BASIC CIVIL AND MECHANICAL ENGINEERING

UNIT IV – PUMPS AND TURBINES

PART A

1. What is a pump? State its application.

Pump is a device that is used to raise or transfer the fluids (liquids, slurries and gases). It is also used to maintain constant flow rate or constant pressure. The various applications of a pump are treatment of sewage, irrigation. Medical industries and chemical industries use pumps for transfer of fluids.

2. What are the various classifications of pumps?

Pumps are mainly classified into positive displacement pumps and rotodynamic pumps.

In positive displacement pumps the fluid is drawn or forced into a finite space and then sealed by mechanical means. Then the fluid is forced out to a higher level.

Example: Reciprocating pump

In rotodynamic pumps there is a free passage between the inlet and outlet without any intermittent sealing.

Example: Centrifugal pump

3. Write short notes on priming.

Priming is a process used to drive out the air occupied in the casing by filling it with water. Before starting the centrifugal pump, priming is performed. Priming means filling suction pipe and casing with water. When the pump is switched on the pump, sends away the water filled in the casing and the suction is created.

4. What are the types of reciprocating pump?

Reciprocating pumps are classified into single acting reciprocating pump and double acting reciprocating pump.

5. What are the advantages of a reciprocating pump?

(i) It is compact in design.
(ii) High viscosity performance.
(iii) It handles high differential pressure

6. Differentiate between single acting reciprocating pump and double acting reciprocating pump.

S. No.	Single acting reciprocating pump	Double acting reciprocating pump
1.	Fluid is pumped during delivery stroke of the piston	Fluid is delivered during forward and return stroke of the piston
2.	Volume of fluid pumped is low.	High volume of fluid can be pumped
3.	Idle stroke is present	No idle stroke
4.	Less efficient interms of volume of flow	Highly efficient interms of volume of flow
5.	Weight is less	Weight is more when compared to single acting reciprocating pump
6.	Less initial cost	High initial cost
7.	Maintenance cost is less	High maintenance cost

7. What are the various applications of a centrifugal pump?

(i) It is used in drainage
(ii) It is used in marine applications.
(iii) It is used for irrigation in agriculture
(iv) It is used for large discharges and high heads.

8. What are the advantages of a centrifugal pump?

(i) It is reliable
(ii) It runs smoothly.
(iii) Discharge of fluid from centrifugal pump is smooth and continuous.
(iv) It is very compact and easy to use.

9. Differentiate between centrifugal pump and reciprocating pump.

S. No.	Reciprocating pump	Centrifugal pump
1.	It is heavy	Compact in design and it is light
2.	Discharge is not smooth	Discharge is smooth
3.	Less efficient in low heads	Highly efficient in low heads
4.	Discharge is less	Discharge is more
5.	Used for high heads	Used for low heads
6.	Maintenance cost is high	Less maintenance cost

10. Write short notes on multistage centrifugal pumps.

A centrifugal pump having more than one impellers is known as a multistage centrifugal pump. Multistage centrifugal pumps are used for high head and large quantity of discharge.

For high head of discharge, the impellers are mounted on the same shaft. (*Pump in series*)

For high discharge, the impellers are mounted on different shafts. (*Pumps in parallel*).

11. What is the purpose of a foot valve?

Foot valve is a one way non return valve fitted with a strainer, to prevent the foreign matter to enter into the pump. The pumping should be stopped when water level is just above the foot valve, otherwise air particles will enter the suction pipe causing air locking.

12. Write short notes on a turbine.

Turbine is also known as a **prime mover**, as it drives the generator in a power plant. It is a rotary engine, which is being driven by pressurized fluid, steam with high energy content or gas. The working fluid possesses pressure energy and kinetic energy. The turbine converts potential and kinetic energy of working fluid into mechanical energy.

13. Write short notes on gas turbines.

Gas turbines are used for power generation and also in jet engines in an aircraft and in turbochargers of internal combustion engines. Gas turbines have the flexibility of using any type of fuel such as liquid or gaseous fuel.

