# GOVERNMENT POLYTECHNIC, SONEPUR

**Lecture Note On-**

# Element of Mechanical Engg.

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(Lect. In Mechanical Engg)

# Thermodynamics

Thermo → Heat
dynamics → motion. (Heat in motion)

Energy in motion. (Heat energy → Mech energy)

It is the science of energy transfer and its effect on the properties of system.

System → It is the regin on space upon which study is focus or considered.

Surrounding → Anything external to the system is known as surrounding.

Boundry → Separation between the system and surrounding.

(#) Note :- Boundry may be rigid or flexible

## Types of System.

(1) Open system → Heat & mas may transfer.
Eg → Turbine, Pump, Compressor, Nozzle
(Control volume system or flow system)

(2) Closed system → Heat may transfer but mas can't be transfer.

~~Closed → stiff~~

Ex → Closed tiffin box, Pinston & cylinder without valve.

(Control mass system)

(3) Isolated system.

Heat and ~~mag~~ mass can't transfer.

Example → Universe, thermoflax.

Properties.

all the quantities, which is identify the state of a system are called properties

volume, Pressure, temperature, density.

The thermodynamic properties of a system may be divided in to the following two general class.

(1) Extensive properties.

The properties of a system, whose value for the entire system is equal to the sum of their values for the individual part of the system are called extensive properties

Ex → total volume, total mass. total energy.

Pressure → $\frac{\text{Force}}{\text{Area}}$ $N/m^2$

Volume →

density → $\frac{\text{mass}}{\text{volume}}$ → $kg/m^3$.

Heat → Jule
The form of energy

Heat (Q) (Jule)
→ The heat is deffined as the energy transfered without transfer of mass, across the boundry of a system because of a temprature difference the system and surrounding.

→ Heat can be transferred in three way.
① conduction, conversion, Radiation.

→ The heat is transferred across a boundry from a system at higher temperature to a system of low temperature

SUNDAY 02

→ Heat is a form of transit energy which can be identified only when it crosses the boundry of a system.

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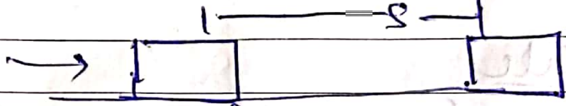
→ Heat flowing in to a system is considered as positive and heat flowing out of a system is consider negative.

**work** → force × displacement.



f × s.

(Boundary Fenomena)

~~Pdv work~~

→ Work is the quantity of energy transferred from one system to another without an accompanying transfer of entropy.

**Unit of work**

SI unit of work is Joule or kilo joule

(i) Conduction

Heat transfer through Solid wall is called conduction

Ex →

(ii) Convection

Heat transfer through liquid wall is called convection.

Ex →

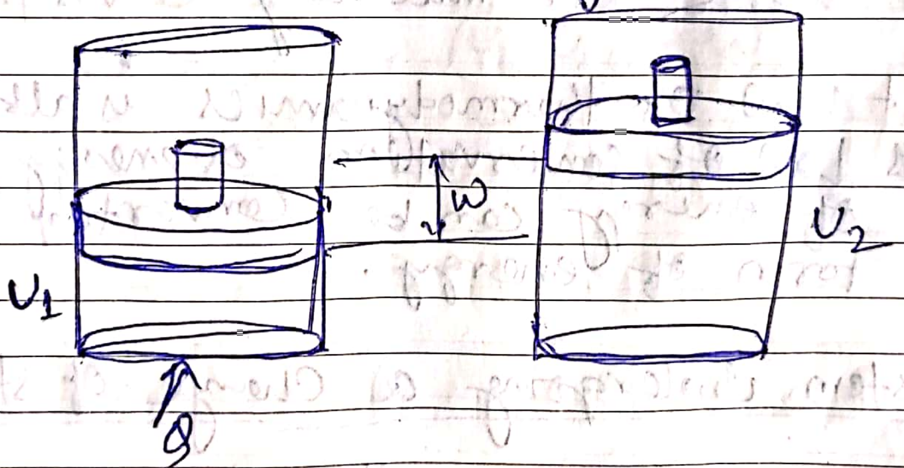
(iii) Radiation

Heat transfer through a vaccume is called Radiation.

Ex →

9am 10am 11am 12.00 1pm 2pm 3pm 4pm 5pm 6pm

First Law of thermodynamics



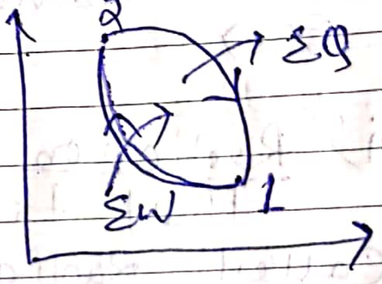

change in internal energy $\Delta U = U_2 - U_1$

$Q = \Delta U + W$

(*) <u>Closed system undergoing a cycle</u>

(i) When a system undergoes a cycle then the summation of the work transfer to or from the system is equal to the summation of heat transfer to or from the system surrounding

$$\Sigma W = \Sigma Q$$




In cyclic integral form of this equation is

$$\oint \delta W = \oint \delta Q$$

(ii) Heat and work are mutually convertable

(iii) The first law of thermodynamics is also called as Law of conservation of energy i.e one form of energy can be converted into another form of energy.

(*) <u>Closed system undergoing a change of state.</u>

When a system changes its state, the energy possessed by its own is also change.



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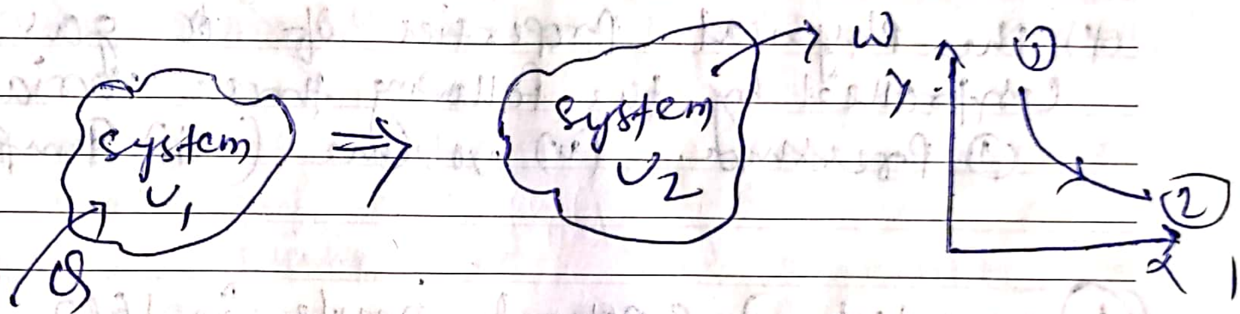
Let $U_1$ is the initial energy possed by a system undergoes a process by receiving a certain amount of heat "Q". After the process is over let $U_2$ is the final energy possed by the system by transfering equivalent amount of work "W".




According to conservation of energy

$$Q + U_1 = U_2 + W$$
$$\Rightarrow Q = (U_2 - U_1) + W$$
$$\Rightarrow Q = \Delta U + W$$

($\Delta U$ = change in energy)

$Q =$

## Law's of Perfect Gases.

A Perfect gas or an ideal gas may be defined as a state of a substance, whose evaporation from its Liquid state is complete. and strickly obeys all the gas law under all conditions of temperature and pressure.

(*) The physical properties of a gas are controlled by the following three variable.
(i) Pressure (ii) volume (iii) Temperature

### (1) Boyle's Law (Robert Boyle in 1662)

when the temperature remain constant the absolute Pressure of a given mass of perfect gas varies inversely as its volume.

$$P \propto \frac{1}{V} \Rightarrow PV = \text{constant}$$

$$\Rightarrow P_1V_1 = P_2V_2 = P_3V_3 = \cdots = \text{constant}$$

### (2) Charle's Law (Jacques A.C Charles in 1787)

(a) when the absolute Pressure remain constant the volume of a given mass of perfect gas varies directly as its absolute temperature.

$$V \propto T \Rightarrow \frac{V}{T} = \text{constant}$$

$$\Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3} = \cdots = \text{constant}.$$

~~All perfect gases change in volume by 1/273 th of its original volume at 0°C for every 1°C change in temperature, when pressure remain constant.~~

③ <u>Gay-Lussac Law</u>

This law state that. "The absolute pressure of a given mass of perfect gas varies directly as its absolute temperature, when the volume remain constant."

$$P \propto T \Rightarrow \frac{P}{T} = \text{constant}$$

$$\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2} = \frac{P_3}{T_3} = \cdots = \text{constant}$$

④ <u>General gas equation.</u>

$$P \propto \frac{1}{V} \Rightarrow V \propto \frac{1}{P} \quad \text{— (I)}$$



$$V \propto T \quad \text{— (II)}$$

$$\Rightarrow V \propto \frac{1}{P} \propto T \Rightarrow V \propto \frac{T}{P}.$$

$$\Rightarrow PV \propto T$$

$PV = CT$

$\Rightarrow \frac{PV}{T} = C$

9am

$\Rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \frac{P_3V_3}{T_3} = \cdots = C$

10am

11am

⑤ Joule's law

The change in internal energy of a

12.00 Perfect gas is directly proportional to

the change of temperature.

1pm

$dE \propto dT$

2pm

$\Rightarrow dE = mc\,dT$

3pm

$\Rightarrow dE = mc(T_2 - T_1)$

4pm

where $m$ = mass of the gas

5pm

$c$ = A constant of proportionality called specific heat.

6pm

**Problem**

A gas occupies a volume of 0.1 $m^3$ at a temperature of 20°c and a pressure of 1.5 bar. find the final temperature of the gas, if it is compressed to a pressure of 7.5 bar and occupies a volume of 0.04 $m^3$.

Given data

$V_1 = 0.1\ m^3$, $T_1 = 20°c$, $P_1 = 1.5$ bar

$V_2 = 0.04\ m^3$, $T_2 = ?$, $P_2 = 7.5$ bar

$T_1 = 20°c + 273 = 293K$

(1 bar = $10^5\ N/m^2$)

$P_1 = 1.5 \times 10^5\ N/m^2$

$P_2 = 7.5 \times 10^5\ N/m^2$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\Rightarrow T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{7.5\times10^5 \times 0.04 \times 293}{1.5\times10^5 \times 0.1}$$

## (i) Characteristic Equation of a Gas.

It is a modified form of general gas eqn if the volume (V) in the general gas eqn is taken as that of 1 kg of gas (known as its specific volume and denoted as $V_s$), then the constant C is represent by another constant R.

Thus the general gas eqn may be written as-

$$PV_s = RT$$

$$\Rightarrow mPV_s = mRT \qquad (mV_s = V)$$

$$\Rightarrow PV = mRT$$

Unit of gas constant R =

$$R = \frac{PV}{mT} = \frac{N/m^2 \times m^3}{kg \times K} = \frac{N\cdot m}{kg\,K} = \frac{J}{kg\text{-}K}$$

## (v) Universal Gas constant or Molar constant

The universal gas constant or molar constant ($R_u$) of a gas is the product of the gas constant and the molecular mass of the gas.

$$R_u = M \times R$$

M = molecular mass of the gas expressed in kg-mole

R = Gas Constant

In general if $M_1, M_2, M_3$ etc are the molecular mass of different gases and $R_1, R_2, R_3$ etc are their gas constant respectively, then -

$$M_1R_1 = M_2R_2 = M_3R_3 = \cdots = R_u.$$

(*) In S.I unit $R_u = 8314\ J/kg\text{-}mole\text{-}K$

(*) A mass of 2.25 kg of Nitrogen occupying $1.5\ m^3$ is heated from $25°C$ to $200°C$ at a constant volume. Calculate the initial and final pressure of gas. Take universal constant as 8314 J/kg-mole K. The molecular mass of the nitrogen is 28.

$m = 2.25\ kg$, $V = 1.5\ m^3$, $T_1 = 25°C = 298\ K$

$T_2 = 200°C = 473\ K$ $R_u = 8314\ J/kg\,mole\text{-}K$

$M = 28$

$$R = \frac{R_u}{M} = R = \frac{8314}{28} = 297\ J/kg\,K$$

$$P_1V_1 = mRT_1 \Rightarrow P_1 = \frac{2.25 \times 297 \times 298}{1.5}$$

$$= 0.133 \times 10^6\ N/m^2$$

$$= 1.33\ bar$$

$$P_2V_2 = mRT_2 = \frac{2.25 \times 297 \times 473}{1.5}$$

$$= 2.11 \times 10^5\ N/m^2$$

$$= 2.11\ bar$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\Rightarrow P_2 = \frac{P_1T_2}{T_1} = \frac{1.33 \times 473}{298}$$

$$= 2.11\ bar$$

(1) <u>specific heat of a gas</u>

The specific heat of a substance may be broadly defined as the amount of heat required to raise the temperature of its unit mass through one degree.

(2) <u>specific heat at constant volume</u>

It is the amount of heat required to raise the temperature of a unit mass of gas through one degree ~~when the gas~~ at constant volume.

$m$ = mass of the gas
$T_1$ = Initial temperature of gas
$T_2$ = Final temperature of gas

Total heat = $m\,C_v(T_2 - T_1)$
= mass × specific heat at constant volume × change in Temperature

work done = 0

## (X) Specific Heat at Constant Pressure

It is the amount of heat required to raise the temperature of a unit mass of gas through one degree at constant pressure.

Total heat = $M\,C_p\,(T_2 - T_1)$

where, $m$ = mass of the gas

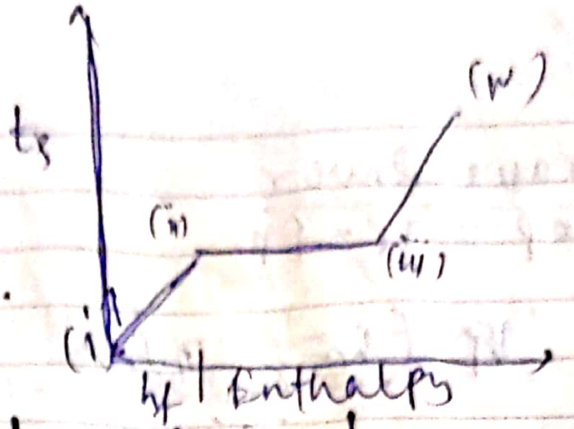
$T_1$ = Initial temp. of gas

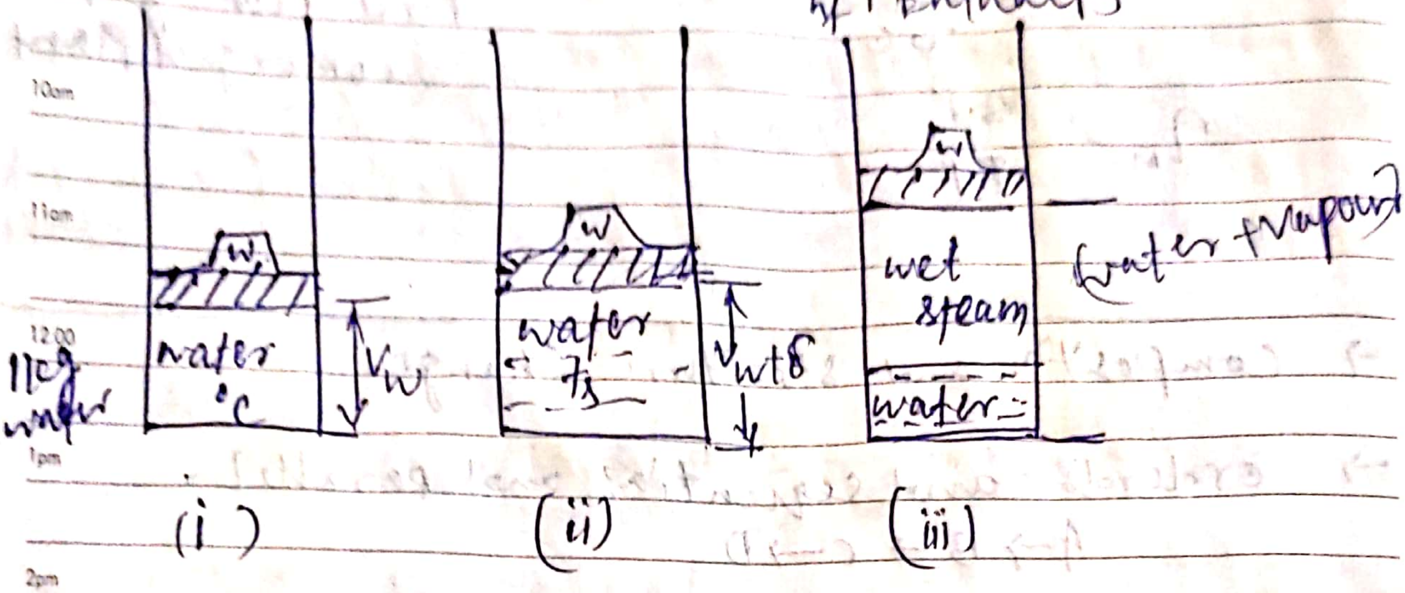
$T_2$ = final temp. of gas

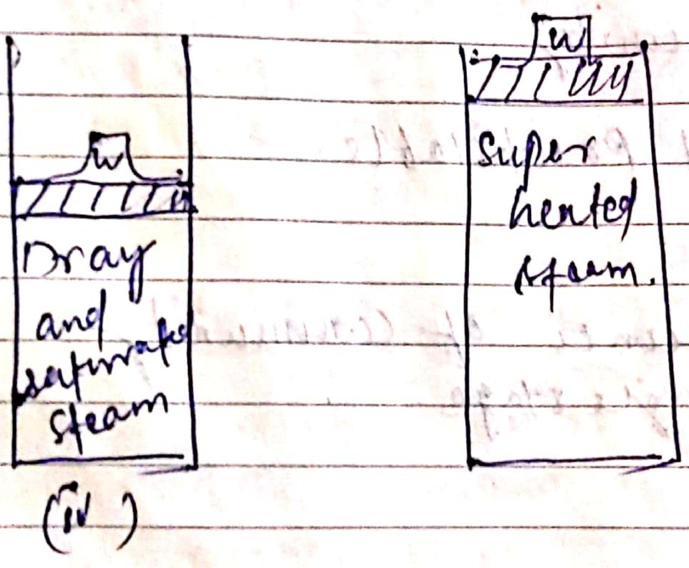
Total heat = mass of gas × specific heat at constant pressure × (change in temperature)

# CH-2

## (1) Properties of Steam.




① Saturation Temperature ($t_s$)

$t_s \propto$ Pressure

② ~~0°C~~ 0°C → $t_s$ (sensible heat)

③ Latent heat (~~after~~ at $t_s$)

① **wet steam.**
When the steam contain moisture or particle of water in suspension, it is called wet steam.

② **Dry staturated steam.**
When the wet steam is further heated, and it does not contain any suspended particle of water, it is called dry and saturated steam.

③ **Superheated steam.**
When the dry steam is further heated at constant pressure, thus raising its temperature it is said to be superheated steam.

④ **Dryness fraction** (or quantity of wet steam)

It is the ratio of the mass of actual dry steam to mass of same quantity of wet steam, and it is denoted as $x$.

$$x = \frac{m_g}{m_f + m_g} \quad \frac{m_s}{m_s + m_w}$$

$m_s$ $m_g$ = mass of actual dry steam

$m_w$ = mass of water in suspension

⑤ **Sensible heat** amount of heat absorbed by 1 kg of water when heated at constant pressure, from the temperature
It is the ~~heat supply between~~ of 0°C to the temperature of formation of steam i.e ~~saturation~~ saturation temp.

(6) Latent heat

It is the amount of heat absorbed to evaporate 1kg of water at its ~~boiling~~ boiling point or saturation temperature ~~which~~ without change of temperature.

(7) Enthalpy or total heat of steam.

Sensible heat + Latent heat

It is the amount of heat absorbed by water from freezing point to saturation temperature plus the heat absorbe during evaporation.

(5) Sensible heat

It is the amount of heat absorbed by 1kg of water when heated at a constant pressure, from the freezing point (0°C) to the temperature of formation of steam i.e saturation temperature.

9am

10am

11am

12:00

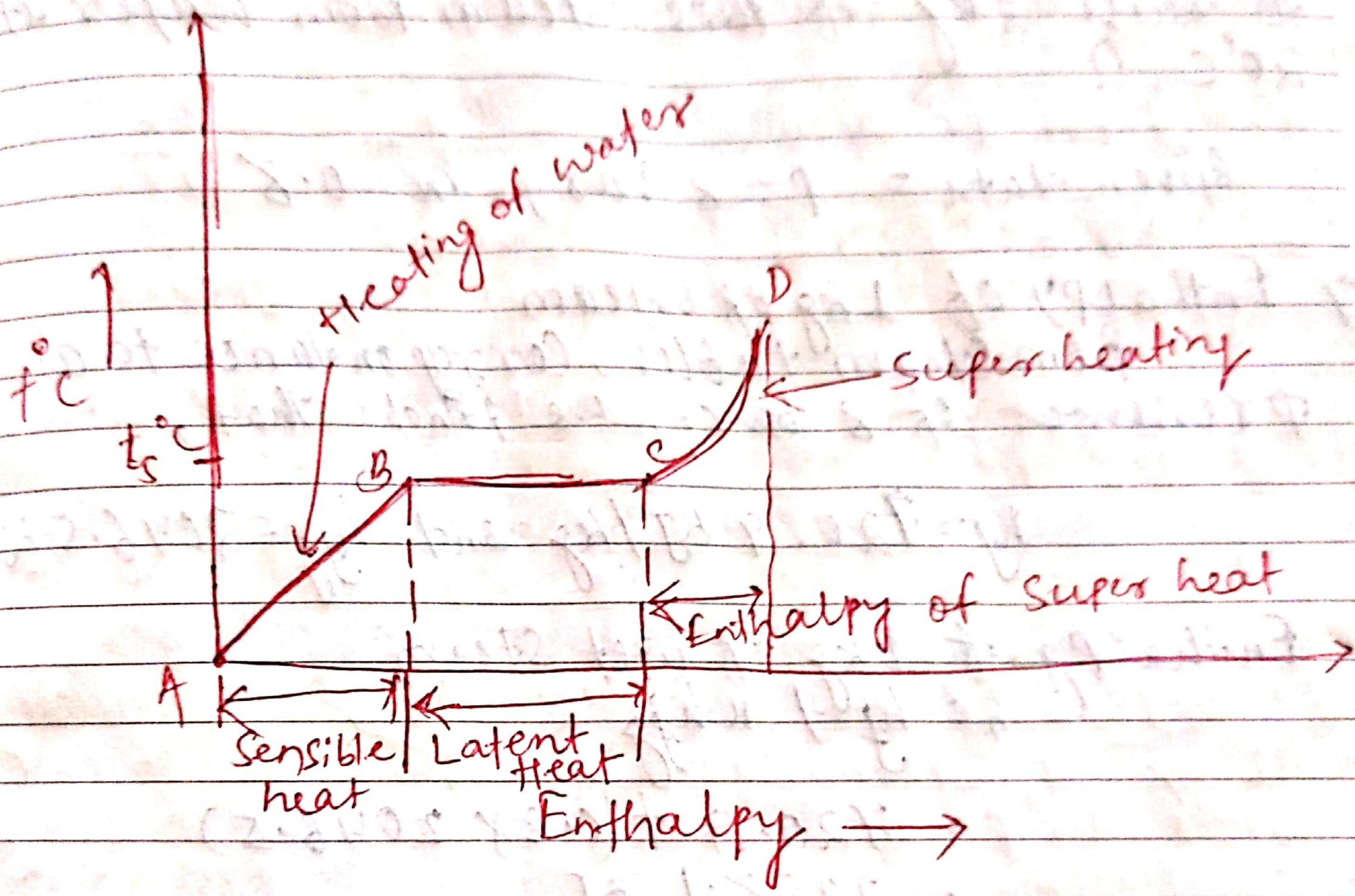
1pm

2pm

3pm

4pm

5pm




6pm

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(*) Calculate the enthalpy of 1 kg of steam at a pressure of 8 bar and dryness fraction of 0.8. How much heat would be required to raise 2 kg of this steam from water at 20°C ?

Given data = $p = 8$ bar, $x = 0.8$

→ Enthalpy of 1 kg of steam

from steam tables, corresponding to a pressure of 8 bar, we find that,

$h_f = 720.9$ kJ/kg and $h_{fg} = 2046.5$ kJ/kg

Enthalpy of 1 kg of wet steam

$h = h_f + x h_{fg}$

$= 720.9 + (0.8 \times 2046.5)$

$= 2358.1$ kJ

→ Heat required to raise 2 kg of this, steam from water at 20°C

we have calculated above the enthalpy or total heat required to raise 1 kg of steam from water at 0°C.
Since the water, in this case, is already at 20°C, therefore

Heat already in water
$4.2 \times 20 = 84$ kJ

[$\because$ Sensible heat associated with 1 kg of water
$= m_w \times$ sp.heat $\times (t_w - 0)$

$= 1 \times 4.2 \times 20$

$\therefore$ Heat required per kg of steam

$= 2358.1 - 84 = 2274.1$ kJ

$\therefore$ Heat required for 2 kg of steam.
$= 2274.1 \times 2 = 4548.2$ kJ

Total heat of steam.

(1) wet steam $= h = h_f + x h_{fg}$

(2) Dry steam $= h_g = h = h_f + h_{fg}$

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(iii) Super heated steam $= h_{sup} = h_f + h_{fg} + C_p(t_{sup} - t_s)$

$= h_g + C_p(t_{sup} - t_s)$

$c_p$ = mean specific heat at constant pressure

$t_{sup}$ = temp. of super heated steam.

$t_s$ = saturated temp

(4) Dryness Fraction (x) : $\frac{m_g}{m_g + m_f} = \frac{m_g}{m}$.

$m_g$ = mass of actual dry steam

$m_f$ = mass of water in suspension

$m$ = mass of wet steam = $m_g + m_f$

(1) Determine the heat required to produced 1 kg of steam at a pressure of 6 bar at a temp of 25°C, under the following condition.

