USN 1 P E

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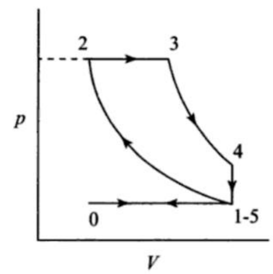
Department of Basic Science and Humanities

INTERNAL ASSESSMENT TEST 2

Date : 03/04/2018		Marks: **60**
Subject & Code : **Elements of Mechanical Engineering – 17EME24**	Sec : A, B, C, D and E	
Name of faculty : SP, VNP,CM, AS and MSA	Time : 90 mins	

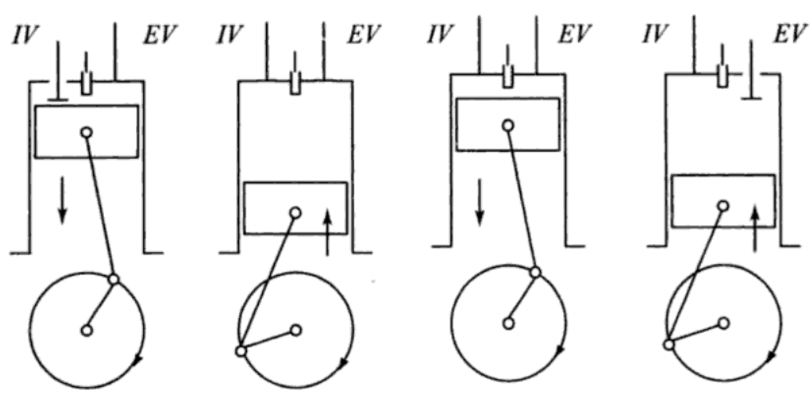
	Note: Answer FIVE full questions, selecting any ONE full question from each part.	**Marks**
	PART 1	
1 a	The following figure shows the PV diagram of a 4S IC Engine. Identify the type of the engine and explain the working of the same with neat diagrams.	**8**



Ans :

The given PV diagram is that of a 4S Diesel (Compression Ignition) Engine.

The four stroke Diesel (CI) Engine consists of Suction, Compression, Power and Exhaust strokes. The following figure shows the working of a 4S Diesel Engine.



(a) Suction (b) Compression (c) Expansion (d) Exhaust

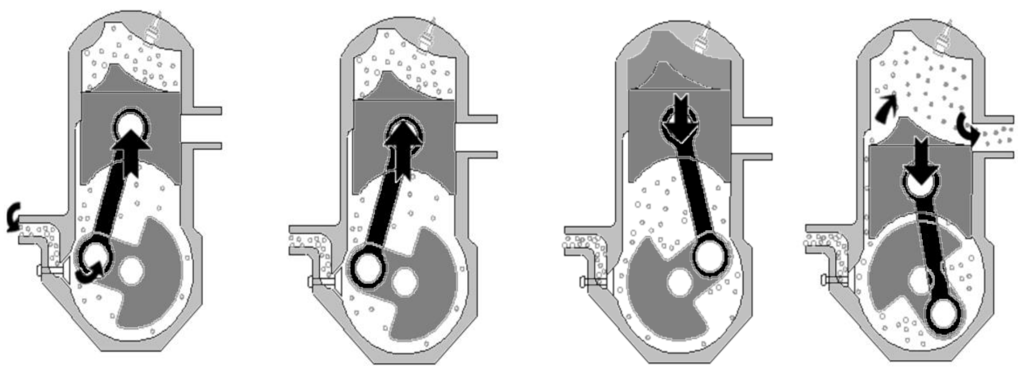
	<u>Suction Stroke:</u> During this stroke, the inlet valve is open and the exhaust valve is closed. The piston moves from TDC to BDC and the crankshaft revolves through half rotation. As the piston moves downwards, a partial vacuum is created in the cylinder, as a result of which suction of air takes place into the cylinder. When the piston reaches BDC, the inlet valve closes marking the end of the stroke. This stroke is represented by line 0-1 of the PV diagram. <u>Compression Stroke:</u> During this stroke, both inlet valve and exhaust valves are closed. The piston moves from BDC to TDC and the crankshaft revolves through half rotation. As the piston moves from BDC to TDC, the air inducted into the cylinder during the last stroke gets compressed. This results in an increase in pressure as well as temperature of the air. At the end of the compression stroke, a metered quantity of fuel is sprayed from the fuel injector. The high temperature of the air ignites the fuel leading to the combustion of the fuel at constant pressure. The compression is represented by line 1-2 of the PV diagram, whereas the constant pressure combustion is represented by the line 2-3 of the PV diagram. <u>Power or Expansion Stroke:</u> During this stroke, both inlet and exhaust valves are closed. The piston moves from TDC to BDC and the crankshaft revolves through half rotation. The burnt gases released due to the combustion of the fuel are subjected to expansion. This causes a force to be acted on the piston head which makes the piston to move from TDC to BDC, producing mechanical work or power. Since, power is produced from the engine during this stroke, it is called as “Power Stroke”. This stroke is represented by the line 3-4 of the PV diagram. <u>Exhaust Stroke:</u> During this stroke, the inlet valve is closed and the exhaust valve is open. The piston moves from TDC to BDC and the crankshaft revolves through half rotation. During the end of the power stroke, some of the burnt gases escape through the exhaust valve due to their own expansion (Exhaust valve opens almost at the end of the power stroke itself). During this stroke, as the piston moves from TDC to BDC, the remaining burnt gases are made to escape through the exhaust valve. This stroke is represented by the line 5-1 of the PV diagram.		
1	**b**	Differentiate clearly between SI engine and CI engine with suitable reasoning, considering the following parameters. i)Thermal Efficiency ii)Weight iii)Noise and Vibration iv)Compression Ratio	**4**

