LABORATORY MANUAL

ON

<u>MECHANICAL ENGINEERING LAB-II</u>

4TH SEMESTER

C.V. RAMAN POLYTECHNIC, BHUBANESWAR

DEPARTMENT OF MECHANICAL ENGINEERING

PR- 2 MECHANICAL ENGG. LAB –II

Name of the Course: Diploma in **Mech/ & Other Mechanical Allied Branches**

Course code		Semester	4th
Total Period:	90	Examination	3 hrs
Lab. periods:	6 P/W	Term Work	25
Maximum marks:	100	End Sem Examination:	75

SL. No	Content
1	Study of 2-S, 4-S petrol & diesel engine models
2	Determine the brake thermal efficiency of single cylinder petrol engine.
3	Determine the brake thermal efficiency of single cylinder diesel engine.
4	Determine the B.H.P, I.H.P BSFC of a multi cylinder engine by Morse test.
5	Determine the mechanical efficiency of an air Compressor.
6	Study of pressure measuring devices (manometer, Bourdon tube pressure gauge)
7	Verification of Bernoulli's theorem
8	Determination of Cd from venturimeter
9	Determination of Cc, Cv, Cd from orifice meter
10	Determine of Darcy's coefficient from flow through pipe

Mechanical Engineering Laboratory-II (4th semester) Code-Pr-2 Full marks: 100

Pr.2 Mechanical Engg. Lab-II		Levels
CO1	Distinguish between petrol, diesel engine models and pressure measuring devices.	2
CO2	Calculate thermal efficiency of single cylinder petrol and diesel engine.	3
CO3	Determine mechanical efficiency of air compressor and BHP, IHP, BSFC of multi-cylinder engine.	4
CO4	Validate Bernoulli's theorem.	4
CO5	Learn flow through pipes and determine Cd, Cc, Cv of Venturi meter and orifice meter and Darcy coefficient.	3

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	Average CO
CO1	2.00	2.00	-	-	1.00	-	-	1.67
CO2	3.00	3.00	-	1.00	1.00	1.00	-	1.80
CO3	3.00	2.00	1.00	1.00	-	-	-	1.75
CO4	3.00	2.00	-	1.00	-	-	-	2.00
CO5	2.00	1.00	-	-	-	-	-	1.50
Average PO	2.60	2.00	1.00	1.00	1.00	1.00	-	**1.74 1.43**

Sessional Rubrics (25)

	Attendance (3)			Record (5)			Experiment/Job (12)			Viva (5)		
	The student attends all the classes.			Presentation with good technical details and good communication skills, refers to the slides to explain the points and completely engaged with audience.			The seminar report is accroding to the specified format. The content is written with clarity and in organized manner. There is a logical flow in the text.			Defends all questions by providing clear and insightful answers to the equestions.		
Rating/Performance criteria	12	11	10	9	8	7	6	5	4	3	2	1
Attendance (3)										Fulfills to 100% of set criteria	Fulfills to 70% of set criteria	Fulfills to 50% of set criteria
Record (5)								Fulfills to 100% of set criteria	Fulfills to 80% of set criteria	Fulfills to 60% of set criteria	Fulfills to 50% of set criteria	Fulfills to 30% of set criteria
Experiment/ Job (12)	Fulfills to 100% of set criteria		Fulfills to 90% of set criteria	Fulfills to 80% of set criteria	Fulfills to 70% of set criteria	Fulfills to 60% of set criteria	Fulfills to 50% of set criteria	Fulfills to 40% of set criteria	Fulfills to 30% of set criteria			
Viva (5)								Fulfills to 100% of set criteria	Fulfills to 80% of set criteria	Fulfills to 60% of set criteria	Fulfills to 50% of set criteria	Fulfills to 30% of set criteria

Sessional (25)

Sl. No.	Name of student	Registration number	Attendance (3)	Record (5)	Experiment (12)	Viva (5)	Total (25)

Practical Rubrics (75)

	Report (20)			Experiment/Job (40)				Answering viva questions (15)				
	Report is well written. The Contents are equipped with neat sketch, error free calculations and free from grammatical errors.			Identifying equipment, instruments and material and setting up of machine tool. Exhibits proper knowledge of the lab procedure. Runs the machine independently. Takes all the readings from machine/apparatus during experiment. The obtained result is calculated correctly to find the result. Analyses if any error occurred with the reason. The experiment is completed within the time limit with taking proper safety precautions.				A set of questions is asked relating to the experiment and subject.				
Rating/Performance	40	38	33	28	24	20	15	12	10	8	6	4
Report						Answers to 100% of questions asked	Answers to 80% of questions asked	Answers to 60% of questions asked	Answers to 50% of questions asked	Answers to 40% of questions asked	Answers to 30% of questions asked	
Experiment/ Job	Follows 100% of the criteria	Follows 90% of the criteria	Follows 80% of the criteria	Follows 70% of the criteria	Follows 60% of the criteria	Follows 50% of the criteria	Follows 40% of the criteria	Follows 30% of the criteria	Answers to 25% of questions asked			
Viva							Answers to 100% of questions asked	Answers to 90% of questions asked	Answers to 75% of questions asked	Answers to 60% of questions asked	Answers to 45% of questions asked	Answers to 30% of questions asked

Practical (75)

Sl. No.	Name of student	Registration number	Report (20)	Experiment (40)	Viva (15)	Total (75)

Programme outcomes (POs) and Programme specific outcomes (PSOs) to be achieved through the practical of this course:-

1. **Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.
2. **Problem analysis:** Identify and analyze well-defined engineering problems using codified standard methods.
3. **Design/development of solutions:** Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.
4. **Engineering Tools, Experimentation and Testing:** Apply mode m engineering tools and appropriate technique to conduct standard tests and measurements.
5. **Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
6. **Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
7. **Life-long learning:** Ability to analyses individual needs and engage in updating in the context of technological changes.

Program Specific Outcomes (PSOs)

PSO-1	Discipline knowledge	Demonstration and understanding of tools with advanced software for design specification and operation of Mechanical Engineering systems, components and processes.
PSO-2	Professional Skills	Apply contextual knowledge to analyze social, environmental, health, safety, legal, and cultural issues with professional ethics as part of the lifelong learning process. To be equipped to lead a team or operate successfully alone as an individual managing tasks in trans-disciplinary areas.

INDEX

List of practical and progressive assessment sheet

Sl. No.	Title of experiment	Date of experiment	Date of Submission	Remarks
1	Study about 2 stroke, 4 stroke petrol and diesel engine models.			
2	Determine the brake thermal efficiency of single cylinder petrol engine.			
3	Determine the brake thermal efficiency of single cylinder diesel engine.			
4	Determine the BHP, IHP and BSFC of multi cylinder petrol engine by Morse test.			
5	To determine the mechanical efficiency of an air compressor.			
6	Study of pressure measuring devices like Manometer & Bourdon tube pressure gauge.			
7	Verification of Bernoulli's theorem.			
8	Determination of the co-efficient of discharge (C_d) from venturimeter.			
9	Determination of C_c, C_v and C_d from orifice meter.			
10	Determination of Darcy’s coefficient from flow through pipe.			

EXPERIMENT - 1

Aim of the experiment: -

To study about two stroke and four stroke petrol and diesel engine models.

Apparatus required: -

Sl. no.	Name of the apparatus	Specification	Quantity
1	Model of petrol engine	2-stroke	1
2	Model of petrol engine	4-stroke	1
3	Model of diesel engine	2 stroke	1
4	Model of diesel engine	4 stroke	1

Theory: -

Two stroke petrol engine

- A two stroke cycle petrol engine was devised by Dug lad clerk in 1880.
- In this cycle, the suction, compression, expansion, and exhaust takes place during two strokes of the piston. It means that there is one working stroke after every revolution of the crank shaft.
- A two stroke engine has ports instead of valves.
- The four stages of a two stroke petrol engine are described below:

1. Suction stage: -

- In this stage, the piston, while going down towards BDC, uncovers both the transfer port and the exhaust port.
- The fresh fuel-air mixture flows into the engine cylinder from the crank case.

2. Compression stage: -

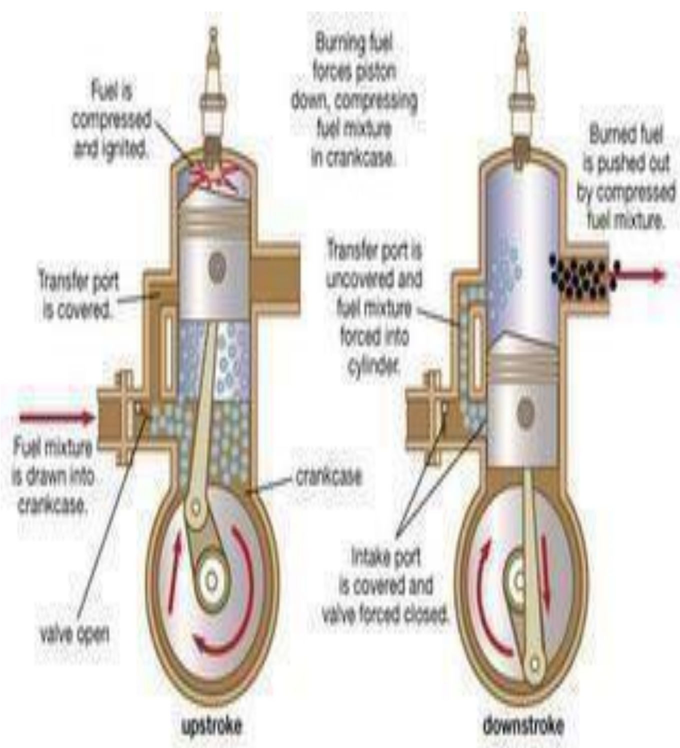
- In this stage, the piston, while moving up, first covers the transferport.
- After that the fuel is compressed as the piston moves upwards BDC to TDC.
- In this stage, the inlet port opens and fresh fuel-air mixture enters into the crank case.

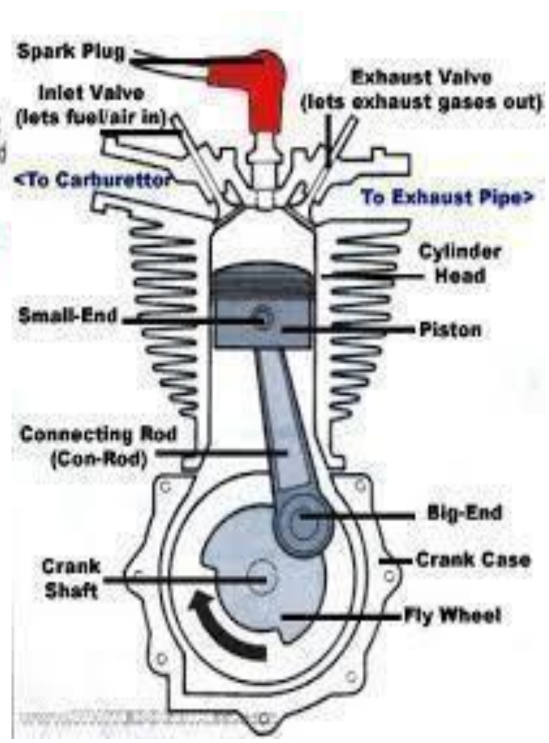
3. **Expansion stroke**: -

- Shortly before the piston reaches the TDC (during compression stroke) the charge is ignited with the help of a spark plug.
- It suddenly increases the pressure and temperature of the product of combustion. But the volume, practically remains constant.
- Due to rise in the pressure, the piston is pushed downwards with a great force.
- The hot burnt gases expand due to high speed of the piston. During this expansion, some of the heat energy produced is transformed into mechanical work.

