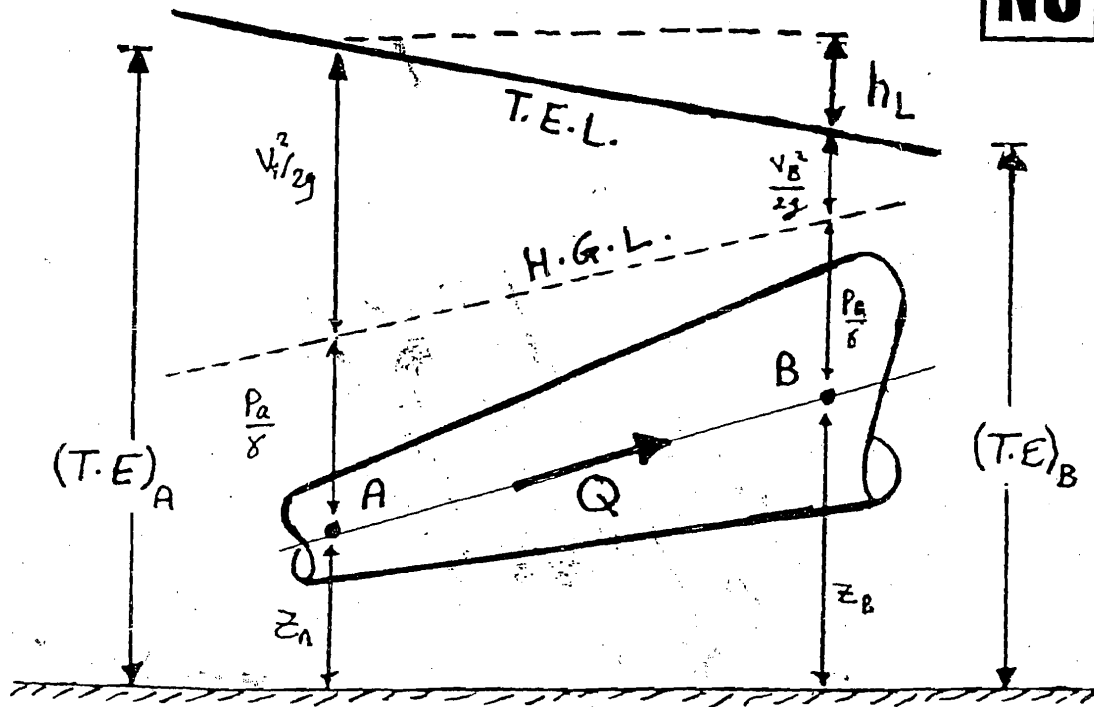


INTRODUCTION TO THE ENERGY EQUATION

6

NO 12



← يتحرك السائل من النقطه التي لها طاقه اكبر (A) الى النقطه التي لها طاقه اقل "B" مكوناً فقد في الطاقه يسمى head loss (h_L)

← طاقه اى سائل تتكون من ٣ عناصر ① طاقه موقع : z : Position head

② طاقه ضغط : $\frac{P}{\gamma}$: Pressure head

③ طاقه حركه : $\frac{V^2}{2g}$: Velocity head

energy Eq.:

$$(T.E)_A = (T.E)_B + h_L$$

معادله الطاقه

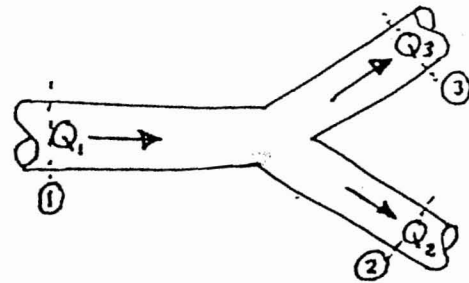
$$z_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} = z_B + \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + h_L$$

• Continuity Equation

$$Q = V \cdot A$$

(2)

$$Q_1 = Q_2 + Q_3$$



T.E.L. total energy line

هو الخط الواصل بين قيم الطاقة الكلية عند المقاطعات المختلفة

H.G.L. Hydraulic gradient line

هو الخط الواصل بين مجموع قيم $(z + \frac{P}{\rho g})$ للمقاطع المختلفة

• direction of flow : اتجاه التصريف من الطاقة الأعلى للطاقة الأقل

• datum : مستوى المقارنة الاختياري بفض اختياره أو من نقطة في الماء

T.E.L.

• مائل في اتجاه التصريف

• افقى عندما 1- الفواقد مهملة

$$h_L = 0.0$$

2- لا يوجد احتكاك

$$V = 0.0$$

H.G.L.

• يوازي T.E.L عند السرعة ثابتة

• ينطبق مع T.E.L عندما السرعة = صفر

• يتقاطع مع المسورة عندما $P = 0.0$

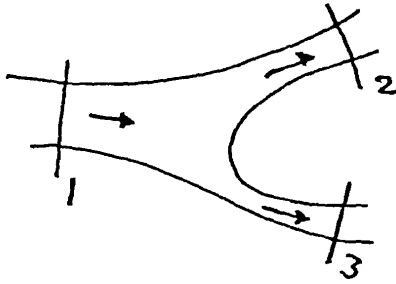
• ... عندما $P = -ve$

③ ملحوظة هامة

لا يتم تطبيق معادلة الطاقة energy equation إلا على خط سريان.

