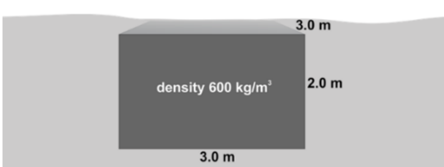
Test, Lesson 6 – Fluids and Gases

1. What volume of helium has to be pumped into this balloon in order to lift this balloon and basket, which together weigh 1000 Kg? The density of air is 1.29 times ten to the minus three kilograms per cubic meter (1.29 (10^{-3}kg/m^3)), and the density of helium is 0.18 times ten to the minus three kilograms per cubic meter (.18 (10^{-3}kg/m^3)).

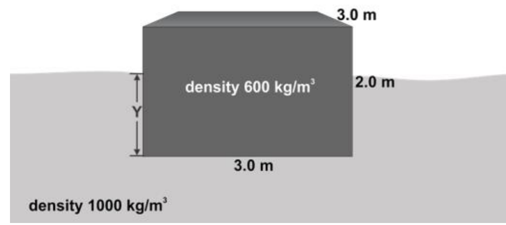
(A) 9.0×10^5 m^3
(B) 10.0×10^5 m^3
(C) 11.0×10^5 m^3
(D) 12.0×10^5 m^3
(E) 13.0×10^5 m^3

2. Here is a 3.0 *x* 3.0 *x* 2.0 meter block of wood floating in the water. The wood's density is 600 kg/m^3 and the density of water is 1000 kg/m^3. How much mass would this block of wood be able to hold before it sank beneath the surface of the water?



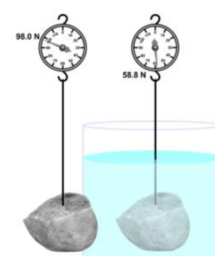
(A) 6600 kg
(B) 6800 kg
(C) 7000 kg
(D) 7200 kg
(E) 7400 kg

3. If this same 3.0 * 3.0 * 2.0 meter block of wood were floating in the water without anything on it, how high above the water would it float? Its density is 600 kg/m^3 and the density of water is 1000 Kg/m^3.



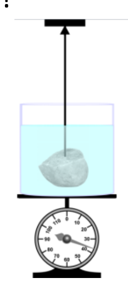
(A) 0.6 m
(B) 0.8 m
(C) 1.0 m
(D) 1.2 m
(E) 1.4 m

4. If a rock weighs 98 kg-meters per second squared, or 98 Newtons, but only 58.8 newtons when submerged in water, what is the density of the rock?



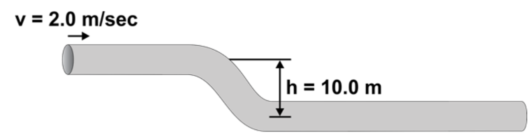
(A) 1800 kg/m^3
(B) 2100 kg/m^3
(C) 2500 kg/m^3
(D) 2800 kg/m^3
(E) 3100 kg/m^3

5. When this rock is lowered into the jar of water being weighed, the scale records additional weight equal to what?



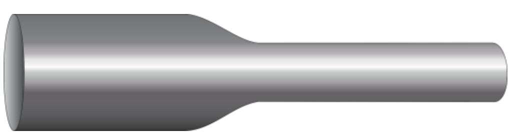
(A) the weight of the rock
(B) the mass of the rock
(C) the mass of the water
(D) the string tension
(E) the force of buoyancy

6. Water is entering this curved pipe at a rate of 2.0 meters per second, and exiting 10.0 meters below the entrance. The pipe is open to the air at both ends. What is the water velocity at the exit?



