

書名&作者: Fluid Mechanics: Fundamentals and applications; Yunus A. Çengel

命題範圍: Ch1~Ch9

Ch1 Introduction and basic concepts

Ch2 PROPERTIES OF FLUIDS

Ch3 Pressure and Fluid Statics

Ch4 Fluid Kinetics

Ch5 MASS, BERNOULLI, AND ENERGY EQUATIONS

Ch6 MOMENTUM ANALYSIS OF FLOW SYSTEMS

Ch7 DIMENSIONAL ANALYSIS AND MODELING

Ch8 FLOW IN PIPES

Ch9 DIFFERENTIAL ANALYSIS OF FLUID FLOW

流體力學 題庫:

1. What is the dimensional representation of :

- (a) Power ; (b) Modulus of Elasticity ; (c) Specific Weight ; (d) Angular Velocity ; (e) Energy ; (f) Moment of a Force ; (g) Poisson' s Ratio ; (h) Strain

2. Basic Definition

- (a) Stream line, Path line, Smoke line, Particle line
(b) Three types of the Bernoulli Eq., write them and describe their meanings of each part
(c) System, Control Volume, Control Surface, Surrounding.
(d) Three basic symmetry behaviors of symmetry analyses
(e) Write the Reynold' s number and describe meanings of each symbols
(f) What' s the Newtonian fluid? Figure?
(g) Define internal, external, and open-channel flows.
(h) Define incompressible flow and incompressible fluid. Must the flow of a compressible fluid necessarily be treated as compressible?
(i) What is the no-slip condition? What causes it?
(j) What is forced flow? How does it differ from natural flow? Is flow caused by winds forced or natural flow?
(k) What is a boundary layer? What causes a boundary layer to develop?

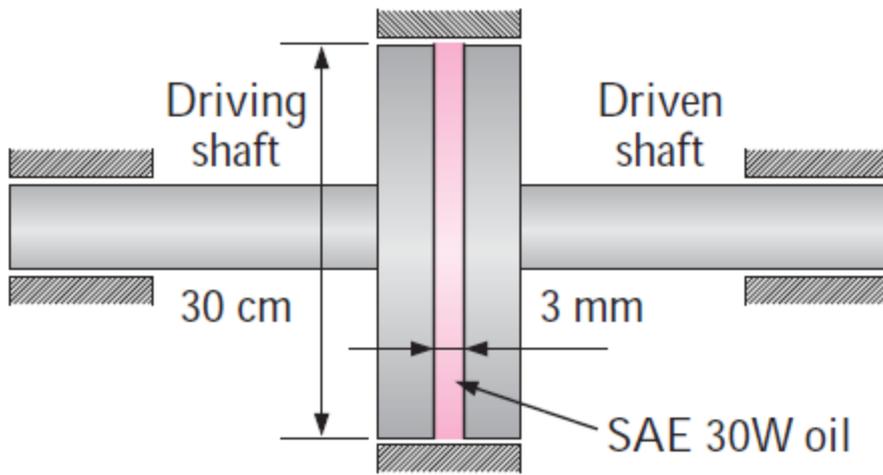
3. The following equation is dimensionally homogeneous:

$$F = \frac{4Ey}{(1 - \nu^2)(Rd^2)} \left[(h - y) \left(h - \frac{y}{2} \right) A - A^3 \right]$$

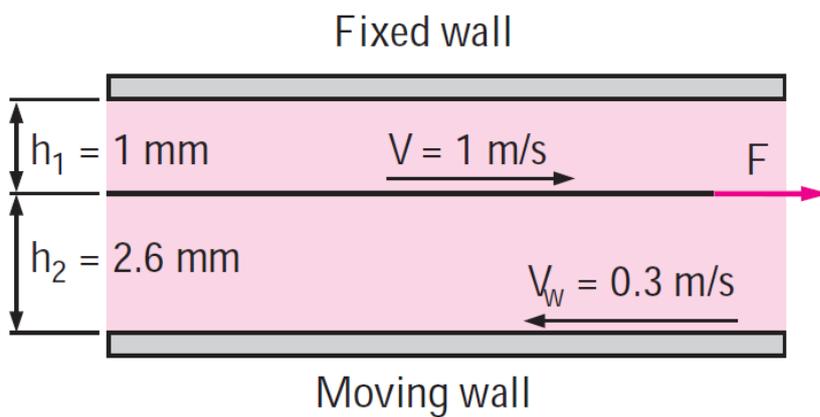
Where, $E \equiv$ Young' s modulus; $\nu \equiv$ Poisson' s ratio; $d, y, h \equiv$ distances; $R \equiv$ ratio of distances; $F \equiv$ force.

What are the dimensions of A ?

