Unit 2: Lab Packet

Lab 5: Kinematic Graphs and the Pull Back Car (Skill 12)

In this lab we will convert "dot motion diagrams" into position vs time graphs from provided data sets in order to recognize patterns associated with constant, increasing or decreasing speed/velocity. From the change in velocity we can evaluate the presence of a force acting on an object.

Part I: Translating dot diagrams to kinematics graphs

Each of the following columns represent the change of position of an object with respect to a stationary observer measured at **equal time intervals**. In this activity each set of data will first be represented on a single axis (y) as dot motion diagram and then be expanded to the time dimension to represent both position (y) and time (x).

For each data set (A-E) complete the following steps:

Step One: Create a "dot motion diagram" of position along the vertical axis by placing a magnet in the indicated position. Roughly sketch the pattern of dots in the RESULTS "dot diagram".

Step Two: Move each magnet horizontally to the right to represent the time at which each position occurred. Record the general shape of the graph in the RESULTS section "Position vs. time"

Step Three: Based on the data and the position vs. time graph determine if the object is moving away from or toward the point of reference. Record your answer under "toward or away"

Step Four: Based on the slope of position vs time, determine if the speed of the object is constant, increasing or decreasing. Record your answer under "What is happening to the speed?"

Step Five: Sketch the rough shape of the graph for the velocity vs time based on your prior answers. Record your answer in the box labeled "velocity vs. time graph"

Step Six: Determine if the object is object is experiencing zero acceleration, constant (ie., uniform) positive acceleration, or constant (ie, uniform) negative acceleration. [Hint: Is a net force present? Is it the force work with/against the initial motion of the object?]

Time	A	B	C	D	E
0	0.0	0.8m	0.0m	1.6m	0.0m
0.1s	0.2m	0.7m	0.05m	1.225m	0.75m
0.2s	0.4m	0.6m	0.2m	0.9m	1.40m
0.3s	0.6m	0.5m	0.45m	0.625m	1.95m
0.4s	0.8m	0.4m	0.80m	0.4m	2.40m
0.5s	1.0m	0.3m	1.25m	0.225m	2.75m
0.6s	1.2m	0.2m	1.80m	0.1m	3.00m
0.7s	1.4m	0.1m	2.45m	0.025m	3.15m
0.8s	1.6m	0.0m	3.20m	0.0m	3.20m

RESULTS:

	Dot Diagram	Position vs. Time Graph	Toward or Away?	Velocity vs Time graph?
A			What is happening to the speed?	Acceleration vs time graph?

	Dot Diagram	Position vs. Time Graph	Toward or Away?	Velocity vs Time graph?
B			What is happening to the speed?	Acceleration vs time graph?

	Dot Diagram	Position vs. Time Graph	Toward or Away?	Velocity vs Time graph?
C			What is happening to the speed?	Acceleration vs time graph?

D	Dot Diagram	Position vs. Time Graph	Toward or Away?	Velocity vs Time graph?
			What is happening to the speed?	Acceleration vs time graph?

E	Dot Diagram	Position vs. Time Graph	Toward or Away?	Velocity vs Time graph?
			What is happening to the speed?	Acceleration vs time graph?

Analysis:

1. For all the data sets, which measurement is the dependent variable and which is the independent variable?

2. How can we tell from a position vs time graph if an object is moving at equilibrium (constant velocity) or experiencing a net force? [ie What feature can you observe if it is not at equilibrium?]

3. How can you determine from looking at a graph of position versus time if it is moving toward or away from an observer?

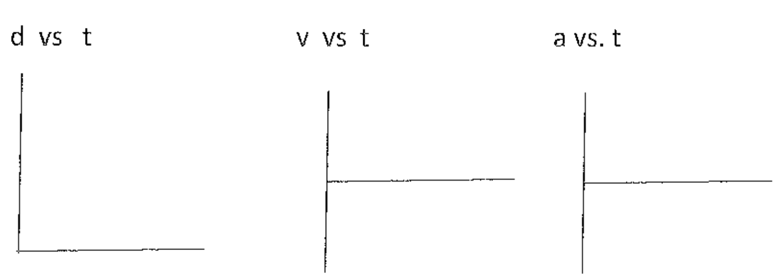
4. When an object is moving at **constant speed,** what is the relationship between distance and time? [What is the pattern? Ie when time doubles, distance ____________]
   Hint: After 1 second the distance is ________
   After 2 seconds the distance _______
   After 3 seconds the distance is ________

5. For Data Set "C", an object is moving with a **uniform (constant) acceleration**, what is the relationship between distance and time? [ie, when time doubles, distance _____________; when time triples, distance _______________]
   Hint: After 1 second the distance is ________
   After 2 seconds the distance _______
   After 3 seconds the distance is ________

6. Scenarios A and D both represent motion covering the same total change in position over the same amount of time. State two ways in which the motions represented by the graph are different.

