PI : PRODUCTION AND INDUSTRIAL ENGINEERING

Duration : Three Hours *Maximum Marks* :150

Read the following instructions carefully

1. This question paper contains **20** printed pages including pages for rough work. Please check all pages and report discrepancy, if any.

2. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the ORS.

3. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.

4. All the questions in this question paper are of objective type.

5. Questions must be answered on **O**bjective **R**esponse **S**heet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **Each question has only one correct answer**. In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as a wrong answer.

6. Questions 1 through 20 are 1-mark questions and questions 21 through 85 are 2-mark questions.

7. Questions 71 through 73 is one set of common data questions, questions 74 and 75 is another pair of common data questions. The question pairs (76, 77), (78, 79), (80, 81), (82, 83) and (84, 85) are questions with linked answers. The answer to the second question of the above pairs will depend on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question in the pair will not be evaluated.

8. Un-attempted questions will carry zero marks.

9. **NEGATIVE MARKING**: For Q.1 to Q.20, ***0.25*** mark will be deducted for each wrong answer. For Q.21 to Q.75, ***0.5*** mark will be deducted for each wrong answer. For the pairs of questions with linked answers, there will be negative marks only for wrong answer to the first question, i.e. for Q.76, Q.78, Q.80, Q.82 and Q.84, ***0.5*** mark will be deducted for each wrong answer. There is no negative marking for Q.77, Q.79, Q.81, Q.83 and Q.85.

10. Calculator **without data connectivity** is allowed in the examination hall.

11. Charts, graph sheets and tables are NOT allowed in the examination hall.

12. Rough work can be done on the question paper itself. Additional blank pages are given at the end of the question paper for rough work.

Q. 1 – Q. 20 carry one mark each.

Q.1 The value of the integral $\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} x\cos(x)\,dx$ is

(A) 0 (B) $\pi-2$ (C) π (D) $\pi+2$

Q.2 The value of the expression $\frac{-5+i10}{3+i4}$ is

(A) $1-i2$ (B) $1+i2$ (C) $2-i$ (D) $2+i$

Q.3 The value of the expression $\lim_{x\to 0}\left[\frac{\sin(x)}{e^x x}\right]$ is

(A) 0 (B) $\frac{1}{2}$ (C) 1 (D) $\frac{1}{1+e}$

Q.4 In inventory cost structure, set up cost is a part of replenishment cost when it

(A) has taken place externally
(B) is dependent on supply conditions
(C) is independent of supply conditions
(D) has taken place internally

Q.5 Acceptable Quality Level (AQL) is associated with

(A) Producer's risk
(B) Consumer's risk
(C) Lot tolerance percent defective
(D) Average outgoing quality limit

Q.6 The REL chart is used for

(A) designing the layout of plants
(B) estimating the valuation of stock
(C) analyzing the movement of an item in a store
(D) maintaining the issue and receipt record

Q.7 If $\vec{r}$ is the position vector of any point on a closed surface S that encloses the volume V, then $\iint_S\left(\vec{r}.d\vec{S}\right)$ is equal to

(A) $\frac{1}{2}V$ (B) V (C) $2V$ (D) $3V$

Q.8 Laplace transform of $8t^3$ is

(A) $\frac{8}{s^4}$ (B) $\frac{16}{s^4}$ (C) $\frac{24}{s^4}$ (D) $\frac{48}{s^4}$

Q.9 For a random variable x $(-\infty < x < \infty)$ following normal distribution, the mean is $\mu = 100$. If the probability is $P = \alpha$ for $x \geq 110$, then the probability of x lying between 90 and 110, i.e., $P(90 \leq x \leq 110)$ will be equal to

(A) $1-2\alpha$ (B) $1-\alpha$ (C) $1-\frac{\alpha}{2}$ (D) 2α

Q.10 Consider a steady, reversible flow process in a system with one inlet stream and one outlet stream. Potential and kinetic energy effects are negligibly small. Given: v = specific volume and p = pressure of the system. The net work done by the system per unit mass flow rate is

(A) $\int pdv$ (B) $-\int pdv$ (C) $\int vdp$ (D) $-\int vdp$

Q.11 A refrigerator, operating in a room at a temperature of 29.5°C, maintains the refrigerated space at 2°C. The maximum possible COP of the refrigerator is

(A) 1.0 (B) 7.0 (C) 10.0 (D) 11.0

Q.12 Self locking condition for a pair of square thread screw and nut having coefficient of friction = μ, lead of thread = L and pitch diameter of thread = d, is given by

(A) $d > \frac{L}{\pi\mu}$ (B) $d > \pi\mu L$ (C) $d > \mu L$ (D) $\mu > Ld$

Q.13 The state of stress at a point in a body under plane state of stress condition is given by $\begin{bmatrix} 60 & 0 \\ 0 & 20 \end{bmatrix}$ MPa. The maximum shear stress (in MPa) is

(A) 0 (B) 20 (C) 30 (D) 40

Q.14 Which one of the following is a heat treatment process for surface hardening?

(A) Normalising (B) Annealing (C) Carburising (D) Tempering

Q.15 Which pair among the following solid state welding processes uses heat from an external source?

