Model Question Paper-I/II with effect from 2021 (CBCS Scheme)

USN | | | | | | | | | |

First Semester B.E Degree Examination
Elements of Mechanical Engineering 21EME15/25

TIME: 03 Hours **Max. Marks: 100**

Note: 01. Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE**.
02. Use of Steam tables are permitted to solve numerical on steam.

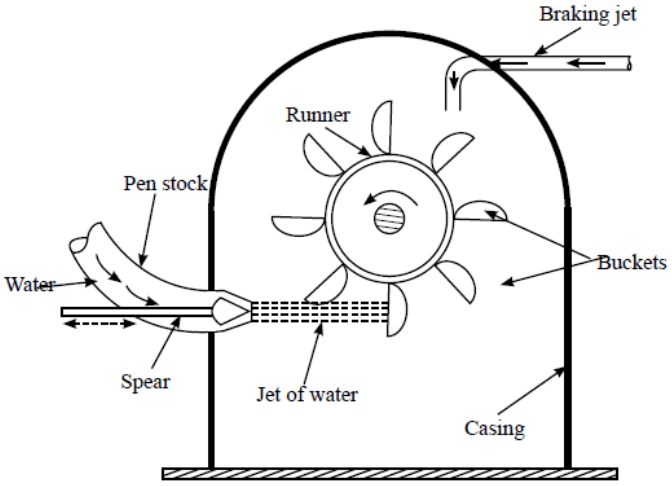
		Module -1	**Marks**
Q. 1	a	Briefly explain the emerging trends of mechanical Engineering in Manufacturing and Energy Sector **Manufacturing:** Manufacturing is the process of converting the raw material into a finished product. The technology had taken a great leap in the manufacturing sector. Along with side of conventional manufacturing methods other manufacturing methods are also practicing in the industry. Lean manufacturing, just in time manufacturing (JIT), Flexible manufacturing system (FMS), Computer Integrated manufacturing (CIM) are already in use. Along with this additive manufacturing is getting its importance in the new product development which reduces the material and time. **Energy:** The energy sector is a category that relate to producing or supplying energy. The energy sector or industry includes companies involved in the exploration and development of oil or gas reserves, oil and gas drilling, and refining. The energy industry also includes integrated power utility companies such as renewable energy and coal	10
	b	Define the following terms with respect to steam: 1. Saturation temperature 2. Latent heat of vaporisation 3. Quality of the steam 4. Sensible heat 5. Degree of superheat **Saturation Temperature :** The boiling point of water at the given pressure is called **saturation temperature**. It is indicated by t_s in ^{0}C or K. Saturation temperature increases with pressure. **Latent Heat :** It is the amount of heat required to convert 1kg of liquid into completely dry steam at saturation temperature at the given pressure. It is represented by h_{fg} in kJ/kg. Latent heat decreases with the increase of pressure. **Quality of steam:** is the proportion of saturated steam (vapor) in a saturated condensate (liquid)/ steam (vapor) mixture. A steam quality of 0 indicates 100 % liquid, (condensate) while a steam quality of 100 indicates 100 % steam. **Sensible heat** It is the amount of heat supplied to 1kg of water to rise its temperature from 0^0C to saturation temperature at the given pressure. It is given by $h_f = Cp_w(t_s - 273)$ in kJ/kg, where Cp_w = Specific heat of water = 4.2 kJ/kg K.	10

		Enthalpy of Superheat : It is the amount of heat required to convert 1kg of dry steam into supper heated steam from t_s, at the given pressure. It is denoted by H_{sh} in kJ/kg. $H_{sh} = C_p (T_{sup} - t_{sat})$ Where, C_p = specific heat of superheated steam = 2.1 kJ/kg K	
		OR	
Q. 2	a	What is solar Energy? Apply the Solar energy conversion technic into electrical energy in a solar cell. In general the energy produced and radiated by the sun, more specifically, the term refers to the sun's energy that reaches the earth. Solar energy received in the form of radiation can be converted directly or indirectly into other forms of energy, such as heat and electricity, which can be utilized by man. Since, the sun is expected to radiate at an essentially constant rate for a few billion years, it may be regarded as an in-exhaustible sources of useful energy. **Solar Cell:** Direct conversion of solar energy into electrical energy takes place by means of photovoltaic effect. **Photo-voltaic effect** is defined as the generation of an electromotive force as a result of the absorption of ionizing radiation. Energy conversion devices which are used to convert sunlight to electricity by the use of photo-voltaic effect is called **photo-voltaic cell or solar cell.** **Working principle:** Photo voltaic cells are made of semi conductors. When the photons from the sun are absorbed in a semiconductor, they create free electrons with higher energies than the electrons which provide the bonding in the base crystal. Once these electrons are created there must be an electric field to introduce these higher energy electrons to flow out of the semiconductor to do useful work. The electric field is provided by a junction of materials which have different electrical properties.	10

Metal Conductor

The positive and negative charges created by the absorption of photons are thus encouraged to drift to the front and back of the solar cell. The back is completely covered by the metallic contact to remove the charges to the electric load. The collection of charges from the front of the cell is aided by a fine grid narrow metallic fingers. The surface coverage of the conducting collectors is typically about 5% in order to allow as much light as possible to reach active junction area. An anti-reflective coating is applied on the top of the cell.

b | With a neat sketch explain the working principle of a Pelton Turbine | 10



Pelton wheel (LA Pelton, American engineer invented it) is a tangential flow, high head, low specific speed impulse turbine. Fig 2.3. Shows the main components of pelton wheel, are

a. Nozzle: It is a tapered mouth piece fitted at the end of the penstock. It guides the water to flow in desired direction with high kinetic energy. The amount of water striking the turbine can be regulated by pushing the spear forward into the nozzle. The spear is operated by hand or automatically.

b. Runner and Buckets: runner is a circular disc on which a number of buckets evenly spaced are fixed. The shape of bucket is of a hemispherical cup or bowl. Each bucket is divided into symmetrical parts by a divided wall called splitter. Buckets are made up cast iron, bronze or stainless steel. Buckets absorb the kinetic energy of the jet and convert it into mechanical energy.

c. Casing: The function of casing is to prevent the splashing of water and to discharge it to tail race. It also acts as a safe guard against accidents.

d. Braking Jet: When the nozzle is completely closed by moving the spear in the

forward direction, the amount of water striking the runner reduces to zero. But the runner due to inertia goes on revolving for a long time. To stop runner in a short time, a small nozzle is provided on the casing which directs the jet of water on the back of the vanes. This jet of water is called braking jet

Working principle

In Pelton wheel, the available energy of water is first converted into kinetic energy by means of an efficient nozzle. The high velocity water jets emerging from the nozzles strikes the series of buckets fixed around the runner. The buckets change the direction of water without changing its pressure. The resulting change in momentum (direction as well as speed) of water stream produces an impulse on the blades of the wheel. This impulse generates the torque and rotation in the shaft of pelton turbine. Thus mechanical energy is made available at the turbine shaft; mechanical energy is converted into electrical energy in generator stage. After performing work, the water freely discharged to the tail race.

Module-2

Q. 3	a	What are polymers? What are its characteristics?	6

It is a substance which has a molecular structure built up chiefly or completely from a large number of similar units bonded together, e.g. many synthetic organic materials used as plastics and resins.

Every polymer has very distinct characteristics, but most polymers have the following general attributes.

1. Polymers can be very resistant to chemicals. Consider all the cleaning fluids in your home that are packaged in plastic. Reading the warning labels that describe what happens when the chemical comes in contact with skin or eyes or is ingested will emphasize the chemical resistance of these materials.
2. Polymers can be both thermal and electrical insulators. A walk through your house will reinforce this concept, as you consider all the appliances, cords, electrical outlets and wiring that are made or covered with polymeric materials. Thermal resistance is evident in the kitchen with pot and pan handles, the foam core of refrigerators and freezers, insulated cups, coolers, and microwave cookware all made of polymers. The thermal underwear that many skiers wear is made of polypropylene, and the fiberfill in winter jackets is acrylic.
3. Generally, polymers are very lightweight, with varying degrees of strength. Consider the range of applications, from toys to the frame structure of space stations, or from delicate nylon fiber in pantyhose or Kevlar, which is used in bulletproof vests.
4. Polymers can be processed in various ways to produce thin fibers or very intricate parts. Plastics can be molded into bottles or the bodies of cars, or be mixed with solvents to become an adhesive or a paint. Elastomers and some plastics stretch and are very flexible. Other polymers can be foamed like polystyrene (StyrofoamTM) and urethane, to name two examples. Polymers are materials with a seemingly limitless range of

