Rule Time:

Salute to Flight!

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Part III

Activity 1 (Algebra version)

In the video, Jim falls out of the plane in an attempt to find his oxygen mask. The question you need to answer is, will Jim land near enough to the field light activation switch so that he can turn it on before it is too late.

Before you begin to work on this question, you must understand how free falling objects behave.

Isaac Newton is credited with discovering that the acceleration due to gravity is –32 feet per square second or –9.8 meters per square second. But what does this mean? Discuss the following with your group.

1. Imagine that a ball is dropped from a height of 2000 feet. Describe the speed of the ball as a function of time. Graph the speed of the ball as a function of time. At this time, you may be conjecturing about this graph.

2. Remember that gravity causes the ball's speed to increase by 32 feet per second for each second that it is in the air. Complete the following table. The average speed for the interval is found by taking the average (mean) of the instantaneous speeds at the endpoints of that interval.

Time Interval (seconds)	**Instantaneous Speed** At the beginning of the interval **(feet per second)**	**Instantaneous Speed** At the end of the interval **(feet per second)**	**Average Speed for the Interval (feet per second)**
0 - 2	0	64	_____
2 - 4			
4 - 6			
6 – 8			
8 – 10			

3. Use the average speed during each 2-second time interval to determine the distance that the ball traveled during that interval. Complete the table. (Hint: d=rt)

Time Interval (seconds)	Distance Traveled (feet)
0 - 2	
2 - 4	
4 - 6	
6 – 8	
8 – 10	

4. Find the total distance traveled by
   a) Calculate the cumulative sum of the distance traveled for each of the 2-second intervals in the table above.

   b) Find the average speed of the falling ball over the entire 10-second interval, then find the distance traveled.

5. How do the two methods compare?

6. Develop a general formula for the height of the ball after ***k*** seconds. (Hint: Find the average velocity of the time interval from $t = 0$ to $t = k$).

7. Find an expression for the amount of time it would take for the ball to reach the ground.

8. Reconsider the situation where the ball was thrown downward with an initial velocity of 25 feet per second. Using the average of the endpoints method, determine a general formula for the ball's speed at any time ***k***.

9. Write a general formula for the height of the ball at any time ***k***.

10. Consider each term in the equation in question 9 and explain how each is obtained. Write a general equation that represents the height of a free falling object for any initial height, and initial velocity .

Activity 2

In our situation with Jim, we have to understand how the speed of the airplane will affect his free fall out of the airplane. Begin by discussing the following situations:

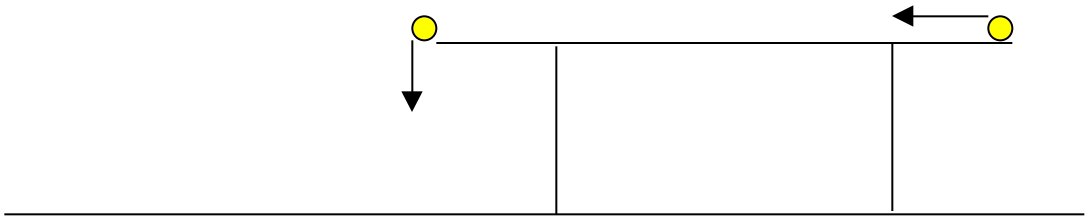
1. Imagine the following two situations:

   - Jim falls from a stationary object, like a hovering helicopter.
   - Jim falls from a moving airplane.

Compare the rate at which Jim falls in each of the situations.

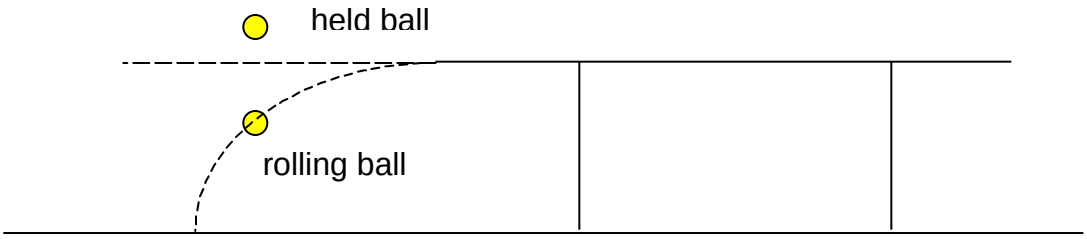
If you are not sure, use two tennis balls (or similar objects) and a partner to conduct the following experiment.

