# ASSIGNMENT 4: GATE 2022
PI : PRODUCTION & INDUSTRIAL ENGINEERING

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1) Inhaling the smoke from a burning _____ could _____ you quickly.

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   a) tire/tier   b) tire/tyre   c) tyre/tire   d) tyre/tier

2) A sphere of radius r cm is packed in a box of cubical shape. What should be the minimum volume $\left(\text{in } cm^3\right)$ of the box that can enclose the sphere?

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   a) $\frac{r^3}{8}$ b) r^3 c) $2r^3$ d) $8r^3$

3) Pipes P and Q can fill a storage tank in full with water in 10 and 6 minutes, respectively. Pipe R draws the water out from the storage tank at a rate of 34 litres per minute. P, Q and R operate at a constant rate. If it takes one hour to completely empty a full storage tank with all the pipes operating simultaneously, what is the capacity of the storage tank (in litres)?

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   a) 26.8   b) 60.0   c) 120.0   d) 127.5

4) Six persons P, Q, R, S, T and U are sitting around a circular table facing the center not necessarily in the same order. Consider the following statements:
   - P sits next to S and T.
   - Q sits diametrically opposite to P.
   - The shortest distance between S and R is equal to the shortest distance between T and U.

   Based on the above statements, Q is a neighbor of

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   a) U and S
   b) R and T
   c) R and U
   d) P and S

5) A building has several rooms and doors as shown in the top view of the building given below. The doors are closed initially. What is the minimum number of doors that need to be opened in order to go from the point P to the point Q?
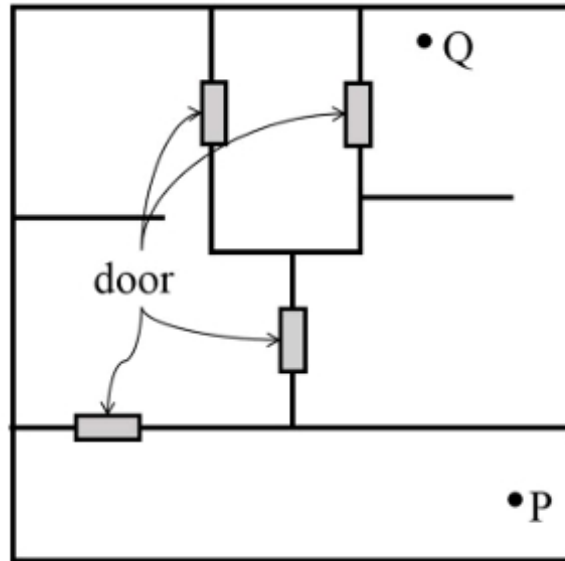
a) 4   b) 3   c) 2   d) 1

6) Rice, a versatile and inexpensive source of carbohydrate, is a critical component of diet worldwide. Climate change, causing extreme weather, poses a threat to sustained availability of rice. Scientists are working on developing Green Super Rice (GSR), which is resilient under extreme weather conditions yet gives higher yields sustainably. Which one of the following is the CORRECT logical inference based on the information given in the above passage?

a) GSR is an alternative to regular rice, but it grows only in an extreme weather.
b) GSR may be used in future in response to adverse effects of climate change.
c) GSR grows in an extreme weather, but the quantity of produce is lesser than regular rice.
d) Regular rice will continue to provide good yields even in extreme weather.

7) A game consists of spinning an arrow around a stationary disk as shown below. When the arrow comes to rest, there are eight equally likely outcomes. It could come to rest in any one of the sectors numbered $1, 2, 3, 4, 5, 6, 7$ or 8 as shown. Two such disks are used in a game where their arrows are independently spun. What is the probability that the sum of the numbers on the resulting sectors upon spinning the two disks is equal to 8 after the arrows come to rest?
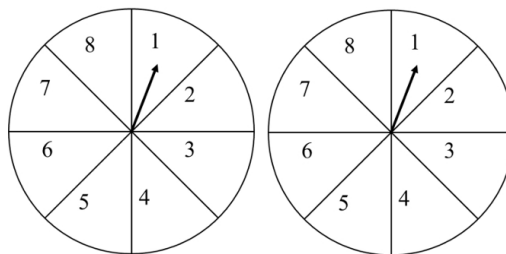
a) $\frac{1}{16}$ b) $\frac{5}{64}$ c) $\frac{3}{32}$ d) $\frac{7}{64}$

8) Consider the following inequalities.

$$3p - q < 4$$
$$3q - p < 12$$

Which one of the following expressions below satisfies the above two inequalities?