P - Diffusion welding; Q – Friction welding; R- Ultrasonic welding; S – Forge welding

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

Q.16 In hollow cylindrical parts, made by centrifugal casting, the density of the part is

(A) maximum at the outer region
(B) maximum at the inner region
(C) maximum at the mid-point between outer and inner surfaces
(D) uniform throughout

Q.17 Brittle materials are machined with tools having zero or negative rake angle because it

(A) results in lower cutting force
(B) improves surface finish
(C) provides adequate strength to cutting tool
(D) results in more accurate dimensions

Q.18 When 0.8% carbon eutectoid steel is slowly cooled from 750°C to room temperature,

(A) austenite transforms to pearlite
(B) pearlite transforms to austenite
(C) austenite transforms to martensite
(D) pearlite transforms to martensite

Q.19 Which one of the following is a unary operation performed in relational data models?

(A) Cartesian product
(B) Set union
(C) Set difference
(D) Selection

Q.20 The process of tracing through the MRP records and all levels in the product structure to identify how changes in the records of one component will affect the records of other components is known as

(A) product explosion
(B) lead time offsetting
(C) updating
(D) pegging

Q. 21 to Q.75 carry two marks each.

Q.21 The eigenvector pair of the matrix $\begin{pmatrix} 3 & 4 \\ 4 & -3 \end{pmatrix}$ is

(A) $\begin{Bmatrix} 2 \\ 1 \end{Bmatrix}$ and $\begin{Bmatrix} 1 \\ -2 \end{Bmatrix}$
(B) $\begin{Bmatrix} 2 \\ 1 \end{Bmatrix}$ and $\begin{Bmatrix} 1 \\ 2 \end{Bmatrix}$
(C) $\begin{Bmatrix} -2 \\ 1 \end{Bmatrix}$ and $\begin{Bmatrix} 1 \\ -2 \end{Bmatrix}$
(D) $\begin{Bmatrix} -2 \\ 1 \end{Bmatrix}$ and $\begin{Bmatrix} 1 \\ 2 \end{Bmatrix}$

Q.22 If the interval of integration is divided into two equal intervals of width 1.0, the value of the definite integral $\int_1^3 \log_e x \, dx$, using Simpson's one-third rule, will be

(A) 0.50
(B) 0.80
(C) 1.00
(D) 1.29

Q.23 In a game, two players X and Y toss a coin alternately. Whosoever gets a 'head' first, wins the game and the game is terminated. Assuming that player X starts the game, the probability of player X winning the game is

(A) $\frac{1}{3}$ (B) $\frac{1}{2}$ (C) $\frac{2}{3}$ (D) $\frac{3}{4}$

Q.24 Laplace transform of $\sinh(t)$ is

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

Q.25 A reservoir contains an estimated 30,00,000 barrels of oil. The initial cost of the reservoir is Rs. 1,50,00,000. If 2,00,000 barrels of oil are produced from this reservoir during a particular year, how much will be the depletion charge (cost depletion) for that year?

(A) Rs. 10,00,000 (B) Rs. 15,00,000 (C) Rs. 20,00,000 (D) Rs. 25,00,000

Q.26 Customers arrive at a service counter manned by a single person according to a Poisson distribution with a mean arrival rate of 30 per hour. The time required to serve a customer follows an exponential distribution with a mean of 100 seconds. The average waiting time (in hours) of a customer in the system will be

(A) 0.138 (B) 0.166 (C) 0.276 (D) 0.332

Q.27 Consider the following linear programming problem (LPP) :

$Maximize\ z = 5x_1 + 3x_2$

Subject to the following constraints

$x_1 - x_2 \leq 2$

$x_1 + x_2 \geq 3$

$x_1, x_2 \geq 0$

The above LPP has

(A) no solution
(B) unique solution
(C) two solutions
(D) unbounded solution

Q.28 A machine costing Rs. 2 lakh, (salvage value of the machine at the end of 4 years = 0) is to be depreciated over 4 years using the double declining balance depreciation method. The amount of the depreciation charged in the 3rd year is

(A) Rs. 1.000 lakh (B) Rs. 0.500 lakh (C) Rs. 0. 250 lakh (D) Rs. 0.125 lakh

Q.29 During a survey of customers in a store, 20 samples of size 200 customers were taken. The number of dissatisfied customers was found to be 180. The upper and lower control limits for the control chart of dissatisfied customers will be

(A) 18.345, 0.205 (B) 17.795, 0.205
(C) 18.345, 0.000 (D) 17.795, 0.000

Q.30 An assembly has 10 components in series. Each component has an exponential time-to-failure distribution with a constant failure rate of 0.02 per 3000 hours of operation. Assuming that the failed component of the assembly is replaced immediately with another component that has the same failure rate, the reliability of the assembly for 2000 hours of operation and the mean time-to-failure (MTTF) is

(A) 0.875, 10,000 hours
(B) 0.875, 15,000 hours
(C) 0.975, 10,000 hours
(D) 0.975, 15,000 hours

Q.31 Match the following:

Group 1	Group 2
P – SLP	1 – Intellectual property system
Q – Margin of Safety	2 – Assembly line balancing
R – LOB	3 – Facility design
S – TRIPS	4 – Break even analysis

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

Q.32 A man has deposited Rs. 1,000 per year for three years in a bank that paid him 5% interest compounded annually. At the end of three years, he had Rs. 3,153 in his account. How much more would he have earned if the bank had paid him 5% interest compounded continuously?