14. Write short notes on steam turbines.

It is a device which converts the pressure energy of steam into kinetic energy. The kinetic energy is then converted into mechanical energy. The major parts of a steam turbine are fixed nozzle, rotor, fixed and moving blades, casing etc.

15. What are the advantages of steam turbine?

(i) It is reliable
(ii) Requirement of floor space is less
(iii) Maintenance cost is low.
(iv) Consumption of lubricating oil is less

16. How turbines are classified? Give examples for each.

Turbines are mainly classified into impulse turbine and reaction turbine. Example for impulse turbine is Pelton wheel. Examples for reaction turbine are Kaplan turbine and Francis turbine.

17. Write short notes on impulse turbine.

- The steam coming out at a very high velocity through the nozzle impinges on the blades fixed on the periphery of rotor.
- The blades change the direction of steam flow without change in pressure.
- The resulting force causes the rotation of the turbine.

E.g Pelton wheel.

18. Write short notes on reaction turbine.

- The high pressure steam from the boiler is passed through the nozzles.
- When the steam comes out through these nozzles, the velocity of steam increases relative to the rotating disc.
- The resulting force of steam on nozzle gives the rotating motion to the disc and the shaft.
- The shaft rotates in opposite direction of the steam.

E.g Francis Turbine, Kaplan Turbine.

19. What are the various losses occur in a centrifugal pump?

Mechanical Losses

- Losses due to disc friction between the impeller and the liquid which fills the clearance spaces between the impeller and casing
- Losses pertaining to friction of the main bearing and glands.

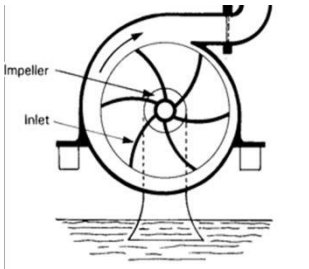
Hydraulic Losses:

- Shock or eddy losses at the entrance to and exit from the impeller
- Losses due to friction in the impeller
- Friction and eddy losses in the guide vanes/diffuser and casing

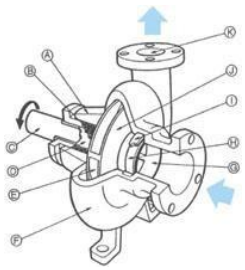
20. Differentiate between impulse and reaction turbine.

S.No.	Impulse turbine	Reaction turbine
1	It consists of nozzles and moving blades	It consists of fixed blades which act as nozzles and moving blades
2	Steam is expanded completely in the nozzle. All the pressure energy is converted into kinetic energy	Steam is partially expanded in the fixed blades. Some amount of pressure energy is converted into kinetic energy
3	Pressure of steam is constant over the moving blades.	Pressure drop takes place in the moving blades.
4	Because of high pressure drop in the nozzles, blade speed and steam speed are high.	Because of small pressure drop, blade speed and steam speed are less.
5	Low Efficiency	High Efficiency
6	Occupies less space per unit power	Occupies more space per unit power
7	Suitable for small power requirements	Suitable for medium and high power requirements.

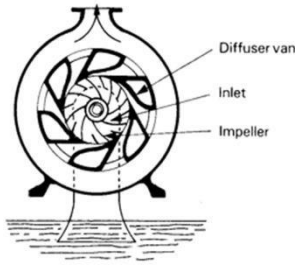
21. What are the various types of casing in centrifugal pump?



Volute casing



Vortex casing



Diffuser casing

Volute Casing: In this type of casing the area of flow gradually increases from the impeller outlet to the delivery pipe.

Vortex Casing: If a circular chamber is provided between the impeller and volute chamber the casing is known as Vortex Chamber.

Diffuser Casing :

- The impeller is surrounded by a diffuser.
- The guide vanes are designed in such a way that the water from the impeller enters the guide vanes without shock.
- It reduces the vibration of the pump.
- Diffuser casing, the diffuser and the outer casing are stationery parts.

