Birla Institute of Technology & Science, Pilani
Hyderabad Campus

FIRST SEMESTER 2022-2023
Comprehensive Examination (Closed Book)
Course No: CE F 312, Time: 2:00PM-5:00PM
Course Title: Hydraulic Engineering
Date: 23.12.2022, Max. Marks: 35, Duration: 3 Hours

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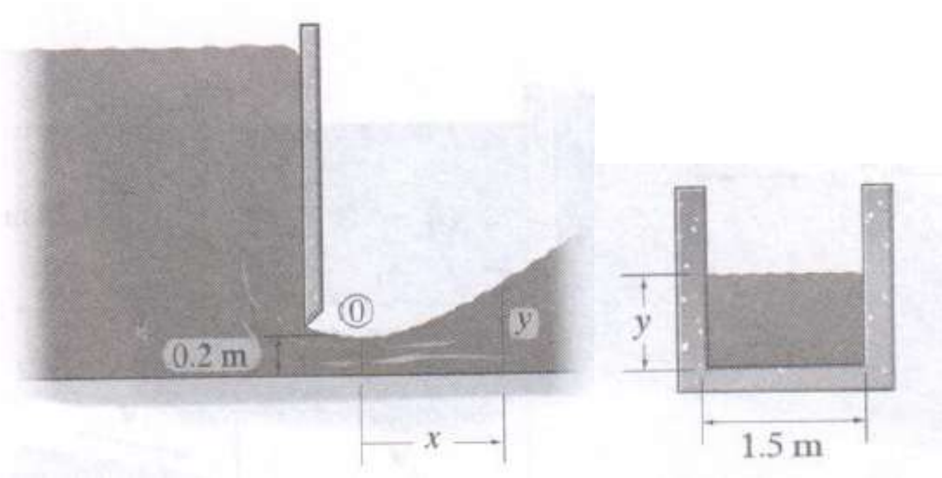
1. The Pelton wheel receives water via a penstock with a gross head of 600 m from a reservoir. Friction in the penstock results in a loss of one-fourth of the gross head. Water flows through the fixed nozzle at the end of the penstock at a rate of 2.5 m^3/s. The jet deflects at a 165^0 angle. Calculate the water's contribution to the runner's power as well as the Pelton wheel's hydraulic efficiency. Consider a speed ratio of 0.45 and a C_v or K_v of 0.98. **(5 Marks)**

2. A curved vane moving at 12 m/s collides with a jet of water travelling at 35 m/s in the same direction. At entry, the jet makes a 35^0 angle with the vane's motion, and it departs the vane at a 140^0 angle. The vane angles at the inlet and outlet should be determined if the water enters and exits the vane without being shocked. Find out how much work is accomplished per second per unit weight of water striking the vane. Disregard friction. Find out how efficient the system or vane is. **(6 Marks)**

3. A 0.5 kg ball has a diameter of 100 mm and is dropped into the tank of oil. Determine its terminal velocity as it falls downward. Take the density of oil = 900 kg/m^3, and dynamic viscosity of oil = 0.0360 Ns/m^2. **(5 Marks)**

4. Under a 200 m head, a Francis turbine generates 8.5 MW of electricity at 250 rpm. Make a calculation of the turbine's unit quantities if the overall efficiency is 81%. What are the needed discharge, power output, and speed when the turbine head is 140 meters? What is its specific speed? **(4 Marks)**

5. Water flows from a reservoir under a sluice gate and into the 1.5 m-wide unfinished concrete rectangular channel, which is horizontal, as shown in the Figure below. At the control point 0, the measured flow is 2 m^3/s and the depth is 0.2 m. Show how to determine the variation of water depth along the channel, measured downstream from this point from 0.2 m to 0.23 m in steps of 0.01 m. The manning's roughness coefficient for the surface may be taken as 0.014. (Hint: Find the total distance) **(5 Marks)**



