m/s

10. The car is released from a location along the track and is found to hit the box and slide a distance of 60 cm. Which one of the following statements is true?
   a. The initial height of the car was 0.60 meters.
   b. The car's initial height was less than 0.60 meters.
   c. The car was traveling with a speed of 3.07 m/s at position B.
   d. The car was released from a height between 0.60 meters and 0.80 meters.

11. Predict the distance that the box and car would slide to a stop if the car were released from a height of 1.60 m?
   a. 73 cm
   b. 133 cm
   c. 147 cm
   d. 294 cm

12. Inspect Trials 1 and 4. Observe that the ratio of the speeds of the car at Position B is a 1:2 ratio. Based on this observation, which one of the following statements is true?
   a. When the car is traveling with twice the speed, it will slide twice the distance.
   b. When the car is released from twice as high, it will move with twice the speed.
   c. To get a car to slide twice the distance, it must be released from four times the height.
   d. To get a car to travel twice the speed, it must be released from four times the height.

13. To measure the distance that the car and box skid to a stop, one should measure from the 0-cm mark to the _____
   a. front end of the box when it finally stops.
   b. back end of the box when it finally stops.
   c. to the middle of the box when it finally stops.
   d. to the back end of the car when it finally stops.

Connecting Questions with a College Readiness Standard

The table below represents an effort to match each question within this passage to one of ACT's College Readiness Standards. Each standard is represented by a three-digit code. The first digit of the code refers to the strand:

1 = Interpretation of Data 2 = Scientific Investigation
3 = Evaluation of Models, Inferences, and Experimental Results

The second digit refers to the level within the strand:

1 = 13-15 2 = 16-19 3 = 20-23
4 = 24-27 5 = 28-32 6 = 33-36

The third digit refers to the actual standard that is stated at that particular level; a 1 represents the first statement; a 2 represents the second statement; etc.

Question	CRS Code
1	124
2	141
3	341
4	133
5	133
6	133
7	152
8	152

Question	CRS Code
9	111
10	111
11	141
12	141
13	141
14	141
15	153
16	153

Question	CRS Code
17	146
18	153
19	153
20	341
21	241