





















**GATE 2022 Production and Industrial Engineering (PI)**

**Q.11 – Q.35 Carry ONE mark Each**

Q.11	If $\mathbf{a}$ , $\mathbf{b}$ and $\mathbf{c}$ are three vectors, the vector triple product $(\mathbf{a} \times \mathbf{b}) \times \mathbf{c}$ is given by
(A)	$(\mathbf{a} \cdot \mathbf{c})\mathbf{b} - (\mathbf{a} \cdot \mathbf{b})\mathbf{c}$
(B)	$(\mathbf{a} \cdot \mathbf{b})\mathbf{c} - (\mathbf{a} \cdot \mathbf{c})\mathbf{b}$
(C)	$(\mathbf{a} \cdot \mathbf{c})\mathbf{b} - (\mathbf{b} \cdot \mathbf{c})\mathbf{a}$
(D)	$(\mathbf{b} \cdot \mathbf{c})\mathbf{a} - (\mathbf{a} \cdot \mathbf{c})\mathbf{b}$
Q.12	The numerical integration of the function $y = 2x + 5$ is carried out between $x = 1$ and $x = 3$ , by using ordinates at $x = 1, 2$ and $3$ . Which one of the following statements is TRUE?
(A)	Simpson's 1/3 rule will provide exact result but trapezoidal rule will not.
(B)	Trapezoidal rule will provide exact result but Simpson's 1/3 rule will not.
(C)	Both Simpson's 1/3 and trapezoidal rules will provide exact result.
(D)	Neither Simpson's 1/3 rule nor trapezoidal rule will provide exact result.



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Q.13	Which one of the following metals has a face-centered cubic (FCC) structure?
(A)	Alpha iron
(B)	Chromium
(C)	Magnesium
(D)	Aluminum
Q.14	If $G$ denotes the shear modulus of an isotropic material, then the maximum possible value of Young's modulus of the material is
(A)	$G$
(B)	$2 G$
(C)	$3 G$
(D)	$4 G$



**GATE 2022 Production and Industrial Engineering (PI)**

Q.15 Match the casting methods with products.

Casting method		Products	
P	Continuous casting	1	Thin and intricate shaped components
Q	Investment casting	2	Hollow axisymmetric parts (such as pipes)
R	Centrifugal casting	3	Slabs and strips

(A) P-3, Q-1, R-2

(B) P-2, Q-3, R-1

(C) P-3, Q-2, R-1

(D) P-2, Q-1, R-3



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Q.16	In injection blow molding of plastic beverage bottles, the blowing is accomplished by
(A)	hot water
(B)	hot air
(C)	hot oil
(D)	alcohol
Q.17	In an electro-discharge machining process, the discharge voltage is $V_b$ . The energy dissipated per spark across the inter-electrode gap is proportional to
(A)	$V_b^{0.5}$
(B)	$V_b$
(C)	$V_b^2$
(D)	$V_b^3$



**GATE 2022 Production and Industrial Engineering (PI)**

Q.18

Match the codes used in CNC part programming with their functions.

Code		Function	
P	G91	1	End of program
Q	M02	2	Programming in incremental coordinates
R	G32	3	Spindle stop
S	M05	4	Thread cutting in turning

(A)

P-2, Q-3, R-4, S-1

(B)

P-2, Q-1, R-4, S-3

(C)

P-4, Q-1, R-2, S-3

(D)

P-4, Q-2, R-3, S-1

Q.19

The control chart for a number of defects in a welded joint is

(A)

$\bar{X}$  – chart

(B)

R – chart

(C)

c – chart

(D)

p – chart



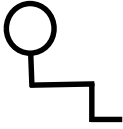

**GATE 2022 Production and Industrial Engineering (PI)**

Q.20	Which one of the following statements is TRUE?
(A)	Concurrent engineering is a non-integrated approach for designing a product.
(B)	Concurrent engineering carries out all product development functions in a sequential manner.
(C)	Concurrent engineering reduces the lead time for the product development.
(D)	Concurrent engineering increases the lead time for the product development.

