# INDEX

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>EXP. NO.</th>
<th>OBJECTIVE</th>
<th>DATE</th>
<th>GRADE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Department of Mechanical Engineering  
IIT GHAZIABAD
## CONTENTS

<table>
<thead>
<tr>
<th>Exp. No</th>
<th>Name of the Experiment</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Impact of Jet</td>
<td>05-08</td>
</tr>
<tr>
<td>2</td>
<td>Hydraulic Brake System</td>
<td>04-06</td>
</tr>
<tr>
<td>3</td>
<td>Multistage Centrifugal Pump</td>
<td>07-09</td>
</tr>
<tr>
<td>4</td>
<td>Pelton Wheel Turbine</td>
<td>10-14</td>
</tr>
<tr>
<td>5</td>
<td>Francis Turbine</td>
<td>15-18</td>
</tr>
<tr>
<td>6</td>
<td>Comparison Pelton Turbine and Francis Turbine</td>
<td>19-20</td>
</tr>
<tr>
<td>7</td>
<td>Reciprocating Pump</td>
<td>21-22</td>
</tr>
<tr>
<td>8</td>
<td>Closed Circuit Reciprocating Pump</td>
<td>23-25</td>
</tr>
<tr>
<td>9</td>
<td>Closed Circuit Gear Oil Pump</td>
<td>26-28</td>
</tr>
<tr>
<td>10</td>
<td>Hydraulic Ram</td>
<td>29-32</td>
</tr>
<tr>
<td>11</td>
<td>Hydraulic Press</td>
<td>33-33</td>
</tr>
<tr>
<td>12</td>
<td>Hydraulic Jack</td>
<td>34-35</td>
</tr>
<tr>
<td>13</td>
<td>Industrial Visit to any Hydraulic Plant</td>
<td>36-37</td>
</tr>
</tbody>
</table>

### Appendix A

Table No. 1 Physical properties of water : 40

Table No. 2 Physical properties of air at atmospheric pressure : 40

Table No. 3 Physical properties of common liquids at 200 : 41

Conversion factors : 41
EXPERIMENT NO. 1 IMPACT OF JET

1.1 Objective
To verify the momentum equation experimentally through impact of jet experiment.

1.2 Apparatus Required
Impact of jet apparatus, weights, Stop watch.

1.3 Theory
The momentum equation based on Newton’s 2\textsuperscript{nd} law of motion states that the algebraic sum of external forces applied to control volume of fluid in any direction equal to the rate of change of momentum in that direction.

The external forces include the component of the weight of the fluid and of the forces exerted externally upon the boundary surface of control volume.

If a vertical water jet moving with velocity ‘V’ made to strike a target (Vane) which is free, to move in vertical direction, force will be exerted on the target by the impact of jet.

Applying momentum equation in z- direction, force exerted by the jet on the vane, \( F_Z \) is given by

\[
F_Z = \rho Q (V_{z\text{out}} - V_{z\text{in}})
\]

For flat plate, \( V_{z\text{out}} = 0 \)

\[
F_Z = \rho Q(0-v)
\]

\[
F_Z = \rho Qv
\]

For hemispherical curved plate , \( V_{z\text{out}} = -v, V_{z\text{in}} = v \)

\[
F_Z = \rho Q[v+(-v)]
\]

\[
F_Z = 2 \rho Qv
\]

Where Q= Discharge from the nozzle (Calculated by volumetric method)

\( V = \) Velocity of jet = \( (Q/A) \)

1.4 Experimental setup
The set up primarily consists of a nozzle through which jet emerges vertically in such a way that it may be conveniently observed through the transparent cylinder. It strikes the target plate or disc positioned above it. An arrangement is made for the movement of the plate under the action of the jet and also because of the weight placed on the loading pan. A scale is provided to carry the
plate to its original position i.e. as before the jet strikes the plate. A collecting tank is utilized to find the actual discharge and velocity through nozzle.

![Fig No. 1 Impact of Jet.](image)

1.5 Procedure:

i. Note down the relevant dimensions as area of collecting tank and diameter of nozzle.

ii. When jet is not running, note down the position of upper disc or plate.

iii. Admit water supply to the nozzle.

iv. As the jet strikes the disc, the disc moves upward, now place the weights to bring back the upper disc to its original position.

v. At this position find out the discharge and note down the weights placed above the disc.

vi. The procedure is repeated for different values of flow rate by reducing the water supply in steps.

1.6 Observation:

Diameter of nozzle (d) = 10 mm

Area of the nozzle (A) = \( \pi d^2 / 4 \)

Mass density of water = 1gm/cm³
Area of collecting tank = 1200 cm²
When jet is not running, position of upper disc = ......................... cm

**Observation Table:**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Discharge/ Velocity measurement</th>
<th>Balancing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial (cm)</td>
<td>Final (cm)</td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
<td>------------</td>
</tr>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.7 Results & Discussion

1. Find the theoretical force & error in balancing.

Discussion:

1.8 Precaution:

1. Apparatus should be in levelled condition.
2. Reading must be taken in steady conditions.
3. Discharge must be varied very gradually from a higher to smaller value.

1.9 Viva Voce Questions:
1. What is the difference between a hydraulic nozzle and diffuser?
2. What is an impulse momentum equation?
3. Define the terms, momentum, moment and impulse.
4. Discuss some applications of impact of jets.

Theoretical data (STANDARD DATA):

(i) Curve Vane: Maximum losses up to 41%
(ii) Flat plate: Maximum losses up to 50%
(iii) Inclined plate: Maximum losses up to 46-51%
2.1 Objective 2.2 Apparatus Required 2.3 Introduction 2.4 Theory 2.5 Viva Voce Questions

2.1 **Objective:** To study the working principle and working of Hydraulic Brake system.

2.2 **Apparatus Required:** Hydraulic Brake system Apparatus.

2.3 **Introduction:**
The most vital factor in the running and control of the modern vehicles is the braking system. In order to bring the moving motor vehicle to rest or slow down in a shortest possible time, the energy of motion possessed by the vehicle must be converted into some other form of energy. The rate of slowing down or retardation is governed by the speed of conversion of energy. Kinetic energy is the energy of motion, which is converted into heat given up to air flowing over the braking system.

For realizing the full potentialities of the engine and road holding safety, it is necessary to bring the car rapidly to rest from any speed by some mean. The means of slowing down or bringing to the rest a moving vehicle in a shortest possible distance is called brakes. Brake is a friction device for converting the power of momentum or kinetic energy of the moving vehicle into heat by means of direction.

2.4 **Theory:**

**Hydraulic Brake System:**

A hydraulic braking essentially consists of (i) A brake pedal, (ii) a master cylinder and piston connected by tubing to hydraulic wheel cylinders, (iii) Pipelines and houses for conveying the fluid under pressure to the wheel brake shoe operating units and the wheel cylinder whose position move out for applying the pressure to the wheel brakes.