22. Write short notes on priming.

- The operation of filling the suction pipe, casing and a portion of delivery pipe with the liquid to be raised, before starting the pump is known as Priming
- It is done to remove any air, gas or vapour from these parts of pump.
- If a Centrifugal pump is not primed before starting air pockets inside impeller may give rise to vortices and causes discontinuity of flow

23. Write short notes on air vessels.

Air vessel is a closed chamber containing compressed air in the upper part and liquid being pumped in the lower part.

Purpose of air vessel :

- To get continuous supply of liquid at a uniform rate.
- To save the power required to drive the pump (By using an air vessel the acceleration and friction heads are considerably reduced)
- To run the pump at much higher speed without any danger of separation

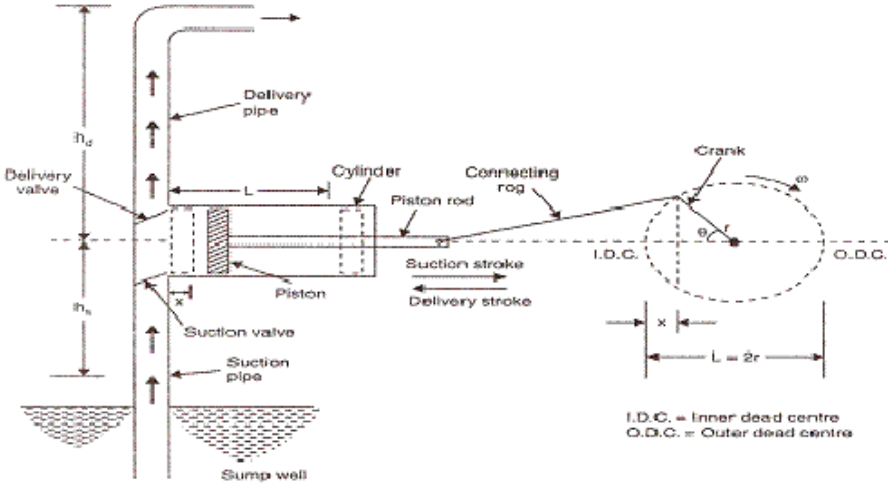
24. Write short notes on cavitation.

When a liquid is subjected to a pressure lower than its vapour pressure, its boils. Hence, vapour bubbles are produced. These bubbles close violently when subjected to high pressure. If the collapse of bubbles is near to a solid surface, then difference in localasied pressures, noise and vibrations are produced. This corrodes the metal where it occurs. This is known as cavitation.

PART B

1. With a neat sketch, explain the construction and working principle of single acting reciprocating pump. State its merits and demerits.

A single acting reciprocating pump consists of a piston, connecting rod, suction and delivery valves.



h_s – Suction head

h_d – Delivery head

Working of Single acting reciprocating pump:

- During suction stroke the piston moves to the right, causing the suction valve to open.
- Water is admitted into the cylinder through the suction valve.
- During the discharge stroke the piston moves to the left, closes the suction valve and opens the delivery valve.
- Through the delivery valve the volume of liquid moves out of the cylinder.

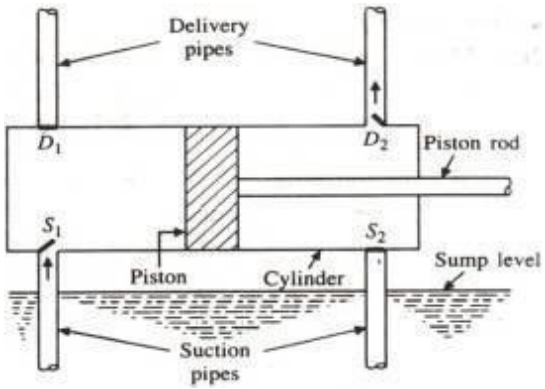
Merits :

- Reciprocating pumps have a wide pressure range, can reach high pressures and the pressure can be controlled without an impact on the rate of flow.
- Reciprocating pumps have a continuous rate of discharge.
- Reciprocating pumps can maneuver viscous fluids, high gas volumes and solids, only if the valves are correctly designed.