(A) Rs. 300 (B) Rs. 30 (C) Rs. 3 (D) Rs. 0.30

Q.33 Two pipes of uniform section but different diameters carry water at the same volumetric flow rate. Water properties are the same in the two pipes. The Reynolds number, based on the pipe diameter,

(A) is the same in both pipes
(B) is larger in the narrower pipe
(C) is smaller in the narrower pipe
(D) depends on the pipe material

Q.34 A single cylinder compression ignition engine, operating on the air-standard diesel cycle, has a mean effective pressure of 1.0 MPa and a compression ratio of 21. The engine has a clearance volume of 5×10^{-5} m^3. The heat added at constant pressure is 2.0 kJ. The thermal efficiency of the engine is

(A) 10% (B) 35% (C) 50% (D) 70%

Q.35 An industrial gas (c_p = 1 kJ/kgK) enters a parallel-flow heat exchanger at 250°C with a flow rate of 2 kg/s to heat a water stream. The water stream (c_p = 4 kJ/kgK) enters the heat exchanger at 50°C with a flow rate of 1 kg/s. The heat exchanger has an effectiveness of 0.75. The gas stream exit temperature will be

(A) 75°C (B) 100°C (C) 125°C (D) 150°C

Q.36 Oil is being pumped through a straight pipe. The pipe length, diameter and volumetric flow rate are all doubled in a new arrangement. The pipe friction factor, however, remains constant. The ratio of pipe frictional losses in the new arrangement to that in the original configuration would be

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 2 (D) 4

Q.37 Air flows steadily at low speed through a horizontal nozzle, which discharges the air into the atmosphere. The area at the nozzle inlet and outlet are 0.1 m^2 and 0.02 m^2, respectively. If the air density remains constant at 1.0 kg/m^3, the gauge pressure (in kPa) required at the nozzle inlet to produce an outlet speed of 50 m/s would be

(A) 0.6 (B) 1.2 (C) 100.2 (D) 101.2

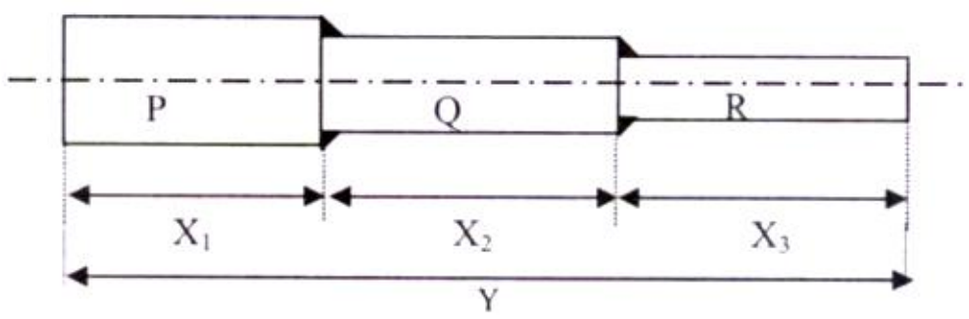
Q.38 Heat is being transferred convectively from a cylindrical nuclear reactor fuel rod of 50 mm diameter to water at 75 °C. Under steady state condition, the rate of heat generation within the fuel element is $5x10^7$ W/m^3 and the convection heat transfer coefficient is 1 kW/m^2K. The outer surface temperature of the fuel element would be

(A) 700 °C (B) 625 °C (C) 550 °C (D) 400 °C

Q.39 In an assembly, the dimension of a component should be between 20 mm and 30 mm. Twenty five components were taken at random during the manufacturing of the components. The mean value of the dimension and the standard deviation of the 25 components were 26 mm and 2 mm respectively. The process capability index C_{pk} of the concerned manufacturing process would be

(A) 0.33 (B) 0.67 (C) 0.83 (D) 1.00

Q.40 A three-component welded cylindrical assembly is shown below. The mean length of the three components and their respective tolerances (both in mm) are given in the table below.



Component	Mean Length (mm)	Tolerance (mm)
P	$X_1 = 18$	± 1.2
Q	$X_2 = 23$	± 1.0
R	$X_3 = 24$	± 1.5

Assuming a normal distribution for the individual component dimensions, the natural tolerance limits for the length (Y) of the assembly (mm) is

(A) 65 ± 2.16 (B) 65 ± 1.56 (C) 65 ± 0.96 (D) 65 ± 0.36

Q.41 For the partial differential equation $\frac{\partial^2 u}{\partial x^2} = \pi^2 \frac{\partial u}{\partial t}$ in the domain $0 \le x \le 1$ with boundary conditions $u(0,t) = 0$ and $u(1,t) = 0$ and initial condition $u(x,0) = \sin(\pi x)$, the solution of the differential equation is

(A) $e^{-t}\sin(\pi x)$ (B) $e^{t}\sin(\pi x)$ (C) $e^{-\pi t}\sin(\pi x)$ (D) $e^{\pi t}\sin(\pi x)$

Q.42 Inverse of the matrix $\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ is

(A) $\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ (B) $\begin{pmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & -1 \end{pmatrix}$ (C) $\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$ (D) $\begin{pmatrix} 0 & -1 & 0 \\ 0 & 0 & -1 \\ -1 & 0 & 0 \end{pmatrix}$

