October 15, 2014

1. A viscous fluid (specific gravity, *SG* = 1.26; kinematic viscosity, ν = 1.28 × 10^{-2} ft^2/s) is contained between two large, horizontal parallel plates as shown in Fig. 1. The fluid moves between the plates under the action of a pressure gradient B. When the lower plate is pulled with a velocity V while the upper plate is fixed, the velocity distribution for this flow takes the form

$$u(y) = \frac{B}{2\mu}(y^2 - hy) + V\left(1 - \frac{y}{h}\right)$$

For V = 0.02 ft/s, h = 1.0 in., B = -0.334 lb/ft^3, and the plate area A = 100 ft^2, determine (a) the shearing stress τ acting *on the moving plate* and (b) the required force $F = \tau \cdot A$ and (c) power $P = F \cdot V$ to pull the plate. (Note: $\nu = \mu/\rho$ and use ρ_{water} = 1.94 $slugs/ft^3$)

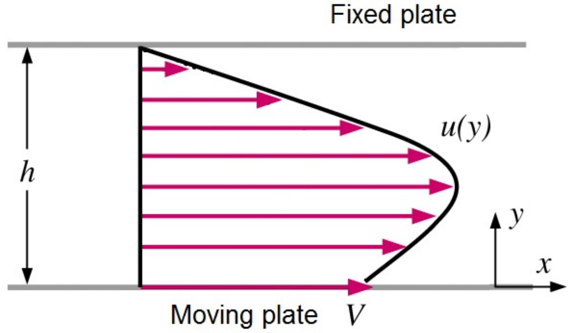

Figure 1

2. The 0.5-m-radius half-cylinder barrier in Fig. 2 is 8 m long into the paper and rests in static equilibrium against a wall. The contact between cylinder and wall is frictionless. Find (a) the horizontal force (magnitude F_H and location y_{cp}) and (b) vertical force (magnitude F_V) exerted on the curved surface of the barrier and (c) the barrier weight W. You can use geometric properties shown on Figure 3. (Note: γ = 9.80 kN/m^3)

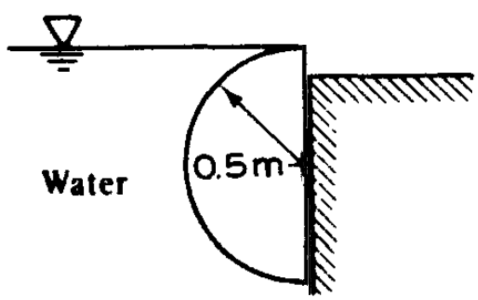

Figure 2

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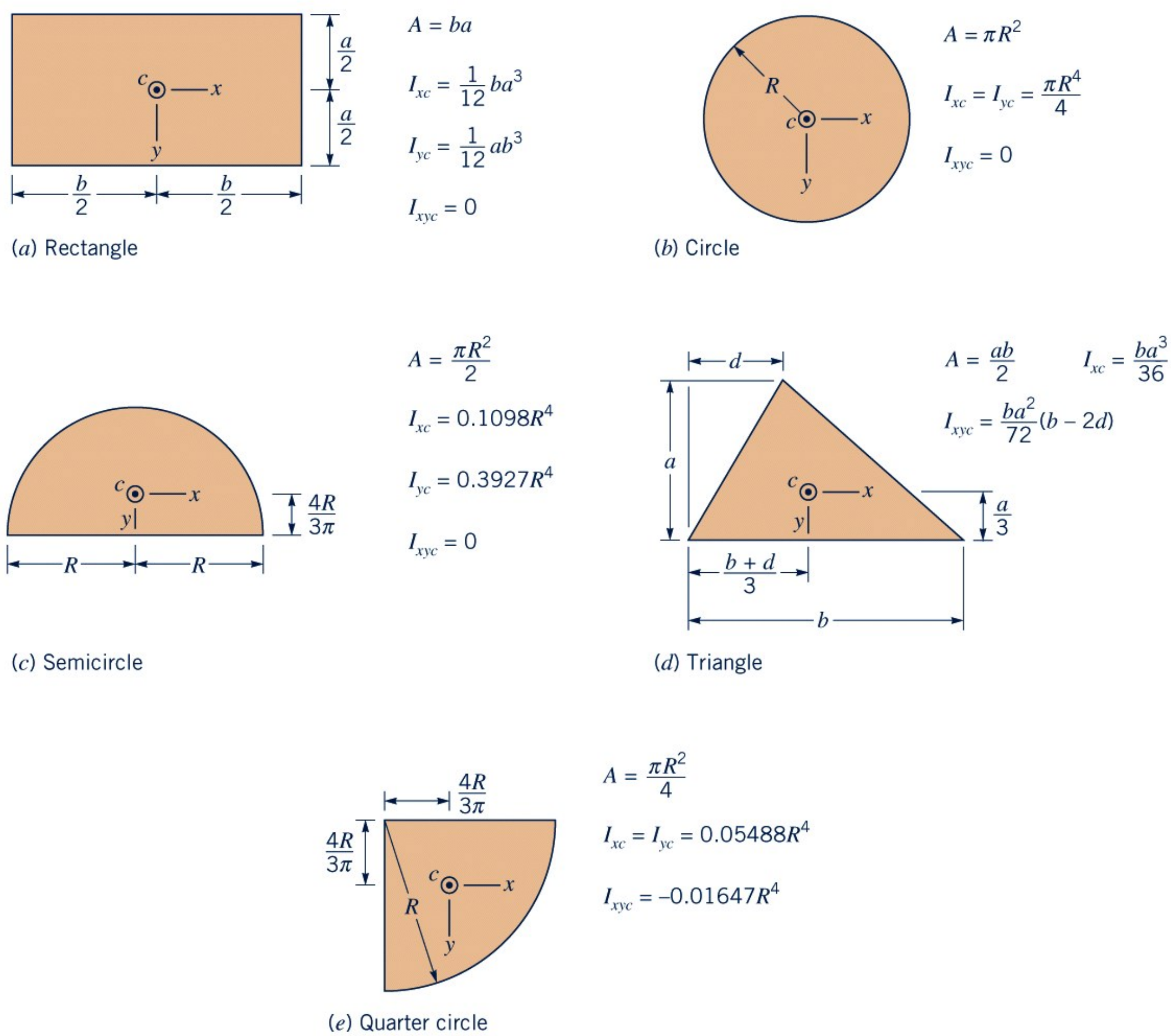

