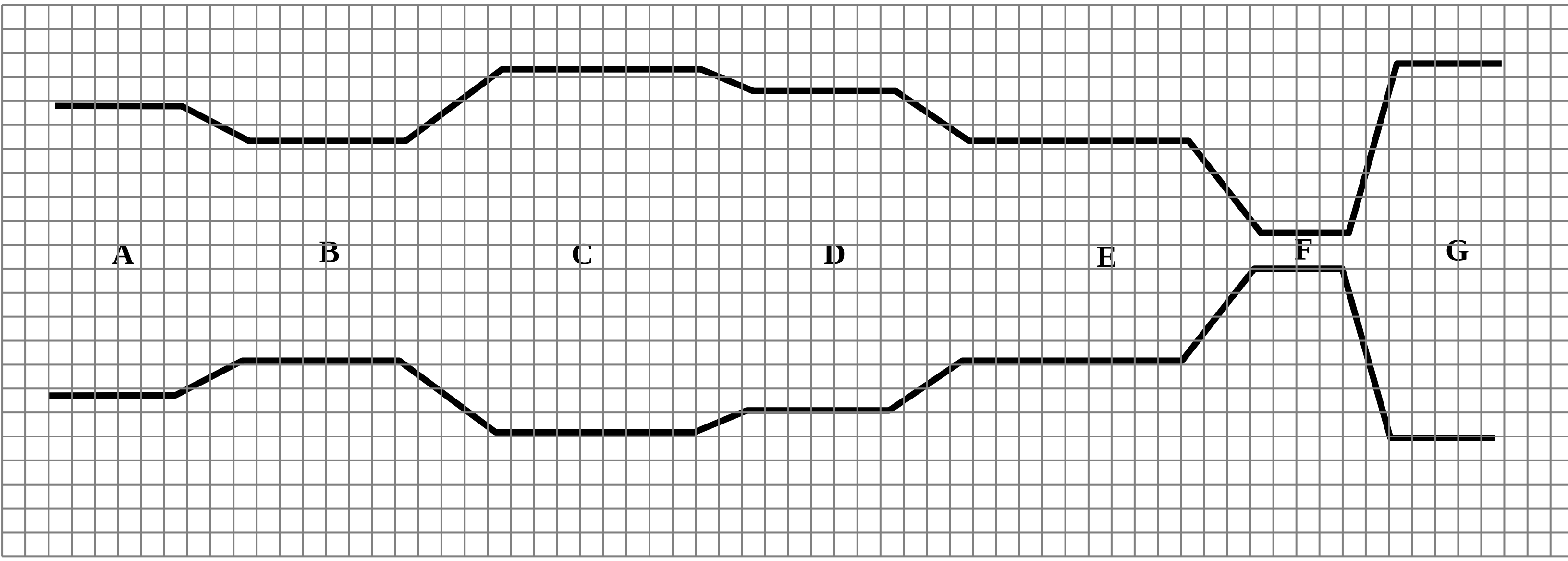
Name: ____________________

Date: ______________ Period: ____________

Fluids Worksheet 3
Interaction Energy Density = Pressure

The following three questions refer to the diagram below, in which fluid flows smoothly through the tube under steady state conditions and without dissipation.



1. (a) Rank the flow rate in the tube from greatest to least.

(b) Carefully explain your reasoning.

2. (a) Rank the velocity of flow in the tube from greatest to least.

(b) Carefully explain your reasoning.

3. (a) Rank the pressure in the tube from greatest to least.

(b) Carefully explain your reasoning.

4. Perform the following demonstrations with common household items and explain the results.

(a) Set a dime on a table and blow air quickly over it.

(b) With a loose shower curtain – one that is not weighted at the bottom – turn on the water in your shower and observe what the curtain does.

(c) Hold two pieces of paper vertically in front of you so you are looking at their edges and between them. Blow between the pieces of paper.

(d) "Curl" a piece of paper by rolling it up tightly so that when it unrolls you can set it on the table and it will stand on its edges making a hill in the center. Blow under the paper and observe what happens.

