PI : PRODUCTION AND INDUSTRIAL ENGINEERING-2024

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Genral Aptitude:GA

Q.1 – Q.5 carry one mark each

1) If → denotes increasing order of intensity, then the meaning of the words [sick → infirm → moribund] is analogous to [silly → _____ → daft].
Which one of the given options is appropriate to fill the blank? (GATE 2024)

a) frown b) fawn c) vein d) vain

2) The 15 parts of the given figure are to be painted such that no two adjacent parts with shared boundaries (excluding corners) have the same color. The minimum number of colors required is (GATE 2024)

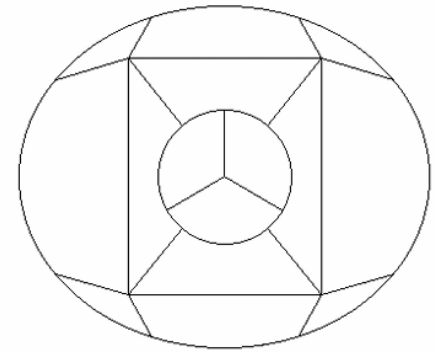


Fig. 2.

a) 4 b) 3 c) 5 d) 6

3) How many 4-digit positive integers divisible by 3 can be formed using only the digits {1, 3, 4, 6, 7}, such that no digit appears more than once in a number? (GATE 2024)

a) 24 b) 48 c) 72 d) 12

4) The sum of the following infinite series is

$$2+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{8}+\frac{1}{9}+\frac{1}{16}+\frac{1}{27}+\cdots$$

(GATE 2024)

a) 11/3 b) 7/2 c) 13/4 d) 9/2

5) In an election, the share of valid votes received by the four candidates A, B, C, and D is represented by the pie chart shown. The total number of votes cast in the election were 1,15,000, out of which 5,000 were invalid.

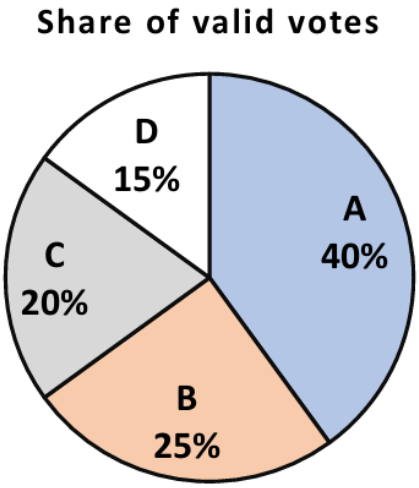


Fig. 5. Share of valid votes

Based on the data provided, the total number of valid votes received by the candidates B and C is (GATE 2024)

a) 45,000 b) 49,500 c) 51,750 d) 54,000

6) Thousands of years ago, some people began dairy farming. This coincided with a number of mutations in a particular gene that resulted in these people developing the ability to digest dairy milk.
Based on the given passage, which of the following can be inferred? (GATE 2024)

a) All human beings can digest dairy milk.
b) No human being can digest dairy milk.
c) Digestion of dairy milk is essential for human beings.
d) In human beings, digestion of dairy milk resulted from a mutated gene.

7) The probability of a boy or a girl being born is 1/2. For a family having only three children, what is the probability of having two girls and one boy? (GATE 2024)

a) 3/8 b) 1/8 c) 1/4 d) 1/2

8) Person 1 and Person 2 invest in three mutual funds A, B, and C. The amounts they invest in each of these mutual funds are given in the table.

	Mutual fund A	Mutual fund B	Mutual fund C
person 1	10,000	20,000	20,000
person 2	20,000	10,000	10,000

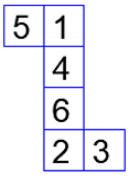
At the end of one year, the total amount Person 1 get a 500 more than Person2. The annual rate of return on one person (GATE 2024)

a) 7.5% b) 10% c) 15% d) 20%

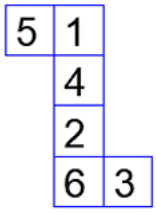
9) Three different views of a dice are shown in the figure below.

