University of Technology

Engineering Department of Building and Construction

Final Exam-First attempt 2014-2015

Subject: Fluid Mechanics Year: Second

Division: All Divisions Time: 3 hours.

Examiner: Fluid mechanics committee Date :27/5/2015

Answer FIVE Questions Only

Q1: A- *1))* For a wide rectangular open channel flow show that: - $F_r^2 = \frac{8}{f} S_o$

where F_r= Froude No., f= friction factor and S_o=Slope of the bed. *(7 Marks)*.

2)) Write the following quantities in M.LT and F.L.T dimensions:-

I) Shear velocity. II) Critical slope. III) Chezy's constant. IV) Mass density. *(8 Marks).*

B –Dose water boil at higher temperature or higher pressure? Why? Explain the principle of "Pressure Pot cooker" *(6 Marks).*

Q2: A) –Fill in the blanks with *"increases" or "decreases" or "remains constant"* : - *(8 Marks).*

1- As tube diameter decreases the capillary rise ____.

2- In a fluid at rest, the pressure at a point_____.

3- The force due to liquid pressure ____with depth of immersion.

4- If the changing in velocity with time is ____then the type of flow named by steady flow.

5-In flow over a flat plate, the boundary layer thickness ____with distance.

6- Minor losses will ____ as velocity increases.

7- Drag force ____ with increase in free stream velocity.

8- For a given specific energy, as the flow depth increases Froude number will ____.

B) – For the steady entrance flow in a pipe shown in figure (1) develops from uniform flow velocity (V_{o1}) at section (1) to laminar paraboloid velocity ($V_{o2}=\frac{4}{3}V_{o1}$) at section (2),velocity distribution [$V=V_{max}(1-r^2/R^2)$].Show that the force (F) is equal to [F= $(F_1 - F_2 - \frac{1}{3}\rho V_o^2 \pi R^2)$] where R= radius of pipe,F_1,F_2= Forces at section 1 and 2 respectively, V= mean velocity and $V_{max.}$=maximum velocity. *(5 Marks).*

C) – The area of a square gate is (12.69m²) provided in oil tank is hinged at its top edge as shown in figure (2).The tank contains gasoline up to a height of 1.8m above the top edge of the plate. The space above the oil is subjected to a negative pressure of 8250N/m². Determine the necessary vertical pull to be applied at the lower edge to open the gate. *(7 Marks).*

Q3: A) – Consider two identical small glasses balls dropped into two identical containers, one filled with water and the other with oil. Which ball will reach the bottom of the container first? Why? *(5 Marks).*

B) – A vented tanker is to be filled with fuel oil as shown in figure (3), with ρ =920 kg/m³ and (μ= 0.045 kg/m.s) from an underground reservoir by smooth plastic hose a 20m-long, 5cm-diameter with a slightly rounded entrance[k=0.12] and two smooth bends 90° [k=0.3]. The elevation difference between the oil level in the reservoir and the top of the tanker where the hose is discharged is 5 m. The capacity of the tanker is 18 m³ and the filling time is 30 min.Assume an overall efficiency of the pump is 82 percent; determine the required power input to the pump. *(8 Marks).*

C) – 1)) Consider a person walking first in air and then in water at the same speed. For which motion will the Reynolds number be higher? *(4 Marks).*

2)) What are the differences between manometer and piezometer? *(3 Marks).*

Q4: A) – Firefighters are holding a nozzle at the end of a hose while trying to extinguish a fire figure (4).If the nozzle exit diameter is 6 cm and the water flow rate is 5 m^3/min, determine:- {Assume the water enters the control volume vertically}
I) the average water exit velocity. II) the horizontal resistance force required by the firefighters to hold the nozzle. *(8 Marks).*

B) - For a given flow rate through an open channel, the variation of specific energy with flow depth is studied. One person claims that the specific energy of the fluid will be minimum when the flow is critical, but another person claims that the specific energy will be minimum when the flow is subcritical. What is your opinion? And draw the equation of specific energy [$E_s = Y + \frac{V^2}{2g}$]. *(6 Marks).*

C) – Consider a 1.8-m tall man standing vertically in water and completely submerged in a pool. Determine the difference between the pressures acting at the head and at the toes of this man, in kPa. *(6 Marks).*

Q5: A) – A car runs out of gasoline (ρ = 750 kg/m^3) as shown in figure (5), with a small diameter hose, and to start the siphon work ,it is necessary to insert one siphon end in the full gas tank and the other end in a gas can below the level of the gas tank fill. The hose of the siphon filled with gasoline via suction.
The siphon diameter is 4 mm, and frictional losses in the siphon are to be disregarded.
Determine: - a) The velocity in the hose and minimum time required withdrawing 4litter of gasoline from the tank to the can. *(8 Marks).*
b) The pressure at point (3).