(e) browse to the web site http://www.new-fitness.com/Blood_Pressure/numbers.html and read about how blood pressure is measured.

define the following terms and explain briefly how they are measured:

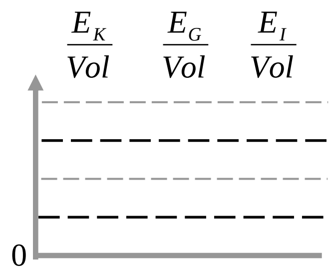
Systolic pressure

Diastolic pressure

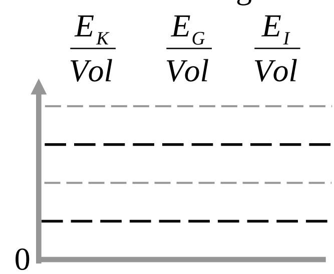
Explain the meaning and units for the commonly known blood pressure numbers 120/80

5. What pressure is necessary in a water main if a fire hose is to spray water to a height of 20.0m?

In water main

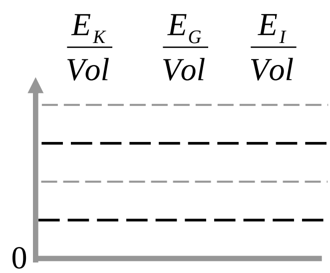


20.0m high

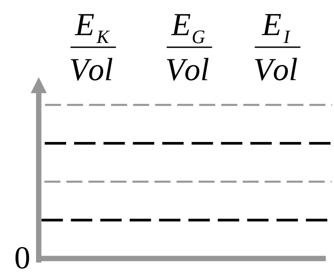


6. In the midst of a hurricane, winds can reach speeds over 100mi/h. If your house is 10m wide x 12m long x 12m tall, what is the net force on the roof with a 100mi/h hurricane wind blowing over the top of it?

In house

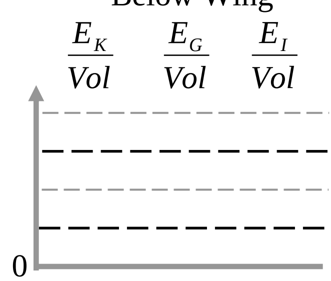


above roof

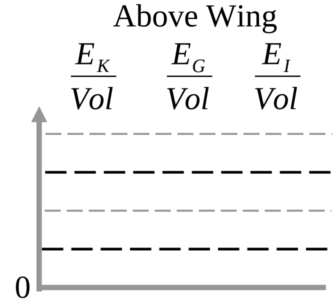


7. An airplane wing is shaped with a curved upper surface and a flat lower surface so that the air will have to flow more quickly over the top surface. (a) Draw qualitatively correct energy density bar graphs for air above and below the wing and use them to explain how this helps to "lift" the airplane.

Below Wing

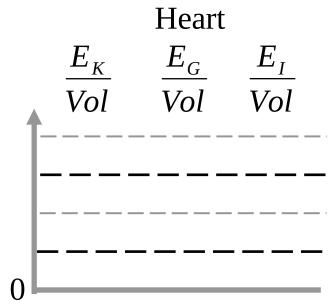


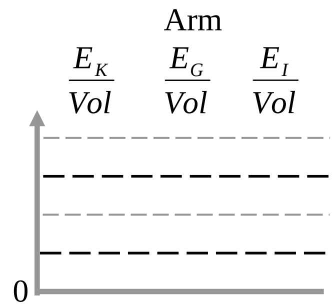
Above Wing



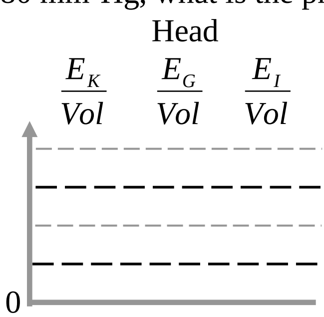
(b) What is the net force exerted by the air on a wing of area $80m^2$ if the air passes over the top and bottom surfaces at speeds of 340m/s and 290m/s, respectively? Add numbers to your bar graphs above to help answer this question.

