PROGRAM	:	NATIONAL DIPLOMA EXTRACTION METALLURGY
SUBJECT	:	**PROCESS ENGINEERING 2**
CODE	:	**MPE 21- 1**
DATE	:	WINTER EXAMINATION 9 JUNE 2014
DURATION	:	(SESSION 2) 12:30 - 15:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

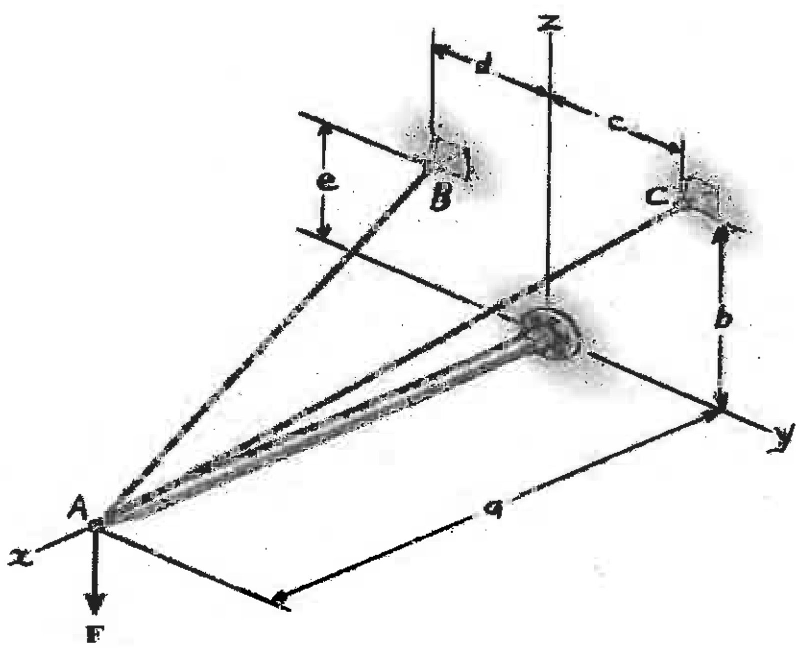
ASSESSOR	:	MISS M MADIBA	
MODERATOR	:	DR C CHITEME	5119
NUMBER OF PAGES	:	4 PAGES AND 2 ANNEXURES	

INSTRUCTIONS	:	ANSWER ALL QUESTIONS.
REQUIREMENTS	:	2 SHEETS OF GRAPH PAPER PER STUDENT

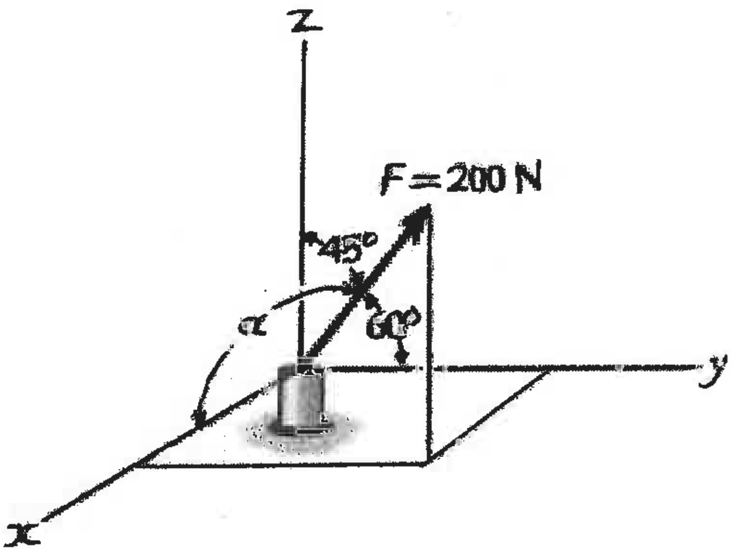
QUESTION 1

1.1 Determine the magnitudes of the projected components of the force F in the direction of the cables AB and AC.

Given:
a = 3 m
b = 1.5 m
c = 1 m
d = 0.75 m
e = 1 m
F = (60i + 12j – 40k) N (15)



