Passage #1 (Data Representation)

The key parameters used to discuss rocket engine performance involve *Thrust* (F_T), which is the force exerted by the expanding gases as they leave the combustion chamber, and *Impulse* (*I*), *which* concerns the relationship of this force to the time over which it acts. Figure 1 shows a typical *Thrust-Time Curve* for a model rocket. On this curve, the *Total Impulse* (I_{total}) is given by the area under the curve. *Average Thrust* (F_{Tavg}) can then be determined by dividing I_{total} by the duration of the burn. In rocketry, fuel mass is critical, since it contributes to the overall mass of the craft and must be balanced with the payload and vehicle mass. *Specific Impulse* (I_{sp}), therefore, is another important parameter determined by the ratio of I_{total} to the mass of the fuel.

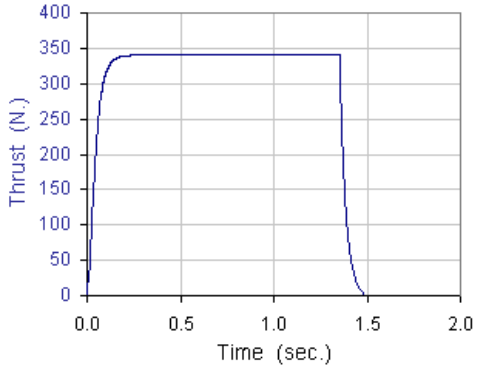

Figure 1: Thrust vs. Time Curve (http://www.nakka-rocketry.net/epoch.html)

In solid-rocket motors, the cross-section of the solid fuel determines the burn rate and, therefore, the thrust produced over the duration of the burn. Figure 2 shows the thrust-time curves for some common types of solid-rocket motor cross-sections.

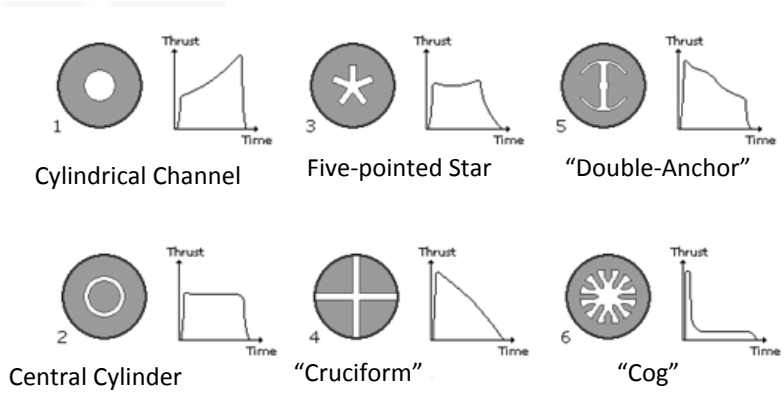

Figure 2: Solid Rocket Motor Cross-sections (http://aerospacengineering.net/?p=1255)

1. For the thrust-time curve shown, what is the approximate *Total Impulse* (I_{total})?
   a. 255 N·s
   b. 350 N·s
   c. 475 N·s
   d. 510 N·s

2. What is the approximate *Average Thrust* (T_{avg})?
   a. 175 N
   b. 255 N
   c. 320 N
   d. 340 N

3. Given that the mass of the fuel is 450g, what is the approximate *Specific Impulse* (I_{sp}) for this rocket?
   a. 1060 s
   b. 530 s
   c. 1.0 s
   d. 0.7 s

4. Which solid rocket motor cross-section provides a period of sustained increase in thrust?
   a. Central channel
   b. Five-pointed star
   c. Double anchor
   d. Cylindrical channel

5. Which best describes the performance of the "Cog" cross-section?
   a. Maximum thrust followed by a steady decrease in thrust
   b. Maximum thrust followed by constant lower thrust
   c. Maximum thrust followed by a gradual, then sudden decrease in thrust
   d. Maximum thrust sustained during most of the burn followed by a sudden decrease in thrust

Answer Key:

1) (c) 475 N·s
2) (b) 320 N
3) (a) 1060 s
4) (d) Cylindrical channel
5) (b) Maximum thrust followed by constant lower thrust

Passage #2 (Conflicting Viewpoints)

Pluto was long considered the ninth planet in our solar system, but then new discoveries challenged this status. In 2006, the International Astronomical Union (IAU) sought to establish a definition for a "planet" based on three requirements: the object "must (1) be in orbit around the sun, (2) have sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (3) have mostly 'cleared the neighborhood' of other bodies (e.g., asteroids) around its orbit."