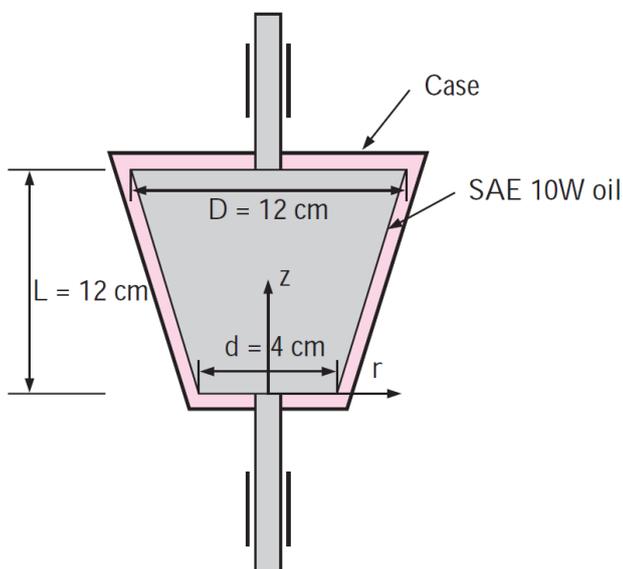
4. The clutch system shown in Fig. is used to transmit torque through a 3-mm-thick oil film with $\mu = 0.38 \text{ N} \cdot \text{s/m}^2$ between two identical 30-cm-diameter disks. When the driving shaft rotates at a speed of 1450 rpm, the driven shaft is observed to rotate at 1398 rpm. Assuming a linear velocity profile for the oil film, determine the transmitted torque.



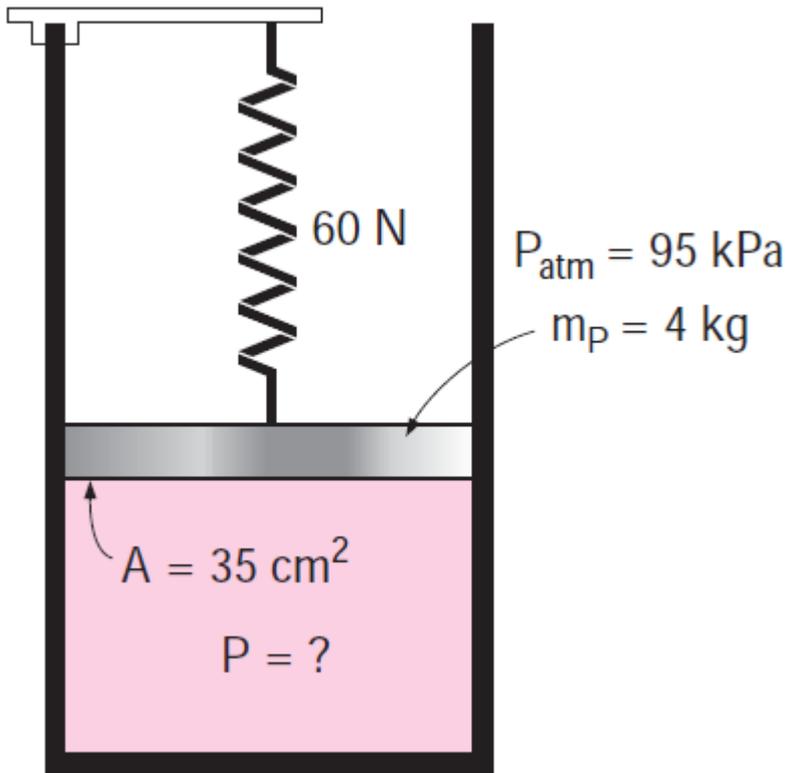
5. 2-45 A thin 20-cm \times 20-cm flat plate is pulled at 1 m/s horizontally through a 3.6-mm-thick oil layer sandwiched between two plates, one stationary and the other moving at a constant velocity of 0.3 m/s, as shown in Fig.. The dynamic viscosity of oil is $0.027 \text{ Pa} \cdot \text{s}$. Assuming the velocity in each oil layer to vary linearly, (a) plot the velocity profile and find the location where the oil velocity is zero and (b) determine the force that needs to be applied on the plate to maintain this motion.



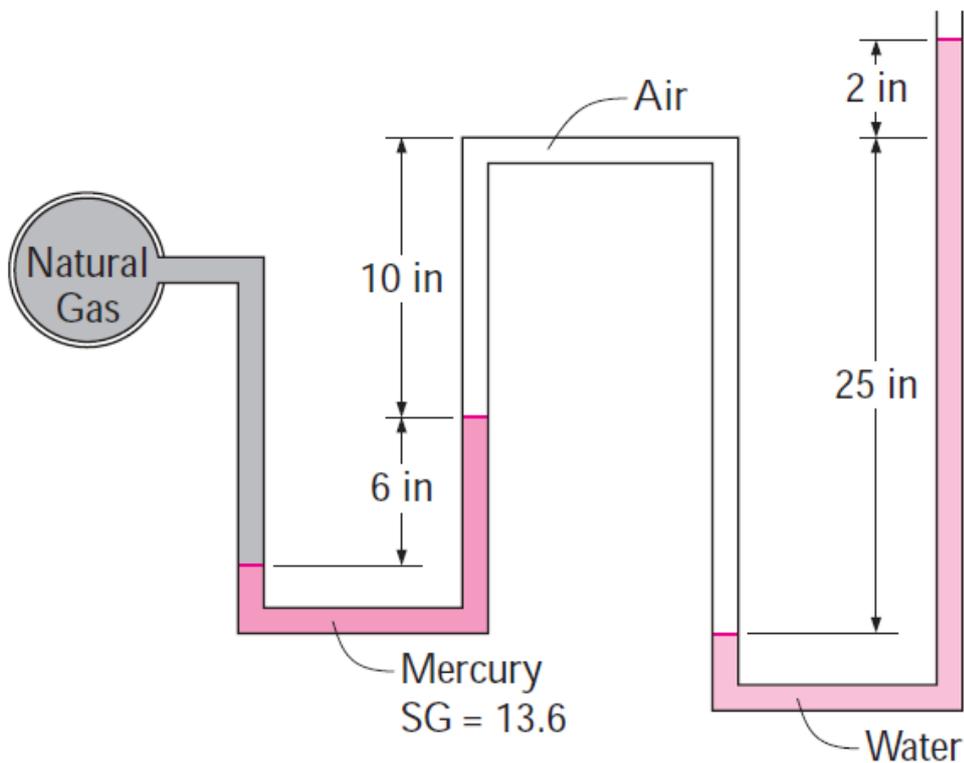
6. A frustum-shaped body is rotating at a constant angular speed of 200 rad/s in a container filled with SAE 10W oil at 20°C ($\mu = 0.1 \text{ Pa} \cdot \text{s}$), as shown in Fig.. If the thickness of the oil film on all sides is 1.2 mm , determine the power required to maintain this motion. Also determine the reduction in the required power input when the oil temperature rises to 80°C ($\mu = 0.0078 \text{ Pa} \cdot \text{s}$).



