University of Alabama
Department of Physics and Astronomy

PH 125 / LeClair Fall 2014

Problem Set 6

Instructions:

1. Answer all questions below. Show your work for full credit.
2. All problems are due by the end of the day on 7 Nov 2014.
3. You may collaborate, but everyone must turn in their own work.

1. With strong inspiratory effort, the gauge pressure in the lungs can be reduced to about 10^4 Pa. Molasses has a density of about $1.4 \times 10^3\,\mathrm{kg/m^3}$. **(a)** What is the greatest height that molasses can be sucked up a straw? **(b)** What is the greatest height if the pressure could be reduced to zero?

2. **(a)** Calculate the gauge pressure inside a spherical bubble of radius 8×10^{-5} m located in a water tank 15 m below the surface of the water. **(b)** How about if there is a 5 m layer of oil of density $500\,\mathrm{kg/m^3}$ on top of the water?

3. Consideration of the gravitational, buoyant, and viscous forces on a sphere falling in a fluid leads to this expression for terminal velocity:

$$v_t = \frac{2}{9}\frac{r^2 g}{\eta}\left(\rho_s - \rho_l\right) \tag{1}$$

(a) If the viscous force on the sphere is given by Stoke's law, $F_v = 6\pi\eta r v$, derive the expression above. **(b)** Two spheres of the same size but differing density have terminal velocities in the same medium in the ratio of 9 to 1. If the slower has a density twice that of water, what is the density of the faster sphere?

4. An ideal fluid flows in a tube which constricts and drops. It starts out going through an inlet of area A_1 at velocity v_1 with pressure P_1, and goes through a lower outlet of area A_2 at velocity v_2 with pressure P_2. What must h be in order that the pressure in the fluid at the bottom P_2 equals the pressure at the top P_1?

5. The space shuttle releases a 470 kg satellite while in an orbit 280 km above the surface of the earth. A rocket engine on the satellite boosts it to a geosynchronous orbit. How much energy is required for the orbit boost? (Note: the earth's radius is 6378 km, its mass is 5.98×10^{24} kg, and $G = 6.67 \times 10^{-11} N \cdot m^2 kg^{-2}$. Hint: "geosynchronous" means the satellite's period T is 24 hrs.)

6. Calculate the mass of the Sun given that the Earth's distance from the Sun is 1.496×10^{11}m. (Hint: you already know the period of the Earth's orbit.)

7. The free-fall acceleration on the surface of the Moon is about one sixth of that on the surface of the Earth. If the radius of the Moon is about $0.250\,R_E$, find the ratio of their average densities, $\rho_{\mathrm{Moon}}/\rho_{\mathrm{Earth}}$.

8. A satellite is in circular orbit around a spherical asteroid, at an altitude of 100 km **above the surface**, moving at a uniform speed of 80 m/s. If the asteroid has a radius of 321 km, what is the mass of the asteroid?

9. In the figure below, a spherical planet has a spherical hole carved out of it. The planet has radius R and density ρ, while the hole has radius $R/2$, such that the hole 'touches' both the center of the planet and its surface. What is the gravitational force on a body of mass m sitting on the planet's surface where the hole 'touches' the surface? *Hint: think of the problem as a superposition of the forces of two different masses lying on top of one another.*