(i) when the steam is wet having a dryness fraction 9.

(ii) when the steam is dry and saturated.

(iii) when it is superheated at constant pressure at 250°C assuming the mean specific heat of super heated steam to be 2.3 kJ/kg K.

2017

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TUESDAY JUNE 27

Given :- $p = 6$ bar, $t_w = 25°C$
$x = 0.9$, $t_{sup} = 250°C$
$c_p = 2.3$ kJ/kg K

from steam table, corresponding to pressure 6 bar, we find -

$h_f = 670.4$ kJ/kg K, $h_{fg} = 2085$ kJ/kg
and $t = 158.8°C$

(i) when the steam is wet :-

$h = h_f + x h_{fg} = 670.4 + 0.9 \times 2085 = 2546.9$ kJ

Since water is at a temperature of 25°C, therefore
Heat already in water $= 4.2 \times 25 = 105$ kJ

Heat actually required $= 2546.9 - 105 = 2441.9$ kJ

(ii) when the steam is dry saturated.

$h_g = h_f + h_{fg}$

$= 670.4 + 2085 = 2755.4$ kJ

Heat actually required ~~27550~~ $2755.4 - 105 = 2650.4$

(iii) when the steam is superheated

$h_{sup} = h_g + c_p (t_{sup} - t) = 2755.4 + 2.3 (250 - 158.8)$
$= 2965.16$ KJ

Heat actually required $= 2965.16 - 105 = 2860.16$ kJ

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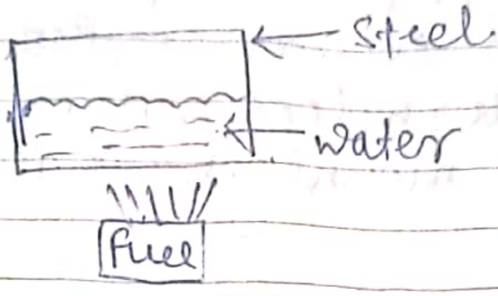
# CH-3

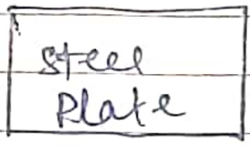
## Boiler

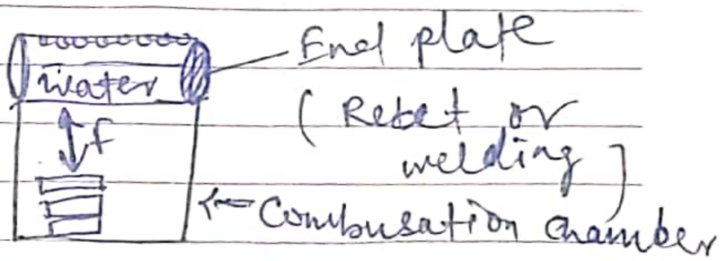
→ Steam generator.




A Boiler is closed contener which is madeup steel. The Boiler convert the water in to steam inside it (by the use of hot steam which comes from burned Fuel)

(i) Boiler Shell
→ made from steel plates.




(ii) Combusation chamber:
made up → concrit or fire brickes

(iii) Grate

(iv) furnance ( fire box )

(v) Ash Pit

(vi) Heating Surface

(vii) mountaing

(viii) Assosiandes.

# Boiler

## Types of Boiler

MONDAY AUGUST 21 2017

(1) According to the contents in the tubes–
(a) fire-tube Boiler
(b) water-tube Boiler

(2) According to the Number of Tubes –

(a) Single tube boiler
(b) Multi-tube boiler

(3) According to the Position of the Furnance.

(a) Internal fired Boilers
(b) External fired Boiler

(4) According to the Axis of the Shell

(a) Vertical Boiler
(b) Horizontal Boiler

(5) According to the Methods of circulation of water and steam

(a) Natural circulation Boiler
(b) forced circulation Boiler

(6) According to the use.
(a) stationary boiler
(b) mobile boiler.

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SATURDAY APRIL 22

# Boiler

→ A steam generator or boiler is a closed vessel mad of steel. The main function of a boiler is to transfer the heat (which is produced by the combusation of fuel) to water and ultimately to ~~generaty~~ generate steam.

## Parts of a Boiler

### ① Boiler Shell

It is made up of steel plates bent into cylindrical form and riveted or welded together. The end of the shell are closed by means of end plates. A boiler shell should have sufficient capacity to contain water and steam.

### ② Combusation chamber.

Generally it is maunten below the boiler shell, there we burn the burning fuel and used to produced steam from ~~water~~ the water contained in the shell.

### ③ Grate

It is a platform, in the combusation chamber ~~at~~ upon which fuel is burnt. The ~~grate~~ grate generally consist of cast iron bar which ~~is~~ are spaced part ~~which help in~~ so that air can pass through them which is help in burning.

SUNDAY 23

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(4) Furnance
It is the above the grate and below the boiler shell, in which ~~as~~ the fuel is actually burent. The furnance is also called fire box.

(5) Heating surface
It is that Part of boiler surface, ~~which is the ~~ ~~gases~~ which is exposed to the fire.

(6) mounting
These are the fittings which are mounted on the boiler for it proper functioning.
- water level indicator
- Pressure gauge
- safty valve

(The boiler cannot be functioning safely with out the mounting)

(7) Accessories :-
There are the internal parts of a boiler which are helps in controlling and running the boiler efficiently
- Superheater
- economiser
- feed pump.

(8) Ash pit
It collect the Ash after burning ~~the~~ of wastage fuel.

# Cochron Boiler

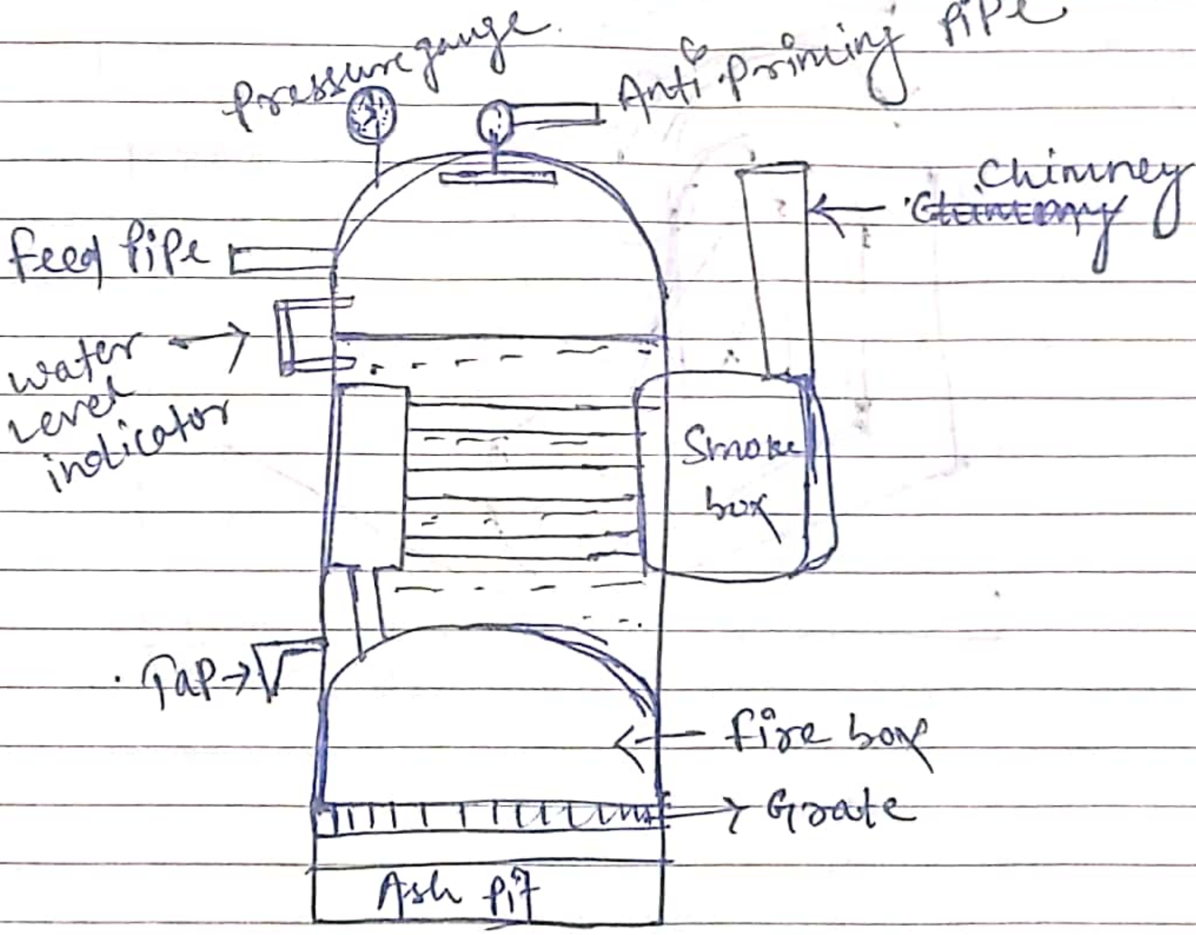
→ It is a verctical, multitubular, internally fired, Natural circulation Boiler.
9am → It is a fire tube boiler.

10am **Components.**

→ Boiler shell with Hemispherical crown.
11am → Furnance, fire box, and Grate.
→ Combustion chamber, and fuel pipes.
12.00 → Smoke box and chimney
→ Boiler Mounting and Acceceries.

1pm

2pm




3pm

4pm

5pm

6pm

## Cochran Boiler

→ It is a vertical, Multitubular, Internally fired, Natural circulation Boiler
→ It is a fire tube boiler.

Components.
→ Boiler shell with hemispherical crown,
→ Furnance, Fire box, and grate.
→ Combusation Chamber
→ Smoke box and chimney.
→ Boiler Mounting and Accecceries.

→ The boiler consists of an external cylindrical shell and a fire box. The shell and fire box are both hemispherical.
→ The hemispherical crown of the boiler shell gives maximum space and strength to withstand the pressure of steam inside the boiler.
→ The hemispherical crown of the fire box is also advantage for ~~resistan~~ resisting intant heat.

→ The fire box and the combusation chamber is connected through a short pipe.
→ The flue gas from the from the combusation chambers flow to the smoke box through a number of smoke tubes,

→ These Tubes generally have ~~62.5~~ 62.5 mm external diameter and are 165 in number.

9am → At the bottom of the fire box, there is a Grate made up cast iron. and the Coal is
10am ~~feed~~ fed through the fire hole.

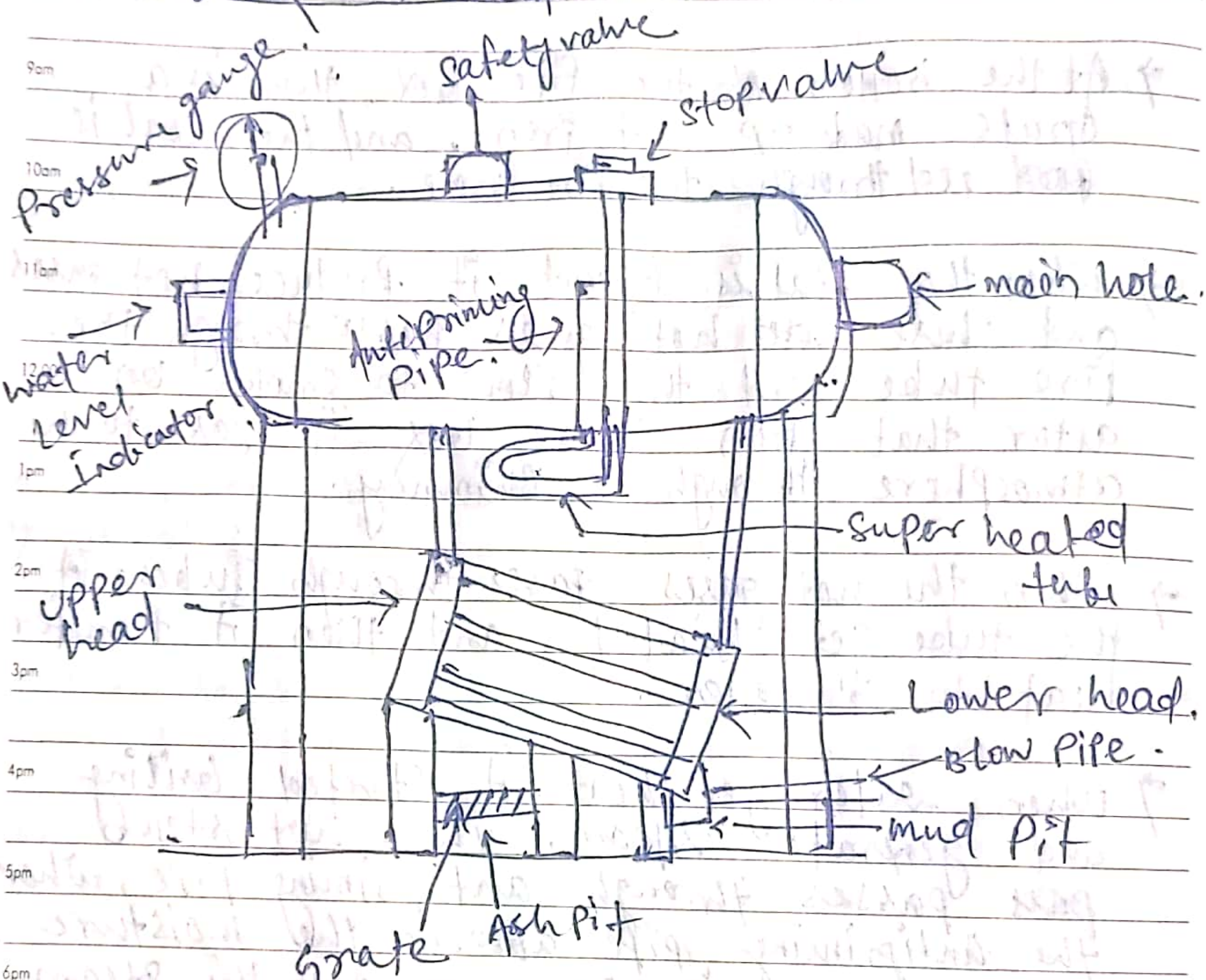
11am → when the Coal is burnt it produce hot gases. and these ~~gases~~ hot gases passes through the
12.00 fire tube and then flow to smoke box after that from smoke box it pass to the
1pm atmosphere through a chimney.

2pm → when the hot gases pass through Tubes, ~~it~~ the tube get heated, and then it transfer
3pm heat to ~~t~~ water.

4pm → when water get heat it started boiling and generate steam. These hot steam
5pm ~~pass~~ passes through antipriming pipe, where the antipriming pipe absorbe the moisture
6pm particle which is comes through the steam.

→

(e) Babcock and wilcox boiler.




water level indicator, pressure gauge, saftey valve,
(NRV) feed check valve, stop valve
Blow of ~~cock~~ cock
main hole, mud hole
safty valve

| M | T | W | T | F | S | S | M | T | W | T | F | S | S | |
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| 29 | 30 | 31 | | | | | | | | | | | | |

## Babcock and wilcox Boiler

→ It is a straight tube, stationary type water tube boiler. It consist of a steam and water drum. It is connect by a short tube with uptake header at the back end.

→ The water tubes are inclined to the horizental and Connects the uptake header to the ~~do~~ down take header.

→ The headers are curved when viewed in the direction of tubes so that is not in the space of the other, and the hot gases can passes ~~pos~~ properly after heating all the tubes.

→ A mud box is provided with each downtake header and the mud, that settle down is removed.

→ There is a slow moving automatic chain grate on which the coal is ~~fed~~ Fed from the hopper.

→ The boiler is suspended on steel girders, and suspended on all the four side by fire bricks wall.

→ The doors are provided for a man to enter the boiler for repairing and cleaning.

⇒ water circulate from the drum into the header and through the tubes to uptake header. And again to the drum.

⇒ A steam superheater consists of a large number of steel tubes and contain two boxes; one is superheated steam box and other is saturated steam box.

⇒ The steam generate above the water level in the drum, flow in the dry pipe and through the inlet tube into the ~~superheater~~. ~~Steam~~ superheated steam box.

⇒ It then passes through the tubes into the saturated steam box. The steam during its passes through tubes get further heated and passes through the outpipe to the stop value.

SUNDAY 07

| | | | | | | | | | | | | | | | |
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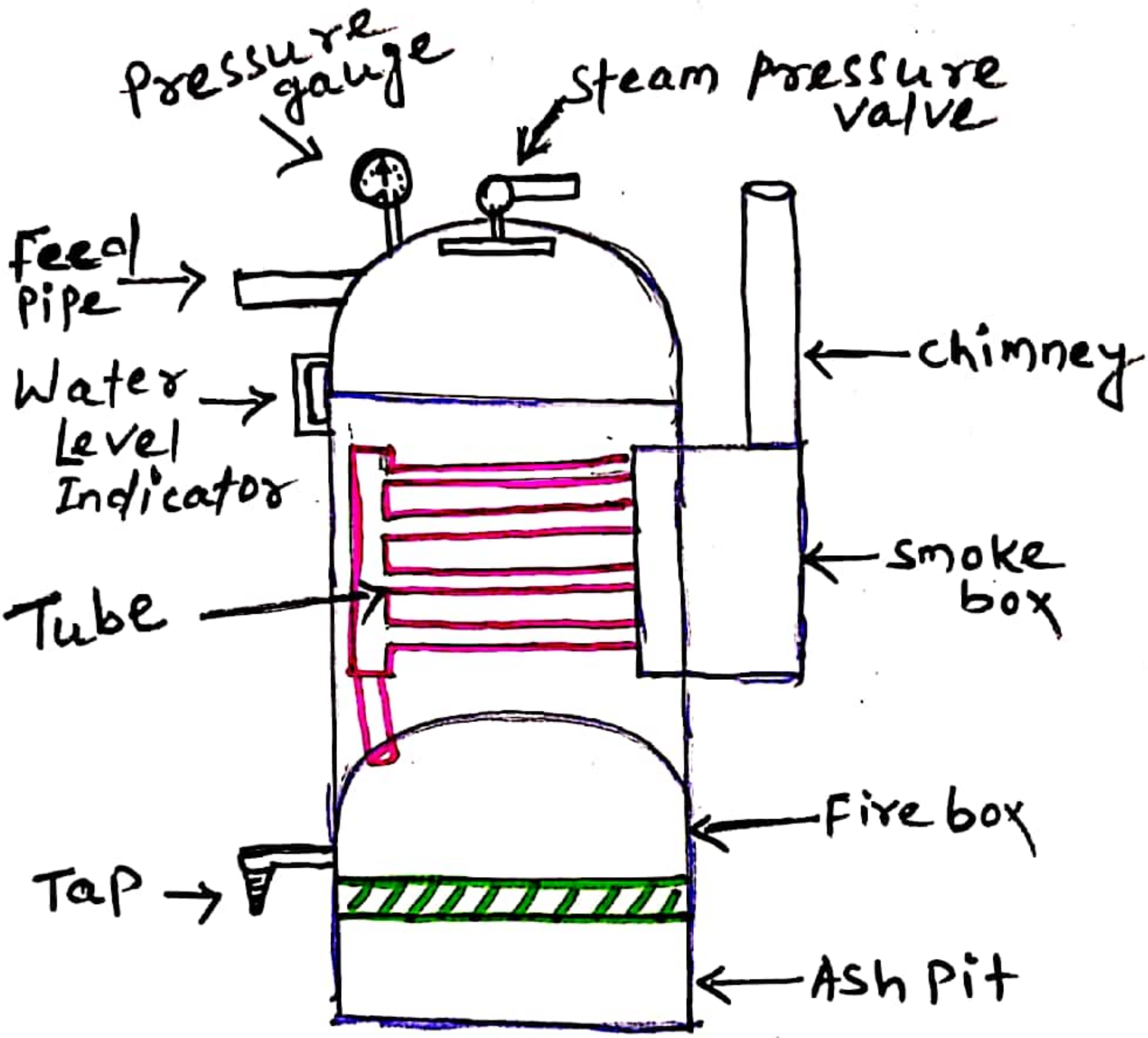
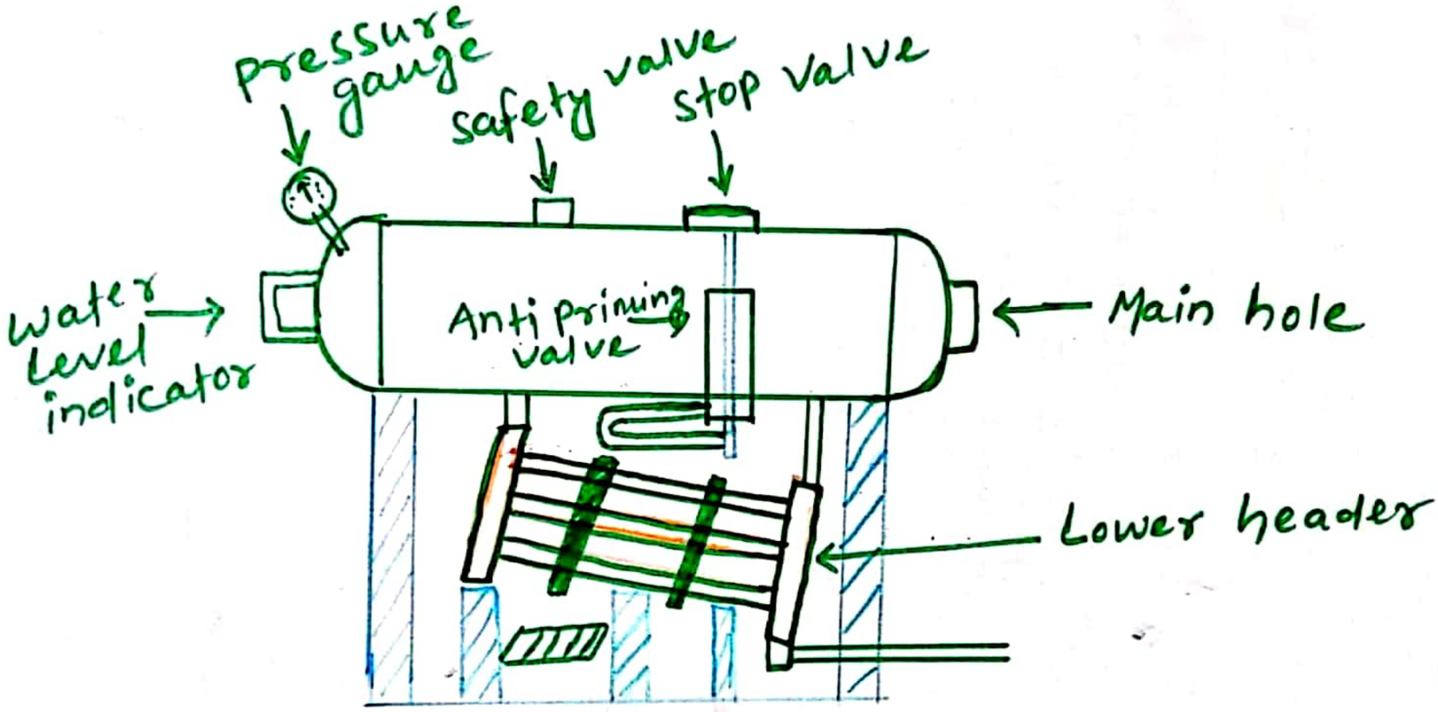



(COCHRAN BOILER)


pressure gauge
safety valve
stop valve
water level indicator
Anti priming valve
Main hole
Lower header

## Boiler Accessories.

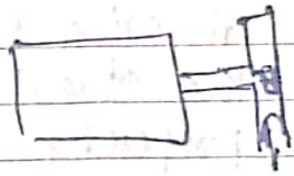
(1) The accessories are mounted on the boiler to increase efficiency.

9am

(i) Economiser
10am
(ii) Super heater
(iii) Air preheater
11am
(iv) feed water pump
(v) steam injector
12:00

## Boiler Mounting

1pm
(i) water Level Indicator.
(ii) Pressure gauge.
2pm
(iii) Main steam stop valve
(iv) saftey valve
3pm
(v) ~~stop valve~~.
(vi) ~~Blow of~~ feed check valve
4pm
(vii) main hole.
(viii) mud hole. → (cleaning Purpose)
5pm
(ix) Blow of cock — (slages Removing)



6pm

# Boiler mounting

## (1) water Level Indicator

It is an important fitting ~~____~~ which indicates the water level inside the boiler to an observer. It is a safety device, up on which the correct working of boiler depends. This fitting may be ~~____~~ seen in front of the boiler, and are generally two in number.

## (2) Pressure Gauge

A Pressure ~~____~~ gauge is used to measure the pressure of the steam inside the steam boiler. It is fixed in front of the steam boiler. The pressure gauge is fitted in such a way that the operator can conveniently read it.

## (3) Safety valve.

Safety valve are located on the top of the boiler. They guard the boiler against the excessive high pressure of steam inside the drum. If the pressure of steam in the boiler drum exceeds the working pressure then the ~~____~~ safety valve allows blow-off the excess quantity of steam to out side from the boiler.

There are 4 types of safety valve
(1) Lever safety valve
(2) Dead weight safety valve
(3) High steam and Low water safety Valve
(4) spring Loaded safety valve.

(4) <u>steam stop valve</u>

It is the Largest valve ~~[illegible]~~ on the steam boiler. It is Located on the highest part of the steam space. It regulate the steam supply to use. It can be operated manually or automatically. Main function of steam stop valve is –

(i) To control the flow of steam from the boiler to the main steam pipe
(ii) To shut off the steam completely when required.

(5) <u>Blow of cock</u>

~~The Blow of cock fitted to the bottom of~~

The Blow of cock fitted to the bottom of the boiler drum. The main function of the Blow of cock is to discharge mud and other sediments deposited in the bottom most part of the water space in the boiler. It can also be used to drain off boiler water.

⑥ Feed Check valve.