1.2 Express the force F shown in the figure below as a Cartesian vector. (10)



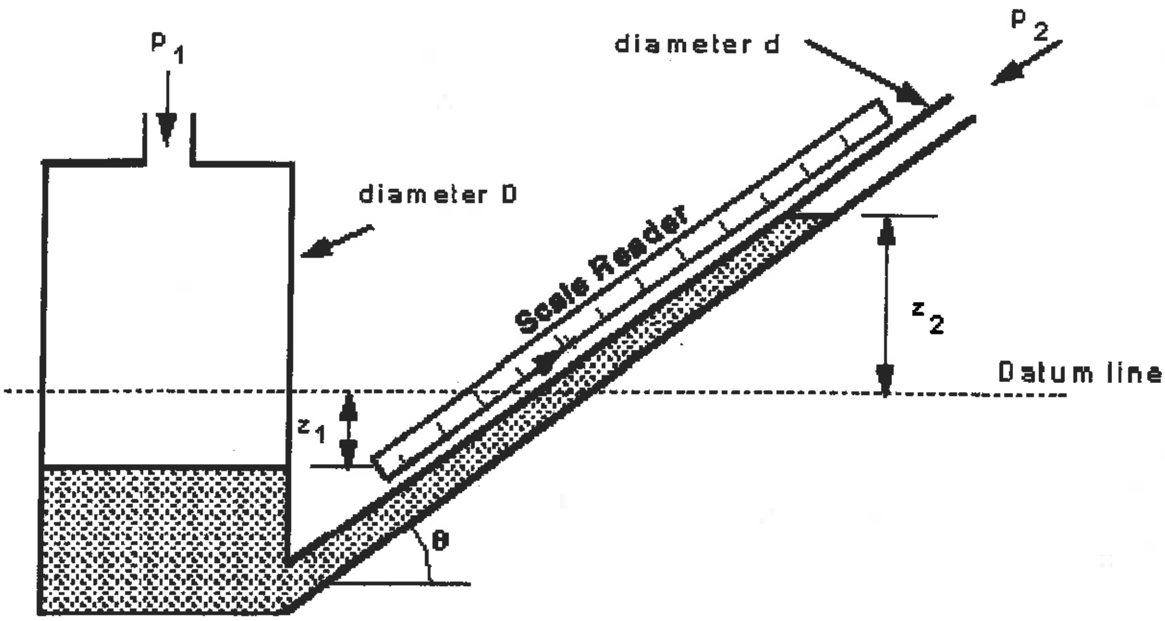
[25]

QUESTION 2

2.1 An inclined tube manometer consists of a vertical cylinder 35mm diameter. At the bottom of this is connected a tube 5mm in diameter inclined upward at an angle of 15 to the horizontal, the top of this tube is connected to an air duct. The vertical cylinder is open to the air and the manometric fluid has relative density 0.785.

(i) Determine the pressure in the air duct if the manometric fluid moved 50mm along the inclined tube. (8)

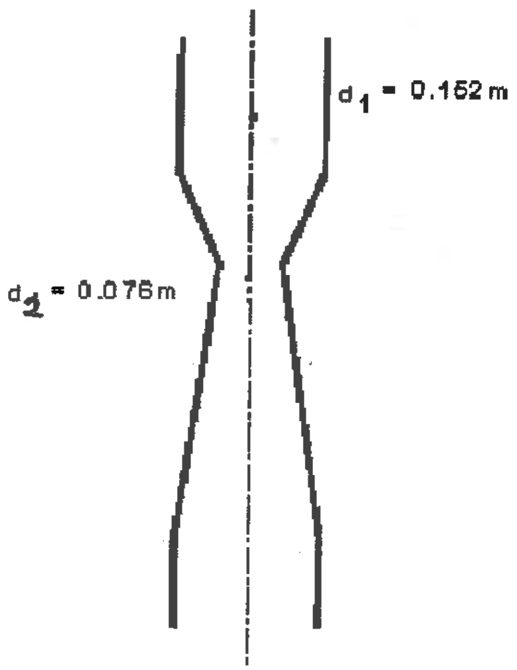
(ii) What is the error if the movement of the fluid in the vertical cylinder is ignored, what will be P_2? (6)



