University of Jordan
Faculty of Engineering & Technology
Chemical Engineering Department

الجامعـة الاردنية
كلية الهندسة و التكنولوجيا
قسم الهندسـة الكيميائية

Zero

Fluid Mechanics

Student name: [redacted] ***Student No.:*** [redacted]

Quiz #1

First semester 2017/2018

Student No.: 13

October 10, 2017

The kinematic viscosity of oxygen at 20 °C and an absolute pressure of 150 kPa is 0.104 stokes. Determine the dynamic viscosity of oxygen in poise at this temperature and pressure.

$T = 20°C$

$P_{abs} = 150\ kPa$

$\mu = 0.104$ stokes

$\tau = \mu \frac{\Delta V}{\Delta y}$

$\tau = \frac{0.104\ g \cdot cm}{s}$

CGS → $\mu \frac{\Delta \theta}{\Delta t}$

$\gamma = \frac{w}{V}$

$\gamma = \frac{mg}{V}$

$\gamma = \rho g$

$\tau = \mu \frac{\Delta V}{\Delta y}$

CGS

g·cm

kg·m/s²

$\Delta V \mu = \tau \Delta y$

$\mu = \frac{\tau \Delta y}{\Delta V}$

$\mu = \frac{g \cdot cm}{s^2} \cdot m \Big/ \frac{m}{s}$

$\mu = \frac{g \cdot cm}{s^2} \cdot \frac{s}{cm}$

$\mu = \frac{g \cdot cm}{s}$

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Zero / 10

Fluid Mechanics

Student name:

Student No.: [redacted]

Quiz #2

[redacted]

First semester 2017/2018

Student No.: 13

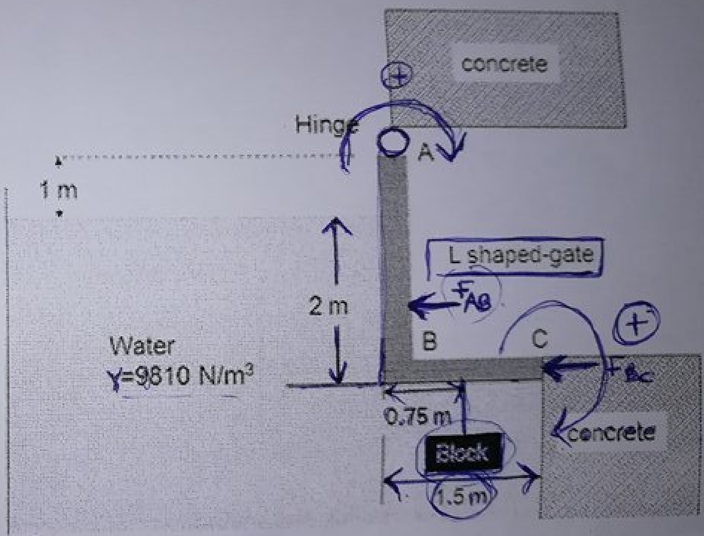
October 29, 2017

An L-shaped gate 3-m-wide with a hinge is shown in the figure below. Rigid block with volume of 200 L is hanged at the mid of BC part of the gate. Neglect the weight of the gate. Find the mass of the block required just to open the gate.

$w = 3m$

$\forall_{Block} = 200L$

$m_{Block} = ??$



$F_{BC} * 3m + F_{AB}$

$F \; P = \frac{F}{A}$

$F = PA$

$F = Pah$

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Fluid Mechanics (Section 2)
Student name: [redacted]
Quiz #3

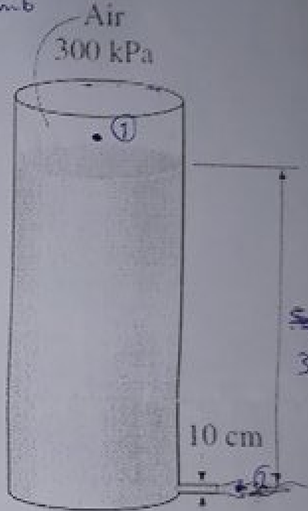
Student No.: [redacted]

Second semester 2016/2017
Student No.:
March 27, 2017

A pressurized reservoir of water has a 10 cm diameter hole at the bottom, where water discharge to the atmosphere as shown in the figure below. The water level is 30 m above the outlet. The tank air pressure above the water level is 300 kPa (absolute) while the atmospheric pressure is 100 kPa. Neglecting friction affects.

a) What are the main energy transformations for the flow from water level inside the reservoir to water outlet section?

b) Estimate the initial discharge volumetric flow rate of water out from the reservoir.