The pedal force in this system is transmitted to the brake shoes for its actuation through a confined liquid as brake fluid. The fluid pressure acting upon positions in the wheel brake operating causes the brake shoes to expand. A system of force transmission based on Pascal’s Law (i.e. confined liquids transmit pressure without loss equally in all directions) helps to multiply and transmit the force applied on the pedal to the brake shoes. The hydraulic braking system is fully compensated due to the use of hydraulic fluid as the transmission medium because the pressure is transmitted to pistons of each wheel cylinder with equal and undiminished force resulting in the pressure applied to brake shoes to be identical.
Master cylinder is the central unit in the hydraulic braking system. The hydraulic pressure required to operate the system is produced here. The pressure of the driver’s pedal through different linkage arrangement is transmitted to the master cylinder piston. It can be considered as the heart of the hydraulic braking system. The purposes served by a master cylinder are as under:

(a) The hydraulic pressure required to operate the system is built up.

(b) Due to the reservoir provided with it, it serves to maintain a constant volume of fluid in the system. © To bleed or force air out of the brake line and wheel cylinders.

The brake system consists of internal expending type brake, which consists of brake shoes, which are made to contact an auxiliary wheel, know as drum. To keep out the dust and the moisture the entire mechanism is enclosed in the drum. The wheel brake unit consists of a drum, anchor plate or back plate, two shoes, and operating unit and an adjusted unit. The anchor plate, which contains the shoes pivoted on an anchor pin, allows them to expand while the friction linings help it to make contact with the drum. In order to bring the shoes back to the off position when the brake is released return springs are used.

Fig. 2 Hydraulic Brake system
The shoes of the brake consist of segmental castings with a web and a relatively wide flange; a strip of friction material is externally secured to the flange. Fitted inside the flanged drum, the shoes are expanded by some type of the operating unit. To allow the drum to revolve freely with the wheel the diameter of the shoes is kept little less then the internal diameter of the drum when they are at rest. By operating shoes, they are forced against the inner surface of the drum. This results in stoppage of the further rotation of the drum with the wheels becoming stationary.

**BRAKE FLUID:**

Brake fluid is a special liquid for use in hydraulic brake systems, which must meet highly exact performance specifications. It is designed to be impervious to wide temperature changes and to not suffer any significant changes in important physical characteristics such as compressibility over the operating temperature range. The fluid is designed to not boil, even when exposed to the extreme temperatures of the brakes.

Different types of brake fluid are used in different systems, and should NEVER be mixed. Most cars use “DOT 3” or “DOT 4” brake fluid. Some newer cars use silicon brake fluids. These should NEVER be mixed together, because the seals in each car are designed to work with only their specific fluid types. For example, the mixing of “Silicon” brake fluid and conventional glycol based DOT 3 OR DOT 4 fluids should be avoided, as the two fluid types are not miscible (they will not mix together) DOT 3 brake fluids and DOT 4 brake fluids can be mixed.

### 2.5 Viva Voce Questions:

1. Give some the applications of hydraulic braking system.
2. What is the operating of a hydraulic braking system?
3. What are the advantages and limitations of a hydraulic braking system?
EXPERIMENT NO. 3  MULTISTAGE CENTRIFUGAL PUMP

3.1 Objective

3.2 Apparatus Required

3.3 Experimental setup

3.4 Procedures

3.5 Observation Table

3.6 Calculation

3.7 Results & Discussions

3.8 Precaution

3.9 Viva Voce Questions

3.1 Objective:

To study the characteristics of Multistage (Two Stage) Centrifugal pump, to calculate the efficiency and to draw the following curves:
- Discharge VS Head
- Discharge VS Efficiency
- Discharge VS Power

3.2 Apparatus Required:

Multistage Centrifugal pump Test rig.

3.3 Experimental setup:

The test rig consists of a motor and multi stage pump directly couple through a flanged coupling arrangement and further it is mounted on a sump tank. A collecting tank is provided to measure discharge of the pump. A panel board consisting of energy meter to measure the power input to the motor, and a starter to start the pump. The rig is complete with suction and discharge pressure gauges along with suitable pipeline and control valve arrangements.

3.4 Procedure:

a. Prime the pump if necessary.

b. Keep the bypass valve and main valve fully open.

c. Start the pump.

d. Note down the readings at different pressure heads and discharge.

3.5 Observation Table:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Discharge Q (cm³/s)</th>
<th>Input power Pᵢ (HP)</th>
<th>Suction Head Hₛ (cm)</th>
<th>Delivery Head Hₜ (cm)</th>
<th>Total Head Hₑ (cm)</th>
<th>Output power Pₒ (Hp)</th>
<th>Efficiency η</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.6 Calculations:

Shaft input power to the motor = power input by energy meter

\[ \text{Shaft input power} = \frac{\text{No. of revolution} \times 3600}{\text{Time} \times \text{Energy meter constant} \times 0.736} \]

Where

- \( \text{rpm} \) = Rotation of energy meter disc
- \( \text{Time} \) = Time for one revolution of the disc
- 0.736 = Conversion factor from KW to HP
- Motor efficiency = 75%

Shaft input to the pump (Pi) = Shaft input to the motor X Motor efficiency

\[ \text{Shaft input to the pump (Pi)} = \text{Shaft input to the motor} \times \text{Motor efficiency} \]

Total Head \( (H_m) \) = Suction head \( (H_s) \) + Delivery head \( (H_d) \)

\[ \text{Total Head} (H_m) = H_s + H_d \]

Output of the pump = \( \frac{\rho Q H_m}{75} \)

Where

- \( \rho \) = Density of water
- \( Q \) = Discharge in m³/s
- \( Q = \frac{WLH}{\text{Time}} \)
- \( L \) = Length of the collecting tank in m
- \( W \) = Width of the collecting tank in m
- \( H \) = Height of Water in collecting tank in m read through Gauge glass and scale.

Efficiency of the pump \( (\eta_0) \) = \( \frac{\text{Output Power}}{\text{Input Power}} \times 100 \)

3.7 Results & Discussions:

Following curves are drawn and efficiency is calculated.

- Discharge Vs Head
- Discharge Vs Efficiency
- Discharge Vs Power
Discussions:

3.8 Precaution:
   a. Priming is must before starting the pump.
   b. Pump should never be run empty.
   c. Use clean water in the sump tank.

