TEST ID: 405

ACE
Engineering Academy

Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad – 500001.

Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437

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ESE- 2019 (Prelims) - Offline Test Series Test – 9

MECHANICAL ENGINEERING

SUBJECT: MANUFACTURING, INDUSTRIAL AND MAINTENANCE ENGINEERING + MECHATRONICS & ROBOTICS - SOLUTIONS

01. Ans: (c)

Sol:

- The properties desired in a **good wax pattern** include low ash content (up to 0.05%), resistance to the primary-coat material used for investment, *high tensile strength and hardness,* ***High wettability****, resistance to oxidation, low shrinkage, and substantial weld strength.*
- Wax patterns are excellent for the investment casting process. The materials generally used are blends of several types of waxes and other additives, which act as polymerising agents and stabilisers.
- The waxes commonly chosen are paraffin wax, carnauba wax, shellac wax, bees wax, cerasin wax, and microcrystalline wax.
- The blending or compounding of waxes and other additives is so done that most of the desired properties can be achieved. The actual ingredients and composition to be used have generally to be determined by trial and experimentation.

02. Ans: (a)

Sol: Classifying robots is based on their kinematic structure:

A *serial robot* is constructed from an open loop kinematic chain, while a *parallel robot* is made from a number of closed loop chain.

03. Ans: (c)

Sol:

- If feasible solution exist for both primal and dual problems then both problems have optimal solutions of which objective functions values are equal.
- In any LPP, the dual of dual is primal itself.
- If the primal (maximization) is unbounded, the dual is infeasible.
- If the primal is infeasible, the dual is unbounded or infeasible.

04. Ans: (d)

Sol:

- The cross-section of a sprue may be *square, rectangular or circular*. If a single sprue is not adequate to fill a large casting in the required time, two or more sprues and the same number of ladles may be employed for pouring.
- *The sprues are generally tapered downwards to avoid aspiration of air and metal damage*. If a sprue of uniform cross-section is used, severe aspiration occurs because the metal velocity increases as it descends the vertical sprue.
- On the other hand, if the sprue is tapered to a degree, that the metal lies firmly against the mould, aspiration and *turbulence are minimized*. (Flow is said to be turbulent when the atoms of metal do not flow in a straight streamlined path but travel from side to side).

05. Ans: (a)

Sol: In Robot specification, precision measure of the spatial resolution with the tool can be positioned in work envelop.

	Horizontal precision	**Vertical precision**
Cartesian (Gantry)	Uniform	Uniform
Cylindrical	Decrease rapidly	Uniform
Spherical	Decrease rapidly	Decrease rapidly
SCARA	Varies	Uniform
Articulated	Varies	Varies

06. Ans: (a)

Sol: Safety stock = (Safety factor)$_\sigma$ × standard deviation of demand

$= 3 \times 50 = 150$

[For 99.87 percent service level, the (safety factor)$_\sigma$ = 3]

07. Ans: (d)

Sol: *Resistance welding* (RW) covers a number of processes in which the heat required for welding is produced by means of *electrical resistance* across the two components to be joined. These processes have major advantages, such as high-quality welds that do not require consumable electrodes, shielding gases, or flux, and can be produced quickly.

In friction welding (FRW), the heat required for welding is generated through friction at the interface of the two components being joined. No filler metal, flux, or shielding gases are normally used.

08. Ans: (a)

Sol: A simple moving average is a method of computing the average of a specified number of the most recent data values in a series.

$$\text{Moving Average} = \frac{\Sigma x}{\text{Number of period}}$$

where x is demand at each interval.

Here equal weightage is given to all data points.

09. Ans: (c)

10. Ans: (a)

Sol: Selection of gases (and mixtures of gases) depends on the metal being welded, as well as other factors. Inert gases are used for welding aluminum alloys and stainless steels, while CO_2 or a mixture of argon / carbon dioxide is commonly used for welding low and medium carbon steels.

