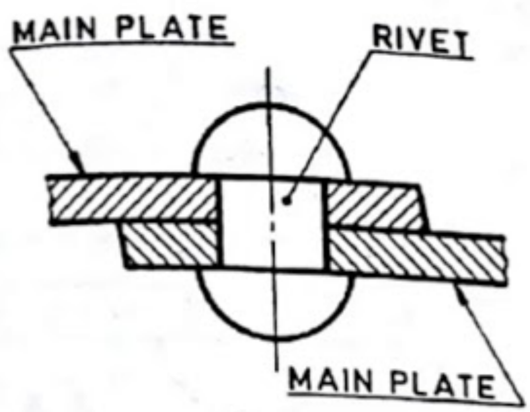
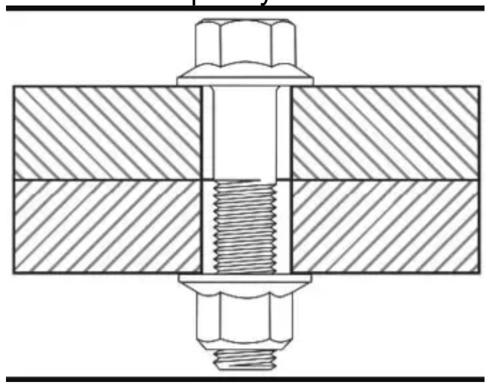
Section - A
Permanant Joints

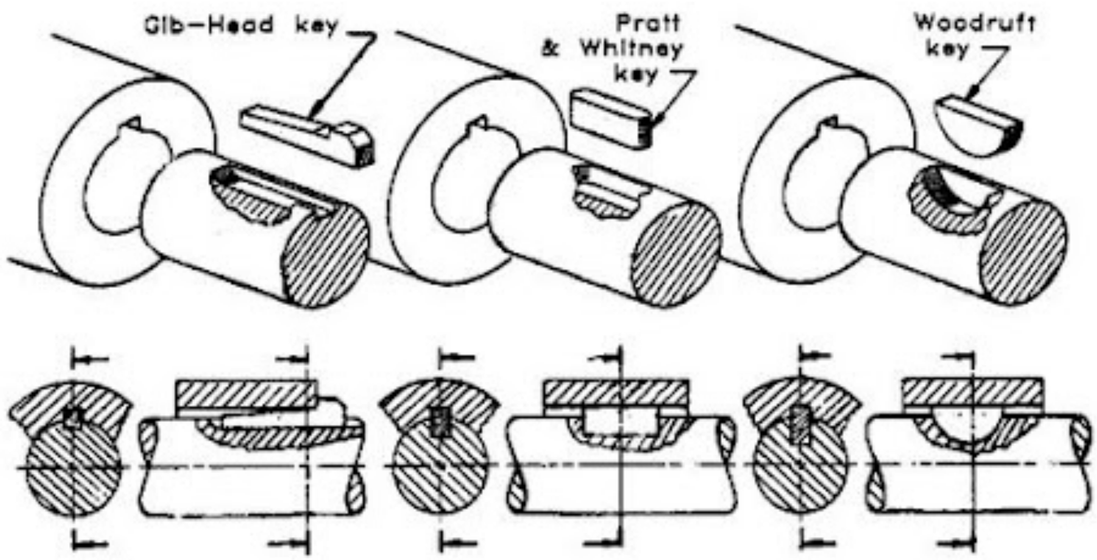


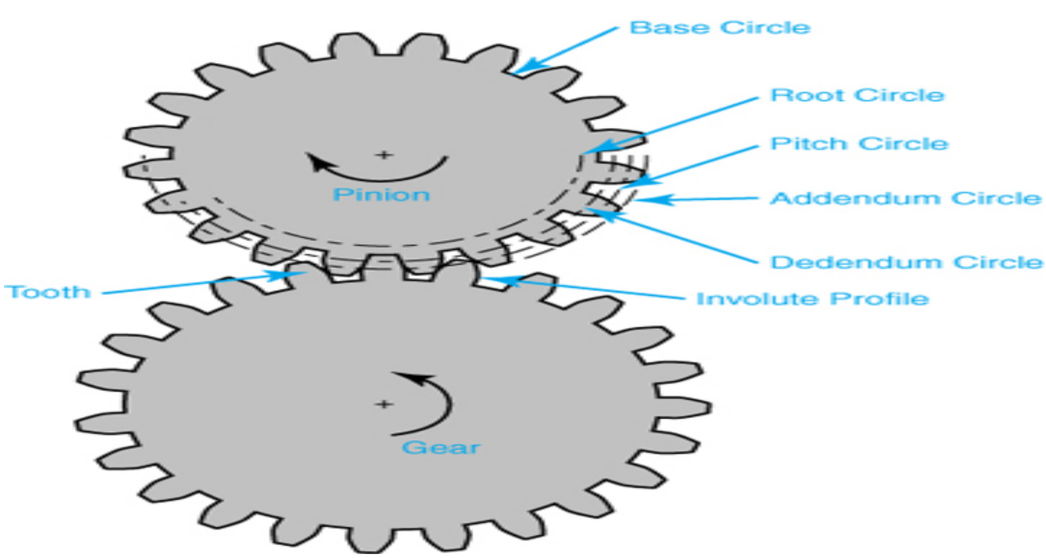
S. No.	form of weld	Sectional representation	Symbol
1.	Fillet		
2.	Square butt		
3.	Single-V butt		
4.	Double-V butt		
5.	Single-U butt		
6.	Double-U butt		
7.	Single bevel butt		
8.	Double bevel butt		

