|| Jai Sri Gurudev ||

Sri Adichunchanagiri Shikshana Trust (R.)

BGS INSTITUTE OF TECHNOLOGY

(Affiliated to VTU, Belgaum; Approved by AICTE, New Delhi and Recognized by Govt. of Karnataka)

BG Nagara – 571 448 (Bellur Cross)
Nagamangala Taluk, Mandya District

Certificate

This is to certify that Mr/Ms. BHUVAN. K.R

USN: 4BW17ME007 has satisfactorily completed the course of experiments

in Fluid Mechanics Laboratory (Course Code: 17MEL57)

prescribed by the Visvesvaraya Technological University, Belagavi for 5th

Semester, BE Mechanical Engineering,

of this College in the year 20 - 20

Record Marks : 22 Test Marks : 04

IA Marks : 26/40

Date : 28/11/19

Staff Incharge

Head of the Department

Rubrics for CIE of Practical Subject

1. For 20 Marks

Sl.No.	Description	Marks
1	a) Observation write up & punctuality	02
	b) Conduction of experiment and output	04
	c) Viva voce	02
	d) Record write up	04
2.	Internal Test	08
	Total	20

2. For 40 Marks

Sl.No.	Description	Marks
1	a) Observation write up & punctuality	05
	b) Conduction of experiment and output	10
	c) Viva voce	05
	d) Record write up	10
2.	Internal Test	10
	Total	40

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Name of the Student Bhuvan. k.R Class .... Sem. 5th

Expt. No.	Date	Tittle of the Experiment	Page No.	Marks obtained a	b	c	d	Total	Sign. of the Staff
1	7/8/19	Venturimeter	0-6	04	08	03	07	22	[signature]
2	14/8/19	ORificemeter	7-12	04	08	03	07	22	[signature]
3	21/8/19	V- Notch	13-22	04	08	02	08	22	[signature]
4	28/8/19	Impact of Jet on Vanes	23-28	04	08	02	08	22	[signature]
5	4/9/19	Pelton wheel turbine test Rig	29-38	04	08	02	08	22	[signature]
6	11/9/19	Minor Losses in flow through Pipes	39-50	03	07	02	07	19	[signature]
7	25/9/19	Multistage Centrifugal Pump	51-56	04	08	03	08	23	[signature]
8	9/10/19	Two Stage Reciprocating Air Compressor	57-66	04	08	03	08	23	[signature]
9	11/9/19	Friction in Pipes	67-74	03	07	02	07	19	[signature]

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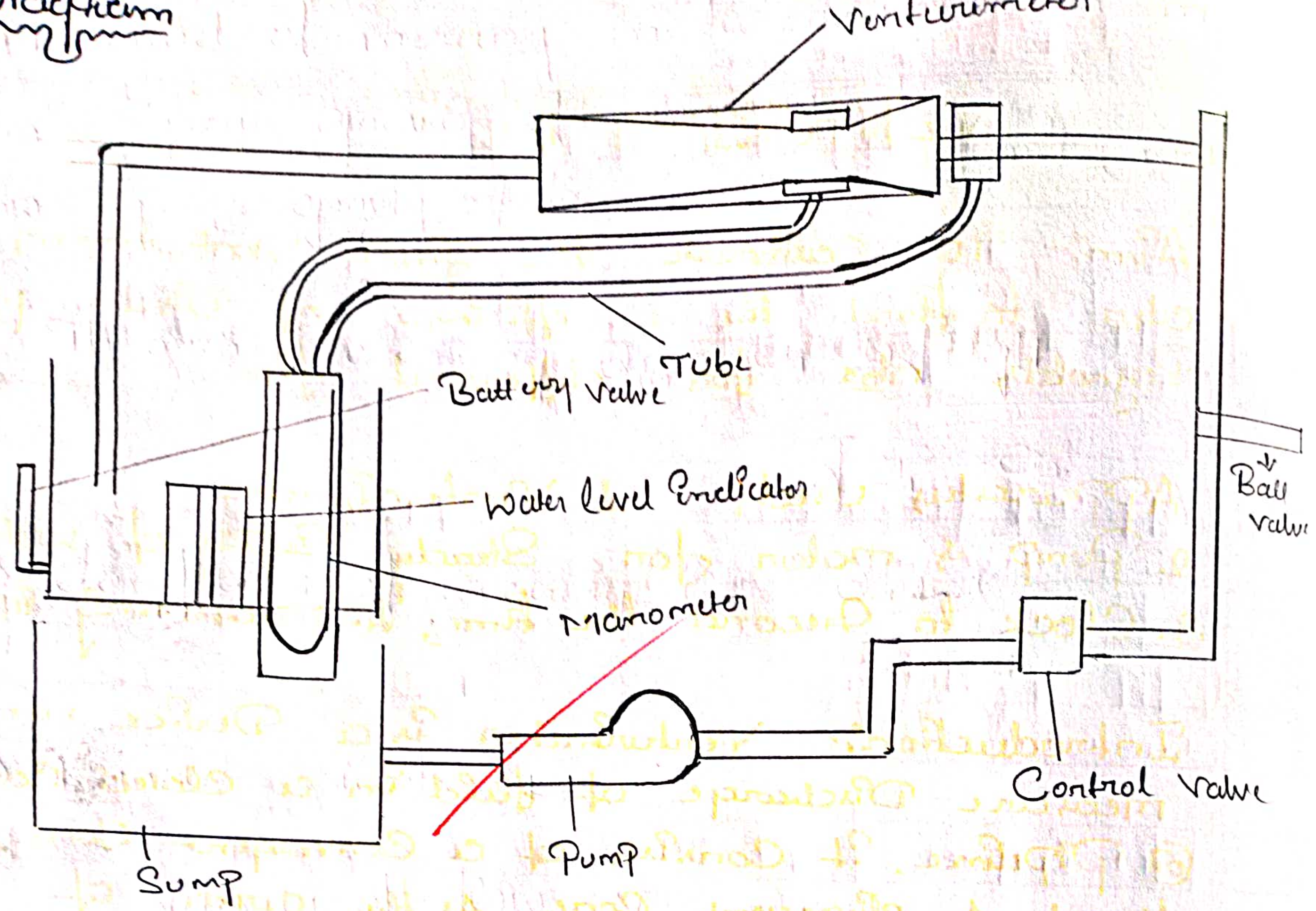
Name of the Student Bhuvan. k.R Class .... Sem. 5th

Expt. No.	Date	Tittle of the Experiment	Page No.	Marks obtained a	b	c	d	Total	Sign. of the Staff
10	16/10/19	Francis turbine	75-84	04	08	04	08	24	[signature]
11	30/10/19	kaplan Turbine	85-94	04	08	03	07	22	[signature]
12	30/10/19	Reciprocating Pump test Rig	95-100	04	08	03	07	22	[signature]
13	25/9/19	Single Stage Centrifugal Pump	101-108	04	08	04	08	24	[signature]

Diagram



Specimen Calculations:-

1) Actual Discharge $Q_a = \frac{A_E R \times 10^{-2}}{t}$

A_E = Effective area of the measuring tank in m^2

R = Rise of water level in the tank for time 't' in cm

t = Time taken for R cm rise in the tank in S

2) Theoretical Discharge Q_{th}

$H = h_m \left[\frac{S_m}{S_w} - 1 \right]$ in m of water

Name of Experiment: Venturimeter Date: 7/8/19
Experiment No. 1 Page No. 2

VENTURIMETER

Aim:- To calibrate the given Venturimeter & also to find the Co-efficient of Discharge & Reynolds nbr for different flows

Apparatus used:- 1. Venturimeter, 2. Pump & motor for Steady Supply of water, 3. Clock to record the time, 4. Measuring tank

Introduction:- Venturimeter is a Device used to measure Discharge of fluid in a Closed Conduit or Pipeline, it Consist of a Convergent Cone, throat & divergent Cone As the area of the flow decreases in the Convergent Cone velocity of flow increases & Pressure Decreases the measurement of Pressure Difference b/w the inlet Section & throat Section leads to the measurement of Discharge. The angle of Divergent Cone will be 60° & that of Convergent Cone will be about 20°. The length of the Divergent Cone will be more than the length of Convergent Cone. The Diameter of the throat will be 0.5-0.6 times the diameter of the Pipeline or the inlet Section if a fluid is made to flow through a Varying Section due to the Variation in Pressure, there will be Variation in Velocity & this effect is known as Venturi Effect

h_m = head of mercury in the manometer in m

S_m = Specific gravity of mercury

S_w = Specific gravity of the Standard fluid (water)

Theoretical discharge $Q_{th} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$

3) Co-efficient of Discharge $C_d = \frac{Q_{actual}}{Q_{theoretical}}$

4) Reynolds Number Re

Velocity of flow $= V = \frac{Q_{actual}}{a_1}$

Reynolds number $= Re = \frac{\rho V d_1}{\mu}$

Where,

ρ = Density of water in kg/m^3

μ = Dynamic Viscosity of water in $N\text{-}s/m^2$

Name of Experiment .... Date : ....

Experiment No. ....

Specifications :-

d_1 = Diameter of the pipe = ~~mm~~ 25 mm

d_2 = Throat diameter = 12.5mm

a_1 = Area of the pipe = 490.87 mm^2

a_2 = Area of the throat = 122.71 mm^2

A_1 = Area of the measuring tank = $L_{mm} \times B_{mm}$ = 250x500 = 125000mm^2

D = Diameter of the pipe in the measuring tank = 75mm

A_2 = Area of the pipe in the measuring tank = $\pi D^2/4$ = 4417.86 mm^2

A_E = Effective area of the measuring tank = $A_1 - A_2$ = 120582.14 mm^2

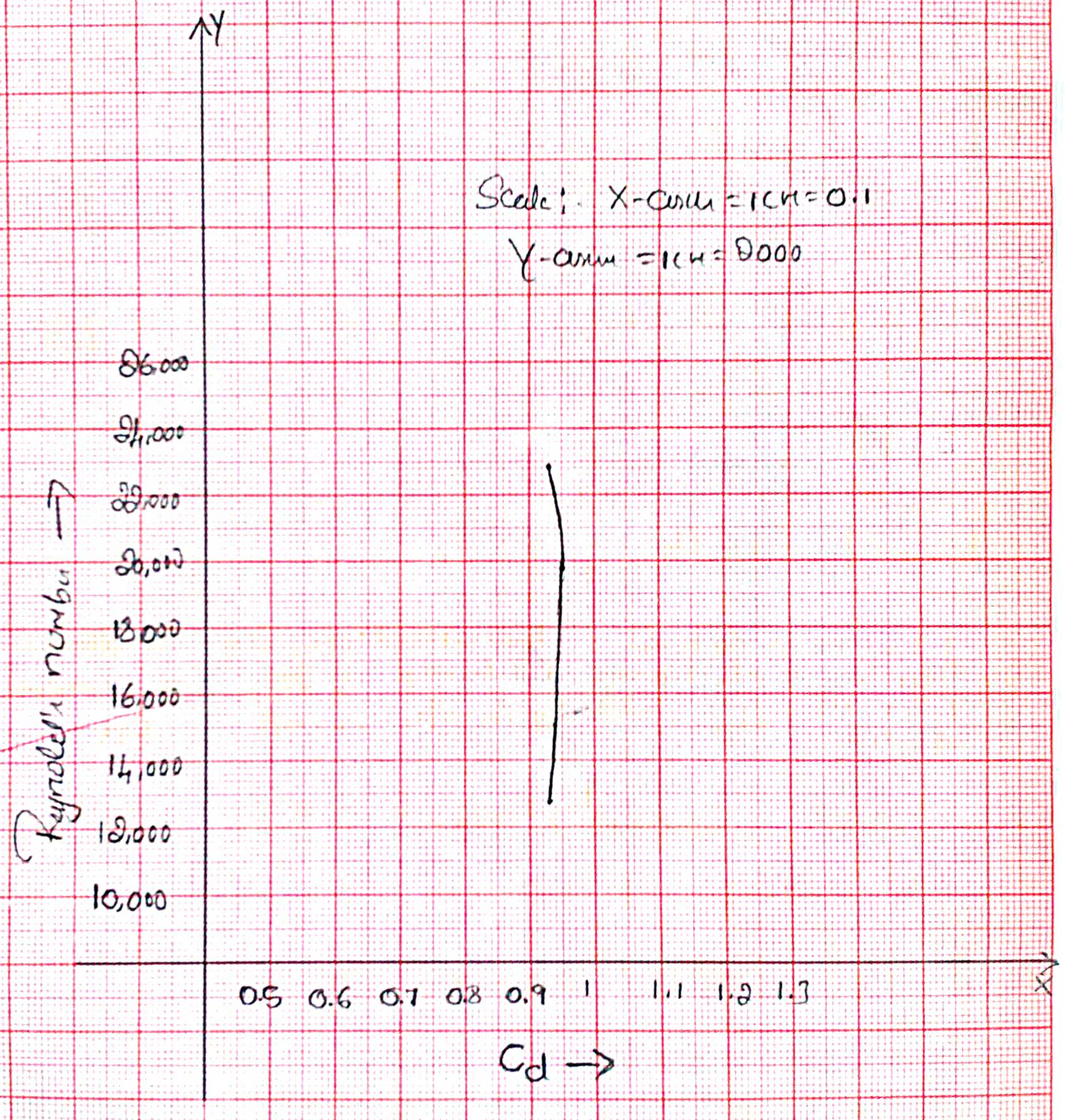
Table of Readings

Sl. No	Manometer reading in h1 (left limb in cm)	h2 (right limb in cm)	hm = (h1 - h2) cm	Time taken for Rcm rise of water in the storage tank 't' in sec
1	2.4	-3.4	5.8	27
2	2.0	-2.2	4.2	31
3	1.2	-0.6	1.8	48

Table of Results

Sl No	Manometer reading H in m of water	Actual discharge Qa in m³/s	Theoretical Discharge Qth in m³/sec	Velocity of flow V in m/s	Co-efficient of Discharge Cd	Reynolds number Re
1	0.7308	4.4659×10^{-4}	4.798×10^{-4}	0.909	0.93	22725
2	0.5292	3.8896×10^{-4}	4.083×10^{-4}	0.7925	0.95	19812.5
3	0.2268	2.512×10^{-4}	2.673×10^{-4}	0.511	0.93	12775

Date : ________ Batch. No............................



Calculation:-

1) $Q_{a_1} = \frac{0.12058 \times 10 \times 10^{-2}}{27} = 4.4659 \times 10^{-4} \, m^3/s$

$Q_{a_2} = 3.8896 \times 10^{-4} \, m^3/s$

$Q_{a_3} = 2.512 \times 10^{-4} \, m^3/s$

2) $H_1 = 0.058 \, (13.6 - 1) = 0.7308 m$

$H_2 = 0.072 \, (13.6 - 1) = 0.5292 m$

$H_3 = 0.018 \, (13.6 - 1) = 0.2268 m$

3) $Q_{th} = \frac{4.9087 \times 10^{-4} \times 1.2271 \times 10^{-4} \times \sqrt{2 \times 9.81 \times 0.7308}}{\sqrt{(4.9087 \times 10^{-4})^2 - (1.2271 \times 10^{-4})^2}}$

$Q_{th_1} = 4.7982 \times 10^{-4} \, m^3/s$

$Q_{th_2} = 4.083 \times 10^{-4} \, m^3/s$

$Q_{th_3} = 2.673 \times 10^{-4} \, m^3/s$

4) $C_{d_1} = \frac{Q_{act}}{Q_{th}} = \frac{4.4659 \times 10^{-4}}{4.7982 \times 10^{-4}} = 0.93$

$C_{d_2} = 0.95$, $C_{d_3} = 0.93$

5) $V_1 = \frac{Q_{act}}{a_e} = \frac{4.4659 \times 10^{-4}}{4.9087 \times 10^{-4}} = 0.909$

$V_2 = 0.7925$ $\quad V_3 = 0.511$

6) $Re_1 = \frac{\rho V d_1}{\mu} = \frac{1000 \times 0.909 \times 0.025}{1 \times 10^{-3}} = 22725$

$Re_2 = 19812.5$ $\quad Re_3 = 12775$

Procedure:-

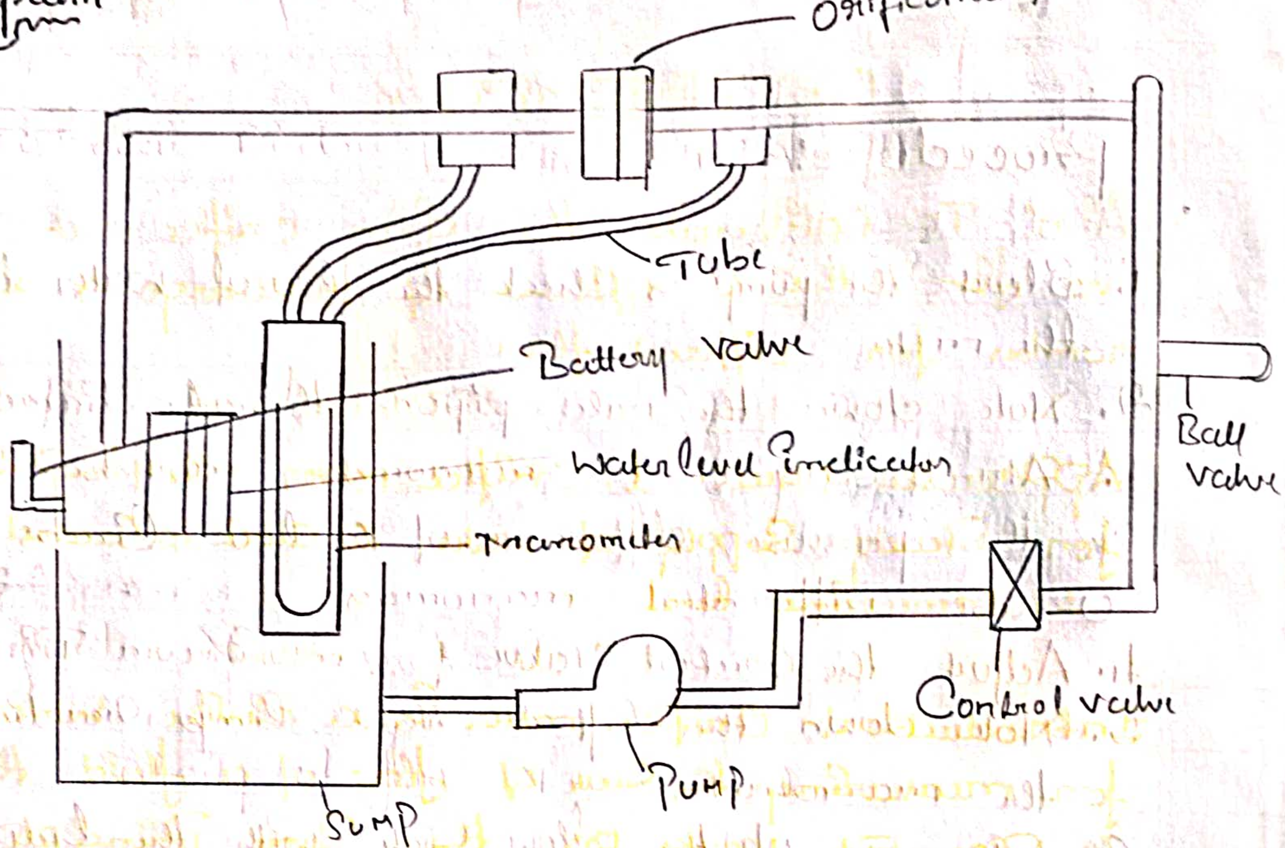
1. Start the Pump & Check the flow of water through the meter
2. Note down the inlet pipe & throat diameter
3. Air if any in the manometer must be removed & the Pressure difference of the two limbs of the U-tube Differential manometer
4. Adjust the Control valve for maximum Discharge
5. Note down the left & right limb readings of the manometer
6. Measure of the flow rate with the help of Discharge measuring tank with the Stop watch
7. Repeat the Experiment for 4-5 Set of reading for different flow rate by regulating the Control valve
8. After Completion of the Experiment Close the valve & Stop the Pump

Result:- Find out the Co-efficient of Discharge & Reynolds nbr of the Venturimeter for different flows & Plot the graph of Cd v/s Re ?

22/30

14/02

Diagram



Experimental Setup

Specimen Calculation

1. Actual Discharge $Q_a = \frac{A_E R \times 10^{-2}}{t}$

A_E = Effective area of the measuring tank in m^2

R = Rise of water level in the tank for time t in cm

t = Time taken for R cm rise in the tank in S

2. Theoretical Discharge Q_{th}

$$H = h_m \left[\frac{S_m}{S_w} - 1 \right] \text{ in m of water}$$

h_m = head of mercury in the manometer in m

S_m = Specific gravity of mercury

ORIFICEMETER

Aim:- To calibrate the given orifice meter & also to find the Co-efficient of discharge & Reynolds number for different flows

Apparatus used:- 1. Orifice meter, 2. Pump & Motor for Steady Supply of water 3. Clock to record the time 4. Measuring tank

Introduction:- Orifice meter is a device which is used for measuring the rate of flow of a fluid through the Pipe. It works on the Same Principle as that of the Venturimeter. It Consists of a flat Circular plate which has Circular sharp edged hole called Orifice which is Concentric with the pipe. The Orificemeter diameter is kept generally 0.5 times the diameter of the pipe. the orifice plate is Provided with the Pressure tappings one upstream at a distance of approximately equal to pipe diameter & another down Stream at a distance of 0.5 times pipe diameter The Pressure difference is used a measure of Discharge

Specifications:-

d_1 = Diameter of the Pipe = 25mm

d_2 = Throat diameter = 12.5 mm

S_w = Specific gravity of the Standard fluid

Theoretical Discharge $Q_{th} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$

3. Co-efficient of Discharge $C_d = \frac{Q_{actual}}{Q_{theoretical}}$

4. Reynolds Number Re

Velocity of flow = $V = \frac{Q_{actual}}{a_1}$

Reynolds number = $Re = \frac{\rho v d_1}{\mu}$

Where

ρ = Density of water in kg/m³

μ = Dynamic Viscosity of water in N-s/m²

a_1 = Area of the pipe = 490.87 mm^2

a_2 = Area of the throat = 122.71 mm^2

A_1 = Area of the measuring tank = $L_{mm} \times B_{mm}$ =
= 12500 mm^2

D = Diameter of the pipe in measuring tank = 75mm

A_2 = Area of the pipe in measuring tank = $\frac{\pi D^2}{4}$ = 4417.86 mm^2

A_E = Effective area of the measuring tank = $A_1 - A_2$
A_E = 120582.14 mm^2

Procedure:-

1. Start the pump & check the flow of water through the meter
2. Note down the inlet pipe & throat diameter
3. Air if any in the manometer must be removed & the pressure difference of the two limbs of the U tube differential manometer
4. Adjust the control valve for maximum discharge
5. Note down the left & right limb readings of the manometer

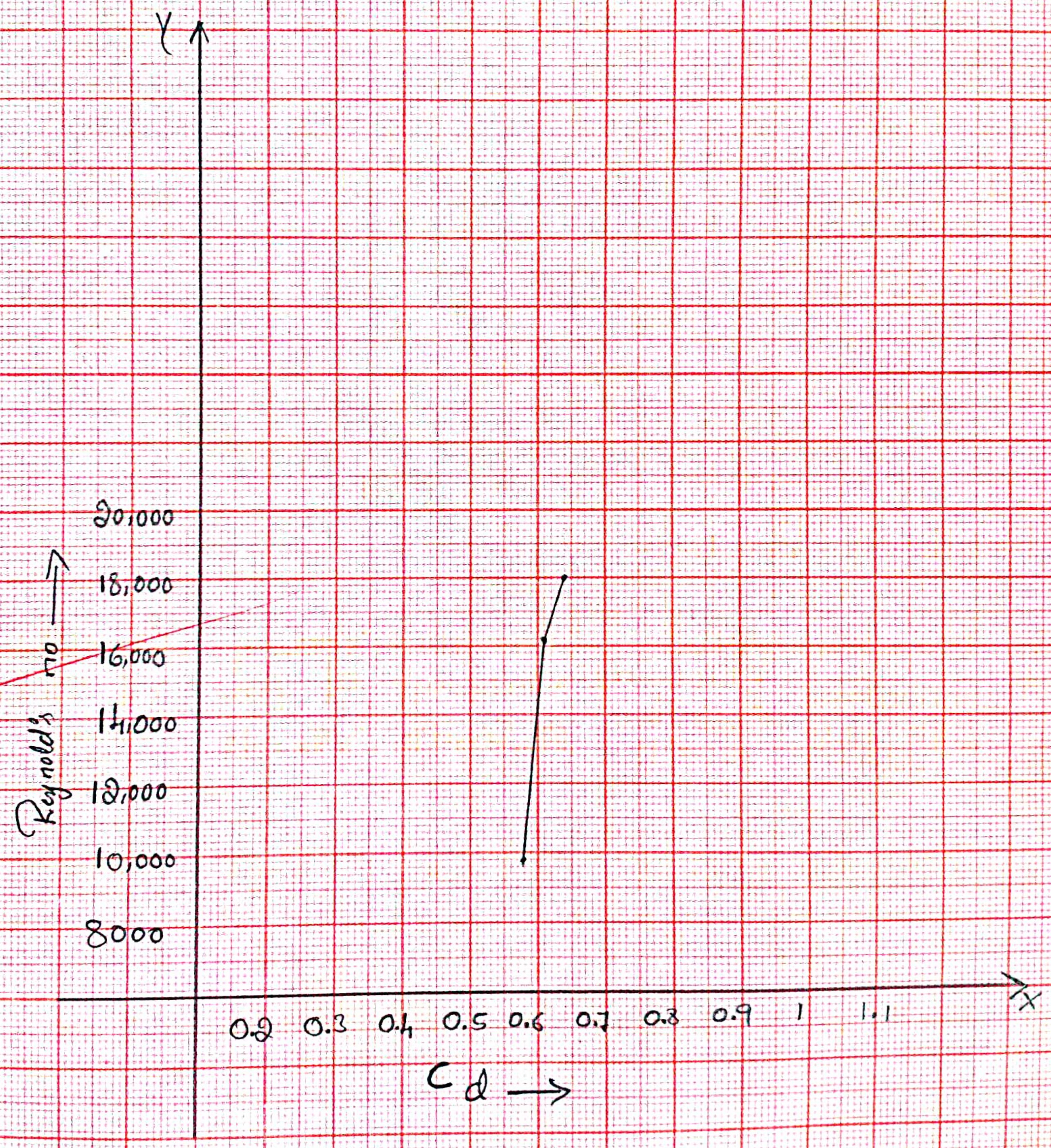
Table of Readings:-

SL NO	Manometer reading in (mm) of hg: h_1 (left limb in cm)	h_2 (right limb in cm)	$h_m = (h_1 - h_2)$ cm	Time taken for 2cm rise of water in the storage tank (t) in sec
1	4.9	-1.9	6.8	38
2	5.4	-2.3	7.7	34
3	2.9	0.2	2.7	63

Table of Results:-

SL NO	Manometer reading H in mof water	Actual Discharge Q_{act} in m^3/s	Theoretical Discharge Q_{th} in m^3/s	Velocity of flow V in m/s	Co-efficient of Discharge Cd	Reynolds nbr Re
1	0.8568	3.173×10^{-4}	5.195×10^{-4}	0.6464	0.61	16160
2	0.9702	3.5464×10^{-4}	5.529×10^{-4}	0.7024	0.64	18060
3	0.3402	1.9139×10^{-4}	3.274×10^{-4}	0.3898	0.584	9745

Date : Batch. No...........................



Calculation:- 1) $Q_{a_1} = \frac{0.12058 \times 10 \times 10^{-2}}{38} = 3.173 \times 10^{-4}\ m^3/s$

$Q_{a_2} = \frac{0.12058 \times 10 \times 10^{-2}}{34} = 3.5464 \times 10^{-4}\ m^3/s$

$Q_{a_3} = 1.9139 \times 10^{-4}\ m^3/s$

2) $H_1 = 0.068\ (13.6 - 1) = 0.8568\ m$

$H_2 = 0.077\ (13.6 - 1) = 0.9702\ m$

$H_3 = 0.027\ (13.6 - 1) = 0.3402\ m$

3) $Q_{th} = \frac{4.9087 \times 10^{-4} \times 1.2271 \times 10^{-4} \times \sqrt{2 \times 9.81 \times 0.8568}}{\sqrt{(4.9087 \times 10^{-4})^2 - (1.2271 \times 10^{-4})^2}}$

$Q_{th_1} = 5.195 \times 10^{-4}\ m^3/s$ $Q_{th_2} = 5.5293 \times 10^{-4}\ m^3/s$

$Q_{th_3} = 3.2742 \times 10^{-4}\ m^3/s$

4) $C_{d_1} = \frac{Q_{act}}{Q_{the}} = \frac{3.173 \times 10^{-4}}{5.195 \times 10^{-4}} = 0.61$

$C_{d_2} = 0.64$ $C_{d_3} = 0.584$

5) $V_1 = \frac{Q_{act}}{a_1} = \frac{3.1731 \times 10^{-4}}{4.9087 \times 10^{-4}} = 0.6464\ m/s$

$V_2 = 0.7224$ $V_3 = 0.389.8$

6) $Re_1 = \frac{\rho v d_1}{\mu} = \frac{1000 \times 0.6464 \times 0.025}{1 \times 10^{-3}} = 0.1610$

$Re_2 = 18060$ $Re_3 = 9745$

6. Measure the flow rate with the help of discharge measuring tank with the stop watch

7. Repeat the experiment for 4-5 set of readings for different flow rate by regulating the control valve

8. After completion of the experiment close the valve & stop the pump

Result:- Find out the Co-efficient of Discharge & Reynolds nbr of the orifice meter for different flows & plot the graph of Cd v/s Re ?

22/30

24/08/16

Diagram

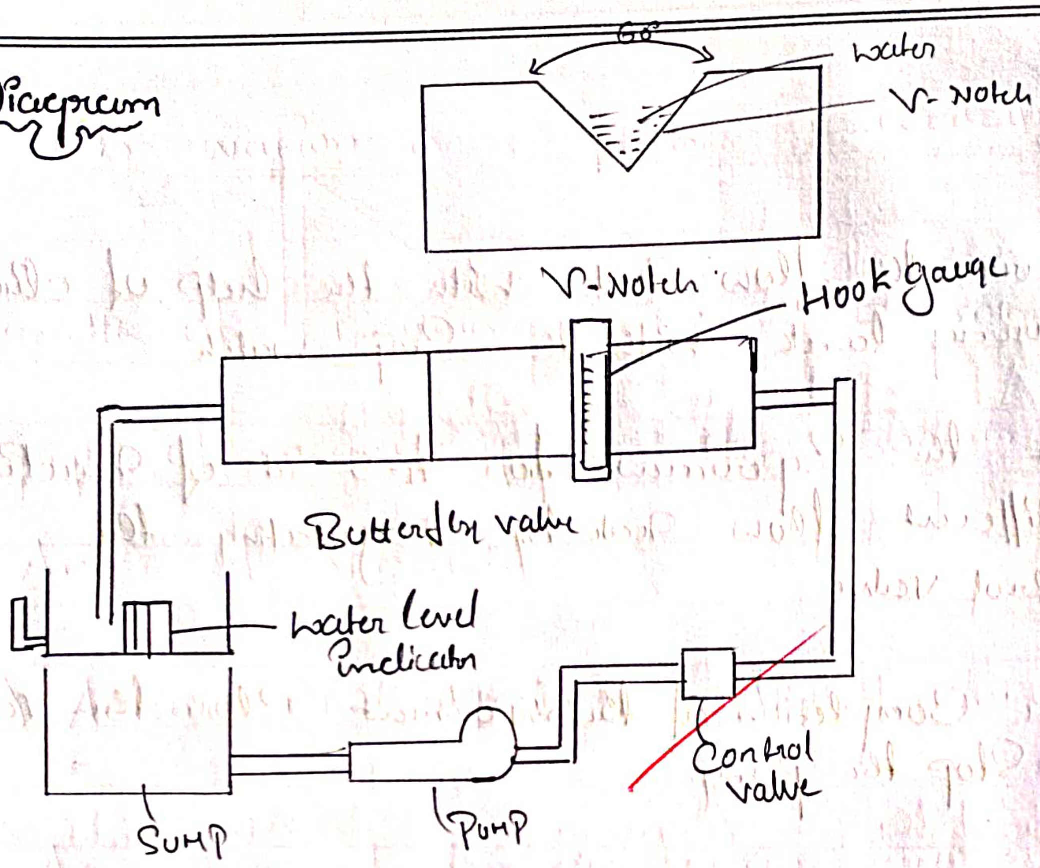


Table of Readings:-

SL No	Type & angle of Notch	Hook gauge reading in (mm) of water			Time taken for H rise of water in storage tank (t) (For 10cc)
		H_1	H_2	$H = H_2 - H_1$	
1	60°	5.78	11.36	5.58	31.57
2		5.78	14.78	9	11.5
3		5.78	15.2	9.42	10

Name of Experiment V-Notch Date : 21/8/19

Experiment No. 03 Page No. 14

V - NOTCH

Aim:- To Determine the Co-efficient of Discharge for given notch

Introduction:-

A Notch is defined as sharp edged obstruction over which fluid flow occurs Notches are used for measuring the rate of flow of liquid from a reservoir small channel and tank Generally notches are rectangular Δle notches has advantage of greater accuracy at reduced flow rate compared to other shapes the co-efficient of contraction will be constant for all heads the sheet of water discharged by notch is called "Nappe" @ Vein

Test Rig details:-

1) Given Notch in open channel provided with piezometer the over the notch
2) A Discharge measuring tank fitted with a piezometer & graduated scale
3) Storage tank (Sump) & Centrifugal pump

Procedure:-

Observation & Specimen Calculation

Breadth of measuring tank (B) = 500mm

Length of measuring tank (L) = 500mm

Angle of V-notch (θ) = 60°

1) Actual Discharge (Q_a) = $\frac{A_E R}{t}$ m^3/s

A_E = Area of the measuring tank in m^2

R = Rise of water level in the tank for time t

t = Time taken for R cm rise in the tank in s

2) Theoretical Discharge (Q_{th}) = $\frac{8}{15} \tan\frac{\theta}{2} \sqrt{2g} \times H^{5/2}$ m^3/s

H = Head over the notch in m of water Column

3) Co-efficient of Discharge = Cd = $\frac{Q_{act}}{Q_{the}}$

4) Dia of measuring tank = 110mm

5) Area of measuring tank A_1 = 0.25 m^2

6) Effective area $A_E = A_1 - A_2 = 0.24042$ m^2

Calculation :-

1) $Q_a = \frac{A_E R}{t}$

$$Q_a = \frac{0.24049 \times 10 \times 10^{-2}}{31.57} = 7.60 \times 10^{-4}\ m^3/s$$

2) $Q_{th} = \frac{8}{15} \times \tan\frac{60}{2} \times \sqrt{2 \times 9.81} \times (0.058)^{5/2}$

$Q_{th} = 1.1049 \times 10^{-3}\ m^3/s$

3) $C_d = \frac{Q_{act}}{Q_{the}} = \frac{7.60 \times 10^{-4}}{1.1049 \times 10^{-3}} = 0.69$

Table of Results

Sl No	Actual discharge Qact in m^3/s	Theoretical discharge Qth in m^3/s	Cd
1	7.60×10^{-4}	1.1049×10^{-3}	0.69
2	2.086×10^{-3}	3.314×10^{-3}	0.629
3	2.4×10^{-3}	3.7146×10^{-3}	0.646

Name of Experiment .... Date : ....

