OT4620 Offshore Hydromechanics Module 1 Quiz 1b

June 2005

Instructions:

1. Be sure to put your name and student number on each answer page submitted.
2. This quiz includes 4 groups of questions, each associated with one of the chapters 2 through 5. The last page includes a number of formulas that may or may not be useful.
3. The questions here are stated in English. Answers may given using either Dutch or English.

Group 1 Hydrostatics

1.1 One is rowing across a small lake in a wooden boat that leaks a bit. How does the lake level change as more and more water seeps into the boat during this journey? Explain you answer and assume that the boat remains floating during the entire journey.

1.2 A single rectangular block of concrete (ρ=2400 kg/m^3) without residual internal stresses is placed on the deck of a ship. The block is 1 x 1 meters square and 0.8 m high. Please discuss the forces on a horizontal cross section of this block which passes through its center of gravity in the following situations:
a. The block is resting on the deck of the ship.
b. The block has been pushed overboard and is falling freely (neglect air resistance) but has not yet hit the water suface.
c. The block has come to rest on the sea bed at a depth of 1000 m.

1.3 Explain why an initially curved bar hanging more or less vertically and initially in air will curve more sharply as water comes up around it even though a perfectly straight bar under the same conditions will remain perfectly straight - at least in theory. The density of the bar is greater than that of water, by the way.

Group 2 Potential Flows

2.1 Gyro Gearloose (Willie Wortel in Dutch, the inventor in the Donald Duck comic strips) has just designed a new pump to supply the water mains within Duckstad. The flow in this pump can be described by the following potential:

$$\Phi = -4\,x\,y^3 - 12\,y + 4\,x^4\,y + 15\,x - 3\,x^2 + 3\,y^2$$

that - in Gyro's design - must be valid for x and y in the range from -4 to +5. Would you advise Uncle Scrooge, (Dagobert in Dutch) who owns the water supply system, to invest in this new pump designed by Gyro? Motivate your answer!

2.2 List the basic potential flow elements or building blocks. What procedure is followed to generate realistic flow patterns from these building blocks?

Group 3 Real Flows

3.1 A ship of 50,000 tons displacement is driven at a speed of 12 knots. A ship of 40,000 tons of similar form is being designed.

- At what speed of the larger ship should its performance be compared with the 50,000 ton ship?
- Has the larger ship has a smaller or a larger still water resistance coefficient than the smaller one? Explain your answer.

3.2 A bicyclist moving with speed V directly against the wind of speed U experiences a wind resistance which is proportional to the frontal area of him (or her) self (plus the bicycle) and the square of the his or her velocity relative to the (moving) air, thus $(V+U)^2$. The density of air and a drag coefficient are also involved by the way, but these are not essential to this discussion.

If a bicyclist becomes tired from delivering impulse (force times duration), then what speed, V (relative to the wind speed, U) should he or she choose in order to be the least tired when going from a point A to a point B. Note that point B is upwind from point A.

3.3 Sketch a realistic representation of the propulsive characteristics of a fixed pitch open water propeller.

- Determine the relation between the propulsive efficiency, η_O, on one hand and the thrust coefficient, K_T, the torque coefficient, K_Q, and the speed ratio, J, on the other hand.

- Explain why the K_T-curve intersects its zero-axis at a smaller J-value than the K_Q-curve; in other words, why does the K_T-curve there lie beneath the K_Q-curve?

Group 4 Waves

3.1 The mast of a small floating raft is observed to oscillate with a period of 7.0 seconds and amplitude from the vertical of about 8.0 degrees, due to the passage of a train of (more or less regular) deep-water beam waves.
Estimate of these waves:

- the circular wave frequency,
- he wave height,
- the wave length and
- the phase velocity of waves.

3.2 A fully developed sea and swell are defined by:

$$H_{1/3 \text{ sea}} = 3.0 \text{ m} \qquad \text{and} \qquad H_{1/3 \text{ swell}} = 4.0 \text{ m}$$
$$T_{1 \text{ sea}} = 6.0 \text{ s} \qquad \qquad T_{1 \text{ swell}} = 12.0 \text{ s}$$

- Give a realistic sketch (including dimensions) of the energy spectra of this sea and swell and of the combined sea and swell.
- Calculate the characteristics $H_{1/3}$ and T_1 of the combined sea and swell.

3.3 Irregular waves

- How are a JONSWAP wave spectrum and a Weibull or semi-logarithmic wave height distribution used differently?
- List two assumptions which are made in the derivation of the Rayliegh wave height distribution from a water surface elevation record or statistics.

Formulas

$$Rn = \frac{V \cdot L}{\nu} \qquad Fn = \frac{V}{\sqrt{g \cdot L}} \qquad R = C_R \cdot \frac{1}{2} \rho V^2 S \qquad 1 \text{ knot} = 0.5144 \text{ m/s}$$

$$T = K_T \cdot \rho D^4 n^2 \text{ and } \quad Q = K_Q \cdot \rho D^5 n^2 \quad \text{where} \quad J = \frac{V_e}{n \cdot D}$$

$$H_{1/3} = 4 \cdot \sqrt{m_0} \quad \text{and} \quad T_1 = 2\pi \cdot \frac{m_0}{m_1}$$