2.2 A Venturimeter of throat diameter 0.076m is fitted in a 0.152m diameter vertical pipe in which liquid of relative density 0.8 flows downwards. Pressure gauges are fitted to the inlet and to the throat sections. The throat being 0.914m below the inlet. Taking the coefficient of the meter as 0.97 find the discharge

(i) when the pressure gauges read the same (8)

(ii) when the inlet gauge reads 15170 N/m^2 higher than the throat gauge (8)



2.3 A Newtonian fluid with a dynamic or absolute viscosity of 0.38 Ns/m^2 and a specific gravity of 0.91 flows through a 25 mm diameter pipe with a velocity of 2.6 m/s.
Calculate the Reynolds number and identify the flow pattern. (5)

2.4 Determine the friction coefficient for a pipe 100 mm bore with a mean surface roughness of 0.06 mm when a fluid flows through it with a Reynolds number of 20 000. (5)

[40]

QUESTION 3

3.1 Some types of pump ('suction' pumps) operate by producing a reduced pressure in the area towards which you want the fluid to flow. A landscape gardener wishing to create an artificial waterfall plans to use such a device to pump water from a lake to the head of her waterfall, from where it will cascade decoratively back into the lake.
What is the absolute maximum possible height of fall she can achieve using a pump of this type (neglecting viscosity and similar effects)? Take atmospheric pressure to be 1.01×10^5 Pa; the density of freshwater is 1000 kg/m^3. (5)

3.2 In this system d = 25 cm, D = 40 cm, and the head loss from the venturi meter to the end of the pipe is given by $h_L = 0.9V^2/2g$, where V is the velocity in the pipe. Neglecting all other head losses, determine what head H will first initiate cavitation if the atmospheric pressure is 100 kPa absolute.
What will be the discharge at incipient cavitation? Assume $\alpha = 1.0$ at all locations. (10)

3.3 A pump draws water from a tank and delivers it to another with the surface 8 m above of the lower tank. The delivery tank is 30 m long, 100 bore diameter has a friction coefficient of 0.003. The pump impeller is 500 mm diameter and revolves at 600 rev/min. The pump is geometrically similar to another pump with an impeller 550 mm diameter which gave the data below when running at 900 rev/min.

ΔH (m)	37	41	44	45	42	36	28
Q(m^3/s)	0	0.016	0.32	0.048	0.064	0.08	0.096

Determine the flow rate and developed head for the pump used. (20)

[35]

TOTAL **[100]**

Formulas

$Q = VA$

$H_f = f\,l\,u^2/(Dx2g)$

$f = 16/Re$

$f = 64/Re$

$f = 0.316/Re^{1/4}$

$f = [1.14 + 2\log_{10}(D/\varepsilon)]^{-2}$

$f = \{-2\log_{10}[(\varepsilon/D)/3.7 + 2.51/(Re(f^{1/2})]\}^{-2}$

$P = \rho gHQ$

$N_s = \dfrac{NQ^{0.5}}{H^{0.75}}$

inch x 1.133/ sg = ft of liquid

Pounds/square inch x 2.31/sg = ft of liquid

mm / (22.4 x sg) = ft of liquid

NPSHA = $P_a - (V_p + H_l + H_f)$ or $P_a + H_s - (V_p + H_f)$ or $P_t - (V_p + H_l + H_f)$ or $P_t + H_s - (V_p + H_f)$

$H_{vapor} = 0.0623 \exp[(17.27 \times T)/(T + 237.3)]$

$H_{atm} = 10.3 - (0.00105 \times Z)$

$Re = DV/v$

$Re = \rho VD/\mu$

Fluid Mechanics: Formula sheet

This sheet should be used as an aid to memory. You should know how to use all these formulae

$$\tau = \mu \frac{du}{dy} \qquad \nu = \frac{\mu}{\rho} \qquad \gamma = \rho g \qquad p_{gauge} = \rho g h$$

$$p_{absolute} = p_{atmospheric} + \rho g h$$

$$Q = Au = A_1 u_1 = A_2 u_2 \qquad \frac{p_1}{\rho g} + \frac{u_1^2}{2g} + z_1 - h_f + h_a - h_s = \frac{p_2}{\rho g} + \frac{u_2^2}{2g} + z_2$$

$$u_1 = \sqrt{2g(h_2 - h_1)} \qquad u_1 = \sqrt{\frac{2gh(\rho_{man} - \rho_{fluid})}{\rho_{fluid}}}$$