**GATE 2022 Production and Industrial Engineering (PI)**

Q.21

Match the therblig symbols with their meanings.

Therblig symbol		Meaning	
P		1	Rest for overcoming fatigue
Q		2	Avoidable delay
R		3	Inspect
S		4	Search

(A)

P-4, Q-3, R-1, S-2

(B)

P-4, Q-3, R-2, S-1

(C)

P-3, Q-4, R-1, S-2

(D)


P-3, Q-4, R-2, S-1



**GATE 2022 Production and Industrial Engineering (PI)**

Q.22	Match the types of layout with the types of production.			
	<b>Type of layout</b>		<b>Type of production</b>	
	P	Process layout	1	Job production
	Q	Product layout	2	Batch production
R	Fixed position layout	3	Mass production	
(A)	P-2, Q-3, R-1			
(B)	P-3, Q-1, R-2			
(C)	P-2, Q-1, R-3			
(D)	P-3, Q-2, R-1			
Q.23	Matrix A as a product of two other matrices is given by			
	$A = \begin{bmatrix} 3 \\ 2 \end{bmatrix} \begin{bmatrix} 1 & 4 \end{bmatrix}.$			
	The value of $\det(A)$ is _____. [ <i>round off to nearest integer</i> ]			

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<p>Q.24</p>	<p>The order of the following differential equation is _____. [<i>in integer</i>]</p> $\left(\frac{dy}{dx}\right)^2 + 5\frac{dy}{dx} + 4y = 5x^3$
<p>Q.25</p>	<p>An operator manufactures 10 identical spur gears in a lot. One spur gear is defective in the lot. Three spur gears are drawn at random without replacement. The probability of getting all three gears as non-defective is _____. [<i>round off to two decimal places</i>]</p>
<p>Q.26</p>	<p>In a slider crank mechanism (schematic shown in the figure), the crank rotates at 60 revolutions per minute. The radius of the crank is 30 mm and the length of the connecting rod is 120 mm. The average speed (in mm/s) of the piston over one revolution of the crank is _____. [<i>round off to nearest integer</i>]</p>
	
<p>Q.27</p>	<p>Water (kinematic viscosity <math>\nu = 1 \times 10^{-6} \text{ m}^2/\text{s}</math>) is flowing through a circular horizontal pipe of diameter 8 mm. If the flow is laminar and fully developed with a maximum axial velocity of 0.5 m/s, the Reynolds number is _____. [<i>round off to nearest integer</i>]</p>



**GATE 2022 Production and Industrial Engineering (PI)**

Q.28	Yielding starts in a material when the principal stresses are 100 MPa, 100 MPa and 200 MPa. As per the von Mises criterion, yield stress (in MPa) of the material is _____. [ <i>round off to nearest integer</i> ]
Q.29	A single-point cutting tool with zero rake angle is used for orthogonal machining. If the chip-compression ratio is 1.25, then the shear angle (in degree) during machining is _____. [ <i>round off to one decimal place</i> ]
Q.30	It is required to cut a single-start thread of 2 mm pitch in a lathe machine with a single-start lead screw of 4 mm pitch. For one revolution of the workpiece, the number of revolution of the lead screw is _____. [ <i>round off to two decimal places</i> ]
Q.31	The absolute deviations of 8 points from the datum line of a surface are 10, 15, 12, 10, 13, 12, 20 and 25 $\mu\text{m}$ . The root mean square value of the surface roughness (in $\mu\text{m}$ ) is _____. [ <i>round off to one decimal place</i> ]



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Q.32	In a machine there are two motors, but only one motor is needed for the functioning of the machine. The reliabilities of the motors are 0.90 and 0.70. The overall reliability of the machine is _____. [ <i>round off to two decimal places</i> ]
Q.33	If the interarrival time is exponential and 8 customers per hour arrive in a bank, then the probability of no arrival of customer during a period of 15 minutes is _____. [ <i>round off to two decimal places</i> ]
Q.34	A company buys a machine worth ₹ 65000, which has a salvage value of ₹ 5000. The annual depreciation cost is ₹ 10000 based on the straight line depreciation method. The useful life (in year) of the machine is _____. [ <i>in integer</i> ]