a) $p + q < 8$ c) $8 \le p + q < 16$
b) $p + q = 8$ d) $p + q \ge 16$

9) Given below are three statements and four conclusions drawn based on the statements. Statement 1: Some engineers are writers. Statement 2: No writer is an actor. Statement 3: All actors are engineers. Conclusion I: Some writers are engineers. Conclusion II: All engineers are actors. Conclusion III: No actor is a writer. Conclusion IV: Some actors are writers. Which one of the following options can be logically inferred?
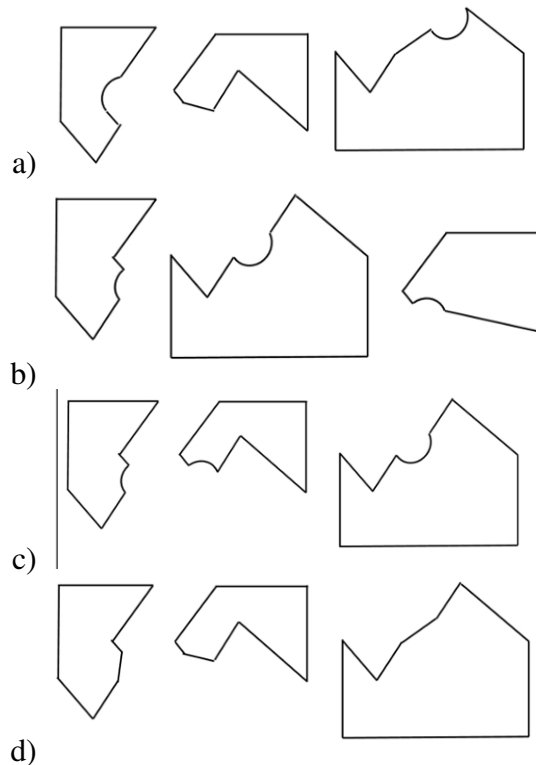
a) Only conclusion I is correct
b) Only conclusion II and conclusion III are correct
c) Only conclusion I and conclusion III are correct
d) Either conclusion III or conclusion IV is correct

10) Which one of the following sets of pieces can be assembled to form a square with a single round hole near the center? Pieces cannot overlap.

11) If a, b and c are three vectors, the vector triple product $(a \times b) \times c$ is given by

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

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?

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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.

13) Which one of the following metals has a face-centered cubic (FCC) structure?

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a) Alpha iron   b) Chromium   c) Magnesium   d) Aluminum

14) If G denotes the shear modulus of an isotropic material, then the maximum possible value of Young's modulus of the material is

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a) G   b) 2 G   c) 3 G   d) 4 G

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

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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

16) In injection blow molding of plastic beverage bottles, the blowing is accomplished by

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a) hot water   b) hot air   c) hot oil   d) alcohol

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

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a) $0.5V_b$ b) V_b c) $2V_b$ d) $3V_b$

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

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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

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

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

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

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

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a) X chart   b) R chart   c) c chart   d) p chart

20) Which one of the following statements is TRUE?

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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.

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

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

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

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

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

22) Match the types of layout with the types of production.

Type of layout		Type of production	
P	Process layout	1	Job production
Q	Product layout	2	Batch production
R	Fixed position layout	3	Mass production

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a) P-2, Q-3, R-1

c) P-2, Q-1, R-3

b) P-3, Q-1, R-2

d) P-3, Q-2, R-1

23) Matrix A as a product of two other matrices is given by

$$A = \begin{pmatrix} 3 & 1 \\ 4 & 2 \end{pmatrix}$$

The value of det (A) is _____.

24) The order of the following differential equation is _____.

$$\left(\frac{d^2y}{dx^2}\right)^3 + 5\frac{dy}{dx} + 4y = 5x$$

25) 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 _____.

26) 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 _____.
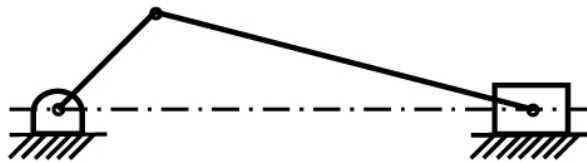
27) Water $\left(\text{kinematic viscosity } v = 1 \times 10^{-6}m^2/s\right)$ is flowing through a circular horizontal pipe of diameter 8 mm. If the flow is laminar and fully developed with a maximum axial velocity of 0.5 m/s, the Reynolds number is _____.

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 _____.

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 _____.

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 _____.

31) The absolute deviations of 8 points from the datum line of a surface are $10, 15, 12, 10, 13, 12, 20$ and 25 μm. The root mean square value of the surface roughness (in μm) is _____.

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 _____.

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 _____.

34) A company buys a machine worth Rs 65000, which has a salvage value of Rs 5000. The annual depreciation cost is Rs 10000 based on the straight line depreciation method. The useful life (in year) of the machine is _____.

35) A project comprises of seven activities. The expected durations of activities and their variances are as follows: The critical path consists of activities B, E and G. The standard deviation (in minute) of

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 project duration is _____.

