PNS School of Engineering & Technology,

Nisamani Vihar, Marshaghai, Kendrapara

Thermal Engineering-I Lab Manual

Department of Mechanical Engineering

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Prepared by**: Er.Prafulla Kumar Nayak**

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Experiment No. 1: Flash & Fire Point Tests

Using Able's, Cleveland, and Pensky-Martens Apparatus

Objective:

To determine the flash and fire points of a given oil sample using Able's, Cleveland, and Pensky-Martens apparatus.

Apparatus Required:

Able's Flash Point Apparatus
Cleveland Open Cup Apparatus
Pensky-Martens Closed Cup Apparatus
Thermometer
Stopwatch
Heating Source
Oil Sample (Mineral oil, Diesel, Kerosene etc.)

Theory:

Flash Point is the lowest temperature at which the vapor of a combustible liquid will ignite momentarily on the application of a flame under specified conditions.
Fire Point is the lowest temperature at which the vapor burns continuously for at least 5 seconds.

Types of Apparatus:

1. Able's Apparatus – Used for fuels with low flash points (e.g., alcohol).
2. Cleveland Apparatus – Open cup used for high flash point fuels (e.g., lubricating oils).
3. Pensky-Martens Apparatus – Closed cup used for intermediate flash point fuels (e.g., diesel).

Procedure:

A. Able's Apparatus:

1. Clean and dry the apparatus.
2. Fill the test cup with the sample up to the marked level.
3. Insert the thermometer.
4. Heat the sample at a controlled rate (~5–6°C/min).
5. At regular intervals, apply the test flame.
6. Note the temperature when a flash is observed (Flash Point).
7. Continue heating and note the temperature when the flame sustains (Fire Point).

B. Cleveland Apparatus (Open Cup):

1. Clean the cup and fill with the sample.
2. Place thermometer centrally.
3. Heat uniformly and apply flame every 2°C rise.
4. Record flash and fire points.

C. Pensky-Martens Apparatus (Closed Cup):

1. Fill the cup and insert the lid with a stirrer and thermometer.
2. Heat with stirring at a standard rate.
3. Apply test flame at intervals.
4. Note flash and fire points.

Observations:

Sample Name	Apparatus Used	Flash Point (°C)	Fire Point (°C)
Diesel	Pensky-Martens		
Kerosene	Able's		
Lubricant	Cleveland (Open Cup)		

Calculations:

No numerical calculations required. Flash and fire points are recorded directly.

Precautions:

• Ensure the apparatus is clean and dry before use.
• Maintain proper ventilation in the lab.
• Use flame carefully—keep flammable materials away.
• Do not overheat the sample.
• Use standard heating rate and follow instructions for each apparatus.

Result:

The flash and fire points of the given samples were successfully determined using the specified apparatus.

Viva Questions:

1. What is the difference between flash point and fire point?
2. Why are closed and open cup apparatus used?
3. Which apparatus is suitable for diesel and why?
4. What safety measures should be followed during this test?
5. How does volatility of fuel affect its flash point?

Experiment No. 2: Viscosity Measurement using Redwood/Saybolt Viscometer

Viscosity Measurement

Using Redwood/Saybolt Viscometer

Objective:

To determine the viscosity of the given oil sample using Redwood or Saybolt viscometer.

Apparatus Required:

Redwood Viscometer / Saybolt Viscometer
Thermometer
Stopwatch
Measuring Flask
Heating Bath
Oil Sample

Theory:

Viscosity is the measure of a fluid's resistance to flow. It plays a crucial role in the lubrication of engine components. There are two types of viscosity:
1. Dynamic (absolute) viscosity
2. Kinematic viscosity (used in this experiment)

In this experiment, the time taken for a fixed volume of oil to flow through an orifice under gravity is measured, and the kinematic viscosity is calculated using a calibration constant.

Procedure:

1. Ensure the viscometer is clean and dry.
2. Pour the oil sample into the viscometer cup up to the marked level.
3. Insert the thermometer.
4. Heat the oil to the required test temperature using the water bath.
5. Remove the cork and allow the oil to flow into the receiving flask.
6. Measure the efflux time using a stopwatch.
7. Repeat the test for consistency and note the average time.