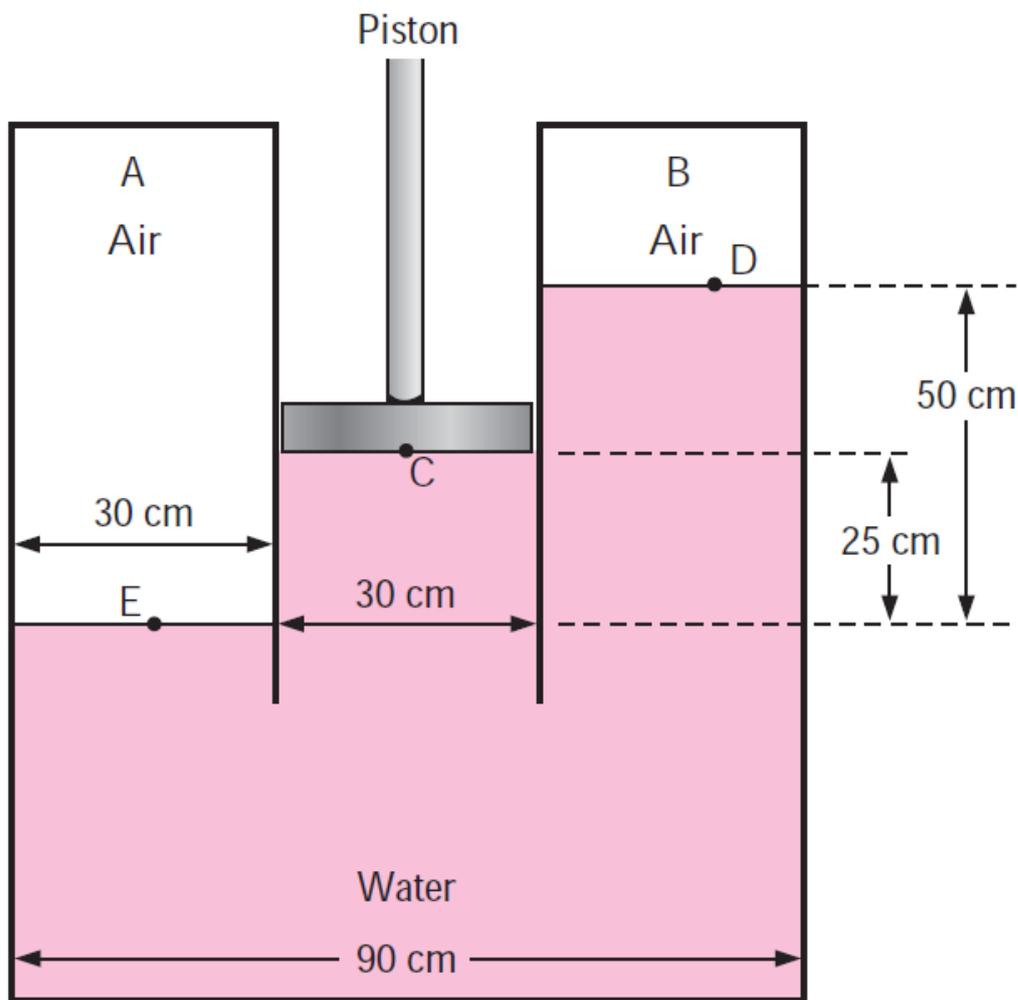
7. A gas is contained in a vertical, frictionless piston – cylinder device. The piston has a mass of 4 kg and a cross-sectional area of 35 cm². A compressed spring above the piston exerts a force of 60 N on the piston. If the atmospheric pressure is 95 kPa, determine the pressure inside the cylinder.