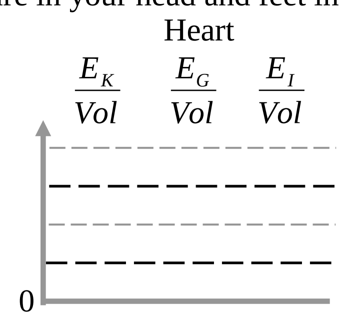
8. (a) When blood pressure reading are taken, they are taken on your arm at the same height as your heart. Draw a set of qualitative energy density bar graphs for blood in your heart and at the same height in your arm and use them to explain why the readings are taken there.

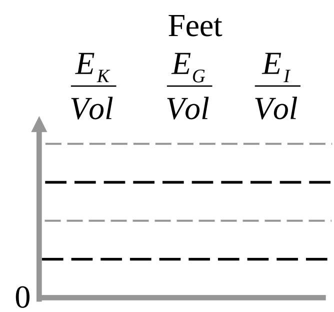




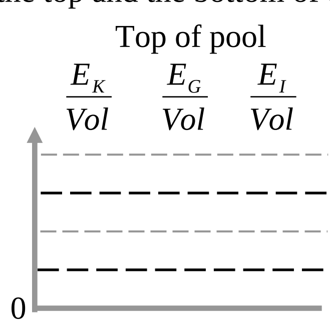
(b) Draw a set of quantitative energy density bar graphs for the blood in your body at the top of your head, in your heart, and at the bottom of your feet while you are standing vertically. You may assume we are talking about veins of the same diameter in each location. If the blood pressure at the level of your heart falls in the normal range of 120/80 mm-Hg, what is the pressure in your head and feet in each case?

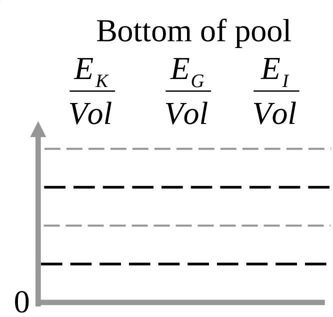






9. A swimming pool is 100m long x 9m wide x 2m deep. (a) Draw a set of energy density bar graphs for water at the top and the bottom of the pool.

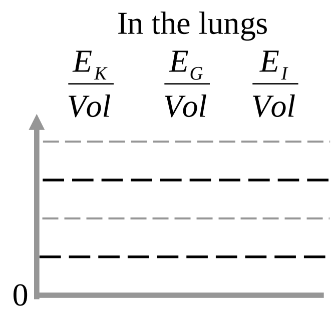


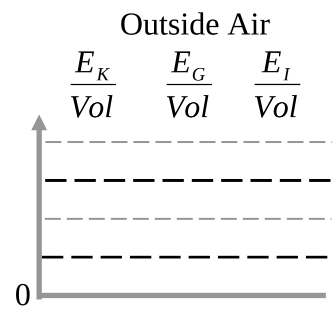


(b) What is the pressure of the water on the bottom of the pool? What is the total force of the water on the bottom of the pool?

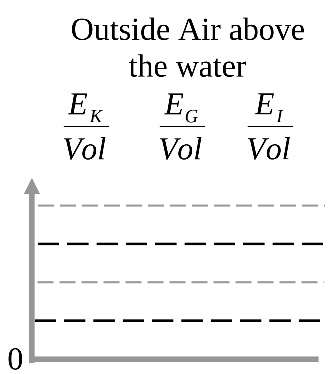
(c) What is the approximate total force of the water on a 10cm square section of wall near the bottom of the pool?

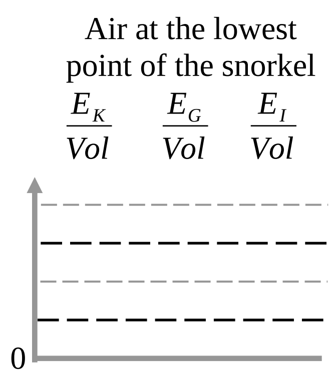
10. (a) The lowest pressure difference that human lungs can create is about 80mm-Hg lower than the outside pressure. Draw a set of energy density bar graphs for the air outside and inside the lungs while a person is inhaling. Atmospheric pressure is 760mm-Hg.

