

PI: Production and Industrial Engineering

Q.No. 1 The solution of $\int_1^a \int_1^b \frac{dx dy}{xy}$ is

- (A) $\ln(ab)$
- (B) $\ln(a/b)$
- (C) $\ln(a) + \ln(b)$
- (D) $\ln(a)\ln(b)$

Answer: (D)

Q.No. 2 In a sine bar, let h denote height of slip gauge and l be the distance between the rollers. The relationship between error in angular measurement ($d\theta$) and errors in the slip gauge combination (dh) and in the spacing of the rollers (dl) is

- (A) $d\theta = \sin \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- (B) $d\theta = \cos \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- (C) $d\theta = \tan \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$
- (D) $d\theta = \cot \theta \left(\frac{dh}{h} - \frac{dl}{l} \right)$

Answer: (C)

Q.No. 3 The process capability ratio C_p is given by

- (A) Upper Specification Limit - Lower Specification Limit / $6 \times$ Process Standard Deviation
- (B) Upper Control Limit - Lower Control Limit / $6 \times$ Process Standard Deviation
- (C) $6 \times$ Process Standard Deviation / Upper Specification Limit - Lower Specification Limit
- (D) $6 \times$ Process Standard Deviation / Upper Control Limit - Lower Control Limit

Answer: (A)

Q.No. 4 Which one of the following instruments makes use of the principle of interference of light?

- (A) Optical flat
- (B) Auto-collimator
- (C) Optical projector
- (D) Coordinate measuring machine

Answer: (A)

Q.No. 5 The improper integral $\int_0^{\infty} e^{-2t} dt$ converges to

- (A) 0
- (B) 1.0
- (C) 0.5
- (D) 2.0

Answer: (C)

Q.No. 6 In Value Engineering approach, the value of the product is

- (A) inversely proportional to its functions and directly proportional to its cost
- (B) directly proportional to its functions and inversely proportional to its cost
- (C) inversely proportional to its functions as well as its cost
- (D) directly proportional to its functions as well as its cost

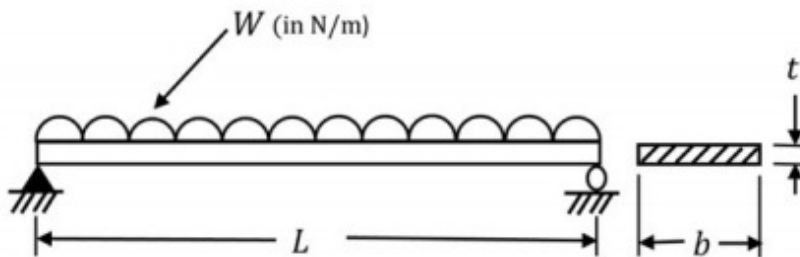
Answer: (B)

Q.No. 7 Which one of the following defects is NOT associated with the casting process?

- (A) Hot tear
- (B) Porosity
- (C) Blister
- (D) Central burst

Answer: (D)

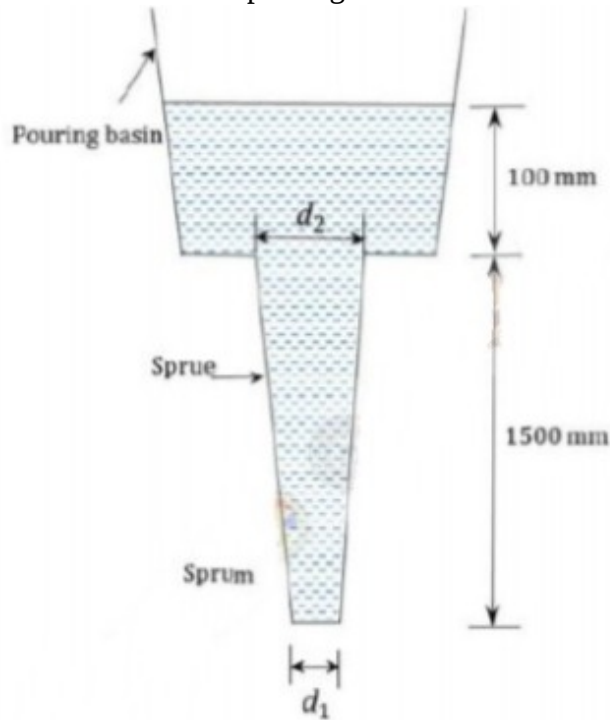
Q.No. 8 The figure shows a beam of length L (in m) with a uniformly distributed transverse load of W (in N/m) acting over it. The width and depth of the beam cross section are b (in m) and t (in m), respectively. The magnitude of the maximum bending stress in the beam in N/m² is