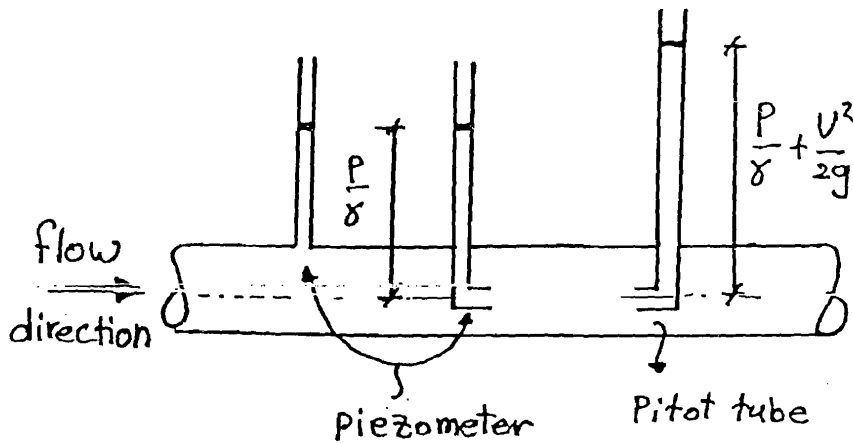


مثال هنا يتم تطبيق معادلة الطاقة بين ① و ② .
لا يتم تطبيق معادلة الطاقة بين ② و ③



• أي ضغط مجهول يتم حسابه من معادلة الطاقة

• لاحظ الفرق بين :-



• خلايا بالك من وحدات ②

m^3/s

or

lit/s

or

m^3/hr

✓

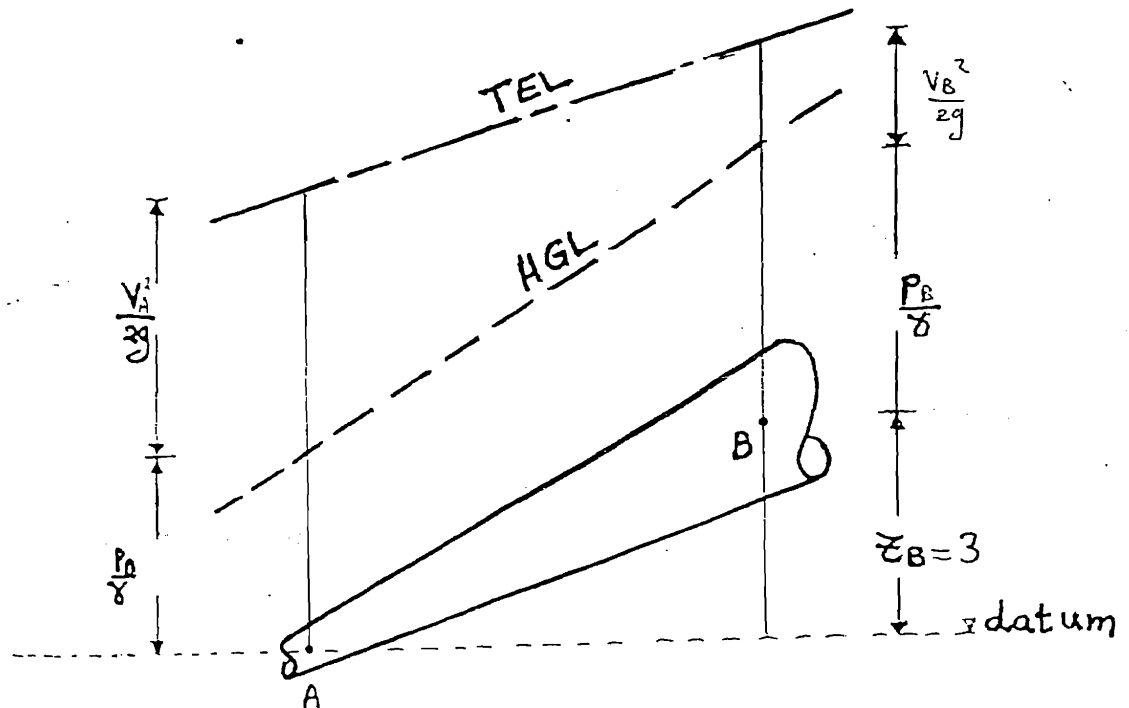
$\times 10^{-3}$

$\times 1/60 \times 60$

Problem (1) sh#7

(4)

A 150 lit/sec of oil ($S=0.9$) is flowing through an inclined pipe. The pipe diameter changes from 15 cm at sec A to 30 cm at sec B which lies 3.0 m vertically above sec A. The pressure at A is 0.30 kg/cm^2 while the pressure at B is equivalent to 0.40 m of mercury. Find the direction of flow and the losses between A & B. Draw the total energy line (T.E.L.) and the hydraulic gradient line (H.G.L.).