Theoretical data: (STANDARD DATA):
   Monomeric efficiency = 39-45 %
   Overall efficiency = 75-85 %

3.9 Viva Voce Questions:
1. What is priming of a pump? Why it is necessary to prime a pump?
2. What is cavitation? Where does it occur in a centrifugal pump?
3. What are the main parts of a centrifugal pump?
4. What is the basic difference between a centrifugal and a reciprocating pump?
EXPERIMENT NO. 4  PELTON WHEEL TURBINE

4.1 Objective 4.2 Apparatus Required 4.3 Theory 4.4 Experimental setup 4.5 Technical Specification 4.5 Procedures 4.6 Observation Table 4.7 Calculation 4.8 Results & Discussions

4.1 Objective: To study the performance characteristics of a Pelton Wheel Turbine.

4.2 Apparatus Required: Pelton Wheel Turbine

4.3 Theory:
The Pelton Wheel Turbine is an impulse or a free jet or a constant pressure water turbine. This is the only choice when available water head is very high. It consists of a wheel called rotor. The rotor of the turbine consists of a circular disc with a number of double spoon shaped buckets evenly distributed over the periphery. The water is the supplied from the reservoir. One or more nozzles may supply to the wheel depending upon the power that can be developed as per the quantity of water available. In such type of Turbine available hydraulic energy of the water is converted in to the kinetic energy at atmospheric pressure by means of the nozzle. Each nozzle directs the jet along a tangent to the circle through the centers of the buckets. Each bucket consists of a splitter which divides the incoming jet in to two equal portions and after flowing round the smooth inner surface of the bucket the water leaves with a relative velocity almost opposite in direction to the original jet. The change in momentum of the water jet in passing over the buckets exerts tangential force on the wheel causing it to rotate. Thus converts the hydraulic energy in to the mechanical energy by means of the shaft rotation.

4.4 Experimental setup:
In the experimental setup the water is usually supplied the Turbine by means of a centrifugal pump. A Venturimeter and manometer measures the rate of the flow. The discharge of the water may be varied by changing the nozzle opening by means of spear wheel. The head on the turbine can be varied by the controlling the bypass valve. The speed of the turbine can be measured by the tachometer and power by the dynamometer. The rotor shaft of the wheel consists of the flywheel. The flywheel is wrapped by the belt. The two ends of the belt are connected to the lower end of the circular spring balance. The upper end of the spring balance is connected to the bolt. The load can be added to the flywheel by tightening the belt by means of tightening the bolt.
4.5 Technical Specification:

- 5 hp, 3 phase, Kirlosker make.
- Head Upton 38 m of water
- 7.4 l/s
- Suction line – 2.5”
- Discharge line 2”
- No. of buckets – 18
- Diameter of the rotor – 25 cm
- PCD of the buckets –
- Diameter of the jet - 2 cm
- Diameter of the pipe line – 2”
- Throat diameter – 3 cm

4.6 Procedure:

1. Check the tension of the belt (It should be loose)
2. Check the pointer of the circular spring balance (should be at zero)
3. Check the bypass valve, which should be fully open.
4. Turn on the MCB switch.
5. Check the 3 phases of the power supply by means of the indicators.
6. Turn on the starter. Pump is started and water is allowed to flow through the turbine.
7. Adjust the spear valve for a particular nozzle opening.
8. Adjust the bypass valve for the desired inlet water pressure.
9. Load the flywheel by tightening the bolt up to 0.5 kg.
10. Record the pressure reading, Manometer reading, speed readings of the circular spring balance.
11. Repeat the experiment for 1 kg, 1.5 kg & 2 kg load.
12. Repeat the experiment for three more spear valve settings.
4.7 Calculations:

Unit Speed \( (N_u) = \frac{N}{\sqrt{H}} \)

Unit Power \( (P_u) = \frac{P}{H^{3/2}} \)

Unit Discharge \( (Q_u) = \frac{Q}{\sqrt{H}} \)

Specific Speed \( (N_s) = \frac{N_u}{\sqrt{P_u}} \)

\[
BHP = \frac{2\pi r (W - S)N}{4500} =
\]

\[
WHP = \frac{\gamma QH}{75} =
\]

Overall Efficiency \( (\eta) = \frac{BHP}{WHP} \times 100 \)

\[
Discharge (Q) = \frac{C_d A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{\frac{2g}{h}}
\]

\[
H = H_m \times 12.6 \text{ (in m)}
\]

Effective water head \( (H) = H_1 + Z + \frac{V^2}{2g} \)

\( H_1 = \) Pressure water head

\( V = \frac{Q}{(\text{Cross sectional area of pipe})} \)

4.8 Observations:

- Specific weight of water \( (\gamma) = 1000 \text{ Kg/m}^3 \)
- Effective radius of the flywheel and belt = 0.11 m
- Diameter of the Pipe \( (d_1) = 0.05 \text{ m} \)
- Diameter of the Throat \( (d_2) = 0.03 \text{ m} \)
- Area of cross-section of the Pipe \( (A_1) = 0.00196349 \text{ m}^2 \)
- Area of cross-section of the Throat \( (A_2) = 0.00070685 \text{ m}^2 \)
- Distance between pressure gauge and the center line of turbine \( Z = 0.15 \text{ m} \)
- Water Head shown by pressure gauge = \( p \text{ (lbs)} \)
- \( (H_1) = 0.703 \times P \text{ (m of water)} \)
- Manometer reading \( (h_m) = \ldots \text{ m} \)
- Coefficient of discharge \( C_d \) = 0.91
- Applied load (higher side reading) (W) = ……………… kgf

### Observation Tables:

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Pressure water Head ( H_1 ) (m)</th>
<th>Load W (Kgf)</th>
<th>Load S (Kgf)</th>
<th>Manometer Reading ( h_m ) (m)</th>
<th>h (m)</th>
<th>Revolution R.P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Reading shown with the direction of the flywheel (S) = ……………… Kgf

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Effective Water Head ( H )</th>
<th>Discharge ( Q ) (m³/s)</th>
<th>BHP</th>
<th>WHP</th>
<th>Overall Efficiency ( \eta )</th>
<th>Unit Speed ( N_a )</th>
<th>Unit Power ( P_a )</th>
<th>Unit Discharge ( Q_a )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.9 Results and Discussions:

Plot the graph between

- Speed $V_s$ vs. Efficiency
- Speed $V_s$ vs. BHP
- BHP $V_s$ vs. Efficiency
- Efficiency $V_s$ vs. Unit speed
- Unit discharge $V_s$ vs. Unit speed

Discussions:

- Effect of mass of the flywheel over the performance.
- Effect of reducing the buckets from the rotor over the performance.

4.10 Precautions:

- Take one set of reading with one spear wheel position.
- After taking one set of reading release the tension of the belt and run the turbine at no load condition for at least five minutes.
- By pass valve should always fully open at the time of starting the pump.
- Before starting the pump check the manometer tapings.
- Tachometer should not touch with any moving part at the time of r.p.m. measurement.
- After experiment drain off the water from the tank.

Theoretical data (Standard Data):

$N_u=10-20; \quad P_u=1.5-3.0; \quad Q_u=0.18$
Specific speed = 15-60
Overall efficiency = 72-85 %

PELTON TURBINE
1. What is an impulse turbine?
2. What is the basic difference between an impulse and a reaction turbine?
3. What is the function of a spear in an impulse turbine?
4. What do you mean specific speed of a turbine?
5. Define Unit speed, Unit Power and unit discharge.