The piece of paper that can be folded to make this dice is (GATE 2024) The piece of paper that can be folded to make this dice is (GATE 2024)

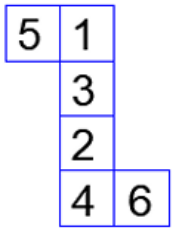
a)



b)



c)



d)

5	1
	4
	6
3	2

10) Visualize two identical right circular cones such that one is inverted over the other and they share a common circular base. If a cutting plane passes through the vertices of the assembled cones, what shape does the outer boundary of the resulting cross-section make? (GATE 2024)

a) A rhombus b) A triangle c) An ellipse d) A hexagon

11) In the Taylor series expansion of $\sin z$ around $z = 0$, the coefficient of the term z^3 is (GATE 2024)

a) 0 b) $1/3$ c) $-1/6$ d) $-1/3$

12) A vector field is given as $\mathbf{F}(x, y) = (100x + 100y)\,\hat{i} + (-50x + 200y)\,\hat{j}$, where $\hat{i}$ and $\hat{j}$ are the unit vectors along the x and y axes in the Cartesian frame, respectively. Then the value of

$$\oint_C \mathbf{F}(x, y) \cdot d\mathbf{l}$$

where $d\mathbf{l} = dx\,\hat{i} + dy\,\hat{j}$ is an elemental path taken over an anticlockwise circular contour C of radius $r = 2$ is

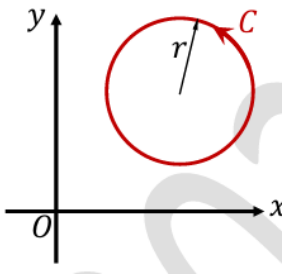


Fig. 12.

a) -100π b) -800π c) -400π d) 400π

13) A uniform cantilever beam of length L and flexural rigidity EI is loaded by a force F as shown in the figure. Assuming that the Euler-Bernoulli beam theory is applicable here, the magnitude of the static deflection at the free end of the beam is

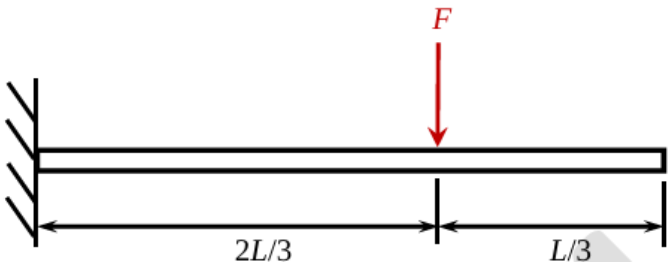


Fig. 13.

a) $\frac{FL^3}{6EI}$ b) $\frac{14FL^3}{81EI}$ c) $\frac{5FL^3}{27EI}$ d) $\frac{7FL^3}{48EI}$

14) A thin copper wire carries electric current and is insulated by putting a sleeve, of thickness t, over it. In steady state conditions, the rate of heat loss from the insulated wire per unit length is Q. Which of the following is TRUE? (GATE 2024)

a) Q increases monotonically with t.
b) Q decreases monotonically with t.
c) Q first increases with increase in t, and then it decreases with further increase in t.
d) Q first decreases with increase in t, and then it increases with further increase in t.

15) The solidification time of a cube and a cylinder of the same material, produced through the same sand casting process, is found to be equal. Each side of the cube is a, and the radius and the length of the cylinder are r and $4r$, respectively. If the solidification time is governed by Chvorinov's equation, then the ratio r/a is (GATE 2024)

a) 1/3 b) 5/12 c) 7/12 d) 5/9

16) Match each of the listed defects in deep drawing cup with the corresponding reason in the table.

