AP Lab #1: Video Analysis of Moving Objects (Big Idea 4)

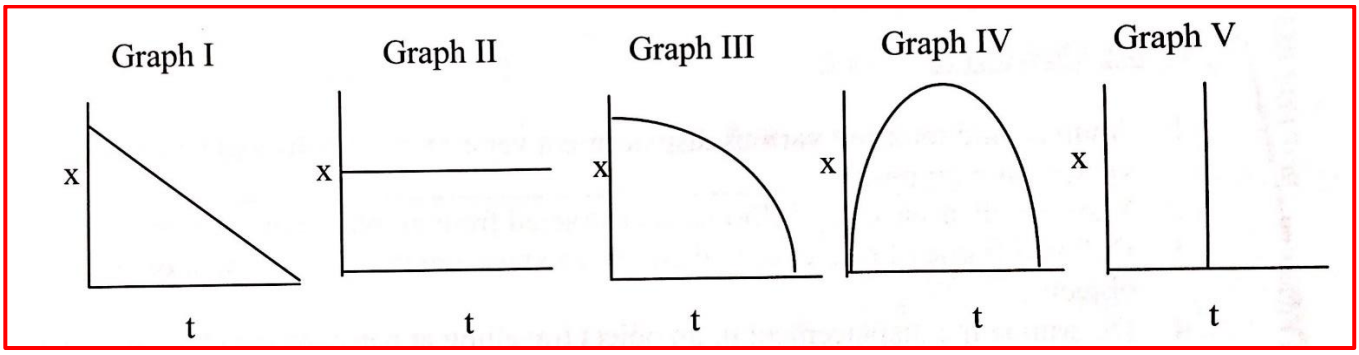
4.A.2.1: The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.

Question: *How can I use video analysis, or any other standard physics equipment, to explore the displacement of an object moving at a constant velocity and then an object in free fall.*

As an object moves, its position changes with respect to time. The object can move slowly or quickly. It can even accelerate. An object that moves away and the returns to its starting point has a displacement of zero. However, its distance traveled is directly proportional to the length of the trip. A position versus time graph summarizes the motion of an object. A straight line x versus t graph (nonzero slope) indicates that the object is traveling at a constant speed, whereas a curve means the object's speed is changing. When the speed (or velocity) of an object changes with time, the object is accelerating.

Video Analysis of Moving Objects Pre-Lab:

P1. The following graphs summarize the motion of an object in terms of its displacement with respect to time. Position x=0 is considered the reference, such as a child standing in a single static position. Describe the motion depicted by each graph in one sentence. Also, provide an example of an object for each graph that would behave as depicted in the graph.



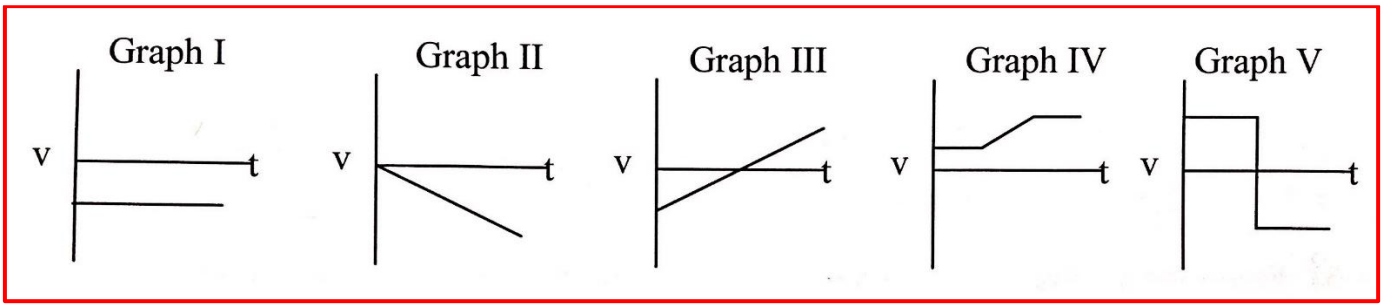
P2. Study the graphs in P1 and then skecth the velocity graphs for each case. According to College Board's course description, a sketched graph means to "draw a graph that illustrates key trends in a particular relationship, such as slope, curvature, intercept(s), or asymptote(s). Numerical scaling or specific data points are not required in a sketch."

P3. Study the graphs in P2 and then skecth the acceleration graphs for each case.

P4. What is the direction of the acceleration of the object in Graph IV in P1? Explain how the graph helps to reveal the answer to this question.

P5. In Graph IV in P1, notice how the curve moves away from the x-axis and then returns to it. What exactly is occurring half-way through the curve? Is the object still accelerating? Explain how you know.

P6. The graphs on the next page summarize the motion of an object in terms of its velocity with respect to time. Study these graphs and then sketch the displacement versus time graphs for each case.



Video Analysis of Moving Objects Lab:

Materials: constant velocity car, Hudl technique, Video Physics, Tracker, meter stick, spring powered launcher, golf ball, other projectiles of your choice.

The speed of an object is a measure of how far it moves in a set time period. Therefore the first step in calculating speed of an object on screen, is to calculate the distance the object moved. Once this is determined, you will need to know what the frame rate of the video recording is. Frame rates can vary, often 24 or 25 frames per second, sometimes 30 frames/sec (fps). For high speed filming (slow motion) it can be as great as 1000 fps. Most Smart phones in slow motion mode have a rate of 240 fps. For example, if the rate is 25 frames per second, this means that there is 0.04 seconds between each frame. When you view the video frame by frame, and calculate the distance an object moves from one frame to the next, you can calculate the velocity of that object. For speed measurements, you will need to have video footage from directly side-on, a calibration mark that can be viewed on the screen (for distance measurement), and you need to know the frame rate of the video (or have a time scale in view).

Part 1: Video Analysis of Constant Velocity Car: *In this activity you will make a video of a toy car moving at a constant velocity. You will then analyze individual frames of the video in order to determine the displacement of the toy car per unit time. Lastly, you will use the data to determine the average velocity of the toy car (shown on right).*

Q1. Carefully plan out your methods for this part of the investigation. Then construct a data table that will clearly summarize your data.

Q2. Calculate the average velocity for each interval. As always, show your work and include units.

Q3. Create a graph ¾-1 page in size for the horizontal displacement as a function of time.

Part 2: Video Analysis of a Projectile: *In this activity you will make a video of a ball launched upward and allowed to move under the influence of gravity. As you did with the toy car, you will then analyze individual frames of the video to determine the displacement of the ball per unit of time. Lastly, you will use the data to calculate the acceleration of the ball under the influence of gravity.*

Q4. Carefully plan out your methods for this part of the investigation. Then construct a data table that will clearly summarize your data.

Q5. Calculate the average velocity for each interval and the acceleration.

Q6. Create a graph ¾-1 page in size for the vertical displacement as a function of time.

Make your claim and write your summary/reflection using ARMS and the STEM Journal rubric.

Please self-assess your lab report using the STEM Journal rubric/checklist.