Q.43 For real x, the maximum value of $\frac{e^{\sin(x)}}{e^{\cos(x)}}$ is

(A) 1 (B) e (C) $e^{\sqrt{2}}$ (D) $e^{\frac{1}{\sqrt{2}}}$

Q.44 A 19-tooth pinion paired with a 33-tooth gear has a 2-mm module and 20 degree pressure angle. Tooth forms are standard AGMA full depth involutes. If the centre distance, during assembly, is increased by 3 percent, then the new pressure angle (in degrees) will be

(A) 24.17 (B) 22.21 (C) 17.49 (D) 14.56

Q.45 The solutions of the differential equation $\frac{d^2 y}{dx^2} + 2\frac{dy}{dx} + 2y = 0$ are

(A) $e^{-(1+i)x}$, $e^{-(1-i)x}$ (B) $e^{(1+i)x}$, $e^{(1-i)x}$

(C) $e^{-(1+i)x}$, $e^{(1+i)x}$ (D) $e^{(1+i)x}$, $e^{-(1+i)x}$

Q.46 By application of tensile force, the cross sectional area of a bar 'P' is first reduced by 30% and then by an additional 20%. Another bar 'Q' of the same material is reduced in cross sectional area by 50% in a single step by applying tensile force. After deformation, the true strains in bar 'P' and bar 'Q' will, respectively, be

(A) 0.50 and 0.50 (B) 0.58 and 0.69 (C) 0.69 and 0.69 (D) 0.78 and 1.00

Q.47 In sand casting of a hollow part of lead, a cylindrical core of diameter 120 mm and height 180 mm is placed inside the mould cavity. The densities of core material and lead are 1600 kg/m^3 and 11,300 kg/m^3 respectively. The net force (in N) that tends to lift the core during pouring of molten metal will be

(A) 19.7 (B) 64.5 (C) 193.7 (D) 257.6

Q.48 Aluminium strips of 2 mm thickness are joined together by resistance spot welding process by applying an electric current of 6000 A for 0.15 sec. The heat required for melting aluminium is 2.9 J/mm^3. The diameter and the thickness of weld nugget are found to be 5 mm and 2.5 mm, respectively. Assuming the electrical resistance to be 75 micro-ohms, the percentage of total energy utilized in forming the weld nugget is

(A) 28 (B) 35 (C) 65 (D) 72

Q.49 In a rolling process, thickness of a strip is reduced from 4 mm to 3 mm using 300 mm diameter rolls rotating at 100 rpm. The velocity of the strip (in m/sec) at the neutral point is

(A) 1.57 (B) 3.14 (C) 47.10 (D) 94.20

Q.50 A blank of 50 mm diameter is to be sheared from a sheet of 2.5 mm thickness. The required radial clearance between the die and the punch is 6% of sheet thickness. The punch and die diameters (in mm) for this blanking operation, respectively, are

(A) 50.00 and 50.30 (B) 50.00 and 50.15
(C) 49.70 and 50.00 (D) 49.85 and 50.00

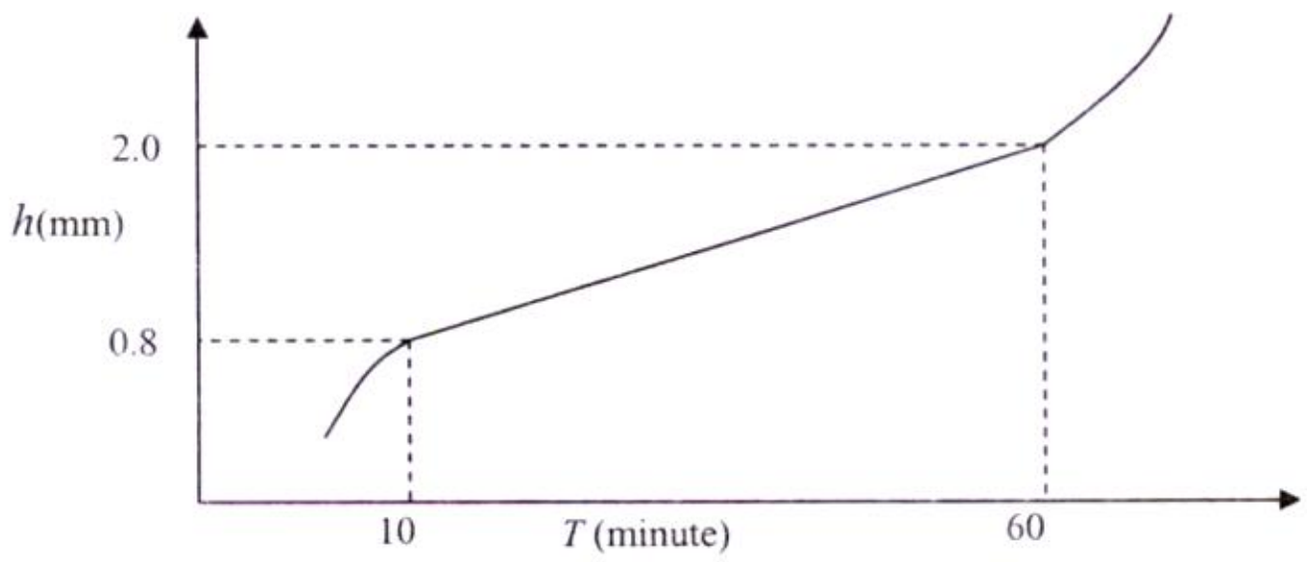
Q.51 In an electro chemical machining (ECM) operation, a square hole of dimensions 5 mm × 5 mm is drilled in a block of copper. The current used is 5000 A. Atomic weight of copper is 63 and valency of dissolution is 1. Faraday's constant is 96500 Coulomb. The material removal rate (in g/s) is