4. **Exhaust stroke: -**

- In this stage, the exhaust port is opened as the piston moves downwards.
- The product of combustion, from the engine cylinder is exhausted through the exhaust port into the atmosphere.
- This completes the cycle and the engine cylinders ready to suck the charge again.





Four stroke petrol engine: -

- It requires four strokes of the piston to complete one cycle of operation in the engine cylinder.
- The four strokes of a petrol engine are described below:

1. **Suction stroke: -**

- In this stroke, the inlet valve opens and the charge is sucked into the cylinder as the piston moves downward from TDC.
- It continues till the piston reaches its BDC.

2. **Compression stroke: -**

- In this stroke, both the inlet and exhaust valves are closed and the charge is compressed as the piston moves upwards from BDC to TDC.
- As a result of compression, the pressure and temperature of the charge increases considerably.
- This completes one revolution of the crank shaft.

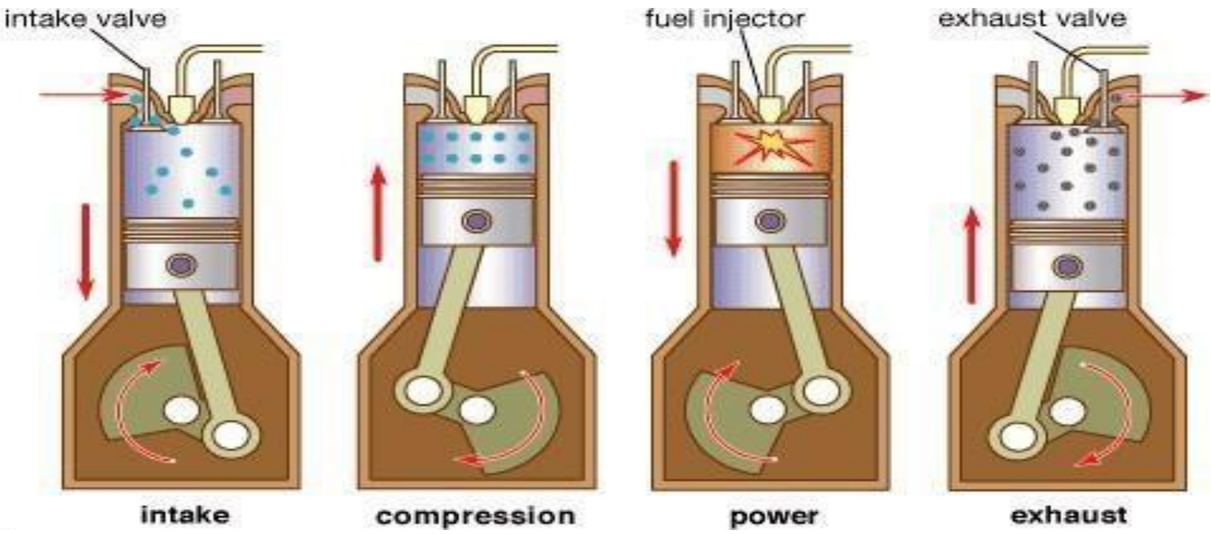
3. **Expansion stroke: -**

- Shortly before the piston reaches TDC (during compression stroke), 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 the rise in pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston.
- During this expansion, some of the heat energy produced is transformed into mechanical work.

4. **Exhaust stroke: -**

- In this stroke, the exhaust valve is open as piston moves from BDC to TDC.
- This movement of the piston pushes out the products of combustion, from the engine cylinder and is exhausted through the exhaust valve into the atmosphere.
- This completes the cycle, and the engine cylinder is ready to suck the charge again.

4- stroke petrol engine



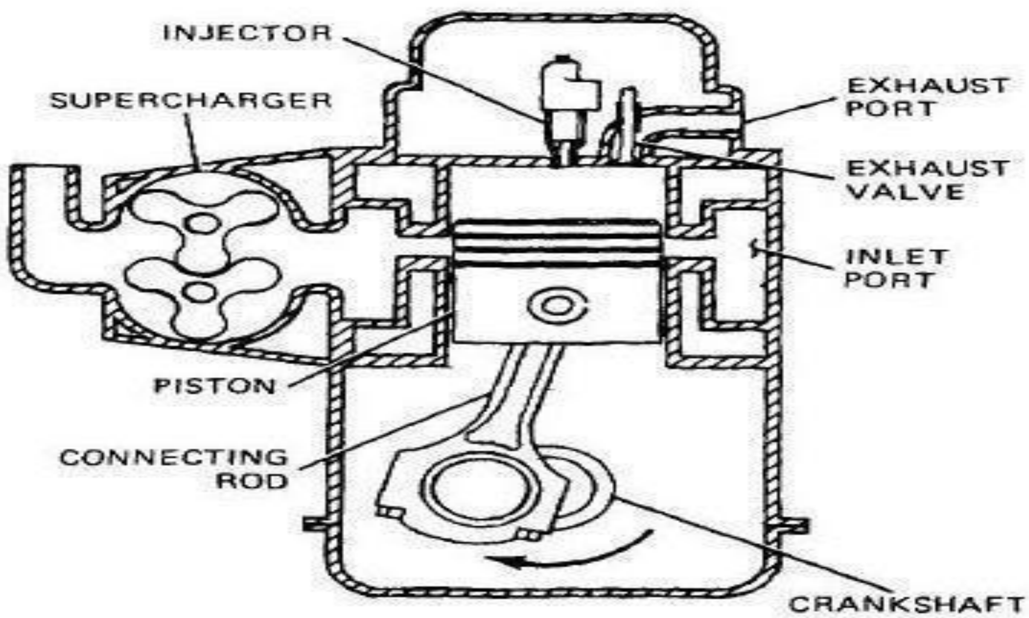
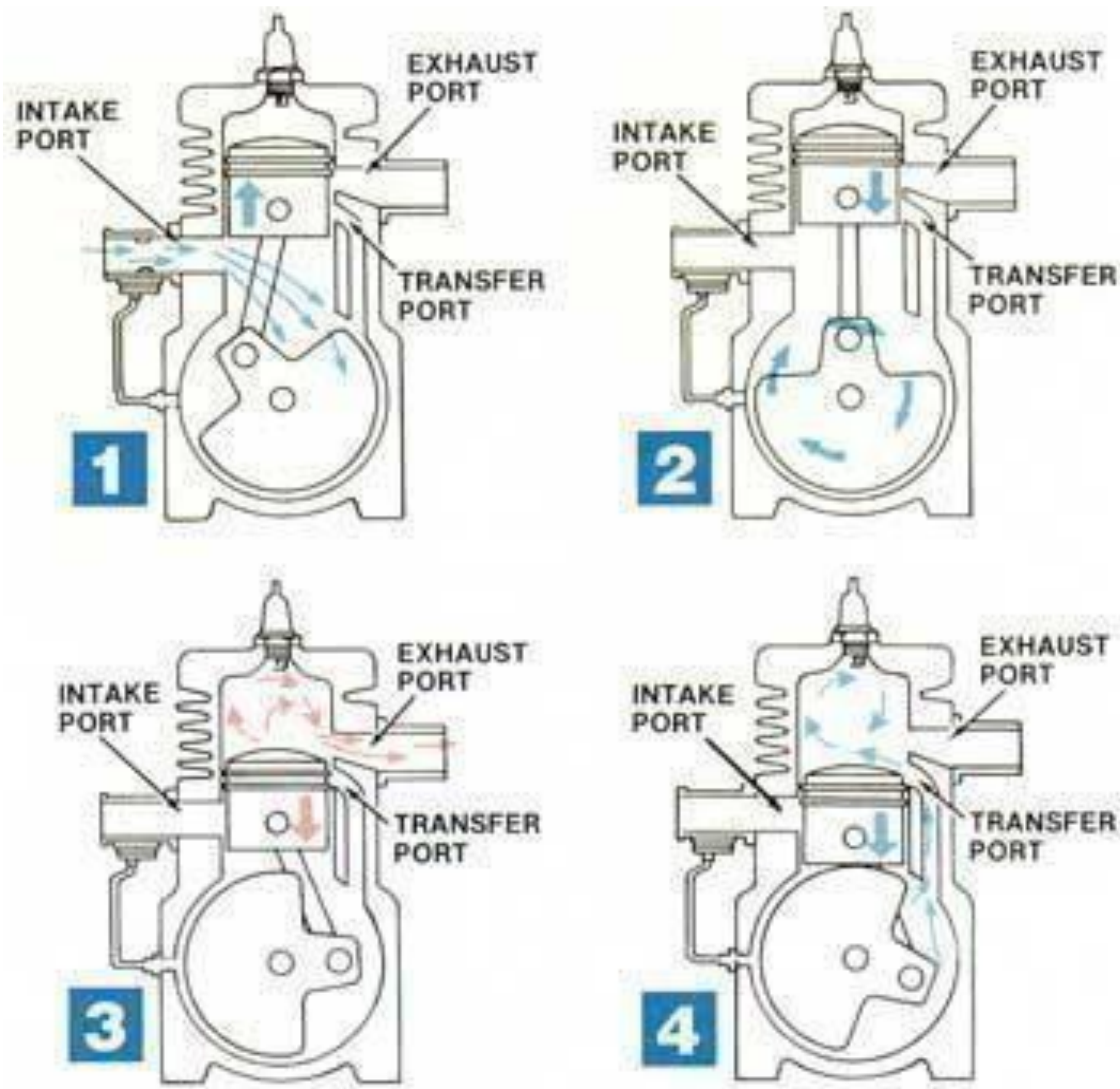


Figure 2-21. The Two Stroke Cycle Diesel Engine

Two stroke diesel engine: -

- A two stroke diesel engine also has one working stroke after revolution of the crank shaft.
- All the four stages of a two stroke cycle diesel engine are described below:



Suction stage: -

- In this stage, the piston while going down towards BDC uncovers the transfer port and the exhaust port.
- The fresh air flows into the engine cylinder from the crank case.

1. **Compression stage: -**

- In this stage, the piston while moving up, first covers the transfer port and then exhausts post.
- After that the air is compressed as the piston moves upward.
- In this stage, the inlet port opens and the fresh air enters in the crank case.