11. Ans: (d)

Sol: $Z_{max} = x_1 + 2x_2$

Subjected to

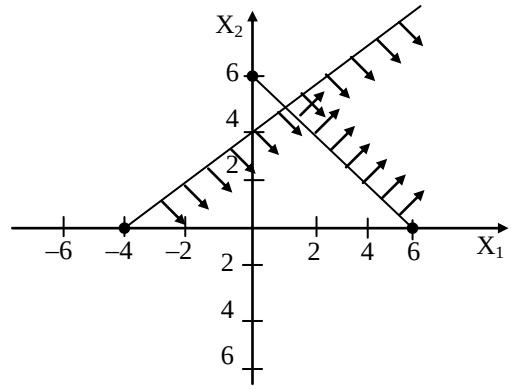
$$-x_1 + x_2 \le 4$$

$$x_1 + x_2 \ge 6$$

$$x_1, x_2 \ge 0$$

$$\frac{x_1}{-4} + \frac{x_2}{4} \le 1$$

$$\frac{x_1}{6} + \frac{x_2}{6} \ge 1$$



Unbounded solution space and unbounded optimal solution to problem exist.

12. Ans: (b)

13. Ans: (c)

Sol: $T_2 = T_1/4$, $n = 0.5$, $T_1 = 180$ min,

$V_1 = 18$ m/min and $V_2 = ?$

$$V_1 T_1^n = V_2 T_2^n$$

$$\Rightarrow \quad V_2 = V_1 [T_1/T_2]^n = V_1 [4]^{0.5}$$

$$= 2V_1 = 36 \text{ m/min}$$

14. Ans: (b)

Sol: SCARA configuration provides high stiffness to the arm in the vertical direction and *high compliance in the horizontal plane* thus making SCARA congenial for many assembly tasks.

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15. Ans: (a)

Sol: Johnson rule of sequencing gives minimum make span time and the sequence is

3	2	4	5	1	6

16. Ans: (b)

Sol: *Effect of various factors on chip formation (or) metal cutting characteristics.*

- **Cutting Velocity:** It directly effects the temperature at the tool point. *It does not affect the direction of chip flow*, low cutting speed causes built up edge and discontinuous chips. On ductile materials, high velocity forms continuous chips.
- **Material of workpiece**: Ductile material produce continuous chips, where as brittle material produce segmented (or) discontinuous chips.
- **Depth of cut and feed**: Increasing the feed and depth of cut results in greater distortion of chip. *The direction of chip flow changes with the change in the size of cut*. The high values of feed and depth of cut leads to formation of buitup edge and poor surface finish.
- **Tool geometry:** This changes the shear angle and ultimately the chip thickness.
- **Friction in metal cutting:** Friction between the chip and the tool plays a significant role in the cutting process.

17. Ans: (a)

Sol: D requirement = $4 \times 2 \times 250 + 2 \times 1 \times 250$

$= 2000 + 500 = 2500$ units

18. Ans: (b)

Sol: The conversion of the position and orientation of a robot manipulator end effectors from the Cartesian space to the joint space is called the *inverse kinematics problem.*

19. Ans: (d)

Sol: Given data:

Cutting Stroke time (t_c) = 3s,

Return stroke time (t_r) = 2 s,

Length of work piece (L) = original length = 200 mm,

Approach length (L_A) = 60 mm,

Cutting velocity (N) = 50 double stroke/min,

Cutting speed (V_a) = ?

$$\text{Return cutting ratio (k)} = \frac{\text{Re turn stroke Time}}{\text{Cutting stroke time}}$$

$$= \frac{2}{3} = 0.67$$

The return-cutting ratio (k) = 0.67

The stroke length is the sum of the original length and two times the approach length.

$$L_s = L + 2 L_A$$

$$L_A = 200 + (2 \times 60) = 320 \text{ mm}$$

The stroke length (Ls) = 320 mm.

Average cutting speed (v_a) = N L_s (1 + k)

= 50 × 320 (1 + 0.67)

= 26,720 mm/min = 26.7 m/min

The cutting speed of the shaper = 26.7 m/min.

