1. Please briefly explain what microfluidics is. Determine whether the flow is laminar or turbulent if water at 70°C (kinematic viscosity = $4.11X10^{-7}$ m^2/s) flows in a microfluidic channel with the diameter of 0.5 mm and height of 24 μm with a flow rate of 30 mL/h. (10 points)

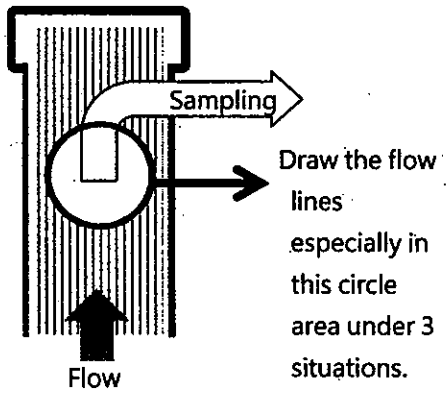
2. Please determine the friction factor if glycerine at 20°C flows 30 m through a 150-mm-diameter pipe with an average velocity of 5.0 m/s. Glycerine at 20°C has a specific gravity of 1.263 and dynamic viscosity of 9.6×10^{-1} Pa•s. The roughness of the pipe is 1.2×10^{-4} m. (10 points)
Swamee/Jain Equation is shown below.

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7\,(D/\epsilon)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2}$$

3. Compute the change in pressure (MPa) that must be applied to water (20°C) to change its volume by 2 percent. Please also explain how the density will change after the change in pressure. (bulk modulus of water (20°C) is 316000 psi) (10 points)

4. Please write the Bernoulli's equation. Please explain the meaning of each term and the meaning of each symbol. Please describe clearly the assumptions and the limitations to apply Bernoulli's equation. (10 points)

5. Isokinetic sampling is widely used in power plants flue gas sampling for gaining the representative samples of the particles. Please explain what Isokinetic sampling is. Draw the flow lines including inside and outside of the sampling nozzle under 3 different situations: (1) sample taking velocity is lower than the moving aerosol stream, (2) sample taking velocity is the same as the moving aerosol stream, (3) sample taking velocity is higher than the moving aerosol stream. Please also explain under the 3 situations, whether the measured value will be overestimated, underestimated or equal compared with the true concentration. (10 points)



6. Explain the following terms:
(a) Critical Reynold Number (5 points)
(b) Continuity Equation (5 points)
(c) Streamline (5 points)
(d) Navier–Stokes equations (5 points)

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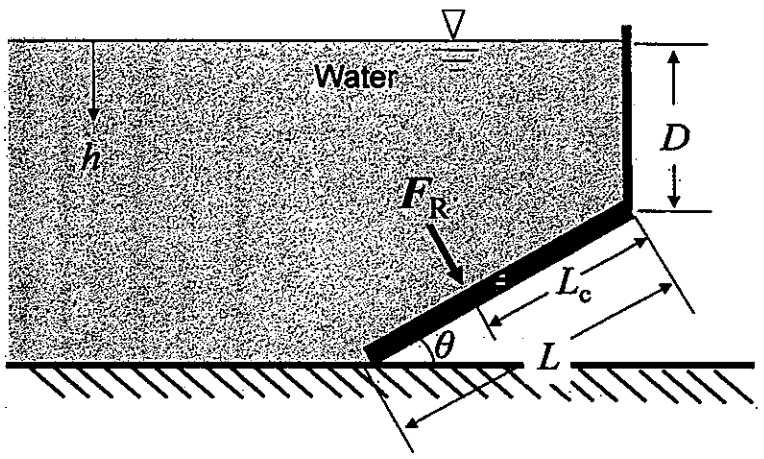
7. A rectangular and inclined gate of uniform thickness holds back a depth of water, as shown. The width of the gate normal to the plane is 6 m. Describe any assumption you use.
   (a) Determine the resultant force (F_R) on the inclined surface. (8 points)
   (b) Find the location of the center of pressure on the inclined surface (L_c). (7 points)

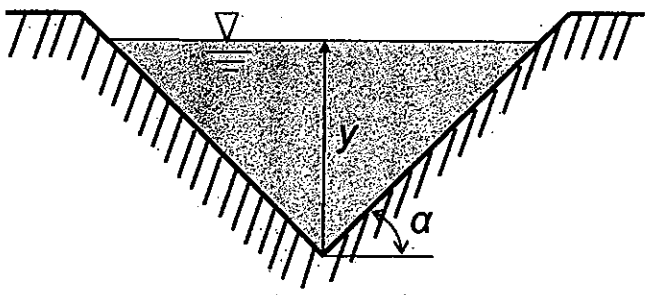
where D = 5 m; L = 8 m; θ = 30°;

Water: ρ = 999 Kg/m^3; g = 9.81 m/s^2



8. (a) Open channel is a flow system with a free surface. The most efficient channel has the least wetted perimeter for a given area. Please determine the optimum geometry of equilateral triangular channel including α, cross-sectional area (A), wetted perimeter (P), Hydraulic radius (R). Describe any assumption you use. (8 points)

   (b) The triangular channel with optimum cross section is designed to deliver water at Q = 20 m^3/s, on a given slope (S=0.002) and roughness (n=0.013), evaluate the required size (depth (y), cross-sectional area (A), wetted perimeter(P)) using Manning's equation. (7 points)



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