One person stands on one end of a table, poised to roll the ball across the table. The second person holds the other ball at the edge of the table. Person 1 rolls the ball across the table. At the very instant the ball reaches the other edge of the table, Person 2 drops the second ball. Observe which ball hits the ground first. Carefully repeat the experiment until you are able to determine which ball hits the floor first.



Record your observations

The second part of this experiment is more difficult to perform, but will reveal much. Have the first tennis ball roll across the table as before. This time, just as it leaves the edge of the table, have the second tennis ball follow alongside the first while the first one rolls across the table, but then continue horizontally as if the table extended further out and it were continuing with the same speed as it had on the table. Observe which ball is farther away from the table when the first ball hits the ground. Allow many observers to carefully watch the results of this experiment and repeat the experiment several times until you are able to clearly determine which ball would be farther away from the table when the first ball hits the ground.



Record your observations

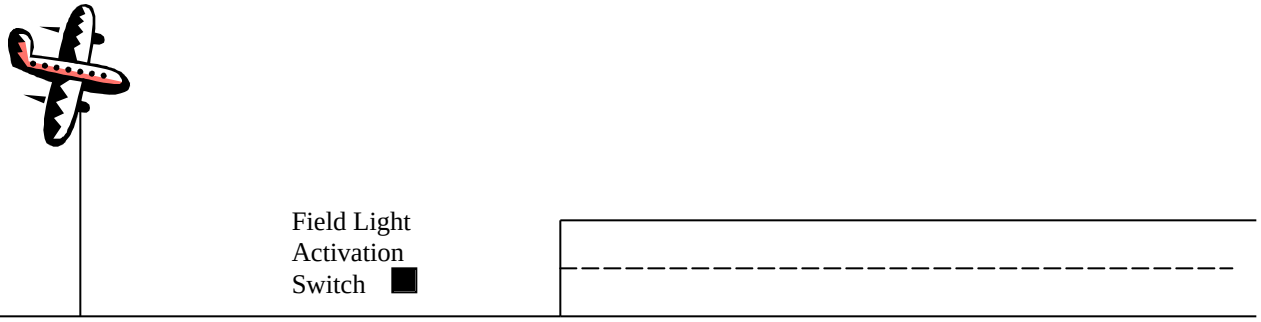
The two experiments can be summed up as follows.

If an object (or person) is moving horizontally as it falls, then
- the rate at which it falls is the same as if it were falling straight down.
- the rate at which it moves horizontally is the same as if there were no gravity.

Activity 3 (Algebra Version)

Now back to the problem: where will Jim land when he hits the ground?
Here are the details that you need in order to solve the problem:

- The ground speed of the airplane is 150 miles per hour
- The altitude of the plane, at the time of the heroic jump, is 1500 feet
- The airplane is 1.2 miles away from the approach end of the runway
- The emergency field light activation switch is located 2500 feet away from the approach end of the runway
- The airplane is descending at a rate of 650 feet per minute
- Jim is capable of running at a speed of 10 miles per hour



1. Label the picture appropriately.

2. Write a linear equation to express the airplane's horizontal distance from the end of the runway.

3. Write a linear equation to express the airplane's vertical distance from the ground.

4. Write a linear equation to express Jim's horizontal distance from the end of the runway.

5. Write a quadratic equation to express Jim's vertical distance from the end of the runway.

6. How long will it take Jim to hit the ground?

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7. What will Jim's horizontal position be at that time?

8. Where will the plane be (both horizontally and vertically) at that time?

9. Will Jim save the day? Explain.