Demerits :

- Reciprocating pumps cost more per unit to run compared to centrifugal and roller pumps.
- The mechanical parts are prone to wear, so the maintenance costs can be high.
- The valves must be resistant to abrasives for large solids to pass through.
- Reciprocating pumps are heavy due to their large size and the weight of the crankshaft that drives the pump.

2. With a neat sketch, explain the construction and working principle of a double acting reciprocating pump.



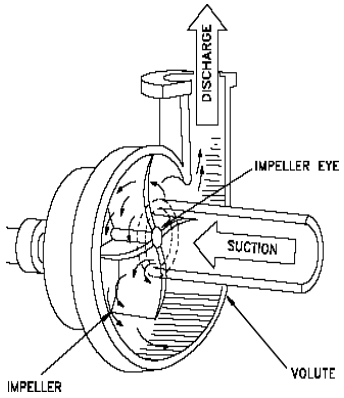
Construction :

A double acting reciprocating pump consists of a piston, connecting rod and crank. It also consists two suction valves and two delivery valves.

Working :

- When the piston moves towards left, the suction valve S_2 opens and water is being sucked into the cylinder. Hence suction takes place on the right side of piston.
- On the other side, the delivery valve D_1 opens and the quantity of water taken during the previous stroke is discharged. Delivery takes place on the left side of piston.
- When the piston moves towards right, the suction valve S_1 opens and water is taken into the cylinder. Hence suction takes place on the left side of piston.
- On the other side, the delivery valve D_2 opens the quantity of water taken during the previous stroke is discharged. Delivery takes place on the right side of piston.

3. With a neat sketch, explain the construction and working principle of a centrifugal pump.



Construction: It consists of a rotating component comprising of an impeller and a shaft and also a stationery component comprising a volute (casing), suction and delivery pipe.

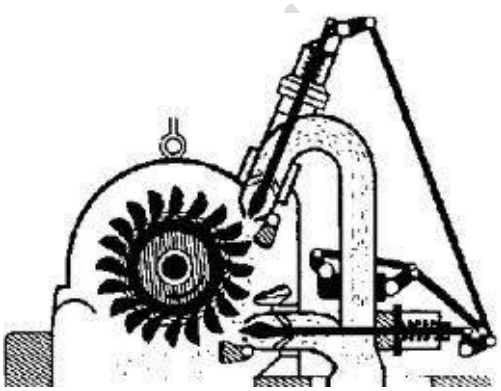
Principle: When a certain mass of fluid is rotated by an external source, it is thrown away from the central axis of rotation and a centrifugal head is impressed which enables it to rise to a higher level

Working

- The delivery valve is closed and the pump is primed, so that no air pocket is left.
- Keeping the delivery valve still closed the electric motor is started to rotate the impeller.
- The rotation of the impeller is gradually increased till the impeller rotates at its normal speed.
- After the impeller attains the normal speed the delivery valve is opened when the liquid is sucked continuously upto the suction pipe.
- It passes through the eye of the casing and enters the impeller at its centre.
- The liquid is impelled out by the rotating vanes and it comes out at the outlet tips of the vanes into the casing.
- Due to the impeller action the pressure head as well as the velocity heads are increased.
- From the casing the liquid passes into the pipe and lifted to the required height.
- When pump is to be stopped the delivery valve is to be first closed, otherwise there may be some backflow of water into the reservoir.

4. With a neat sketch, explain the construction and working principle of a impulse turbine (Pelton wheel turbine).

Principle: In an impulse turbine all the potential (pressure) energy of water is converted in to kinetic energy (velocity) in the nozzle before striking the buckets of the turbine wheel. Hence an impulse turbine requires high head and low discharge at the inlet.