20. Ans: (b)

21. Ans: (a)

22. Ans: (d)

Sol: Hobbing: It is the most accurate of the roughing processes since no repositioning of tool or blank is required and each tooth is cut by multiple hob-teeth, averaging out any tool errors. Excellent surface finish is achieved by this method and is widely used for production of gears.

23. Ans: (c)

24. Ans: (d)

Sol: Total Variable Cost = Ordering Cost + Interest + Storage + Purchase Cost

$$TC = C_0\left(\frac{1}{Q}\right)D + \left(\frac{Q}{2}\right)C_i + QC_s + PD$$

The storage cost is evaluated for the entire lot because we have to pay whether there is material or no material in the storage space.

$$\frac{dT}{dQ} = -C_0 DQ^{-2} + \frac{C_i}{2} + C_S + 0$$

Setting the 1st derivative equal to zero, the order quantity is now

$$0 = -\frac{C_0 D}{Q^2} + \frac{C_i}{2} + C_s$$

$$\frac{C_0 D}{Q^2} = \frac{C_i + 2C_s}{2}$$

$$Q = EOQ = \sqrt{\frac{2C_0 D}{C_i + 2C_s}}$$

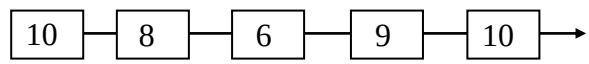
25. Ans: (d)

Sol:

- Extrusion - Fir-tree-cracking
- Closed die forging - Flash cracking
- Rolling - Alligatoring
- Deep drawing - Earing

26. Ans: (c)

Sol:



Cycle time, C = 10

No. of work stations, n = 5

Assembly time = Σt_i = 10+8+6+9+10

= 43 minutes

Line efficiency = $\frac{\sum t_i}{nc} \times 100$

$= \frac{43}{5 \times 10} \times 100$

= 86 %

Balance delay = 100 – (Line η)

= 100 – 86 = 14 %

27. Ans: (a)

Sol: 1024 tera bites

$2^n = 2^{10} \times 2^{40} = 2^{50}$

So, Number of address lines (n) = 50 Address lines

28. Ans: (c)

Sol: *Rotary Swaging:* In this process (also known as radial forging, rotary forging, or simply swaging), a solid rod or tube is subjected to radial impact forces by a set of reciprocating dies of the machine. So option (c) is correct.

29. Ans: (b)

Sol: *Single Action Presses*. A single action press has one reciprocation slide that carries the tool for the metal forming operation. The press has a fixed bed. It is the most widely used press for operations like blanking, coining, embossing, and drawing. Hence given options (a) and (d) are incorrect.

Double Action Presses. A double action press has two slides moving in the same direction against a fixed bed. It is more suitable for drawing operations, especially deep drawing, than single action press. For this reason, its two slides are generally referred to as outer blank holder slide and the inner draw slide. The blank holder slide is a hollow rectangle, while the inner slide is a solid rectangle that reciprocates within the blank holder.

The blank holder slide has a shorter stroke and dwells at the bottom end of its stroke, before the punch mounted on the inner slide touches the workpiece. In this way, practically the complete capacity of the press is available for drawing operation.

Another advantage of double action press is that the four corners of the blank holder are individually adjustable. This permits the application of non uniform forces on the work if needed.

A double action press is widely used for deep drawing operations and irregular shaped stampings. So given option (b) is correct.

Triple Action Presses. A triple action press has three moving slides. Two slides (the blank holder and the inner slide) move in the same direction as in a double – action press and the third or lower slide moves upward through the fixed bed in a direction opposite to that of the other two slides. This action allows reverse – drawing, forming or

bending operations against the inner slide while both upper actions are dwelling.

Cycle time for a triple – action press is longer than for a double – action press because of the time required for the third action. Hence given option (c) is incorrect.