$W_p = 0$ → there is no pumb
$W_f = 0$

atm = 100 k

* Steady state

$$g(z_2 - z_1) + \frac{1}{2\alpha}(u_2^2 - u_1^2) + \frac{P_2 - P_1}{\rho} = W_p - W_f$$

potinial → less
P → less

The potinial energy and the kinetic energy are convert to pressure and some friction.

$Q_2 = ?$ $\quad Q_2 = u_2 A_2$

$$9.8\ m/s^2 \times -30\ m + \frac{1}{2\times 1}(u_2^2 - u_1^2) + \frac{100\ kPa - 300\ kPa}{1000\ kg/m^3} = 0$$

$$-294 + \frac{u_2^2 - u_1^2}{2} + -\frac{200}{1000} = 0$$

$$-294 + \frac{u_2^2 - u_1^2}{2} - 0.2 = 0$$

$$293.8 + \frac{\Delta u^2}{2} = 0$$

$$u_2^2 - u_1^2 = -587.6$$

$$A_2 = \frac{\pi D^2}{4} = \frac{3.14 \times (10\times10^{-2})^2}{4} = 7.85\times10^{-3}\ m^2$$

K = 1000
SI units!

$Q_2 = u_2 A_2$

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9/10

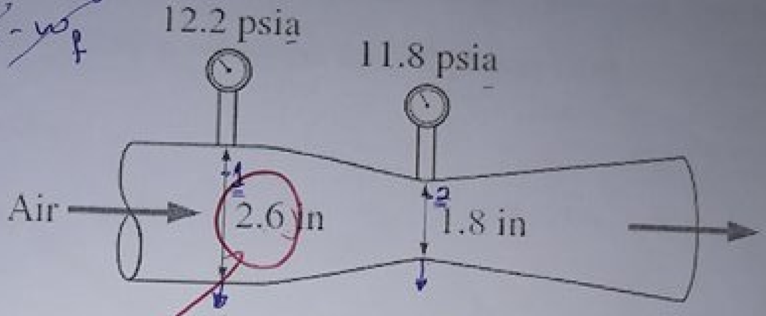
Fluid Mechanics (Section 1)
Student name: [redacted]
Quiz #3
Student No.: [redacted]

Second semester 2016/2017
Student No.: 24
March 27, 2017

Air (density of 0.075 lbm/ft^3) flows steadily according to the figure shown below.

a) What are the main energy transformations for the flow from the section with the diameter 2.6 in to the section with diameter of 1.8 in?

b) Find mass flow rate of air.



$\frac{\Delta P}{\rho} + \frac{1}{2}\Delta u + g\Delta z = W_p - W_f$

$\frac{P_2 - P_1}{\rho} + \frac{1}{2}(u_2^2 - u_1^2) = 0$

under low velocity ρ is constant.

$u_2^2 - u_1^2 = \frac{2(P_1 - P_2)}{\rho}$

$= \frac{2(12.2 - 11.8)\,\frac{lb_f}{in^2} \cdot \frac{(12)^2 (in)^2}{1\,ft^2}}{\frac{0.075\,lbm}{ft^3} \cdot \frac{slug}{32.2\,lbm} \cdot \frac{lb_f \cdot s^2/ft}{slug}}$

a) from pressure to kinetic and some friction

$u_2^2 - u_1^2 = 49612.8 \; \frac{ft^2}{s^2}$

$\dot{V}_1 = \dot{V}_2$

$u_1 A_1 = u_2 A_2$

$u_1 = \frac{A_2}{A_1} u_2$

$= \frac{\frac{\pi}{4} D_2^2}{\frac{\pi}{4} D_1^2} u_2$

$= \frac{D_2^2}{D_1^2} u_2$

$= \left(\frac{1.8}{2.8}\right)^2 \frac{in^2}{in^2} u_2$

2.6 not 2.8

$u_1 = 0.41\, u_2$

$u_2^2 - (0.41)^2 u_2^2 = 49612.8$

$\frac{0.829\, u_2^2}{0.829} = \frac{49612.8}{0.829}$

$u_2 = 244.6$ ft/s

$\dot{V} = u_2 A_2$

$= \frac{244.6\,ft}{s} \cdot \frac{\pi}{4}(1.8)^2\, in^2 \cdot \frac{1\,ft^2}{(12)^2 in^2}$