		Ans : i)Thermal Efficiency Thermal Efficiency of CI engine is more than that of SI engine because the compression ratio used in case of CI engines is more than that used in case of SI engines. ii)Weight Weight of CI engine is more than that of SI engine. Due to higher compression ratio, pressure and temperature developed in the engine is higher, which requires heavier and stronger engine. Hence the weight of CI engine is more. iii)Noise and Vibration Noise and Vibration are high in CI engines when compared to those in SI engine due to higher operating pressures inside the cylinder. iv)Compression Ratio Compression ratio used in case of SI engines ranges from 6:1-10:1, whereas CR used in case of CI engines are relatively high and is in the range of 16:1-22:1.	
2	**b**	Define the following performance parameters of an engine with their expressions. i)Indicated Mean Effective Pressure ii)Indicated Power iii)Indicated Thermal Efficiency iv)Brake Specific Fuel Consumption Ans: i)Indicated Mean Effective Pressure It can be defined as the average pressure developed inside the cylinder of an IC engine. It is calculated using the equation, $$P_m = Sa/l,$$ Where, S = Spring Value of the Spring used in the Indicator; a = Area of the Indicator Diagram; l = Length of the Indicator Diagram. ii)Indicated Power It can be defined as the total power developed inside the engine cylinder due to combustion of fuel. It is given by,	**4**

		$$IP = nP_mLANK/(60\times1000)$$ Where, IP = Indicated Power in KW; n = No. of Cylinders; L = Stroke in m; A = Piston Area in m^2; N = Engine Speed in rpm; K = 1 for 2S engine and ½ for 4S engine. iii)Indicated Thermal Efficiency It is defined as the ratio of Indicated Power to the heat supplied by the burning fuel. It is given by, $$\eta_{ITh} = IP/(m_f \times CV);$$ where, η_{ITh} = Indicated Thermal Efficiency; IP = Indicated Power in KW; m_f = Mass of fuel in kg/sec; CV = Calorific Value of fuel in KJ/kg. iv)Brake Specific Fuel Consumption It can be defined as the ratio of mass of the fuel consumed to the Brake Power developed. It is given by, $$BSFC = m_f /BP;$$ Where, BSFC = Brake Specific Fuel Consumption in Kg/KWhr; m_f = Mass of Fuel Consumed in kg/hr; BP = Brake Power in KW.	
2	**a**	Explain the working of a 2S petrol engine with neat diagrams. Ans **Upward stroke or working stroke**: In two-stroke petrol engine some charge is present either in the cylinder block or in the crankcase. To start a two-stroke engine, power is supplied either by using a kicker or by electric start. During upward stroke, the piston reciprocates from top dead center to bottom dead center. As the piston moves upward; volume below the piston increases and results in decrease in pressure in the crankcase. Due to pressure difference charge (petrol & air) is drawn from the carburetor. As the piston moves further upwards covers both exhaust and transfer port, now the charge is subjected to compression. Before the end of the compression stroke the spark (crank angle	

20^{o} before TDC) occurs in the combustion chamber. Due to combustion of charge, the pressure increase, which pushes the piston downwards i.e. the working stroke of the piston? As the piston moves rapidly in the down ward direction compresses the charge present in the crankcase.

