SMS-204: Integrative Marine Sciences II (2012).

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 wood log is floating on a river. Its density is 0.95 g cm^{-3} while the density of the river's water is 997 kg m^{-3}. How much of the log's volume is below the water surface (give you answer in percent)?

Based on Archimedes' principle, the log displaces a volume of water that has a mass that equals its own mass: V_displaced x 0.997= V_log x 0.95. The volume of displaced water = volume of the log below the surface.

→ V_diplaced/ V_log=0.95/0.997=0.953 →95.3% of the log's volume is below the surface.

2. You are asked by your supervisor at a USGS internship to measure the volume flux of water at a stream nearby at a certain time of the day.
a. What measurements will you do and how will you use them to obtain the volume flux of water?
b. It turns out that the stream is a salmon run. What additional information will you need to obtain the salmon flux in the stream and how would you compute it given that this information is collected?

a. Need to measure the stream's cross section and the average stream velocity. Volume flux=cross section of stream x mean stream velocity.
b. To calculate the salmon flux we need to know, in addition to the volume flux, the salmon concentration (number of fish per volume).
Salmon flux=cross section of stream x mean stream velocity x salmon concentration.
If the salmons have a significant velocity in the stream direction replace mean-stream velocity in the formula with mean stream+mean salmon velocity in the along stream direction.

3. In the first class we discussed how the physical aspects of the ocean affect marine organisms. Choose a micro-organism (<0.1mm) and a macro-organism (>1m) and three physical properties of ocean waters. For each physical property describe how it may affect either reproduction or foraging or predation of each organism.

Physical Property	***Effect on copepod***
Temperature	*Affects enzymatic reactions (hence feeding)-digestion speed*

Sound speed *affects propagation of information on movement near a small organism – hence reaction to a predator/prey*
Light intensity *Affects visual information – hence ability of predator to prey.*

Physical Property	***Effect on Dolphin***
Temperature	*Affects enzymatic reactions – for example digestion and swimming*
Sound speed	*Affects foraging for prey – eco location*
Light intensity	*Affects foraging for prey – visual examination*

4. A buoy in the Gulf of Maine registers a decrease in temperature at its top most sensor (0.5m below the surface). Name at least four different processes that may cause the observed decrease.

Evaporation – decrease temperature of surface waters.
Advection – bring cold waterx to the buoy from a site near by or from depth (upwelling).
Radiation – night-time IR radiation decreases temperature of water near the surface.
Conduction – cold air blowing above the ocean cools the surface ocean.
Wind mixing – results in cooling of surface waters by mixing water from the surface with cooler waters from below.

5. A clam is buried near the sediment water interface pumping approximately 6ml of water each minute and filtering it of its particles.
a. How many cubic meters of water does it filter in a day?
b. Assuming a concentration of food particles of 30 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 one minute?

a. $6ml \times 60min/hr \times 24\ hr/day \times 0.000001m^3/ml = 0.00864\ m^3\ day^{-1}$
b. $30particles\ cm^{-3} \times 1000000\ cm^3\ m^{-3} \times 0.00864\ m^3\ day^{-1} = 259{,}200\ particles\ day^{-1}$
c. $2C\ particle^{-1} \times 259{,}200\ particles\ day^{-1} \times 1day/(24x60)min = 360C\ min^{-1}$

6. You are asked to relocate a sunken boat used as an artificial reef. The boat's weight in air is 200,000N and the volume of its solid parts is $8m^3$. Approximately what minimal volume of an air bag should be attached to it so it can be moved to its new location?

Weight in air=200,000N=volume x density x $9.81ms^{-2}$ →
density = 200,000/8/9.81 = 2548Kg m^{-3}
Weight of boat in water: 200,000- volume_boat x density_water x $9.81ms^{-2}$
{=80,050}=119950N
We need a lift bag that displaces enough water to counter this weight (neglecting the weight of bag and air):
V_bag x 1020 x 9.81 = 119950N → V_bag=$12m^3$

7. Why is a long snorkel not a practical tool for sub-surface diving below a few meters?

Because the ambient pressure in the water (from air and water) is sufficiently high that our body cannot expand our lungs given an input of air at atmospheric pressure.