2. **Expansion stage: -**

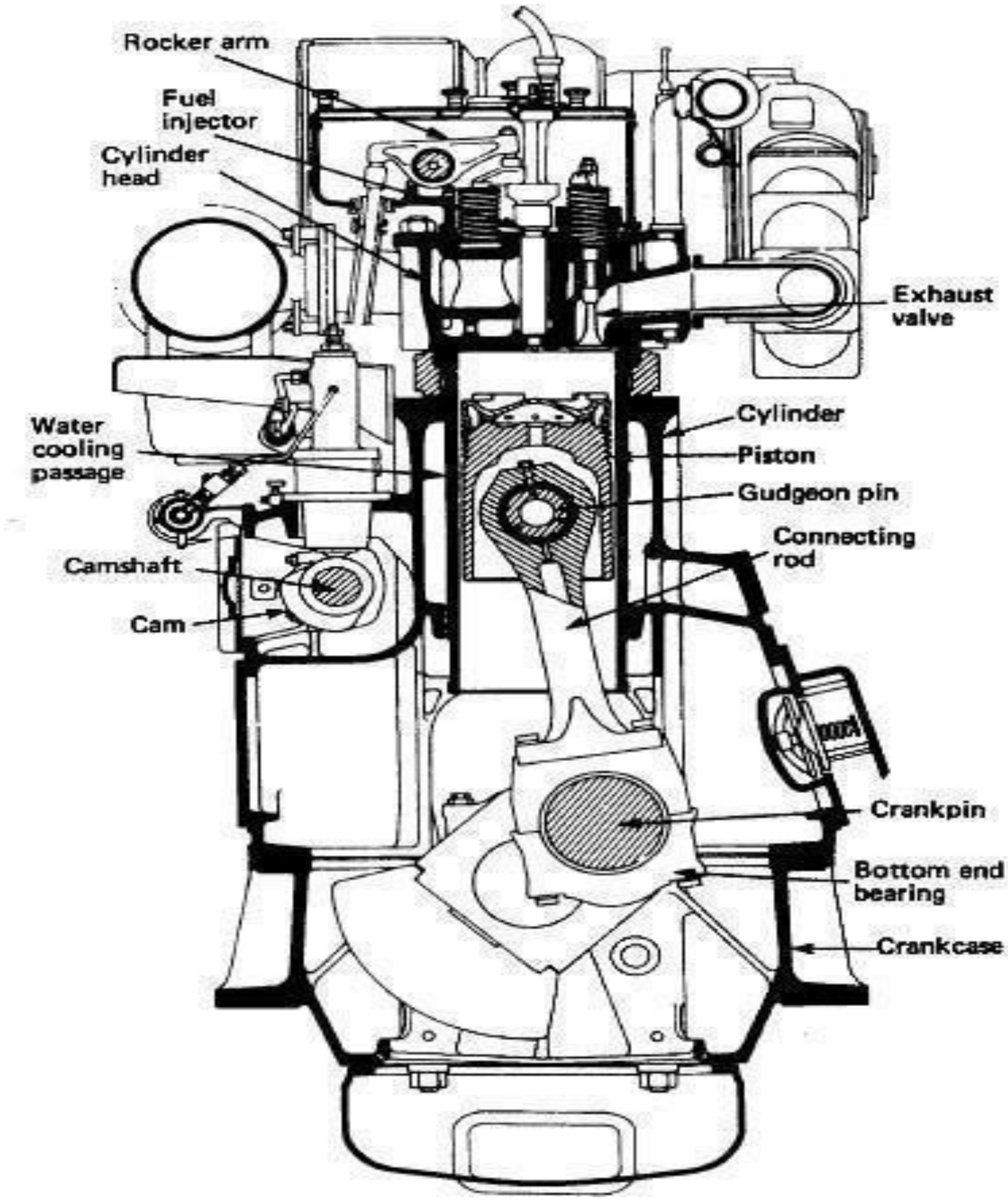
- Shortly before the piston reaches the TDC (during compression stroke), the fuel oil is injected in the form of very fine spray into the engine cylinder through the nozzle known as fuel injection valve.
- At this moment, temperature of the compressed air is sufficiently high to ignite the fuel. It suddenly increases the pressure and temperature of the products of combustion.
- Due to increase in pressure, the piston is pushed with a great force. The hot burnt gases expand due to high speed of the piston.
- During the expansion, some of the heat energy produced is transformed into mechanical work.

3. **Exhaust stage: -**

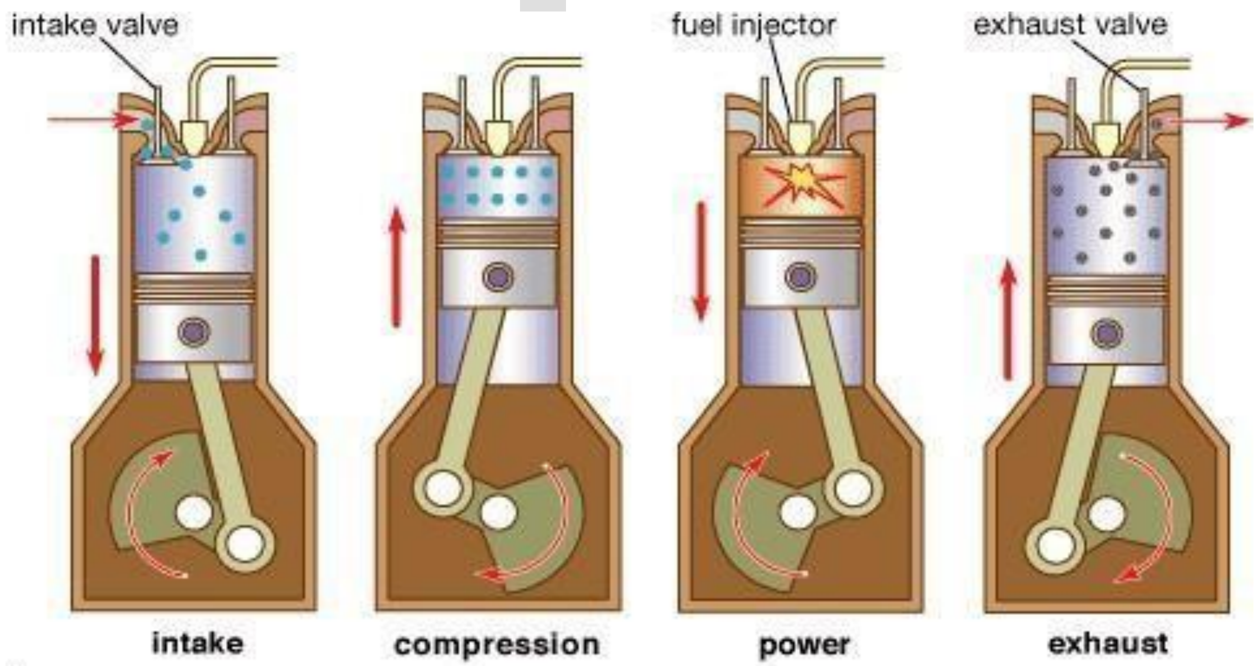
- In this stage, the exhaust port is opened and the piston moves downwards.
- The product of combustion from the engine cylinder is exhausted through the exhaust port into the atmosphere.
- This completes the cycle, and the engine cylinder is ready to suck the air again.

Four stroke diesel engine: -

- It is also known compression ignition engine because the ignition takes place due to the heat produced in the engine cylinder at the end of compression stroke.
- The four stokes of the diesel engine are described below:



4-stroke diesel engine



4- Stroke diesel engine

1. **Suction stroke: -**

- In this stroke, the inlet valve opens and the pure air is sucked into the cylinder as the piston moves downwards from TDC.
- It continues till the piston reaches in the BDC.

2. **Compression stroke: -**

- In this stroke, both the valves are closed and the air is compressed as the piston moves upwards from BDC to TDC.
- As result of compression, pressure and temperature of the air increases considerably.
- This completes the revolution of the crank shaft.

3. **Expansion stroke: -**

- Shortly before the piston reaches the TDC, fuel is injected in the form of very fine spray in to the engine cylinder through the nozzle known as fuel injector or fuel injection valve.
- At this moment, temperature of the compressed air is sufficiently high to ignite the fuel. It suddenly increases the pressure and temperature of product of combustion.
- Due to increased pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston.
- During the expansion, some of heat energy is transformed into mechanical work.

4. **Exhaust stroke: -**

- In this stroke the exhaust valve is open as the piston moves from BDC to TDC.
- This movement of the piston pushes out the product of combustion from the engine cylinder through the exhaust valve into the atmosphere.
- This completes the cycle and the engine cylinder is ready to suck the fresh air again.

Conclusion: -

From the above experiment we have successfully studied about the two stroke and four stroke petrol and diesel engine.

EXPERIMENT - 2

Aim of the experiment: -

To determine the brake thermal efficiency of the single cylinder petrol engine.

Objective: -

After performing this experiment, students will be able to know about:

- Single cylinder petrol engine.
- BP, IP & SFC.
- How to calculate the performance of single cylinder petrol engine.

Apparatus required: -

Sl. No.	Equipment	Specification	
1	Single cylinder petrol engine	Make	Honda
		Bhp	3HP
		Speed	3000RPM
		No of cylinder	1
		Compression ratio	7.4:1
		Bore	57mm
		Stroke	57mm
		Orifice dia	16.55 mm
		Ignition type	Spark ignition
		Types of cooling	Air cooled
		Types of loading	Hydraulic loading
		Types of starting	Kick starting
		Dynamometer	Rope brake
		Belt thickness	12mm
		Drum diameter	195 mm

Specifications

1. Engine - single cylinder, vertical, air cooled four stroke self-governed engine developing 3 HP at 3000 rpm.
2. Dynamometer -A rope brake pulley of Φ 195 mm with rope attached to spring balance. Thickness of belt 12 mm.
3. Orifice diameter = 16.55 mm

4. Measurements & Controls -

a) Calibrated burette for fuel intake measurement.

b) Orifice meter with water manometer for air intake measurement.

c) Exhaust gas colorimeter to measure heat carried away by exhaust gases.