Defect in deep drawing cup	**Reason**
P. Orange peel on the surface of cup	1. No blank holding force
Q. Wrinkling at the flange of cup	2. Very small corner radius of the punch
R. Tearing at the bottom corner of cup	3. Large grain size in the blank material
S. Earring at the top edge of the cup	4. Anisotropy of the blank material

a) P-3, Q-4, R-2, S-1 b) P-4, Q-1, R-3, S-2 c) P-3, Q-1, R-2, S-4 d) P-2, Q-3, R-1, S-4

17) Which one of the following pure metals has the hexagonal close packed (HCP) crystal structure at room temperature? (GATE 2024)

a) Magnesium b) Iron c) Aluminium d) Copper

18) To create 12 divisions on a disc by using simple indexing and dividing head on a horizontal milling machine, choose the correct option for the rotation of the crank pin. (GATE 2024)

a) 3 full rotations and 5 holes on a 15-hole circle
b) 5 full rotations and 4 holes on a 16-hole circle
c) 3 full rotations and 5 holes on a 18-hole circle
d) 5 full rotations and 4 holes on a 20-hole circle

19) The following layout of four departments P, Q, R and S is provided as input to CRAFT (Computerized Relative Allocation of Facilities Technique). Which one of the following department pairs cannot be considered for exchange in CRAFT?

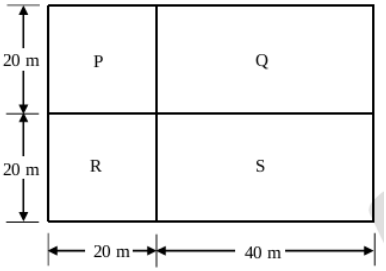


Fig. 19.

a) P and Q
b) R and S
c) P and R
d) Q and R

20) Which of the following concepts is **not** closely inter-related with **INTERCHANGEABILITY** in the context of product design? (GATE 2024)

a) Standardization
b) Simplification
c) Diversification
d) Specialization

21) Which one of the following THERBLIGS does not advance the progress of the work and can be eliminated by applying the principles of motion economy? (GATE 2024)

a) Move
b) Grasp
c) Search
d) Preposition

22) If work sampling is carried out using a large number of observations, then the required sample size is estimated using (GATE 2024)

a) Poisson distribution
b) Uniform distribution
c) Normal distribution
d) Exponential distribution

23) Which of the following is NOT an assumption of a linear programming problem? (GATE 2024)

a) Proportionality b) Additivity c) Integrality d) Certainty

24) In a single server Markovian queuing system, if the customers arrive following the Poisson distribution, then the inter-arrival time follows (GATE 2024)

a) Poisson distribution
b) Uniform distribution
c) Exponential distribution
d) Binomial distribution

25) Which one of the following methods requires the least amount of data for forecasting? (GATE 2024)

a) Econometric forecasting method
b) Linear regression method
c) ARIMA method
d) Simple exponential smoothing method

26) Which one of the following is not true about Total Productive Maintenance (TPM)? (GATE 2024)

a) It allows operators to perform preventive maintenance on the machines.
b) It allows operators to perform reactive maintenance on the machines.
c) It is consistent with the Just-in-Time (JIT) system.
d) It is consistent with the Lean system.

27) In a complex function

$$f(x, y) = u(x, y) + i\, v(x, y),$$

i is the imaginary unit, and x, y, $u(x, y)$ and $v(x, y)$ are real.
If $f(x, y)$ is analytic then which of the following equations is/are TRUE? (GATE 2024)

a) $\dfrac{\partial^2 u}{\partial x^2} + \dfrac{\partial^2 u}{\partial y^2} = 0$

b) $\dfrac{\partial^2 v}{\partial x^2} + \dfrac{\partial^2 v}{\partial y^2} = 0$

c) $\dfrac{\partial^2 u}{\partial x^2} + \dfrac{\partial^2 v}{\partial y^2} = 0$

d) $\left(\dfrac{\partial u}{\partial x}\right)\left(\dfrac{\partial v}{\partial x}\right) + \left(\dfrac{\partial u}{\partial y}\right)\left(\dfrac{\partial v}{\partial y}\right) = 0$

28) For a mild steel specimen subjected to uniaxial tensile load, which of the following is/are TRUE? (GATE 2024)
   a) The engineering stress-strain curve is linear within the elastic limit.
   b) The specimen fails in cup and cone type fracture.
   c) The true stress is always more than the engineering stress at any finite strain.
   d) The specimen does not regain its original dimensions after complete unloading from an initial stress above the yield stress.