7. Draw the position vs. time, velocity vs. time and acceleration vs time graph for an object that moves toward the observer and speeds up with a uniform acceleration. [Hint: Replicate the dot diagram of the motion indicating the starting point, from that diagram, sketch the other three graphs]

Dot diagram



Part Two: Pull Back Car and Spark Timer

Follow instructions to obtain a spark tape for a short run (less than 55cm) of a "pull back vehicle" in which it completes a full cycle of motion. For each dot (time interval) measure the distance from the starting point (total change in position).

8. Roughly replicate the pattern on the dot diagram (spark tape) in the space provided below. Label each phase of motion (speeding up, slowing down, constant speed).

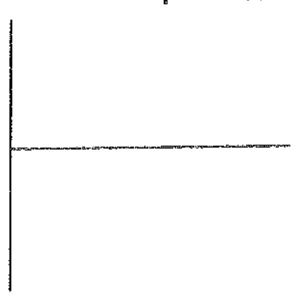
9. Plot the dots onto the scaled "y" axis and then expand to the time dimension "x" to create a position vs time kinematics graph.

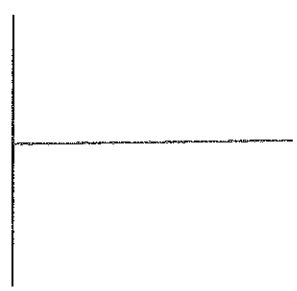
10. How is velocity represented on the d vs t graph? (ie what feature of the graph gives us velocity?)

11. Does the vehicle ever have a negative velocity? How do you know this from the graph?

12. How are increasing speed (positive acceleration), decreasing speed (negative acceleration) and constant speed (zero acceleration) represented on the position vs time graph? (give time intervals for each)

Conclusion: Based on the position vs time graph, draw the rough shape of the velocity vs time and acceleration vs time graphs on the axes provided below





Lab 6: Cart on a ramp (Skill 12 and 13)

This activity will use motion detectors connected to a SPARK LEARNING SYSTEM in combination with a cart on a ramp to produce kinematics (motion) graphs.

You will attach the motion detector to the SPARK and then power on the device. Follow these steps to complete activity.

- Choose Build
- Under Motion Sensor select "Position" and then tap the top left graph option
- Repeat for "Velocity" and hit "OK". You should see two stacked graphs.

Experiment #1: Place the motion detector at the bottom of the ramp. Make sure the "cart" feature is selected. Attach an index card to the cart, facing the motion detector and gently push the cart up the ramp (be careful that it does not leave the top of the ramp). You may need to conduct a few trials in order to get a smooth "run".

1. a.) Sketch a dot diagram of the motion. Since a change in direction is involved, draw dots for the return trip below the trip out.

   b.) Draw the graph of both position vs time and velocity vs time for the perspective of the cart at the bottom of the ramp after the push.

   c.) What is the sign (direction) of the cart's initial velocity?

   d.) What is the sign of the cart's acceleration? How do you know? (ie explain your reasoning)

   Draw the graph of the acceleration vs. time.

Experiment #2

2. Reposition the motion detector to the top of the ramp and the cart at the bottom (flip cart so index card faces detector).

a.) Sketch a dot diagram of the motion noting the position of the detector and time zero.

b.) Draw the position vs. time and velocity vs time graph for the motion.

c.) What is the direction of the initial velocity? (consider the perspective of the motion detector)

d.) What is the direction of the acceleration? Explain your reasoning [Hint: Does the force agree in direction with the initial velocity?]

3. The cart is pushed up the ramp away from the motion detector with an initial velocity of 2m/s. The cart slows to a speed of 0 m/s over a distance of 1.1m, what is the acceleration acting on the cart?

4. The cart is released from rest at the top of a ramp and it reaches a velocity of 3m/s after 1.2 seconds. What is the acceleration of the cart? What is distance did it travel in that time?