30. Ans: (d)

31. Ans: (c)

Sol:

Activity	t_o	t_L	t_P	$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1-2	2	6	8	1
2-3	5	7	17	4
3-4	4	10	16	4

$$\sigma = \sqrt{\sigma^2_{1-2} + \sigma^2_{2-3} + \sigma^2_{3-4}}$$

$$= \sqrt{1+4+4} = 3$$

32. Ans: (b)

Sol: If the dimension of the shaft is more than that of the hole it is termed as *interference fit.*

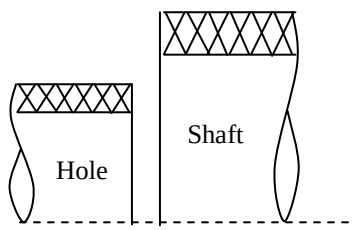


Fig: interference fit.

33. Ans: (b)

34. Ans: (c)

35. Ans: (c)

Sol: SPT rule can minimize

- Average flow time
- No. of tardy jobs
- Total inventory cost

EDD rule can minimize

- Average tardiness or mean tardiness
- Maximum lateness

36. Ans: (c)

Sol: The distinguishing characteristics of three categories of flexible manufacturing cells and systems are summarized in figure given below.

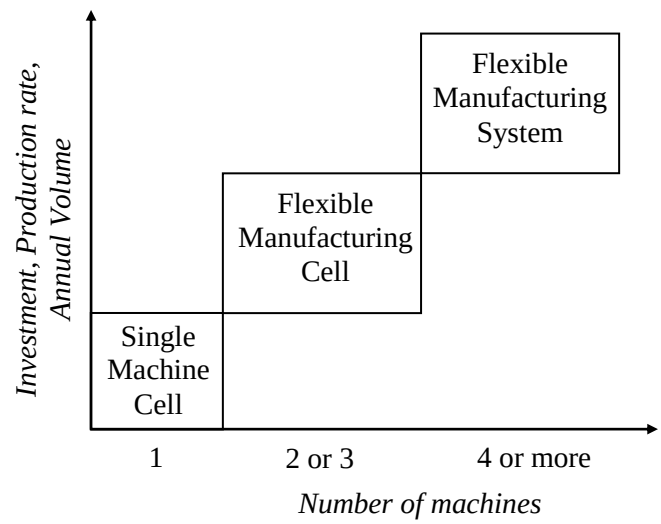


Fig: *Features of the three categories of flexible cell and systems.*

37. Ans: (a)

Sol: If total demand is higher than the supply, then we assume one more row in supply, such that its total supply = demand and all the costs in that row are zero.

To get an optimal solution in transportation, the initial solution must be non-degenerate i.e., No. of allocation should be greater than or equal to no. of (Rows + Columns – 1).

38. Ans: (c)

Sol: Hall Effect sensors are commonly used to the speed of wheels and shafts such as for IC engine ignition timing, tachometers and anti lock braking systems.

39. Ans: (a)

Sol:

N010 P02 G21 G90 G94	Absolute and metric programming.
N020 T01 F200 M03 S2018	Select tool T01 and rotate spindle CW with 2018 rpm.
N030 G00 X27.00 Z1.00	Rapid feed position 1.
N040 G01 Z-40.00 F403	Move to position 2 with feed rate 403 mm/min.
N050 X32.00	Move to position 3 to relieve from workpiece.
N060 G00 X150.00 Z100	Rapid retract to tool home position 0.
N070 M05	Spindle stop.
N080 M30	End of the program.

40. Ans: (c)

41. Ans: (d)

Sol: $\text{Efficiency} = \dfrac{\text{actual output}}{\text{effictive capacity}}$

$$= \frac{36}{40} = 0.9 \text{ or } 90\%$$

$$\text{Utilization} = \frac{\text{actual output}}{\text{Design capacity}}$$

$$= \frac{36}{50} = 0.72 \text{ or } 72\%$$

42. Ans: (d)

Sol: **Electrodes**: Electrodes for EDM usually are made of graphite, although brass, copper, or copper-tungsten alloys also are used. The tools can be shaped by forming, casting, powder metallurgy, or CNC machining techniques.