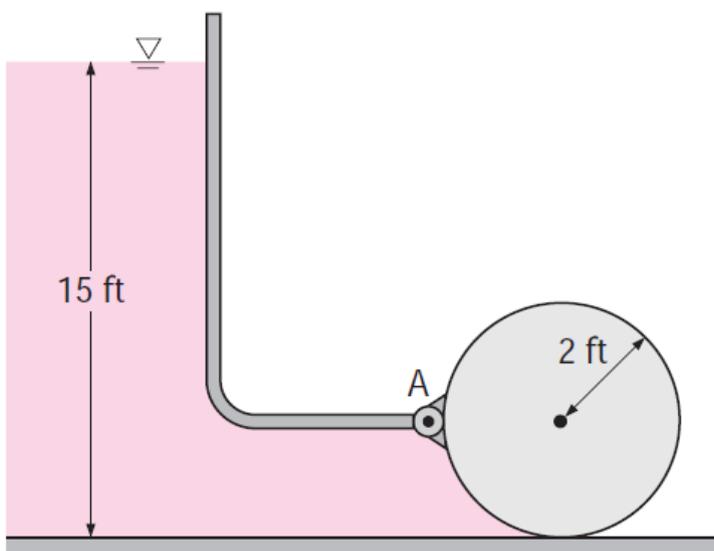
8. The pressure in a natural gas pipeline is measured by the manometer shown in Fig. with one of the arms open to the atmosphere where the local atmospheric pressure is 14.2 psia. Determine the absolute pressure in the pipeline.



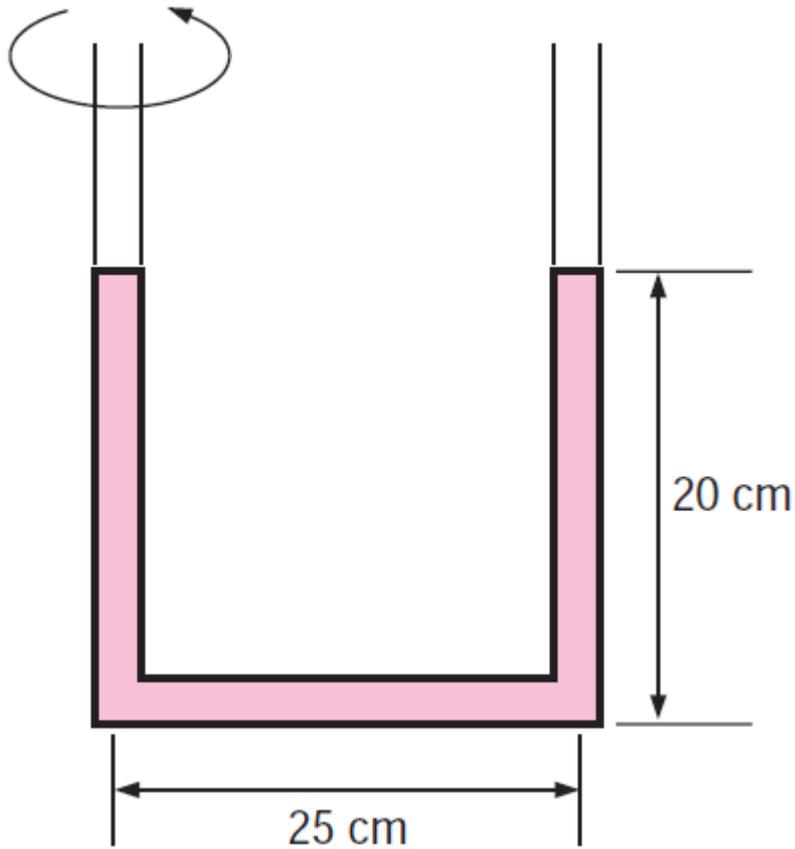
9. Two chambers with the same fluid at their base are separated by a piston whose weight is 25 N, as shown in Fig. P3 - 47. Calculate the gage pressures in chambers A and B.



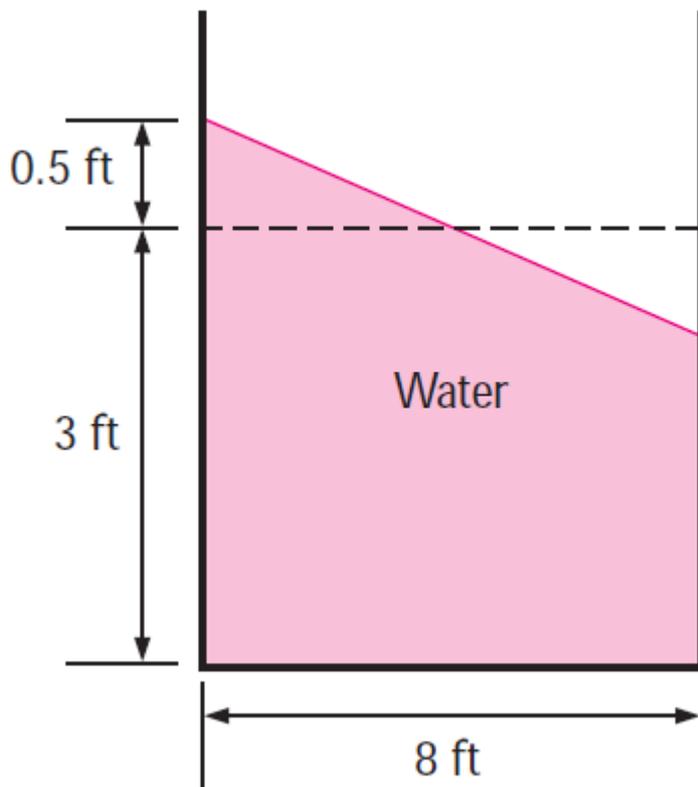
10. A long, solid cylinder of radius 2 ft hinged at point A is used as an automatic gate, as shown in Fig. P3 - 61E. When the water level reaches 15 ft, the cylindrical gate opens by turning about the hinge at point A. Determine (a) the hydrostatic force acting on the cylinder and its line of action when the gate opens and (b) the weight of the cylinder per ft length of the cylinder.