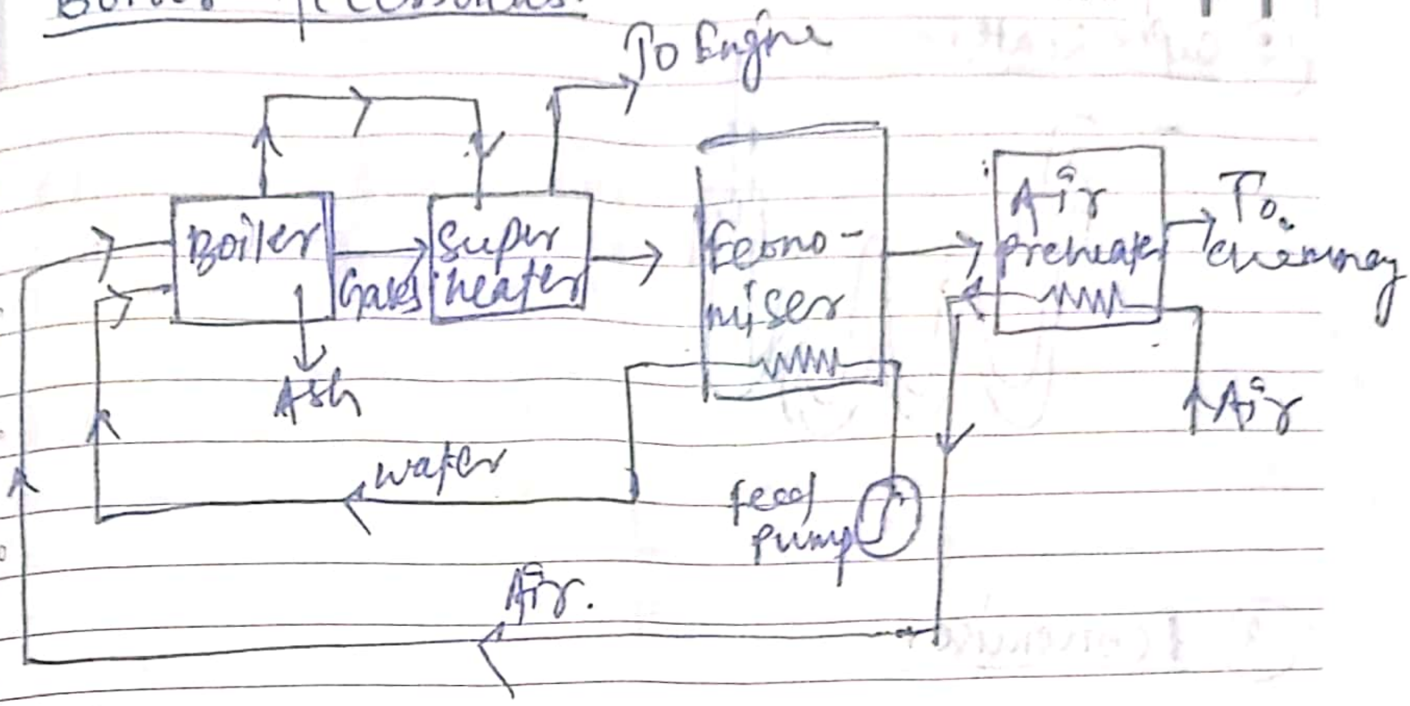
It is an non-return valve, fitted to the boiler, slightly below the working level in the boiler. Its main function is to regulate the supply of water, which is pumped in to the boiler by the feed pump. It also prevents the returning of feed water from the boiler if the feed pump fail to work.

⑦ Fusible Plug

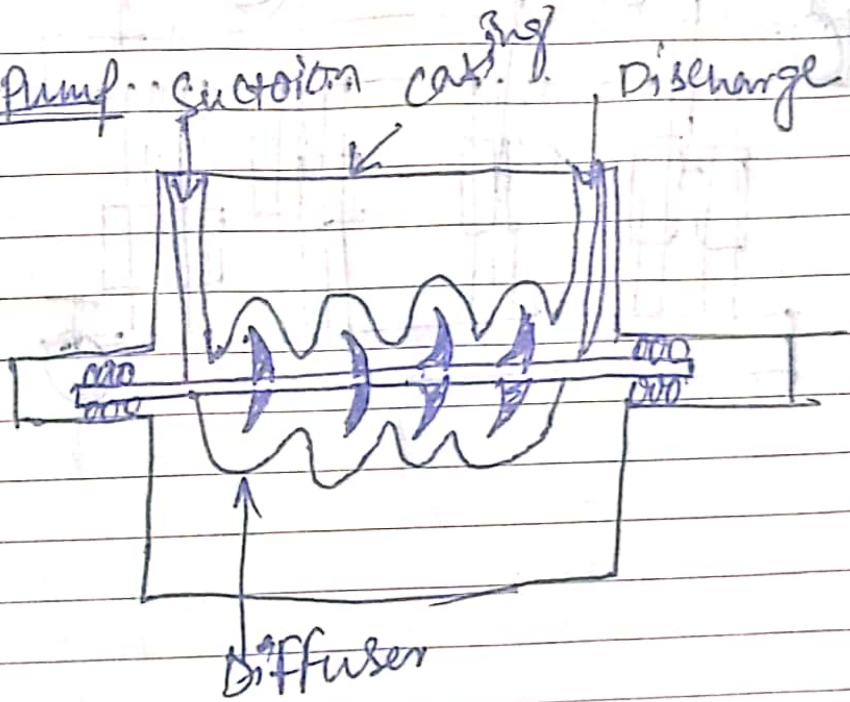
It is a very important safety device, which protects the fire tube boiler against overheating. It is located just above the furnace in the boiler.

During the normal boiler operation, the fusible plug is covered by water and its temperature does not rise to its melting point. But when the water level falls too low in the boiler, it uncovers the fusible plug, The furnace goes heat up the plug and fusible metal of the plug melts, The water and steam then rush through the hole and extinguish the fire before any major damage occurs to the boiler due to over heating.

# Boiler Accessories.

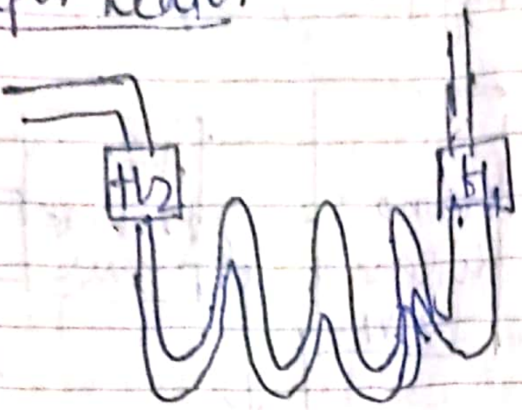



Feed Pump.



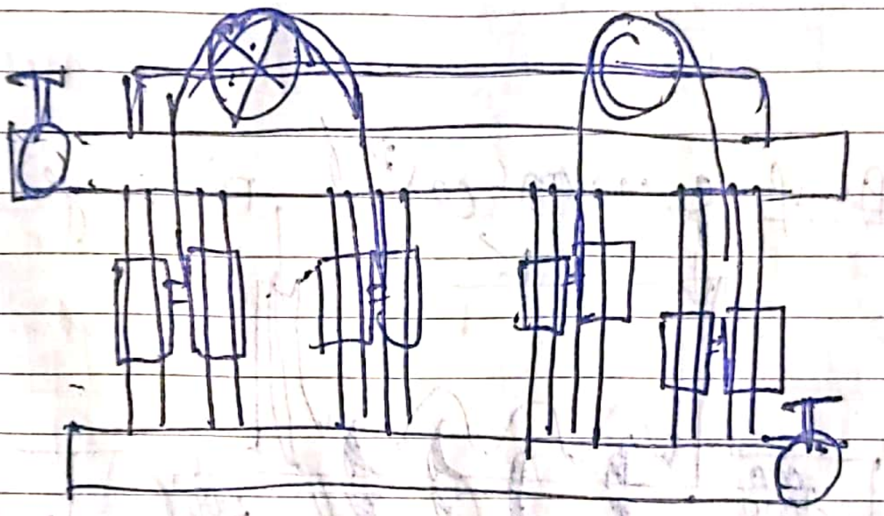

→ multistage – Impellers
→ Centrifugal type

② Super heater



9am
10am
11am
12.00
1pm

③ Economiser



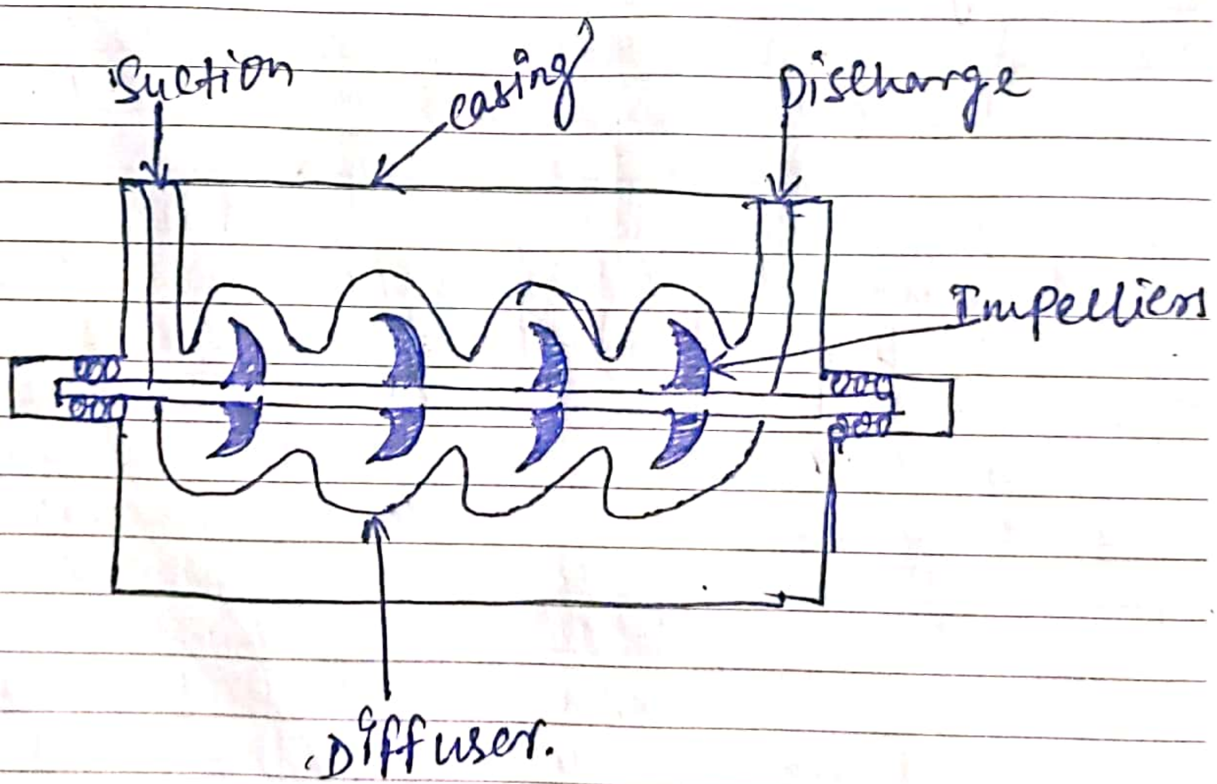
2pm
3pm
4pm
5pm
6pm

## (*) Boiler Accessories.

These are the devices which are used as integral part of a boiler, and help in running efficiently.

1. Feed Pump
2. Super heater.
3. Economiser
4. Air preheater.

### (1) Feed Pump.

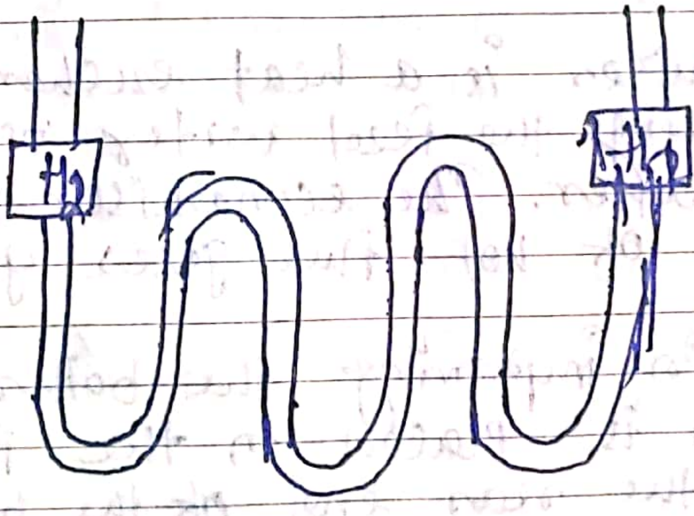


we know that water, in a boiler, is continuously converted into steam, which is used by the engine, thus we need to a feed pump to deliver water to the boiler.

The pressure of steam inside a boiler is high. So the pressure of feed water has to be increased ~~proportionately~~ proportionately before it is made to enter the boiler. Generally, the pressure of feed water is 20% more than that in boiler.

A feed pump may be of centrifugal type or reciprocating type. But a double acting reciprocating pump is commonly used as a feed pump these days.

(2) Super Heater



137-228 • WK 20

17 WEDNESDAY MAY 2017

A superheater is a important device of a steam generating unit. Its Purpose is to increase the temperature of saturated steam with out raising its pressure. It is generally a integral Part of a boiler, and is placed in the Path of hot flue gases from the furnance.

The heat given up by these flue gases is used in superheating the steam. Basically, a superheater consist of a set of small diameter U ~~tape~~ tubes in which steam flows and takes up the ~~hot~~ heat from hot flue gases.

(3) ~~Economiser~~

~~A) Economiser~~

(3) Economiser

An Economiser is a heat exchanger, used for heating the feed water before it enter the boiler. The economiser recovers some of heat of hot flue gases going to chimney.

It helps in improving the boiler efficiency. It is placed in the Path of flue gases at the rear end of the boiler before air pre-heater.

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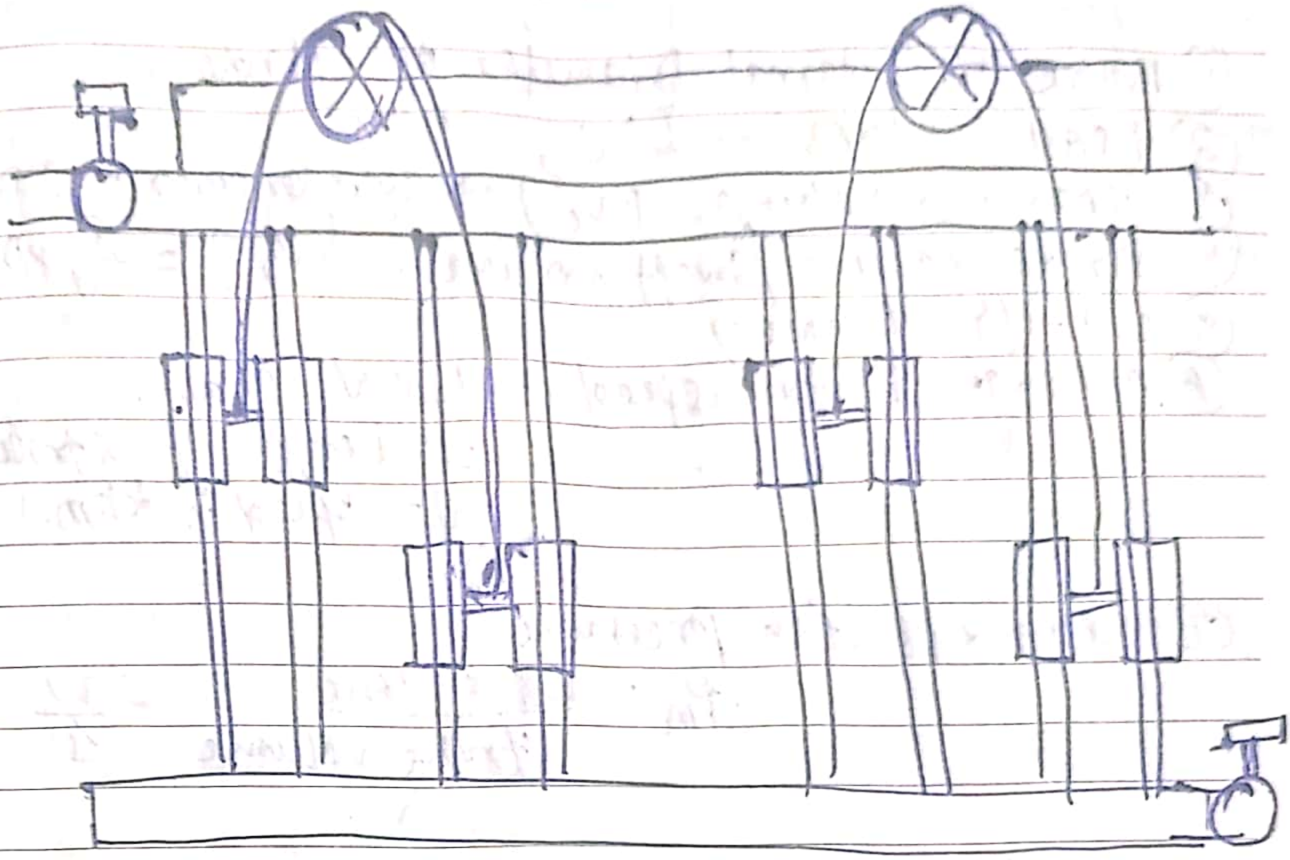
| 29 | 30 | 31 | | | | | | | | | | | |

MAY 2017



## (4) Air Preheater

Air Preheater is used to recover heat from the exhaust flue gases. It is Installed between the economiser and chimney. The air required for the purpose of combusation is drawn through the air Pre-heater where its temperature raised.

It is then Pass through ducts to the furnance. The air is passed through the tubes of the heater internally wile the hot flue gases are passed over the outside of the tube.

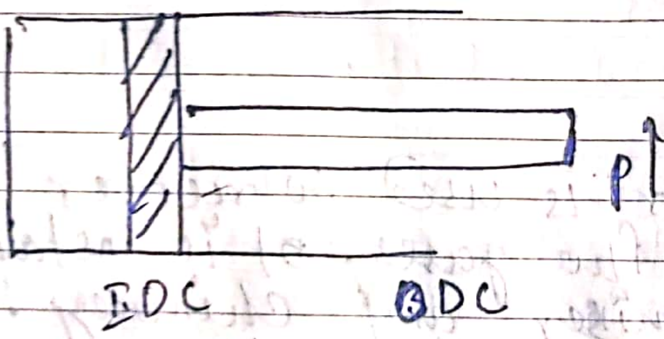
139-226 • WK 20

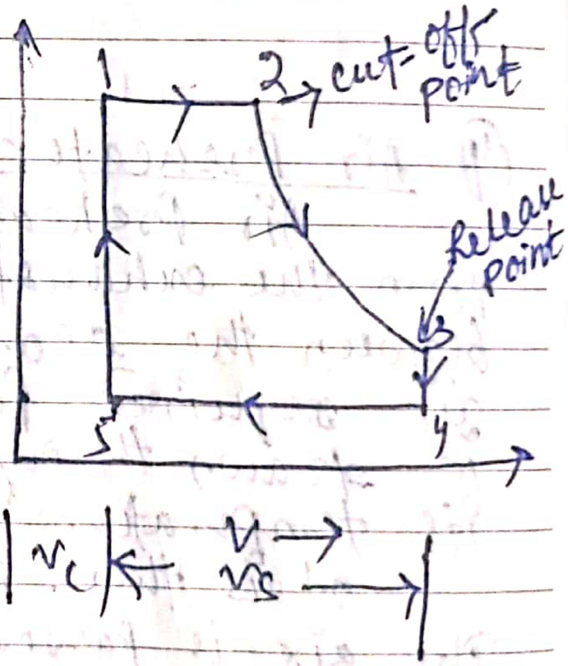
19 FRIDAY MAY

## Steam Engine & Important term

1. Bore → Internal Diameter of cylinder.
2. Dead centres → IDC, ODC
3. Clearance value (Vc) → cylinder cover → IDC.
4. Stroke volume / swept volume. $(V_s) = \frac{\pi}{4} \times D^2 \times L$
5. cut-off volume →
6. Average piston speed = L×N m/min
   L = Length of stroke
   N = speed in Rpm.

7. mean effective pressure.
   $P_m = \frac{\text{work done}}{\text{stroke volume}} = \frac{W}{V_s}$




M T W T F S S M T W T F S S
1 2 3 4 5 6 7 8 9 10 11 12 13 14
15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31
MAY 2017

## Steam Engine

In all steam engine, the steam is used as the working a substance. These engines operates on the principle of first law of thermodynamics. i.e heat and work are mutually convertable.
In a steam engine the heat energy is converted in to mechanical work.

### Parts of Steam Engine

(1) Frame :- It is a heavy cast iron part, which supports all the stationary as well as moving parts and holds them in proper position.

(2) cylinder :- It is a hollow vessel made up cast Iron, in which piston moves to and fro under the steam pressure, Both ends of the cylinder are closed and made steam tight

(3) steam Chest :- It supply steam to the cylinder with the movement of D-slide valve.



(4) D-Slide valve :- It moves in steam chest. Its function is to exhaust steam from the cylinder at proper movement.

⑤ Inlet and exhaust ports:- Thes are the holes provided in the body of the cylinder for the proper moment of steam. The steam enter to the cylinder from Inlet port and exhaust through exhaust port.

⑥ Piston:- It is a cylindrical disc, moving to and fro, ~~and~~ in the cylinder because of steam. ~~Its~~ Its function is to convert heat energy of the steam in to mechanical work.

⑦ Piston rod:- It is a circular rod, which is connected to the piston on one side and cross head to the other. Its main function is to transfer motion from the piston to the cross head.

⑧ Cross head:- It is the Link between the piston ~~rod~~ rod and connecting rod. Its function is to guide motion of the ~~Pist~~ Piston rod.

~~⑨ Connecting rod~~

⑨ Connecting rod:- Its main function is to convert reciprocating motion of the piston in to rotary motion of the crank.

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| 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | | | | | | | | |

MAY 2017

(10) Crank Shaft :- It is the main shaft of engine having a crank.

(11) Eccentric :- It is generally made of cast iron, and is fitted to the crank shaft. Its ~~motion~~ function is to provide reciprocating motion ~~to the~~ ~~shaft~~ to the slide valve.

9am
10am
11am
12.00
1pm
2pm
3pm
4pm
5pm
6pm



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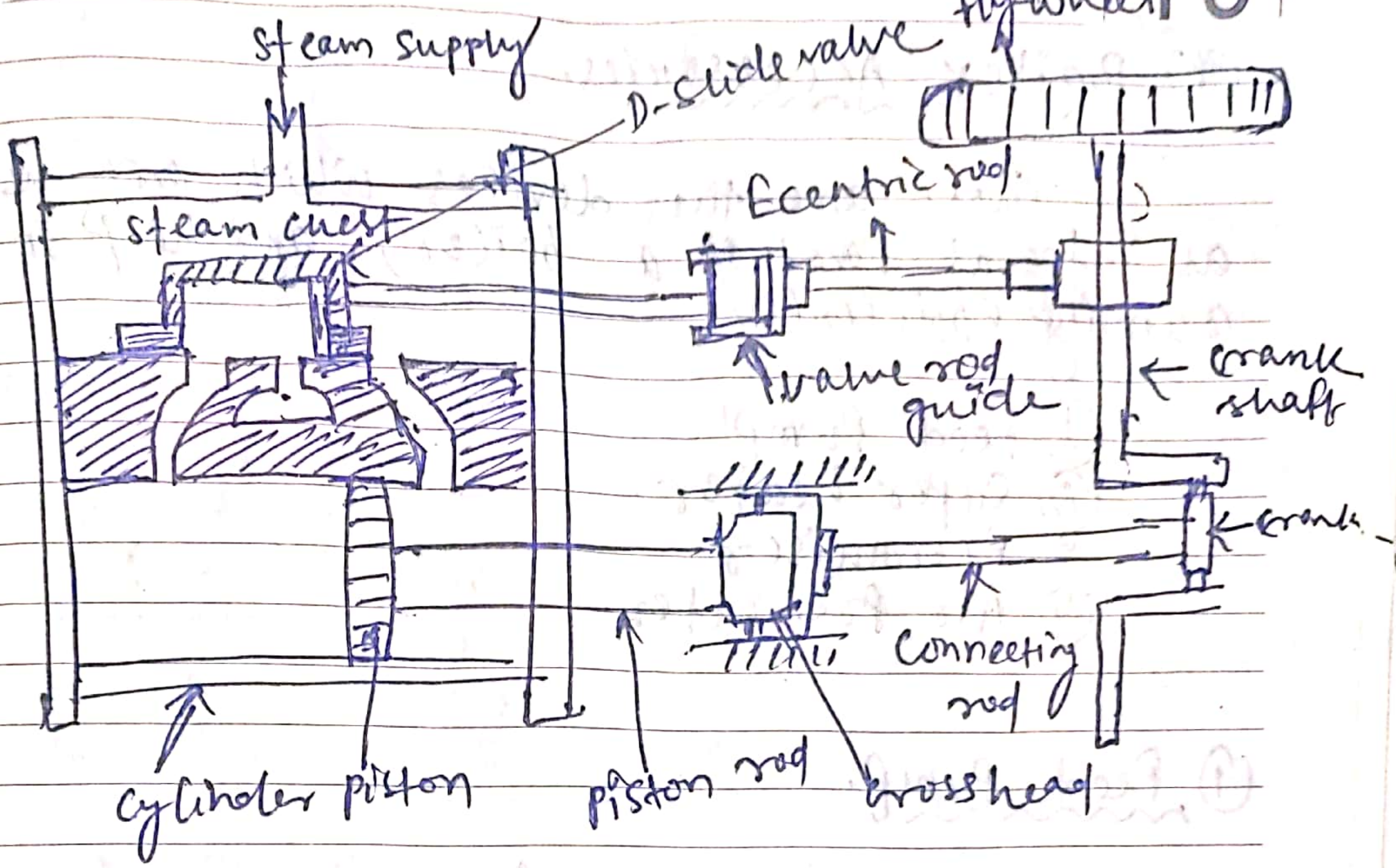
# Steam Engine




9am
10am
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12.00
1pm
2pm
3pm
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6pm

SUNDAY 14

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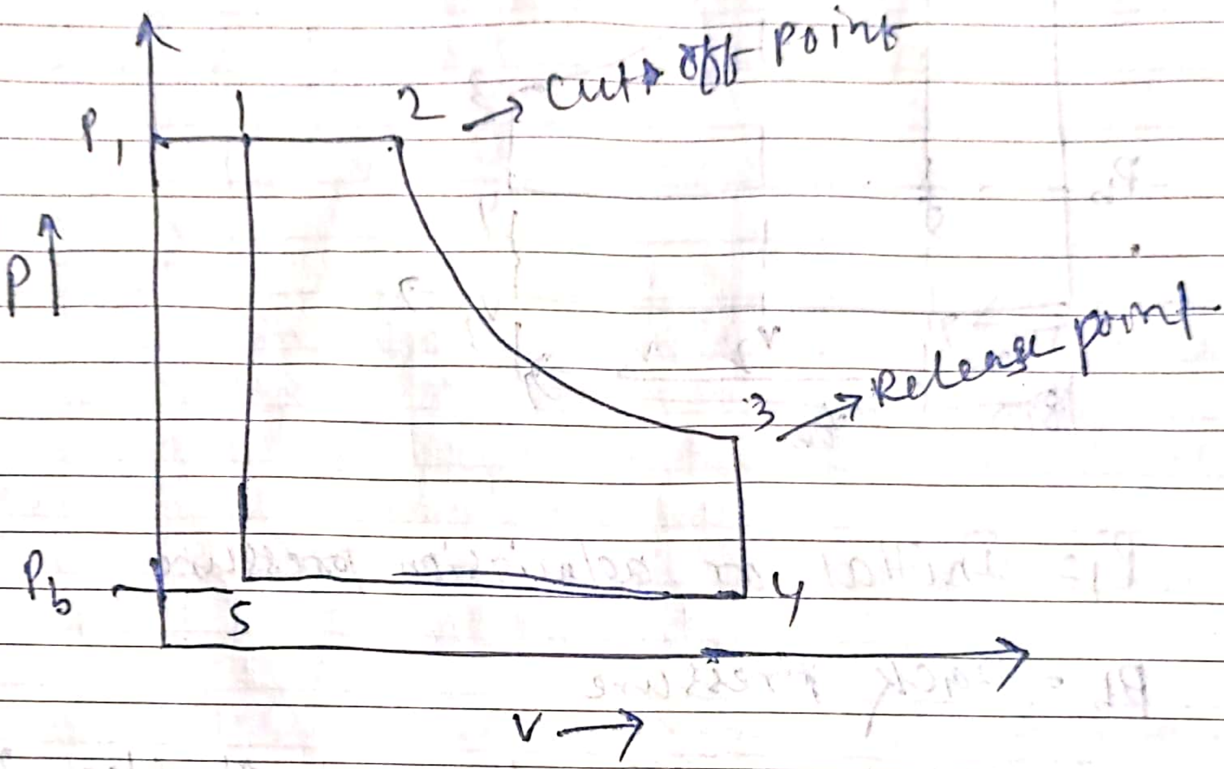
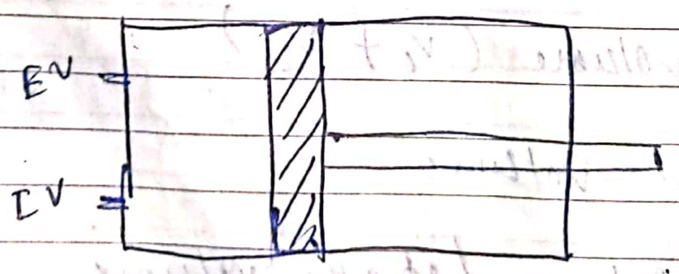
# Indicator Diagram.



