OE4620 Offshore Hydromechanics Module 1

22 June 2007

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.
3. The questions here are stated in English. Answers may be given using either Dutch or English.
4. You may answer any combination of questions, however to a maximum of 10 points to be earned and at least one out of each group.

Group 1 Hydrostatics

1.1 The initial stability of a floating barge is governed by GM, which is calculated as GM = MB + BK – GK. The parameter MB of a rectangular barge with vertical sides is easily calculated as $MB = B^2 / 12\,T$. Derive this formula from the basics of barge wedges entering or leaving the water when the barge is heeled over a small angle. (2 points).

1.2 Explain why the melting of ice floating on the north polar (Arctic) sea will not contribute to sea level rise, but that melting ice on the Antarctic continent will increase the sea level. (1 point)

1.3 A 100 m long steel pipe with a closed lower end is suspended in seawater from the hook of an offshore crane barge. The suspension point is 20 m above water level. The specific density of seawater is 1025 kg/m3, that of steel is 7850 kg/m3. The pipe has an outside diameter of 400 mm and a wall thickness of 25 mm.

a. What is the longitudinal stress in the pipe immediately under the suspension point ?

b. Where does the longitudinal stress become 0 ?

c. Explain the difference between effective tension and real tension. (1 point)

Group 2 Potential Flow

2.1 Potential flow descriptions are popular, amongst other because you may superpose several simple potentials to create a specific flow pattern. Make a sketch of flowlines if you combine a uniform flow potential and a sink potential. (1 point)

2.2 What are the basic assumptions in the application of potential flow theory ? (1 point)

2.3 Is the following potential function possibly valid to describe flow of an incompressible fluid : $\Phi = 2x^4 - x^3y - 12x^2y^2 + xy^3 + 2y^4 + 6z$ (1 point)

Group 3 Real Flows:

3.1 Explain why the value of the drag coefficient of a circular cylinder versus the Reynolds number shows a dip at around Rn = 4×10^5. What happens to the Strouhal number in this same Reynolds number range ? (1 point)

3.2 Explain why in the real world of model testing (for instance in the tanks of the faculty of 3Me) it is practically impossible to test at both the correct Reynolds and the correct Froude number (1 point)

3.3 Sketch an open water diagram of a screw propeller and describe in words or formulae what is represented in the diagram. (1 point)

3.4 A viscous fluidum flowing along a plate forms a boundary layer, which changes in nature at some distance from the leading edge. Describe the characteristics of the boundary layer in front of and past the transition point or zone. (1 point)

Group 4 Waves

4.1 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.

Note: $k = \frac{2 \cdot \pi}{\lambda} = \frac{\omega^2}{g}$

Amplitude of wave slope = $k \cdot \zeta_a$ (1 point)

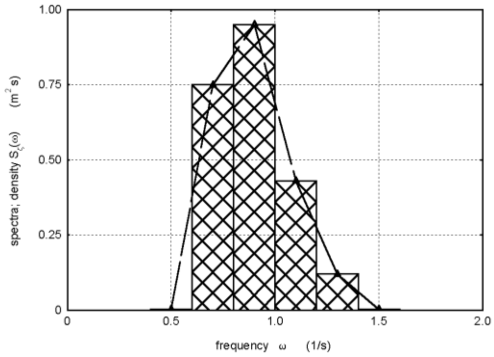
4.2 A fully developed sea and swell are defined by:

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

a) Sketch the spectra of this sea and swell and of the combined sea and swell.
b) Calculate the characteristics $H_{1/3}$ and T_1 of the combined sea and swell.

Note: $H_{1/3} = 4 \cdot \sqrt{m_0}$ and $T_1 = 2 \cdot \pi \cdot \dfrac{m_0}{m_1}$ (1 point)

4.3 A simplified wave energy spectrum of a storm in the North Atlantic Ocean, measured by a wave buoy, is given by:



ω	(s^{-1})	0.5	0.7	0.9	1.1	1.3	1.5
$S_\zeta(\omega)$	(m^2s)	0.00	0.75	0.95	0.43	0.12	0.00

Sketch and data for a wave spectrum

- Calculate the significant wave height, $H_{1/3}$, and the mean wave period T_1 and the zero-up crossing wave period T_2.
- Determine the probability P of exceeding a wave height of 4.00 meters in this storm, by using the Rayleigh probability density function.
- Determine also the approximate number of times per hour that this wave height will be exceeded.
- What is the probability that the significant wave height $H_{1/3}$ will be exceeded?

Rayleigh : $$P\{H_w > H\} = \exp\left\{-2\left(\frac{H}{H_{1/3}}\right)^2\right\}$$

(2 points)

4.4 Linear wave theory assumes infinitely small wave heights. Reality is different as you know. Linear theory does not define wave particle velocities above the still water level. Name and describe three methods to extend the particle velocity profile above the still water level. (1 point)