

Sixth Semester B.E. Degree Examination, Aug./Sept.2020
Computer Integrated Manufacturing

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define Automation. List and explain different types of automation. (08 Marks)

b. The average part produced in a certain batch manufacturing plant must be processed through an average of 6 machines. There are 20 new batches parts launched each week. Data for the average problem are as follows:
Average operation time = 6 min
Average setup time = 5 hrs
Average non-operation time = 10 hrs
Average batch size = 25 parts.
There are 18 machines in the plant. The plant operates an average of 70 hours/week. Scrap rate is negligible. Determine
(i) Manufacturing Lead Time (ii) Production rate (iii) Plant capacity (iv) Plant Utilization (08 Marks)

OR

2 a. Explain the following :
(i) Upper bound and lower bound approach.
(ii) Starving and blocking of stations. (08 Marks)

b. What are the two reasons for partial automations analyse the performance of partial automation along with suitable assumptions. (08 Marks)

Module-2

3 a. With a block diagram, explain the phases of design and manufacturing process. (08 Marks)

b. Explain the following :
(i) Translation (ii) Rotation (iii) Scaling (iv) Concatenation. (08 Marks)

OR

4 a. Define CAPP. With block diagram, explain generative type of CAPP system. (08 Marks)

b. Explain the structure of MRP system. (08 Marks)

Module-3

5 a. Explain the components of flexible manufacturing system. (08 Marks)

b. Discuss the benefits and limitations of Flexible Manufacturing System. (08 Marks)

OR

6 a. Define the following terms : (i) Minimum rational work element
(ii) Total work content
(iii) Balance delay. (06 Marks)

b. In a plant, a product is to be assembled as per the following data:

Element	1	2	3	4	5	6	7	8	9	10
Time in mins (T_{ck})	5	3	8	2	1	6	4	5	3	6
Immediate precedence	-	1	1	2	2	3	4, 5	3, 5	7, 8	6, 9

(i) Construct the precedence diagram.
(ii) If the cycle time is 10 min, find the number of stations required.
(iii) Compute the balance delay, smoothness index and line balance efficiency using largest candidate rule. (10 Marks)

Module-4

7 a. What are the elements of CNC system? List the salient features. (08 Marks)
b. Explain the fundamental steps involved in CNC part programming of milling and drilling operations. (08 Marks)

OR

8 a. Sketch and explain the robot configurations. (12 Marks)
b. Define : (i) Resolution (ii) Repeatability, as applied to robots. (04 Marks)

Module-5

9 a. Explain the advantages and applications of additive manufacturing. (08 Marks)
b. Explain with a sketch, binder jetting process. (08 Marks)

OR

10 a. Discuss the Internet of Things (IoT) applications in manufacturing. (08 Marks)
b. Explain the following :
(i) Big Data (ii) Cloud computing. (08 Marks)

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Computer Integrated Manufacturing

Scheme & Solution

Q1)

a) Automation can be defined as the technology that incorporates and integrates all the traditional engineering fields of electrical/mechanical/electronic with the modern computer technology to operate and control the manufacturing process.

Types of Automation

1. Fixed or rigid automation.
2. Programmable automation.
3. Flexible automation.

1) **Fixed or rigid automation**

In this type of automation the system is set for a unique type of operation, production system & cannot be changed.

The operations/sequence of processing/assembly is fixed by the automation configuration.

Ex:- Mechanised assembly lines, machining transfer lines.

Features of fixed automation

1) The sequence of operations are clearly defined and simple.
2) Applicable to limited number of operations.
3) Production rates are high.
4) It is not suitable for accommodating changes in the product range.
5) The overall investment is lower compared to other automation system.

2) Programmable Automation

In this automation System, the production equipment / process is designed such that the Sequence of Operations can be modified to suit different product configurations.

Ex:- NC Machine tools, Industrial robots.

Features of Programmable automation

1) The System is most suitable for batch production.
2) Flexibility exists to accommodate changes in the product | Process | Sequence of operations.
3) The overall investment is high compared to the fixed automation System.
4) Change in Sequence of operations requires a change in the program code, change over in tooling, jigs, fixture, machine setting etc. to suit required o/p.
5) The investment is particularly huge in general - Purpose equipment.

3) Flexible Automation

This is an extension of Programmable automation but more benefecial than it. This differs from the programmable automation in that there is no change over time involved from batch to batch.

Features of Flexible automation

1) This is the most ~~common~~ Complex System for all type
2) very high flexibility with respect to product, variety, batches and production schedule.
3) No changeover time involved, Compared to programm-able System.
4) Low production costs, Compared to programmable System.

Q1) b)

Given:-

$Q = 25$

$n_o = 6$

$T_c = 6\,min = 0.1\,h$

$T_{su} = 5\,h$

$T_{no} = 10\,h$

$A = 0.95$

$S_w H_{sh} = 70\,h/week$

$MLT = ?$

$R_p = ?$

$PC = ?$

a) Manufacturing lead time (MLT)

$$MLT = n_o(T_{su} + QT_c + T_{no})$$

$$= 6(5 + 25 \times 0.1 + 10)$$

$$\boxed{MLT = 105\,h}$$

b) Production rate (R_p)

$$T_b = T_{su} + QT_c$$

$$T_b = 5 + 25 \times 0.1$$

$T_b = 7.5\,h$ per batch

$$T_p = \frac{T_b}{Q} = \frac{7.5}{25} = 0.3\,h/pc$$

$$R_p = \frac{1}{T_p} = \frac{1}{0.3} = 3.33\,pc/hr$$

c) Production Capacity (PC)

$$PC = \frac{(n \cdot S_w \cdot H_{sh} \cdot R_p)}{n_o}$$

$$= \frac{(18 \times 70 \times 3.33)}{6}$$

$$\boxed{PC = 700\,pc/week}$$

d) Plant Utilisation (U)

$$U = \frac{output}{Capacity} = \frac{500}{700} = 7.43\,\%$$

Q2)

i) a) Upper Bound Approach

The upper bound analysis, assumes that the wor part is not removed from the Station when a breakdown occurs in the flow line. This approach is used to estimate the upper limit of the frequenc of line Stops per cycle.