Based on this definition, Pluto was demoted to a "dwarf planet," but the debate still continues among scientists. The issue centers not only on Pluto's planetary status, but also on the very definition of "planet." Consider these opinions of two astronomers on the debate of whether Pluto should be classified as a planet or not.

Astronomer #1

Pluto has been a considered a planet since its discovery in 1930, long before the subsequent discovery of the surrounding asteroid region known as the Kuiper Belt. It is part of our solar system, and although small, having a mass 25 times less than that of Mercury (the next smallest planet in our solar system), it still has sufficient mass to maintain a substantially spherical shape. Pluto is surrounded by the Kuiper Belt, so it has not "cleared the neighborhood," but is still 9 times larger than the largest known asteroid in the Kuiper Belt. It may not exert sufficient gravitational influence over the vast majority of objects in the region to encompass them, but it is still the significantly dominant object there. This fact in conjunction with the other two criteria should allow Pluto to retain its planetary status.

Astronomer #2

When originally discovered, Pluto was classified as a planet, but as scientific knowledge and understanding changes, so too should this classification. We know that Pluto orbits the sun and holds a spherical shape. However, its mass is much less than originally thought, and due in part to this, it falls short on meeting the criterion relating to its interaction with the other objects in the Kuiper Belt. As far as is known, Pluto is more massive than the largest single object in the region, but its mass is considerably less than the estimated total mass of the other Kuiper Belt objects. As a result, Pluto does not encompass the surrounding asteroids (as does, for example, Jupiter), but instead merely sits among them. Therefore, Pluto should be demoted to a status below "planet" to clarify that it is a body akin to asteroids.

1. On which point would the astronomers most likely agree?
    a. Pluto orbits the sun.
    b. Pluto lacks sufficient mass to maintain a spherical shape.
    c. Pluto is the dominant body in the Kuiper Belt.
    d. Pluto lacks sufficient gravitational influence in the Kuiper Belt.

2. Which statement best summarizes the argument of Astronomer #2?
    a. Pluto should not be considered a planet because it is surrounded by asteroids.
    b. Pluto is not large enough to be a planet because it is only 9 times larger than the largest known asteroid in the Kuiper Belt.
    c. Although Pluto is a relatively large object in the Kuiper Belt, it does not exert enough gravitational influence on the other objects to be considered a planet
    d. Pluto should not be considered a planet because it is 25 times smaller than the smallest planet in the solar system.

3. Which best states the most controversial point of debate in planetary classification?
    a. Whether or not a body orbits the sun
    b. Whether or not a body has a mass sufficient to maintain a spherical shape
    c. Whether or not a body has a mass larger than that of surrounding objects
    d. Whether or not a body exerts enough gravitational influence to clear an area of surrounding asteroids

4. A new spherical celestial body is discovered orbiting the sun. It is estimated to have a mass 5 times that of earth, and is surrounded by a dense asteroid region. What would be the likely opinions of the Astronomers?
    a. Astronomer #1 would say it is not a planet; Astronomer #2 would say it is a planet.
    b. Astronomer #1 would say it is a planet; Astronomer #2 would say it is not a planet.
    c. Both Astronomer #1 and Astronomer #2 would agree it is a planet.
    d. Both Astronomer #1 and Astronomer #2 would agree that it is not a planet.

5. Which of the following is *not* a criterion that must be met for a celestial body to be considered a planet?
    a. It must be able to maintain hydrostatic equilibrium.
    b. It must have sufficient gravitational pull to encompass other objects into its orbit.
    c. It must orbit the sun.
    d. It must be free from all surrounding objects in a region.

Answer Key:

1. (a) Pluto orbits the sun.
2. (c) Although Pluto is a relatively large object in the Kuiper Belt, it does not exert enough gravitational influence to be considered a planet.
3. (d) Whether or not a body exerts enough gravitational influence to clear an area of surrounding asteroids
4. (b) Astronomer #1 would say it is a planet; Astronomer #2 would say it is not a planet.
5. (d) It must be free from all surrounding objects in a region.