Given

$$Q = 150 \text{ lit/s} = 0.15 \text{ m}^3/\text{s}$$

$$P_A = 0.3 \text{ kg/cm}^2 \times \frac{10^{-3}}{10^{-4}} = 3 \text{ t/m}^2$$

$$P_B = 0.4 \times 13.6 = 5.44 \text{ t/m}^2$$

$$S = 0.9$$

Req

1- Flow direction

2. draw TEL & HGL

3- losses.

Solution

⑤

$$V_A = \frac{Q}{A} = \frac{0.15}{\pi/4 * 0.15^2} = 8.48 \text{ m/s}$$

$$V_B = \frac{Q}{A} = \frac{0.15}{\pi/4 * 0.3^2} = 2.12 \text{ m/s}$$

(T.E.)_A الطاقة الكلية لنقطة "A"

$$\begin{aligned} (T.E.)_A &= Z_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} \\ &= 0.0 + \frac{3}{0.9} + \frac{8.48^2}{2g} = 7.00 \text{ m} \end{aligned}$$

(T.E.)_B الطاقة الكلية لنقطة "B"

$$= 3 + \frac{5.144}{0.9} + \frac{2.12^2}{2g} = 9.27 \text{ m}$$

$$(T.E.)_B > (T.E.)_A$$

∴ flow direction from "B" to "A"

$$(T.E.)_B = (T.E.)_A + h_{L_{B \rightarrow A}}$$

$$9.27 = 7.00 + h_{L_{A-B}}$$

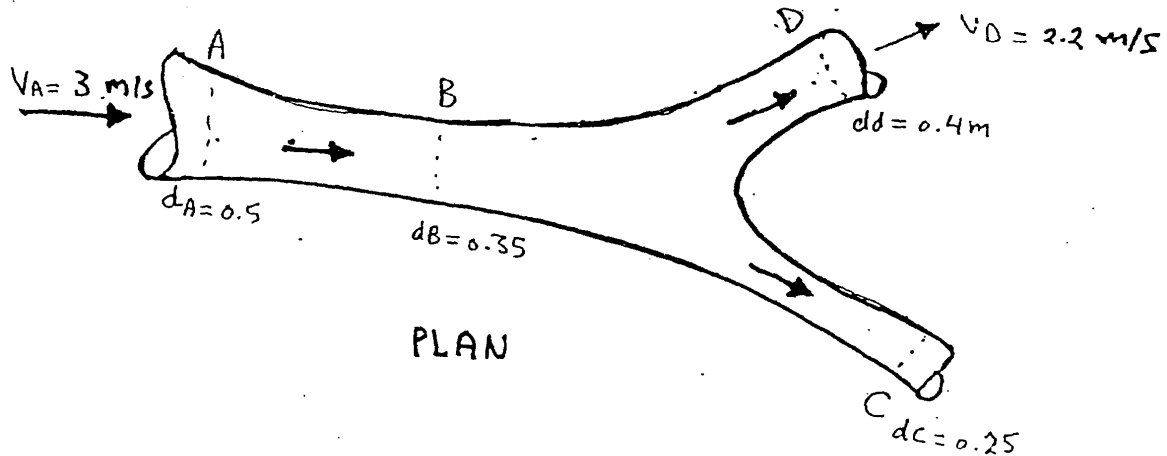
$$\therefore h_{L_{A-B}} = 2.27 \text{ m}$$

PRoblem (4) sh#7

⑥

For the shown horizontal pipe in Fig. (41). the diameters at A, B, C and D are 50cm, 35, 25 and 40 cm respectively. The mean velocities at A and D are 3.0 and 2.2 m/sec respectively, Find:

- The discharge through the three parts.
- The mean velocities at B and C.
- If the pressure at A is 1.5 Kg/cm^2 , calculate the pressure at C and B. (Neglect all hydraulic losses).



SOL.

1 Q_A, D, C ?

$$Q_A = V_A A_A = 3.0 \times \frac{\pi}{4} \times 0.5^2 = 0.59 \text{ m}^3/\text{sec}$$

$$Q_D = V_D A_D = 2.2 \times \frac{\pi}{4} \times 0.4^2 = 0.27 \text{ m}^3/\text{sec}$$

$$(ماتجاه السريان) \quad Q_C = Q_A - Q_D = 0.32 \text{ m}^3/\text{s}$$

2 V_B, V_C ?

$$V_B = \frac{Q_B}{A_B} = \frac{0.59}{\frac{\pi}{4} \times 0.35^2} = 6.13 \text{ m/s}$$

$$V_C = \frac{Q_C}{A_C} = \frac{0.32}{\frac{\pi}{4} \times 0.25^2} = 6.52 \text{ m/s}$$

(7)

3 $P_B?$

$$P_A = 1,5 \text{ Kg/cm}^2 = 15 \text{ t/m}^2$$

Eng. Eq. bet. A & B

$$Z_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} = Z_B + \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + h_L \quad \text{neglected}$$

$$0.0 + \frac{15}{1} + \frac{3.0^2}{2g} = 0.0 + \frac{P_B}{1.0} + \frac{6.13^2}{2g}$$

$$P_B = 13,24 \text{ t/m}^2$$

4 $P_C?$

Eng. Eq. bet. A & C

$$Z_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} = Z_B + \frac{P_C}{\gamma} + \frac{V_C^2}{2g} + h_L \quad \text{neglected}$$