Down ward stroke or exhaust stroke: As the piston moves further down wards, first it uncovers the exhaust port. Due to pressure difference the high-pressure gases leaves the combustion chamber. As the piston moves further down wards, it uncovers transfer port, which allows the compressed charge in the crankcase to the cylinder. The fresh charge is deflected upwards by the deflector provided on the top of the piston and pushes the remaining exhaust gases present in the cylinder. The process of removal of exhaust gases from the cylinder is known as scavenging.



PART 2

3 a The following are the details of a 4S Petrol Engine. Diameter of the brake drum = 60.03 cm; Full brake load on drum = 250 N; Brake drum speed = 450 rpm; Calorific Value of Petrol = 40 MJ/kg; Brake Thermal Efficiency = 32%; Mechanical Efficiency = 80%; Specific gravity of Petrol = 0.82. Determine Brake Power, Indicated Power, Fuel Consumption in litres per second and Indicated Thermal Efficiency. **8**

Ans:

Given : Engine Type = 4S;
Diameter of brake drum = 60.03cm ; Radius of brake drum = 30.015cm;
Brake Load on Drum = W = 250N;
Brake Drum Speed = Engine Speed = N = 450 rpm;
CV of Petrol = 40MJ/kg = 40000 KJ/kg;
η_{BTh} = 32%;
η_{mech} = 80%;
Specific gravity of Petrol = 0.82.

	i)Brake Power We know that, $BP = 2\pi NT/(60\times1000)$; Torque = $T = (W-S)\times R = 250 \times 30.015\times10^{-2} = 75.0375$ Nm. (S is neglected) $BP = 2\times\pi\times450\times75.0375/(60\times1000) = 3.5360$ KW. ii)Indicated Power We know that, $\eta_{mech} = BP/IP$; $IP = BP/\ \eta_{mech} = 3.5360/0.8 = 4.42$ KW. iii)Fuel Consumption in litres/sec We know that, $\eta_{BTh} = BP/(m_f\times CV)$; $m_f = BP/(\ \eta_{BTh}\times CV) = 3.5360/(0.32\times40000) = 2.7625\times10^{-4}$ kg/s. We have, Density of Fuel = Mass of Fuel/Volume of Fuel; Therefore, Volume of fuel = Mass of Fuel/Density of Fuel; Density of Fuel = Specific gravity of fuel × Density of water = 0.82 × 1000 = $820 kg/m^3$ Volume of fuel = $2.7625 \times 10^{-4}/(820) = 3.3689 \times 10^{-7}\ m^3/s = 3.3689 \times 10^{-4}$ litres/sec. iv)Indicated Thermal Efficiency We know that, $\eta_{ITh} = IP/(m_f \times CV) = 4.42/(2.7625 \times 10^{-4} \times 40000) = 0.4 = 40\%$.	
3 b	Define Indicated Mean Effective Pressure. With a neat diagram, explain its significance. It is defined as the average pressure acting on the piston during the expansion stroke which does the same amount of work as the varying pressure in one cycle. The mean effective pressure is defined as the equivalent constant pressure which has to be acting on the piston during the expansion stroke, to give the same work output	

as the varying pressure, in one cycle.

From the indicator diagram, the mean effective pressure can be calculated as,

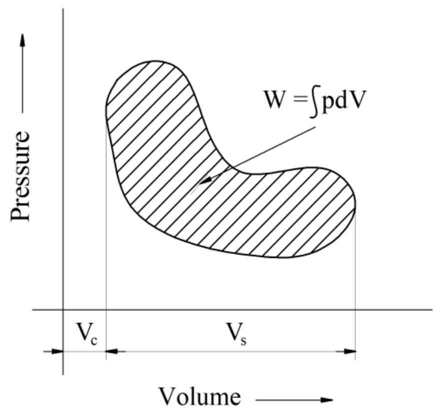
$p_m = s.a/l.$

where,

s = spring constant of the spring used in the piston indicator,

l = length of the indicator diagram,

a = area of the indicator diagram.



