SMS-204: Integrative Marine Sciences II (2015).

Final examination (physics part)

Name:

Please answer all questions (total time 50min): Please provide a <u>short</u> answer to the 6 following questions (8pts each). Please provide your derivations so I can provide you with partial credit in case the answer is not correct.

1. A grouper weighs 20kg and has a volume of 19.5 liters.
a. How much air does it needs to put into its swim bladder to be neutrally buoyant in water of density of 1020kg m^{-3}?
b. It swims from a depth of 10m to a depth of 20m (density of surrounding waters stays the same). How much more air does he needs to add to the swim bladder to stay neutrally buoyant?
a. The density of the grouper is 20/0.0195=1053kg m^{-3}. To have a density of 1020kg m^{-3} and neglecting the density of air (it is ~1000 smaller than that of water), its volume needs to be ~19.6liters. It needs about 100ml of air in its swim bladder to stay neutrally buoyant.
b. When it dives to 20m the atmospheric pressure increases from 2->3 atmospheres. Given that product of pressure and volume needs to stay constant, 100ml x 2 = new volume x 3, hence the swim bladder shrank to ~67ml. It will need 33ml more to stay neutrally buoyant.

2. An iceberg floats in arctic waters (density of water 1023kg/m^{-3}). If a tenth of its volume is outside water, what is the ice density?
Based on Archimedes' principle, the iceberg displaces a volume of water that has a mass that equals its own mass: V_displaced x 1023= V_iceberg x ρ_iceberg. The volume of displaced water = volume of the iceberg below the surface.
But we know that 9/10 of the iceberg is submerged. Hence:
→ V_diplaced/ V_log=1/10 →ρ_iceberg = 9/10 x 1023=920.7kg m^{-3}

3. A jellyfish sinks at a constant speed while feeding on plankton.
a. How many cubic meters of water does it filter as function of time through its tentacle (0.05m^2 area) if it sinks through the water at 0.05 m s^{-1}?
b. How many plankton can the jellyfish ingest per minute if the plankton concentration is 1,000 per m^3?
c. Each plankton provides 0.01 Calories to the jellyfish. How many Calories does the jellyfish ingest each day?
a. Volume filtered per time=speed × area filtered =0.5m^2 × 0.05 m s^{-1}=0.0025m^3 s^{-1}
b. Plankton ingested per time= Volume filtered × plankton concentration = 0.0025m^3 s^{-1} × 1,000 plankton per m^3=2.5s^{-1}=150 plankton min^{-1}.
c. Calories per time = Plankton ingested per time × calories per plankton =150 plankton min^{-1} × 0.01 Calories per plankton = 1.5Cal min^{-1} = 2,160Cal day^{-1}

4. 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 contains many sediment particles that it carries with it to the ocean. What additional information will you need to obtain the sediment flux in the stream and how would you compute it given that this information is collected?
c. What will be an example for the units of sediment flux you would report?
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 sediment flux we need to know, in addition to the volume flux, the sediment concentration (e.g. mass of particulate material per volume).
Sediment flux=cross section of stream x mean stream velocity x sediment concentration (example units kg/s).

5. 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 phytoplankton:
Temperature affects rates of diffusion of solutes to/from cells.
Light – affects ability to photosynthesize (foraging)
Viscosity – affects drag experienced while swimming (dinoflagellates) and hence energetic costs of foraging.

Physical Property Effect on Dolphin
Temperature Affects enzymatic reactions – for example digestion and muscles temperature for swimming
Sound speed Affects foraging for prey – eco location
Pressure affects gas solubility in blood and volume of air in lungs, hence overall fitness to hunt.

6. Name the three mechanisms for heat transfer. Give one example for each that may be relevant to a marine organism?

Radiation: transfer of heat by photons.
Conduction: transfer of heat through contact.
Convection: transfer of heat through fluid motion.
Radiation warms a sea lion basking in the sun on the Oregon coast as well as cools him through infra-red emission (blackbody radiation).
Conduction cools the sea lion as it swims in the ocean.
Convection causes water close to its skin to move upward replacing it by cold water and thus accelerating the loss of heat.