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Q.35

A project comprises of seven activities. The expected durations of activities and their variances are as follows:

Activity	Expected duration (minute)	Variance (minute)
A	4	1
B	5	1
C	4	1
D	1	0
E	7	4
F	6	1
G	8	4

The critical path consists of activities B, E and G. The standard deviation (in minute) of the project duration is \_\_\_\_\_. [*round off to two decimal places*]

**Q.36 – Q.65 Carry TWO marks Each**

Q.36

If a matrix is squared, then

(A)

both eigenvalues and eigenvectors must change

(B)

both eigenvalues and eigenvectors are retained

(C)

eigenvalues get squared but eigenvectors are retained

(D)

eigenvalues are retained but eigenvectors change

**GATE 2022 Production and Industrial Engineering (PI)**

Q.37	<p>Consider the following ordinary differential equation:</p> $4 \frac{d^2 y}{dx^2} - 4 \frac{dy}{dx} + y = 0.$ <p>Given that <math>c_1</math> and <math>c_2</math> are constants, the general solution of the differential equation is</p>
(A)	$y = (c_1 + c_2 x) e^x$
(B)	$y = c_1 e^{x/2} + c_2 e^x$
(C)	$y = c_1 e^x + c_2 e^{2x}$
(D)	$y = (c_1 + c_2 x) e^{x/2}$



**GATE 2022 Production and Industrial Engineering (PI)**

Q.38	A market survey with a sample size of 1000 was conducted for a parameter that follows normal distribution. The confidence interval was estimated as [500, 700] with a mean of 600. It is now desired to reduce the confidence interval to [550, 650]. The sample size for achieving the desired interval at the same confidence level is
(A)	1000
(B)	4000
(C)	9000
(D)	16000



**GATE 2022 Production and Industrial Engineering (PI)**

Q.39

A eutectoid steel with 100% austenite is cooled from a temperature of 750 °C to a room temperature of 35 °C. Match the cooling methods with transformed structures.

Cooling method		Transformed structure	
P	Water quenching	1	Coarse pearlite
Q	Oil quenching	2	Fine pearlite
R	Air cooling	3	Martensite
S	Furnace cooling	4	Very fine pearlite

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

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

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

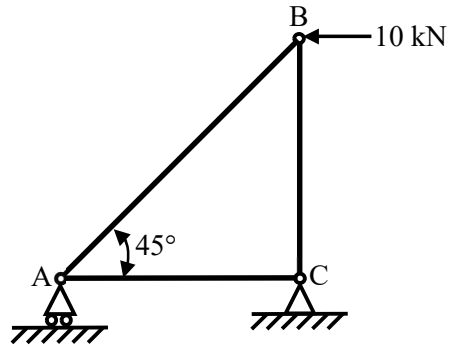
(D) P-3, Q-4, R-1, S-2



**GATE 2022 Production and Industrial Engineering (PI)**

Q.40

In the three-member truss shown in the figure,  $AC = BC$ . An external force of 10 kN is applied at B, parallel to AC. The force in the member BC is



(A)

zero

(B)

10 kN (tensile)

(C)

10 kN (compressive)

(D)

7.07 kN (tensile)



**GATE 2022 Production and Industrial Engineering (PI)**

Q.41

Match the processing steps related to production of powder metallurgy parts with their descriptions.