		characteristics and colors. Polymers have many inherent properties that can be further enhanced by a range of additives to broaden their uses and applications.	
	b	State the application of Composites related to Aircraft and Automobile industry **Aircraft Applications:** 1. Composites are used to manufacture load-bearing and non-load-bearing components which are used in both fixed-wing and rotary wing aircraft. 2. Many military and civil aircraft now contain substantial quantities of lightweight, high-strength carbon-, Kevlar- and glass-fibre composites, as laminated panels and mouldings. 3. Composite honeycomb structures with metallic or rein-impregnated paper honeycomb core materials are used in military and civil aircraft. 4. Composites are used to manufacture air frames, wing spars, spoilers, tail-plane structures, fuel tanks, drop tanks, bulkheads, flooring, helicopter rotor blades, propellers, and structural components, pressured gas containers, radomes, nose and landing gear doors, fairings, engine nacelles, air distribution ducts, seat components and access panels. 5. Many modern light aircrafts are being increasingly designed to contain as much lightweight composite material as possible. 6. For elevated-temperature applications carbon-fibre-reinforced carbon is in use. 7. Concord's disk brakes use carbon-fibre-reinforced material. Rocket nozzles and reentry shields have been fashioned from it, 8. There are other possibilities for its use as static components in jet engines. Rocket motor casings and rocket launchers are also frequently made of reinforced plastics **Automobile Applications:** 1. The majority applications involve glass-reinforced plastics (GRP) because the extra cost of carbon or aramid fibre is rarely considered to be acceptable in this market. 2. Even so, the cost of using GRP is usually being weighed against the much lower cost of pressed steel components, and the substitution is often rejection on purely economic grounds, leaving aside the question of energy savings. 3. A wide range of car and truck body mouldings, panels and doors is currently in service, including complete front - end mouldings, fascias, bumper mouldings, and various kinds of trim. 4. There is considerable interest in the use of controlled crush components based on the high energy - absorbing qualities of materials like GRP. 5. Selective reinforcement of aluminium alloy components, such as pistons and connecting rods, with alumina fibres is much discussed with reference to increased temperature capability. 6. Body pannels in passenger cars as well as race cars are commonly made of composite materials. Other applications include composite leaf springs for suspensions and composite drive shafts. 7. Tyre has a complex internal structure with multiple reinforcing plies at various orientations Reinforcement can be steel wires, polyester or kevlar cords and the matrix is a synthetic Elastomer with carbon black as a	4

		particulate reinforcement.	
	c	What is gas welding? Explain with neat sketch principle of operation of oxy-acetylene gas welding.	10

Gas welding is a fusion welding, in which a strong gas flame generated by combustion of gases, used to raise the temperature of the workpiece so as to melt them. The gases are mixed in proper proportions in a welding blow pipe called 'Welding torch'. As in arc welding, a filler metal is used to fill the joint, after cooling a solid joint is formed. The gases that can be used for heating are,

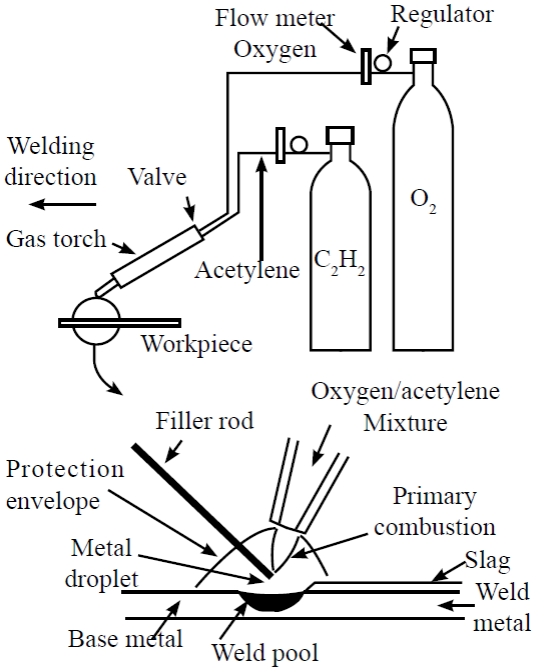
- Oxygen and acetylene mixture.
- Oxygen and hydrogen mixture.

The oxygen and acetylene mixture is most commonly used in gas welding and the process is called oxy-acetylene process.

oxy-acetylene gas welding:

The oxy-acetylene gas welding method consists of two sets of large cylinders in which one cylinder consist oxygen at high pressure and other contains acetylene gas. Welding torch is used to mix both oxygen and acetylene gases at required proportion and it will burn the mixture at the tip as shown in figure 4.10.The pressure at which both gasses supplied to the torch are controlled by the pressure regulators.

Operation: Acetylene gas (C2 H2) and oxygen gas are mixed; acetylene is highly flammable, so the mixture can be ignited and burns generating very high temperatures of up to 3000°C. The flame is used to melt the metal at the joint, along with a filler rod to provide some extra material to fill the gap. The filler rod is coated with flux. The flux is a chemical with two uses: part of it evaporates, and the vapor surrounds the region around the molten metal, preventing oxidation. Another part of the flux melts, and dissolves impurities and metal oxides; since these are lighter than the molten metal, they float to the surface and can be removed by a finishing process later.



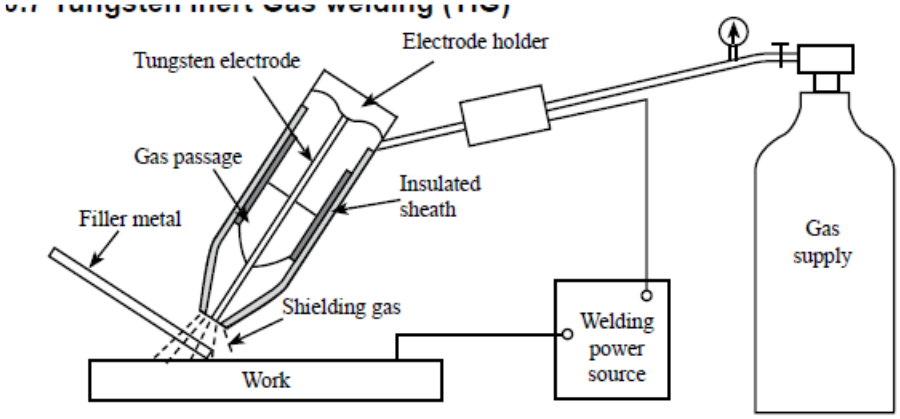
OR

Q. 4	a	Give the differences between thermoplastics and thermosetting plastics.	10

Difference Between Thermoplastic and Thermosetting Plastic

Thermoplastic	Thermosetting Plastic
Thermoplastic can be synthesized by the process called addition polymerization.	Thermosetting plastics are synthesized by condensation polymerization.
Thermoplastic is processed by injection moulding, extrusion process, blow moulding, thermoforming process, and rotational moulding.	Thermosetting Plastic is processed by compression moulding, reaction injection moulding.
Thermoplastics have secondary bonds between molecular chains.	Thermosetting plastics have primary bonds between molecular chains and held together by strong cross-links.
Thermoplastics have low melting points and low tensile strength.	Thermosetting plastics have high melting points and tensile strength.
Thermoplastic is lower in molecular weight, compared to thermosetting plastic.	Thermosetting Plastic is high in molecular weight.

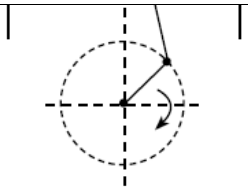
b With a neat sketch explain the principle and working of TIG welding. List its applications — 10



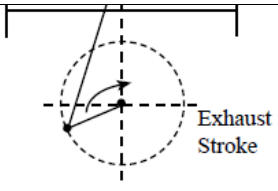
Tungsten inert gas(TIG) welding or Gas Tungsten Arc Welding(GTAW) is an inert gas shielded arc welding process. It uses non-consumable tungsten electrode.
The schematic diagram of TIG welding is shown in figure.

Principle of operation:
Welding current and inert gas supply are turned on. The arc is struck either by touching the electrode with scrap metal tungsten piece or using high frequency unit. The arc is the struck between the electrode and pre cleaned job to be welded . The welding electrode is brought nearer to the job. When electrode tip reaches with in a distance of 3 to 2mm from the job, a spark jumps across the air gap between the electrode and the job.

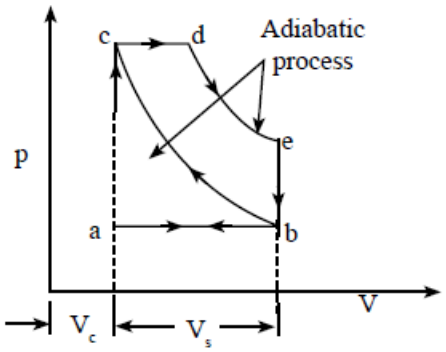
		The air path gets ionized and arc is established. After striking the job, it is allowed to impinge on the job and a molten weld pool is created. the welding is starting by moving the torch along the joint. The shielding gas is allowed to impinge on the solidifying weld pool to avoid atmospheric contamination of the weld metal. The welding torch and filler metal are kept inclined at angles of 70-80^{o} and 10-20^{o} respectively.	
		Module-3	
Q. 5	a	With the help of a P-V diagram explain the working of a four-stroke diesel engine. **Four-Stroke Diesel Engine** Four stroke diesel engine works on the theoretical diesel cycle. It is also called as contant pressure cycle. Since ignition results due to high temperature of compressed air, it is also called as compression ignition engine. The construction and working principle of four-stroke diesel engine is shown in Fig. 3.4 The four strokes of the diesel engine are explained as follows. **Suction Stroke** It starts when the piston is at TDC. The crank shaft is revolved either by the momentum of the flywheel or by the electric motor to move the piston to BDC. When the piston starts to move downward, the inlet valve opens and exhaust valve closes. Due to creation of suction pressure, air is drawn into the cylinder through the inlet valve at constant pressure. It is denoted by a-b on p-v diagram as shown in Fig below. When the crank completes half a revolution, the piston reaches to BDC. Thus the suction stroke ends.	10



Working Stroke



Exhaust Stroke



Theoretical Diesel Cycle (P V diagram)

Compression Stroke

During this stroke both the inlet and exhaust valves are closed. The piston moves from BDC to TDC by compressing air. The energy required to perform this stroke is supplied by cranking in first cycle and in the next cycle flywheel supplies the energy. The process of compression is a theoretical reversible adiabatic compression. At the end of the compression stroke the volume of air decreases, pressure increases and crank perform another half rotation. This process is represented by b-c on p-v diagram.

