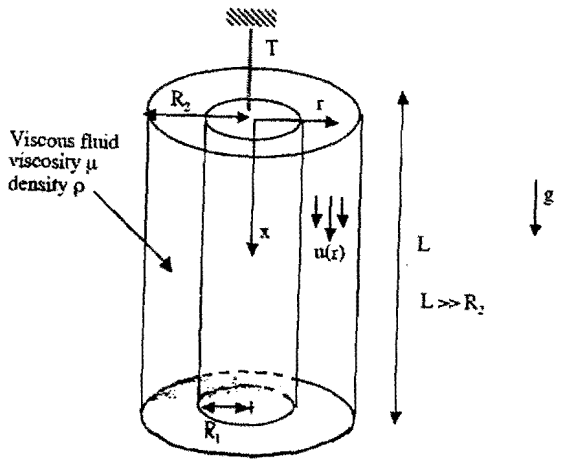
1. A flow field having the velocity components as following: $u = x(1 = 2t), v = y, w = 0$. Find the streamline and plot its flow pattern as well. (15%)

2. A steady, 2-D, incompressible flow exists between two fixed plane surface spaced at a distance b apart.
   (1) Determine the velocity profile (u and v) from the Navier-Stokes equations after simplification (5%).
   (2) Determine the stream function for the flow (5%).
   (3) Also determine is this flow irrotational (5%)?

3. Consider viscous fully developed laminar flow in an annulus between two concentric cylinders, placed vertically under action of gravity according to the sketch shown below. The inner cylinder hangs from cable, but remains at fixed position.
(a) Write down the Navier Stokes equation in cylindrical coordinates in the axial direction, x = downward. (5%)
(b) Write down the boundary conditions for this problem. (5%)
(b) In terms of the parameters given in the figure, find the vertical force acting on the inner cylinder (i.e the tension T in the cable, assuming that the inner cylinder has negligible weight). (10%)



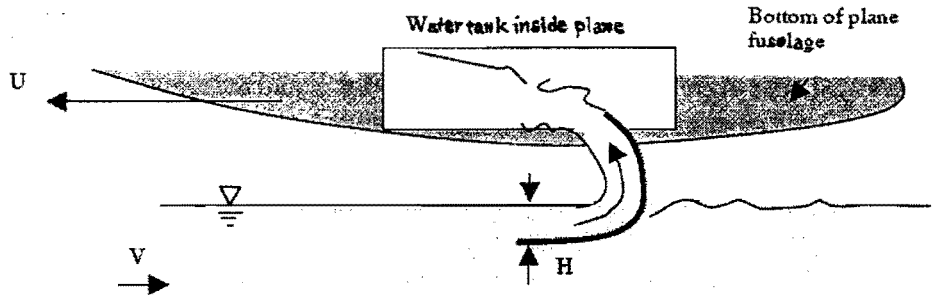
(背面仍有題目,請繼續作答)

4. A firefighter plane to combat forest fires shown below moves at constant velocity U from right to left over a river that has a current velocity V from left to right. The plane takes on water (density ρ) with a scoop of width W (into the page), which dips a height H into the water

(a) Clearly mark what control volume you are using, and state in which reference frame you are formulating the problem. (5%)

(b) Write down the governing equations on formulating this problem.(5%)

(c) Estimate the additional force required to keep the plane moving at constant velocity U.(10%)



5. Consider a steady velocity field $(u, v) = (-5x, 5y)$ where (u, v) are the Cartesian velocity components and (x, y) is the position in Cartesian system. Suppose at time $t = 0$ a fluid element P is located at (x_0, y_0).

(a) Find the position (x, y) of the fluid element P at time $t > 0$. Express x and y as functions of x_0, y_0 and t. (6%)

(b) Let us follow the fluid element P as it flows in this velocity field. When P passes through the position (x, y), what are the Cartesian acceleration components (a_x, a_y) experienced by P? Express a_x and a_y as functions of x and y. (6%)

(c) Find the equation for the streamline passing through (x_0, y_0). (6%)

6. Consider the steady, inviscid and incompressible flow of density ρ in a horizontal channel with smooth-varying cross-sectional area. There is no flow separation or reversed flow in the channel. At station 1 the cross-sectional area is A_1, the average flow velocity is u_1, and the pressure is P_1. At station 2 the cross-sectional area is A_2, the average flow velocity is u_2, and the pressure is P_2. We don't know the value of u_1 and u_2, but we have measured the value of ρ, A_1, P_1, A_2 and P_2.

(a) Derive u_1 in terms of the measured ρ, A_1, P_1, A_2 and P_2. (6%)

(b) Derive u_2 in terms of the measured ρ, A_1, P_1, A_2 and P_2. (6%)