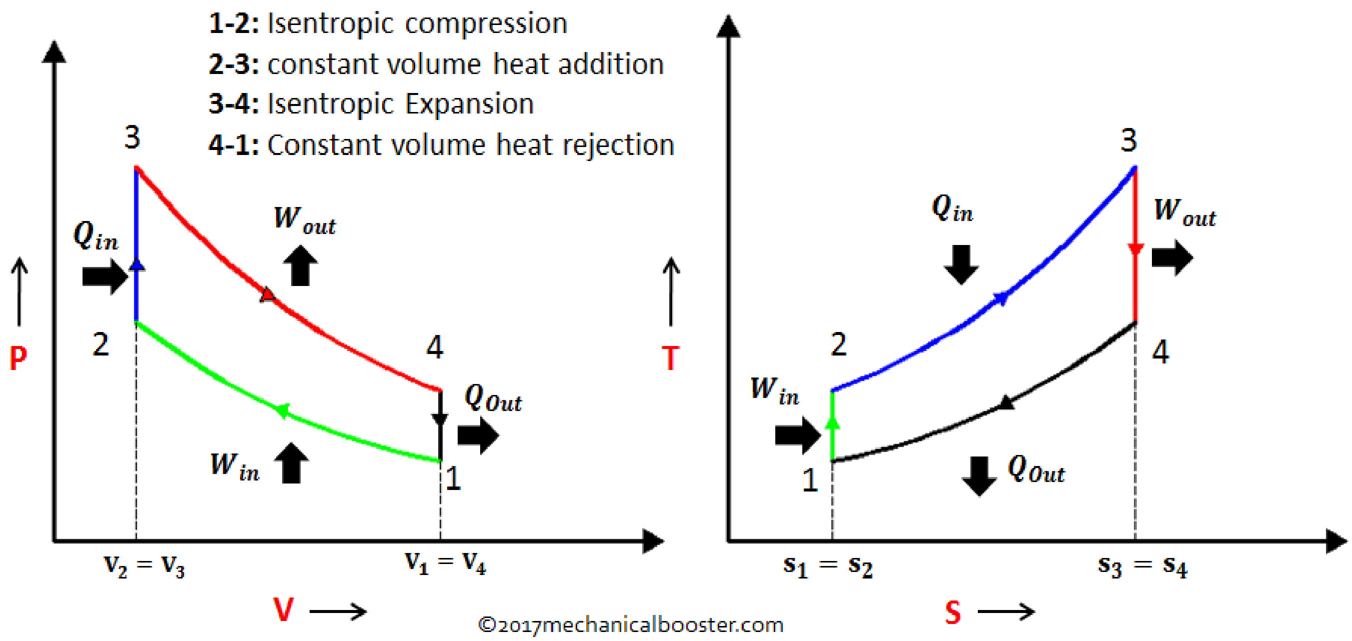
d) Multichannel digital temperature indicator.

e) Spring balances to measure the load.

Theory: -

Loading system:

- The engine test rig is directly coupled to a hydraulic dynamometer which is loaded by water flow into the dynamometer at 0.5kg/cm^2 constant head pressure. the load can be varied by operating gate valve provided on the inlet line of the dynamometer.
- A breather valve is provided at the bottom of dynamometer which is to be kept crack opened throughout working range. The outlet will be connected to a valve to be adjusted depending upon the load conditions.



P-V and T-S Diagram of Otto Cycle

Experimental procedure

1. Fill up sufficient petrol (without oil) in both tanks.
2. Check oil level in the crankcase of the engine. If it is lesser than mark 'H' on dipstick level it up to the mark with clean SAE-40 oil.
3. Fill up water in manometer up to half of height.
4. Check water supply to the brake drum and exhaust gas calorimeter.
5. Wind the starting rope over the starting drum and give a brisk pull. Initially, it may be required to operate the choke, if the engine is cold. As the engine starts, put the choke off.
6. Start loading the drum, Adjust the spring balance reading difference to say 2kg. (Maximum spring balance load = 5 kg.)
7. Note down manometer difference, time for 10 ml fuel consumption, engine speed and calorimeter water flow rate.
8. Note down the temperatures on channels 1 to 4.
9. Now, increase the load and again note down the readings and complete the observation table.

Observations

Sl. no.	Parameters	Reading
1	Brake drum Speed, ‘N’ rpm	
2	Load ‘L’ Kg (Spring balance difference)	
3	Time for 10 ml fuel t_f sec	
4	Manometer difference ‘h_w’ cms	
5	Time for 1 litre, calorimeter water $t_w$sec	
6	Temperatures Exhaust gas before calorimeter, T_1 Exhaust gas after calorimeter, T_2 Water inlet to calorimeter, T_3 Water outlet from calorimeter, T_4	

Calculations

1. Brake Power -

$$BP = \frac{2\pi NT}{60000} \quad kW.$$

Where,

N = Brake drum speed, rpm.

T= (Load x 9.81) x (effective brake radius + thickness of belt)

= (L x 9.81) x 0.131 N-m

2. Fuel Consumption -

Let, time required for 10 ml fuel be t_f sec.

$$FC = \frac{10}{t_f} \times \frac{3600 \times 0.7}{1000} \ Kg/hr$$

(Where, Sp. gravity of petrol=0.7)

$$= \frac{25.2}{t_f} \quad Kg / hr.$$

3. Specific fuel consumption -

$$SFC = \frac{FC}{BP} \quad kg / kw.hr.$$

4. Heat supplied by fuel -

H_F = FC x 43890 KJ /hr.

(Where, calorific value of petrol = 43890 KJ /kg)

5. Heat equivalent to BP

$$H_{BP} = BP \times 3600 \quad KJ / hr.$$

6. Brake thermal efficiency -

$$\eta_{BT} = \frac{\text{Heat equivalent to BP}}{\text{Heat supplied by fuel}}$$

$$\eta_{BT} = \frac{H_{BP}}{H_F} \times 100 \%$$

7. Air consumption -

Air head across orifice

$$h_a = \frac{hw}{100} \times (1000 - \rho_a)$$

where,

ρ_a = density of air w.r.t T-3

$$= \frac{P}{287 \times T} \quad Kg / m^3$$

P = Atmospheric pressure, (1.014×10^5 N / m^2)

(Pressure is to be noted from barometer which is not the part of the test rig)

T = Absolute ambient temperature K.

Mass flow of air -

$$m_a = 0.62 \times 4.5 \times 10^{-4} \sqrt{2 g h_a} \times \rho_a \times 3600 \quad Kg / hr.$$

where,

cd of orifice = 0.62

Area of orifice = 4.5×10^{-4} m^2

8. Air fuel ratio

$$AFR = \frac{m_a}{FC}$$

9. Heat carried away by exhaust gases- from the heat balance of calorimeter, heat given by exhaust gases in calorimeter = Heat gained by water.

$$m_{eg} \cdot c_{peg} \cdot (T_1 - T_2) = m_w \cdot c_{pw} \cdot (T_4 - T_3)$$

$$\therefore (m_{eg} \cdot c_{peg}) = \frac{m_w \cdot c_{pw} \cdot (T_4 - T_3)}{(T_1 - T_2)}$$

where,

m_{eg} = mass flow of exhaust gases.

c_{peg} = specific heat of exhaust gases

m_w = calorimeter water flow rate, Kg / hr.

C_{pw} = specific heat of water 4.18 KJ / kgk.

Hence, heat carried away by exhaust gases, on ambient temperature basis.

$$H_{eg} = (m_g \cdot c_{peg}) (T_1 - T_2)$$

Plot the graph of efficiency, FC and SFC vs. BP.

Precautions

1) Check water supply and crankcase oil level before starting the engine.
2) Do not tamper with any of the engine or carburetor settings.
3) Never stop the engine on load.

(Note - Tachometer and barometer are not the part of the test rig and are to be made available by the user.)

CONCLUSION: -

The brake thermal efficiency of single cylinder petrol engine is found to be-----------------.

EXPERIMENT - 3

Aim of the experiment: -

To determine the brake thermal efficiency of the single cylinder diesel engine.

Objective: -

After performing this experiment student will be able to:

- Know about single cylinder diesel engine.
- Find the brake thermal efficiency of the single cylinder diesel engine

Apparatus required: -

SL. NO.	EQUIPMENT	ENGINE SPECIFICATION	
01	Single Cylinder Diesel Engine Test Rig	Make	Kirloskar
		BHP	5
		Speed	1500 RPM
		No. of Cylinder	One
		Compression Ratio	16.5:1
		Bore	80mm
		Stroke	110mm
		Orifice Dia.	20 mm
		Type of Ignition	Compression Ignition
		Method of loading	Rope brake
		Method of Starting	Crank Start
		Method of Cooling	Water

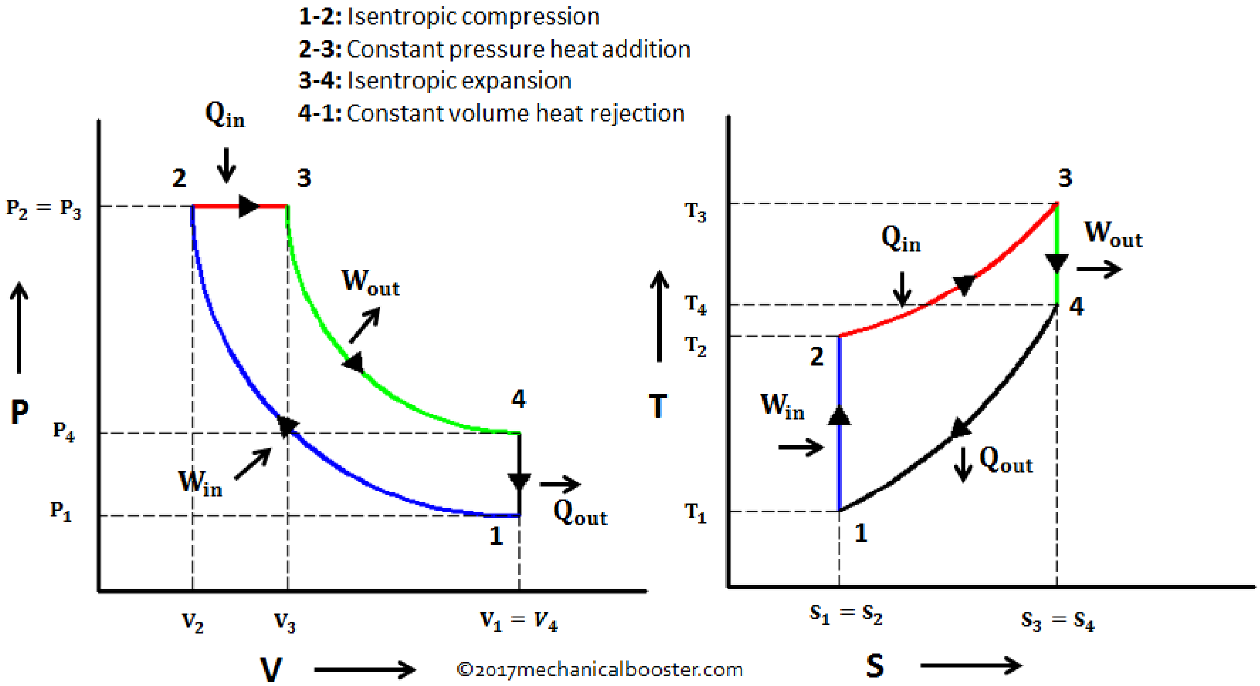
Theory

Diesel engine use diesel as the working fluid. Here high compression ratio of the fuel ignites the fuel. Diesel cycle consist of four different stages i.e., suction, compression, expansion and exhaust. Here only air which is sucked in the suction stroke is compressed in the compression stroke. Then fuel from the fuel injector enters in to the engine cylinder at the end of compression and combustion of fuel takes place. After combustion, in the exhaust stroke, the burnt out gases escapes from the engine cylinder.

Brake thermal efficiency:

Brake thermal efficiency is the ratio of energy in the brake power (BP) to the input fuel energy in appropriate units.

