OE4620 Offshore Hydromechanics Module 1 Quiz 1

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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 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 (1 point) 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.

1.2 (1 point) Describe how in essence it is possible, that a transport barge carrying a large jack-up platform does not capsize. Which dimension of the barge is most important in this respect ?

1.3 (1 point) A small steel boat is floating in a pond. Originally it is dry and empty inside, but after a while it starts leaking and ultimately it sinks to the bottom, disappearing completely from the surface. Does the water level in the pond change ? Explain your anwer.

Group 2 Potential Flows

2.1 (1 point) Four basic building blocks can be used - via superposition - to make up any potential flow pattern. One of these is the uniform flow. Name the remaining three.

2.2 (1 point) The Magnus effect results in a force perpendicular to the direction of an oncoming potential flow. How do you call this force ? What causes it ? Sketch a cross section of a circular cylinder in a flow in a condition where the Magnus effect occurs, showing the flowlines.

2.3 (2 points) A pipeline of radius R is resting on a flat, impermeable sea bed. Using potential flow theory, estimate the ratio of the flow velocity at the crown (uppermost part, x=0 $y=y_0+R$) of the pipe to that of the ambient flow. It is known that the stream function for two cylinders whose centers are located $2y_0$ apart (in the direction perpendicular to the flow) is given by:

$$\Psi = \mu \frac{y - y_0}{x^2 + (y - y_0)^2} + \mu \frac{y + y_0}{x^2 + (y + y_0)^2} - U_\infty y$$

in which:

$\mu = U_\infty R^2$ is the doublet strength.

$x =$ the horizontal coordinate along the sea bed.

$y =$ the vertical coordinate (+up) from the sea bed.

$y_0 =$ the vertical elevation of the pipeline axis.

$R =$ the pipeline radius.

Is the direction of the oncoming flow into the positive X direction or against it ?

Group 3 Real Flows

3.1 (1 point) A ship of 60,000 tons displacement is driven at a speed of 12 knots. A ship of 45,000 tons of similar form is being designed.

- At what speed of the smaller ship should its performance be compared with the 12 knots of the 60,000 ton ship?
- Does the larger ship have a smaller or a larger still water resistance coefficient than the smaller one? Explain your answer.

3.2 (1 point) Explain why the value of the drag coefficient of a circular cylinder versus the Reynolds number shows a dip at around Rn = 4 x 10^5. What happens to the Strouhal number in this same Reynolds number range ?

3.3 (1 point) A Spanish galleon during the 80 years war fires a 100 kg cannon ball in the direction of a Dutch ship but of course misses its target. The sea is deep, and the solid iron cannon ball disappears in the water forever. At what speed will it hit the sea bed ? Assume a drag coefficient Cd as a function of the Reynolds number Rn as given under Formulas (interpolate for intermediate values).

Group 4 Waves

4.1 (1 point) The dispersion relation is based on one of the boundary conditions used in the derivation of the potential function for sinusoidal surface waves of small amplitude. Which is it ? What are the other three boundary conditions ?

4.2 (1 point) A fully developed sea and swell are defined by:

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

- 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.

4.3 (1 point) Irregular waves

- Explain in words how a wave spectrum is determined from the record of an irregular sea, such as obtained by a wave rider buoy.
- Why does one have to supply a random series of phase angles in generating an irregular wave train from a given spectrum ?

4.4 (1 point) Probabilities

- Describe the difference in nature and use of short term and long term wave height distributions
- Which distribution functions are normally used in either case (names, not the formulas)
- What is the usual definition of a maximum wave height during a storm of typically 3 hours

Formulas

$$Rn = \frac{V \cdot L}{\nu} \qquad Fn = \frac{V}{\sqrt{g \cdot L}} \qquad R = C_R \cdot \frac{1}{2}\rho V^2 S$$

1 knot = 0.5144 m/s

Kinematic viscosity of the seawater $\nu = 1.01 * 10^{-6}$ m^2/s
Density of seawater $\rho = 1025$ kg/m^3
Density of cannon ball iron = 8000 kg/ m^3

Drag coefficients of a ball as a function of the Reynolds number :

Rn =	10^3	10^4	10^5	10^6	10^7
Cd =	1.2	1.1	1.0	0.4	0.6

Dispersion relation : $\omega^2 = k\, g \cdot \tanh kh$

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