$= 4.3\; ft^3/s$

$\dot{m} = \rho \dot{V} = \frac{0.075\,lbm}{ft^3} \cdot \frac{1\,slug}{32.2\,lbm} \cdot \frac{4.3\,ft^3}{s}$

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Fluid Mechanics
Student name: [redacted]
Quiz #3
Student No.: [redacted] (13)

First semester 2017/2018
Student No.: 13
November 21, 2017

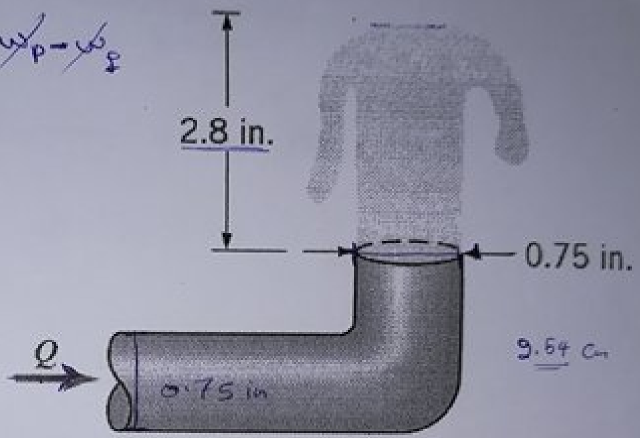
Water is flowing as shown in the figure below. Determine the volumetric flow rate and the mass flow rate.

Q / ṁ

MEB

$\frac{1}{2}(u_2^2 - u_1^2) + g(z_2 - z_1) + \frac{P_2 - P_1}{\rho} = W_P - W_f$

Jet → u_2 = zero



9.54 cm

$\frac{1}{2}(u_2^2 - u_1^2) = g(z_1 - z_2)$

(−2.8 in)

Convert to ft

= in | 1 ft / 12 in

$-\frac{1}{2}u_1^2 = -2.8 * g$ in

$A = \frac{\pi D^2}{4}$

$A = \frac{3.14 * (0.75)^2 \text{ in}^2}{4}$

$u_1^2 = (-2.8g) * -2$

$u_1^2 = 2.8 * 32.2$ ft/s²

A = 3.06 ft²

A = 3.068×10^{-3} ft²

$u_1^2 = 2.8$ in | 32.2 ft/s² | *2 | 1 ft / 12 in

$\dot{m} = Q\rho$

$\dot{m}$ = 11.84 ft³/s | 64 lbm/ft³ | 1 slug / 32.2 lbm

u_1 = 3.87 ft/s

$\dot{m}$ = 23.5 slug/s

Q = u · A

Q = 3.87 ft/s | 3.06 ft² ⇒ Q = 11.84 ft³/s

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Fluid Mechanics
Student name: [redacted]
Quiz #4
Student No.: [redacted]

First semester 2017/2018
Student No.: 13
December 3, 2017

Fluid (density=700 kg/m³) is flowing through a pipe (internal diameter=4 cm, roughness= 0.16 mm, length=100 m) with a rate of 32.3 L/min. It is found that the pressure drop across the pipe is 6.4 kPa. Determine the viscosity of the fluid.

$\rho = 700\ kg/m^3$

$D = 0.04\ m$

$\varepsilon = 1.6 \times 10^{-4}\ m$

$L = 100\ m$

$Q = 32.3\ L/min$

$P_1 - P_2 = 6.4\ kPa$

$\rightarrow Re = \frac{\rho u D}{\mu}$

$\downarrow$

$\mu = \frac{\rho u L}{Re}$

$\mu = \frac{700\ kg}{m^3} \cdot \frac{0.43\ m}{s} \cdot 100\ m \cdot \frac{1}{8\times10^3} =$

$\mu = 3.76\ kg/m.s$

$\rightarrow wf = \frac{P_1 - P_2}{\rho} \Rightarrow wf = \frac{6.4\times10^3\ N}{m^2} \cdot \frac{m^3}{700\ kg} \Rightarrow wf = 9.14\ \frac{N.m}{kg}$

$\Rightarrow wf = \frac{4 f L u^2}{2D}$

$wf = \frac{128 \mu L}{4 D^2 \rho} Q$

$u = Q/A$

$u = \frac{32.3\ L}{min} \cdot \frac{4}{3.14 \times (0.04)^2\ m^2} \cdot \frac{1\ m^3}{1000\ L} \cdot \frac{1\ min}{60\ s}$

$u = 0.43\ m/s$

$\frac{\varepsilon}{D} = 0.004$

$Re = 8\times10^3$

$\downarrow$

turbelant.