Diagram:



P-V and T-S Diagram of Diesel Cycle

Experimental procedure

1. Fill fuel into the fuel tank mounted on the panel frame.
2. Check the lubricating oil in the engine sump with the help of dipstick provided.
3. Open the fuel lock provided under the fuel tank and ensure that no air is trapped in the fuel line connecting fuel tank and engine.
4. De-compress the engine by decompression lever provided on the top of the engine head. (Lift the lever for decompression)
5. Crank the engine slowly, with the help of handle provided, and ascertain proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder.

6. When maximum cranking speed is attained, pull the decompression lever down, now. The engine starts. Allow the engine to run and stabilize. (Approximately 1500 RPM. The engine is a constant speed engine fitted with centrifugal governor).

7. Now lead the engine by placing the necessary dead weights on the weighing hanger, to load the engine in steps of 1/4, 1/2, 3/4, full and 10% over load. Allow the engine to stabilize on every load change.

8. Record the following parameters indicated on the panel instruments on each load step. A) Speed of the engine from RPM indicator. B) Rate of fuel from burette.

9. Exact load in kg (W) on the engine by adding the amount of weight added on the pan in kg (W1) plus weight of pan in kg (W2) minus spring balance reading in kg (W3).

10. To stop the engine after the experiment is over push/pull the governor lever towards the engine cranking side.

Calculation: -

In this experiment, we have to calculate the brake thermal efficiency of the Single Cylinder Four Stroke Diesel engine:

$$B.P = \frac{\pi N(W - S)(D + d)}{60 \times 1000} \quad \text{KW}$$

where, W = Dead Weight in N,
S = Spring Balance reading in N,
D = Diameter of Brake drum in meter,
d = Diameter of rope in meter
N = Speed of the engine

$$Brake\ thermal\ efficiency = \frac{Brake\ Power}{Energy\ supplied\ to\ the\ engine}$$

$$\eta_{bt} = \frac{B.P}{m_f \times C.V}$$

where, C_V = Calorific value of fuel (Diesel) = 46200 kJ/kg Density of petroleum diesel = 850.8 kg/m^3

Conclusion: -

The brake thermal efficiency of single cylinder diesel engine is found to be --------------.

EXPERIMENT - 4

Aim of the experiment: -

Determine the B.H.P, I.H.P and BSFC of multi cylinder engine by Morse test.

Objective: -

After performing this experiment student will be able to understand:

i) Why morse test is required?
ii) What is BHP, IHP & BSFC?

Apparatus required: -

SL. NO.	EQUIPMENT	SPECIFICATION	
01	Four cylinders Petrol Engine Test Rig.	BHP	10
		Speed	1500 RPM
		No of cylinder	4
		Compression Ratio	78.5: 1
		Bore	84 mm
		Stroke	82mm
		Orifice Dia	20mm
		Type of ignition	Spark Ignition
		Type of cooling	Water Cooling
		Type of loading	hydraulic Loading
		Type of starting	Self-starting

Theory: -

- The Morse test is used to find out the indicated power of a multi cylinder reciprocating engine.
- The engine is run at a particular speed and the torque is measured by cutting out the firing of each cylinder in turn and noting the fail in brake power each time while maintaining the set engine speed by reducing load.
- The observed difference in brake power between all cylinder firing and with one cylinder cut out is the indicated power of the cut out cylinder.

Procedure: -

1. Connect the water inlets of the engine jacket calorimeter and hydraulic dynamometer to a 0.5 kg/cm^2 constant head water source.
2. Open the inlet gate valves of the engine jacket and calorimeter to suitable desired flow rate.
3. Connect the battery terminals to a well charged 12V battery with the terminals marked "+" and "– "respectively to the engine cable terminals.
4. Connect the instrumentation power input plug to a 230V single phase power supply. Now all the digital meters namely rpm, fuel weight and flow rate and air flow rate and temperature indicator display the respective readings.
5. Fill up petrol into the petrol tank provided mounted on a 5kg capacity load cell until the fuel weight meter reads approximately 4000gms.
6. Open the petrol cock provided underneath the petrol tank and ensure all the knife switches provided for the morse test are in engaged position. Also ensure the accelerator knob is in off position.
7. Insert the ignition key into the starter switch and turn it clock wise to hear a click sound by which the negative deflection will be shown at the bottom of the panel. Turn the key further clockwise to start the engine. Now the engine is running at idle speed (600- 800) on the digital rpm indicator. Ensure the oil pressure gauge reads $2kg/cm^2$ to $3kg/cm^2$.
8. Increase the speed by turning the accelerator knob clockwise until the rpm indicator reads 1500 rpm.
9. Now open the dynamometer inlet gate valve to load the engine through hydraulic dynamometer. The load is indicated on a dial type spring balance in terms of kgs. the dynamometer arm having a length of r=0.32m gives the torque.
10. Load the engine to full load at rated speed. Allow it to run for few minutes cut off the power to one cylinder by pulling the knife switch provided on the engine panel. Now the engine is running on 3 cylinders only. As a result, the speed of the engine drops down by operating the water inlet valve to reduce the load slowly so that the speed of the engine comes back to its rated speed(1500rpm). Record the spring balance reading.
11. Pull out the next knife switch immediately and observe the engine speed.

Calculation: -

$$BHP = \frac{2\pi NT}{4500} \text{ HP}$$

Let W = Dynamometer load in Kg

N = RPM of the engine
B = BHP of 4 cylinder
IHP = Indicated horse power
BHP = Brake horse power
B1 = BHP of 3 cylinder when 1st is cut off
B2 = BHP of 3 cylinder when 2^{nd} is cut off
B3 = BHP of 3 cylinder when 3^{rd} is cut off
B4 = BHP of 3 cylinder when 4^{th} is cut off

IHP Calculation:

IHP of 1^{st} cylinder = B-B1
IHP of 2^{nd} cylinder = B-B2
IHP of 3^{rd} cylinder = B-B3
IHP of 4^{th} cylinder = B-B4

Total IHP Calculation:

Total IHP of the engine = IHP (1^{st} + 2^{nd} + 3^{rd} +4^{th})

BSFC Calculation:
It is the ration between the mass of fuel consumed per hour to the BHP.

$$B.S.F.C = \frac{m_f}{BHP} kg/BHP.\ hr$$

Where m_f = Fuel consumed in kg/hr

<u>TABULATION: -</u>

Sl. No.	Condition	N (rpm)	W (kg)	BHP	IHP	BSFC
1	A	1500				
2	B	1500				
3	C	1500				
4	D	1500				

<u>Conclusion: -</u>

The B.H.P, I.H.P and BSFC of multi cylinder engine was found out to be____________________.

EXPERIMENT – 5

Aim of the experiment: -

To determine the mechanical efficiency of a single stage air compressor.

Objective: -

After performing this experiment student will be able to understand:

i) About air compressor.

ii) Different components and working of air compressor.

Apparatus required: -

SL.NO.	EQUIPMENT	SPECIFICATION	QUANTITY
01	Air compressor test rig		01
02	Tachometer		01
03	Stop watch		01

Theory: -

An air compressor is the machine which compress the air and to raise its pressure. The air compressor sucks air from atmosphere, compresses it and then delivers the same under a high pressure to a storage vessel. From the storage vessel, it may be converged by the pipe line to a place where the supply of compressed air is required, since the co impression of air required some work to be done on it. Therefore, a compressor must be driven by some prime mover.

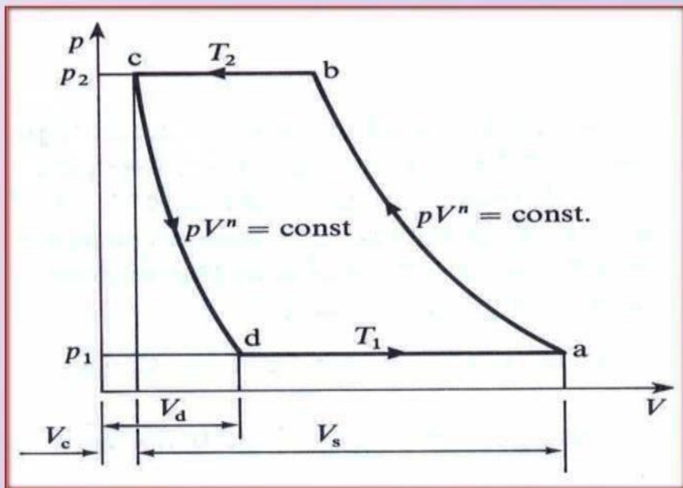
Construction:

An air compressor consists of the following components:

1. Cylinder
2. Piston
3. Inlet valve
4. Outlet valve
5. Pressure gauge
6. Pressure vessel

Working procedure:

- When the piston moves downward the pressure inside the cylinder falls below the atmospheric pressure.
- Due to this pressure difference the I.V. gets opened and the air is sucked into the cylinder.
- Now when the piston moves upward the pressure inside the cylinder goes on increasing till it reaches the discharge pressure. At this stage the discharge valve gets opened and air is delivered to the container.
- At the end of delivery stroke a small quantity of air at high pressure is left in the clearance space. As the piston start its suction stroke, the air contained in the clearance space expands till pressure reaches upto the required limit.
- At this stage the inlet valve gets opened as a result of which fresh air is sucked into the cylinder and the cycle is repeated.



Indicator diagram for a reciprocating compressor

Calculation: -

Mechanical efficiency of compressor,

$$\eta_{mech} = {I.P}/{B.P}$$

$$I.P = \frac{W \times N}{60 \times 1000} kW$$

Work done by the compressor (W) =

$$= \frac{n}{n-1} mRT_1 \left(\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right)$$

$$B.P = \frac{W \times N}{2000} \quad kW$$

Where W = Work done
N = Number of revolution in RPM
P_1 = Pressure of air at the inlet of the compressor
P_2 = Pressure of the air at the outlet of the compression
T_1 = Absolute temp. Of air the inlet of the compressor
T_2 = Absolute temp. Of air the outlet of the compressor

Tabulation: -

Sl. No.	**P1**	**P2**	**T1**	**T2**	**I.P**	**B.P**	**Mech efficiency**
1							
2							
3							

Conclusion: -

The mechanical efficiency of a single stage air compressor was found to be__________________.

Precaution: -

i) Handle the set up carefully.
i) Before starting the setup check all connections are tight.
ii) Wear safety shoes.
iii) Follow the instructions properly.

EXPERIMENT – 6

Aim of the experiment: -

Study of pressure measuring devices like Manometer & Bourdon tube pressure gauge.