Experiment No. .... Page No. 18

1. Place the notch under test & end of the approach channel in the vertical plane. With the sharp edge on the up-stream side
2. Record the geometric shape of the notch
3. Allow the water in the tank till it just passes over the notch
4. Start the water supply & recorded the water level by the gauge when water just passes over the notch
5. Collect the water discharging from the notch in measuring tank & measure the rise of water level in the tank for certain period of time 't'
6. Repeat the above procedure the for various discharge by operating the regulating valve & different notch

Result:-

The Co-efficient of Discharge of the given Notch = 0.64

22/30

27/01

Diagram

For Rectangular Notch $Q_{the} = \frac{2}{3} \times L \times \sqrt{2g} \times H^{3/2}$

L = Length of notch

Table of Readings

SL NO	Type of Notch	Hook gauge reading in (mm) of water			Time taken for the of water in Storage tank (t) in sec
		H_1	H_2	$H = H_2 - H_1$	
1	Rectangular Notch	79.2	14.8	61.8	10
2		79.2	15.1	71	8
3					
1	V-notch (90°)	11.214	15.808	4.5932	27
2		11.214	17.9	6.6857	11
3		11.214	18.20	6.9892	10

Calculations: [For Rectangular notch]

1) $Q_a = \frac{0.24049 \times 10 \times 10^{-2}}{10} = 2.4 \times 10^{-3}\ m^3/s$

Name of Experiment V- Notch [90°] & Rectangular Notch Date : 21/8/19

Experiment No. Page No. 20

V-Notch [90°] & Rectangular Notch

Formula used:-

1) Actual Discharge

$$Q_a = \frac{AR}{t}$$

A = Area of the measuring tank in m^2
R = Rise of water level in the tank for time t
t = Time taken for R cm rise in the tank in S

2) Theoretical Discharge

~~For V-notch $Q_{th} = \frac{8}{15} \times \sqrt{2g} \tan\frac{\theta}{2} \times H^{5/2}$~~

$$Q_{th} = \frac{8}{15} \times \sqrt{2 \times 9.81} \times \tan\left(\frac{90}{2}\right) \times (H)^{5/2}$$

3) Co-efficient of Discharge = $C_d = \frac{Q_{act}}{Q_{theori}}$

Table of Result :-

SL NO	Type of Notch	Actual discharge Q_{act} in m^3/sec	Theoretical discharge Q_{the} in m^3/sec	Cd
1	Rectangular Notch	2.41×10^{-3}	3.4946×10^{-3}	0.68
2		3×10^{-3}	4.275×10^{-3}	0.70
1	V-Notch (90°)	9.259×10^{-3}	1.068×10^{-3}	0.86
2		2.27×10^{-3}	2.903×10^{-3}	0.78

2) $Q_{th} = \frac{2}{3} \times 0.075 \times \sqrt{2 \times 9.81} \times (0.618)^{3/2} = 3.4946 \times 10^{-3}\ m^3/s$

3) $Cd = \frac{2.4 \times 10^{-3}}{3.49 \times 10^{-3}} = 0.68$

V- Notch (90°) :-

1) $Q_a = \frac{0.24049 \times 10 \times 10^{-2}}{27} = 9.259 \times 10^{-3}\ m^3/s$

2) $Q_{th} = \frac{2}{3} \times 0.075 \times \sqrt{2 \times 9.81} \times (0.0459)^{3/2} = 1.068 \times 10^{-3}$

3) $Cd = \frac{9.259 \times 10^{-3}}{1.068 \times 10^{-3}} = 0.86$

Name of Experiment .... Date : ....

Experiment No. .... Page No. 29

Result:- The Co-efficient of Discharge of the given Notch = ?

22/30

21-8-19

Diagram

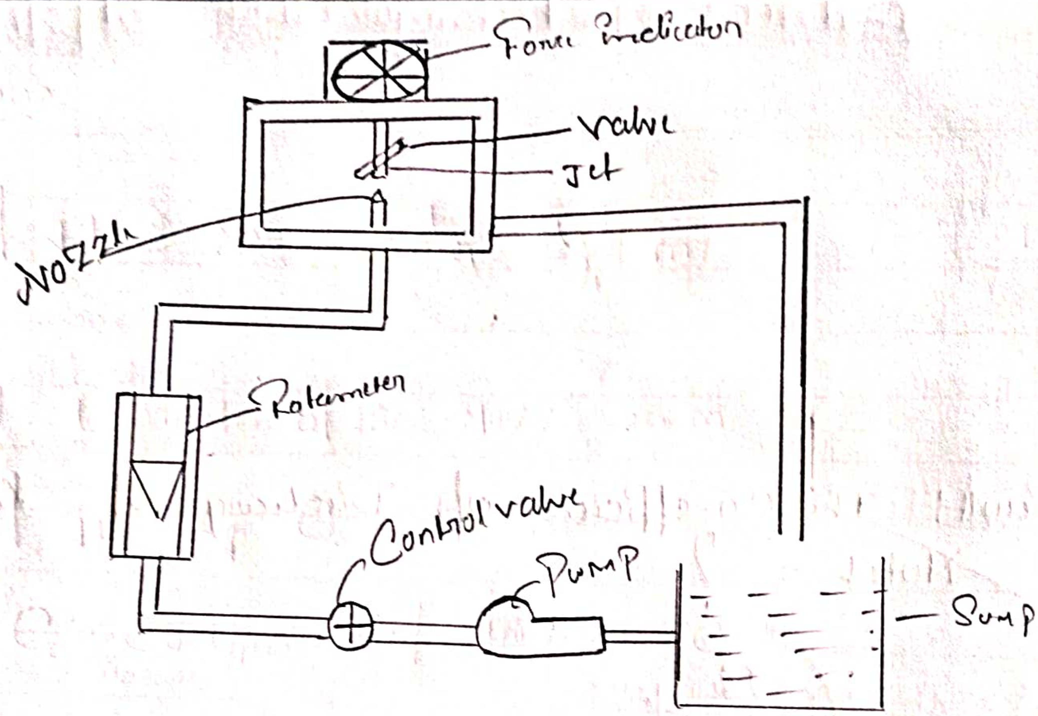


Table of Calculations & Readings

Sl NO	Type of Valve	Dia of Jet (d) (m)	Qact LPm	Qact m^3/s	Force (digital) Indicator Fact kgf	Force (digital) Indicator Fact N
1)	Hemispherical	7×10^{-3}	10	1.66×10^{-4}	0.67	~~0.65~~ 6.5727
		7×10^{-3}	20	3.33×10^{-4}	0.215	2.109
		7×10^{-3}	30	5×10^{-4}	0.587	5.758
2)	Flat	7×10^{-3}	10	1.66×10^{-4}	0.021	0.206
		7×10^{-3}	20	3.33×10^{-4}	0.220	2.1582
		7×10^{-3}	30	5×10^{-4}	0.50	4.905
3)	Inclined	7×10^{-3}	10	1.66×10^{-4}	0.062	0.608
		7×10^{-3}	20	3.33×10^{-4}	0.220	2.158
		7×10^{-3}	30	5×10^{-4}	0.50	4.905

Name of Experiment: Impact of Jet on Vanes Date: 28/8/19

Experiment No. 04 Page No. 21

IMPACT OF JET ON VANES

Aim:- TO Determine the co-efficient of impact on vanes

Theory:- The liquid comes out in the form of a jet from the outlet of a nozzle which is fitted to a pipe through which the liquid is flowing under pressure if some plate which may be fixed or moving is placed in the path of the jet the jet on the plate exert a force. This force is obtained from Newton's second law of motion or from impulse momentum equation thus impact of jet means the force exerted by the jet on a plate which may be stationary or moving

a) Force exerted by the jet on a stationary plate is when

(i) Plate is vertical to jet (ii) Plate is inclined to jet

(iii) Plate is curved

b) Force exerted by the jet on a moving plate is when

(i) Plate is vertical to jet (ii) Plate is inclined to jet

(iii) Plate is curved

Apparatus used

1) vanes (flat inclined with θ=60° & hemispherical experimental setup comprising orifice meter nozzle of different diameter steady supply of water using pump

Observation

(1) Area of Jet @ Nozzle : $A_n = \frac{\pi d^2}{4} m^2$ $d = 7 \times 10^{-3}$

where d = Diameter of the Nozzle in m

(2) Area of Jet $A_J = C_c \times A_n$ m^2

where C_c = Co-efficient of friction = 0.96

Calculations:-

1) Hemispherical

$F_{th} = 2 \rho A_J V^2$

$F_{th_1} = 1.491N$

$F_{th_2} = 6.0025N$

$F_{th_3} = 13.52N$

Avg $F_{th} = 7.004N$

Avg $F_{act} = 4.813N$

$k = 0.687$

$A_n = \frac{\pi \times (7 \times 10^{-3})^2}{4} = 3.8484 \times 10^{-3} m^2$

$A_J = 0.96 \times 3.8484 \times 10^{-5}$

$A_J = 3.6945 \times 10^{-5} m^2$

$V = \frac{Q_{act}}{A_J} = \frac{1.66 \times 10^{-4}}{3.6945 \times 10^{-5}}$

$V_1 = 4.493$ m/s

$V_2 = 9.013$ m/s

$V_3 = 13.53$ m/s

Procedure:-

1. Fix the measured diameter of nozzle & the vane of the measured shape in position
2. Bring the force indicator position to zero
3. Keep the delivery valve closed & switch on the pump
4. Close the front transparent glass tightly
5. Observe the force as indicated on the force indicator
6. Open the delivery valve & adjust the flow rate
7. Note down the diameter of the pipe of the jet & shape of the valve & the discharging in calculation

Formula used:-

Velocity of jet $= V = Q_{act} / A_J$ m/s

where Q = is discharge in m^3/s

Theoretical force:-

$F_{the} = \rho A_J V^2$ N [flat plate]

$F_{theo} = \rho A_J V = 2 \rho A_J V^2$ N [Hemispherical plate]

2) Flat :- $F_{th1} = \rho A_j V^2 = 1000 \times 3.6945 \times 10^{-5} \times (4.4933)^2 = 0.7458 N$

$F_{th2} = 3.0011 N$ Avg $F_{th} = 3.503 N$ $k = 0.691$

$F_{th3} = 6.7831 N$ Avg $F_{act} = 2.423 N$

3) Inclined

$F_{th1} = \rho A_j V^2 \sin^2\theta = 1000 \times 3.6945 \times 10^{-5} \times (4.4933)^2 \sin^2 60°$

$F_{th1} = 0.559 N$

$F_{th2} = 2.250 N$

$F_{th3} = 5.072 N$

Avg $F_{th} = 2.627 N$

Avg $F_{act} = 2.488 N$

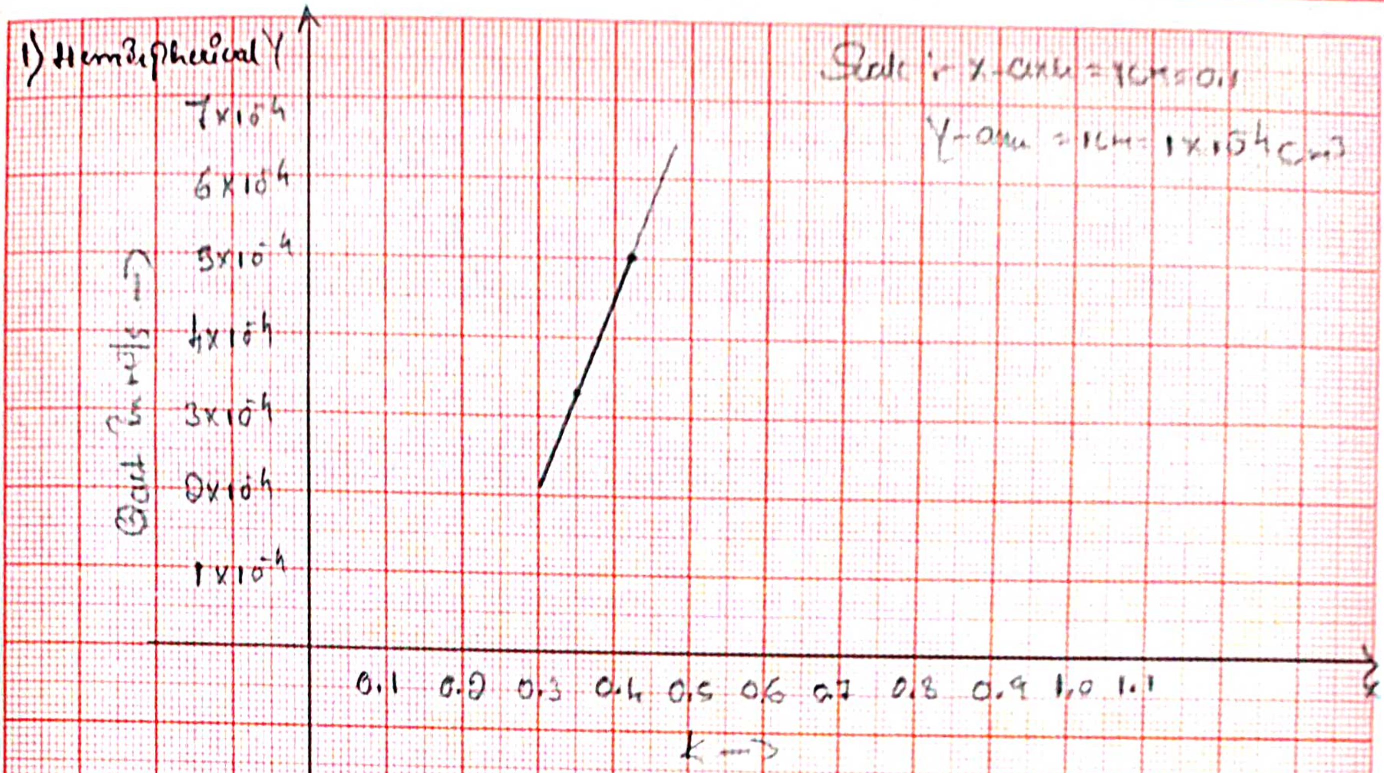
$k = 0.947$

Table of Result

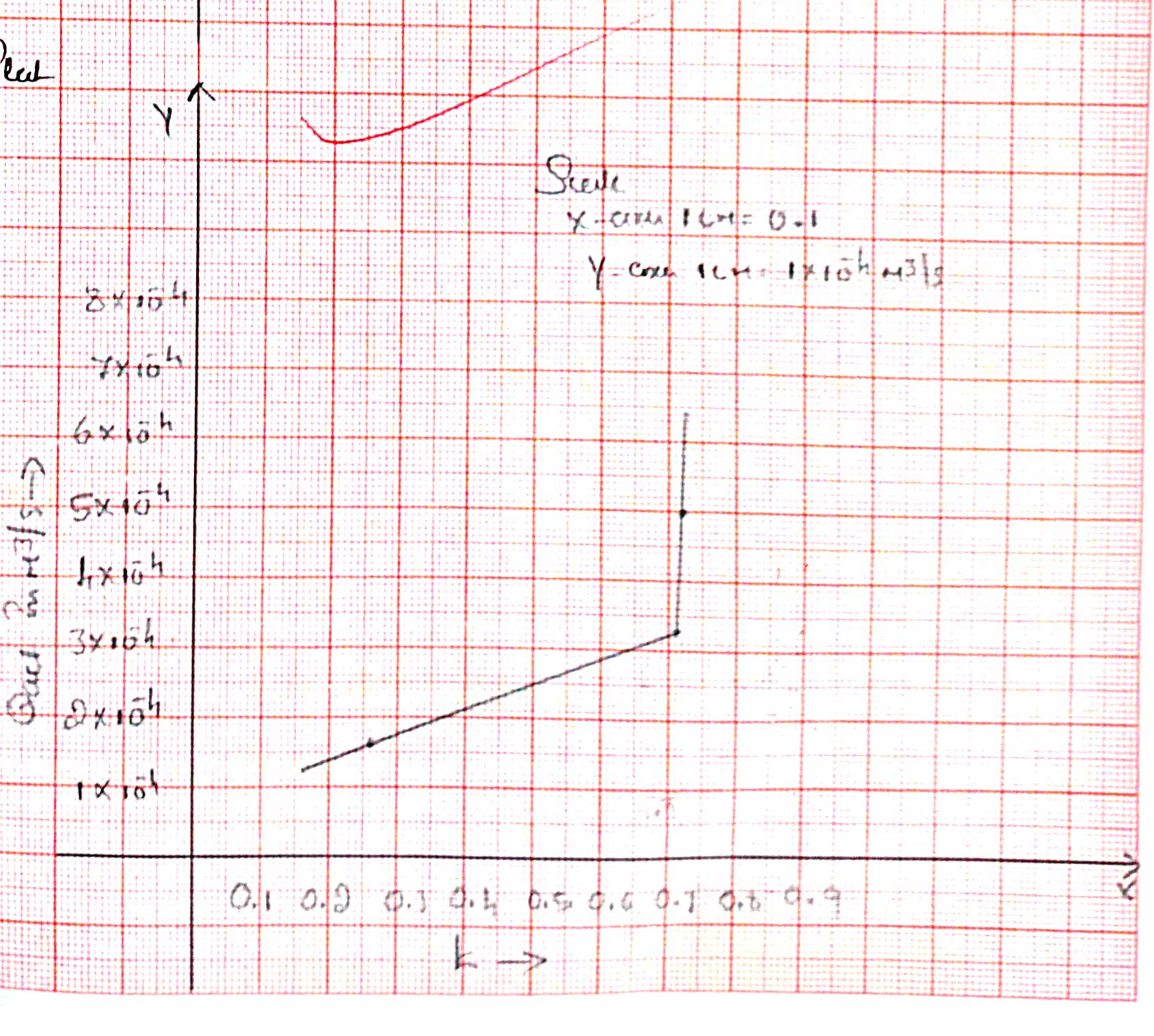
Type of Vane	Dia of Jet d (m)	F_{the}	$k = \frac{F_{actual}}{F_{theor}}$	Avg. k
Hemispherical	0.007	7.004	0.687	
Flat	0.007	3.503	0.691	0.775
Inclined	0.007	2.627	0.947	

Date : ☐☐ ☐☐ ☐☐☐☐ Batch No. ....

1) Hemispherical



2) Flat



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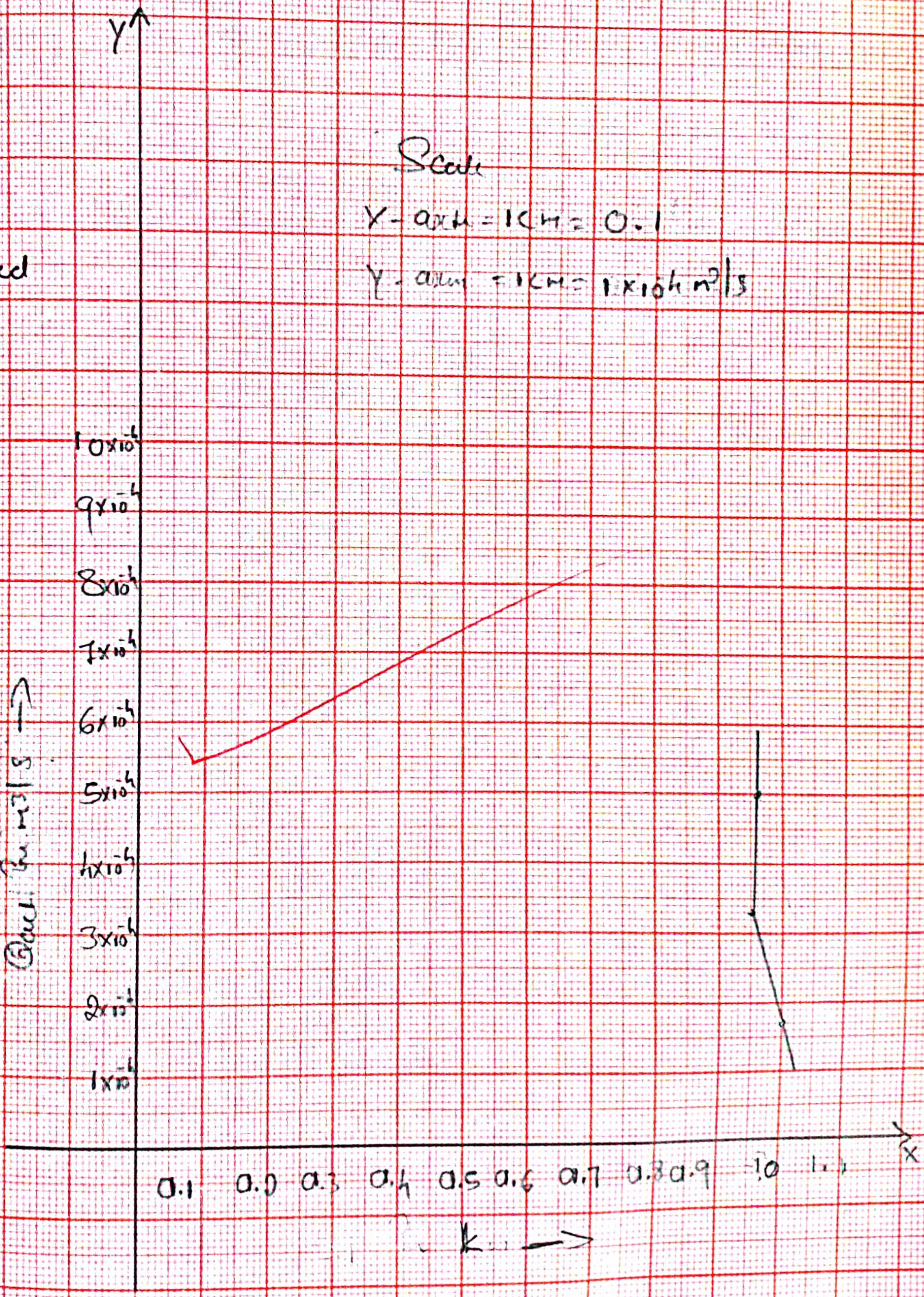
3) Inclined



$F_{theor} = \rho A J V^2 \sin 2\theta$ N [Inclined Plate]

Actual force = F_{act} (Observed in force Indicator)

Co-efficient of Impact $k = \frac{F_{act}}{F_{the}}$

Result:

The Co-efficient of Impact on

1) Flat vane

2) Inclined vane

3) Hemispherical vane

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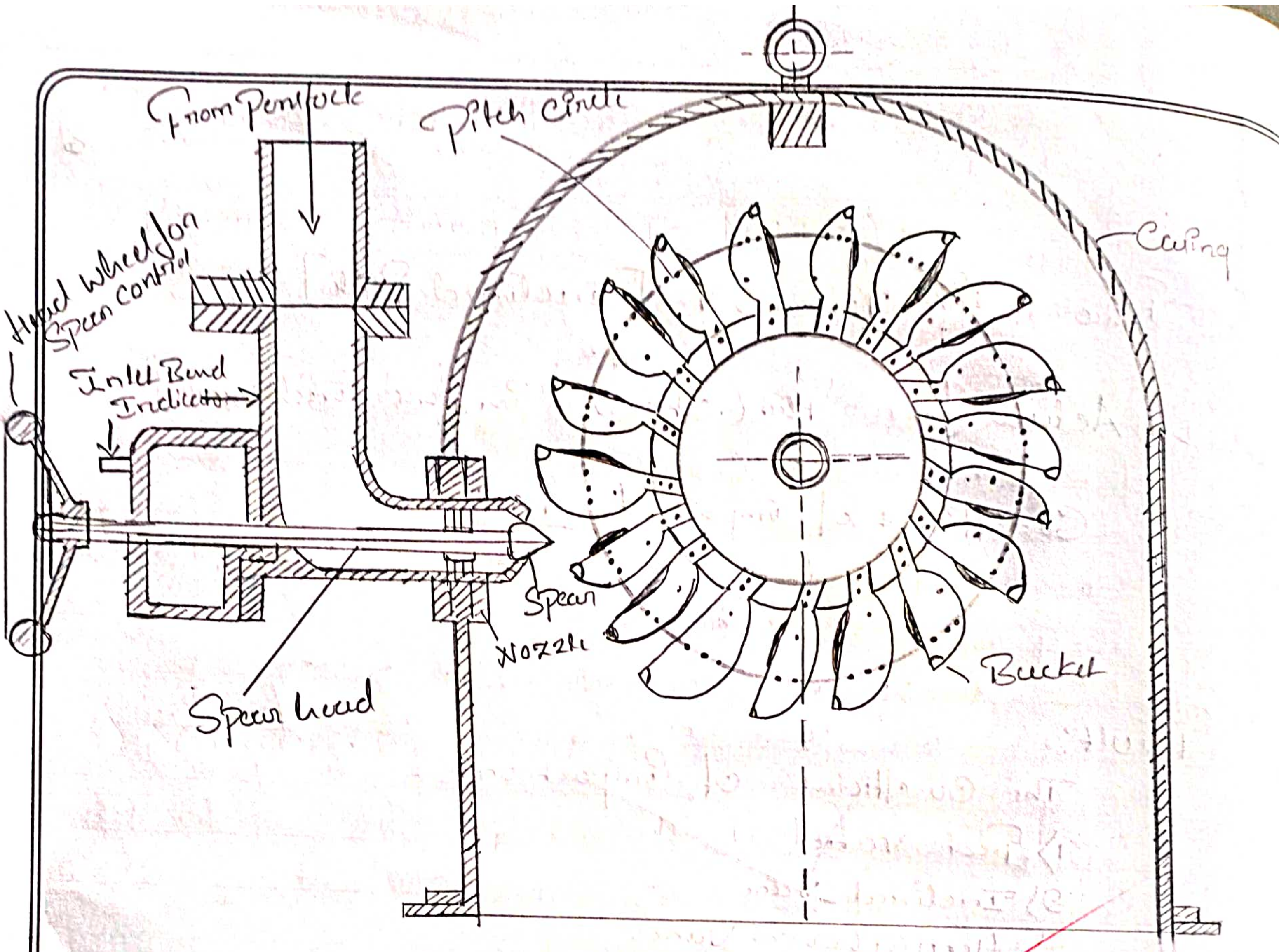

Fig:- Pelton wheel

Tabular Column:- [For Constant Head]

SL NO	Delivery Pressure 'P' in (kg/cm²)	Speed 'N' in (rpm)	Venturimeters head R2	R1	Weight W in kg	Spring balance S in kg
1	1.6	920	1.5	1.8	1	0.5
2	1.7	900	1.4	1.6	2	0
3	1.6	835	1.4	1.6	3	1.5

PELTON WHEEL TURBINE TEST RIG

Aim:- To Study the Performance Characteristics of a Pelton wheel turbine & to draw the main & operating Characteristics Curves

Introduction:- Pelton wheel turbine is a tangential flow impulse turbine used for high head conditions. water is made to Pass through a Set of nozzle wherein the high Pressure energy is Converted into K.E. Higer velocity water Jet is made to impinge on a Set of Cups mounted on the Periphery of a wheel. The cups have a double semiellipsoidal Shape to avoid axial thrust & are Provided with a notch at the bottom to optimize time of energy transfer. In this test rig the output is measured by a brake drum dynamometer Coupled to the turbine. The inlet Power to the turbine is Calculated by means of a Venturimeter to measure discharge, & a Pressure gauge to measure the inlet Pressure to the turbine

Test Rig details

1) Pelton wheel with rope brake dynamometer
2) Pressure gauge to measure turbine entry Pressure

Specimen Calculations:-

1) Torque transmitted $T = [(W-S) + \text{hanger weight}] \times 9.81 \times R_{eff}$ N-m

where R_{eff} = Radius of Brake drum + radius of rope

2) Output Power $OP = \frac{2 \times \pi \times N \times T}{60{,}000}$ kW

3) Venturimeter head

$$h = h_1 - h_2 = 10(P_1 - P_2) \text{ m of water}$$

$$Q = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

4) Delivery head $H = 10 \times P$ in m of water

5) Input Power $IP = \frac{WQH}{1000}$ in kW

6) Efficiency $= \eta = \frac{OP}{IP} \times 100$

7) Specific speed $= N_s = \frac{N\sqrt{OP}}{H^{5/4}}$

Name of Experiment .... Date : ....

Experiment No. ....

