A Simple Gauge in a Fuel Tank - I

This is a photo of the Space Shuttle main fuel tank just after being jettisoned at an altitude of 50 miles. The liquid hydrogen is approximately shaped like a cylinder with a diameter of 8.4 meters and a length of 29.6 meters.

The formula for the volume of a cylinder is given by

$$V = \pi R^2 h$$

where **R** is the radius of the cylinder and **h** is its length.

Problem 1 – To two significant figures, what is the volume of the fuel tank in:

A) Cubic meters?

B) Cubic centimeters?

C) Liters (1 liter = 1000 cm^3)?

D) Gallons? (1 liter = 0.26 gallons)

Problem 2 – For safety, engineers want to install a gauge that will indicate when there is only 1/8 of the original fuel volume remaining in the tank. How many meters from the bottom of the tank must the gauge be located to be triggered?

Problem 3 – The rate at which fuel is burned by the Space Shuttle engines is about 1000 gallons per second. From ignition, how many minutes (to the nearest tenth) will it take for the fuel to reach the level of the fuel gauge?

Problem 1 – What is the volume of the fuel tank for R = 8.4/2 = 4.2 meters and h = 29.6 meters.

A) V = 3.14 $(4.2)^2$ (29.6) = 1639 **= 1600 meters^3**

B) V = 1600 x (100 cm / 1 m)^3 = **1.6 billion cm^3**

C) V = **1.6 million liters**

D) V = 1.6 million liters x (0.26 gallons/1 liter)
= 416,000 = **420,000 gallons**

Problem 2 – For safety, engineers want to install a gauge that will indicate when there is only 1/8 of the original fuel volume remaining in the tank. How many meters from the bottom of the tank must the gauge be located to be triggered?

Answer: Method 1: V = 1/8 (1600) = 200 meters^3. Then since R = 4.2 meters, from the formula we get

200 = 3.14$(4.2)^2$ h and solving for h we get **3.6 meters** from the bottom of the tank.

Method 2: From the formula for the cylinder, since R remains the same, only h will vary and so the gauge will be located 1/8(29.6 meters) = **3.7 meters** from the bottom of the tank.

Problem 3 – The rate at which fuel is burned by the Space Shuttle engines is about 1000 gallons per second. From ignition, how many minutes (to the nearest tenth) will it take for the fuel to reach the level of the fuel gauge?

Answer: The tank must lose 7/8 of its original volume in gallons which equals 7/8 (420,000) = 367,500 gallons. At a rate of 1000 gallons per second, this will take 367.5 seconds or **6.1 minutes**.