3 Fig. 3.1 shows the front view of a container ship.

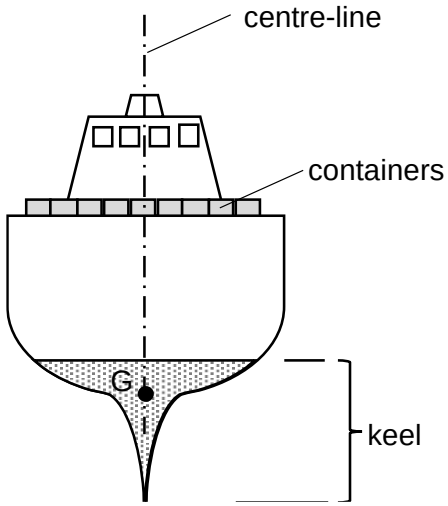

Fig. 3.1

The line of symmetry of the ship is known as the centre-line.

An important part of the ship is the ballast keel, a vertical downward extension of the ship's hull, that is loaded to keep the centre of gravity G of the boat low as shown in Fig. 3.1.

When the ship floats in the sea, the upthrust of the ship is equal in magnitude but opposite in direction to the weight of the ship.

(a) Explain

(i) what is meant by the *centre of gravity* of the ship,

……

……

…… [2]

(ii) the origin of the upthrust acting on the ship.

……

…… [1]

(b) The ship has a mass of 2.20×10^8 kg and the density of seawater is 1030 kg m^{-3}.

Calculate the volume of seawater displaced by the ship.

volume = …….. m^3 [2]

(c) A ship will roll on its sides due to the wind and the water waves. Fig 3.2 shows ship on its side at a particular instant.

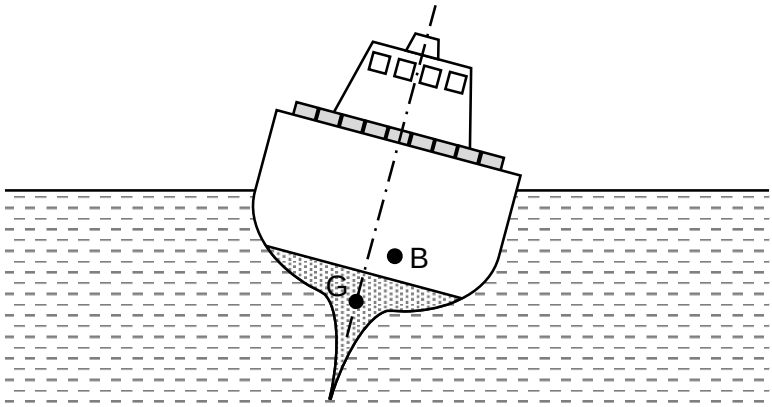

Fig. 3.2

The upthrust acts through the centre of gravity of the displaced fluid, known as the centre of buoyancy B shown in Fig. 3.2.

(i) On Fig. 3.2, mark with arrows labelled *W* for the weight and labelled *U* for the upthrust. [1]

(ii) By reference to the completed diagram of Fig. 3.2, explain why the ship will not overturn.

……

……

…… [2]

(d) When the ship is fully loaded with containers (you may assume the containers are secured and will not shift), the centre of gravity G will be at a higher position along the centre-line.

Draw relevant forces on Fig. 3.3 to explain the danger of a fully loaded ship rolling to its side.

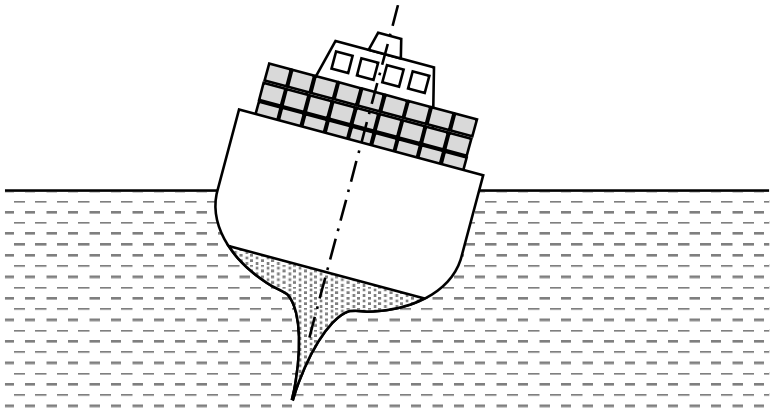

Fig. 3.3

……

…… [2]

[Total: 10]

[Turn over