Temporary Joints

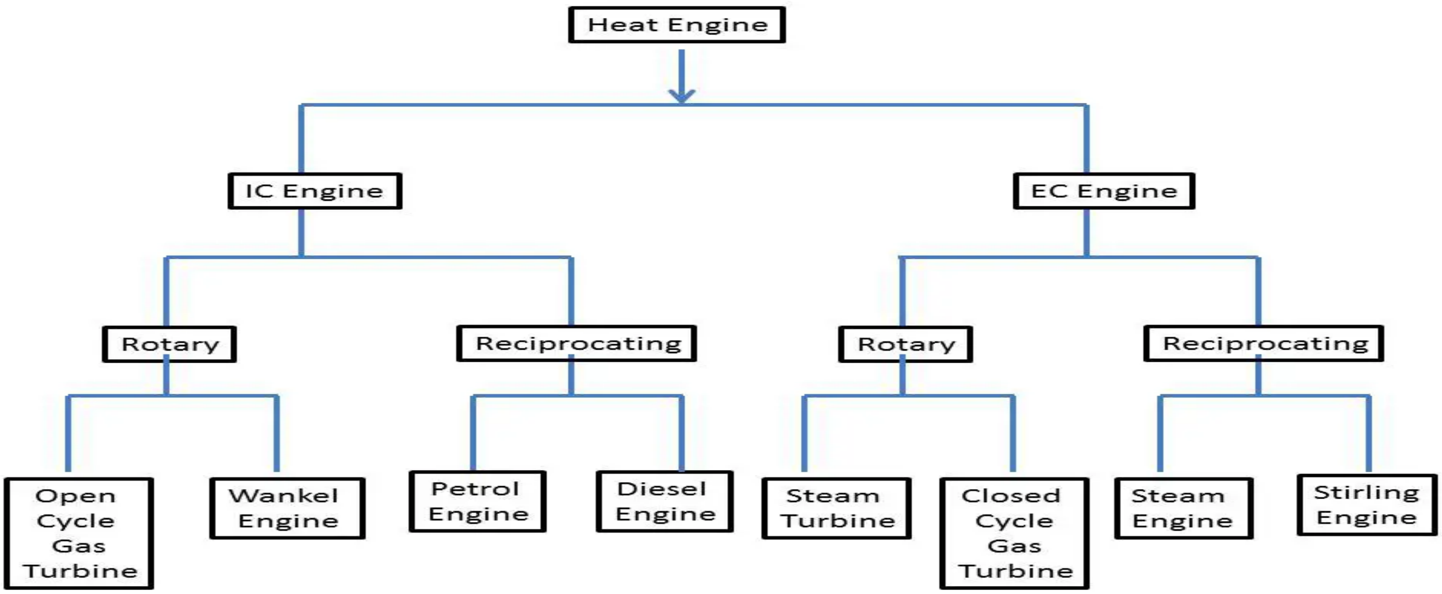


Gears, Keys and Spline joints

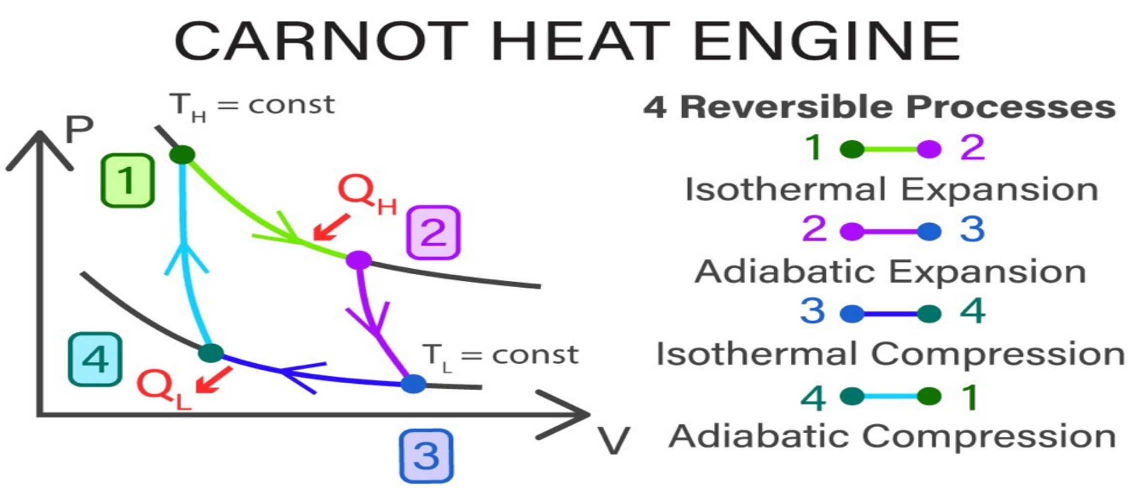


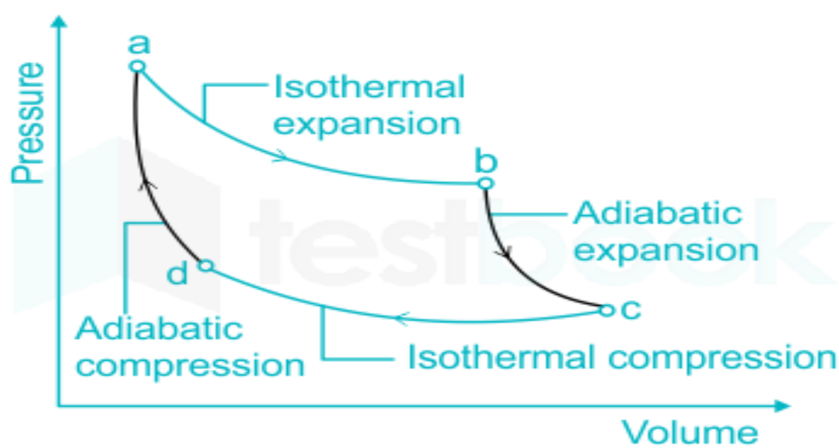


2. Heat Engines



Different cycles involved in heat engines





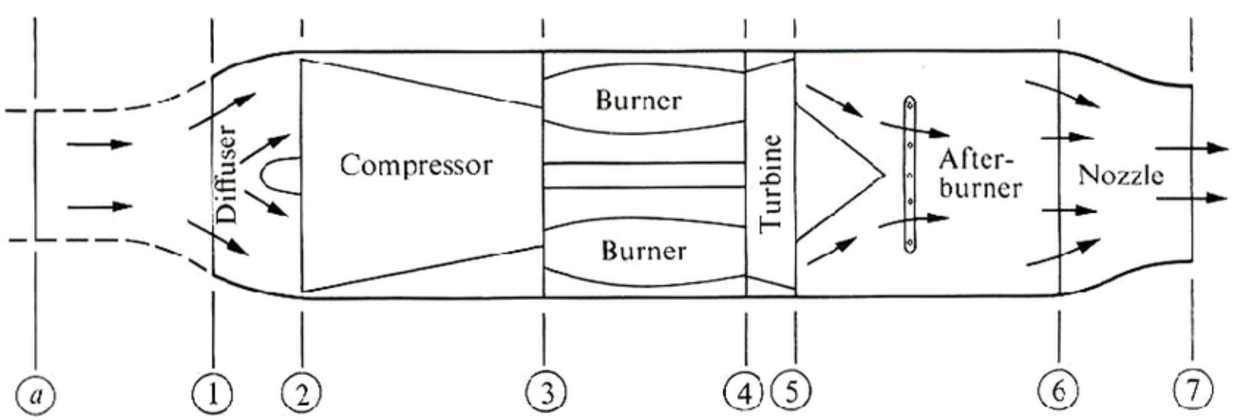
Basic difference in Steam Engine and Automotive engines

S. No	Steam Engines	I.C. Engines
1.	The combustion of fuel takes place outside the engine cylinder (*i.e.* in a boiler)	The combustion of fuel takes place inside the engine cylinder.
2.	Since combustion of fuel takes place outside the engine cylinder, therefore these engines are smooth and silent running.	Since combustion of fuel takes place inside the engine cylinder, these engines are very noisy.
3.	The working pressure and temperature inside the engine cylinder is low.	The working pressure and temperature inside the cylinder is very high.
4.	Because of low pressure and temperature, ordinary alloys are used for the manufacture of engine cylinder and its parts.	Because of very high pressure and temperature, special alloys are used for the manufacture of engine cylinder and its parts.
5.	A steam engine requires a boiler and other components to transfer energy. Thus, it is heavy and cumbersome.	An I.C. engine does not require a boiler or other components. Thus, it is light and compact.
6.	The steam engines have efficiency about 15-20 percent.	The I.C. engines have efficiency about 35-40 percent.
7.	It can not be started instantaneously.	It can be started instantaneously.

Different types of power plants (engine) used in civil Aircraft

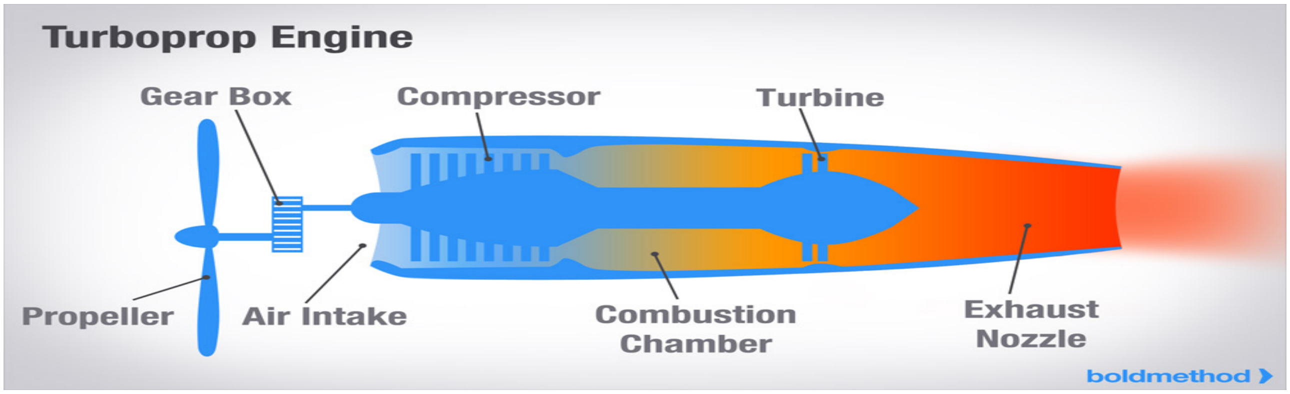
1. **Turbojet Engines:**

- Turbojets are simple jet engines that are effective at high speeds and altitudes. They work by pulling air in through the front with a fan, compressing it, mixing it with fuel, igniting the mixture, and expelling it out the back at high speed. However, they are mostly phased out in modern civil aviation due to their inefficiency at lower speeds and noise levels.



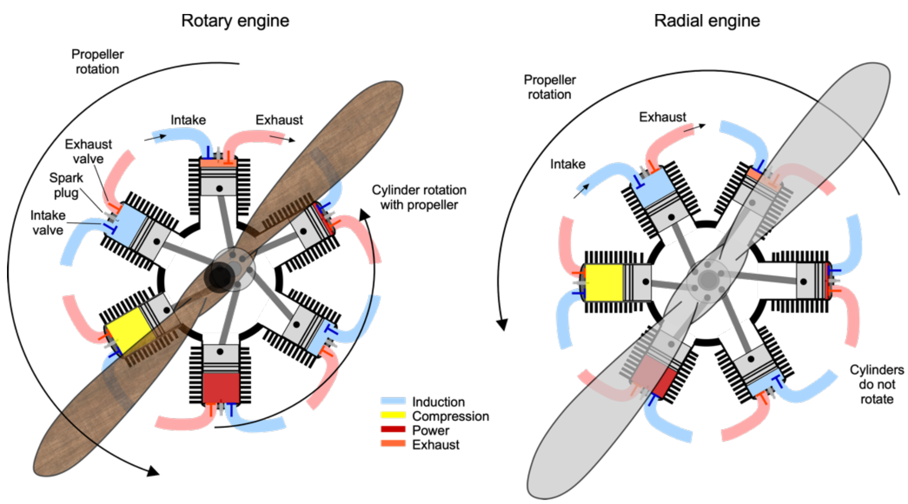
3. **Turboprop Engines:**

- Turboprop engines combine a gas turbine engine with a propeller. They are efficient at lower flight speeds and are commonly used in regional airliners, cargo aircraft, and aircraft that operate in rugged environments because of their excellent short takeoff and landing capabilities.



5. **Piston Engines:**

- Piston engines are often used in light aircraft and are similar to automobile engines. They are generally more economical for smaller planes, used for training, personal use, or light commercial use. They can be powered by avgas or standard automotive gasoline, driving a propeller through a crankshaft.



3. Thermodynamics

3.1 General

3.1.1. Boyle's law, Charles' law and combined gas law

1. **Boyle's Law**:
   - Equation: $P \times V = \text{constant}$
   - This states that the product of the pressure P and volume V of a gas remains constant when the temperature is held constant. If the volume increases, the pressure decreases proportionally, and vice versa.
2. **Charles' Law**:
   - Equation: $\frac{V}{T} = \text{constant}$
   - It indicates that the volume V of a gas is directly proportional to its absolute temperature T (in Kelvin) when the pressure is constant. As the temperature increases, the volume increases at a constant rate.
3. **Combined Gas Law**:
   - Equation: $\frac{P \times V}{T} = \text{constant}$
   - This law combines Boyle's and Charles' laws, showing that the ratio of the product of pressure P and volume V to the temperature T remains constant, assuming the amount of gas doesn't change. It can be used to calculate changes in any of the variables when the others are adjusted.

3.1.2 Characteristics of gas constant

The gas constant, denoted as R, is a fundamental constant in the ideal gas law which relates the number of moles of a gas to its pressure, volume, and temperature. It has a value of approximately 8.314 J/(mol·K) in the International System of Units. The constant is used to express the behavior of an ideal gas under various conditions of pressure, volume, and temperature.

1. **Value and Units**: The gas constant R has a value of approximately 8.314 J/(mol·K), and it relates energy scale per temperature per mole, crucial for calculations in thermodynamics.
2. **Universal Application**: It appears in the ideal gas law $PV = nRT$, linking pressure P, volume V, temperature T, and number of moles n for ideal gases.
3. **Versatility in Equations**: R is used across various gas laws and equations, not just the ideal gas law, but also in other contexts like calculating changes in entropy or energy within thermodynamic processes.