Wear ratio is defined as the ratio of the volume of workpiece material removed to the volume of tool wear. *This ratio ranges from about 3:1 for metallic electrodes to as high as 100:1 for graphite electrodes.*

Tool wear is related to the melting points of the materials involved: The lower the melting point of the electrode, the higher is the wear rate. Also, the higher the current, the higher is the wear. Consequently, graphite electrodes have the highest wear resistance.

43. Ans: (c)

Sol: Dispatching starts with input as route sheet and schedule chart. It concerns itself with starting the process and operation of production.

44. Ans: (a)

Sol: 90° in 0.025 sec

Then 360° (1 revolution) $\rightarrow 0.025\times4$

1 Rotation = 0.1 sec.

Then, 10 rotation per sec = 10 RPS

$$\text{Resolution} = 3000\ \frac{\text{P}}{\text{sec}} \times \frac{\text{sec}}{10\,\text{Re volutions}}$$

= 300 steps/revolution.

45. Ans: (a)

Sol: In EDM, the frequency of discharge or the energy per discharge, the voltage, and the current usually are varied to control the removal rate.

The removal rate and surface roughness increase with (a) increasing current density and (b) decreasing frequency of sparks. So given statement (1) & (2) are correct. Hence option (a) is Correct.

Because the process doesn't involve mechanical energy, *the hardness, strength, and toughness of the workpiece material do not necessarily influence the removal rate.* So given statement (3) is incorrect.

46. Ans: (b)

47. Ans: (a)

Sol: Average arrival rate, $\lambda = 6$ per hour

Average service time,

$\mu = 6$ minutes = 10/hour

$$\rho = \frac{\lambda}{\mu} = \frac{6}{10} = 0.6$$

The probability that an arrival will find the place free = $P(0) = 1 - \rho = 1 - 0.6 = 0.4$

$$P(1) = \rho \times P(0) = 0.6 \times 0.4 = 0.24$$

The probability that an arriving customer will have to wait outside

$= 1 - [(0.4) + (0.24)] = 0.36 = 36\%$

48. Ans: (c)

Sol: In a balanced transportation problem, the primal constraints are equations. Hence dual variables are unrestricted in sign.

49. Ans: (d)

Sol: Power = Force × Velocity

$$= 20\,\text{kN} \times \frac{150 \times 10^{-3}}{0.5\,\text{sec}} = 6\ \text{kW}$$

50. Ans: (a)

Sol: Inherent availability

$$(A_i) = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

where, MTBF = Mean time between failure, MTTR = Mean time to repair / mean time to replace (if given, mean waiting time for spares and mean administrative time is also included)

$$\text{Availability} = \frac{500}{500 + 5 + 48 + 2}$$

$$= \frac{500}{555} = 0.90$$

The automobile would be available 90% of the time.

51. Ans: (a)

Sol:

- Lead Time Forecast → Inventory Control
- Master Production Schedule → Material Requirement Planning
- Payback Period → Financial Appraisal
- Early Start Schedule → Project Planning

52. Ans: (a)

53. Ans: (a)

Sol: Available hours are total machine available time and down time are the time machine is not available for performing its normal function. Ratio of down time to available hours gives the machine effectiveness.

54. Ans: (d)

Sol: $Z_{max} = 7x_1 + 6x_2 + 0x_3 + 0x_4$

$x_1 + x_2 + x_3 = 4$

$2x_1 + x_2 + x_4 = 6$

x_3 , x_4 → Slack variables

There are 4 variables and 2 constraints.

There are $4C_2 = 6$ basic solutions.

The four corner points (0, 0), (3, 0), (0, 4) and (2, 2) are four basic feasible solutions.

When we solve x_2 & x_3, the equations are $x_2 + x_3 = 4$ and $x_2 = 6$ which gives $x_3 = -2$.

