Massachusetts Institute of Technology
Subject 2.019 Design of Ocean Systems

HOMEWORK 1

1. **Ship's Lines.** Lines for a 100m vessel are shown in the figure below, and detailed in the file `shiplines.dat` on the MIT server. The first line of the file has NaN and then the longitudinal station locations (meters) measured positive aft from the bow. The successive lines in the file have the height above the keel (meters), followed by the lateral offsets from the centerline (meters):

$$\begin{bmatrix} NaN & x_1 & x_2 & \cdots \\ z_1 & y_{11} & y_{12} & \cdots \\ z_2 & y_{21} & \cdots & \end{bmatrix}.$$

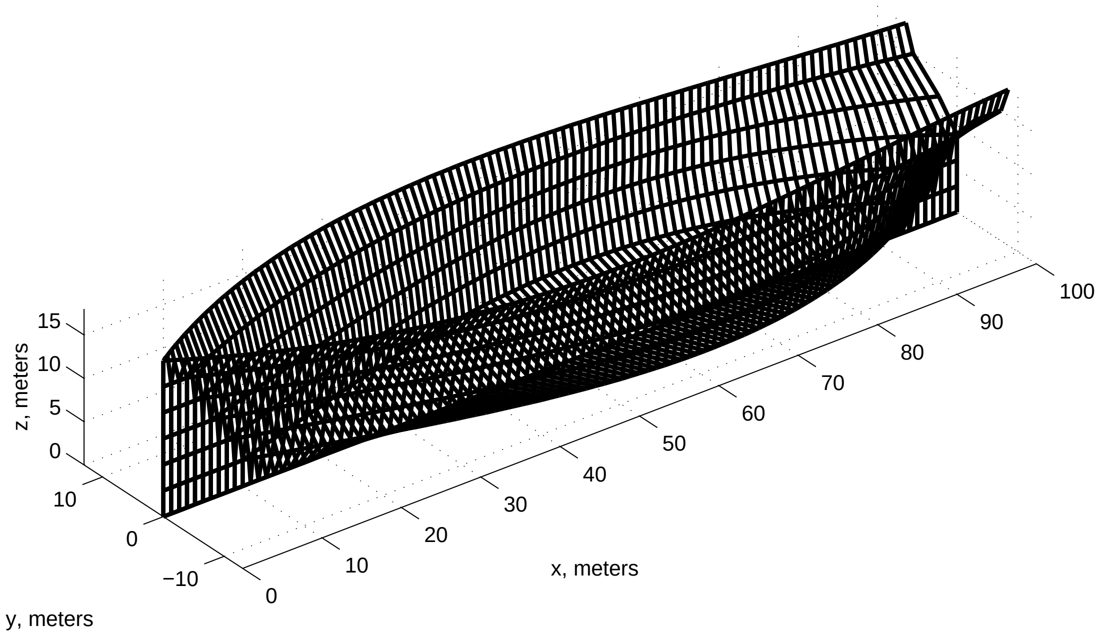
   The vessel has a design draft of twelve meters. You are asked to compute the following parameters. DO NOT SPEND TIME GOING AFTER MORE THAN THREE SIGNIFICANT DIGITS - THE RESOLUTION GIVEN IS MORE THAN ADEQUATE FOR TRAPEZOIDAL INTEGRATION. Note I use zero offset to indicate both the keel and those locations where there is no actual material; this makes your calculations very easy.

   (a) Displacement.
   (b) Waterplane area.
   (c) Longitudinal center of waterplane area.
   (d) Vertical center of buoyancy (centroid of the submerged volume).
   (e) Longitudinal center of buoyancy.
   (f) Heave natural frequency (Hint: think about $\sqrt{k/m}$).
   (g) Hydrostatic righting moment for a one degree roll angle.

   In addition to turning in your answers in hardcopy, please email them to me and I will keep and broadcast a tally of answers given.

2. **Liquid Helium.** The impossibility of simultaneous Froude and Reynolds number scaling in water has led to the consideration of some exotic fluids. For instance, Helium II is a superfluid that exists at one atmosphere and temperatures below about 2.1 degrees Kelvin. The analogue of superconducting materials, this superfluid has zero viscosity; there is no dissipation of energy through turbulence. Below 4.1 degrees Kelvin, we have Helium I, which is a normal (but cold!) fluid. Helium I has an absolute viscosity of 3.85 microPascal-seconds, and a density of 143 kilograms per cubic meter. As you know, water has typical viscosity of 1000 microPascal-seconds and a density of 1000 kilograms per cubic meter, at "human" conditions.

   Consider a 60-meter vessel travelling at 20 meters per second. What are the length and speed of a model that achieves exact Froude and Reynolds scaling, operating in Helium I? This is a set of two equations with two unknowns.



3. **Preliminary Propeller Design.** B-series propeller characteristics are given on page 5.38 of the Naval Architecture notes. Shown are the thrust and torque coefficients and the efficiency that go with five different pitch-to-diameter ratios.

   (a) For an effective power (the product of resistance and forward speed) of 19 megaWatts, a speed of 12 meters per second, and a single prop diameter of 6.5 meters, determine what is the constant value of K_t/J^2.

   (b) What P/D should be chosen if the goal is to achieve highest design efficiency? It may help you to make a hardcopy of the chart, and plot the constant K_t/J^2 line on it. Also, remember that the design efficiency is usually at J about five percent down from the peak value.