B) – Define the following: - I) kinematics of fluids. II) Flow nets. *(6 Marks).*
III) Normal and tangential accelerations.

C) – In figure (6) when open tubes called piezometers are connected to a tank of liquid under pressure, the liquid rises to piezometer. If P_A is the pressure at point (A). *(6 Marks).*
Are the piezometers rise to the same level ($h = \frac{P_A}{\gamma}$)?

Q6:- A) A brick rectangular channel with bed slope of 0.002 is designed to carry 6.372m^3/s of water in uniform flow. There is an argument about whether the channel width should be (1.22m) or (2.44m).Which design needs for less bricks? *(8 Marks).*

B) A viscous liquid is flowing laminarly in a pipe of 6cm diameter, the velocity profile is $V = K\left(\left[1 - \frac{r^2}{R}\right]\right)$. A pitot tube at a distance of 2cm from the center line of the pipe indicates a velocity of 0.6m/s. Calculate the maximum velocity, mean velocity and the rate of flow through the pipe. *(6 Marks).*

C) – Determine the diameter of galvanized iron pipe is needed to be "Hydraulically smooth"(e=0.0005) at R_e= 3.5×10^5?

(6 Marks).

With Best Wishes For Your Success

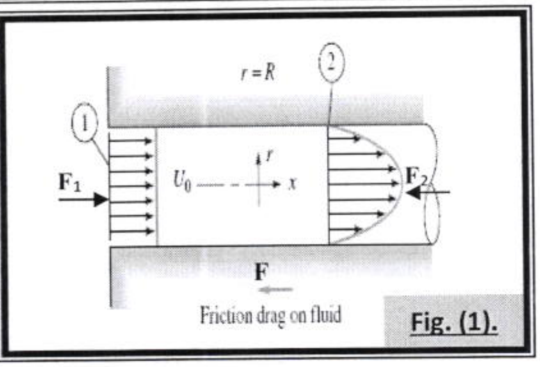


Fig. (1).

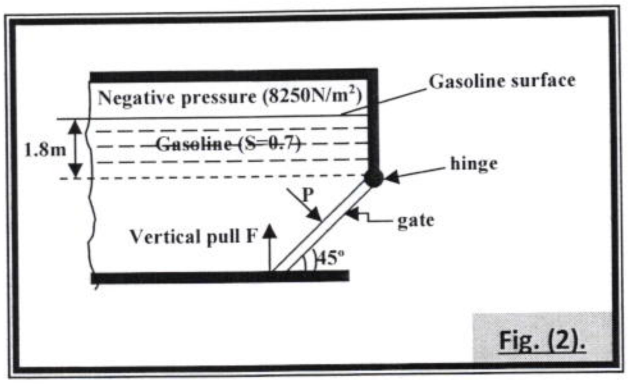


Fig. (2).

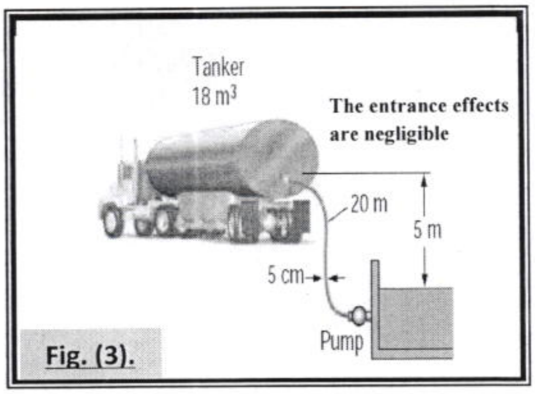


Fig. (3).