The frequency of line Stops per cycle is

$$F = \sum_{i=1}^{n} p_i$$

If all the probabilities are equal $(p_1 = p_2 = p_3 = \cdots = p)$

$$F = np.$$

b) Lower Bound Approach

In the lower bound analysis approach, it is assumed the the work part is taken out of the Station, when the Station breakdown occurs. This approach is used to estimate the lower limit of the expected number of line stops per cycle

$$F = 1 - (1-p)^n$$

where, p = probability of part jam at workstations

n = number of work stations.

ii)

a) Starving Stations

Starving refers to the non-performance / non processing in a work Station due to non-availability of a work part. Starving occurs in down stream work Stations after the breakdown Station.

b) Blocking Station

Blocking refers to a Situation when a Workstation is unable to perform it's processing action, as it is not able to transfer the just completed Part to the immediate next down stream station. Thus, when a workstation Suffers a breakdown it is not in a position to receive parts from the upstream stations, thus resulting in blocking in the upstream stations.

Q2.

b) Partial Automation

All industries Cannot be automated for Complete operation, for reasons of investment or Complication involved in Some part of the mfg processes.
In Such Cases partial automation process Can be adopted, which is a Combination of both manual & automated Systems.

Let us Consider a Case of partial automation without a Storage buffer for analysis.
In a partial automated assembly line, the ideal cycle time is decided by the Slowest Station on the line, which obviously would be one of the manual Stations. Let us assume that this cycle time is Constant. Let us also assume that breakdowns occurs only in the automated Stations & let.

n_a = Number of automated stations

T_d = Averaged downtime per occurrence

n_m = number of manual Stations

q_i = The defect rate

m_i = Probability that the defect will result in a jam

The average production time is given by

$$T_p = T_c + \sum P_i \cdot T_d$$

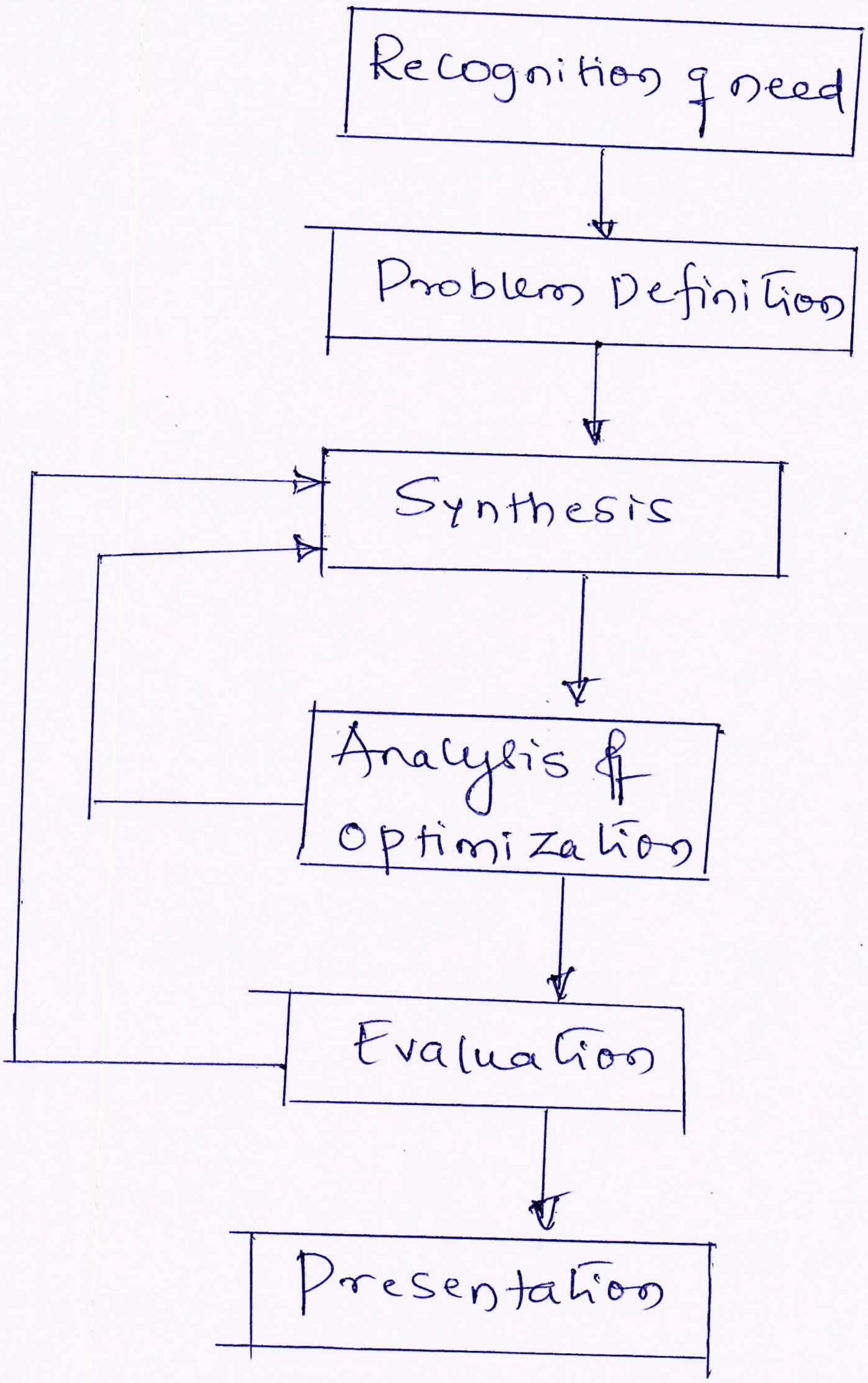
where, $P_i = m_i \cdot q_i$

For a special case, when $P_i = P$, $m_i = m$ & $q_i = q$, then the production time is

$$T_p = T_c + n_a \cdot P \cdot T_d$$

where, $P = mq$

Q3) a) Design and manufacturing process



Recognition of need involves the realization by someone that a problem exists that a thoughtful design could solve. This recognition might mean identifying some deficiency in a current m/c design by an engineer or perceiving some new product opportunity by a salesperson.

