Elementary Fluid Mechanics

2009 Mid-term Examination

October 26, 2009

1. Fill in the blank.

(1) In late 15th century, da Vinci observed and sketch the water flow over the (   ).

(2) In 1744, d'Alembert showed that there is no resistance to motion when a body moves through an (   ) fluid.

(3) In the middle of 19th century, Navier and Stokes succeeded in modifying the general equations for ideal fluid motion to fit those of a (   ) fluid.

(4) For the fluids at rest, (2 words   ) cannot exist, the pressure is the only stress to be considered.

(5) (   ) is the mass, that is, the amount of matter, contained in a unit volume.

(6) For Newtonian fluids, τ is observed to be proportional to the rate of relative strain, that is, to the (2 words) with the coefficient of viscosity.

(7) (   ) may be expected in a flowing liquid wherever the local pressure falls to the vapor pressure of the liquid.

(8) The pressure is constant in a (   ) plane in a static fluid.

(9) Absolute pressure = Atmospheric pressure - (   )

Absolute pressure = Atmospheric pressure + (   ) pressure

(10) The resultant force on the plane surfaces equals the pressure at the (   ) of the area times the area.

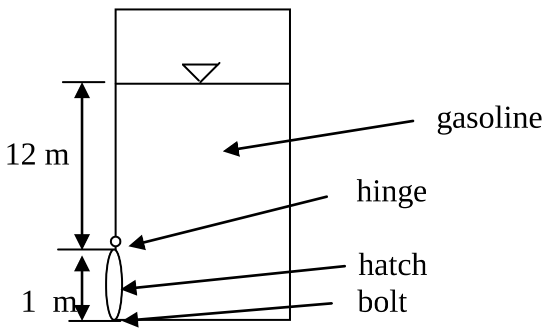
(11) The circulation is defined as the line integral of the (   ) component of velocity around a closed curve fixed in the flow.

(12) A matter, mass, momentum, energy, and the like can flow through boundary of the (2 words   ).

(13) The Reynolds Transport Theorem is the link between (   ) and the control volume.

(14) The Reynolds Transport Theorem says that for any extensive property E of the system, its time rate of change in the system is equal to its time rate change within the control volume plus the (   ) of it across the control surface.

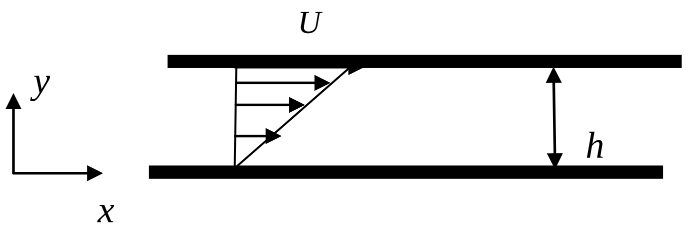
2. A circular hatch on the side of a pressurized tank is hinged at the top and held closed by a single bolt at the bottom. If the tank is filled with gasoline and pressurized to two atmospheres, find the force in the bolt necessary to counteract the fluid force on the hatch, i.e., to hold the hatch closed. The specific gravity of gasoline is 0.68; one atmosphere is the equivalent of 101.3 kN/m^2; I_c of the circle is $\pi d^4/64$.



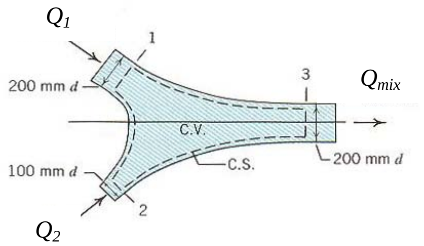
4. The laminar flow between parallel plates is known as a Couette flow. The upper plate is in motion and the lower plate is stationary. The velocity distribution is given by $u = \frac{Uy}{h}$.

a) Calculate the shear stress τ at the top plate if U = 0.087 m/s, h = 0.005 m, and μ = 1.49 Pa·s.

b) Calculate rotation ω. Is this flow rotational?



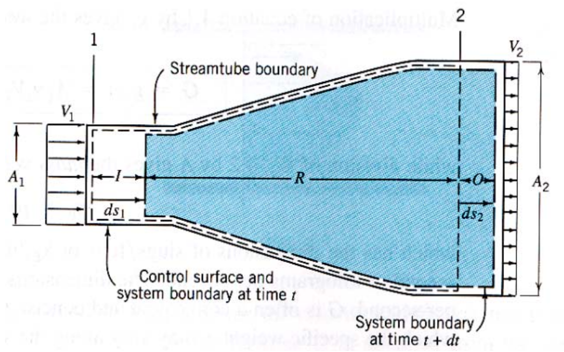
4. Using the wye pipe junction shown below, find the mixture velocity and density if fresh water (ρ_1 = 1,000 kg/m^3) enters section 1 at 50 l/s, while salt water (ρ_2 = 1,030 kg/m^3) enters section 2 at 25 l/s.



5. Derive 1-D continuity equation for a steady flow of compressible fluid using the Reynolds Transport Theorem?

[Hints]

1) Steady one-dimensional flow:



2) Reynolds Transport Theorem:

$$\frac{dE}{dt} = \frac{\partial}{\partial t}\left(\iiint_{c.v.} i\rho \, dvol\right) + \oint\oint_{c.s.} i\rho \vec{V} \cdot \overrightarrow{dA}$$

3) 1-D continuity equation for a steady flow of compressible fluid:

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$