Observations:

Temperature (°C)	Efflux Time (s)	Kinematic Viscosity (Stokes)

Calculations:

Kinematic Viscosity (ν) = C × t
Where,
C = Calibration constant of the viscometer
t = Efflux time (in seconds)
ν = Kinematic viscosity in Stokes (1 St = 10^{-4} m^2/s)

Precautions:

- Ensure the viscometer is clean before each use.
- Avoid air bubbles in the oil sample.
- Maintain a constant temperature throughout the test.
- Start the stopwatch as soon as oil starts flowing.
- Use the correct calibration constant for the instrument.

Result:

The viscosity of the given oil sample was determined using the Redwood/Saybolt viscometer.

Viva Questions:

1. What is the difference between dynamic and kinematic viscosity?
2. What is the significance of viscosity in lubrication?
3. Why is temperature control important in viscosity measurement?
4. What are the units of viscosity?
5. What is the use of calibration constant in viscometer readings?

Experiment No. 3: Calorific Value Tests using Bomb Calorimeter and Junkers Gas Calorimeter

Objective

To determine the calorific value (heat of combustion) of a gaseous fuel using the Junkers Gas Calorimeter.

Apparatus Required

- Junkers Gas Calorimeter: Measures heat released by combustion of gaseous fuel
- Gas supply (e.g., LPG, coal gas, natural gas)
- Gas flow meter: Measures volume of gas consumed
- Thermometers (inlet & outlet): Measure water temperature before and after heating
- Water supply: Cools the calorimeter and absorbs heat from combustion
- Weighing balance: To determine water collected
- Stopwatch: To measure time
- Measuring cylinder / burette: To collect and measure volume of water

Theory

The calorific value of a gas is the amount of heat liberated when 1 m^3 of gas is burned completely under standard conditions.

Formula:

$CV = (W \times Cp \times (T2 - T1)) / V$

Where:

W = Mass of water (kg)

Cp = Specific heat of water = 4.187 kJ/kg·°C

T1 = Inlet water temperature (°C)

T2 = Outlet water temperature (°C)

V = Volume of gas consumed (m^3)

Procedure

1. Open water supply and maintain a steady flow rate.

2. Record inlet and outlet water temperatures using thermometers.

3. Start gas supply and ignite the burner inside the calorimeter.

4. Use the gas flow meter to measure the volume of gas consumed.

5. Collect water output and measure mass or volume.

6. Measure the time taken to burn a known amount of gas.

7. Use the formula to calculate calorific value.

Observations

Mass of water collected (W): 5.0 kg

Inlet water temperature (T1): 25.0 °C

Outlet water temperature (T2): 38.0 °C

Volume of gas consumed (V): 0.25 m^3

Time duration: 10 minutes

Sample Calculation

CV = (5.0 × 4.187 × (38 - 25)) / 0.25

= (5.0 × 4.187 × 13) / 0.25

= 272.155 / 0.25 = 1088.62 × 4 = 4354.48 kJ/m^3

Result

The calorific value of the given gas sample is approximately 4354.48 kJ/m^3.

Precautions

- Ensure a steady gas and water flow rate.

- Avoid gas leakage.

- Record accurate temperatures using calibrated thermometers.

- Don't allow water to overflow or splash out.

- Burn gas completely and steadily for reliable results.

Conclusion

The calorific value of gaseous fuels can be determined efficiently and accurately using the Junkers Gas Calorimeter.

This method is widely used for domestic gas analysis, power plant fuel testing, and quality control.

Experiment No. 4: Carbon Residue Test

Using Conradson's Apparatus

Objective:

To determine the carbon residue of a given fuel sample using Conradson's apparatus.

Apparatus Required:

Conradson's Carbon Residue Apparatus
Weighing Balance
Crucible
Burner or Heating Source
Fuel Sample
Tongs and Safety Gear

Theory:

The carbon residue of a fuel is the percentage of carbon left after the evaporation and pyrolysis of the sample. It is an indication of the tendency of the fuel to form carbon deposits under high temperature conditions.

In the Conradson method, the sample is placed in a crucible and heated strongly in the absence of air. The residue left after complete evaporation is weighed and expressed as a percentage of the original sample weight.

Procedure:

1. Clean and dry the crucible.
2. Weigh the empty crucible and record its mass (W1).
3. Fill the crucible with a known amount of fuel sample and weigh it (W2).
4. Place the crucible in the apparatus and heat strongly until the sample is completely evaporated.
5. Allow the crucible to cool, then weigh it again with the residue (W3).
6. Calculate the carbon residue as a percentage of the original sample.

