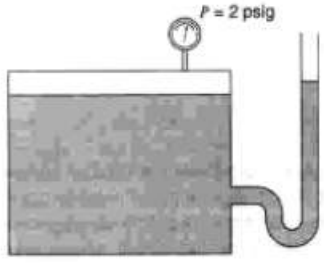
INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY
Department of Metallurgical Engineering and Materials Science
MM 204 : TRANSPORT PHENOMENA : 2019-20: SPRING

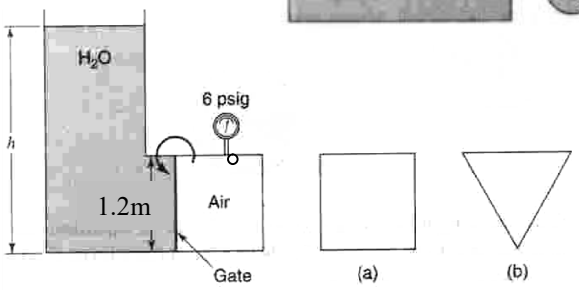
Assignment 2 **Submit: Jan 24; 2020, 0830h**

1. Derive equations that give the pressure and density at any elevation in a static ideal gas when conditions are known at one elevation and the temperature gradient β is known. By use of the above result determine the pressure and density at 3000m elevation, when p=100 kPa, abs. and temperature is 20°C, at an elevation of 300m for air, and β = -0.005°C/m ? (WWWR)

2. The tank is accelerated upwards at a uniform rate. Does the manometer level go up or down ? Give quantitative reasons.
(psig - pounds per square inch) (WWWR)



3. Find the minimum value of h below which the gate shown will rotate counterclockwise if the gate cross section is (a) rectangular 1.2m x1.2m; (b) triangular (inverted) with 1.2 m base and 1.2 m height as shown. Neglect bearing friction. (6 psi,g ~ 0.41 bar, above the atmospheric pressure) WWWR.



4. (a) Italians love birds, many homes have these happy tiny songsters called canaries, in little cages, and to supply them is a big business. Tunisian Songbirds, Inc., is a major supplier of canaries for Southern Italy, and every Wednesday a large truck carrying these chirpy feathered creatures is loaded aboard the midweek Tunis to Naples ferry. The truck's bird container is 2.4 m wide, 3.0 m high, solid on the sides and bottom, open at the top except for a restraining screen, and has a total open volume available for birds of 36 m^3. On arrival at Naples a tax of 20 lira/bird is to be charged by the customs agent, but how to determine the amount to be assessed ? Since counting these thousands of birds one by one would be impractical the Italians use the following ingenious method.

The customs agent sets up his pressure gauges, then loudly bangs the side of the van with a hammer. This scares the birds off their perches up into the air. Then he carefully records the pressure both at the bottom and at the top of the inside of the van. If the pressure at the bottom is 103,316 Pa, the pressure at the top is 102,875 Pa, and the temperature is 25°C, how much tax should the customs agent levy ?

Additional data : Juvenile canaries have a mass of 15 gm and a density estimated to be 500 kg/m^3.

(b) Referring to above, the importers suspect that the simplifying assumption being used by Italian customs is unfair to them. To check this, determine the tax to be paid if the air density term was accounted for in the calculations. [Levenspiel].

5. A pressure die casting machine operates at a pressure of 10^6 Pa. Low melting metal like zinc is taken into the cylinder and is forced to the die through a runner of 10 mm inner diameter (as shown). If the stress in the runner is not to exceed 100 MPa, calculate the outer diameter of the runner.{Stress is in the azimuthal direction. Slit the tube into two axially and find the pressure force/m length acting on one of them. From this calculate stress in the shell}.