29) Which among the following is/are TRUE for friction stir welding (FSW) process? (GATE 2024)
   a) It can be used to produce lap, butt and tee joints.
   b) A non-consumable rotating tool with shoulder and pin is used to melt the work-piece material.
   c) Retreating side of the weld is where the linear velocity vector at a point on that side of the rotating tool and the welding direction are opposite.
   d) Advancing side of the weld is where the linear velocity vector at a point on that side of the rotating tool and the welding direction are opposite.

30) Which of the following areas is/are supply chain decision(s)? (GATE 2024)

   a) Location b) Inventory c) Distribution d) Machine scheduling

31) If X is a continuous random variable with the probability density function

$$f(x) = \begin{cases} \frac{K}{4}, & 0 \le x \le 1 \\ 0, & \text{otherwise} \end{cases}$$

   then the value of K is _____. *(Answer in integer)*

32) If

$$\lim_{x \to \infty} \left(\frac{x^2 - 2ax + b}{x - 1} \right) = 8$$

   then $(a - b)$ is _____. *(Answer in integer)*

33) In the truss shown in the figure, member AC is an inextensible string, other members are rigid, and ABCD is a square with each side of length a. The maximum value of force F (in kN) for which the truss will remain in static equilibrium is _____. *(Rounded off to 2 decimal places)*

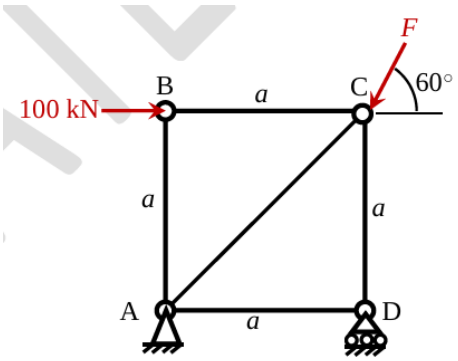


Fig. 33.

34) An offset slider-crank mechanism is shown in the figure. If the length l = 10 cm, then the stroke length (in cm) of the slider is _____. *(Rounded off to 1 decimal place)*

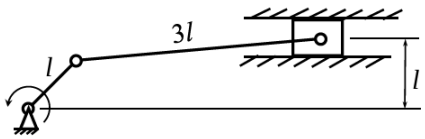


Fig. 34.

35) A blank of 100 mm diameter is to be cut out of a 2 mm thick sheet through blanking operation. If the radial clearance between the punch and die is 6% of the sheet thickness then the diameter (in mm) of the punch is _____. *(Rounded off to 2 decimal places)*

Q.36 – Q.65 carry two mark each

36) If $\mathbf{A} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$ such that $\mathbf{A}^2 = \mathbf{I}$, where $\mathbf{I}$ is an identity matrix, then which of the following is TRUE? (GATE 2024)

a) $1 + a^2 + bc = 0$ b) $1 - a^2 + bc = 0$ c) $1 - a^2 - bc = 0$ d) $1 + a^2 - bc = 0$

37) In the iron-carbon equilibrium phase diagram, the temperature and composition of the eutectoid point are 727C and 0.77 weight % carbon, respectively. If a steel specimen with 1.2 weight % carbon is cooled from 1000C to the room temperature, then the fraction of pro-eutectoid cementite phase in the steel is _____. *(Rounded off to 2 decimal places)*

a) 0.07 b) 0.93 c) 0.18 d) 0.12

38) For polymers, match each process with the most suitable application listed.