**Process - 1-2**

At point 1, the steam is admitted in to the cylinder through the inlet port, As the piston moves towards right, therefore the steam is admitted at constant pressure. Since the supply of steam is cut off at point 2. There fore this point is known as cut-off point.

**Process - 2-3**

At point 2, expansion of steam, in the cylinder, starts with movement of the piston till it reaches the dead end. This expansion takes place hyperbolically (PV=C) and pressure falls considerable as shown in fig. 17.3.

**Process - 3-4**

At point 3, the exhaust port opens and steam is released from the cylinder to the exhaust. As a result of steam exhaust, pressure in the cylinder falls suddebly (with out change in volume) as shown in fig. The point 3 is called Release point.

**Process - 4-5**

At point 4 Return journey of piston starts. Now the used steam is exhausted at constant pressure, till the exhaust port is closed, and the inlet port is open. The steam pressure at point 4 is called back pressure.

Process-5-1

At point 5, the inlet port is opened and some steam suddenly enters in to the cylinder, which increases the pressure of steam (without change in volume). This process continues till the original position is restored.

$$P_1\left(\frac{V_2 - V_c}{V_s}\right) + 2.3\frac{P_1 V_2}{V_s}\log\left(\frac{V_3}{V_2}\right)$$

$= P_1$ R +

$$\frac{c_c}{V_s} v_s + \frac{v_2 - v_c}{v_s} v_2$$

$b = \frac{v_c}{v_s}$

$c = \frac{v_2 - v_c}{v_s}$

$$2.3 P_1\left(\frac{v_2}{v_s}\right).$$

$$\frac{v_c \times v_s}{v_s} - \frac{v_2 - v_c}{v_s}$$

SATURDAY JUNE 17

2017

# Q. working of a Simple steam engine

→ The Superheated steam at a high pressure from the boiler is enters in to the steam chest

→ After that, the steam guided ~~through~~ by the D-slide valve and makes a way in to the cylinder through ~~one~~ any one of ~~two~~ the port.

→ when port 'a' is open, the steams enters to the left side of the piston and forcess it to right.

→ At this stage, the slide valve covers the exhaust port and the other steam port 'b'.

→ when the pressure of steam increases on the left side than, the piston moves to the right.

→ when the piston reaches near the end of the cylinder, it closes the steam ~~at~~ port "a" and exhaust port. The steam port 'b' is now open, and the steam enters to the right side of the piston.

→ This forces the piston in to the left side and at the same time the exhaust steam goes out through ~~exhaus~~ exhaust ~~pipe~~ port. and thus comple the cycle of operation.

SUNDAY 18

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| | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | | | | | | |

(7) Important Terms ~~used~~ in used in Steam Engine.

(1) Bore:- The internal diameter of the cylinder of the engine is known as bore.

(2) Dead centres:- The extreme position of the piston inside the cylinder during its motion are known as dead centres()

~~(a) Inner Dead centres (IDC)~~

~~(b) Outer Dead centres (ODC)~~

(a) Inner Dead centres:
The ~~most~~ Inner most position of the piston is known as I.D.C

(b) Outer Dead centres (O.D.C)
The Outer most position of the piston is called O.D.C.

(3) ~~Clearan~~ Clearance Volume ($V_c$)
The volume of space between the cylinder cover and the piston, when the piston is at IDC position is called ~~clearance~~ clearance volume ($V_c$)

(4) Stroke volume ~~of~~ or Swept volume

The volume swept by the piston when it moves from I.D.C to O.D.C is known as stroke volume ($V_s$). It is also known as piston displacement.

9am

10am

$$V_s = \frac{\pi}{4} \times D^2 \times L$$

11am

D = Internal diameter of the cylinder
L = Length of the stroke.

12.00

1pm

(5) Cut-off volume

~~Theoretically, the steam from the boiler enters the clearance space and~~

2pm

The point or the volume where the cut-off of steam takes place is called the ~~point~~ point of cut-off or cut-off volume.

3pm

4pm

5pm

(6) Average Piston speed

The distance travelled by the piston per unit time is known as average piston speed

6pm

(7) Mean effective Pressure :-

$$P_m = \frac{\text{workdone per cycle}}{\text{Stroke volume}}$$

| 2017 JUL | M | T | W | T | F | S | S | M | T | W | T | F | S | S |
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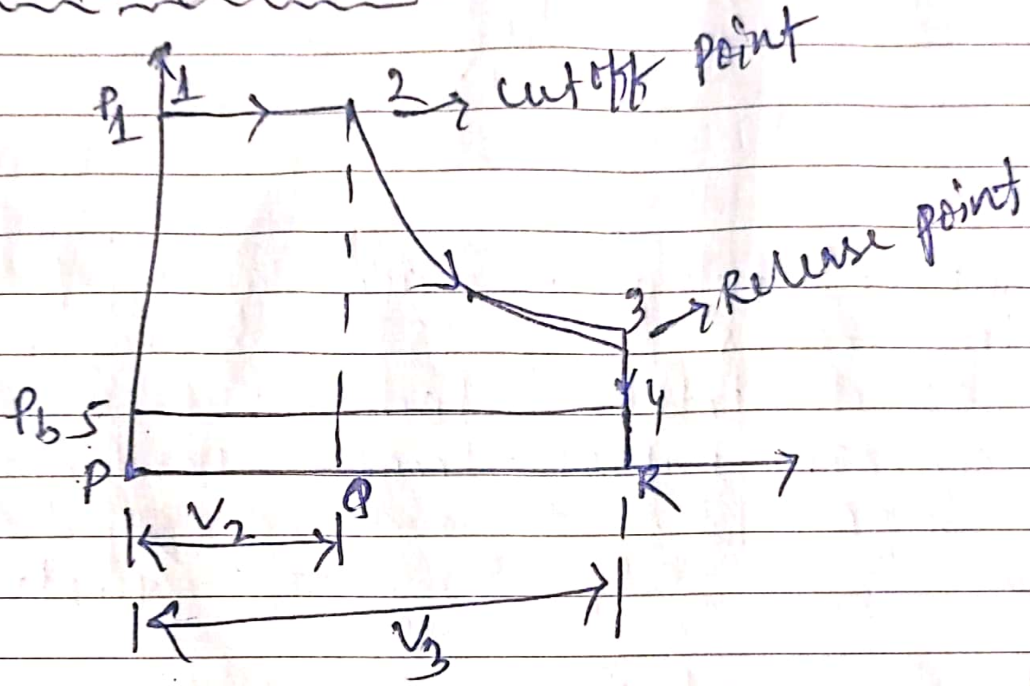
| | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | | | | | | |

① Calculate mean effective Pressure, IHP, BHP? and Mechanical efficiency.

Theoretical or Hypothetical Mean effective Pressure

(1) without clearence




$P_1$ = Initial or admission pressure of steam (or boiler pressure)

$P_b$ = Back pressure (condenser pressure)

$V_2$ = volume of steam in the cylinder at the point of cutoff.

$V_3$ = Stroke volume or swept volume or piston displacement volume.



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we know that, theoritical or ~~hyp~~ hypothetical work done per cycle =

$= \text{Area of figure } 123451$

$= \text{Area of } 12QP + \text{Area of } 23RQ - \text{Area of } 45PR$

$= P_1 V_2 + 2.3 P_1 V_2 \log(V_3/V_2) - P_b V_3$

mean effective pressure $(P_m)$ =

$$= \frac{\text{workdone per cycle}}{\text{stroke volume}}$$

$$= \frac{P_1 V_2 + 2.3 P_1 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b V_3}{V_3}$$

$$= \frac{P_1 V_2}{V_3} + 2.3 P_1 \frac{V_2}{V_3} \log\left(\frac{V_3}{V_2}\right) - P_b$$

= ~~$P_1 r + 2.3 P_1 r (\log(\frac{1}{r})) P_b$~~

= ~~$P_1$~~

$$= \frac{P_1}{r} + 2.3 \frac{P_1}{r} \log r - P_b$$

$$= \frac{P_1}{r}(1 + 2.3 \log r) - P_b$$

$r = \frac{V_3}{V_2}$ = (Expansion Ratio)

$= \frac{\text{volume of steam at the end of stroke}}{\text{volume of steam at the cut-off point}}$

9am

10am

$\frac{1}{r} = \frac{V_2}{V_3}$ = cut off ratio

11am

12.00 **Problem**

1pm A steam engine cylinder receives steam at a pressure of 11.5 bar and cut off
2pm take place at half of the stroke. find the theoritical mean effective pressure. if
3pm the back pressure of the steam is 0.15 bar Neglect clearance.

4pm

$P_1 = 11.5$ bar, $V_2 = 0.5 V_3$, $P_b = 0.15$ bar

5pm

$r = \frac{V_3}{V_2} = \frac{V_3}{0.5 V_3} = r = 2$

6pm

$P_m = \frac{P_1}{r}[1 + 2.3 \log(r) - P_b]$

$= \frac{11.5}{2} \times (1 + 2.3 \log 2) - 0.15$

$= 9.58$ bar

| M | T | W | T | F | S | S | M | T | W | T | F | S | S |
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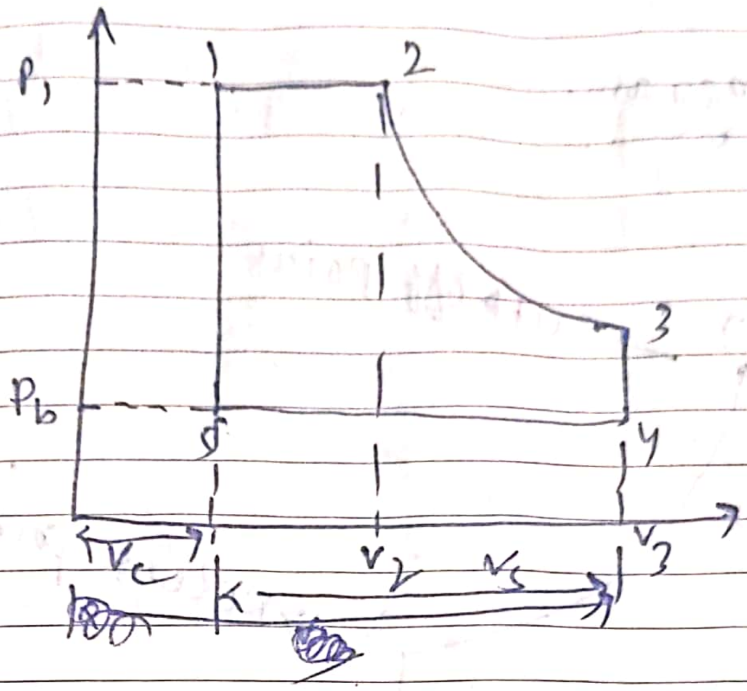
| 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | | | | | | | | |

MAY

## (2) With clearance




$P_1$ = Initial or admission pressure

$P_b$ = Back pressure

$v_2$ = cut off volume (volume of steam in the cylinder at the point of cut off.

$v_3$ = Total volume ($v_c + v_s$)

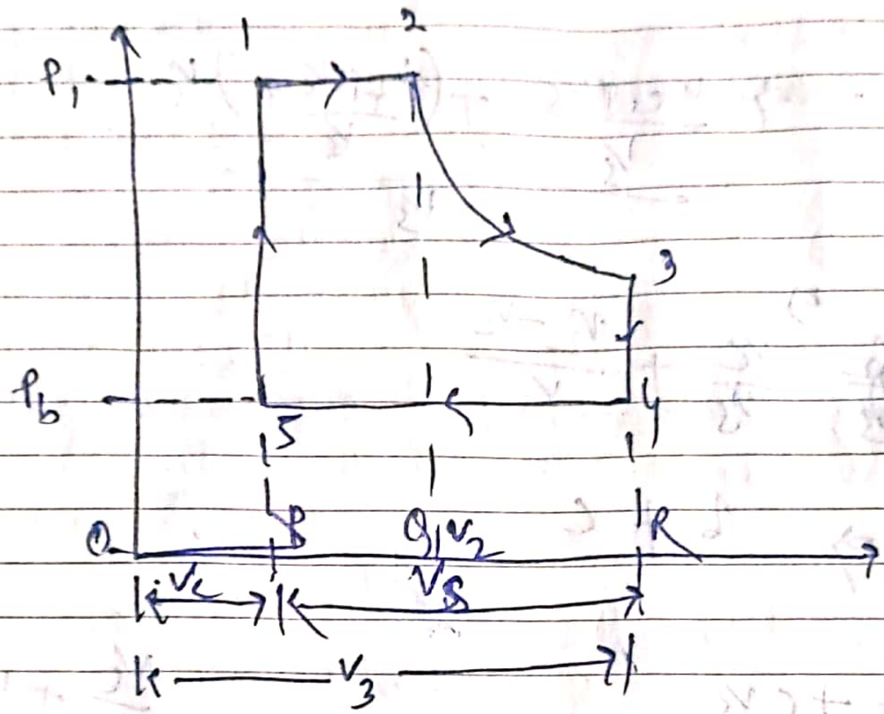
SUNDAY 28

$v_c$ = Clearance volume

$v_s$ = swept volume / stroke volume

$b = \frac{v_c}{v_s}$ , $c = \frac{v_2 - v_c}{v_s}$

## (*) Hypothetical Indicator diagram with Clearance




$P_1$ = Initial and admission Pressure of steam

$P_b$ = Back Pressure

$V_c$ = clearance volume of the cylinder

$V_s$ = stroke volume

$V_3$ = Total volume of steam in the cylinder ($V_c + V_s$)

b> Ratio of ~~volume~~ clearance volume to stroke volume

$$\frac{V_c}{V_s}$$

c> Ratio of volume between the point of admission and cut off of steam to the stroke volume

$$\left( \frac{V_2 - V_c}{V_s} \right)$$

We know that theoritical work done per cycle

= Area ~~under~~ of figure 123451

= Area 12QP + Area of 23RQ − Area of 54RP

$$= P_1 (V_2 - V_c) + 2.3 P_1 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b V_s$$

$$P_m = \frac{\text{work done}}{V_s}$$

SUNDAY 04

$$= \frac{P_1 (V_2 - V_c) + 2.3 \log P_1 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b V_s}{V_s}$$

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$$v_2 = bv_s + cv_s$$

$$= P_1\left(\frac{v_2 - v_c}{v_s}\right) + 2.3\,\frac{P_1 v_2}{v_s}\log\left(\frac{v_3}{v_2}\right) - P_b$$

$$= P_1 c + 2.3 P_1 \left(\frac{v_2}{v_s}\right)\log\left(\frac{v_3}{v_2}\right) - P_b$$

$$= P_1 c + 2.3 P_1 \left(\frac{v_c + v_2 - v_c}{v_s}\right)\log\left(\frac{v_c + v_s}{bv_s + cv_s}\right) - P_b$$

$$= P_1 c + 2.3 P_1\left(\frac{v_c}{v_s} + \frac{v_2 - v_c}{v_s}\right)\log\left\{\frac{v_s\left(\frac{v_c}{v_s}+1\right)}{v_s(b+c)}\right\} - P_b$$

$$= P_1 c + 2.3 P_1 (b + c)\log\left(\frac{b+1}{b+c}\right) - P_b$$

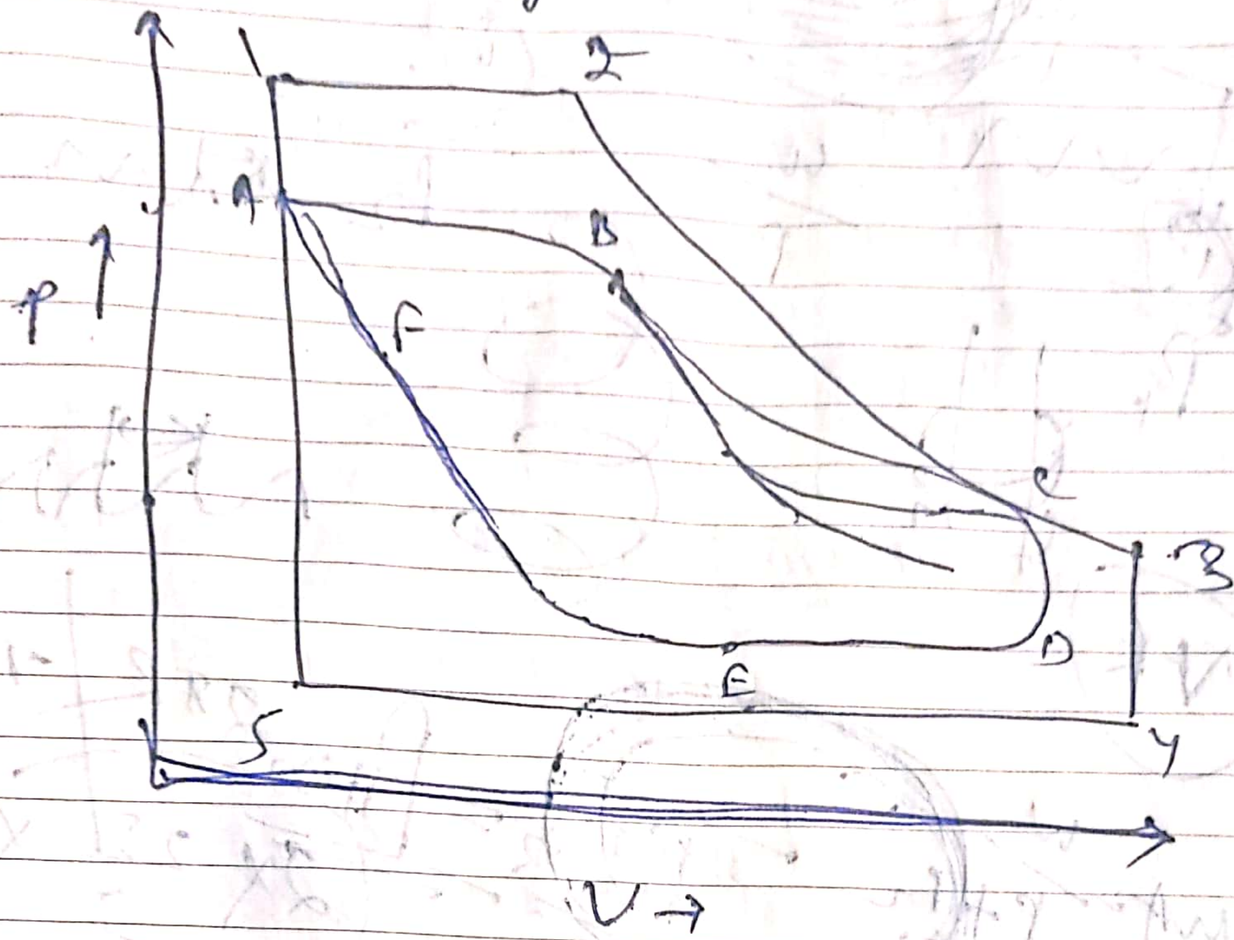
(1) $\frac{v_2}{v_3} = \frac{bv_s + cv_s}{v_c + v_s} = \frac{b+c}{b+1}$ (cut of ratio)

(2) $r = \frac{v_3}{v_2} = \frac{b+1}{b+c}$

(3) $v_c = 0 \Rightarrow b = 0,\ r = \frac{1}{c},\ c = \frac{1}{r}$

$$\frac{P_1}{r} + 2.3\,\frac{P_1}{r}\log\left(\frac{1}{r}\right) - P_b$$

## Actual Indicator Diagram




## Diagram factor (k)

$$k = \frac{\text{Area of actual indicator diagram}}{\text{Area of theoretical indicator diagram}}$$

$$= \frac{P_a}{P_m}$$

$$K = \frac{\text{Actual work done per stroke}}{\text{Theoretical work done per stroke.}}$$

$$P_M = \frac{\text{work done}}{\text{Stroke volume}}$$

$\Rightarrow$ work done = Theoritical m.e.p × swept volume

$$K = \frac{\text{Actual m.e.p } (P_a)}{\text{Theoretical m.e.p } (P_m)}$$

(*) An average value of K lies between 0.65 and 0.9

<u>Power developed</u>

$$P = \frac{\text{work done}}{\text{Time taken.}}$$

## ① Indicated power (I.P)

$$I.P = \frac{P_a LAN}{60} \; W$$

$P_a$ = Actual m.e.p. in $N/m^2$
L = Length of stroke in m
A = Area of cylinder or piston
N = speed of the crank shaft in r.p.m.

$$\frac{2 P_a LAN}{60} \; W$$

~~Others~~

when actual m.e.p is given in bar.

$$I.P = \frac{P_a \times 10^5 LAN}{60} \; W$$

$$= \frac{P_a \times 10^5 LAN}{1000 \times 60} \; kW$$

$$= \frac{P_a \times 10^2 LAN}{60} \; kW$$

$$= \frac{100 \, P_a LAN}{60} \; kW$$

**Double acting**

$$\frac{200 \, P_a LAN}{60} \; kW$$

# Steam-Turbine

## Classification of steam turbine

1. According to mode of steam action.
   - (a) Impulse Turbine
   - (b) Reaction Turbine

2. According to direction of steam flow
   - (a) Axial flow turbine
   - (b) Radial flow turbine

3. According to exhaust condition of steam.
   - (a) Condensing type turbine
   - (b) Non-condensing type turbine

4. According to no. of stages.
   - (a) Single stage turbine
   - (b) Multi stage turbine

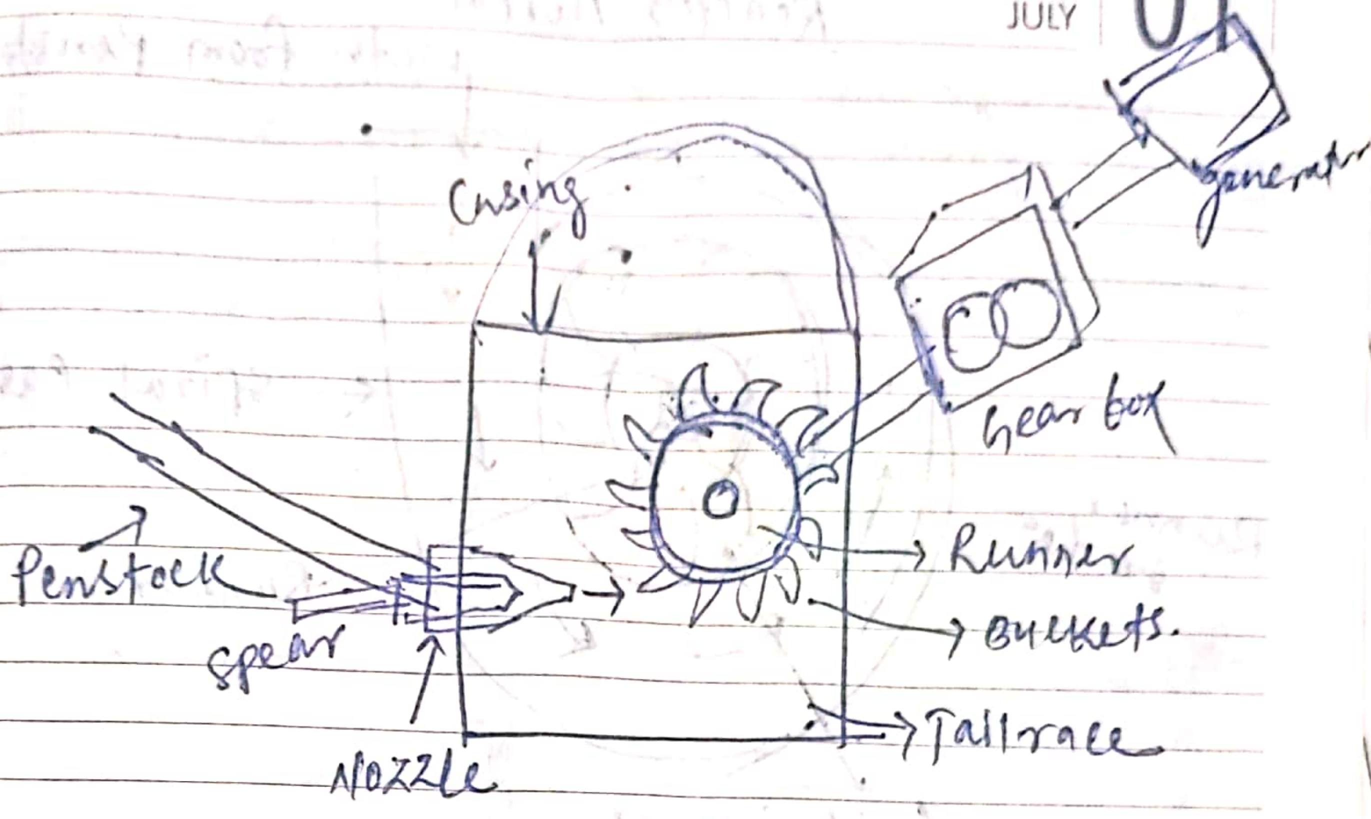
5. According to Pressure of steam.
   - (a) High Pressure
   - (b) Low pressure
   - (c) Medium Pressure

2017

# Impulse Turbine

SATURDAY 01
JULY
182-183 • WK 26

9am
10am
11am
12.00
1pm
2pm




3pm
4pm
5pm
6pm

SUNDAY 02

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# Turbine

## Impulse Turbine.

An Impulse Turbine, as the name indicates, is a turbine which runs by the impulse of steam jet in the turbine, the steam is first made to flow through the nozzle. The steam jet impinges on the turbine blades and are mounted on the ~~Circal~~ circumference of the wheel. The steam jet after ~~impingi~~ impinging glides over the concave surface of the blades and finally leave the turbine.

