VELOCITY AND ACCELERATION

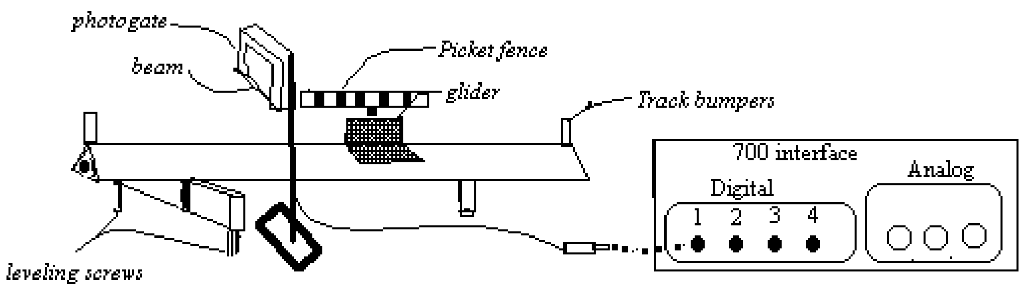
Velocity is the term which describes how fast something travels. If a Dodge Colt travels at 15 m/s while a Ford Mustang travels at 30 m/s, in 10 seconds the Mustang would have traveled twice as far (300 meters compared to the 150 meters for the Colt). The basic formula used to calculate the velocity is

$$\text{Velocity} = \frac{\text{Distance}}{\text{time}} = \frac{x_2 - x_1}{t_2 - t_1}$$

where x_2 is the position of the object at time = t_2 , and x_1 at t_1 .

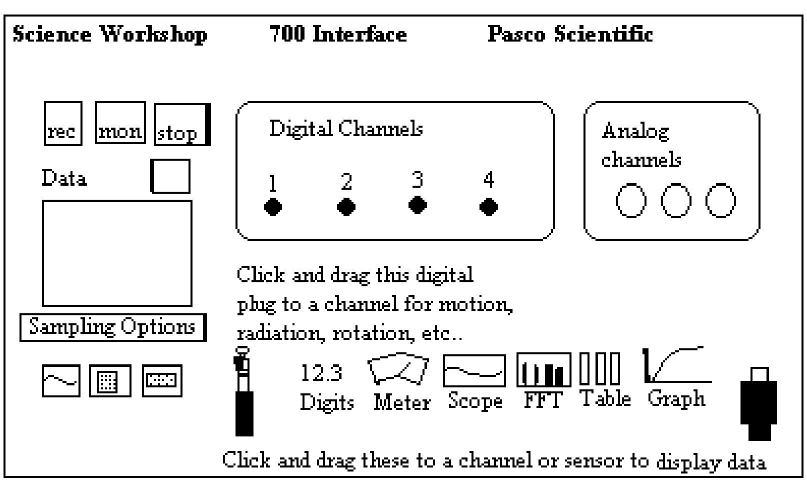
Part I Constant Velocity:

If the velocity of an object does not change, then it should always take the same amount of time to travel the same amount of distance. Verify that this is correct by measuring the time a glider takes to travel equal distances on a level air track.



Procedure:

1. Place the glider on the air track, connect the air pump to the track, set the pump speed to 3. Turn on the pump.
2. **Using the leveling screws adjust the height of the left end until the glider does not accelerate down the air track**.
3. Place a photogate approximately 40 cm from the end with the air intake. Adjust the height of the photogate so that the glider with a picket fence attached will pass through the beam without hitting the gate.
4. Plug the photogate plug into the digital channel #1 of the 700 interface box.
5. Click on "Science Workshop" in the windows screen of the computer.
6. From the main Science Workshop Setup window, drag the phone plug symbol to the digital #1 input.



When the channel you are "plugging" the sensor into is highlighted with the box, release the mouse button.
A sensor selection window will appear. Click on *photogate and picket fence,* then click OK.
8. Drag the Table to channel #1. Select "delta time"," position"," velocity" and "acceleration".

9. Click **REC** in the upper left hand corner of the experiment window. Give the glider a small push and let it coast through the photogate. The table should fill up with data. Click **STOP** after the picket fence clears the photogate.
10. You can also drag the Graph icon to the sensor and graph the velocity.
11. If your click on the Σ ***(statistics)*** symbol of the graph and select linear fit, it will display the equation of the best straight line that fits your data. ***Note : for the velocity vs. time graph, the slope is the acceleration.***

PART II: ACCELERATED MOTION

When the velocity increases or decreases, there is acceleration. The rate of change of the velocity is called the acceleration. Mathematically, the acceleration is found by:

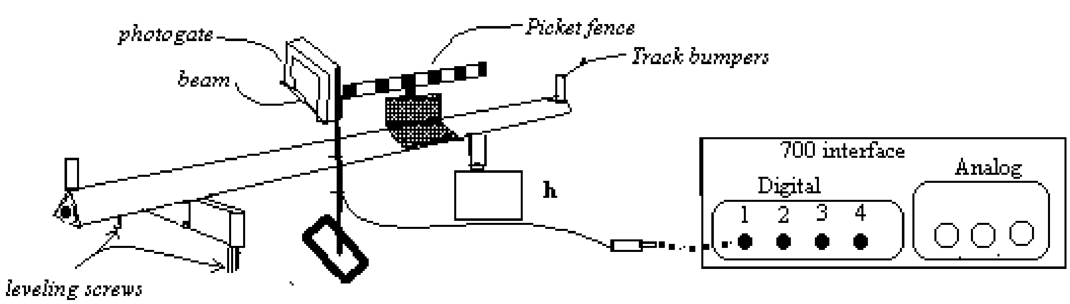
$$\mathbf{a_{12}} = \frac{v_2 - v_1}{t_2 - t_1}$$

When a glider slides down a straight hill, its velocity increases at a steady rate, increasing its velocity by the same amount each second. The displacement of the glider also increases at a continuously increasing rate. The relationship between the position, velocity and time of the object is summarized in the following equations:

$$x_2 = x_1 + v_1 (t_2 - t_1) + \frac{1}{2} a (t_2 - t_1)^2$$

$$v_2 = v_1 + a (t_2 - t_1)$$

$$v_2^2 = v_1^2 + 2 a (x_2 - x_1)$$



For the glider on the inclined plane, the acceleration along the plane depends on the component of gravity that is directed along the plane, $\mathbf{a = g \cdot Sin\ \theta}$. (**g** is divided into two components: one perpendicular to the air track; the other parallel to the air track). **mg Sin θ** is the is the force of gravity directed along the plane. Sin θ can be determined using some trigonometry, studying the triangle formed by the spacer, the support screws and the inclined air track, the Sin θ is also equal to the height of the spacer divided by the length of the air track between the supporting screws.

The velocity during each distance interval can be calculated by: $v_1 = \frac{x_2 - x_1}{t_2 - t_1}$, $v_2 = \frac{x_3 - x_2}{t_3 - t_2}$ etc... $v_i = \frac{\Delta x_1}{\Delta t_1}$.

The acceleration can be calculated by:

$$a_1 = \frac{v_2 - v_1}{\text{(time between midpoints of the velocity measurements)}} = \frac{\Delta v_1}{\frac{1}{2}(\Delta t_2 + \Delta t_1)} .$$

Procedure continues:

*Measure the thickness of your spacer, h.
*Place the spacer under the support screw.
*With the air compressor off, Place the glider inside the photogate and adjust the height of the photogate so that the picket fence is in the beam of the photogate.
*Place the glider at the top of the inclined plane.
*****Turn on the air compressor, the glider should move down the plane.
*Now hold the glider just a centimeter above the photogate.
*Press the REC button to collect data.
*Print the table of data, and the graphs of Velocity vs. Time and Displacement vs. Time <u>for one set of data</u>.
*From the graph of Velocity vs. Time determine a value for the acceleration of the glider.
*From the acceleration of the glider, find the acceleration of gravity, **g.**

$$a = g \text{ Sin } \theta$$

*You need to know the thickness of the spacer, h, you used to raise one side of the air track to make it inclined.

$$L = 100 \text{ cm. then Sin } \theta = \frac{h}{L}$$

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accel (th) = $(\frac{h}{L})$ g = $(\frac{h}{100\text{ cm}})$ * 9.8 m/s^2

(1) how the angle of inclination affects the acceleration (use the 500 gram slotted weights as spacers) L = 100 cm

	A	B	C	D		E
1	Mass	h	accel (th)	$a\ from\ slope\ of\ graph$		% Error
2	(grams)	(cm)	(m/s^2)	(m/s^2)		=100*Abs(9.8 – E2)/9.8
3						
4						
5						
6						

Turn off the computer and put everything away.

Use the following questions to guide you in writing your discussion of the results.

Did the acceleration of the glider down the inclined track vary as the g sin θ? Did you have a sufficient range of angles to rule out a = g Tan θ? Would an angle of 10° be enough? (hint: calculate 9.8*Sin θ and 9.8* Tan θ then find the difference.)

Was friction a factor in the acceleration? Since friction is equal to μmg Cos θ, the friction should decrease as the angle increases. Friction would increase your % error. Does the % error decrease with increasing angle?

* **procedure to check for friction**: * If you were to give the glider a hard push up the incline and through the photogate, would you get the same acceleration as when it was accelerating down the incline? Try doing this. Why should it be different is there is friction?

(2) how the mass of the glider affects the acceleration. Use 2 spacers and change the mass of the glider

	A	B	C	D		E
1	Mass	h	accel (th)	$a\ from\ slope\ of\ graph$		% Error
2	(grams)	(cm)	(m/s^2)	(m/s^2)		=100*Abs(9.8 – E2)/9.8
3						
4						
5						
6						

The acceleration should not change when you change the mass of the glider. Did your observations support this premise?