11. The distance between the centers of the two arms of a U-tube open to the atmosphere is 25 cm, and the U-tube contains 20-cm-high alcohol in both arms. Now the U-tube is rotated about the left arm at 4.2 rad/s. Determine the elevation difference between the fluid surfaces in the two arms.



12. An 8-ft-long tank open to the atmosphere initially contains 3-ft-high water. It is being towed by a truck on a level road. The truck driver applies the brakes and the water level at the front rises 0.5 ft above the initial level. Determine the deceleration of the truck.



13. Consider the following steady, two-dimensional velocity field:

$$\vec{V} = (u, v) = (a^2 - (b - cx)^2)\vec{i} + (-2cby + 2c^2xy)\vec{j}$$

Is there a stagnation point in this flow field? If so, where is it?

14. A steady, incompressible, two-dimensional velocity field is given by the following components in the xy -plane:

$$u = 1.1 + 2.8x + 0.65y \quad v = 0.98 - 2.1x - 2.8y$$

Calculate the acceleration field (find expressions for acceleration components a_x and a_y), and calculate the acceleration at the point $(x, y) = (-2, 3)$.

15. Consider the following steady, incompressible, two dimensional velocity field:

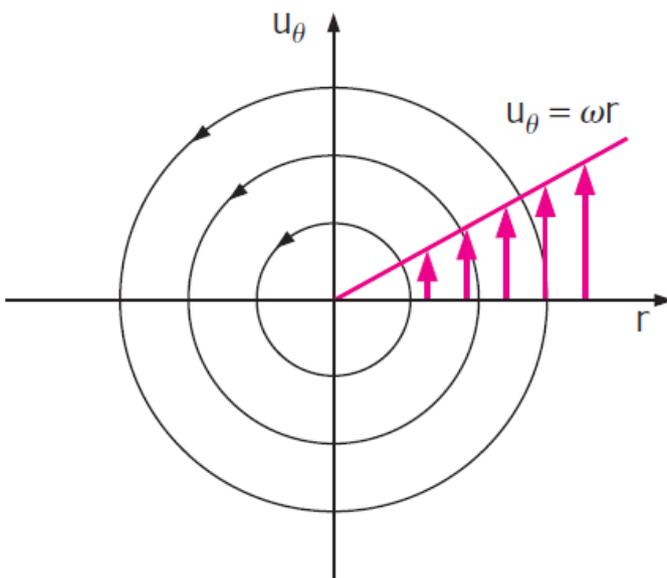
$$\vec{V} = (u, v) = (0.5 + 1.2x)\vec{i} + (-2.0 - 1.2y)\vec{j}$$

Generate an analytical expression for the flow streamlines and draw several streamlines in the upper-right quadrant from $x = 0$ to 5 and $y = 0$ to 6.

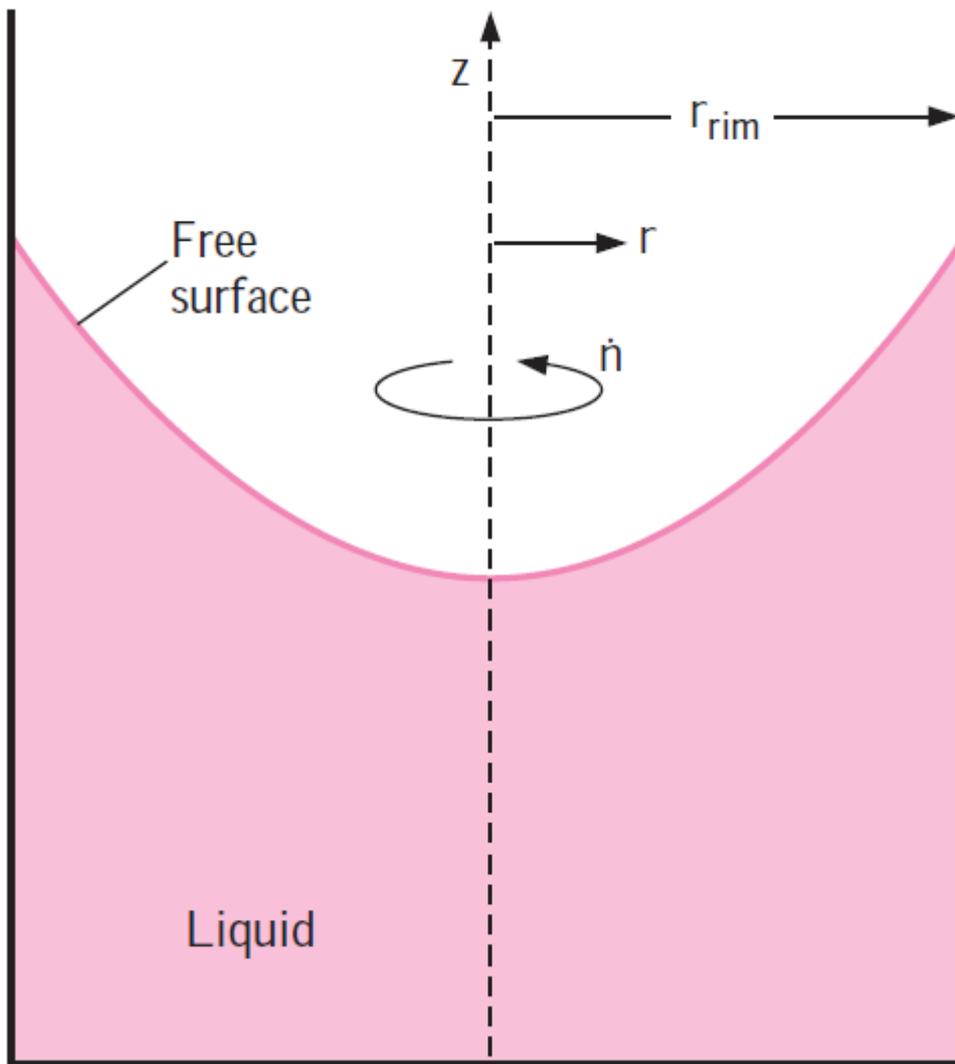
16. The velocity field for solid-body rotation in the $r\theta$ -plane is given by