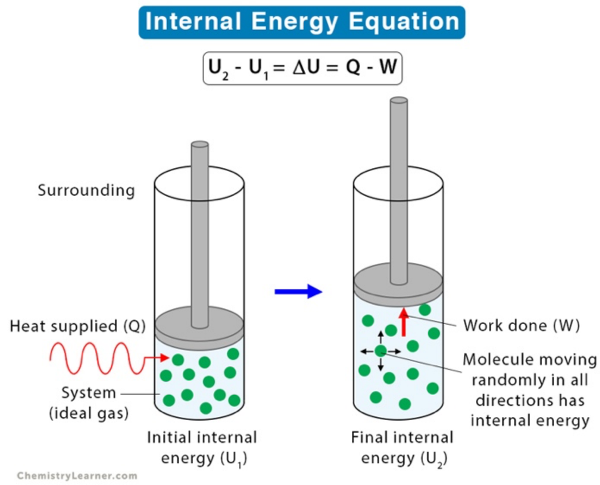
3.2 First law of thermodynamics

3.2.1 Definition of the first law

The First Law of Thermodynamics states that energy cannot be created or destroyed; it can only be converted from one form to another.

3.2.2 Total internal energy

The **internal energy** of a thermodynamic system is the energy contained within it, measured as the quantity of energy necessary to bring the system from its standard internal state to its present internal state of interest, accounting for the gains and losses of energy due to changes in its internal state, including such quantities as magnetization.



3.2.3 Mechanical equivalent of heat engine

Equation

The mechanical equivalent of heat can be expressed by the equation:

$$J = \frac{W}{Q}$$

where:

- J is the mechanical equivalent of heat, measured in joules per calorie (J/cal). The modern value of J is approximately 4.184 J/cal, meaning that 4.184 joules of mechanical work are equivalent to 1 calorie of heat.
- W is the mechanical work done, measured in joules (J).
- Q is the heat energy produced or absorbed, measured in calories (cal).

Heat Engines and Thermodynamics

In the context of heat engines, this concept is used to determine the efficiency of converting heat energy into mechanical work. The efficiency (η) of a heat engine is defined by the ratio of the work output to the heat input:

$$\eta = \frac{W}{Q_h}$$

where Q_h is the heat energy absorbed from the hot reservoir.

Mechanical Equivalent of Heat

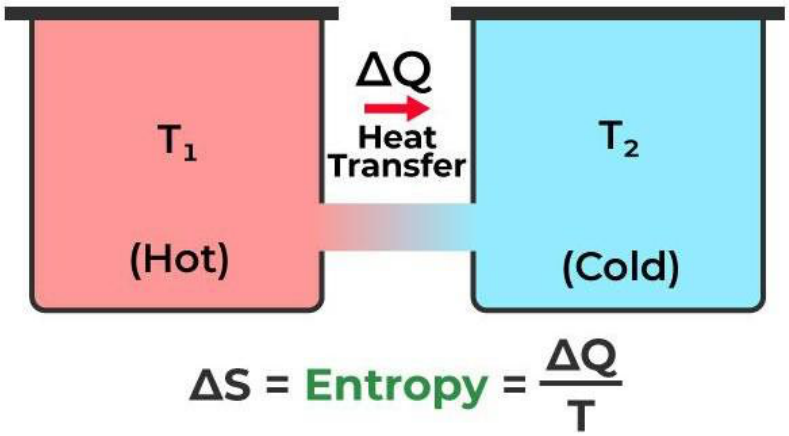
- Joule found that it took approximately 4.18 J of mechanical energy to raise the temperature of 1g water at 1°C
- Later, more precise measurements determined the amount of mechanical energy needed to raise the temperature of 1g of water from 14.5°C to 15.5°C
- 1 cal = 4.186 J

  This is known as the ***mechanical equivalent of heat***

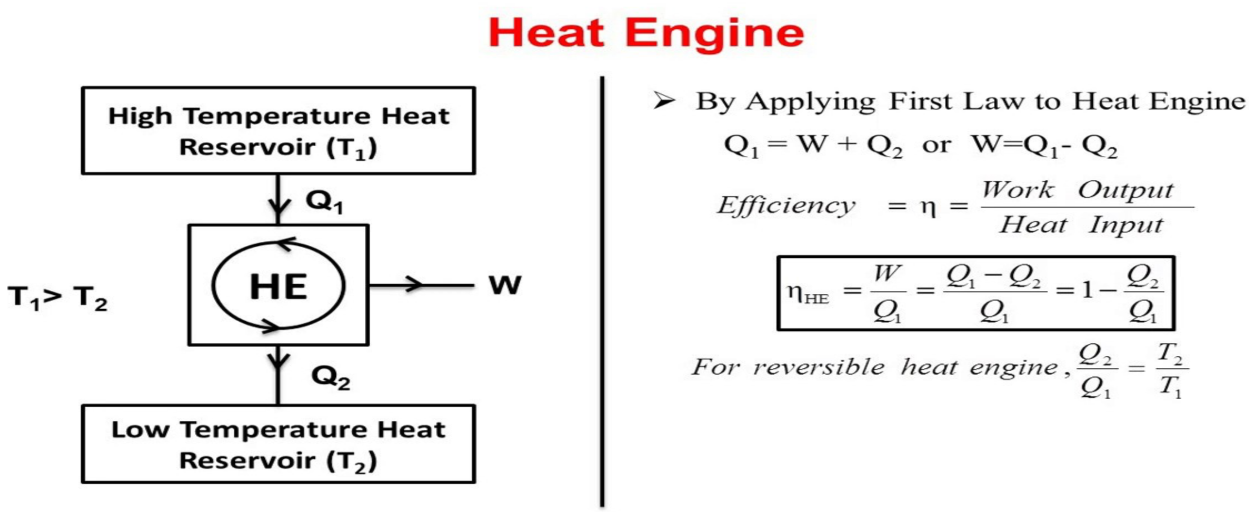
3.3 Second law of thermodynamics

3.3.1 Definition of the second law

The Second Law of Thermodynamics states that the state of entropy of the entire universe, as an isolated system, will always increase over time. The second law also states that the changes in the entropy in the universe can never be negative.



3.3.2 Thermal efficiency of heat engine



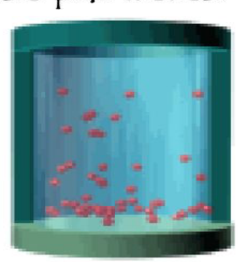
3.4 Thermodynamics Properties of Fluid (Definitions only)

3.4.1 Internal energy

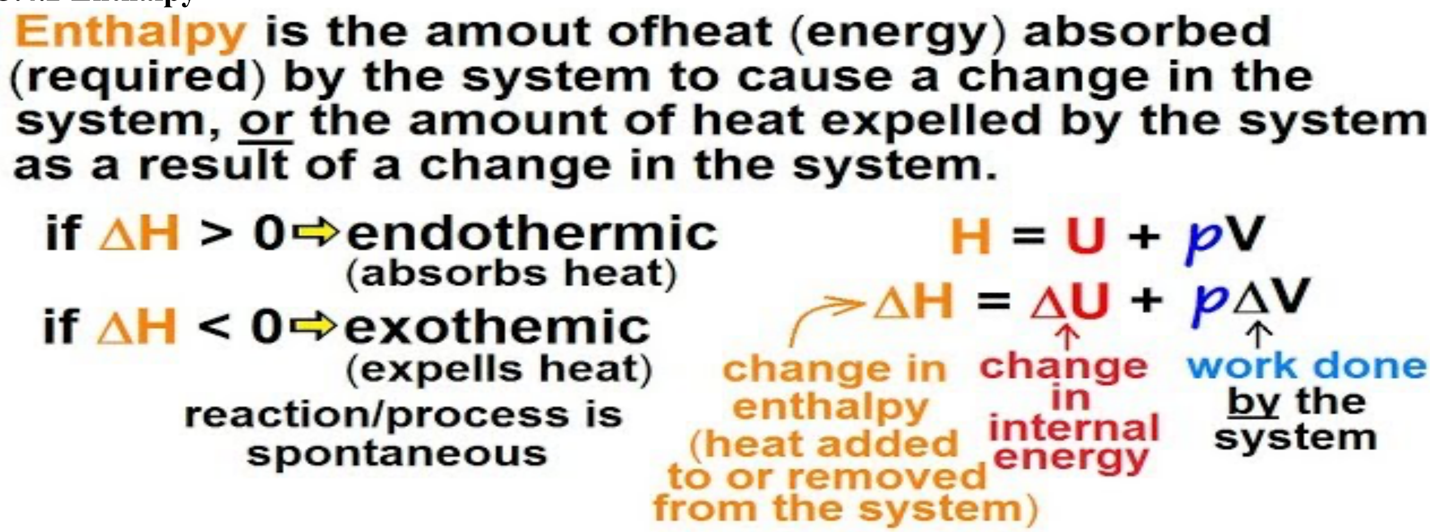
Internal Energy of a system is the sum of kinetic energies of all of its constituent particles, plus the sum of all the potential energies of interaction among these particles.

$$\Delta U = U_2 - U_1$$

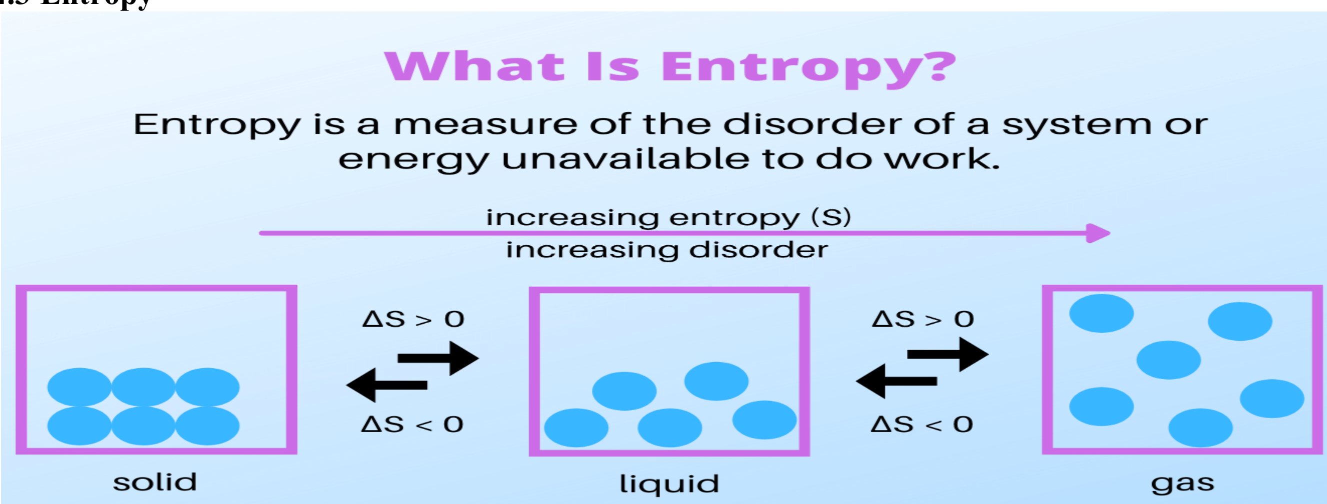
Where:
ΔU = change in internal energy
U_1 = initial internal energy
U_2 = final internal energy



3.4.2 Enthalpy



3.4.3 Entropy



3.4.4 Specific heat at constant volume

Specific heat at constant volume, often denoted as c_v, is a thermodynamic property that describes the amount of heat energy required to raise the temperature of a unit mass of a substance by one degree Celsius (or one Kelvin) while maintaining constant volume. Here are the key aspects:

1. **Measurement and Units**: Specific heat at constant volume is measured in joules per gram per degree Celsius (J/g°C) or joules per kilogram per Kelvin (J/kg·K).
2. **Formula**: It is mathematically expressed as:

$$c_v = \left(\frac{\partial U}{\partial T}\right)_V$$

   where $\frac{\partial U}{\partial T}$ is the partial derivative of internal energy U with respect to temperature T, holding volume V constant.
3. **Physical Significance**: c_v is crucial for understanding how much energy is needed to heat a substance without changing its volume. This property is particularly important in contexts where the substance is confined and cannot expand, such as in rigid containers or within the cylinder of an internal combustion engine during compression.

