每題２０分　共五題　　請依題號次序作答

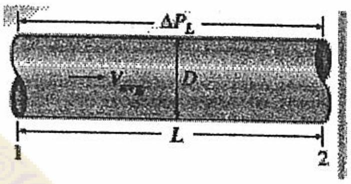
I. Consider an unsteady, two-dimensional, incompressible velocity field with

$$\vec{V} = (x+1)\vec{i} + (-y+3+5\sin t)\vec{j}\,.$$

(1) Consider a fluid particle initially ($t=0$) at position $(x,y)=(0,0)$, what will be the location of this particle at time $t=2\pi$. .

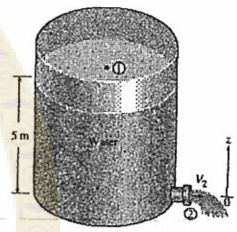
(2) Find the equation of streamline which pass through $(x,y)=(0,0)$ at time $t=2\pi$.

II. In fully developed laminar flow in a circular pipe, the velocity profile is given by : $u(r)=2V(1-\frac{r^2}{R^2})$; where V is the average velocity. Show that the volume flow rate, Vol, in the pipe can be expressed by the so called Poiseuille's equation: $Vol = A\frac{\Delta P \pi D^4}{\mu L}$; where L is the pipe length, D is the pipe diameter, ΔP is the total pressure drop. Determine the value of the constant A in the Poiseuille's equation .



III. (1) A large tank open to the atmosphere is filled with water to a height of *5 m* from the outlet tap. A tap near the bottom of the tank is now opened, and water flows out from the smooth and rounded outlet. Determine the water velocity at the outlet. (*g=9.8 m/s²*).

(2) If the diameters of the tank and the outlet are D_1 (1.0 m) and D_2 (*0.03 m*) respectively, determine how long it will take for the water level in the tank to drop to *2.5 m* from the bottom.



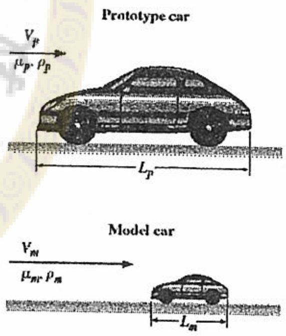
IV. If the drag force F_D of a sport car moving with constant velocity V in air is a function of air density ρ, viscosity μ and its size,(characteristic length), L, i.e. $F_D = f(V, L, \rho, \mu,)$. The drag force of a new sport car is to be predicted at a speed of 90 km/hr. Automotive engineers build a 1/5 scale model of the car to be tested in a water tunnel.

(1) Determine how fast the model car should be run in the water tunnel in order to achieve dynamic similarity between the model and the prototype.

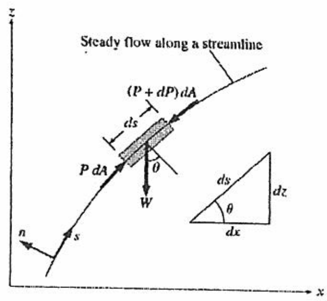
(2) If the drag force at this water tunnel testing speed is measured to be $20N$, and the length of the prototype is $L_p = 3.8m$. what is the drag force of the prototype ?

$$\rho_{air} = 1.2\,kg/m^3;\ \mu_{air} = 1.85\times10^{-5}\,kg/(m\cdot s)$$

$$\rho_{water} = 1.0\times10^3\,kg/m^3;\ \mu_{water} = 1.0\times10^{-3}\,kg/(m\cdot s)$$



V. Consider a fluid particle moving along with a streamline. The velocity of the particle along a streamline is given as $V = V(s, t)$, where s is the distance along the streamline and t is time. Derive the Bernoulli's Equation along a streamline for a steady incompressible flow. (Please write down all the details of your derivation)



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