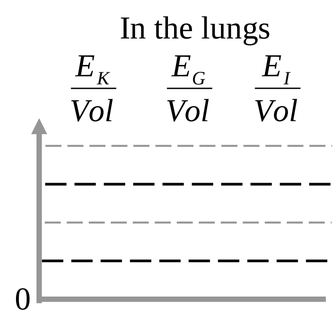




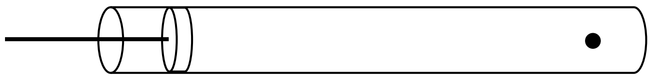
(b) Draw a set of energy density bar graphs for a diver at a depth, d, below the surface of the ocean while breathing through a snorkel. What is the greatest depth at which such a diver can breathe?







11. Imagine a tube of water lying horizontally on its side. The tube is closed at one end and the hole near that end is initially plugged. When a person pushes on the piston with a force F, the pressure of the water in the tube increases by an amount P = F/A, where A is the area of the piston. Since pressure is also interaction energy density, the interaction energy density of the water has increased by the same amount P = F/A. The total interaction energy of the water has then increased by an amount $\Delta E = P(Vol) = PAL = FL$, where L is the length of the tube between the piston and the end.

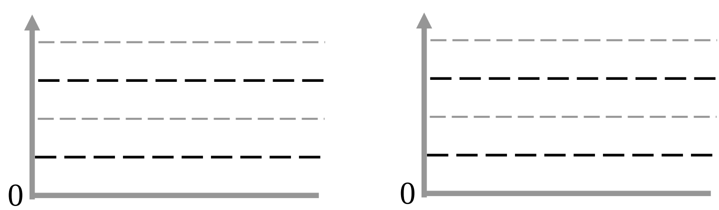


(a) Where did this energy come from?

(b) Draw a set of energy density bar graphs for the fluid near the piston and near the closed end.

Near Piston: $\frac{E_K}{Vol}$ $\frac{E_G}{Vol}$ $\frac{E_I}{Vol}$

Near Fixed End: $\frac{E_K}{Vol}$ $\frac{E_G}{Vol}$ $\frac{E_I}{Vol}$



(c) The hole is now unplugged. Draw a set of energy density bar graphs for the fluid near the piston, near the fixed end, and just after it squirts out of the hole.

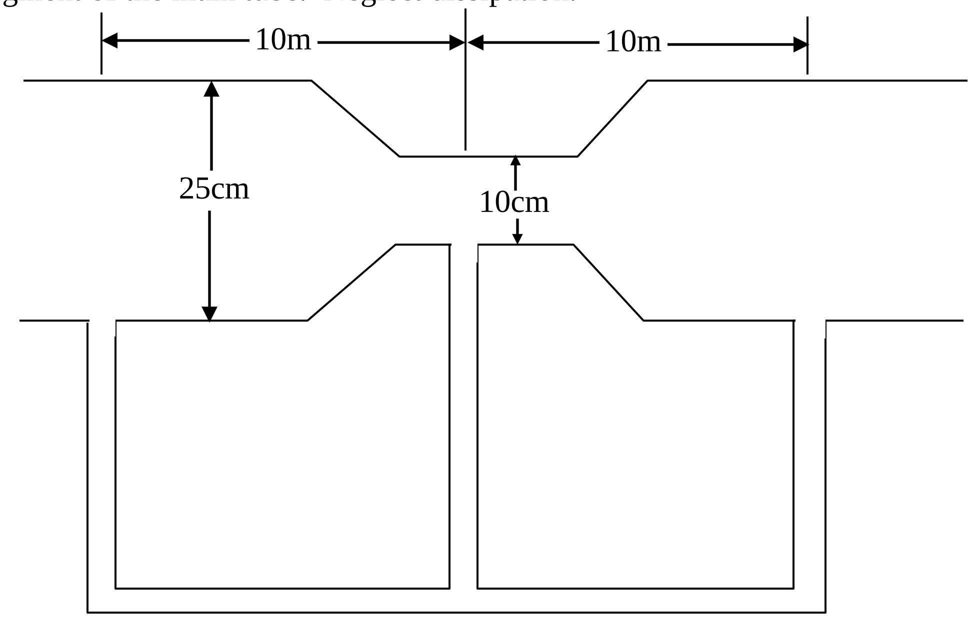
Near Piston: $\frac{E_K}{Vol}$ $\frac{E_G}{Vol}$ $\frac{E_I}{Vol}$