Apparatus required: -

SL.NO.	EQUIPMENT	SPECIFICATION	QUANTITY
01	Manometer	U-tube	01
02	Bourdon tube pressure gauge		01

Theory: -

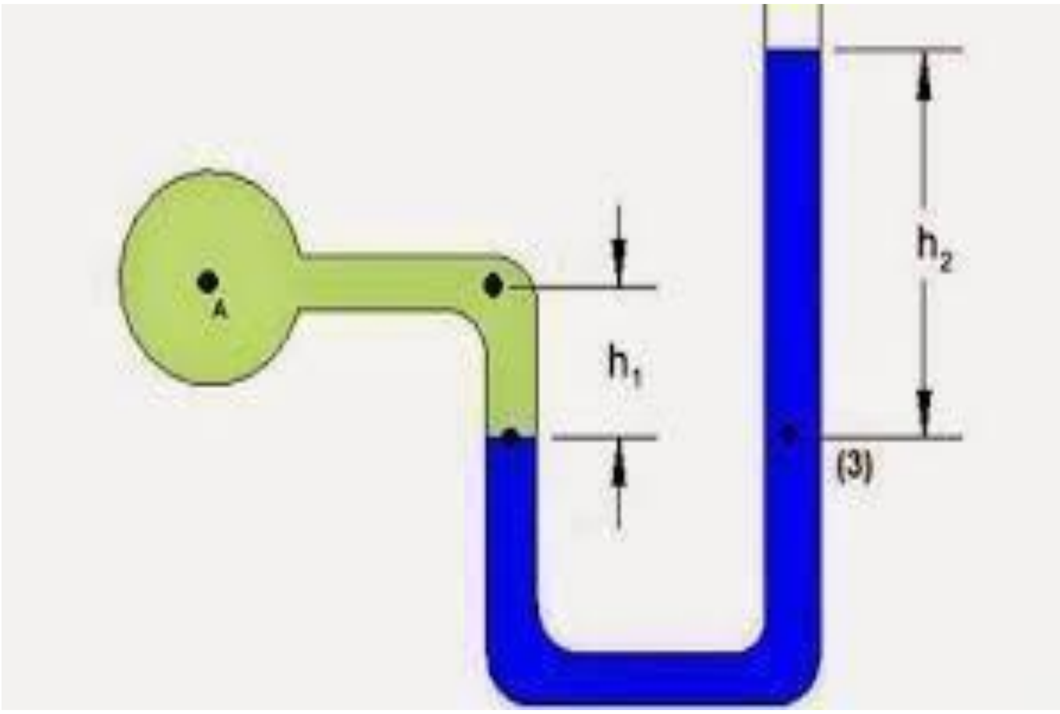
Manometer:

- A Manometer is slightly improved form of a piezometer tube for measuring high as well as negative pressure.
- A simple manometer, in its simplest form, consists of a tube bent in U-shape, one end of which is connected to the vessel containing the liquid whose intensity of pressure is to be measured and other end is open to the atmosphere.
- The liquid used in the bent tube is generally Mercury (Hg) which is 13.6 times heavier than water.
- The pressure of the liquid containing in the vessel will force the manomeric liquid in the left hand vertical limb of the U-tube downward and will force the manometric liquid to rise up in the right hand vertical limb of the U-tube through equal distance. This will happen when the pressure in the vessel is greater than atmospheric pressure.
- If pressure of liquid in the vessel is less than atmospheric pressure, the deflection of manomeric liquid will be observed in the left hand limb of the u-tube.
- Since below the surface A-B, the liquid is homogenous and since the liquid is at rest, the pressure along the plane A-B in the left hand limb of the U-tube is equal to the pressure in the right hand limb of the U-tube along the plane A-B.
- Then by measuring the difference in mercury level above line A-B, and equating the pressure at A and pressure at B we can measure pressure of liquid flowing in the pipe.

Different types of manometer:

1. **U-tube manometer:**

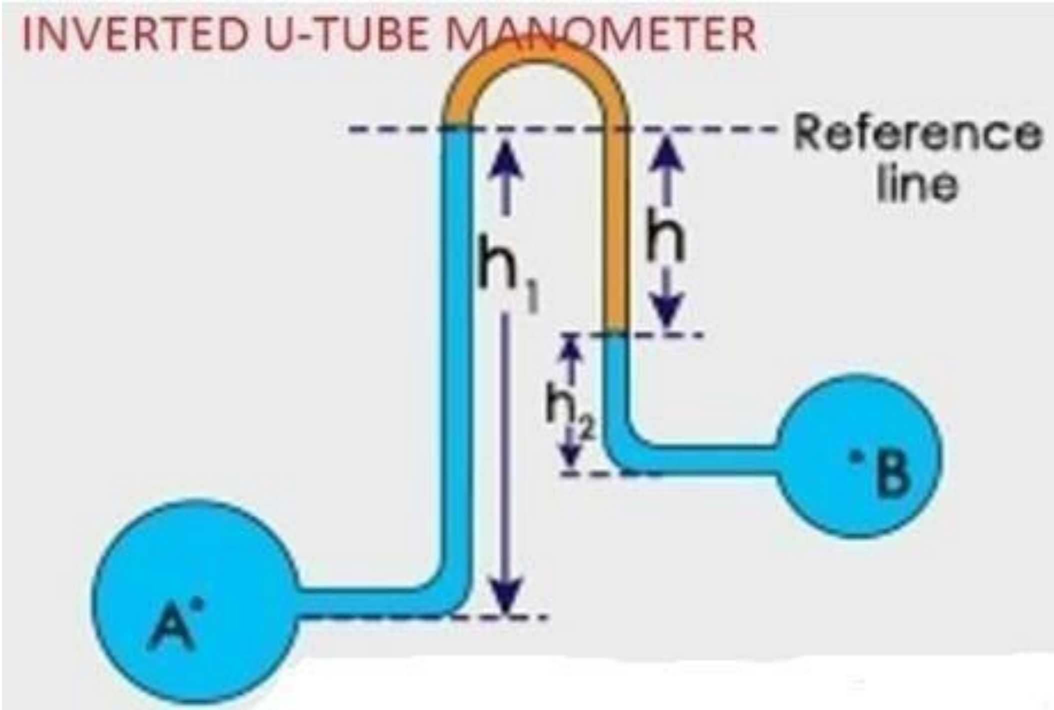
U-Tube manometer consists of a U – formed bent tube whose one end is hooked up to the gauge Location 'A' and alternative Location is receptive the atmosphere. it's then stuffed with a Liquid. The density of the Liquid dictates the vary of pressures that may be observed.



U-TUBE MANOMETER

2. **Inverted U-Tube Manometer:**

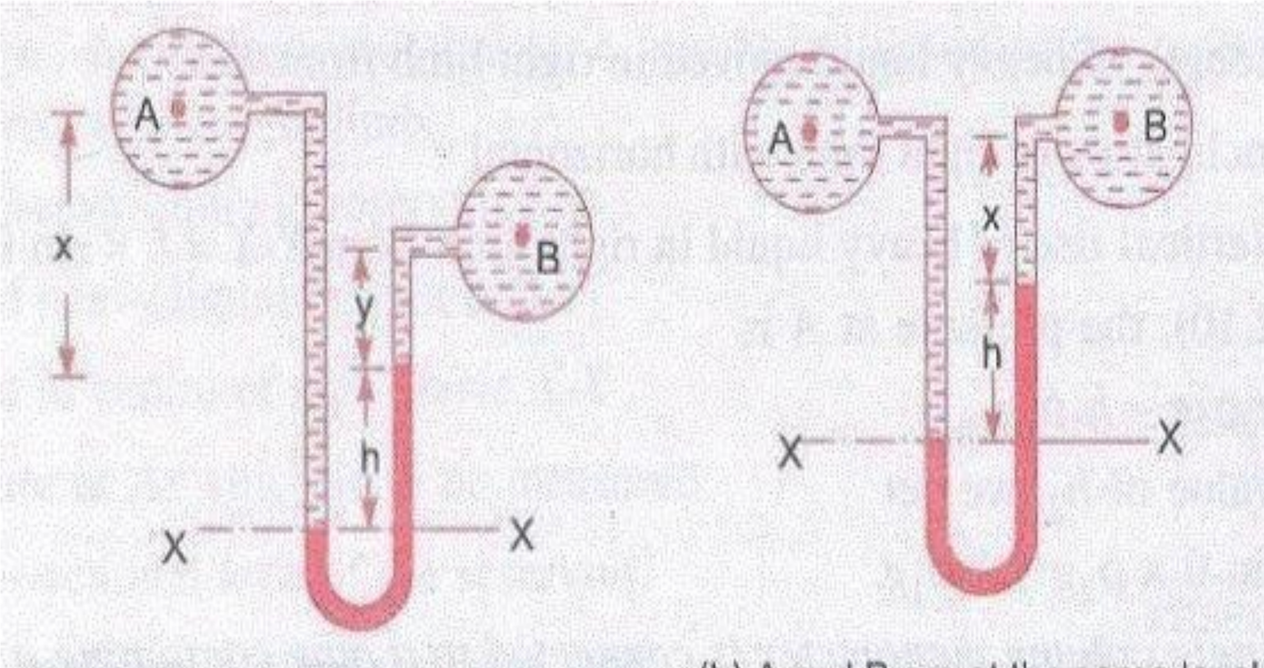
Inverted U-Tube manometer is employed for the measuring of tiny pressure differences in liquids. It consists of associate inverted U – Tube containing a light-weight liquid. this is often used to observe the differences of low pressures between 2points wherever higher accuracy is needed. It typically consists of associate air cock at prime of Mano-metric Liquid kind.



INVERTED U-TUBE MANOMETER

3. Differential U-Tube Manometer:

Differential U-tube manometer is extremely similar to the U-tube manometer. Here one open Location (which was thought-about as atmospheric Location in U-Tube manometer) is connected to a different pressure Location. This manometer is largely used to observe the differences between to totally different points otherwise you will say we tend to calculate the difference.