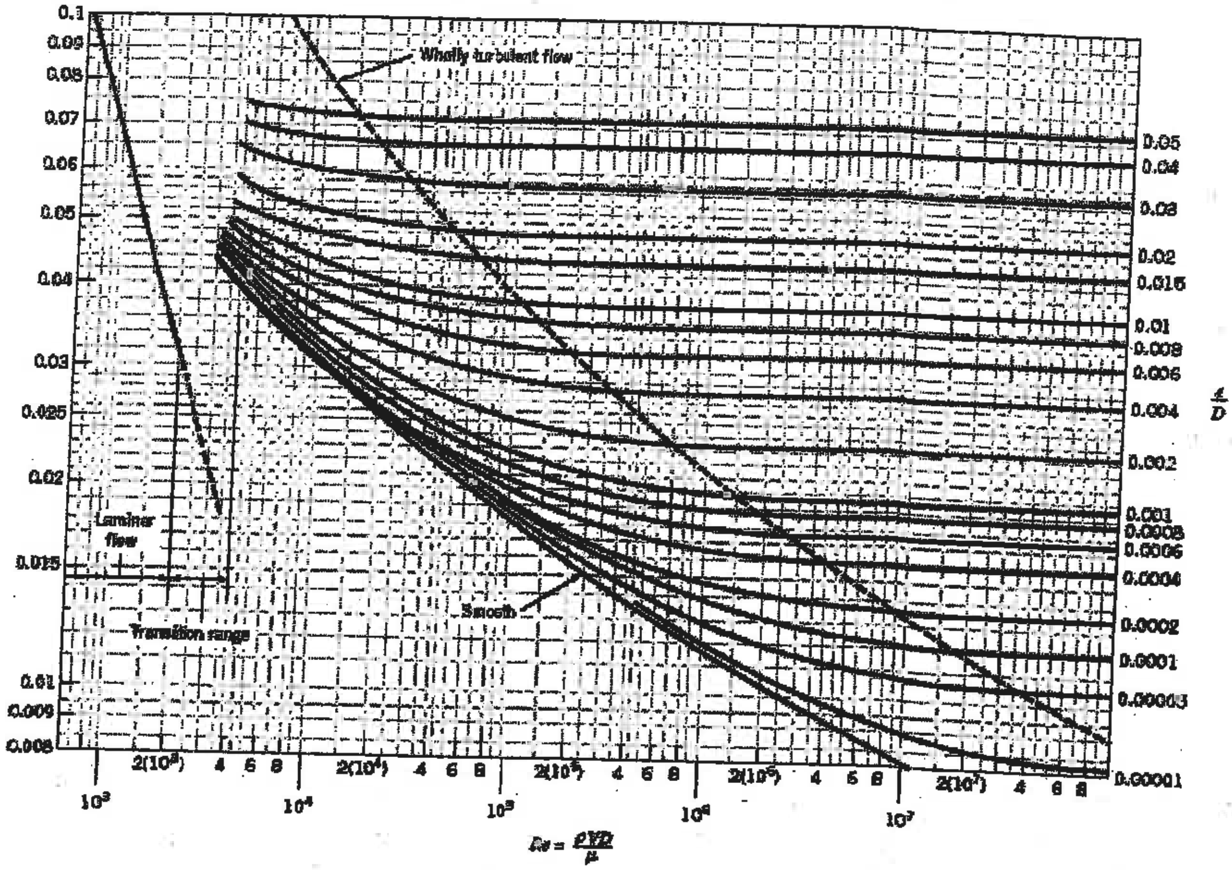
$$u_1 = \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{\left(\frac{A_1}{A_2}\right)^2 - 1}} = \sqrt{\frac{2gh\left(\frac{\rho_{man} - \rho_{fluid}}{\rho_{fluid}}\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$$\mathrm{Re} = \frac{\rho u d}{\mu} = \frac{ud}{\nu} \qquad Q = \frac{\Delta p}{L} \times \frac{\pi d^4}{128\mu} \qquad h_f = 4 \times \frac{16}{\mathrm{Re}} \times \frac{L}{d} \times \frac{u^2}{2g}$$

$$h_f = 4f \times \frac{L}{d} \times \frac{u^2}{2g} = \frac{fLQ^2}{3d^5}$$

$$N_s = \frac{N\sqrt{Q}}{H^{\frac{3}{4}}} \qquad P_{delivered} = \rho g Q h_a \qquad P_{supplied} = \frac{\rho g Q h_a}{\eta}$$