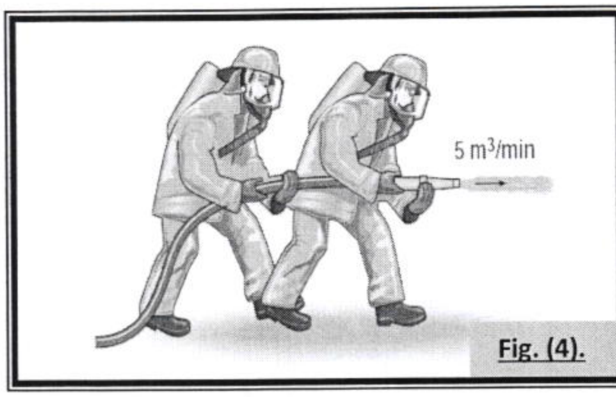


Fig. (4).

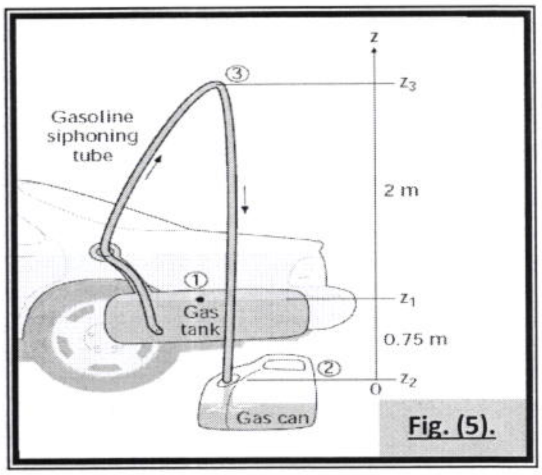


Fig. (5).

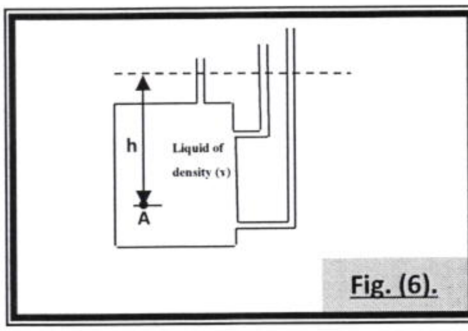
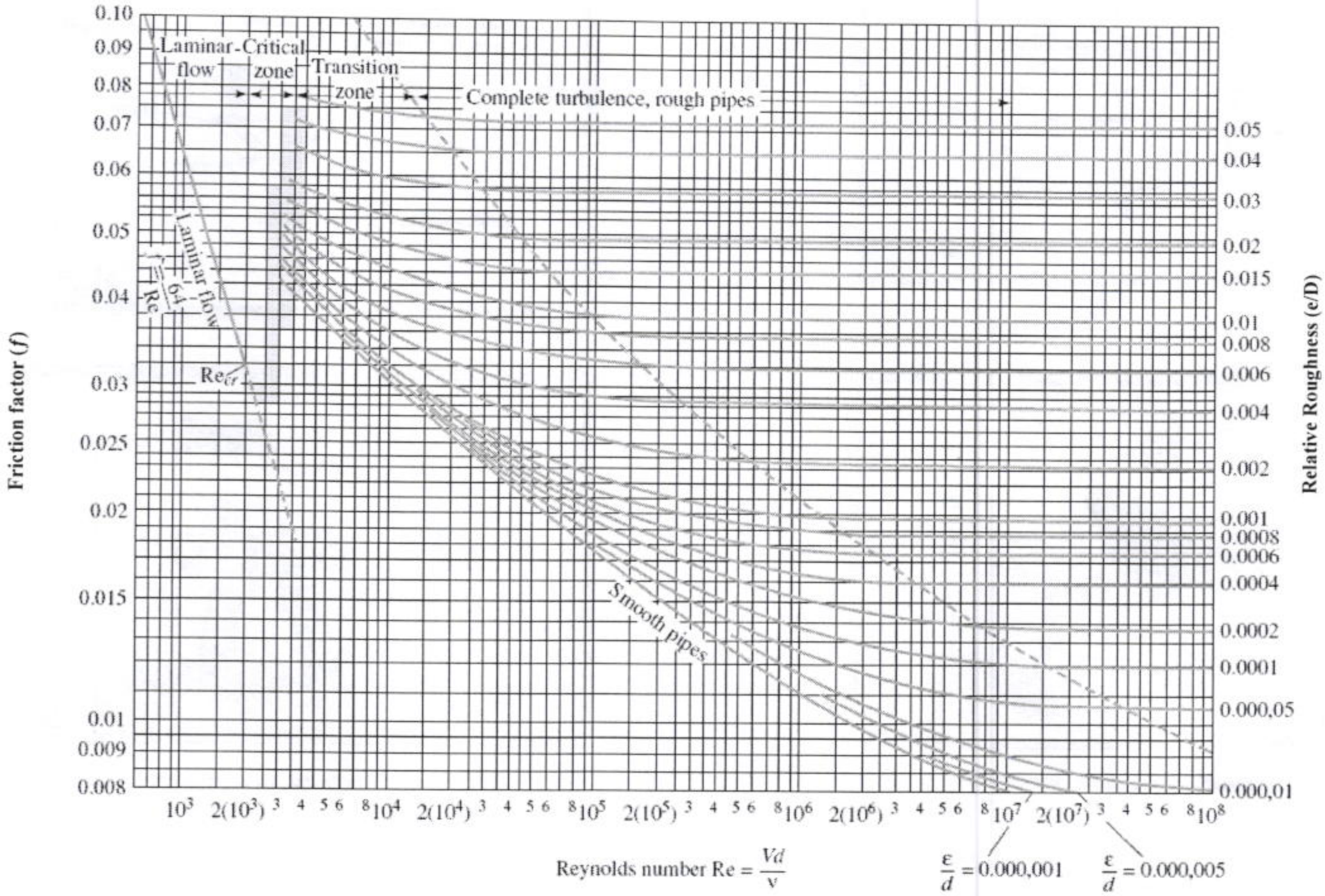


