King Saud University
College of Engineering
Mechanical Engineering Dept.

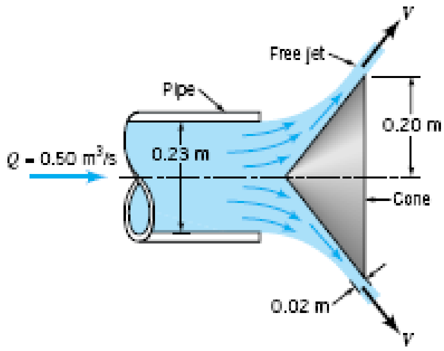
ME 381
Fluid Mechanics I
Time Allowed: 3.00 hrs
Final Exam, 1st semester
1429/1430

Final-Term Exam (18-2-1430)

- **Answer the following questions:**

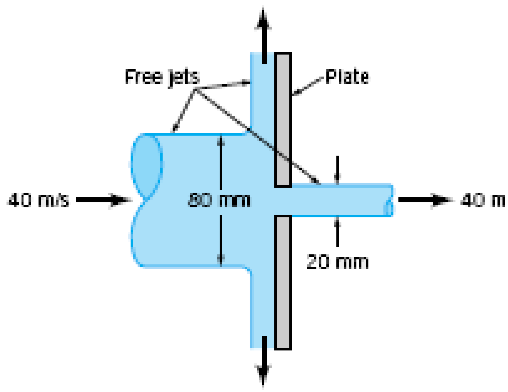
Question (1): [10 points]

A conical plug is used to regulate the air flow from a pipe as shown in figure. The air leaves the edge of the cone with a uniform thickness of 0.02 m. If viscous effects are negligible and the flow rate is 0.50 m^3/s. Determine the pressure within the pipe.



Question (2): [10 points]

A circular plate having a diameter of 300 mm is held perpendicular to an axisymmetric horizontal jet of air having a velocity of 40 m/s and a diameter of 80 mm as shown in figure. A hole at the center of the plate results in a discharge jet of air having a velocity of 40 m/s and a diameter of 20 mm. Determine the horizontal component of force required to hold the plate stationary.



Question (3): [10 points]

The three components of velocity in a flow field are given by:

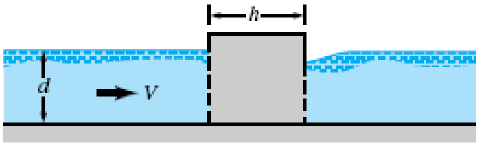
$$u = x^2 + y^2 + z^2$$
$$v = xy + yz + z^2$$
$$w = -3xz - z^2/2 + 4$$

Determine:

(a) The volumetric dilatation rate (conservation of mass for incompressible flow field).
(b) The rotation vector.
(c) Is this an irrotational flow field?

Question (4): [15 points]

A solid block in the shape of a cube rests partially submerged on the bottom of a river as shown in figure. The drag, ***D***, on the block depends on the river depth, ***d***, the block dimension, ***h***, the stream velocity, ***V***, the fluid density, ***ρ***, and the acceleration of gravity, ***g***.



(a) Express these variables in dimensionless form. (Take the repeated variable as: ***ρ, d** and **V***)

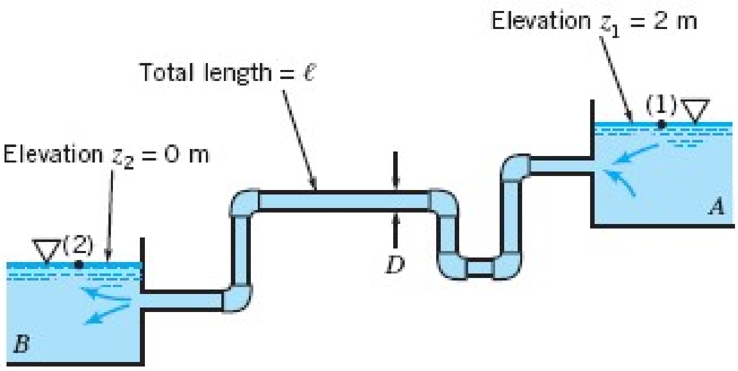
The drag is to be determined from a model study using a length scale of 1:5. Water is to be used for the model fluid.

(b) What model velocity should be used to predict the drag on the prototype located in a river with a velocity of 3 m/s?

(c) Determine the expected prototype drag in terms of the model drag.

Question (5): [15 points]

Water at 10°C ($\nu = 1.307 \times 10^{-6}$ m^2/s) is to flow from reservoir *A* to reservoir *B* through a 45 mm diameter of cast-iron pipe at a rate of $Q = 0.002$ m^3/s as shown in figure. The system contains a sharp-edged entrance ($K_{ent.} = 0.5$), six regular threaded 90° elbows ($K_{elb.} = 1.5$) and a sharp-edged exit ($K_{exit} = 1.0$). Determine the pipe total length needed.



Equivalent Roughness for New Pipes [From Moody (Ref. 7) and Colebrook (Ref. 8)]

Pipe	Equivalent Roughness, ε Feet	Equivalent Roughness, ε Millimeters
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)