$f = 2 \times 0.04\ m \times 9.14\ N.m \cdot \frac{s^2}{4 \times 100\ m \times (0.43)^2\ m^2} = 9.8\times10^{-3}$

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$\frac{19}{20}$

$A = \frac{\pi(D^2 - d^2)}{4}$

Fluid Mechanics (Section 1 & 2) — **Second semester 2016/2017**

Student name: [redacted] — *Student No.:* [redacted] — *Student No.:* 24

Quiz #4 — **March 22, 2017**

Question 1. Give five major differences between Laminar and turbulent flow in pipe:

Laminar flow	Turbulent flow
$u = 0.5 u_{max}$	$u = 0.8 u_{max}$
low ~~translation~~ transfer rate	high ~~translation~~ transfer rate (good mixing)
$u = u_{max}[1 - (\frac{r}{R})^2]$	$u = u_{max}[1 - \frac{r}{R}]^{1/7}$
~~small~~ large boundary layer	Small boundary layer
$\alpha = 0.5$	$\alpha = 1$

5

$\frac{D^2 - d^2}{D + d}$

(5 points)

Question 2. Liquid with density of 890 kg/m³ (ρ) and viscosity of 0.002 kg/(m.s) (μ) flow through smooth annular ($\varepsilon = 0$) with length of 80 m (L). The external diameter of the inside pipe is 5 cm. The average velocity of the liquid is 4.5 m/s (u) and the corresponding head loss is 29.7 m (h_f).

a) Find the pressure drop across the annular?
b) Is this laminar or turbulent flow? Why?
c) Find the internal diameter of the outer pipe.
d) Find the volumetric flow rate of liquid.

$Re = \frac{\rho u D_{eq}}{\mu}$ $\frac{\varepsilon}{D} = 0$ $h_f = \frac{4 f L}{D_{eq}} \frac{u^2}{2g}$

$\rho = 890 \, kg/m^3$
$\mu = 0.002 \, kg/(m.s)$
$\varepsilon = 0$ $d = 5 \times 10^{-2} \, m$
$L = 80 \, m$ $\bar{u} = 4.5 \, m/s$
$h_f = 29.7 \, m$

a) $P_1 - P_2 = \rho g h_f$
$= 890 \times 9.81 \times 29.7$
$= 259.3 \, kPa$ — 3

b) it's turbulent because $Re \geq 4000$ — 1

c) $D_{eq} = \frac{4 f L u^2}{2 g h_f} = 11.12 f$

$f = 0.005$

$D_{eq} = 0.0566 \, m$ — 7

$Re = 1.2 \times 10^5 \rightarrow f = 0.0045$
$\frac{\varepsilon}{D} = 0 \rightarrow$

0.0044

$D_{eq} = 0.05 \, m$
$Re = 1 \times 10^5 \} \rightarrow f = 0.0045$

$D_{eq} = D - d$
$0.05 = D - 0.05$
$D = 0.1 \, m$ #

$Q = u A$ $\frac{\pi}{4}(D^2 - d^2)$
$= 4.5 \times \frac{\pi}{4}((0.1)^2 - (0.05)^2)$ 7.5×10^{-3}
$0.027 \, m^3/s$ — 3

(15 points)

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10/10
Excellent

Fluid Mechanics (Section 1)
Student name: [redacted]
Quiz #5
Student No.: [redacted]
Second semester 2016/2017
Student No.: 24
May 2, 2017

Water enters a centrifugal pump at radius of 1.5 in and leaves at a radius of 7 in. The total flow rate is 400 LPM. The steady-state torque exerted on the rotor is 30 J. Find the rotational speed of the pump impeller in rpm. Neglect friction.

$$T_{net} = \dot{m}\left[(\bar{r}u_\theta)_{out} - (\bar{r}u_\theta)_{in}\right]$$