Fig. (6).

Values of Manning's Roughness	
Natural of surface	**n**
Concrete Precast	0.013
Cement mortar surface	0.015
Common – clay drainage tile	0.017
Concrete monolithic	0.016
Smooth concrete	0.012
Brick	0.015
In rock cuts smooth	0.035
Rough beds a Fig. (5). sides	0.04



The Moody chart for pipe friction with smooth and rough walls.

Ideal solution

for fluid Mechanics

First attempt 2014-2015

Q.1 A) ① $Fr = \frac{V}{\sqrt{g y_h}}$ & $V = C\sqrt{R_h S_e}$ [from chezy's formula]

$R_h = y$ [for wide rectangle channel]

$[Fr.\sqrt{gy} = C\sqrt{R_h S_e}]$ By sequaring two side

$Fr^2 . gy = C^2 y S_e \Rightarrow Fr^2 = \frac{C^2 y . S_e}{g y} = \frac{C^2 . S_e}{g}$

& $C = \sqrt{\frac{8g}{f}}$ $\therefore Fr^2 = \frac{8g}{f} . \frac{S_e}{g} = \frac{8 S_e}{f}$

② (I) Shear velocity $= \frac{m}{s} \xrightarrow{by}$ M.L.T $\to LT^{-1}$
F.L.T $\to LT^{-1}$

(II) Critical slope $= \frac{m}{m} \xrightarrow{by}$ M.L.T $\to 1$
F.L.T $\to 1$

(III) Chezy's const. $= \sqrt{\frac{m}{s^2}} \xrightarrow{by}$ M.L.T $\to L^{0.5} . T^{-1}$
F.L.T $\to L^{0.5} . T^{-1}$

(IV) Mass density $= \frac{kg}{m^3} \xrightarrow{by}$ M.L.T $\to M . L^{-3}$

$kg = \frac{N.s^2}{m} = \frac{N.s^2}{m^4} \Rightarrow$ F.L.T $\to F . L^{-4} . T^2$

B) water boil at higher pressure & higher temp. because when increase a pressure the temp. also increase.

<u>pressure cooke</u> it cooks a lot faster than an oridinary pan by maintaning a higher pressure & higher temp. inside it.

Q.2 A) 1- increases. 2- remains constant. 3- increases
4- remains constant. 5- increases. 6- increases
7- increases. 8. decreases

B) By applying momentum eq.

$$\Sigma F_x = -F + (F_1 - F_2) = \rho Q \Delta V$$

$$F = \left[F_1 - F_2 - \rho v_0 \left(\tfrac{4}{3} v_0 - v_0\right) \cdot A\right]$$

$$\therefore F = F_1 - F_2 - \tfrac{1}{3} \rho v_0^2 \cdot \pi R^2$$

C) $h = \frac{P}{\gamma} = \frac{8250}{0.7 * 9810} = 1.2\,m$

The negative pressure will reduce the head above oil by $1.8 - 1.2 = 0.6\,m$ $\quad$ ($A = 12.69, \sqrt{A} = 3.6$)