55. Ans: (c)

Sol: Resolution = $\frac{360^o}{2^{10}}$ = 0.35 degrees

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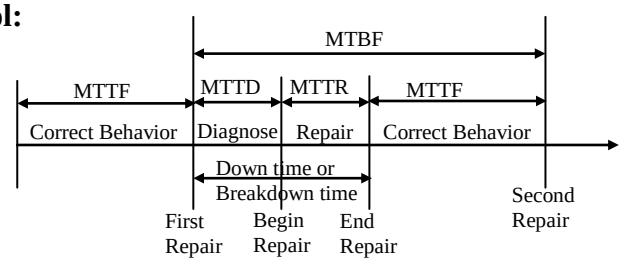
56. Ans: (c)

Sol:



57. Ans: (c)

Sol: No. of units to be produced = N = 120 units

Time = $8 \times 60 = 480$ min

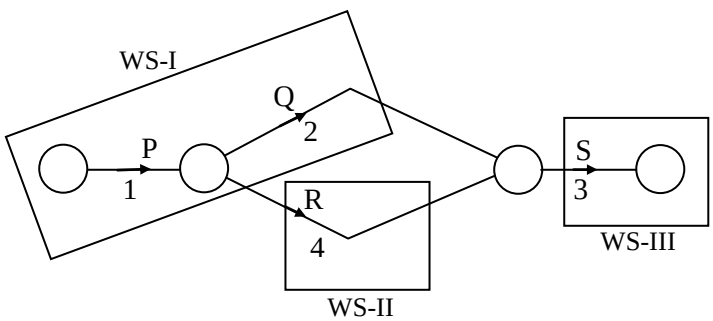
Cycle time = $C = \frac{T}{N} = \frac{480}{120} = 4$ min

Time to assemble one unit

$$\sum t_i = 1 + 2 + 4 + 3 = 10 \text{ minutes}$$

Theoretical minimum number of workstations = $\frac{\sum t_i}{C} = \frac{10}{4} = 2.5 \approx 3$

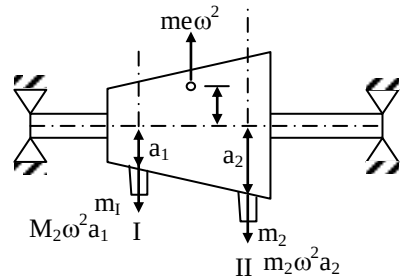
Technological Precedence diagram



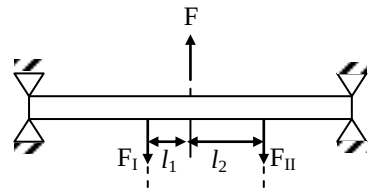
58. Ans: (d)

59. Ans: (d)

Sol:



(a) Actual system



(b) Equivalent force model

Balancing is attained if the centrifugal force $F = me\omega^2$ is cancelled by the other centrifugal forces by placing weights m_1 and m_2 either by removing parts of the rotor or by attaching correction masses in plane I and II.

To cancel the unbalance force $F = me\omega^2$ by centrifugal force $F_I = ma\omega^2$ and $F_{II} = ma\omega^2$, the following relationship must hold

$$F_I + F_{II} = F$$

and $$F_I \ell_1 = F_{II} \ell_2$$

60. Ans: (b)

Sol: $\lambda = 16\ hr^{-1}$

$\mu = 20\ hr^{-1}$

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{16^2}{20(20-16)}$$

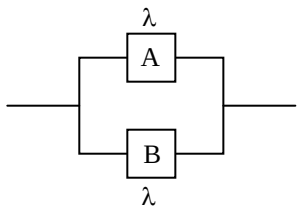
$$= \frac{16\times16}{20\times4} = 3.2$$

Queue discipline has no effect on number of persons in queue.