3.4.5 Specific heat at constant pressure

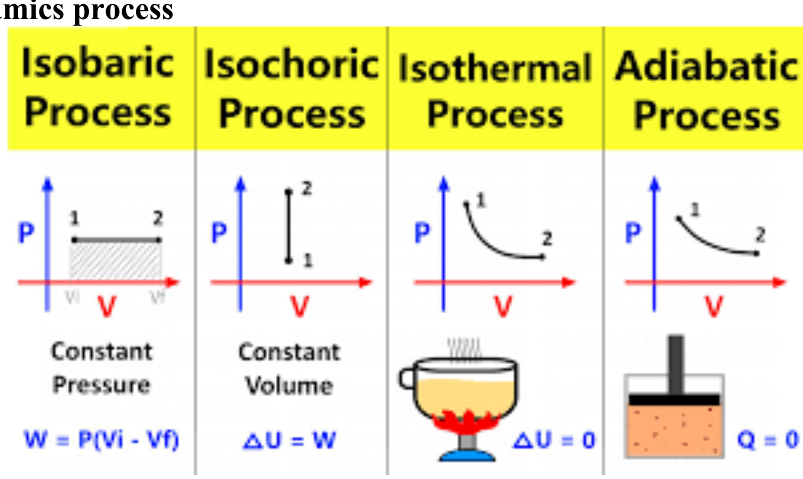
Specific heat at constant pressure, often denoted as c_p, is a thermodynamic property that describes the amount of heat energy required to raise the temperature of a unit mass of a substance by one degree Celsius (or one Kelvin) while maintaining constant pressure. Here are the key points about c_p:

1. **Measurement and Units**: Specific heat at constant pressure is measured in joules per gram per degree Celsius (J/g°C) or joules per kilogram per Kelvin (J/kg·K).
2. **Formula**: It is mathematically expressed as:

$$c_p = \left(\frac{\partial H}{\partial T}\right)_P$$

   where $\frac{\partial H}{\partial T}$ is the partial derivative of enthalpy H with respect to temperature T, holding pressure P constant.
3. **Physical Significance**: c_p is important for understanding how much energy a substance can absorb or release at constant pressure, which is common in open systems where substances typically expand or contract freely, such as in atmospheric processes or in heating and cooling systems. c_p is typically higher than c_v (specific heat at constant volume) for the same substance, due to the additional work done against the external pressure when the substance expands upon heating.

3.5 Basic thermodynamics process

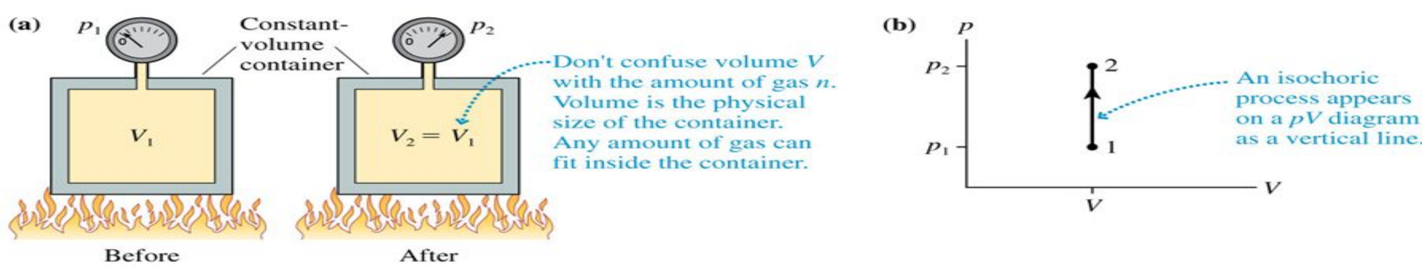


Process	Relationship between p, V, T	Work (W)	Internal-energy change ($U_2 - U_1$)	Heat (Q)
constant pressure	p = constant $\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$p(V_2 - V_1)$	$mc_v(T_2 - T_1)$	$mc_p(T_2 - T_1)$
constant volume	V = constant $\frac{p_1}{T_1} = \frac{p_2}{T_2}$	0	$mc_v(T_2 - T_1)$	$Q = U_2 - U_1$ $Q = mc_v(T_2 - T_1)$
isothermal	$T = c$ $p_1V_1 = p_2V_2$	$p_1V_1 \ln \left(\frac{V_2}{V_1}\right)$	0	$Q = W$ $Q = p_1V_1 \ln \left(\frac{V_2}{V_1}\right)$
polytropic	pV^n = constant $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{n-1}$ $\frac{p_2}{p_1} = \left(\frac{T_2}{T_1}\right)^{\frac{n}{n-1}}$	$\frac{p_1V_1 - p_2V_2}{n-1}$	$mc_v(T_2 - T_1)$	$Q = W + U_2 - U_1$
adiabatic	as for polytropic with $n = \gamma$	as for polytropic with $n = \gamma$	$mc_v(T_2 - T_1)$	0

3.5.1 Constant volume process

a.k.a. *isochoric process*

- the gas is in a *closed, rigid container*.
- Warming the gas with a flame will *raise its pressure* w/out changing its volume.
- *Vertical* line on pV diagram

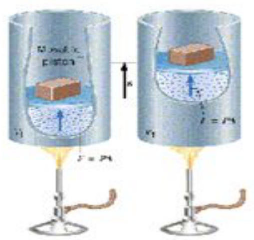


3.5.2 Constant pressure process

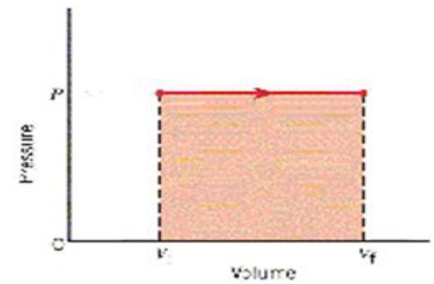
- process in which pressure is kept constant

Isobaric Process

Isobaric Process



- Constant Pressure
- Work = Force x distance
- Force = Pressure x Area
- Work = Pressure x Area x distance
- W = P Δ V
- Work is equal to the area under the PV diagram.



$$W = P\Delta T$$

$$Q = mc_p\Delta T$$

$$\Delta U = Q - W$$

3.5.3 Constant temperature process

In isothermal process, temperature is constant i.e $T=0$ and ∴ internal energy of the system is also constant i.e. $U=0$

Acc. to Ist Law of Thermodynamics :-

$$\Delta U = q + P\Delta V$$

$$0 = q + P\Delta V$$

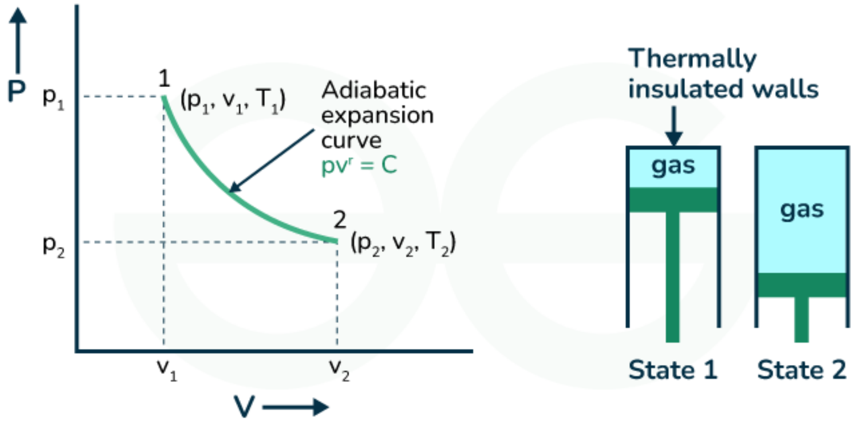
$$\boxed{q = -P\Delta V} \text{ or } \boxed{q = -W}$$

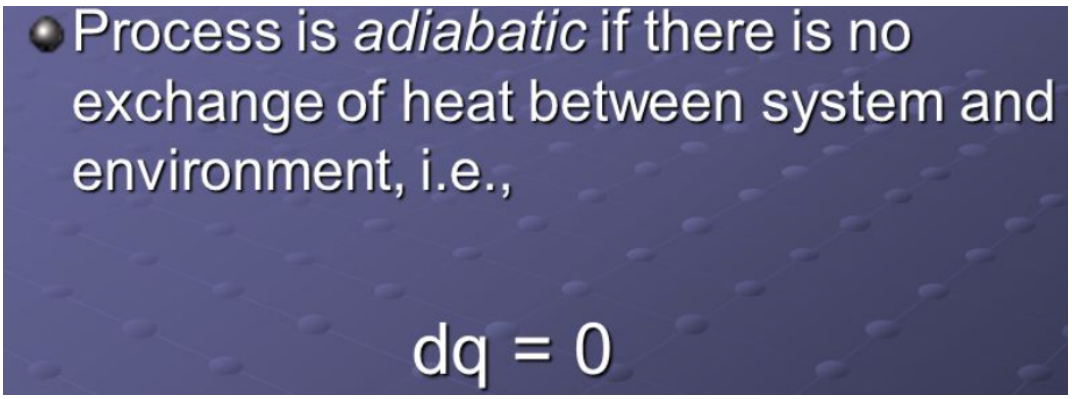
i.e. Heat supplied or released is equal to the work done on the system or work done by the system.