- (A) $\frac{3WL^2}{4bt^2}$
- (B) $\frac{4WL^2}{3bt^2}$
- (C) $\frac{2WL^2}{3bt^2}$
- (D) $\frac{3WL^2}{2bt^2}$

Answer: (A)

Q.No. 9 Schematic diagram of pouring basin and sprue of a gating system is shown in the Figure. Depth of molten metal in the pouring basin is 100 mm and the height of the sprue is 1,500 mm.



Considering the cross-section of the sprue is circular, the ratio $d_1 : d_2$ to avoid aspiration is

- (A) 3:2
- (B) 5:6
- (C) 15:16
- (D) 1:2

Answer: (D)

Q.No. 10 In a machine shop, four jobs need to be assigned to four different machines. Each of the jobs is to be assigned to one machine only at a time. The time taken to complete the job in different machines is given in the

		Machines			
		M_1	M_2	M_3	M_4
Jobs	J_1	15	13	14	17
	J_2	11	12	15	13
	J_3	13	12	10	11
	J_4	15	17	14	16

Table.

In order to ensure that the total time required to complete all the jobs is minimum, the optimal assignment of the job is

- (A) $J_1 \Rightarrow M_4, J_2 \Rightarrow M_2, J_3 \Rightarrow M_3, J_4 \Rightarrow M_1$
- (B) $J_1 \Rightarrow M_2, J_2 \Rightarrow M_1, J_3 \Rightarrow M_4, J_4 \Rightarrow M_3$
- (C) $J_1 \Rightarrow M_2, J_2 \Rightarrow M_1, J_3 \Rightarrow M_3, J_4 \Rightarrow M_4$
- (D) $J_1 \Rightarrow M_4, J_2 \Rightarrow M_2, J_3 \Rightarrow M_1, J_4 \Rightarrow M_3$

Answer: (B)

Q.No. 11 A rigid link PQ of length 1.0 m is pinned at P. It rotates about P in a vertical plane with a uniform angular acceleration of 1.0 rad/s^2 . At an instant when the angular velocity of the link is 1.0 rad/s , the magnitude of total acceleration (in m/s^2) of point Q relative to point P is

(A) 1.41

(B) 1.73

(C) 2

(D) 2.83

Answer: (A)

Q.No. 12 If roots of the auxiliary equation of $\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = 0$ are real and equal, the general solution of the differential equation is

(A) $y = c_1 e^{-x/2} + c_2 e^{ax/2}$

(B) $y = (c_1 + c_2 x) e^{-ax/2}$

(C) $y = (c_1 + c_2 \ln x) e^{-x/2}$

(D) $y = (c_1 \cos x + c_2 \sin x) e^{-ax/2}$

Answer: (B)

Q.No. 13 In a gear manufacturing company, three orders P, Q and R are to be processed on a hobbing machine. The orders were received in the sequence P — Q — R. The Table indicates the process time remaining and production calendar due date for each order.

Order	Process Time Remaining (day)	Due date
P	4	Day 20
Q	16	Day 30
R	6	Day 19

Considering today as the Day 10 in the production calendar of the Hobbing Shop, the sequence of the orders scheduled using the 'Critical Ratio' rule is

(A) P-Q-R

(B) P-R-Q

(C) Q-P-R

(D) Q-R-P

Answer: (D)

Q.No. 14 Vector triple product $\mathbf{a} \times (\mathbf{b} \times \mathbf{c})$ of three vectors $\mathbf{a}$, $\mathbf{b}$ and $\mathbf{c}$ is given by

(A) $(\mathbf{a} \cdot \mathbf{c}) \mathbf{b} - (\mathbf{a} \cdot \mathbf{b}) \mathbf{c}$

(B) $(\mathbf{b} \cdot \mathbf{c}) \mathbf{a} - (\mathbf{a} \cdot \mathbf{c}) \mathbf{b}$