61. Ans: (b)

62. Ans: (a)

Sol:



λ = failure rate of A and B systems

Reliability of system $R = R_1 + R_2 - R_1R_2$

$[R_1 = e^{-\lambda t}, R_2 = e^{-\lambda t}]$

$R = e^{-\lambda t} + e^{-\lambda t} - e^{-(\lambda+\lambda)t}$

$R = 2e^{-\lambda t} + e^{-2\lambda t}$

Mean time to failure MTTF

$$= \int_0^\infty R.dt$$

$$= \int_0^\infty (2e^{-\lambda t} - e^{-\lambda t})dt$$

$$= \frac{2}{\lambda} - \frac{1}{2\lambda} = \frac{3}{2\lambda}$$

Failure rate of the system = $\frac{1}{MTTF} = \frac{2\lambda}{3}$

63. Ans: (d)

Sol: Strategies for adjusting capacity :

- Overtime and under time (increasing or decreasing working hours)
- Subcontracting (let outside companies complete the work)
- Part time workers (hiring part time workers to complete the work)
- Backordering (providing the service or product at a later time period)
- Level production (producing at a constant rate and using inventory to absorb fluctuation in demand)
- Chase demand (hiring and firing workers to match demand)

64. Ans: (c)

Sol: Green sand molding is the most widely used molding process. The green sand used for molding consists of silica, water and other additives. One typical green sand mixture contains 10 to 15% clay binder, 4 to 6% water and remaining silica sand. The green sand mixture is prepared and used in the molding procedure is used to complete the mold (cope and drag). So statement (1) is correct and statement (2) is incorrect. Hence the correct option is (c).

65. Ans: (a)

Sol: Work envelop is defined as the envelop (or) space within which the robot can manipulated the end of the wrist.

- It depends on the number of type of joints, physical size of the joints and links and the ranges of various joints.
- Since the arm movements in different robot configurations are different the work volumes or work envelop of different coordinates systems are also different.

66. Ans: (b)

Sol: Plasma-arc welding has better arc stability, less thermal distortion, and higher energy concentration, thus permitting deeper and narrower welds.

67. Ans: (a)

68. Ans: (a)

Sol: Negative rake angles are most effective when used with tool materials capable of machining at high speeds because negative rake angles have less effect on tool pressures in the higher speed ranges. Negative rake angles are a necessity when taking interrupted cuts with carbide cutting tools. In taking an interrupted cut the shock load occurs back of the cutting edge, where there is more strength.

69. Ans: (b)

Sol:

- Microprocessor is just electronic device, composed of only combinational and sequential circuits.
- Some Microprocessors and micro controllers contain more than one CPU in order to achieve faster instruction processing. So, both the statements are correct but a statement (II) is not correct reason for statement (I).

70. Ans: (b)

Sol: The motion from the spindle motor is communicated to the carriage through a lead screw. Engagement of the lead screw with the carriage is through the use of a half nut. Both statements are correct. But statement (II) is not correct justification of statement (I).

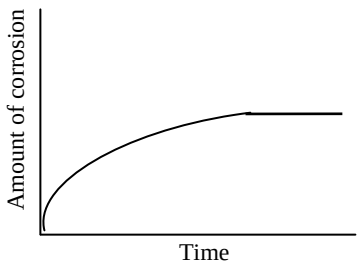
71. Ans: (c)

Sol: The stepper motors are very popular due to precision incremental movement in steps. i.e., the position is proportional to the number of input pluses sent to the motor.

The disadvantages is that they *cannot be used* at high speed and resonance occurs if not properly controlled.

72. Ans: (a)

Sol: The most corrosion films are passivate or cease to grow beyond a certain thickness and this layer act as protective layer to other part of the material. Hence it is desirable and favourable as corrosion process stops its own



Passivation of corrosion.

73. Ans: (a)

Sol: The independent jaw chuck has four jaws, which can be moved in their slots independent of each other, thus other, thus clamping any type of configuration. Since each of these jaws could move independently, any irregular surface could be effectively centered. *Better accuracy in location could be maintained because of the independent movement.*

Note:

More time is spent in fixturing a component in a 4-Jaw chuck compared to the 3-jaw chuck. This is generally used for heavy work pieces and for any configuration.

74. Ans: (a)

75. Ans: (d)

Sol:

- Wrist roll involves rotation of the wrist mechanism about the arm axis. So statement (I) is incorrect.
- Wrist yaw involves the motion of the right or left of the wrist. Statement (II) is correct. Hence, option (d) is correct.

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