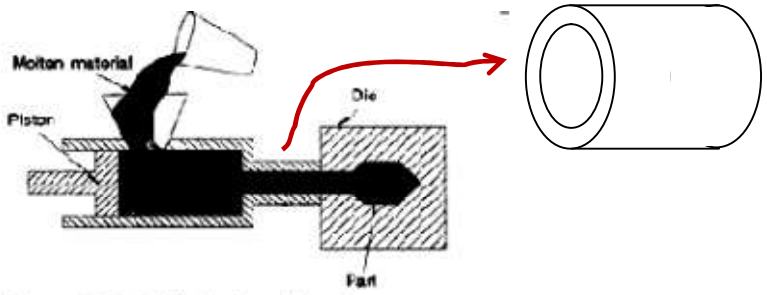
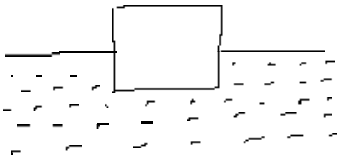


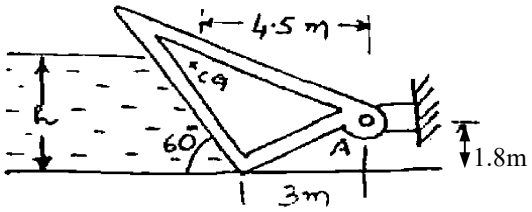
Figure 11.18 Cold chamber die-casting process.

Parashar and Mittal: Ele.Manf.Proc., PHI, 2003

6. In the figure, an object having a specific gravity of 0.5 is floating in water held in a container. If the container and the liquid are given an upward acceleration of 3 m/s^2 , what will be the position of the object relative to the water surface.(Hughes-Schaum's)

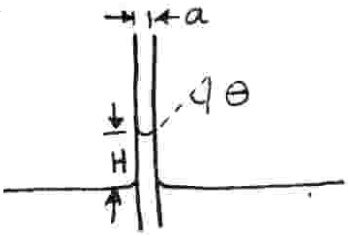


7. A dam spillway gate holds back water of depth *h*. The gate weighs 750 kg/(m width) and is hinged at A. At what depth of water will the gate raise up and permit water to flow under it ? (WWWR)

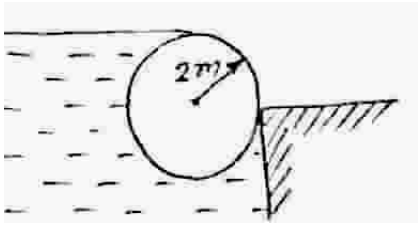


8. A thin glass tube of radius *a* is inserted down into a free surface of a certain liquid. It is observed that the liquid rises a distance *H* in the tube. The contact angle θ depends on the wetting of the glass and is a constant parameter that depends only on the material of the tube and the liquid. The free surface in the tube will be approximately spheroidal in shape.

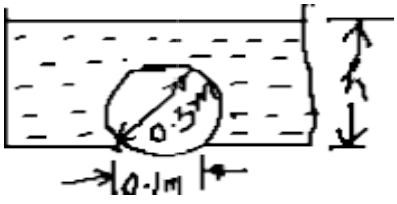
   For a given value of θ, surface tension σ of the air-water interface, and *a*, find an expression for *H* . Give one physical situation where this phenomenon is used advantageously. (WWWR)



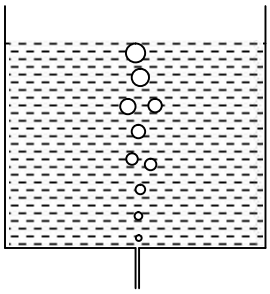
9. A log holds water as shown. Find the specific gravity of the log. The surface of the log is rough, so neglect any tendency to rotate.



10. Beyond what height *h* will the beach ball shown be operative as a stopper in the water tank ?

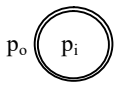


11. One of the techniques of removing dissolved hydrogen from molten steel is to bubble argon through the liquid column. The bubbles are introduced at the bottom through refractory tubes. As the bubbles float up, hydrogen diffuses into them and escapes. Calculate the following when such a process is carried out. The height of metal in the ladle is 2m.



    i. Minimum pressure at which argon should be supplied to the injection tube.
    ii. The size of the bubble as a function of the height from the bottom, given an initial size
    iii. If each argon bubble is at equilibrium with the metal hydrogen and contains on an average 5 vol % H_2 at 1873K when it escapes, the amount of argon to be blown to bring down the hydrogen content from 5ppm to 2ppm in a 100 ton ladle.

12. What is the difference in pressure ($p_i - p_o$) between inside and outside a soap bubble floating in air? Note that the soap film has two surfaces (one inside and one outside). Further liquid inside the thin film has no tensile strength. Only the surfaces display surface tension. (similar to problem 5)



13. Two soap bubbles (these can be thin balloons too) are connected through a tube as shown. When the valve is opened what will happen?