4 a The indicated thermal efficiency of 4S engine is 32% and its mechanical efficiency is 78%. The fuel consumption rate is 20 Kg/hr running at a fixed speed. The brake mean effective pressure developed is 6 bar and the mean piston speed is 720 m/min. Assuming it to be a single cylinder square engine (L=d), calculate bore and speed of engine. **8**

Ans :

Given : Engine Type = 4S;

η_{ITh} = 32%;

η_{mech} = 78%;

m_f = 20kg/hr = 5.5555×10^{-3} kg/s;

P_{bm} = 6bar = 6×10^5 N/m^2;

Mean Piston Speed = 720m/min;

L=d;

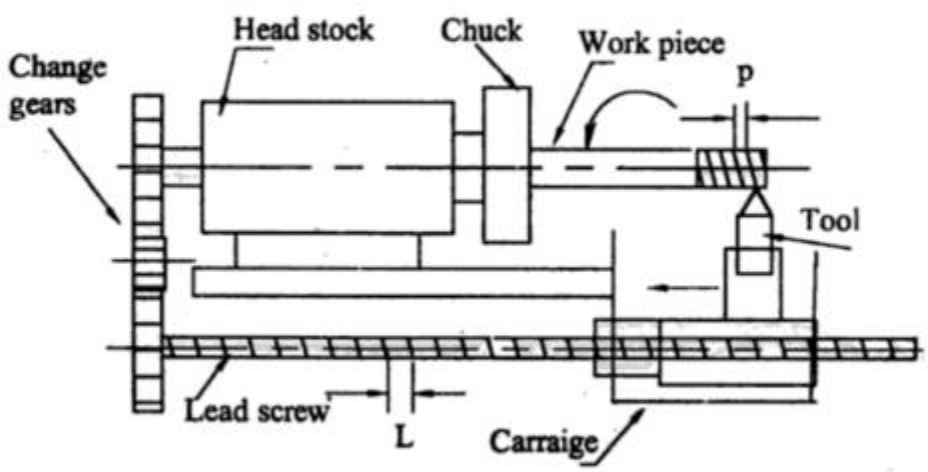
CV = 42000KJ/kg;

<u>i)Calculation of Bore</u>

We know that,

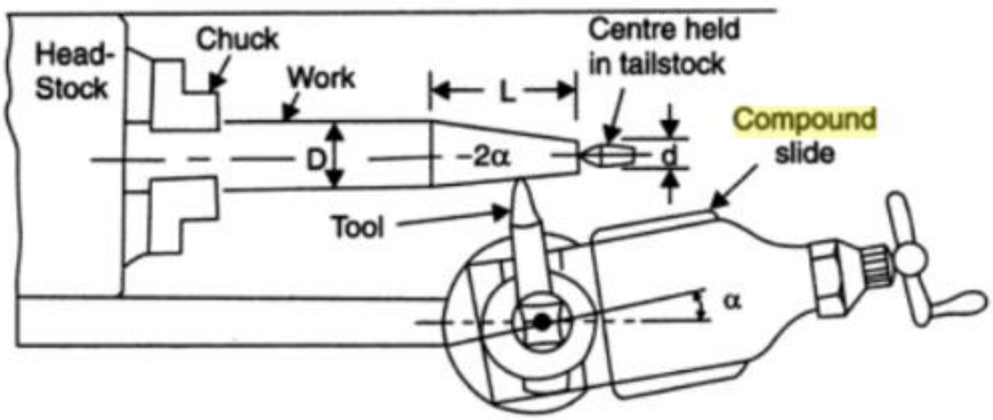
$\eta_{ITh} = IP/(m_f \times CV)$;

	Therefore, IP = $\eta_{ITh} \times m_f \times CV = 0.32 \times 5.5555 \times 10^{-3} \times 42000 = 74.6659$ KW. We know that, η_{mech} = BP/IP; Therefore, BP = $\eta_{mech} \times IP = 0.78 \times 74.6659 = 58.2394$ KW. We know that, BP = $nP_{mb}LANK/(60 \times 1000)$; Substituting the respective values in the above equation, we get, $58.2394 = \frac{1\times 6\times 10^5 \times L \times \frac{\Pi}{4} \times L^2 \times N \times 1/2}{60\times 1000}$ (L=d)…….(1) On solving, we get, $L^3N = 14.8305\ m^3/min$; We have mean piston speed = 2LN = 720 m/min which implies, N = 360/L; Substituting above expression in (1) and solving for L, we get, L = 0.2029m = 202.9mm; Since L=d, Bore = 202.9mm. N = 360/L = 360/0.2029 = 1774.27rpm.	
4 b	The power developed by an engine can be increased by enlarging the size of a single cylinder or having more cylinders of same size. Which method is more advantageous? Substantiate your answer With a given piston speed and BMEP, the engine power varies as the square of the bore (piston area) but the mass varies as the cube of the bore (Volume of metal used). Increasing power by using a large cylinder therefore the number of cylinders	**4**