3. Storage tank with Centrifugal Pump Powered by a Motor

4. Venturimeter with Pressure gauge

Specifications:-

* Weight of the hanger W = 1 kg
* Number of buckets = 20
* Normal Speed = 1000 RPM
* Jet Diameter = 20mm
* Jet Ratio = 12 approx
* Brake drum dynamometer D_{drum} = 300mm = 0.3m
* Rope diameter = d_{rope} = 20mm = 0.02m
* Cd = 0.98

Venturimeter details:-

* d_1 = Diameter of the Pipe [mouth diameter of the Venturimeter] = 50mm = 0.05m
* d_2 = Throat diameter = 25mm = 0.025m
* a_1 = Area of the Pipe = 1.96×10^{-3} m
* a_2 = Area of the throat = 4.90×10^{-4} m

Procedure:-

Main Characteristics of Pelton wheel (Constant head)

1) Adjust the gate opening to the specified value
2) With the discharge valve of the pump closed, Start the Centrifugal Pump
3) Adjust the inlet valve of the turbine to

8) Unit Speed $= N_U = \frac{N}{\sqrt{H}}$

9) Unit discharge $= Q_U = \frac{Q}{\sqrt{H}}$

10) Unit Power $= P_U = \frac{OP}{H^{3/2}}$

Table of Results:-

Delivery head H in (m)	Discharge Q in (m^3/s)	Torque T in N-m	OP in (kW)	IP in (kW)	% of Efficiency	N_s in SI units	N_u in rpm	Q_u in m^3/s	P_u in (kW)
16	3.888×10^{-3}	2.35	0.226	0.609	37.11	13.66	230	9.7×10^{-4}	3.53×10^{-3}
17	8.17×10^{-3}	3.13	0.295	0.523	55.87	14.56	218.32	7.68×10^{-4}	4.2×10^{-3}
18	3.17×10^{-3}	3.92	0.343	0.493	69.01	15.28	208.75	7.92×10^{-4}	5.35×10^{-4}

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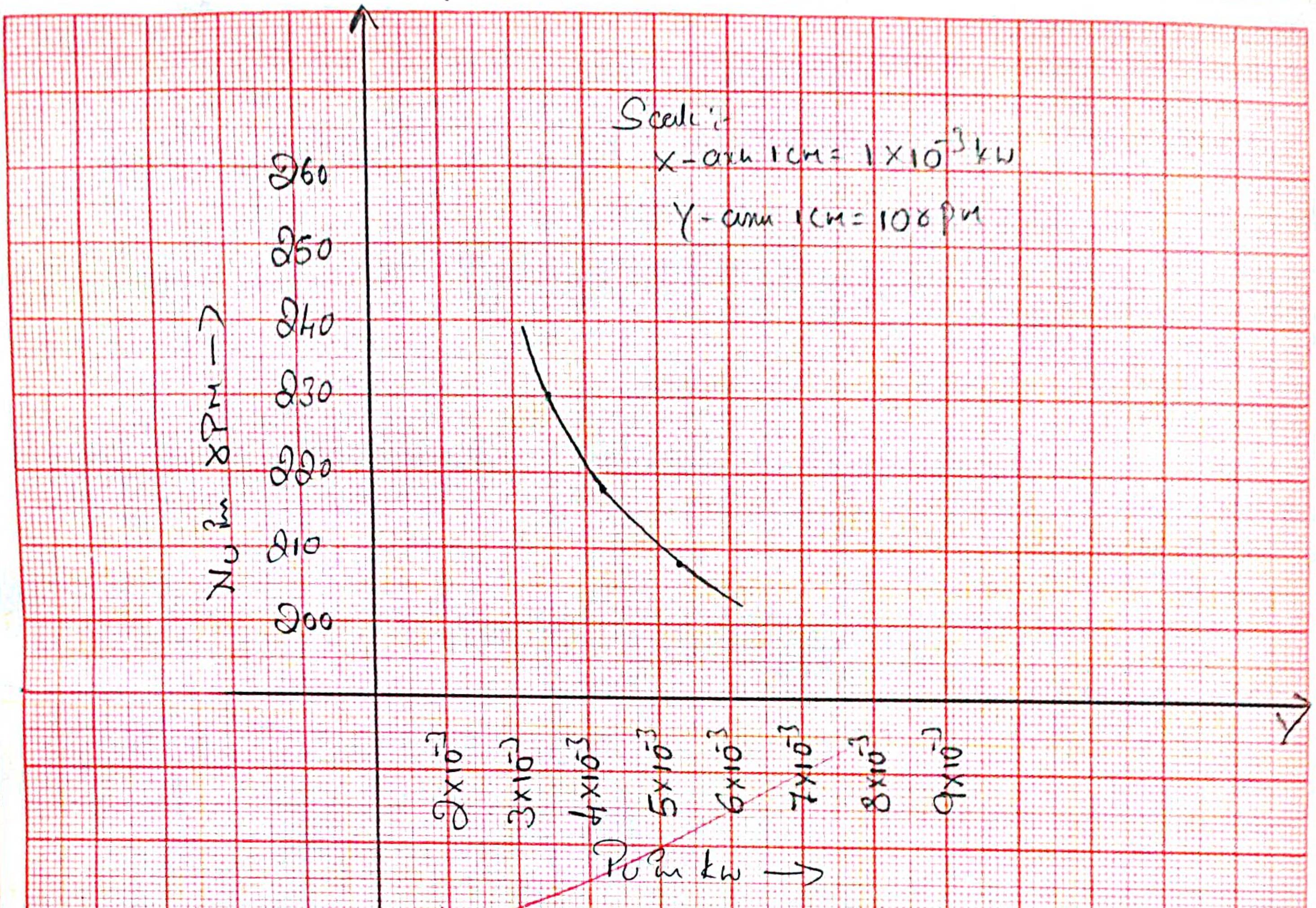
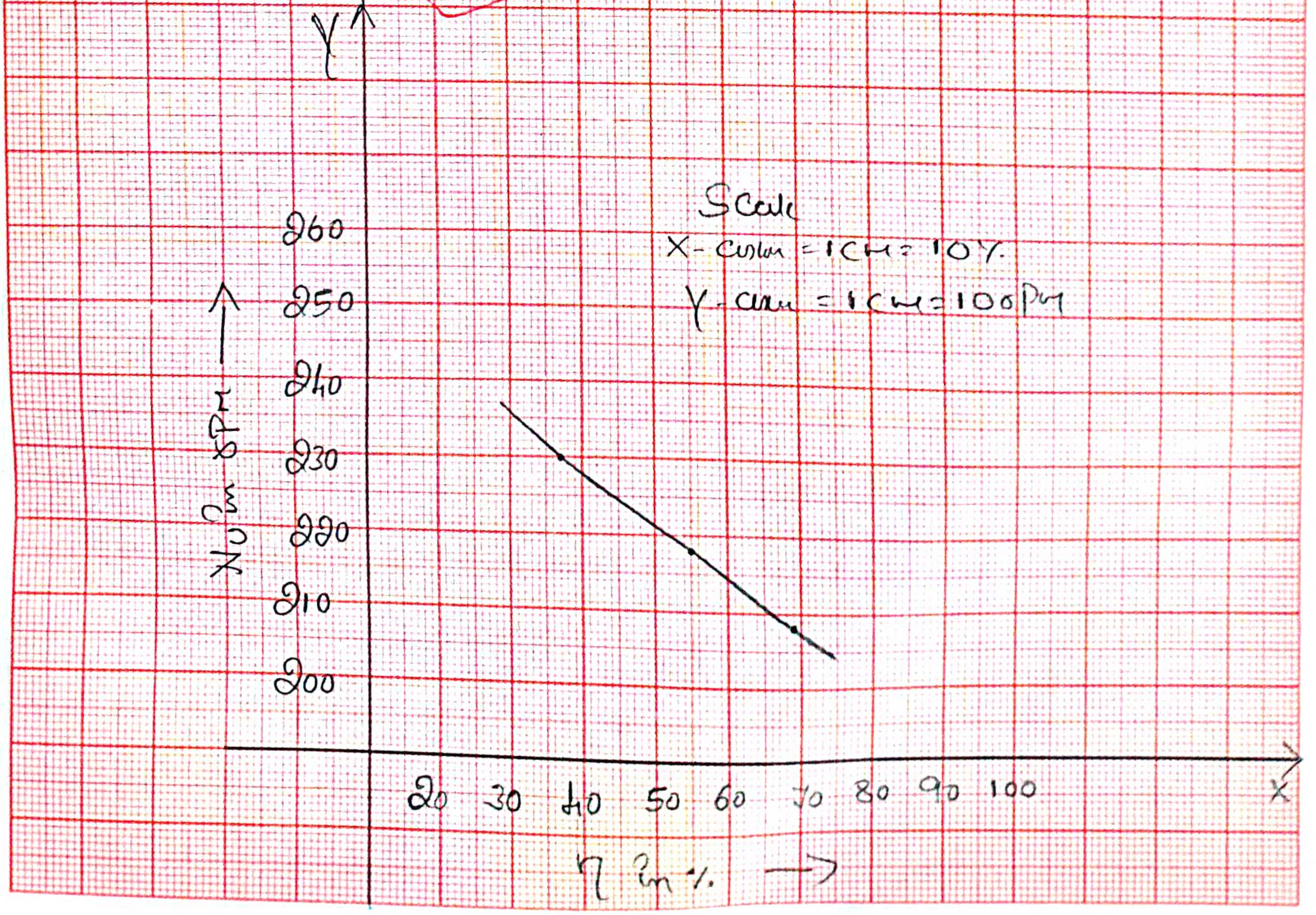
For Constant Load





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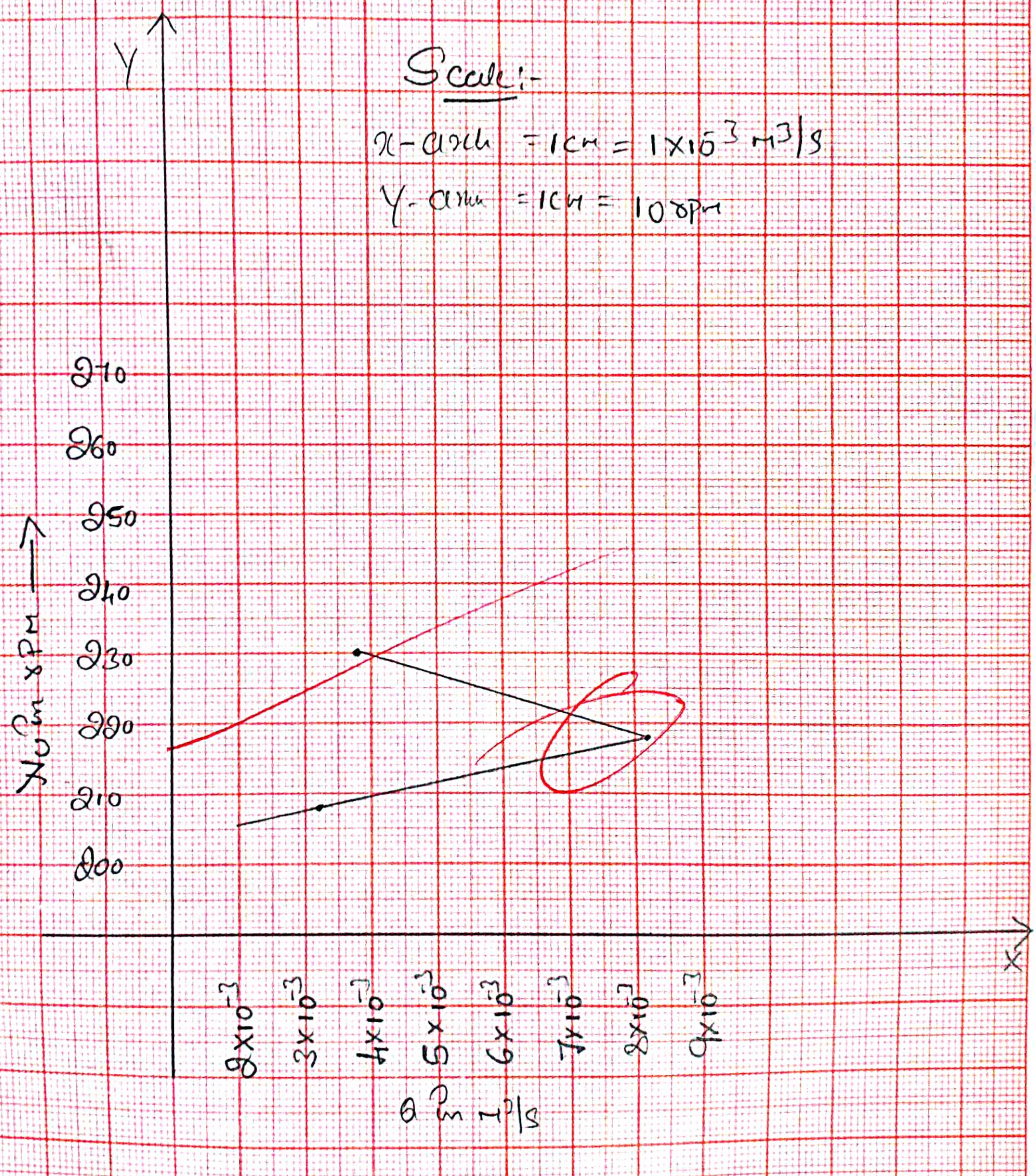


Calculations: (1) $T = [(W-S) + \text{hanger weight}] \times 9.81 \times R_{eff}$

$T = [(1-0.5)+1] \times 9.81 \times 0.16 \Rightarrow 2.3544$

2) $OP = \frac{2\pi NT}{60,000} = \frac{2\pi \times 920 \times 2.3544}{60,000} = 0.2268\,kw$

3) $h = 10(P_1 - P_2) = 10(1.8-1.5) = 3$

4) $Q = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} = \frac{1.9634\times10^{-3} \times 4.908\times10^{-4} \times \sqrt{2\times9.81\times3}}{\sqrt{(1.9634\times10^{-3})^2 - (4.908\times10^{-4})^2}}$

$Q = 3.888\times10^{-3}\,m^3/s$

5) $H = 10 \times Pd = 10\times1.6 = 16$

6) $IP = \frac{\rho g Q H}{1000} = \frac{1000\times9.81\times3.888\times10^{-3}\times16}{1000} = 0.609\,kw$

7) $\eta = \frac{OP}{IP}\times100 = \frac{0.226}{0.609}\times100 = 37.11\%$

8) $N_s = \frac{N\sqrt{OP}}{H^{5/4}} = \frac{920\sqrt{0.2268}}{16^{5/4}} = 13.69$

9) $N_u = N/\sqrt{H} = \frac{920}{\sqrt{16}} = 230\,rpm$

10) $Q_u = \frac{Q}{H^{1/2}} = \frac{3.888\times10^{-3}}{16^{1/2}} = 9.7\times10^{-4}\,m^3/s$

11) $P_u = \frac{OP}{H^{3/2}} = \frac{0.2268}{16^{3/2}} = 3.54\times10^{-3}\,kw$

to give the Specified head on the turbine
4). Note down the readings such as Pressure gauge reading. Vaccum gauge reading the Speed of the turbine
5. Now load the turbine by adding weight at the bottom end of the rope brake dynamometer,
6. Adjust the inlet valve to give the Same head & to note down all the Previously mentioned reading along with the load & the Spring balance reading
7. Repeat the Experiment at different loads
8. Change the gate opening to the other Specified values & repeat the Experiment.

Operating characteristics (Constant Speed)

1. keep the gate opening at the Specified value & adjust the inlet valve to give a Specific Speed for different loads on the turbine
2. Take the readings on the Pressure gauge, Speed, weight & the Spring balance reading
3 Repeat the Experiment for Different loads on the turbine

Tabular Column: for Constant Speed

SL No	Delivery Pressure 'P' in (kg/cm²)	Speed N in (rpm)	Venturimeter Time (t) for head 'N' revolutions in sec P_2	P_1	weight w in kg	Spring Balance S in kg
1	1.6	1000	1.5	1.8	1	0.5
2	1.7	1000	1.4	1.6	2	0

Specimen Calculations:-

1) Torque transmitted $T = [(W-S) + \text{hanger weight}] \times 9.81 \times R_{eff}$ N-m

Where $R_{eff} = \dfrac{\text{Radius of Brake drum} + \text{Radius of rope}}{2}$

2) Output Power $OP = \dfrac{2 \times \pi \times N \times T}{60{,}000}$ kW

3) Venturimeter head

$h = h_1 - h_2 = 10(P_1 - P_2)$ m of water

$$Q = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

3) Delivery head $H = 10 \times P$ in m of water

4) Input Power $= IP = \frac{WQH}{1000}$ in kW

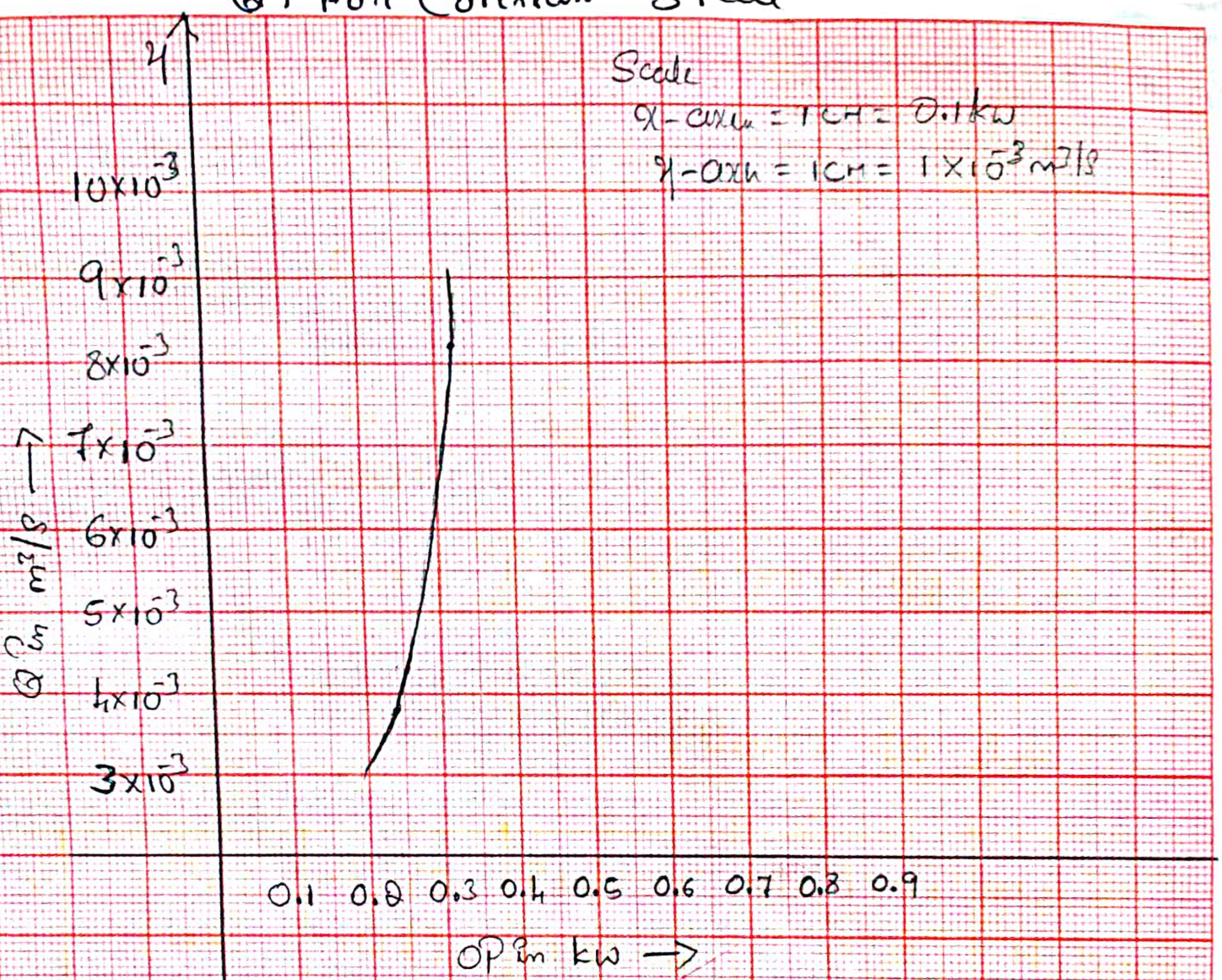
5) Efficiency $= \eta = \frac{OP}{IP} \times 100$

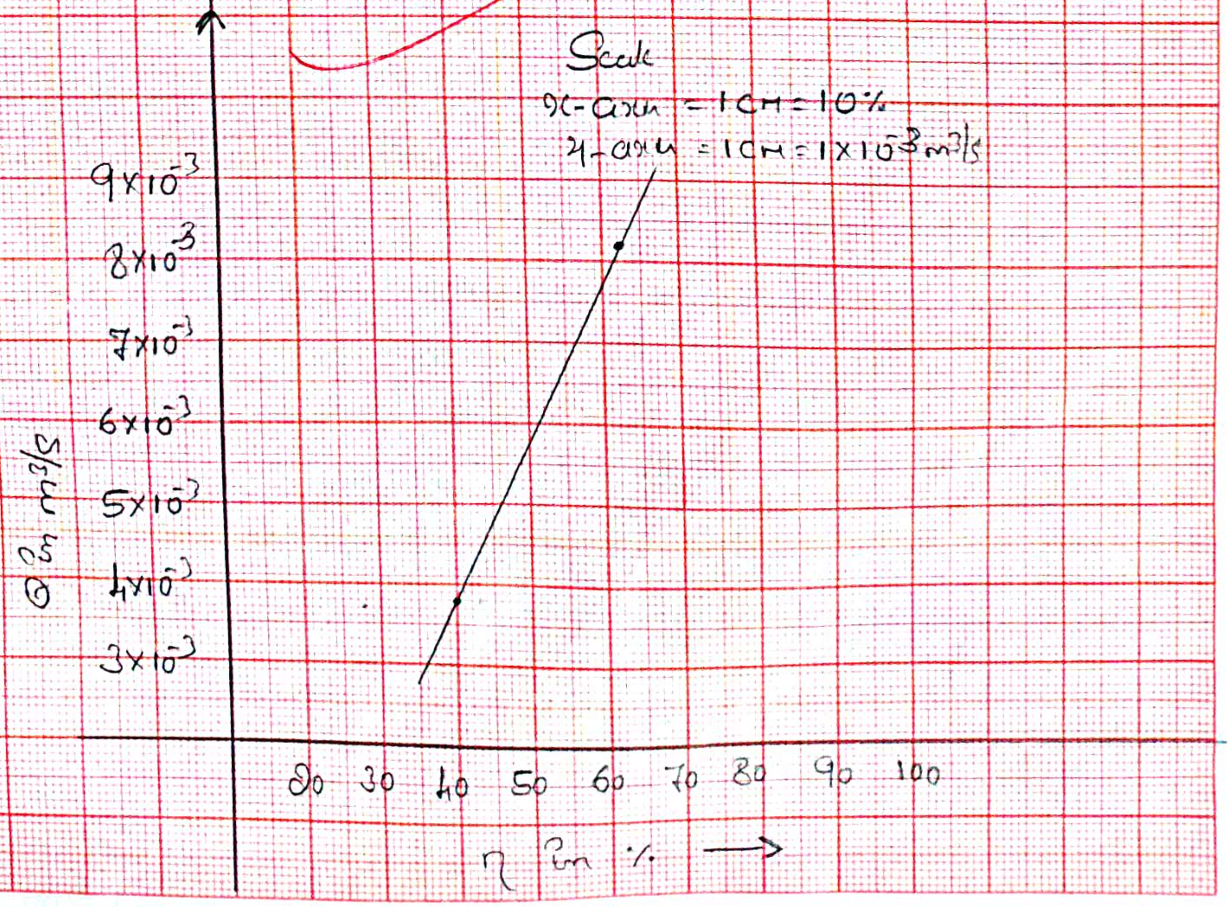
Table of Results:-

Delivery Head 'H' in (m)	Discharge 'Q' in (m^3/s)	Torque T in N-m	OP in (kW)	IP in (kW)	% Efficiency
16	3.88×10^{-3}	2.35	0.246	0.609	40.3
17	8.17×10^{-3}	3.13	0.3277	0.528	62.06

Date : Batch. No.

(2) For Constant Speed





Calculation:- For Constant Speed

1) $T = [(1-0.5)+1] \times 9.81 \times 0.16 = 2.3544$ N-m

2) $OP = \frac{2\pi \times 1000 \times 2.3544}{60000} = 0.2465$ kw

3) $h = 10(P_1 - P_2) = 10(1.8-1.5) = 3$

4) $Q = \frac{1.9634\times10^{-3} \times 4.908\times10^{-4} \times \sqrt{2\times9.81\times3}}{\sqrt{(1.9634\times10^{-3})^2 - (4.908\times10^{-4})^2}}$

$Q = 3.888\times10^{-3}\, m^3/s$

5) $H = 10 \times P_d = 10\times1.6 = 16$

6) $IP = \frac{\rho g Q H}{1000} = \frac{1000\times9.81\times3.88\times10^{-3}\times16}{1000} = 0.609$ kw

7) ~~Table of Sur~~ $\eta = \frac{OP}{IP}$

$= \frac{0.246}{0.609} \times 100 = 40.39\%$

Result :- Draw the graph of operating characteris. of the Pelton wheel

* Output power (OP) VS Discharge (Qu)
* Percentage Efficiency (η) VS Discharge (Qu)

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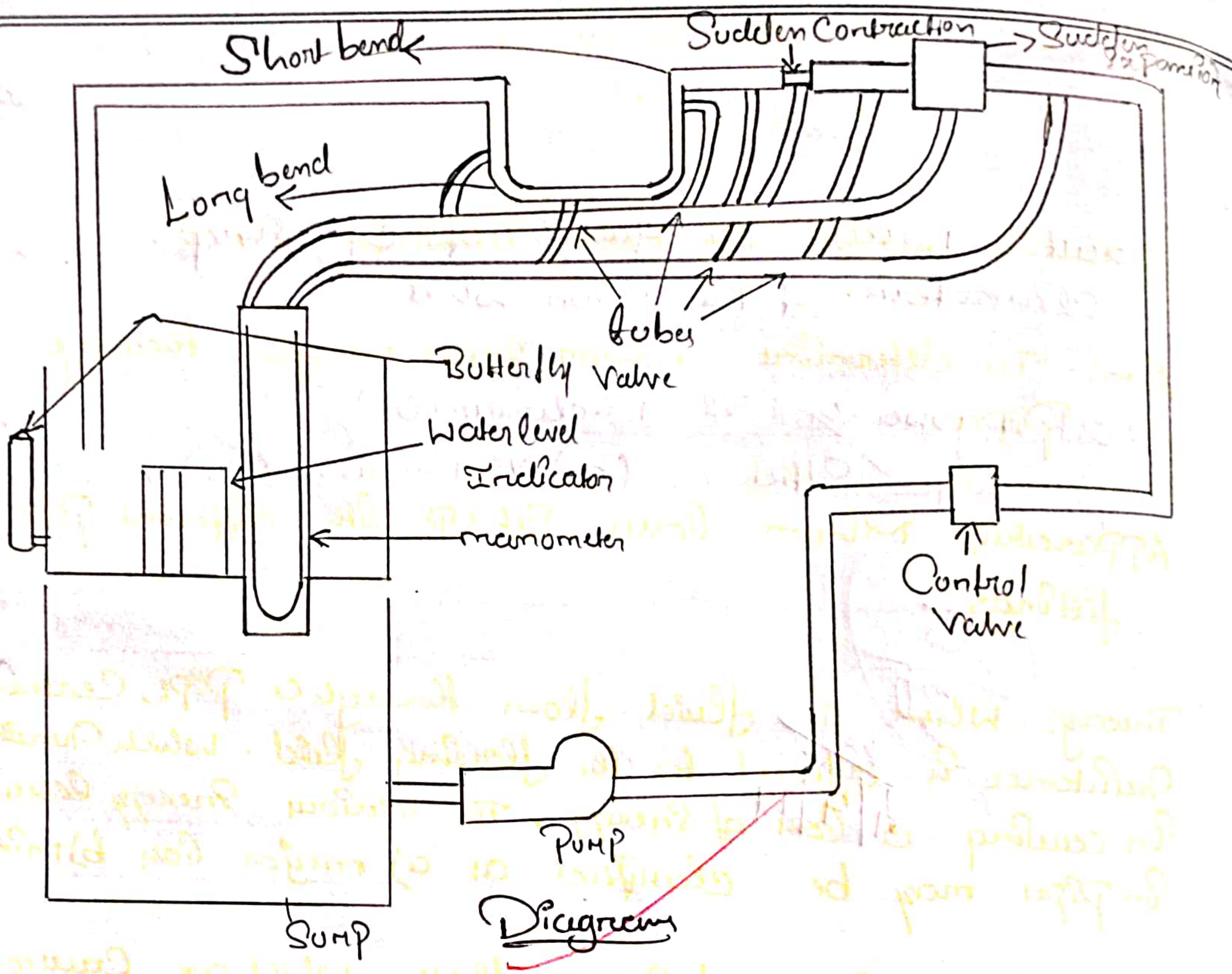

Diagram

Observations:-

1) A_1 = Area of the measuring tank = L x B = 250x400 = 10,0000 mm^2

2) D = Diameter of the pipe in the measuring tank = 75 mm

3) A_2 = Area of the pipe in measuring tank = 4417.86 mm^2

4) A_E = Effective area of the measuring tank

$= A_1 - A_2 = 95582.13\ mm^2$

5) Pipe fitting : Contraction, Expansion, Elbow long bend

MINOR LOSSES IN FLOW THROUGH PIPES

Aim:- To determine minor losses in flow through Pipes

Apparatus:- Minor losses set up with different pipe fittings

Theory:- When a fluid flows through a pipe, certain resistance is offered to the flowing fluid. Which results in causing a loss of energy. The various energy losses in pipes may be classified as - a) major loss b) Minor

The minor loss of energy those which are caused on account of the change in the velocity of flowing fluid In case of long pipes these are usually quite small as compared with the loss of energy due to friction & hence these are termed as "minor loss" which may even be neglected without serious error. However in short pipes these losses may sometimes outweigh the friction loss, Some of the losses of energy which may be caused due to the change to velocity are indicated below

1) The frictional resistance causes loss of head h_f, is given by Darcy Weisbach equation

$$h_f = \frac{4fLV^2}{2gd}$$ f is co-efficient of friction

3) 90° Elbow :-

Sl No	Manometer Reading h_1	h_2	$h = h_1 - h_2$	Head loss h_f m of water	Time taken to complete 10 ltr t in sec	Actual discharge Q_{act} m³/s	Velocity of flow m/s V	Head loss due to Elbow
1	0.1	-0.3	0.2	0.0252	20	4.75×10^{-4}	0.969	0.510
2	0.2	-0.4	0.2	0.0252	25	3.8×10^{-4}	0.7755	0.63
3	0.45	-0.2	0.25	0.0315	28	3.37×10^{-4}	0.698	0.89

4) Bend

Sl No	Manometer Reading h_1	h_2	$h = h_1 - h_2$	Head loss h_f m of water	Time taken to complete 10 ltr t in sec	Actual discharge Q_{act} m³/s	Velocity of flow m/s V	Head loss due to bend
1	0.53	-0.3	0.23	0.0289	32	2.968×10^{-4}	0.6058	0.~~6058~~ 93
2	0.2	-0.4	0.2	0.0262	35	2.57×10^{-4}	0.5528	0.85
3	0.5	-0.3	0.2	0.0252	38	2.5×10^{-4}	0.510	0.96

2) The Loss of head due to Sudden Enlargement

$$h_f = \frac{(V_1 - V_2)^2}{2g}$$

3) The Loss of head due to Sudden Contraction

$$h_f = \frac{0.5 V_2^2}{2g}$$

4) The Loss of head due to Pipe fittings

$h_f = \frac{kV_2}{2g}$, The value of 'k' for different types of valve & for different ratios of the height of opening to the diameter

Procedure:-

1) Fill in the Sump tank with clean water
2) keep the Delivery valve closed
3) Connect the Power cable
4) make sure the Digital manometer is ON
5) Switch ON the Pump & open the Delivery valve
6) Open the Corresponding Ball valve of the Pipe fittings
7) Adjust the flow through the Control valve of the Pump
8) Note down the differential head readings
9) Operate the butterfly valve to note down the Collecting tank reading against the known time & keep it open when the readings are not taken

Calculations:-

1) Contraction

1) Actual discharge Qact :-

$$Q_{act} = \frac{V}{t} \ m^3/s$$

V is volume of water collected in m^3

2) Frictional loss

$h_f = h(13.6 - 1)$ in m of water

$$= h\left[\frac{S_H}{S_W} - 1\right] = h\left[\frac{13.6}{1} - 1\right]$$

3) Velocity at inlet $V_1 = \frac{Q_{act}}{a_1}$ m/s

Inlet area $a_1 = \frac{\pi}{4} d_1^2 \ m^2$

Inlet diameter $d_1 =$ mm

4) Velocity at outlet

$$V_2 = \frac{Q_{act}}{a_2} \ m/s$$

Outlet area $a_2 = \frac{\pi}{4} d_2^2 \ m^2$

Outlet diameter $d_2 =$ mm

5) The loss of Head due to Sudden Contraction

$$h_L = \frac{0.5 V_2^2}{2g} \text{ in m}$$

10) Change the flow rate & repeat the experiment for different pipe fitting

Specifications:-

1) Volume of water collected, V = _ _ _ m^3

2) Pipe fittings: Contraction, Expansion, Elbow, long bend

Calculation:-

(i) Contraction

$d_1 = 25mm$ $a_1 = 4.9087 \times 10^{-4} m^2$

$d_2 = 16mm$ $a_2 = 2.010 \times 10^{-4} m^2$

$Q_{act} = \frac{V}{t} m^3/s$

$\frac{0.09558 \times 10 \times 10^{-2}}{19} = 5.03 \times 10^{-4} m^3/s$

$h_f = 4.5(13.6-1) = 56.7 cm = 0.567 m$

$V_2 = \frac{Q_{act}}{a_2} = \frac{5.03 \times 10^{-4}}{4.9087 \times 10^{-4}} = 2.502 m/s$

2) Expansion

1) Actual discharge Q_{act} :-

$$Q_{act} = \frac{V}{t} \ m^3/s$$

V is the volume of water collected in m^3

$h_f = h(13.6-1)$ in m of water

3) velocity at inlet $V_1 = \frac{Q_{act}}{a_1}$ m/s

inlet area $a_1 = \frac{\pi}{4} d_1^2 \ m^2$

inlet diameter d_1 = ______ mm

4) Velocity at outlet

$$V_2 = \frac{Q_{act}}{a_2} \ m/s$$

outlet area $a_2 = \frac{\pi}{4} d_2^2 \ m^2$

outlet diameter d_2 = ______ mm

5) The loss of head due to Sudden Expansion

$$h_e = \frac{(V_1 - V_2)^2}{2g}$$

3) 90° Elbow

1) Actual discharge Q_{act} :-

$$Q_{act} = \frac{V}{t} \ m^3/s$$

V the volume of water collected in m^3

2) Frictional loss

$$h_{f_1} = \frac{(0.5) \times V_2^2}{2g} = 0.1595 = h_{f_1} = \frac{(0.5) \times (2.502)^2}{2 \times 9.81}$$

$$h_{f_2} = \frac{0.5 \times (2.264)^2}{2 \times 9.81} = 0.13062$$

$$h_{f_3} = \frac{0.5 \times (2.067)^2}{2 \times 9.81} = 0.108$$

2) Expansion

$d_1 = 0.016m$ $a_1 = 2.010 \times 10^{-4} m^2$

$d_2 = 0.025m$ $a_2 = 4.9087 \times 10^{-4} m^2$

$$Q_{act} = \frac{0.09558 \times 10 \times 10^{-2}}{23} = 4.15 \times 10^{-4} m^3/s$$

$$h_f = 0.8\,(13.6 - 1) = 10.08\,cm = 0.1008m$$

$$V_1 = \frac{Q_{act}}{a_1} = \frac{4.15 \times 10^{-4}}{2.010 \times 10^{-4}} = 2.064\,m/s$$

$$V_2 = \frac{Q_{act}}{a_2} = \frac{4.15 \times 10^{-4}}{4.9087 \times 10^{-4}} = 0.8545\,m/s$$

$$h_f = \frac{(V_1^2 - V_2^2)}{2g} = \frac{(2.064 - 0.8454)^2}{2 \times 9.81}$$

$$h_f = 0.075$$

Loss of head due to Sudden Contraction

Sl No	Manometer Readings			Head loss hf m of water	Time taken to collect Rem in 'T' sec	Actual discharge Qact in m^3/s	Velocity of flow m/s V_2	Head loss due to Contraction
	h_1	h_2	$h = h_1 - h_2$					
1	2.2	-2.3	4.5	0.567	19	5.03×10^{-4}	2.502	0.1595
2	1.9	-2.6	4.5	0.567	21	4.55×10^{-4}	2.264	0.13062
3	1.4	-2.1	3.5	0.441	23	4.155×10^{-4}	2.067	0.108