6. A boundary layer's velocity distribution is represented by the equation $\frac{v}{V} = \frac{y}{\delta} - \frac{y^2}{2\,\delta^2}$. Obtain the boundary layer's displacement thickness, momentum thickness, and energy thickness. **(3 Marks)**

7. A channel features a 1.2 m-diameter semicircular invert. Beyond the semicircular inversion, the walls are vertical. The normal depth of the water in the channel is 1.2 meters. The channel is constructed with a 1:1500 slope. Calculate the discharge via the channel if the channel's Chezy's C value is 55. **(3 Marks)**

8. The velocities at 15 cm, and 21 cm from the centerline in a 50 cm diameter pipe are 3.5 m/s and 3 m/s respectively. The flow is turbulent and the pipe is hydrodynamically rough. Determine the discharge and the roughness projections' height. **(4 Marks)**

Formulae sheet

$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}};\ c_f = \frac{\tau_0}{\frac{\rho V^2}{2}} = \frac{0.664}{\sqrt{Re_x}};\quad \frac{\delta^*}{x} = \frac{1.729}{\sqrt{Re_x}};\ \frac{\theta}{x} = \frac{0.664}{\sqrt{Re_x}};\ C_f = \frac{1.328}{(Re_L)^{\frac{1}{2}}}$$

$$\frac{\delta}{x} = \frac{0.376}{(Re_x)^{\frac{1}{5}}};\ c_f = \frac{0.059}{(Re_x)^{\frac{1}{5}}};\ C_f = \frac{0.074}{(Re_L)^{\frac{1}{5}}};\ C_f = \frac{0.455}{(log_{10}Re_L)^{2.58}};\ C_f = \frac{0.074}{(Re_L)^{\frac{1}{5}}} - \frac{1700}{Re_L};\ C_f = \frac{0.455}{(log_{10}Re_L)^{2.58}} - \frac{A}{Re_L};\ \delta' = \frac{11.6\nu}{V*};\ \frac{\tau_0}{\rho V^2} = \frac{d\theta}{dx};$$

$$\frac{v_{max} - v}{V*} = 5.75 log_{10}\left(\frac{R}{y}\right);\ \frac{v}{V*} = 5.75 log_{10}\left(\frac{V_* y}{\nu}\right) + 5.5$$

$$\frac{v}{V*} = 5.75 log_{10}\left(\frac{y}{k}\right) + 8.5;\ \frac{V}{V*} = 5.75 log_{10}\left(\frac{V_* R}{\nu}\right) + 1.75$$

$$\frac{V}{V*} = 5.75 log_{10}\left(\frac{R}{k}\right) + 4.75;\ f = \frac{64}{Re};\ \ f = \frac{0.316}{(Re)^{1/4}};\quad f = 0.0032 + \frac{0.221}{(Re)^{0.237}}$$

$$\frac{1}{\sqrt{f}} = 2.0 log_{10}\left(Re\sqrt{f}\right) - 0.8;\ \frac{1}{\sqrt{f}} = 2.0 log_{10}\left(\frac{R}{k}\right) + 1.74$$

$$\frac{1}{\sqrt{f}} - 2.0 log_{10}\left(\frac{R}{k}\right) = 1.74 - 2.0 log_{10}\left(1 + 18.7\frac{R/k}{Re\sqrt{f}}\right)$$

$$V_* = V\sqrt{\frac{f}{8}};\ \tau_0 = \frac{\rho V^2 f}{8};\frac{v_{max} - V}{V_*} = 3.75;\delta^* = \int_0^\infty \left(1 - \frac{v}{V}\right) dy;\ \theta = \int_0^\infty \frac{v}{V}\left(1 - \frac{v}{V}\right) dy;$$

$$\delta_E = \int_0^\infty \frac{v}{V}\left(1 - \left(\frac{v^2}{V^2}\right)\right) dy$$