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

37) Consider the following ordinary differential equation:

$$4\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + y = 0.$$

Given that c_1 and c_2 are constants, the general solution of the differential equation is

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

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

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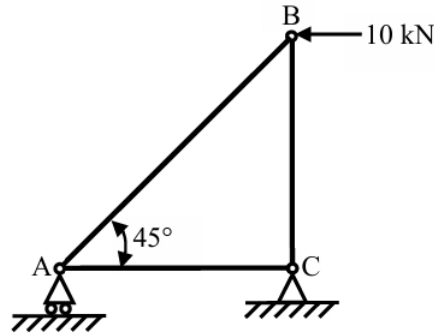
Cooling method		Transformed structure	
P	Water quenching	1	Coarse pearlite
Q	Oil quenching	2	Fine pearlite
R	Air cooling	3	Martensite
S	Furnace cooling	4	Very fine pearlite

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

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

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a) zero
b) 10 kN (tensile)
c) 10 kN (compressive)
d) 7.07 kN (tensile)

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

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a) P-1, Q-5, R-2, S-3   c) P-2, Q-3, R-1, S-4
b) P-3, Q-2, R-1, S-5   d) P-2, Q-5, R-1, S-4

42) In an assembly comprising shaft and hole, the nominal sizes with tolerances are specified as

$$\text{Hole: } 25.000^{+0.002}_{-0.001} \text{ mm,}$$
$$\text{Shaft: } 25.000^{+0.001}_{-0.003} \text{ mm.}$$

The type of fit is

(GATE PI 2022)

a) Clearance fit
b) Interference fit
c) Transition fit
d) Running fit

43) In a manufacturing system, four different types of products $(P, Q, R \text{ and } S)$ are produced. The batch size of each product is 2×10^7. 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?

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.

44) Match the processes of product development with their characteristics.

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

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

45) The value of

$$\lim_{x \to 1} \frac{x^3 - 3x + 2}{x^3 - x^2 - x + 1}$$

is _____.

46) 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 _____.

47) 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 _____.

48) 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 $R = 287$ J/kg-K, the ratio of the specific heats as $\gamma = 1.4$ and treat air as a calorically perfect gas. The change of entropy (in J/kg-K) in the process is _____.

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 _____.

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 _____.

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 _____.

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 _____.

(GATE PI 2022)

53) A cylindrical workpiece is turned using two different tools. Tool 1 has zero nose radius; side and end cutting edge angles are 20° and 10°, 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 _____.

(GATE PI 2022)

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 λ is $6 \times 10^{-3} cm^2$/minute. For maintaining a constant inter-electrode gap of 0.1 mm, the feed (in mm/minute) should be _____.

(GATE PI 2022)

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°. The number of pulses required to move the table by 200 mm is _____.

(GATE PI 2022)

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 _____.
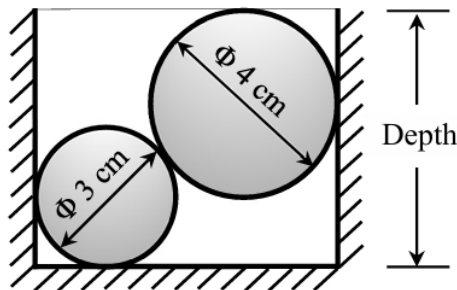
(GATE PI 2022)

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 (σ 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 _____.

(GATE PI 2022)

58) In a factory, 100 bulbs are in use. The table lists the cumulative probability of the failure of a bulb for various durations. The factory follows the individual replacement policy. If the cost of replacing

Duration (*month*)	Cumulative probability
1	0.10
2	0.25
3	0.47
4	0.68
5	1.00

a bulb is Rs 300, then the expected cost (in Rs) of replacement per month is _____.

(GATE PI 2022)

59) A company procures 384 parts annually. The annual holding cost per part is Rs 30. If the ordering cost is Rs 1000, then the economic order quantity is _____.

(GATE PI 2022)

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 _____.

Cycle time (*minute*)	Frequency
42	1
43	2
44	3
45	2
46	1

(GATE PI 2022)

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 _____.

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

(GATE PI 2022)

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 Rs) 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 Rs) as _____.

63) Consider the linear programming problem:

$$\text{Maximize } z = 20x_1 + 6x_2 + Px_3,$$
$$\text{subject to}$$
$$(C1)\ 8x_1 + 2x_2 + 3x_3 \leq 250,$$
$$(C2)\ 4x_1 + 3x_2 \leq 150,$$
$$(C3)\ 2x_1 + x_3 \leq 50,$$
$$x_1, x_2, x_3 \geq 0$$

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 _____.

64) A company is planning to produce 24 electric cars per day. The setup cost of the plant is estimated as Rs 19476 million and the variable cost is Rs 0.6 million per car. The car will be sold at a price of Rs 1.5 million. The number of days required for achieving the breakeven is _____.

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 _____.