EXPERIMENT NO. 5   FRANCIS TURBINE

5.1 Objective 5.2 Apparatus Required 5.3 Theory 5.4 Experimental setup 5.5 Procedures 5.6 Observation Table & Calculation 5.7 Results & Discussions 5.8 Precaution

5.1 Objective: To study the characteristics of Francis Turbine to calculate the efficiency and to draw the following curves.
• Efficiency Vs Discharge
• BHP Vs Discharge

5.2 Apparatus Required: Francis Turbine

5.3 Theory:
The model Francis Turbine is an inward mixed flow reaction turbine i.e. the water under pressure enters the runner from the guide vanes towards the center in radial direction and discharge out of the runner axially. The Francis Turbine operates under medium head and also requires medium quality of water. A
part of the head acting on the turbine is transformed into kinetic energy and rest remains as pressure head. There is a difference of pressure between the guide vanes and the runner, which is called the reaction pressure and is responsible for the motion of the runner. That is why a Francis Turbine is also known as reaction turbine. In this turbine the pressure at the inlet is more than that at the outlet. This means that the water in the turbine must flow in a closed conduit, unlike the Pelton type where the water strikes only a few of the runner buckets at a time. In the Francis turbine the runner is always full of water. The movement of runner is affected by the change of both the kinetic and potential energies of water. After doing work the water is discharged to the tailrace through a closed tube of gradually enlarging section. This tube is known as draft tube. The free end of the draft tube is submerged deep in the tailrace water. Thus the entire water passage, right from the headrace up to the tailrace, totally enclosed.

5.4 Experimental setup:
The turbine is placed on a substantial concreted base. The supply pump set draws water from the main tank and supplies it to turbine. A venturimeter is mounted to measure the flow. A gate valve is provided just above the inlet of the turbine in relation to the guide vane setting. A set of guide vanes is provided around the periphery of the runner to control the load. The whole guide vane mechanism is being operated through a hand wheel by a suitable link mechanism.

Technical Specification:

A. FRANCIS TURBINE

1. Rated Supply head : 15 Meters
2. Discharge : 1500 LPM
3. Rated Speed : 1500 rpm
4. Power Output : 1 kW
5. Runway Speed : 2250 rpm
6. Runner Diameter : 160 mm
7. No. of guide vanes : 10
8. P.C.D. guide vanes : 230 mm
9. Brake Drum Diameter : 300 mm
10. Rope Brake Diameter : 15 mm
B. SUPPLY PUMP SET:

1. Rated Head : 19 m
2. Discharge : 1500 LPM
3. Normal Speed : 1440 rpm
4. Power Required : 7.5 HP
5. Size of Pump : 100 mm X 100 mm
6. Type : High Speed, Centrifugal, Single Suction volute
7. Impeller Diameter : 280 mm

C. FLOW MEASURING UNIT:

1. Inlet diameter of Orificemeter : 100 mm
2. Orificemeter area Ratio : 0.45
3. Orificemeter diameter : 67.08 mm
4. Pressure Gauge : 4” dial, 0-4 kgf/cm²
5. Meter constant for Orificemeter : K = 9.3873 X 10⁻³ (Q = kh)
   h = mm of Hg

5.5 Procedures:

1. Prime the pump and start it with closed gate valve.
2. Guide vanes in the turbine must be in closed position while starting the pump.
3. Now slowly open the gate valve and open the chock fitted to the pressure gauge and see that the pump develops the rated head.
4. If the develops the required head, slowly open the turbine guide vanes by rotating the hand wheel until the turbine attains the rated speed.
5. Load the turbine slowly and take the readings.

5.6 Observation Table & Calculation:

\[ WHP = \frac{\rho g Q H}{75} \]
Where \( \rho \) = Density of water = 1000 Kg/m\(^3\)
\( Q \) = Discharge (measured by orifice meter)
\( H \) = Supply head in m
\[
BHP = \frac{2\pi r (W - S)N}{4500}
\]
Where \( R \) = Effective radius of drum (0.165m)
\( W \) = Brake weight (kgf)
\( S \) = Spring balance reading (kgf)
\( N \) = R.P.M.

Overall Efficiency \( (\eta) \) = \( \frac{BHP}{WHP} \times 100 \)

Observation Table:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Supply Head ( H ) (m)</th>
<th>Gate Opening</th>
<th>Discharge ( Q ) (m(^3)/s)</th>
<th>WHP</th>
<th>Brake load ( W ) (kgf)</th>
<th>Spring reading ( S ) (kgf)</th>
<th>( N ) RPM</th>
<th>BHP</th>
<th>Efficiency ( \eta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>3/4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>fully</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.7 Results & Discussions:
Plot the graph between the following:
- Efficiency Vs Discharge
- BHP Vs Discharge

Discussions:
5.8 Precaution

- The main valve should be closed before starting the machine.
- Do not load the turbine suddenly. Loading should be done gradually and at the same time supply of water should be increased so that the run at normal speed.

Theoretical data (Standard Data):

Specific speed = 150-240
Overall efficiency = 80-85 %

FRANCIS TURBINE

1. Why the runner of a reaction turbine runs full?
2. What is the function of guide vanes in a reaction turbine?
3. What is the function of draft tube in a reaction turbine?
4. Explain the phenomenon of cavitations.
5. What is the surge tank? Where it is installed and why?
6. Explain the term ‘Degree of reaction?’

EXPERIMENT NO. 6 PELTON & FRANCIS TURBINE

6.1 Objective: To compare the performance characteristics of Pelton Turbine & Francis turbine.
6.2 Apparatus Required: Pelton Turbine & Francis turbine.
6.3 Theory:

The comparison is based upon the following characteristics curves.

(i) Main characteristics curves: These show variation of quantities Q, P and η with respect to speed, head and gate opening remaining constant throughout the variation.
(ii) **Operating characteristics curves**: In turbines if in addition to \( H \), speed is also maintained constant, and then we can plot discharge or Load, against power or efficiency to get operating characteristics.

(iii) **Constant efficiency curves**: Referring to \( n-\eta \) and \( n-Q \) curves we can say that since \( n-\eta \) curve is of parabolic nature, there exist low speed for one value of efficiency except for maximum efficiency which occurs at one speed only.

Corresponding to these values of speeds there are also two values of discharge for each value of efficiency. Hence on \( n-Q \) curves we can plot two points for each value of efficiency and one point for maximum efficiency. Now if these procedures are carried out for different gate opening or heads we can get number of \( n-Q \) curves and we can plot on them efficiency points as described now. The points denoting the same efficiencies can now be joined to get constant efficiency curves.

