RTU ROLL NO. .....

ARYA GROUP OF COLLEGES

I MID TERM EXAMINATION 2018-19 (I Sem.)

1FY3-07_Basic Mechanical Engineering

BRANCH: Common to All

Max Marks:- 40 **Time:- 2 hrs.**

PART A (Attempt All)

Q.1

(a) First law of thermodynamics

(b) Thermodynamic systems

(c) Steam boilers 5*2

(d) Steam turbines

(e) IC Engines

PART B (Attempt any Four)

Q.2

(a) What is thermal power plant Explain its components.

(b) Differentiate between two stroke and four stroke engine.

(c) Explain centrifugal pump with suitable diagram. 4*4

(d) Define:- (i) Second law of thermodynamics (ii) Charle's Law

(e) Comparison between water tube and fire tube boiler.

(f) Explain major components of an IC petrol engine and their functions.

PART C (Attempt any Two)

Q3

(a) An amount of a perfect gas has initial conditions of volume 1m^3, pressure 1 bar and temperature 18°C. It undergoes ideal diesel cycle operations, the pressure after isentropic compression being 50 bar and the volume after constant pressure expansion being 0.1 m^3. Calculate the temperatures at the major points of the cycle and evaluate the thermal efficiency of the cycle. Assume $\gamma = 1.4$ for the gas. Explain otto cycle efficiency.

(b) In an ideal Otto cycle the compression ratio is 8. The initial pressure and temperature of the air are 1 bar and 100°C. The maximum pressure in the cycle is 50 bar. For 1 kg of air flow, calculate the values of the pressure, volume, and temperature at the four salient points of the cycle. What is the ratio of heat supplied to the heat rejected? 2*7

(c) Describe the construction and working of Babcock and Wilcox Boiler with suitable diagram.

Part-C

Q.3

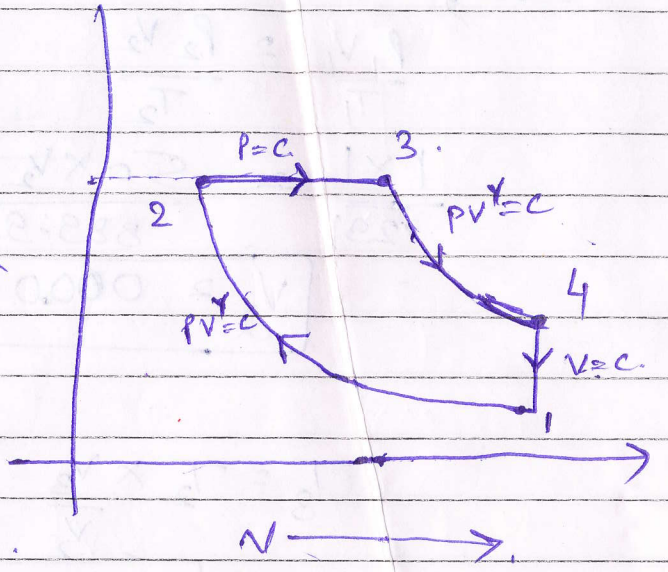
Ans(a) **Operations**

1 — 2 Isentropic Compression.

2 - 3. Heat Addition at Constant Pressure

3 - 4 Isentropic Expansion

4 - 1 Heat Rejected at Constant Volume



Process 1-2

Isentropic Compression.

$V_1 = 1 m^3$, $P_1 = 1$ bar $T_1 = 18^\circ C$.

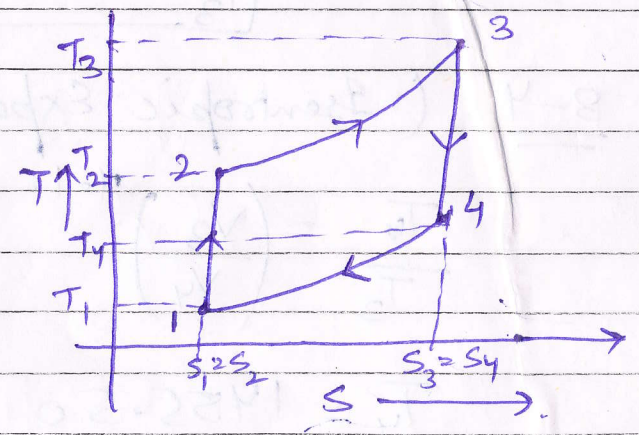
or $T_1 = 18 + 273 = 291 K$.