Evaluate the statement as true of false (2pts each, circle T for true of F for false):

a. On the moon, the pressure at the base of a milk carton is smaller than on Earth. T
b. An object whose center of gravity is above its center of buoyancy is unstable. T
c. Rising bubbles expand on their way to the surface. T
d. A solid object that sinks in seawater may float in freshwater (same temperature) F
e. Viscosity is a major contributor to the drag experienced by a swimming tuna. F
f. The no-slip condition implies that swimming organisms will *always* experience drag while swimming. T
g. Streamlining reduces pressure (more than viscous) drag for high Reynolds number swimmers. T
h. Some microorganisms use jet propulsion as a mechanism to propel themselves F
i. The difference between wet and dry bulb thermometers increases with humidity. F
j. Units of energy in MKS are equivalent to Kg m^2 s^{-2}. T
k. The density of water is approximately 1,000,000g m^{-3}. . T
l. As water warms in a cup the hydrostatic pressure at its bottom decreases F

Multiple-choice questions (6pts each):

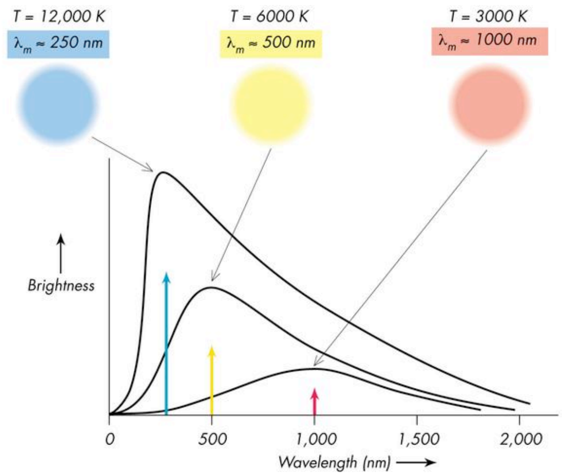
1. Which weigh more on the earth surface, a kg of helium (less dense than air) or a kg of sand?
   a. They will weigh the same.
   b. The sand will weigh more, as it displaces less air.
   c. The helium will weigh more, as its mass is the same but it has more volume.
   d. None of the above.

2. Turbluence:
   a. Is the property of the fluid.
   b. Is the property of the flow.
   c. Is the property of a body in the flow.
   d. None of the above.

3. Divers use lift bags to move heavy object under water.
Which is the underlying physical principle can be used to determine the size of the lift bag needed?
   a. Archimedes principle.
   b. Bernoulli's principle.
   c. Continuity principle.
   d. Newton's third law.

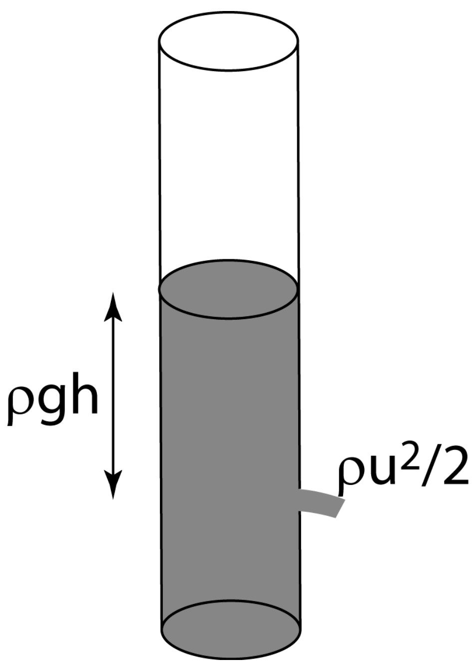
Please provide short answers to the following questions (5pts for questions associated with each picture):

1. How is the following graph related to heat and temperature?



Every body radiates heat (energy) depending on its own temperature. The warmer it is the more it radiates and the shorter is the average wavelength it radiates at.

2. Explain what energy is converted in the setup drawn below? How does the pressure change as the water crosses from within the cylinder to outside the hole? What is the speed of the water leaving the hole?



Potential energy, associated with the weight of the fluid above the hole is converted to kinetic energy of the fluid leaving the hole. The pressure at the hole is the atmospheric pressure (p_{atm})+ the hydrostatic pressure: $\rho gh+p_{atm}$.

The speed is computed by assuming all the potential energy per unit mass (hydrostatic pressure) has been converted to kinetic energy (since the atmospheric pressure is the same outside and inside, it cancels out):

$$\rho gh= \rho u^2/2 \rightarrow u=(2gh)^{1/2}$$

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