Observations:

Description	Weight (g)	Remarks	Sample Type
Empty Crucible (W1)			
Crucible + Sample (W2)			
Crucible + Residue (W3)			
Carbon Residue (%)			

Calculations:

Carbon Residue (%) = $[(W3 - W1) / (W2 - W1)] \times 100$

Where,
W1 = Weight of empty crucible

W2 = Weight of crucible + sample
W3 = Weight of crucible + carbon residue

Precautions:

- Use dry and clean crucibles for accurate measurement.
- Handle the crucible with tongs to avoid burns.
- Avoid exposure of the sample to air during heating.
- Perform the test in a well-ventilated area.
- Cool the crucible completely before final weighing.

Result:

The carbon residue of the given fuel sample was determined using Conradson's apparatus and recorded as a percentage of the sample weight.

Viva Questions:

1. What is the significance of carbon residue in fuel testing?
2. How is Conradson's method different from Ramsbottom method?
3. Why should the sample be heated in the absence of air?
4. What is the impact of high carbon residue in engines?
5. Can this method be used for all types of fuels? Why or why not?

Experiment No. 5: Assembling and Disassembling of I.C. Engines

Objective:

To understand the procedure for assembling and disassembling an internal combustion (I.C.) engine and to identify its major components.

Apparatus Required:

I.C. Engine (Petrol or Diesel)
Set of hand tools (spanners, screwdrivers, etc.)
Cleaning brushes and cloth
Safety gloves and goggles
Component checklist sheet

Theory:

Internal combustion engines work by burning fuel inside the engine cylinder, converting thermal energy into mechanical work. These engines can be classified as 2-stroke or 4-stroke, and as petrol (spark ignition) or diesel (compression ignition) engines.

Understanding the assembly and disassembly of an I.C. engine helps students learn the function, design, and interaction of engine parts.

Procedure:

1. Ensure the engine is clean and properly mounted on a stand.
2. Note the original positions of parts before disassembly.
3. Begin disassembling the engine systematically:
   a. Remove external components (air filter, exhaust, etc.)
   b. Dismantle cylinder head and valve assembly
   c. Remove piston, crankshaft, and connecting rod
4. Clean and inspect each component.
5. Reassemble the engine in reverse order, ensuring each part is aligned and secured.
6. Verify the engine rotates smoothly by hand cranking.

Observations:

Component Name	Function
Piston	
Cylinder	
Connecting Rod	
Crankshaft	
Camshaft	
Valves	
Spark Plug / Fuel Injector	
Flywheel	

Precautions:

• Use proper tools to avoid damage to engine parts.
• Wear gloves and safety goggles during disassembly.
• Handle delicate parts like valves and piston rings carefully.
• Keep parts organized to ensure proper reassembly.
• Verify torque specifications if using power tools.

Result:

The I.C. engine was successfully disassembled and reassembled. All major components were identified and understood in terms of function and placement.

Viva Questions:

1. What is the function of a piston in an I.C. engine?
2. How does a 4-stroke engine differ from a 2-stroke engine?
3. What is the purpose of a crankshaft?
4. Why is lubrication important during assembly?
5. What safety precautions must be followed when working with engines?

Experiment No. 6: Port Timing Diagram of Petrol Engine

Objective:

To draw the port timing diagram of a two-stroke petrol engine and understand the timing of the opening and closing of ports with respect to crank angle.

Apparatus Required:

Two-Stroke Petrol Engine Model
Protractor or Crank Angle Disc
Pointer
Chalk or Marker
Stopwatch (if rotating by motor)
Crank handle or electric drive

Theory:

In a two-stroke petrol engine, the functions of intake, compression, power, and exhaust are completed in one revolution of the crankshaft. The piston movement controls the opening and closing of the ports (inlet, transfer, and exhaust ports).

The port timing diagram is a graphical representation showing the angular positions at which the ports open and close during the engine cycle.