### 6.4 Observation Table:

#### Pelton Wheel

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Pressure Water Head ( H_1 ) (m)</th>
<th>Load ( W ) (kgf)</th>
<th>Load ( S ) (kgf)</th>
<th>Manometer Reading ( h_m ) (m)</th>
<th>( h ) (m)</th>
<th>Revolution ( rpm )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Effective Water Head ( H )</th>
<th>Discharge ( Q ) (m(^3)/s)</th>
<th>BHP</th>
<th>WHP</th>
<th>Overall Efficiency ( \eta )</th>
<th>Unit Speed ( N_u )</th>
<th>Unit Power ( P_u )</th>
<th>Unit Discharge ( Q_u )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Francis Turbine

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Supply Head ( H ) (m)</th>
<th>Gate Opening</th>
<th>Discharge ( Q ) (m(^3)/s)</th>
<th>BHP</th>
<th>Brake Load ( W ) (kgf)</th>
<th>Spring reading ( S ) (kgf)</th>
<th>( N ) (rpm)</th>
<th>BHP</th>
<th>Efficiency ( \eta )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Department of Mechanical Engineering

IIT Ghaziabad
6.5 Results & Discussions: Plot different characteristics curves and compare the results with the actual data.

Discussions:

6.6 Precaution:
- The main valve should be closed before starting the machine.
- Do not load the turbine suddenly. Loading should be done gradually and at the same time supply of water should be increased so that the run at normal speed.

EXPERIMENT NO. 7  RECIPROCATING PUMP

7.1 Objective: To obtain the efficiency of a reciprocating pump under different heads and plot Efficiency vs Head (Delivery) curve.

7.2 Apparatus Required: Pump, Pipe work system with all necessary control valves, collecting tank, and Pressure gauge located on suction and discharge side.

7.3 Theory: The reciprocating pump is a positive displacement pump, i.e., it operates on the principle of actual displacement or pushing of liquid by a piston or plunger that executes a reciprocating motion in a closely fitted cylinder. The liquid is alternately
  - Drawn from the sump and filled into suction side of the cylinder.
Led to the discharge side of the cylinder and emptied to the delivery pipe. The piston or plunger gets its reciprocating motion (moves backward & Forward) by means of the crank and connecting rod mechanism. In a double acting reciprocating pump suction and delivery strokes occur simultaneously. A pump gives comparatively a more uniform discharge than the single acting pump, because of the continuity of suction and delivery strokes.

Let Discharge pressure = P m
  Head = H m
  Flow rate = Q m³/s
  Input power = P watt
  Water power (P_o) = (ρgHQ) Watt
  Efficiency (η) = (P/P_o) x 100

7.4 Experimental Setup: The experimental setup consists of a double acting reciprocating pump on whose discharge side a pressure gauge is fitted for measurement of the delivery head. A digital wattmeter may be connected to the motor of the pump as the motor is directly connected to the pump. A collecting tank is used to find the actual discharge through the pump.

7.5 Procedures:
1. Note down the area of collecting tank.
2. Fill the reciprocating pump with the oil up to the level marked on the pointer.
3. Priming the pump before starting. Priming means taking the air present in the suction and pressure pipes.
4. Before starting ensure that the pump is free to rotate.
5. Flow regulating valve was adjusted to give the maximum possible discharge.
6. Conditions were allowed to steady before the rate of discharge Q, discharge head & load on the motor were recorded.
7. The flow rate is reduced in stages and the above procedure is repeated.

7.6 Observation: __
Efficiency of Motor = 75%
Area of collecting tank A = 1600 cm²

Observation Table:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Discharge measurement</th>
<th>Delivery Head</th>
<th>Water Power</th>
<th>Input Power</th>
<th>Efficiency (η) %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial h₁ (cm)</td>
<td>Final h₂ (cm)</td>
<td>Time (S)</td>
<td>Discharge Q (m³/s)</td>
<td>H (m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.7 Results & Discussions:

Plot the Efficiency Vs Head (Delivery) curve.

Discussions:

7.8 Precaution:

1. Operate all the controls gently
2. Never allow to rise the discharge pressure above 4 kg/cm²
3. Always use clean water for experiment
4. Before starting the pump ensure that discharge valve is opened fully

Theoretical data (Standard Data): Overall efficiency =50-65% 

7.9 Viva Voce Questions

1. Why a reciprocating pump is called positive displacement pump?
2. What is negative slip in case of reciprocating pump?
3. What do you understand by single acting and double acting pump?
4. What is the function of air vessel in a reciprocating pump?
5. What does the indicator diagram of a reciprocating pump represent?
EXPERIMENT NO. 8  CLOSED CIRCUIT RECIPROCATING PUMP

8.1 Objective 8.2 Apparatus Required 8.3 Experimental Setup 8.4 Procedures  8.5 Observation Table & Calculation 8.6 Results & Discussions 8.7 Precaution

8.1 Objective: To determine the efficiency of closed circuit reciprocating pump Test Rig.

8.2 Apparatus Required: Closed Circuit Reciprocating Pump Test Rig.

8.3 Experimental Setup:

The Experimental Reciprocating pump test Rig is design to study the performance of the multi speed reciprocating pump at multi speeds. This unit has several advantages like does not require any foundation, trench keeping in the laboratory.

The Reciprocating pump test rig mainly consists of,

2) A Reciprocating pump double acting type.

3) A single phase 1.0HP 1420 RPM AC Motor

4) A stepped pulley speed change arrangement
5) Piping system & collecting tank and
6) Input power Measuring arrangement and
7) Sump.

Technical Specification:

- Motor (AC 50 Hz, 220/230 V): Single Phase 1.0 HP, 1420 rpm
- Reciprocating Pump: Double Acting Type
  - Speed: 200, 250 and 300 rpm
  - Suction & Delivery Size: 1” X ¾”
  - Bore: 40 mm
  - Stroke: 45 mm
- Area of Measuring Tank: 250 mm X 250 mm

8.4 Procedures:

Start the pump and run it at a constant speed and the hand head may be tried, say from 10 meters to 3 meters. The discharge will be more or less than the total head on the pump 6 to 8 readings can be taken within this head range. Then the speed say be varied by changing the V belt to another groove in the motor pulley and in counter shaft pulley. The above procedure can be repeated and the pump tested the different speeds.

8.5 Observation Table & Calculation:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Pressure Gauge reading (Kg/cm²)</th>
<th>Vacuum Gauge Reading (mm of hg)</th>
<th>Difference in gauge levels 0.3m.</th>
<th>Total Head H</th>
<th>Time in sec for raise of water level (cm)</th>
<th>Discharge in (m³/s)</th>
<th>Time for 3 rev. of energy meter disc (sec)</th>
<th>Input power (kW)</th>
<th>Output Power (kW)</th>
<th>Overall Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Department of Mechanical Engineering
IIT Ghaziabad
Sample Calculation:

1. \[ \text{Efficiency} \, (\eta) = \frac{\text{Output Power}}{\text{Input Power}} = \ldots \]

2. \[ \text{Output Power} = \rho \, gHQ \, \text{Watt} = \ldots \]

3. \[ \text{Pressure gauge reading in m} + \text{Vacuum gauge reading in m} + \text{datum head (0.3 m)} = P \times 10 + \frac{V}{1000} (13.6-1) + 0.3 = \ldots \]
   Where \( V \) = Vacuum pressure gauge
   \( P \) = Pressure gauge