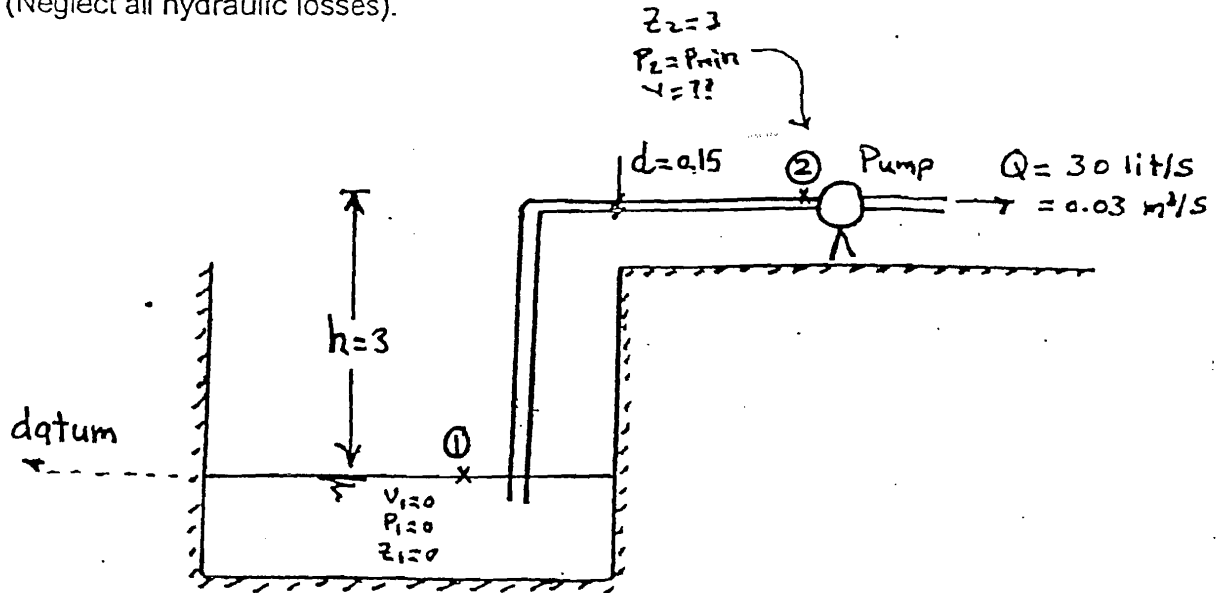
$$0.0 + \frac{15}{1.0} + \frac{3.0}{2g} = 0.0 + \frac{P_C}{1.0} + \frac{6.52^2}{2g}$$

$$P_C = 12,98 \text{ t/m}^2$$

PROBLEM (3) sh#7

(8)

Fig. (40) shows a sketch for a pump used to lift water from a ground tank. For the given data, find the minimum pressure in the shown pipe. Find the maximum height of the pump if the minimum allowable absolute pressure in the pipe is 0.5 kg/cm^2 (Neglect all hydraulic losses).



SOL.

1- $P_{min} :=$

يكون اقل ضغط في انما سور قبل ال Pump مباشرة اي عند نقطة "2"

$$V = \frac{Q}{A} = \frac{0.03}{\pi/4 \times 0.15^2} = 1.69 \text{ m/s}$$

Eng Eq bet. ① & ②

$$0 + 0 + 0 = 3.0 + \frac{P_2}{\gamma} + \frac{1.69^2}{2g}$$

$$\therefore P_2 = -3.14 \text{ t/m}^2$$

سالب يعني سوي

$h_{max} :=$

$$\therefore P_2 = 5 - 10.33 = -5.33 \text{ t/m}^2$$

Eng. Eq ① & ②

$$0 + 0 + 0 = h_{max} + \frac{-5.33}{1} + \frac{1.69^2}{2g}$$

$$h_{max} = 5.10 \text{ m}$$

Problem (2) Sh#7

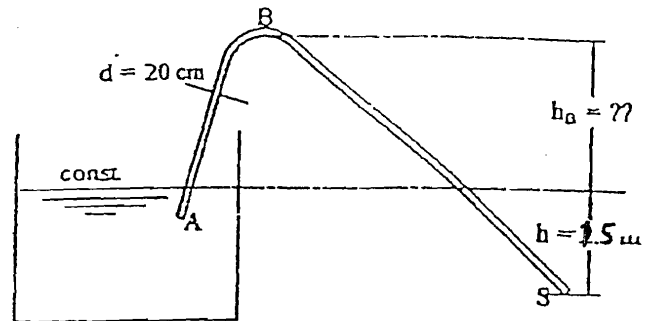
(9)

Fig. (39) shows a sketch of a siphon pipe ABS. If the minimum absolute pressure in the pipe is 3.33 t/m^2 , find the maximum height h_B , the velocity and discharge. (Neglect energy losses). Draw T.E.L. and H.G.L. Show two different methods to double the flow through the siphon. Discuss the effect of increasing the distance h_B on the discharge.

