



4. (10 points, suggested time 20 minutes)

A large boat like the one shown above has a mass  $M_b$  and can displace a maximum volume  $V_b$ . The boat is floating in a river with water of density  $\rho_{water}$  and is being loaded with steel beams each of density  $\rho_{steel}$  and volume  $V_{steel}$ . The boat owners want to be able to carry as many beams as possible.

- (a) Derive an expression for the maximum number  $N$  of steel beams that can be loaded on the boat without exceeding the maximum displaced volume, in terms of the given quantities and physical constants, as appropriate.
- (b) The captain realizes that oil is leaking from the boat, creating a thin film of oil on the water surface. In one area of the oil film the surface looks mostly green. Explain in detail how constructive interference contributes to the green appearance. Assume the index of refraction of the oil is greater than the index of refraction of the water.
- (c) Later the boat is floating down the river with the water current, heading for a town. The river has a width of 60 m and a constant depth and flows at a speed of 5 km/hr. Partway to the town, the river narrows to a width of 30 m while its depth remains the same. Calculate the speed of the water in the narrow section.