In Class Practice Problem – Vorticity (Fall 2025)

1. Vorticity transport.

a. Consider the vorticity transport equation shown below.

$$\underbrace{\frac{\partial \vec{\omega}}{\partial t}}_{I} + \underbrace{\left(\vec{u}\cdot\vec{\nabla}\right)\vec{\omega}}_{II} = \underbrace{\left(\vec{\omega}\cdot\vec{\nabla}\right)\vec{u}}_{III} + \underbrace{\frac{\vec{\nabla}\rho\times\vec{\nabla}P}{\rho^2}}_{IV} + \underbrace{\nu\vec{\nabla}^2\vec{\omega}_V}$$

1. Give the name and a short description of the physical meaning of each term I–V.

   I –

   II –

   III –

   IV –

   V –

2. Which term in the vorticity transport equation is linked to the turbulent energy "cascade" process?

b. Define (in words) what a <u>vortex line</u> is.

c. What is the <u>solenoidal</u> condition for vorticity?

d. Assume you have a steady flow with a velocity field that only varies in the vertical direction ($\vec{V} = f(y)$) and for which the density ρ is constant everywhere. Simplify the original vorticity equation given at the top.

e. Does vorticity exist at a solid wall? Why or why not [support your position with equations or words]