Given

• ABS Siphon Pipe

• min. abs. Pressure = 3.33 t/m^2



Required

1. Velocity & discharge.

2. The maximum height " h_B ".

3. Draw T.E.L & H.G.L.

4. Show 2 methods to increase " Q ".

× لكل نقطة يوجد عند أعلى نقطة خرابا دور

SOL :-

$$P_A = P_S = 0.0$$

الضغط عند نقطة A و S معروف = صفر

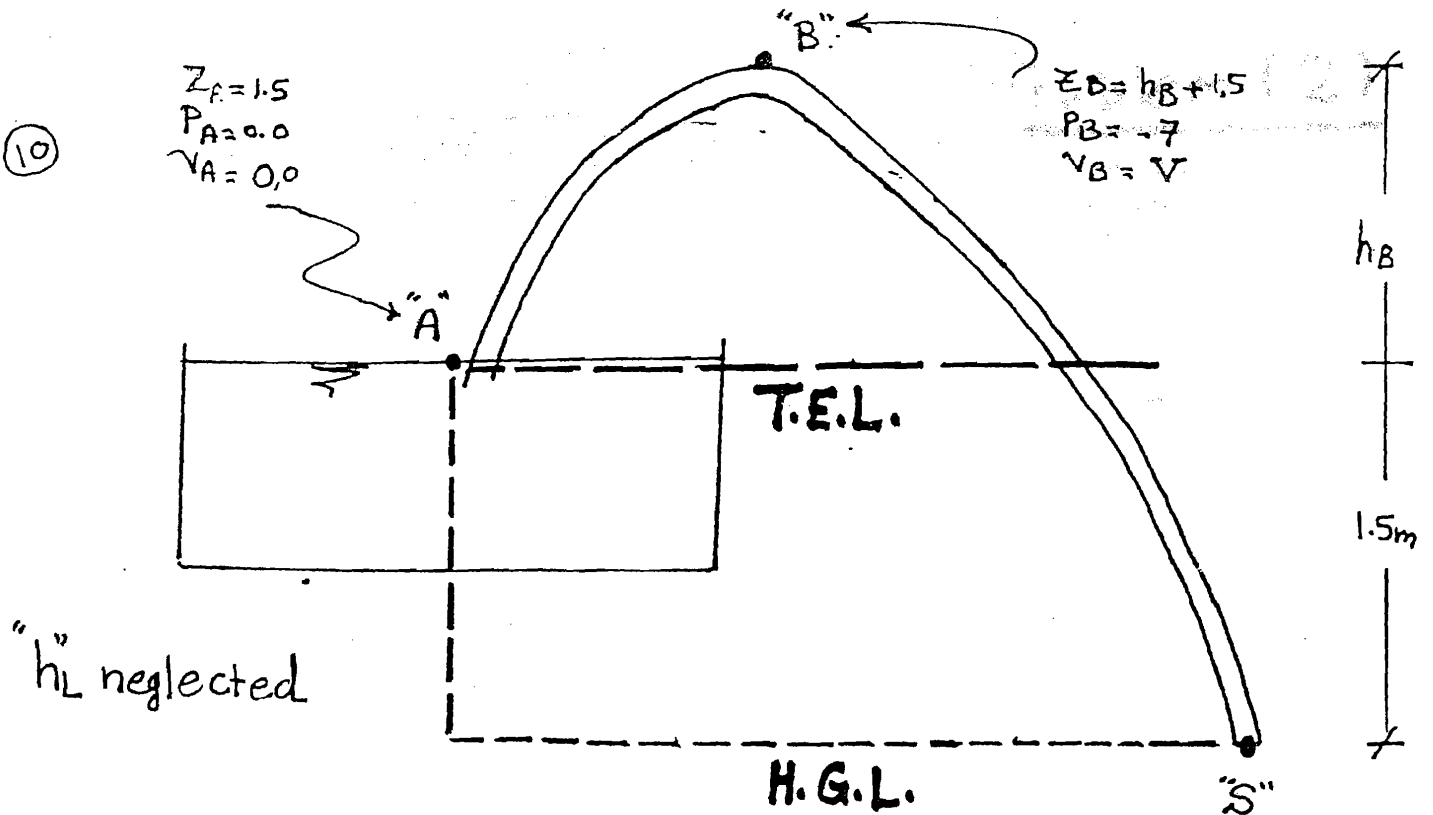
$$P_{abs \min} = 3.33 \text{ t/m}^2$$

$$P_{gauge \min} = P_{abs} - 10.33 = 3.33 - 10.33 = -7 \text{ t/m}^2$$

هذا الضغط يوجد عند نقطة "B" لأنها أعلى نقطة في السورة

$$\therefore P_B = -7 \text{ t/m}^2$$

10



• Energy Eq bet. (A) & (S) :-

$$1.5 + 0 + 0 = 0.0 + 0.0 + \frac{V^2}{2g}$$

$$V = 5.42 \text{ m/sec}$$

$$\therefore Q = V \cdot A = 5.42 * \frac{\pi}{4} * 0.15^2$$

$$\therefore Q = 0.096 \text{ m}^3/\text{s}$$

Energy Eq. bet. (A) & (B)

$$1.5 + 0.0 + 0.0 = [h_B + 1.5] + -7 + \frac{5.42^2}{2g}$$

$$\therefore h_B = 5.5 \text{ m}$$

القطر ثابت
السرعات ثابتة

• ملخص على رسم HGL & T.E.L
 (11)