Working or Power or Expansion Stroke

During this stroke both inlet and exhaust valves are still closed. At the end of the compression, the fuel injector sprays the diesel on to the hot compressed air and starts burning. Due to combustion of fuel, large quantity of gases are released. The high pressure hot gases force the piston to move downward producing mechanical energy at the crankshaft. Some part of this mechanical energy is stored in the fly wheel and it will be utilized to move the piston in suction, compression and exhaust strokes of next cycle.

When the piston moves downward, the hot gases undergoes expansion which is called reversible adiabatic expansion. Due to this, the pressure of hot gases decrease, volume increase and crank performs third half rotation. The combustion and expansion process are indicated by bc and cd on p-v diagram.

Exhaust Stroke

At the end of expansion stroke exhaust valve opens and piston starts to move towards TDC.

The energy required to perform this stroke is supplied by flywheel. During this stroke, the

		burnt gases will be expelled out of the cylinder. This stroke is indicated by d-e and ea an p-v diagram. Thus the cycle completes.	
	b	With help a line diagram describe the working principle of Electric vehicle	10

Configurations of Electric Vehicles

Previously, the EV was mainly converted from the existing ICEV by replacing the internal combustion engine and fuel tank with an electric motor drive and battery pack while retaining all the other components, as shown in Figure 4.1. Drawbacks such as its heavy weight, lower flexibility, and performance degradation have caused the use of this type of EV to fade out.

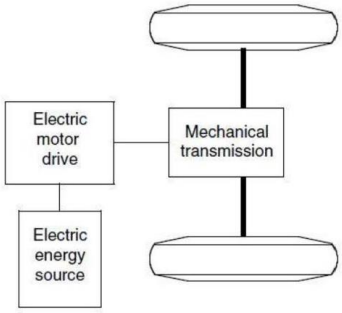


Figure: Primary electric vehicle power train

The modern EV is built based on original body and frame designs. This satisfies the structure requirements unique to EVs and makes use of the greater flexibility of electric propulsion. A modern electric drive train is conceptually illustrated in Figure below.
The drive train consists of three major subsystems: electric motor propulsion, energy source, and auxiliary.

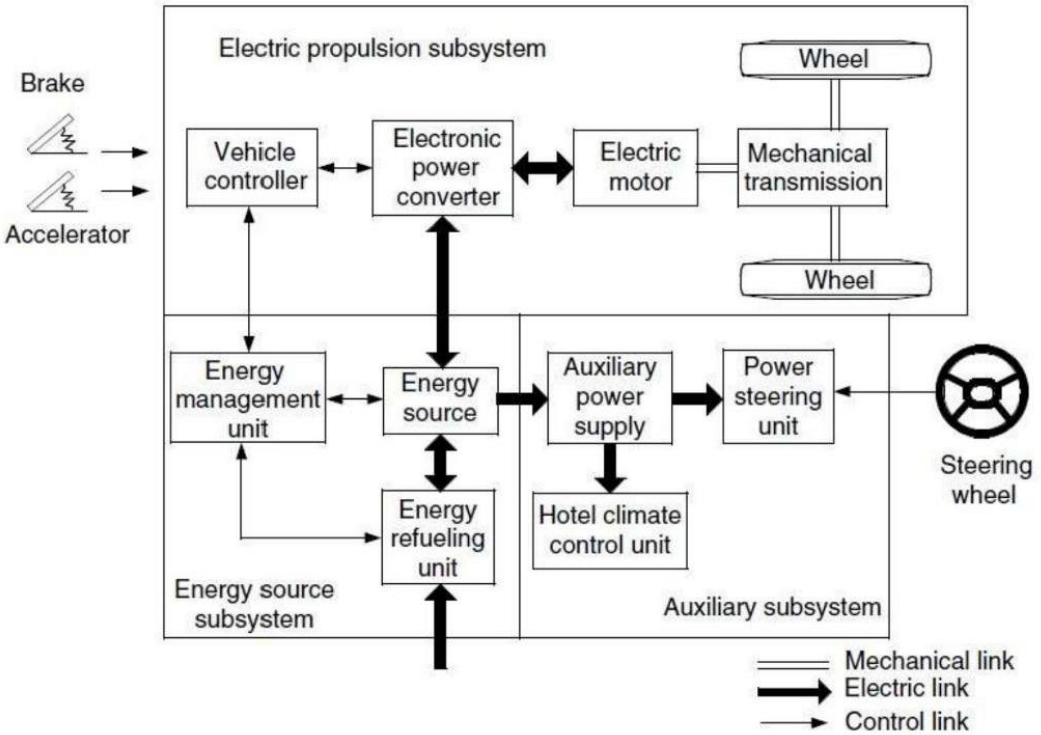


Figure: Conceptual illustration of general EV configuration

The electric propulsion subsystem is comprised of a vehicle controller, power electronic converter, electric motor, mechanical transmission, and driving wheels. The energy source subsystem involves the energy source, the energy management unit, and the energy refuelling unit. The auxiliary subsystem consists of the power steering unit, the hotel climate control unit, and the auxiliary supply unit.

Based on the control inputs from the accelerator and brake pedals, the vehicle controller provides proper control signals to the electronic power converter, which functions to regulate the power flow between the electric motor and energy source. The backward power flow is due to the regenerative braking of the EV and this regenerated energy can be restored to the energy source, provided the energy source is receptive. The auxiliary power supply provides the necessary power at different voltage levels for all the EV auxiliaries, especially the hotel climate control and power steering units.

OR

Q. 6 a — With Suitable example enumerate the application of refrigeration in Food Processing Industry — 10

1. Storage of Raw Fruits and Vegetables: It is well-known that some bacteria are responsible for degradation of food, and enzymatic processing cause ripening of the fruits and vegetables. The growth of bacteria and the rate of enzymatic processes are reduced at low temperature. This helps in reducing the spoilage and improving the shelf life of the food. Table below shows useful storage life of some plant and animal tissues at various temperatures.

Food Product	Average useful storage life (days)		
	0°C	22°C	38°C
Meat	6-10	1	< 1
Fish	2-7	1	< 1
Poultry	5-18	1	< 1
Dry meats and fish	> 1000	> 350 & < 1000	> 100 & < 350
Fruits	2 - 180	1 – 20	1 – 7
Dry fruits	> 1000	> 350 & < 1000	> 100 & < 350
Leafy vegetables	3 - 20	1 – 7	1 – 3
Root crops	90 - 300	7 – 50	2 – 20
Dry seeds	> 1000	> 350 & < 1000	> 100 & < 350

It can be seen that the storage temperature affects the useful storage life significantly. In general the storage life of most of the food products depends upon water activity, which essentially depends upon the presence of water in liquid form in the food product and its temperature. Hence, it is possible to preserve various food products for much longer periods under frozen conditions.

In case of fruits and vegetables, the use of refrigeration starts right after harvesting to remove the post-harvest heat, transport in refrigerated transport to the cold storage or the processing plant. A part of it may be stored in cold storage to maintain its sensory qualities and a part may be distributed to retail shops, where again refrigeration is used for short time storage. Depending upon the size, the required capacity of refrigeration plants for cold storages can be very high. Ammonia is one of the common refrigerants used in cold storages.

2. Fish: Icing of fish according to ASHRAE Handbook on Applications, started way back in 1938. In India, iced fish is still transported by rail and road, and retail stores store it for short periods by this method. Freezing of fish aboard the ship right after catch results in better quality than freezing it after the ship docks. In some ships, it is frozen along with seawater since it takes months before the ships return to dock. Long-term preservation of fish requires cleaning, processing and freezing.

3. Meat and poultry: These items also require refrigeration right after slaughter during processing, packaging. Short-term storage is done at 0°C. Long-term storage requires freezing and storage at -25°C.

4. Dairy Products: The important dairy products are milk, butter, buttermilk and ice cream. To maintain good quality, the milk is cooled in bulk milk coolers immediately after being taken from cow. Bulk milk cooler is a large refrigerated tank that cools it between 10 to 15°C. Then it is transported to dairy farms, where it is pasteurized. Pasteurization involves heating it to 73°C and holding it at this temperature for 20 seconds. Thereafter, it is cooled to 3 to 4°C. The dairies have to have a very large cooling capacity, since a large quantity of milk has to be immediately cooled after arrival. During the lean period, the refrigeration plants of dairies are used to produce ice that is used during peak periods to provide cooling by melting. This reduces the required peak capacity of the refrigeration plant.

Ice cream manufacture requires pasteurization, thorough mixing, emulsification and stabilization and subsequently cooling to 4 to 5°C. Then it is cooled to temperature of about – 5 °C in a freezer where it stiffens but still remains in liquid state. It is packaged and hardened at –30 to –25°C until it becomes solid; and then it is stored at same temperature.

Buttermilk, curd and cottage cheese are stored at 4 to 10°C for increase of shelf life. Use of refrigeration during manufacture of these items also increases their shelf life. There are many varieties of cheese available these days. Adding cheese starter like lactic acid and several substances to the milk makes all of these. The whey is separated and solid part is cured for a long time at about 10°C to make good quality cheese.