(C) $(\mathbf{a} \cdot \mathbf{b}) \mathbf{c} - (\mathbf{a} \cdot \mathbf{c}) \mathbf{b}$

(D) $(b \cdot c) a - (a \cdot b) c$

Answer: (A)

Q.No. 15 For the complex numbers $z_1 = 2 + 3i$ and $z_2 = 4 - 5i$, the value of $(z_1 + z_2)^2$ is

(A) $32 - 24i$

(B) $-32 - 24i$

(C) $32 + 24i$

(D) $-32 + 24i$

Answer: (A)

Q.No. 16 An acceptance sampling plan is selected with sample size $n = 80$, acceptance number $c = 2$ for a lot size of 10,000 units. The probability of accepting the lot is based on Poisson distribution. Assuming rectification inspection, if incoming lot quality p is 0.03 and mean (λ) is 2.4, the average outgoing quality (AOQ) is closest to

(A) 0.0011

(B) 0.0087

(C) 0.0170

(D) 0.0338

Answer: (C)

Q.No. 17 A pair of spur gears with 20° full-depth involute teeth is used to transmit 3.5 kW of power. The pinion rotates at 700 rpm and has a pitch circle diameter of 100 mm. Assuming a single pair of teeth in contact, the total force acting on a gear tooth (in kN) is

(A) 0.347

(B) 0.954

(C) 1.016

(D) 1.302

Answer: (C)

Q.No. 18 An LPP is defined as Maximize $z = 15x_1 + 12x_2$ Subject to $x_1 + 2x_2 \leq 3$, $x_1, x_2 \geq 0$ The objective function of the dual of this LPP is

(A) Maximize $w = y_1 + y_1$

(B) Maximize $w = y_1 + 2y_1$

(C) Maximize $w = 2y_1 - 4y_2$

(D) Maximize $w = 3y_1 + 5y_2$

Answer: (D)

Q.No. 19 In a shaft-hole system, the dimensions with tolerances (in mm) are as follows:

Shaft: $\phi 20^{+x}_{-x}$ Hole: $\phi 20^{-0.01}_{-y}$ where both x and y are positive real numbers. Which one of the following will provide an interference fit?

(A) $x = 0.05, y = 0.040$

(B) $x = 0.04, y = 0.035$

(C) $x = 0.04, y = 0.032$

(D) $x = 0.02, y = 0.035$

Answer: (D)

Q.No. 20 In a service centre, cars arrive according to Poisson distribution with a mean of 2 cars per hour. The time for servicing a car is exponential with a mean of 15 minutes. The expected waiting time (in minute) in the queue is

(A) 10

(B) 15

(C) 25

(D) 30

Answer: (B)

Q.No. 21 A 100 mm long cylindrical workpiece of diameter 50 mm is reduced to 25 mm diameter using extrusion process. The flow curve for the metal has strength coefficient as $K = 750$ MPa and the strain hardening co-efficient is 0.15. Assuming no friction and no redundant work, the required ram pressure (in MPa) is closest to

(A) 164

(B) 364

(C) 428

(D) 950

Answer: (D)

Q.No. 22 For a classical (Wilson) model of determining economic order quantity (EOQ), the carrying and ordering costs are C_r and C_o , respectively. For an annual demand D , the minimum yearly total inventory cost is

(A) $\sqrt{D C_e C_r}$

(B) $\sqrt{1.5 D C_o C_r}$

(C) $\sqrt{2 D C_o C_r}$

(D) $\sqrt{3 D C_o C_r}$

Answer: (C)

Q.No. 23 The capacity of a passenger airline is expressed in terms of

(A) available seats

(B) available miles

(C) available sectors

(D) available seat miles

Answer: (D)

Q.No. 24 True centrifugal casting process in horizontal configuration is to be used for casting a metallic cylinder with outside diameter 0.275 m and inside diameter 0.250 m. If G-factor (ratio of centrifugal force experienced by the rotating cast metal to its weight) is 65 and acceleration due to gravity is 9.8 m/s^2 , the minimum rotational speed (in rpm) required is closest to

- (A) 325
- (B) 650
- (C) 975
- (D) 1300

Answer: (B)

Q.No. 25 To make holes of 0.5 mm diameter and 30 mm depth in a mild steel component, the most suitable process is