(A) 0.326 (B) 3.260 (C) 3.15×10^3 (D) 3.15×10^5

Q.52 A shaft of diameter 10 mm transmits 100 W of power at an angular speed of $\frac{800}{\pi}$ rad/s. The maximum shear stress (in MPa) developed in the shaft is

(A) 2 (B) 4 (C) 8 (D) 16

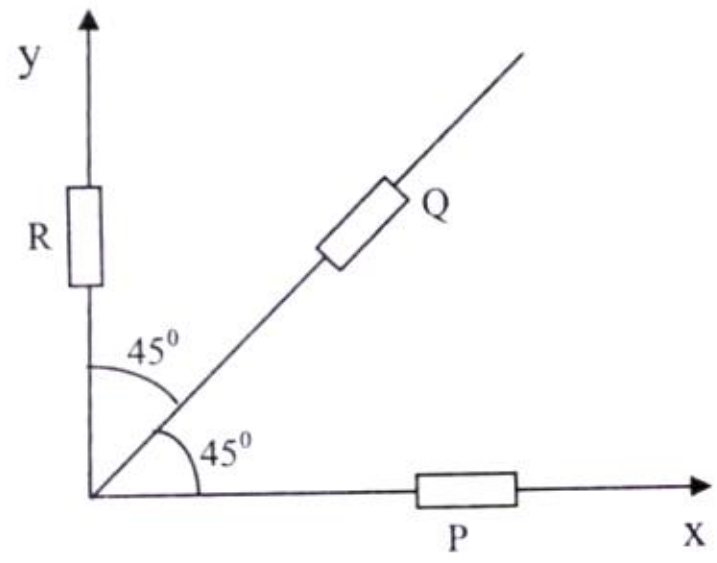
Q.53 During machining, the wear land (h) has been plotted against machining time (T) as given in the following figure.



For a critical wear land of 1.8 mm, the cutting tool life (in minute) is

(A) 52.00 (B) 51.67 (C) 51.50 (D) 50.00

Q.54 A strain rosette, as shown in the figure, has three strain gauges P, Q and R.



If the values of strain indicated in the three strain gauges are

$\varepsilon_P = 100 \times 10^{-6}$,

$\varepsilon_Q = 150 \times 10^{-6}$ and

$\varepsilon_R = 200 \times 10^{-6}$,

the largest principal strain is

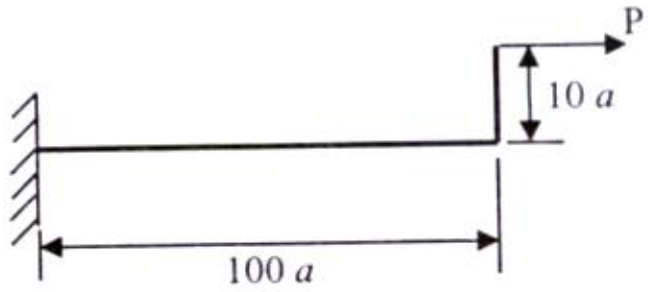
(A) 200×10^{-6} (B) 250×10^{-6} (C) 300×10^{-6} (D) 350×10^{-6}

Q.55 A cantilever beam XY of length 2 m and cross-sectional dimensions 25 mm x 25 mm is fixed at X and is subjected to a moment of 100 N-m and an unknown force P at the free end Y as shown in the figure. The Young's modulus of the material of the beam is 200 GPa.

If the deflection of the free end Y is zero, then the value of P (in N) is

(A) 67 (B) 75 (C) 133 (D) 150

Q.56 A frame of square cross-section of $(a \times a)$ is as shown in the figure. The stress near the fixed end on the upper side of the frame is



(A) $\frac{58P}{a^2}$ (B) $\frac{59P}{a^2}$ (C) $\frac{60P}{a^2}$ (D) $\frac{61P}{a^2}$

Q.57 A steel wire of diameter 2 mm is wound on a rigid drum of diameter 2 m. If the Young's modulus of the steel is 200 GPa, the maximum stress (in MPa) in the steel wire is