$P_2 = P_3 = 50$ bar. Given

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$T_2 = 291 \times \left[\frac{50}{1}\right]^{\frac{1.4-1}{1.4}}$$

$$\boxed{T_2 = 889.9 K}$$



Now,

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

$$\frac{1 \times 1}{291} = \frac{50 \times V_2}{889.9}$$

$$V_2 = 000.0612 \text{ m}^3$$

$$T_3 = T_2 \times \frac{V_3}{V_2} \Rightarrow 889.9 \times \frac{0.1}{0.00612}$$

$$T_3 = 1455.50 \text{ K}$$

3-4 (Isentropic Expansion).

$$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{\gamma - 1}$$

$$T_4 = 1455.50 \times \left(\frac{.0612}{.0.1}\right)^{1.4-1}$$

$$T_4 = 578.9 \text{K}$$

Thermal Efficiency.

$$\eta_{thermal} = \frac{\text{Heat Supplied} - \text{Heat Rejected}}{\text{Heat Supplied}}$$

$$\eta_{thermal} = 1 - \frac{H_R}{H_S}$$

$$\eta_{therm} = 1 - \frac{C_v (T_4 - T_1)}{C_p (T_3 - T_2)} \qquad \therefore \frac{C_p}{C_v} = \gamma$$

$$= 1 - \frac{1}{\gamma} \frac{(578.9 - 291)}{(1455.50 - 889.9)}$$

$$= 1 - \frac{1}{1.4} \left(\frac{287.9}{565.6} \right)$$

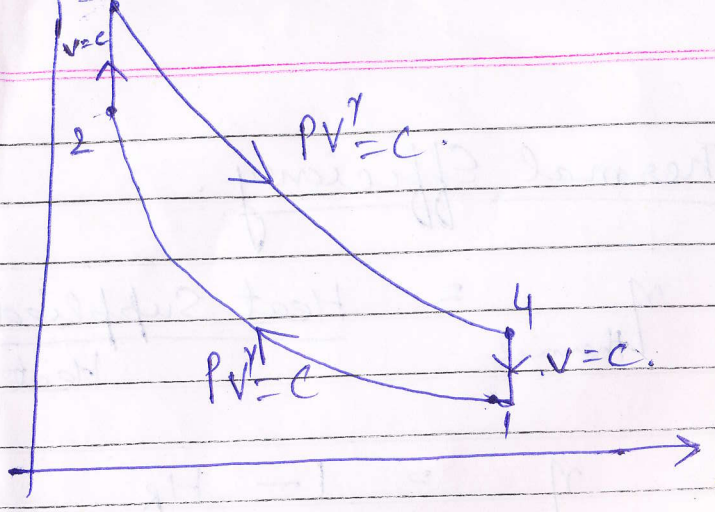
$$\eta_{thermal} = .6364 \text{ or } 63.64\%$$

Otto Cycle →

Otto Cycle is air standard Cycle on which a petrol Engine Works Completely. There are four strokes

used in Otto cycle.

1. Suction Stroke (1–2)
2. Compression Stroke (2–3)
3. Expansion Stroke (3–4)
4. Exhaust Stroke. (4–1).



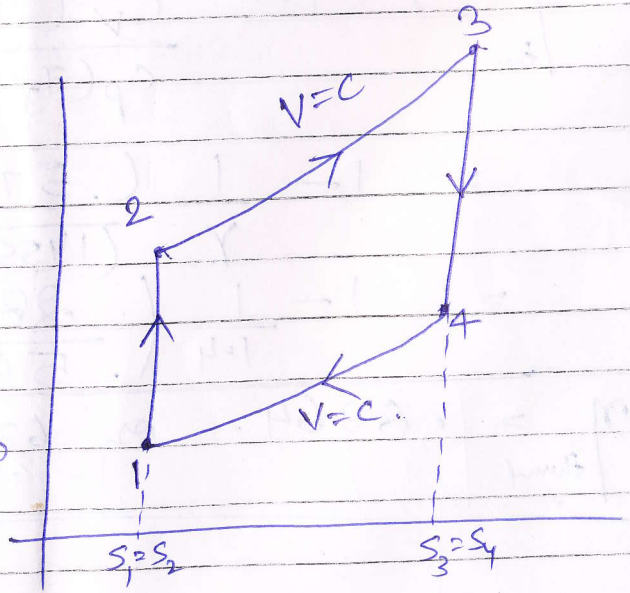
Pressure – Volume Curve

⇒ Heat added at Constant Volume.
Process is given by –

Heat Added = $C_V(T_3 - T_2)$.