- (A) chemical machining
- (B) electrochemical machining
- (C) abrasive jet machining
- (D) plasma arc machining

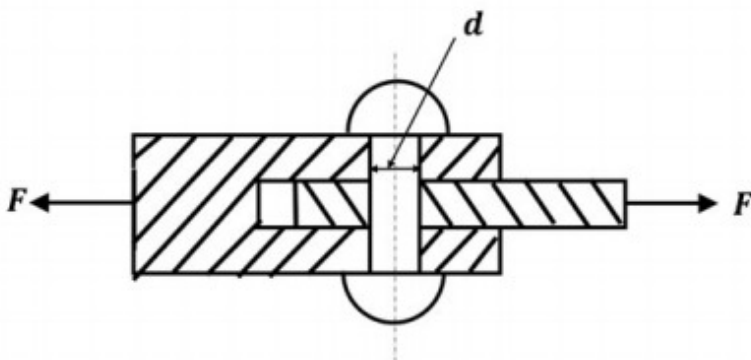
Answer: (B)

Q.No. 26 In Glass Fiber Reinforced Plastic (GFRP) composites with long fibers, the role of matrix is to (P) support and transfer the stresses to the fibers (Q) reduce propagation of cracks (R) carry the entire load (S) protect the fibers against damage The correct statements are

- (A) P, Q and R
- (B) Q, R and S
- (C) P, Q and S
- (D) P, R and S

Answer: (C)

Q.No. 27 The figure shows two bodies connected through a riveted joint with one rivet. The diameter of the rivet is d (in m). The joint transmits a load of F (in N) whose line of action is perpendicular to and intersects the vertical axis of the rivet. Neglect any effect of bending of the rivet. If the allowable shear stress for the material of the rivet is $\tau \text{ N/m}^2$, the diameter of the rivet required to prevent failure in shear is



(A) $\sqrt{\frac{F}{\pi\tau}}$

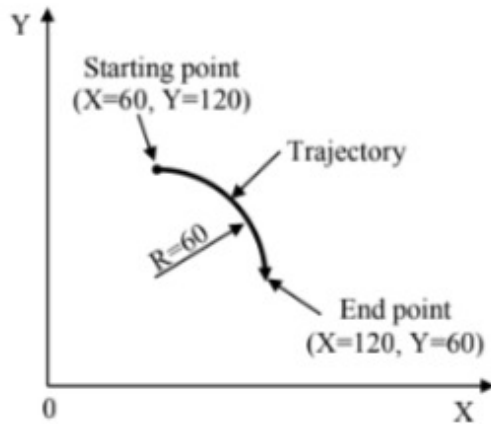
(B) $\sqrt{\frac{2F}{\pi\tau}}$

(C) $\sqrt{\frac{4F}{\pi\tau}}$

(D) $\sqrt{\frac{8F}{\pi\tau}}$

Answer: (B)

Q.No. 28 In a NC milling operation, the tool path is generated using absolute programming for the trajectory



shown in the figure

The corresponding block of the NC program is

(A) G02 X 120.0 Y 60.0 R 60.0;

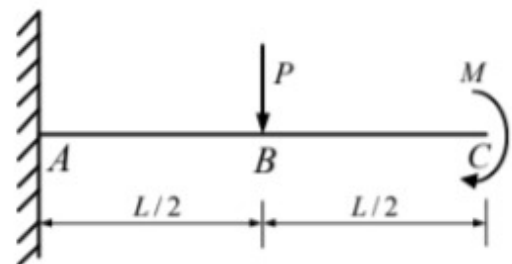
(B) G02 X 60.0 Y 120.0 R 60.0;

(C) G03 X 60.0 Y 120.0 R 60.0;

(D) G03 X 120.0 Y 60.0 R 60.0;

Answer: (A)

Q.No. 29 A uniform cantilever beam ABC of length L is subjected to a point load P at point B and a concentrated moment M at point C (as shown in figure). Let E be the Young's modulus of the beam material and I be the area moment of inertia of the beam's cross-section. Assuming the validity of the Euler-Bernoulli



theory of slender beams, the downward deflection at point C is

(A) $\frac{PL^3}{3EI} + \frac{ML^2}{2EI}$

(B) $\frac{PL^3}{24EI} + \frac{ML^2}{EI}$

(C) $\frac{PL^3}{48EI} + \frac{ML^2}{2EI}$

(D) $\frac{5PL^3}{48EI} + \frac{ML^2}{2EI}$

Answer: (D)

