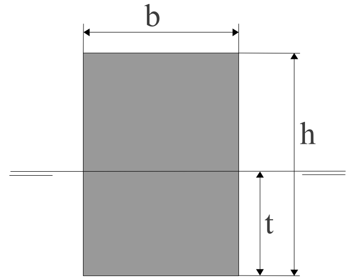
Exam OE4630D1 Offshore Hydromechanics Module 1
Friday January 29th 2010
09:00-12:00u
Examiner: P. de Jong

Instructions

1. Be sure to put your name and student number on each submitted page. The questions are stated in English. Answers may be given using either Dutch or English.
2. This quiz includes 4 groups of questions, each associated with one of the chapters 2 through 5. An extensive formula sheet is included at the end of the exam.
3. No book or notes allowed during the exam. You are required to include in your answers full calculations and motivations.
4. Finish all questions to complete the exam (contrary to previous exams where one was able to choose the questions). A maximum of 36 points can be earned.

1 Hydrostatics (10 points)

1.1 Consider a solid homogeneous rectangular floating beam with a cross section given in the figure below.



The dimensions are given as:

length	*l*	*4.0 m*
width	*b*	*0.6 m*
depth	*h*	*0.5 m*
draft	*t*	to be determined.

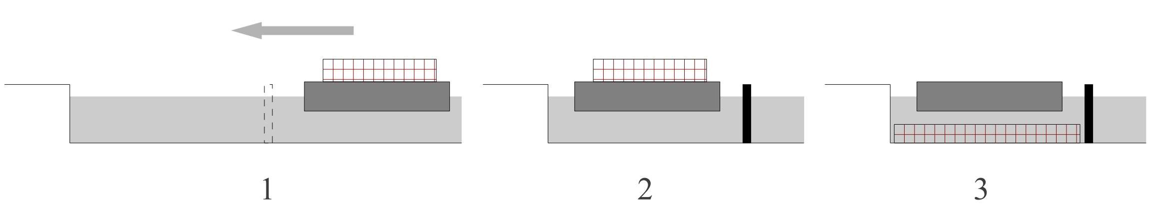
The density of the material of the beam is denoted ρ_b, the gravity acceleration is given as $g = 9.81\ m/s^2$, the density of the surrounding water is $\rho = 1000\ kg/m^3$.

a Determine for which (range(s) of) values of ρ_b the beam will be **floating** in a **stable upright** condition. *(3 points)*

b Explain under which conditions the formula of Scribanti for the righting arm is *exact*. *(2 points)*

c Is the beam floating upright in a stable condition (for the rotation about the longitudinal axis) when the density of the material of the beam is $\rho_b = 550\ kg/m^3$? If not, what at heeling angle will the beam float? *(3 points)*

1.2 A rectangular barge loaded with *300 1.0x1.0x1.0 m* concrete blocks of $1500\ kg/m^3$ has entered a dock (1). After the barge has entered the dock the dock doors are closed (2), after which the barge discharges its load of blocks in the (water of the) dock (3). Is the water level going to change, if so will it rise or lower? Explain. *(2 points)*



2 *Potential Flow (10 points)*

2.1 The velocity components of a steady three-dimensional flow are given as:

$$u = A\,x\,; \quad v = -2\,A\,y\,; \quad w = A\,z$$

where $A > 0$ is a constant. The flow is assumed to be incompressible and inviscid.

a Show whether the flow field satisfies the conditions necessary for potential flow. *(3 points)*

b Determine the streamline pattern in the *xy*-plane (also indicate the flow direction). *(2 points)*

2.2 Consider a given by the velocity potential and the stream function given below:

$$\Phi = \frac{Q}{2\pi} \cdot \ln\sqrt{x^2 + y^2} + U_\infty \cdot x \qquad\qquad \Psi = \frac{Q}{2\pi} \cdot \arctan\left(\frac{y}{x}\right) + U_\infty \cdot y$$

a The flow is build up by two components, which are these and what are their flow directions? *(2 points)*

b Derive the location of the stagnation point. *(3 points)*

3 *Real Flows (8 points)*

3.1 In order to calculate the resistance of a ship advancing with forward speed through calm water a method based on potential flow is used.

a Name the three main resistance components this ship is experiencing. *(1 point)*

b Explain which of these components can be calculated by applying the potential flow method. *(2 points)*

3.2 Explain why an increase in blade area ratio of a ship propeller reduces the occurrence of cavitation. Why does one still try to keep the blade area ratio as low as possible? *(2 points)*

3.3 We are performing a extrapolation of the resistance of a model towed in waves. The dimensions of the experiment are chosen such that the Froude number during the experiments equals the full scale Froude number. Given that the scaling factor for length is α_L and the scaling factor for density is α_ρ, derive scaling factors for the following quantities:

- velocity (m/s)
- acceleration (m/s^2)
- time (s)
- displacement (m^3)
- force (N)
- wave frequency (rad/s)

expressing these only in α_L and α_ρ. *(3 points)*

4 *Waves (8 points)*

4.1 We consider an irregular sea state in a storm with a mean wave period of $T_1 = 6.3\ s$ and a significant wave height of $H_{1/3} = 3.4\ m$. You may assume that the wave amplitudes are Rayleigh distributed.

a In order to assume Rayleigh distributed wave amplitudes, what two conditions must the wave elevation spectrum fulfill? *(1 point)*

b Calculate the maximum expected wave height when the duration of the storm is 6 hours. *(3 points)*

4.2 A fully developed sea and swell are defined by:

$$H_{1/3\,sea} = 3\,m \quad \text{and} \quad H_{1/3\,swell} = 4\,m$$
$$T_{1\,sea} = 6\,s \qquad\qquad T_{1\,swell} = 12\,s$$

a Give a realistic sketch (including dimensions) of the energy spectra of this sea and swell and of the combined sea and swell. *(2 points)*

b Calculate the characteristics $H_{1/3}$ and T_1 of the combined sea and swell. *(2 points)*