So, thus, the given statement is $\boxed{\text{False}}$.

Hence, $\boxed{\text{option b}}$ is correct.

3.5.4 Adiabatic process





3.5.5 Polytropic process

Polytropic processes and work

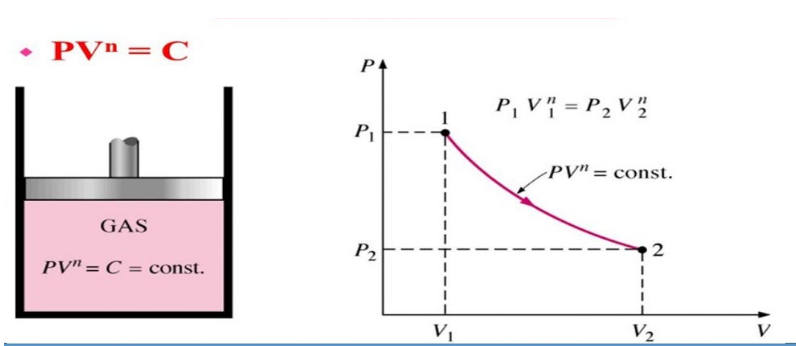
A polytropic process is described by the equation

$$PV^n = constant$$

where P is the pressure, V is the volume, and n is a constant referred to as the *polytropic exponent*. Recall that the work done by a moving boundary is

$$W = \int_{V_1}^{V_2} PdV$$

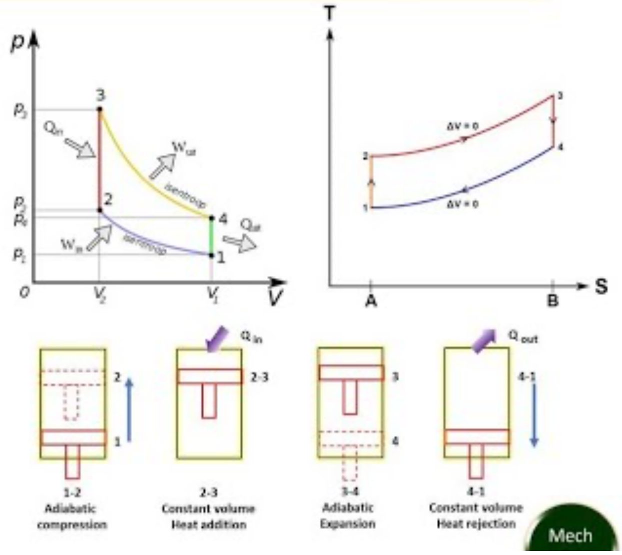
Using this definition, derive an expression for the work done by a fluid undergoing a polytropic process on a piece of scratch paper. Show your work to an instructor when finished. (**Hint:** How does P vary with V for a polytropic process?)



3.6 Petrol and Diesel Engine Cycles
3.6.1 Constant volume cycle petrol cycle

OTTO CYCLE

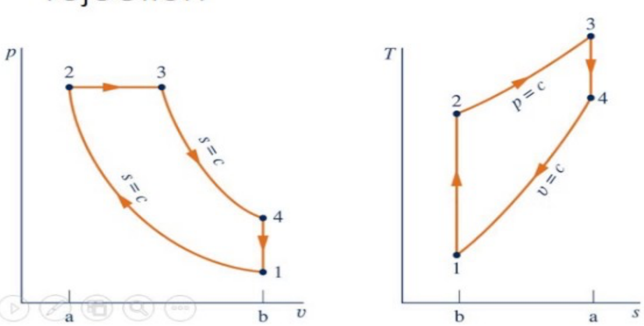
- This engine was discovered by otto.
- It works under four stroke principle.
- It has two adiabatic and two constant volume process.
- In this engine heat addition and heat rejection is conducted at a constant volume process.
- So that it is called as constant volume cycle.



3.6.2 Constant pressure cycle or diesel cycle

Diesel Cycle

- Heat addition occurs at constant pressure
  - Process 1-2: isentropic compression
  - Process 2-3: constant-pressure heat addition
  - Process 3-4: isentropic expansion
  - Process 4-1: constant-volume heat rejection



- Air-standard analysis (preferred)
  - Process 2-3

$$W_{23} = mp_2(v_3 - v_2)$$

$$m(u_3 - u_2) = Q_{23} - mp_2(v_3 - v_2)$$

$$Q_{23} = m(h_3 - h_2)$$

  - Thermal efficiency

$$\eta = \frac{W_{cycle}}{Q_{in}} = \frac{Q_{23} - Q_{41}}{Q_{23}} = 1 - \frac{u_4 - u_1}{h_3 - h_2}$$

  - Cutoff ratio

$$r_c = \frac{V_3}{V_2}$$

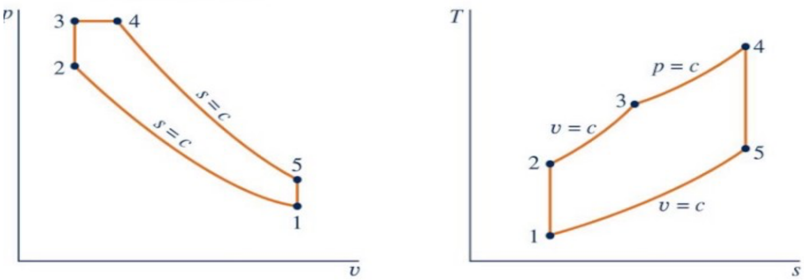
  - Process 3-4

$$\frac{v_{r4}}{v_{r3}} = \frac{V_4}{V_3} = \frac{V_1}{V_2}\frac{V_2}{V_3} = \frac{r}{r_c}$$

3.6.3 Mixed cycle or Dual cycle

Dual Cycle

- Heat addition occurs in two steps
  - Process 1-2: isentropic compression
  - Process 2-3: constant-volume heat addition
  - Process 3-4: constant-pressure heat addition
  - Process 4-5: isentropic expansion
  - Process 5-1: constant-volume heat rejection



- Air-standard analysis

$$W_{12} = m(u_2 - u_1)$$

$$Q_{23} = m(u_3 - u_2)$$

$$W_{34} = mp_3(v_4 - v_3) \qquad Q_{34} = m(h_4 - h_3)$$

$$W_{45} = m(u_4 - u_5)$$

$$Q_{51} = m(u_5 - u_1)$$

Basic Industrial Management

4.1 Labour law

Workers have been entitled to several rights by the Latest Labour Laws of Nepal. They are entitled to Minimum Wage of NRS 17,300. They cannot be worked for more than 8 Hours a Day and 48 Hours a Week. Further, Workers cannot be, without sufficient reason, terminated from Employment.

4.2 Rights of Unions

Employees have the right to unionize, to join together to advance their interests as employees, and to refrain from such activity. It is unlawful for an employer to interfere with, restrain, or coerce employees in the exercise of their rights.

A union is an organization formed by workers who join together and use their strength to have a voice in their workplace. Through their union, workers have the ability to negotiate from a position of strength with employers over wages, benefits, workplace health and safety, job training and other work-related issues.

4.3 Wages and compensation

The Compensation Act provides for property acquired or to be acquired by the Government of Nepal in accordance with the Nepal laws. The Government of Nepal may, if it considers necessary to acquire any property for the public interest, acquire that property.

The current minimum wage in Nepal is NPR17,300.00 per month in 2023. It became valid on August 18, 2023. The amounts are in Nepalese Rupee. Workers have been entitled to several rights by the Latest Labour Laws of Nepal. They are entitled to Minimum Wage of NRS 17,300. They cannot be worked for more than 8 Hours a Day and 48 Hours a Week. Further, Workers cannot be, without sufficient reason, terminated from Employment.

The Labor Act, 2074 has replaced the previous labor law completely i.e. Labor Act, 2048 has ceased to be in effect. The New Labor Act has been passed for provisions for the rights, interest, facilities and safety of workers and employees working in enterprises of various sectors.

4.4 Labour and Management relations

Labor-Management Relations is the interaction of employees, their exclusive representatives, and management to resolve, bilaterally, concerns affecting the working conditions of bargaining unit employees.
Enhanced labor relations result in improved work productivity, and work profits. It also plays an important role in customer retention. When the employees feel satisfied with their work, they pay attention to the needs of the clients, resulting in a positive customer experience.

4.5 Basic functions of ILO

The International Labour Organization (ILO) performs several key functions to promote workers' rights and enhance working conditions globally. Here are five basic functions:

1. **Setting International Labor Standards**: Develops international conventions and recommendations to improve labor conditions and ensure fair treatment for workers.
2. **Promoting Decent Work**: Advocates for policies and programs that ensure decent work opportunities, including fair wages, safety, and dignity at work.
3. **Technical Assistance and Training**: Provides technical assistance and training to member countries to help them adopt and implement ILO standards effectively.
4. **Research and Publication**: Conducts research and disseminates information on labor standards, employment, social policy, and working conditions.
5. **Tripartite Cooperation**: Facilitates tripartite cooperation among governments, employers, and workers to foster dialogue and consensus on labor and social policy issues.

4.6 Industrial Hygiene and safety

Industrial hygiene and safety involve the anticipation, recognition, evaluation, and control of environmental factors or stresses arising in or from the workplace that may cause sickness, impaired health, or significant discomfort among workers. This discipline is crucial for:

1. **Preventing Workplace Illness and Injury**: By managing chemical, physical, and biological hazards to protect worker health.
2. **Enhancing Productivity**: Improved safety and health conditions lead to better employee performance and efficiency.
3. **Reducing Healthcare Costs**: Minimizing the incidence of workplace injuries reduces medical costs and financial strain on the business.
4. **Ensuring Compliance**: Helps organizations comply with legal standards and avoid penalties, maintaining a strong reputation.