$$u_r = 0 \quad u_\theta = \omega r$$

where ω is the magnitude of the angular velocity ($\vec{\omega}$ points in the z -direction). For the case with $\omega = 1.0 \text{ s}^{-1}$, plot a contour plot of velocity magnitude (speed). Specifically, draw curves of constant speed $V = 0.5, 1.0, 1.5, 2.0,$ and 2.5 m/s . Be sure to label these speeds on your plot.



17. A cylindrical tank of water rotates in solid-body rotation, counterclockwise about its vertical axis at angular speed $n = 360$ rpm. Calculate the vorticity of fluid particles in the tank.

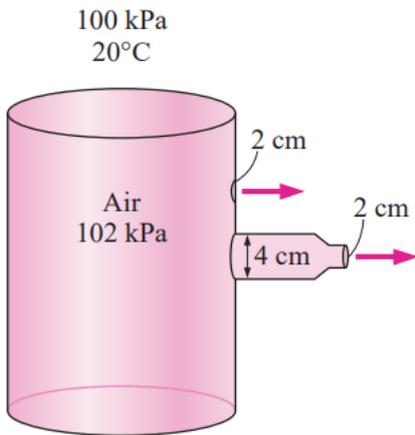


18. Consider the general form of the Reynolds transport theorem (RTT) given by

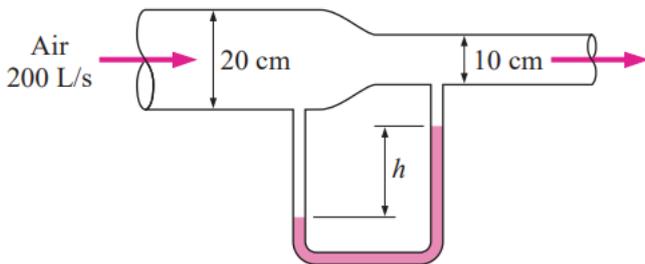
$$\frac{dB_{sys}}{dt} = \frac{d}{dt} \int_{CV} \rho b \, dV + \int_{CS} \rho b \vec{V}_r \cdot \vec{n} \, dA$$

where \vec{V}_r is the velocity of the fluid relative to the control surface. Let B_{sys} be the mass m of a system of fluid particles. We know that for a system, $dm/dt = 0$ since no mass can enter or leave the system by definition. Use the given equation to derive the equation of conservation of mass for a control volume.

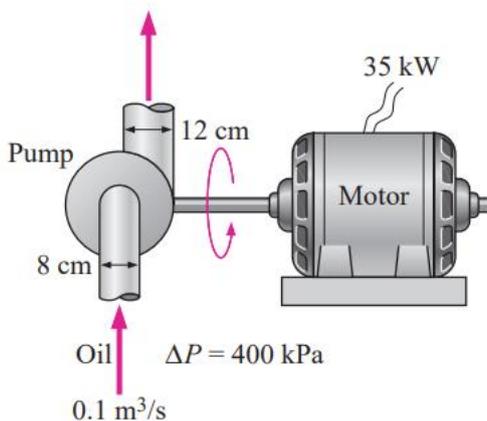
19. A very large tank contains air at 102 kPa at a location where the atmospheric air is at 100 kPa and 20°C. Now a 2-cm-diameter tap is opened. Determine the maximum flow rate of air through the hole. What would your response be if air is discharged through a 2-m-long, 4-cm-diameter tube with a 2-cm-diameter nozzle? Would you solve the problem the same way if the pressure in the storage tank were 300 kPa?



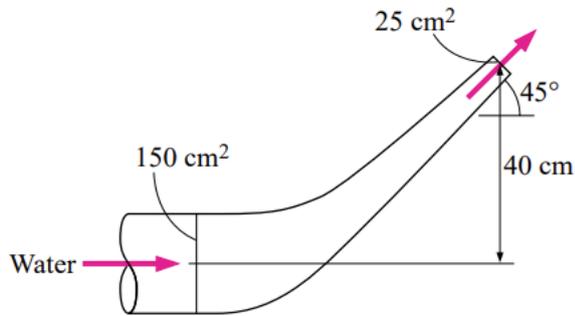
20. Air flows through a pipe at a rate of 200 L/s. The pipe consists of two sections of diameters 20 cm and 10 cm with a smooth reducing section that connects them. The pressure difference between the two pipe sections is measured by a water manometer. Neglecting frictional effects, determine the differential height of water between the two pipe sections. Take the air density to be 1.20 kg/m³.