Q.No. 30 General solution of $x^2 \frac{d^2y}{dx^2} + x \frac{dy}{dx} - y = 0$ is

(A) $y = \frac{C_1}{x} + \frac{C_2}{x^3}$

(B) $y = C_1 x^2 + \frac{C_2}{x^2}$

(C) $y = C_1 x + \frac{C_2}{x}$

(D) $y = C_1 x + C_2 x^3$

Answer: (C)

Q.No. 31 Consider the analytic function $f(z) = x^2 - y^2 + i2xy$ of the complex variable $z = x + iy$, where $i = \sqrt{-1}$. The derivative $f'(z)$ is

(A) $2x + i2y$

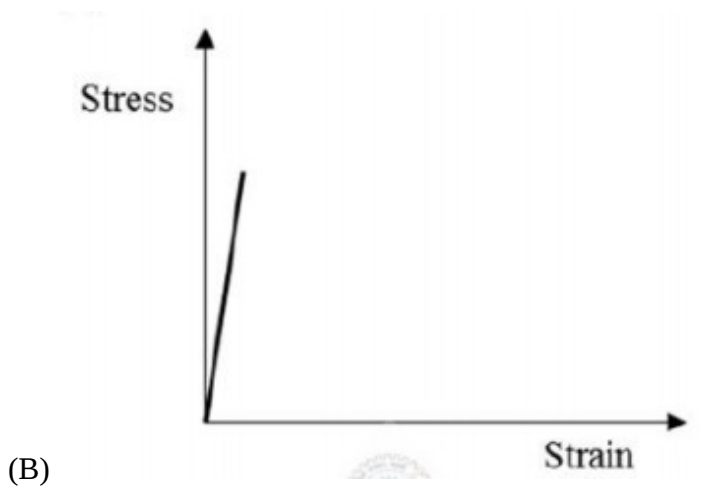
(B) $x^2 + iy^2$

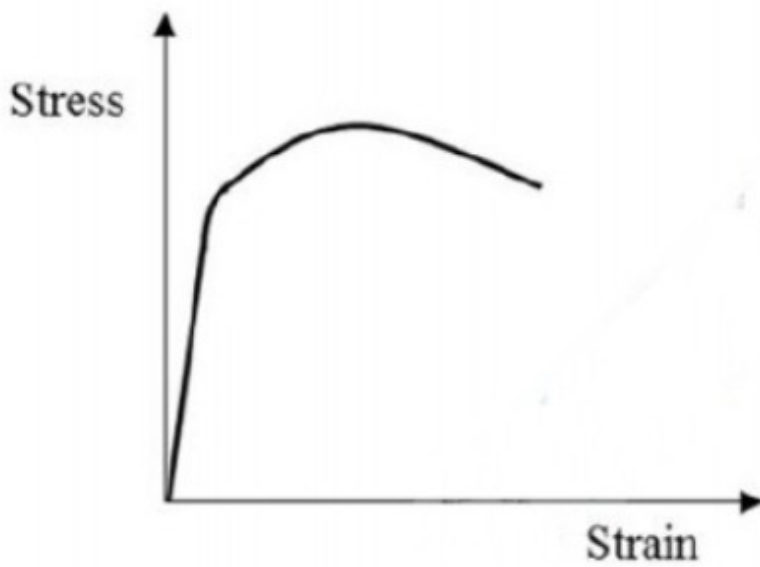
(C) $x + iy$

(D) $2x - i2y$

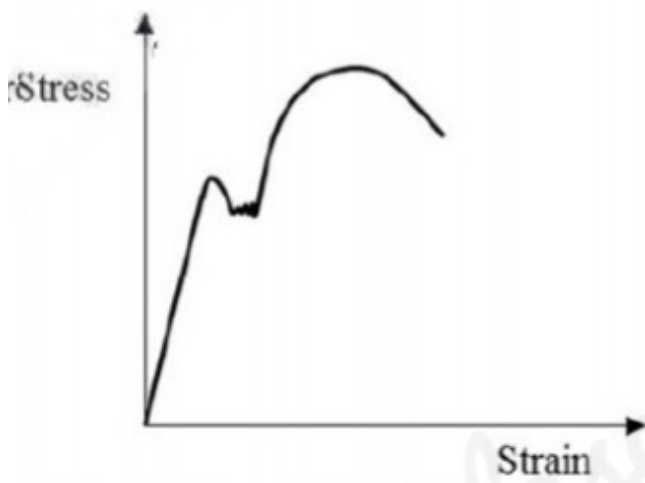
Answer: (A)