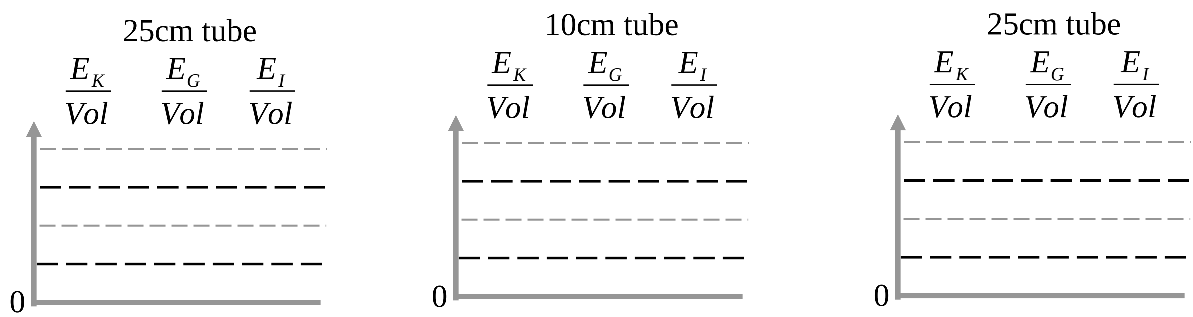
Near Fixed End: $\frac{E_K}{Vol}$ $\frac{E_G}{Vol}$ $\frac{E_I}{Vol}$

After squirting: $\frac{E_K}{Vol}$ $\frac{E_G}{Vol}$ $\frac{E_I}{Vol}$

(d) How can the description of energy density in parts (c) and (d) be correct if energy density fails to explain where the energy in part (a) came from?

12. In the section of tubing below, water flows through the 25cm diameter section with a velocity of 2.0m/s. There is a distance of 10m between the places where the smaller tubes are connected. (a) Draw quantitatively correct energy density bar graphs for each segment of the main tube. Neglect dissipation.



