Max. Marks: 60   **Duration:** 3 hours

Instructions
1. Answer all questions in sequence.
2. Start the new answer from next page.
3. Draw the diagrams neatly as and where required.
4. Answer Part –A and Part –B on separate answer sheets.
5. Time duration for Part –A is 2 hours.
6. Time duration for Part-B is one hour. You are allowed to use open notes for Part-B.

<div align="center">

Part-A (Closed book/closed notes)   **(MM: 45)**
</div>

1. A flexible manufacturing system is being planned. It has a ladder layout as pictured in Figure below and uses a rail guided vehicle system to move parts between stations in the layout. All work parts are loaded into the system at station 1, moved to one of three processing stations (2, 3, or 4), and then brought back to station 1 for unloading. Once loaded onto its RGV, each work part stays onboard the vehicle throughout its time in the FMS. Load and unload times at station 1 are each 1.0 min. Processing times at other stations are: 5.0 min at station 2, 7.0 min at station 3, and 9.0 min at station 4. Hourly production of parts through the system is: 7 parts through station 2, 6 parts through station 3, and 5 parts through station 4.   [5]
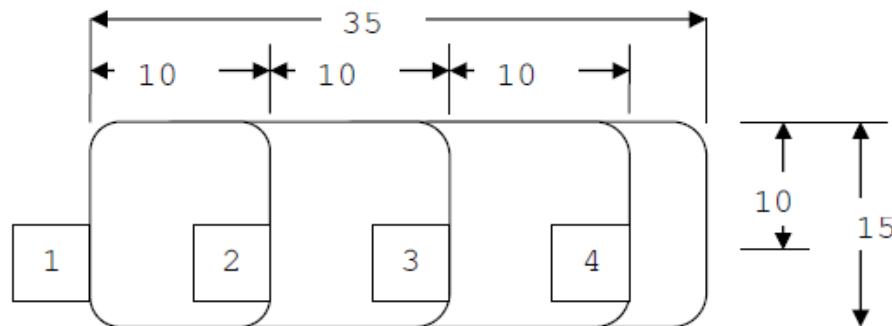

a. Develop the from-to Chart for trips and distances
b. Develop the network diagram for this data
c. Determine the number of rail guided vehicles that are needed to meet the requirements of the flexible manufacturing system, if vehicle speed = 60 m/min and the anticipated traffic factor = 0.85. Assume reliability = 100%.

2. A toy assembly should be done as per the information given in the following table and the cycle time is 1 min. [5]

Element	1	2	3	4	5	6	7	8	9	10
Time (min.)	0.5	0.3	0.8	0.2	0.1	0.6	0.4	0.5	0.3	0.6
Immediate Predecessor	-	1	1	2	2	3	4,5	3,5	7,8	6,9

1) Construct precedence diagram.
2) Calculate number of workstations and balance delay using largest candidate rule.

3. Write a G-code to create a square 2-3-4-5 using milling tool as per the following diagram.   Follow   the   tool   movement   as   shown. [4]
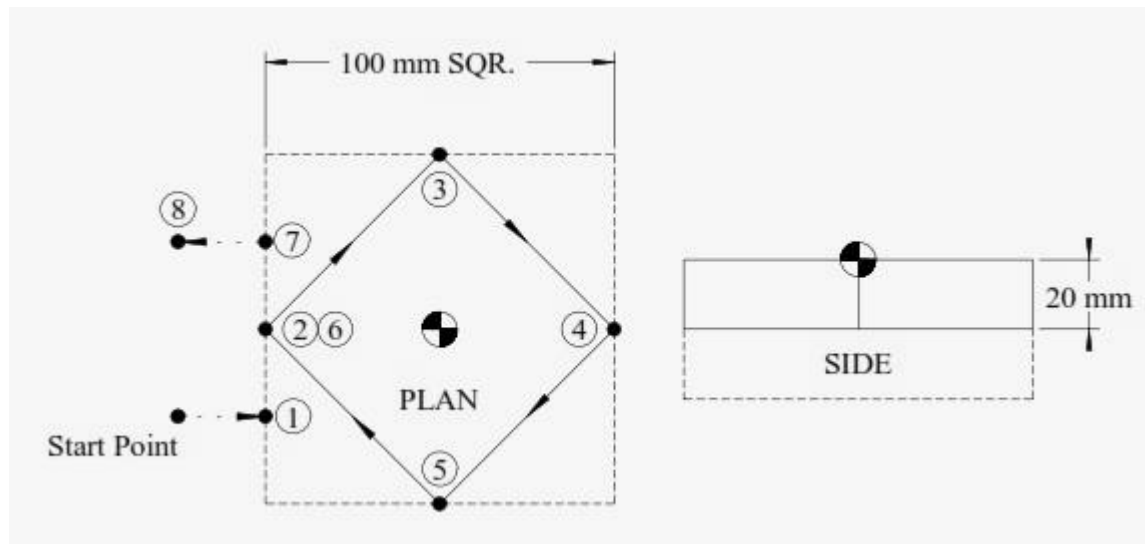
4. Interpret the tool movement in the following two cases on X-Y co-ordinate system: [4]