① T.E.L افقر لأن الفواقد مهملة

② القطر ثابت وبالتالي السرعات ثابتة فيكون $TEL \parallel HGL$ ويقع اسفله
 بمسافة $\frac{V^2}{2g}$

③ نقطة "A" يقان على "HGL" لأن عندها $P=0.0$

• How to double "Q"

$Q \Rightarrow 2Q \Rightarrow Q = VA \Rightarrow 2 \text{ ways}$
 إما نضاعف المساحة $2A$
 أو نضاعف السرعة $2V$

$A \Rightarrow 2A \quad \frac{\pi}{4} * d^2 = 2 * \frac{\pi}{4} * 0.15^2$

$\therefore d^* = 0.21 \text{ m}$

نزد قطر الماسورة

$V^* \Rightarrow 2V$

Energy Eq bet (A) & (S)

$h + 0 + 0 = 0 + 0 + \frac{(2 * 5.42)^2}{2g}$

$\therefore h = 6 \text{ m}$

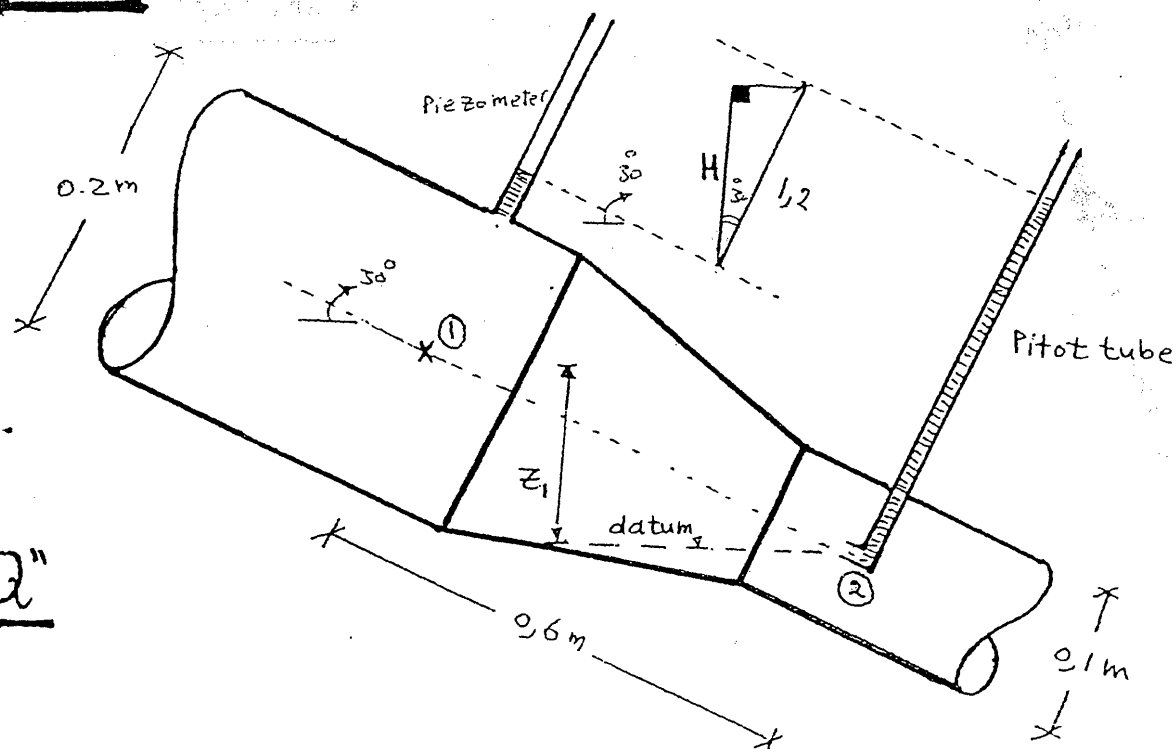
بنزاد 6 متر ارتفاع h من 1.5 إلى 6 متر

Note

المسافة h_B لا تؤثر في حساب السرعة أو القوت وبالتالي تغييرها لا يؤثر
 في قيم Q و V.

