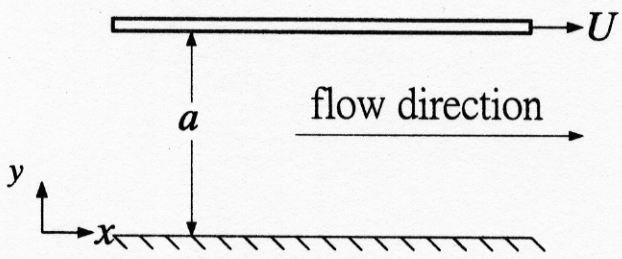
/. (a) Viscous fluid flowing through two infinite parallel plates is shown in the following figure (Fig. (a)). The distance between the plates is a. The bottom plate is stationary and the upper plate moves with constant velocity U. The flow is considered as fully developed laminar flow. Derive the velocity distribution $u(y)$ as the following equation.

$$u(y)=\frac{Uy}{a}+\frac{a^2}{2\mu}\left(\frac{\partial P}{\partial x}\right)\left[\left(\frac{y}{a}\right)^2-\left(\frac{y}{a}\right)\right]$$

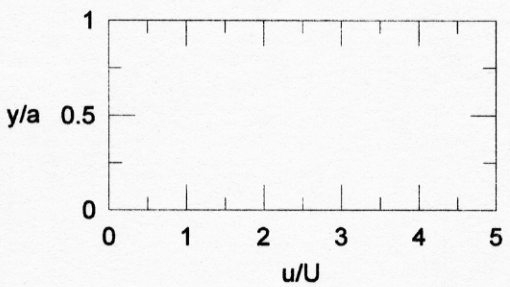
where μ is viscosity of fluid, $\frac{\partial P}{\partial x}$ is pressure drop in the flow direction. (12%)

(b) Plot the separated velocity profile of (i)$\frac{\partial P}{\partial x}=0$ and (ii) $\frac{\partial P}{\partial x}<0$ qualitatively in the following coordinate (Fig. (b)) in your answer sheet. (8%)

(註：將Fig.(b)之座標畫在答案卷上，並將(i)和(ii)之速度分佈圖繪於答案卷上之座標內)



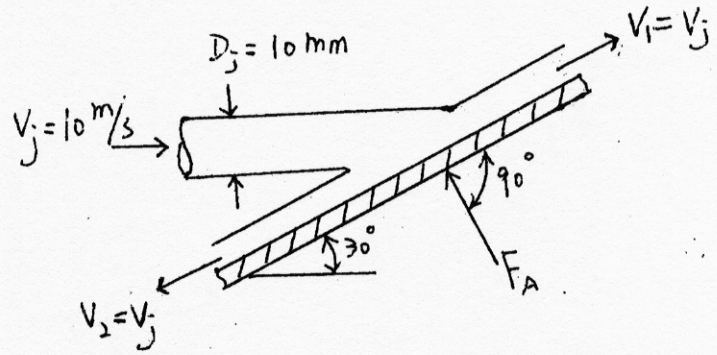
(a)



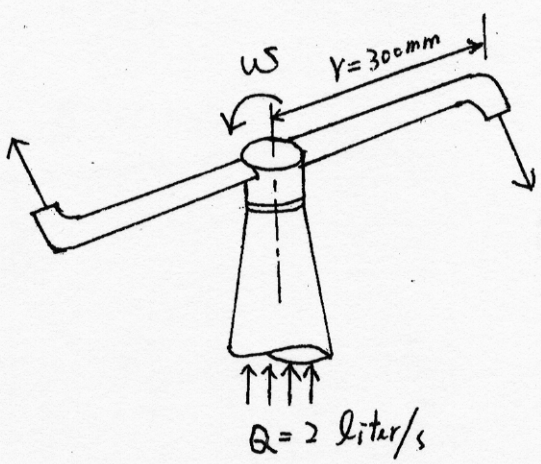
(b)

2. Viscous fluid flows through a circular rough pipe of which the length is L. Consider suitable parameters to determine a set of dimensionless groups that can be used to correlate data of pressure lose. (13%)

3. A horizontal circular jet of water strikes a flat plate as shown in the figure. The velocity magnitude remains constant as the water flows over the plate. Determine (a) the magnitude of the force F_A to hold the plate stationary; (b) the fraction of mass flow along the plate in each of the two directions; (c) the magnitude of F_A to allow the plate to move to the right at a constant speed of 2 m/s. (17%)



4. Water enters a rotating lawn sprinkler through its base at a rate of 2 liter/s as seen in the following sketch. The exit area of each of the nozzles is 50 mm^2 and the flow leaving each nozzle is in the tangential direction. The radius of the sprinkler is 300 mm. Determine (a) the resisting torque required to hold the sprinkler stationary; (b) the resisting torque when the sprinkler rotating at 100 rev/min; (c) the speed of the sprinkler if no resisting torque is applied. (17%)



5. An aluminum sphere ($\rho = 2735 {kg}/{m^3}$, $c_p = 837.3 {W \cdot s}/{kg \cdot °C}$, $k = 207.6 {W}/{m \cdot °C}$) of diameter $d = 2.5cm$ at uniform temperature $To = 95°C$ is suddenly immersed at time $t = 0$ in a well-stirred fluid which is kept at a constant temperature $T_\infty = 5°C$. The sphere loses heat by convection from its surface to the fluid with a heat transfer coefficient $h = 100 {W}/{m^2 \cdot °C}$. Use a simple lump-system analysis to estimate the time required for the average temperature of the sphere to reach $30°C$. (17%)

6.Consider a laminar flow inside a long circular tube subjected to uniform heat flux at the wall.

(a). Plot the average fluid and tube wall temperature distributions in the axial direction. (5%)

(b). Specify the condition for the fully developed heat transfer and explain its physical meaning. (5%)

(c). Define the convection heat transfer coefficient in the flow. (6%)