(A) 50 (B) 100 (C) 200 (D) 400

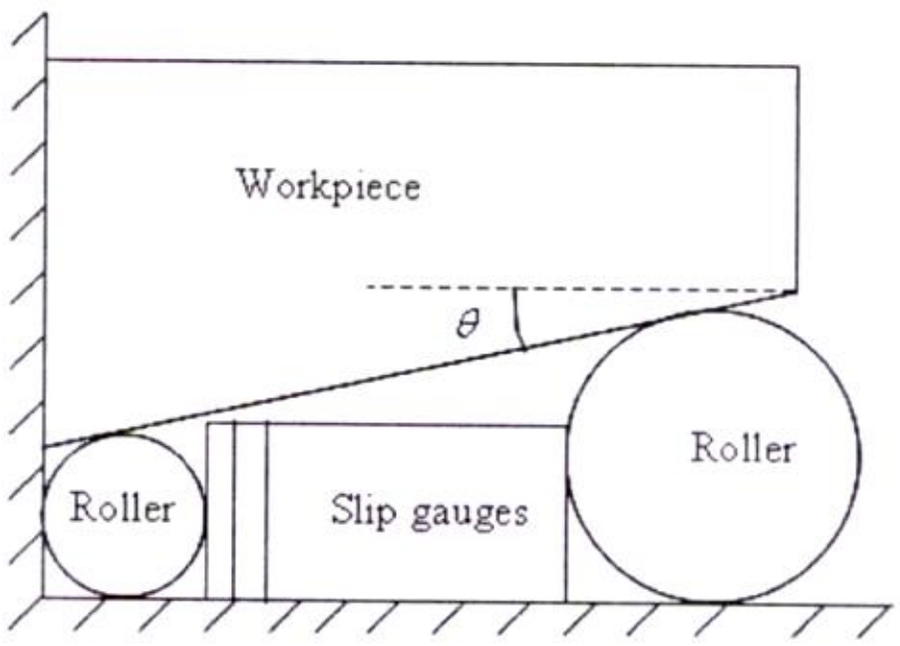
Q.58 The quick return mechanism used in a shaper has rocker arm drive of length 200 mm. If the crank radius is 50 mm and the offset between crank centre and rocker arm pivot is 20 mm, length of the stroke (in m) is

(A) 0.5 (B) 1.0 (C) 1.5 (D) 2.0

Q.59 A stepper motor has 150 steps. The output shaft of the motor is directly coupled to a lead screw of pitch 4 mm, which drives a table. If the frequency of pulse supply to the motor is 200 Hz, the speed of the table (in mm/min) is

(A) 400 (B) 320 (C) 300 (D) 280

Q.60 An experimental setup is planned to determine the taper of workpiece as shown in the figure. If the two precision rollers have radii 8 mm and 5 mm and the total thickness of slip gauges inserted between the rollers is 15.54 mm, the taper angle θ is



(A) 6 degree (B) 10 degree (C) 11 degree (D) 12 degree

Q.61 Following data are given for calculating limits of dimensions and tolerances for a hole: Tolerance unit $i\ (\mu m) = 0.45\sqrt[3]{D} + 0.001D$. The unit of D is mm. Diameter step is 18-30 mm. If the fundamental deviation for H hole is zero and $IT8 = 25i$, the maximum and minimum limits of dimension for a 25 mm H_8 hole (in mm) are

(A) 24.984, 24.967
(B) 25.017, 24.984
(C) 25.033, 25.000
(D) 25.000, 24.967

Q.62 Match the following:

Group 1	Group 2
P – Wrinkling	1 – Upsetting
Q – Centre burst	2 – Deep drawing
R – Barrelling	3 – Extrusion
S – Cold shut	4 – Closed die forging

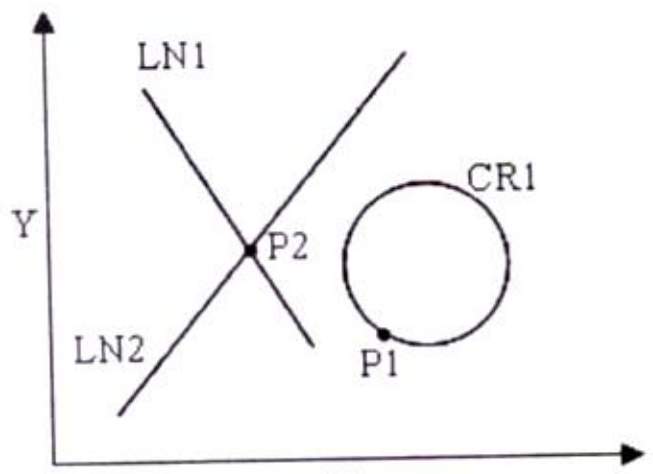
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-2, Q-3, R-1, S-4
(D) P-2, Q-4, R-3, S-1

Q.63 Suppose point P_1 in APT (Automatically Programmed Tool) programming is coded by statement

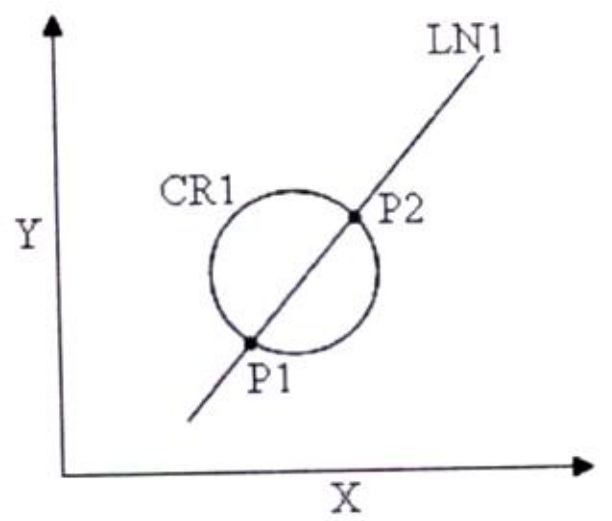
$$P_1 = \text{POINT/XSMALL,INTOF,}LN1,CR1$$