Process		**Application**	
P	Extrusion	1	Producing complex parts with close tolerance
Q	Injection molding	2	Producing thermosetting plastic components
R	Blow molding	3	Producing long uniform sections
S	Compression molding	4	Producing hollow shapes

a) P-3, Q-1, R-2, S-4 b) P-2, Q-3, R-4, S-1 c) P-4, Q-2, R-1, S-3 d) P-3, Q-1, R-4, S-2

39) In a forming operation, the plastic deformation of a steel specimen starts under plane stress condition, where the principal stresses are σ_1 = 200 MPa and σ_2 = 100 MPa. If the steel specimen follows von-Mises yield criterion, then the uniaxial tensile yield strength (in MPa) of this steel material is _____. *(Rounded off to 1 decimal place)*

a) 173.2 b) 200.0 c) 100.0 d) 223.6

40) Match the configurations of the listed 3 degrees-of-freedom industrial robots with the type of joints.

Configuration		**Type of joints**	
P	Cartesian	1	One prismatic and two rotary
Q	Cylindrical	2	Three rotary
R	Spherical	3	Two prismatic and one rotary
S	Articulated	4	Three prismatic

a) P-3, Q-1, R-2, S-4 b) P-4, Q-3, R-1, S-2 c) P-4, Q-2, R-1, S-3 d) P-3, Q-1, R-4, S-2

41) A project has six activities and the precedence relationship among them is shown in the table.

Activity	Precedent activities
A	None
B	None
C	None
D	A, B
E	B, C
F	A, B

The minimum number of dummy activities needed to draw an activity-on-arrow (AOA) representation of the project network is (GATE 2024)

a) 0 b) 1 c) 2 d) 3

42) Consider the following linear programming problem with two decision variables x_1 and x_2. There are three constraints involving resources R1, R2 and R3 as indicated.
Maximize $Z = 6x_1 + 5x_2$
Subject to
$2x_1 + 5x_2 \leq 40$ R1
$2x_1 + x_2 \leq 22$ R2
$x_1 + x_2 \leq 13$ R3
$x_1 \geq 0, \quad x_2 \geq 0$
The optimal solution of the problem is: $x_1 = 9$ and $x_2 = 4$.
For which one of the following options, the shadow price of the resource(s) will have non-zero value(s)? (GATE 2024)

a) R1, R2 and R3 b) R1 and R2 c) R2 and R3 d) R1 only

43) Choose the item(s) which is/are required to make an eccentric hole on a disc, as shown, using a lathe.

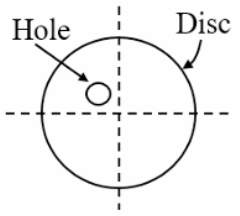


Fig. 43.

(GATE 2024)

a) Single point cutting tool
b) Four jaw chuck
c) Drill bit
d) Three jaw chuck

44) Which of the following statement(s) is/are TRUE for a given acceptance sampling plan? (GATE 2024)

a) Type II error decreases with an increase in type I error.
b) The probability of rejecting a good quality lot is producer's risk.
c) Type II error decreases with a decrease in sample size.
d) The probability of rejecting a good quality lot is consumer's risk.

45) Seven cards numbered 1 to 7 are placed in a box. After thoroughly mixing all the cards, one card is drawn at random. (GATE 2024)
If it is known that the number on the card drawn is odd, then the probability that the number on the card drawn is greater than 4 is _____ %. *(Answer in integer)*

46) The following differential equation governs the evolution of variable $x(t)$ with time t, $t \geq 0$.

$$\frac{d^2x}{dt^2} + 4x = e^{-t}$$

Given the initial conditions $x = 0$ and $\frac{dx}{dt} = 0$ at $t = 0$, the value of x at $t = \pi/8$ is _____ . *(Rounded off to 3 decimal places)* (GATE 2024)

47) The values of function $y(x)$ at discrete values of x are given in the table. The value of $\int_0^4 y(x)\,dx$, using Trapezoidal rule is _____ . *(Rounded off to 1 decimal place)*

x	0	1	2	3	4
$y(x)$	1	3	6	9	12

(GATE 2024)

48) An irrigation pump is used to draw water from a pond. One end of a 5.05 cm diameter hose pipe is connected to the outlet of the pump at 1.02 m below the surface level, and just after the pump, the static gauge pressure and flow rate of the water are 50 kPa and 8 kg/s, respectively. The pumped water is discharged at the ground level through a nozzle. Assume that the flow through the hose pipe and nozzle is steady and laminar, and frictional and viscous losses are negligible. The density of water is 1000 kg/m^3 and the acceleration due to gravity is 9.81 m/s^2. If the static pressure at the nose/exit of the nozzle just reduces to atmospheric pressure then the nose diameter (in cm) of the nozzle is _____. *(Rounded off to 2 decimal places)* (GATE 2024)

