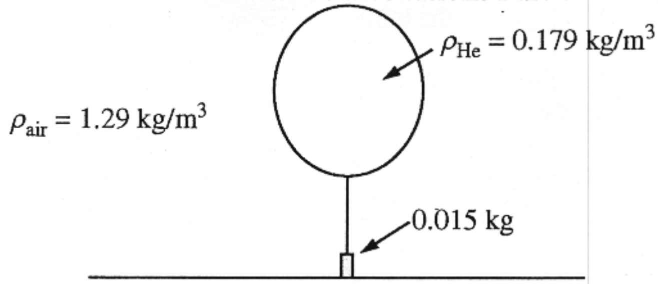
Name: KEY

Period:______

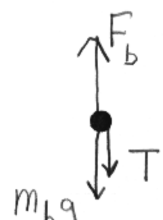
Fluids and Thermo Recitations Part 1



1. (10 points)

A helium-filled balloon is attached by a string of negligible mass to a small 0.015 kg object that is just heavy enough to keep the balloon from rising. The total mass of the balloon, including the helium, is 0.0050 kg. The density of air is $\rho_{air} = 1.29$ kg/m^3, and the density of helium is $\rho_{He} = 0.179$ kg/m^3. The buoyant force on the 0.015 kg object is small enough to be negligible.

(a) On the dot below that represents the balloon, draw and label the forces (not components) that act on the balloon.



(b) Calculate the buoyant force on the balloon. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

$\Sigma F = 0$

$F_b - m_b g - T = 0$

$F_b = m_b g + T$

$F_b = m_b g + m_m g = \boxed{0.20N}$

$\Sigma F_m = 0$

$T - m_m g = 0$

$T = m_m g$

(c) Calculate the volume of the balloon.

$V = \frac{m}{\rho}$

$F_b = m_{air} g$

$F_b = \rho_{air} V_b g$

$V_b = \frac{F_b}{\rho_{air} g} = \boxed{0.0155 m^3}$

(d) A child holds the string midway between the balloon and the 0.015 kg object. The child gets into a car, brings the balloon and the 0.015 kg object into the car, and holds the string so that neither the balloon nor the 0.015 kg object touches any surface. The car then begins to move forward, accelerating in a straight line. What behavior does the 0.015 kg object exhibit when the car accelerates?

_____It swings toward the front of the car.

__✓__It swings toward the back of the car.

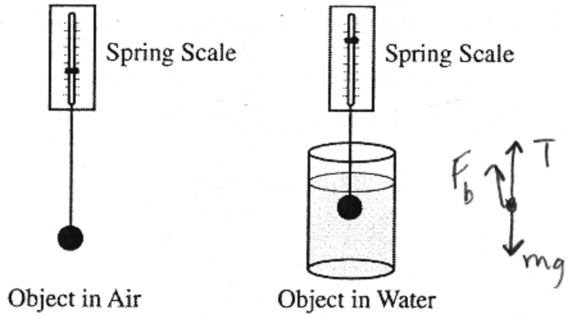
_____It swings toward the right side of the car.

_____It swings toward the left side of the car.

_____It remains vertical below the child's hand.

Explain your reasoning.

The balloon has inetia and wants to stay $V = 0$



2. (10 points)

An object is suspended from a spring scale first in air, then in water, as shown in the figure above. The spring scale reading in air is 17.8 N, and the spring scale reading when the object is completely submerged in water is 16.2 N. The density of water is 1000 kg/m^3 .

(a) Calculate the buoyant force on the object when it is in the water.

$mg = 17.8N$

$T = 16.2N$

$\Sigma F = \emptyset$

$F_b + T - mg = \emptyset$

$F_b = mg - T$

$F_b = \boxed{1.6N}$

(b) Calculate the volume of the object.

$F_b = m_w g$

$m = \rho V$

$F_b = \rho_w V_o g$

$V_o = \frac{F_b}{\rho_w g} = \boxed{1.6 \times 10^{-4} m^3}$

(c) Calculate the density of the object.

$\rho_o = \frac{m_o}{V_o}$

$m_o = \frac{F_g}{g}$

$\rho_o = \frac{F_g}{V_o g} = \boxed{1.1 \times 10^4 kg/m^3}$

(d) How would the absolute pressure at the bottom of the water change if the object was removed?

_____ increase   ✓ decrease   _____ remain the same

Justify your answer

$P = P_{atm} + \rho g h$

height of water level will decrease

3. (10 points)

$e = .12$

A locomotive runs on a steam engine with a power output of 4.5x10^6 W and an efficiency of 12 percent.