### ① Nozzle

It is a circular guide mechanism, which guide the steam to flow at the designed direction and velocity. It also regulate the flow of steam. The nozzle is kept very close to the blades, in order to minimise the losses due to windage.

### ② Runner and blades.

The runner of a Impulse turbine essentialy consist of a circular disc fixed to a horizental shaft. On the periphery of the runner, a number of blades are fixed uniformly. The steam jet impinges on the buckets, which move in the direction of the jet. The movement of the blades makes the runner to ratate.

(3) Casing.

It is an air-tight metalic case, which contains the turbine & runner and blades. It control the movement of steam from the blades to the condenser, and doesnot permit it to move into the space. moreover, it is essential to safeguard the runner against any accedent.

## Reaction Turbine.

In reaction Turbine, the steam enters the wheel under pressure and flows over the blades, The steam, while gliding, propels the blades and make them move. As a matter of facts the turbine runner is rotated by the reactives forces of steam jets. The backward motion of the blades is similar to the recoil of a gun. It may be noted that an absolute reaction turbine is rerely used in actual practice.

(1) Casing.

It is an air-tight metalic case, in which the steam from the boiler, under a high pressure and temperature, is distributed around the fixed blades in the casing

The casing is designed in such a way that the steam enters the fixed blades with a uniform velocity

② Guide Mechanism.

It is a mechanism madeup with the help of guides blades, in the form of a wheel. The ~~wheel~~ wheel is generally fixed to the casing, that is why these guide blades are also called fixed blades. The guide blades are properly designed in oodered to -

(i) allow the steam to enter the runner without shock.

(ii) allow the required quantity of steam to enter the turbine.

③ Turbine Runner

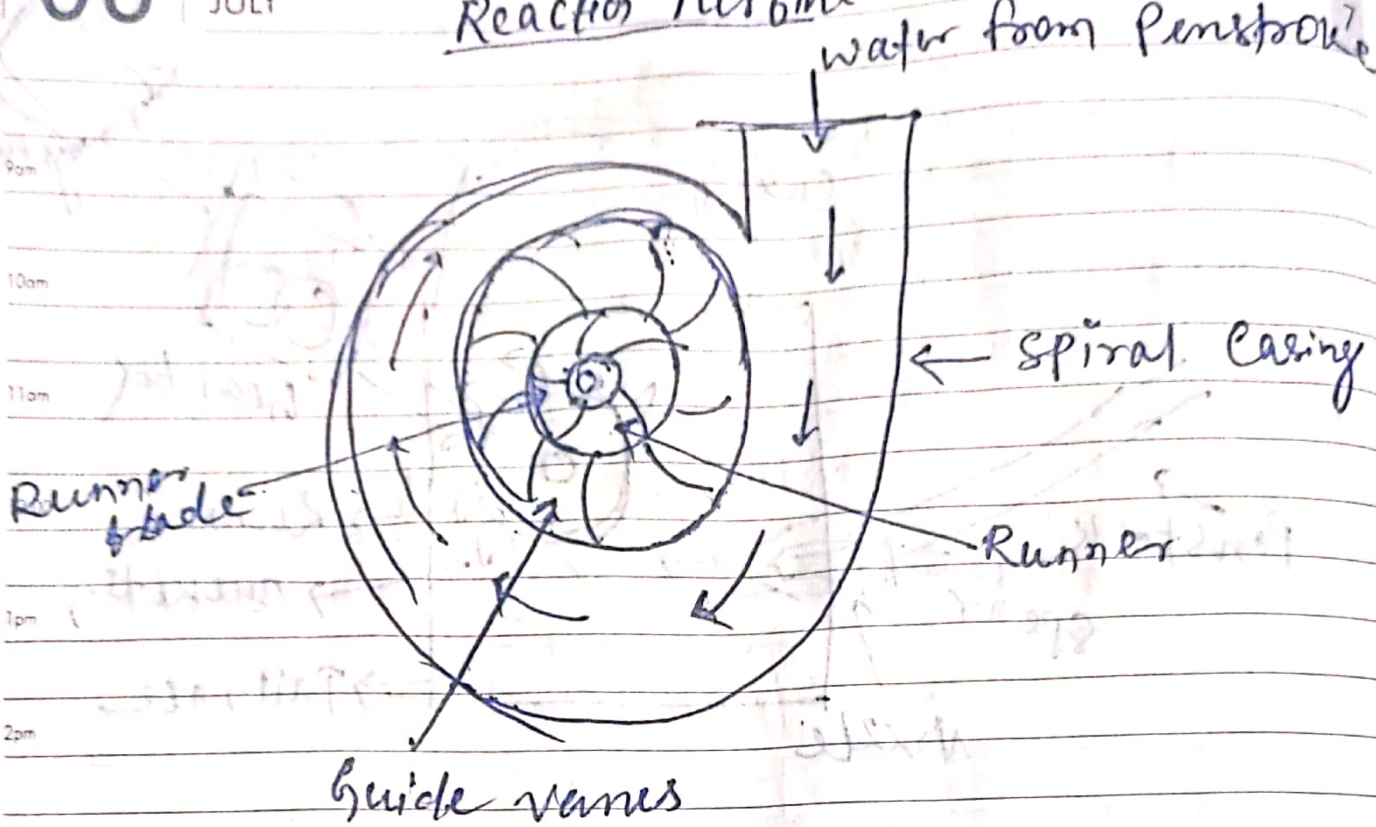
The turbine runner of a Reaction Turbine essentially consist of runner blades fixed to the shaft or rings; depending upon the types of turbine The blades, fixed to the runner, are properly designed in order to allow the steam to enter and leave the runner with out suck.



④ Draft Tube

The steam, after passing through the runner, flow in to the condenser through a tube called ~~draf~~ draft tube. It may ~~be~~ be noted that if this tube is not provided in the turbine.

## Reaction Turbine



then the steam will ~~not~~ moves freely and will causes steam eddies

| Impulse Turbine | Reaction Turbine |
|---|---|
| → The steam flows through the nozzle and impinges on the moving blades. | → The steam flows first through the guide mechanism and then through the moving blades. |
| → The steam impinges on the buckets with kinetic energy. | → The steam guides over the moving vanes with pressure and kinetic energy. |
| → The steam may or may not be admitted over the whole ~~circum~~ circumference | → The steam must be admitted over the whole circumference. |
| → The steam pressure remains constant during its flows through the moving blades. | → The steam pressure is reduced during its flow through the moving blades. |
| → The relative velocity of steam while gliding over the blades remain constant. | → The relative velocity of steam while gliding over the moving blades increases. |

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| | |
|---|---|
| → The blades are symmetrical | → The blades are not symmetrical. |
| → The number of stages required are less for the same power developed. | → The number of stages required are more for the same power developed. |

CH 6

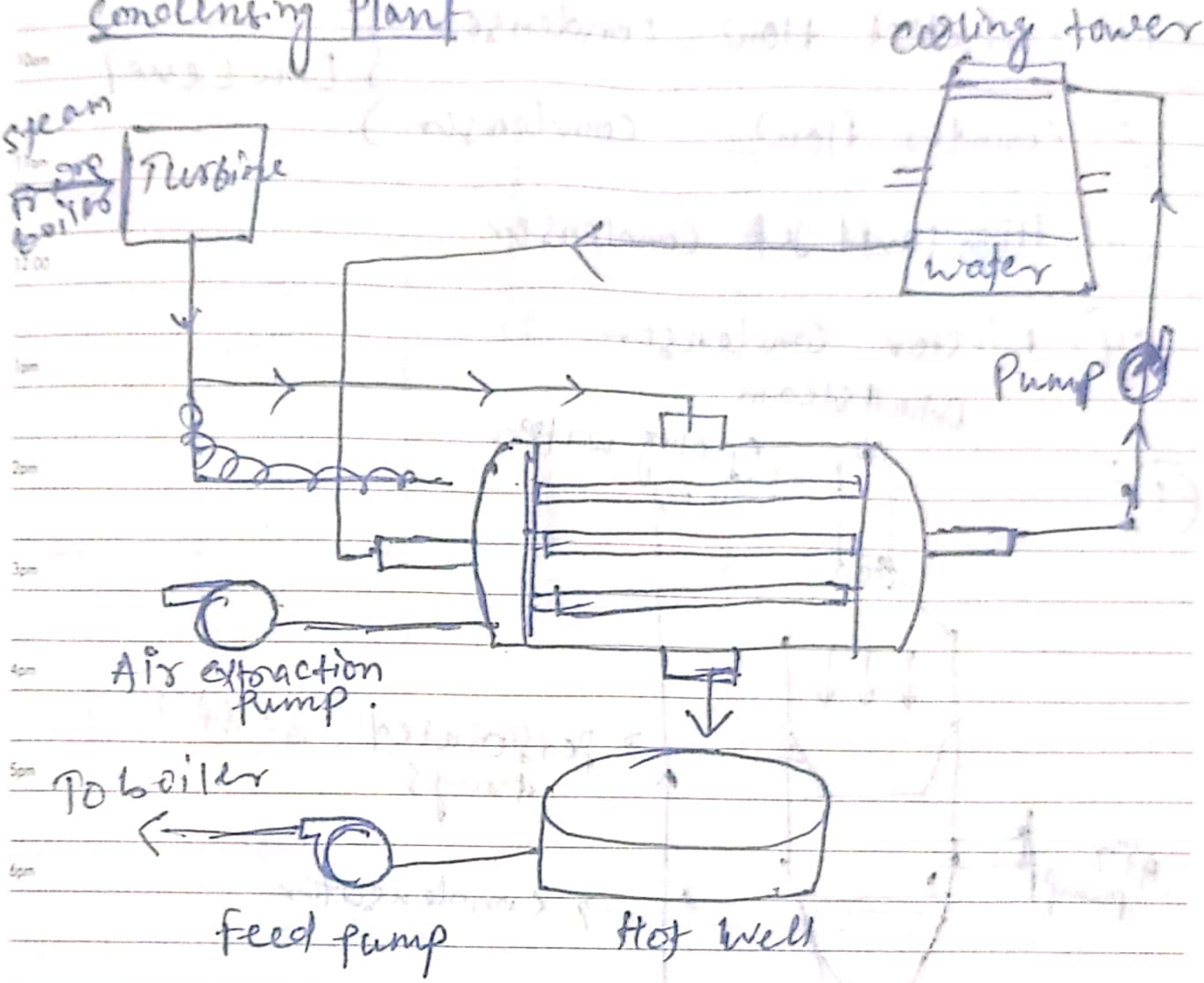
2017

## Condenser

TUESDAY JULY 04

1. Jet condenser or mixing type condenser
2. Surface condenser or non-mixing type condenser

### Condensing Plant



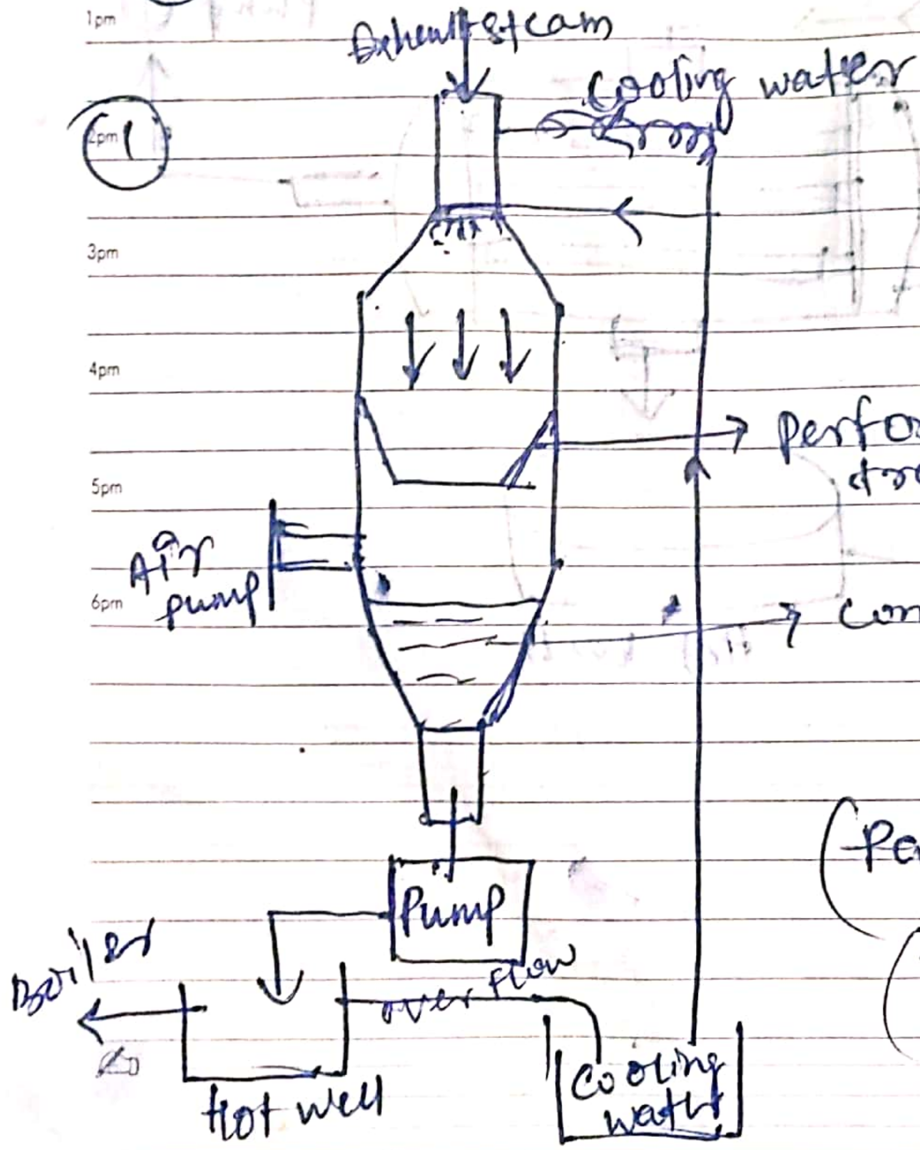
186-179 • WK 27

05 WEDNESDAY JULY 2017

(i) Jet condenser (mixing type)

(1) Parrallel flow condenser } Low Level
(2) Counter flow condenser }
(3) High Level jet condenser
(4) Ejector condenser

(1)




(Parrallel flow condenser)

(pump for cooling not use)

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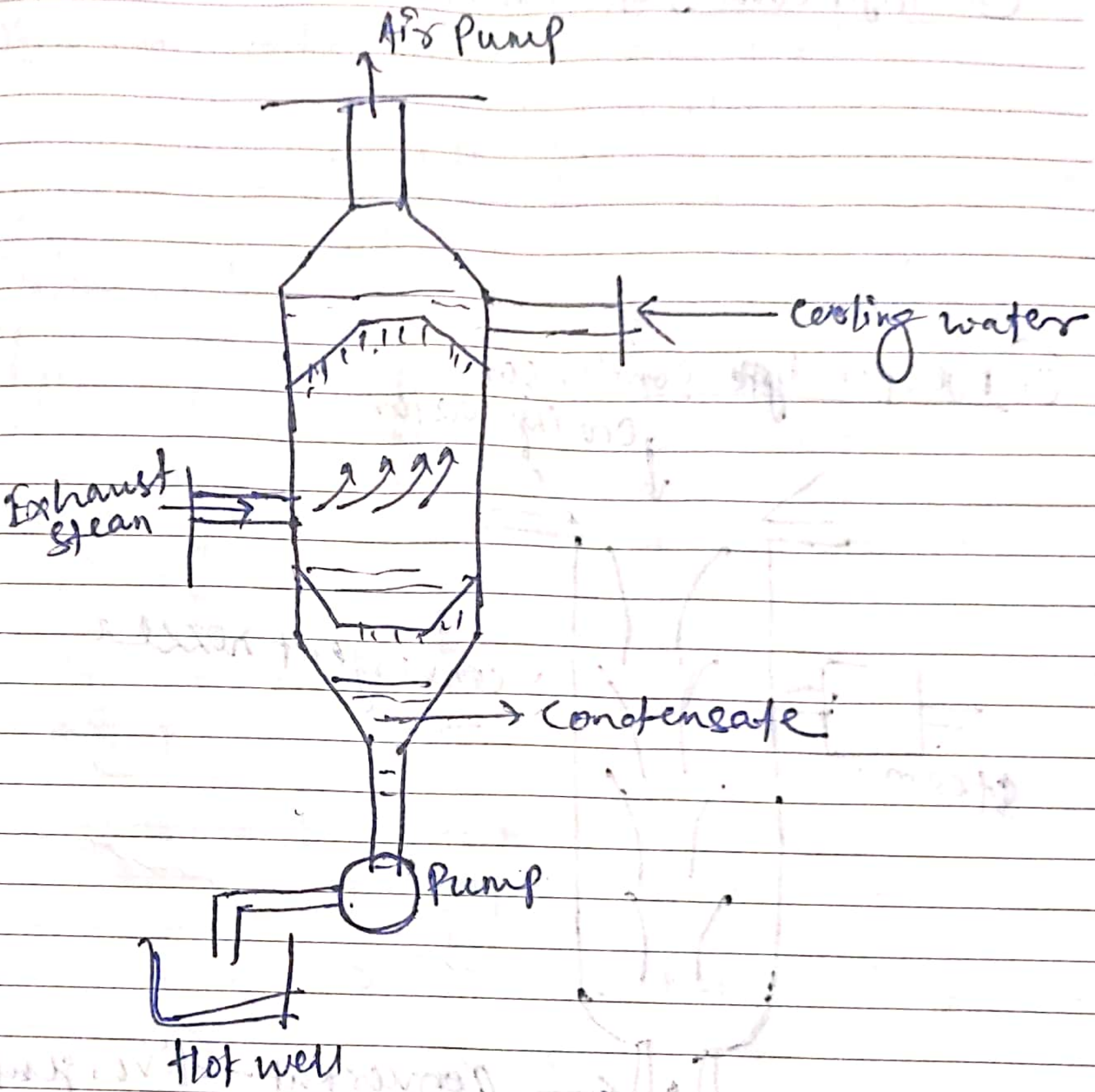
JUL 2017

## (2) Counter flow condenser.

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| | 28 | 29 | 30 | 31 | | | | | | | | | | |

(3) High Level Jet condenser

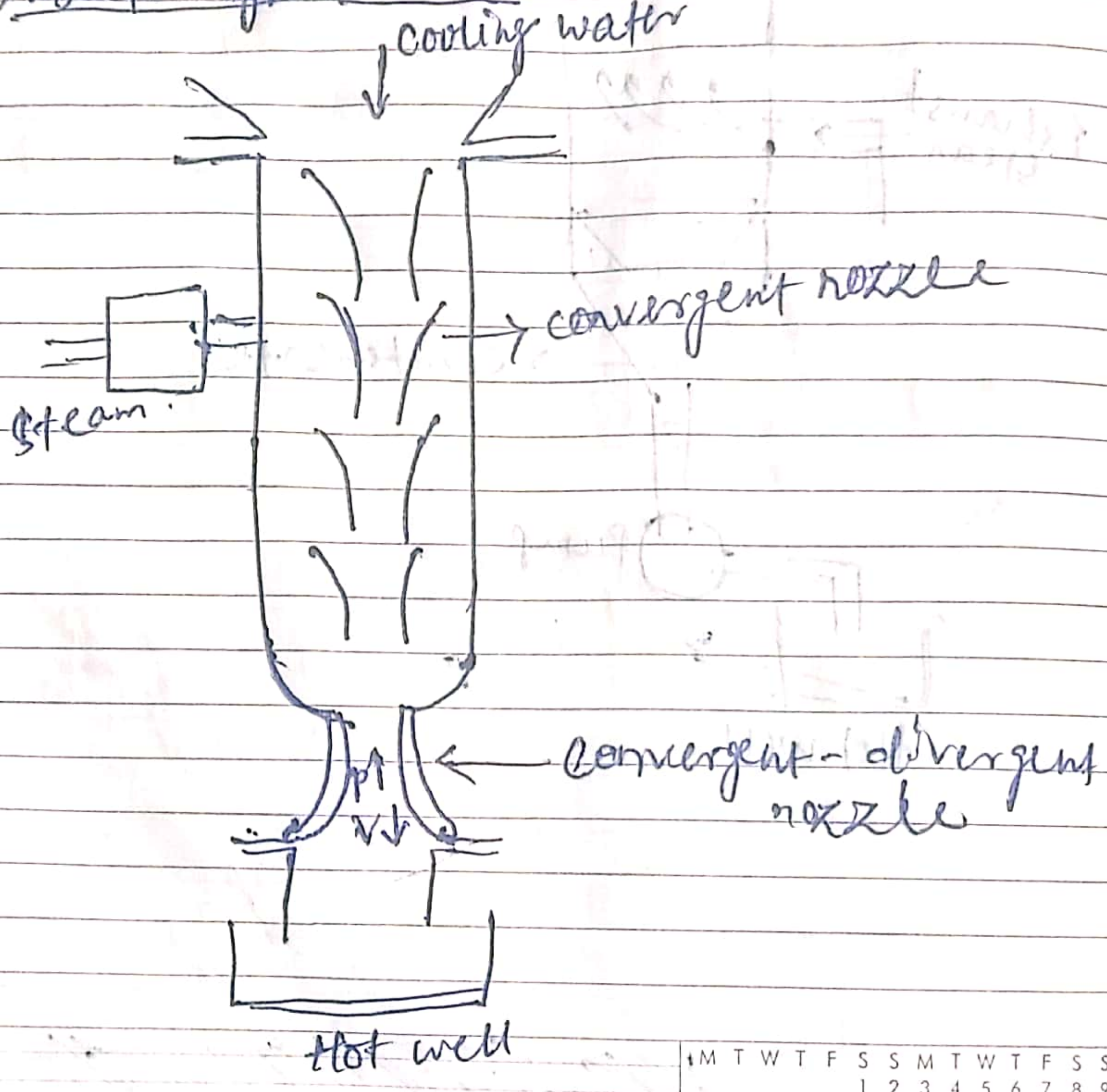
9am

10am

11am

12.00 (4) Ejector type condenser

1pm 2pm 3pm 4pm 5pm 6pm

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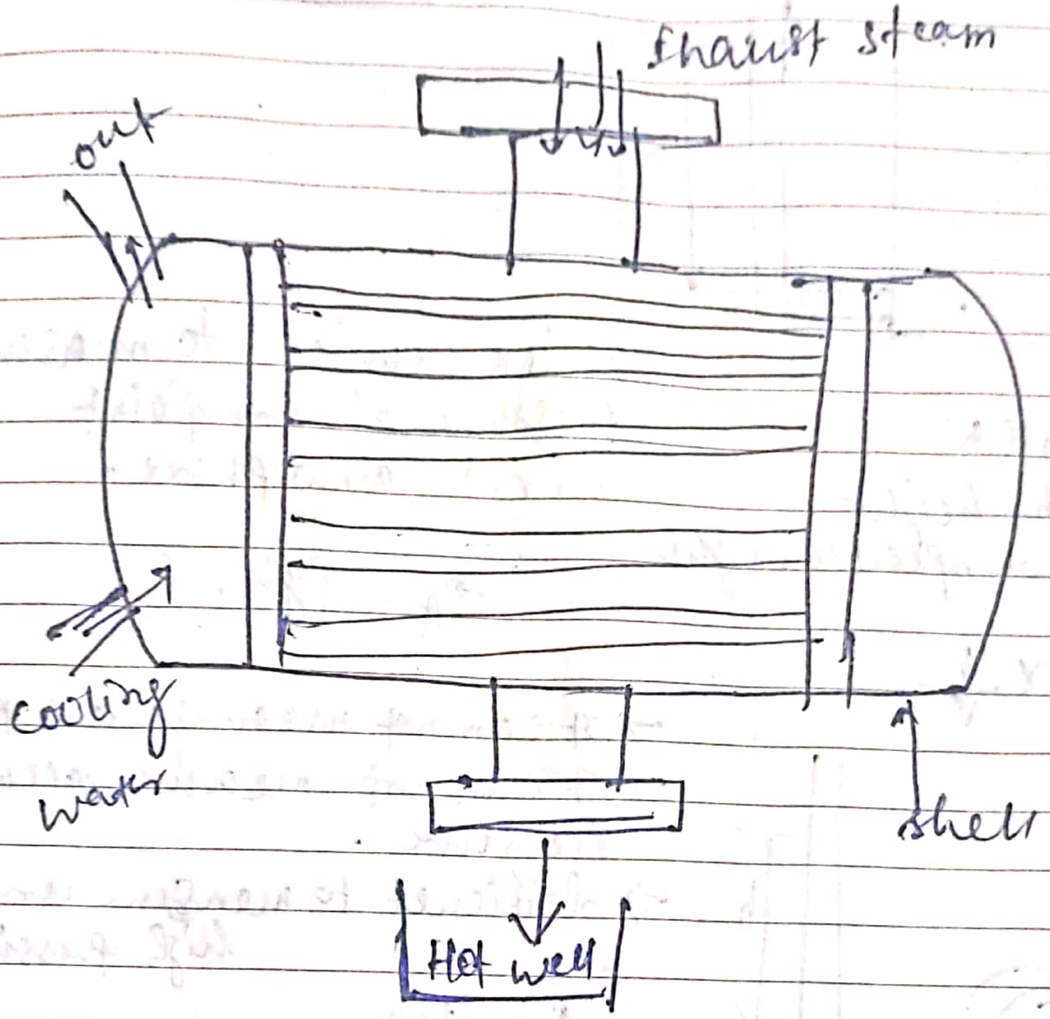
## (4) Surface condenser