Problem (5) sh#7

(12)



Find "Q"

Sol

Pitot tube reading - Piezometer reading = H

$$\left(\frac{P_2}{\gamma} + \frac{V_2^2}{2g} \right) - \left(\frac{P_1}{\gamma} \right) = 1.2 \cos 30 = 1.04 \text{ m}$$

$$z_1 = 0.6 \sin 30 = 0.3 \text{ m}$$

Eng. Eq. bet. ① & ②

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

$$\frac{V_1^2}{2g} = z_2 - z_1 + \left(\frac{P_2}{\gamma} + \frac{V_2^2}{2g} \right) - \left(\frac{P_1}{\gamma} \right)$$

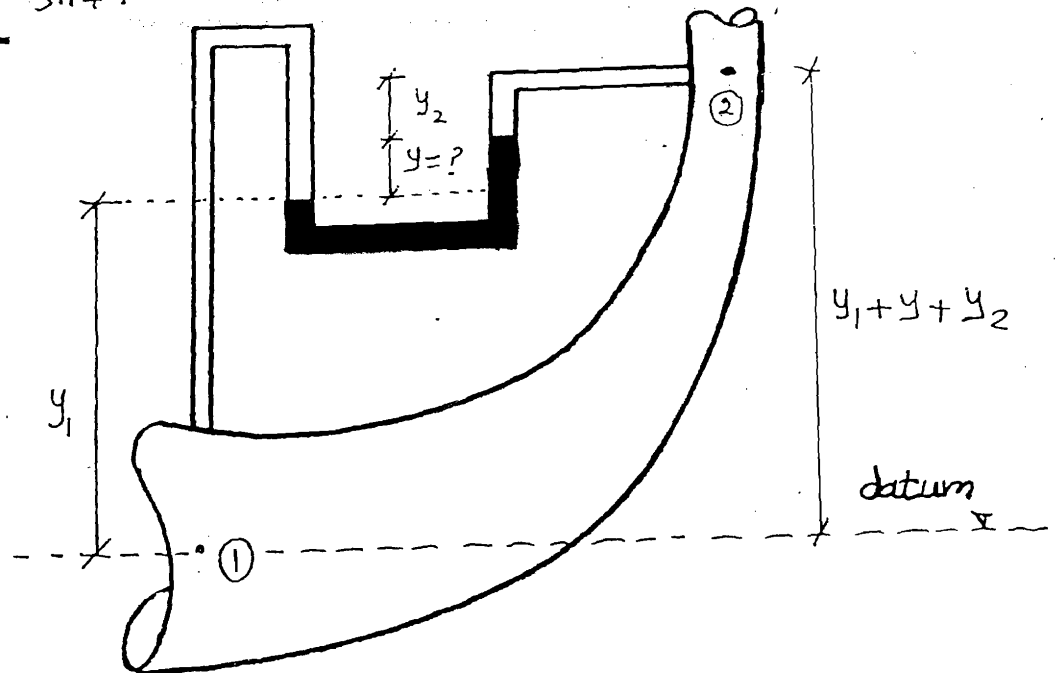
$$\frac{V_1^2}{2g} = 0.0 - 0.3 + 1.04 = 0.74$$

$$\therefore V_1 = 3.81 \text{ m/s}$$

$$Q = VA = 3.81 \times \frac{\pi}{4} \times 0.2^2$$

Problem (6) sh#7

(13)



Given

• $Q = 40 \text{ lit/s} = 0.04 \text{ m}^3/\text{s}$

• $d_1 = 0.3 \text{ m}$

• $d_2 = 0.2 \text{ m}$

• $S = 0.8$

• " h_L " neglected

Req

Manometer deflection " y " ?

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{\frac{\pi}{4} \times 0.3^2} = 0.566 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{\frac{\pi}{4} \times 0.2^2} = 1.27 \text{ m/s}$$

$$Z_1 = 0.0$$

$$Z_2 = y + y_1 + y_2$$

(14)

- Apply Energy Eq. bet ① & ② :-

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

$$0 + \frac{P_1}{0.8} + \frac{0.566^2}{2g} = (y + y_1 + y_2) + \frac{P_2}{0.8} + \frac{1.27^2}{2g}$$

$$\boxed{P_1 - P_2 = 0.8(y + y_1 + y_2) + 0.053} \rightarrow \textcircled{1}$$

- from Manometer

$$P_1 - y_1 \times 0.8 - y \times 13.6 - y_2 \times 0.8 = P_2$$

$$\boxed{P_1 - P_2 = (y_1 + y_2) \times 0.8 + 13.6 y} \rightarrow \textcircled{2}$$

