Physics 30 eLab
Rocket Engine Impulse

Background:

Model rocketry provides many insights into how objects are sent into space. For example, the solid rocket boosters of NASA's Space Shuttle are not much different from the engines used to launch model rockets. Solid fuel is packed into a tube, then ignited at one end. As the fuel burns violently through the tube, the force produced can be used to accelerate an object.

Rocket engines (or motors) for model rocketry are compact units made to slide into the body of your model rocket.

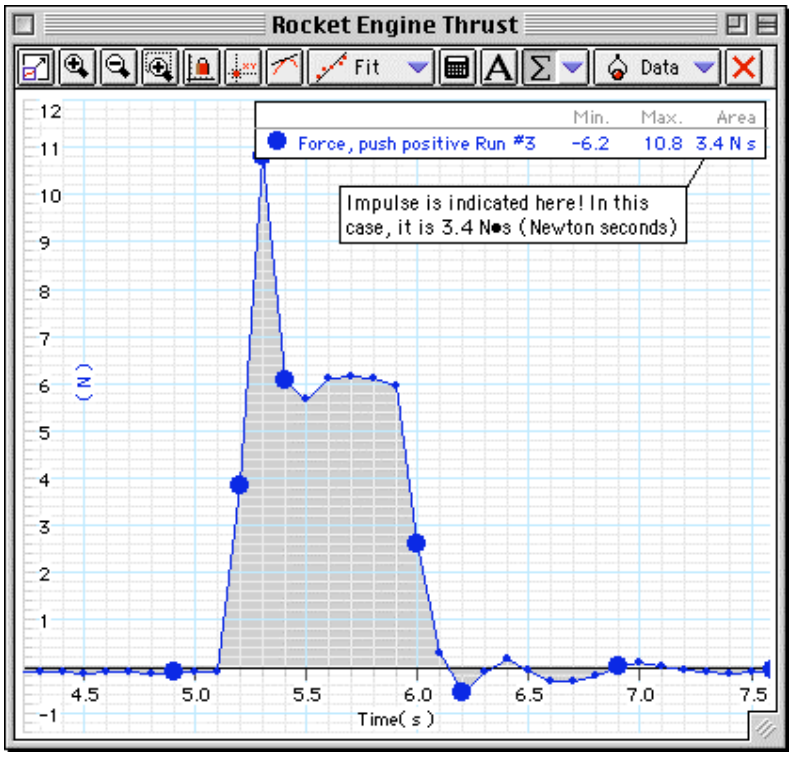
The rockets come in different sizes and packed with different amounts of propellant to provide different amounts of force and different burn times. In this lab, you will measure the amount of force provided by different rocket engines and compare the results to manufacturers specifications.

To provide a fair comparison of engines, impulse can be calculated. To calculate impulse, simply multiply the force produced (in Newtons) by the time (in seconds) that the engine burns.

Rocket engines are sold labeled from "1/4A" all the way up to "H", indicating how much impulse they deliver - according to manufacturers, they should deliver the following:

Impulse of Engine (Newton·seconds)	Motor Label
0.00-1.25	1/4A-1/2A
1.26-2.50	A
2.51-5.00	B
5.01-10.00	C
10.01-20.00	D
20.01-40.00	E
40.01-80.00	F
80.00-160.00	G
160+	H

The only minor problem is that a rocket engine may not deliver a constant amount of force. While it may be difficult to get a measure of impulse manually, a computer analysis can make it much easier. As you can see in the DataStudio graph above, the line clearly indicates the force of the engine. By choosing "Area" from the statistics menu, the computer will automatically calculate the area under the graph. This is equal to force x time, or impulse.



Safety Warning: Rocket engines are flammable and dangerous and should only be ignited by someone with experience with them. Anyone igniting an engine or observing the burn should be wearing eye protection. When firing rocket engines, no buildings, people, or flammable materials should be in the path of the rocket's blast. Aim carefully. Allow rocket engines to cool before touching them for removal.

The Question:

What is the impulse produced by different model rocket engines?

Materials:

- model rocket engines - size A, B, C, D are recommended.
- lab stand
- force sensor
- rocket engine test bracket
- rocket igniters, plugs
- remote ignition system
- Xplorer, GLX or laptop computer and USB link
- computer
- DataStudio software

Procedure:

Step 1:

Obtain a force sensor and connect it to your method of choice for collecting data outdoors. This may be a hand held Xplorer or GLX unit, or perhaps a laptop computer with a USB link.

Screw a rocket engine test bracket into the end of the force sensor (do not over-tighten, this can damage your force sensor).

Plug the sensor into the Xplorer data logger.

Step 2:

Use the mounting hole on the force sensor to attach it to the lab stand. Take the whole apparatus outside, and place a large mass (such as the edge of a heavy garbage can or a vise) on the base of the lab stand to prevent it from moving when the rocket fires.

Step 3:

Place an igniter and igniter plug into the engine. The leads of the igniter are then connected to the leads of the remote ignition system. Access the rate of data collection for the force sensor and increase the sampling rate to 50 Hz. Press the ZERO button on the force sensor.

Step 4:

Start collecting data - if you are using the Xplorer data logger, press the large green button. Now press the launch button on the remote ignition system. Once the rocket has completed its burn, press the large green button on the Xplorer again to stop recording data.

