1. A siphon is used to draw water at 20°C from a large container as indicated in Fig.1 . The inside diameter of the siphon line is 1 in. and the pipe centerline rises 3 ft above the essentially constant water level in the tank . Show that by varying the length of the siphon below the water level , h ,the rate of flow through the siphon can be changed . Assuming frictionless flow determine the maximum flowrate possible through the siphon . The limiting condition is the occurrence of cavitation in the siphon. Will the actual maximun flow be more or less than the frictionless value ? Explain.
The vapor pressure of water at 20°C is 2,378 N/m^2, and the pressure at point A is 101,000 N/m^2.The maximun flow will occur when the pressure at somewhere is just equal to the vapor pressure of water at 20°C.

20%

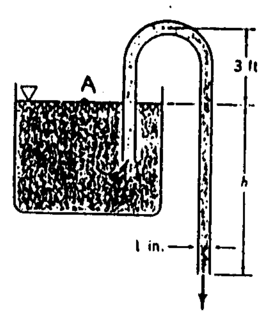

Fig. 1

2. The concentric cylinder device of the type shown in Fig. 2 is commonly used to measure the viscosity , μ , of liquids by relating the angle of twist , θ , of the inner cylinder to the angular velocity , ω , of the outer cylinder . Assume that

$$\theta = f(\omega, \mu, K, D_1, D_2, l)$$

where K depends on the suspending wire properties and has the dimensions FL . The following data were obtained in a series of tests for which $\mu = 0.01$ lb·s/ft², $K = 10$ lb·ft , $l = 1$ ft , and D_1 and D_2 were constants .

θ (rad)	ω (rad/s)
0.89	0.30
1.50	0.50
2.51	0.82
3.05	1.05
4.28	1.43
5.52	1.86
6.40	2.14

Determine from these data, with the aid of dimensionless analysis, the relationship between θ, ω, and μ for this particular apparatus.

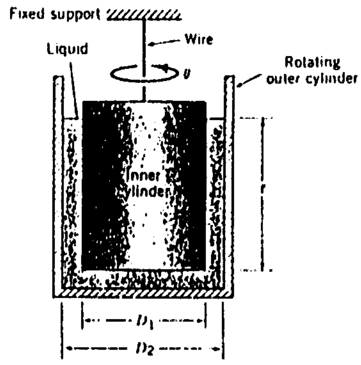

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Fig.2

3. A potential flow with a free stream uniform velocity of 5 m/s flows over a long semicircular bump. If the free stream pressure is 101,325 Pa and temperature is 60 °C, what is the force from the flow on the bump per unit length of the bump? The radius of the bump is 2 m. Gas constant, R = 287 N·m/ kg·K.

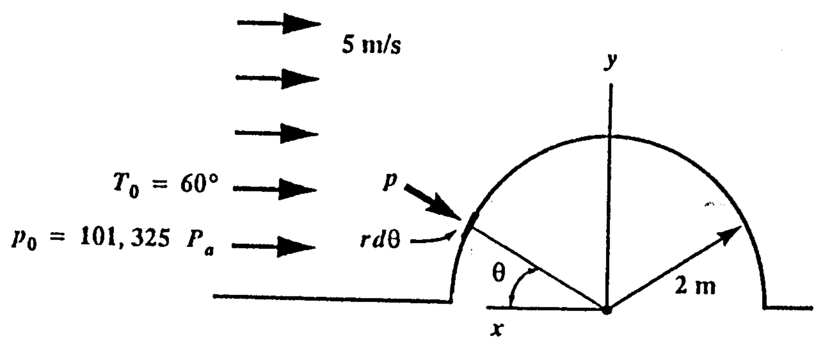

Fig.3

10%

4. . Consider the simple power–law model for a non--Newtonian fluid given by

$$\tau_{yx} = k\left(\frac{du}{dy}\right)^n$$

show that the velocity profile for fully developed laminar flow of a power–law fluid between parallel plates separated by distance, 2h, may be written

$$u = \left(\frac{h}{k}\frac{\Delta p}{L}\right)^{1/n}\frac{nh}{n+1}\left[1-\left(\frac{y}{h}\right)^{\frac{n+1}{n}}\right]$$ (12%)

where y is the coordinate measured from the channel centerline.

5. . A manufacture makes two types of drinking straws : one with a square cross–sectional shape, and the other type the typical round shape. The amount of material in each straw is to be the same. That is, the length of the perimeter of the cross section of each shape is the same. For a given pressue drop, what is the ratio of the flowrate through the straw?

Assume the drink is viscous enough to ensure laminar flow and neglect gravity. and friction factor for square cross–sectional shape is

$$f = \frac{56.9}{Re}$$ (18%)

6. .The laminar boundary layer results obtained from the momentum integral equation are relatively insensitive to the shape of the assumed velocity profile. Consider the profile given by

$$u = U \text{ for } y > \delta,$$

$$u = U\{1 - [(y - \delta)/\delta]^2\}^{1/2} \text{ for } y \le \delta$$

as shown in Fig. 4 Note that this satisfies the conditions u = 0 at y = 0 and u = U at y = δ. Show that such a profile produces meaningless results when used with the momentum integral equation. Explain. (20%)

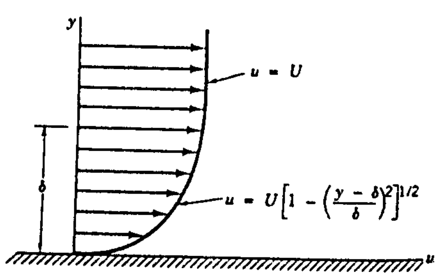

Fig.4