### (1) Shell and Tube surface condenser.

9am
10am
11am
12:00
1pm
2pm
3pm
4pm
5pm

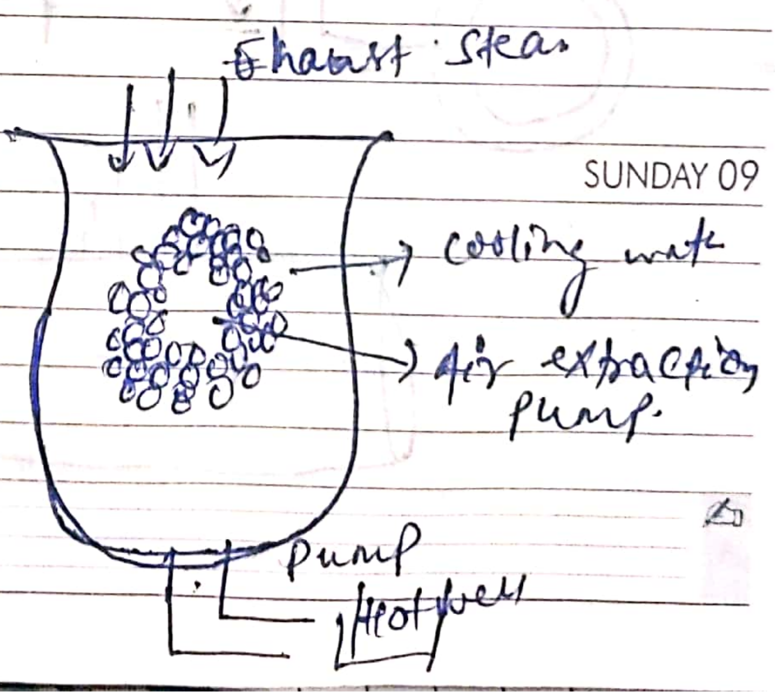



6pm

(2) central flow

(3) down flow



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448, 449, 450, 451



# Steam Condenser

A Steam condenser is a closed vessel into which the steam is exhausted, and condensed after doing work in an engine cylinder or turbine. A steam condenser has the following two object :-

① The primary object is to maintain a low pressure (below atmospheric pressure) so as to obtain the maximum possible energy from steam and thus to secure a high efficiency.

② The secondary object is to supply pure feed water to the hot well, from where it is pumped back to the boiler)

## Jet condensers :-

① Parallel flow jet condensers.

In parallel flow jet condensers, both the steam and water enter at the top, and the mixture is removed from the bottom.

The principle of this condenser is shown in Fig - 20.2. The exhaust steam is condenser when it mixes up with water. The condensate, cooling water and air flow downwards and are removed by two separate pumps known as air pump and condensate pump. Sometimes, a single pump known as wet air pump, is also used to remove both air and condensate. But the former gives a greater vacuum. The condensate pump delivers the condensate to the hot well, from where surplus water flows to the cooling water tank through an overflow pipe.

## Counterflow or Low Level Jet Condensers :-

In counterflow or low level jet condensers, the exhaust steam enters at the bottom, flows upwards and meets the downcoming colling water.

The vacuum is created by the air pump, placed at the top of the condenser shell. This draws the supply of cooling water, which falls in a large number of jets, through perforated conical plate as shown in Fig. [illegible]. The falling water is caught in the trays, from which it escapes in a second series of jets and meets the exhaust steam entering at the bottom. The rapid condensation occurs, and the condensate and cooling water descends through a vertical pipe to the condensate pump, which delivers it to hot well.

## Barometric or High Level Jet Condensers :-

These condensers are provided at a high level with a long vertical discharge pipe as shown in Fig. [illegible]. In high level jet condensers, exhaust steam enters at the bottom, flows upwards and meets the downcoming cooling water in the same way as that of low level jet condenser. The vacuum is created by the air pump, placed at the top of the condenser shell. The condensate and cooling water descends through a virtical pipe to the hot

~~well w·~~
well without the aid of any pump. The surplus water from the hot well flows to the cooling water tank through an overflow pipe.

Enjector condensers

In enjector condensers, the steam and water mix up while passing through a series of metal cones. Water enters at the at the top through a number of guide cones. The exhaust steam enters the condensers through non-retur valve arrangement: The steam and air then passes through the hollow truncated cones. After that it is dragged into diverging cones where its kinetic energy is partly transformed to pressure energy. The condensate and cooling water is then discharged to the hot well as shown in Fig. ·

Surface Condensers

A Surface condenser has a grate advantage over the jet condensers, as the condensate does not mix up with the cooling water. as a result of this whole condensate can be reused in the boiler. this type upf condenser is essential in ships which can carry only a limited quantity of fresh water for the boilers. it is also widly used in land instalations where inferior water is available or the better quality of water for feed is to be used economically.



A surface condenser consist of a horizontal cast iron cylindrical vessel packed with tubes, through which cooling water flows. The ends of the condenser are cut off by vertical perforated types plates into which water tubes are fixed. This is done in such a manner that the leakage of water in to the centre condensing space is prevented. The water tubes passes horizentally through the main condensing space for the steam. The steam enters at the top and is forced to flow downwards over the tubes due to the suction of the extraction pump at the bottom.

The cooling water flows in one direction through the lower half of the tubes and returns in opposite direction through the upper half.

(ii) Down flow surface condenser:

In down flow surface condenser, the exhaust steam enters at the top and flow downwards over the tubes due to force of gravity as well as suction of the extraction pump fitted at the bottom. The condensate is collected at the bottom and then pumped by the extraction pump. The dry air pump suction pipe, which is provided near the bottom, is covered by a baffle so as to prevent the entry of condensed steam in to it.

As the steam flow perpendicular to the direction of flow of cooling water, this is also called a cross-surface condenser.

(x) Central flow surface condenser.

In central flow surface condenser the exhaust steam enters at the top and flow downwards. The suction pipe of the air extraction pump is placed in the ~~centor~~ centre of the tube nest. This causes the steam to flow radially inwards over the tubes towards the suction pipe. The condensate is collected at the bottom and then pumped by the extraction pump.

The central flow surface condenser is an improvement over the down flow types as the steam is directed radially inwards by a volute casing around the tube nest. It ~~thus~~ thus gives an access to the whole periphery of the tubes.

(x) Evaporative condenser.

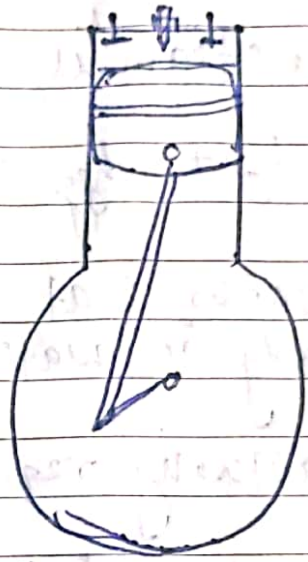
The steam to be condensed enters at the top of a series of pipes outside of which a film of cold water is falling. At the same time, a current of air circulates over the water film, causing rapid evaporation of some of the cooling water. As a result of this, the steam circulating inside the pipe is condensed. The remaining cooling water is collected at a increased temperature and is reused. Its original temp. is restored by the addition of the requisite quantity of cold water. The evaporative condensers are provided when the circulating water is to be used again and again.

# CH-7

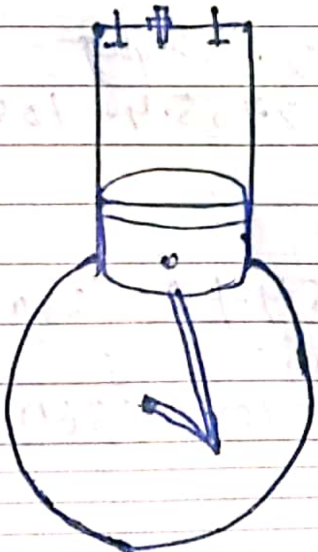
## I.C Engine

1. Suction stroke
2. Compression stroke
3. Expansion stroke
4. Exhaust stroke

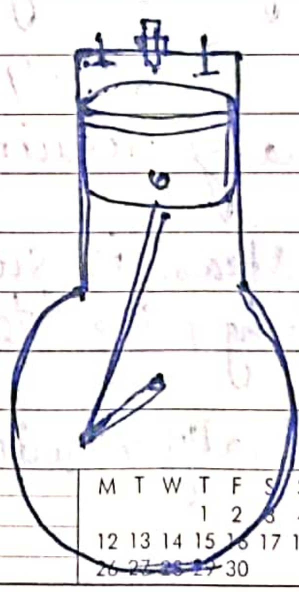
(Suction or Charging stroke)



(compression stroke)

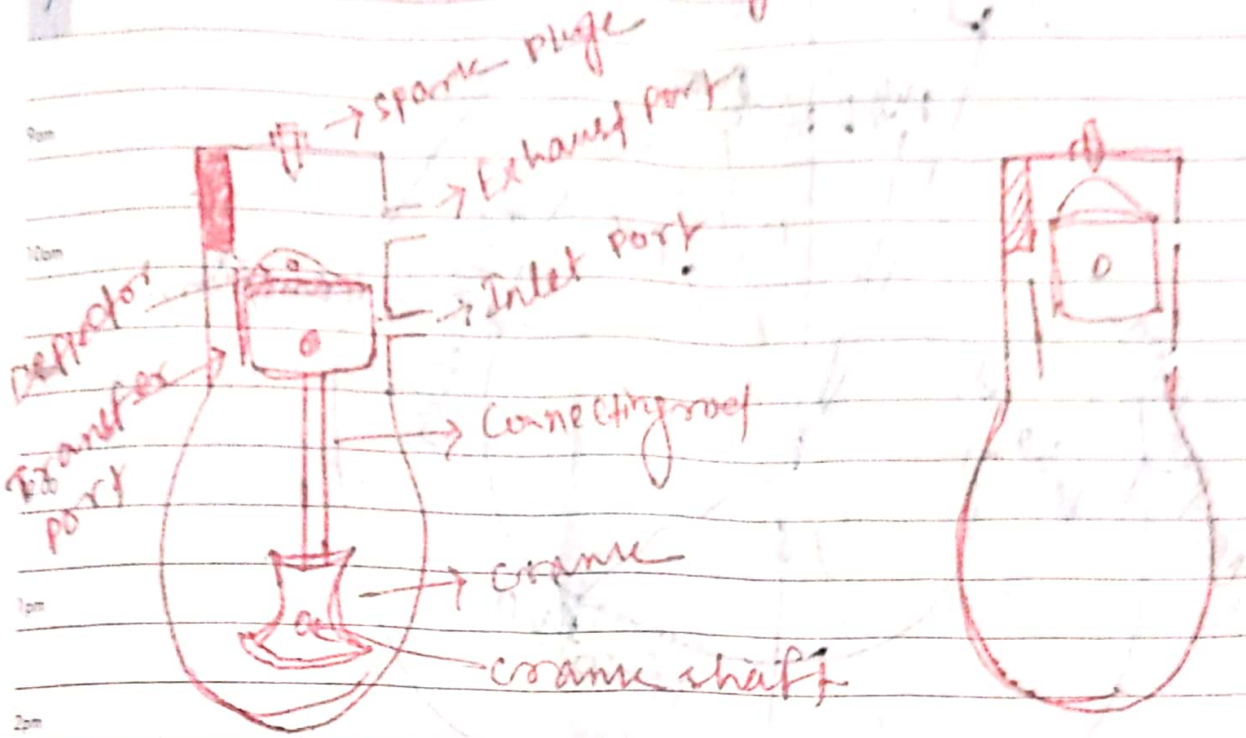


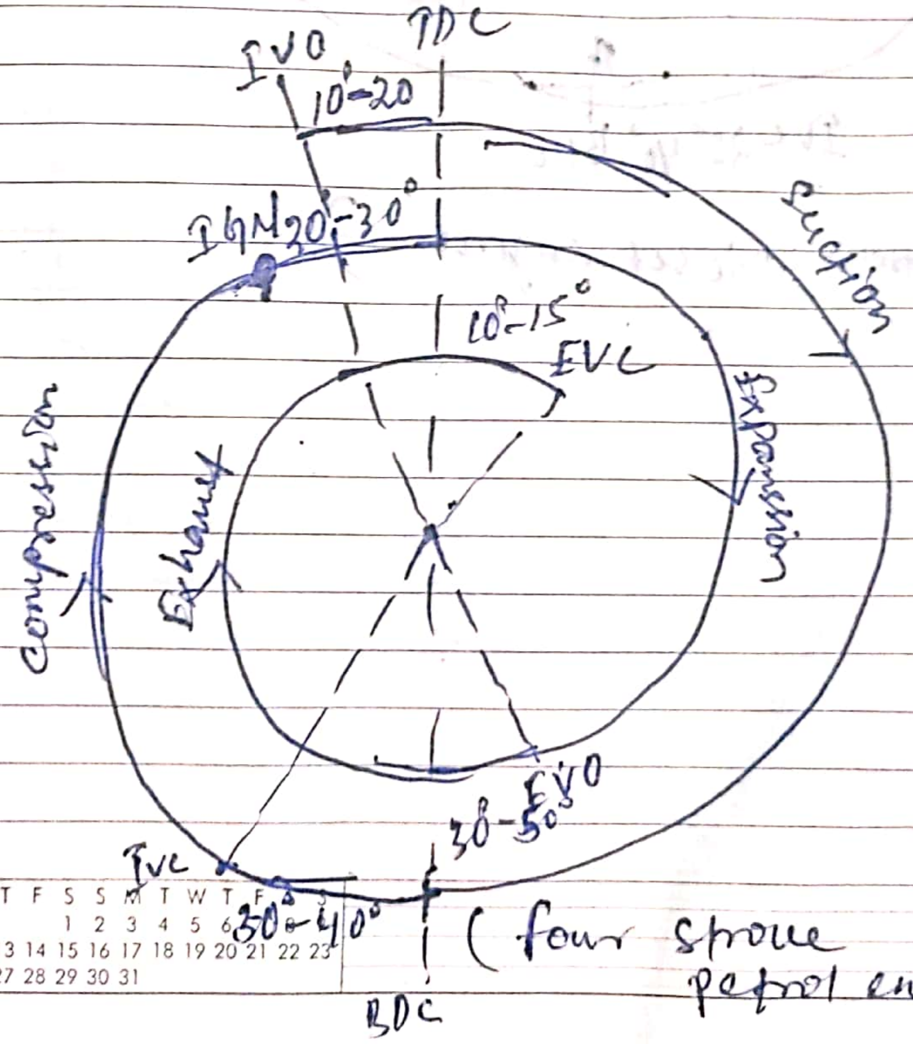
(Expansion or working stroke)



(Exhaust stroke)

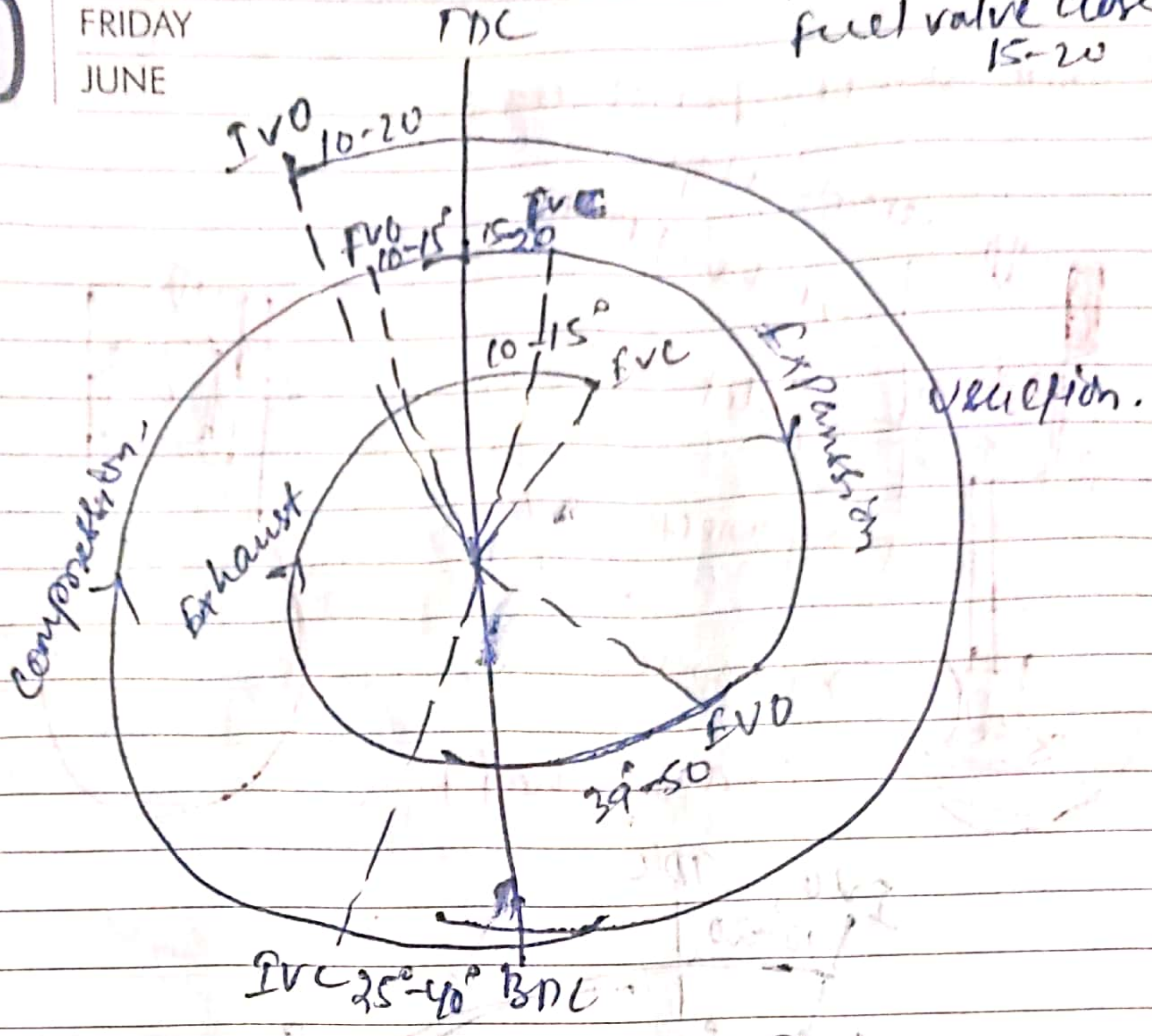
## (R) Two stroke petrol engine.




( four stroke petrol engine )

fuel valve open (10-15)
fuel valve close
15-20




(four stroke Diesel engine)

# Internal Combustion Engine.

Internal Combustion Engines are those engines in which the Combustion of fuel takes place inside the engine cylinder.
These are petrol, diesel, gases engine..

## (4) Main Component of I.C Engine

**(1) Cylinder:-**
It is one of the most important part of the engine, in which the piston moves to and fro in order to develop power.

**(2) Cylinder head:-**
It is fitted one one end of the cylinder, and acts as a cover to close the cylinder bore. Generally the cylinder head contains inlet and and exhaust valve for admitting fresh charge and exhausting the burnt gas.

**(3). Piston:**
It is considered as the heart of the I.C Engine, whose main function is to transmit the force exerted by the burning of charge to the connecting rod.

④ Piston rings.

These are circular rings made of special steel alloy which retain elastic properties even at high temperature. There are two set of rings mounted for the piston. The function of the upper rings is to provide air tight seal to prevent leakage of the burnt gases in to the lower piston. Similarly, the function of the lower rings is to provide effective seal to prevent leakage of the oil in to the engine cylinder.

⑤ Connecting rod.

It is the link between the piston and the crankshaft, whose main function is to transmit force from piston to the crankshaft.

⑥ Crankshaft

It is considered as the backbone of IC Engine whose function is to connect the reciprocating motion of the piston to the rotary motion with the help of connecting rod.

⑦ Crank case

It is a cast iron case, whose holds the cylinder and the crankshaft of an I.C Engine.

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(4) Four-stroke Petrol Engine.

It requires four stroke of the piston to complete one cycle of operation in the engine cylinder. The four stroke of a petrol engine sucking fuel-air mixture are describe bellow-

(i) Suction or charging stroke.

In this stroke, the inlet valve opens and charge is sucked into the cylinder as the piston moves downward from T.D.C. It continues till the piston reaches its B.D.C

(ii) Compression stroke

In this stroke, bothe the inlet and exhaust valve are closed and the charge is compressed as the piston moves upwards from B.D.C To T.D.C. As a result of compression, the pressure and temperature of charge increases considerably. This complete one revolution of the crank shaft.

(iii) Expanssion or Working stroke.

Shortly before the piston reaches T.D.C the charge is ignited with the help of a spark plug. It suddenly increases the pressure and temperature of the products of combusation but the volume, practically remains constant. Due to the rise in pressure, the piston is pushed down with a



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great force. The hot burnt gases expands due to high speed of piston. In this stroke both the valve are closed and the piston moves from T.D.C to B.D.C.

(iv) Exhaust Stroke.

~~opd~~ in this stroke, the exhaust valve is open as piston moves from BDC to T.D.C. This movement of piston pushes out the product of combusation from engine cylinder and are exhaust through the exhaust valve in to the atmosphere. This complete the cycle, and the engine cylinder is read to suck the charge again.

(*) Two-stroke cycle petrol engine.

In this cycle, the suction, compression, expansion, and exhaust ~~take~~ take place during two stroke of the piston. It means that there is one working stroke after every revolution of the crank shaft. A two stroke engine has port instead of valve.

(1) Suction stage

In this stage, the piston, while going down ~~[illegible]~~ ~~[illegible]~~ towards BDC, uncovers both the ~~[illegible]~~ transfer port and exhaust port. The fresh fuel-air mixture

Flows into the engine cylinder from the crank case,

(ii) Compression Stage:

In this stage, the piston while moving up, first covers the transfer port and then exhaust port. After that the fuel is compressed as the piston moves upwards. ~~[crossed out]~~ In this stage the inlet port opens and the fresh fuel-air mixture ~~[crossed out]~~ enters in to the crank case.

(iii) Expansion stage.

Shortly before this piston reaches the TDC the charge is ignited with the help of a spark plug. It suddenly increases the pressure and temperature of the products of combustion. But the volume, practically, remains constant. Due to raise in pressure, the piston is pushed downwards with a great force. The hot burnt gas expands due to high speed of piston. During this expansion, some of the heat energy produced is transformed in to mechanical work.

(iv) Exhaust stage.

In this stage, the exhaust port is opened as the piston moves downwards. The products of combustion, from the engine cylinder are exhaust through the exhaust port in to the atmosphere.