5. Beverages: Production of beer, wine and concentrated fruit juices require refrigeration. The taste of many drinks can be improved by serving them cold or by adding ice to them. This has been one of the favourite past time of aristocracy in all the countries. Natural or man-made ice for this purpose has been made available since a very long time. Fruit juice concentrates have been very popular because of low cost, good taste and nutritional qualities. Juices can be preserved for a longer period of time than the fruits. Also, fruit juice concentrates when frozen can be more easily shipped and transported by road. Orange and other citrus juices, apple juice, grape juice and pineapple juice are very popular. To preserve the taste and flavour of juice, the water is driven out of it by boiling it at low temperature under reduced pressure. The concentrate is frozen and transported at –20°C.

Brewing and wine making requires fermentation reaction at controlled temperature, for example lager-type of beer requires 8 to 12°C while wine requires 27- 30°C. Fermentation is an exothermic process; hence heat has to be rejected at controlled temperature.

6. Candy: Use of chocolate in candy or its coating with chocolate requires setting at 5-10°C otherwise it becomes sticky. Further, it is recommended that it be stored at low temperature for best taste.

7. Processing and distribution of frozen food: Many vegetables, meat, fish and poultry are frozen to sustain the taste, which nearly duplicates that of the fresh product. Freezing retains the sensory qualities of colour, texture and taste apart from nutritional qualities. The refrigeration systems for frozen food applications are very liberally designed, since the food items are frozen in shortest period of time. The sharp freezing with temperature often below –30°C, is done so that the ice crystals formed during freezing do not get sufficient time to grow and remain small and do not pierce the cell boundaries and damage them. Ready-to-eat frozen foods, packed dinners and bakery items are also frozen by this method and stored at temperatures

		of –25 to -20°C for distribution to retail stores during peak demands or off-season demands.	
	b	Write a short note on Centralised Air Conditioning and enumerate how it is differed from the comfort room air conditioner.	10

Central air conditioning (or central A/C) is a system in which air is cooled at a central location and distributed to and from rooms by one or more fans and ductwork. The work of the air conditioner compressor is what makes the whole process of air conditioning possible. The

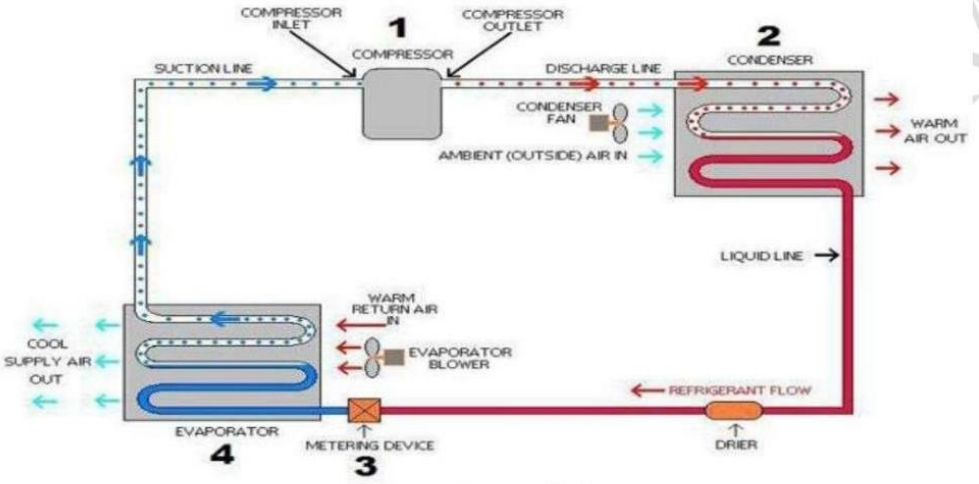


Figure: Basic Central Refrigeration system

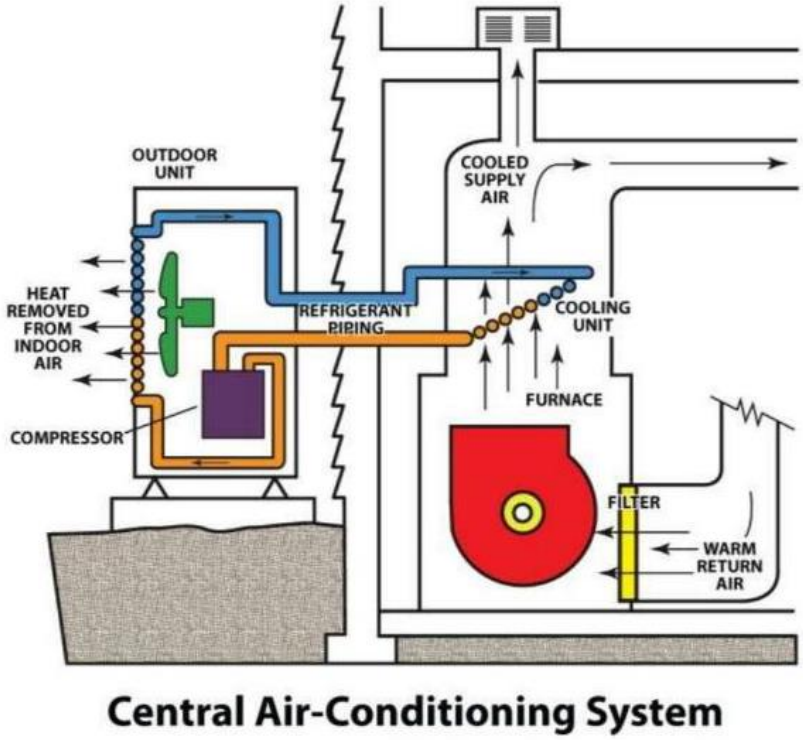


Figure: Working of Central Air Conditioning System

temperature gas then flows to the condenser coil.

The condenser coil is a series of piping with a fan that draws outside air across the coil. As the refrigerant passes through the condenser coil and the cooler outside air passes across the coil, the air absorbs heat from the refrigerant, which causes the refrigerant to condense from a gas to a liquid state. The high-pressure, high-temperature liquid then reaches the expansion valve.

The expansion valve is the "brain" of the system. By sensing the temperature of the evaporator, or cooling coil, it allows liquid to pass through a very small opening, which causes the refrigerant to expand to a low-pressure, low-temperature gas. This "cold" refrigerant flows to the evaporator.

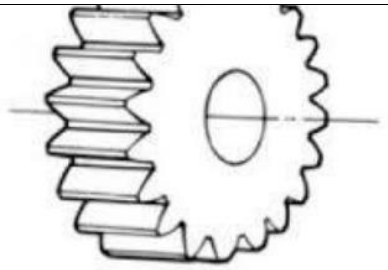
The evaporator coil is a series of piping connected to a furnace or air handler that blows indoor air across it, causing the coil to absorb heat from the air. The cooled air is then delivered to the house through ducting. The refrigerant then flows back to the compressor where the cycle starts over again.

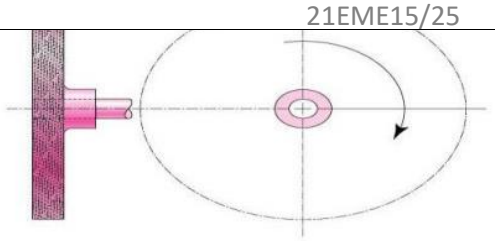
Difference Between Split And Central AC System

Central and split AC both work on the same principle, but they have different cooling capacities, so both are suitable for different sites. Split AC is divided into two parts, as it has a large capacity, so it is ideal for use in large offices and big places inside the house. On the other hand, the Central AC system is a single unit conditioner, as it is suitable for small rooms only. Central AC creates noise, whereas the Split unit works as a calm customer inside the room. Central AC is lesser in size as compared to Split AC units.

Central AC is easy to install, but in the case of Split AC, you have to connect the exterior and interior units through connecting tubes, which may cause trouble in case of a loose connection. Furthermore, a center can be completely installed in your room, but in terms of split AC, the interior unit must be connected to the compressor unit through a small hole in the wall. If you live in a rented house, a central AC is a good choice as it can easily be relocated, as it does not require installation by an expert professional.

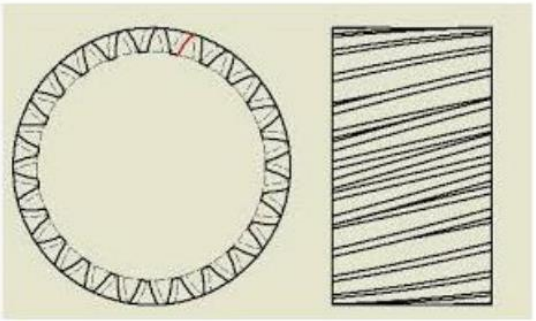
		Module-4	
Q. 7	a	Give the classifications of Gear Drives. Enlist each of their applications	6





2. Helical Gears

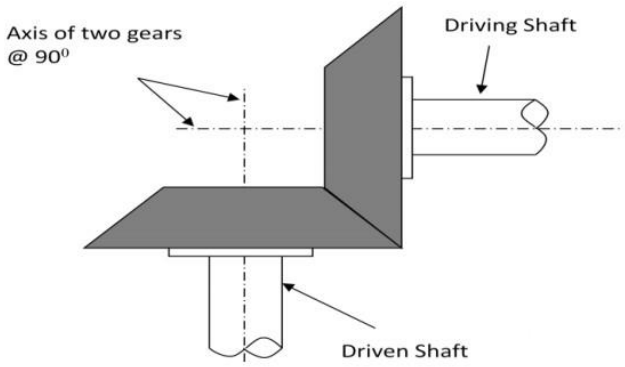
- Used to transmit power between parallel or non parallel but non-intersecting shaft.
- Teeth are curved and helical in shape
- Smooth operation as it results in gradual gear engagement
- Used in smooth and quiet running



Areas of applications of helical gears are very large but let us find few applications here where helical gears are preferred to use.