(a)Two pipes at different levels (b) A and B are at the same level

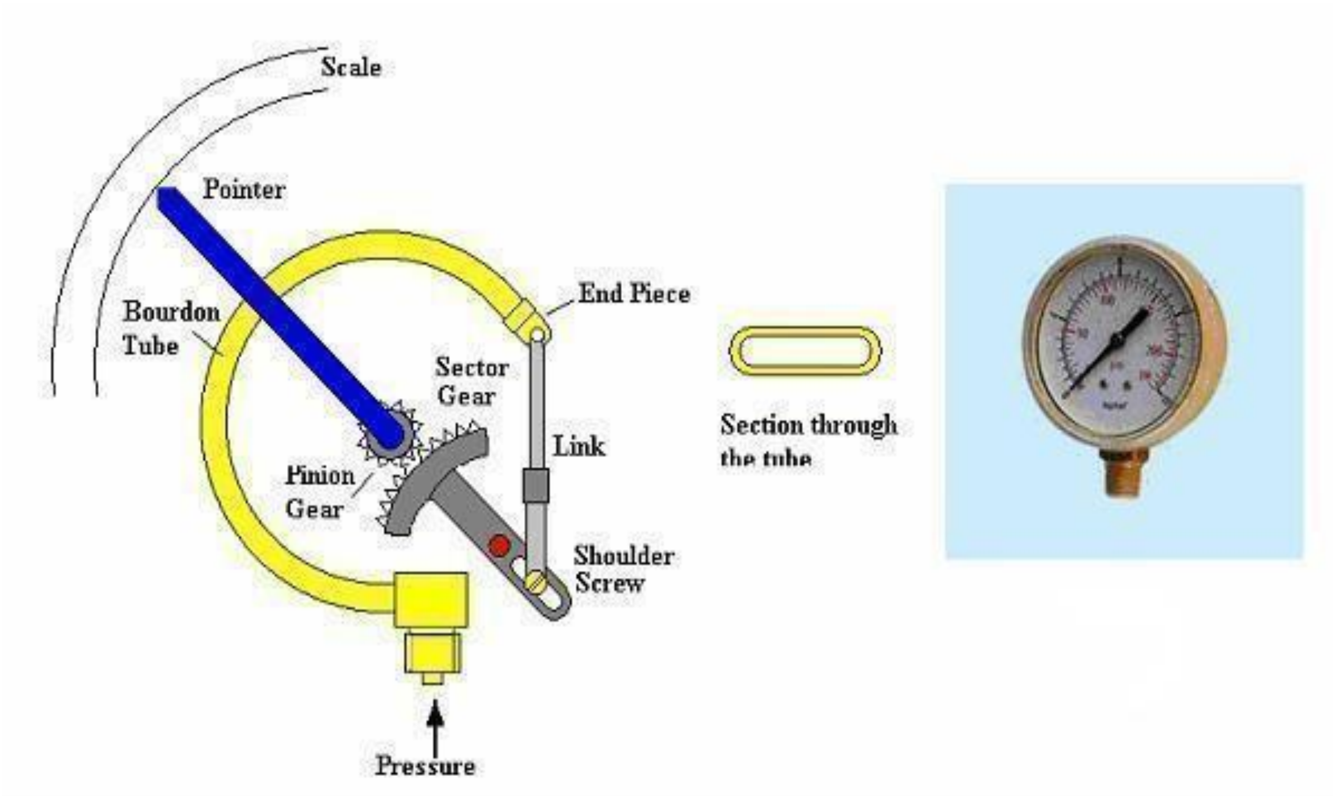
DIFFERENTIAL MANOMETER

Bourdon tube pressure gauge*:*

- Bourdon pressure gauge consists of a circular spring tube A, called Bourdon tube.
- The Bourdon tube is made up of special quality bronze and oval in cross section.
- One end of the Bourdon tube is closed and connected to a link L and the other end is secured in a vertical tube B.
- The link L connects the closed end of the Bourdon tube to a toothed sector C which is hinged at O.
- The toothed sector C gears with a pinion D which is mounted on a central spindle carrying a pointer P.
- The pointer moves on a dial graduated in pressure unit (i.e. bar)
- The pressure gauge is connected to the vessel containing fluid under pressure.
- Due to fluid pressure in the Bourdon tube, it has tendency to achieve a circular shape. But before the tube can do so, it must be straighten itself.
- This tendency of straightening moves the free end of the Bourdon tube outwards.
- As a result, the toothed sector moves about the hinge O and causes the pinion D to rotate which, in turn moves the pointer F to move on a dial graduated in bar.
- The movement of the free end of the Bourdon tube is proportional to the difference

between the external atmospheric pressure and internal fluid pressure.

- Hence the pressure gauge records the gauge pressure which is the difference between fluid pressure and outside atmospheric pressure.



Conclusion: -

Hence we successfully studied about Manometer and Bourdon tube pressure gauge.

EXPERIMENT – 7

Aim of the experiment: -

Verification of Bernoulli's theorem.

Apparatus required: -

S l no	Equipment's	Specification	Quantity
01	Bernoulli's Apparatus test rig		01
02	Stop watch	Digital	01
03	Steel rule	30cm	01
04	Discharge tank	40 cm x 30 cm x 100 cm	01

Theory: -

Bernoulli's theorem states that "For a steady, continuous, incompressible, &non viscous fluid flow, the total energy or total head remains constant at all the sections along the fluid flow provided there is no loss or addition of energy".
i.e.-

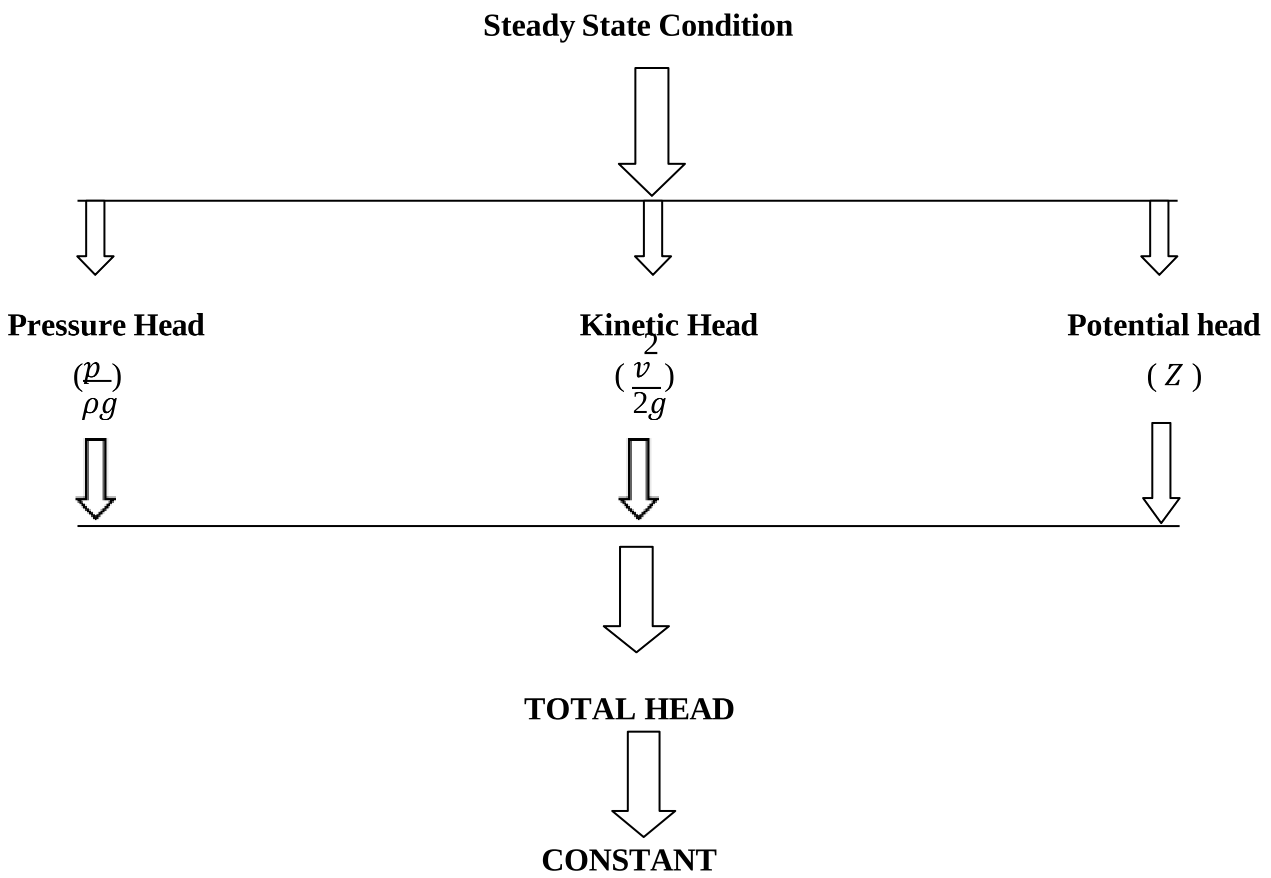
$$\frac{p}{\rho g} + \frac{v^2}{2g} + Z = H = Constant$$

Where, $\frac{p}{\rho g}$ = Pressure head in m

$\frac{v^2}{2g}$ = Velocity or kinetic head in m (Velocity of water = $\frac{Q}{A}$, m/s)

Z = Potential head (Height above some assumed datum level i.e .- Z=0)
Bernoulli's equation is based on Euler's equation of motion. It is applicable to flow of fluid through pipe and channel. It is required to be modified if the flow is compressible & unsteady.

Concept structure: -
The pressure head at every gauge point depends upon the velocity at that cross section. If the cross section area of the conduit is more the velocity will be less and pressure head is more.
The values of pressure head of the first gauge point is more and subsequently decrease up to Centre of gauge point. Again the pressure head increases and will form a parabolic curve.



<u>Procedure: -</u>

i) Measure the area of conduit at various gauge points.
ii) Open the supply valve and adjust the flow so that the water level in the inlet tank remains constant.
iii) Measure the height of water level in the collecting tank by a piezo metric tube with the help of steel rule.
iv) Measure the discharge of the conduit with the help of measuring tank.
v) Note the time duration by stop watch from beginning of initial flow to end of the flow
vi) Repeat the step (i) to (v) for two more readings.

<u>Technical specification: -</u>

Length of the discharge tank (L) = 40cm = 0.4m
Breadth of the discharge tank (b) = 30cm = 0.3m
Area of the measuring tank (A) =L x b =0.4 x 0.3= 0.12 m^2

Observation: -

Depth of water collected in discharge tank, h =______________cm =_____m

Volume of water collected in the tank, q = A x h = 0.12 m^2 x m^3

Time of collection (t) =_____________sec

Calculation table: -

Tube No.	Area of flow of tubes, **A** (m^2)	Discharge, **Q = q/t** (m^3/s)	Velocity of flow, **V** (m/s) **V= Q/A**	Velocity Head, **$V^2/2g$** (m)	Pressure Head, **$P/\rho g$** (m)	Datum Head, **Z** (m)	Total Head, **H = $P/\rho g$+ $V^2/2g$ + Z** (m) (v +vi + vii)	Remark
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
01								
02								
03								
04								
05								
06								
07								

Conclusion: -

Hence we have successfully verified Bernoulli's Theorem and we see that the total head in all the sections of the Bernoulli's apparatus test rig is constant. The slight variation if any is due to losses.

EXPERIMENT – 8

Aim of the experiment: -

Determination of the Co-efficient of Discharge (Cd) from venturimeter.

Apparatus required: -

Sl. No.	Equipment	Specification	Quantity
01	Venturimeter test rig		01
02	Stop Watch	Digital	01
03	Steel Rule	L=30cm	01

Theory: -

A venturimeter is an instrument used to measure the rate of discharge at different sections of the pipe line. A venturimeter consists of 3-parts: -

- Converging section
- Throat section
- Divergent Section

Co-efficient of discharge, $C_d = \frac{Qact}{Q_{theo}}$

where,

$$Qact = \frac{l \times b \times h}{t}$$

l = length of discharge tank
b = breadth of discharge tank h
= height of of discharge tank t =
time taken in sec

$$Q_{theo} = \frac{A_1 \times A_2 \times \sqrt{2gH}}{\sqrt{A_1^2 - A_2^2}}$$

A_1= inlet area of venturimeter

A_2= Outlet area of venturimeter

Procedure: -

1. Set the manometric pressure tube to atmospheric pressure by opening the upper valve
2. Now the supply of water may be controlled by the stop valve
3. One of the valves of any pipe may be opened and close a
4. ll of other three valves/pipes.
5. Note the discharge reading for the particular flow by measuring the height of the discharge tank.
6. Note the time taken by stop watch for the particular flow.
7. Note the reading for the pressure head from the U-tube manometer, with its corresponding reading of discharge.
8. Now take three readings for this pipe and calculate C_d for that instrument using formula given above.
9. Now close this valve and open another valve having different diameter pipe and repeat this procedure as mentioned above. Three such readings also taken and calculate C_d.
10. Similarly take readings for all other diameter pipe and calculate C_d in eachcase.