$$\textcircled{1} = \textcircled{2}$$

$$0.8(y_1 + y_2) + 13.6 y = 0.8(y + y_1 + y_2) + 0.053$$

$$13.6 y = 0.8 y + 0.053$$

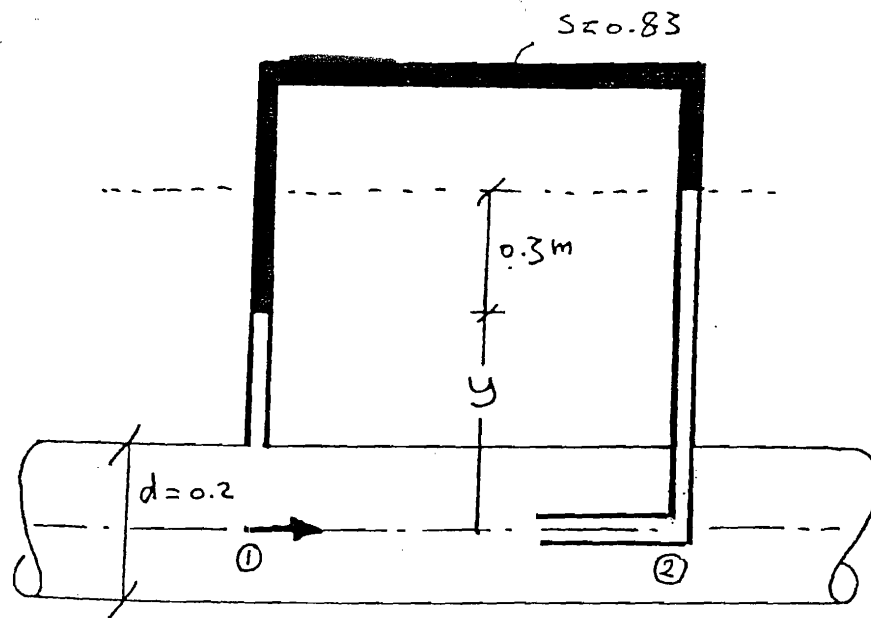
$$12.8 y = 0.053$$

$$\boxed{y = 0.004 \text{ m}}$$

Problem (7) sh#7

(15)

final exam "2004"



Find: "Q"

① طب الكانونية عادي خالص

$$P_1 - y \times \gamma_w - 0.3 \times 0.83 + (0.3 + y) \times \gamma_w = P_2 + \frac{V_2^2}{2g}$$

for Pitot

$$P_1 - y - 0.249 + 0.3 + y = P_2 + \frac{V_2^2}{2g}$$

$$P_2 - P_1 + \frac{V_2^2}{2g} = 0.051$$

② Energy Eq

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

$$\frac{V_1^2}{2g} = P_2 - P_1 + \frac{V_2^2}{2g} = 0.051$$

$$\therefore V_1 = 1 \text{ m/s}$$

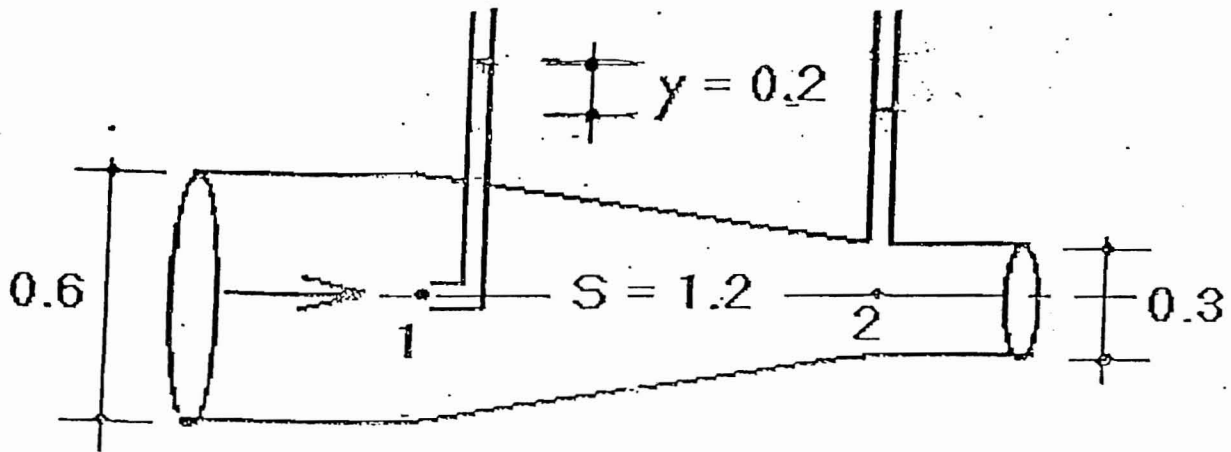
$$Q = VA = 1 \times \frac{\pi}{4} \times 0.2^2$$

$$Q = 0.0314 \text{ m}^3/\text{s}$$

Midterm - 2005

QUESTION FOUR (20 %)

For the pipe shown in Figure 4, apply energy equation between 1 & 2 neglecting losses to determine the passing discharge. Draw TEL and HGL for the pipe between 1 & 2.



$$P_1 - (0.2)(1) = P_2 + \frac{V_2^2}{2g}$$

$$0 + \frac{P_1}{\gamma} - \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

$$P + 0.2 = (P_2 - P_1) + \frac{V_2^2}{2g} \rightarrow Q$$

$$\frac{V_1^2}{2g} = \left(\frac{P_2}{\gamma} - \frac{P_1}{\gamma} \right) + \frac{V_2^2}{2g}$$

$$\left(\frac{V_1^2}{2g} \right) (8) = (0.2 - P_1) + \frac{V_2^2}{2g} (8) = (0.2)(8)$$

$$\frac{V_1^2}{2g} = 0.2$$

$$V_1 = 1.9 \text{ m/s}$$