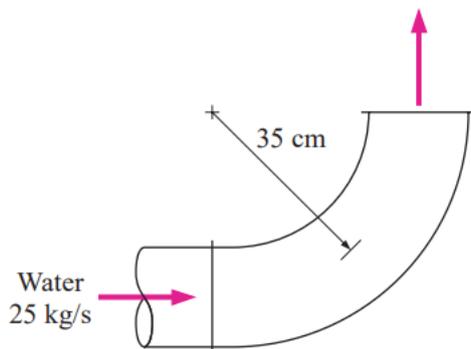
21. An oil pump is drawing 35 kW of electric power while pumping oil with $\rho = 860 \text{ kg/m}^3$ at a rate of 0.1 m³/s. The inlet and outlet diameters of the pipe are 8 cm and 12 cm, respectively. If the pressure rise of oil in the pump is measured to be 400 kPa and the motor efficiency is 90 percent, determine the mechanical efficiency of the pump. Take the kinetic energy correction factor to be 1.05.



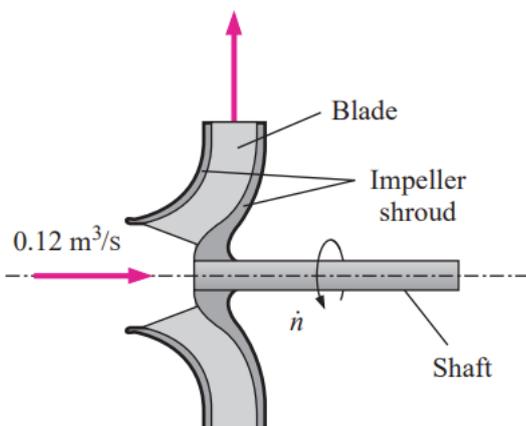
22. A reducing elbow is used to deflect water flow at a rate of 30 kg/s in a horizontal pipe upward by an angle $\theta = 45^\circ$ from the flow direction while accelerating it. The elbow discharges water into the atmosphere. The cross-sectional area of the elbow is 150 cm^2 at the inlet and 25 cm^2 at the exit. The elevation difference between the centers of the exit and the inlet is 40 cm . The mass of the elbow and the water in it is 50 kg . Determine the anchoring force needed to hold the elbow in place. Take the momentum-flux correction factor to be 1.03 .



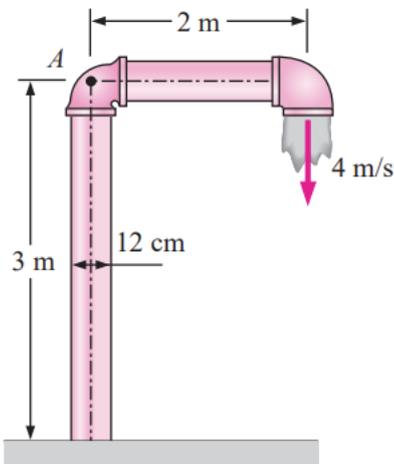
23. A 90° elbow is used to direct water flow at a rate of 25 kg/s in a horizontal pipe upward. The diameter of the entire elbow is 10 cm . The elbow discharges water into the atmosphere, and thus the pressure at the exit is the local atmospheric pressure. The elevation difference between the centers of the exit and the inlet of the elbow is 35 cm . The weight of the elbow and the water in it is considered to be negligible. Determine (a) the gage pressure at the center of the inlet of the elbow and (b) the anchoring force needed to hold the elbow in place. Take the momentum-flux correction factor to be 1.03 .



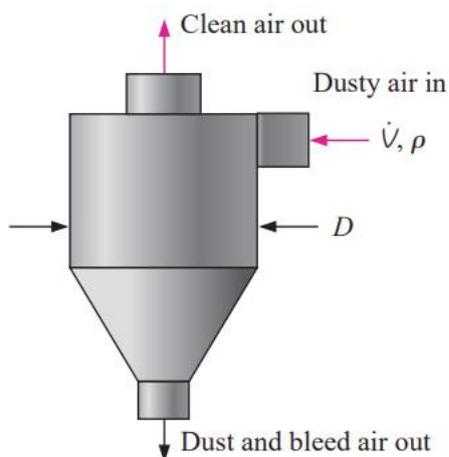
24. Water enters a centrifugal pump axially at atmospheric pressure at a rate of $0.12 \text{ m}^3/\text{s}$ and at a velocity of 7 m/s , and leaves in the normal direction along the pump casing, as shown in Fig.. Determine the force acting on the shaft (which is also the force acting on the bearing of the shaft) in the axial direction.



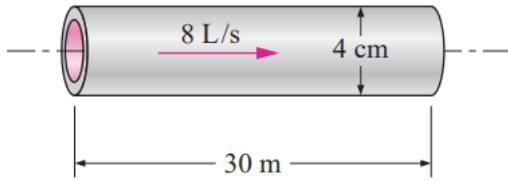
25. Water is flowing through a 12-cm-diameter pipe that consists of a 3-m-long vertical and 2-m-long horizontal section with a 90° elbow at the exit to force the water to be discharged downward, as shown in, in the vertical direction. Water discharges to atmospheric air at a velocity of 4 m/s, and the mass of the pipe section when filled with water is 15 kg per meter length. Determine the moment acting at the intersection of the vertical and horizontal sections of the pipe (point A). What would your answer be if the flow were discharged upward instead of downward?