4. \[ \text{Discharge} \, Q = A \times \frac{h}{T} = \ldots \]
   Where \( A \) = Area of the measuring tank in meters
   \( h \) = Rise of water level (say 10 cm) in meters
   \( T \) = time in seconds for rise of water level

5. \[ \text{Input Power} = \frac{X}{t} \times 3600 \times \frac{1}{C} \times 0.8 \, \text{kW} = \ldots \]
   Where \( X \) = No. of revolutions of energy meter disc (say 3 rev)
   \( T \) = Time for Energy meter revolution disc (say 3 rev)
   \( C \) = Energy meter constant
   0.8 = Efficiency of the motor

8.6 Results & Discussions:

The efficiency of Reciprocating pump is \( \eta_o = \ldots \)

The following graph can be drawn:
- Head \( V \), Discharge
- Head \( V \), Power output
- Head \( V \), Overall efficiency

Discussions:
8.7 Precautions:

- Never run the pump without water in it, as this would cause damage to stuffing box, bush bearing etc.
- Never try to throttle the suction side of the valve to control discharge, as it would seriously affect the performance of the pump.

Theoretical data (Standard Data):

Overall efficiency = 65-75%

8.9 Viva Voce Questions:

1. Why a reciprocating pump is called positive displacement pump?
2. What is negative slip in case of reciprocating pump?
3. What do you understand by single acting and double acting pump?
4. What is the function of air vessel in a reciprocating pump?
5. What does the indicator diagram of a reciprocating pump represent?

EXPERIMENT NO. 9  GEAR OIL PUMP

9.1 Objective

9.2 Apparatus Required

9.3 Experimental Setup

9.4 Procedures

9.5 Observation Table & Calculation

9.6 Results & Discussions

9.7 Precaution

9.1 Objective: To determine the efficiency of closed circuit Gear Oil Pump test rig.

9.2 Apparatus Required: Gear Oil Pump test Rig.

9.3 Experimental Setup:

The experimental Gear Oil Pump test Rig. is design to study the performance of the Gear Oil pump at a particular speed. The performance characteristic between –

(1) Head  (2) Discharge  (3) power and  (4) Efficiency can be studied with the help of this unit. This unit has several like does not require foundation, trench work and can keep anywhere in the laboratory.

Gear Oil Pump Test Rig consists of mainly

(1) A gear oil pump  (2) A motor  (3) Reservoir tank  (4) Piping system
9.4 Procedures:

Start the pump and run it at a particular ‘head’ on it. This can be adjusted with the help of the delivery valve provided. The pressure gauge reading has to be noted to find out the total head on the pump.

The discharge can be calculated from the reading taken from the measuring tank. The input power is measured with the help of the energy meter supplied.

At the normal working speed the total head on the pump may be varied up to a maximum of 5kg/sq.cm. The Discharge will be slightly decreased as the working pressure increase on the pump as a result of the leakage pastes the rotor. The required number of readings can be taken within the head range.

9.5 Observation Table & Calculation:

Efficiency of the motor = 0.8

<table>
<thead>
<tr>
<th>S.No.</th>
<th>(Kg/cm²)Gauge reading Pressure</th>
<th>(mm of hg)Reading Vacuum Gauge</th>
<th>Difference in gauge levels 0.3m.</th>
<th>HHeadTotal</th>
<th>Discharge in (m³/s)</th>
<th>Time for 3 rev. of energy meter dial (sec)</th>
<th>Power (kw)Input</th>
<th>Power (kw)Output</th>
<th>Efficiency Overall</th>
</tr>
</thead>
</table>
Important Formulas:

1. Efficiency (\(\eta\)) = \(\frac{Output \ Power}{Input \ Power}\) = .........................

2. Output = 9.81 x HQ kW = .......................

3. Pressure gauge reading in m + Vacuum gauge reading in m + datum head (0.3m) = P x 10 + V/1000 (13.6-1) + 0.3 = .....................

   Where V = Vacuum pressure gauge
   P = pressure gauge

4. Discharge Q = A x h/T = .........................

   Where A = Area of the measuring tank in meters
   h = Rise of water level (say 10 cm) in meters
   T = time in seconds for rise of water level (say 10 cm)

5. Input = X/t x 3600 x 1/C x 0.8 kW = .........................

   Where X = No. of revolutions of energy meter disc (say 3 rev)
   T = Time for Energy meter revolution disc (say 3 rev)
   C = Energy meter constant
   0.8 = Efficiency of the motor

9.6 Results & Discussions:

   The following graphs can be drawn:
   a) Discharge \(V_s\), Total head
   b) Discharge \(V_s\), Power input
   c) Discharge \(V_s\), Efficiency

Discussions:
9.7 Precaution:

- Never run the pump without liquid in it, as this would cause damage to stuffing box, bush bearing etc.
- Never try to throttle the suction side of the pump to control discharge, as it would seriously affect the performance of the pump.

GEAR OIL PUMP

1. Which types of gears are used in gear oil pump?
2. What is the application of gear oil pump?
EXPERIMENT NO. 10  HYDRAULIC RAM

10.1 Objective: To study the operation & determine the efficiency of the Hydraulic Ram.

10.2 Apparatus Required: Hydraulic Ram.

10.3 Theory:

The Hydraulic Ram is a contrivance utilizing the water hammer principle. Ram is used when a natural source of water like a spring or steam at low head is available at a nearby place to pump a part of water to higher heads. The ram requires no external energy. The work done by a large quantity of water in falling through a small height is used to raise a small part of water to a greater height.

A quantity of water is first allowed to pass through a long column of pipe connected to the Hydraulic Ram and discharge a waste valve. The momentum of the water flowing through the pipe is then suddenly destroyed by the automatic closing of the waste valve which pumps a small quantity of water to high head tank. When the moving column of water is brought to rest, the waste valve opens and the cycle is repeated automatically.

The efficiency of Hydraulic Ram can be determined by following formulae:

1. D’ Aubuisson’s Efficiency

\[ \eta_A = \frac{q \times h_d}{(q + Q)\bar{h}_2} \]

2. Rankine’s Efficiency

\[ \eta_R = \frac{q \times h_d}{Q \times h_s} \]

Where:
- \( q \) = Discharge of water lifted up
- \( Q \) = Discharge of waste water
- \( h_d \) = Delivery Head of Ram
- \( h_s \) = Head of water supply to Ram

The Hydraulic Rams are most widely used in hilly regions where natural water steams are available. It requires no external energy and the running and maintenance expenditure is practically nil.
10.4 Experimental Setup:

The experimental setup consists of a Hydraulic ram having a cylindrical air vessel connected to a small rectangular chamber through a non returning valve. A waste valve is also provided in the rectangular chamber to discharge the excessive water to the collecting tank. The chamber is connected to an elevated supply tank. A delivery pipe is connected to the foot of air chamber to deliver the water to collecting tank to measure the discharge delivered by the Ram.