Problem definition - Involves a thorough specification of the item to be designed. This specification includes the physical characteristics, function, cost, quality & operating performance

Synthesis & Analysis

Synthesis & Analysis are closely related & highly interactive. Consider the development of certain product design: Each of the subsystems of the product must be conceptualized by the designer, analyzed, improved through this analysis procedure, redesigned, analyzed again and so on.

Evaluation:- It is concerned with measuring the design against the specifications established in the problem definition phase. this evaluation often requires the fabrication & testing of a prototype model to assess operating performance quality, reliability, & other criteria.

Presentation:- Presentation is concerned with documentation the design by means of drawings material specifications, assembly lists, & so on.

Q3)

i) Translation:- This moves a geometric entity in space in such a way that the new entity is parallel at all points to the old entity.

ii) Rotation:- The final position & orientation of a geometric entity is decided by the angle of rotation (θ) & the base point about which the rotation is to be done. for a positive angle the rotation is ccw.

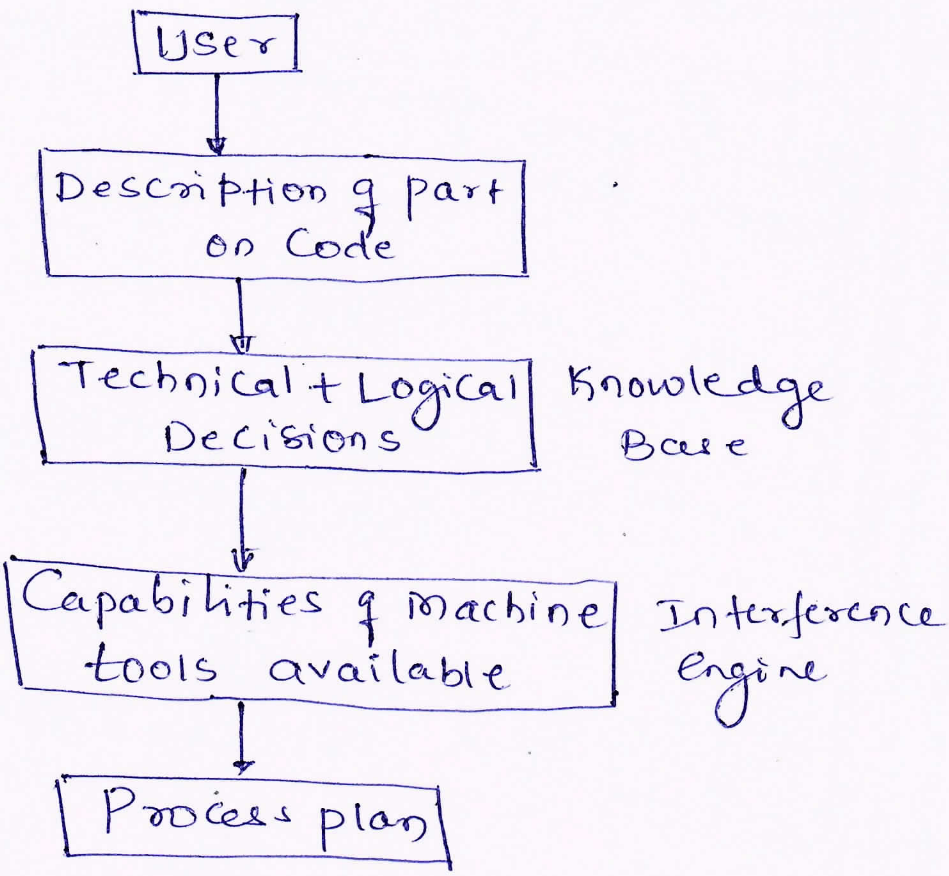
iii) Scaling:- Scaling is the transformation applied to enlarge or reduce the size of an entity. the size is altered as per the scaling factor applied.

iv) Concatenation:- Many a times it becomes necessary to combine the aforementioned individual transformations in order to achieve the required results.

Q4)
a) **Computer Aided Process planning (CAPP)**

Computer Aided Process planning is a means of implementing process planning function by compu[ter]. The CAPP represents the link between design & manufacturing. There is a much interest by a manufacturing firm in automating the task of Process planning.

Generative Type CAPP System



Generative Type CAPP involves the use of the Computer to create an individual process plan from Scratch automatically and without human assistance, Instead of retrieving & editing an existing plan Contained in a Computer database, a generative System Creates the plan ~~contained in a Computer database~~ process plan based on logical procedures Similar to the human process planer. In a fully generative CAPP System, the process Sequence is planned without human assistance & without set of predefined std plans.