Loss of Head due to Sudden Enlargement / Expansion

Sl No	Manometer Readings			Head loss hf m of water	Time taken to collect Rem in 'T' sec	Actual discharge Qact in m^3/s	Velocity of flow		Head loss due to Expansion
	h_1	h_2	$h = h_1 - h_2$				V_1	V_2	
1	0.1	-0.7	0.8	0.1008	23	4.15×10^{-4}	2.064	0.8454	0.075
2	0.2	-0.8	1	0.12	21	4.55×10^{-4}	2.26	0.926	0.090
3	0.3	-1	1.3	0.1638	22	4.34×10^{-4}	2.15	0.88	0.082

3) 90° Elbow

$d_1 = 25mm$ $a_1 = 4.9087 \times 10^{-4} m^2$

$$Q_{act} = \frac{0.09558 \times 10 \times 10^{-2}}{20} = 4.75 \times 10^{-4} m^3/s$$

$$h = 0.2(13.6-1) = 2.528 cm = 0.02528 m$$

$$V = \frac{Q_{act}}{a_1} = \frac{4.75 \times 10^{-4}}{4.9087 \times 10^{-4}} = 0.969$$

$$k_f = \frac{2gh}{V^2} = \frac{2 \times 9.81 \times 0.02528}{(0.969)^2}$$

$$k_f = 0.510$$

4) Bend:-

$d_1 = 25mm$ $a_1 = 4.9087 \times 10^{-4} m^2$

$$Q_{act} = \frac{0.09558 \times 10 \times 10^{-2}}{32} = ~~4.75 \times 10^{-4} m^3/s~~ \; 2.968 \times 10^{-4} m^3/s$$

$$h = 0.23(13.6-1) = 2.898 cm = 0.02898 m$$

$$V = \frac{Q_{act}}{a} = \frac{2.968 \times 10^{-4}}{4.9087 \times 10^{-4}} = 0.6058$$

$$k_f = \frac{2gh}{V^2} = \frac{2 \times 9.81 \times 0.02898}{(0.6058)^2} = 0.93$$

$h_f = h(13.6-1)$ in m of water

3) Velocity at outlet

$$V = \frac{Q_{act}}{a} \text{ m/s}$$

Area $a = \frac{\pi}{4} d^2 \text{ m}^2$

Diameter of Elbow $d =$ ________ mm

4) The Loss of head due to Elbow

$$h_e = \frac{2g \times h_f}{V^2}$$

4) Long Bend:- 1) Actual discharge Q_{act}:-

$$Q_{act} = \frac{V}{t} \text{ m}^3/\text{s}$$

V = volume of water collected in m^3

2) Frictional loss

$$h_f = h(13.6-1) \text{ in m of water}$$

3) Velocity at outlet

$$V = \frac{Q_{act}}{a} \text{ m/s}$$

Area $a = \frac{\pi}{4} d^2 \text{ m}^2$

Diameter of Bend $d =$ ________ mm

4) The Loss of head due to Elbow

$$h_e = \frac{2g \times h_f}{V^2}$$

Results:-

Loss of head due to
(a) Sudden Contraction
(b) Sudden Enlargement
(c) 90° Elbow
(d) Long bend

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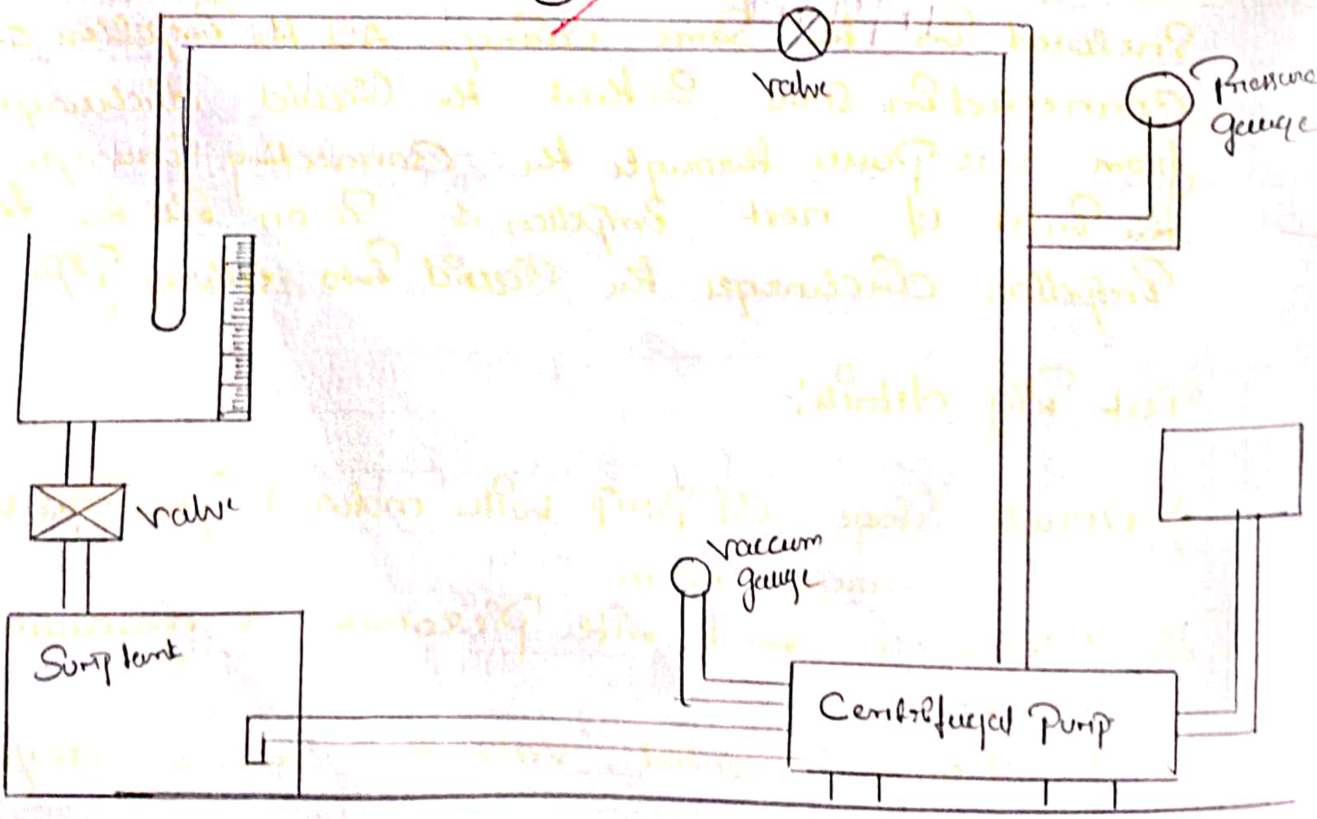
Tabular Column:-

Sl No	Speed in RPM	Delivery Pressure P_d in kg/cm²	Suction Pressure P_s in kg/cm²	Time taken for 'n' revolution of Energy meter t_1 in sec	Time taken for 'R' cm rise in water scale t_2 in sec
1	1500	2.1	460	4.81	16.10
2	1500	3	420	4.91	17.3
3	1500	4	350	5.15	21.25

Stage	Pressure
1st	2nd
0.8	1
1	1.5
1.4	2

Diagram :-



MULTISTAGE CENTRIFUGAL PUMP

Aim:- To Study the Performance Characteristics of the multi Stage Centrifugal Pump & to draw the Characteristics curve

Introduction:- The head Produced by a Centrifugal Pump depends on the Rim Speed of the impeller. To increase the Rim Speed either Relative Speed or the diameter of impeller or both need to be increased But this leads to increase stress on the impeller material which is not desirable. This is overcome by multi Staging of pumps This involves mounting two or more impellers on a common Shaft & Enclosed in the Same casing. All the impellers are connected in Series So that the liquid discharged from one Passes through the Connecting Passages to the inlet of next impeller & So on till the last impeller discharges the liquid into delivery Pipe

Test Rig details:-

1) Double Stage CF Pump with motor & Provided with Energy meter
2) Collecting tank with Piezometer & graduated Scale
3) Discharge Control valve & Pressure gauge

Table of Readings:-

Sl No	Actual discharge Q_a in m^3/s	Total head of water H in (m of H_2O)	OP (kw)	IP (kw)	Percentage Efficiency
1	7.329×10^{-4}	27.05	0.1944	0.877	22.16
2	6.820×10^{-4}	35.52	0.2396	0.8592	27.88
3	5.552×10^{-4}	34.60	0.188	0.8192	22.95

Suction head in m (H_s)	Delivery head H_d in m
6.256	21
5.712	30
4.76	40

Calculations:-

1) $Q_a = \frac{0.118 \times 10 \times 10^{-2}}{16.10} = 7.329 \times 10^{-4} \, m^3/s$

2) $H = 10 \left(2.1 + \frac{460}{760}\right) = 27.05 \, m$

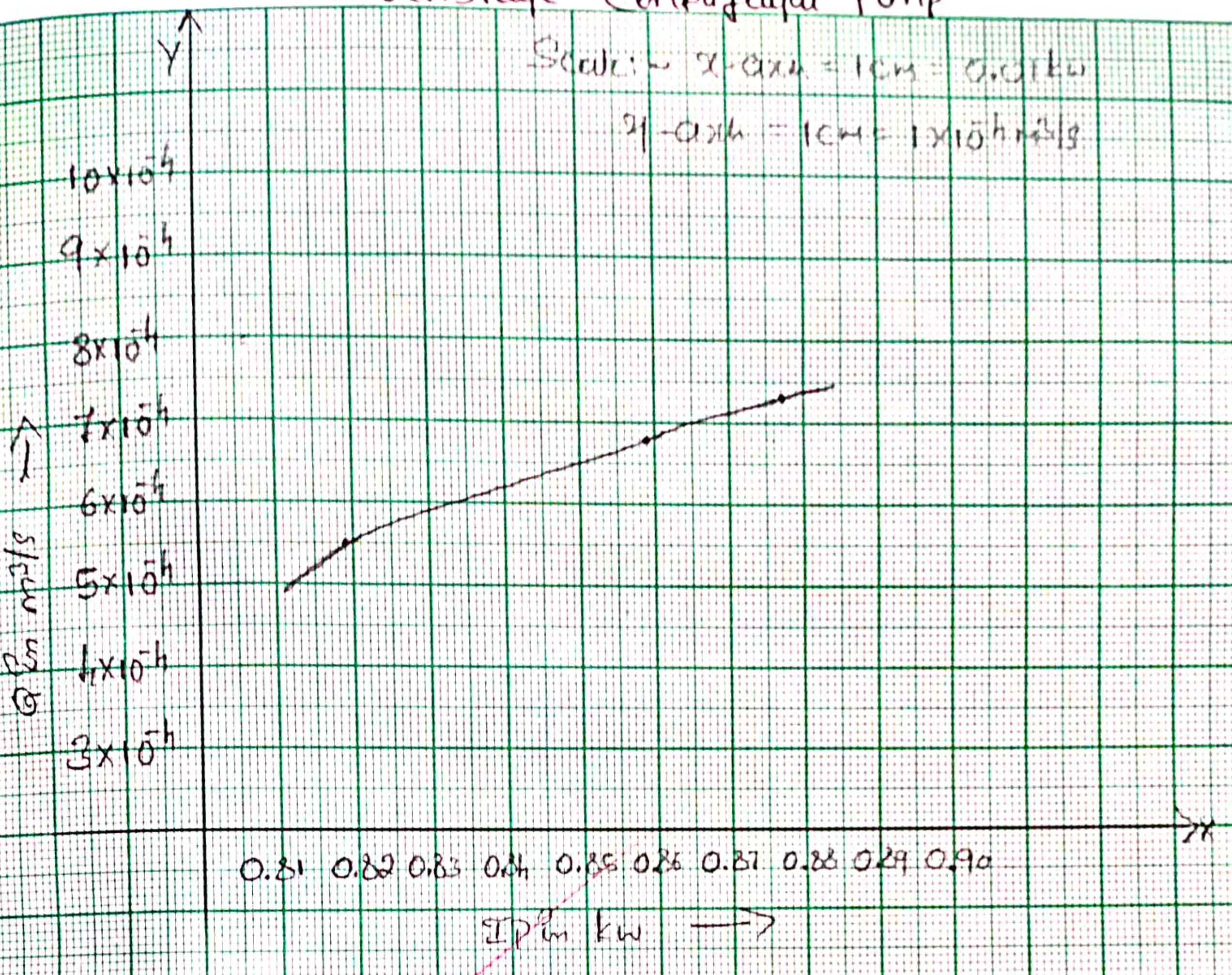
3) $IP = \frac{5 \times 3600 \times 0.75}{4.81 \times 3200} = 0.877 \, kw$

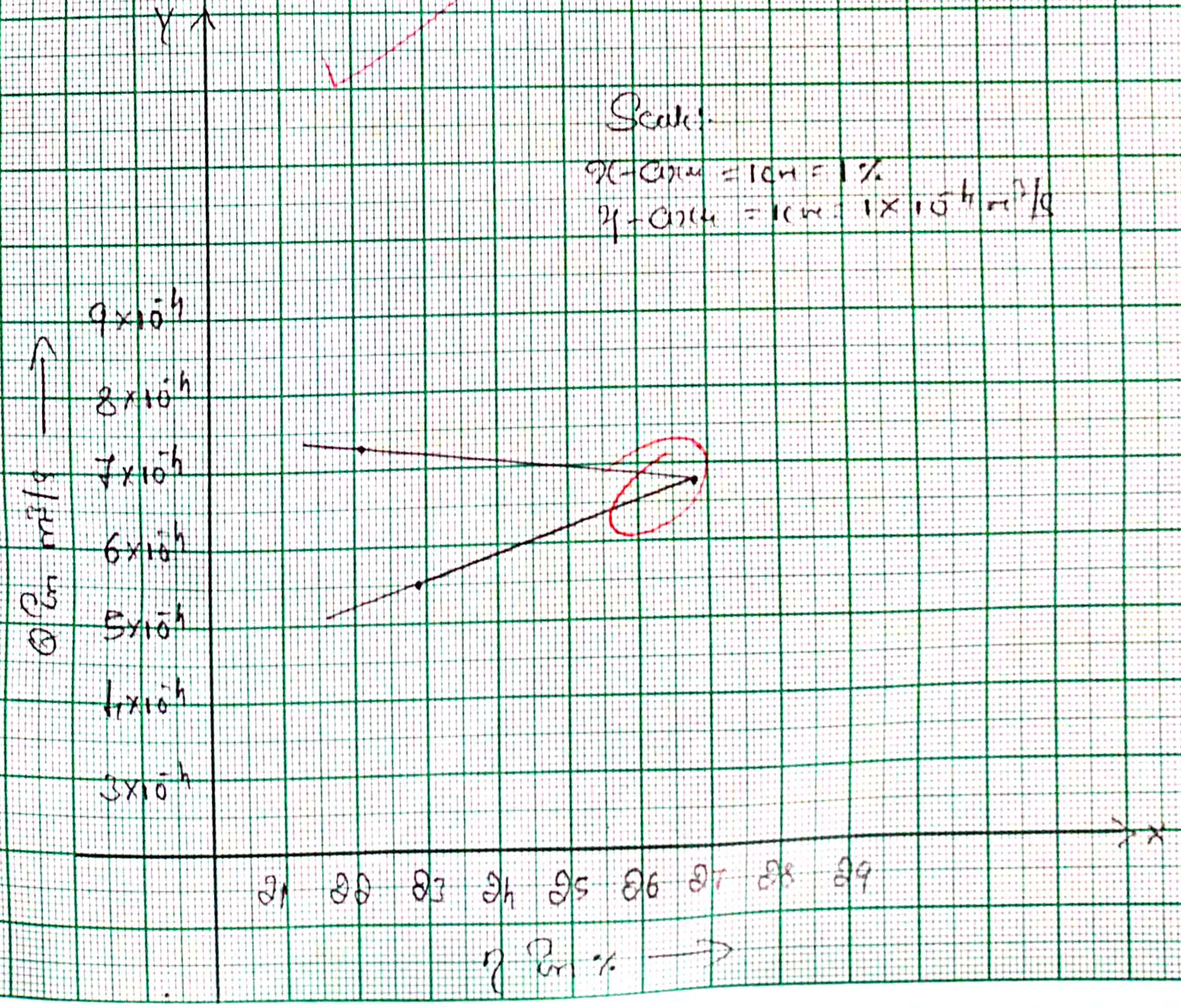
4) $OP = \frac{1000 \times 9.81 \times 7.329 \times 10^{-4} \times 27.05}{1000}$

$OP = 0.1944 \, kw$

Name .... Roll No .... Date:

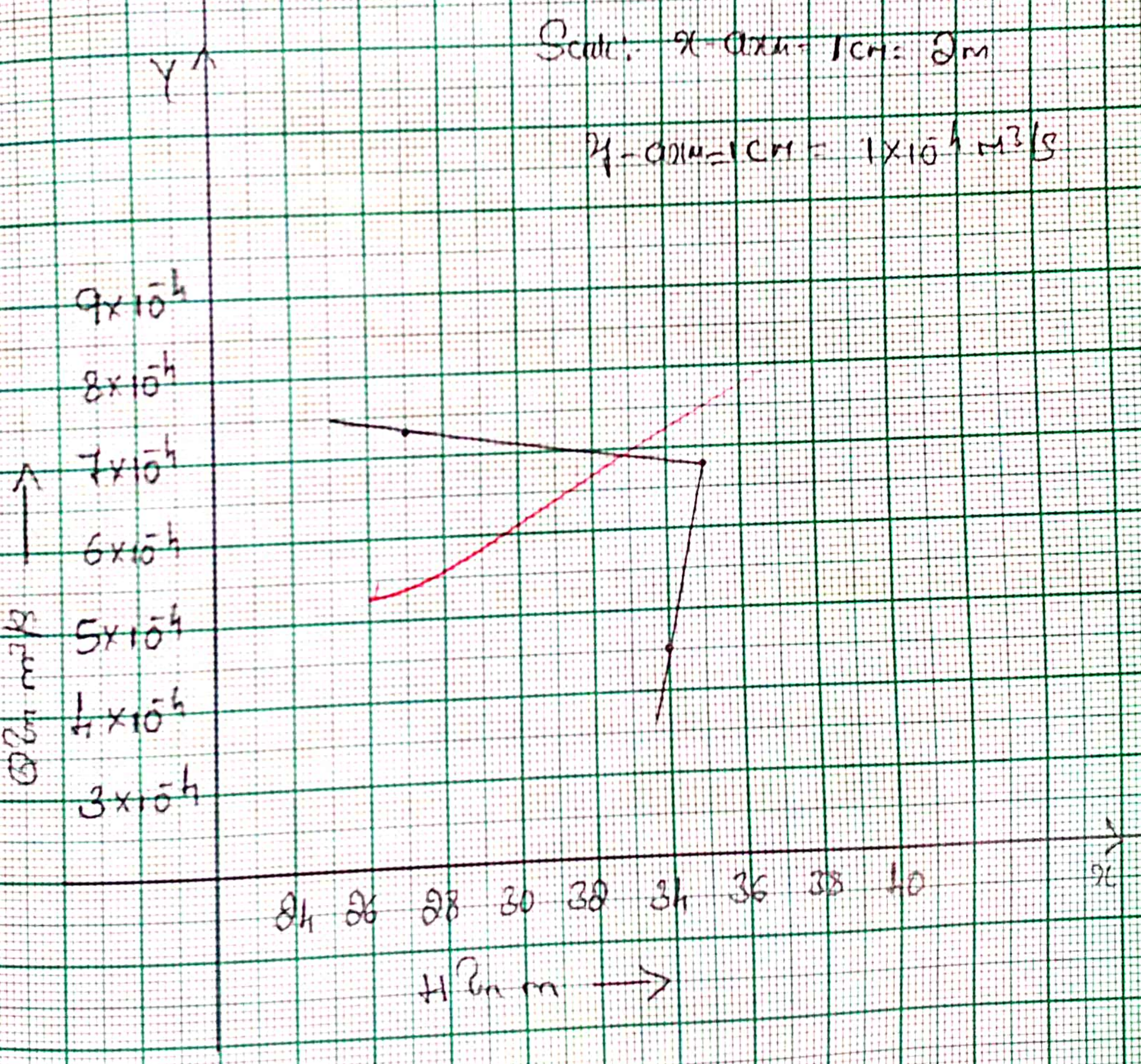
Multistage Centrifugal Pump





Roll No.   Date:

Multistage Centrifugal Pump



Specifications:-

Energy meter Constant = k = 3200 kWH
Efficiency of the motor = η_m = ~~60%~~ 75%
Gauge Correction = Z = 0.25m
Area of measuring tank = A_1 = 0.35 × 0.35 = 0.1225m²

Procedure:-

1) Prime the pump with water
2) Start the pump with the delivery valve completley closed
3) Open the delivery valve by one revolution & note down
 * Speed of the motor
 * Pressure gauge reading
 * Vaccum gauge reading
 * Time taken for 10cm rise of water in collecting tank
 * Time taken for 10 rev of the energy meter
4) Repeat the experiment for different heads by operating the discharge valve

Formula used:-

(1) I/P Power, IP = $\dfrac{n \times 3600 \times \eta_m}{t_1 \times k}$

(2) Discharge, Q = $\dfrac{A_E \times R \times 10^{-2}}{t_2}$

5) $\eta = \frac{0.1944}{0.877} \times 100 = 22.16\%$

6) Suction head ; $H_s = \frac{P_s \times S_m}{1000} = \frac{460 \times 13.6}{1000}$

$= 6.256\ m$

7) Delivery head $H_d = P_d \times 10$

$0.1 \times 10 = 01\,m$

3 total head

$$H = 10\left(Pd + \frac{Ps}{760}\right)$$

where Pd = Delivery Pressure
Ps = Suction Pressure

4 Output Power

$$OP = \frac{\rho g Q H}{1000} \text{ in kW}$$

5 Efficiency $\eta = \frac{OP}{IP} \times 100$

6 Hs = Suction head = $\frac{Ps + \rho m}{1000}$ in m of water

Result:-

The Efficiency of the Centrifugal Pump is found to be

Draw the Performance Characteristics like
* Input Power (IP) V/S Discharge (Q)
* Efficiency (η) VS Discharge (Q)
* Head (H) VS Discharge (Q)

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Table of Reading

Sl No	Speed of the Compressor in rpm.	Inter Cooler Pressure in kg/cm2	Delivery Pressure in kg/cm2	Time taken for impulse of energy meter in sec
1	930	0.9	2	6.93
2	927	1	3	6.28
3	924	1	4	5.94

Temperature				manometer reading in (cm of water)		
T_1	T_2	T_3	T_4	h_1	h_2	h_w
25	72	61	43	2.8	-2.5	5.3
25	75	62	54	2.9	-2.4	5.3
25	77	64	64	2.9	-2.4	5.3

TWO STAGE RECIPROCATING AIR COMPRESSOR

Aim:- To Conduct a Performance test on the two Stage air Compressor & to determine the Volumetric Efficiency & Isothermal Efficiency of various Pressures

Test Rig details:-

* Air Chamber Containing an orifice Plate Provided with a manometer Connected to the Compressor
* Air reservoir Provided with a Pressure gauge & the discharge valve
* Compression Powered by an induction motor by means of a belt drive
* A fan Provided for Cooling the Cylinders & an Energy meter is Provided to measure the i/P Energy to the motor
* Intercooler b/w the high & low Pressure cylinder with the thermometers, Provided at the inlet Section & Pipe at the outlet of the intercooler to measure the intercooler Efficiency

Specifications:-

Diameter of the low Pressure Cylinder D_{LP} = 100mm
Stroke of the low Pressure cylinder = 85 mm
Diameter of the high Pressure cylinder D_{HP} = 60mm
Diameter of the Orifice = ~~Bd~~ d = 20mm
Cd of orifice = 0.62

Table of Results:-

Sl No	Speed of the Compressor in Rpm	Actual discharge Qa	Volumetric Efficiency	Overall Efficiency	Work input in kW
1	930	3.1066×10^{-3}	83.39	2.222	1.2175
2	927	3.1066×10^{-3}	83.66	3	1.3435
3	924	3.1066×10^{-3}	83.96	4	1.42

Isothermal work done in kW	Isothermal Efficiency	
0.2187	19.96%	
0.3348	24.91%	
0.422	29.91%	

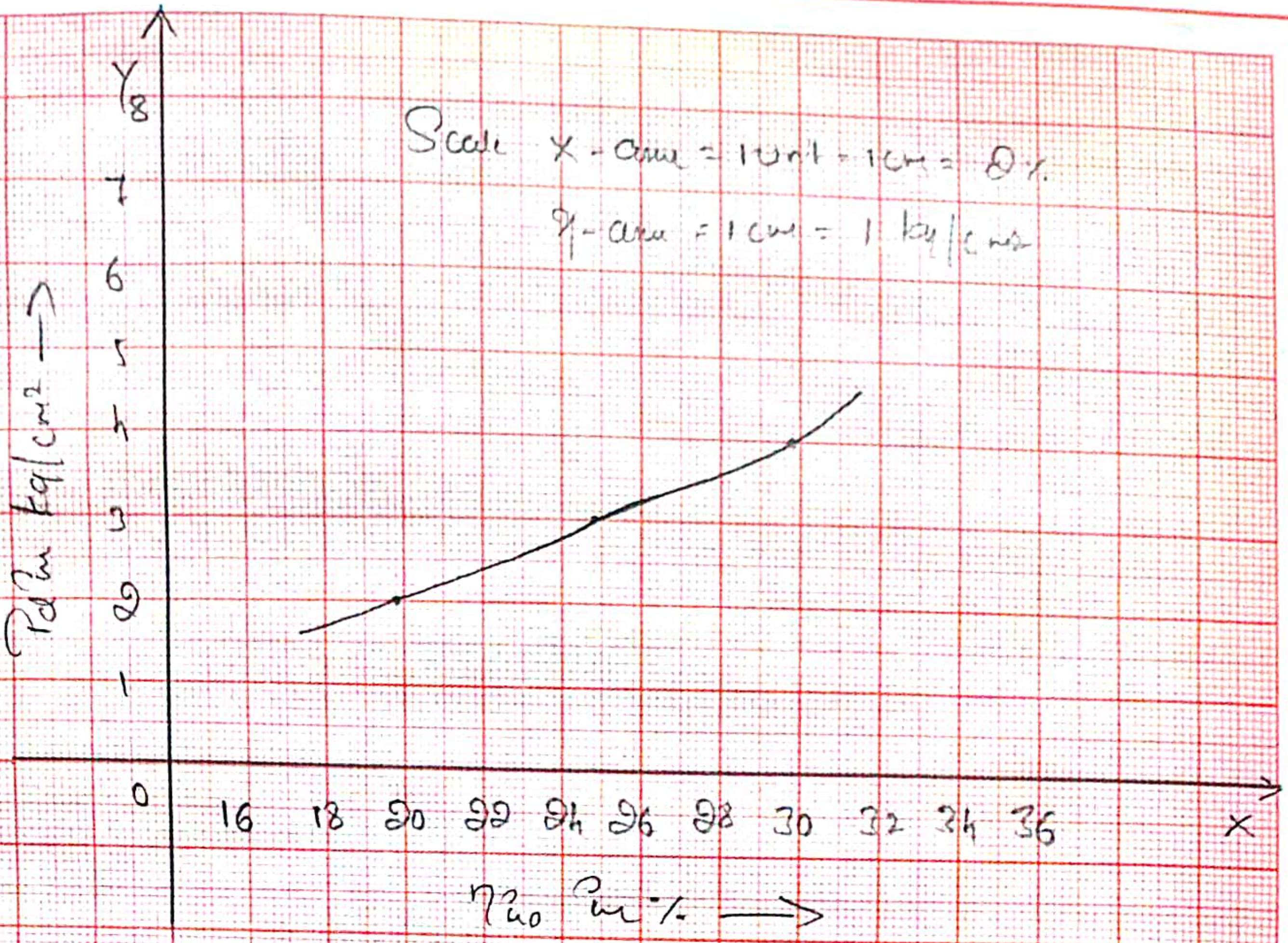
Table of Results:-

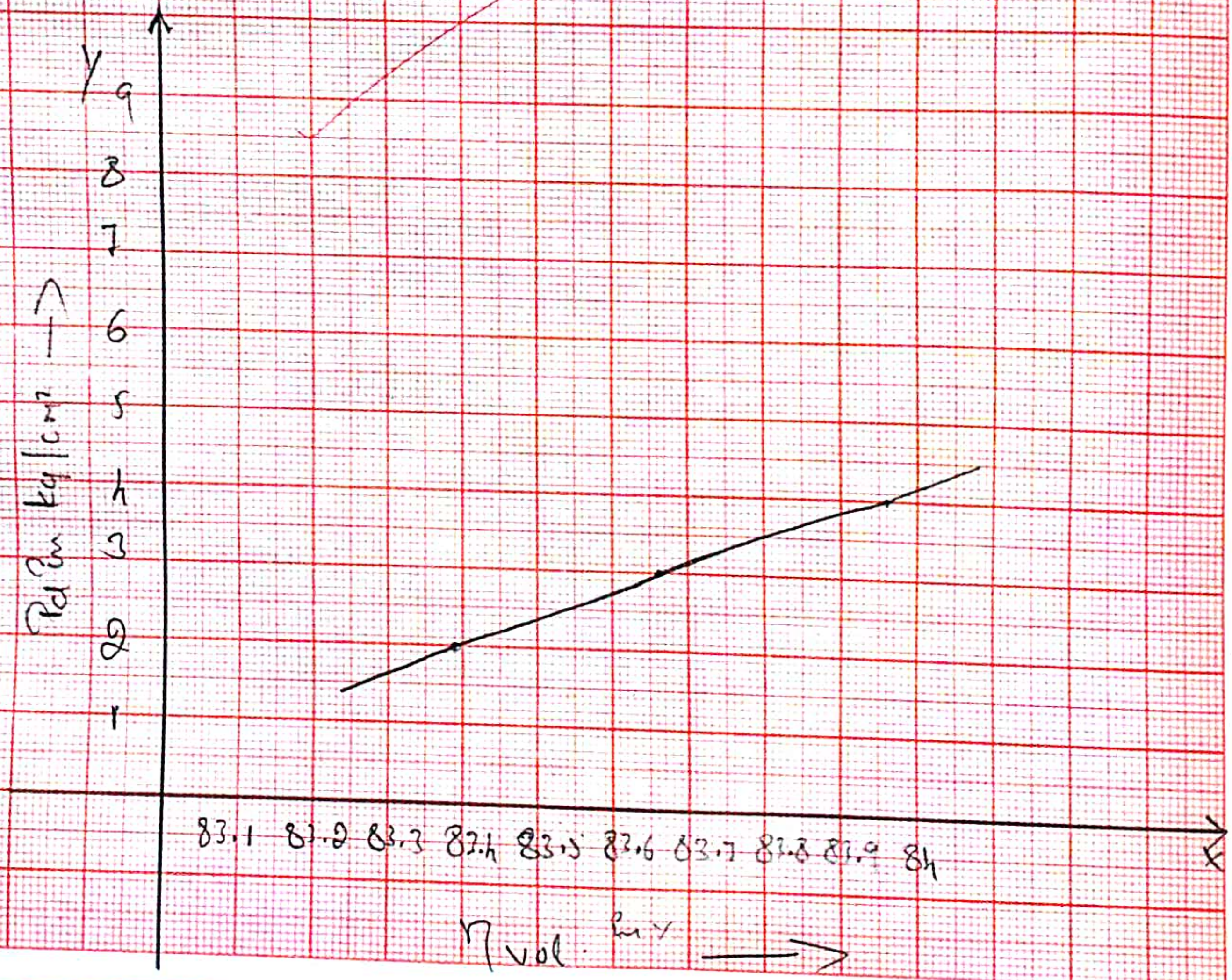
Sl No	Speed of the Compressor in RPM	Actual discharge Qa	Volumetric Efficiency	Overall Efficiency	Work Input in kW
1	930	3.1066×10^{-3}	83.39	2.222	1.2175
2	927	3.1066×10^{-3}	83.66	3	1.3435
3	924	3.1066×10^{-3}	83.96	4	1.42

Isothermal work done in kW	Isothermal Efficiency	
0.2187	19.96%	
0.3348	24.91%	
0.422	29.91%	

Date:

Batch No.