	maintains power and weight in the same propotions.	
	PART 3	
5 a	With a neat sketch, explain the following lathe operations. i)Thread Cutting ii)Taper Turning by swiveling the Compound Rest Ans : <u>i)Thread Cutting</u> Thread cutting on lathe machine is schematically shown in the following figure.  Thread cutting can be defined as an operation of cutting screw threads on cylindrical work pieces. The work piece on which the thread is to be cut is held rigidly in the chuck of the headstock and supported by the dead centre of the tailstock. The spindle of the headstock is rotated at a suitable speed which in turn rotates the work piece at that speed. The carriage is moved longitudinally at an uniform speed with the help of lead screw which engages split nut in the carriage. The lead screw is driven by a set of gears called change gears in the headstock. The change gears are chosen such that they synchronize the speed of the job and the motion of the tool to produce the thread of desired pitch. The depth of the cut is given by cross slide and the shape of the tool resembles the thread profile.	**8** **(4+4)**

ii) Taper Turning by Swiveling the Compound Rest

Taper turning operation by swiveling the compound rest is schematically shown in the following figure.



Taper turning is the process of producing a conical surface from a cylindrical shaped work piece. A taper is produced when the cutting tool moves at an angle to the lathe axis. In this method, the compound rest supporting the cutting tool is swiveled to the desired angle at which the taper is to be produced. This angle is called half taper angle α calculated as,

$$\alpha = \tan^{-1}\left(\frac{D-d}{2L}\right)$$

where D = Larger Diameter of Taper ; d = Smaller Diameter of Taper and L = Length of Taper

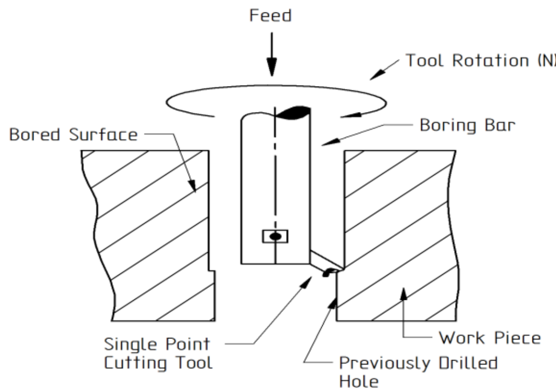
The compound rest has a circular base graduated in degrees. The rotation of the compound rest to the calculated taper angle will cause the tool to be fed at that angle, thereby producing the corresponding taper on the work piece. This method is more suitable for producing steep taper with short lengths.

5 b A hole of 185 mm diameter needs to be made on a big flat work piece. The size of twist drills available ranges from 0.2 mm – 180 mm. The machinist first performs drilling operation with the maximum sized drill bit available. Suggest a suitable operation for the machinist to finish the hole to the required size. Explain the same with a neat sketch. **4**

Ans :

The machinist should perform boring operation in order to achieve the hole of size equal to 185mm. Boring operation is schematically represented in the following figure.

Boring is the operation of enlarging a previously drilled hole by means of an adjustable cutting tool having only one cutting edge. The operation is performed when a drill bit of the required dimension is not available. In such cases, a hole is drilled first to the nearest dimension and then a single point cutting tool is fastened and adjusted to a boring bar to enlarge the size of the existing hole to the required dimension. Additionally, it also corrects the hole location, roundness errors etc. The spindle is rotated at lower speeds during this operation.



6 **A** With a neat sketch, explain the following milling operations. **8**

a)End Milling b)Conventional Slab Milling

Ans

End Milling:

End milling is the operation performed for producing flat surfaces, slots, grooves or finishing the edges of the work piece by means of a tool called end mill or end milling cutter. It is the combination of peripheral and face milling operations. The cutter has teeth both on its periphery and its end. If the direction of helix of the cutter is same as the direction of the rotation of it, the end cutting edges are used only to remove metal. If the direction of helix and the direction of rotation of the cutter are opposite to each other, the peripheral cutting edges are used to remove metal. The surface produced by end milling may be horizontal, vertical or inclined with respect to the top of the machine table.