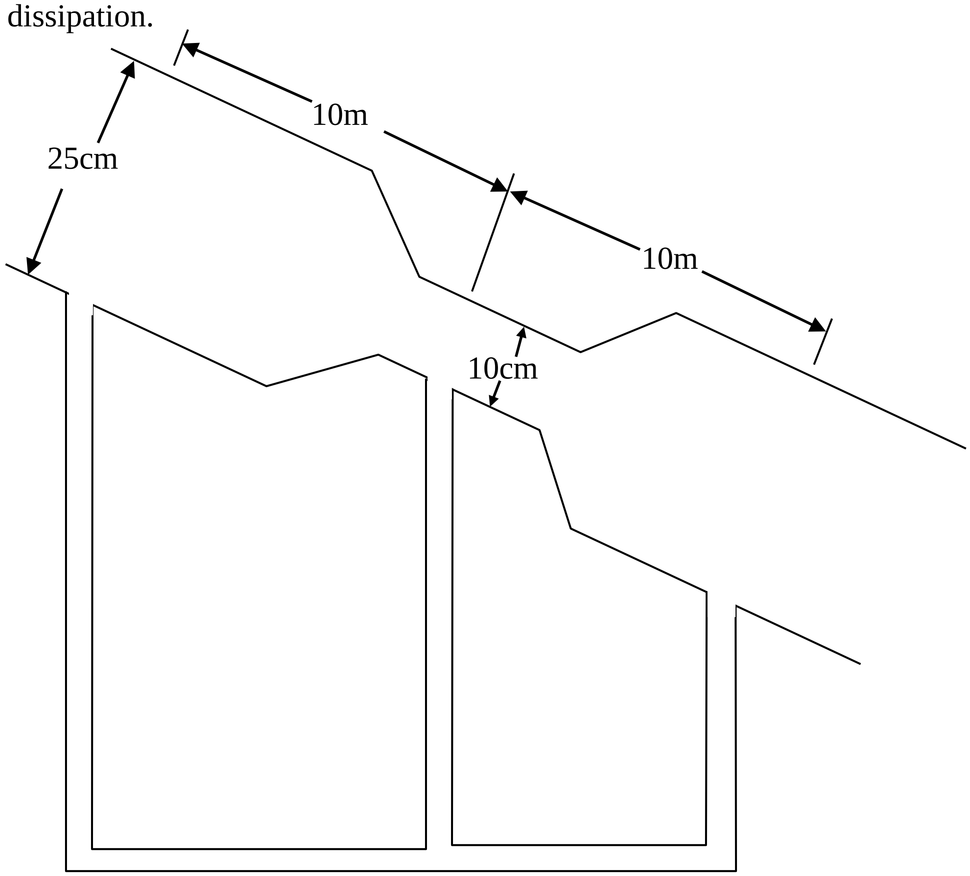


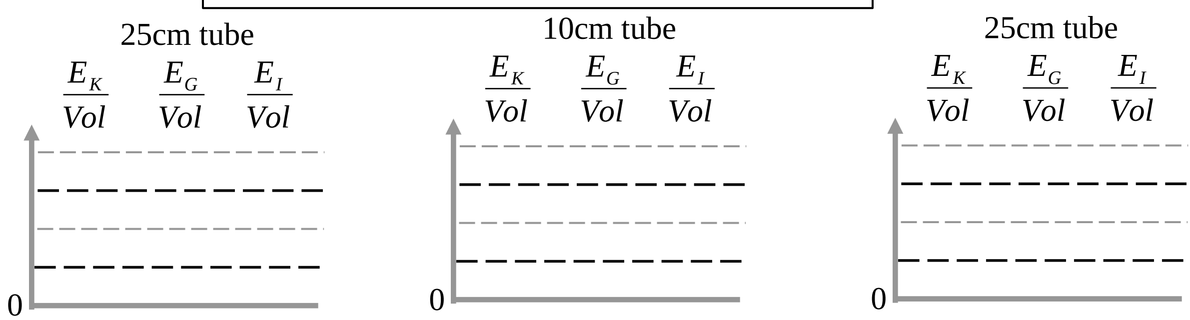
(b) The small tubes below the main tube are partially filled with mercury. If the height of mercury in the first vertical tube is 5.0cm, determine the height of the mercury in the second and third vertical tubes.

(c) i. Determine the flow rate of the fluid in the 10cm and 25cm segments

ii. At what rate (erg/s) is energy transferred to (or from) kinetic energy in the transition segments between the 25cm and 10cm diameter sections?

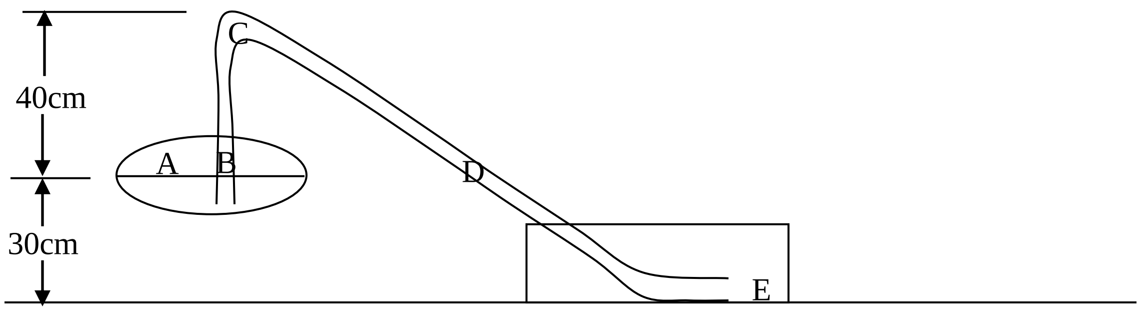
13. The section of tubing below is tilted at an angle of 25° from the horizontal, and once again water flows through the first 25cm diameter section with a velocity of 2.0m/s. There is a distance of 10m between the places where the smaller tubes are connected. (a) Draw quantitatively correct energy density bar graphs for each segment of the main tube. Neglect dissipation.