ANNEXURES



0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.009
0.008
Wholly turbulent flow
Laminar flow
Transition range
Smooth
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.00005
0.00001
$\frac{\varepsilon}{D}$
10^3
10^4
10^5
10^6
10^7
$Re = \frac{\rho V D}{\mu}$

$$\tau = \mu \frac{du}{dy}$$

$$\nu = \frac{\mu}{\rho}$$

$$p = \rho g h$$

$$R = \rho g \bar{z} A$$

R = pressure at centroid × area

$$S_c = \frac{I_{oo}}{A\bar{x}}$$

$$I_{oo} = I_{GG} + A\bar{x}^2$$

$$Q = Au = A_1 u_1 = A_2 u_2$$

$$\frac{p_1}{\rho g} + \frac{u_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{u_2^2}{2g} + z_2 + h_f$$

$$u = \sqrt{2g(h_2 - h_1)}$$

$$u_1 = \sqrt{\frac{2gh(\rho_m - \rho)}{\rho}}$$

$$h_f = \frac{32 \mu L u}{\rho g d^2}$$

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{A_1^2 - A_2^2}}$$

$$Q = C_d A_o \sqrt{2gh}$$

$$Q_{theoretical} = \sqrt{2g} \int_0^H b h^{1/2} \, dh$$

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{A_1^2 - A_2^2}}$$

$$Q = C_d \frac{2}{3} B \sqrt{2g} H^{3/2}$$

$$Q = C_d \frac{8}{15} \sqrt{2g} \tan\left(\frac{\theta}{2}\right) H^{5/2}$$

$$F_T = F_R + F_B + F_P$$

$$\mathrm{Re} = \frac{\rho u d}{\mu}$$

$$Q = \frac{\Delta p}{L} \frac{\pi d^4}{128 \mu}$$

$$F = Q\rho(u_2 - u_1)$$

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Pipe Flow

Darcy-Weisbach formula $h_f = \frac{4flv^2}{2gd} = \frac{fIQ^2}{3d^5}$

Rough pipe formula $\frac{1}{\sqrt{f}} = 4.0\log_{10}\left(\frac{R}{k_s}\right) + 3.48$

Colebrooke-White formula $\frac{1}{\sqrt{f}} = -4.0\log_{10}\left(\frac{2.51}{2R_e\sqrt{f}} + \frac{k_s}{3.7d}\right)$

Pumps

Work done per unit weight of fluid $= \frac{1}{g}\left(V_{w2}u_2 - V_{w_1}u_1\right)$