(a) Calculate the rate at which heat is being delivered to the steam engine.

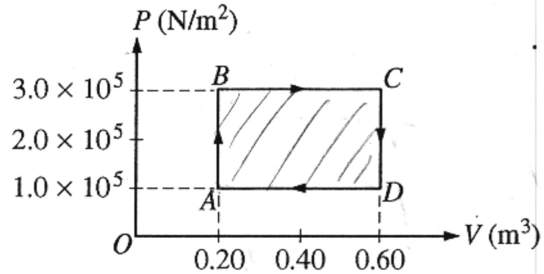
$e = \left|\frac{W}{Q_H}\right|$ $\quad P_{in} = \frac{Q}{t}$ $\quad P_{out} = \frac{W}{t}$ $\quad e = \frac{P_{out}}{P_{in}}$ $\quad P_{in} = \frac{P_{out}}{e} =$

$\boxed{P_{in} = 3.8\times10^7 W}$

(b) Calculate the magnitude of the resistive forces acting on the locomotive when it is moving with a constant speed of 7.0m/s

$P = Fv$ $\quad F = \frac{P_{out}}{v} = \boxed{6.4\times10^5 N}$

Suppose the gas in another heat engine follows the simplified path *ABCDA* in the *PV* diagram below at a rate of 4 cycles per second.



(c)

i. What does the area bounded by path *ABCDA* represent?

Work done by the gas.

ii. Calculate the power output of the engine.

$P = \frac{W}{t}$

$t = 0.25s$

$W = \text{area}$

$W = bh = 2.0\times10^5 \cdot 0.4 = 8\times10^4 J$

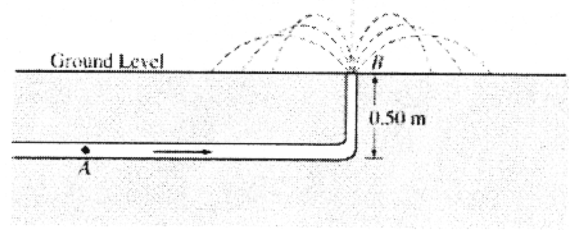
$P = \frac{8\times10^4 J}{0.25 s} = \boxed{3.2\times10^5 W}$

(d) Indicate below all of the processes during which heat is added to the gas in the heat engine.

✓ *AB* ✓ *BC* ____*CD* ____*DA*

$\uparrow P V = nR \uparrow T$

$P \uparrow V = nR \uparrow T$



4. (15 points)

An underground pipe carries water of density 1000 kg/m^3 to a fountain at ground level, as shown above. At point *A*, 0.50 m below ground level, the pipe has a cross-sectional area of $1.0\text{x}10^{-4}$ m^2 (A_1). At ground level, the pipe has a cross-sectional area of $0.50\text{x}10^{-4}$ m^2 (A_2). The water leaves the pipe at point *B* at a speed of 8.2 m/s (V_2).

(a) Calculate the speed of the water in the pipe at point *A*.

$$A_1 v_1 = A_2 v_2$$

$$V_1 = \frac{A_2}{A_1} V_2 = \boxed{4.1\,m/s}$$

(b) Calculate the absolute water pressure in the pipe at point *A*.

$$P_1 + \rho g y_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2 \qquad y_1 = \varnothing \quad y_2 = 0.5m \qquad P_2 = P_{atm}$$

$$P_1 = P_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2 - \tfrac{1}{2}\rho v_1^2 = \boxed{1.3\times10^5\,Pa}$$

(c) Calculate the maximum height above the ground that the water reaches upon leaving the pipe vertically at ground level, assuming air resistance is negligible.

$$V^2 = V_0^2 + 2a\Delta X \approx V^2 = V_{oy}^2 - 2g\Delta y$$

$$\Delta y = \frac{-V_0^2}{-2g} = \boxed{3.4m}$$

(d) Calculate the horizontal distance from the pipe that is reached by water exiting the pipe at 60° from the level ground, assuming air resistance is negligible.

$$\Delta y = \frac{-V_{oy}^2}{-2g} = \frac{(V_0 \sin\theta)^2}{2g} = 2.52\,m$$

$$t = \sqrt{\frac{2\Delta y}{g}} = 0.71_s \times 2 = 1.42_s$$

$$\Delta X = V_{ox} t$$

$$\Delta X = (V_0 \cos\theta) t = \boxed{5.82m}$$