Q.No. 32 The ideal stress-strain behavior for a completely brittle material during tensile testing up to failure is described by





(C)



(D)

Answer: (B)

Q.No. 33 The divergence of the vector $\vec{v} = y^2\hat{i} + z^2\hat{j} + x^2\hat{k}$ is

- (A) $2x$
- (B) $2y$
- (C) $2z$
- (D) 0

Answer: (D)

Q.No. 34 The preparatory and miscellaneous codes used in CNC part programming and the functions are given in the Table.

Group I	Group II
P. G01	1. Circular interpolation, counter-clock wise
Q. G03	2. End of program
R. M06	3. Tool change
S. M02	4. Linear interpolation

The correct combination of code and the respective function is

- (A) P-4, Q-1, R-3, S-2
- (B) P-4, Q-1, R-2, S-3
- (C) P-1, Q-4, R-3, S-2
- (D) P-2, Q-1, R-3, S-4

Answer: (A)

Q.No. 35 The statement that best describes the function of a GO gauge in the context of Taylor's principle of gauging is

- (A) GO gauge checks the Maximum Material Condition and is designed to check as many dimensions as possible
- (B) GO gauge checks the Least Material Condition and is designed to check as many dimensions as possible
- (C) GO gauge checks the Maximum Material Condition and is designed to check only one dimension
- (D) GO gauge checks the Least Material Condition and is designed to check only one dimension

Answer: (A)

Q.No. 36 An approach used In product development which combines the efforts of design, manufacturing, and other functions to reduce the total time in introducing a new product in the market is

- (A) Concurrent engineering
- (B) Lean manufacturing
- (C) Value engineering
- (D) Break-even analysis

Answer: (A)

Q.No. 37 Accuracy of a measuring instrument is expressed as

- (A) true value — measured value
- (B) measured value — true value
- (C) $\$1 - \left| \frac{\text{true value} - \text{measured value}}{\text{true value}} \right| \$$
- (D) $\$1 + \left| \frac{\text{true value} - \text{measured value}}{\text{true value}} \right| \$$

Answer: (C)

Q.No. 38 With reference to Iron-Carbon equilibrium phase diagram, the Crystal structure of 0.3% plain carbon steel at 1,100°C is

- (A) HCP
- (B) BCT
- (C) BCC
- (D) FCC

Answer: (D)

Q.No. 39 A non-traditional machining process which utilizes mechanical energy as the principal energy source for removing the material is

- (A) Electric discharge machining
- (B) Laser beam machining
- (C) Ultrasonic machining
- (D) Plasma arc machining

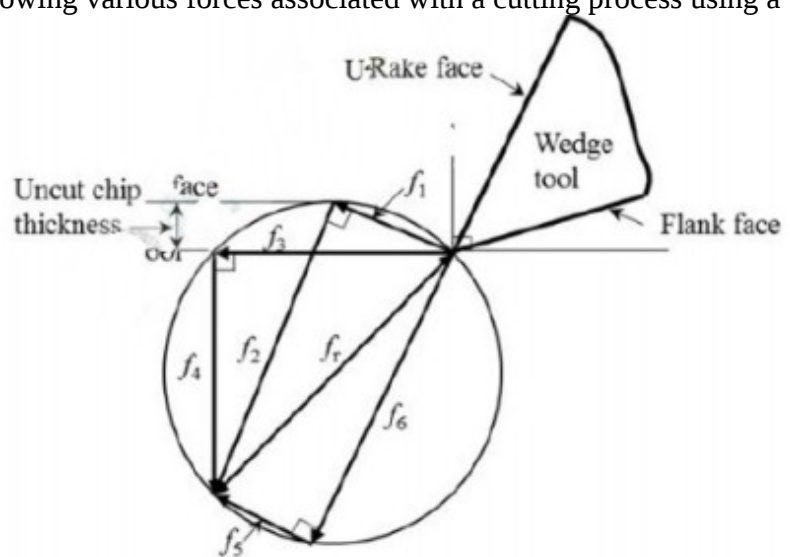
Answer: (C)

Q.No. 40 Which of the following is a causal forecasting method?