Procedure:

1. Mount the engine model securely on the test bench.
2. Attach a degree wheel (crank angle disc) to the crankshaft.
3. Fix a pointer on the engine to indicate crank angle.
4. Rotate the crankshaft slowly and note the crank angles at which:
   a. Inlet port opens and closes
   b. Exhaust port opens and closes
   c. Transfer port opens and closes
5. Record all angular positions with reference to the Top Dead Center (TDC).
6. Plot a port timing diagram based on your observations.

Observations:

Port Type	Opening Angle (°)	Closing Angle (°)
Inlet Port		
Exhaust Port		
Transfer Port		

Diagram:

Draw the port timing diagram based on your recorded angles. The X-axis represents crank angle (0°–360°), and the Y-axis indicates port status (open/close).

Precautions:

- Rotate the crankshaft slowly and carefully to avoid missing the exact angle.
- Ensure proper alignment of the pointer and crank angle disc.

• Record the angles accurately at the moment of port opening/closing.
• Do not tamper with port mechanisms.

Result:

The port timing diagram of the two-stroke petrol engine was plotted successfully and analyzed for port timing characteristics.

Viva Questions:

1. What is a port timing diagram?
2. How does port timing affect engine performance?
3. Why are there no valves in a two-stroke engine?
4. What is scavenging in a two-stroke engine?
5. Why is the exhaust port opened before the transfer port?

Experiment No. 7: Port Timing Diagram of Diesel Engine

Objective:

To draw the port timing diagram of a two-stroke diesel engine and understand the timing of the opening and closing of ports with respect to crank angle.

Apparatus Required:

Two-Stroke Diesel Engine Model
Protractor or Crank Angle Disc
Pointer
Chalk or Marker
Stopwatch (if rotating by motor)
Crank handle or electric drive

Theory:

In a two-stroke diesel engine, ports control the flow of gases rather than valves. The piston covers and uncovers the inlet, exhaust, and transfer ports as it moves. The port timing diagram shows the crank angle positions at which these ports open and close.

This diagram helps understand the scavenging process and how efficiently the engine breathes. Diesel engines usually have a longer power stroke and require better compression, so the timing of ports differs slightly from that of petrol engines.

Procedure:

1. Mount the two-stroke diesel engine model securely.
2. Attach a degree wheel (crank angle disc) to the crankshaft.
3. Fix a pointer to indicate crank angles.
4. Slowly rotate the crankshaft and observe the positions where:
   a. Exhaust port opens and closes
   b. Transfer port opens and closes
   c. Inlet port opens and closes (if present)
5. Record the crank angles with respect to the Top Dead Center (TDC).
6. Use these values to plot a port timing diagram.

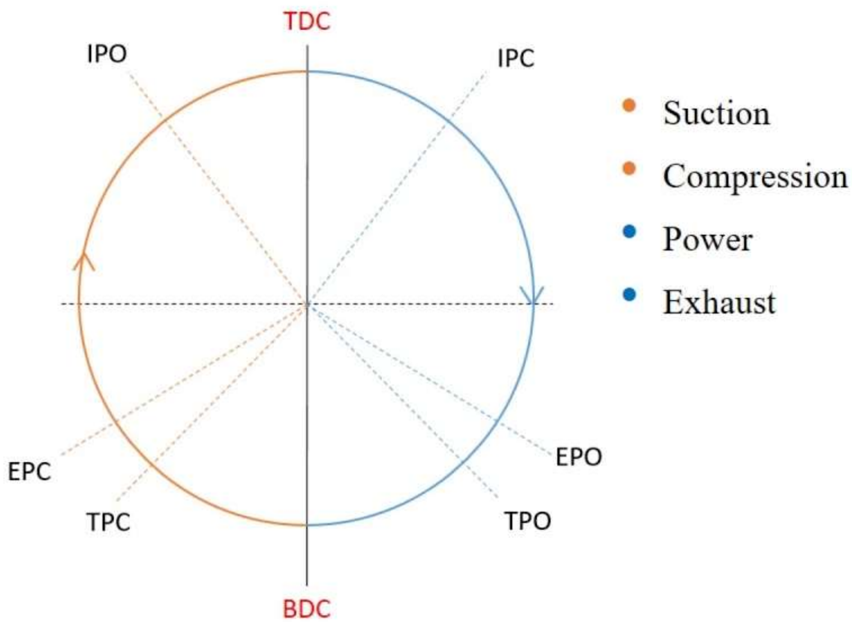
Observations:

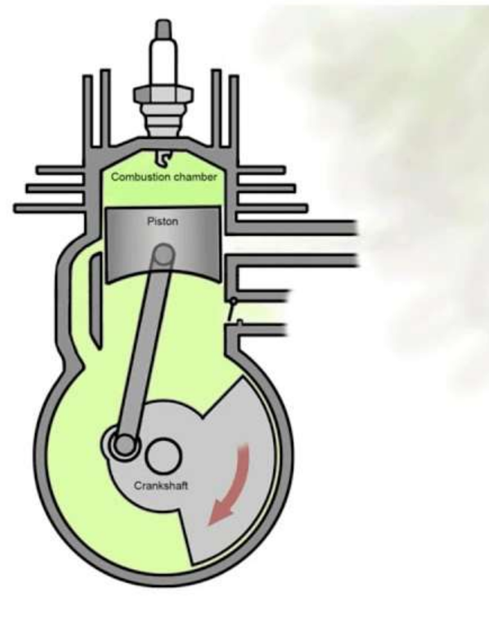
Port Type	Opening Angle (°)	Closing Angle (°)
Exhaust Port		
Transfer Port		
Inlet Port (if any)		

Diagram:

Draw the port timing diagram using the recorded crank angles. The diagram should show the positions of port opening and closing over a full 360° crankshaft rotation.

PORT TIMING DIADRAM





Precautions:

- Rotate the crankshaft slowly to accurately record port timings.
- Ensure the degree wheel is fixed tightly and aligned correctly.
- Handle engine parts gently during observation.
- Verify angle readings at least twice for accuracy.

Result:

The port timing diagram of the two-stroke diesel engine was successfully plotted and the port timing characteristics were studied.

Viva Questions:

1. What is the function of the port timing diagram in a two-stroke engine?
2. How does the port timing of a diesel engine differ from a petrol engine?
3. What is scavenging and how is it represented in the diagram?
4. Why is it important to know the exact timing of port operations?
5. What is the significance of transfer and exhaust port overlap?

Experiment No. 8: Valve Timing Diagram of Petrol Engine

Objective:

To study and draw the valve timing diagram of a four-stroke petrol engine and determine the valve opening and closing positions with respect to crank angle.

Apparatus Required:

Four-Stroke Petrol Engine Model
Crank Angle Disc
Pointer
Hand Crank or Motor Drive
Chalk or Marker
Stopwatch (if needed)

Theory:

In a four-stroke petrol engine, two valves are used: the intake (inlet) valve and the exhaust valve. These valves open and close at specific crank angles to allow the engine to breathe properly. The valve timing diagram shows the crank angles at which these valves open and close relative to Top Dead Center (TDC) and Bottom Dead Center (BDC). Due to inertia and flow requirements, the valves open and close slightly before or after TDC/BDC. This phenomenon is called valve overlap and is necessary for improved engine performance.

Procedure:

1. Mount the petrol engine securely and ensure it can rotate freely.
2. Fix a crank angle disc to the crankshaft and align a pointer.
3. Slowly rotate the crankshaft and observe the crank angle at which:
   a. Inlet valve opens (IVO)
   b. Inlet valve closes (IVC)
   c. Exhaust valve opens (EVO)
   d. Exhaust valve closes (EVC)
4. Record all the valve events relative to TDC and BDC.
5. Use this data to draw a valve timing diagram.

Observations:

Valve Event	Crank Angle Position	Reference (TDC/BDC)
Inlet Valve Opens (IVO)		
Inlet Valve Closes (IVC)		
Exhaust Valve Opens (EVO)		
Exhaust Valve Closes (EVC)		

Diagram:

Plot the valve timing diagram showing the valve opening and closing angles. Indicate TDC and BDC clearly and show the valve overlap period.

Precautions:

• Ensure proper alignment of the pointer and crank angle disc.
• Rotate the crankshaft slowly to avoid missing any valve event.
• Mark angles accurately and repeat observations to confirm results.
• Do not force any moving part of the engine model.

Result:

The valve timing diagram of the four-stroke petrol engine was drawn successfully and the valve timing characteristics were analyzed.

Viva Questions:

1. What is the purpose of a valve timing diagram?
2. Why does the inlet valve open before TDC?
3. What is valve overlap and why is it important?
4. How does incorrect valve timing affect engine performance?
5. What is the function of the camshaft in valve timing?

