sheet#1: FLUID PROPERTIES

1- Define the following physical quantities and write down its dimensions in (SI) units :

a) Specific gravity.
b) Specific weight.
c) Density.
d) Bulk modules of elasticity.

2 - The density of a substance is 800 kg/m^3. What is its :

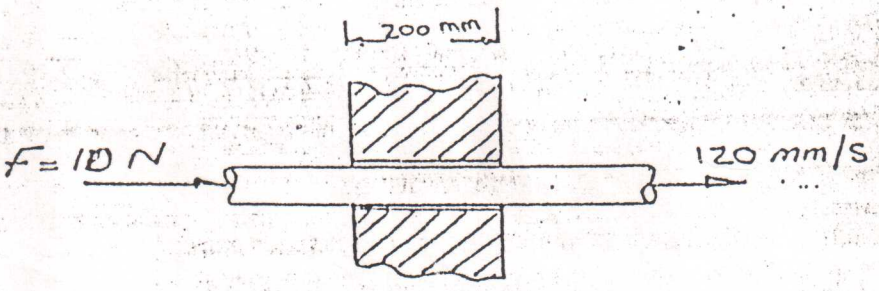
a) Specific gravity.
b) Specific weight .
c) Specific volume.

3 - If the pressure of a fluid increases from 1 bar to 100 bars at constant temperature . Find the corresponding change in fluid volume if :

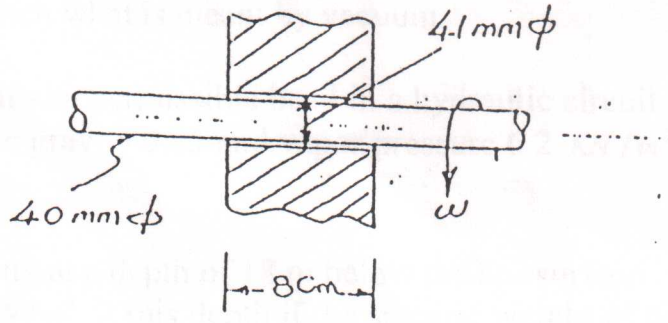
a) The fluid is gas.
b) The fluid is liquid (k= 21000* 10^5 N/m^2).

4 - The space between two large flats and parallel walls 25 mm apart is filled with a liquid of absolute viscosity 0.7 Pa.s . Within this space a thin flat plate, 250 mm x 250 mm is moved at velocity 150 mm/s at distance of 6 mm from one wall, the plate and its movement being parallel to the walls.
Assuming linear variation of velocity between the plate and the walls ,determine the force exerted by the liquid on the plat.

5 - A 75 mm diameter shaft slides at 120 mm/s through a 200 mm long sleeve with radial clearance of 0.075 mm as shown in figure.
When a 10 N force is applied . Determine the viscosity of fluid between the shaft and sleeve.



6 - The shaft turning inside a stationary journal as shown , with a rotating speed 20 rps the torque is 0.0036 N.m . Estimate the viscosity of oil .



sheet # 2: FLUID STATICS

1- Sketch the relation between gauge , absolute and atmospheric pressure . show on the sketch what is meant by vacuum.

2- What is the minimum permissible head in a hydraulic circuit using a liquid of specific gravity 0.85 and vapor pressure 6.2 KN/m^2 at the working temp.

3- A diver is working at a depth of 18 m below the sea surface . Determine the pressure in N/m^2 at this depth if the specific weight of the sea water is $10000 N/m^3$.

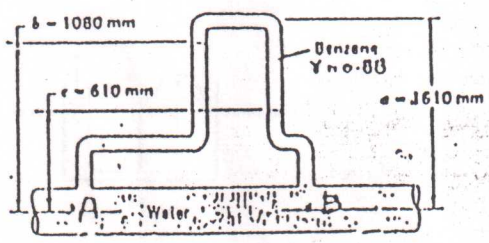
4- At what depth of oil , sp.gr. 0.8 the pressure is 3 bar . What is the equivalent depth of water that would produce the same pressure .

5- Convert a pressure head of 15 m of water to meters of carbon tetra chloride of sp.gr. is 1.6 .