Case 1: G92 X200 Y40 Z0
    G90 G03 X140 Y100 R60 F300
    G02 X120 Y60 R50
Case 2: G92 X200 Y40 Z0
    G90 G03 X140 Y100 I-60 F300
    G02 X120 Y60 I-50

5. An automated guided vehicle system is being proposed to deliver parts between 40 workstations in a factory. Loads must be moved from each station about once every hour; thus, the delivery rate = 40 loads per hour. Average travel distance loaded is estimated to be 250 ft and travel distance empty is estimated to be 300 ft. Vehicles move at a speed = 200 ft/min. Total handling time per delivery = 1.5 min (load = 0.75 min and unload = 0.75 min). Traffic factor F_t becomes increasingly significant as the number of vehicles n_c increases; this can be modeled as:
$$F_t = 1.0 - 0.05(n_c-1) \text{ for } n_c = \text{Integer} > 0$$

Determine the minimum number of vehicles needed in the factory to meet the flow rate requirement. Assume that availability = 1.0 and worker efficiency = 1.0.   [4]

6. a) Explain the three phases of a typical automation migration strategy.   [3]
   b) Products can be different, but extent of differences may be small or great. Based on this statement classify product variety.   [2]
   c) Differentiate between mechanization and automation.   [2]
   d) Logic control is used for execution of time driven changes and sequence control is used for execution of event-driven changes. Comment on the statement.   [2]
   e) Explain with suitable diagram SCADA.   [3]
   f) In double acting cylinder, the piston speed is slightly lower and the applied force is slightly more when the piston is retracting than when it is in forward stroke. Comment on the statement.   [2]
   g) What is the function of transponder in an RFID?   [2]

7. Calculate the cycle and production rate for a single-machine robotic cell for an 8-hr shift if the system availability is 85%. Also determine the percent utilization of machine and robot. On average, the machine takes 35 sec. to process a part. The other robot operation times are as follows: [3]

Robot picks a shaft from the conveyor	4.0 sec
Robot moves the shaft to the lathe	1.5 sec
Robot loads the shaft onto the lathe	1.0 sec
Robot unloads the shaft from the lathe	0.5 sec
Robot moves the conveyor	1.5 sec
Robot puts the shaft on the outgoing conveyor	0.5 sec
Robot moves from the output conveyor to the input conveyor	5.0 sec

8. A digital to analog convertor uses a reference voltage of 100V and has a 6-bit precision. In three consecutive sampling instants, 0.5 sec apart, the data contained in the binary register are as follows:

Instant	Binary data
1	101000
2	101010
3	101101

Determine the equation of voltage signal between instants 2 and 3 using zero order hold, if possible. If not, then which data holding technique can be useful for determining the same.   [4]

9. An FMS station consists of four stations. Station 1 is load/unload station with one server. Station 2 consists of three identical CNC milling machines. Station 2 consists of two CNC drill presses. Station four is an inspection station with one server. The stations are connected by a part handling system with two work carriers having mean transport time of 2.0 min. four parts are being produced as per the given table with the operation frequency of 1.0 for all stations except the inspection station. The operation frequency in inspection for part A is 0.5, for part B is 0.2, for part C is 0.5, while for part D is 0.333. Determine the
(a) Maximum production rate,
(b) production rate of each part,
(c) Utilization of each station,
(d) Average utilization of the regular stations.   [1+2+2.5+2.5=8]

Part j	Part Mix p_j	Operation k	Description	Station i	Process Time t_{ijk} (min)
A	0.1	1	Load	1	4
		2	Mill	2	20
		3	Drill	3	15
		4	Inspect	4	12
		5	Unload	1	2
B	0.2	1	Load	1	4
		2	Drill	3	16
		3	Mill	2	25
		4	Drill	3	14
		5	Inspect	4	15
		6	Unload	1	2
C	0.3	1	Load	1	4
		2	Drill	3	23
		3	Inspect	4	8
		4	Unload	1	2
D	0.4	1	Load	1	4
		2	Mill	2	30
		3	Inspect	4	12
		4	Unload	1	2

10. (a) The overall width of four aisle AS/RS system is 48 feet. Length of each aisle is 280 ft. and the height is 46 ft. each aisle has 60 storage compartments in length direction and 12 compartments can be accommodated in the vertical direction. Determine the dimensions of the standard sized pellet.   [1.5]
(b) The horizontal speed for S/R M/C is 200 ft./min. and it requires 20 secs to accomplish the P and D operation. Determine the single command and dual command cycle time/aisle if the vertical speed 37.5% of the horizontal speed.   [2]
(c) How will the through put/ aisle be affected if the vertical speed is made 50% of the horizontal speed. Determine quantitatively.   [3.5]
[Hints: System utilization=90%, allowances: a=6 in, b=8 in, c=10 in].