1. Helical gears are used in fertilizer industries, Printing industries and earth moving industries
2. Helical gears are also used in steel, Rolling mills, section rolling mills, power and port industries.
3. Helical gears are also used in textile industries, plastic industries, food industries, conveyors, elevators, blowers, compressors, oil industries & cutters.

- Used to transmit power between two non-parallel and intersecting shaft a any angle usually at an angle of 90^0
- teeth are formed on a conical surface, thicker at the base.
- The teeth may be straight or spiral.
- Spiral bevel gears are used to eliminate impact effect.

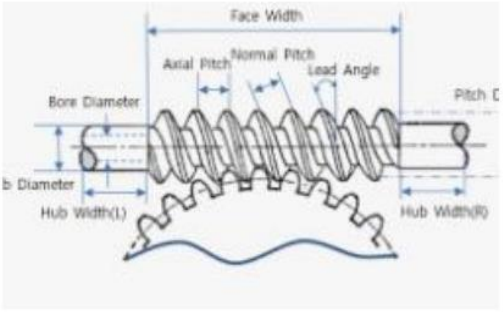


Straight Bevel Gearbox

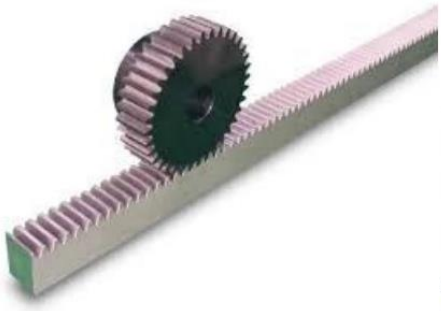
Bevel gears are found in a number of everyday items, devices, and machines, including automobiles, printing presses, power plants, cooling towers, marine applications, steel plants, and railway track inspection machines.

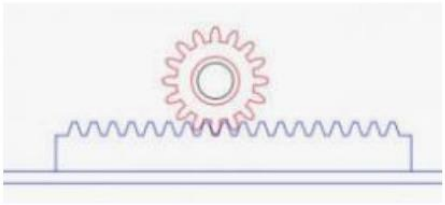
4. Worm Gear

- Used to transmit power between shaft at 90 but non-intersecting.
- Consists of screw (worm) and wheel (worm wheel)
- Used where large gear reduction is required. 20:1 to 300:1.
- High torque transmission
- Used in power steering systems, presses, rolling mills



- Rack is a gear having teeth along a straight line and pinion is a gear wheel with teeth on its periphery
- Could have straight or bevel teeth
- Greater feedback





Rack and pinions gears are commonly used in the steering system of cars to convert the rotary motion of the steering wheel to the side to side motion in the wheels. The steering wheel rotates a gear which engages the rack.

	b	A belt drive is used to transmit 20kw power from an electric motor to an exhaust fan. The diameter of motor and fan pulley are 250mm and 1000mm respectively. The speed of motor shaft is 750 rpm and thickness of belt is 6mm. Determine i) Speed of the exhaust fan pulley ii) Velocity of the belt iii) Torque required to transmit the power	6

the power

We know that,

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

$$\therefore \quad 20 \times 10^3 = \frac{2\pi \times 190.8548 \times T}{60}$$

$$\therefore \quad T = 1000.6870 \text{ N.m} \quad \text{... Ans.}$$

c Classify the robots on the basis of physical configurations — 8

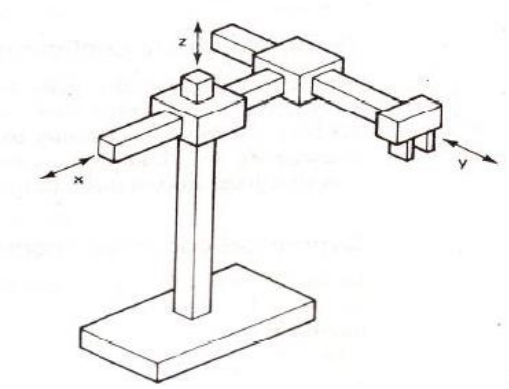
Classification based on Physical configurations

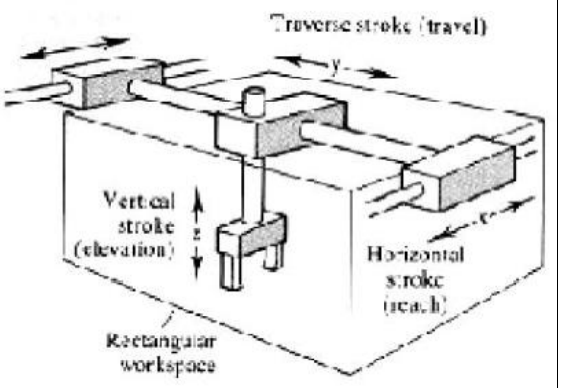
Possess five distinct design configurations:

A. Rectangular (Or Cartesian)
B. Cylindirical (Or Post-Type)
C. Spherical (Or Polar)
D. Jointed Arm (Articulated Or Revolute)
E. Scara (Selective Complaince Assembly Robot Arm)

A. **Cartesian / Rectangular configuration**

Notation: [**LOO**]: Linear, Orthogonal, Orthogonal
Figure illustrates a typical Cartesian configuration
Cartesian configuration is also called as **Rectilinear or Rectangular** configuration as the joints allow only translational or linear relative motion between the adjacent links of the joint. A robot using such a configuration is called as X-Y-Z robot. Other names are xyz robot or Rectilinear robot or **Gantry robot**. Any point in X, Y and Z coordinate system can be reached using this configuration. By appropriate movements of these slides, the robot is capable of moving its arm at any point within its three dimensional rectangular spaced work space.

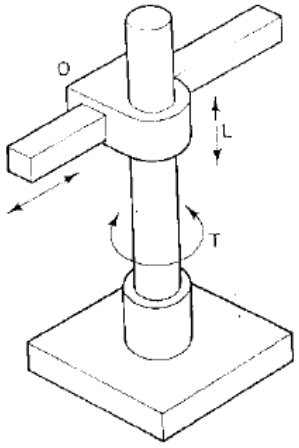


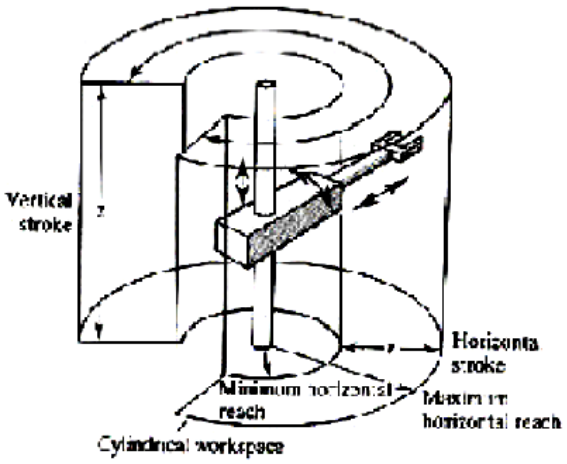


Features:
i) Operate within a **rectangular** work volume
ii) Three prismatic joints are used.
iii) The position is specified by X, Y and Z locations.
iv) Easy to visualize motion
v) Easy to program the motions
vi) Adapted in gantry crane and CNC milling machines.
vii) Gantry type can handle heavy loads.
viii) Addition axes can be incorporated to the wrist action.
ix) Difficult to protect the sliding axes from contaminants such as dust and moisture as it is open.

B. Cylindrical / Post-Type configuration:

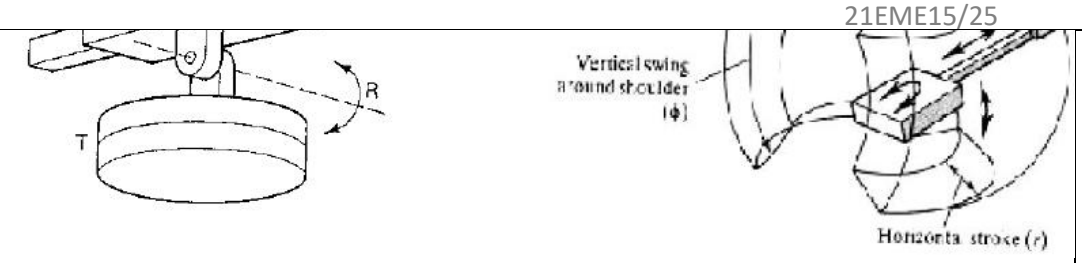
Notation: [**TLO**]: Twisting, Linear and Orthogonal
This also has 3 degrees of freedom, 2 prismatic and 1 revolute joints. It moves linearly along X and Y axes and rotaion about at its base i.e. Z- axis. The robot body is a vertical column that swivels about a vertical axis. The arm consists of several orthogonal slides which allow the arm to be moved up or down and in and out with respect to the body. This is illustrated schematically in figure.
Features:
i) Operate within a **cylindrical** work volume
ii) 2 prismatic and 1 revolute joints.
iii) Postion is specified by Y value (height) extension of arm X axis and angle of rotation of Z axis ( )
iv) Recommended for pick and place operation such as machine loading and unloading.
v) Lower repeatability and accuracy
vi) Require more sophisticated control
vii) Rigid structure & high lift-carrying capacity