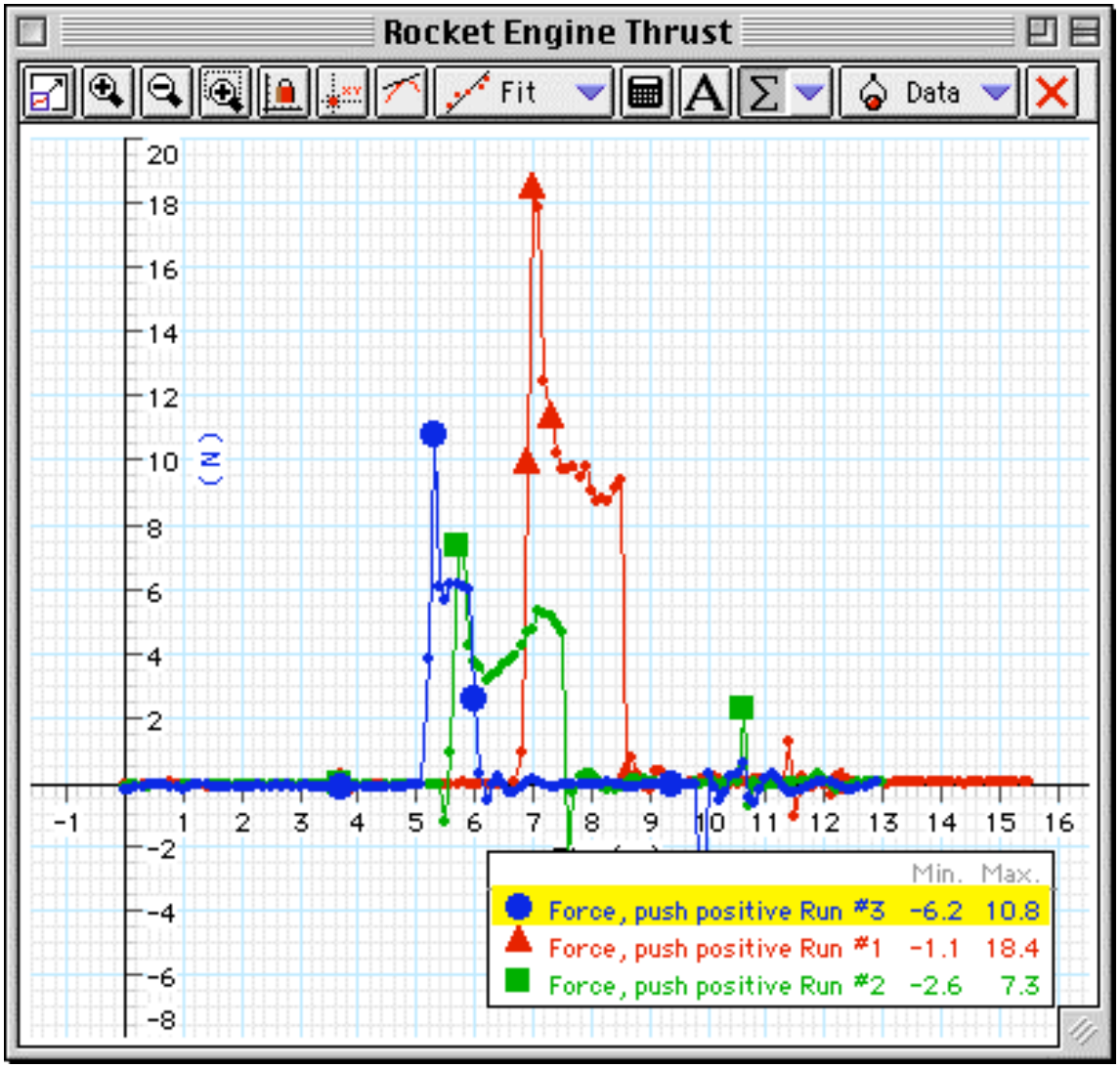
Step 5:

Repeat steps 3 and 4 with any other rocket engines you wish to test.

Step 6:

Take your apparatus back to the lab. Launch the DataStudio software on your computer.

Disconnect the Xplorer from the force sensor, and connect it to the computer with the USB cable that came with the Xplorer. The computer will ask you if you would like to retrieve collected data. Your data for multiple trials should look something like this:



Use the "Data" button at the top of the graph to isolate the first data trial. Then, as described in the background information for this lab, use the statistics button to select the area under the graph. Use your cursor on the graph to click and drag a square over the area of the graph you wish calculated. Make note of the value for the impulse of the engine. Repeat this process for all the engine data.

Analyzing and Interpreting:

1. Look at the peaks on the graph. Which rocket engine produced the highest force value? Is force the same as impulse? Explain.

2. Which rocket engine burned for the longest period of time? How does the length of the burn affect the amount of impulse delivered by the engine?

Forming Conclusions:

3. Based on the data you have collected, write a conclusion regarding the different rocket engines and the total amount of thrust they provide.

Applying and Connecting:

4. A particular rocket engine produces 15 N of force but for only one second. Does this engine produce more or less impulse than another engine that burns for 10 seconds and provides 1 N of force? Explain.

5. Compare the impulse values to the chart of standard values (in the background section of this lab) that rockets are supposed to produce. Did your rocket engines meet the standard values? If there is a significant difference, offer an explanation for it.