The coded geometric situation without causing error is

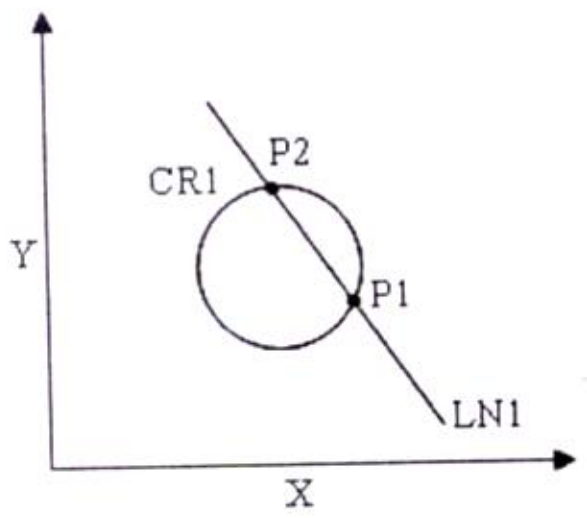
(A)



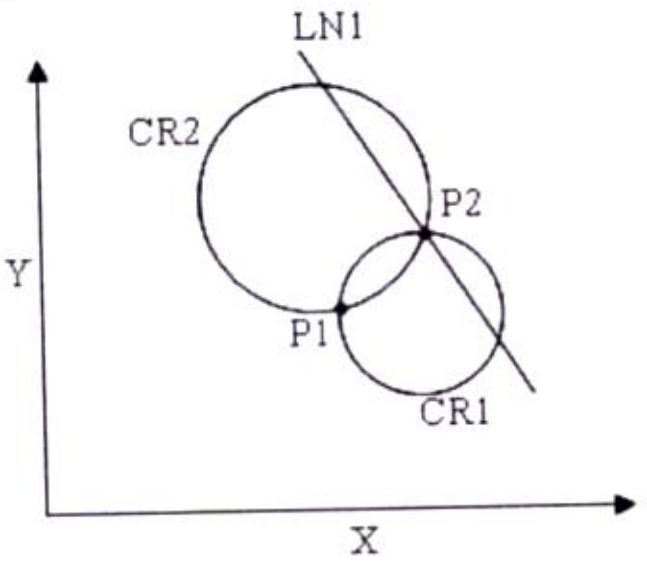
(B)



(C)



(D)



Q.64 Match the following:

Group 1	Group 2
P – Mulling	1. Powder metallurgy
Q – Impregnation	2. Injection moulding
R – Flash trimming	3. Processing of FRP composites
S – Curing	4. Sand casting

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

Q.65 When P is the rate of production, D is the demand rate and t is the duration of production, the actual inventory built up during production period in the EPQ model is

(A) Zero (B) $(P+D)\,t$ (C) $P\,t$ (D) $(P-D)\,/\,t$

Q.66 Consider the following work sampling data:
working time = 60%, average rating = 90%, relaxation allowance = 12.5%,
actual output during the study = 1000 units and study duration = 480 minutes.
The standard time per unit (in minutes) will be

(A) 0.2592 (B) 0.2916 (C) 0.3240 (D) 0.4860

Q.67 Six jobs are received for processing and their processing times and delivery dates are given below:

Job Sequence	Production Time (days)	Delivery Date (days)
P	2	4
Q	5	18
R	3	8
S	4	4
T	6	20
U	4	24

Using FCFS dispatching rule, the average lateness is

(A) 2.0 (B) 1.5 (C) 1.0 (D) 0.5

Q.68 An assembly line data is given below:

Station	**1**	**2**	**3**	**4**	**5**	**6**
Cycle time	90	90	90	90	90	90
Task time	70	70	80	70	80	60
Idle time	20	20	10	20	10	30

The percentage utilization of labour on the assembly line is

(A) 20.37 (B) 25.58 (C) 26.63 (D) 79.62

Q.69 In mostly accepted and applicable PTS systems (i.e. MTM-2), the motions and their codes are specified. Match the following.

Group 1	Group 2
P – Weight factors	1. GW
Q – GET	2. GA
R – PUT	3. PB
S – Apply pressure	4. A

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

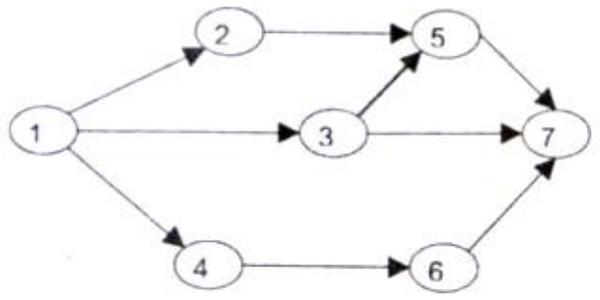
Q.70 Daily demand of a product is normally distributed with a mean of 50 units and a standard deviation of 5. Supply conditions are virtually certain with a lead time of 6 days. If a 95 percent service level is desired, the reorder point ($Z_{0.95}$ =1.645) is

(A) 340 units (B) 320 units (C) 300 units (D) 280 units

Common Data Questions

Common Data for Questions 71, 72 and 73:

The figure illustrates a PERT network describing the precedence relationship among different activities. The optimistic time, most likely time and pessimistic time of the activities are given in the table below.