4.7 Basic functions of ICAO

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations that helps to ensure safe, secure, efficient, and environmentally responsible civil aviation globally. Here are four basic functions of ICAO:

1. **Setting Standards and Regulations**: ICAO develops international standards and recommended practices which are then adopted by member states to ensure their local aviation operations meet global norms.
2. **Safety Oversight**: Enhances global aviation safety by monitoring member states' adherence to ICAO standards and facilitating audits and reviews to ensure compliance.
3. **Facilitating Navigation Services**: Provides guidance and support for the management and coordination of air traffic services, ensuring efficient and safe air navigation.
4. **Environmental Protection**: Works on developing policies and measures to reduce the environmental impact of aviation activities, focusing on emissions and noise reduction.

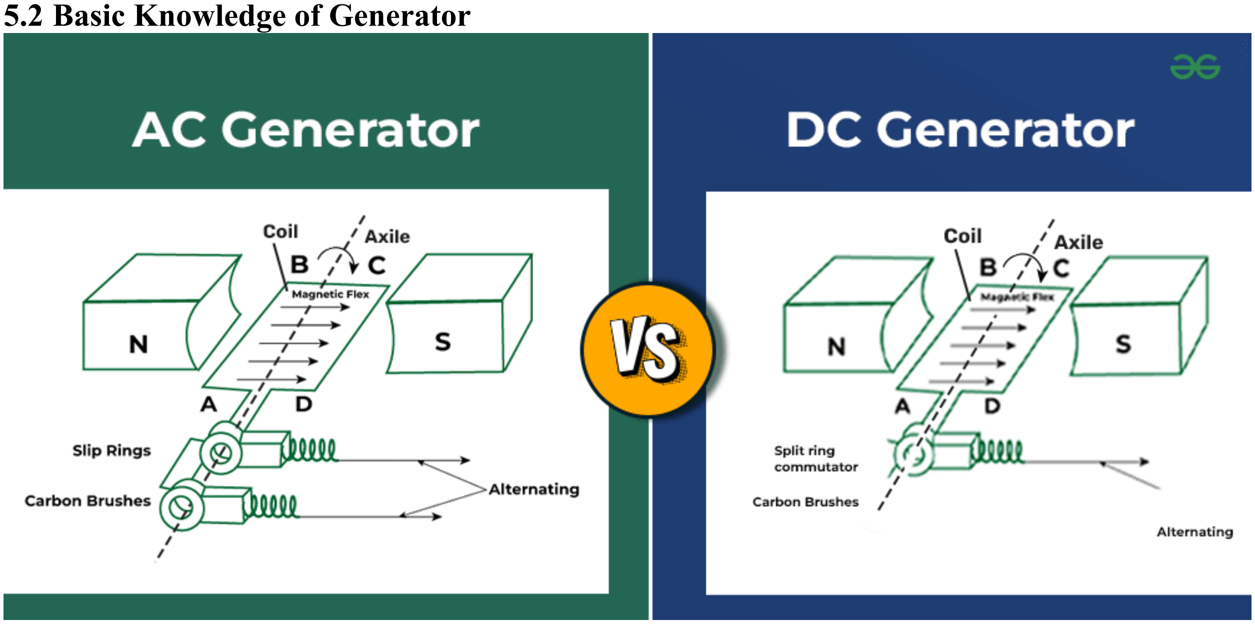
Section – B

5. **Basic Knowledge of Electro- Mechanical Principle**

5.1 Basic Knowledge of AC and DC Motors

AC Motors	DC Motors
Ac motors are powered from AC current.	DC motors are powered from DC current.
In AC motors conversion of current is not required.	In DC motors conversion of current is required like ac into dc current.
AC motors are used where power performance is sought for extended periods of time.	DC motors are used where motor speed required to be controlled externally.
AC motors can be single phase or three phase.	All DC motors are single phase.
In AC motors Armatures do not rotate while magnetic field continuously rotates.	In DC motors, the armature rotates while magnetic field does rotate.
Repairing of DC motors is costly.	Repairing of AC motors is not costly.
AC motor does not use brushes.	DC motor uses brushes.
AC motors have a longer life spam.	DC motors have not a longer life spam.
Speed of AC motors is simply controlled by varying the frequency of current.	Speed of DC motors is controlled by varying the armature winding's current.
AC motors require an effective starting equipment like capacitor to start operation.	DC motors do not require any external help to start operation.

5.2 Basic Knowledge of Generator



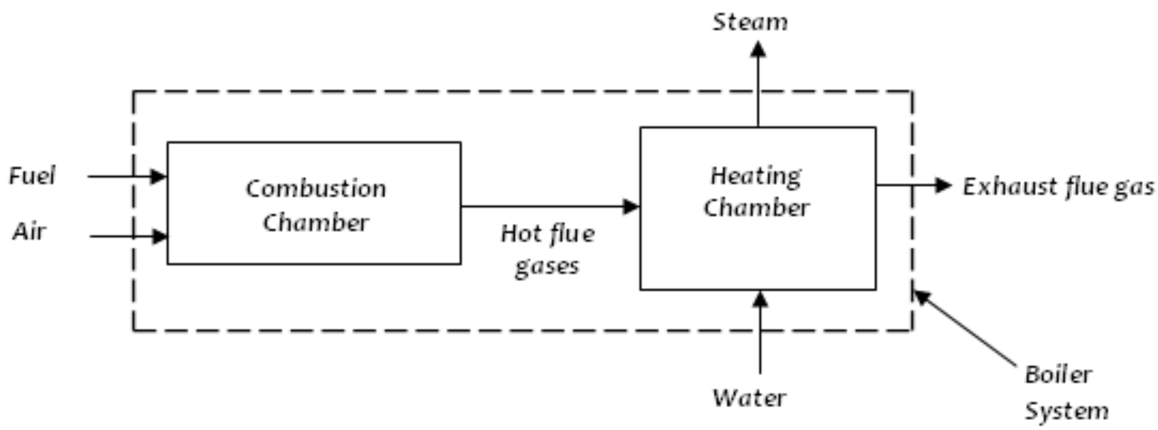
AC Generator	DC Generator.
1. A mechanical device that converts mechanical energy into AC electrical power.	1. A mechanical device that converts mechanical energy into DC electrical power.
2. The electrical current reverses direction periodically.	2. The electrical current flows in one direction.
3. The coil is fixed while the magnet moves.	3. The coil rotates in a fixed field.
4. Does not have commutators.	4. Have commutators.
5. Produce high voltage, with varying amplitude.	5. Produce low voltage, constant in amplitude.
6. Used in small motors and home appliances.	6. Used to power large electric motors.

→ Hence, these are the differences between an AC Generator and a DC generator.

Industrial Boiler

6.1 Basic working principle

Industrial boilers operate by heating water to generate steam through fuel combustion. Various fuels like natural gas, oil, coal, or biomass are ignited in a combustion chamber, where they mix with air. The generated heat is transferred to the water via heat exchangers, often using pipes or tubes. This process converts the water into steam, which can then be used for heating, powering turbines, or other industrial processes. The steam is circulated through the system, and the cycle repeats as needed.



6.2 Common types of Boilers

There are several common types of boilers used in various industrial and commercial applications. Each type has its own specific uses and advantages:

1. **Fire-Tube Boiler**: In fire-tube boilers, hot gases pass through one or more tubes, which are surrounded by water. These are simpler in design, easier to operate, and typically used for lower pressure applications.
2. **Water-Tube Boiler**: Unlike fire-tube boilers, water-tube boilers have water running inside the tubes and hot gases surrounding them. They are more suitable for high-pressure applications and can produce higher temperatures and steam capacities.
3. **Electric Boiler**: Electric boilers use electricity to heat water. They are highly efficient and produce no emissions, making them ideal for environments where pollution or space is a concern.
4. **Condensing Boiler**: Condensing boilers are designed to increase efficiency by recovering heat from the exhaust gases. They are most often used in residential and small commercial settings but are gaining popularity in larger applications for their energy-saving properties.
5. **Biomass Boiler**: These boilers burn organic materials, such as wood pellets, agricultural waste, and other biomass fuels. They are a sustainable option and are used in places where biomass is readily available.

6.3 Boilers Fuels

1. **Natural Gas**: This is the most commonly used fuel for boilers due to its efficiency and clean-burning properties. It is readily available in many regions and typically requires less maintenance for the boiler.
2. **Oil**: Often used where natural gas is not available. Oil-fired boilers are efficient, but oil prices can be volatile and depend on global oil supplies.
3. **Coal**: Used in industrial boilers for large scale heating and power generation. Coal is less expensive than other fossil fuels but has a higher environmental impact due to higher emissions.
4. **Biomass**: Includes wood chips, pellets, and agricultural waste. Biomass boilers are considered renewable and sustainable but require more space for fuel storage and more frequent maintenance.
5. **Electricity**: Used in electric boilers to heat water through electrical resistance. While electric boilers are clean and silent, they can be more expensive to operate depending on local electricity prices.
6. **Propane**: Similar to natural gas, propane is used where natural gas is not available. It is stored in liquid form in pressurized tanks and is efficient but can be more expensive than natural gas.

6.4 Boilers Efficiency:

Boiler efficiency is a critical factor in the performance and cost-effectiveness of industrial and residential heating systems. It measures how well a boiler converts the energy in its fuel to heat over a typical year.

1. **Input-Output Method (Direct Method)**:

   This method calculates the efficiency by directly measuring the heat input and the heat output. The formula is:

$$\text{Efficiency (\%)} = \left(\frac{\text{Useful Heat Output}}{\text{Heat Input}}\right) \times 100$$

   - **Useful Heat Output** can be measured as the heat absorbed by the water or steam.
   - **Heat Input** comes from the total amount of fuel used, typically measured in BTUs or Kcal.

2. **Heat Loss Method (Indirect Method)**:

   This method calculates efficiency by accounting for the losses occurring in the boiler. The various types of losses are summed up, and the efficiency is given by:

$$\text{Efficiency (\%)} = 100 - (\text{Total Losses (\%)})$$

   - **Total Losses** include stack losses, radiation losses, blowdown losses, etc.

