Physics CST (2021-22) Homework 4

Please send the completed file to my mailbox yy.lam@qq.com by December 1st, with using the filename format:

`2020xxxxxx_yourname_cst_hw4`

Please answer the questions by filling on these sheets.

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1. A thin spherical shell with a mass of 2.2 kg and a diameter of 0.18 m is filled with helium (density 0.18 kg/m^3). It is then released from rest on the bottom of a pool of water that is 4 m deep. (a) Neglecting the fluid friction, show that the shell rises with constant acceleration and determine the value of that acceleration. (b) How long does it take for the **top** of the shell to reach the water's surface?

2. Suppose you hit a steel nail with a 0.5 kg hammer, initially moving at 15 m/s and brought to rest in 2.8 mm. (a) What average force is exerted on the nail? (b) How much is the nail compressed if it is 2.5 mm in diameter and 6 cm long? (c) What pressure is created on the 1 mm diameter tip of the nail?

3. To 130 g of water ($c = 1$ cal/g °C) at 12°C is added 190 g of iron ($c = 0.11$ cal/g °C) at 85°C and 75 g of marble ($c = 0.21$ cal/g °C) at 23°C. What is the final temperature of the mixture?

4. When a person sits erect, increasing the vertical position of their brain by 34 cm, the heart must continue to pump blood to the brain at the same rate. (a) What is the gain in gravitational potential energy for 95 mL of blood raised 34 cm? (b) What is the drop in pressure, neglecting any losses due to friction? (c) Discuss how the gain in gravitational potential energy and the decrease in pressure are related. (Given the density of blood 1.05 g cm^{-3})

5. Compute the decrease in the blood pressure of the blood flowing through an artery the radius of which is constricted by a factor 2.5. Assume that the average flow velocity in the unconstricted region is 50 cm/sec. Express the result both in SI and torr. (Density of blood: $\rho = 1.05$ g/cm^2)

6. Given the coefficient of conductivity of human tissue 18 Cal cm/m^2-hr-°C, calculate the heat transfer in 2.8 hours by conduction in the unit of kilo-Joule. Assume that the thickness of tissue is 2.6 cm, the average area of the cross section is 1.65 m^2 and the temperature difference is 2.2 °C between inner body and skin.

7. A sample of gas is enclosed in a sealed chamber. The gas consists of molecules, which are then split in half through some process such as exposure to ultraviolet light, or passing an electric spark through the gas. The gas returns to thermal equilibrium with the surrounding room. How does its pressure now compare with its pressure before the molecules were split? Explain your answer.

8. Pouring a volume 330 cm^3 with temperature 85°C hot water into a 6.5 cm interior diameter wooden cup, what is the amount of water level decrease if the temperature of the water drops to 38°C? Given the coefficient of volume expansion of water is 210×10^{-6} K^{-1} and the thermal expansion of the cup is ignored.

9. Nine particles, each of mass m and confined to a container have various speeds: one have speed v; three have speed $2v$; two have speed $3v$; the other two have speed $4v$. (a) Find the mean-square speed of the particles. (b) Use the ideal gas law to find the pressure in a volume V that the particles exerting on the walls of the container.

10. Much of the gas near the Sun is atomic hydrogen. Its temperature would have to be 1.5×10^7 K for the average velocity v_{rms} to equal the escape velocity from the Sun. What is that velocity?

11. What is the final temperature of a cake when a 1.72×10^5 J of heat transfers into the cake initially at 22 °C, with its entropy increasing by $520\, JK^{-1}$?

12. Heat is slowly added to a 0.06 kg chunk of ice at 0 °C until it comletely melts into water at the same temeprature. What is the entropy change of the ice? (Given the latent heat of fusion of water: 335 Jg^{-1})

13. Determine the amplitude, frequency, period, wavelength, and velocity of the wave $y = 0.003 \sin(0.5x - 425t)$.

14. For copper the bulk modulus is 14×19^{10} Nm^{-2} and the density is 8920 kgm^{-3}. What is the speed of sound in copper?

15. Find the length of an one end open and one end closed air pipe if the change of frequency between two alternate resonances (i.e., every twice) of the standing waves is 100 Hz at 50 °C.