10.5 Procedure:

1. Clean the apparatus and make all tanks free from dust.
2. Close all the drain valves provided.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Close all control valves provided.
5. Ensure that all ON/OFF switches given on the panel are at OFF position.
6. Now switch on the main power supply (220V AC, 50 Hz)
7. Switch ON the pump.
8. Fill overhead tank with water.
9. Adjust the Ram stroke at minimum.
10. When overhead tank overflows, open control valve of Ram.
11. Now Ram is in operation.
12. Adjust stroke of am to vary the head developed by the Ram.
13. Open slightly the control valve provided at useful water discharge line of air vessel.
14. Record Pressure gauge reading in air vessel.
15. Measure flow rate of useful water and waste water discharged by the Ram using stop watch and measuring tank.
16. Repeat experiment at different flow rates of useful water discharged by the Ram by regulating the control valve provided at useful water discharge line of air vessel.
10.6 Observation & Calculation:

\( H_d \) = Delivery head of Ram = 10 m  
\( H_s \) = Supply head = 1.4 m  

**Useful Water**

\( A = \) Area of measuring tank for Useful water  
Diameter = 100 mm = 0.1 m  
\( R = \) Rise in water level in measuring tank of waste water  
\( = h_2 - h_1 \)  
\( t = \) Time taken = 15 sec

**Waste Water**

\( H = h_2 - h_1 \)  
\( \theta = 60^0 \)

### Observation Table

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Useful Water Tank</th>
<th>Waste Water Tank</th>
<th>Pressure kg/cm²</th>
<th>No. of beats per min.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Level cm</td>
<td>Final Level cm</td>
<td>Time T sec</td>
<td>Rise in Water R</td>
</tr>
</tbody>
</table>

### Sample Calculation:

1. D’ Aubuisson’s Efficiency

\[ \eta_A = \frac{q \times h_d}{(q+Q)h_z} \]

2. Rankine’s Efficiency

\[ \eta_R = \frac{q \times h_d}{Q \times h_s} \]
3. Discharge of Useful Water

\[ Q = \frac{R \times A}{t} \]

4. Discharge of Waste Water

\[ Q = \frac{8}{15} \sqrt{2g} \frac{H^{5/2}}{\tan^2 \theta} \]

Where \( \theta = 60^\circ \)

\[ H = h_2 - h_1 \quad \text{(Pointer Gauge difference)} \]

### Calculation Table

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Discharge of Waste Water (Q) m³/sec</th>
<th>Discharge of Useful Water (q) m³/sec</th>
<th>Delivery Head (h_d) m</th>
<th>Efficiency ( \eta_A ) %</th>
<th>Efficiency ( \eta_R ) %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 10.7 Results & Discussions:

### 10.8 Precaution:
- Do not run the pump at low voltage i.e. less than 180 volts.
- Never fully close the delivery line and by pass line valves simultaneously.
- Always keep apparatus free from dust.
- To prevent clogging of moving part, run pump at least once in a fortnight.
- Frequently grease/oil the rotating parts, once in three months.
- Always use clean water.
10.9 **Viva Voce Questions:**

1. The hydraulic ram is a pump which raises water without any external power. Justify this statement.

2. On which principle hydraulic ram works?

3. What is the purpose of air vessel in hydraulic ram?

4. What is the difference between centrifugal pump and hydraulic ram?
EXPERIMENT NO. 11  HYDRAULIC PRESS

11.1 Objective: Study of the hydraulic press.

11.2 Apparatus Required: Hydraulic Press and specimen.

11.3 Theory:

The hydraulic pressure is a device used for pressing anything by the application of much smaller force. It is based on Pascal’s Law, which states that the intensity of pressure in a static fluid is transmitted equally in all direction.

The hydraulic press consists of two cylinders of different diameter. One of the cylinder is of large diameter and contains a ram, while the other cylinder is of smaller diameter and contains a plunger. The two cylinders are connected by a pipe. The cylinders and pipe contain a liquid through which pressure is transmitted.

When a small force is applied on the plunger, a pressure is produced on the liquid in contact with the plunger. This pressure is transmitted equally in all directions and acts on the ram. The specimen placed below the ram is then pressed.

Let $A =$ area of ram,

$p =$ pressure intensity produced by the plunger at ram

Net force available at ram for pressing the specimen $F = p \times A$

11.4 Procedure:

11.5 Results & Discussions:
11.6 Viva Voce Questions:
1. On which principle hydraulic press works?
2. How many cylinders are there in hydraulic press?
3. Why two cylinders of different diameters are used in hydraulic press?
12.1 Objective: Study of the Hydraulic Jack.

12.2 Apparatus Required: Hydraulic Jack and weight/load.

12.3 Theory:

Hydraulic Jack is used to lift the loads from one level to another. A hydraulic jack consists essentially of a ram and cylinder arrangement with a cage or platform fitted to the top of the end of ram. When fluid under pressure is forced into the cylinder, the ram gets a push vertically upwards. The platform carries the loads moves.

12.4 Specification:

- Capacity : 10 Ton
- Heat-treated extension screw

12.5 Procedure:

a. Keep the jack below the load which has to lift.

b. Push up and down the handle, so that the load is lifted as per desire.

c. To bring down the load, open the release valve.

12.6 Safety instructions:

- Never exceed the jack’s rated load capacity.
- Base of jack should always rest on a firm, lever surface.
- Never work under the lift load without additional support means.
• Never operate jack in angular or horizontal position.
• The contact between the top and the lifted body must be perfect.
• When several jacks are used together. The raising speed should be coincident with each other and the duty of each should be balanced otherwise the danger of toppling over will happen.
• Secure the vehicle against running away.
• Apply the jack at the points indicated by the vehicle manufacturer.
• Apply the jack in such a way that it is not necessary to reach under the vehicles in order to operate the jack.
• The adjustment of the pressure relief valve is set by factory the user do not a dust it.