5. Consider the motion of the school elevator. Since we have only 2 floors, we can summarize the possible motions into four categories. Draw a "d vs t" graph for each motion. Consider the reference point to be the first floor for all four graphs. In the ACC column indicate if the acceleration is positive, zero or negative.

	Up	ACC		**Down**	ACC
Increasing Speed (Starting)			Increasing Speed (Starting)		
Constant Speed			Constant Speed		
Decreasing Speed (Stopping)			Decreasing Speed (Stopping)		

6. What does the term "negative acceleration" mean? (ie What are the possible motions of an object relative to an observer if it is experiencing negative acceleration?)

Lab 7: Free Fall in One Dimension (Skill 14)

Purpose: In this lab we will determine the relationship between vertical displacement and time of fall for an object under the force of the gravitational field.

Procedure:

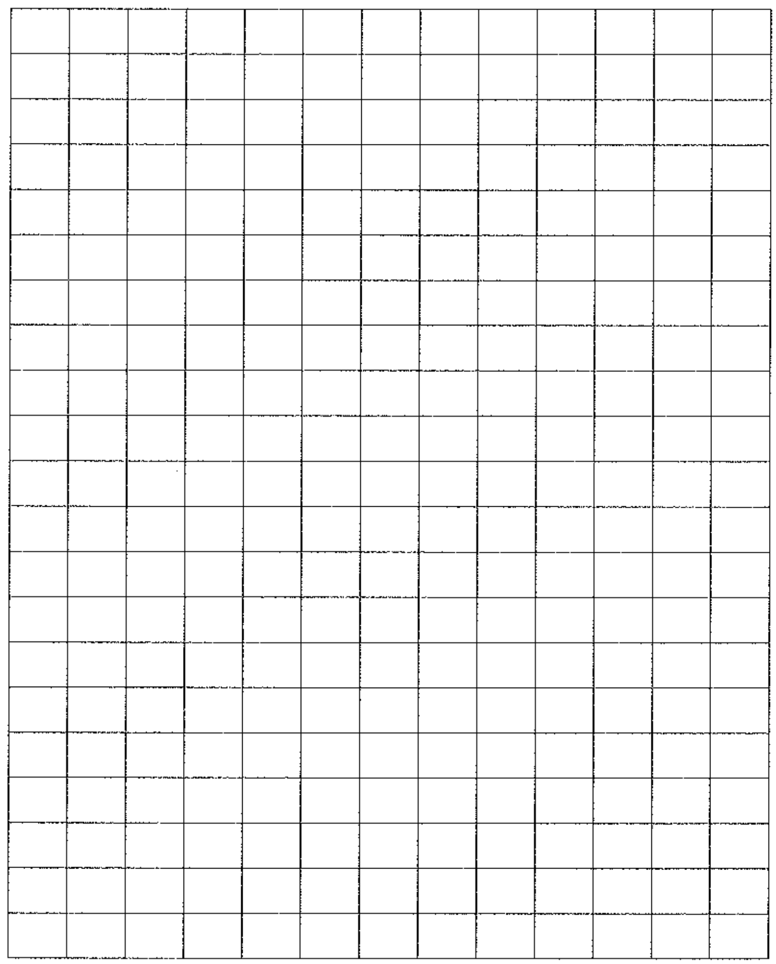
In this activity we will use a photogate in combination with a "time of flight" apparatus to determine how the time of fall changes with the height of the drop for a ping-pong ball. All objects will be dropped from rest so the initial velocity is zero.

1. As a class we will set-up the SPARK systems to measure the time of fall.
2. The height of the photo-gates will be adjusted using ring-stands in combination with tables etc. The ping-pong ball will be dropped from above the photogate in order to determine the time of the fall.
3. Plot the data onto the graph so that time is a function of height. [ie, time is dependent (y) and height is the independent (x) variable]

DATA – Part One

Height or Position (m)	Time of Fall (s)
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	
1.1	
1.2	
1.3	

Time of fall (y-axis) vs. height of drop (x-axis)



Questions:

1. Calculate the time of fall for an object that falls from a height of 3m (show your work). If we double the height to 6m how much time would it take to fall?

