ME 55600:I0200
Homework #9: Turbulent Boundary Layer/Immersed Bodies

1. A wind turbine is located 1000 m from the seashore and exposed to winds at 30 km/hr.The blades of the turbine are 20 m in length. In order to avoid lower wind velocity near the ground, the turbine tower is placed high enough so that the blades are at least 3 m above the boundary layer. What should be the height of the axis of the turbine? Use air properties at 10^oC, and assume the boundary layer is turbulent from the leading edge.

2. A flat-bottomed barge is 25 m long and 10 m wide. It is submerged to a depth of 1.5 m and moves at a speed of 8 km/hr. Determine the power required to move the barge if the water temperature is 15^oC. Assume the surface of the barge is smooth, and the entire boundary layer is turbulent.

3. A torpedo is 4 m long and has a diameter of 0.5 m. It moves at a speed of 40 $knots$ in seawater at 10^oC. What power is needed to overcome the skin-friction drag is transition to turbulence occurs at $Re_{cr} = 10^6$?
For seawater use $\nu = 1.361x10^{-6}\ m^2/s$, and $\rho = 1025\ kg/m^3$.

4. A ship has a length of 250 m and is moving at a speed of 30 $knots$ 30. The wetted area is 14,000 m^2.

(a) Determine the minimum admissible roughness and the corresponding minimum possible skin drag. What is the power needed to overcome the minimum skin drag?
(b) Determine the skin drag and power needed to overcome it if the surface roughness is 0.1875 mm.
(c) What is the percent increase in power needed due to surface roughness?

Use $\nu = 10^{-6}m^2/s,$ and $\rho = 1010\ kg/m^3$. $Re_{cr} = 500{,}000$