SMS-491: Integrative Marine Sciences.

Mid-term examination (physics part) -ANSWERS

Name:

Please answer all questions (total time 50min):Please provide a <u>short</u> answer to the 7 following questions (6pts each):

1. A whale swims at a constant speed while feeding on plankton.
   a. How many cubic meters of water enter the open mouth ($4m^2$ area) of the whale each minute as it swims through the water at 2 m s^{-1}?
   b. How many plankton can the whale ingest per second if the plankton concentration is 2,000 per m^3?
   c. A whale ingests 500,000 calories per day. How many are ingested per second?

   a. **$4*2=8m^3\ s^{-1}$**
   b. **$8*2{,}000=16{,}000$ plankton s^{-1}**
   c. **500,000 cal day^{-1} x $(24x60x60\ s\ day^{-1})^{-1}$ ~ 5.8cal s^{-1}**

2. An iceberg is floating on the ocean. Its density is 920 kg m^{-3} while the density of the ocean is 1030 kg m^{-3}. How much of the iceberg's volume is above water (in percent)?

Archimedes: 920*volume of iceberg=1030*volume of water displaced

- ⇨ **volume of water displaced/volume of iceberg = 920/1030~0.9**
- ⇨ **10% of the iceberg {(1-0.9)x100} is above the water.**

3. Name the three mechanisms for heat transfer. How are they different from each other?

Radiation- the only that can pass heat in vacuum
Conduction – requires physical contact
Convection – requires movement of fluid to transport the heat

4. You are asked by the US Geological Survey to measure the volume of water flowing per hour down the Penobscot River near Bangor. How would you go about determining how much water flows downstream? What properties do you need to measure?

Volume of water flowing down stream = mean velocity x cross-sectional area

In order to obtain the mean velocity, velocity measurements need to be made at enough locations across the river to provide the value with a small uncertainty. The cross- sectional area also needs to be measured.

5. A log floats on water (ρ =1000 kg m^{-3}) with 1/3 of its volume outside the water. What is the density of the log?

Archimedes: volume of log x log's density = volume of displaced water x density of water.
→ log's density = density of water x (volume of displaced water /volume of log) =1000x(1-1/3)=667 kg m^{-3}.

6. What causes waves that do not break in the deep ocean to break when they arrive on a shallow beach?

As the wave approach the beach it starts feeling the bottom and its speed decreases. As the speed decrease the wavelength between crest decreases (much like distance between cars near a stop sign) and the wave become steeper. The slope of the wave increases to the point it is unstable and it breaks.

7. How is the wave frequency related to its wavelength and its phase speed?

Frequency=phase speed/wavelength (can be arrived at using dimensions only)

True/False questions (2pts each):

a. Pressure and shear stress are two examples of force per unit area. **T**
b. Kinematic viscosity = dynamic viscosity/density, with units $m^2 s^{-1}$. **T**
c. Work = Force*distance **T**
d. In a fluid at rest, pressure at a point is isotropic (equal in all directions). **T**
e. A solid object completely immersed in oil will experience the same upward buoyant force as when it is immersed in water. **F**
f. An object that floats on water on Earth may sink if the gravitational acceleration is changed. **F**
g. The no-slip condition causes momentum to pass from the boundary of the fluid into the fluid itself. **T**
h. A boat is most stable when its center of gravity is as high as possible above its center of buoyancy. **F**
i. At high Reynolds number, the drag force on an object is proportional to U^2. **T**
j. The hull speed of a boat increases with its size. **T**
k. The amplitude of particle motion due to surface waves decays with depth. **T**
l. In the absence of other forces, water flows from low pressure to high pressure. **F**
m. The Reynolds number is a property of the fluid. **F**
n. In the absence of viscosity a stirred cup of coffee will never come to rest. **T**
o. On the moon one would expect gravity waves to propagate faster than on Earth. **T**

Multiple choice questions (6pts each):

A. When we calculate the pressure at the base of a fluid column:
a. the width of the column does not matter;
b. the height of the column does not matter;
c. the density of the fluid does not matter;.
d. all of the above.

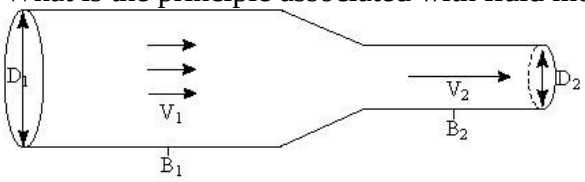
B. You are asked to evaluate whether a water-tight, rectangular container will float or sink in fresh water at room temperature. What measurements do you need to do in order to be able to answer this question?
a. weight of the container;
b. volume of the container;
c. temperature of the container;
d. a and b;
e. a, b, and c.

C. Two particle made of the same material are settling in water and the Re<<1. One has a diameter which is three times larger than the other. Which is true:

a. The larger one will sink 3 times faster than the other.
b. The smaller one will sink 9 times slower than the other.
c. The larger one will sink 3 times slower than the other.
d. The smaller one will sink 9 times faster than the other.

Please provide short answers to the following questions (5pts for questions associated with each picture):

What is the principle associated with fluid motion that is illustrated below?



Continuity: the fluid flux through a pipe (blood vessel) is equal along it,

$$v_1 * \pi D_1^2/4 = v_2 * \pi D_2^2/4$$

Below is a cartoon of a very famous and smart Greek man (His name starts with an A). What principle did he discover in his bathtub? How is it related to the fact that ocean vessels made of steal can sail across the oceans?

The smart person is Archimedes who found that the buoyancy force equals to the mass of the volume of water displaced by an object immersed in water. When the buoyancy force is not exceeded by the mass of the object times the gravitational acceleration, the object floats. Ocean going vessels made of steal are made in a way that displaces a lot of water providing them with the necessary buoyancy to stay afloat.