University of Saskatchewan
Department of Mechanical Engineering
ME 215.3 Fluid Mechanics I
Final Examination
April 16, 2005

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(20) 1. Define the following terms.

(a) Kutta-Joukowski theorem

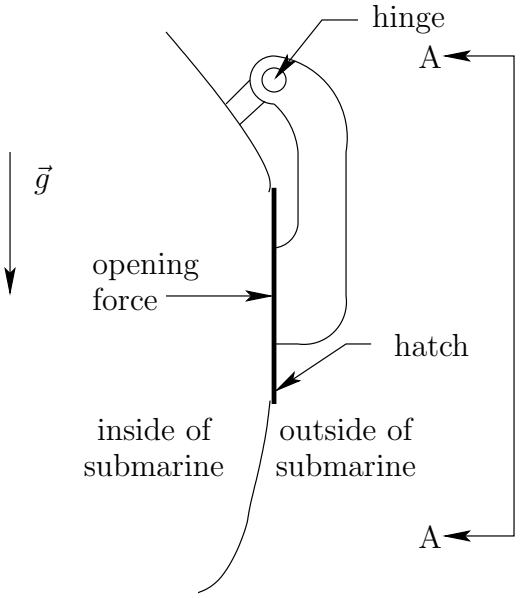
(b) Specific gravity

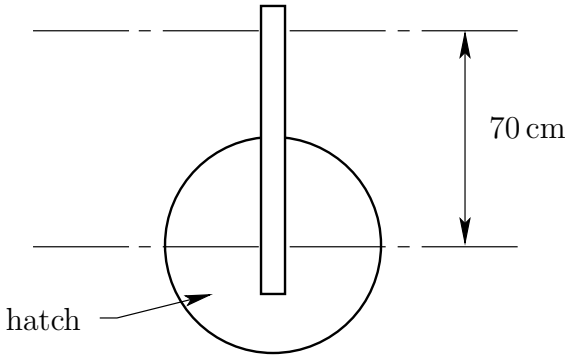
(c) Newtonian fluid

(d) Piezometric head

(e) Vorticity

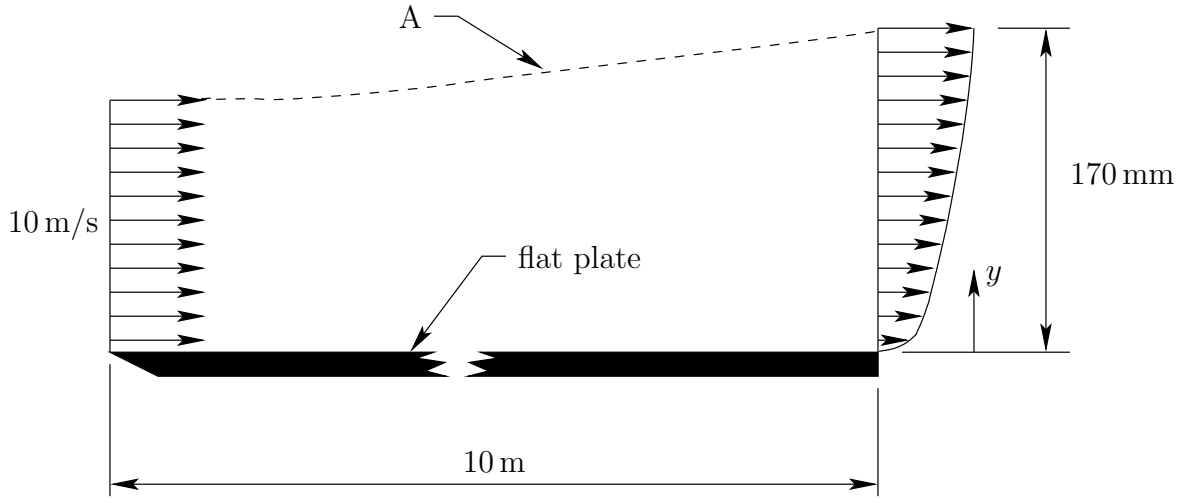
(20) 2. A circular hatch on a submarine is hinged as shown. The radius of the hatch is 35 cm. The hinge is 70 cm above the centre of the hatch. Determine how hard a sailor has to push on the centre of the hatch to open it. The seawater density is $1025\,\mathrm{kg/m^3}$ and the centre of the hatch is 2 m below the surface of the ocean. The air pressure inside the submarine is equal to atmospheric pressure.



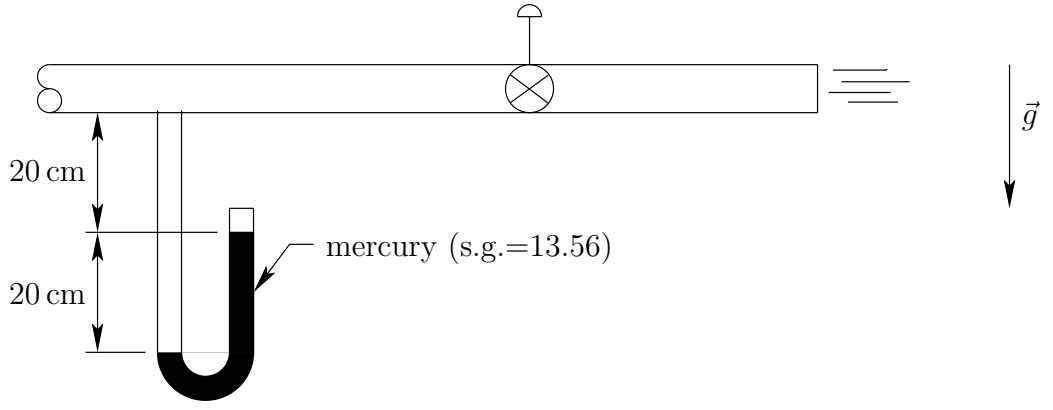


View A-A

(20) 3. Air ($\rho = 1.2\,\mathrm{kg/m^3}$) blows parallel to a flat plate upon which a boundary layer grows. The plate is 10 m long in the streamwise direction and 4 m wide (normal to the page). At the leading edge of the plate the air speed is uniform at $U_\infty = 10\,\mathrm{m/s}$. The velocity profile is measured at the end of the plate and is found to vary with distance y from the plate according to $u = U_\infty (y/\delta)^{1/7}$ where $\delta = 170\,\mathrm{mm}$ is the boundary layer thickness. Determine the viscous force on the plate. Consider only the flow over the top surface of the plate. The dashed line labeled "A" is a streamline in this flow.



(20) 4. A piping system contains a valve ($K_\mathrm{m} = 6.5$) and discharges water ($\rho = 998\,\mathrm{kg/m^3}$, $\nu = 10^{-6}\,\mathrm{m^2/s}$) to atmosphere. A mercury manometer 20 m from the end of the pipe reads as shown. The right leg of the manometer is open to atmosphere. The pipe is smooth and its diameter is 5 cm. Determine the volume flowrate through the pipe in L/min.



(20) 5. A crude aerofoil is modeled using a freestream ($U_\infty = 50\,\text{m/s}$) and three doublets. The doublets are spaced 20 cm apart. The left and right doublets have equal strength (λ) and the centre doublet has twice the strength (2λ). Determine λ to make the aerofoil 60 cm long. For this λ, what is the thickness h of the aerofoil?