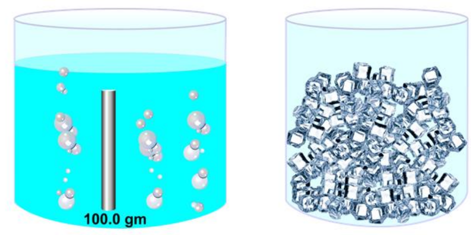
(A) 10 m/sec
(B) 20 m/sec
(C) $10\sqrt{2}$ m/sec
(D) $2\sqrt{10}$ m/sec
(E) $\sqrt{20}$ m/sec

7. What happens if we enlarge the opening to the pipe to twice the diameter of the exit hole? If water flowing through this pipe has the same pressure entering the pipe as it does exiting the pipe, how does the water velocity exiting the pipe compare to the water velocity entering the pipe?



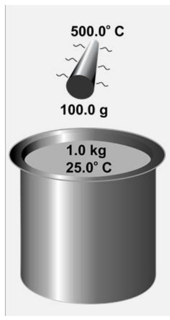
(A) The flow velocity at the exit is greater than at the entrance
(B) The flow velocity at the exit is less than at the entrance
(C) The flow velocity at the exit is equal to the flow velocity at the entrance.
(D) More information is needed to answer this question.

8. If a 100 gram piece of iron is transferred from boiling water into a bucket of ice, how much ice will melt? The specific heat capacity of iron is 0.11 cal/g/degree C. The latent heat of freezing for ice is 80 cal per gram.



(A) 11.75 g
(B) 12.75 g
(C) 13.75 g
(D) 14.75 g
(E) 15.75 g

9. If the 100.0 gram piece of iron were heated to 500 degrees Celsius and then dropped into 1.0 kg of water at 25 degrees Celsius, what would the final temperature of the water and the piece of iron be?

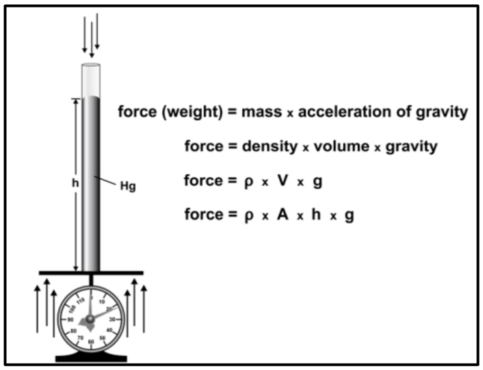


The specific heat capacity of iron is 0.11 cal/g°C, and for water, 4.18 cal/g°C.

(A) 26.2^{o} Celsius
(B) 28.4^{o} Celsius
(C) 30.1^{o} Celsius
(D) 32.3^{o} Celsius
(E) 35.6^{o} Celsius

Intro to Questions 10 and11

This scale is measuring the weight of the column of mercury.



The weight of a mass is the downward force acting on the mass when the mass enters the gravitational field of another mass.

Mathematically, this downward force is its weight, which is equal to its mass times the acceleration of gravity.

The mass of a liquid like mercury is its density times its volume, so force is density times volume times the acceleration of gravity, symbolized as rho times V times g ($\rho * V * g$).

The volume of a column is its cross-sectional area times its height, A times h, so the downward force, or weight, of a column of liquid is density, rho, times cross-sectional area, A, times height, h, times the acceleration of gravity, g.

What about the weight of the air above the column of mercury?

It's cancelled out. The downward force of the column of air above the mercury is offset by an equal upward force being exerted by air underneath the scale, so the scale is measuring only the weight of the mercury.

Here is an open glass tube sitting in a dish of mercury. Will the atmospheric pressure push the mercury up the glass tube?

No, atmospheric pressure pressing down on the dish of mercury will not push mercury up the tube, because there is an equal atmospheric pressure pressing down on the mercury column inside the glass tube. How can we get the mercury to climb up the glass tube?

The only way to get the mercury up the glass tube is to remove the air pressure above the column of mercury, which we can do by closing off the top of the glass tube, turning the tube upside down, and filling it with mercury. Then when we invert the tube again and place it in the dish of mercury, the mercury in the glass tube will only fall part way down the tube. Why only part way?