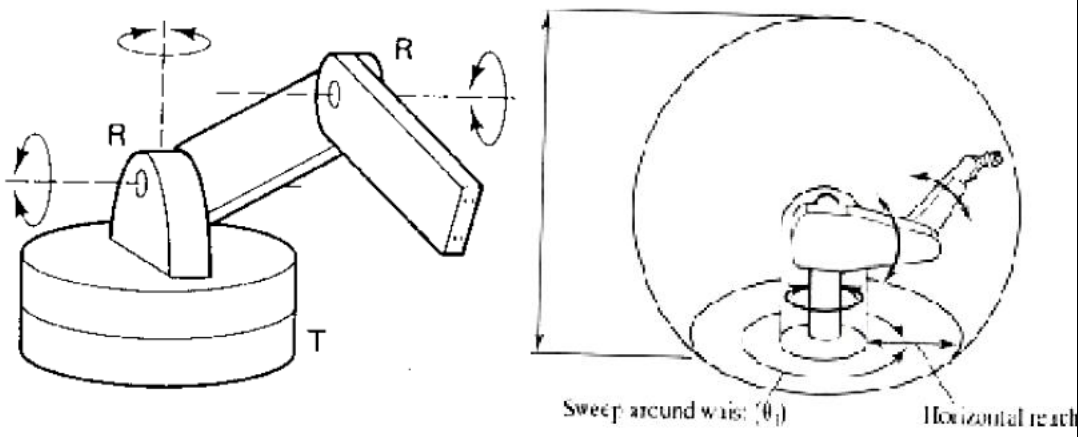
C. Spherical / Polar configuration:

Notation: [**LTR**]: Linear, Twisting and Rotational joint
This configuration also called as Polar coordinate configuration. It goes by the name "spherical coordinate" also because the workspace within which it can move its arm is a partial sphere as shown in figure. The robot has a rotary base and a pivot that can be used to raise and lower a telescoping arm.
Features:
i) Operate within a **spherical** work volume
ii) Has 1 prismatic and 2 revolute axes.
iii) First motion is a base rotation, Second motion correspond to an elbow rotation and Third motion is radial or in-out motion
iv) Elbow rotation and arm reach limit the design of full spherical motion.
v) Rarely used in industries but common in automated cranes.



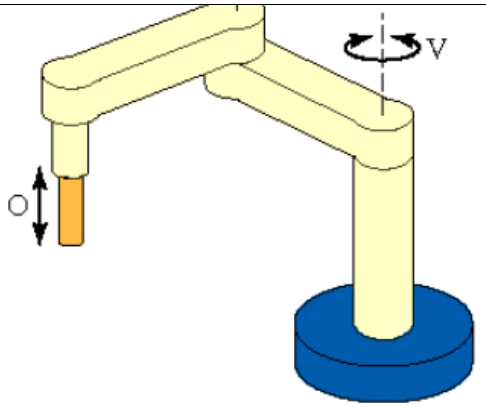
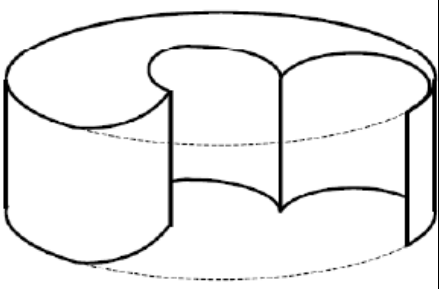
D. Revolute / Articulate / Jointed-arm configuration:

Notation: [**TRR**]: Twisting, Rotational and Rotational joint
It is combination of cylindrical and articulated configurations. This is similar in appearance to the human arm, as shown in fig. the arm consists of several straight members connected by joints which are analogous to the human shoulder, elbow, and wrist. The robot arm is mounted to a base which can be rotated to provide the robot with the capacity to work within a quasi-spherical space.
Features:
i) Operate within a **quasi-spherical** work volume.
ii) All 3 are revolute joints.
iii) Can reach above, below and around obstacles.
iv) Joints can be sealed easily.
v) Difficult to calculate angular motion of the axis for a given top or end motion.



E. SCARA (Selective Compliance Assembly Robot Arm)

Notation: [**VRO**]: Revolving, Rotational and Orthogonal joint
This configuration consists of 1 prismatic and 2 revolute joint. The important features being the relative motion of all the links at the joints are about vertical axes.
SCARA stands for Selective Compliance Assembly Robot Arm. This joint is similar to jointed-arm robot except that vertical axes are used for shoulder and elbow joints to be compliant in horizontal direction for vertical insertion tasks.
Features:
i) Work volume is **cylindrical** in nature
ii) Most common in assembly robot
iii) Arm consists of two horizontal revolute joints at the wrist and elbow and a one prismatic joint
iv) Can reach at any point within horizontal planar defined by two concentric circles
v) Most assembly operations involve building up assembly by placing parts on top of a partially complete assembly
vi) Floor area is small compare to work area
vii) Rectilinear motion requires complex control of the revolute joints

		 	
		OR	
Q. 8	a	With Suitable example explain the working principal Rack & pinion and Gear & Bevel gear. Rack and pinion gears are used to convert rotation into linear motion. The circular gear, or pinion, meshes with the rack and the rotation of the pinion causes the rack to translate. The steering mechanism in automobiles utilizes a rack and pinion system. As the pinion rotates, it forces the rack to move linearly. Since the length of the rack is not infinite, these mechanisms are not used in applications that have continuous rotation. Rack and pinions are used for lifting mechanisms (vertical movement), horizontal movement, positioning mechanisms, stoppers and to permit the synchronous rotation of several shafts in general industrial machinery. On the other hand, they are also used in steering systems to change the direction of cars. The characteristics of rack and pinion systems in steering are as follows: simple structure, high rigidity, small and lightweight, and excellent responsiveness. With this mechanism, the pinion, mounted to the steering shaft, is meshed with a steering rack to transmit rotary motion laterally (converting it to linear motion) so that you can control the wheel. In addition, rack and pinions are used for various other purposes, such as toys and lateral slide gates. Rack and pinion combinations are often used as part of a simple linear actuator, where the rotation of a shaft powered by hand or by a motor is converted to linear motion. The rack carries the full load of the actuator directly and so the driving pinion is usually small, so that the gear ratio reduces the torque required. This force, thus torque, may still be substantial and so it is common for there to be a reduction gear immediately before this by either a gear or worm gear reduction. Rack gears have a higher ratio, thus require a greater driving torque, than screw actuators. **Working Principle of Bevel Gears** Bevel gears can be used in mechanisms to change the axis of rotation. Although they can be designed to work at other angles, they are most often used to change the axis of rotation by 90 degrees. Similar to spur gears, bevel gears may also feature straight or helical teeth. Additionally, hypoid bevel gears can be used when the input and output shafts' axes do not intersect. Bevel gears are used as the main mechanism for a hand drill. As the handle of the drill is turned in a vertical direction, the bevel gears change the rotation of the chuck to a horizontal rotation. The bevel gears in a hand drill have the added advantage of increasing the speed of rotation of the chuck and this makes it possible to drill a range of materials.	8
	b	Explain the Industrial application of robots specific to material handling and Assembly Material handling robots can automate some of the most tedious, dull, and unsafe tasks in a production line and is one of the easiest ways to add automation. Material handling robots enhance the efficiency of your production line and increase customer satisfaction by providing quality products in a timely manner. The term material handling encompasses a wide variety of product movements. Part selection and	8

		transferring, palletizing, packing, and machine loading are just a few of the applications that are considered material handling. When picking material handling equipment for your facility, you should consider payload and speed requirements, end-of-arm tooling or grippers needed, facility layout and floor-space, the type of material being handled and any additional possible production problems. • Part transfer, a dull and tedious process, can also be injury-inducing to human workers. By adding robots to this job, human workers are kept free of the hazardous environment. • Packaging robots are extremely flexible and easy to integrate into a workspace. Some of the advantages of packaging robots include reduced part package time, ability to lift larger packages and labor cost reduction . With the right end of arm tooling, a robot can complete any packaging process. There is a large variety of robot sizes, mounting options, payload and reach available to choose from. • Palletizing robots can be seen in many industries including food processing, manufacturing, and shipping. • Machine loading robots not only increase production speeds, it also protects workers from injury. **Die casting:** The robot unloads parts from the die casting machine. Peripheral operations sometimes performed by the robot include dipping the parts into a water bath for cooling. **Plastic molding:** Plastic molding is a robot application similar to die casting. The robot is used to unload molded parts from the injection molding machine. **Machining operations:** The robot is used to load raw blanks into the machine tool and unload finished parts from the machine. The change in shape and size of the part before and after machining often presents a problem in end effector design; and dual grippers are often used to deal with this issue. **Forging:** The robot is typically used to load the raw hot billet into the die, hold it during the forging blows, and remove it from the forge hammer. The hammering action and the risk of damage to the die or end effector are significant technical problems. Forging and related processes are difficult as robot applications because of the severe conditions under which the robot must operate. **Press working:** Human operators work at considerable risk in sheet-metal press working operations because of the action of the press. Robots are used as substitutes for the human workers to reduce the danger. In these applications, the robot loads the blank into the press, the stamping operation is performed, and the part fails out the back of the machine into a container. In high production runs, press working operations can be mechanized by using sheet metal coils instead of individual blanks. These operations require neither humans nor robots to participate directly in the process **Heat treating:** These are often relatively simple operations in which the robot loads and/or unloads parts from a furnace.	
	c	Differentiate between Mechanics and Machines	4

			motion and thus makes use of mechanisms.	the transfer of motion only.	
		Nature	A machine can use one or more than one mechanism to perform the desired function.	A mechanism is a single system to transfer or transform motion.	
		Components	A machine may contain several mechanism and other elements.	A mechanism consists of several links joined together.	
		Examples	Shaping machine, lather machine, screw jack etc are examples of machines.	Oscillating cylinder mechanism and scotch yoke mechanism are examples of mechanism.	