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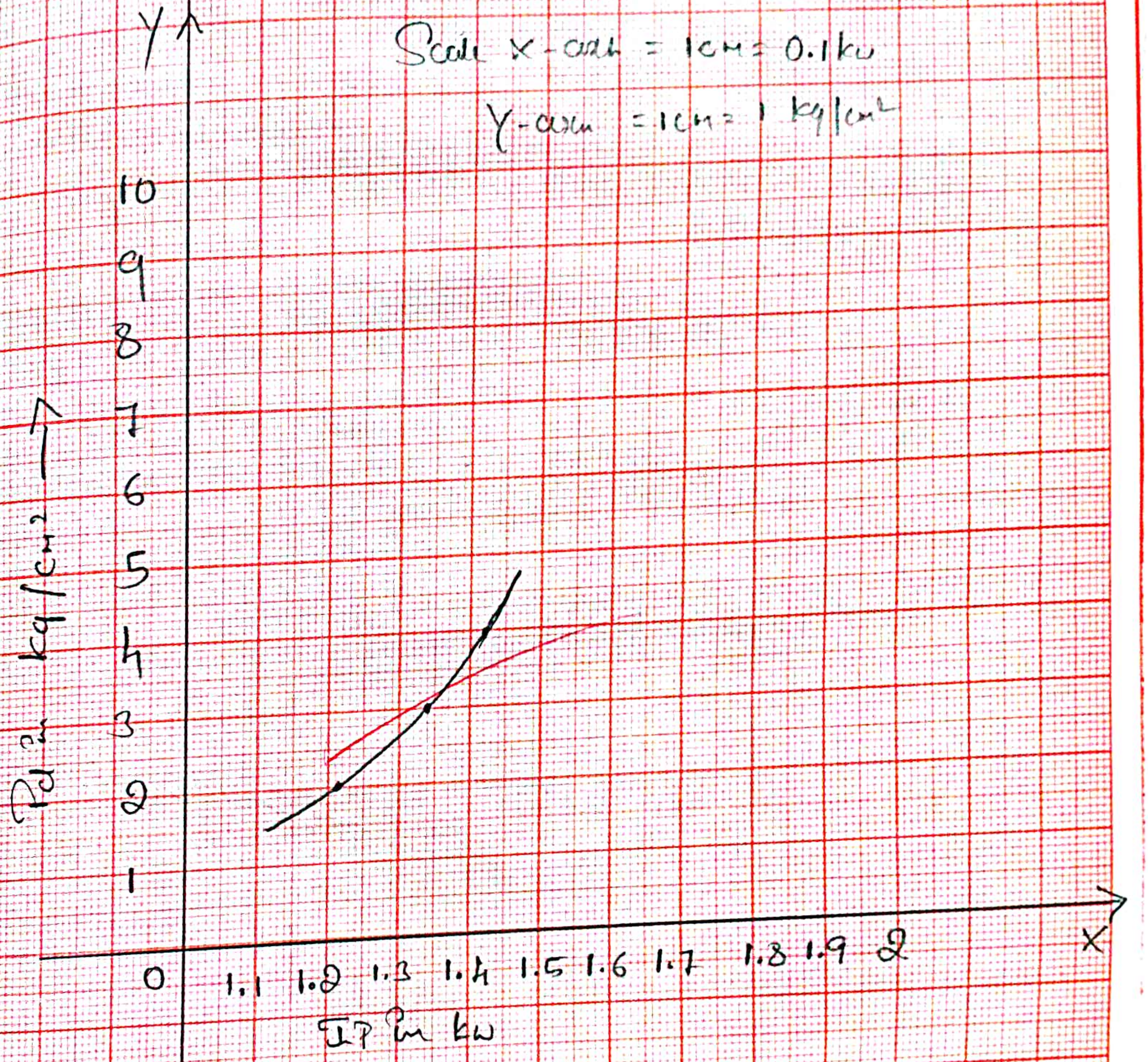


Energy meter Constant k =

Specifications:-

Engine:
Type :- Reciprocating Air cooled, Splash Lubricated
Working Pressure = 10kg/cm^2

Procedure:-

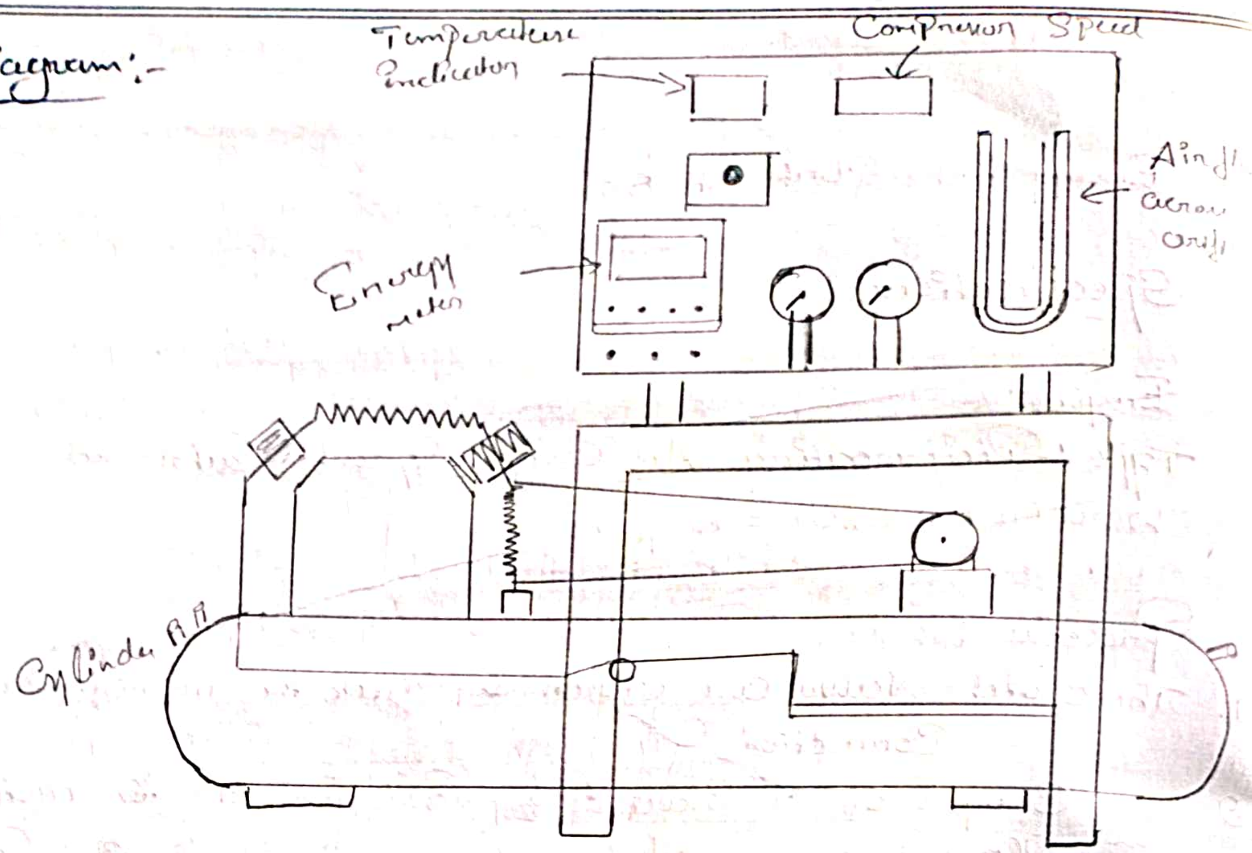
1. The outlet Valve are Closed & Check the manometer Connection
2. The Compressor is Started by Switching on the motor
3. The Slow increase of the Pressure inside the air reservoir is observed
4. At the required Pressure discharge Valve is opened Slowly & adjusted So that the Pressure is maintained Constant
5. Note down the readings Such as Speed of the Compressor, manometer readings Pressure gauge readings, Room temperature, Energy meter reading
6. Repeat the Experiment for different delivery Pressure

Formula used:-

1) To determine Volumetric Efficiency

$$h_a = \frac{h_w \times \rho_{water}}{\rho_{air}} \text{ in m of air}$$

Diagram:-



Temperature
Indicator
Compressor Speed
Energy
meter
Cylinder A

ha is head of air in m of air

Density of air $\rho_a = \frac{P}{RT_1}$ kg/m³

where P is atmospheric pressure in Pa
R is gas constant = 287 J/kgK
T_1 is atmospheric temperature in K

Air volume flow rate (V_a) (or) actual discharge
$Q_a = C_d \times a \sqrt{2gh_a}$ in m³/s
a = area of orifice in m

Swept volume of the compressor (or) actual discharge

$$Q_{th} = \frac{\pi \times D_{HP}^2 \times L \times N_c}{4 \times 60} \text{ in m}^3/s$$

$$\eta_{vol} = \frac{Q_a}{Q_{th}} \times 100$$

2. To Determine Isothermal Efficiency

Input Power, $IP = \frac{3600 \times n \times \eta_m}{K \times T}$ in kW

(a) First Stage P_2 = (Inter Cooler Pressure × 0.981) + P_{atm} bar
= ______ bar

(b) Second Stage P_3 = (Delivery Pressure × 0.981) + P_{atm}
= ______ bar

Calculation :-

1) $h_{a_1} = \frac{1000 \times 0.053}{1.093} = 40.98m = h_{a_2} = h_{a_3}$ (ρ_w, $= h_w$)

2) $Q_{a_1} = C_d \times a \sqrt{2gh_a}$ $a = \frac{\pi d^2}{4} = \frac{\pi \times 0.015^2}{4}$ $a_1 = 1.7671 \times 10^{-4}$

$= 0.62 \times 1.7671 \times 10^{-4} \sqrt{2 \times 9.81 \times 40.98}$

$\therefore Q_{a_1} = 3.1066 \times 10^{-3} \; m^3/sec = Q_{a_2} = Q_{a_3}$

3) $Q_{th_1} = \frac{\pi \times 0.062^2 \times 0.086 \times 930}{4 \times 60} = 3.7251 \times 10^{-3} \; m^3/s$

$Q_{th_2} = \frac{\pi \times 0.062^2 \times 0.085 \times 927}{4 \times 60} = 3.7131 \times 10^{-3} \; m^3/s$

$Q_{th_3} = \frac{\pi \times 0.062^2 \times 0.085 \times 924}{4 \times 60} = 3.7 \times 10^{-3} \; m^3/s$

4) $\eta_{vol_1} = \frac{3.1066 \times 10^{-3}}{3.7251 \times 10^{-3}} \times 100 = 83.39\%$

$\eta_{vol_2} = \frac{3.1066 \times 10^{-3}}{3.7131 \times 10^{-3}} \times 100 = 83.66\%$

$\eta_{vol_3} = \frac{3.1066 \times 10^{-3}}{3.7 \times 10^{-3}} \times 100 = 83.96\%$

(c) P_1 = Suction Pressure = P_{atm} = ______ bar

(d) First Stage Compression Ratio $\gamma_1 = \frac{P_2}{P_1}$

(e) Second Stage Compression Ratio $\gamma_2 = \frac{P_3}{P_2}$

(f) Overall Compression Ratio, $\gamma = \frac{P_3}{P_1}$

$$W_{iso} = P_1 V_1 \ln(\gamma) \text{ watt}$$

(or)

$$W_{iso} = \rho_a \times Q_a \times \ln(\gamma) \text{ in kW}$$

3. $\eta_{iso} = \frac{W_{iso}}{IP} \times 100$ $\eta_{vol} = \frac{Q_{act}}{Q_{th}} \times 100$

4. Work input

$$W_{in\,ELE} = \frac{n \times 3600 \times \eta_{motor}}{k \times T}$$

Where n is no. of Revolution of Energy meter = 5
k is Energy meter Constant = 1600 rev/kWh
T is time taken in Sec

η_{motor} = Efficiency of motor = 0.75

5) $W_{iso_1} = P_1 V_1 \ln(r)$

Overall Compression Ratio $r = \frac{P_2}{P_1}$

$r_1 = \frac{2}{0.9} = 2.222$

$r_2 = \frac{3}{1} = 3$

$r_3 = \frac{4}{1} = 4$

$W_{iso_1} = 88290 \times 3.1066 \times 10^{-3} \ln(2.22)$

$W_{iso_1} = 0.2187\ kw$

$W_{iso_2} = 98100 \times 3.1066 \times 10^{-3} \ln(3)$

$= 0.3348\ kw$

$W_{iso_3} = 98100 \times 3.1066 \times 10^{-3} \ln(4)$

$= 0.422\ kw$

6) $IP_1 = \frac{5 \times 3600 \times 0.75}{1600 \times 6.93} = 1.2175\ kw$

$IP_2 = \frac{5 \times 3600 \times 0.75}{1600 \times 6.28} = 1.3435\ kw$

$IP_3 = \frac{5 \times 3600 \times 0.75}{1600 \times 5.94} = 1.42\ kw$

7) $\eta_{iso_1} = \frac{0.2187}{1.2175} \times 100 = 17.96\%$ $= \frac{W_{iso}}{W_{ip_1}}$

$\eta_{iso_2} = \frac{0.3348}{1.3435} \times 100 = 24.91\%$

$\eta_{iso_3} = \frac{0.422}{1.42} \times 100 = 29.71\%$

Name of Experiment .... Date : ....

Experiment No. .... Page No. 66

Result :-

Draw the graph Such as

* Isothermal Efficiency V/S Delivery Pressure
* Volumetric Efficiency V/S Delivery Pressure
* Input Power V/S Delivery Pressure

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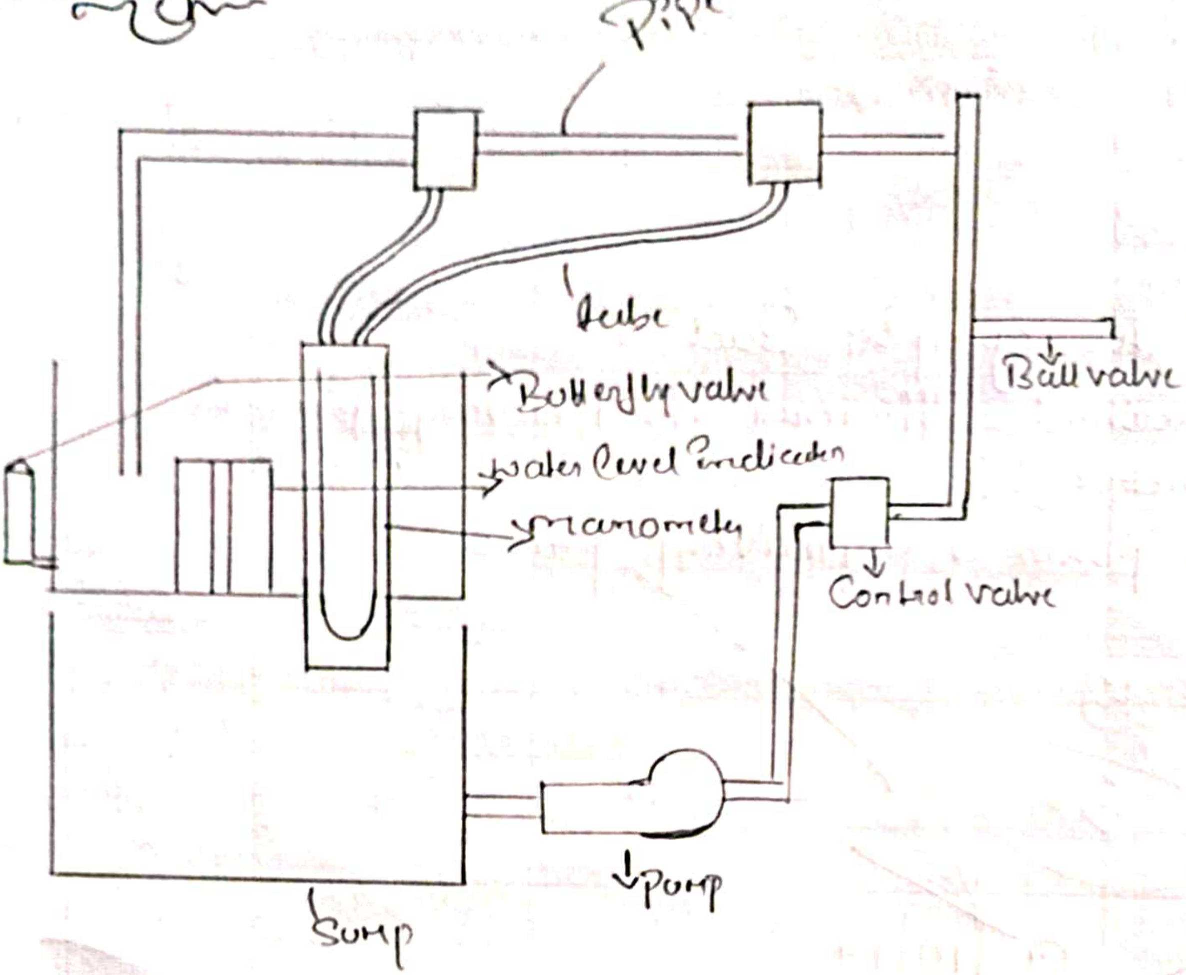
Diagram



Observation:-

* Length of Pipe, L = 1.2 mm
* Dia of pipe, D_1 = 16 mm

D_2 = 18 mm

D_3 = 26 mm

D_4 = 27 mm

* A_1 = Area of measuring tank = $L \times B$ = $100000\ mm^2$
* D = Dia of pipe in measuring tank = 75 mm
* A_2 Area of the pipe in the measuring tank = 4417.86 mm
* A_E = Effective area of the measuring tank $= A_1 - A_2 = 95582.13\ mm^2$

FRICTION IN PIPES [MAJOR LOSS]

Aim:- To Determine the Darcy's friction Co-efficient & Reynold's nbr for different flows through the pipe of different diameter

Introduction:- A closed of any c/s & material are used for flow of liquid is known as pipe. Generally the pipes are assumed to be running full & of circular c/s. liquid flowing through pipe are subjected to resistance resulting in loss of head or energy. the resistance is of two types depending on the velocity of flow (a) viscous resistance (b) Frictional resistance. Viscous resistance is due to molecular attraction b/w the molecules of the fluid at low velocity of flow is laminar or in the layers & hence the flow is called laminar flow. when the velocity of liquid is gradually increased to lower critical velocity the parallel layers of the liquid will become & further increase in the velocity flow becomes disturbed & is known as turbulent flow. In turbulent flow the resistance of motion is due to the resistance of the pipe surface for the flow

Table of Readings:-

Sl No	Pipe type	Manometer Reading in mm of Hg: h_1 in cm	h_2 in cm	$h_M = (h_1 - h_2)$ in m	Time taken for 10cm rise of water in the tank (t) in sec
1	16MM	9.4	-10.4	19.8	22
2		8.8	-9.8	18.6	25
1	18MM	1.5	-0.9	2.4	33
2		1.3	-0.6	1.9	39
1	26MM	0.7	-0.1	0.8	31
2		0.6	-0.2	0.8	35
1	27MM	0.9	-0.1	1	28
2		0.8	0	0.8	32

Calculation:- 1) 16mm = $Q_1 = \frac{0.09558 \times 10 \times 10^{-2}}{22} = 4.3445 \times 10^{-4}\ m^3/s$

$Q_2 = 3.8232 \times 10^{-4}\ m^3/s$

2) 18mm :- $Q_1 = 2.8963 \times 10^{-4}\ m^3/s$

$Q_2 = 2.4507 \times 10^{-4}\ m^3/s$

3) 26mm

$Q_1 = 3.082 \times 10^{-4}\ m^3/s$

$Q_2 = 2.7308 \times 10^{-4}\ m^3/s$

4) 27mm

$Q_1 = 3.4135 \times 10^{-4}\ m^3/s$

$Q_2 = 2.9868 \times 10^{-4}\ m^3/s$

Procedure:-

* Switch on the Equipment & Check for the flow of water
* Note down the length & the diameter of the Pipe
* Open the valve Connection of the Specified Pipe to manometer
* Open the Control valve on the Pipe for a Small discharge
* Record the following readings
  * The left & Right Limb readings of the manometer
  * Time required for raising 'R' in the measuring tank
* Repeat the Experiment for different heads of manometer for Discharge is controlled by operating the valve

Formulae used:-

1) Actual Discharge :- $Q_a = \frac{A_E \times R \times 10^{-2}}{T}$

   A = Area of the measuring tank in m^2
   R = Rise of water level in the tank for time (t)

2) Cross-Sectional area of the Pipe $A_P = \frac{\pi D^2}{4}$

   D = dia of the Pipe

3) Velocity of flow = $V = \frac{Q_{act}}{A_P}$

2) Loss of head (h_f):-

(i) 16mm $h_{f1} = 0.198 \times 12.6 = 2.4948m$

$h_{f2} = 2.3436m$

(3) Velocity of flow:-

(i) 16mm = $V_1 = \frac{Q_{act}}{AP}$

$AP = \frac{\pi D^2}{4} = \frac{\pi \times 0.016^2}{4} = 2.0106 \times 10^{-4} m^2$

$V_1 = \frac{4.3445 \times 10^{-4}}{2.0106 \times 10^{-4}} = 2.16079 m/s$

$V_2 = 1.9015 m/s$

(ii) 18mm :- $AP = \frac{\pi \times 0.018^2}{4} = 2.5446 \times 10^{-4} m^2$

$V_1 = 1.1382 m/s$ $V_2 = 0.9630 m/s$

(iii) 26mm :- $AP = \frac{\pi \times 0.026^2}{4} = 5.3092 \times 10^{-4} m^2$

$V_1 = 0.58072 m/s$ $V_2 = 0.5143 m/s$

(iv) 27mm : $AP = \frac{\pi \times 0.027^2}{4} = 5.7255 \times 10^{-4} m^2$

$V_1 = 0.5961 m/s$

$V_2 = 0.5216 m/s$

4) Coefficient of friction:- (i) 16mm

$f_1 = \frac{2 \times 9.81 \times 0.016 \times 2.4948}{1.2 \times 2.160792} = 0.1397$

$f_2 = 0.1695$

(4) Loss of head due to friction

$$h_f = h_m \left[\frac{S_m}{S_w} - 1\right] \text{ in m of water}$$

where h_m = head difference of mercury in m
S_m = Specific gravity of the mercury
S_w = " — " — of water

(5) Darcy's Co-efficient of friction B/w the fluid & the pipe

$$f = \frac{2gDh_f}{LV^2}$$

where D = dia of pipe in m
L = Length of pipe in m
V = velocity of flow
h_f = loss of head due to friction in m

(6) Reynold's number $R_e = \frac{\rho V D}{\mu}$

ρ = Density of water in kg/m³
μ = Dynamic viscosity in N-s/m² = 1×10^{-3}

(ii) 18mm:- $f_1 = 0.06869$

$f_2 = 0.07597$

5) $R_e = \frac{\rho V D}{\mu}$

(iii) 26mm : $f_1 = 0.12707$

$f_2 = 0.162$

16mm $R_{e1} = \frac{1000 \times 2.16079 \times 0.016}{1 \times 10^{-3}}$

(iv) 20mm:- $f_1 = 0.0933$

$f_2 = 0.0853$

$R_{e1} = 34572.64$

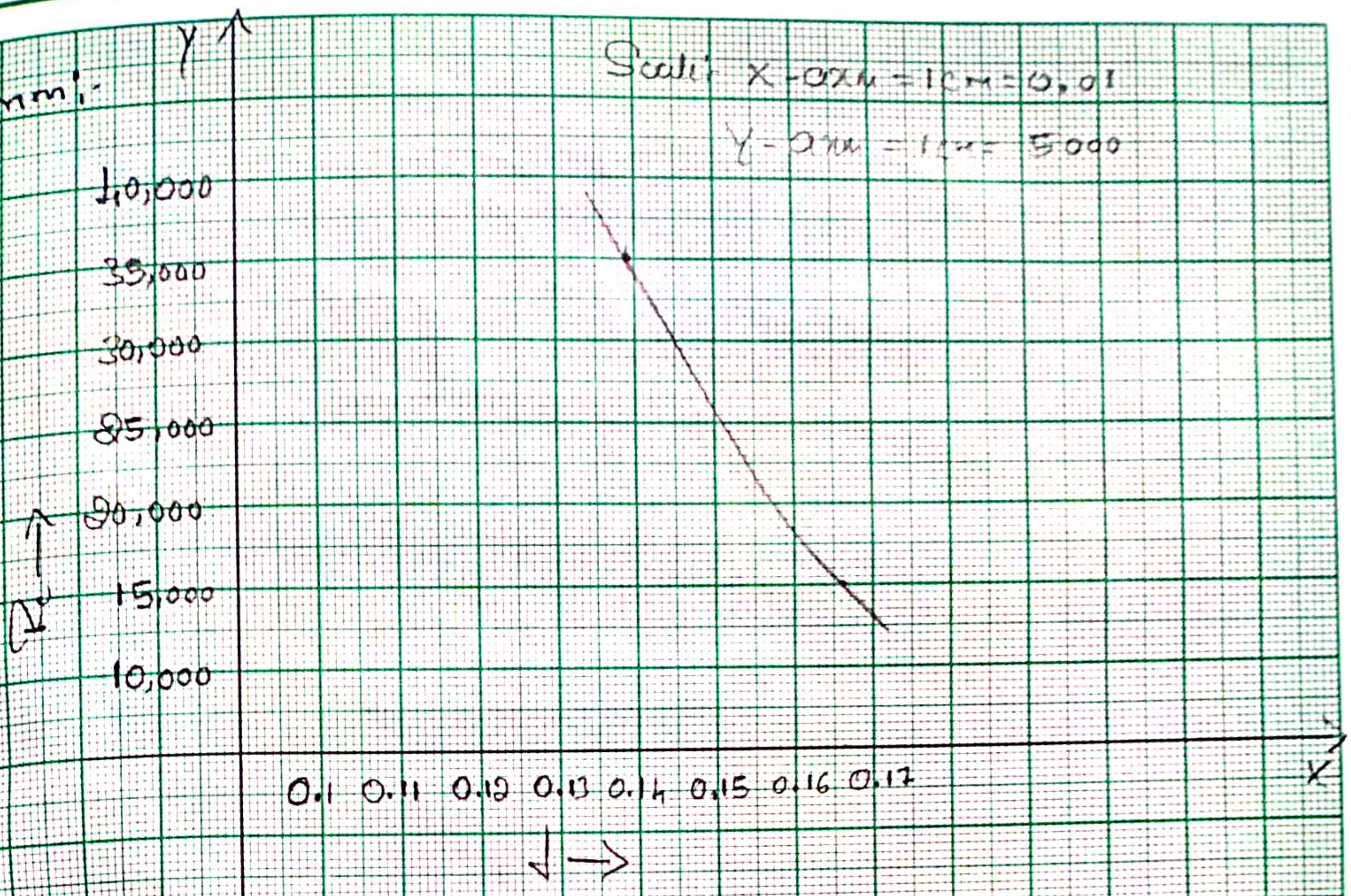
$R_{e2} = 15408$

Table of Results:-

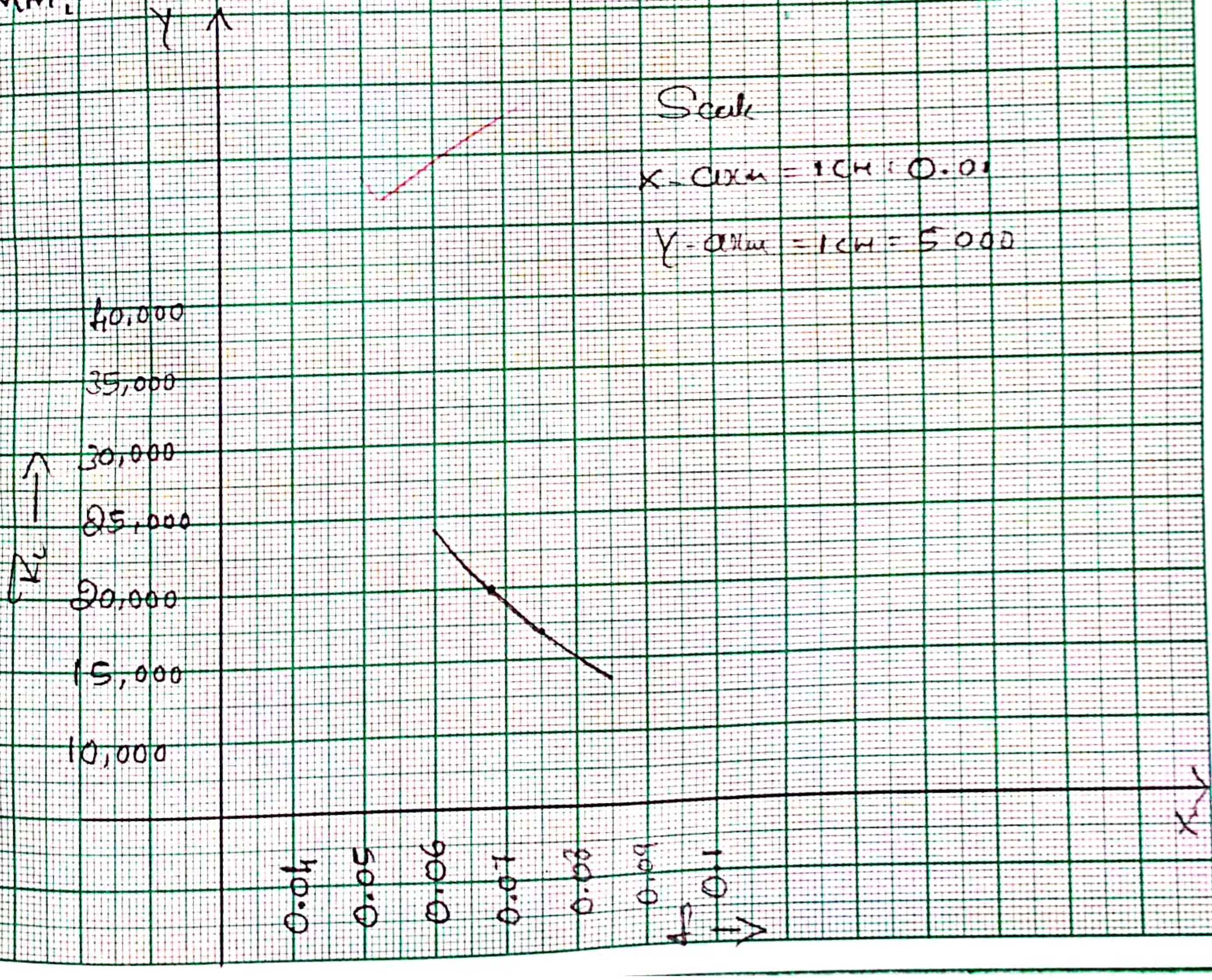
Sl No	Pipe type	Head loss hf in m of water	Actual discharge Q_A in m3/s	Velocity of flow V in m/s	Co-efficient of friction f	Reynold's number
1	16mm	2.4948	4.344×10^{-4}	2.16079	0.1397	34572.64
2		2.3436	3.8232×10^{-4}	0.9630	0.1659	15408
1	18mm	0.3024	2.8963×10^{-4}	1.1382	0.06869	20487.6
2		0.2394	2.4507×10^{-4}	0.9630	0.07597	17334
1	26mm	0.1008	3.0832×10^{-4}	0.58072	0.12707	15098.72
2		0.1008	2.7308×10^{-4}	0.5143	0.162	13371.8
1	27mm	0.126	3.4135×10^{-4}	0.5961	0.0933	2519.1
2		0.1008	2.9868×10^{-4}	0.5216	0.0853	2303.1

Roll No .... Date:

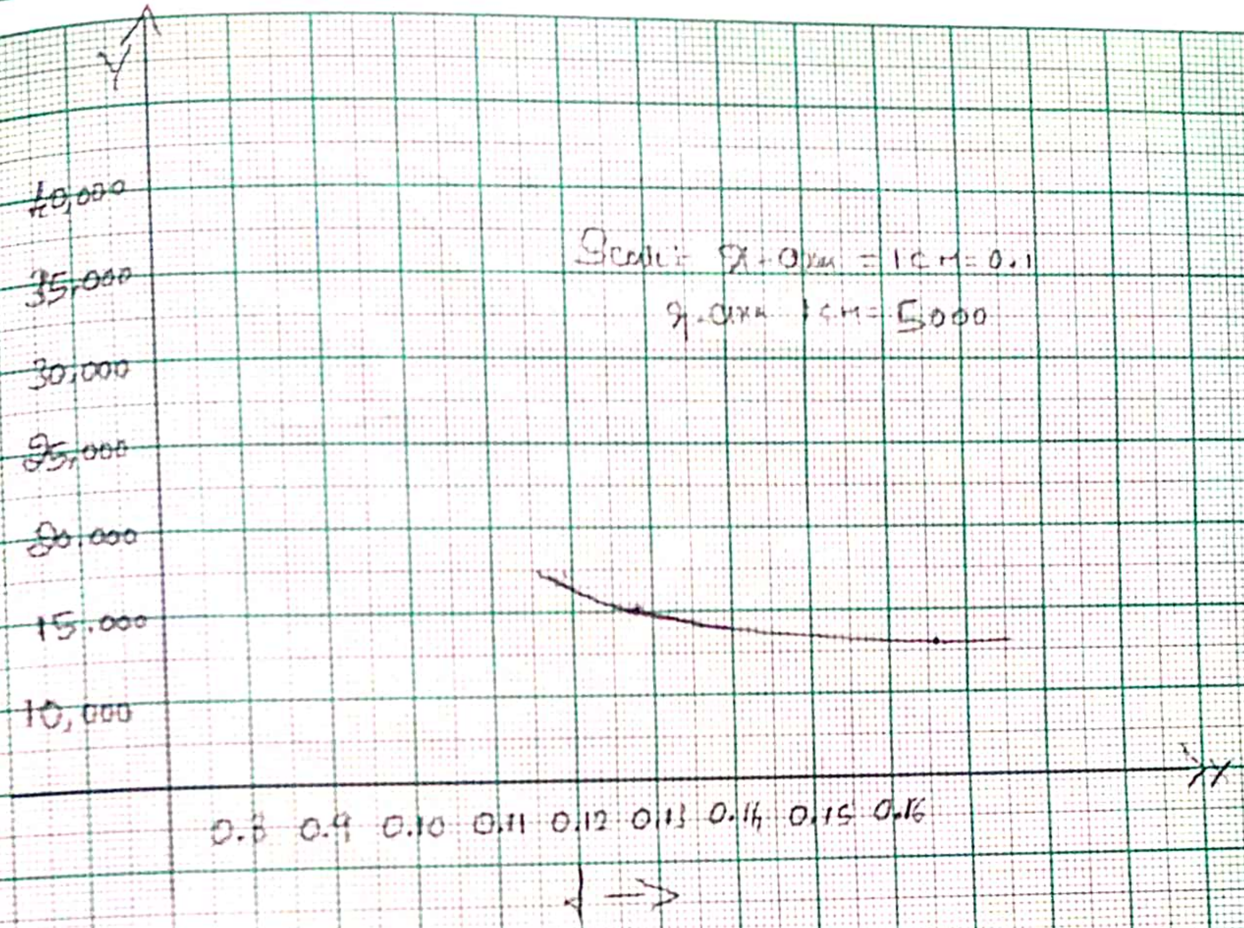
1) 16mm:



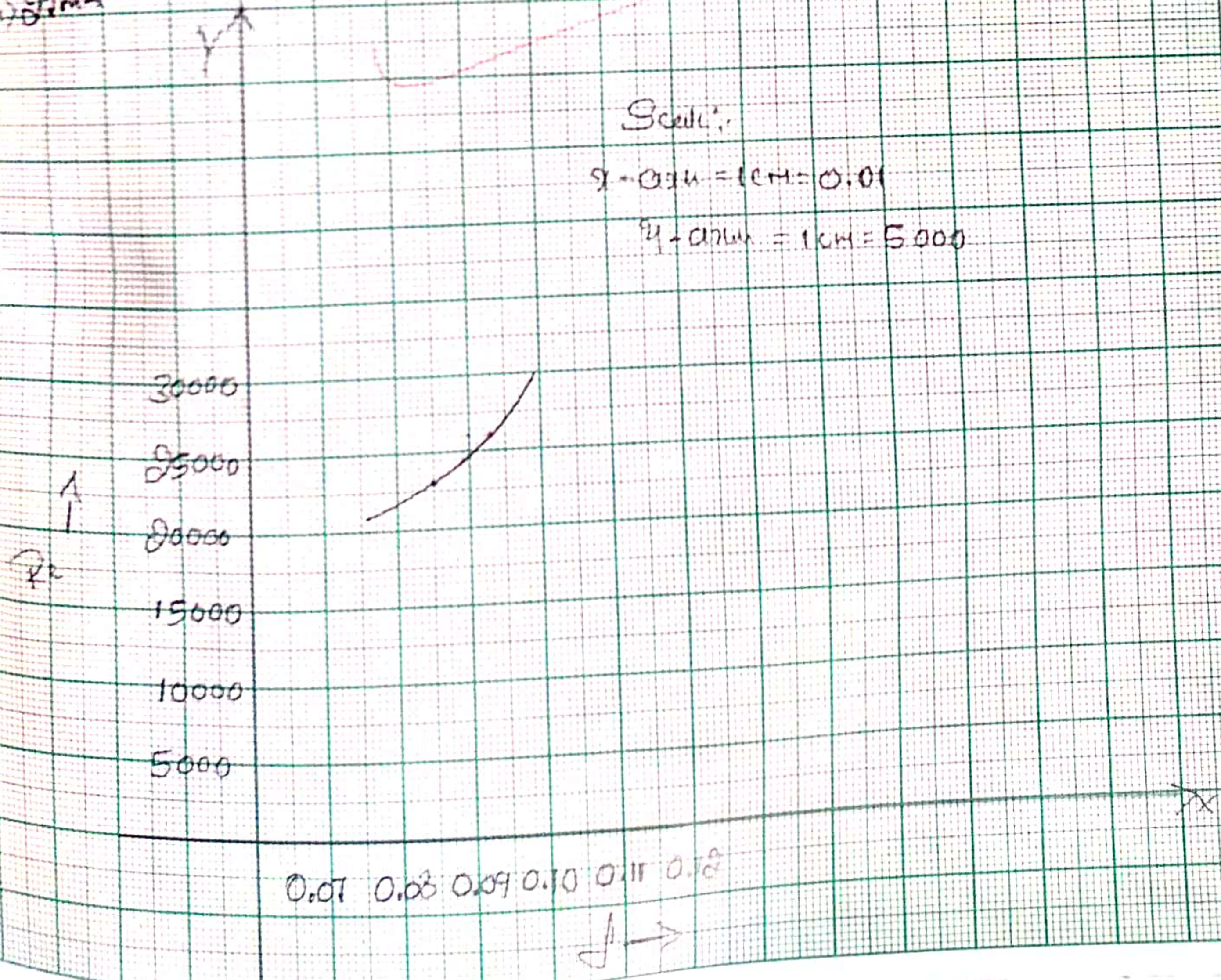
2) 18mm:



3) 26mm


Y
40,000
35,000
30,000
25,000
20,000
15,000
10,000
R
Scale: x-axis = 1cm = 0.1
y-axis 1cm = 5000
X
0.8 0.9 0.10 0.11 0.12 0.13 0.14 0.15 0.16
d →

4) 27mm


Y
Scale:
x-axis = 1cm = 0.01
y-axis = 1cm = 5000
30000
25000
20000
R
15000
10000
5000
X
0.07 0.08 0.09 0.10 0.11 0.12
d →

Result:-

Find out the Darcy's friction Co-efficient for & Reynold's number for different flows & Plot the graph of f verses Re

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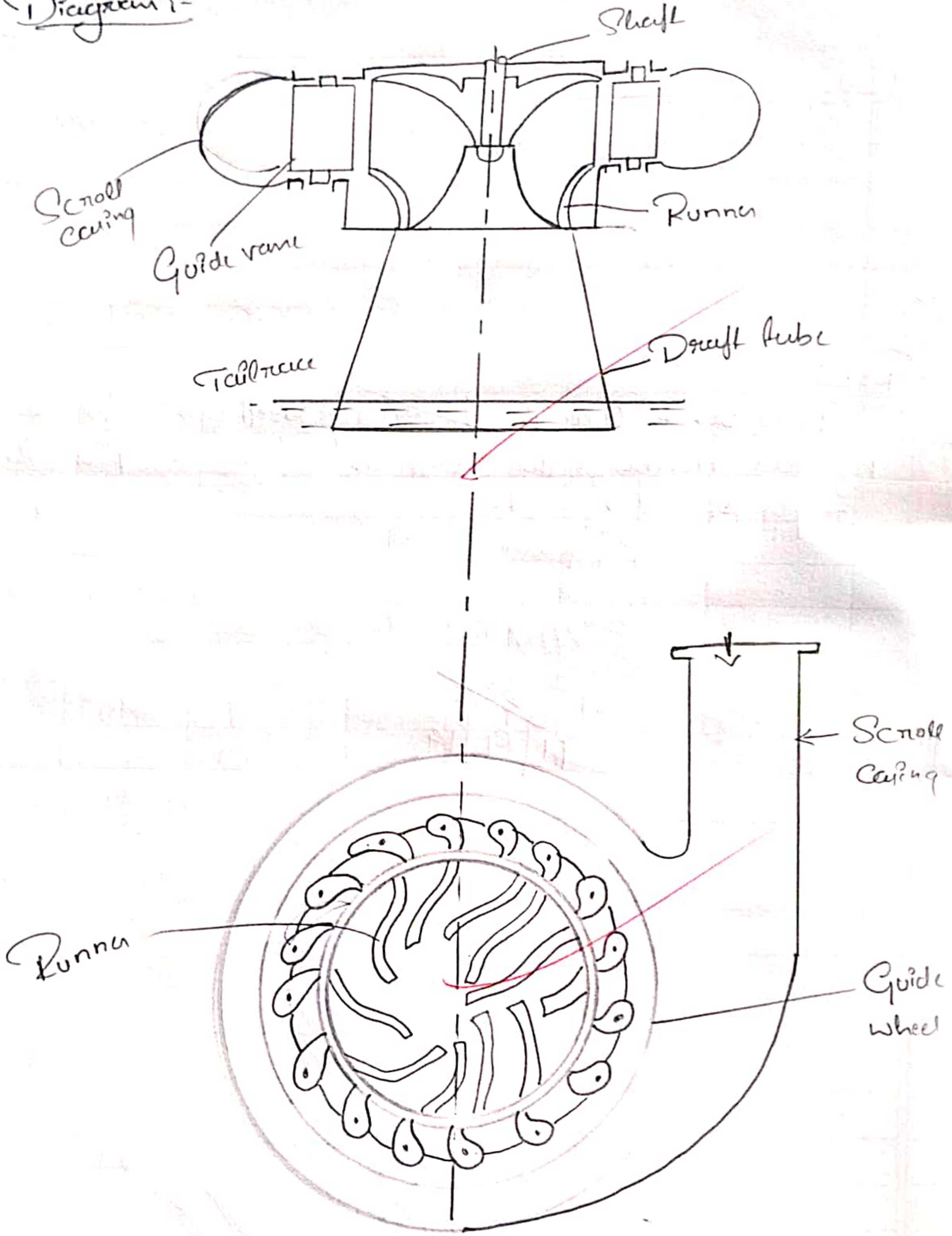
Diagram:-



Francis turbine

PERFORMANCE TEST ON FRANCIS TURBINE

Aim:- To Study the Performance Characteristics of the Francis turbine & to find Efficiency at Constant head & Constant Speed

Apparatus:- Centrifugal Pump Setup turbine unit, Venturimeter, Pressure gauge, Pump, tank & recirculating water System

Theory:- Francis turbine is an inward axial flow reaction turbine named after the American Engineer James B Francis in a Francis turbine water enters the runner at its outer periphery & flows out axially at its centre it operates under medium heads (35 to 100 m of water) A Spiral casing enclosing a number of Stationary guide blades fixed all around the circumference of an inner ring of moving vanes forming the runner water at high pressure enters through the inlet in the casing & flows radially inwards to the outer periphery of the runner through the guide blades from outer periphery of runner the water flows inwards through the moving vanes & discharges at the centre of the runner at low pressure During flow over the moving blades it imparts KE to the runner to set it in to rotational motion To enable discharge of water at lower pressure

Tabular Column:-

	Sl No	Speed in rpm	Head on turbine P_t in kg/cm²	Load on Brake P_1 (kg)	P_2 (kg)	Venturimeter Reading Inlet P_1 kg/cm²	Throat pressure P_2 in kg/cm²	Draft tube Pressure in mm (P_v)
Constant Speed	1	1500	0.8	2	0.1	1.2	0.8	0
	2	1500	0.8	3	0.2	1.2	0.4	0
	3	1500	1.0	4	0.3	1.4	0.4	0
Constant Head	1	1950	1.2	1	0	1.6	1.4	0
	2	1820	1.1	2	0.1	1.5	0.6	0
	3	1610	1	3	0.1	1.4	0.4	0

Formula used:-

1) Venturimeter details
d_1 = dia of venturimeter inlet = 100 mm
d_2 = dia of throat = 50 mm

2) Head on turbine $H = 10 \times \left(P_t + \frac{P_v}{760}\right)$

P_v is the draft tube reading

3) Discharge $Q = C_d \times \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$

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Experiment No. .... Page No. 78

a diverging Conical tube called draft tube is fitted at the Center of Runner

Procedure:-

* Connect the Supply Pump-motor unit to 3Ph, 440V, 30A Electrical Supply with neutral & Earth Connections & Ensure the Correct direction of Pump-motor unit
* keep the gate Closed
* keep the load on brake drum at minimum
* Press the green button of the Supply Pump Starter & then release
* Slowly open the gate So that the turbine Rotor Picks up the Speed & attains maximum at full opening of the gate
* Select the guide vane Position by operating the hand wheel for required Position
* Slowly open the brake drum cooling valve & allow very little water before loading the brake drum
* Slowly operate the hand wheel on the Rope of Spring balance to increase the load on the brake drum Set the Spring balance reading Say, 2kg, 3kg, 4kg &c
* for different loads on the brake drum note down the Speed head on turbine, Venturimeter Pressure gauge reading & draft tube vacuum
* Change the Position of Guide vane angle & Repeat the Experiment & if necessary the gate valve

where Cd of Venturimeter Cu 0.95

$Q = 10 \times (P_1 - P_2)$

4) Hydraulic Input to the turbine

$$IP = \frac{\rho g Q H}{1000} \text{ kW}$$

5) Output Power $OP = \frac{2\pi NT}{60,000}$

N = Turbine Speed

T = torque $= (F_1 - F_2) \times R \times 9.81$

6) Turbine Efficiency, $\eta = \frac{OP}{IP} \times 100$

7) unit quantities

(a) $N_U = \frac{N}{H^{1/2}}$ (b) $P_U = \frac{P}{H^{3/2}}$ c) $Q_U = \frac{Q}{H^{1/2}}$

(d) $N_{sp} = \frac{NP^{1/2}}{H^{5/4}}$ Here P = output Power

can also be used for speed control
* Close the gate & then switch off the supply water pump set
* Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Francis turbine

To obtain constant speed characteristics:-
1) Keep the guide vane operating on the required position
2) For different loads on the turbine change the gate valve position so that the speed be held constant
3) Repeat the experiment for different speeds & tabulate the results

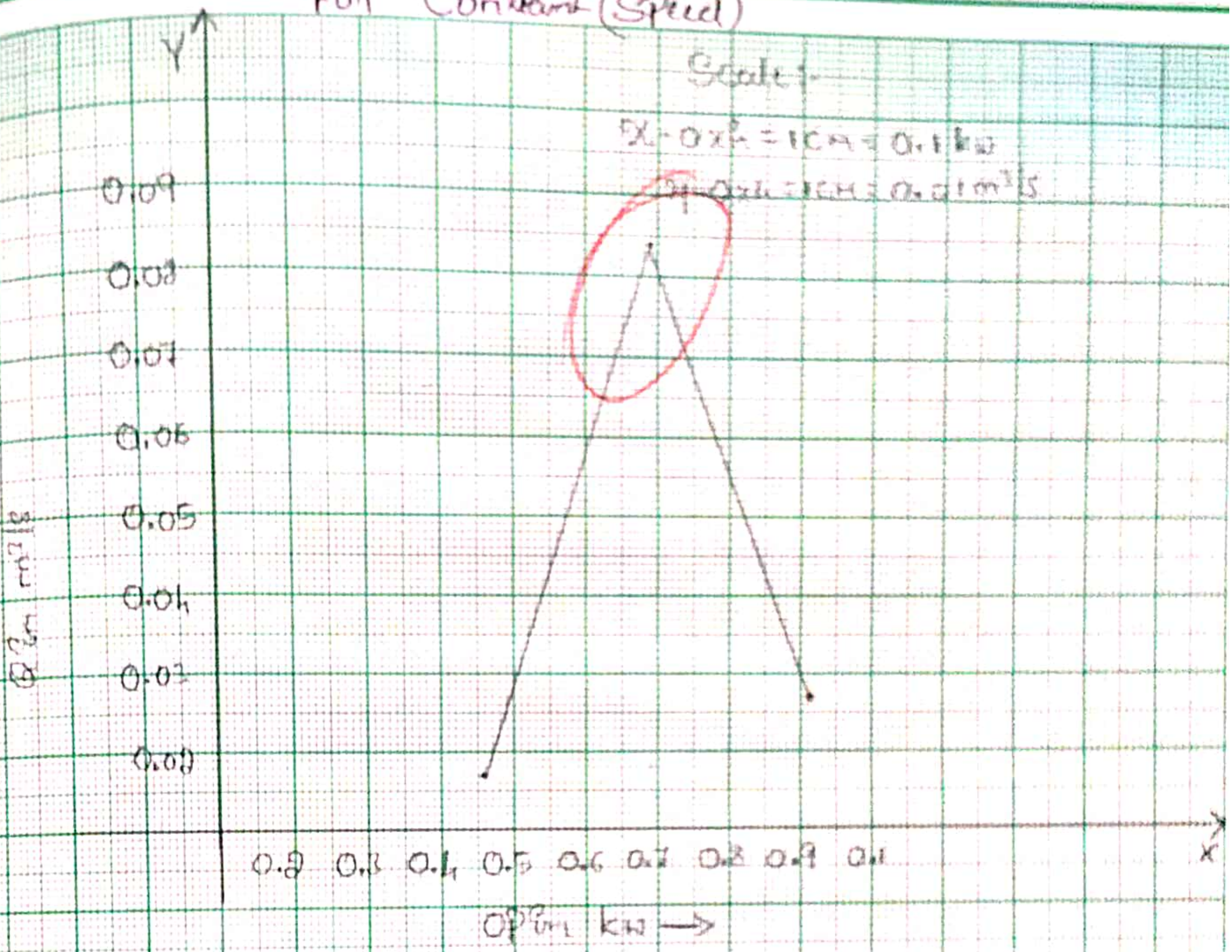
To obtain constant head characteristics
1) Select the guide vane angle position
2) Keep the gate valve closed & start the pump.
3) Slowly open the gate valve & set the pressure on the gauge
4) For different loads on the brake drum set the pressure constant by operating the gate valve to maintain the constant head & tabulate the results

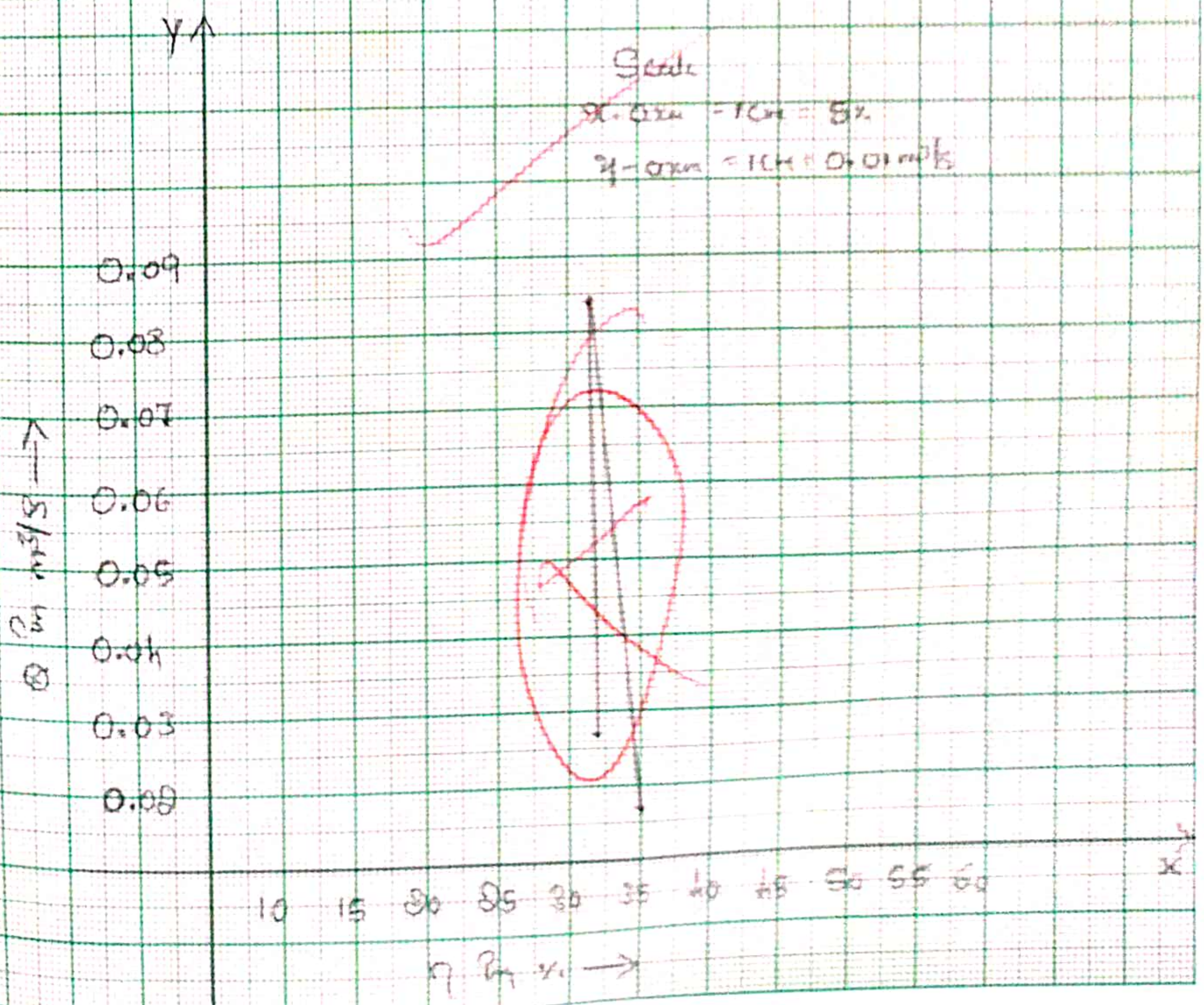
Table of Results:-

	Sl No	Delivery head H in m	Discharge Q in m^3/s	Torque in N-m	OP in kW	IP in kW	Efficiency η
Constant Speed	1	8	0.0170	1.334	0.468	1.334	35.08
	2	8	0.0840	1.883	0.690	1.883	33.64
	3	10	0.0269	2.638	0.911	2.638	34.53
Constant head	1	10	0.0120	1.1772	0.3205	1.1772	27.22
	2	10	0.0255	2.8015	0.56	2.8015	22.38
	3	10	0.026	2.55	0.716	2.550	27.98

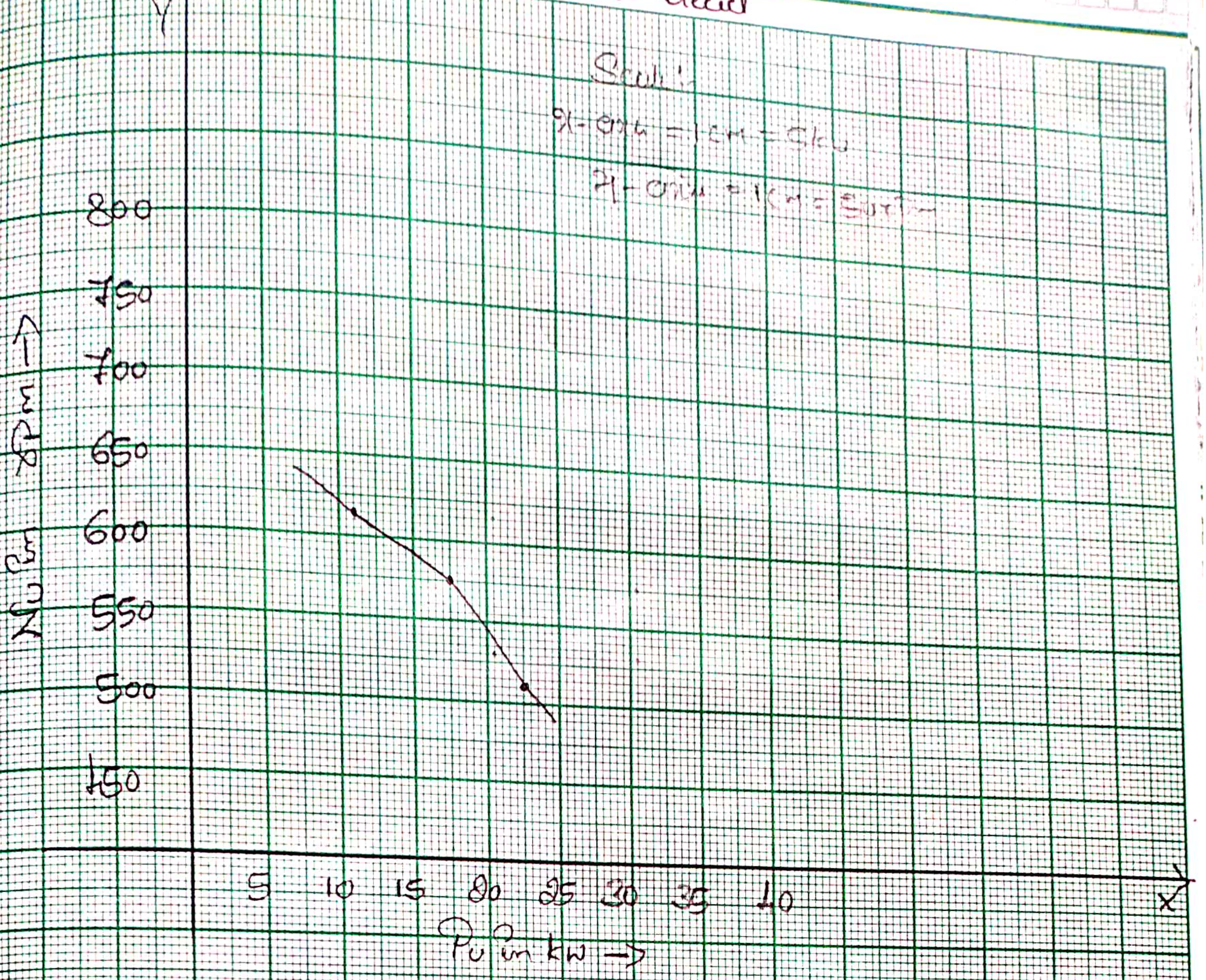
Ns in SI unit	Nu in rpm	Qu in m^3/s	Pu in kW
76.26	530.33	6.01×10^{-3}	20.68
76.92	530.33	0.0296	30.49
58.20	474.34	8.506×10^{-3}	28.80
62.07	616.64	3.79×10^{-3}	10.13
73.80	575.53	8.06×10^{-3}	17.7
76.44	509.12	8.22×10^{-3}	22.54

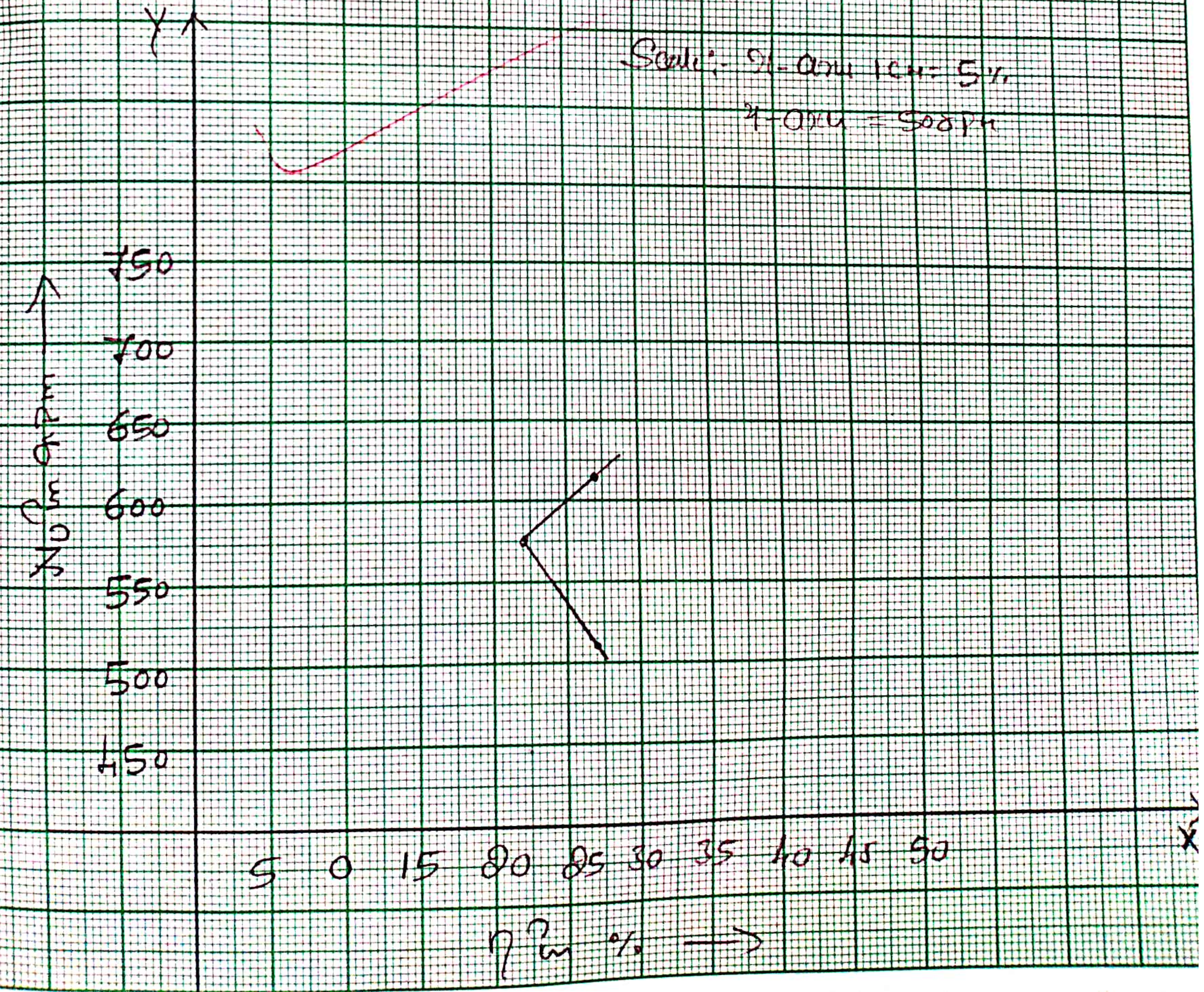
For Constant (Speed)





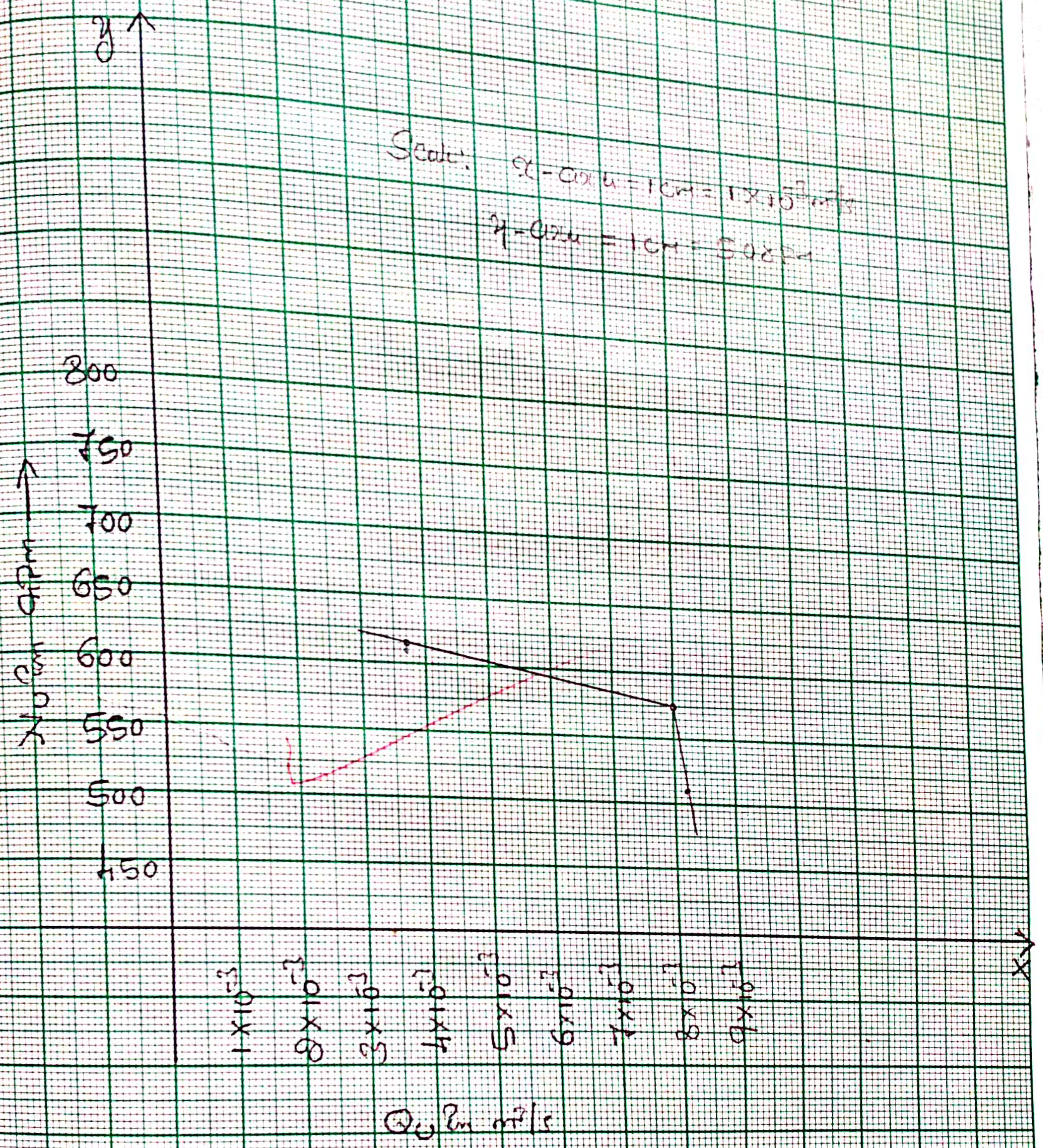
1) For constant head





For constant head

Date:



Calculations:-

1) $H = 10\left(0.8 + \frac{0}{760}\right) = 8$

2) $Q = \frac{0.95 \times 7.85\times10^{-3} \times 1.963\times10^{-3} \times \sqrt{2\times9.81\times h}}{\sqrt{(7.85\times10^{-3})^2 - (1.963\times10^{-3})^2}}$

$Q = 0.0170 m^3/s$ $h = 10(P_1 - P_2) = 10(1.2 - 0.8) = h$

3) $IP = \frac{1000 \times 9.81 \times 0.170 \times 8}{1000} = 1.3341 kW$

4) $OP = \frac{2\pi \times 1500 \times 2.9822}{60.000} = 0.468 kW$

$T = (2 - 0.1) \times 0.16 \times 9.81 = 0.2922 N\text{-}m$

5) $\eta = \frac{0.468}{1.3341} \times 100 = 35.08\%$

6) $N_U = \frac{1500}{8^{1/2}} = 530.338 rpm$

7) $P_U = \frac{0.468}{8^{3/2}} = 20.68 kW$

8) $Q_U = \frac{0.0170}{8^{1/2}} = 6.01\times10^{-3} m^3/s$

9) $N_{sp} = \frac{1500 \times 0.468^{1/2}}{8^{5/4}} = 76.26$

Result :-
Draw the graph of main Characteristics of the Francis turbine
* For Constant Speed
* Output Power (OP) V/S Discharge (Q)

For Constant head
* unit Power (Pu) V/S unit Speed (Nu)
* Efficiency (η) V/S unit Speed (Nu)
* Unit discharge V/S unit Speed (Nu)

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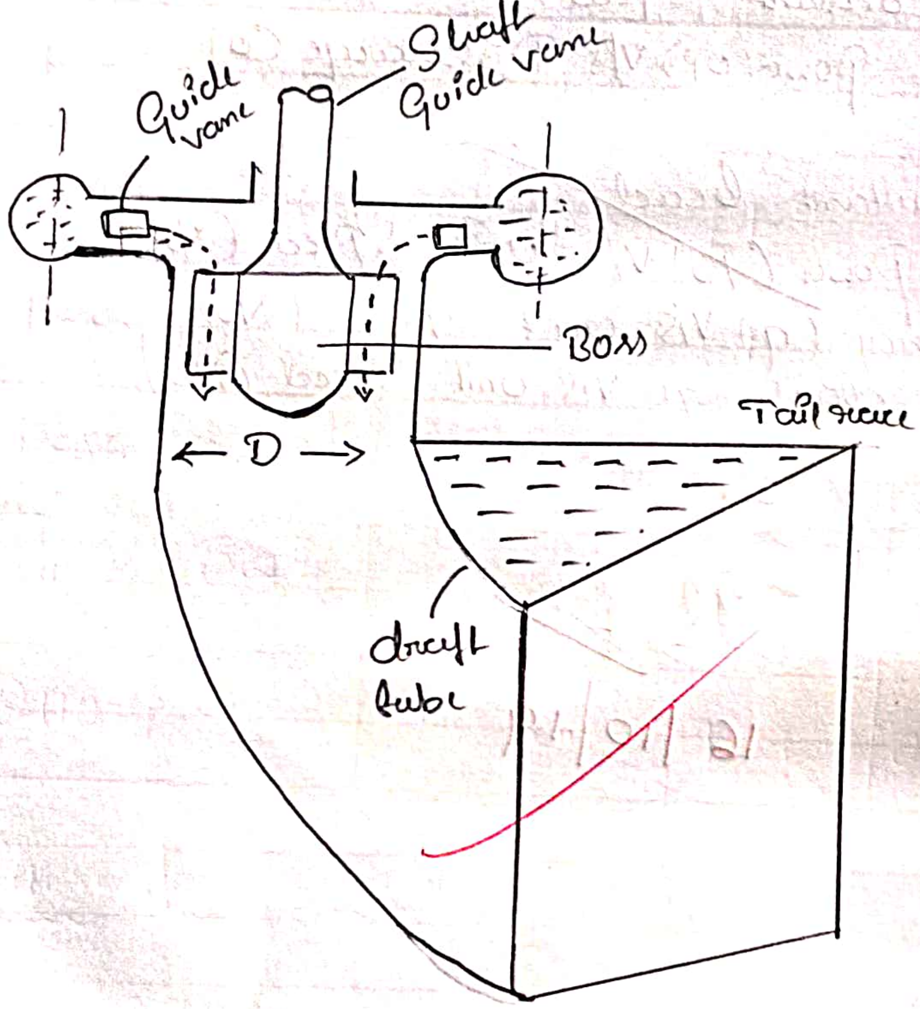
Diagram



Kaplan turbine

Name of Experiment: Kaplan Turbine Date: 30/10/19

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PERFORMANCE TEST ON KAPLAN TURBINE

Aim:- To study the performance characteristics of the kaplan turbine & to find efficiency at constant & constant speed

Description :- kaplan turbine the reaction type which is of of present concern consist of main components such as propeller scroll casing & draft tube B/w the scroll casing & the runner the water turns through right angle & passes through the runner & thus rotating the runner shaft & thus rotating the runner shaft when guide vane angle are varied high efficiency can be maintained over wide range of operating condition the actual experimental set-up consist of a CF pump set turbine unit sump tank, arranged in such a way that the whole unit works on recirculating water system the CF pump supplies the water from the sump tank to the turbine through get valve the water after passing through the turbine unit enters the sump tank through the draft tube the loading of the turbine is achieved by rope brake drum connected to spring balance the provision for measurement of brake force (spring balance) turbine speed (Digital RPM indicator) Head

$T = (2 - 0.2) \times 0.16 \times 9.81 = 2.8252$

4) $OP = \frac{2\pi \times 1800 \times 2.8252}{60,000} = 0.5325 kw$

5) $\eta_1 = \frac{0.5325}{3.227} \times 100$

$\eta_1 = 16.5\%$

$\eta_2 = \frac{0.8284}{0.414} \times 100 = 18.76\%$

$\eta_3 = \frac{1.1242}{5.345} \times 100 = 20.83\%$

Calculations for Constant head :-

1) $H = 10 \times \left(0.7 + \frac{0}{760}\right) = 7$

2) $Q = \frac{0.95 \times 0.0176 \times 4.4178 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 6}}{\sqrt{(0.0176)^2 - (4.4178 \times 10^{-3})^2}} = 0.047 m^3$

$H = 10 \times (0.9 - 0.3) = 6$

3) $IP = \frac{1000 \times 9.81 \times 0.0470 \times 7}{1000} = 3.227 kw$

4) $OP = \frac{2\pi \times 1800 \times 2.9822}{60,000} = 0.5617 kw$

$T = (2 - 0.1) \times 0.16 \times 9.81 = 2.9822 \ N\text{-}m$

Characteristics of the kaplan turbine

To obtain Constant Speed Characteristics:-

(a) For Different loads on the turbine change the gate valve position so that the speed is held constant

(b) Repeat the experiment for different speed say 1500 rpm 1000 rpm & tabulate the results

(c) The above readings will be utilized for drawing constant speed characteristics
(a) % of full load vs Efficiency
(b) Efficiency & BFBP VS Discharge

To obtain Constant head Characteristics:-

1) Keep the gate valve closed & start the pump
2) Slowly open the gate valve & set the pressure gauge
3) For Different loads on the brake drum set the pressure constant by operating the gate valve to maintain the constant head & tabulate the results as given in table

Formula used:-

(1) Venturimeter details
d_1 = dia of venturimeter inlet = mm
d_2 = dia of throat = mm

2) Head on turbine $H = 10 \times \left(\frac{P_d + P_v}{760}\right)$

5) $\eta = \frac{0.5617}{3.227} \times 100 = 17.4\%$

6) $N_{sp} = \frac{1800 \times 0.5617^{1/2}}{7^{5/4}} = 115.36$

7) $N_U = \frac{1800}{\sqrt{7}} = \frac{1800}{7^{1/2}} = 680.33$ rpm

8) $Q_U = \frac{0.047}{H^{1/2}} = \frac{0.047}{7^{1/2}} = 0.0177\ m^3/s$

9) $P_U = \frac{0.5617}{7^{3/2}} = 30.32$ kW

Table of Results for Constant Speed

SL No	Total head	Discharge Q (m^3/s)	IP in kW	OP in kW	Efficiency η
1	7	0.047	3.227	0.5325	16.5
2	11	0.059	4.414	0.824	18.76
3	9	0.059	5.345	1.1242	20.83

5) $\eta = \frac{0.5617}{3.227} \times 100 = 17.4\%$

6) $N_{sp} = \frac{1800 \times 0.5617^{1/2}}{7^{5/4}} = 115.36$

7) $N_U = \frac{1800}{\sqrt{7}} = \frac{1800}{7^{1/2}} = 680.33$ rpm

8) $Q_U = \frac{0.047}{H^{1/2}} = \frac{0.047}{7^{1/2}} = 0.0177\ m^3/s$

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Table of Results for Constant Speed

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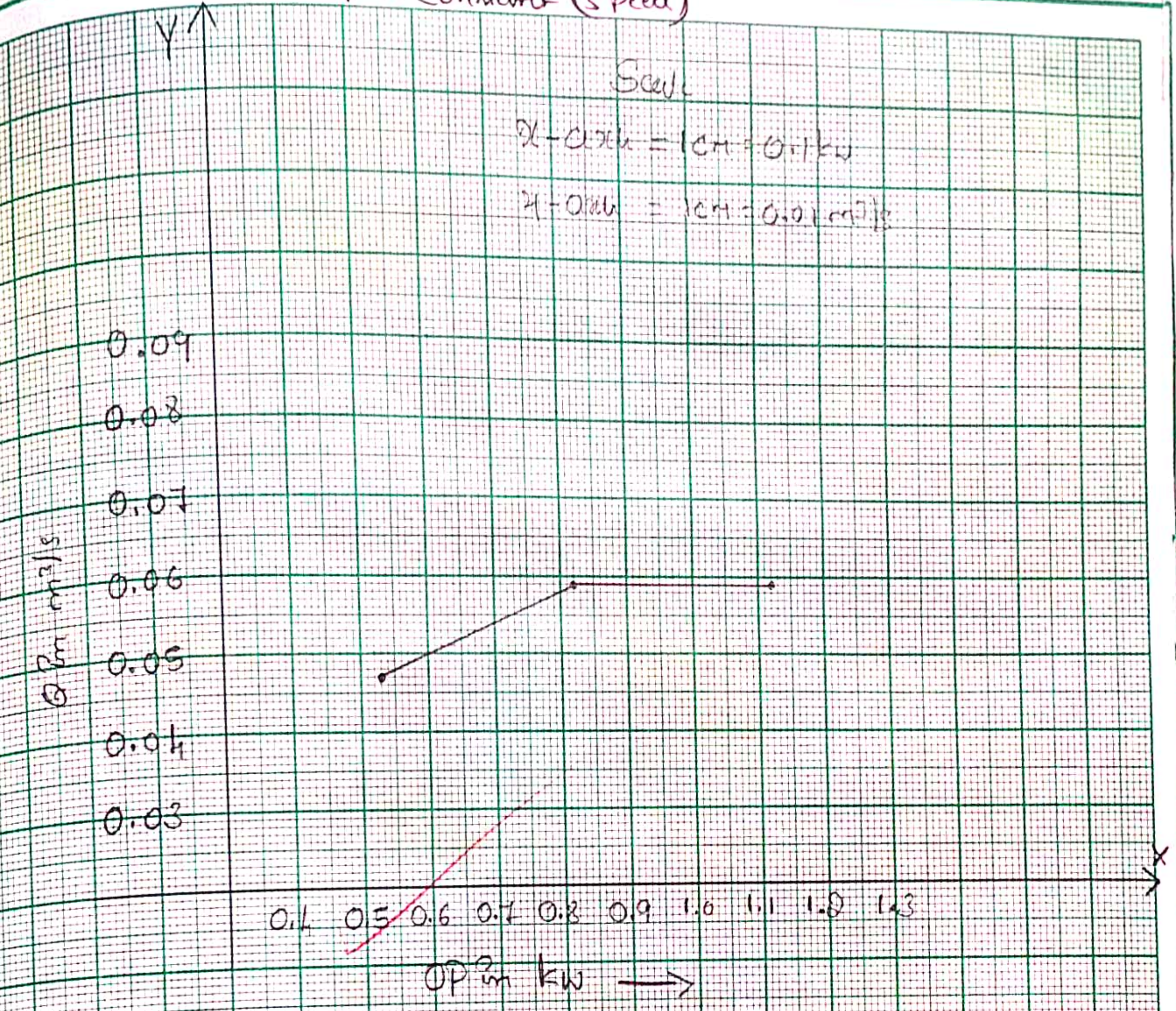
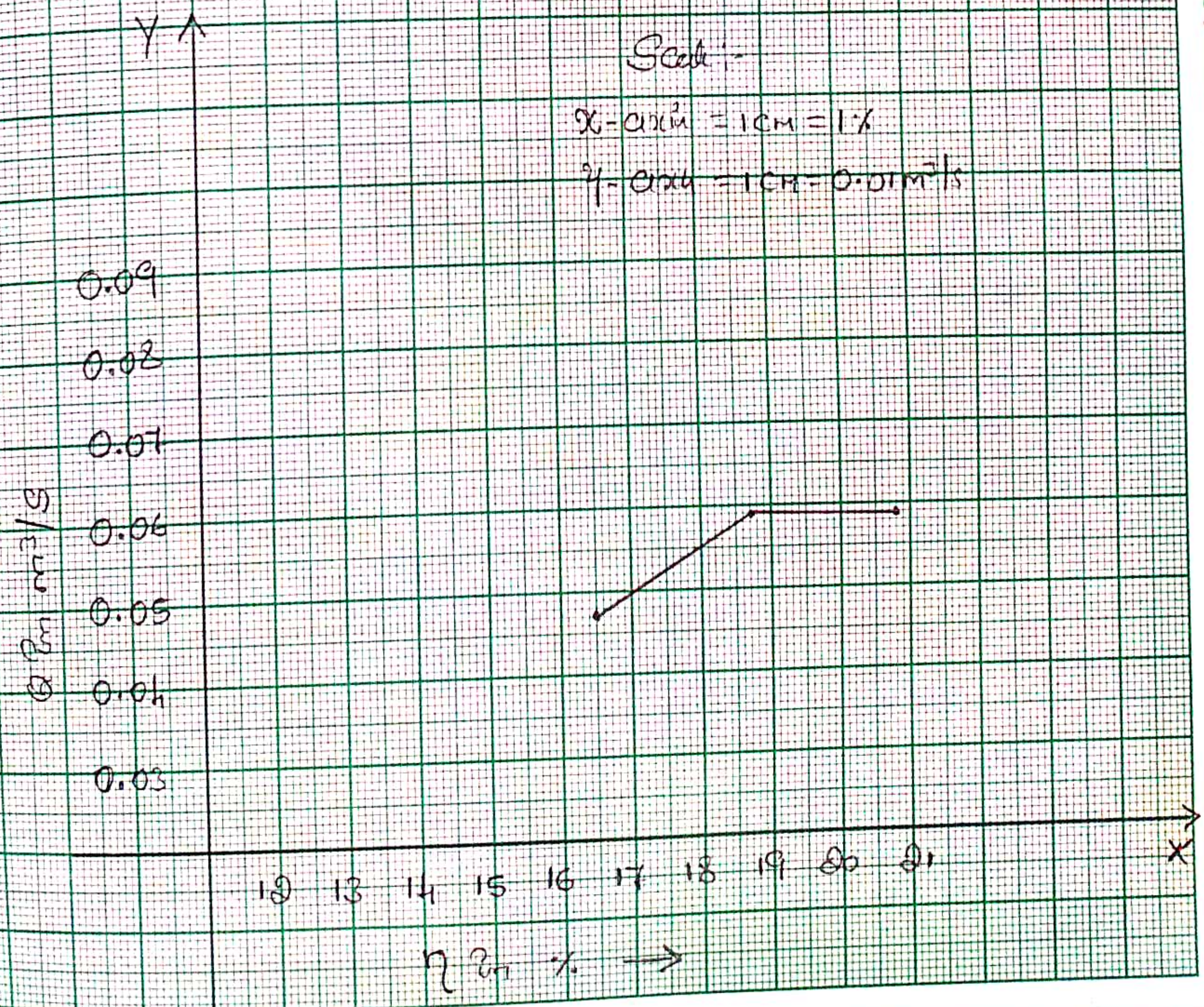
3	9	0.059	5.345	1.1242	20.83

For Constant (Speed)





3) Discharge $Q = \frac{C_d \times a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$

C_d of Venturimeter is 0.95

$h = 10 \times (P_1 - P_2)$

4) Hydraulic input to the turbine

$IP = \frac{\rho g Q H}{60,000}$ kw

5) Output Power $OP = \frac{2 \pi N T}{60,000}$

Where N = Turbine Speed

T = torque $= (F_1 - F_2) \times R \times 9.81$

6) Turbine Efficiency $\eta = \frac{OP}{IP} \times 100$

7) Unit Quantities

(a) $N_U = \frac{N}{H^{1/2}}$, (b) $P_U = \frac{P}{H^{3/2}}$ c) $Q_U = \frac{Q}{H^{1/2}}$

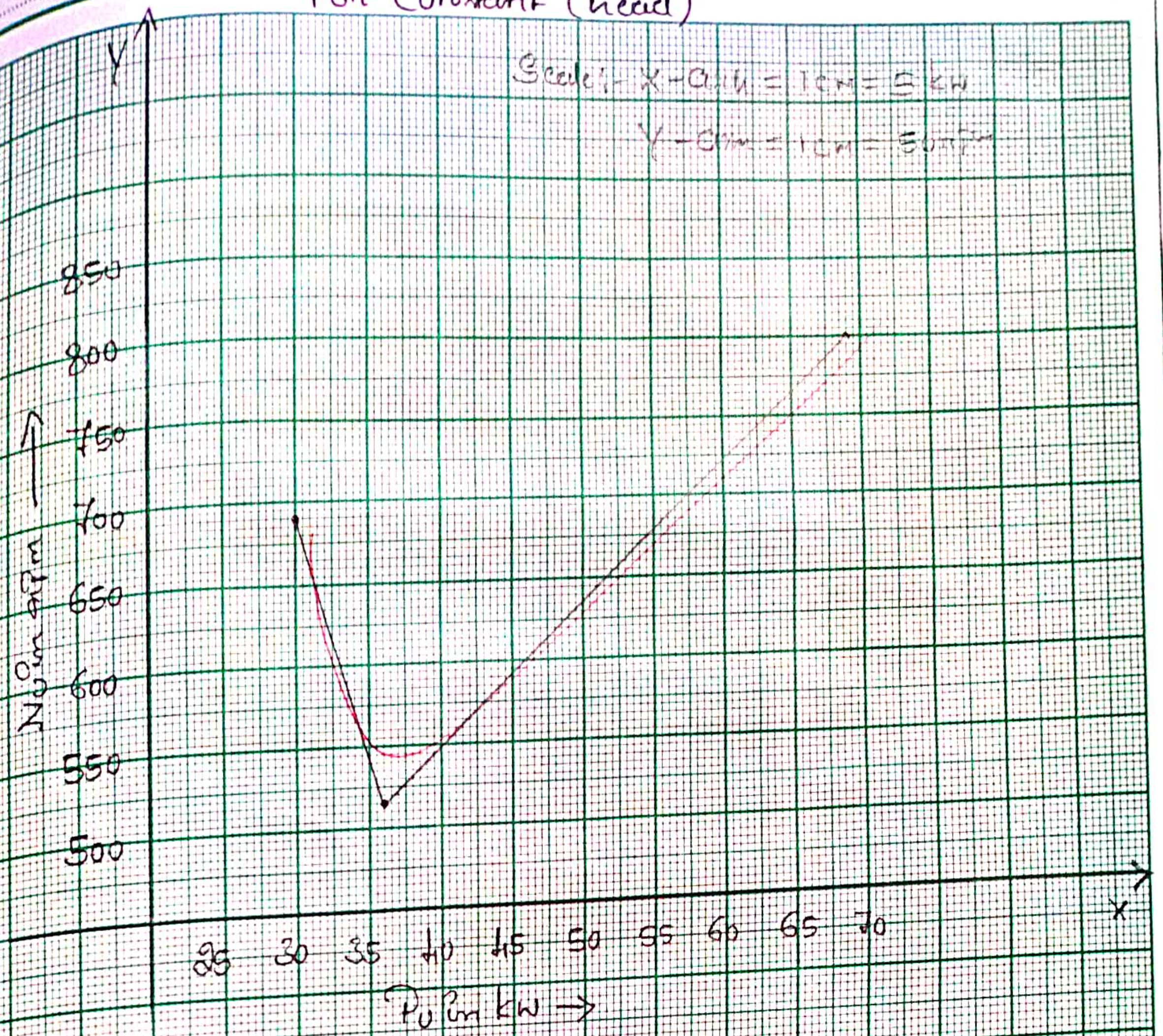
d) $N_{sp} = \frac{N P^{1/2}}{H^{5/4}}$

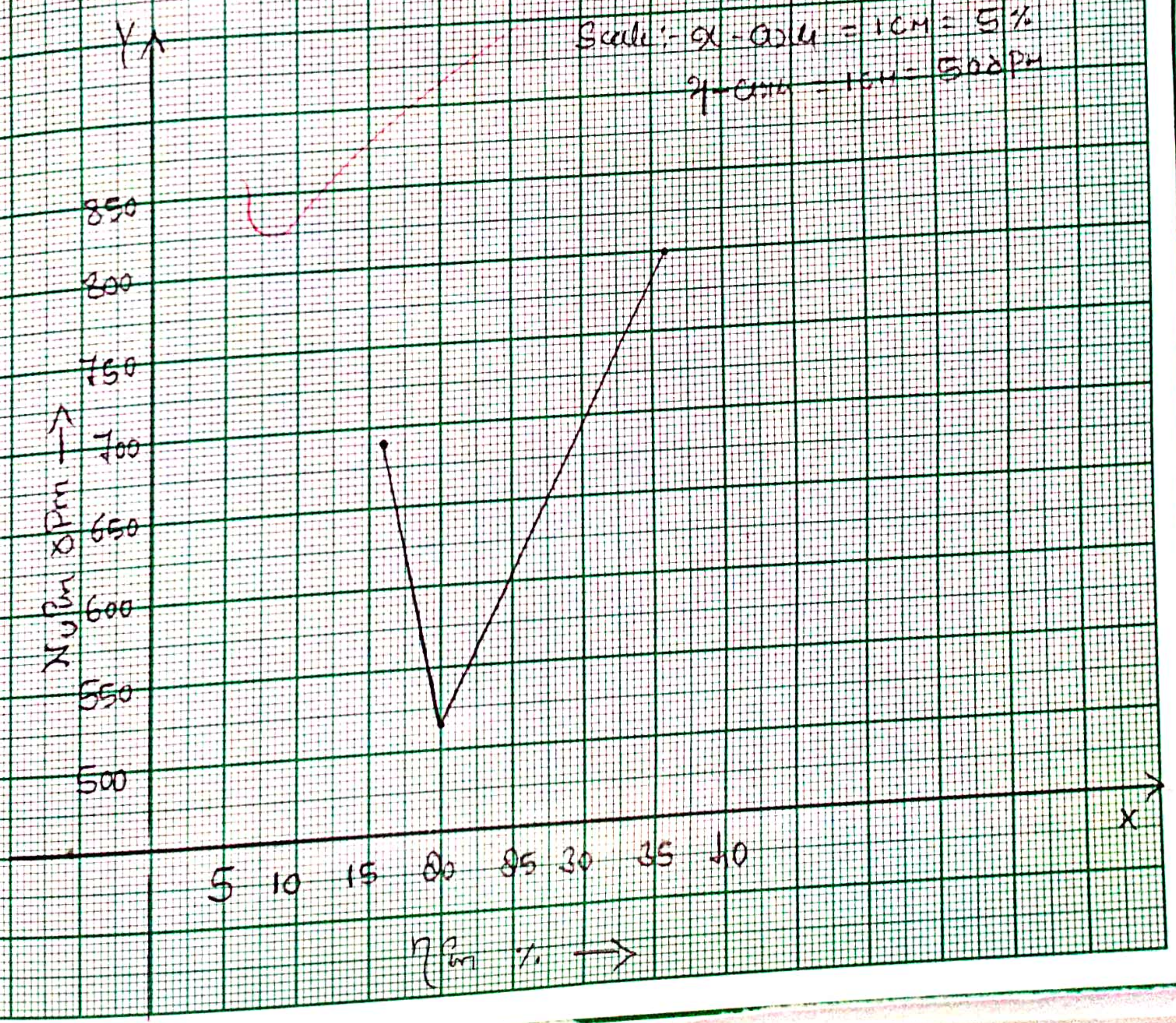
Table of Results for Constant Head:-

SL No	Total Head	Discharge Q (m³/s)	IP in kW	OP in kW	Efficiency η	Nu in rpm
1	7	0.0470	3.2274	0.5617	17.40	680.33
2	7	0.0470	3.2274	0.6670	20.60	529.15
3	7	0.0508	3.428	1.2713	37.25	797.80

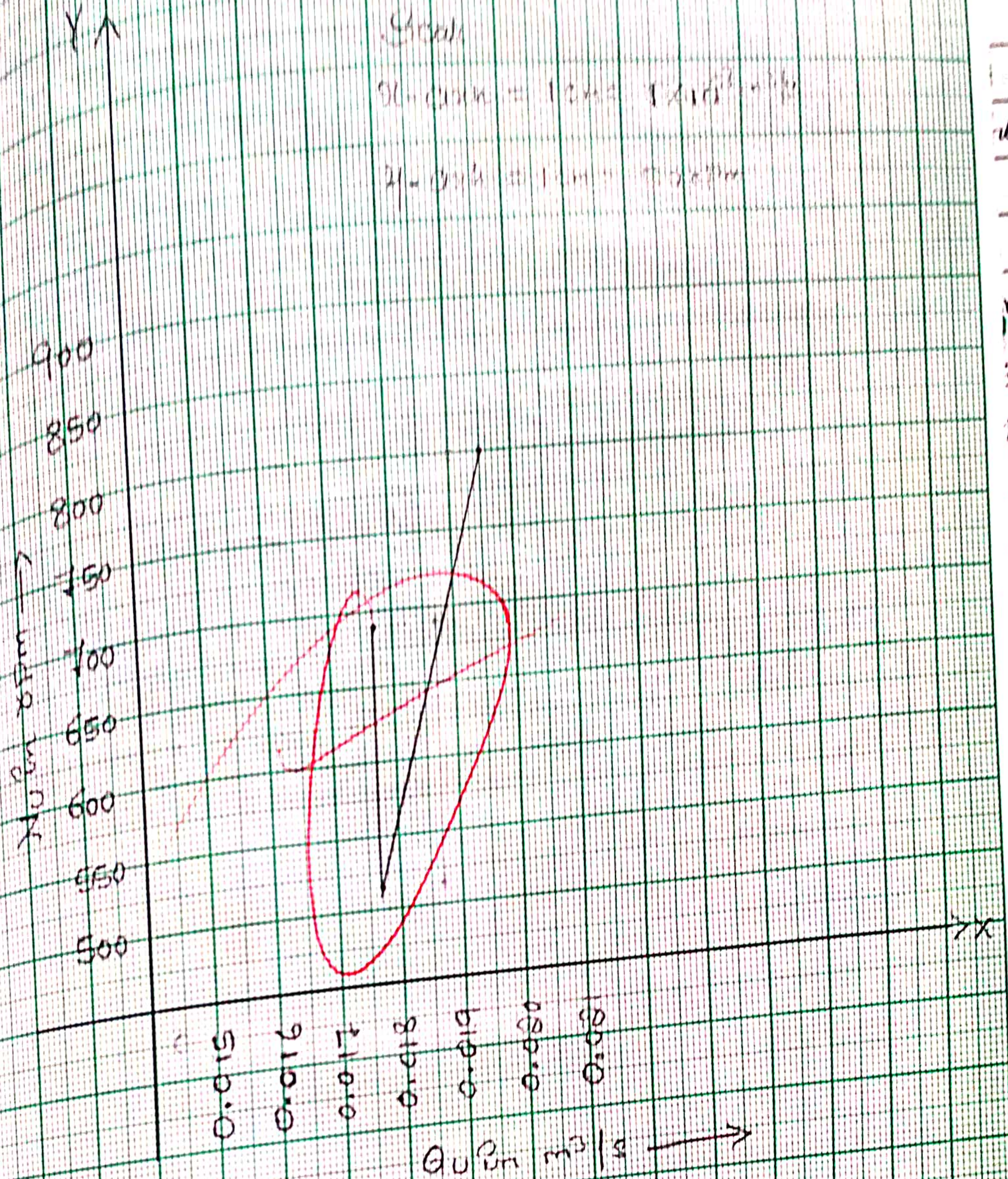
Qu in m^3/s	Pu in kW	Nsp
0.0171	30.32	115.36
0.0171	36.1	129.11
0.2192	68.96	178.66

For Constant (head)





For Constant (head)



Result:-
Draw the graph of main Characteristics of the kaplan turbine

For Constant Speed

* Output power (OP) vs Discharge (Q)
* Efficiency (η) vs Discharge (Q)

For Constant head

* Unit Power Pu vs Unit Speed (Nu)
* Efficiency (η) vs unit Speed (Nu)
* Unit discharge vs unit Speed (Nu)

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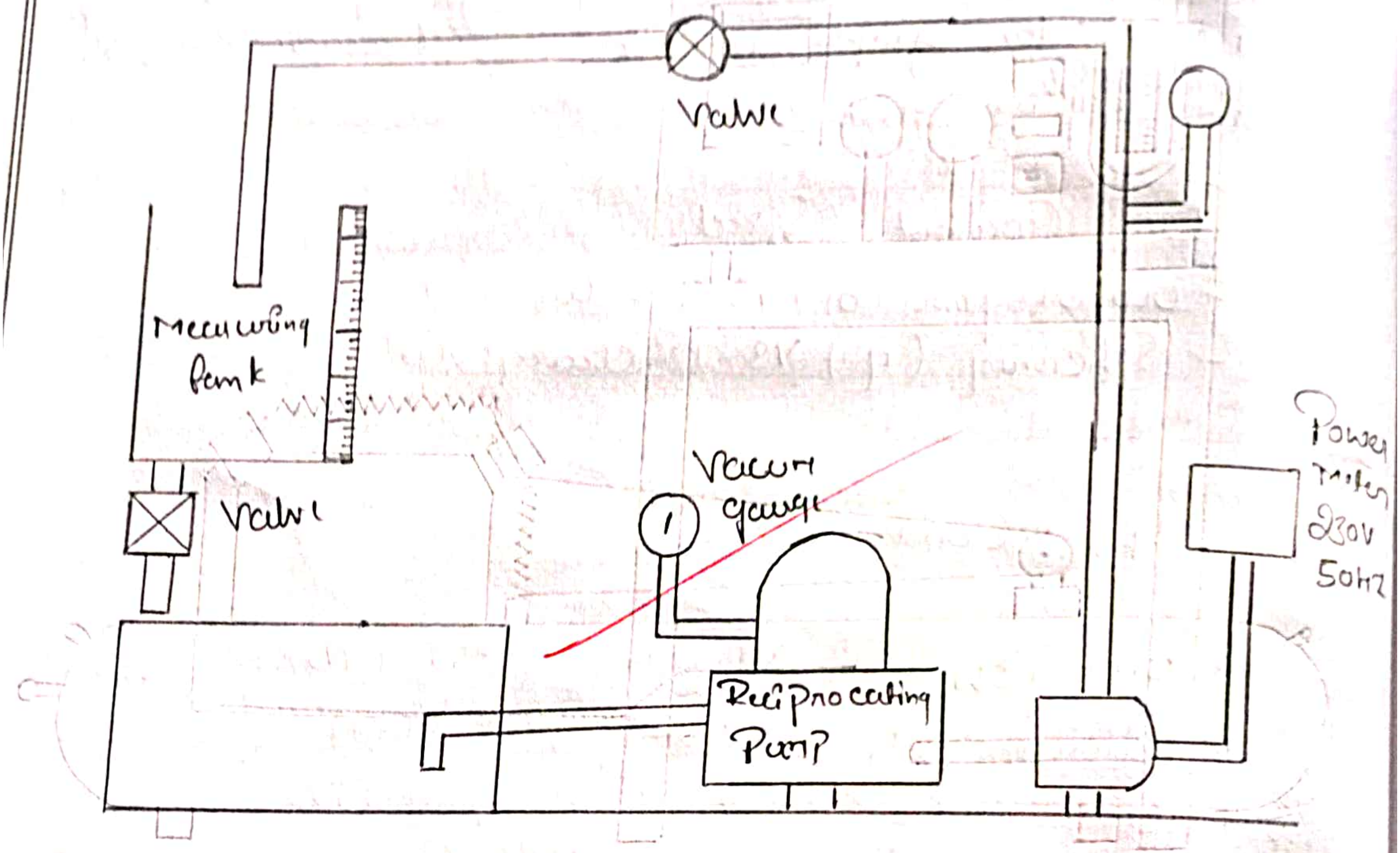
Diagram:


Valve
Measuring tank
Valve
Vacum gauge
Reciprocating Pump
Power meter
230V
50Hz

RECIPROCATING PUMP TEST RIG

Aim:- To Study the Performance Characteristics of double acting Reciprocating Pump

Introduction:- A reciprocating pump is a positive displacement machine which converts mechanical energy into fluid energy by the reciprocating motion of a piston within a cylinder there are 2 types (i) Single acting pump:- in which the liquid is acted upon by only one force of the piston (ii) Double acting pump :- in which the liquid acted upon by the both the forces of piston A reciprocating pump is provided with air vessels to maintain uniform discharge in suction & delivery pipe. Air vessels function in a manner similar to the fly wheel in an IC engine they store liquid when discharge the high

Test Rig Details:-

* Reciprocating pump with an electric motor
* Pipe system with all control valve & provided with vaccum & delivery pressure gauge
* measuring tank
* Energy meter to measure I/P power

Table of Reading

Sl No	Pump Speed in rpm	Delivery Pressure P_d in (kg/m²)	Suction Pressure h_s in (mm of Hg)	Energy meter reading		Discharge time taken for R cm rise in sec
				No of Pulse	Time taken in T, Sec	
1	200	0.3	80	5	16.25	8.98
2	200	0.3	80	5	17.13	7.53
3	200	0.4	80	5	19.25	6.33

Calculations:

(i) $IP_1 = \frac{5 \times 3600 \times 0.75}{3200 \times 16.25} = 0.2596 kw$

$IP_2 = 0.2462 kw$

$IP_3 = 0.2191 kw$

(ii) $Q_{act_1} = \frac{0.118 \times 0.1}{8.98} = 1.3439 \times 10^{-3} m^3/s$

$Q_2 = 1.5670 \times 10^{-3} m^3/s$

$Q_3 = 1.475 \times 10^{-3} m^3/s$

3) $H_1 = 10\left(0.3 + \frac{80}{760}\right) = 4.005 m$

$H_2 = 4.005 m$

$H_3 = 4.55 m$

* Reciprocating Pump 2HP 2 Stage

Procedure:-

* open the delivery valve completely
* Start the pump
* Adjust the delivery pressure to the required reading by operating the delivery valve
* Note down the following readings
(a) Delivery pressure gauge readings
(b) Vacuum gauge reading
(c) Pump speed
(D) Time for R cm rise of water
(e) Energy meter reading
(5) Repeat the experiment for different value of delivery pressure (Pd)

Formula used:-

1) Input Power $IP = \frac{n \times 3600 \times \eta_m}{k \times t_1}$

2) Discharge $Q = \frac{A_E \times R \times 10^{-2}}{t_2}$

3) Total head $H = 10\left(Pd + \frac{Ps}{760}\right)$

4) Output Power $OP = \frac{\rho Q g H}{1000}$ kw

4) $OP_1 = \frac{1000 \times 9.81 \times 1.34 \times 10^{-3} \times 4.005}{1000} = 0.0533\,kw$

$OP_2 = 0.0622\,kw$ $OP_3 = 0.0658\,kw$

5) $\eta = \frac{OP}{IP} \times 100 = 25.96\%$

$= 24.62\%$

$= 21.91\%$

6) $Q_{th_1} = \frac{2 \times 0.04 \times 2.37 \times 10^{-3} \times 200}{60} = 6.32 \times 10^{-4}\,m^3/s$

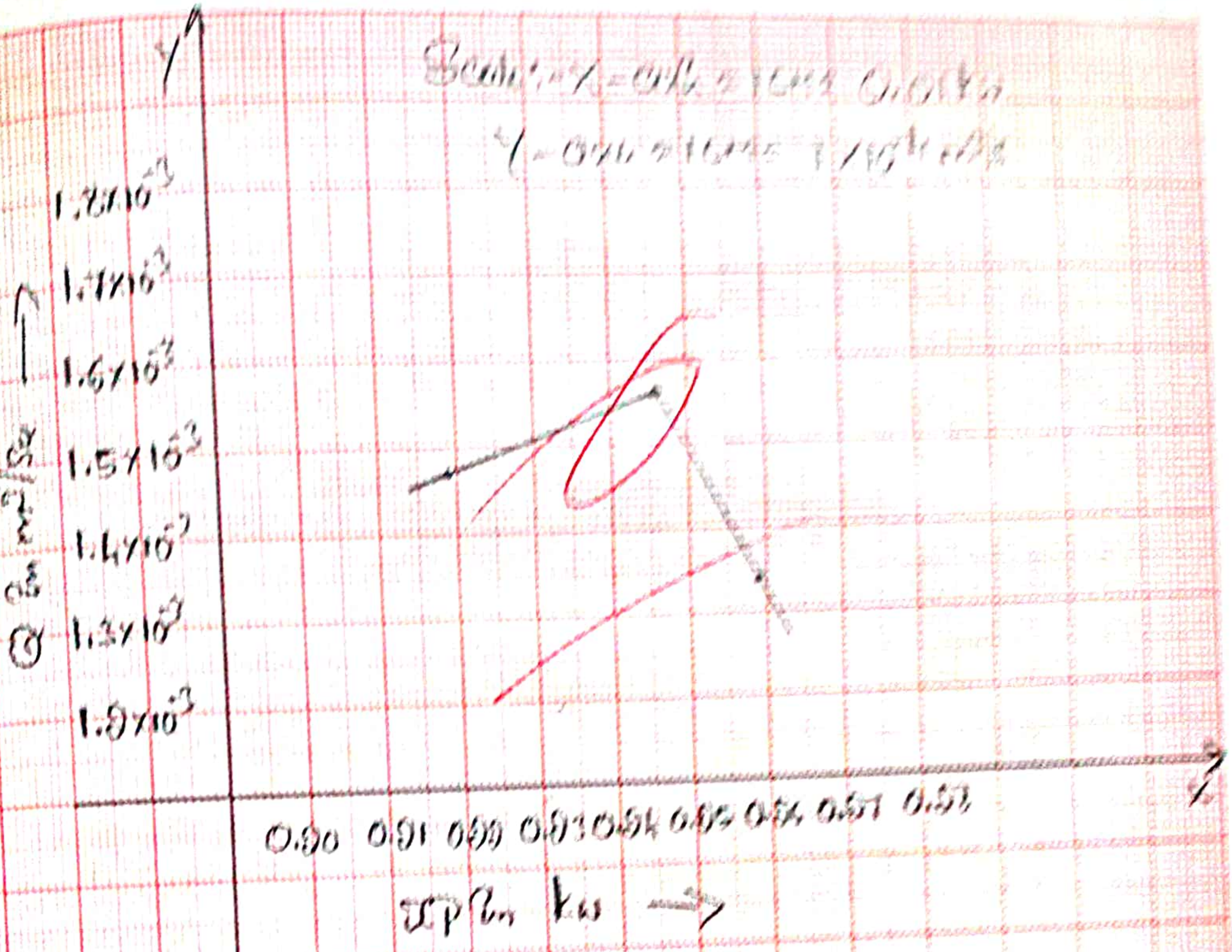
7) $\%\ Slip = \frac{Q_{th} - Q_{act}}{Q_{th}} \times 100$

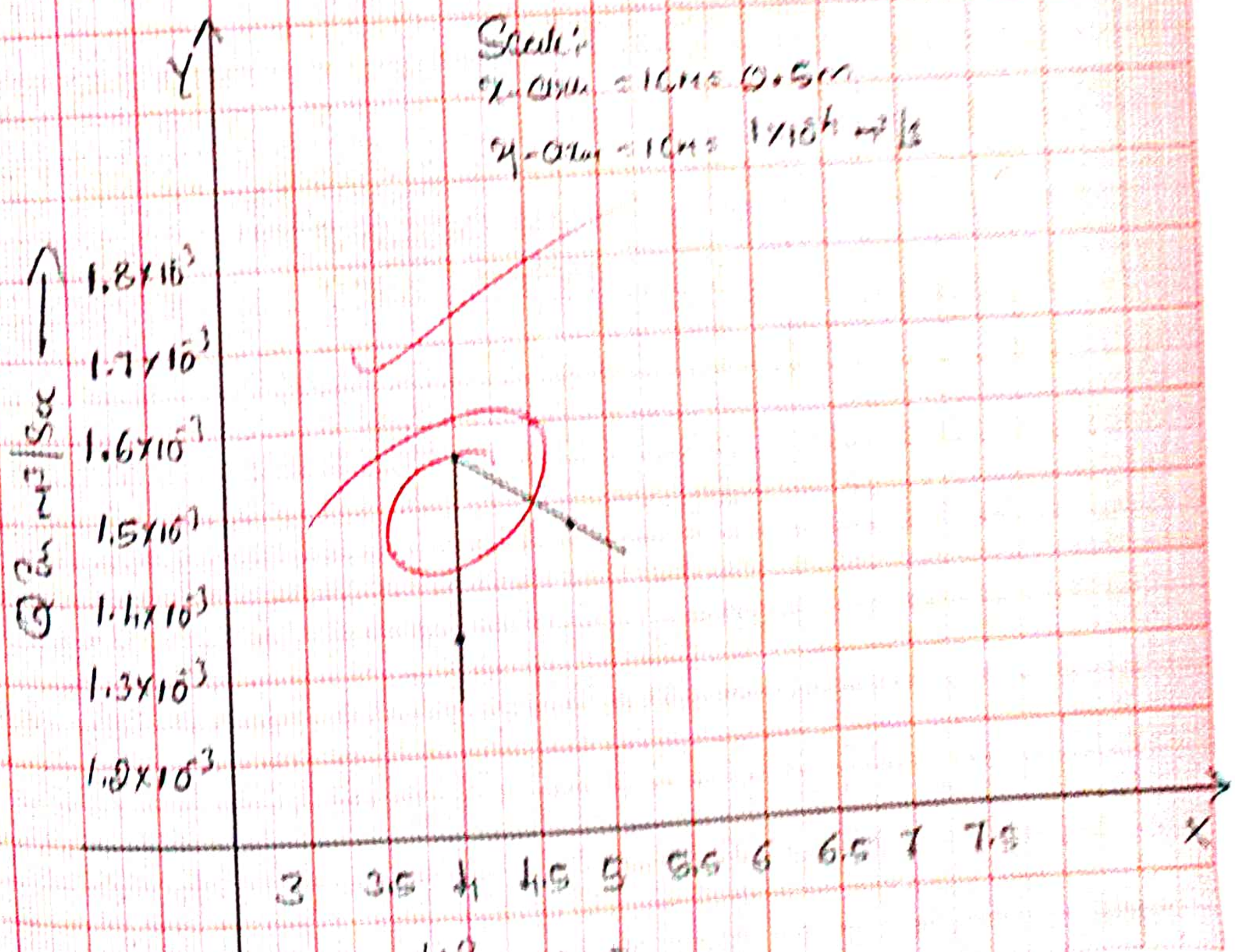
$\%\ Slip_1 = \frac{6.32 \times 10^{-4} - 1.3439 \times 10^{-3}}{6.32 \times 10^{-4}}$ $= 112.64$

$= 147.94$

$= 133.3$

Sl No	Actual discharge	Total head water H in m	OP (kw)	IP kw	%age Efficiency	Q_{th}	% Slip
1	1.3439×10^{-3}	4.005	0.0533	0.2596	20.53	6.32×10^{-4}	112.64
2	1.567×10^{-3}	4.005	0.0622	0.2462	25.26	6.32×10^{-4}	147.94
3	1.475×10^{-3}	4.55	0.0658	0.2191	30.03	6.32×10^{-4}	133.3


Y
1.8x10^3
1.7x10^3
1.6x10^3
1.5x10^3
1.4x10^3
1.3x10^3
X
0.90
0.91
0.93
0.96
0.97
0.98


Scale:
Y
1.8x10^3
1.7x10^3
1.6x10^3
1.5x10^3
1.4x10^3
1.3x10^3
X
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5

5) Pump Efficiency

$$\eta_{pump} = \frac{OP}{IP} \times 100$$

6) $$Q_{theoretical} = \frac{\partial LAN}{60}$$

for L = Stroke of the Piston = 0.04m
Cylinder bore dia D = 0.055m

$$A = \pi D^2/4$$

7) $$\%\,Slip = \frac{Q_{th} - Q_{act}}{Q_{th}} \times 100$$

Result :- Draw the Performance of Characteristics of
(i) Input Power v/s Discharge
(ii) Head v/s Discharge
(iii) Slip v/s Speed

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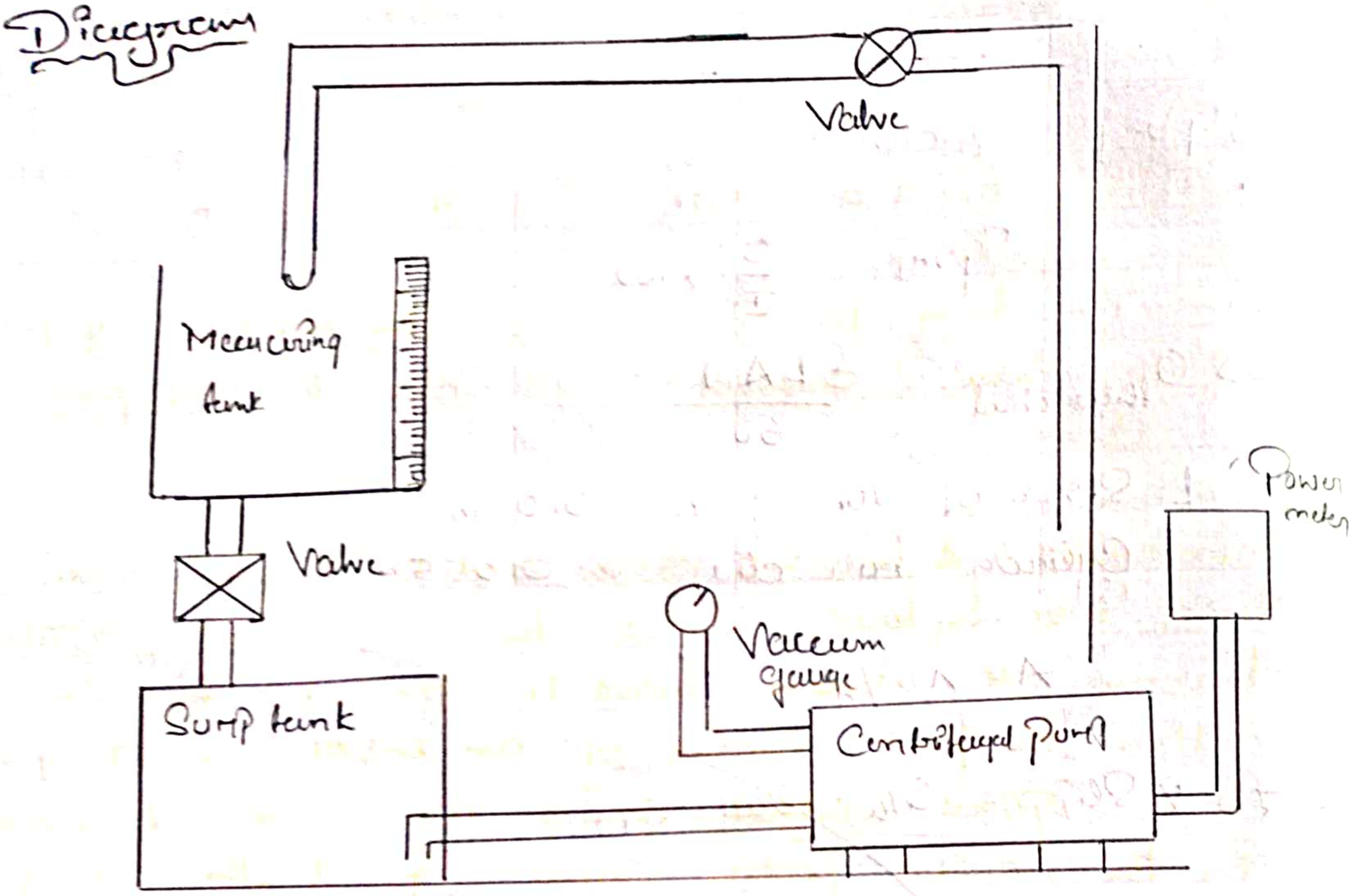
Diagram



Specification

* Energy meter Constant $k = 3200$ kWH
* Efficiency of the motor $\eta_m = 75\%$

Observations:-

* Area of measuring tank $A_1 = 0.35 \times 0.35$

$A_1 = 0.1225 m^2$

* Area of pipe inside the tank $= A_2 = \frac{\pi D^2}{4} = 4.417 \times 10^{-3}$

D = dia of pipe = 75mm

* Effective area $A_E = 0.118 m^2 = A_1 - A_2$

SINGLE STAGE CENTRIFUGAL PUMP

Aim:- TO Study the Performance Characteristics of the Single Stage Centrifugal Pump & draw the Characteristic Curve

Introduction:- A Pump is a device used to convert mechanical energy into hydraulic energy the CF Pump is so called because the pressure head is generated by centrifugal action the pump consist of an impeller which rotates in a spiral shaped casing. Fluid enters the impeller in the control portion called eye & flows radially outwards & discharged around the entire circumference of the casing then to the delivery pipe since a large part of the energy of the fluid leaving the impeller is kinetic & it is necessary to transform the large portion of this velocity head into pressure head. Centrifugal pump basically consist of a stationary pump casing & an impeller mounted on a rotating shaft the pump casing provides a pressure boundary for the pump & contains channels to properly direct the suction & discharge flow

Test Rig Details:-
* Centrifugal Pump with Electrical motor drive
* tank with measuring scale is provided to measure discharge

Tabular Column

Sl No	Speed in RPM	Delivery Pressure Pd in kg/cm²	Suction Pressure Ps in kg/cm²	Time taken for 'n' revolution of energy meter 't' in sec	Time taken for 'R' cm rise in water scale t_2 in sec
1	1800	0.25	80	16.25	8.78
2	1800	0.2	90	17.13	7.57
3	1800	0.15	100	19.28	6.33

Calculations:-

1) Discharge $Q_1 = \frac{A_E R \times 10^{-2}}{t_2} = \frac{0.118 \times 10 \times 10^{-2}}{8.78}$

$Q_1 = 1.3443 \times 10^{-3}\ m^3/s$

$Q_2 = 1.567 \times 10^{-3}\ m^3/s$

$Q_3 = 1.868 \times 10^{-3}\ m^3/s$

2) $H = 10\left(Pd + \frac{Ps}{760}\right) = 10\left(0.25 + \frac{80}{760}\right) = 3.5526$

$H_2 = 3.184$ $H_3 = 2.815$

3) $OP = \frac{\rho g Q H}{1000}$

$OP = \frac{1000 \times 9.81 \times 1.3443 \times 10^{-3} \times 3.5526}{1000} = 0.0468\ kw$

$OP_2 = 0.0489\ kw$

$OP_3 = 0.0515\ kw$

* Pressure gauge to measure delivery pressure & suction pressure
* An energy meter to measure the power input to the motor

Procedure:-

1 Prime the pump
2 Switch on the motor with the discharge fully closed
3 Then open the discharge valve completely & note down the following readings
* Delivery pressure gauge
* Speed of the motor
* Time taken for 'R' cm rise in measuring tank
* Time taken for 10 revolutions in the energy meter
4 Repeat the experiment for different value of the discharge valve of the pump by a few revolution each to get a different value of discharge

Formula used

1) Input Power = $IP = \frac{n \times 3600 \times \eta_m}{t_1 \times k}$ in kW

2) Discharge = $Q = \frac{A_E R \times 10^{-2}}{t_2}$ in m^3/s

3) Total head

$$H = 10\left(Pd + \frac{Ps}{760}\right)$$

4) $IP = \frac{n \times 3600 \times \eta_m}{t_1 \times k}$

$IP_1 = \frac{5 \times 3600 \times 0.75}{16.25 \times 3200} = 0.2596 kw$

$IP_2 = 0.2462 kw$

$IP_3 = 0.2191 kw$

5) $\eta = \frac{OP}{IP} \times 100$

$\eta_1 = \frac{0.0468}{0.2596} \times 100 = 18.02\%$

$\eta_2 = \frac{0.0489}{0.2462} \times 100 = 19.86\%$

$\eta_3 = \frac{0.0515}{0.2191} \times 100 = 23.56\%$

where, P_d = delivery Pressure
P_s = Suction Pressure

4) Output Power

$$OP = \frac{\rho g Q H}{1000} \text{ in kW}$$

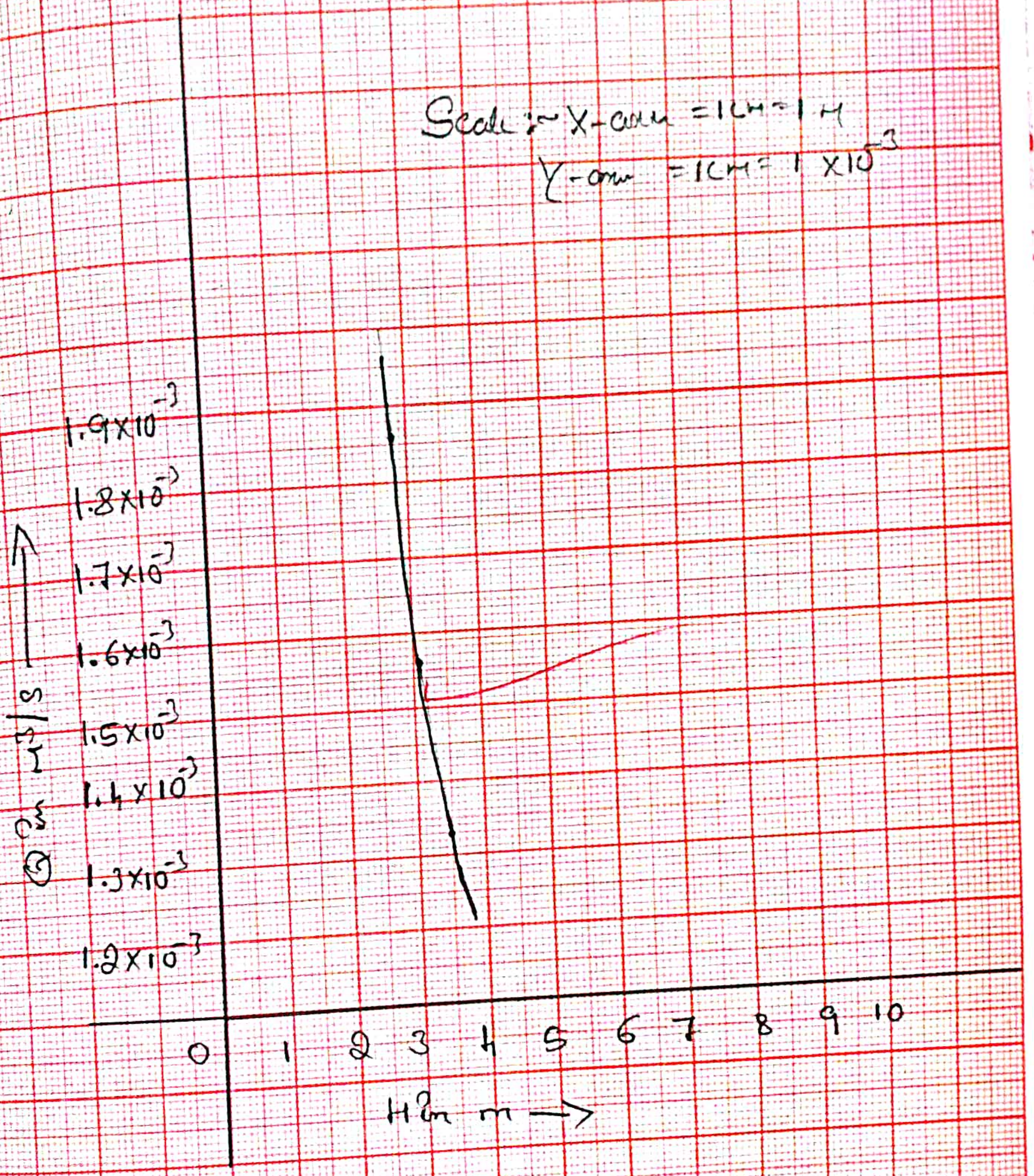
5) Efficiency $\eta = \frac{OP}{IP} \times 100$

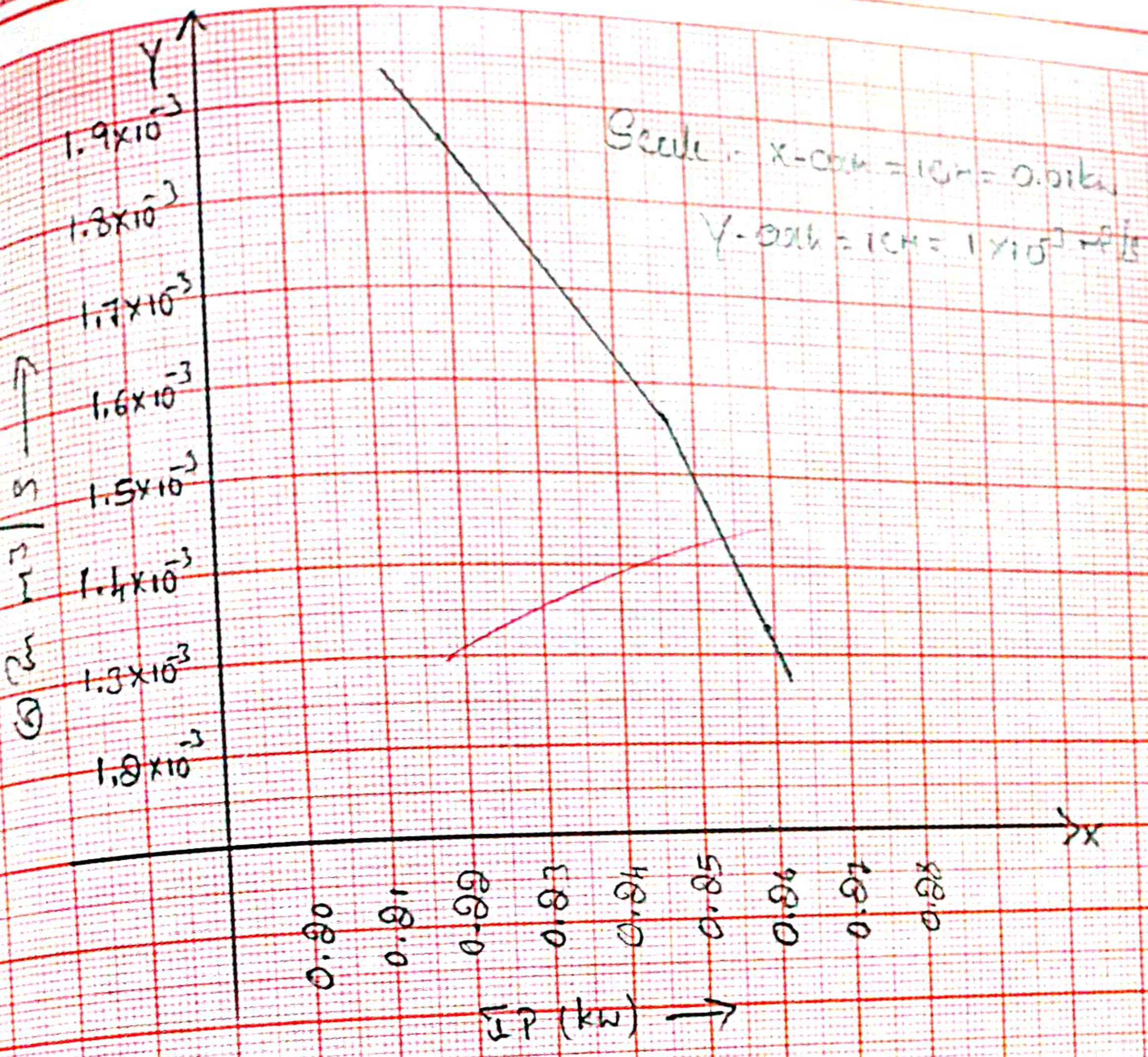
Table of Readings

Sl No	Actual discharge Q_a in m^3/s	Total head of water H in (m of water)	OP (kw)	IP (kw)	Percentage Efficiency
1	1.3343×10^{-3}	3.5526	0.0468	0.2596	18.02
2	1.567×10^{-3}	3.184	0.0489	0.2462	19.86
3	1.868×10^{-3}	2.815	0.0515	0.2191	23.56

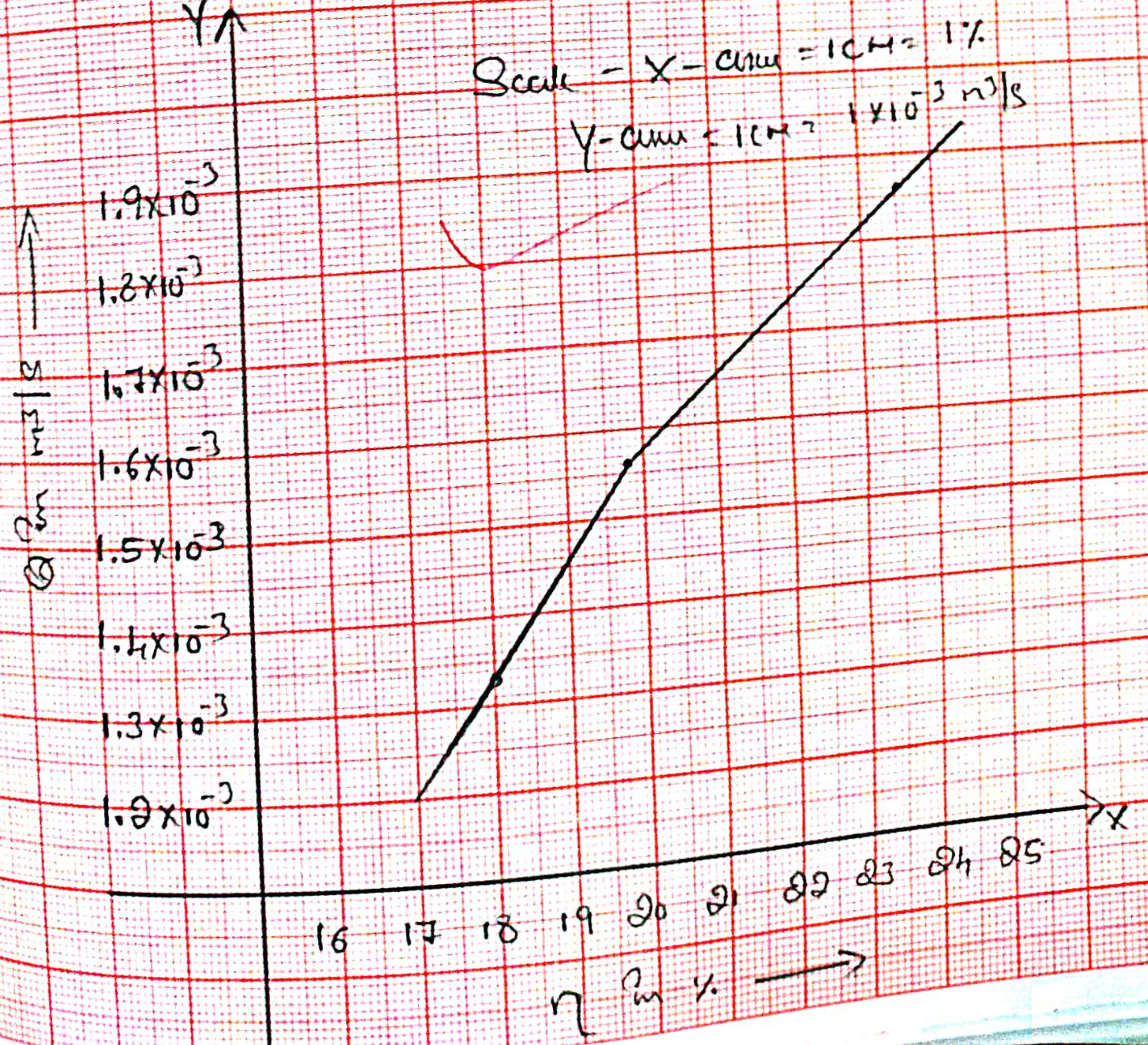
Date:

Batch No.





Scale :- X-axis = 1cm = 0.01kw
Y-axis = 1cm = 1×10⁻³ m³/s
Y
1.9×10⁻³
1.8×10⁻³
1.7×10⁻³
1.6×10⁻³
1.5×10⁻³
1.4×10⁻³
1.3×10⁻³
1.2×10⁻³
Q in m³/s
X
0.80
0.81
0.82
0.83
0.84
0.85
0.86
0.87
0.88
IP (kw)



Scale - X-axis = 1cm = 1%
Y-axis = 1cm = 1×10⁻³ m³/s
Y
1.9×10⁻³
1.8×10⁻³
1.7×10⁻³
1.6×10⁻³
1.5×10⁻³
1.4×10⁻³
1.3×10⁻³
1.2×10⁻³
Q in m³/s
X
16
17
18
19
20
21
22
23
24
25
η in %

Name of Experiment .... Date : ....

Experiment No. .... Page No. 108

Result:-

The Efficiency of the Centrifugal Pump is found to be 20.48%

Draw the Performance Characteristics like

* Input Power vs Discharge (Q)
* Efficiency η vs Discharge (Q)
* Head (H) vs Discharge (Q)

24/30

25/9/19