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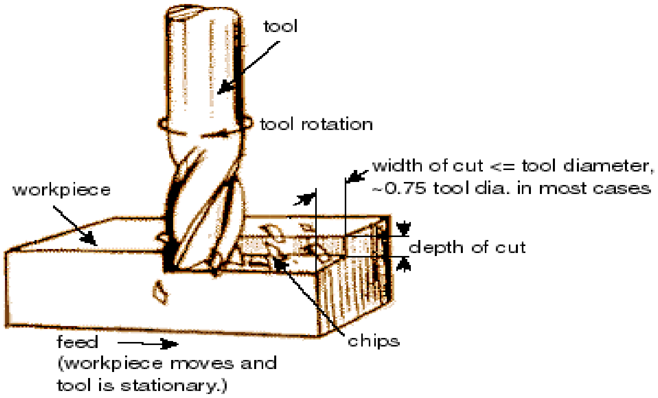
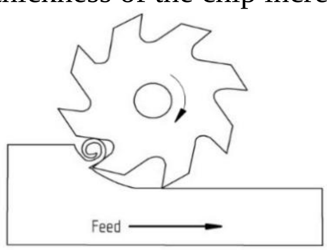
<tr><td></td><td></td><td>
</td><td></td></tr>
<tr><td></td><td></td><td>Conventional Slab Milling
Metal is removed when the cutter moves upwards i.e. the cutter rotates opposite direction of feed of work piece. At the beginning of the cutting process the chip thickness is at minimum as the process of cutting proceeds the thickness of the chip increases.

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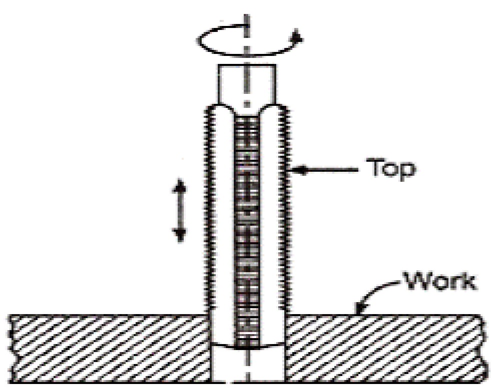
<tr><td>6</td><td>b</td><td>Explain tapping operation with a neat sketch.

Ans :

Tapping operation is schematically shown in the following figure.


Tapping
Tapping is the operation of producing internal threads in a previously drilled</td><td>4</td></tr>
</table>

hole by means of a tool called tap. The tap has threads cut on its periphery and is hardened to improve its properties. Taps are available in standard sizes. Hence, to generate a specific size thread in the work piece, a hole with diameter smaller than the size of the tap is first drilled using a twist drill and then using a standard tap, threads are cut in the same way as drilling. The spindle rotates at low speeds compared to drilling.

PART 4

7 List the three types of automation in the descending order of production quantity that can be produced from them. Explain each type with examples. **12**

Ans :

The three types of automation in the descending order of production quantity is as follows.

1) Fixed Automation
2) Flexible Automation
3) Programmable Automation

Fixed Automation

It is a system in which the sequence of processing or assembly operations is fixed by the equipment configuration. Each operation in the sequence is usually simple involving a plain linear or rotational motion or uncomplicated combination of two such as feeding the rotating spindle. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. Typical features of fixed automation are

1) High initial investment for custom engineered equipment
2) High production rates
3) Relative inflexibility of the equipment to accommodate product variety.

The economic justification for fixed automation is found in products that are produced in large quantities and at high production rates. The high initial cost of the equipment can be spread over a very large number of units, thus making the unit cost attractive compared with alternative methods of production. Examples are machining transfer lines and automated assembly lines.

Flexible Automation

It is an extension of programmable automation. It is capable of producing a variety of parts with virtually no time lost for changeovers from one part style to the next. There is no lost production time while reprogramming the system and altering the physical setup. Accordingly, the system can produce various mixtures and schedules of parts instead of requiring that they be made in batches. What makes flexible automation possible is that the differences between parts processed by the system are not significant, so that the amount of changeover required between styles is minimal.

The features of flexible automation are

1) High investment for custom engineered equipment
2) Continuous production of variable mixtures of products
3) Medium production rates
4) Flexibility to deal with product design variations.