$$h_c = 0.6 + \frac{3.6}{2}\sin 45 = 1.873\,m$$

$$P = \gamma h_c A = 0.7 \times 9810 \times 12.69 \times 1.873 = 16669\,N$$

Center of pressure $h_p = \frac{I_G \sin^2\theta}{A h_c} + h_c$

$$= \frac{\frac{1}{12} \times 3.6 (3.6)^3 (\sin 45)^2}{12.69 \times 1.873} + 1.873$$

$$= 2.16$$

vertical distance of center of pressure below top edge

$$= 2.16 - 0.6 = 1.56\,m$$

Taking moment about the hinge

$$F \times \sin 45 \times 3.6 = P \times \frac{1.56}{\sin 45}$$

$$\therefore F = \frac{P \times 1.56}{3.6 \times (\sin 45)^2} = \frac{166690 \times 1.56}{3.6 \times (\sin 45)^2}$$

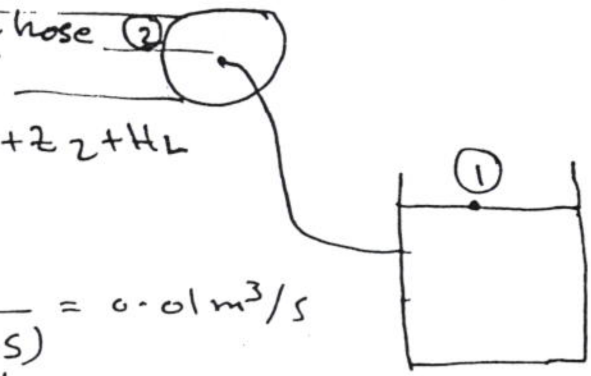
$$= 144465\,N$$

Q.3 A) the ball dropped in water reach the bottom of the Container first because of the much lower viscosity of water relative to oil.

B) Applying Bernolli's eq. between ① & ②

Point ① at the free surface of oil in the reservoir

Point ② at the exit of the hose in the beaker



$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1+E_P=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2+H_L$$

where $H_L = h_f + \Sigma K\left(\frac{V^2}{2g}\right)$

$$Q=\frac{\text{Volume}}{\text{Time}}=\frac{18}{(30\times 60s)}=0.01\,m^3/s$$

then $V_2=\frac{Q}{A}=\frac{0.01}{\frac{\pi}{4}(0.05)^2}=5.093\ m/s$

$$Re=\frac{\rho v D}{\mu}=\frac{920\times 5.093\times 0.05}{0.045}=5206$$

from Moody digram $e=0$ (smooth) & $Re=5206$

$f = 0.037$

$\Sigma K_L = 0.12 + 2 * 0.3 = 0.72$

$$H_L=\left(f\cdot\frac{L}{D}+\Sigma K_L\right)\frac{V_2^2}{2g}=\left(0.037\times\frac{20}{0.05}+0.72\right)\left(\frac{5.093^2}{19.62}\right)$$

$= 20.5\,m$

Sub. in Bernolli eq. $\Rightarrow E_P=\frac{V_2^2}{2g}+Z_2+H_L$

$E_P = 26.9$

$P_{rp} = Q\gamma E_P = 0.01\times(920\times 9.81)(26.9) = 2.427\ kW$

eff. of pump 82% then $P_{rp}=\frac{2.427}{0.82}=2.96\ kW$

C) ① Reynolds No. is inversely proportional to kinematic viscosity, which is much smaller for water than for air therefore (Re) is higher for motion in water for the same dia & speed. of Course it is not possible to walk as fast in water as in air.

② the diffrences between Manometer & Pitometer in the pizometer used the same oil or fluid which is measured pressure

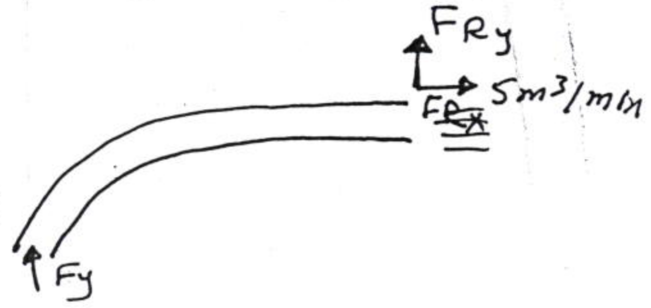
But manomiter using another fluid in it.