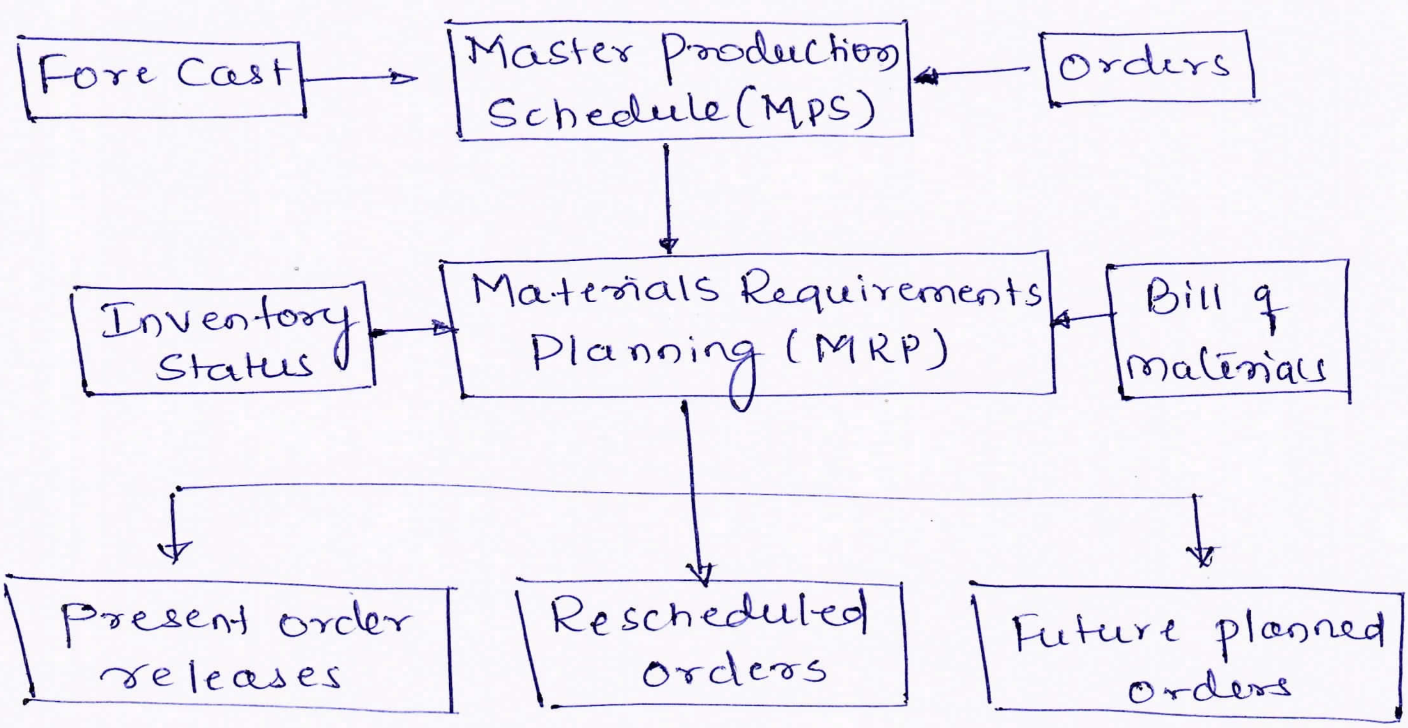
1) Creation of Knowledge base

In this the Complete technical Knowledge of mfg & the logic developed by expert human planners is coded & loaded in to a Computer.

2) Inferference engine

It Should Solve the process planning problem for the given part & Generate the o/p. This problem Solving Procedure is termed as the inference engine.

Q4) b) Structure of MRP System



Forecasts plus orders, the basic input for planning, are planned & Combined in the Master Production Schedule (MPS). Then the material requirements plans is evolved using the MPS, Bill-of-Materials (BOM) and the inventory status data. MRP decides what components, in what quantity are required, and when they are to be ordered. (both from an external suppliers or in-house)

Q5)

a) <u>Components of Flexible Manufacturing System</u>

There are several basic components of a flexible manufacturing system 1) Workstations.

2) Material handling & Storage System

3) Computer Control System

4) People are required to manage & operate the system.

1) <u>WorkStations</u>

Following are the types of workstations typically found in a FMS.

a) <u>Load/Unload Stations</u>

The load/unload station is the physical interface between the FMS & the rest of the factory. It is where raw workparts enter the system & finished parts exit the system.

b) <u>Machining Stations</u>

- other processing stations
  - The processing workstations consist of presswoorking operations, such as punching shearing, & certain bending & forming processes.
- Assembly
  - Some FMS's are designed to perform assemby operations.

Ex:- Programmable Component placement

2) Material handling & Storage System

Functions of handling system.

- Random, independent movement of work-parts between stations.
- Handle a variety of workpart configurations
- Temporary storage
- Convenient acess for loading & unloading work-parts.
- Compatible with computer control.

3) Computer Control System

Typical FMS computer system consists of a central computer & microcomputers controlling the individual machines & other components.

Functions:-

1) Workstation control
2) Distribution of control instructions to workstations.
3) Production control
4) Traffic control
5) Shuttle control
6) Workpiece monitoring
7) Tool control
8) Performance monitoring & reporting
9) Dignostics.

4) Human Resources:

In FMS humans are required to manage the operations of the FMS. Functions typically performed by FMS includes.

1) Loading raw workparts in to the system
2) Unloading finished workparts.
3) Changing and setting tools
4) Equipment maintenance & repair
5) Overall management of the system.

Q5) b) Benefits of Flexible Manufacturing System

- Increased machine utilization:-
  Flexible mfg systems achieve a higher avg utilization than machines in a conventional batch production m/c shop.
  Reasons for this include :- (1) 24 hour per day operat
  (2) automatic tool changing of machine tools.
  (3) Automatic pallet changing at workstations.
  (4) Queues of parts at Stations
- Fewer machines required.
- Greater responsiveness to change.
- Reduced inventory requirements.
- Lower manufacturing lead times.
- Reduced direct labor requirements & higher labour productivity
- Opportunity for unattended production.

Limitations of FMS

- FMS is a complex system.
- Requires highly skilled technicians.
- Needs high level of planning
- Demands high initial investment.

Q6)

a) Define

1) Minimum rational work element.

In the design and analysis of a line balancing prob the first step is to divide the total assembly work in to it's component tasks. Each task is referred to as the minimum rational work elemen These are the smallest work elements that canno be divided further and are performed either on a single or multiple workstations.

Ex:- Drilling a hole, fastening one part to another

2) Total Work Content

This time is the sum of all the work element times and represented by Twc.

$$T_{wc} = \sum_{i=1}^{n} T_{si}$$

where T_s = Station time.

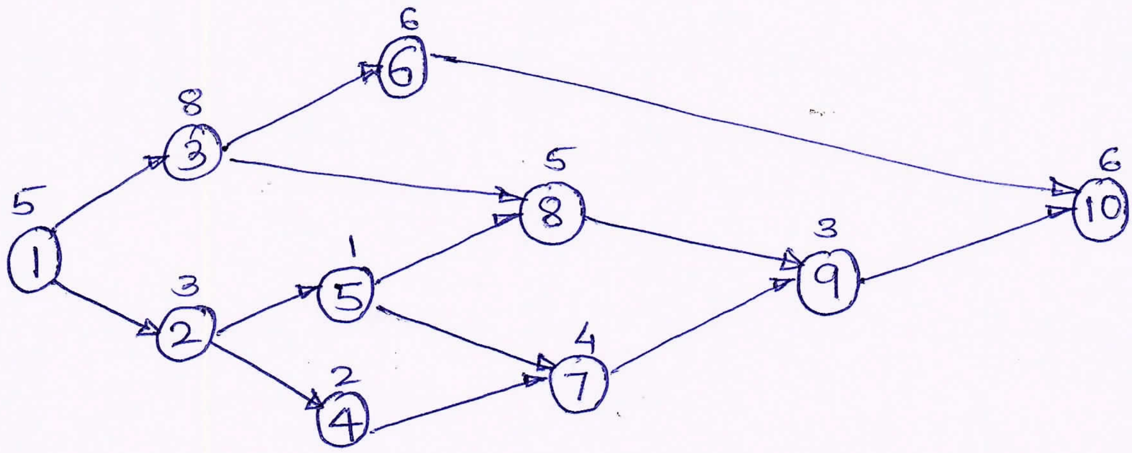
3) Balance delay

This is also referred to as the balancing loss. It is a measure of the inefficiency of the assembly line, that occurs from idle time, may be due to technically incorrect assignment of work elements among different work stations.