Examples are flexible manufacturing systems for performing machining operations.

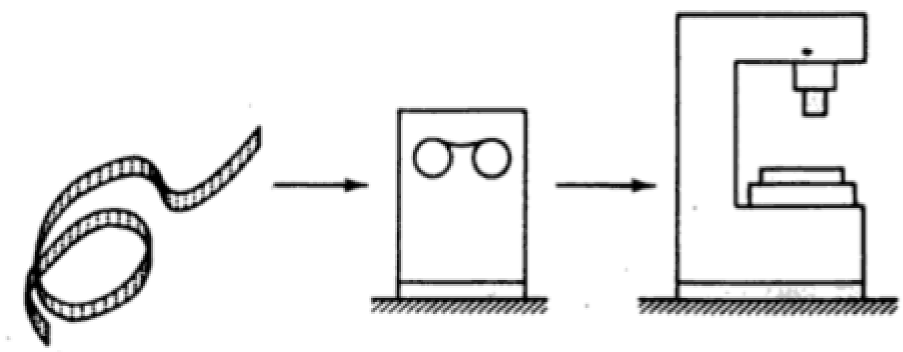
<u>Programmable Automation:</u>

Programmable automation is a form of automation for producing products in batches. The products are made in batch quantities ranging from several dozen to several thousand units at a time. For each new batch, the production equipment must be reprogrammed and changed over to accommodate the new product style. This reprogramming and changeover take time to accomplish, and there is a period of nonproductive time followed by a production run for each new batch. Production rates in programmable automation are generally lower than in fixed automation, because the equipment is designed to facilitate product changeover rather than for product specialization. A numerical-control machine tool is a good example of programmable automation. The program is coded in computer memory for each different product style, and the machine tool is controlled by the computer program. Industrial robots are another example.

8 a Explain three basic components of a NC system. **8**

Ans :

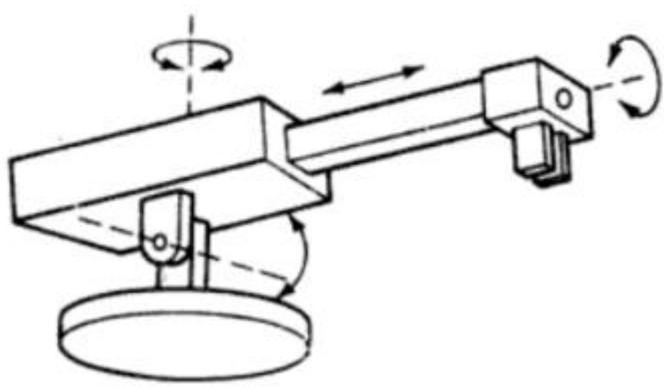
A NC system consists of three basic components. They are 1) a part program of instructions 2) machine control unit and 3) processing equipment.



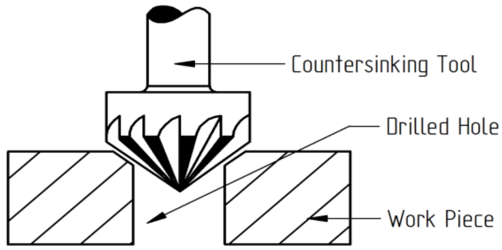
<u>Part Program</u>

It is a set of detailed step by step commands that direct the actions of the processing equipment. In machine tool applications, the individual commands refer to positions of a cutting tool relative to the work table on which the work piece is fixed. Additional instructions are usually included such as spindle speed, feed rate, cutting tool selection and other functions. The program is coded on a suitable medium for

	submission to the MCU. The common medium is 1 – inch wide punched tape using a standard format that could be interpreted by the large MCU. Other forms of media include magnetic tapes, diskettes etc. <u>MCU</u> It consists of the electronics and hardware that read and interpret the program of instructions and convert them into mechanical actions of the machine tool. The typical elements of a conventional NC controller unit include 1) Tape Reader 2) Data Buffer 3) Signal Output channels to machine tool 4) Feedback channels from machine tool 5) Sequence controls to coordinate the overall operation of the foregoing elements. Tape reader is an electromechanical device for winding and reading the punched tape containing the program of instructions. The data contained on the tape are read into the data buffer. The purpose of this device is to store the input instructions in logical blocks of information. A block of information usually represents one complete step in the sequence of processing elements. E.g., One block may be the data required to move the machine table to certain position and drill a hole at that location. The signal output channels are connected to the servomotors and other controls in the machine tool. Through these channels, the instructions are sent to the machine tool from the MCU. To make sure that the instructions have been properly executed by the machine, feedback data are sent back to the MCU via feedback channels. Sequence controls coordinate the activities of the other elements of the MCU. <u>Processing Equipment</u> It is the equipment which performs the actual productive work. It accomplishes the processing steps to transform the starting work piece into a completed part. Its operation is directed by MCU which in turn is driven by instructions contained in the part program.	
8 b	List any two additional features of CNC when compared to NC. Ans : The additional features of CNC when compared to NC are	**4**