Working :

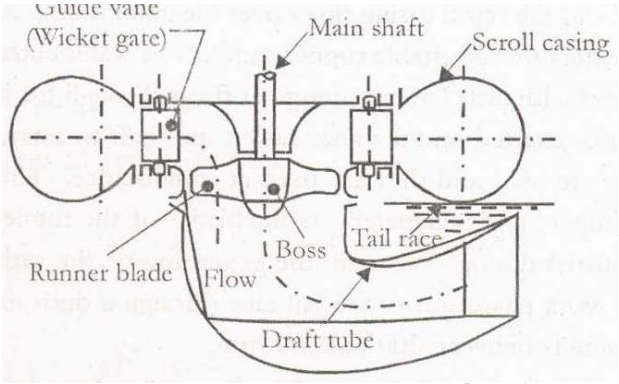
- Water at high pressure from the penstock pipe enters the nozzle provided with a spear.
- The pressure energy of water is converted into velocity (Kinetic energy), as it flows through the nozzle.
- By rotating the hand wheel, the spear is moved to control the quantity of flow of water.
- When the spear is pushed forward, the quantity of water flowing will be reduced.
- The jet of water with high velocity strikes buckets at the centre of the cup. The impulsive force of the jet striking on the buckets causes the rotation of the wheel in the direction of striking.
- Thus pressure energy of jet, is converted into the mechanical energy.
- The pelton wheel operates under high head of water.

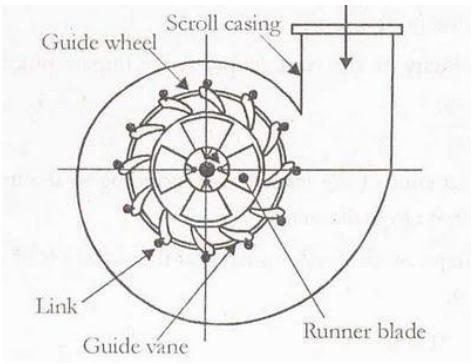
5. Explain briefly the about a Reaction turbine. Also explain the working of

(a) Kaplan turbine (b) Francis turbine.

- A reaction turbine is one, in which the water loses both its potential and kinetic energy at its inlet.
- First the water enters the guide blades, which guide the water to enter the moving blades.
- In the moving blades, a part of pressure energy is converted into kinetic energy, which causes the rotation of the runner.
- Water entering the moving blades will be at low pressure.
- Thus there is a pressure difference between the entrance and exit of the moving blades.
- The difference in the pressure is known as **reaction**.

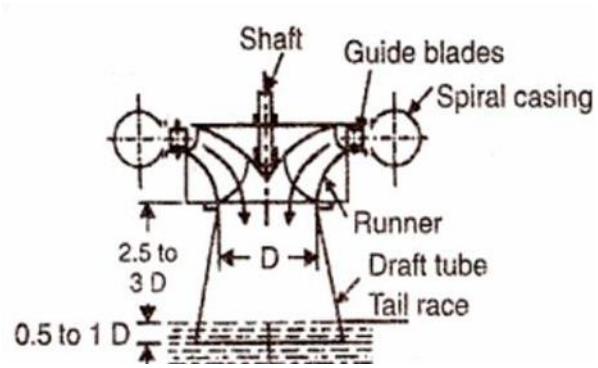
(a) Kaplan turbine





- Water at high pressure enters the spiral (Scroll) casing through the inlet and flows over the guide blades.
- The water from the guide blades strikes the runner blades axially.
- Thus the kinetic energy is imparted by water to the runner blades, causing the rotation of the runner.
- The water discharges at the center of the runner in the axial direction into the draft tube.
- The draft tube will be of L shape with its discharging end immersed into the tail race.

(b) Francis Turbine



The principle of working :

The Francis turbine is a mixed flow reaction turbine. It is used for medium heads with medium discharge. Water enters the runner and flow towards the centre of wheel in the radial direction and leaves parallel to the axis of the turbine.

Working :

- Water at high pressure from penstock pipe enters the inlet in the spiral casing
- Water flows radially inwards towards outer periphery of the runner through the guide blades.
- From the outer periphery of the runner, the water flows through the moving blades and dischargers at the center of the runner at low pressure.
- During its flow over the moving blades, the water imparts the kinetic energy to the runner, causing the rotation of the runner.