Hydraulic efficiency $\eta_h = \frac{gH}{V_{w2}\ u_2}$

Specific speed $N_s = \frac{N\sqrt{Q}}{H^{3/4}}$

Open channel hydraulics

Chezy formula $Q = A\,C\sqrt{mi}$

Manning's formula $C = \frac{1}{n}m^{1/6}$

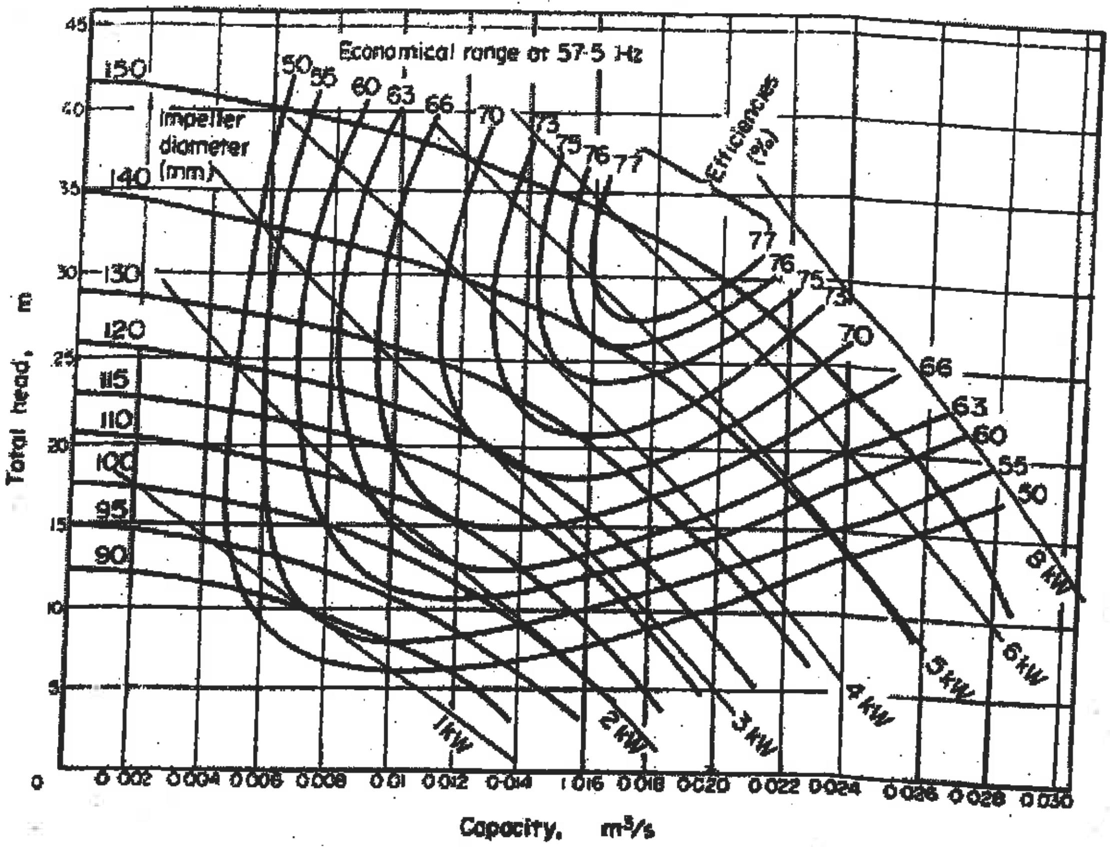
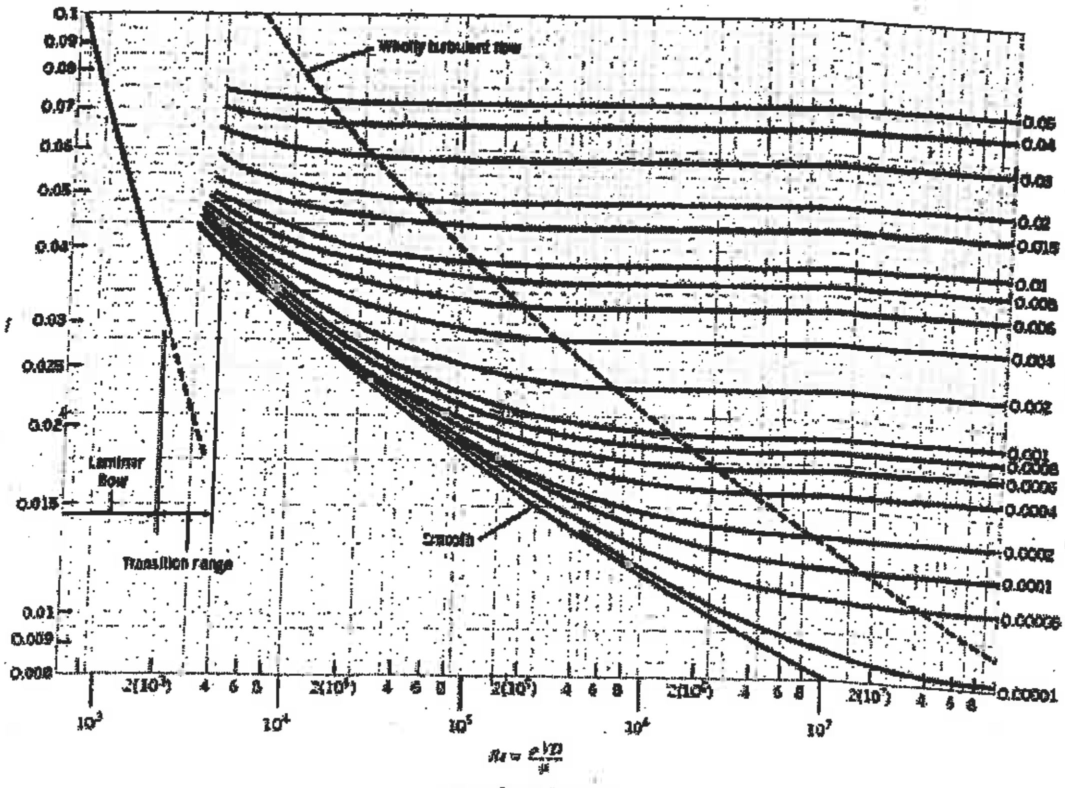