3. **Combustion Efficiency**:

   Combustion efficiency focuses on how well the fuel is burned in the boiler and is calculated by:

$$\text{Efficiency (\%)} = \left(\frac{\text{Heat Released}}{\text{Heat Content of Fuel}}\right) \times 100$$

7. Estimating and costing

7.1General

Estimating and costing is a critical process in construction and engineering that involves calculating the anticipated expenses associated with a project. This process includes assessing material, labor, equipment, and overhead costs to determine the total expenditure. The outcome aids in budget preparation, financial planning, and economic evaluation of potential projects

7.1.1 Concept of profitability, break-even point, return on investment, liability, assets, fixed cost, variable cost, fixed capital, working capital equity, depreciation and amortization

1. **Profitability**: This is a measure of a company's ability to generate earnings relative to its revenue, assets, or equity over time. It indicates the financial health and efficiency of the business in generating profit.

2. **Break-Even Point**: The break-even point is the level of production or sales at which costs equal revenues, resulting in neither a profit nor a loss. It helps businesses understand the minimum performance required to avoid losing money.

3. **Return on Investment (ROI)**: ROI is a financial ratio used to calculate the benefit an investor will receive in relation to their investment cost. It's widely used to assess the efficiency of an investment or compare the efficiency of several different investments.

4. **Liability**: In financial accounting, a liability is an obligation resulting from past transactions or events, which may result in the transfer of assets, provision of services, or other yielding of economic benefits in the future.

5. **Assets**: Assets are resources owned by a business or individual that are expected to bring future economic benefits. These include physical items like buildings and machinery, as well as intangible items like patents and copyrights.

6. **Fixed Cost**: Fixed costs are expenses that do not change with the level of goods or services produced by the business, such as rent, salaries, and insurance premiums.

7. **Variable Cost**: Variable costs are expenses that vary directly with the level of production, such as raw materials and direct labor costs.

8. **Fixed Capital**: Fixed capital includes assets and capital investments that are used in the long-term operations of a business, such as machinery, buildings, and land.

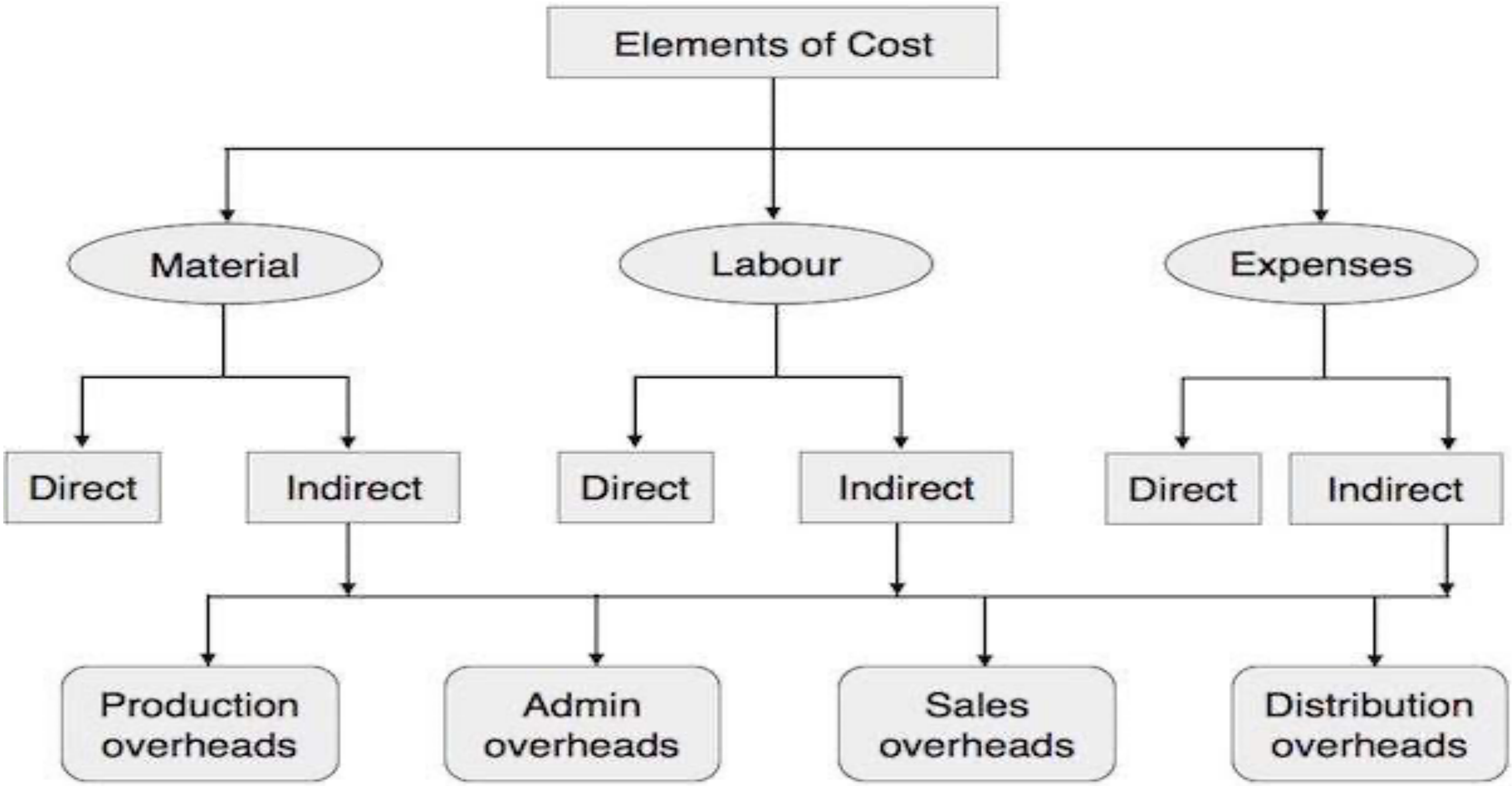
9. **Working Capital**: Working capital refers to the difference between a company's current assets and current liabilities, indicating the liquidity available to run its day-to-day operations.

10. **Equity**: Equity represents the value that would be returned to a company’s shareholders if all the assets were liquidated, and all the company's debts were paid off.
11. **Depreciation**: Depreciation is an accounting method of allocating the cost of a tangible asset over its useful life to account for declines in value over time.

12. **Amortization**: Amortization involves spreading the initial cost of an intangible asset over its useful life, thereby reflecting its consumption, expiration, or obsolescence in financial statements.

7.1.2 Elements of cost and classification

Elements of cost are divided into three main categories: material, labor, and expenses, which together determine the total production cost. These elements are further classified as direct costs, which can be directly attributed to the production of specific goods or services, and indirect costs, which are general costs not directly linked to production but necessary for the operation, such as overheads. This classification helps in accurately tracking and managing costs for financial reporting and decision-making.



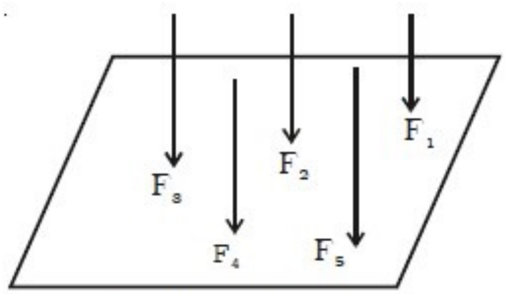
8. Applied Mechanics

8.1 Statics

Statics is the branch of mechanics that deals with bodies at rest or forces in equilibrium. Static equilibrium is a physical state in which the net force through the system is zero and the system's components are at rest.

8.1.1 Coplanar system of intersecting forces

A coplanar force system is one in which all of the forces are located in the same plane. Complete answer: A force system can be coplanar or non-coplanar. When all of the forces in a system are in the same plane, the force system is said to be coplanar.



Coplanar forces

8.1.2 Coplanar parallel forces, the moment of a force

A parallel coplanar force system consists of two or more forces whose lines of action are ALL parallel. This is commonly the situation when simple beams are analyzed under gravity loads. These can be solved graphically, but are combined most easily using algebraic methods.

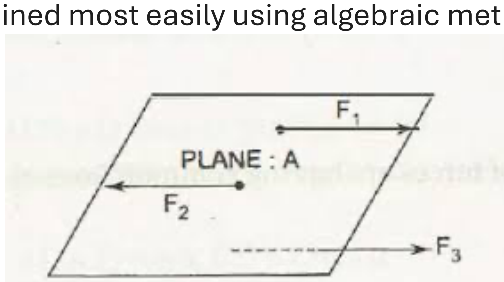
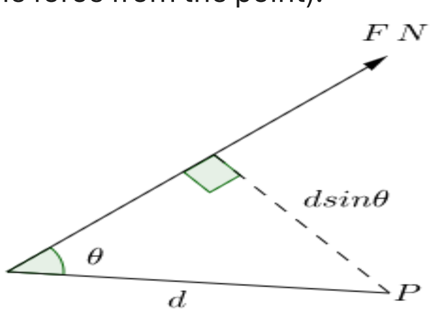


Fig. 1.8

The moment of a force depends on the magnitude of the force and the distance from the axis of rotation. The moment of a force about a point is (the magnitude of the force) × (the perpendicular distance of the line of action of the force from the point).



8.1.3 Centre of Gravity

The Centre of gravity is a theoretical point in the body where the body's total weight is thought to be concentrated. It is important to know the Centre of gravity because it predicts the behavior of a moving body when acted on by gravity. It is also useful in designing static structures such as buildings and bridges.

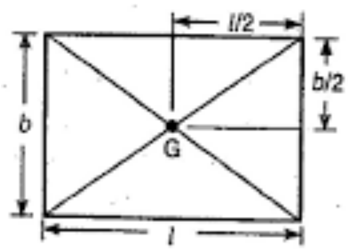


Fig. 1.5

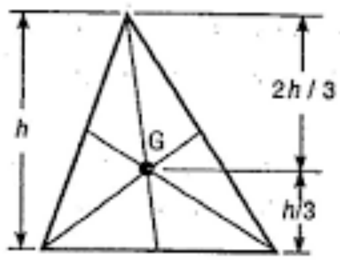


Fig. 1.6

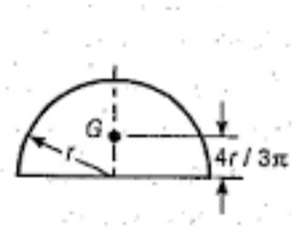


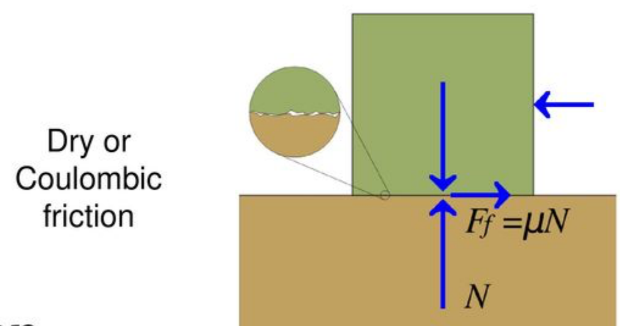
Fig. 1.7

8.1.4 Friction

Friction is defined as the contact resistance exerted by one body upon a second body when the second body moves or tends to move past the first body. Friction is a retarding force always acting opposite to the motion or tendency to move.