2. How does the increase in time of fall respond to an increase in height of fall? (Hint when distance is multiplied by 2, time is multiplied by roughly ________; When distance is multiplied by 4, time is multiplied by roughly _______; When distance is multiplied by 9, time is multiplied by roughly ______)

3. Prior to this activity we have investigated the relationship of position responding to time in two different scenarios:
   - constant positive velocity
   - uniform positive acceleration

   In each case, if an object is moving away from an observer, the change in position increases with time but the patterns differ in each scenario.

   a) Draw the graphs of position vs time for both constant positive velocity and for uniform positive acceleration.

   b) Show a simplified equation, written in terms of "d", that shows the relationship between position and time shown in your graphs from question 3a

4. The graph of time responding to height reveals a third graph pattern and type of equation. Write a simplified equation in terms of "t" (y variable) that show the relationship to height (x variable) when an object is in free fall.

5. As you double the height of the drop what happens to the landing velocity of the object? Justify your answer with examples.

Lab 8: Shoot for your grade (Skill 15)

Purpose: To predict the path and landing spot of a projectile launched horizontally from the mini launcher.

Procedure:

Step A: Use a SPARK system and a pair of photogates positioned 10 cm apart to determine the horizontal launch velocity of the projectile from the 1st launch speed. You must not let the ball hit the ground. This location will be calculated in Part 3 and you will be challenged to hit the target. Letting the ball hit the ground is "cheating".

Step B: Based on the velocity determined in Step One, calculate the vertical displacements (d_y) for each of the 5 horizontal displacements listed below.

HORIZONTAL						VERTICAL		
d_x	v_x	a_x		time		v_i	a_y	d_y
0.20m								
0.35m								
0.50m								
0.65m								
0.80m								

1. Show 1 sample calculation for each time (t) and vertical displacement (d_y) for any one of the d_x values given above:

Time:

Vertical displacement (d_y)

Step C: Determine the landing location (horizontal range, d_x) for the projectile

Horizontal

2. Givens/Knowns:

Unknowns:

Vertical

Givens/Knowns:

Unknowns:

Show Calculations:

Step D: Set-up hoops and landing target based on calculations. COMMENCE CHALLENGE

3. Describe your group's success

Questions:

4. Draw the path of the projectile.

5. Sketch the qualitative graphs for the horizontal and vertical motion of the projectile

	Horizontal	Vertical
d vs t		
v vs.t		
a vs. t		

6. If the height of the mini-launcher were doubled, how would the horizontal range change? Justify your answer with an explanation or an example.

Lab 9: Projectiles launched at an angle (Skill 17 and 18)

Purpose: To determine how the launch angle impacts the horizontal range for a constant launch velocity.

Procedure: Shoot the projectile at the 1st launch speed and record the horizontal range for each of the angles listed in the chart.

EXPERIMENTAL DATA:

Launch Angle	Horizontal range (d_x)	Time of flight
30^0		
40^0		
45^0		
50^0		
60^0		
80^0		

Questions:

1. What launch angle results in the maximum horizontal range?

2. What launch angle results in the maximum time of flight?

3. Predict the horizontal range of a projectile launched with a velocity of 10 m/s at an angle of 30 degrees. [Show your work, including equation and substitution with units]

4. Complete the chart below, by calculating the values for each angle at a constant launch velocity of 5m/s.

	V_i	V_{ix}	V_{iy}	t	d_x	d_y
		$v_{ix} = v_i cos\theta$	$v_{iy} = v_i sin\theta$	$t = \frac{2v_{iy}}{g}$	$d_x = v_{ix}t$	$d_y = v_{iy}t$
10°	5 m/s					
30°						
45°						
60°						
80°						

5. What happens to the magnitude of the horizontal velocity as angle increases? What happens to the horizontal range? Justify your answer.

6. What happens to the magnitude of the vertical velocity as angle increases? Justify your answer?

7. Based on the data above, what pairs of launch angles result in the same horizontal range? What pattern is evident in the initial horizontal and initial vertical velocities for these angle pairs?

8. What happens to the time of flight as the angle increases? Which of the other variables also increases with an increase in launch angle? Therefore, time of flight is directly linked to which component of the initial velocity?

9. We did not calculate the maximum vertical displacement in this chart. Predict which launch angle would result in the greatest vertical displacement at the halfway point.

10. Sketch the general path of the projectiles from various angles. Label the launch angles on the path.

11. When we conducted the experiment with the mini launcher we observed a greater difference between "symmetrical" launch angles as compared with the calculated values in question 4. What accounts for the difference between the experimental evidence and the ideal values we calculated?

Conclusion: Summarize the impact of changing launch angle on each of the following variables for a fixed launch setting:

v_{ix}, v_{iy}, v_i, a_x, a_y, d_x, t