Experiment No. 9: Valve Timing Diagram of Diesel Engine

Objective:

To study and draw the valve timing diagram of a four-stroke diesel engine and determine the valve opening and closing positions with respect to crank angle.

Apparatus Required:

Four-Stroke Diesel Engine Model
Crank Angle Disc
Pointer
Hand Crank or Motor Drive
Marker or Chalk
Stopwatch (if needed)

Theory:

In a four-stroke diesel engine, the intake and exhaust valves operate at specific crank angles to allow air to enter and exhaust gases to leave the cylinder. Unlike petrol engines, diesel engines do not use a spark plug but rely on compression ignition. The valve timing diagram shows the exact crank angles at which the intake valve opens and closes (IVO & IVC) and the exhaust valve opens and closes (EVO & EVC). Valve overlap occurs when both valves are open simultaneously near the end of the exhaust stroke and the beginning of the intake stroke, improving scavenging.

Procedure:

1. Secure the diesel engine model on the test bench.
2. Mount a crank angle disc on the crankshaft and align a fixed pointer.
3. Slowly rotate the crankshaft and note the crank angles at which:
   a. Inlet valve opens (IVO)
   b. Inlet valve closes (IVC)
   c. Exhaust valve opens (EVO)
   d. Exhaust valve closes (EVC)
4. Record each valve event with respect to TDC and BDC.
5. Draw the valve timing diagram using the recorded data.

Observations:

Valve Event	Crank Angle Position	Reference (TDC/BDC)
Inlet Valve Opens (IVO)		
Inlet Valve Closes (IVC)		
Exhaust Valve Opens (EVO)		
Exhaust Valve Closes (EVC)		

Diagram:

Using the observations, draw a valve timing diagram showing the valve events on a 360° crank angle representation. Highlight the valve overlap clearly.

Precautions:

- Ensure correct alignment of the crank angle disc and pointer.
- Rotate the crankshaft slowly and carefully to identify valve events accurately.
- Repeat observations for accuracy.
- Handle all engine parts with care during the experiment.

Result:

The valve timing diagram of the four-stroke diesel engine was successfully plotted and analyzed for accurate valve event timings.

Viva Questions:

1. What is the function of valve timing in diesel engines?
2. Why is there valve overlap in four-stroke engines?
3. How does incorrect valve timing affect engine performance?
4. What are the differences between petrol and diesel valve timing diagrams?
5. What is the role of the camshaft in controlling valve timing?

Experiment No. 10: Study of Petrol and Diesel Engine Components and Models

Objective:
To study the various components of petrol and diesel engines and understand their construction, working principles, and differences.

Apparatus Required:
Cut-section models of petrol engine
Cut-section models of diesel engine
Charts and diagrams
Handbook or manuals for reference

Theory:
Petrol and diesel engines are internal combustion (IC) engines that convert chemical energy in fuel into mechanical energy. Although both operate on similar principles, they differ in their method of ignition and some constructional features.

Petrol engines use spark ignition (SI) where an electric spark ignites the air-fuel mixture. Diesel engines use compression ignition (CI), where high compression causes the air temperature to rise and ignite the fuel injected into the cylinder.

Both engines consist of several essential components including the cylinder block, piston, connecting rod, crankshaft, camshaft, valves, spark plug or fuel injector, and others.

Procedure:
1. Observe the cut-section models of both petrol and diesel engines.
2. Identify and note down all key components such as:
   - Cylinder block
   - Cylinder head
   - Piston
   - Connecting rod
   - Crankshaft
   - Camshaft
   - Valves
   - Spark plug (Petrol) / Fuel injector (Diesel)
   - Carburetor (Petrol)
   - Fuel pump
3. Understand the function of each part and how it differs between petrol and diesel engines.
4. Study any additional systems such as lubrication, cooling, and ignition systems.
5. Note the key differences in engine construction and operation between the two types.