Technical specification: -

Length of discharge tank, l = 40cm = 0.4m, Breadth of

the discharge tank, b = 30 cm = 0.3m Height of

discharge tank, h = 100cm = 0.10m, Inlet dia of

Venturimeter, D_1 = 2cm =0.02m

Inlet Area (A_1) = $\pi/4 \times (D_1)^2 = \pi/4 \times (0.02)^2$ =___________ m^2

Outlet dia of Venturimeter, D_2 = 1cm =0.01m

Outlet Area (A_2) = $\pi/4 \times (D_2)^2$ **= $\pi/4 \times (0.01)^2$** =_________ m^2

Specific gravity of mercury (S_g) = $\frac{\rho_{Hg}}{\rho H2O} = \frac{13600}{1000}$ = **13.6**

Specific gravity of mercury (So) =

$$\frac{\rho H2O}{\rho H2O}$$

= 1000/1000 = 1

Sl No.	MANOMETER READING (m)			Q_{act} (m^3/sec)	Q_{theo} (m^3/sec)	$C_d = \frac{Q_{act}}{Q_{theo}}$	Remark
	Initial height, $\boldsymbol{h1}$	Final height, $\boldsymbol{h2}$	Net head ($\boldsymbol{H}$)= $(\boldsymbol{h1} - \boldsymbol{h2})\left(\frac{S_g}{S_0} - 1\right)$				
01							
02							
03							

<u>Conclusion: -</u>

From the above experiment, the Co-efficient of Discharge (C_d) of venturimeter was found out to be……………………….

EXPERIMENT – 9

Aim of the experiment: -

Determination of the C_c, C_d and C_v from orifice meter.

APPARATUS REQUIRED: -

SL.NO.	EQUIPMENT	SPECIFICATION	QUANTITY
01	Orifice Tank With Piezometer		01
02	Stop Watch	Digital	01
03	Collecting Tank		01

THEORY: -

Orifices are devices used for discharging fluids into the atmosphere. It is the opening in the wall of a tank or in a plate which may be fitted in a pipe such that the plate is normal to the axis of the pipe. The discharging fluid from the tank/conduit through the orifice comes out in the form of a free jet. In the process, the total energy of the fluid in the tank is converted to kinetic energy as the jet issues out into the atmosphere. The jet cross section initially contracts to a minima and then expands partly due to the viscous resistance offered by the surrounding atmosphere and partly due to inertia of the fluid particles. The section which has the minimum area is known as 'vena contracta'. The contraction and expansion of the jet results in loss of energy.

The actual velocity at vena contracts is smaller than the theoretical velocity due to frictional resistances at the orifice edges. The ratio between the actual velocity and the theoretical velocity of the jet is known as coefficient of velocity Cv. Its value also depends upon the size and shape of the orifice and the head causing flow. The coefficient velocity for a vertical orifice is determined experimentally by measuring the horizontal and vertical coordinates of the issuing jet. The water flows through an orifice under a constant head H. Let V be the actual velocity (which is horizontal) of the jet. Obviously, while covering horizontal distance, the jet is acted upon by gravity with a downward acceleration 'g'. Consider a small particle of water at vena contracta. Suppose it falls through a vertical distance 'y' in a horizontal distance x, in time t sec.

Since actual area of the jet is less than the area of the orifice, and the actual velocity is less than the theoretical velocity; therefore, actual discharge is less than the theoretical discharge. The ratio between the actual discharge and the theoretical discharge is called coefficient of discharge C_d.

$$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$$

where $\sqrt{2gH}$ is the theoretical discharge

The actual discharge passing through an orifice is given by

= Actual velocity at vena contracta × Area of jet at vena contracta

$$= C_v\sqrt{2gH} \times C_c \times a$$

But $\sqrt{2gH}$ is the theoretical discharge

$$\frac{Actual\ discharge\ through\ Orifice}{Theoritical\ discharge\ through\ Orifice}$$

Or $$C_d = C_c \times C_v$$

Where $C = \frac{Q\ act}{Q_{theo}}$

The value of C_d of a standard orifice varies from 0.61 to 0.67

Actual discharge, $$Q_{act} = \frac{A \times r}{t}\ \text{m}^3/\text{s}$$

Where A = area of measuring tank (m^2)

R = rise in water level in the measuring tank in m

t = time taken for the rise in water level

Theoretical discharge, $Q_{theo} = a\sqrt{2gH}$ m^3/sec

a = area of the orifice in m^2

g = acceleration due to gravity m/s^2

H = head over the orifice in m

<u>Procedure</u>: -

1. Adjust the inflow of water to the inlet tank till the steady state condition is achieved by in and outflow from the orifice and the head causing flow through the orifice as indicated by the Piezometer tube is constant. Measure the head '*H*'.

2. Using the hook gauge, measure *x* and *y* coordinates at different points on the centre line of the jet. Knowing '*H*', the head causing flow and *x* and *y* co-ordinates, coefficient of velocity can be obtained

from the formula,

$$C_v = \frac{x^2}{4yh},$$

3. Note the initial reading of water level in the measuring tank, and simultaneously start the stop watch. After an interval of time note the reading of the water level. Difference in the two readings gives the rise in water level during the given time. Knowing, area of measuring tank, actual discharge Q_a can be obtained. Hence C_d can be calculated as

$$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$$

4. Calculate

$$C_c = C_d / C_v$$

5. Repeat the above steps for different heads h and take five readings.

6. Repeat the experiment for mouth piece and convergent orifice.

Observation: -

Dia of circular orifice = 10mm = 1 cm

Area of circular orifice (a) = $\frac{\pi d^2}{4}$ cm^2 = 0.78 cm^2

Dia of circular mouth piece = 10mm = 1 cm

Area of circular mouth piece (a) = $\frac{\pi d^2}{4}$ cm^2 = 0.78 cm^2

Sump Tank Capacity = 50 Liter

Collecting tank Capacity = 30 Liter

Area of collecting tank (A) = 25*30 = 750 cm^2

Observation and tabulation:

Sl. No.	Head (H)	Time (t)	x	y	$Qact$	Q theo	Cd	Cv	Cc
1									
2									
3									
4									
5									

Area of the measuring tank (A) $= L \times B$ L = length of measuring tank

B = breadth of measuring tank

Actual discharge,

$$Qact = \frac{A \times r}{t} \text{ m3/s}$$

Theoretical discharge, $Q_{theo} = a\sqrt{2gH}$ m^3/sec

Coefficient of discharge, $Cd = Q_{act} / Q_{theo}$

$$C_v = \frac{x^2}{4yh},$$

$$C_c = C_d / C_v$$

Conclusion: -

From the above experiment, the value of C_d, C_c and C_v of orifice meter was found to be -----------------------------&------------------- respectively.

EXPERIMENT – 10

Aim of the experiment: -

Determination of darcy's coefficient from flow through pile.

Apparatus required: -

SL. NO.	EQUIPMENT	SPECIFICATION	QUANTITY
01	Differential manometer		01
02	Pressure tapping cocks		01
03	Stop watch		01
04	Collecting tank fitted with piezometer tube		01
05	Different diameter pipes		

Theory: -

When a fluid flows through a pipe, certain resistance is offered to the flowing fluid, which results causing loss of energy. Froude conducted a series of experiments to investigate frictional resistance offered to the flowing water by different surfaces. From the results of this experiments, Froude derived the following conclusions:

1. The frictional resistance varies approximately with the square of the velocity.
2. The frictional resistance varies with the nature of the surface.

According to Darcy's equation,

$$hf = \frac{4flv^2}{2gd}$$

where hf = head loss due to friction in m in water = $x(\frac{Sm}{Sw} - 1)$

x = Manometer deflection = $x2 - x1$ in m of Hg
Sm = Specific gravity of Hg
Sw = Specific gravity of water
l = length of pipe between pressure tapping's in m
v = velocity of flow = Q/aQ
= actual discharge

a = area of pipe in m^2

$a = \frac{^2}{4} m^2$

d = diameter of the pipe in m

$Q = \frac{A \times R}{t}$ m^3/s

A = area of measuring tank in m^2

R = Rise in water level in the collecting tank in m

t = Time taken for the rise in sec

f = Co-efficient of friction (Darcy's constant)

$$f = \frac{2gdh_f}{4lv^2}$$

<u>Procedure: -</u>

1. Note the pipe diameter (d), length of the pipe(l)
2. Make sure only required water regulator valves and required valves at tapping's connected to manometer are opened.
3. Start the pump and adjust the control valve just enough to make fully developed flow but laminar flow. Wait for sometimes so that flow is stabilized.
4. Measure the manometer deflection x across the pressure tapping's.
5. Close the outlet valve of the collecting tank and record the time t taken for rise in water level R in the collecting tank by using a stopwatch.
6. Change the pressure tapping's to the pipes of different diameters and repeat the steps from 1 to 5.
7. Calculate the Darcy's Constant for Pipe no 1, 2 & 3.

<u>Observation and tabulation: -</u>

A. <u>For pipe no.1:</u>

Diameter of the pipe (d) = Length
of the pipe (l) =
Length of the collecting tank (L) =
Breadth of the collecting tank (B) =

Rise in water level in the measuring tank (R) =

Sl. No.	Time (sec)	Manometer readings			h_f (m)	Q (m^3/s)	Velocity (v) (m/s)	Coefficient of friction (f)
		$X1$	$X2$	x				
1								
2								
3								
4								
5								
6								

B. FOR PIPE NO.2:

Diameter of the pipe (d) =
Length of the pipe (l) =
Length of the collecting tank (L) =
Breadth of the collecting tank (B) =
Rise in water level in the measuring tank (R) =

Sl. No.	Time (sec)	Manometer readings			h_f (m)	Q (m^3/s)	Velocity (v) (m/s)	Coefficient of friction (f)
		$X1$	$X2$	x				
1								
2								
3								
4								
5								
6								

C FOR PIPE NO.3:

Diameter of the pipe (d) =
Length of the pipe (l) =
Length of the collecting tank (L) =
Breadth of the collecting tank (B) =
Rise in water level in the measuring tank (R) =

Sl. No.	**Time (sec)**	**Manometer readings**			**h_f (m)**	**Q (m^3/s)**	**Velocity (v) (m/s)**	**Coefficient offriction (f)**
		X1	***X2***	***x***				
1								
2								
3								
4								
5								
6								

CONCLUSION: -

From the above experiment, the value of Darcy's coefficient from flow through pipe was found out to be___________________.