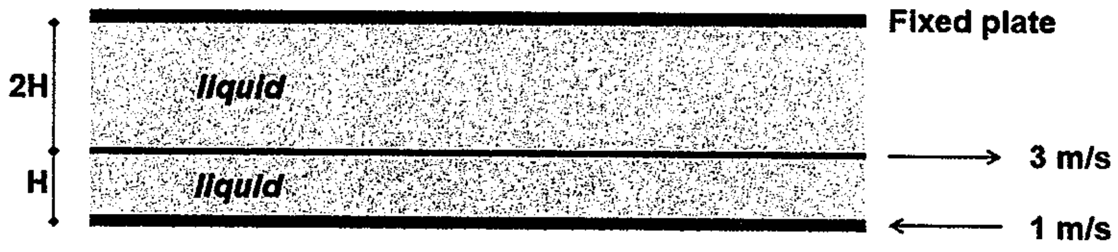
1. An incompressible liquid is placed between three plates as illustrated.
   (a) Plot the velocity profile in both compartments. (5%)
   (b) Determine the position where liquid velocity is zero. (10%)
   (c) Determine the force needed to keep the middle plate moving at 3 m/s. (10%)



2. An air stream is flowing at 5000 m^3/d through a square duct with 2 m in width and height. Given that: (i) air density = 1.2 kg/m^3, (ii) air dynamic viscosity = 1.8×10-5 kg m^{-1}s^{-1}, and particle density of 2000 kg/m^3, determine:
   (a) The required length for 95% settling of 0.1 μm particulates. (20%)
   (b) Comment on your answer in (a). (5%)

3. A gas velocity field is given by:

$$\vec{V} = (x^2y - z)\hat{\imath} + (z^2y - x)\hat{\jmath} + (y^2z - x)\hat{k}$$

   (a) Determine whether the flow is incompressible. Can Bernoulli equation be applied here? Why yes, or why not? (5%)
   (b) Compute the vorticity vector $\vec{\omega}$. Analyze the physical meaning of the non-zero vorticity and identify any stagnation points in the flow. (5%)
   (c) Sketch the streamlines on the xy-plane. Compare these with potential pathlines if a particle starts at (1,0,0) [please derive the streamline equation]. (5%)
   (d) For this gas flow, calculate the dynamic pressure distribution on the xz-plane. If we want to treat this as an incompressible flow, estimate the maximum meaningful kinetic energy per unit volume and justify your answer. (10%)

4. A smooth riverbed has a steady flow of water with velocity $U_\infty = 2\,m/s$. The boundary layer forms along the riverbed, and the velocity profile near the bed can be approximated as:

$$u(y) = U_\infty\left(2\frac{y}{\delta} - \left(\frac{y}{\delta}\right)^2\right), 0 \le y \le \delta.$$

   (a) Explain what factors influence the growth of the boundary layer thickness $\delta(x)$ in the river flow (5%)
   (b) Using the given velocity profile, derive an expression (in terms of kinematic viscosity) for the shear stress τ_w at the riverbed. (5%)

5. A municipal water pipeline with diameter $D = 0.3\,m$ and length $L = 500\,m$ delivers water at a flow rate of $Q = 0.1\,\frac{m^3}{s}$. The pipe material has a roughness $\epsilon = 0.0002\,m$, and the kinematic viscosity of water is $\nu = 1.0 \times 10^{-6}\,\frac{m^2}{s}$.
   (a) Estimate the energy loss per unit length due to friction using the Darcy-Weisbach equation. (5%)
   (b) Calculate the entrance length (Le) required for the flow to become fully developed. Discuss why understanding entrance effects is critical for optimizing pipeline performance at varying Reynolds numbers (10%)

Smooth pipe approximation for Darcy friction factor, $f = \frac{0.3164}{\mathrm{Re}^{0.25}}$;

The Colebrook equation: $\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\epsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$;

The Haaland equation: $\frac{1}{\sqrt{f}} = -1.8\log_{10}\left[\left(\frac{\epsilon/D}{3.7}\right)^{1.11} + \frac{6.9}{\mathrm{Re}}\right]$.

試題隨卷繳回