49) In an air-standard Otto cycle, the pressure and temperature of air just before the compression stroke are 200 kPa and 26.85°C, respectively. The combustion process is assumed to be a constant volume process, where 1.02 MJ/kg heat is added. The cycle efficiency is 50%. The adiabatic index γ and specific heat at constant volume c_v can be considered to be constant during the process (corresponding values taken from cycle temperature).
Assuming that the ideal gas law is applicable, $\gamma = 4/3$ and $c_p = 0.85$ kJ/kg-K, the maximum pressure (in MPa) reached during the cycle is _____. *(Rounded off to 1 decimal place)* (GATE 2024)

50) A metallic cylindrical pressure vessel, used to store compressed air in a plant, has 1 m mean radius and 4 mm wall thickness. The maximum allowable normal and shear stresses in the cylindrical portion of the vessel are 100 MPa and 40 MPa, respectively. Considering only these data in the design, the maximum allowable internal gauge pressure (in MPa) of the compressed air is _____. *(Rounded off to 2 decimal places)* (GATE 2024)

51) A flat belt drive with pulley of r = 20 cm radius is designed to transmit 6.283 kW power at 600 RPM. In the figure, τ is the corresponding torque. If the coefficient of static friction between the belt and the pulley is 0.3, then the minimum value of the tightening force F (in kN) required to prevent the belt slip is _____. *(Rounded off to 2 decimal places)* (GATE 2024)

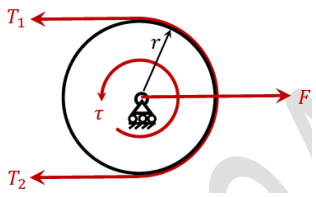


Fig. 51.

52) Mild steel plates are welded to make butt joints by arc welding with 85% heat transfer efficiency ignoring other losses. The first weld joint is made by selecting arc voltage of 30 V and current of 180 A with a welding speed of 6 mm/s. Using identical plates, a second weld joint is made with the same arc voltage and a welding speed of 8 mm/s. If both the welds have the same heat input, then the welding current (in A) for the second weld joint is _____. *(Answer in integer)* (GATE 2024)

53) In a single pass cold rolling operation, a flat plate is reduced to a thickness of 3 mm. In this operation, two rolls of diameter 400 mm each are rotating in opposite direction at 300 RPM, and the elastic deflection of these rolls is negligible. The angle of bite is 10°. If the neutral point is present at an angle of 7° from the exit side, then the thickness of the plate (in mm) at the neutral point is _____. *(Rounded off to 1 decimal place)* (GATE 2024)

54) In a sand mold, a sprue of height h_2 = 200 mm is to be provided for maintaining the molten metal flow rate of 10^5 mm^3/s. The height of liquid column above the point 2 is set as constant at h_c = 25 mm. The cross-sectional areas of the sprue at points 2 and 3 are A_2 and A_3, respectively. The points 1 and 3 are at the atmospheric pressure. Assuming the gauge pressure at point 2 to be zero as the limiting case to prevent aspiration effect, the ratio A_3/A_2 is _____. *(Rounded off to 2 decimal places)* (GATE 2024)

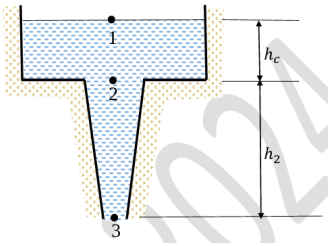


Fig. 54.