		Module-5	
Q. 9	a	Explain with neat diagrams, any two metal cutting operations performed on a lathe machine.	8

1. Facing : -

Facing is the operation performed on the lathe to produce flat surface at the ends of the work piece. It is also used to cut the work piece to the required length. Fig.5.3 shows the facing operation. The one end of the workpiece is held rigidly in head stock using chuck. The tool is moved perpendicular to the axis of rotation of the workpiece. The facing operation is usually performed in two steps. In the first step a rough facing operation is done with a heavy cross feed in the order of 0.5 to 0.7 mm and a depth of cut upto 5 mm. It is followed by a finer cross feed of 0.1 to 0.3 mm with a smaller depth of cut of about 0.5 mm.

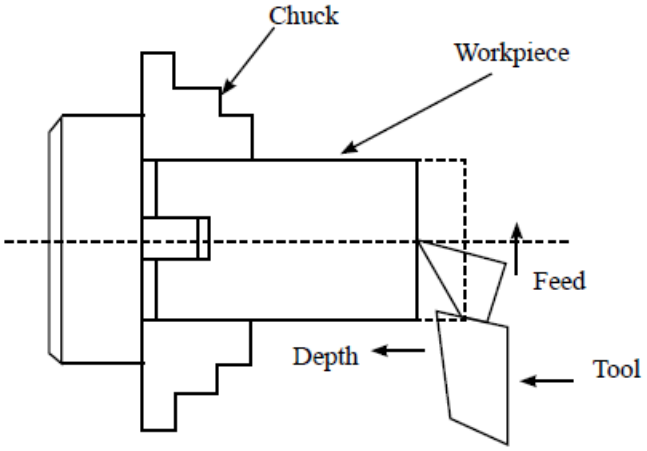


Fig: Facing Operation

2. Turning

It is the operation in which the workpiece is reduced to cylindrical section of required diameter. Turning operation removes excess material from the workpiece to produce a cylindrical surface. Two types of turning operations are

Straight (plain) tuning: - Straight turning, sometimes called cylindrical turning, is the process of reducing the workpiece diameter to a specific dimension for a required length.

Fig. 5.4.a. shows the plain turning operation. The workpiece is machined on its surface parallel to its axis so that there is no variation in the work piece diameter throughout the length of the cut. Straight turning usually consists of a rough cut followed by a finishing cut. When a large amount of material is to be removed, several rough cuts may be needed.

The finishing cut should be light and produce specified dimension in one pass of the tool.

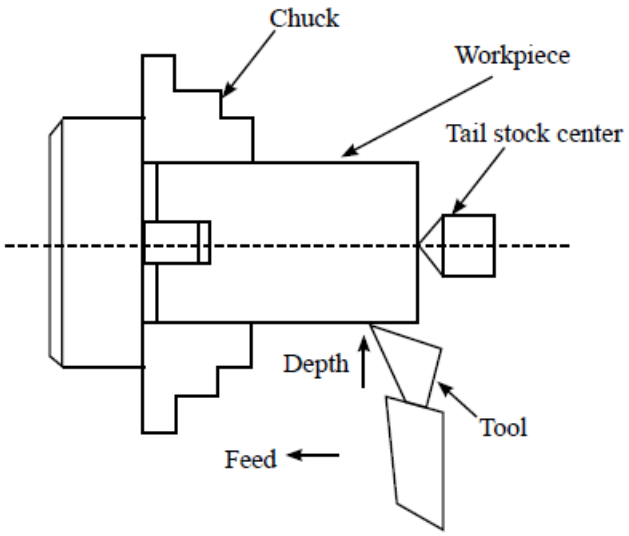


Fig: Straight Turning Operation

b With the help of a block diagram, explain the basic elements of CNC machines 8

CNC System

The main components of CNC system are

1. Input device
2. Machine control unit
3. Machine tool
4. Driving system
5. Feedback devices
6. Display unit

The machine control unit (MCU) is a microcomputer that stores the program and executes the commands into actions by the machine tool. The MCU consists of two main units: the data processing unit (DPU) and the control loops unit (CLU). The DPU software includes control system software, calculation algorithms, translation software that converts the part program into a usable format for the MCU, interpolation algorithm to achieve smooth motion of the cutter, editing of part program (in case of errors and changes).

The DPU processes the data from the part program and provides it to the CLU which operates the drives attached to the machine leadscrews and receives feedback signals on the actual position and velocity of each one of the axes. A driver (dc motor) and a feedback device are attached to the leadscrew. The CLU consists of the circuits for position and velocity control loops, deceleration and backlash take up, function controls such as spindle on/of. Refer Fig

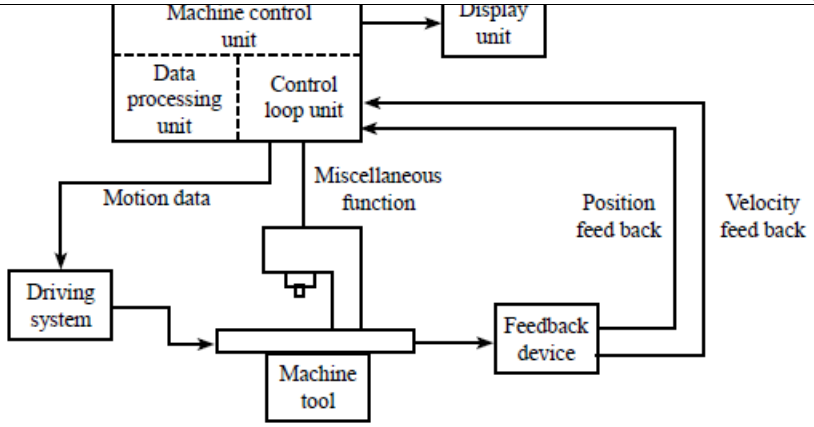
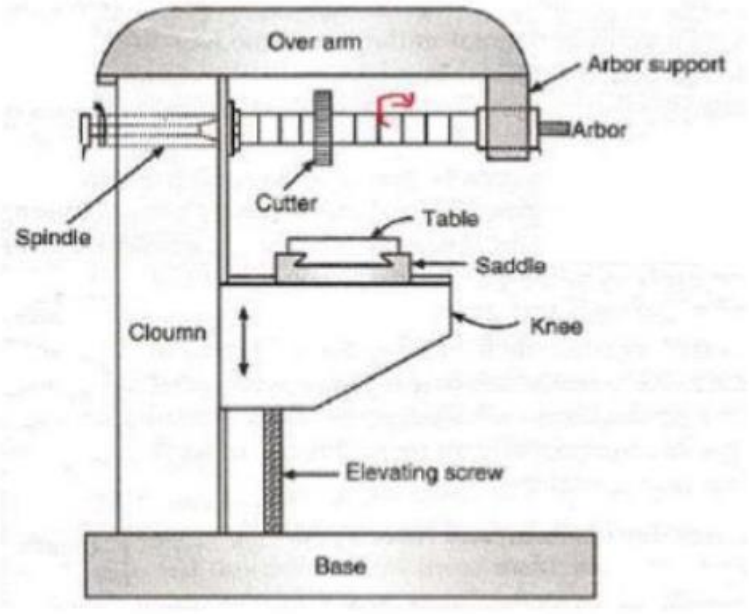


Fig: CNC system

c Differentiate between open loop and close loop System — 4

Basis For Comparison	**Open Loop System**	**Closed Loop System**
Definition	The system whose control action is free from the output is known as the open loop control system.	In closed loop, the output de the control action of the syst
Other Name	Non-feedback System	Feedback System
Components	Controller and Controlled Process.	Amplifier, Controller, Contr Process, Feedback.
Construction	Simple	Complex
Reliability	Non-reliable	Reliable
Accuracy	Depends on calibration	Accurate because of feedbac
Stability	Stable	Less Stable
Optimization	Not-Possible	Possible
Response	Fast	Slow
Calibration	Difficult	Easy
System Disturbance	Affected	Not-affected
Linearity	Non-linear	Linear
Examples	Traffic light, automatic washing machine, immersion rod, TV remote	Air conditioner, temperature system, speed and pressure

		etc. system, refrigerator, toaster.	
		OR	
Q.10	a	Explain the principle of working of horizontal milling machine The Horizontal Milling Machine is a very robust and sturdy machine. A variety of cutters are available to removed/shape material that is normally held in a strong machine vice. This horizontal miller is used when a vertical miller is less suitable. For instance, if a lot of material has to be removed by the cutters or there is less of a need for accuracy - a horizontal milling machine is chosen. Figure 1.19 shows the different parts of horizontal machine. Horizontal milling machine consist of the following parts. **Base** It is accurately machined on its top and bottom surface and serves as a foundation member for all other parts. It carries the column at its one end. In some machines, the base is hollow and serves as a reservoir for cutting fluid. **Column** It is the main supporting frame mounted vertically on the base. The column is box shaped, heavily ribbed inside and houses all the driving mechanisms for the spindle and table feed. The front vertical face of the column is accurately machined and is provided with dovetail guide ways to supporting the knee. The top of the column is finished to hold an over arm that extends outward at the front of the machine. **Knee** It slides up and down on the vertical guide ways of the column face. The adjustment of height is affected by an elevating screw mounted on the base that also supports the knee. The knee houses the feed mechanism of the table, and different controls to operate it. The top face of the knee forms a slideway for the saddle to provide cross travel of the table. **Table** The table rests on ways on the saddle and travels longitudinally. The top of the table is accurately finished and T-slots are provided for clamping the work and other fixtures on it. A lead screw under the table engages a nut on the saddle to move the table horizontally by hand or power. The longitudinal travel of the table may be limited by fixing trip dogs on the side of the table. In universal machines, the table may also be swiveled horizontally.  **Overhanging arm** The overhanging arm that is mounted on the top of the column extends beyond the column face and serves as a bearing support for the other end of the arbor. The arm is adjustable so that the bearing support may be provided nearest to the cutter. **Front brace** The front brace is and extra support that is fitted between the knee and the over arm to	6

ensure further rigidity to the arbor and the knee. The front brace is slotted to allow for the adjustment of the height of the knee relative to the over arm.

