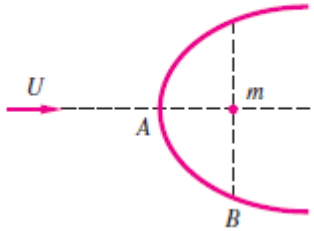
ESO204A: Fluid Mechanics and Rate Processes
TUTORIAL 13 PROBLEMS

August-November 2017

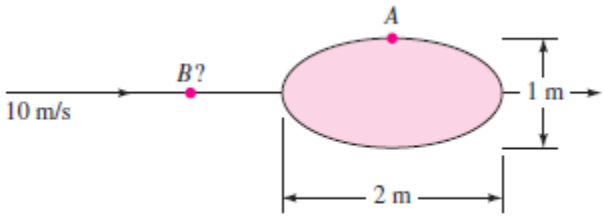
1. Review of Tutorial 12

2. Water at 20°C flows past a half-body as shown in Fig. P8.27. Measured pressures at points *A* and *B* are 160 kPa and 90 kPa, respectively, with uncertainties of 3 kPa each. Estimate the upstream velocity and its uncertainty.




P8.27

3. A Rankine oval (full body) 2 m long and 1 m high is immersed in a stream $U_\infty = 10$ m/s, as in Fig. P8.37. Estimate (*a*) the velocity at point *A* and (*b*) the location of point *B* where a particle approaching the stagnation point achieves its maximum deceleration.




P8.37

4. A large Rankine oval, with $a$ = 1 and $h$ = 1 m, is immersed in 20°C water flowing at 10 m/s. The upstream pressure on the oval centerline is 200 kPa. Calculate (a) the value of $m$; and (b) the pressure on the top of the oval (analogous to point *A* in Fig. P8.37).

5. Air, $\rho = 1.2$ kg/m$^3$ and $\mu = 1.8$ E$^{-5}$ kg/m s, flows at 10 m/s past a flat plate. At the trailing edge of the plate, the following velocity profile data are measured:

| $y$, mm | 0 | 0.5 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 |
|---|---|---|---|---|---|---|---|---|
| $u$, m/s | 0 | 1.75 | 3.47 | 6.58 | 8.70 | 9.68 | 10.0 | 10.0 |

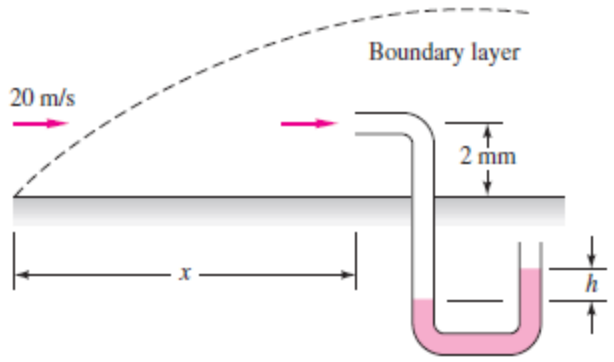
If the upper surface has an area of 0.6 m$^2$, estimate, using momentum concepts, the friction drag, in N, on the upper surface.

6. A thin flat plate 55 by 110 cm$^2$ is immersed in a 6 m/s stream of SAE 10 oil at 20°C. Compute the total friction drag if the stream is parallel to (*a*) the long side and (*b*) the short side.

7. (For discussion) For the experimental setup of Fig. P7.20, suppose the stream velocity is unknown and the pitot stagnation tube is traversed across the boundary layer of air at 1 atm and 20°C. The manometer fluid is Meriam red oil, and the following readings are made:

| $y$, mm | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $h$, mm | 1.2 | 4.6 | 9.8 | 15.8 | 21.2 | 25.3 | 27.8 | 29.0 | 29.7 | 29.7 |

Using these data only (not the Blasius theory) estimate (*a*) the stream velocity, (*b*) the boundary layer thickness, (*c*) the wall shear stress, and (*d*) the total friction drag between the leading edge and the position of the pitot tube.




**P7.20**