⇒ Heat Rejected at Constant Volume
Process is given by –

Heat Rejected = $C_V(T_4 - T_1)$



Efficiency = $\frac{\text{Heat Supplied} - \text{Heat Rejected}}{\text{Heat Supplied}} \times 100$

$= 1 - \frac{C_V(T_3 - T_2)}{C_p(T_4 - T_1)}$.

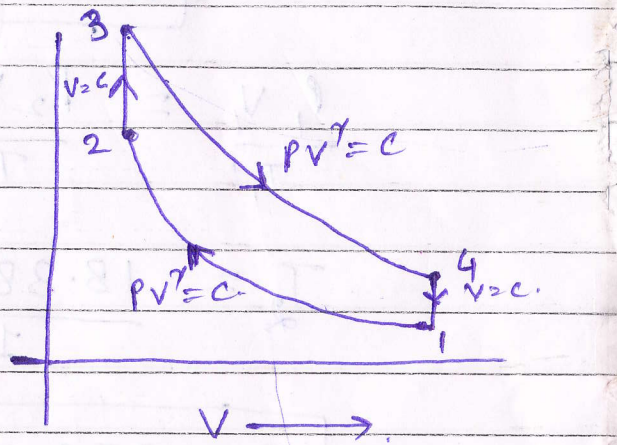
or $\eta = 1 - \left(\frac{T_3 - T_2}{T_4 - T_1}\right) \times \frac{1}{\gamma}$

where; $\frac{C_p}{C_V} = \gamma$.

Ans (b) Data Given :-

Compression Ratio $\left(\frac{V_1}{V_2}\right) = 8$ $P_1 = 1$ bar $T_1 = 100^\circ C$ or $373 K$.

$P_3 = 50$ bar $m = 1 kg$



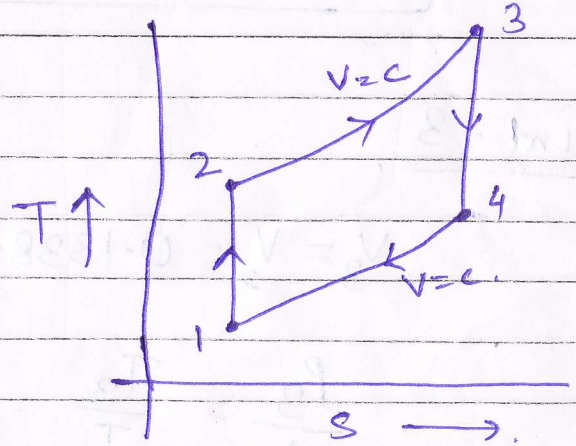
for Point - 1

$P_1 = 1$ bar $T_1 = 100^\circ C$ or $373 K$.

$$V_1 = \frac{mRT_1}{P_1}$$

$$V_1 = \frac{1 \times .287 \times 373}{1.}$$

$$\boxed{V_1 = 1.0705 \ m^3}$$



for Point - 2

$$P_1 V_1^\gamma = P_2 V_2^\gamma.$$

$$P_2 = P_1 \times \left(\frac{V_1}{V_2}\right)^\gamma.$$

$$P_2 = 1 \times (8)^{1.4}.$$

$$\boxed{P_2 = 18.38 \text{ bar}}$$

$V_2 = \frac{V_1}{8}$ or $\frac{1.0705}{8} = 0.1338$.

$$V_2 = 0.1338 \ m^3$$

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

$$T_2 = \frac{18.38 \times 0.1338}{1 \times 1.071} \times 373.$$

$$T_2 = 856.8 K \text{ or } 583.8^\circ C$$

Point - 3.

$V_3 = V_2 = 0.1338 m^3$. $P_3 = 50$ bar.

$$\frac{P_3}{P_2} = \frac{T_3}{T_2}$$

$$T_3 = \frac{P_3}{P_2} \times T_2$$

$$T_3 = \frac{50}{18.38} \times 856.8\ K.$$

$$\boxed{T_3 = 2331.4\ K. \text{ or } 2063.4^\circ C}$$

Point -4

$$P_3 V_3^{\gamma} = P_4 V_4^{\gamma}.$$

$$P_4 = P_3 \times \left(\frac{V_3}{V_4}\right)^{\gamma}.$$

$$P_4 = 50 \times \left(\frac{1}{8}\right)^{1.4}$$

$$\boxed{P_4 = 2.72\ bar}$$

$$V_4 = V_1 = 1.0705\ m^3.$$

$$\frac{P_4}{P_1} = \frac{T_4}{T_1}$$

$$T_4 = \frac{P_4}{P_1} \times T_1 \Rightarrow \frac{2.72}{1} \times 373.$$

$$\boxed{T_4 = 1014.6\ K \text{ or } 741.6^\circ C}$$

$$C_v = \frac{R}{\gamma - 1} = \frac{0.287}{1.4 - 1} = 0.718 \text{ KJ/K}.$$

Heat Supplied $= C_v (T_3 - T_2)$
$= 0.718 (2331.4 - 856.8)$
$= 1062.4 \text{ KJ}.$