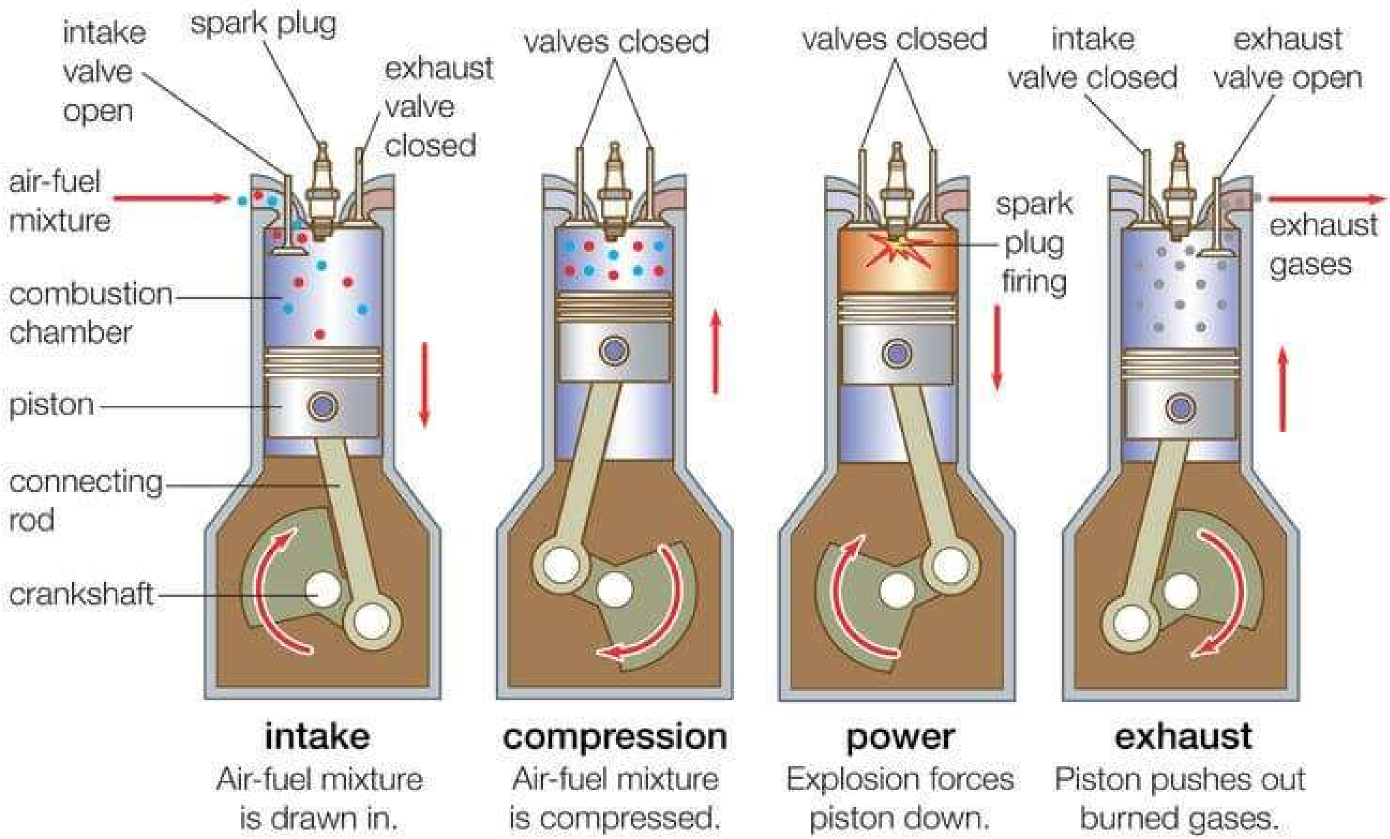
Observations:

Component	Petrol Engine	Diesel Engine
Ignition System		
Fuel Supply System		

Compression Ratio		
Fuel Injector / Carburetor		
Spark Plug		
Starting Mechanism		

Diagram:

Draw or observe labeled diagrams of petrol and diesel engine components. Identify each part and its function.



Precautions:

- Handle the engine models carefully.
- Follow the instructor's guidance while observing internal parts.
- Do not tamper with or damage any components.
- Note observations systematically.

Result:

The components of petrol and diesel engines were studied successfully, and the major differences between them were understood.

Viva Questions:

1. What is the main difference between petrol and diesel engines?
2. What is the function of the spark plug and why is it absent in diesel engines?
3. What role does the carburetor play in a petrol engine?

4. How does compression ratio differ in petrol and diesel engines?
5. Why are diesel engines generally more fuel-efficient?