1. Which of the following fluids is Newtonian:
   (a) ammonia gas
   (b) highly concentrated sugar solution
   (c) petrol
   (d) blood

2. Which of the following statements is true for a Newtonian fluid:
   (a) Viscous stress vs strain relation is linear.
   (b) Viscous stress is proportional to the strain rate
   (c) Viscosity is independent of shear stress.
   (d) Viscosity is a material constant; it may change from material to material but will not change for a given material.

By definition

3. Consider the rectangular fluid element shown in the figure below representing a small fluid element in steady, laminar, fully developed flow of an incompressible fluid between two infinitely long and wide parallel plates. After a short time δt, the corner points occupy new positions resulting in a parallelogram shown in red. Which of the following statements is true?
   (a) The fluid element has undergone rotational strain
   (b) The fluid element has undergone extensional strain
   (c) The fluid element has undergone shear strain.
   (d) None of the above.

By definition

4. For a Newtonian fluid, τ_{yy} is given by
   (a) \( \frac{1}{2} \mu (\partial u_i/\partial x_j + \partial u_j/\partial x_i) \)
   (b) \( \frac{1}{2} \mu (\partial u_i/\partial y + \partial v/\partial x) \)
   (c) \( \mu (\partial u/\partial y) \)
   (d) none of the above.

\( \frac{1}{2} \mu (\partial v/\partial y + \partial v/\partial x) \) or \( \frac{1}{2} \mu (\partial u_i/\partial x_j + \partial u_j/\partial x_i) \)

5. The advection term in the momentum conservation equation in the i^{th} direction for constant-property Newtonian fluid flow can be written as
   (a) \( u_k \partial u_i/\partial x_k \)
   (b) \( u_j \partial u_i/\partial x_j \)
   (c) \( u_i \partial u_i/\partial x_i \)
   (d) \( u_i \partial u_j/\partial x_j \)

Both are derived from the same general form
You wish to demonstrate your CFD skills by doing a calculation for the developing flow between infinitely wide plates separated by a constant height $H$. Assume that the flow is steady, incompressible and laminar and that the fluid is Newtonian. Assume that x-direction is along the plate and y-direction is normal to the plate and you want to do a two-dimensional flow simulation. For this case,

6. The steady-state, 2-D momentum balance in the y-direction, neglecting gravity, can be written for constant property flow as

   (a) $u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y} = -1/\rho \frac{\partial p}{\partial x} + \mu/\rho (\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 v}{\partial y^2})$
   (b) $u\frac{\partial v}{\partial x} + v\frac{\partial u}{\partial y} = -1/\rho \frac{\partial p}{\partial y} + \mu/\rho (\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2})$
   (c) $u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y} = -1/\rho \frac{\partial p}{\partial x} + \mu/\rho (\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2})$
   (d) None of the above

**Direct expansion of 2-D momentum balance in y-direction**

7. For the above problem, which of the following statements is true?
   (a) We do not need to solve the y-momentum equation.
   (b) Since the flow is developing, we need to include time derivatives in the governing equations.
   (c) We need to solve the y-momentum equation.
   (d) We can neglect pressure variation within the flow domain.

8. Taking advantage of symmetry, we wish to solve only for the flow field up to mid-height, i.e., from $y=0$ (bottom plate) to $y=H/2$. The boundary condition on the surface of the plate is as follows:

   (a) $\frac{\partial v}{\partial y} = 0$  (b) $\frac{\partial u}{\partial y} = 0$  (c) $v = 0$  (d) none of the above.

**No slip BC**

9. The following boundary condition applicable at $y = H/2$ is

   (a) $\frac{\partial v}{\partial y} = 0$  (b) $v = 0$  (c) $u = 0$  (d) $\frac{\partial u}{\partial y} = 0$

**For a parabolic velocity profile, flux is zero (tangent with a zero slope) at the centre maximum:**

**Neumann BC**  $\frac{\partial u}{\partial y} = 0$

**V-velocity is constant with respect to y, if the system doesn’t have external or internal heating effects or plate movement. Hence V-y profile will be a straight line so, $\frac{\partial v}{\partial y} = 0$**

10. For fully developed flow, the steady state momentum balance equation reduces to

    (a) $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$  (b) $\frac{\partial^2 u}{\partial y^2} = 0$  (c) $\frac{\partial^2 u}{\partial x^2} = 0$  (d) $\frac{\partial^2 v}{\partial y^2} = 0$

**For fully developed flow, u-velocity variation is only along y-axis ; not x-axis**

11. The diffusion term in the x-momentum conservation equation for constant-property Newtonian fluid flow can be written as

    (a) $\mu \frac{\partial^2 u}{\partial x^2}$  (b) $\mu \frac{\partial^2 u}{\partial x^2}$  (c) $\mu \frac{\partial^2 u}{\partial x^2}$  (d) $\mu \frac{\partial^2 u}{\partial x^2}$
\[ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = \frac{-1}{\rho} \frac{\partial p}{\partial x} + \frac{\mu}{\rho} \left( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) \]: X-momentum equation

\[ \frac{\mu}{\rho} \left( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) \]: Diffusion term

As a general form: \( \frac{\mu}{\rho} \left( \frac{\partial^2 u}{\partial x_j^2} \right) \); \( \rho \) can be taken to left hand side of X-mom as it is specified as constant property fluid

12. The continuity equation for compressible flow can be written as
(a) \( \frac{\partial u_n}{\partial x_m} = 0 \)  
(b) \( \frac{\partial u_i}{\partial x_j} = 0 \)  
(c) \( \frac{\partial p}{\partial t} = 0 \)  
(d) None of the above.