Ch-8
# HYDROSTATICS

## Propertis of fluid

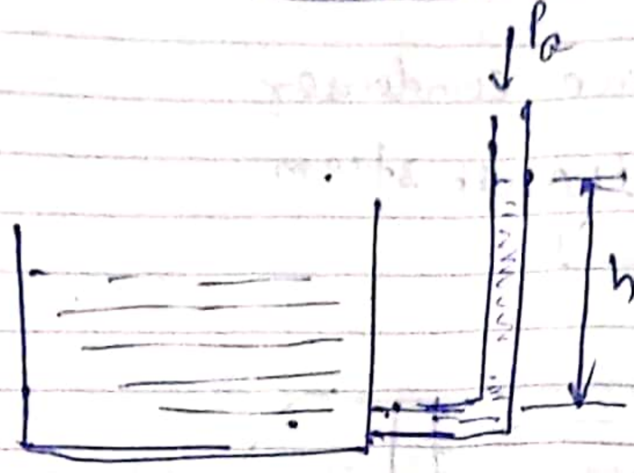
The basic Propertis of fluid are

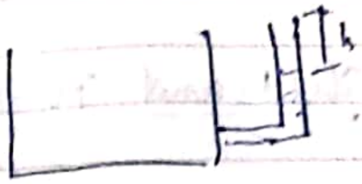
(1) Density
(2) specific weight
(3) specific volume
(4) specific gravity
(5) Incompressibility
(6) Viscosity
(7) cohesion
(8) Adhesion
(9) surface tension
(10) capillarity
(11) Vapour pressure

10 MONDAY
JULY



# Piezometer




9am

10am

11am

12.00

It is a device to measure pressure at any point w.r.t atmosphere.

$P = h \times w$

h = height
w = specific weight

1pm

$P_A = \rho g h$.

2pm

$P = h \times \frac{W}{V}$

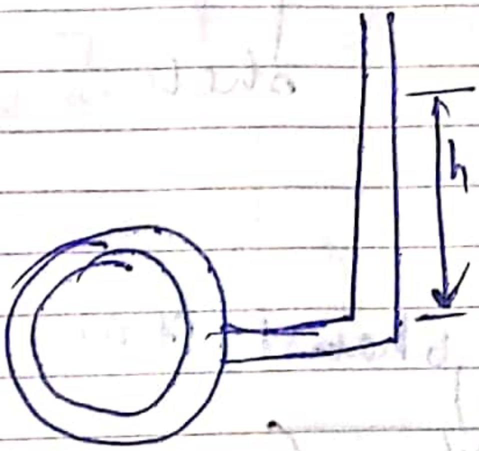
3pm

→ It can not measure gas pressure
→ It can not measure vaccume pressure.
→ difficult to measure very high pressure.

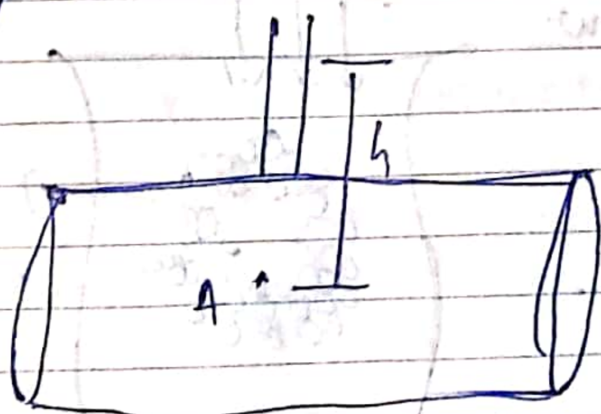
4pm

$P = wh$

5pm




6pm

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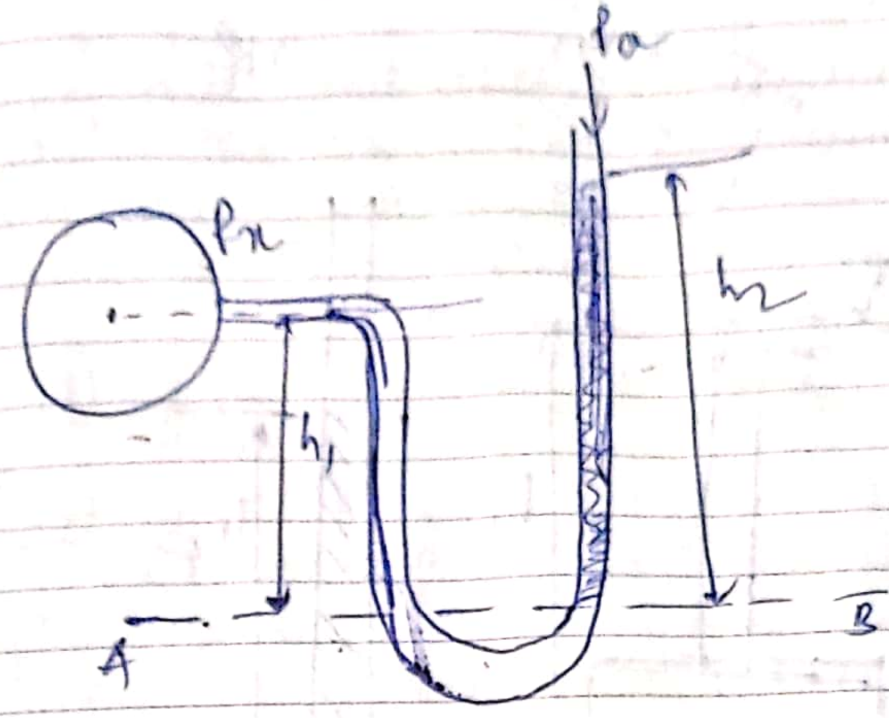
| 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | | | | | | |

JUL 2017

# U-Tube Manometer




$P_2 = P_a + w_2 h_2$

$P_1 = P_x + w_1 h_1$

$P_x + w_1 h_1 = w_2 h_2$

$P_x = w_2 h_2 - w_1 h_1$

$\frac{P_x}{w} =$

~~$-(w_1 h_1 + w_2 h_2)$~~

$P_x = w_2 h_2 - w_1 h_1$

$\frac{P_x}{w} = \frac{w_2}{w} h_2 - \frac{w_1}{w} h_1$

$P_x + \rho_1 g h_1 = P_a + \rho_2 g h_2$

$$\boxed{\frac{P_x}{w} = S_2 h_2 - S_1 h_1}$$

$\Rightarrow P_x =$

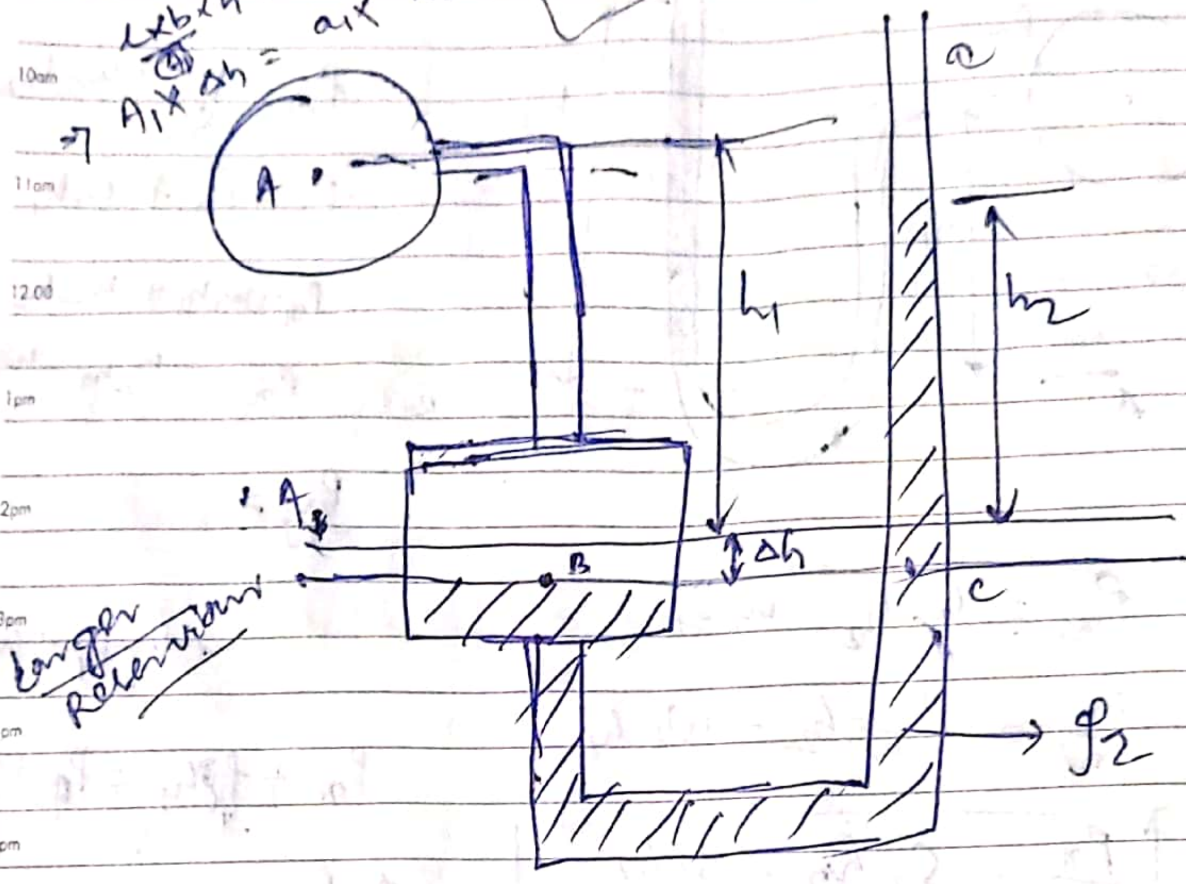
$\frac{P_x}{w} = -(S_1 h_1 + S_2 h_2)$

# Single Column (Tube) Manometer.

Volume Reservoir = Volume pipe

$L \times b \times h = L \times b \times h$

$A_1 \times \Delta h = a_1 \times h_2 \Rightarrow \boxed{\Delta h = \frac{a_1 h_2}{A_1}}$




$P_B = P_C$

$\Rightarrow P_A + \rho_1 g (h_1 + \Delta h) = \rho_2 g (h_2 + \Delta h)$

$P_A = \rho_2 g \Delta h + \rho_2 g h_2 - \rho_1 g h_1 - \rho_1 g \Delta h$

$P_A = \rho_2 g h_2 - \rho_1 g h_1 + \Delta h (\rho_2 g - \rho_1 g)$

# (x) Measurement of fluid Pressure

## (1) Piezometer

Piezometer tube is the simple form of a pressure measuring instrument by which pressure head of a liquid contained in a vessel can be directly measured.

Piezometer consist of a glass tube which is open at both ends. One end is connected to the vessel containing a liquid whose pressure head or intensity of pressure is required to be found out. The other end of the glass tube is exposed to the atmospher.

### Limitation of a Piezometer.

(i) Piezometer cannot be used to measure very high pressure of a liquid, because in that case a long glass tube will required

(ii) Since one end of the piezometer is exposed to atmosphere, it cannot be used to measure negative pressure (i.e. pressure below atmospheric pressure)

## (2) Simple Manometer

Simple manometer is an improved variety of piezometer used for measuring both high pressure and negative pressure of fluid.

Simple manometer consist of a U-tube made a glass. The manomatric liquid Mercury is used in simple manometer. One end of the U-tube is connected to the vessel containing the liquid whose intensity of pressure is to be measured and the other end is exposed to the atmosphere.

The pressure of the liquid contained in the vessel will force the manometric liquid in the left hand vertical limb of the U-tube downwards and will force the manometric liquid rise up in the right hand vertical limb of the U-tube through equal distance.


If the pressure of the liquid in the vessel is less than atmospheric pressure, the deflection of manometric liquid will be observed in the left hand limb of the U-tube.

226-139 • WK 33

14 MONDAY AUGUST

2017

(1) Bourdon tube Pressure gauge.

⇒ Bourdon tube Pressure gauge consist of a circular spring tube, called Bourdon tube. The Bourdon tube is made up of special quality Bronze and is oval in cross-section.

⇒ One end of the Bourdon tube is closed and connected to link. and the other end is ~~secured~~ secured in vertical tube.

⇒ The Link connects the closed end of the Bourdon tube to a toothed sector. The toothed sector gears ~~which~~ with a pinion which is mounted on a central spindle carrying a pointer.

⇒ The pointer moves on a dial graduated in pressure unit

⇒ The Pressure gauge is connected to the vessel Connecting fluid under Pressure. Due to

15 TUESDAY

fluid Pressure in the Bourdon tube, it has a tendency to assume a circular section. But before the tube can do so, it must straighten itself. The

| M | T | W | T | F | S | S | M | T | W | T | F | S | S | |
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| 28 | 29 | 30 | 31 | | | | | | | | | | | |

→ This tendency of straightening moves the free end of the Bourdon tube outwards. As a result, the toothed sector moved about the hinge and cause the pinion to rotate, which, in turn, moves the pointer to move on a dial graduated in bar.

## (2) Diaphragm Pressure gauge.

In Diaphragm Pressure gauge, the Bourdon tube of the ~~[illegible]~~ Bourdon pressure gauge is replaced by a corrugated diaphragm. When the fluid enters in to ~~a~~ the diaphragm, it causes its elastic deformation which is converted in to rotational of motion of a pinion carrying a pointer which moves ~~in~~ on a dial ~~[illegible]~~ graduated in pressure unit.
Diaphragm pressure gauge is used to measure comparatively Low pressure.

214-151 • WK 31

02 WEDNESDAY
AUGUST

2017

(7) Bourdon Tube Pressure gauge.

9am

10am

11am

12.00

1pm

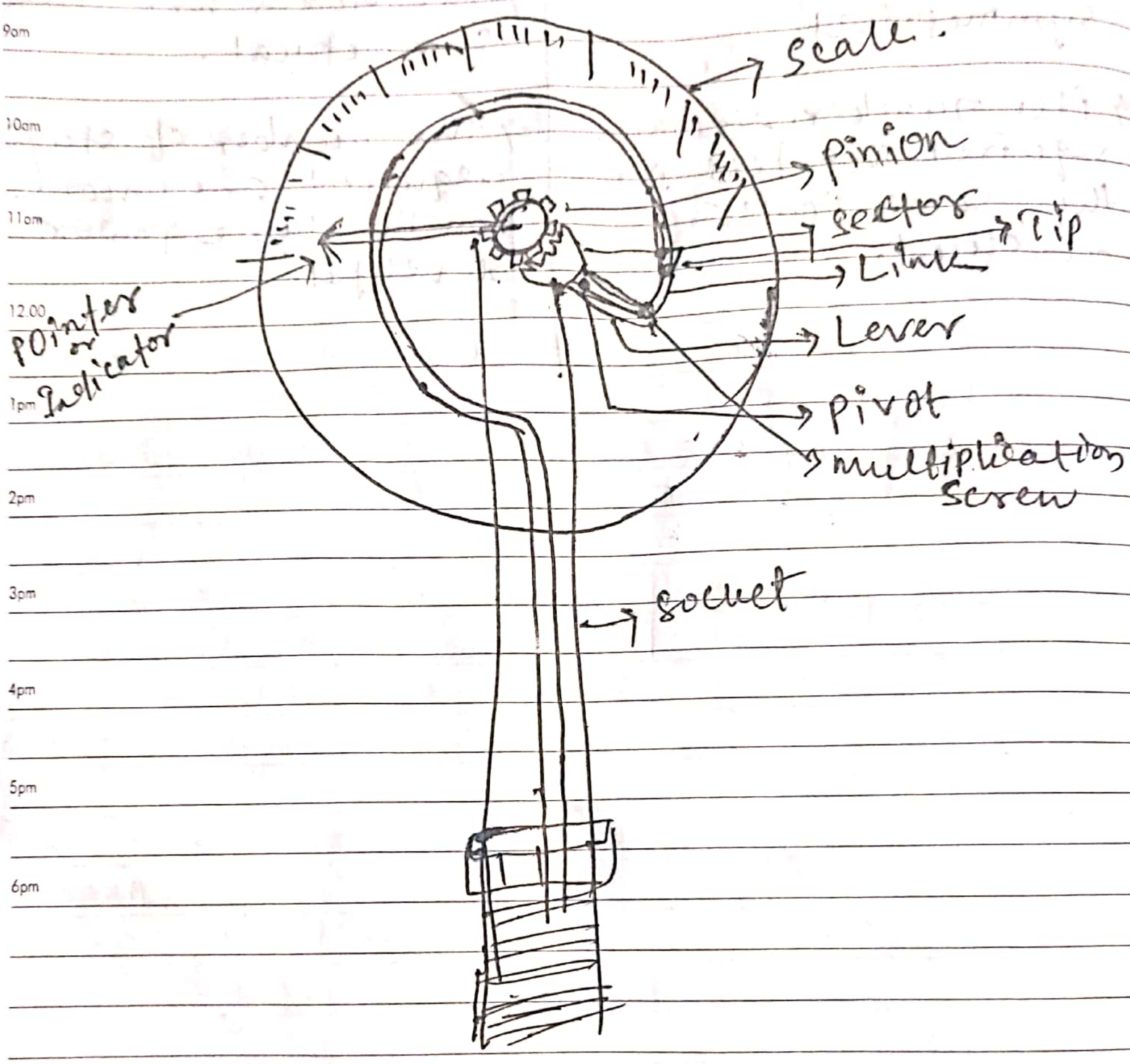
2pm

3pm

4pm

5pm

6pm

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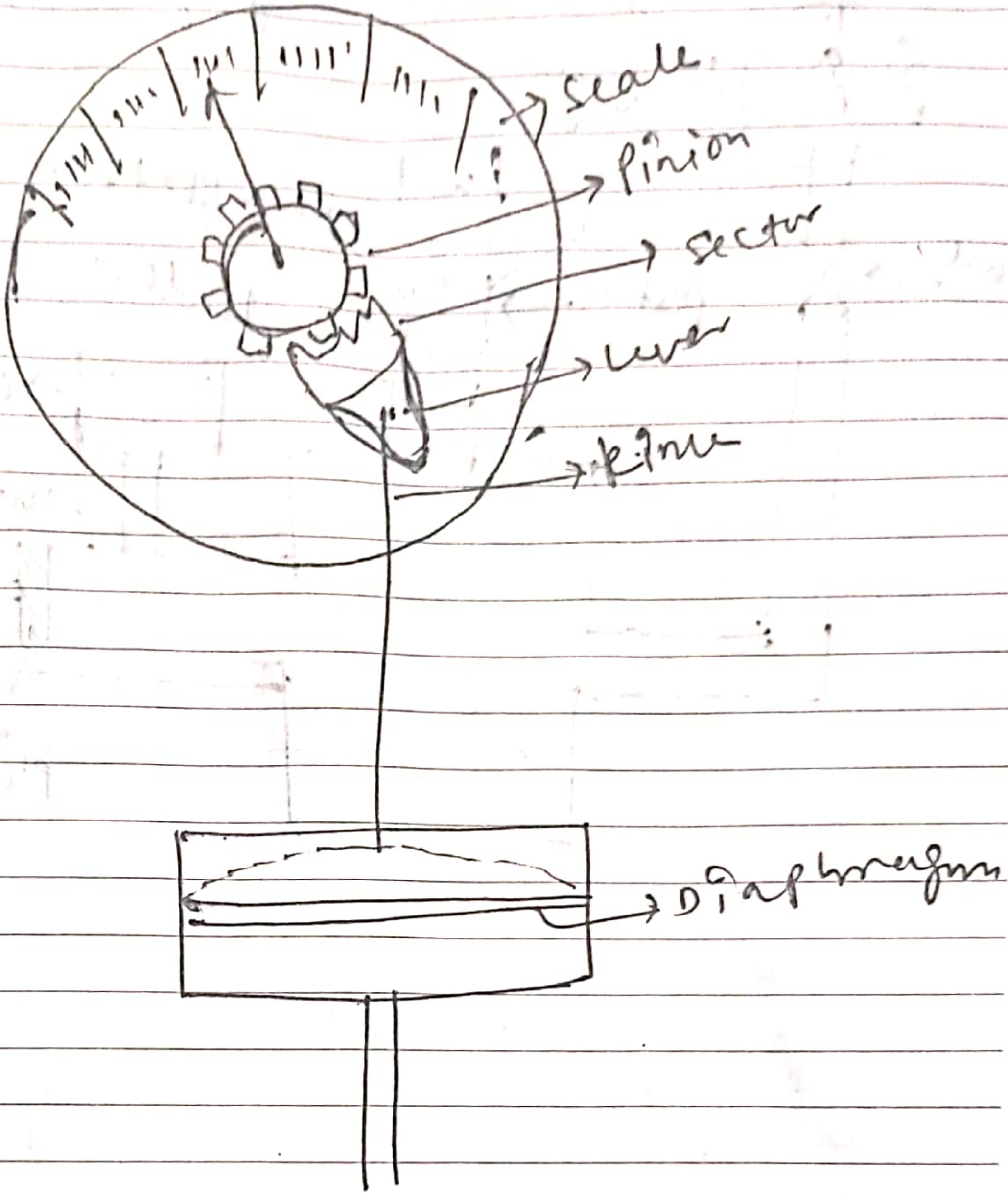
| 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | | | | | | | | |

④ Diaphragm pressure gauge

9am
10am
11am
12.00
1pm
2pm
3pm
4pm
5pm
6pm

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| | 25 | 26 | 27 | 28 | 29 | 30 | | | | | | | | |

## Dead weight Pressure gauge.

9am

10am

11am

12.00

1pm

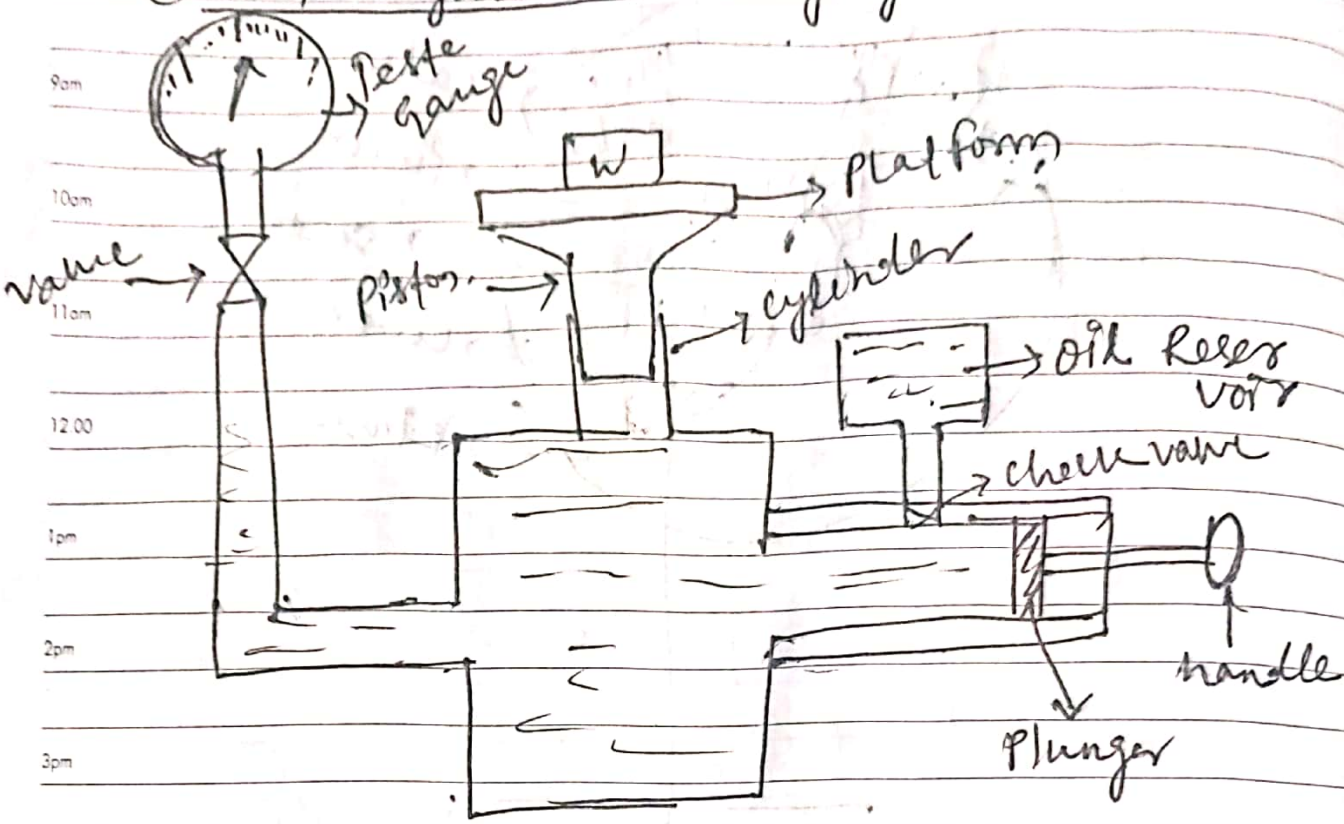
2pm

3pm

4pm

5pm

6pm



# CH-9
## HYDROKINETICS

**Compressible flow**

9am Compressible flow is that flow in which density of the fluid is different at differen
10am section of the path of fluid.
Compressible flow occurs when a gas
11am flow through a pipe line

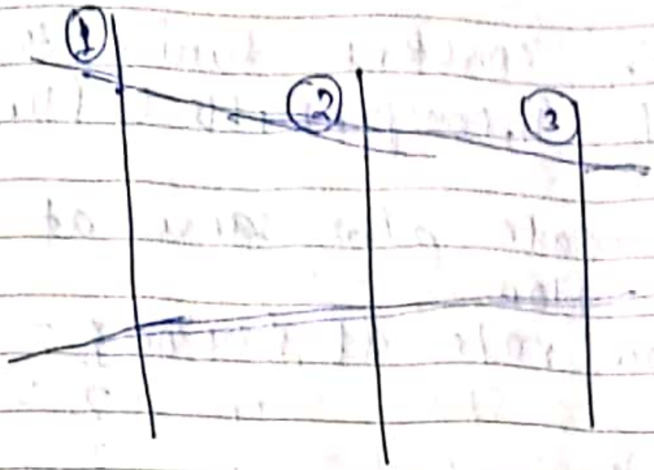
12.00 **Incompressible flow.**
Incompressible flow occurs when a liquid
1pm flow through a pipe line.
Incompressible flow is that type of flow
2pm in which density of the fluid does not change at any section in the path of flow.
3pm

**Continuity eqn.**
4pm

① Theorem of continuity for Incompressible fluid.
5pm

This theorem states that for a perfect
6pm incompressible fluid flowing continuously from one section to another, the discharge rate is the same at any section in its path of flow, provided no fluid is added to or subtracted from the flowing liquid

## Explanation




Let an incompressible fluid (i.e liquid) flow through a pipeline whose diameter is not constant.