Q6 b)

Element	1	2	3	4	5	6	7	8	9	10
Time in min	5	3	8	2	1	6	4	5	3	6
Immediate Precedence	–	1	1	2	2	3	4,5	3,5	7,8	6,9

i) Construct the precedence diagram



Arrange elements in descending order of element time value.

Work element NO	Duration (Tek) min	Preceded by
3	8	1
6	6	3
10	6	6,9
1	5	–
8	5	3,5
7	4	4,5
2	3	1
9	3	7,8
4	2	2
5	1	2

Assign the work element time to Station

Station	Element NO	Tek (min)	Station time	Idle time, min
1	1	5	10 min	0
	2	3		
	4	2		
2	3	8	9 min	1 min
	5	1		
3	6	6	10 min	0
	7	4		
4	8	5	8 min	2 min
	9	3		
5	10	6	6 min	4 min

Number of Stations Required $= 5 = w$

i) Balance delay $= D_b = \dfrac{wT_s - T_{wc}}{w \cdot T_s}$

$$= \frac{5 \times 10 - 43}{5 \times 10}$$

$$= 0.14 = 14\%$$

ii) Balance efficiency $= E_b = \dfrac{T_{wc}}{w \cdot T_s}$

$$= \frac{43}{5 \times 10} = 0.86 = 86\%$$

iii) Smoothness Index SI

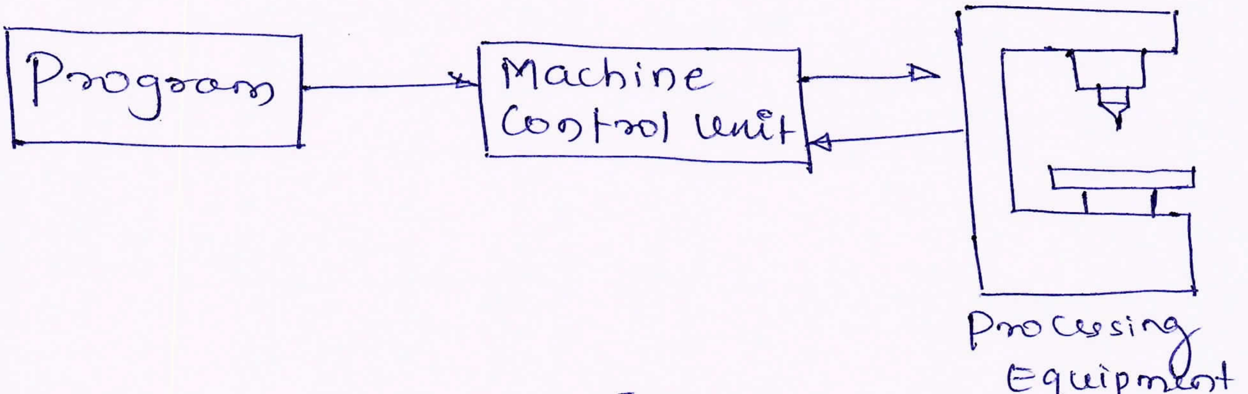
$$SI = \sqrt{\sum_{i=1}^{w} (T_s - T_{si})^2} = \sqrt{0^2 + 1^2 + 0^2 + 2^2 + 4^2}$$

$$SI = \sqrt{21} = 4.58 \text{ min}$$

Q7 **Elements of CNC System.**

a) CNC System Consists of basic three Components

1) Program of instructions
2) Machine Control unit
3) Processing Equipment.



The program of instructions is a detailed
Step by Step Commands that direct the action of
the Processing Equipment. program of instructions
is called a part Program. In this the workable
is present. Additional instructions like Spindle
Speed, feed rate, Cutting tool Selection are also
present. Earlier, the common medium is 1 inch
wide punched tape. Now, the punched tape has
been replaced by newer Storage technologies.

In modern NC technology, the machine Control
unit Consists of a microcomputer and related
Control hardware that stores the program of
instructions & executing it by converting each
Command into mechanical actions of the m/c tool.
The hardware of MCU also includes one or
more reading devices for entering part program
in to memory.