Processing step		Description	
P	Atomization	1	Blended powders are pressed into shapes using dies and pressure
Q	Sintering	2	A process for producing metal powder
R	Compaction	3	Metal powders are heated below their melting points to allow bonding
S	Infiltration	4	A slug of low melting point metal is placed in contact with the sintered part and heated
		5	Metal powders are heated significantly above their melting points for bonding

(A) P-1, Q-5, R-2, S-3

(B) P-3, Q-2, R-1, S-5

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

(D) P-2, Q-5, R-1, S-4



**GATE 2022 Production and Industrial Engineering (PI)**

<p>Q.42</p>	<p>In an assembly comprising shaft and hole, the nominal sizes with tolerances are specified as</p> <p>Hole: <math>25.000^{+0.002}_{-0.001}</math> mm,</p> <p>Shaft: <math>25.000^{+0.001}_{-0.003}</math> mm.</p> <p>The type of fit is</p>
(A)	Clearance fit
(B)	Interference fit
(C)	Transition fit
(D)	Running fit
<p>Q.43</p>	<p>In a manufacturing system, four different types of products (P, Q, R and S) are produced. The batch size of each product is <math>2 \times 10^7</math>. The numbers of defective units are 60, 71, 80 and 55, for P, Q, R and S, respectively. Which one of the following statements is TRUE?</p>
(A)	All products conform to six sigma standard.
(B)	Only product S conforms to six sigma standard.
(C)	Except R, all other products conform to six sigma standard.
(D)	Products P and S conform to six sigma standard.



**GATE 2022 Production and Industrial Engineering (PI)**

Q.44	Match the processes of product development with their characteristics.																				
	<table border="1"> <thead> <tr> <th colspan="2">Process</th> <th colspan="2">Characteristic</th> </tr> </thead> <tbody> <tr> <td>P</td> <td>Product synthesis</td> <td>1</td> <td>Process of conversion of conceptual design into engineering science based model</td> </tr> <tr> <td>Q</td> <td>Product simplification</td> <td>2</td> <td>Process related to design conceptualization</td> </tr> <tr> <td>R</td> <td>Product analysis</td> <td>3</td> <td>Process of maintaining uniformity and consistency</td> </tr> <tr> <td>S</td> <td>Product standardization</td> <td>4</td> <td>Process of reducing the number of parts without losing the functionalities</td> </tr> </tbody> </table>	Process		Characteristic		P	Product synthesis	1	Process of conversion of conceptual design into engineering science based model	Q	Product simplification	2	Process related to design conceptualization	R	Product analysis	3	Process of maintaining uniformity and consistency	S	Product standardization	4	Process of reducing the number of parts without losing the functionalities
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(A)	P-2, Q-4, R-1, S-3																				
(B)	P-2, Q-3, R-1, S-4																				
(C)	P-4, Q-3, R-1, S-2																				
(D)	P-4, Q-3, R-2, S-1																				



**GATE 2022 Production and Industrial Engineering (PI)**

<p>Q.45</p>	<p>The value of</p> $\lim_{x \rightarrow 1} \frac{x^3 - 3x + 2}{x^3 - x^2 - x + 1}$ <p>is _____ . [round off to one decimal place]</p>
<p>Q.46</p>	<p>A thick-cylinder has inner diameter of 20 mm and outer diameter of 40 mm. It is subjected to an internal pressure of 100 MPa. Follow the convention of taking tensile stress as positive and compressive stress as negative. The sum of radial and hoop stresses (in MPa) at a radius of 15 mm is _____ . [round off to two decimal places]</p>
<p>Q.47</p>	<p>A shaft is used to transmit a power of 10 kW. The shear yield stress of the material is 150 MPa and factor of safety is 2. The shaft rotates at 1440 revolutions per minute. The diameter of the shaft (in mm) based on static strength is _____ . [round off to two decimal places]</p>
<p>Q.48</p>	<p>Air at an initial temperature and pressure of 15 °C and 1 bar, respectively is heated in an irreversible process. The final temperature and pressure are 303 °C and 2 bar, respectively. Take gas constant for air as <math>R = 287 \text{ J/kg-K}</math>, the ratio of the specific heats as <math>\gamma = 1.4</math>, and treat air as a calorically perfect gas. The change of entropy (in J/kg-K) in the process is _____ . [round off to nearest integer]</p>