$u_\theta = r\omega$

$T_{net} = \dot{m}\,[r_{out}^2\omega - r_{in}^2\omega]$

$T_{net} = \rho Q\omega\,[r_{out}^2 - r_{in}^2]$

$\omega = \dfrac{T_{net}}{\rho Q[r_{out}^2 - r_{in}^2]}$

$r_{in} = 1.5\ in \,\Big|\, \dfrac{1\ m}{39.37\ in} = 0.0381\ m$

$r_{out} = 7\ in \,\Big|\, \dfrac{1\ m}{39.37\ in} = 0.1778\ m$

$Q = \dfrac{400\ L}{min} \,\Big|\, \dfrac{1\ m^3}{1000\ L} \,\Big|\, \dfrac{1\ min}{60\ s} = 6.67\times10^{-3}\ m^3/s$

$\omega = \dfrac{30}{1000\ \frac{kg}{m^3} \times 6.67\times10^{-3} \times [(0.1778)^2 - (0.0381)^2]}$ 0.030

$\omega = 149.12\ rad/s$

$\dfrac{\omega}{2\pi} = \dfrac{149.12}{2\pi} \times 60 = 1423.99\ rpm$

$r = 1.5\ in$

$r_{out} = 7\ in$

$Q = 400\ LPM$

$T = 30\ J$

$u_\theta = ??$

$r\omega$

$\dfrac{rpm \times 2\pi}{60}$

$\dfrac{rad/s \times 60}{2\pi}$

$\omega \to \dfrac{2\pi}{60}$

$\dfrac{rpm \times 2\pi}{60\ s} = \dfrac{rad/s \times 60}{2\pi}$

$\dfrac{kg \cdot m^2/s^2}{\frac{kg}{m^3} \,\big|\, \frac{m^3}{s} \,\big|\, m^2}$ $\dfrac{1}{s}$

$\dfrac{60\ s}{s \,|\, 1\ min}$

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$\frac{3}{10}$

Fluid Mechanics (Section 2)
Student name: [redacted]
Student No.:
Quiz #5

Second semester 2016/2017
Student No.: [redacted]
May 2, 2017

$\dot{W} = 3\,kW$

The motor which drives a pump is supplied by 3 kW to pump 12 MPH of water. If the efficiency of the pump is 60%, find the pressure rise across the pump in kPa. What is the head of the pump in meters?

ΔP $\quad h_p$

$\dot{W}_{total} = 3 \times 10^3$

$Q = 12\ \frac{m^3}{h} = \frac{12}{3600} = 3.3 \times 10^{-3}\ m^3/s$

$\rho = 10^3\ \frac{kg}{m^3}$

$\text{efficiency} = \frac{\dot{W}_p}{\dot{W}_{total}} = \frac{\dot{m}\, W_p}{\dot{W}_{total}} = \frac{\rho Q\, \dot{W}_p}{\dot{W}_{total}}$

$\dot{W} = 3\,kW$
$\eta = 60\%$
$P = ??\ kPa$
$h_p = ??$

$\eta = \frac{\dot{W}_p}{W} \rightarrow \dot{W}_p =$

$0.60 = \frac{\dot{W}_p}{3 \times 10^3} \rightarrow \dot{W}_p = 1800\ W$

$\dot{W}_p = 1800\,W$
$\dot{W}_p = \frac{\dot{W}_p}{\dot{m}} = 1800\,W$

$g(z_2 - z_1) + \frac{1}{2}(u_2^2 - u_1^2) + \frac{P_2 - P_1}{\rho} = W_p - \cancel{W_f}$

$W_p = \frac{P_2 - P_1}{\rho}$

$1800 = \frac{\Delta P}{1000}$

$\Delta P = 1800\ kPa$

$\dot{W}_p = \dot{m}\, W_p$

$\dot{W}_p$ not W_p

$\text{head} \rightarrow \frac{W_p}{g} = \frac{\dot{W}_p\, m}{g} = \frac{\dot{W}_p\, \rho Q}{g} = \frac{1800 \times 10^3 \times 3.3 \times 10^{-3}}{9.8}$

$= 606.1\ m$

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Fluid Mechanics
Student name: [redacted]
Quiz #5

Student No.: 13

First semester 2017/2018
Student No.: [redacted]
December 19, 2017

A. Mention six parameters that must be involved in pump selection:

1) Natural of liquid in the pump

2) Coast of the pump

3) weight of the pump

4) suction and discharge Natural

5) the place of the pump

6)

Conditions

B. Give two types of:

- **Rotary pumps:** → Gear
  screw

- **Reciprocating pumps** → Single piston
  double piston