Figure 2: Characteristic curves for centrifugal pumps



Moody Diagram

Figure 3: Moody Diagram

Component	K_L
a. Elbows	
Regular 90°, flanged	0.3
Regular 90°, threaded	1.5
Long radius 90°, flanged	0.2
Long radius 90°, threaded	0.7
Long radius 45°, flanged	0.2
Regular 45°, threaded	0.4
b. 180° return bends	
180° return bend, flanged	0.2
180° return bend, threaded	1.5
c. Tees	
Line flow, flanged	0.2
Line flow, threaded	0.9
Branch flow, flanged	1.0
Branch flow, threaded	2.0
d. Union, threaded	0.08
e. Valves	
Globe, fully open	10
Angle, fully open	2
Gate, fully open	0.15
Gate, $\frac{1}{4}$ closed	0.26
Gate, $\frac{1}{2}$ closed	2.1
Gate, $\frac{3}{4}$ closed	17
Swing check, forward flow	2
Swing check, backward flow	∞
Ball valve, fully open	0.05
Ball valve, $\frac{1}{3}$ closed	5.5
Ball valve, $\frac{2}{3}$ closed	210

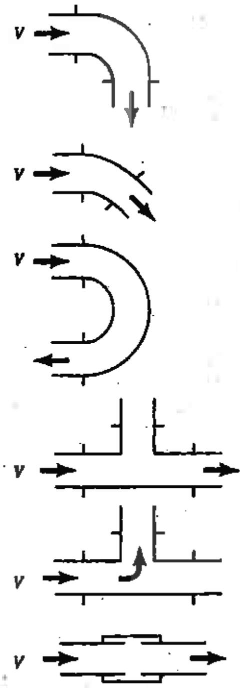


Table. Average roughness of commercial pipes, Streeter and Wylie (1983)

Material	ε (mm)
Cast iron	0.26
Galvanised iron	0.15
Asphalt cast iron	0.12
Commercial steel or wrought iron	0.046
Drawn tubing	0.0015

CONVERSION TABLES

PRESSURE	1 atm	101325 Pa
	1 bar	100000 Pa
Pa = N/m^2 = J/m^3	1 dyn/cm^2	0.1 Pa
	1 in Hg (0°C)	3386.389 Pa
	1 inH$_2$O (4°C)	249.082 Pa
	1 inH$_2$O (20°C)	248.642 Pa
	1 kg f/m^2	9.80665 Pa
	1 kg f/cm^2	98066.5 Pa
	1 kg f/mm^2	9806650 Pa
	1 lb f/in^2	6894.757 Pa
	1 mbar	100 Pa
	1 mm Hg (0°C)	133.3224 Pa
	1 N/m^2	1 Pa
	1 kg/mm^2	10000000 Pa
	1 psi	7030.7 Pa
	1 kg/ms^2	1 Pa
POWER	1 ft lbf/s	1.355818 W
W = J/s	1 hp	745.6999 W
		550 ft lbf/s
	1 metric hp	735.4987 W
		75 m kgf/s
LENGTH	1 Angstrom	1E-10 m
	1 ft	0.3048 m
	1 in	0.0254 m
	1 mile	1609.344 m
	1 nautical mile (UK)	1853.184 m
	1 nautical mile (Int)	1852 m
	1 yd	0.9144 m