- (A) Naive approach
- (B) Moving average
- (C) Exponential smoothing
- (D) Linear regression

Answer: (D)

Q.No. 41 The Merchant circle diagram showing various forces associated with a cutting process using a



wedge-shaped tool is given in the Figure.
coefficient of friction can be estimated from the ratio

- (A) $\frac{f_1}{f_2}$
- (B) $\frac{f_3}{f_4}$

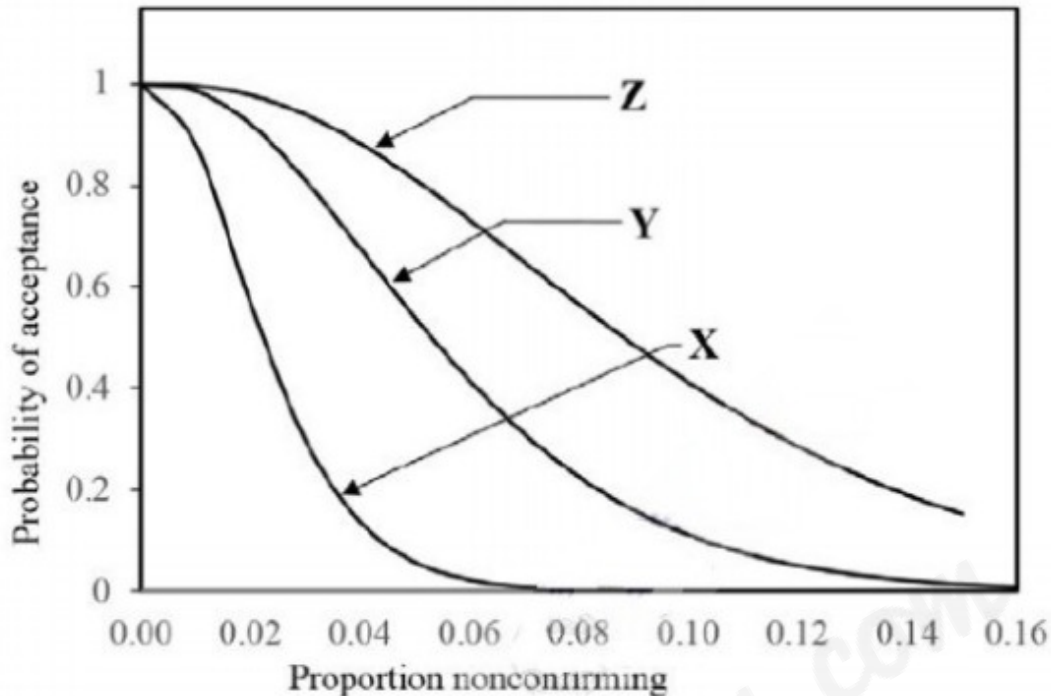
The

(C) $\frac{f_5}{f_6}$

(D) $\frac{f_6}{f_5}$

Answer: (D)

Q.No. 42 The operating characteristic curves of three single sampling plans X, Y and Z with same lot size and acceptance number are shown in the Figure.



Considering the above operating characteristic curves, the correct relationship of the plans with respect to sample size is

- (A) sample size of X < sample size of Y < sample size of Z
- (B) sample size of X = sample size of Y = sample size of Z
- (C) sample size of X > sample size of Y > sample size of Z
- (D) sample size of X > sample size of Y < sample size of Z

Answer: (C)

Q.No. 43 For any real, square and non-singular matrix B, the $\det \mathbf{B}^{-1}$ is

- (A) zero
- (B) $\det \mathbf{B}^{-1}$
- (C) $-(\det B)$
- (D) $\det B$

Answer: (B)

Q.No. 44 A 20 mm HSS drill with a point angle of 118° is used for drilling a through hole on a metallic plate of thickness 100 mm with a cutting speed of 333.33 mm/s and feed of 0.22 mm/rev. Assuming that the drill is touching the surface of the plate at the start, the drilling time (in s) is closest to