Heat Rejected $= C_v (T_4 - T_1)$
$= 0.718 (1014.6 - 373)$
$= 460.7 \text{ KJ}.$

$$\frac{\text{Heat Supplied}}{\text{Heat Rejected}} = \frac{1062.4 \text{ KJ}}{460.7 \text{ KJ}}$$

$$\boxed{\frac{H_S}{H_R} = 2.306.}$$ Ans.

Ans-c Babcock and Wilcox Boiler -

It is a stationary water tube Boiler. The boiler is hung on steel griders and Enclosed by brick wall on all sides.

The feed pump fills half of the water drum with water leveling, rest of the space for Steam.

WORKING →.

Fuel is burn in the Grate to generate fuel gases. These gases travels end to end in the boiler through tubes. The water tubes are arranged in row inside the boiler inclination at 10°-15° and Connect the Uptake and downtake headers. The header hand holes in front of the tube which are covered with caps. Once water reaches to tube through the downtake header, the tube closer to the furnance is heated more to decrease the water density and cause the steam to flow back in the drum through uptake header.

The water flows from header to tubes and tubes to header and then to the drum naturally due to difference in densities. It gets converted into the saturated steam and is collected in the upper half of the drum. The steam is later

carried to the superheated steam box. Dampers are used to regulate the draught. The steam finally exist through the outlet pipe controlled by a stop valve out of the chimney.

Mud is removed from the downtake header by collecting it in a mud box. Safety valve, feed valve, pressure gauge and water level indicator are also present in this boiler.

Part-B

Q. 2

Ans (a) **Thermal Power Plant** -

The Steam Plant which works on the application of heat in form of Steam. It works on the principle of Rankine Cycle. Heat generated from fuel is to used for making a Steam. Steam strikes on the turbine blade and leads to run generator, which produces Electricity.

Main Parts of Thermal Power Plant -

a) **Fuel and Combustion Chamber** -

Coal is used as fuel in thermal power plant. Bitmous coal or Brown coal is mostly used. Firstly coal is pulverized into a pulverize to convert it in powder form. Benefit of powder form of coal is, it burns properly. Then it goes complete combustion in a Chamber in which air is supplied through air vents.

b) **Boiler** -

Heat produce after burning a coal is used to heat

up the boiler in which water converts into steam at high pressure and high temperature. The flue gases produced in boiler passes through super heater, economizer and air preheater, where it is taken in the for different purposes. After then it release to the atmosphere through the chimney.

c) Turbine - High Pressure steam is fed to the turbine due to which the blade rotates. Kinetic Energy of Steam is Converted into Mechanical Energy. Further this Mechanical Energy is converted into Electrical Energy by means of Generator.

d) Condenser - The Exhausted steam from turbine gets condensed in the condenser by cold water circulation. Due to condensation steam gets converted into water.

e) Feed Water Pump - Water coming from condenser is fed into boiler by feed water pump. This helps in recovering the water, Exhausted from turbine. Preheating the feed water before supplying it into boiler increases thermal Efficiency of the cycle.

Q.2

Ans (b)

S.No.	Two Stroke	Four Stroke.
1	It has one revolution of Crankshaft with one Power Stroke.	It has two revolution of Crankshaft between one power stroke.
2	It can generate high torque compare to 4 stroke Engine	It generates less torque due to 2 revolution of Crankshaft between one power strokes.
3	It used port to Inlet and Outlet of fuel.	It used valve to Inlet and outlet.
4	Thermal Efficiency is less	Thermal Efficiency is more
5	It creates more Noise	It is less Noisy
6	These are mostly used in Ships, Scooters, etc.	These Engine mostly used in Car, Truck, etc.