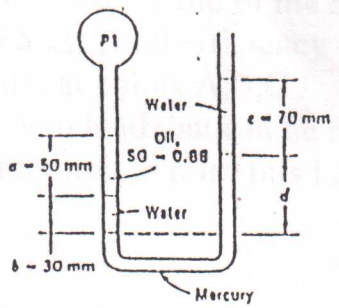
6- Convert a pressure head of 70 cm mercury to meters of oil of sp.gr. 0.8

7- A mercury U-tube manometer is used to measure the pressure of water in a pipe , the water being in contact with mercury in the left hand limb . If the mercury is 30 cm below (A) in the left hand limb and 20 cm above (A) in the right hand limb . What is the gauge pressure at (A) ?

8- Consider a manometer connected as shown . Calculate the pressure difference between A and B .



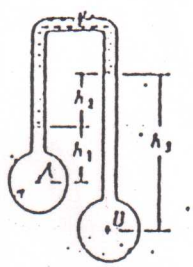
The manometer shown contains three liquids . When $P_1 = 10kPa$, determine the deflection distance d .



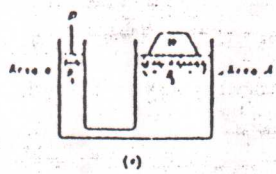
10 - In the shown figure , the liquid at A and B is water and the manometer liquid is oil with sp.gr = 0.8 , $h_1 = 300\ mm$, $h_2 = 200\ mm$, $h_3 = 600\ mm$

a) Determine $P_A - P_B$

b) If P_B = 50 kPa and the barometer reading is 730 mmHg ,find the absolute pressure at A in meters of water .



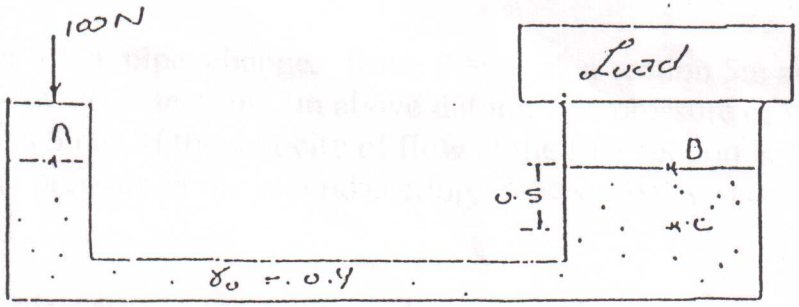
11 - A force of 850 N is applied to the smaller cylinder of a hydraulic jack. The area (a) of the small piston is 15 cm^2 and the area (A) of the larger piston is 150 cm^2 . What load (W) can be lifted on the larger piston if the pistons are in the same level.



12 - In a hydraulic jack , a force (F) is applied to the small piston to lift the load on the large piston . If the diameter of the small piston is 15 mm and that of the large piston is 180 mm , calculate the value of (F) required to lift 1000 kg .

3 - A motor operated hydraulic *Press* has a small piston area 10 cm^2, and large piston ram area of 500 cm^2.
If the force applied on the top of the small piston is 100 N , motor power equals 0.5 kw , and efficiency of the *Press* is 0.8 .Determine :

a) The pressure at points A,B,C .
b) The maximum load that can be raised .
c) The time required to raise this loads a distance of 2 m .

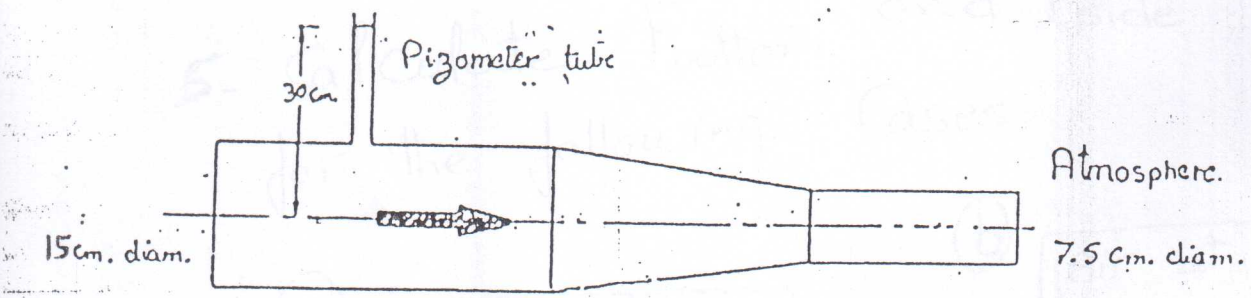


Sheet #3: Flow of Incompressible Fluids

1- Two horizontal circular discs 30cm diameters each are 1cm apart. Water enters at the center of one disc & flows outwards discharging into atmosphere at the outer diameter with a velocity of 20cm/sec. Calculate the pressure head between the two discs at a radius 5cm. (Assume ideal flow) (h= -1.63 cm water)

