ENGINEERING TRIPOS PART IIB
ELECTRICAL AND INFORMATION SCIENCES TRIPOS PART II

Friday 2 May 2003 9 to 10.30

Module 4D12

COASTAL AND OFF-SHORE ENGINEERING

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

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1 (a) Using small-amplitude wave theory obtain first-order expressions for the horizontal and vertical displacement of fluid particles about their mean positions under progressive waves. The expression for velocity potential given in the Data Sheet may be assumed without proof. [30%]

(b) Discuss in qualitative terms how the fluid particle orbits are modified when the solution is taken to a higher order of approximation. [25%]

(c) Why is it important to know the direction of net drift at various heights above the bed when considering the stability of beaches? [20%]

(d) What currents are important in the marine environment? [25%]

2 (a) Show that for small amplitude progressive waves approaching a coast

$$\frac{H^2}{k}(1+\frac{2kd}{\sinh 2kd}) = const\,,$$

where the symbols are defined in the Data Sheet. [40%]

(b) State and briefly discuss any assumptions made. [25%]

(c) Waves are approaching a beach and at a depth of 15 m their amplitude is 0.5 m and wavelength is 50 m. The shear stress on the bed is assumed to be proportional to the square of the velocity at the bed given by ideal wave theory. Find the ratio of the shear stress under these waves at a water depth of 15 m to that at a water depth of 1 m. [35%]

3 Derive Snell's law for a steady train of waves approaching a coast,

$$\frac{c}{\sin\alpha} = \frac{c_0}{\sin\alpha_0},$$

where the symbols are defined in the Data Sheet. [25%]

A steady train of waves of period 10 s advances towards a straight coast running North-South. In deep water the waves have a height of 6 m and their direction of propagation is towards the North-West.

(a) What angle do the wave crests make to the shoreline in water of depth 7 m? [20%]

(b) What is their height at this depth? [20%]

(c) Would you expect the waves to break before reaching this depth? Give reasons. [35%]

4 The force per unit length on a body of diameter D in an unsteady flow of velocity u is given in the Data Sheet as

$$F = C_D \rho \frac{u|u|D}{2} + C_M \rho \frac{\pi D^2}{4} \frac{du}{dt}.$$

(a) A vertical circular cylinder of diameter D extends from the sea bed to the water surface. Using the above equation and small-amplitude wave theory derive an expression for the total force due to waves on this cylinder in terms of C_D, C_M, ρ the wave parameters k, ω, H, the water depth d and the time t. [50%]

(b) Show that for both shallow-water and deep-water waves the first term in the above equation may be neglected when the Keulegan-Carpenter number (based upon the maximum velocity at the mean water surface level) is less than about 1. [50%]

END OF PAPER