**GATE 2022 Production and Industrial Engineering (PI)**

Q.49	During a hot-working process, the homologous temperature is 0.8. The melting point of the work metal is 800 °C. The temperature (in °C) during hot-working is _____. [ <i>round off to nearest integer</i> ]
Q.50	A workpiece of 30 mm diameter and 40 mm height is compressed between two platens in an open die forging process. Assume a perfectly plastic material with a flow stress of 300 MPa. The ideal forging load (in kN) at 30% reduction (in height) is _____. [ <i>round off to nearest integer</i> ]
Q.51	In a gas tungsten arc welding process under steady state condition, the input voltage and current are measured as 18 V and 160 A, respectively. Heat loss during creation of arc is 40% of the input power. Heat loss through convection and radiation from the workpiece is 800 W. The effective power (in W) utilized to melt the workpiece is _____. [ <i>round off to nearest integer</i> ]
Q.52	During straight turning of a 20 mm diameter steel bar at a spindle speed of 400 revolutions per minute (RPM) with an HSS tool, a tool life of 10 minute was observed. When the same bar was turned at 200 RPM, the tool life increased to 40 minute. The tool life (in minute) while machining the bar at 300 RPM is _____. [ <i>round off to nearest integer</i> ]

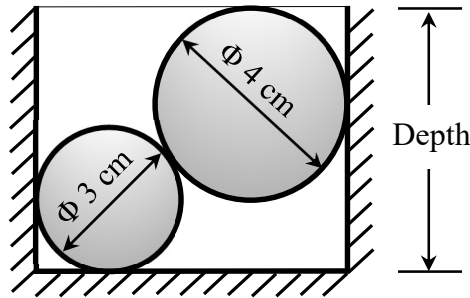
**GATE 2022 Production and Industrial Engineering (PI)**

Q.53	A cylindrical workpiece is turned using two different tools. Tool 1 has zero nose radius; side and end cutting edge angles are $20^\circ$ and $10^\circ$ , respectively. Tool 2 has 0.5 mm nose radius. Both the tools machine at a feed of 0.2 mm/rev. The ratio of ideal maximum height of unevenness on the surface produced by Tool 1 to that produced by Tool 2 is _____. [round off to one decimal place]
Q.54	For an electrochemical machining process $\frac{dy}{dt} = \frac{\lambda}{y} - f,$ where $y$ is the inter-electrode gap in mm at time $t$ in minute, and $f$ is the feed of the tool in mm/minute. The value of $\lambda$ is $6 \times 10^{-3} \text{ cm}^2/\text{minute}$ . For maintaining a constant inter-electrode gap of 0.1 mm, the feed (in mm/minute) should be _____. [round off to one decimal place]
Q.55	The worktable of an open loop positioning system is driven by a lead screw with a pitch of 4 mm. The lead screw is connected to the shaft of a stepper motor. A gear of 80 teeth mounted on the stepper motor shaft meshes with a gear of 20 teeth mounted on the lead screw. The step angle of the stepper motor is $9^\circ$ . The number of pulses required to move the table by 200 mm is _____. [in integer]

**GATE 2022 Production and Industrial Engineering (PI)**

Q.56

The diameter of a cylindrical cavity is measured by using two spherical steel balls of diameters 3 cm and 4 cm. The balls are placed inside the cavity such that the bigger ball is above the smaller one as shown in the figure. If the depth of cavity is 6 cm, then the diameter (in cm) of cavity is \_\_\_\_\_. [round off to two decimal places]



Q.57

In a mobile screen manufacturing process on a mass scale basis, 5 samples of size 80 are inspected. Consider a p-chart with  $\pm 3\sigma$  limits ( $\sigma$  is the standard deviation). The numbers of defective items are given in the table.