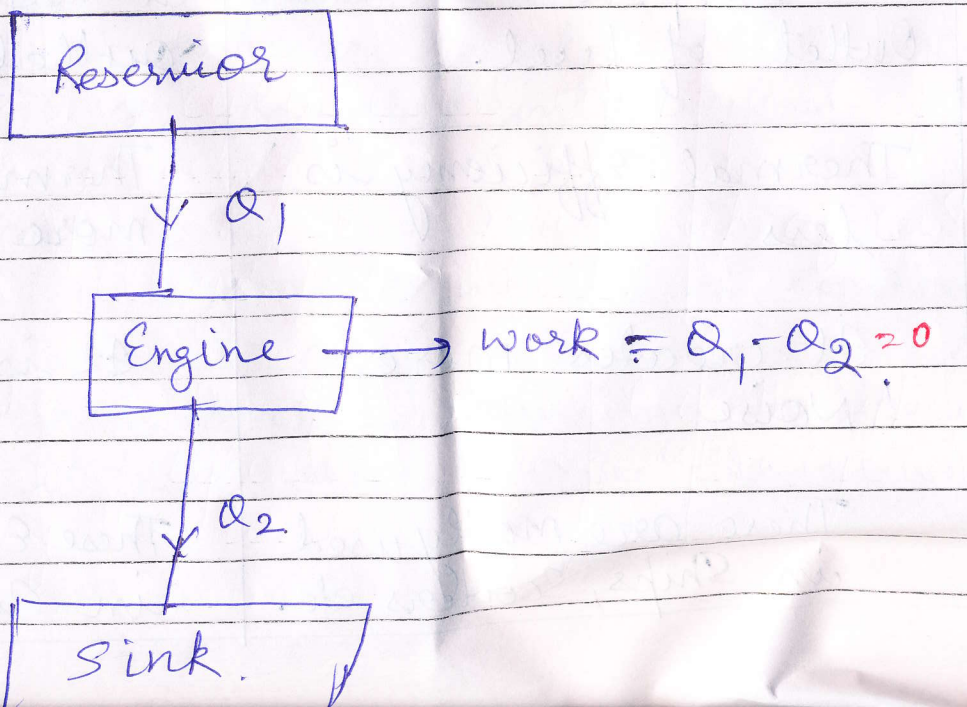
Q.2

Ans(d) Second Law of Thermodynamic -

The second law of thermodynamic states that the total Entropy of an Isolated system can never decrease over time.

⇒. Kelvin Statement -

It is impossible to design a thermal Engine operating in a cyclic process which absorb Energy in the form of heat from a single Thermal Reservior and delivered an equal amount of work.



⇒ Charle's Law

It states that when keeping the pressure constant, the volume of gas varies directly with the temprature. Charle's law Equation can be represented by -

$$V \propto T$$

where V = Volume

T = Temprature

Q.2

Ans (e)

S.No.	Water Tube Boiler	Fire Tube Boiler.
1.	Water is circulated inside the tube surrounded by hot furnance gases.	Hot gases from grate are passed through the tubes surrounded by water.
2.	Steam Pressure is higher and goes upto 165 bar.	Steam Pressure can rise only upto 24.5 bar.
3	Rate of Steam generation is high 450 tonnes per hour.	About 9 tonne of steam per hour can be genrated.
4	Operating Cost is High.	Operating Cost is Low

Q.2

Ans:- The main components of IC Engine are -

1) Cylinder Block - It is the main supporting structure for the various components! The cylinder head is kept into tight to cylinder block by no. of bolts and studs.

2) Cylinder - It is a cylinderical vessel or space in which piston makes a reciprocating motion. The varying volume created in the cylinder during the operation of the engine if filled with the working fluid and subject to diffrent thermodynamic process.

3) Piston - It is a cylinderical component fitted into cylinder forming the moving boundary of the combustion system. It is made up of Cast Iron or Alluminium alloys for lightness.

4) Combustion Chamber - The space Enclosed in the upper part of the cylinder between the cylinder head and piston top during the combustion process, is called Combustion Chamber.

5.) Inlet Mainfold - The pipe which connects the intake system to the inlet valve of the engine through which air or air-fuel mixture is drawn into the cylinder is known as Inlet Mainfold.

6.) Exhaust Mainfold - The pipe which connects the Exhaust system to the Exhaust valve of the engine through which the products of combustion escape out into atmosphere is called the Exhaust mainfold.

7.) Spark Plug - It is a component that initiate the combustion process in spark Ignition (SI) engine and usually located on the cylinder head. The main function of the spark plug is to provide a gap in the combustion chamber for the discharge of a high voltage electric pulse that will ignite the air-fuel mixture at desire point in the cycle.

8.) Cams - These are made as integral parts of the camshaft and are designed in such way to open the valve at the correct timing to keep them open for the necessary duration.

