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Impulse-Momentum Theorem Lab
AP Physics C – Mechanics
http://www.thephysicsaviary.com/Physics/Programs/Labs/ImpulseLab/

Objective: I can form an expression relating impulse to the change in velocity of an object by calculating the change in momentum of an object given a function of the net force acting on an object over time.

Background: The impulse of an object describes how much an object is being "pushed" or "pulled" and for how long. For a constant net force, the impulse is given to be $\boldsymbol{J} = \boldsymbol{F}\Delta t$. Note that because the force has direction, so too will the impulse. The impulse points in the same direction as the net force acting on the object. For a non-constant net force, the impulse then $\boldsymbol{J} = \int F(t)dt$.

Outer Space is as close to a natural vacuum as we can get. To that end, noting that the acceleration due to gravity is not substantial if you are far away from a celestial body, we can minimize the number of forces acting on an object, giving us a nice situation for investigating impulse and velocity of an object. You will use the simulation in the link above for this lab.

Procedure
Collect data for the force and time that the force is acting for during several trials. You will want the force to stop acting on Wally BEFORE he reaches the photogates! You will also need to measure/calculate the velocity of the astronaut. Keep the mass of the astronaut constant for the entire experiment.
Use "Activate" to activate the extinguisher, and "Stop" to stop it. "Reset" resets the experiment (what a surprise!).

Fill out the data table below using *constant* forces. You should have 5 trials. <u>Keep the time that the force acts on Wally approximately constant across all trials – resist the impulse to change this</u>. Fill out the 1st row with your variables and units of things you measured and calculated.

Force (N)	Photogate distance (m)	Photogate time (s)	Measured velocity (use Col. 2 and 3) (m/s)
100	10	.99	10.10
85	10	1.157	8.64
65	10	1.52	6.58
55	10	1.794	5.57
50	10	1.983	5.04

Mass of Wally = ____50___ kg.
Force time = _____5__ s

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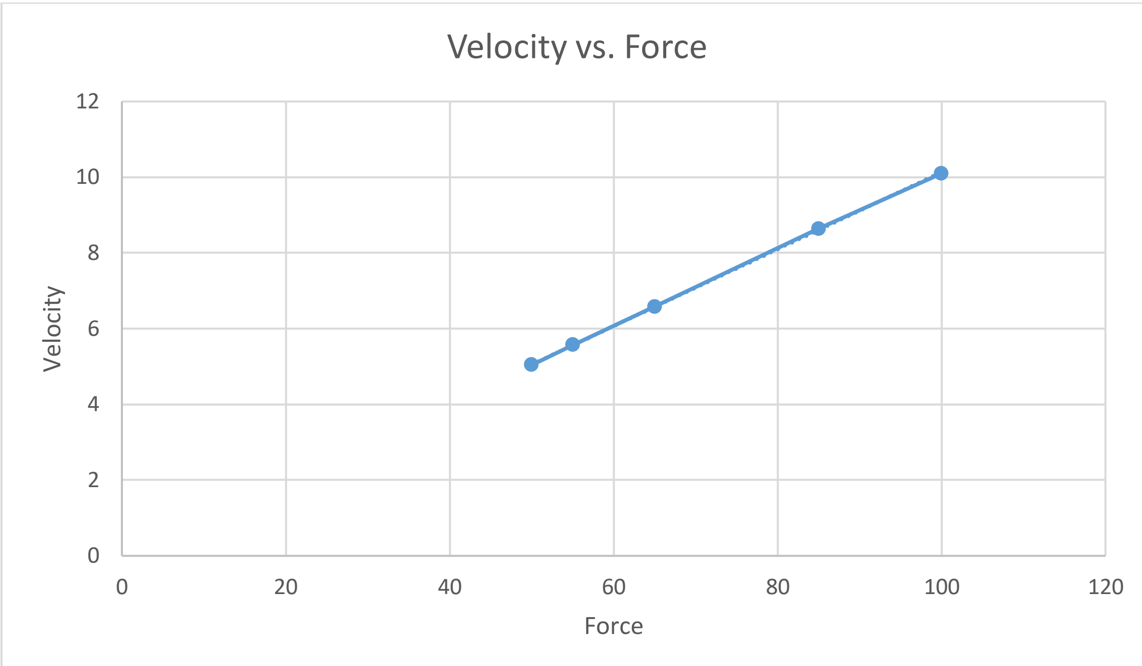
Plot the measured velocity vs. the force. Linearize the graph if needed, and relate the slope to your other values written down. Include the graph (or graphs, if needed), trendline, and analysis below.



Post Lab Questions:

1. How does the final velocity relate to the force? Does this match your expectations? Why or why not?

The final velocity is linearly related to the force, which matches my expectations.

2. Name 2 sources of error in this laboratory from the simulation/measurements alone.

One of the main sources of error is that I was not able to stop the timer exactly on 5 seconds, always going slightly over by a few milliseconds. Another source of error could be the floating point errors the computer might generate, which could slightly skew the data.

3. Name 1 assumption that we made about Wally that is not true in the real world! Would this cause significant error?

In this simulation, it is assumed that Wally experiences no loss of mass. However, the more gas he expels from the fire extinguisher, the lighter he gets, which could contribute significantly to the overall force and momentum of the system.

4. Newton's 3rd law says that every force has an equal and opposite force. What is the equal and opposite force to the one used in the experiment?

The force used in the experiment is provided by the fire extinguisher. The equal and opposite reaction in this system is the force exerted on the astronaut that pushes him forward.

5. Consider your results from this lab as well as your answer for Question 4. Which of Newton's Three Laws, if any, are important for understanding the relation between velocity and force that you found (Hint: using your data, can you rearrange your trendline equation and graph to represent one or more of Newton's Three Laws?)?

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Newton's second law, as F=ma is important for relating velocity, which can be divided by time to be turned into acceleration, to the mass of the object, producing the force we are looking for. The third law is also important in order to realize that an equal and opposite force would be exerted on the astronaut when the fire extinguisher is activated.