Let $a_1$ = cross-sectional area of pipe at section 1
$a_2$ = ,, ,, ,, at section 2
$a_3$ = ,, ,, ,, at section 3

$V_1$ = Velocity of flow at section 1
$V_2$ = ,, ,, ,, at section 2
$V_3$ = ,, ,, ,, at section 3

Then, discharge through section 1 = $a_1 V_1$
,, ,, ,, 2 = $a_2 V_2$
,, ,, ,, 3 = $a_3 V_3$

Thus:- discharge through section 1 = discharge through section 2 = discharge through section 3.

$$a_1 V_1 = a_2 V_2 = a_3 V_3$$

As density remain constant during the flow of ( in case of Incompressible fluid flow

thus mas flow rate also same at any section in its path flow.

Thus - mass flow rate at section 1 =
" " " " 2 =
" " " " 3

$$a_1 v_1 \rho_0 = a_2 v_2 \rho = a_3 v_3 \rho.$$

(*) **Theorem of continuity for compressible fluid**

This theorem States that for a Compressible fluid flowing contineously from one section to another, the discharge is different at different sections depending upon the pressure acting on the fluid.

**Explanation**

for compressible fluid (i.e for gas), density of the fluid is different at different section depending up on the pressure of the fluid.

Let -

$\rho_1$ = density of the fluid at section 1

$\rho_2$ = " " " " " " 2

$\rho_3$ = " " " " " " 3

Then mass flow rate of the fluid through section 1 ≠ mass flow rate of the fluid through section 2 ≠ mass flow rate of the fluid through section 3.

$$a_1 v_1 \rho_1 \neq a_2 v_2 \rho_2 \neq a_3 v_3 \rho_3$$

⑧ <u>Energy in flowing fluid.</u>

① Potential Energy → $= mgh = wh = wZ$

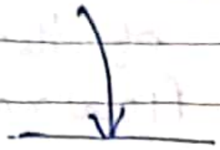
② Kinetic Energy → $\frac{1}{2}mv^2 = \frac{1}{2}\frac{w}{g}v^2$

③ Pressure Energy. $= \frac{PW}{w}$

W = Weight of fluid
w = specific weight of fluid
P = Pressure

① **Potential energy / (datum energy)**

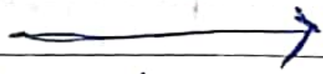
9am
Potential Energy is the energy possessed by a fluid body by virtue of its position with respect to some arbitrary horizontal line called datum line.
10am
11am



12.00
1pm
$P.E = mgh$.
$= Wh$
2pm
$W =$ weight
3pm
$m =$ mass of fluid
$g =$ gravitational force
4pm
$h =$ height
5pm

② **Kinetic Energy**

6pm
Kinetic Energy is the energy possessed by a liquid body by virtue of its motion



$K.E = \frac{1}{2} mv^2$ $m =$ mass, $v =$ velocity

$= \frac{1}{2} \frac{W}{g} v^2$

(3) Pressure Energy

Pressure energy is the energy possessed by a fluid body by virtue of its existing pressure

9am

10am

$P.E = \frac{PW}{w}$

11am

W = weight of fluid

12.00

w = specific weight of fluid

P = pressure

1pm

2pm

3pm

4pm

5pm

6pm

SUNDAY 13

| 2017 SEP | M | T | W | T | F | S | S | M | T | W | T | F | S | S |
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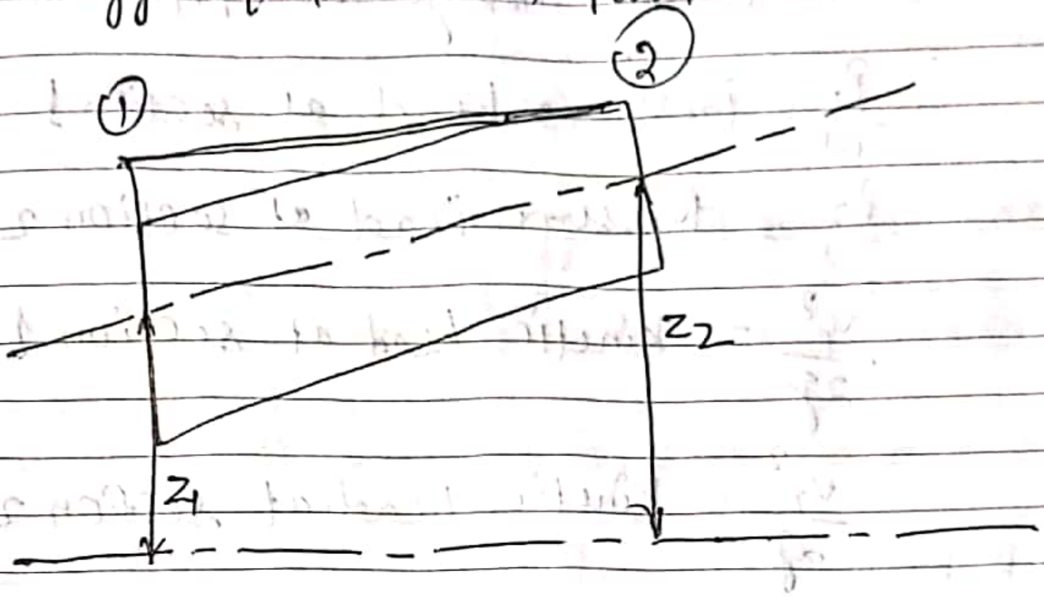
Bernoulli's eqn

Bernoulli's theorem states that for a perfect incompressible fluid flowing from one section to another in a contineous stream, the total energy of the fluid particle remain constant.

9am 10am 11am 12.00 1pm 2pm 3pm




4pm 5pm 6pm

According to Bernoulli's theorem, we get the following equation:

$$\frac{P_1}{w} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{v_2^2}{2g} + Z_2$$

$P_1$ = Intensity of pressure at section 1
$P_2$ = intensity of pressure at section 2

$V_1$ = Velocity of flow at section 1
$V_2$ = Velocity of flow at section 2

$Z_1$ = height of section 1 above the datum

$Z_2$ = height of section 2 above the datum

$w$ = specific weight of the liquid flowing through the pipe.

$\frac{P_1}{w}$ = Pressure head at section 1

$\frac{P_2}{w}$ = Pressure head at section 2

$\frac{V_1^2}{2g}$ = kinetic head at section 1

$\frac{V_2^2}{2g}$ = kinetic head at section 2.

Example

water is flowing ~~through~~ down through a pipe ~~which~~ whose diameter gradually decreases from 30 cm at A, 4.5 m above the datum line to 15 cm at B 1.5 m above datum. The pressure at A is 1.2 bar and velocity of flow at A is 3 m/s. assuming that there is no loss between A and B then find the pressure at B.

Applying ~~Berno~~ Bernoulli's eq$^n$ -

$$\frac{P_1}{w} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{v_2^2}{2g} + Z_2.$$

$P_1$ = Intensity of Pressure at A
$= 1.2 bar = 1.2 \times 10^5 \, N/m^2$

$P_2$ = Intensity of pressure at B

$w$ = Specific weight of water $= 9810 \, N/m^2$

$v_1$ = velocity of flow at A = 3 m/s

$v_2$ = velocity of flow at B = ?

According to theorem of continuity

$a_1 v_1 = a_2 v_2$

$a_1 = \frac{\pi}{4} \times (0.3)^2 \, m^2$.

$a_2 = \frac{\pi}{4} \times (0.15)^2 \, m^2$

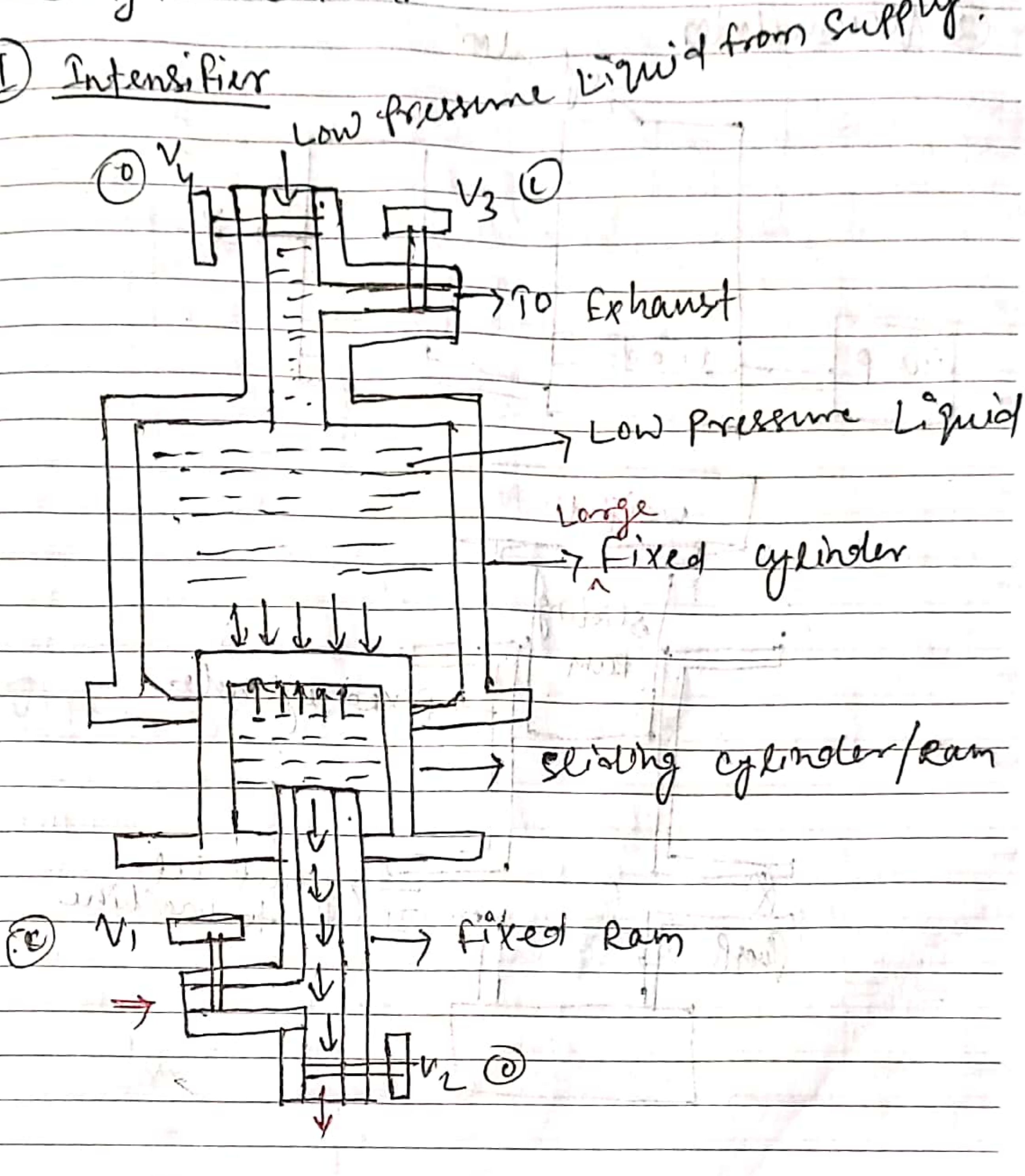
$\therefore \frac{\pi}{4} \times (0.30)^2 \times 3 = \frac{\pi}{4} (0.15)^2 \times v_2$

$v_2 = 12 \, m/s$

# CH-10

1. Intensifier
2. Hydraulic lift
3. Accumulator
4. Hydraulic Ram.

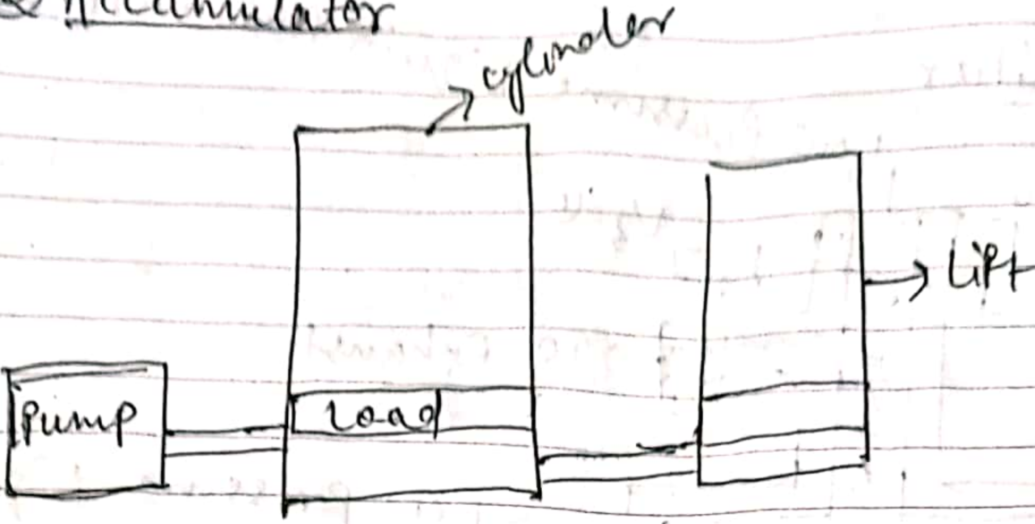
## 1. Intensifier

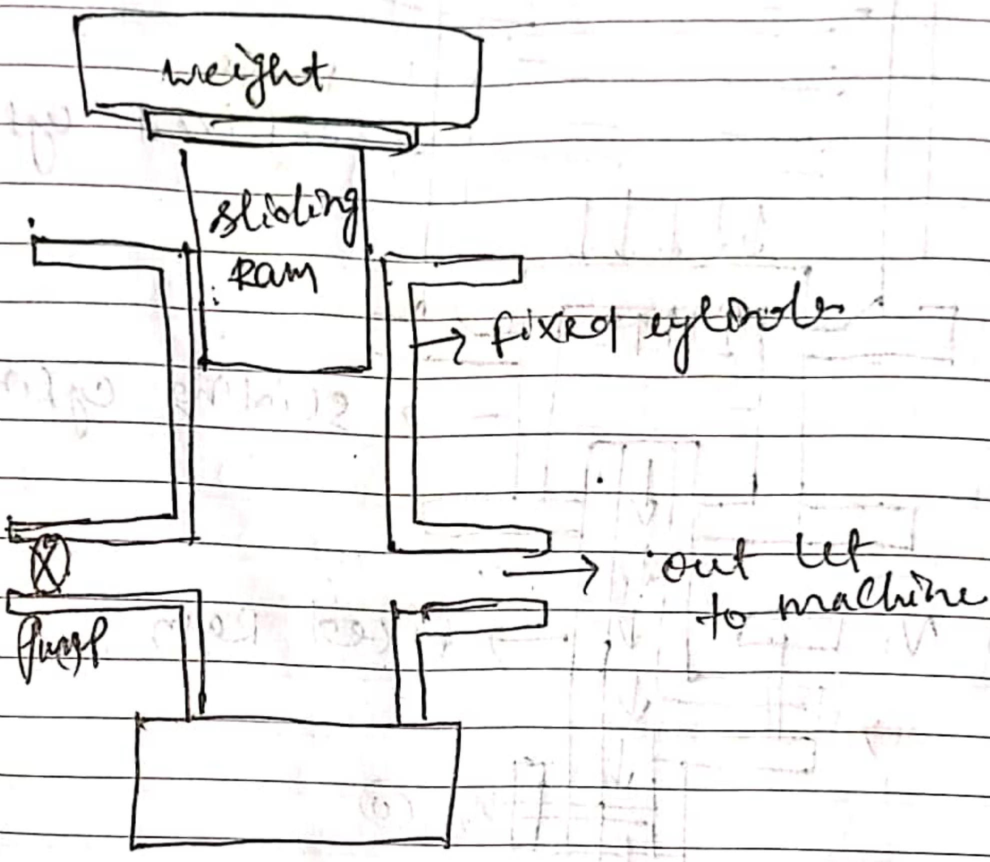


Used to store the energy of Liquid under pressure and makes the energy available to hydraulic machines.

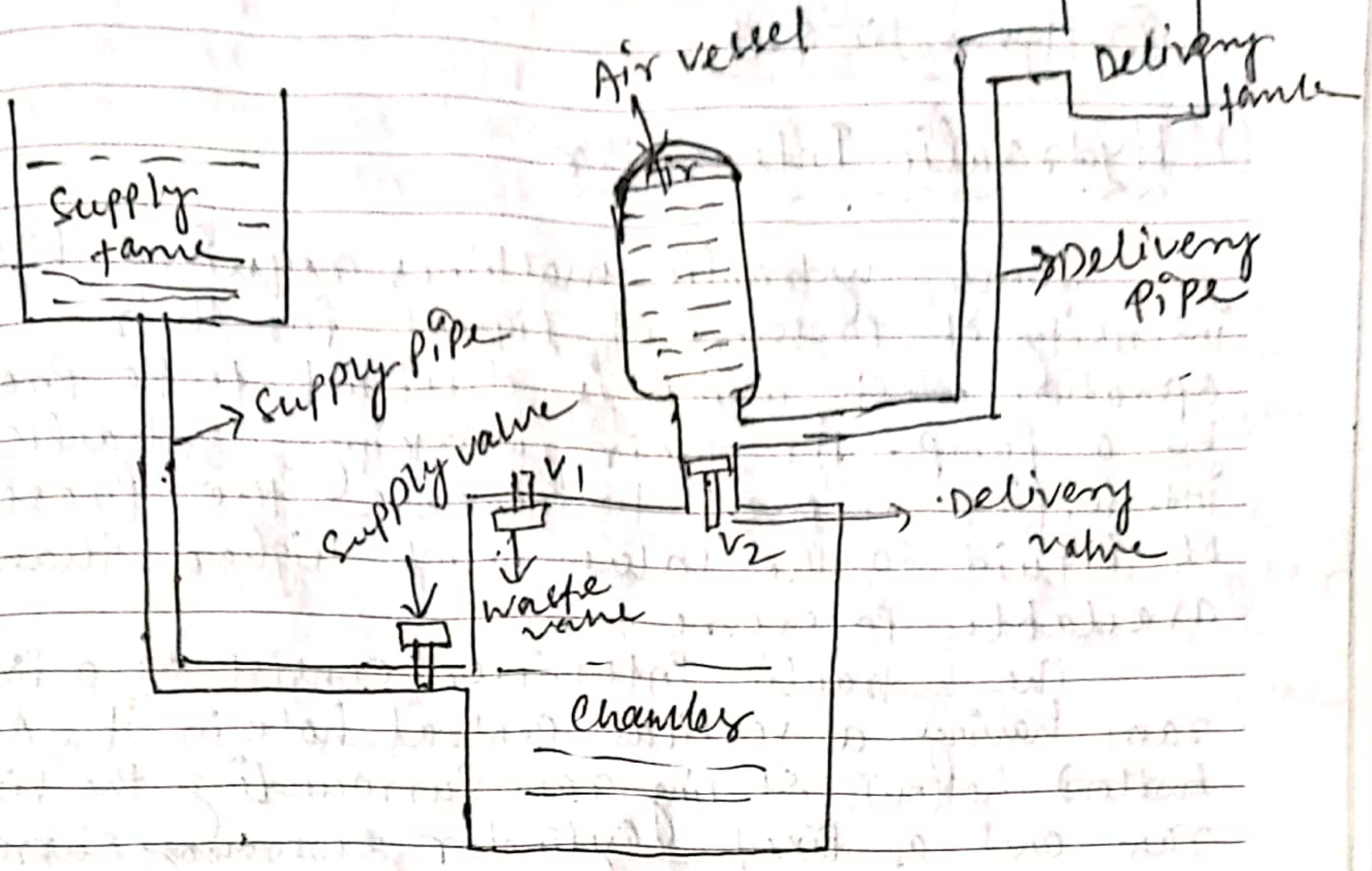
(8) ~~[illegible]~~ Lift

(2) Accumulator

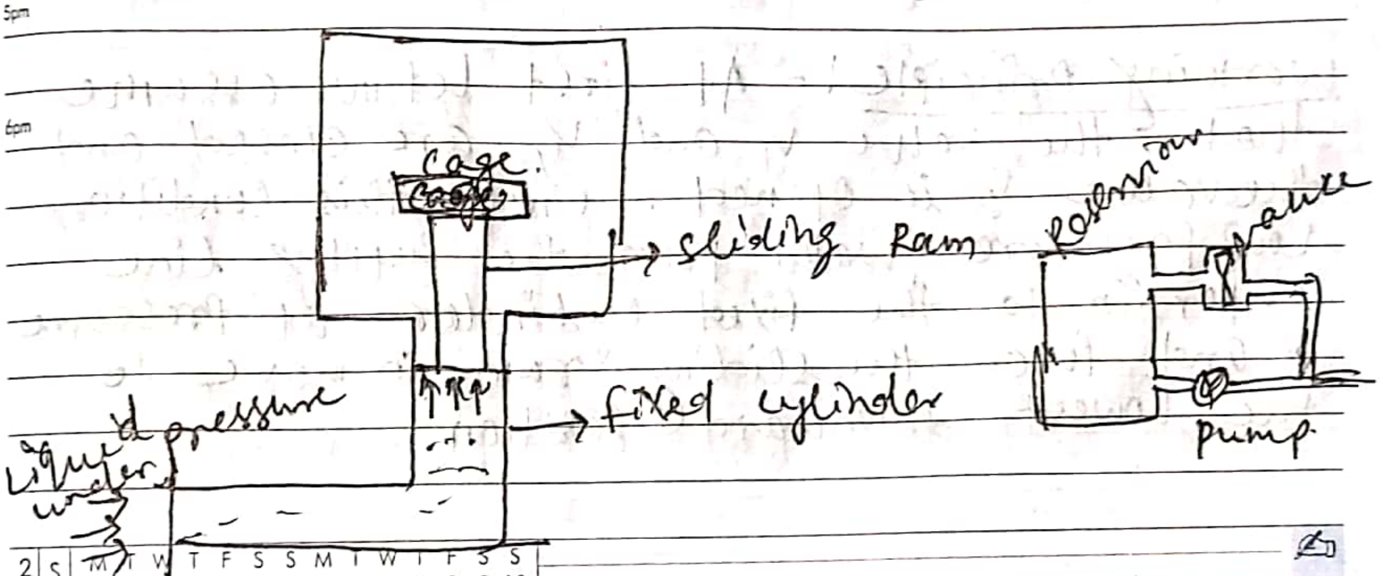


③ Hydraulic Ram.




④ Hydraulic lift (Direct acting)



~~② Hydraulic lift~~

## ① Hydraulic Intensifier

Some hydraulic machines required high intensity of pressure of liquid for their operation ~~which~~ which is difficult to be producing by a pump. For their working, hydraulic intensifier is used to increase the pressure of liquid to the value much higher than the available pressure.

The hydraulic intensifier consist of a fixed ram having a vertical central hole in it. A ~~bottom~~ hollow sliding ram surrounding the fixed ram and a fixed cylinder ~~surrounding~~ surrounds the sliding ram. Valve $v_1, v_2, v_3, v_4$ are fitted to the piping system used for the hydraulic intensifier.

**Working principle:-** At first let us assume that the valve $v_1$ and $v_4$ are closed and the valve $v_3$ is opened. Under this condition low pressure water from the supply line enter in to the fixed cylinder at pressure ~~p~~ and force the sliding ram to move to the lowest downward position.

Now the valves $V_1$ and $V_4$ are opened and the valve $V_2$ and $V_3$ are closed. Then low pressure water ~~are~~ enters in to the sliding ram which moves upward exhausting the water in the fixed cylinder through valve $V_4$

Now the valve $V_2$ and $V_3$ are opened and the valves $V_1$ and $V_4$ are closed; water again enters in to the fixed cylinder at low pressure and pushes the ~~slid~~ sliding ram to move downwards. This downwards movement of the sliding ram increase pressure of water already present in it. This high pressure water than enter in to the hydraulic machine through the valve $V_2$.

## (2) Hydraulic Accumulator.

In an improvement hydraulic Accumulator, the liquid is stored at a high pressure. In consist of a fixed vertical plunger surrounded by a brass bush. There is a small vertical hole in the plunger. The brass bush is surrounded by an inverted moving cylinder having a circular flange at the bottom end for carrying load.

The liquid under pressure from the pump enters in to the fixed vertical cylinder through the central hole in it and exerts force on the horizontal annular roof of moving cylinder loaded at the base. Thus the moving of cylinder rises up and stored the hydraulic energy in the accumulator.

③ Hydraulic Ram.

Hydraulic Ram is a device which raises small quantity of water through a larger height. It does not require any external power. It works on the principle of "water hammering".

It consist of a chamber connected to a low level water source through a supply pipe which is fitted with a gate valve. The chamber is provided with a waste valve and a delivery valve. The delivery valve is fitted to an air vessel.

At starting, the gate valve and the delivery valve remains closed and the



waste valve remains open. Now the gate valve is opened and water from the source starts flowing in to the chamber through the supply pipe and level of water rises in chamber and waste valve begins to rise up-wards.

At one stage the waste value suddenly closes. But the supply from the sources continues which ~~provides~~ produces "water hammering", the delivery valve opens and water is forced into the air vessel through the delivery valve. The water entering in to the air vessel, compresses the air already present in the vessel. In this way the pressure in the vessel rise and ultimately close the delivery valve. Now the water in the air vessel in forced by the compressed air to flow through the delivery pipe. under this condition both waste valve and delivery valve remain closed.

## (4) Hydraulic lift

A Hydraulic lift consist of a fixed cylinder and a sliding ram. The cage of the lift is supported directly on the end of the ram and is pushed up by it. Hence the stroke of the ram is equal to the lift of the platform of the cage. water under pressure enters in to the fixed cylinder through a bottom inlet and pushes the ram upward.

The size of the fixed cylinder depends upon the weight ~~of~~ to be lifted and the height to be lifted. for this type of lift, deep well is necessary to accummodate the cylinder and the ram.