Activity	Optimistic time (hour)	Most likely time (hour)	Pessimistic time(hour)
1-2	7	9	11
1-3	5	7	9
1-4	4	7	10
2-5	8	10	12
3-5	6	9	12
3-7	8	10	12
4-6	4	6	8
5-7	5	8	11
6-7	3	5	7

Q.71 The length of the critical path (in hours) is

(A) 17 (B) 18 (C) 24 (D) 27

Q.72 The standard deviation of the critical path (in hours) is

(A) 0.66 (B) 0.94 (C) 1.37 (D) 1.56

Q.73 The slack at event number 3 (in hours) is

(A) 0 (B) 3 (C) 6 (D) 10

Common Data for Questions 74 and 75:

A quadratic Bezier curve segment is described by $\tilde{r}(u) = \sum_{i=0}^{2} B_{i,2}\tilde{r}_i$ where $\tilde{r}_i$ and $B_{i,2}$ are control points and blending functions respectively. Given: $B_{i,2} = {}^2C_i u^i (1-u)^{2-i}$, $u \in [0,1]$

Consider (0, 0), (4, 4) and (12, 8) as the control points of the Bezier curve.

Q.74 The point (1, 2) lies

(A) on the Bezier curve
(B) on the boundary of the convex hull
(C) outside the convex hull
(D) within the convex hull but not on the Bezier curve

Q.75 Slope of the tangent at point (5,4) to the Bezier curve is

(A) –0.667 (B) –0.333 (C) 0.333 (D) 0.667

Linked Answer Questions: Q.76 to Q.85 carry two marks each.

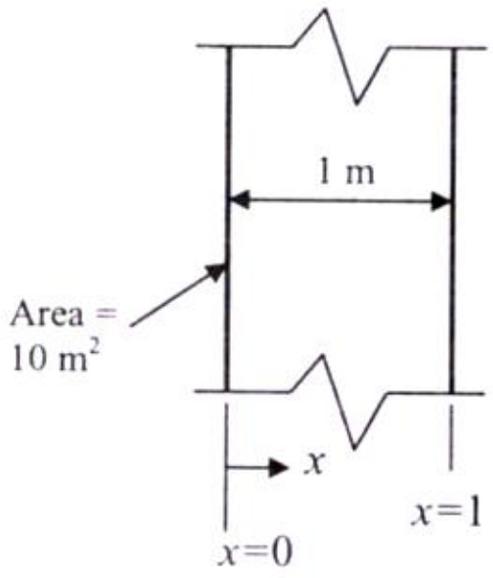
Statement for Linked Answer Questions 76 and 77:

A wall is heated uniformly at a volumetric heat generation rate of 1 kW/m^3. The temperature distribution across the 1m thick wall at a certain instant of time is given by :

$$T(x) = a + bx + cx^2$$

where $a = 900$ °C, $b = -300$ °C/m, and $c = -50$ °C/m^2.

The wall has an area of 10 m^2 (as shown in the figure) and a thermal conductivity of 40 W/mK.



Q.76 The rate of heat transfer (in kW) into the wall (at x=0) is

(A) 900 (B) 450 (C) 120 (D) 60

Q.77 The rate of change of energy storage (in kW) in the wall is

(A) 130 (B) 120 (C) –10 (D) –30

Statement for Linked Answer Questions 78 and 79:

A disk brake has two friction linings with the outside-lining and inside-lining diameters as 120 mm and 60 mm, respectively. The coefficient of friction at the interface of lining and rotating part is 0.35. A 10 kN axial force is applied to stop the part rotating at 8000 rpm. To cool the disk brake, an arrangement of circulating the water (specific heat 4.2 kJ / kg-°C) is made. Assume uniform wear rate of disk linings and heat transfer by convection only.

Q.78 The torque (in N-m) applied by the brake on the rotating part is

(A) 215 (B) 315 (C) 630 (D) 1260

Q.79 The mass flow rate (in kg/s) of water required to maintain a temperature rise of 3°C is

(A) 2.2 (B) 3.4 (C) 10.4 (D) 21.0

Statement for Linked Answer Questions 80 and 81:

A 10 mm diameter annealed steel wire is drawn through a die at a speed of 0.5 m/sec to reduce the diameter by 20%. The yield stress of the material is 800 MPa.

Q.80 Neglecting friction and strain hardening, the stress required for drawing (in MPa) is

(A) 178.5 (B) 357.0 (C) 1287.5 (D) 2575.0

Q.81 The power required for the drawing process (in kW) is

(A) 8.97 (B) 14.0 (C) 17.95 (D) 28.0

Statement for Linked Answer Questions 82 and 83:

In an orthogonal cutting experiment, an HSS tool having the following tool signature in the orthogonal reference system (ORS) has been used: 0-10-7-7-10-75-1.
Given: width of cut = 3.6 mm; shear strength of workpiece material = 460 N/mm^2;
depth of cut = 0.25 mm; coefficient of friction at tool-chip interface = 0.7.

Q.82 Shear plane angle (in degree) for minimum cutting force is

(A) 20.5 (B) 24.5 (C) 28.5 (D) 32.5

Q.83 Minimum power requirement (in kW) at a cutting speed of 150 m/min is

(A) 3.15 (B) 3.25 (C) 3.35 (D) 3.45

Statement for Linked Answer Questions 84 and 85:

A company forecasts the demand for a product to be 400 units per month for each of the next three months. The actual demand, however, turned out to be 400, 550 and 580 units respectively for those three months.

Q.84 The forecast error bias is

(A) –330 units (B) –110 units (C) 110 units (D) 330 units

Q.85 The forecasting technique used has a tendency to

(A) under forecast with 21.56% bias
(B) over forecast with 21.56% bias
(C) under forecast with 64.70% bias
(D) over forecast with 64.70% bias

END OF THE QUESTION PAPER