True/False questions (2pts each):

a. Water in a tube with a hole at a given height will squirt further on the moon than on the Earth (the gravitational acceleration is less on the moon) F
b. A solid object completely immersed in oil will experience the same upward buoyant force as when it is immersed in water. F
c. The hotter an object the longer the wavelength or the radiation it emits. F
d. Units of pressure in MKS are equivalent to Kg m^{-2} s^{-2} F
e. The density of liquid water is approximately 1Kg m^{-3}. F
f. A swimming strategy that is not symmetric can work for propulsion at high Reynolds number. T
g. Two beads of the same material are sinking in a fluid at constant speed. The larger of will sink faster. T
h. The no-slip condition implies that a particle next to a stationary wall will sink slower than one in further from that wall. T
i. Light and sound wave increase in speed when propagating from air to water. F
j. Viscosity is a major contributor to the drag experienced by a swimming tuna. F
k. In the absence of other forces, fluids flow from high to low pressure. T
l. Algae are green because they absorb green light. F

Multiple choice questions (6pts each):

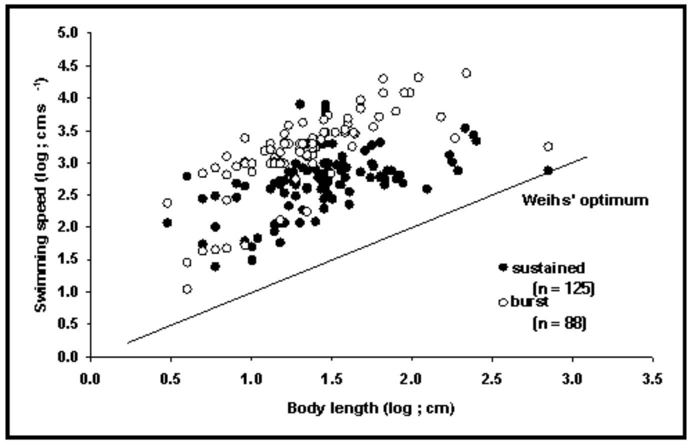
1. **The 'greenhouse' effect:**
a. Is mostly due to reflection/emission of visible radiation by the atmospheric greenhouse gases to the Earth's surface.
b. Is mostly due to absorption of visible radiation by the atmosphere greenhouse gases
c. Is mostly due to scattering of infrared radiation by the atmosphere greenhouse gases.
d. Is mostly due to absorption and reflection/emission of infrared radiation by the atmosphere greenhouse gases to the Earth's surface.

2. **On the moon (smaller gravitational accelearation), pressure on the bottom of a milk carton is:**
a. *Smaller than on Earth.*
b. Larger than on Earth.
c. Equal to that on Earth.
d. Zero.

3. **An object floats in water because:**
a. It is lighter than water.
b. Its mass is less than that of water.
c. It has a smaller volume than water.
d. *It is less dense than water.*

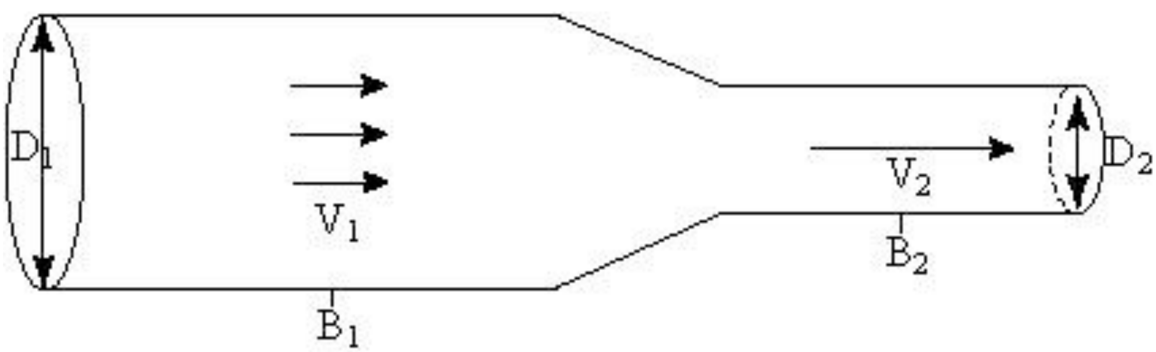
Please provide short answers to the following questions (7pts for questions associated with each picture):

1. What do we learn from the graph below?



This graph shows that, in general, swimming speed correlates with size. The longer an organism the faster is swims.

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



The principle associate with this motion is continuity, which is basically the principle of mass conservation associated with highly incompressible fluids. It states that the same volume flux will be at any point along this pipe (volume flux = velocity x cross-sectional area). Given Bernoulli's principle (which assumes that viscous losses can be neglected) we will expect a higher pressure where the velocity of the fluid is smaller (B1) compared to where it is faster (B2).