Q.2

Ans(c) Centrifugal Pump -

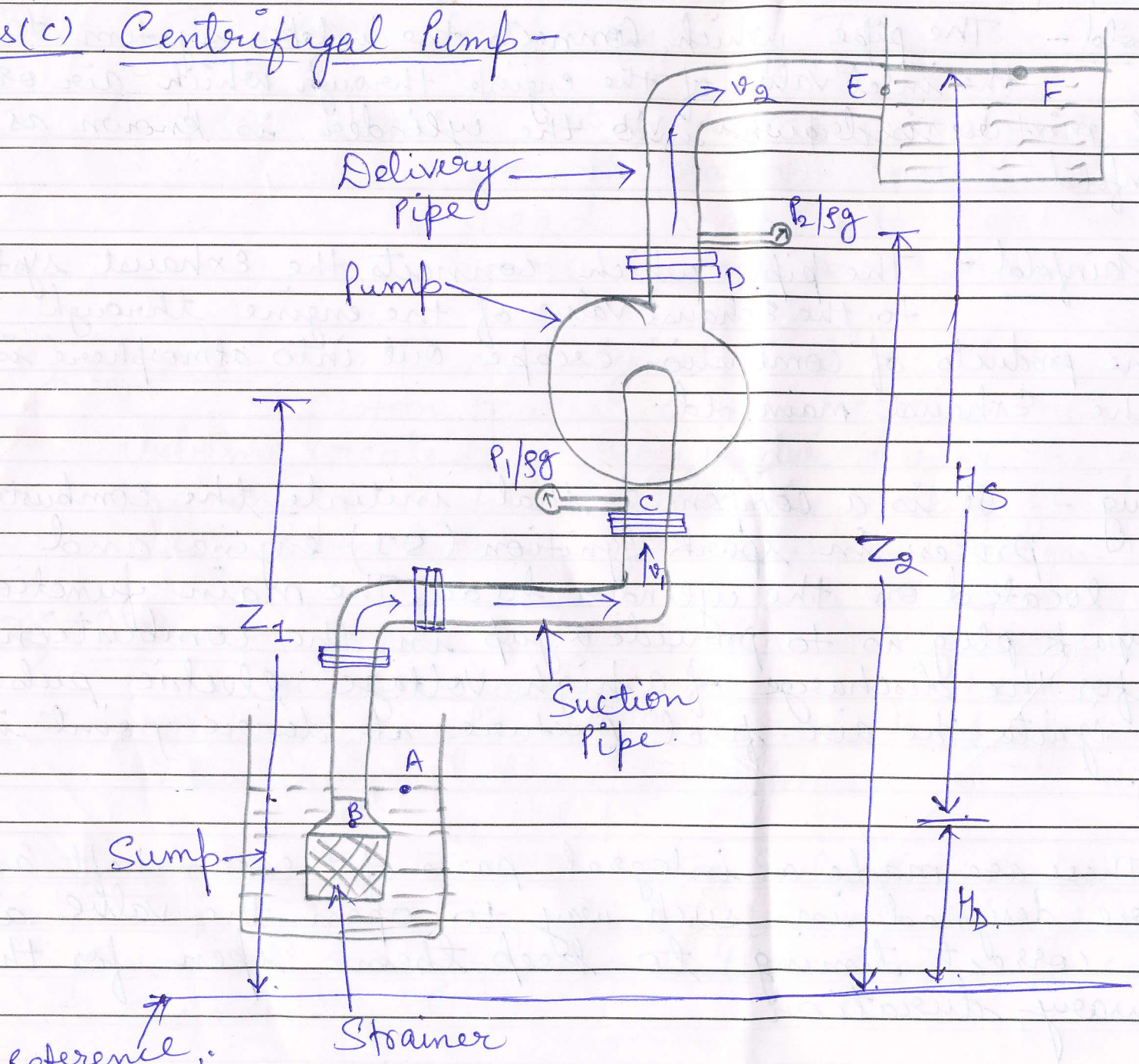
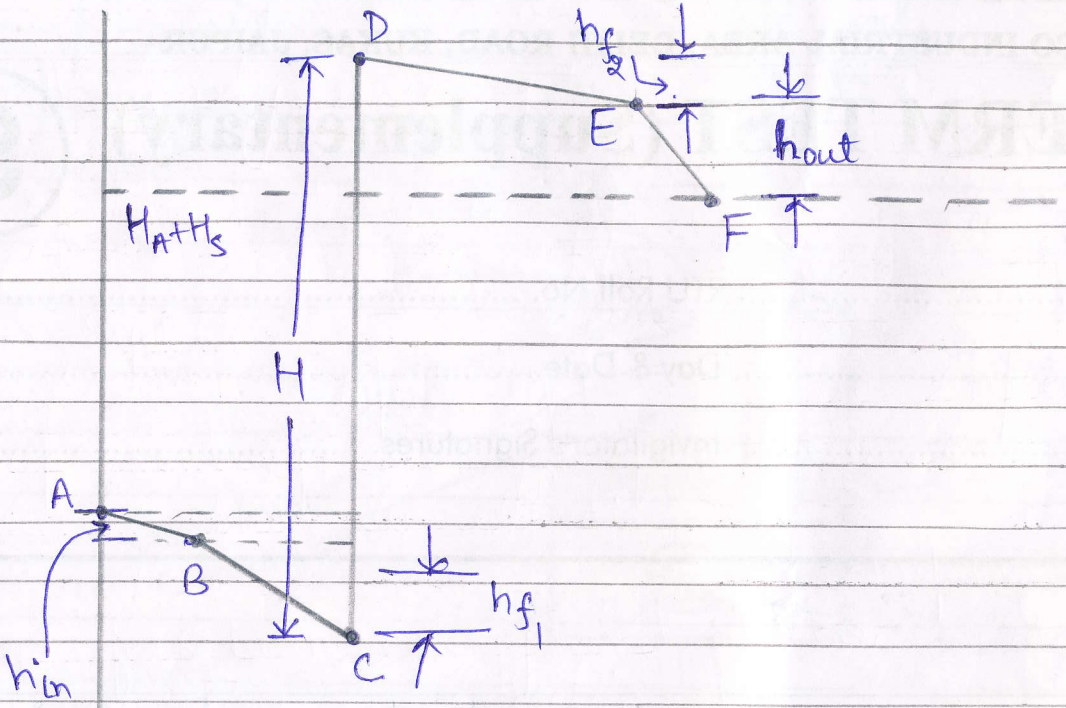


