# SMS-204: Integrative Marine Sciences II (2020).

## Final examination (physics part)

**Name:**

**Please answer all questions (total time 50min): Please provide a <u>short</u> 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. Benjamin Franklin spilled a teaspoon (1.6ml) of oil on a lake to calm its capillary waves. The oil ends up covering 1,000 $m^2$.
   a. What is the width of the layer of oil after spreading (it turns out this is a good estimate of an oil molecule width)?
   b. If the weight of the oil in the teaspoon is 0.0015kg what is its density?
   c. The pond near your house is rectangular with sides of 50m by 60m. What is the least amount of oil (in units of mass) you will need to spill onto it to calm capillary waves throughout the whole pond?

2. A clam is buried near the sediment water interface pumping approximately 6ml of water each minute and filtering it of its nutritious particles.
   a. How many cubic meters of water does it filter in an hour?
   b. Assuming a concentration of food particles of 40 per $cm^3$, how many particles does it filter in a day?
   c. If each food particle has a nutritional value of 2 calories, how many Calories does the clam ingests in an hour?

3. What is the Reynolds number (Re) for a swimming organism (write its expression as function of properties of the swimmer and the fluid)? How is the Re useful when we analyze the swimming behavior of organisms? Give an example of a low and high Re swimmer.

4. What gives rise to hydrostatic pressure in a fluid? How is it related to properties of the fluid?

5. You are asked by the Environmental Protection Agency to measure the amount of fecal bacteria that are transported downstream by the Penobscot River near Bangor. How would you go about determining the transport of these bacteria downstream? What properties do you need to measure? Provide an example of the units for bacterial transport down the river (that is their flux)?

6. A person weighing 80kg is sitting in a boat that weighs 220kg floating on the ocean (density =1.02g/ml).
a. How much water (volume) does the boat + person displace?
b. The person decides to jump into the water. How much water does the boat displaces now?
c. If the boat is transferred to a lake (lake density=994kg/$m^3$), will it float higher, lower, or stay with the same water level?

7. Which takes more energy, the evaporation of 1gr of water, the warming of a gr of water by one degree or the melting of 1g of ice?
Which takes the least amount of energy?
When water is evaporated from the ocean where is the energy taken from (what is cooled)?
When a drop condenses in a cloud where is the energy going to (what is warmed)?

**True/False questions (13 questions, 2pts each):**

a. Units of force in MKS are equivalent to Kg $m^{-1}$ $s^{-2}$. T F
b. An object whose center of gravity is below its center of buoyancy is unstable. T F
c. The no-slip condition implies that water next to a the bottom is at rest. T F
d. A solid object that floats in warm seawater may sink in cold seawater. T F
e. A larger object on the Earth's surface feels the same pressure as a smaller object. T F
f. The density of water is approximately 1000g $m^{-3}$. T F
g. Convection refers to passage of heat due to fluid motion. T F
h. A warmer object radiates more energy than a colder one. T F
i. The Reynolds number is a property of the fluid. T F
j. The balance of forces for a sinking object in water which attained terminal velocity is between the gravitational force and drag. T F
k. A consequence of the no-slip condition is that a stirred cup of coffee will eventually come to rest. T F
l. To determine if an object will float in a fluid we need to know the gravitational acceleration. T F

**Multiple choice questions (3 questions, 6pts each):**

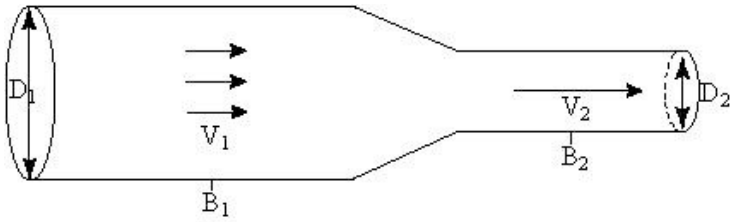
**1. Settling speed of a sinking particle:**
a. Decreases as fluid viscosity increases.
b. Decreases as fluid density increases.
c. Decreases if its size decreases.
d. All of the above.

**2. 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.

**3. A consequence of Bernoulli's principle:**
a. Fluid decelerates as it moves from low to high pressure.
b. Fluid accelerates as it moves from low to high pressure.
c. Mass is conserved along fluid flows.
d. Friction is not important.

**Please provide short answers to the following questions (7pts each):**

1. What is the principle associated with fluid motion that is illustrated below? How would you expect the pressure to change within this pipe?




2. Below is an illustration of Reynolds' experiment. What did he conclude from this experiment regarding laminar and turbulent fluid motions and the conditions under which they occur?

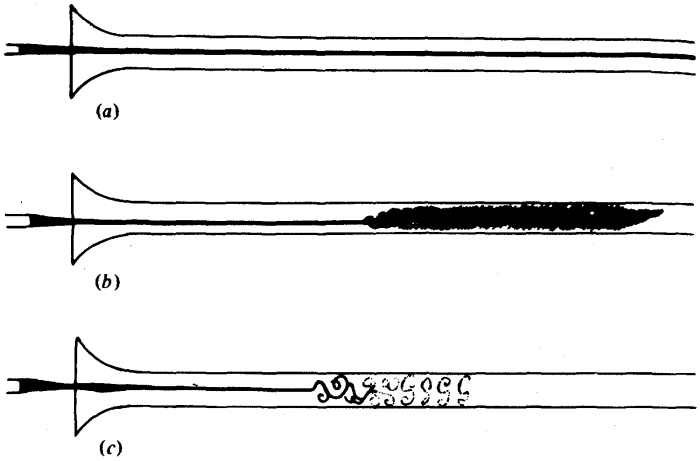



**Fig. 9.2.** Reynolds's drawings of the flow in his dye experiment.