Q.4 A) $v = \frac{Q}{A} = \frac{5 m^3/min}{\frac{\pi}{4}(0.06)^2} = 1768\ m/min = 29.5\ m/s$

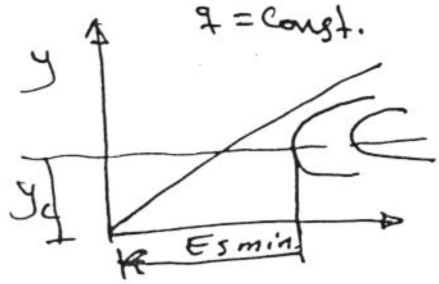
$\Sigma F = \Sigma(\text{Momentum})_{out} - \Sigma(\text{momentum})_{in}$

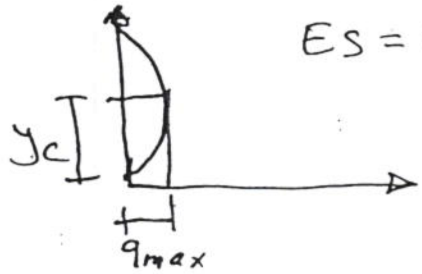
$F_{R_x} = \rho Q V - 0$

$= 1000 * \frac{5}{60} \times 29.5 = 2457 N$



B) The point of min. specific energy is the critical point, and thus the first person is correct.





Es = Const.

C) $P_{head} = P_{atm.} + \gamma h_{head}$ & $P_{toe} = P_{atm.} + \gamma h_{toe}$

$P_{toe} - P_{head} = \gamma(h_{toe} - h_{head})$

$= \frac{1000 \times 9.81}{1000}(1.8 - 0) = 17.7\ kPa.$

Q.5 A) By applying Bernollis eq. between ① & ②

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 \Rightarrow z_1 = \frac{V_2^2}{2g} \quad \&$$

$$V_2 = \sqrt{2gz_1} = \sqrt{19.62 * 0.75} = 3.84 \text{ m/s}$$

$$Q = V_2 A = 3.84 \times \frac{\pi}{4}(0.005)^2 = 7.53 \times 10^{-5} \frac{m^3}{s} = 0.0753 \text{ L/s}$$

then the time needed to Siphon (4 Litter) of gasoline

$$\frac{4L}{0.0753} = 53.1 \text{ Second}$$

to find the pressure at point ③

applying Bernollis eq. between point ② & ③

$$\frac{P_{2atm}}{\gamma} + \frac{V_2^2}{2g} + z_2 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_3$$

$$\frac{P_{2atm}}{\gamma} = \frac{P_3}{\gamma} + z_3 \Rightarrow P_3 = P_{atm} - \gamma z_3$$
$$= 81.1 \text{ kPa.}$$

B) I - Kinamitiss of fluid :- describe the fluid movement with respect to displacent, velocity & accleration.

II - Flow net :- it is produce by drawing the stream lines and equipotintial lines perpendicular to each othars.

III - Normal & tangutial accelrations :-

Normal it is produced when changes velocity in direction (a_r)

tangutial it is produced when chnges velocity in magnitude. (a_s)

C) yes, be cause atmospheric pressure is the Same at all three peizometers surface, and all are Connected by ((water path)) to point (A) therefore have the Same level.

Q.6 A) $Q = 6.372 = \frac{1}{0.015}\left(by\left(\frac{by}{b+2y}\right)\right)^{\frac{2}{3}}(0.002)^{\frac{1}{2}}$

(a) b = 1.22 Solve for y = 2.8 m then. P = wetted perimeter = 6.8 m

(b) 2.44 Solve for y = 1.2 m then P = 4.8 m

∴ use b = 2.44 m then needs 28% loss brik if using this width.

B) $V = \left[1 - \left(\frac{r}{R}\right)^2\right]K \Rightarrow 0.6 = \left[1 - \left(\frac{0.02}{0.03}\right)^2\right]K$

K = 1.08

max. velocity at r = 0

∴ $V_{max} = (1 - 0) \times 1.08 = 1.08$ m/s

mean velocity $= \frac{1}{2} V_{max} = 0.54$ m/s

$Q = 0.54 \times \frac{\pi}{4} \times (0.06)^2 = 0.00152\ m^3/s$

C) From mody digram [Smooth value of $\frac{e}{D} = 0.00001$]

this value of relative roughness is equvelent to smooth pipe

$\frac{e}{D} = 0.00001 = \frac{0.0005}{d} \Rightarrow d = 50$