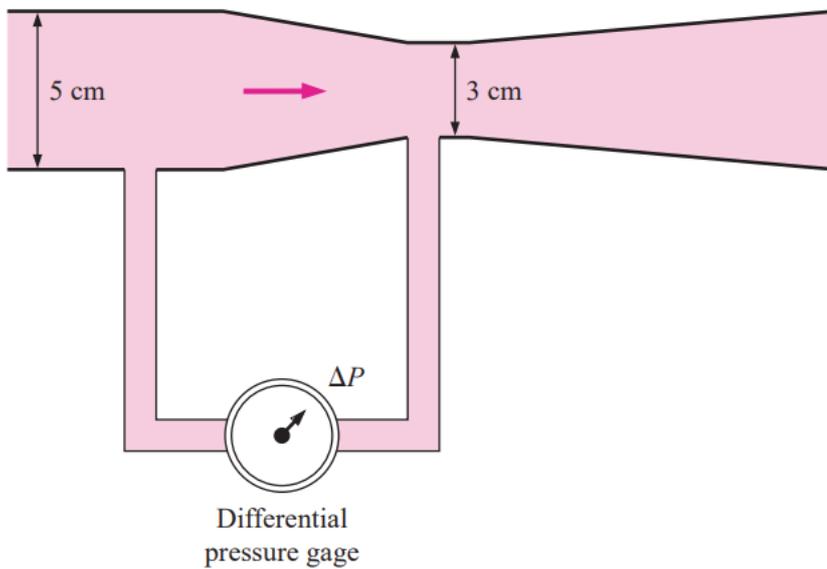
26. A common device used in various applications to clean particle-laden air is the reverse-flow cyclone. Dusty air (volume flow rate and density ρ) enters tangentially through an opening in the side of the cyclone and swirls around in the tank. Dust particles are flung outward and fall out the bottom, while clean air is drawn out the top. The reverse-flow cyclones being studied are all geometrically similar; hence, diameter D represents the only length scale required to fully specify the entire cyclone geometry. Engineers are concerned about the pressure drop dP through the cyclone. (a) Generate a dimensionless relationship between the pressure drop through the cyclone and the given parameters. Show all your work. (b) If the cyclone size is doubled, all else being equal, by what factor will the pressure drop change? (c) If the volume flow rate is doubled, all else being equal, by what factor will the pressure drop change?



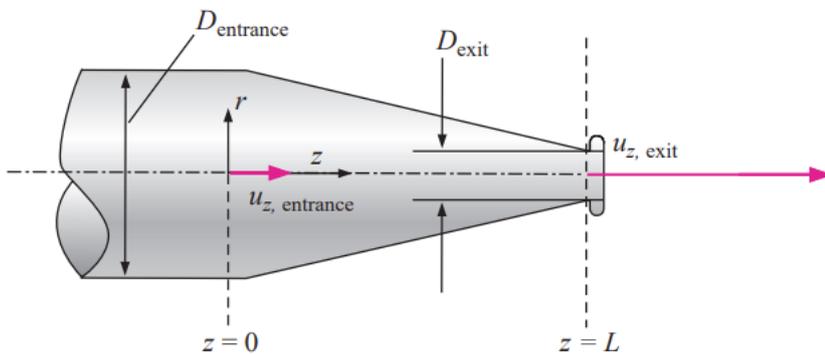
27. Water at 15°C ($\rho = 999.1 \text{ kg/m}^3$ and $\mu = 1.138 \times 10^{-3} \text{ kg/m} \cdot \text{s}$) is flowing steadily in a 30-m-long and 4-cm-diameter horizontal pipe made of stainless steel at a rate of 8 L/s. Determine (a) the pressure drop, (b) the head loss, and (c) the pumping power requirement to overcome this pressure drop



28. A Venturi meter equipped with a differential pressure gage is used to measure the flow rate of water at 15°C ($\rho = 999.1 \text{ kg/m}^3$) through a 5-cm-diameter horizontal pipe. The diameter of the Venturi neck is 3 cm, and the measured pressure drop is 5 kPa. Taking the discharge coefficient to be 0.98, determine the volume flow rate of water and the average velocity through the pipe.



29. Consider steady flow of water through an axisymmetric garden hose nozzle. The axial component of velocity increases linearly from $u_{z, \text{entrance}}$ to $u_{z, \text{exit}}$ as sketched. Between $z = 0$ and $z = L$, the axial velocity component is given by $u_z = u_{z, \text{entrance}} + [(u_{z, \text{exit}} - u_{z, \text{entrance}})/L]z$. Generate an expression for the radial velocity component u_r between $z = 0$ and $z = L$. You may ignore frictional effects on the walls.



30. A steady, incompressible, two-dimensional CFD calculation of flow through an asymmetric two-dimensional branching duct reveals the streamline pattern sketched in Fig., where the values of ψ are in units of m^2/s , and W is the width of the duct into the page. The values of stream function c on the duct walls are shown. What percentage of the flow goes through the upper branch of the duct?