2- The diameter of a pipe changes from 20cm at a section 5m above datum, to 5cm at a section 3m above datum. The pressure of water first section is 5 bar. If the velocity of flow at the first section is 1m/s, determine the pressure at the second section, assuming ideal flow... (P=3.9bar)

3- Calculate the discharge in lit/sec. through the pipe line show below.



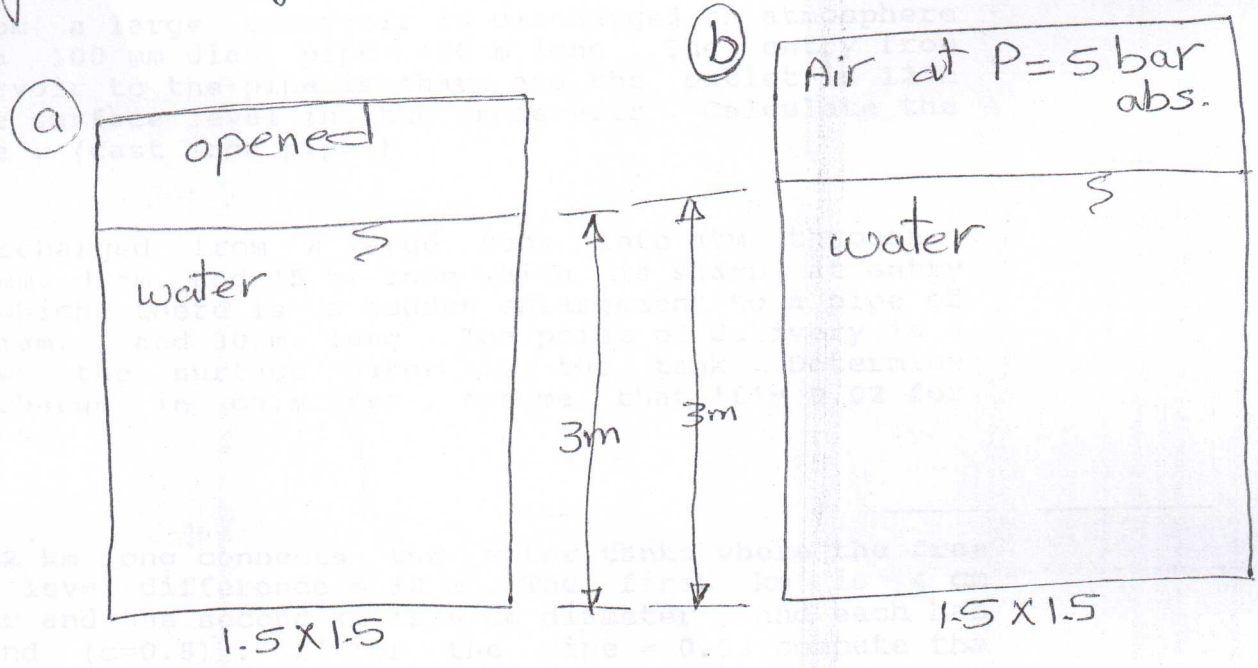
Also draw the T.E.L & H.G., considering ideal flow.

A pipe 4 cm diameter is connected in series to a pipe 8 cm diameter, for a discharge of 6 lit/sec, of a liquid of sp. gr. 0.9. The pressure before and after the sudden enlargement were to be 2 bar and 2.04 bar.

Calculate the head lost in the enlargement

(Sol^n h = 0.64 m of liq.)

