

SMS-204: Integrative Marine Sciences II (2014b).

Final examination (physics part)

Name:

Please answer all questions (total time 50min): Please provide a short answer to the 7 following questions (6pts each). Please provide your derivations so I can provide you with partial credit in case the answer is not correct.

1. A log floats on fresh water ($\rho = 1 \text{ g cm}^{-3}$) with 1/6 of its volume outside the water. What is the density of the log in kg m^{-3} ?

2. The ocean's volume is approximately 328,000,000 cubic miles. What is the ocean's volume in cubic kilometers (1 mi = 1.6093 km)? Given that the ocean is about 70% of the Earth's surface area and that the Earth's radius is 6400km, what is the average depth of the world's ocean (assume the ocean to be rectangular)? The surface ocean temperature is $\sim 15^\circ\text{C}$. If we heat it by 1°C will the volume of the oceans increase, decrease or stay the same? (Surface area of a sphere = $4\pi R^2$)

3. A whale swims at a constant speed while feeding on plankton.

- How many cubic meters of water enter the open mouth ($50,000\text{cm}^2$ area) of the whale each minute as it swims through the water at 200 cm s^{-1} (provide answer in MKS)?
- How many plankton can the whale ingest per second if the plankton concentration is 0.002 plankton per cm^3 (provide answer in MKS)?
- Each plankton provides 2 Calories to the whale. How many Calories does the whale ingest each day?

4. Water is flowing through a horizontal fireman hose. The hose is mated to a garden hose in which the water keeps flowing.

- How is the water speed different between the two hoses?
- How is the pressure different between just before the connection area and just after it?
- What physical principles did you need to invoke to answer part a? to answer part b?

5. Phytoplankton, photosynthetic microorganisms, are observed to have many different shapes. Some scientists think that shape makes a difference in their ability to stay in the near-surface sunlit zone of the oceans. Based on what you learned in class, will their sinking speed increase, decrease or stay the same as a sphere of the same mass and volume? Base your answer on what you learned about drag and the hydrodynamic regime these organisms are experiencing.

6. Which takes more energy, the evaporation of 1gr of water or the melting of 1g of water? When water is evaporated from the ocean where is the energy taken from? When drops condense in clouds where is the energy going?

7. You free dive to spearfish off your boat. You fill your lungs to capacity (4.5 liters) at the surface and jump in. At 20m you exhale 1 liter of air. Assuming you do not exhale any more, what will your lung volume be when you surface following the dive? (Ideal gas law: $PV=nRT$, atmospheric pressure $\sim 10^5$ Pa)?

True/False questions (2pts each):

- a. Liquid water is denser than ice. T F
- b. An object whose center of gravity is below its center of buoyancy is unstable. T F
- c. A larger object on the Earth's surface feels a larger pressure than a smaller object. T F
- d. Solute flux equals the Mass flux of water times solute concentration. T F
- e. Some Microorganisms use jet propulsion as a mechanism to propel themselves. T F
- f. The no-slip condition implies that swimming organisms will *always* experience drag while swimming. T F
- g. Streamlining reduces pressure (rather than viscous) drag for high Reynolds number swimmers. T F
- h. Objects radiate heat according to their color. T F
- i. A solid object that sinks in warm seawater may float in cold seawater. T F
- j. Force has a dimension of ML^2T^{-2} , in MKS its units are: Kgm^2s^{-2} . T F
- k. Conduction refers to passage of heat through contact. T F
- l. At high Reynolds number, viscosity is not a primary contributor to drag. T F

Multiple choice questions (6pts each):

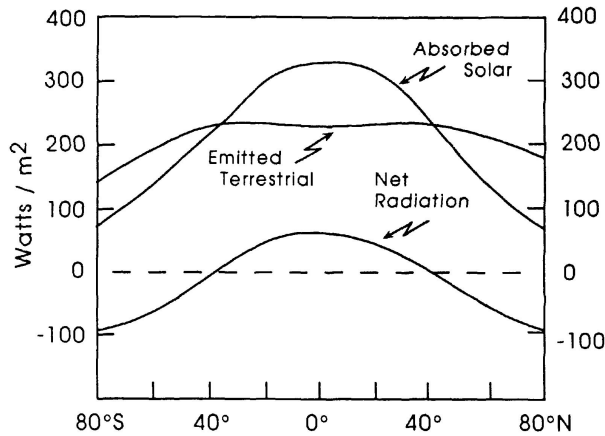
1. How can an organism under water change the buoyancy force acting on it?
 - a. Change its mass (e.g. burn energy, get rid of waste products).
 - b. Change its own temperature (e.g. work harder).
 - c. Change its own volume (e.g. drink ambient fluid and expand).
 - d. All of the above.

- B. You are asked to measure the volume flux of the Penobscot. Which measurement will you conduct (circle all that apply)?
 - a. water depth;
 - b. water temperature;
 - c. water speed;
 - d. water pressure;
 - e. width of the river;

3. 1. A Pitot tube is a device used to measure air speed by measuring the pressure of the moving air and the pressure of air that does not move.
Which is the underlying physical principle it is based on?
 - a. Archimedes principle.
 - b. Bernoulli's principle.
 - c. Continuity principle.
 - d. Newton's second law.

Please provide short answers to the following questions (6pts for questions associated with each picture):

1. How is the following graph related to concepts associated with the Earth heat balance? How can we explain the Polar Regions not getting continuously colder given the data in this graph?



2. Explain what phenomenon is illustrated in the figure below. What is the physical principle causing it? What is its most important implication to swimming organisms?

