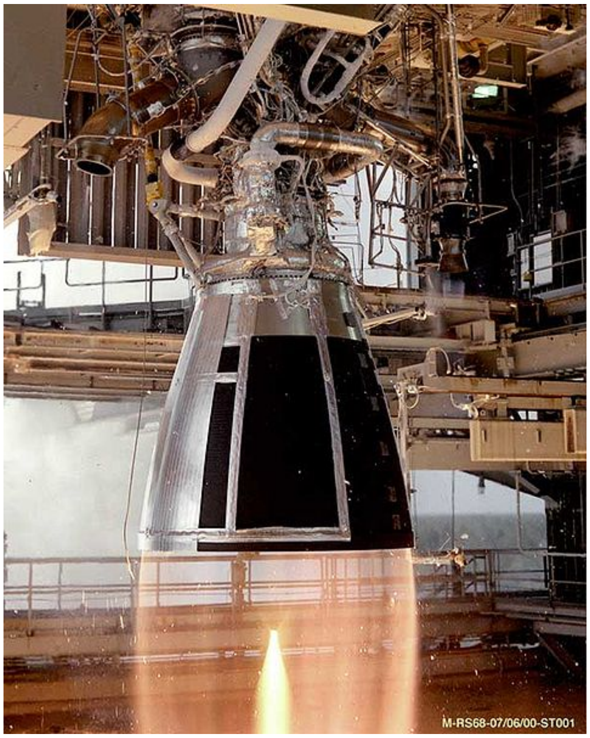

Rocket engines work by throwing matter out the back end of a rocket as fast as they can. Usually this matter is in the form of gas. This causes the rocket to move forward in the opposite direction from the ejected matter, thanks to Newton's Third Law of Motion which says that '*For every Action, there is an equal and opposite Reaction*'.

To lift tons of cargo into space, rocket engines have to be very powerful. Engineers usually compare different engines by their thrust and by their specific impulse. This makes it easy to decide which kind of engine to use to put different payloads into space in the most efficient and low-cost way possible.

Problem 1 – Specific Impulse Isp = V/g is the ratio of the exhaust speed of the engine (V) divided by the acceleration of gravity at Earth's surface (g), where g is 9.8 meters/sec^2 and V is measured in meters/sec. The J-2X rocket engine has an Isp=421 seconds. How fast are the exhaust gases leaving the bottom of the engine in A) kilometers/sec? B) feet per second? C) miles per hour? (1 kilometer = 3280 feet; 1 mile = 5280 feet)

Problem 2 – Thrust is a measure of the force that the rocket can produce to move an object against the pull of gravity. It is measured in Newtons and is defined by Thrust = F x V where F is the rate of flow of fuel in kilograms/sec and V is the exhaust speed of the combusted gases. The new J-2X rocket engines being designed and tested by NASA have an Isp=421 seconds and a thrust of T = 1,310,000 Newtons. At what rate is mass leaving the rocket engine in A) kilograms/second? B) pounds/second? (1 kilogram = 2.2 pounds).

Problem 3 – Ion rocket engines: Instead of chemical rockets using liquid fuels, the Dawn spacecraft has an ion rocket with Isp=3,100 seconds. If the same ion technology was used to design a replacement for the liquid-fueled J-2X engine, what must be the fuel flow rate, F, in order to produce the same thrust as the J-2X engine?

Problem 4 – Rocket Design: What would the Isp and thrust be for an engine that had V = 10,000 meters/sec and F = 500 kg/sec?

http://www.qrg.northwestern.edu/projects/vss/docs/propulsion/3-how-you-calculate-specific-impulse.html

Problem 1 – Specific Impulse Isp = V/g is the ratio of the exhaust speed of the engine (V) divided by the acceleration of gravity at Earth's surface (g), where g is 9.8 meters/sec^2 and V is measured in meters/sec. The J-2X rocket engine has an Isp=421 seconds. How fast are the exhaust gases leaving the bottom of the engine in A) kilometers/sec? B) feet per second? C) miles per hour? (1 meter = 3.280 feet; 1 mile = 5280 feet)

Answer: A) Isp=421 seconds and g = 9.8 m/sec^2 so V = Isp x g and
V = **4,126 meters/second**.
B) 1 meter = 3.28 feet and so V = 4126 m/s (3.28 feet/1 meter) so
V = **13,533 feet/sec**.
C) 1 mile = 5280 feet so V = 13,533/5280 = 2.56 miles/sec and for 3600 seconds in 1 hour, we have **V = 9,216 miles/hour**.

Problem 2 – Thrust is a measure of the force that the rocket can produce to move an object against the pull of gravity. It is measured in Newtons and is defined by Thrust = F x V where F is the rate of flow of fuel in kilograms/sec and V is the exhaust speed of the combusted gases. The new J-2X rocket engines being designed and tested by NASA have an Isp=421 seconds and a thrust of T = 1,310,000 Newtons. At what rate is mass leaving the rocket engine in A) kilograms/second? B) pounds/second? (1 kilogram = 2.2 pounds).

Answer: A) Isp = V/g so V = 421 x 9.8 m/sec2 = 4,126 meters/sec, then T = F x V and F = T/V so F = 1,310,000/4126 = **317 kg/second**. B) 317.5 kg/sec x (2.2 pounds/1kg) = **698 pounds/second**.

Problem 3 – Ion rocket engines: Instead of chemical rockets using liquid fuels, the Dawn spacecraft has an ion rocket with Isp=3,100 seconds. If the same ion technology was used to design a replacement for the liquid-fueled J-2X engine, what must be the fuel flow rate, F, in order to produce the same thrust as the J-2X engine?

Answer: Isp = 3100 sec so V = 3100 sec/9.8 m/sec2 = 316 m/sec. T = F x V and T = 1,310,000 Newtons and so F = 1,310,000/316 = **4,145 kg/sec**.

Problem 4 – Rocket Design: What would the Isp and thrust be for an engine that had V = 10,000 meters/sec and F = 5000 kg/sec?

Answer: Isp = 10,000/9.8 = **1020 sec**, and T = 5000 x 1020 = **5,100,000 Newtons**