Because with all the air removed, atmospheric pressure pushing down on the dish of mercury is now unopposed.
Does it matter how wide the glass tube is? A wider tube contains more mercury. More mercury weighs more, so will the column of mercury drop further?

No. What's preventing the mercury from dropping further in the glass tube is atmospheric pressure. What determines how far the mercury drops is not its weight, but its downward pressure. The mercury will continue to drop until its downward pressure equals the atmospheric pressure pushing the mercury up the glass tube. What is the downward pressure being exerted by the column of mercury?

The pressure exerted by the column of mercury is its downward force, that is, its weight, exerted against 1 unit of cross-sectional area, represented by the formula - force divided by cross-sectional area. The units for pressure, then, are newtons of force per square meter.

$$\text{pressure} = \frac{\text{weight of mercury}}{\text{cross-sectional area of column}}$$

$$\frac{\text{force}}{\text{area}} = \text{pressure } (N/m^2)$$

$$\text{downward force (weight)} = \rho \times A \times h \times g$$

$$\text{pressure} = \frac{\rho \times A \times h \times g}{A}$$

$$\text{pressure} = \rho \times h \times g$$

$$760 \text{ mm Hg} = 1.103 \times 10^5 \text{ N/m}^2 = \text{atmospheric pressure}$$

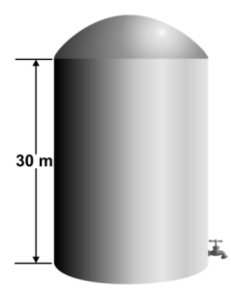
We just determined that the weight of the column of mercury is its density times its cross-sectional area times its height times the acceleration of gravity.

When the weight of the mercury column is divided by the cross-sectional area, A, the cross-sectional areas cancel out, and the downward pressure exerted by the column of mercury equals the density of mercury times the height of the mercury column times the acceleration of gravity.

Density and gravity are constant. So when the height of the column of mercury reaches a point where rho times h times g ($\rho * h * g$) equals atmospheric pressure, the column of mercury will stop falling.

On a normal day, this happens when the height of the column of mercury reaches 760 mm. The atmospheric pressure preventing the column of mercury from falling further is 1.013 times ten to the 5 newtons per square meter.

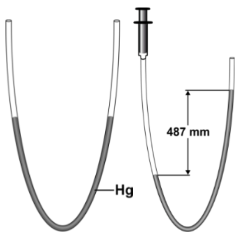
10. How much pressure will it take to fill a water tank 30 meters high? And what will the water pressure be at the spigot attached to the bottom of the tank?



(A) $2.1 * 10^5 \frac{kg\,m}{sec^2} (\frac{N}{m^2})$
(B) $2.3 * 10^5 \frac{kg\,m}{sec^2} (\frac{N}{m^2})$
(C) $2.4 * 10^5 \frac{kg\,m}{sec^2} (\frac{N}{m^2})$
(D) $2.9 * 10^5 \frac{kg\,m}{sec^2} (\frac{N}{m^2})$
(E) $3.1 * 10^5 \frac{kg\,m}{sec^2} (\frac{N}{m^2})$

11. At rest, the columns of mercury in both arms of this U tube are at the same level.

How much downward pressure does this syringe have to exert to create a 487 mm difference in the heights of the two columns? How much downward pressure does the syringe have to exert to create the same 487 mm difference if the right arm of the U tube is now closed with no air in it?



(A) Open: 1.66 * 10^4 N/m^2; Closed: 6.49 * 10^4 N/m^2
(B) Open: 6.49 * 10^4 N/m^2; Closed: 1.66 * 10^5 N/m^2
(C) Open: 1.66 * 10^5 N/m^2; Closed: 6.49 * 10^4 N/m^2
(D) Open: 6.49 * 10^5 N/m^2; Closed: 1.66 * 10^5 N/m^2
(E) Open: 6.49 * 10^5 N/m^2; Closed: 6.49 * 10^4 N/m^2