

## Homework 2

(I) Archimedes' principle:

Useful information:

- On Earth, the weight of an object is equal to its mass multiplied by a constant  $g = 9.8 \text{ m} \cdot \text{s}^{-2}$
- Archimedes' principle states that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid.
- When a body floats at the surface of a fluid, the buoyant force exerted on it by the fluid matches its weight.

- (a) [10 pts.] A solid and uniform cylinder made of a mysterious material is 50 cm in diameter and 2 m in length. It floats horizontally at the surface of water in such a way the axis of the cylinder is exactly at the water level. Find the mass density of the mysterious material in terms of the density of the water.
- (b) [10 pts.] Water has a mass density of  $1 \text{ g} \cdot \text{cm}^{-3}$  while ice has a mass density of  $917 \text{ kg} \cdot \text{m}^{-3}$ . A cube shaped ice cube, one inch on a side, floats in water with one face emerging horizontally. How high is the emerging face of the cube above the water level?
- (c) [10 pts.] A spherical buoy is made of plastic, has a radius of 1 m and a mass of 3 kg. A rope is attached to the buoy. The mass and volume of the rope can be neglected. A sphere, 50 cm in diameter is attached to the other end of the rope. This sphere is made of some heavy material and, as a consequence, the buoy is half immersed. Find the density of the heavy material.
- (d) [10 pts.] A solid uniform sphere, 30 cm in radius, floats on water and is exactly half immersed. A second sphere is identical to the first one except that a hole has been drilled through the sphere. The hole is cylindrical, 1 cm in radius, straight and goes through the center of the sphere. The two opening are plugged when the hole is full of air. The volume and weight of the plugs as well as the weight of the air can be neglected. By how much is this second sphere floating higher than the first. (To solve this problem you need to make approximations: the hole is very small compared to the radius of the sphere. Also the difference in buoyancy level is also going to be very small compared to the radius of the sphere. )

- (II) *[10 pts.]* I use a toy to blow soap bubbles. I can make spherical bubbles 10 cm in diameter. The bubble expands to its final size in about two seconds. The ring I blow air through is 15 mm in diameter. Estimate the speed of the air I blow through the ring to produce a soap bubble.
- (III) *[10 pts.]* I started riding my bicycle from home at speed of 10 mph. My friend realized I had forgotten my cell phone about 10 minutes after I left. She is very nice so, right away, she started driving her car at a speed of 30 mph to catch up with me While I was riding. How far from home were we when she was able to give me my phone.
- (IV) *[10 pts.]* A merry-go-round completes a turn in 5 s. What is the speed in km/h of a person riding just 3.5 m from the center?
- (V) *[10 pts.]* The speed of light is  $3 \times 10^8 \text{ m} \cdot \text{s}^{-1}$  while the speed of sound in the air is  $340 \text{ m} \cdot \text{s}^{-1}$ . What is the time between our perception of a flash and the sound of thunder when a lightning strikes at a distance of 1 mile? What difference would it make if the speed of light were infinite?
- (VI) *[10 pts.]* The distance between Salt Lake City and Wendover is 123 miles. A friend of mine started driving from Wendover toward Salt Lake City at 10:45AM. I started driving from Salt Lake City toward Wendover at 11:10AM. His truck is old and he drives at a speed of 55 mph on the highway while I drive my car at a speed of 70 mph. What time was it when we passed each other?
- (VII) *[10 pts.]* Eratosthenes knew that at local noon on the summer solstice in Syene (modern Aswan, Egypt), the Sun was directly overhead. He also knew that at local noon on the summer solstice in Alexandria the rays of the Sun make a  $7^\circ$  angle with vertical. He also knew that the distance between Syene and Alexandria is 840 km. Using this data and considering Syene to be due south from Alexandria, estimate the radius of the Earth.