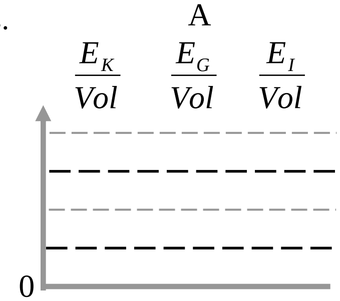
(b) The small tubes below the main tube are partially filled with mercury. If the height of mercury in the first vertical tube is 5.0cm, determine the height of the mercury in the second and third vertical tubes.

14. During the energy crisis of the 1970's, gasoline was in such short supply that its price went way up; there were long lines at every gas station; and the government threatened to start rationing the amount that any one person could purchase in a week. It became a common criminal activity to siphon gasoline from someone's car. On one such evening, Greg the Gas Hog was siphoning gasoline from the car of Frugal Frank, the environmental conservationist. Frank's gas tank holds 10 gallons of gas at an average height of 30cm above the ground. However, Greg must snake his 3m long 8mm diameter siphoning tube from his gas can sitting on the ground, up through the fuel intake and down into the tank. Once he manages to get the tube in place and full of fluid (yech!) the gasoline starts to flow into his can. Gasoline has a coefficient of viscosity of about $5.1 \cdot 10^{-4}$ Pa·s and a density of 705kg/m^3.

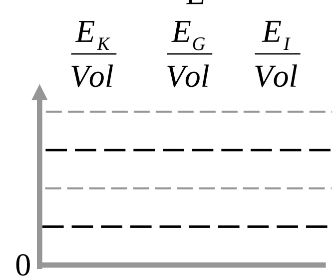


(a) Draw a set of quantitatively accurate energy density bar graphs for point A, at the surface of the gas in the tank (30cm from the ground), and point E, just after the fluid exits the siphon tube. Use them to approximate the rate at which gasoline flows into Greg's tank. Ignore dissipative losses.

A

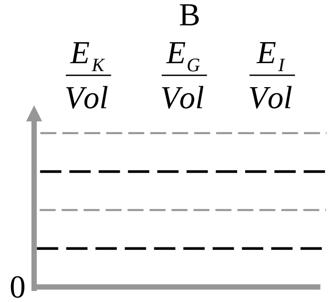


E

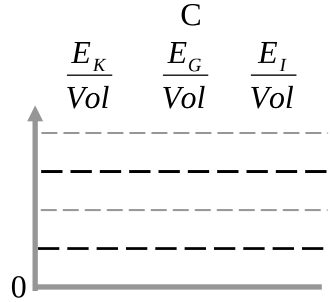


(b) Draw a set of quantitatively accurate energy density bar graphs for points B, C, and D –as the gasoline flows up into the siphon tube, at the gas intake as the fluid is at its highest point, and at the 30cm height on the way downhill.

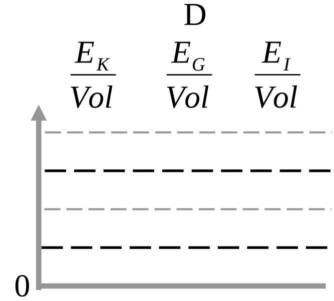
B



C



D



(c) Estimate the pressure in Pascals at points A through E.

(d) Explain why the siphon tube can make the gas run uphill.

(e) Frank looks out the window of his house and observes some suspicious activity. At this point in time, Greg still has 5.5gallons left to drain. Frank knows that if he calls immediately, it will take the police at least three minutes to respond. Would they be in time to catch Greg, or should he take the risk of running out the door and confronting him himself, knowing that Greg could be armed?