Spindle: The spindle of the machine is located in the upper part of the column and receives power from the motor through belts, gears, clutches and transmits it to the arbor. The front end of the spindle just projects from the column face and is provided with a tapered hole into which various cutting tools and arbors may be inserted. The accuracy in metal machining by the cutter depends primarily on the accuracy, strength, and rigidity of the spindle.

Arbor

It may be considered as an extension of the machine spindle on which milling cutters are securely mounted and rotated. The arbors are made with taper shanks for proper alignment with the machine spindles having taper holes at their nose.

OPERATION

The workpiece mounted on the table is raised against the revolving cutter by an elevating screw to give the required depth of cut. The table is moved in a horizontal plane to give feed to the workpiece. Horizontal milling machines are suitable for obtaining grooves, slots, gear teeth etc.

b Illustrate the working of an automated washing machine to demonstrate the mechatronic system — 8

Figure 10.8 shows the basic washing machine system. It gives a basic idea of the constituent elements of a washing machine. It is a mechanical system involving a set of cam-operated switches. When the machine is switched on, the electric motor slowly rotates its shafts, giving an amount of rotation proportional to time. Its rotation, in turn, controls the cams so that each cam operates electricals switches and switch circuits in the correct sequence. The contour of a cam determines the time at which it operates the switch. Thus, contours of the cams are the means by which the washing program is specified and stored in the machine. The instructions used in a particular washing program, and their sequence, are determined by a set of cam chosen. The modern washing machine controller is a microprocessor where the program is not guided by the mechanical arrangement of the cam.

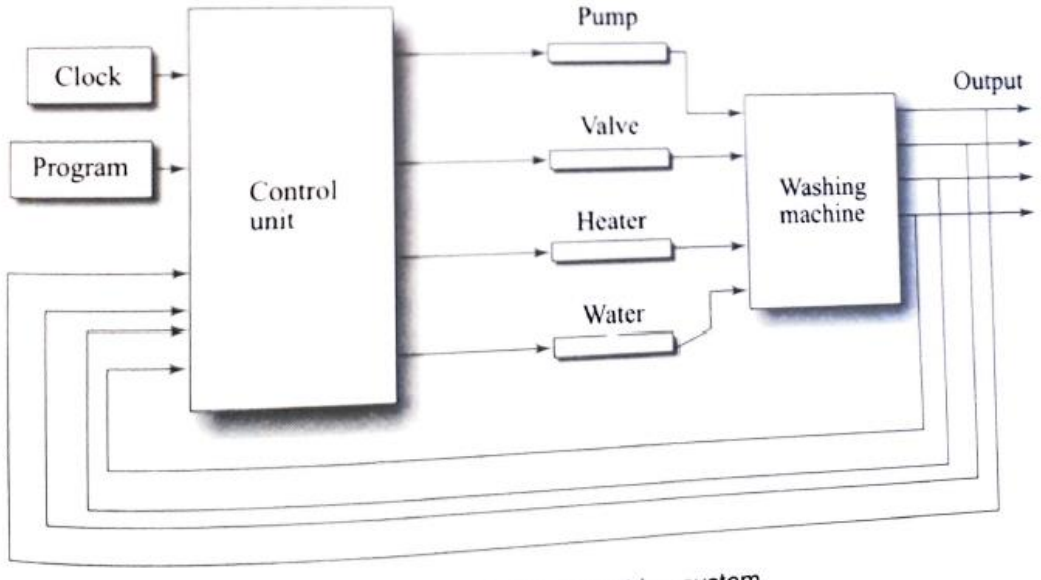


Fig. 10.8 Washing machine system

This valve allows cold water

by the profile of the cam. The output from the microprocessor is

switch. However, since a specific level of water in the washing machine drum is required, there need to be another mechanism that will stop the water going into the drum during the permitted time when it reaches the required level. A sensor is used to give a signal when the specified water level is reached. The preset level gives an output from the microprocessor, which is used to switch off the current to the valve. In the case of a cam-controlled valve, the sensor actuates a switch, which closes the valve admitting water to the washing machine drum. When the event is completed, the microprocessor gives out a signal to turn the prewash mode on for a fixed time. At the end of this time, the cam indicates the pump to empty the drum.

For the main wash cycle, the microprocessor gives output to start when the prewash part of the program is completed. In the case of a cam-operated system, the cam has a profile such that it starts operation when the prewash cycle is completed. It switches a current into a circuit to open a valve to allow cold water into the drum. The water level is continuously sensed and the water flow is shut off when the required level is reached. The microprocessor or cam then supplies a current to actuate a switch, which supplies a higher current to an electric heater to heat the water. A temperature sensor is used to switch off the current when the water temperature reaches the preset value. The microprocessor or cam switches on the drum motor to rotate the drum. This will turn off after some time, determined by the microprocessor or cam profile. Then the microprocessor or cam switches on the current to allow the pump to empty the water from the drum.

The rinse part of the operations is switched on now. It is a sequence of signals to allow cold water into the machine, switch it off, operate the motor to rotate the drum, operate the pump to empty the water from the drum, and repeat the sequence a fixed number of times.

The final part of the operation is the spin stage. It starts with the microprocessor or cam switching on the motor at a higher speed than for rinsing. The spin operations last a preset value and comes to an end after that. Spin operation completes the whole cycle of washing clothes.

Microprocessor is now rapidly replacing the mechanical operated controller. It is used in general to carry out control functions. It has the advantage that a greater variety of actions can be achieved without any change in the design of the mechanical system.

	c	Enlist the advantages of CNC machine in mechanical Industry 1. CNC machines can be used continuously 24 hours a day, 365 days a year and only need to be switched off for occasional maintenance. 2. CNC machines are programmed with a design which can then be manufactured hundreds or even thousands of times. Each manufactured product will be exactly the same. 3. Less skilled/trained people can operate CNCs unlike manual lathes / milling machines etc.. which need skilled engineers. 4. CNC machines can be updated by improving the software used to drive the machines 5. Training in the use of CNCs is available through the use of 'virtual software'. This is software that allows the operator to practice using the CNC machine on the screen of a computer. The software is similar to a computer game. 6. CNC machines can be programmed by advanced design software such as Pro/DESKTOP®, enabling the manufacture of products that cannot be made by manual	6

		machines, even those used by skilled designers / engineers. 7. Modern design software allows the designer to simulate the manufacture of his/her idea. There is no need to make a prototype or a model. This saves time and money. 8. One person can supervise many CNC machines as once they are programmed they can usually be left to work by themselves. Sometimes only the cutting tools need replacing occasionally. 9. A skilled engineer can make the same component many times. However, if each component is carefully studied, each one will vary slightly. A CNC machine will manufacture each component as an exact match.	

Table showing the Bloom's Taxonomy Level, Course Outcome and Program Outcome				
Question		**Bloom's Taxonomy Level attached**	**Course Outcome**	**Program Outcome**
	a	**L2**	**CO1**	**PO1, PO12**
	b	**L1**	**CO1**	**PO1**
	a	**L3**	**CO2**	**PO1**
	b	**L2**	**CO2**	**PO1**
	a	**L1**	**CO1**	**PO1**
	b	**L2**	**CO2**	**PO1**
	c	**L2**	**CO1, CO2**	**PO1**
	a	**L3**	**CO2**	**PO1**
	b	**L2**	**CO2**	**PO1**
	a	**L2**	**CO2**	**PO1**
	b	**L2**	**CO1**	**PO5**
	a	**L2**	**CO2**	**PO1, PO12**
	b	**L3**	**CO1, CO2**	**PO1, PO12**
	a	**L2**	**CO1**	**PO1**
	b	**L3**	**CO2**	**PO2**
	c	**L2**	**CO1**	**PO1**
	a	**L3**	**CO3**	**PO1**
	b	**L2**	**CO2**	**PO1, PO12**
	c	**L3**	**CO2**	**PO5, PO12**
	a	**L2**	**CO2**	**PO1**
	b	**L2**	**CO1**	**PO5**
	c	**L3**	**CO2**	**PO1**
	a	**L2**	**CO1**	**PO1**
	b	**L3**	**CO3**	**PO5**
	c	**L2**	**CO2**	**PO5**

Bloom's Taxonomy Levels	**Lower order thinking skills**		
	Remembering (knowledge): LL_1	Understanding (Comprehension): LL_2	Applying (Application): LL_3
	Higher order thinking skills		
	Analyzing (Analysis): LL_4	Evaluating (Evaluation): LL_5	Creating (Synthesis): LL_6