④ A Couette Viscometer is used to measure the Viscosity of an oil by shearing it between two concentric cylinders. In such a Viscometer, the diameter 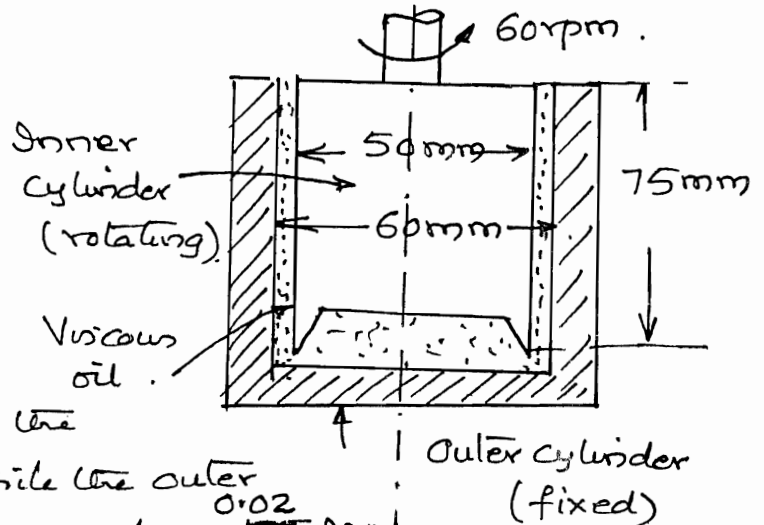of the outer cylinder $= r_2 = 60$ mm, the diameter of inner cylinder $= r_1 = 50$ mm. The height of the sheared layer of oil is 75mm (see the figure).

Inner Cylinder (rotating)

60 rpm.

50 mm

60 mm

75mm

Viscous oil.

Outer cylinder (fixed)

The torque required to rotate the inner cylinder at 60 rpm while the outer cylinder was fixed was measured as 0.02 N-m. Calculate the Viscosity of the oil in Poise. Start from the governing equations of motion (given at the backside) to derive the Velocity profile in the oil layer. Make suitable assumptions and state them. Assume that contribution to torque comes only from the Vertical portion of the inner cylinder surface. (14).

⑤ The wave drag (F_D) on a ship depends on density of sea water (ρ_s), Ship Velocity (U), gravitational force (g) and size of the ship (L). Using dimensional Analysis identify the dimensionless groups using ρ, U and L as repeat Variables. A 1:100 Scale model of the ship was tested in fresh water ($\rho = 997$ kg/m³) in a laboratory and was found to experience a wave drag of 0.5N at a Velocity of 0.5m/s. Calculate the corresponding Values of Ship Velocity and wave drag on the prototype: Assume that the density of sea water is 1025 kg/m³. (9).

⑥ The inlet side of a turbine is a 30cm dia pipe and outlet side is a 45cm dia pipe. If the absolute pressure at the inlet is 6.5 Kgf/cm² and pressure at the outlet is 30cm of mercury Vacuum ($P_{atm} = 1.03$ Kgf/cm² abs) What power is the turbine