55) The following data are given in relation to turning operation of a cylindrical workpiece.
Diameter of the workpiece = 160 mm, length of the workpiece = 190 mm, cutting velocity = 80π m/min, and tool feed = 0.2 mm/rev.
Assuming the approach and the overrun of the tool to be 5 mm each, the machining time (in minutes) is _____. *(Answer in integer)* (GATE 2024)

56) A CNC milling operation is carried out by moving the tool from the point A to point B in anti-clockwise direction to cut a slot of quarter circle with center at C_p as shown. The coordinates of the points A and B are (0,0) and (10,10), respectively. All dimensions are in mm. If the feed rate at point P along x-axis is 6 mm/min, then the feed rate (in mm/min) at point P along y-axis is _____. *(Rounded off to 1 decimal place)* (GATE 2024)

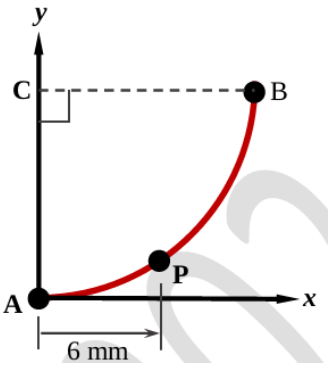


Fig. 56.

57) The pitch of a metric screw thread is calculated from pitch circle diameter measurement through two-wire method. If the thread is single-start with calculated pitch of 1.4 mm then the diameter (in mm) of the best-wire is _____. *(Rounded off to 2 decimal places)* (GATE 2024)

58) During orthogonal turning, the cutting speed, feed and depth of cut are set as 2 m/s, 0.2 mm/rev and 2 mm, respectively. The specific cutting energy (neglecting the effect of feed force on the total cutting power) is 2 J/mm^3. The main cutting force (in N) is _____. *(Answer in integer)*(GATE 2024)

59) Electro-chemical machining is performed on a flat copper workpiece. If the material removal rate is 2 cm^3/min throughout the process, then the required current (in A) is _____. *(Rounded off to 1 decimal place)*
Copper properties: Melting point = 1085 °C, density = 9 g/cm^3, gram atomic weight = 63, and valency of dissolution = 2
Faraday's constant = 96500 C
Stefan-Boltzmann constant = 5.67×10^{-8} W/m^2-K^4 (GATE 2024)

60) A repairable machine operated for 2400 hours in a year and for that year the machine broke down 8 times. The mean time to repair including waiting time is found to be 20 hours for that year.
If the mean time to repair including waiting time could have been reduced to 10 hours for that year, then the improvement in the availability of that machine would be _____ %. *(Rounded off to 2 decimal places)* (GATE 2024)

61) In a time study, the average time taken for packaging a product in a warehouse by a worker with 120% performance rating is observed as 9 minutes. Assuming an allowance of 10% of the standard time, the standard time (in minutes) for packaging is _____. *(Answer in integer)*(GATE 2024)

62) An assembly line consists of three work stations (S1, S2 and S3) in series to assemble a toy. The times required to perform tasks at these stations are 6, 4 and T minutes, respectively. If the efficiency of the assembly line in the steady state is 75%, then the maximum value of T (in minutes) is _____. *(Answer in integer)* (GATE 2024)

63) A company purchased two machines, Machine A and Machine B, at the same time. The purchase price, estimated useful life and the estimated salvage value of the two machines are given in the table. (GATE 2024)

	Machine A	Machine B
Purchase price	INR 20,000	INR 15,000
Estimated useful life	10 years	20 years
Estimated salvage value	INR 5,000	INR 5,000

Using the straight-line depreciation method for both the machines, the difference (in INR) between the value of Machine A and the value of Machine B at the end of five years is _____. *(Answer in integer)*

64) A company orders an item using the classical economic order quantity formula. If the ordering cost per order is increased by 20% and the demand per unit time is also increased by 20%, then the time between orders increases (in %) by _____. *(Answer in integer)* (GATE 2024)

65) Five jobs A, B, C, D and E are available at time $t = 0$ for processing at a machine, and their processing times are listed. (GATE 2024)

Job	A	B	C	D	E
Processing time (in days)	9	6	4	5	8

If the jobs are processed using the shortest processing time (SPT) rule, the average flow time (in days) is _____. *(Rounded off to 1 decimal place)*