		1) Storage of more than one program – With improvements in computer storage technology, new CNC controllers have sufficient capacity to store multiple programs. Fixed cycles and subroutines – The increased memory capacity and the ability to program the control computer provide the opportunity to store frequently used machining cycles as macros that can be called by the part program.	
		PART 5	
9	**a**	List the common body and arm configurations used in commercial industrial robots. Explain any two of them with a neat sketch. Ans : The common body and arm configurations used in commercial industrial robots are 1) Polar Configuration 2) Cylindrical Configuration 3) Cartesian Configuration 4) Jointed Arm Robot Configuration 5) SCARA (Selective Compliance Assembly Robot Arm) <u>Polar Configuration</u> Polar Configuration is also called as spherical configuration because the workspace within which a robot can move its arm is a partial sphere. Its shown in the following figure.  It consists of a sliding arm (L Joint) actuated relative to the body, which can rotate about the vertical axis (T Joint) and a horizontal axis (R joint).	**8**
	b	Explain material handling applications of industrial robots. Ans :	**4**

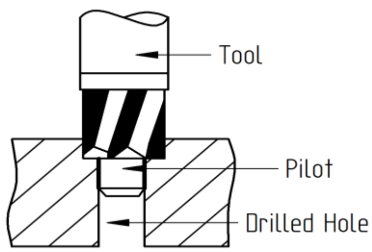
		Material handling applications of industrial robots can be categorized into two types 1) Material Transfer Applications and 2) Machine Loading and/or Unloading. <u>Material Transfer</u> Here the primary purpose of the robot is to pick up parts at one location and place them at new location. This pick and place operation is relatively simple which requires modest and a low technology robot. Example: Transferring parts from one conveyor to another. A more complex example of material transfer is palletizing where the robot retrieves parts from one location and deposits them onto a pallet or other container at multiple positions on the pallet. Other applications similar to palletizing are depalletizing, stacking, insertion etc. <u>Machine Loading and Unloading</u> Here the robot transfers parts into and/or from a production machine. The three possible cases are 1) Machine loading in which the robot loads parts into production machine but the parts are unloaded from the machine by some means. 2) Machine unloading in which the raw materials are fed into the machine without using the robot and the robot unloads the finished parts. 3) Machine loading and unloading in which the robot does both loading of the raw work part and unloading the finished part. Industrial robot applications of machine loading and/or unloading include Die Casting, Plastic Molding etc.	
10	**a**	Explain the objectives of automation. Ans: Increase Productivity Save labor with high precision and repeatability Higher flexibility Reduce cost	**4**
	b	Explain the machining operations which are useful in accommodating heads of fasteners like socket headed cap screw and conical headed screw in assemblies, with neat sketches. **Counter sinking:**	**8**



Countersinking

It is the operation of producing a conical shaped hole in a previously drilled cylindrical hole. The tool used for this operation is called as a counter sink. Counter sinking is also used for locating a center on the work piece and for deburring operation (Deburring- work pieces that are machined by certain processes consists of ragged edges or protrusions called burrs. The process by which burrs are removed is known as deburring). The tool used for the operation is called counter sink and are made in angles of 60° for centering, 82° for counter sinking flat headed screws, 90° for deburring, and 120° for chamfering operations.

Counter boring



Counterboring

It is an operation to enlarge one end of the predrilled hole concentrically to the required depth, using a counter bore tool, to form a square shoulder. A counter bore tool has two or more teeth, and straight or helical flutes that provide the passage for escape of chips and also inlet for passing coolant. The pilot of the tool helps to maintain concentricity with the original hole. Used to drive in the socket head screws, bolts, pins etc. It is replaceable depending on the required size.