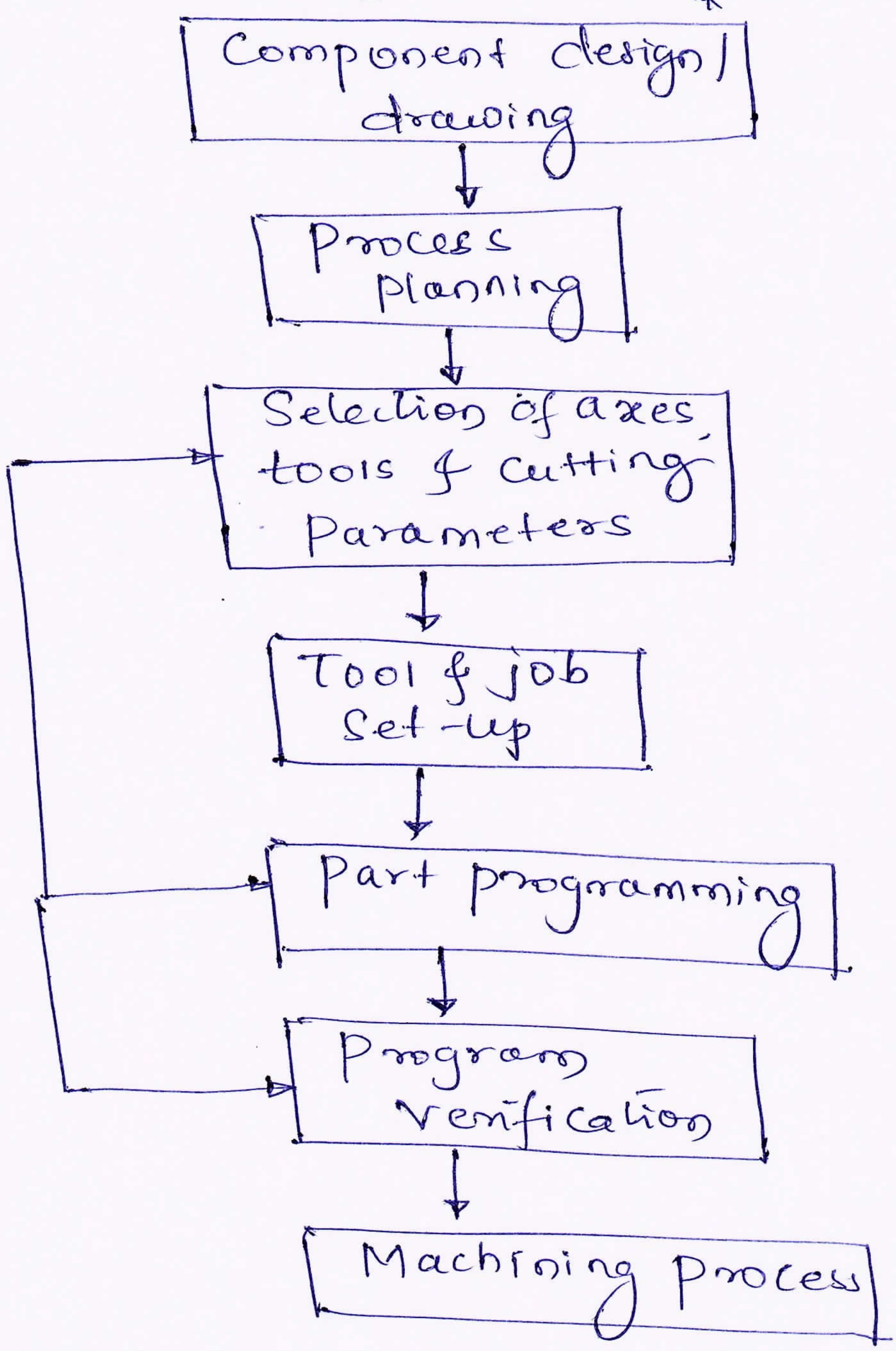
The third Component of CNC System in the
Processing equipment that performs useful work.
It accomplishes the processing Steps to transform
the Starting work Piece to to a Completed Part.

Features of CNC System

- Higher flexibility
- Increased productivity
- Consistent quality
- Reduced Scrap rate
- Reliable Operation
- Reduced manpower
- Higher accuracy.
- Automated material handling
- Reduced non-product time

Q7)

b) Steps Involved in CNC part programming



1) Process planning

Any design transformed into engg drawing cannot be straight away taken to shop production. The process involved should be studied & planned in a proper fashion. This is called process planning.

2) Selection of axes

It is essential to select necessary axes for the programming of machining. Most NC machines come with a specified datum | reference position | axis. The other axes can be selected based on the datum position.

3) Selection of tools

The types of tools required depend mainly of the component geometry, contours, size of the machining operations to be performed. This selection also depends on the tool availability, machining economics, & part complexity.

4) Selection of cutting parameters

The cutting parameters like cutting speed, feed, depth of cut, change of tool etc., need to be decided & included in the part program.

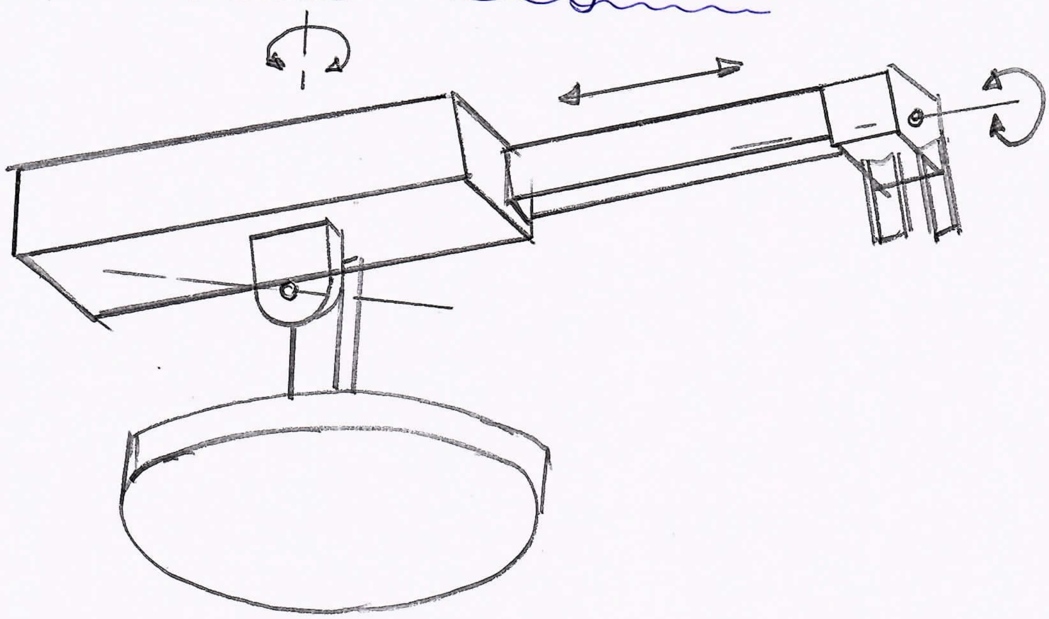
5) Job and Tool Set-up

Most NC machines, though automatic, require initial job setting & tool setting for new operations. Once the setting is complete, the same can be continued until the program is changed.

