

# 13.022

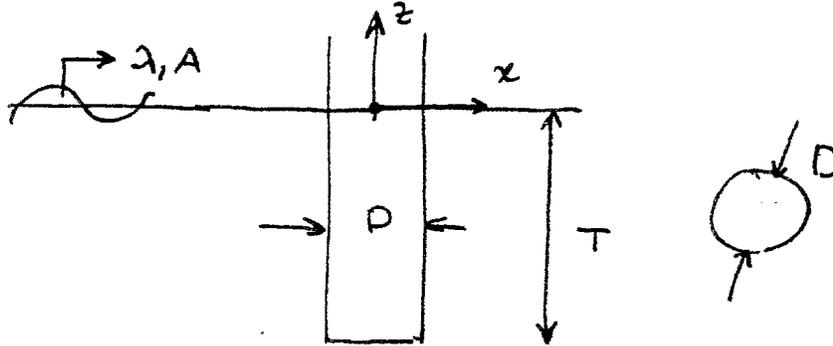
## SURFACE WAVES AND THEIR INTERACTION WITH FLOATING BODIES

### Quiz 3

Monday, December 6<sup>th</sup>, 1999

1:30 Hours - Open Book

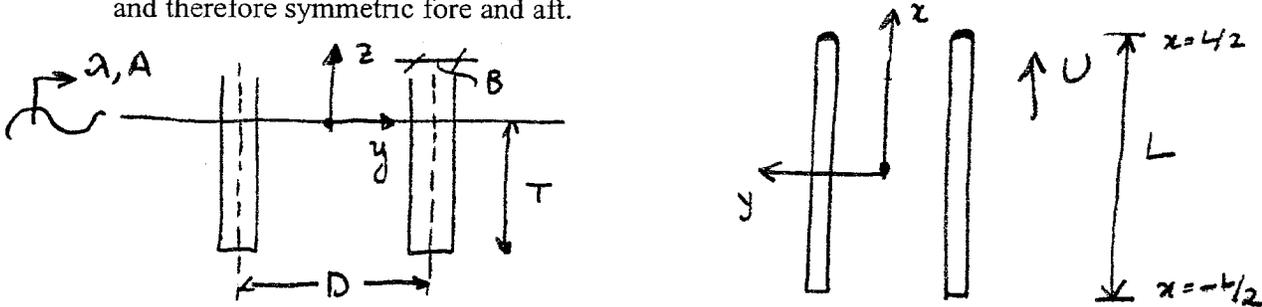
1. (50%) Consider the freely floating slender buoy shown in the figure, consisting of a long slender vertical cylinder with circular cross section of diameter  $D$  and draft  $T \gg D$ .



Ambient waves of amplitude  $A$  and length  $\lambda$  are incident on the buoy propagating in the positive  $x$ -direction.

- Estimate the surge, pitch and heave added mass.
- Which modes of motion are coupled and which are uncoupled according to linear theory.
- Determine the heave and pitch natural frequencies, assuming that the buoy center of gravity is located at a distance  $T/4$  from the buoy bottom.
- Evaluate the heave and pitch responses at resonance. Comment on the importance of viscous effects.
- A current of speed  $U$  flows in the positive  $x$ -direction. Comment qualitatively how your answers in a)-d) change, ignoring viscous effects.

2. (50%) You are involved in the hydrodynamic design of a catamaran vessel shown in the Figure. The cross sectional area of the vessel consists of two thin rectangular sections with beam  $B$ , draft  $T$  and separation distance  $D$ . Assume that  $T \gg B$  and  $T \sim D$ . Assume that the cross sectional shape of the vessel is uniform along its length and therefore symmetric fore and aft.



- Regular waves are incident on the vessel from abeam. Determine the values of the wavelength  $\lambda$  for which the heave exciting force vanishes [Use the long wavelength approximation and assume no hydrodynamic interaction between the hulls].
- Determine the frequencies  $\omega_i$  for which the heave damping coefficient vanishes [Use your result in a)].

The vessel advances in head waves of known observed wavelength  $\lambda$ . The ship captain has in his possession two accelerometers which he wants to use in order to measure the ship speed and the vertical acceleration at any position on the vessel. He decides to place accelerometer 1 at midships, located at  $x=z=0$  and accelerometer 2 at the bow, located at  $z=0$  and  $x=L/2$ . The measured vertical accelerations were:

$$a_1(t) = A_1 \cos(\omega t)$$

$$a_2(t) = A_2 \cos(\omega t + \theta)$$

In terms of the measured quantities  $A_1$ ,  $A_2$ ,  $\omega$  and  $\theta$  determine:

- The ship speed
- The modulus of the vessel heave and pitch motions
- The phase difference between the heave and pitch motions
- The modulus of the vertical acceleration at any location  $x$  on  $z=0$ .