- (A) 85
- (B) 90

(C) 96

(D) 100

Answer: (B)

Q.No. 45 The process used for producing long bars of fiber reinforced plastics (FRP) with uniform cross-section is

(A) Extrusion

(B) Pultrusion

(C) Injection Molding

(D) Thermoforming

Answer: (B)

Q.No. 46 A firm, with a production target of 50,000 units/year, has the following data for the selection of a

Location	Fixed cost (Rs.)	Variable costs per unit (Rs.)
P	110,000	2
Q	95,000	2.5
R	80,000	3
S	75,000	3.5

new location for its plant
location for the firm is

The most economical

(A) P

(B) Q

(C) R

(D) S

Answer: (A)

Q.No. 47 If the Laplace transform of $e^{\rho t}$ is $\frac{1}{s-\omega}$ is the Laplace transform of $t \cos t$ is

(A) $\frac{1+s^2}{(s^2-1)^2}$

(B) $\frac{st}{(s^2-1)}$

(C) $\frac{1-s^2}{(s^2-1)^2}$

(D) $\frac{1+s^2}{1-s^2}$

Answer: (A)

Q.No. 48 In ASME process chart, the symbol represents

(A) operation

(B) inspection

(C) delay

(D) transport

Answer: (B)

Q.No. 49 The purpose of the ratchet in a micrometer is to

(A) impart smooth movement to the spindle

(B) compensate for the wear of the screw thread

(C) prevent rotation of the spindle while reading the scale

(D) maintain sufficient and uniform measuring pressure

Answer: (D)

Q.No. 50 An electrical appliances showroom sells 2,400 ceiling fans in one year (52 weeks). The holding cost is 10 % of the cost of the ceiling fan. The cost of one ceiling fan is Rs. 600. The cost incurred for placing an order is Rs. 201. There is a lead time of 5 weeks. The economic order quantity (EOQ) and the reorder level, respectively (rounded to the next higher integer) are

(A) 231, 127

(B) 38, 231

(C) 127, 231

(D) 127, 13

Answer: (C)

Q.No. 51 The man-hours required T_n to manufacture the nth unit in a plant is given by 1 where $b=0.322$ at the 80% learning rate. If the manufacturing time for the first unit T_1 is 80 man-hours, the total time (in man-hours) required to manufacture the first 4 units, at 80% learning rate, is

(A) 322.11

(B) 251.35

(C) 103.76

(D) 51.19

Answer: (B)

Q.No. 52 An integrating factor for the differential equation $\frac{dy}{dx} + my = e^{-mx}$ is

(A) em

(B) $e-m$

(C) $e-mx$

(D) emx

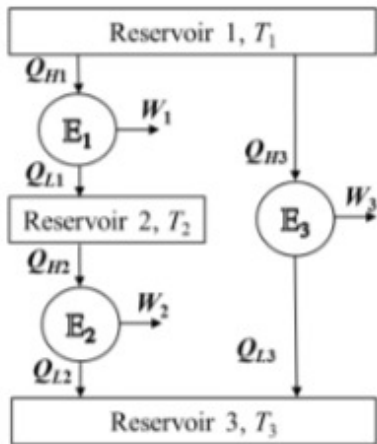
Answer: (D)

Q.No. 53 Self-sharpening tendency of a conventional grinding wheel depends upon

- (A) wheel structure
- (B) wheel grade
- (C) grit hardness
- (D) grit size

Answer: (B)

Q.No. 54 Three Carnot engines E_1 , E_2 , E_3 operate as shown in the figure ($T_1 > T_2 > T_3$)



The efficiency of the engine E_3 in terms of the efficiencies η_1 and η_2 of the engines E_1 and E_2 , respectively, is

- (A) $\eta_1 + \eta_2$
- (B) $\eta_1 + \eta_2 - \eta_1\eta_2$
- (C) $1 - \eta_1 - \eta_2$
- (D) $1 - \eta_1\eta_2$

Answer: (B)

Q.No. 55 REL chart is used in

- (A) Quality management
- (B) Inventory management
- (C) Facility management
- (D) Human resource management

Answer: (C)