5- Calculate F_{bottom} and F_{side} for the following Cases.



sheet #4: "Pipes"

1. A 10 cm commercial steel pipe 100 m long carries oil of sp.gr. 0.9 and viscosity 0.0025 Ns/m^2 from A to B which is 2 m lower than A . Calculate the required pressure at A to deliver 20 lit/sec . If the pressure at B = 4 bar cm

2. A 0.314 lit/sec of oil of sp.gr. 0.8 and viscosity 0.01 Ns/m^2 flow from point 'A' to point 'B' through a pipe 5 cm diameter and 1000 mt long . The pressure at 'B' is 0.8 bar . Calculate the pressure at 'A' . Neglect secondary losses . If the discharge is reduced to 0.0314 lit/sec , and the pressure at 'B' is still the same , calculate the pressure at 'A' . If the flow is turbulent take 'f' = 0.03 .

3. A pump delivers 1 lit/s of a liquid through a galvanized iron pipe "AB" 5 cm diam. and 1 km long discharging into the atmosphere at "B" which is 4 m higher than "A" . What should be the pressure at "A" if the liquid is :-
   1- Water
   2- Liquid of sp.gr. 0.9 and viscosity 0.004 $N.S/m^2$ (0.04 poise) .
   3- Liquid of sp.gr. 0.95 and viscosity 0.35 $N.S/m^2$ (3.5 poise)

4. Water from a large reservoir is discharged to atmosphere through a 100 mm diam. pipe 450 m long . The entry from the reservoir to the pipe is sharp and the outlet is 12 m below the surface level in the reservoir . Calculate the discharge . (cast iron pipe)

5. Water discharged from a large tank into atm. through a pipe 50 mm. diam. and 45 m. long which is sharp at entry , after which there is a sudden enlargement to a pipe of 75 mm. diam. , and 30 m. long . The point of delivery is 6 m. below the surface water in the tank . Determine the discharge in cu.m./sec . Assume that 'f'= 0.02 for both pipes .

6. A pipe 2 km long connects two water tanks where the free surface level difference = 10 m . The first km is 4 cm diameter and the second km is 6 cm diameter , and each has one bend (c=0.8) . 'f' for the pipe = 0.02 compute the discharge .

7. Two water reservoirs with a difference in level of 10 mt. are connected by a pipe line 100 mt. long and 0.5 mt. diameter . If the friction factor for the pipe is 0.001 . Calculate the flow rate . If at a later date the pipe line is replaced by two pipes in parallel each 0.4 mt. diameter with the same friction factor as the original pipe . Calculate the flow rate .

8. What is the effect of pipe roughness on the friction loss under laminar flow condition ? Explain your answer .

9. The friction loss in pipe flow can be written in the form $h = f.L.v^2/2gd$. Is it possible for the factor f to be greater than one ? Explain your answer .

10. Why are eddies formed when there is a change in the velocity vector through a pipe .

11. In a pipe flow , under what condition can you measure the energy difference between two points using only two pressure gauges ? .

12. What are the measuring instruments required to determine the energy difference between two points along an inclined convergent pipe transmitting liquid ?

13. What is the effect of temperature rise on the coefficient of friction . of a rough pipe transmitting liquid at highly turbulent flow condition .

14. What are the factors affecting the friction loss in case of laminar and turbulent flow ?

Sheet #5 : Pumps

1. A three cylinders piston pump having ram. 30 cm diameter by 60 cm stroke,is required to lift 80 liter of water per second against a static head of 85 mt. The friction loss in the suction pipe is estimated at. 1.2 mt and in the delivery pipe at 12 mt. The pipe velocity is 1 mt./ sec. The mechanical eff, of the pump is. 90% and the η_{vol} = 98% Calculate the speed at which the pump should run and the power required to drive it

2. Calculate the weight of oil which leaks from a 3 cylinders piston pump rotating at 120 rpm.The piston has diameter of 4 cm and stroke 6 cm The shp = 4 hp. and mechanical efficiency 89% specific gravity of oil 0.81. Delivery pressure 49.6 bar and Suction pressure 0.4 bar.