Sample No.	Number of defective items
1	4
2	10
3	5
4	6
5	5

The upper control limit of the defective item (in fraction defective) is \_\_\_\_\_. [round off to two decimal places]





**GATE 2022 Production and Industrial Engineering (PI)**

Q.58	<p>In a factory, 100 bulbs are in use. The table lists the cumulative probability of the failure of a bulb for various durations.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Duration (month)</th> <th>Cumulative probability</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0.10</td> </tr> <tr> <td>2</td> <td>0.25</td> </tr> <tr> <td>3</td> <td>0.47</td> </tr> <tr> <td>4</td> <td>0.68</td> </tr> <tr> <td>5</td> <td>1.00</td> </tr> </tbody> </table> <p>The factory follows the individual replacement policy. If the cost of replacing a bulb is ₹ 300, then the expected cost (in ₹) of replacement per month is _____. [round off to nearest integer]</p>	Duration (month)	Cumulative probability	1	0.10	2	0.25	3	0.47	4	0.68	5	1.00
Duration (month)	Cumulative probability												
1	0.10												
2	0.25												
3	0.47												
4	0.68												
5	1.00												
Q.59	<p>A company procures 384 parts annually. The annual holding cost per part is ₹ 30. If the ordering cost is ₹ 1000, then the economic order quantity is _____. [in integer]</p>												

**GATE 2022 Production and Industrial Engineering (PI)**

Q.60

A time study engineer recorded the cycle time (in minute) for machining of a component. The recorded time study data is provided in the table. The performance rating of the worker is 110%. The standard time for machining (in minute) the component by assuming 10% allowance is \_\_\_\_\_. [*round off to nearest integer*]

Time study data	
Cycle time (minute)	Frequency
42	1
43	2
44	3
45	2
46	1

Q.61

A machine component is to be processed at 5 workstations sequentially. The table provides the cycle time (in second) of each workstation. In mass production, the number of components produced per hour (in steady state) is \_\_\_\_\_. [*in integer*]

Workstation	Cycle time of each workstation (second)
WS-1	85
WS-2	55
WS-3	90
WS-4	65
WS-5	70

**GATE 2022 Production and Industrial Engineering (PI)**

Q.62

A vaccine has to be distributed from two warehouses to three hospitals. The supplies at warehouses  $W_1$  and  $W_2$  are 200 and 150, respectively. The demands at hospitals  $H_1$ ,  $H_2$ , and  $H_3$  are 100, 150 and 125, respectively. The transportation cost (in ₹) per vaccine is as follows:

	$H_1$	$H_2$	$H_3$
$W_1$	5	7	3
$W_2$	4	6	7

The initial basic feasible solution using the Northwest-corner method provides the total transportation cost (in ₹) as \_\_\_\_\_. [round off to nearest integer]

Q.63

Consider the linear programming problem:

$$\text{Maximize } z = 20x_1 + 6x_2 + Px_3,$$

subject to

$$8x_1 + 2x_2 + 3x_3 \leq 250, \quad (C_1)$$

$$4x_1 + 3x_2 \leq 150, \quad (C_2)$$

$$2x_1 + x_3 \leq 50, \quad (C_3)$$

$$x_1, x_2, x_3 \geq 0.$$

The optimal solution is given as  $x_1^* = 0$ ,  $x_2^* = 50$  and  $x_3^* = 50$ . The dual variables of constraints  $C_1$ ,  $C_2$  and  $C_3$  are  $y_1$ ,  $y_2$  and  $y_3$ , respectively. The optimal values of dual variables are  $y_1^* = 0$ ,  $y_2^* = 2$  and  $y_3^* = 8$ . The value of parameter  $P$  in the objective function is \_\_\_\_\_. [round off to one decimal place]

**GATE 2022 Production and Industrial Engineering (PI)**

Q.64	A company is planning to produce 24 electric cars per day. The setup cost of the plant is estimated as ₹ 19476 million and the variable cost is ₹ 0.6 million per car. The car will be sold at a price of ₹ 1.5 million. The number of days required for achieving the breakeven is _____. [ <i>round off to nearest integer</i> ]
Q.65	A company forecasts the weekly demand of oxygen cylinders using exponential smoothing method with smoothing constant $\alpha = 0.2$ . The actual demands in Week 1, Week 2, Week 3 and Week 4 were 375, 412, 592 and 439 units, respectively. The forecasted demand for Week 3 was 500 units. The forecast (in unit) for the Week 5 is _____. [ <i>in integer</i> ]