Homework #1 (Due date: June 29, 2018)

1. Consider steady flow of a constant-property fluid in a long duct formed by two parallel planes. Consider a point sufficiently far removed from the duct entrance that the y component of velocity is zero and the flow is entirely in the x direction. Simplify the Navier-Stokes Equations (lecture notes 1.45) in both x and y dirctions. What can you deduce about the pressure gradient?

2. Derive the constant-property energy equation

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}-\alpha\frac{\partial^2 T}{\partial y^2}=0$$

Starting with equation: $$\rho u\frac{\partial i}{\partial x}+\rho v\frac{\partial i}{\partial y}-\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right)-\mu\left(\frac{\partial u}{\partial y}\right)^2-u\frac{\partial p}{\partial x}=0$$

3. Derive the Nusselt number for fully developed (hydrodynamic and thermal) flow between infinite parallel plates with the same magnitude of constant heat flux into the top and bottom surface of the channel. Note that the first step in this derivation is determination of the velocity profile in the channel.