Q8) a)

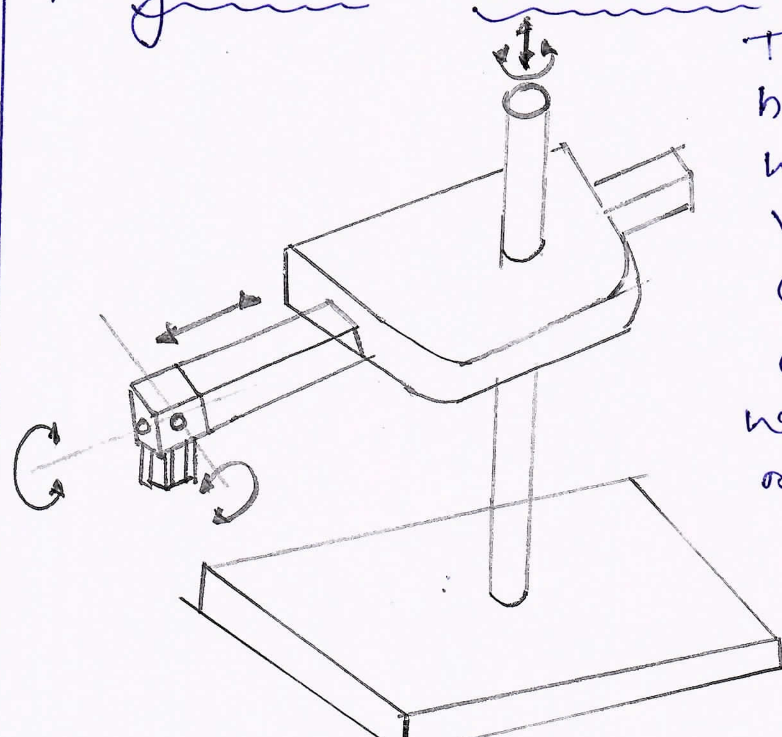
Robot Configurations

1) Polar Coordinate Configuration



This configuration is also called by the name Spherical Coordinate Configuration since the workplace within which it moves its arm is a partial sphere. This robot has a rotary base, & a pivot that can be used to raise & lower its telescoping arm. The work volume is a partial sphere, that means it can function within a volume of partial sphere

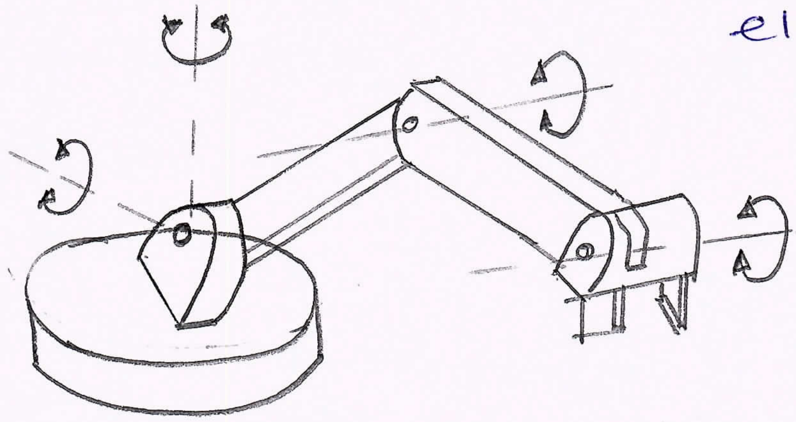
2) Cylindrical Coordinate System



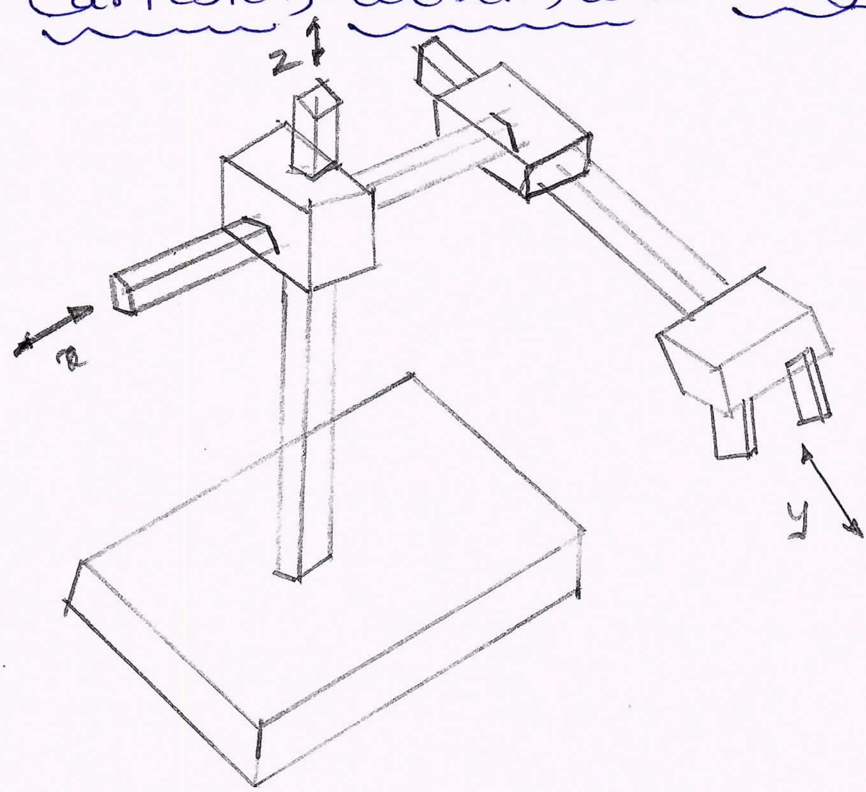
This robot configuration has a vertical column which swivels about a vertical axis. The arm consists of several orthogonal slides, which help the arm to move up or down, & in or out with reference to its body.

3) Jointed arm Configuration

This Configuration is Similar to human arm. The arm consists of many Straight members Connected by joints, hence the name jointed arm Configuration. The joints are analogous to the human shoulder, elbow, & wrist.



4) Cartesian Coordinate configuration



This Configuration Consists of three orthogonal Slides. The three Slides move in x, y & Z directions, hence the name Cartesian Coordinate System. Maximum x, y, Z positions of the arm gives the highest work volume of the robot.