Fig:- Centrifugal Pump.

- Centrifugal pumps are a sub-class of dynamic axisymmetric work absorbing turbomachinery. Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic Energy to the hydrodynamic energy of the fluid flow.

Energy typically comes from the engine or Elebric motor. The rotational The fluid enters the pump impeller along or near to the rotating axis and is accelerated by impeller flowing radially outward into a diffuser or volute chamber (casing), from where it exists.

Energy Flow diagram of Centrifugal Pump - (Extra)



Part-A

Q.1

Ans(a) First law of Thermodynamic →

It states that "Energy can neither be created nor destroyed it transfer from one form to another form.

For Example -

A hot gas, when confined in a chamber, exerts pressure on a piston causing it to move downward. The movement can be harnessed to do work equal to the total force applied to the top of the piston times the distance that the piston moves.

Or

The change in Internal Energy of a system is equal to the heat added to the system minus the work done by the system.

$$\Delta U = Q - W$$

ΔU — Change in Internal Energy

Q — Heat added to the System

W — Work done by the system.

Q.1

Ans(b) Thermodynamic System - There are mainly three types of thermodynamic System.

1) Open System -

Open system have inputs and outputs flow representing exchange of matter, energy or information within the surrounding.

In simple it is a system that transfers both energy and matter across its boundary to is surrounding Environment.

For Ex- Drainage Basin, Solar Energy etc.

2) Closed System -

In this the mass within the boundary of the system remains constant and only the energy transfer may takes place between the system and its surrounding.

For Ex- Pressure Cooker, A ballon filled with air and tightly closed.

3) Isolated System - The system in which no matter and energy transfer within the boundary condition.

For Ex- Thermal Flask.

Q.1

Ans(c) Steam Boilers -

Steam Boiler or simply a boiler is basically a closed vessel into which water is heated until the water is converted into steam at required pressure.

There are mainly two types of Boilers -

1) Water Tube Boiler
2) Fire Tube Boiler

Advantage of Fire Tube Boiler -

1) It is quite compact in construction.
2) Fluctuation of system demand can be met easily.
3) It also quite cheap.

Advantage of Water Tube Boiler -

1) Large heating surface can be achieved by using more number of water tubes.

2) Due to Conventional flow, movement of water is much faster than that of fire tube boiler, hence rate of heat transfer is high which results into higher efficiency.

3) Very high pressure in order of 140 kg/cm^2 can be obtained smoothly.

Q.1

Ans(d) **Steam Turbine -**

A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Its modern manifestation was invented by Sir Charles Parsons in 1884.