3. Calculate the volumetric and mechanical efficiencies of gear pump rotating at 1200 rpm . And discharging 1.27lit /sec. using o.7 hp . The gear is 6 cm. diameter and 4 cm thick. Suction pressure o.2 bar , delivery pressure 2.3 bar when one gear was put in a vessel full of water 80 cm^3 of the water was split ,

4. A parallel cylinder rotary pump is driven by a 40 hp motor calculate the maximum possible inclination of the fixed housing to the vertical, when the pump works against a pressure of 5 bar. Number of cylinders is 11, diam , of cylinders is 6 cm ., pitch circle diam, is 30 cm slip is 3 % efficiency is 7o % speed of pump is 300 rpm and sp,gr. of oil used is 0.95.

5. A pump lifts water from a sump where the free surface level is 2 m below the pump. The free surface level in the delivery tank is 5 m above pump level. The suction pipe is 10 m long and the delivery pipe is 100 m long, both pipes are C.I. 4 inch diameter; the velocity of flow through the pipes is 2 m/s. There is a strainer at the inlet to the suction pipe so that the entrance head loss coeff. = 2.5. A bend in the suction pipe has a head loss coeff. = 0.75. Compute the manometric suction head, the manometric delivery head and the power required to drive the pump assuming its efficiency 80%

6. A water centrifugal pump has the following performance at design speed

Q (lit/s)	0	2	4	6	8	10	12
H (m)	22	24	23.5	21.5	18.5	14	9.5
η %	0	31	54	72	84	84	74

a. What is the normal discharge and normal shaft power?

b. Estimate the shaft power when the delivery valve is completely closed and pump rotating at design speed.

c. Determine the maximum discharge obtained when this pump is used in a 2 in. C.I. pipe 50 m long having 2 bends (k = 0.8) static head = 3 m, f = 0.01.

d. If the delivery valve is partially closed so that the discharge is 6 Lit/s, calculate the power lost in the valve.

7) The performance of a centrifugal pump at the working speed is given by:

Q (lit/s)	0	5	10	15	20
H (m)	24	24	22	18	12
η %	0	36	63	75	60

This pump gave a maximum discharge of 15 Lit/s in a pipeline where the static lift 10 m.

a. If the static lift became 6 m, what would be the maximum discharge? If the delivery valve was partially closed to keep the discharge 15 Lit/s. calculate the shaft power lost in the valve.

b. For the same valve opening in (a) what would be the maximum discharge if the static lit became 10 m again.

8) 40 Lit/s of water flows from tank A to tank B due to difference of water level 10 m. In order to increase this discharge, a booster dynamic pump is used in the line. Calculate the % increase in the discharge and the input power. The performance of the pump is given by:

Q (lit/s)	0	20	40	60	80	100
H (m)	30	31	29	25	20	12.5
η %	0	40	60	70	75	70

9) A dynamic pressure pump has the following performance:

Q (lit/s)	0	10	20	30	40
H (m)	20	19	17.5	15	10
η %	0	55	75	78	70

a. If one pump give 40 lit/s in a pipeline where the static lift is 5 m, Calculate the discharge and shp when two units are used in parallel.

b. If one pump gives 10 lit/s is another pipe line where the static lift is 15 m. Calculate the discharge and shp when two units are used in series.

10) The characteristics of a centrifugal pump at constant speed are as follows:

Q (m^3/s)	0	0.012	0.018	0.024	0.030	0.036	0.042
H (m)	22.6	21.3	19.4	16.2	11.6	6.5	0.6
η %	0	74	86	85	70	46	8

The pump is used to lift water over a vertical distance of 6.5 m by means of a 10 cm diameter , 65 m long pipe line with f = 0.02.

a. Determine the rate of flow and power supplied to the pump.

b. If it is required to increase the rate of flow and this may be achieved only by an addition of a second identical pump (running at the same speed), investigate whether it should be connected in series or in parallel with the original pump. Justify your answer by determining the increased rate of flow and the power consumed by both pumps.

11) The centrifugal pump shown in following figure has the following performance at working speed:

Q (lit/s)	0	20	40	60	80
H (m)	40	38	35	30	20
η %	0	50	70	78	75

When this pump was operated at its normal speed it gave 40 lit/s with the delivery valve fully opened and at this time signs of cavitation were observed. In order to prevent cavitation suction level is to be changed, what will be the minimum allowable level of the suction tank? Estimate the pump shaft power in this case

$h_{atm} - h_{vap}$ = 10 m water)

NPSH = 4 m