What is friction?

- Friction is a retarding force that opposes motion.
- Friction types:
  - Static friction
  - Kinetic friction
  - Fluid friction
- Sources of dry friction
  - Asperities between contacting surfaces
  - Interactions at the atomic level
- *Tribology* studies sources of friction, lubrication, wear and tear etc.



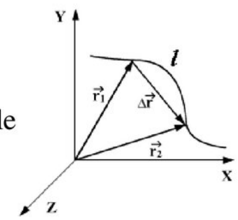
8.2 Kinematics

8.2.1 Definition of technical terms: speed, velocity, acceleration, distance traversed and their units.

1. **Speed:** The rate at which an object covers distance, measured in meters per second (m/s).
2. **Velocity:** The speed of an object in a specific direction, also measured in meters per second (m/s).
3. **Acceleration:** The rate of change of velocity per unit of time, expressed in meters per second squared (m/s^2).
4. **Distance Traversed:** The total path length covered by an object, measured in meters (m).

8.2.2 The trajectory of particles, distance and time

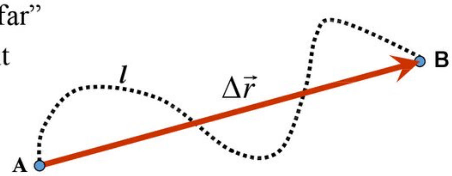
<u>Distance</u>



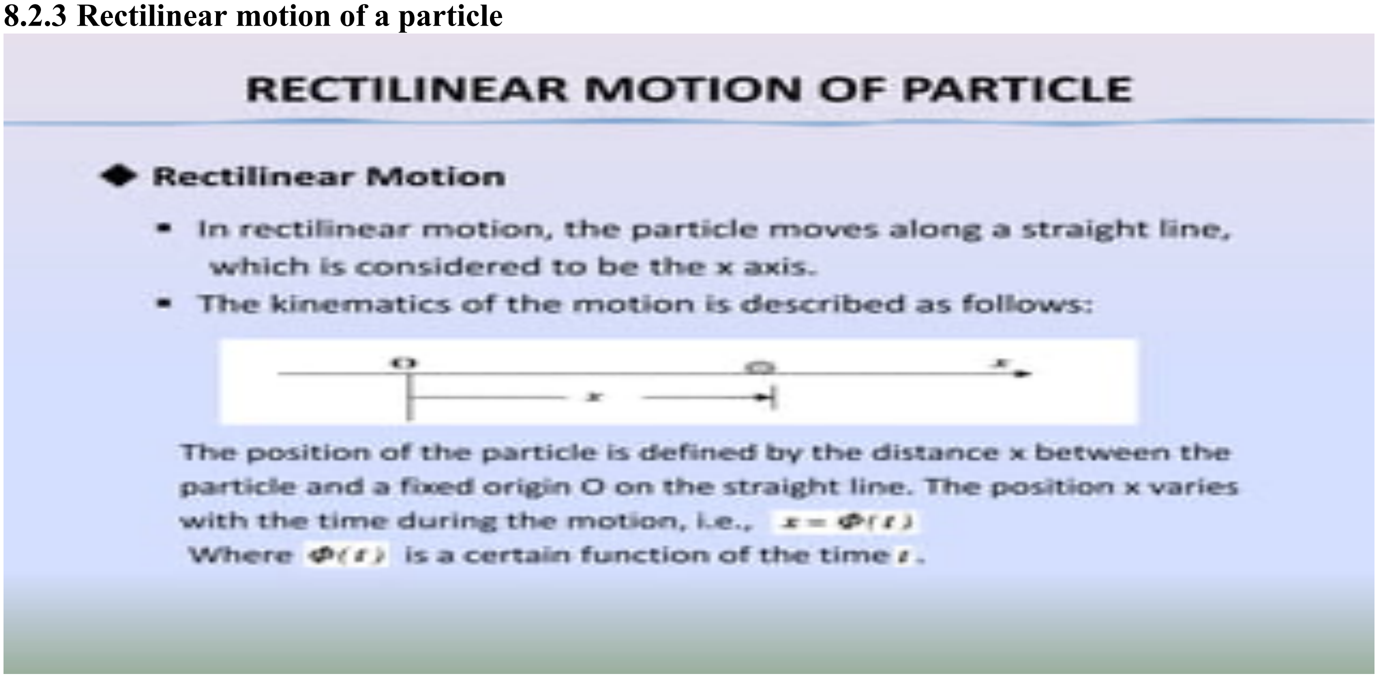
<u>Trajectory</u> is the line that a moving particle follows through space.

<u>Path</u> (<u>distance</u>) l is the length of the trajectory line.

- distance is a scalar - "How far"
- units: same as displacement



8.2.3 Rectilinear motion of a particle



8.3 Composition of a simple motion of a particle

Simple Harmonic Motion (S.H.M)

DEFINITION

S.H.M is a motion in which restoring force is

1. directly proportional to the displacement of the particle from the mean or equilibrium position .
2. always directed towards the mean position.

i.e. $F \propto y$

$$F = -ky$$

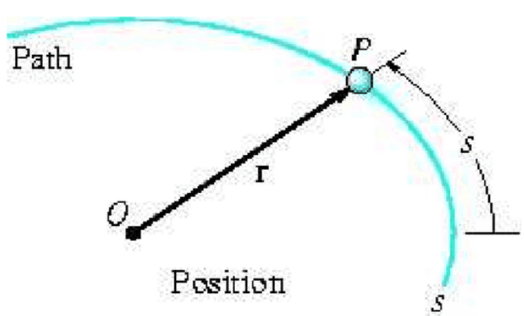
where k is the spring or force constant.

The negative sign shows that the restoring force is always directed towards the mean position.

8.3.1 Curvilinear motion of a particle

Curvilinear motion occurs when the particle moves along a curved path

Position. The position of the particle, measured from a fixed point O, is designated by the *position vector* $\mathbf{r} = \mathbf{r}(t)$.



Position

8.3.2 Simple motion of a solid body

Simple motion of a solid body occurs when the entire body moves uniformly, meaning every part of it moves in the same way at the same time. This can be straight-line movement (translational motion) or spinning around an axis (rotational motion). Such motion is characterized by consistent velocity and acceleration throughout the body.

8.4 Dynamics

8.4.1 Fundamental laws of dynamics: Newton's law of motion

1. **Newton's First Law (Law of Inertia):** An object at rest stays at rest, and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.
2. **Newton's Second Law (Law of Acceleration):** The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass, commonly formulated as $F = ma$, where F is force, m is mass, and a is acceleration.
3. **Newton's Third Law (Action and Reaction):** For every action, there is an equal and opposite reaction; this means that whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

8.4.2 Work, Energy and Power

Work is defined as the force applied to an object times the distance over which that force is applied, following the formula $W = F \cdot d \cdot \cos(\theta)$, where W is work, F is force, d is displacement, and θ is the angle between the force and displacement direction.

Energy is the capacity to do work. Kinetic energy, for instance, is given by $KE = \frac{1}{2}mv^2$, where m is mass and v is velocity. Potential energy related to height is $PE = mgh$, with g being the acceleration due to gravity and h being the height.

Power is the rate at which work is done or energy is transferred, quantified as $P = \frac{W}{t}$, where P is power, W is work, and t is time.

The relationships among these concepts can be summarized by how energy changes form when work is done and power measures how quickly this energy is transferred.

8.4.3 Mechanical Energy

Mechanical energy is the sum of kinetic and potential energies in a system, representing the total energy available for doing work. It is defined by the equation:

$$\text{Mechanical Energy} = \text{Kinetic Energy} + \text{Potential Energy}$$

where:

- Kinetic Energy (KE) is given by $\frac{1}{2}mv^2$, with m being mass and v velocity, describing the energy due to motion.
- Potential Energy (PE) can take various forms, but typically in mechanical systems, it's expressed as mgh for gravitational potential energy, where g is the acceleration due to gravity and h is the height above a reference point.

Mechanical energy is conserved in an isolated system, meaning it remains constant if only conservative forces (like gravity) act on the system, and no energy is added or removed. This principle of conservation of mechanical energy is a cornerstone in the study of physics and engineering.

8.4.4 Relation between RPM, Torque and Power

The relationship between RPM (revolutions per minute), torque, and power in a mechanical system is fundamental in understanding how engines and other rotating machinery operate. Here's how these three variables are interrelated:

1. **Power** is the rate at which work is done or energy is converted. It is dependent on both torque and rotational speed (RPM).
2. **Torque** is a measure of the rotational force applied at a distance from the axis of rotation. It determines how much force an engine can exert to turn an object.

$$\omega = \frac{2\pi \times N}{60}$$

Inserting this into the power formula where $P = T \times \omega$ gives:

$$P = T \times \frac{2\pi \times N}{60}$$

which simplifies to:

$$P = \frac{2\pi \times N \times T}{60}$$

This is the formula you provided, showing how power in a rotating system is directly proportional to both the torque and the rotational speed.

8.4.5 Law of conservation of energy

Conservation of Energy

- The Law of Conservation of Energy simply states that:
  1. **The energy of a system is constant.**
  2. **Energy cannot be created nor destroyed.**
  3. **Energy can only change form (e.g. electrical to kinetic to potential, etc).**
  - **True for any system with no external forces.**

$$E_T = KE + PE + Q \text{ (Constant)}$$

- **KE = Kinetic Energy**
- **PE = Potential Energy**
- **Q = Internal Energy [kinetic energy due to the motion of molecules (translational, rotational, vibrational)]**

- **In mechanics**, when a ball is thrown into the air, its kinetic energy (due to motion) is gradually converted into potential energy (due to height) as it ascends. At the peak of its trajectory, when the ball momentarily stops, all its kinetic energy has been converted into potential energy. As it descends, the potential energy converts back into kinetic energy.