There are mainly two type of Steam turbine –

1) Impulse Turbine
2) Reaction Turbine

Advantages –

1) Thermodynamic Efficiency is more.
2) Less Maintainence Cost.
3) No Rubbing parts hence no internal lubrication is required.
4) Supply of pure feed water to the boiler.

Q.1

Ans(e) IC Engines → .

An Internal combustion engine is a heat Engine where the combustion of fuel occurs with an oxidizer in a Combustion chamber that is an integral part of the working fluid flow circuit.

There are mainly four strokes in IC Engine –

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

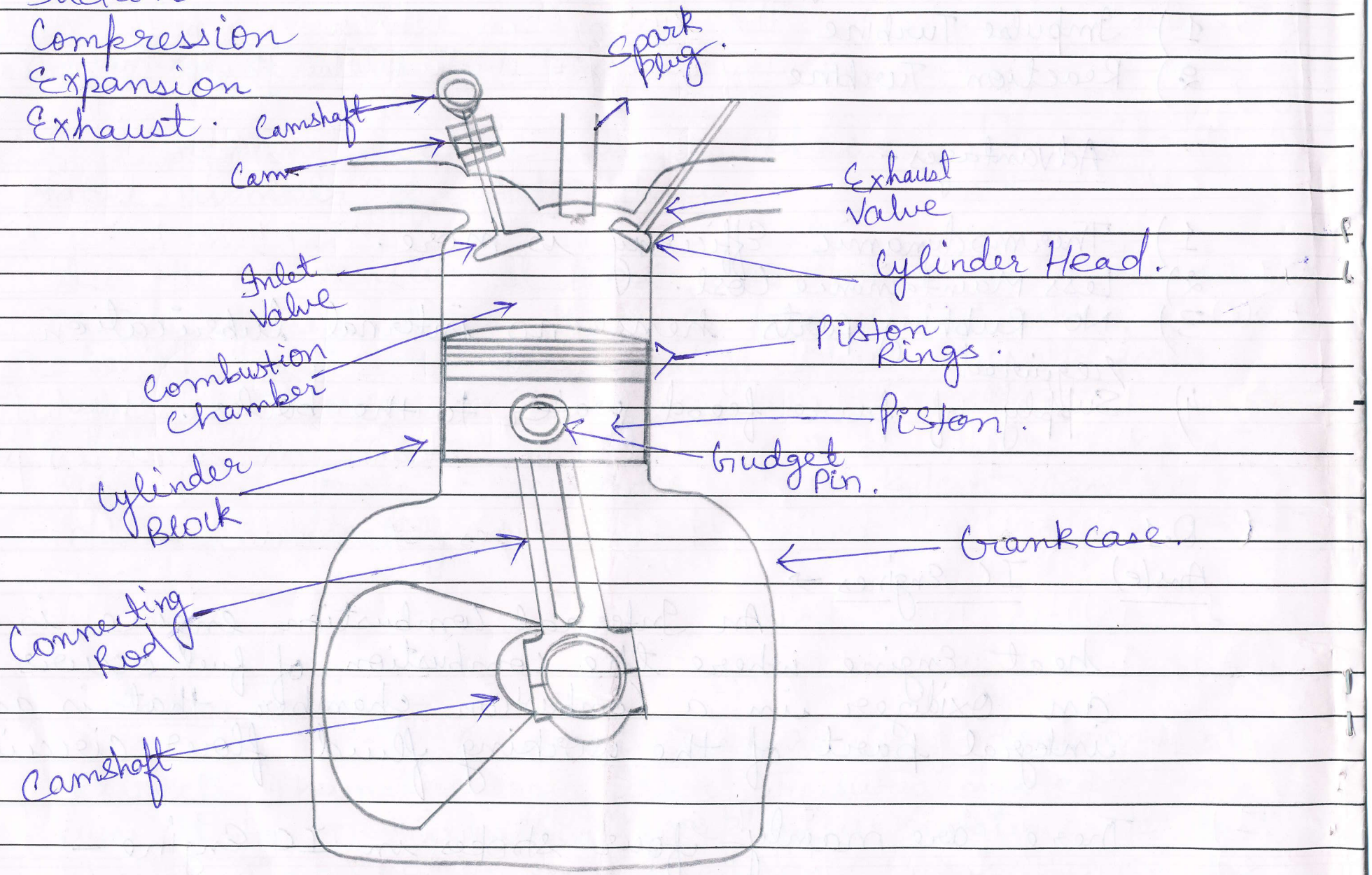


Fig:- IC Engine