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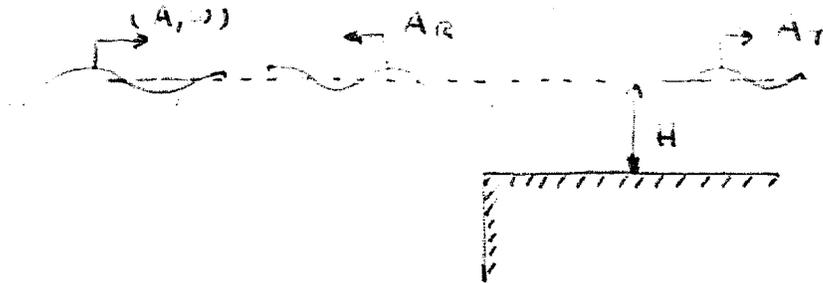
SURFACE WAVES AND THEIR INTERACTION WITH FLOATING BODIES

Quiz 1

Tuesday, March 9, 1998

1:30 Hours - Open Book

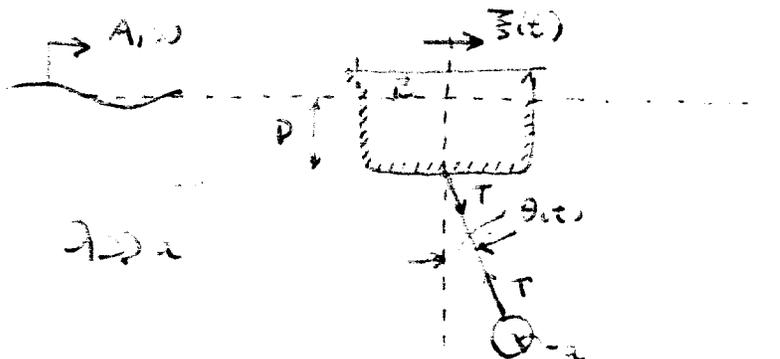
1. (30%) Deep water plane progressive waves of amplitude A and frequency ω are propagating over the step shown in the figure and into water of finite depth H . It is estimated that only 50% of the incident wave energy flux propagates over the step. The remainder 50% is reflected back.



- a) Derive an expression for the amplitude of the regular wave propagating over the finite depth region.
- b) Derive an expression for the amplitude of the regular wave reflected off the step.

(HINT: Apply the energy conservation principle. Make use of the property that the energy flux of two regular waves propagating in opposite directions may be derived as if there is no interaction between the two wave trains).

2. (35%) An oceanographic instrument is mounted in a circular buoy of radius a which is suspended by a cable of length L off the keel of a ship, modeled as a rectangular section with beam B and draft D . In calm water the cable tension is T .



Regular waves of amplitude A and frequency ω are incident upon the ship. Assume that the ship undergoes just a harmonic oscillation in surge with displacement $\xi(t)$ and that the cable deflection off the perpendicular is described by the harmonic angular displacement $\theta(t)$.

- a) Derive the coupled system of equations governing the surge and angular displacements $\xi(t)$ and $\theta(t)$. Assume that the surge added mass, damping and exciting force on the ship are known. Moreover the wavelength of the ambient wave λ is assumed to be large compared to the circle radius a .
- b) Determine the natural frequency of the pendulum, assuming the ship surge displacement is zero.
- c) Determine the amplitude of the surge oscillation of the ship when the ambient wave frequency coincides with the natural frequency of the pendulum.

(HINT: Use linear theory and its implication that all displacements are small. In your derivations use the mean value of the tension T and ignore its time varying component which is small).

3. (35%) Two submarines are engaged in a refueling operation while exposed to beam waves of amplitude A and frequency ω . Each submarine is modeled as a circle with radius a , separation d and draft T . Assume that the wavelength λ is large compared to the radius a and there is no hydrodynamic interaction between the submarines.

- a) Derive an approximation for the heave and surge exciting force on each submarine.
- b) For what values of the wavelength-separation (λ, d) are the sway exciting forces in phase and for what values are they 180 deg out of phase?

(HINT: In your analysis use the coordinate system shown in the figure which is centered between the two circles).