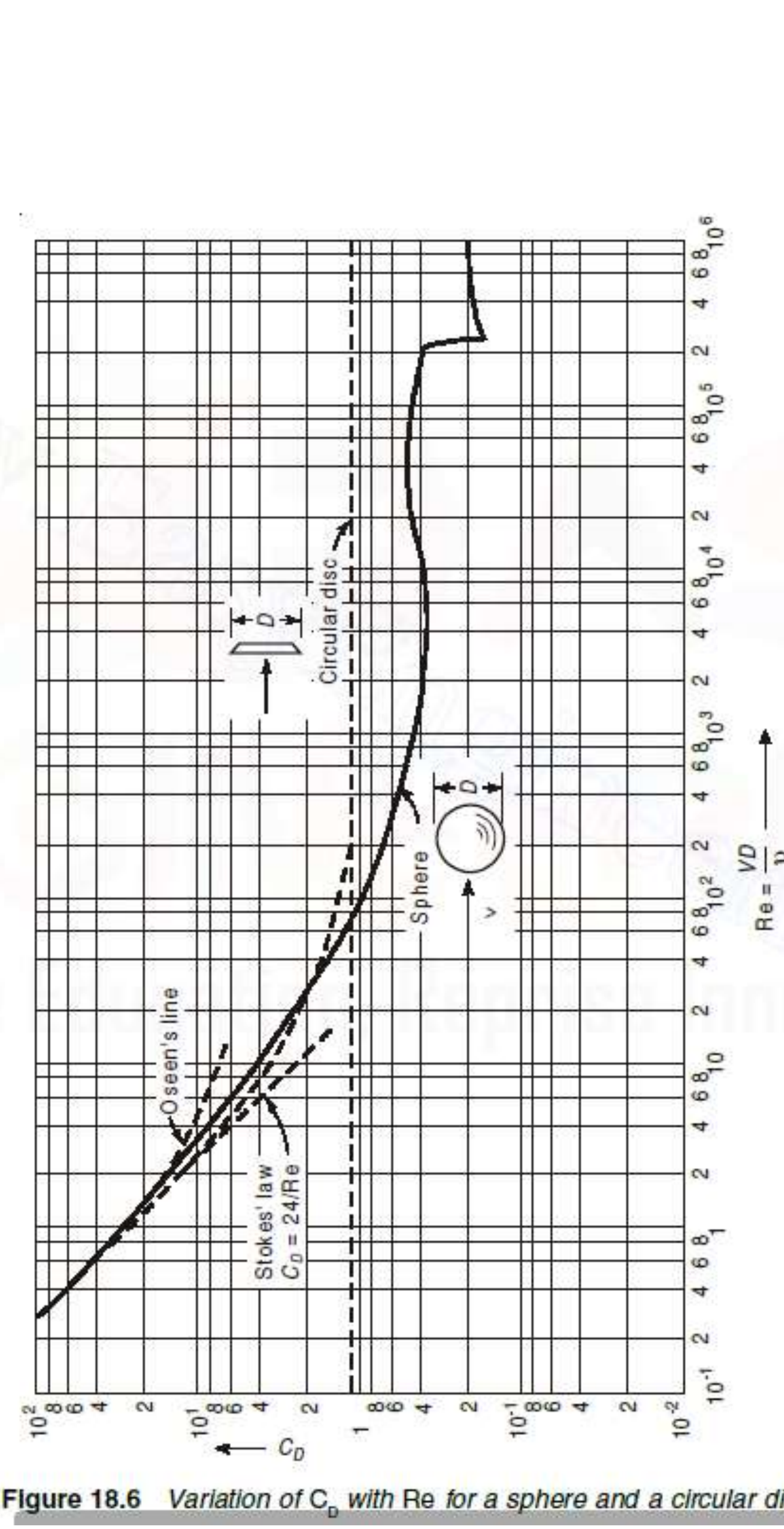


Figure 18.6 *Variation of* C_D *with* Re *for a sphere and a circular disc*