7 A submarine uses cables to recover a submerged wooden chest as shown in Fig. 7.1.

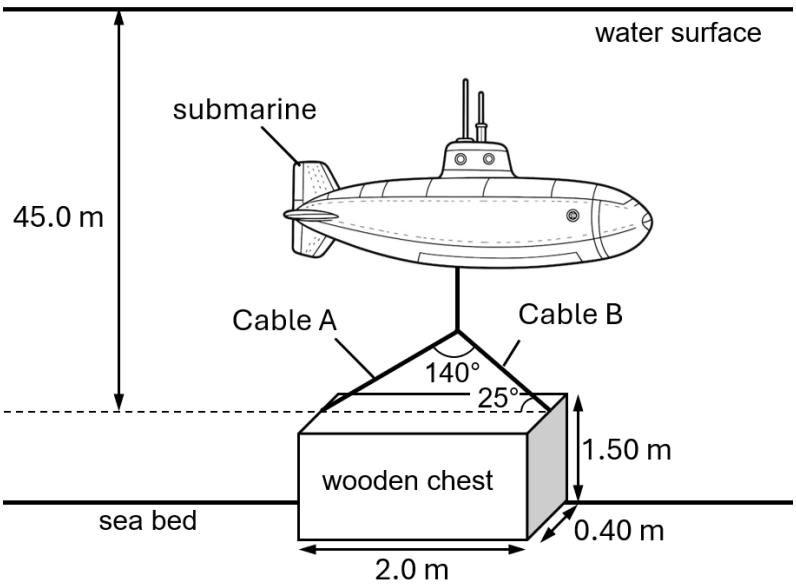

Fig. 7.1 (not to scale)

The submarine has a mass of 3600 kg. The density of seawater is 1030 kg m^{-3} and the average density of the chest is 1800 kg m^{-3}.

(a) Show that the hydrostatic pressure p of a fluid at a depth h and density ρ is given by the expression

$$p = \rho g h.$$

[2]

For Examiner's Use

(b) The box is held in equilibrium slightly above the sea bed.

(i) Explain why the seawater exerts an upthrust on the chest.

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……..……..……. [2]

(ii) Calculate the upthrust of the wooden chest when it is raised above the sea bed.

upthrust = …… N [2]

(iii) Calculate the weight of the wooden chest.

weight = …… N [1]

(iv) Determine the tension in cable A and cable B.

tension in cable A = …… N

tension in cable B = …… N
[4]

[Turn over

For Examiner's Use

(c) The submarine is propelled forward at a constant velocity of 4.5 m s^{-1} by a 0.50 MW motor connected to a propeller. The drag force F_d acting on the submarine and the chest is given by

$$F_d = kv^2,$$

where $k = 3.5 \times 10^3$ N s^2 m^{-2}.

(i) Calculate the thrust provided by the propeller.

thrust = ... N [2]

(ii) Calculate the efficiency of the motor when the submarine is cruising at a speed of 4.5 m s^{-1}.

efficiency = ... % [2]

(d) The total mass of the submarine is suddenly decreased by 200 kg by pumping water out of the submarine horizontally in a negligible time. The volume of the submarine remains unchanged.

(i) Calculate the initial upward acceleration of the submarine.

acceleration = ... m s^{-2} [3]

For Examiner's Use

(ii) Explain why the acceleration of the submarine eventually decreases to zero as the submarine ascends.

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……..……..……. [2]

[Total: 20]