Q8)

b) i) Resolution

It refers to the Smallest increment of motion at the wrist end that Can be Controlled by the robot. This depends on the robot Control resolution which in turn depends on it's position Control & feed back measurement Systems.

ii) Repeatability

It is a ability to position its end effector at a point in its work volume that had been previously taught to it. Repeatability is different from accuracy.

Q9)

a) Advantages & Applications of Additive mfg System

Advantages

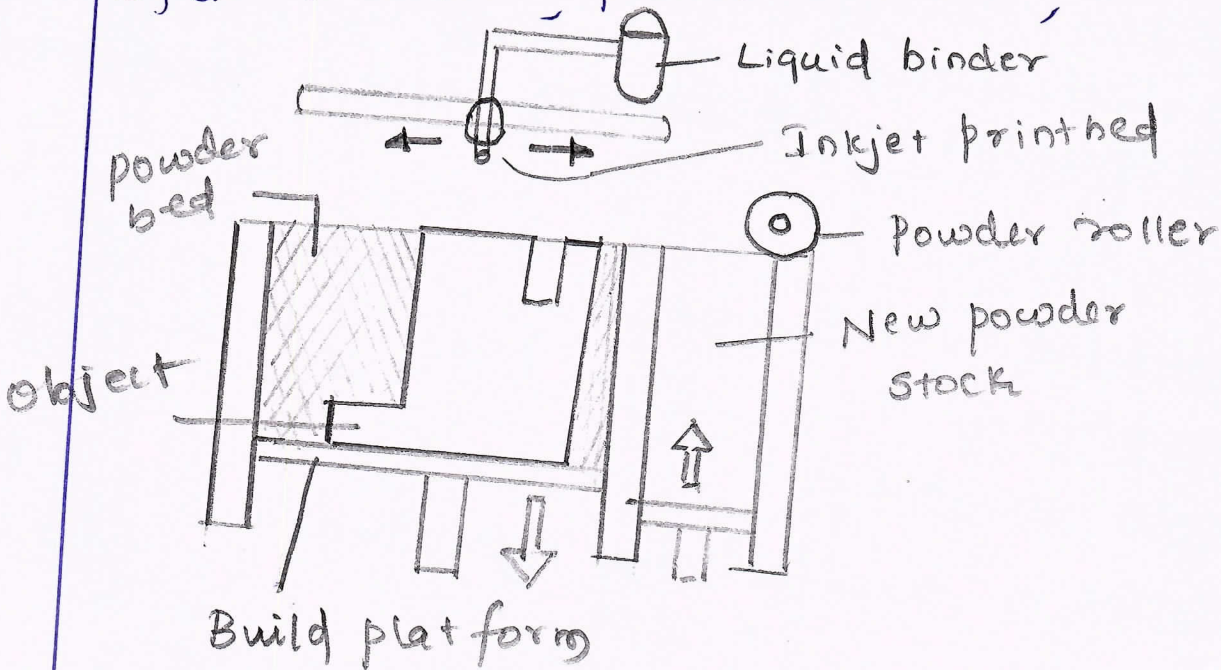
1) Variety is free:- Changing a part is Simple & Can be made easily in the original CAD file & the new print Can be taken easily.

2) Complexity is free:- printing of Complex part Costs less than Simple cubes of the Same Size. The less Solid or more Complex object. It Can be fastly & Cheaply made through additive mfg.

3) No need for assembly:- Hinges & bicycle chains are Some of the moving parts which Can be printed in metal directly into the product and reduce the part numbers.

Q4/
b) Binder jetting Process

Binder jetting process uses two materials powder based material & a binder.
The powder materials are either ceramic ba... or metal. There are various types of binder materials, each suited for a specific applica... (furan binder, phenolic binder, silicate binder)



Step by Step procedure

1) Powder material is spread over the build platform using roller.
2) The print head deposits the binder adhesive on top of the powder where required.
3) The build platform is lowered by the model's layer thickness.
4) Another layer of powder is spread over the previous layer, the object is formed where the powder is bound to the liquid
5) Unbound powder remains in position surrounding the object.
6) The process is repeated until the entire object has been made.

4) Little - Skill manufacturing

Professional take care of the complicated parts with specific parameters of high-tech applicatio
Children in the elementary school have created their on figures by use of 3D printing processe

5) Low Energy Consumption

AM saves energy by eliminating production step using substantially less material, enabling reuse of by-products & producing lighter products.

6) Less waste

7) Reduced time to market

8) Innovation

9) Light weighting

10) Agility to manufacturing operations.

Applications

*) Automotive applications

*) Aerospace Application

*) Biomedical

*) Consumer goods

*) Space applications

*) Health Care applications

*) Artistic Industry.

*) Architectural Industry.

Advantages

1) Parts can be made with a range of different colours.
2) Uses a range of materials: metal, polymers & ceramics.
3) The process is generally faster than others.
4) The two material method allows for a large number of different binder - powder combinatio[ns] & various mechanical properties.

Disadvantages

1) Not always suitable for structural parts, due to the use of binder material
2) Additional post processing can add significant time to the overall process.

Q10)

a) **Internet of Things**

Internet of things refers to a system of connected physical objects via the internet. The 'thing' in IoT can refer to a person or any device which is assigned through an IP address. A thing collects & transfers data over the internet without any manual intervention with the help of embedded technology. It helps them to interact with the external environment or internal states to take the decisions.

IOT applications in Manufacturing

1) Digital/Connected factory
2) Facility management
3) Production flow monitoring
4) Inventory Management
5) Plant Saftey & Security
6) Quality Control
7) Packaging Optimizat[ion]
8) Logistics & Supply ch[ain]

Q 10)
b)

Big Data:

Big data means a large set of structured, unstructured or semi-structured data & analyzing those data to get the insights of the business trend.

Cloud Computing

Cloud computing gives the centralized platform to access the data from anywhere in the world with the shared infrastructure. Thus, you can save a lot of money. Cloud computing offers services to users on a pay-as-you-go model.

[Prof. Santosh. Savaneer]
Staff. 25/03/2022

HOD

Dean, Academics.