

## Homework 6

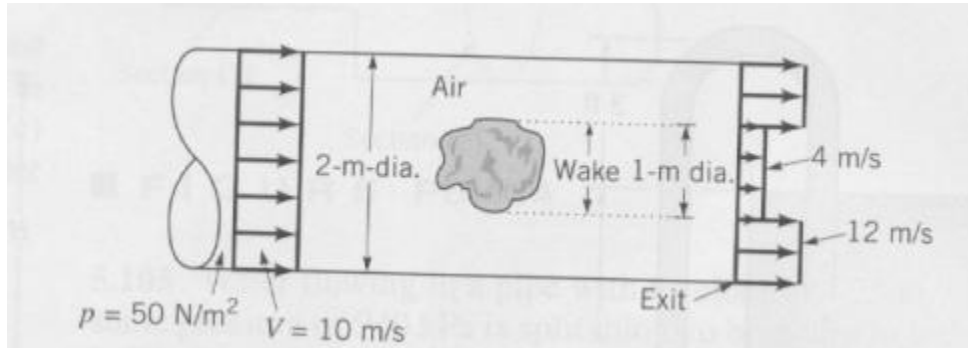
Due Oct 20th.

(1) The RB 207 Turbofan engine used in some “jumbo” transport aircraft produces a thrust of 47,500 lbf when on the ground. The mass flow through the engine is 1383 lbm/s and the engine has an inlet area of 53.3 ft<sup>2</sup> and the inlet and outlet air density is roughly 0.075 lbm/ft<sup>3</sup>.

- (a) What is the outlet velocity (in ft/s)? Use mass and momentum together.
- (b) What is the inlet velocity (in ft/s)?

(2) Air flow pasts an object in a pipe. The initially velocity and pressure are uniform. At the pipe exit (to the atmosphere) the velocity is not uniform.

- (a) Is mass being conserved in this experiment?
- (b) Is the pressure at the exit uniform (the same across the exit)? Explain.
- (c) What force is required to keep the object in place?



(3) Book (5<sup>th</sup> Edition) Problem 6.48.

- (4) A vortex has a streamfunction  $\psi_z = A \ln \theta$  where  $A=5 \text{ m}^2/\text{s}$ .
- Which direction is the vortex rotating?
  - If the vortex is located above the flat ground (given by the line  $y = 0$ ) at a height of 2 m, then use the 'image' vortex idea, to determine the streamfunction when the ground is present.
  - Determine the functional form for the velocity (in Cartesian coordinates) of the air (in the situation given by part b).
  - Show that the vertical velocity ( $v$ ) is always zero on the ground (at  $y = 0$ ).

- (5) The velocity potential for the flow around a rotating cylinder in a uniform flow field is  $\phi = Ur(1 + \frac{a^2}{r^2}) \cos \theta + \frac{\Gamma}{2\pi} \theta$ . For the Flettner rotor ship, each cylinder was 3 m in diameter and rotated at 750 rev/min. Assume the ship is operating in a 10 mph wind.
- What is  $U$  (in m/s),  $a$  (in m), and  $(\Gamma$  in  $\text{m}^2/\text{s})$  for the expression above.
  - What is the maximum and minimum velocity magnitude of the air very near each rotating cylinder? (this may take some plotting and trial and error).
  - What is the maximum and minimum pressure on each cylinder?
  - If the two cylinders were 17 m high, estimate (within an order of magnitude) the force produced by the cylinders (in N).