12.7 Results & Discussions:

12.8 Viva Voce Questions:
1. On which principle hydraulic press works?
2. How many cylinders are there in hydraulic press?
3. Why two cylinders of different diameters are used in hydraulic press?
EXPERIMENT NO. 13 VISIT OF A PUMPING STATION

13.1 Objective 13.2 Observation 13.3 Results & Discussions

13.1 Objective: To visit and study of a pumping station.

13.2 Observation:

1. Total number of pumps.
2. Number of reciprocating pumps.
3. Number of centrifugal pumps.

A. Reciprocating Pumps

1. Essential data for the selection of reciprocating pumps.
   (a) Availability of space, size and position of location
   (b) Properties of flowing liquid viscosity, temperature.
   (c) Specification of reciprocating pumps.
   (d) Capacity of each pump.
   (e) Pressure of liquid being handled.
   (f) Speed of rotation.
   (g) Power required
   (h) Diameter of piston
   (i) Stroke length of piston
   (j) Diameter of suction pipe
   (k) Diameter of delivery pipe.
   (l) Suction and delivery head.
   (m) Makes of pumps

2. Calculation of output power and efficiency of pump.

B. Centrifugal Pumps

1. Essential data for the selection of centrifugal pump
   (a) Make of pump
   (b) Availability of space, size and position of location
   © Properties of liquid being handled
   (d) Capacity of liquid being handled
   (e) Specification of centrifugal pump.
   (f) Shape and type of casing
   (g) Type of impeller
(h) Number of vanes
(i) Working head
(j) Number of stages
(k) Whether one sided or two sided suction
(l) Shaft position
(m) Vane shape
(n) Suction and delivery head
(o) Power consumption

2. Calculation of output and efficiency of pump

C. Application of each pump

13.3 Results & Discussions:
## Appendix-A

### TABLE NO: 1 Physical Properties of Water

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Density ρ kg/m³</th>
<th>Sp. Weight γ kN/m³</th>
<th>Dynamic Viscosity µ N-s/m²</th>
<th>Kinematic Viscosity ν m²/s</th>
<th>Surface Tension σ N/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>999.8</td>
<td>9.805</td>
<td>1.785 x 10⁻³</td>
<td>1.785 x 10⁻⁶</td>
<td>0.0756</td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
<td>9.807</td>
<td>1.518 x 10⁻³</td>
<td>1.519 x 10⁻⁶</td>
<td>0.0749</td>
</tr>
<tr>
<td>10</td>
<td>999.7</td>
<td>9.804</td>
<td>1.307 x 10⁻³</td>
<td>1.306 x 10⁻⁶</td>
<td>0.0742</td>
</tr>
<tr>
<td>15</td>
<td>999.1</td>
<td>9.798</td>
<td>1.139 x 10⁻³</td>
<td>1.139 x 10⁻⁶</td>
<td>0.0735</td>
</tr>
<tr>
<td>20</td>
<td>998.2</td>
<td>9.789</td>
<td>1.002 x 10⁻³</td>
<td>1.003 x 10⁻⁶</td>
<td>0.0728</td>
</tr>
<tr>
<td>25</td>
<td>997.0</td>
<td>9.777</td>
<td>0.890 x 10⁻³</td>
<td>0.893 x 10⁻⁶</td>
<td>0.0720</td>
</tr>
<tr>
<td>30</td>
<td>995.7</td>
<td>9.764</td>
<td>0.798 x 10⁻³</td>
<td>0.800 x 10⁻⁶</td>
<td>0.0712</td>
</tr>
<tr>
<td>40</td>
<td>992.2</td>
<td>9.730</td>
<td>0.653 x 10⁻³</td>
<td>0.658 x 10⁻⁶</td>
<td>0.0696</td>
</tr>
<tr>
<td>50</td>
<td>988.0</td>
<td>9.689</td>
<td>0.547 x 10⁻³</td>
<td>0.553 x 10⁻⁶</td>
<td>0.0679</td>
</tr>
<tr>
<td>60</td>
<td>983.2</td>
<td>9.642</td>
<td>0.446 x 10⁻³</td>
<td>0.474 x 10⁻⁶</td>
<td>0.0662</td>
</tr>
</tbody>
</table>

### TABLE NO: 2 Physical Properties of air at atmospheric pressure

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Density ρ kg/m³</th>
<th>Sp. Weight γ N/m³</th>
<th>Dynamic Viscosity µ N-s/m²</th>
<th>Kinematic Viscosity ν m²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>1.395</td>
<td>13.68</td>
<td>1.61 x 10⁻⁵</td>
<td>1.15 x 10⁻⁵</td>
</tr>
<tr>
<td>0</td>
<td>1.293</td>
<td>12.68</td>
<td>1.71 x 10⁻⁵</td>
<td>1.32 x 10⁻⁵</td>
</tr>
<tr>
<td>10</td>
<td>1.248</td>
<td>12.24</td>
<td>1.76 x 10⁻⁵</td>
<td>1.41 x 10⁻⁵</td>
</tr>
<tr>
<td>20</td>
<td>1.205</td>
<td>11.82</td>
<td>1.81 x 10⁻⁵</td>
<td>1.50 x 10⁻⁵</td>
</tr>
<tr>
<td>30</td>
<td>1.165</td>
<td>11.43</td>
<td>1.86 x 10⁻⁵</td>
<td>1.60 x 10⁻⁵</td>
</tr>
<tr>
<td>40</td>
<td>1.128</td>
<td>11.06</td>
<td>1.90 x 10⁻⁵</td>
<td>1.68 x 10⁻⁵</td>
</tr>
<tr>
<td>60</td>
<td>1.060</td>
<td>10.40</td>
<td>2.00 x 10⁻⁵</td>
<td>1.87 x 10⁻⁵</td>
</tr>
</tbody>
</table>
### TABLE NO: 3 Physical Properties of Common Liquids at 20 °C

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Density’ ρ’ kg/m³</th>
<th>Specific Weight kN/m³</th>
<th>Specific Gravity</th>
<th>Dynamic Viscosity N-s/m² x 10⁻³</th>
<th>Kinematics Viscosity m²/s x 10⁻⁶</th>
<th>Surface Tension N/m x 10⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene</td>
<td>804.0</td>
<td>7.89</td>
<td>0.804</td>
<td>1.914</td>
<td>2.381</td>
<td>27.73</td>
</tr>
<tr>
<td>Mercury</td>
<td>13555.0</td>
<td>132.97</td>
<td>13.555</td>
<td>1.555</td>
<td>0.11471</td>
<td>513.7</td>
</tr>
<tr>
<td>SAE-10 Oil</td>
<td>917.4</td>
<td>9.00</td>
<td>0.917</td>
<td>81.34</td>
<td>88.664</td>
<td>36.49</td>
</tr>
<tr>
<td>SAE-30 Oil</td>
<td>917.4</td>
<td>9.00</td>
<td>0.917</td>
<td>440.2</td>
<td>479.834</td>
<td>35.03</td>
</tr>
<tr>
<td>Benzene</td>
<td>881.3</td>
<td>8.65</td>
<td>0.881</td>
<td>0.651</td>
<td>0.739</td>
<td>28.90</td>
</tr>
<tr>
<td>Gasoline</td>
<td>680.3</td>
<td>6.67</td>
<td>0.680</td>
<td>0.292</td>
<td>0.429</td>
<td>---</td>
</tr>
</tbody>
</table>

### CONVERSION FACTORS

1 kgf = 9.81 N

Atmospheric Pressure = 1.01325 bar = 1.01325 x 10⁵ Pascal

760 mm of Hg = 10.33 meters of Water

1 kgf/cm² = 10 meters of water

1 Poise = 0.1 N-s/m²

1 Stoke = 10⁻⁴ m²/s

1 Metric HP = 75 kgf-m/s = 746 W

1 Bar = 10⁵ Pascal

1 m³ = 1000 L