Figure 3: Geometric Properties of some common shapes

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3. Water (γ = 62.4 lb/ft^3) flows steadily from a large tank as shown in Fig. 4. The deflection in the mercury manometer is 1 in. and viscous effects are negligible. Determine (a) the volume flow rate Q and (b) the water-jet velocity V_j leaving the 3-in. diameter nozzle exit. (Note: *SG* = 13.56 for mercury and g = 32.2 ft/s^2)

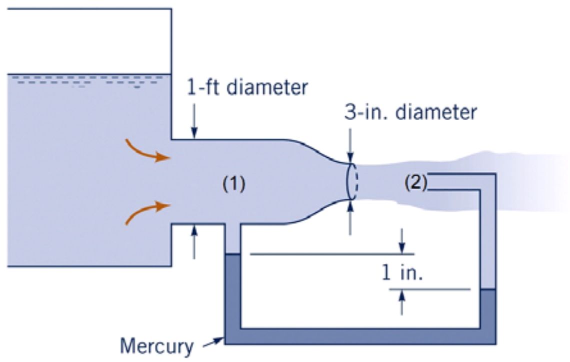

Figure 4

4. According to potential theory for the flow approaching a rounded two-dimensional body, as in Fig. 5, the velocity approaching the stagnation point is given by $\underline{V} = U(1 - a^2/x^2)\hat{\boldsymbol{\imath}}$, where a is the nose radius and U is the velocity at far-upstream. If the fluid is SAE 30 oil (ρ = 917 kg/m^3) with U = 2 m/s and a = 6 cm, calculate (a) the fluid velocity u, (b) the acceleration a_x, and (c) the pressure gradient dp/dx at point 1 (i.e., at x = -2a). For part (c), use the Euler equation, $\rho a_x = -dp/dx$.

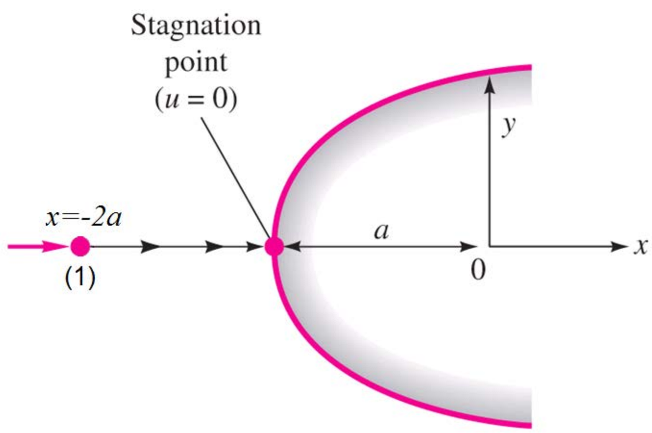

Figure 5