College of Engineering & Technology

Department: Mechanical Engineering — Marks: 20
Lecturer: Dr. Rola Afify — Time: 12:30 – 2:00
Course Code: ME416 — Date: 11/11/2015

Name: **Model Answer** R.N.:

Answer the following questions:

Question one (10 marks)

A) Define:

i- Density : mass per unit volume $\rho = \frac{m}{V}$

For water $\rho = 1000$ kg/m^3

ii- Specific weight : weight per unit volume

$$w = \frac{\text{weight}}{\text{volume}} = \frac{m * g}{V} = \rho g$$

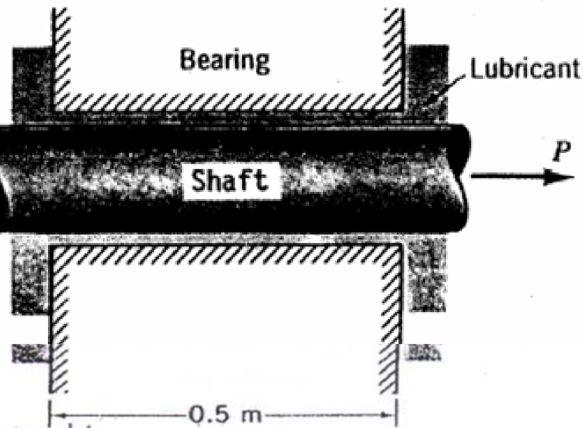
For water $w = 1000 * 9.8$ N/m^3

iii- Kinematic viscosity (υ): is defined as the ratio of dynamic viscosity of water to density

$$\upsilon = \frac{\mu}{\rho} = \frac{Pa.S}{kg/m^3} = \frac{kg.m.s\ m^3}{s^2 m^2\ kg} = (\mathrm{m^2/s})$$

$\upsilon = 0.01$ cm^2/s for water

B) A 25 mm diameter shaft is pulled through a cylindrical bearing as shown in Figure. The lubricant that fills the 0.3 mm gap between the shaft and bearing is oil having a kinematic viscosity of 8 x 10^{-4} m^2/s and a specific gravity of 0.91. Determine the force P required to pull the shaft at a velocity of 3 m/s. Assume the velocity distribution in the gap is linear.



$d = 25 * 10^{-3}$ m

$y = 0.3 * 10^{-3}$ m

$\nu = 8 * 10^{-4}$ m^2/s $= \frac{\mu}{\rho}$

$\gamma = 0.91 = \frac{\rho_f}{\rho_w}$

$u = 3$ m/s

$P = ?? = F_{vis}$

$\mu = \nu \rho = \nu * \gamma * \rho_w$

$F_{vis} = \mu A \frac{u}{y}$

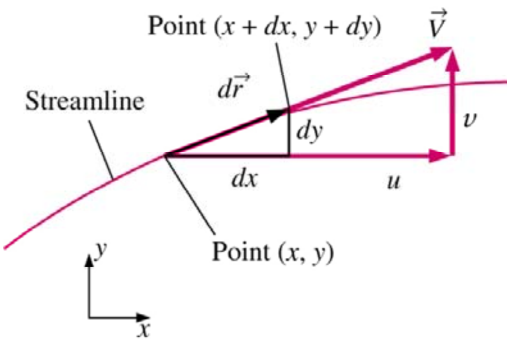
$P = [8 * 10^{-4} * 0.91 * 1000] * (\pi * 25 * 10^{-3} * 0.5) * \frac{3}{0.3 * 10^{-3}}$

$P = 91\pi$ N

$= 285.88$ N

Question two (10 marks)

A) Define Streamline:



A Streamline is a curve that is everywhere tangent to it at any instant represents the instantaneous local velocity vector.

B) Write the general form equation for:

i- Streamline in 3D:

$$\tan\theta = \frac{dy}{dx} = \frac{v}{u}$$

$$\frac{u}{dx} = \frac{v}{dy}$$

in — general — for 3 - D

$$\frac{u}{dx} = \frac{v}{dy} = \frac{w}{dz}$$

ii- Velocity in vector form in 3D:

$$\vec{V} = u\vec{i} + v\vec{j} + w\vec{k}$$

Where:

i ,j, k are the unit vectors in+ ve x, y, z directions

iii- Acceleration in 2D:

$$a = \sqrt{a^2{}_x + a^2{}_y} \quad \& \quad \tan\alpha = \frac{a_y}{a_x}$$

C) If $\vec{V} = 3x\,\vec{i} + 2y\,\vec{j} - 2z\,\vec{k}$, determine:

i- Velocity at origin:

At origin (0,0,0) $\quad \therefore\ \vec{V} = 0 \quad \therefore\ v = 0$

ii- Velocity at x-axis:

At x-axis (x,0,0) $\quad \therefore\ \vec{V} = 3x\,\vec{i} \quad \therefore\ v = 3x$ in x-direction

iii- Acceleration in vector form:

If $\vec{V} = 3x\,\vec{i} + 2y\,\vec{j} - 2z\,\vec{k}$ and the general form of the velocity vector is

$\vec{V} = u\,\vec{i} + v\,\vec{j} + w\,\vec{k}$ then $u = 3x$, $v = 2y$, and $w = -2z$

Then the acceleration components will be

$$a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z},\ a_y = u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z},\ \text{and}\ a_z = u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z}$$

$$a_x = 9x, \qquad a_y = 4y, \qquad \text{and} \qquad a_z = 4z$$

Then the acceleration vector will be

$$\vec{a} = 9x\,\vec{i} + 4y\,\vec{j} + 4z\,\vec{k}$$