ASSIGNMENT 1: GATE 2010
PI : PRODUCTION & INDUSTRIAL ENGINEERING

EE25BTECH11054 - S. Harsha Vardhan Reddy

1) During the filling process of a given sand mould cavity by molten metal through a horizontal runner of circular cross-section, the frictional head loss of the molten metal in the runner will increase with the (GATE PI 2010)

a) increase in runner diameter
b) decrease in internal surface roughness of runner
c) decrease in length of runner
d) increase in average velocity of molten metal

2) Solidification time of a metallic alloy casting is (GATE PI 2010)

a) directly proportional to its surface area
b) inversely proportional to the specific heat of the cast material
c) directly proportional to the thermal diffusivity of the mould material
d) inversely proportional to the pouring temperature

3) In a rolling process, the roll separating force can be decreased by (GATE PI 2010)

a) reducing the roll diameter
b) increasing friction between the rolls and the metal
c) reducing front tension to rolled material
d) providing back-up rolls

4) Ultrasonic machines, used in material removal processes, require ultrasonic transducers. The transducers work on different working principles. One of the working principles of such ultrasonic transducers is based on (GATE PI 2010)

a) eddy current effect
b) Seebeck effect
c) piezo-resistive effect
d) piezo-electric effect

5) Hot die steel, used for large solid dies in drop forging, should necessarily have (GATE PI 2010)

a) high strength and high copper content
b) high hardness and low hardenability
c) high toughness and low thermal conductivity
d) high hardness and high thermal conductivity

6) In powder metallurgy, sintering of a component (GATE PI 2010)

a) improves strength and reduces hardness
b) reduces brittleness and improves strength
c) improves hardness and reduces toughness
d) reduces porosity and increases brittleness

7) Which one among the following statements is TRUE? (GATE PI 2010)

a) Thermoplastic polymers have cross-linked chain structure.
b) Thermosetting polymers have covalent bonded three-dimensional structure.
c) Polyethylene is a thermosetting polymer.
d) Thermoplastic polymers harden on heating and soften on cooling.

8) During turning of a low carbon steel bar with TiN coated carbide insert, one needs to improve surface finish without sacrificing material removal rate. To achieve improved surface finish, one should (GATE PI 2010)
   a) decrease nose radius of the cutting tool and increase depth of cut
   b) increase nose radius of the cutting tool
   c) increase feed and decrease nose radius of the cutting tool
   d) increase depth of cut and increase feed

9) Eutectic composition of iron-carbon alloy always corresponds to its (GATE PI 2010)
   a) lowest melting temperature
   b) highest melting temperature
   c) least carbon percentage
   d) highest fracture toughness

10) As the weight percentage of carbon increases in plain carbon steel, its (GATE PI 2010)
   a) weldability decreases
   b) ductility improves
   c) tensile strength decreases
   d) formability improves

11) Austempering is a heat treatment process that is aimed at obtaining (GATE PI 2010)
   a) martensitic steel
   b) bainitic steel
   c) tempered martensitic steel
   d) austenitic steel

12) A machine component under fluctuating tensile stress, (in MPa)yy, is considered to be safe if the average stress, σ_{avg} (in MPa) and the stress amplitude (variable stress), σ_{amp} (in MPa) satisfy the following inequality:
$$\frac{\sigma_{avg}}{360} + \frac{\sigma_{amp}}{210} \leq 1$$
The machine member is subjected to a stress, $\sigma = 120 + p\sin(20t + 0.5)$. For safe operation of the machine component, the maximum value of p ($(inMPa)$) is (GATE PI 2010)
   a) 70 b) 140 c) 280 d) 320

13) A heat pump is operating between −23°C and 27°C. The compressor power input to the heat pump is 2 kW. The heating COP (coefficient of performance) of the heat pump is 75% of the COP of a Carnot heat pump operating between the same temperatures. The heating power output (in kW) of the heat pump is (GATE PI 2010)
   a) 0.3 b) 7.5 c) 9.0 d) 12.0

14) Among the given four computerized layout techniques, which one is an improvement routine technique requiring a user specified initial layout? (GATE PI 2010)
   a) ALDEP (Automated Layout Design Program)
   b) CORELAP (Computerized Relationship Layout Planning)
   c) PLANET (Plant Layout Analysis and Evaluation Technique)
   d) COFAD (Computerized Facilities Design)

15) Match phrases in Group I with those in Group II.

Group I		**Group II**	
P.	Lead Time Forecast	1.	Material Requirement Planning
Q.	Master Production Schedule	2.	Financial Appraisal
R.	Payback Period	3.	Project Planning
S.	Early Start Schedule	4.	Inventory Control

(GATE PI 2010)

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

16) Which one of the following intellectual properties can be classified as copyrights? (GATE PI 2010)

a) Patents and Trademarks
b) Industrial Designs
c) Trade Secrets
d) Literary and Artistic Expressions

17) The value of q for which the following set of linear algebraic equations

$$2x + 3y = 0$$
$$6x + qy = 0$$

can have non-trivial solution is (GATE PI 2010)

a) 2 b) 7 c) 9 d) 11

18) If $\{1, 0, -1\}^T$ is an eigenvector of the following matrix,

$$\begin{pmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{pmatrix}$$

then the corresponding eigenvalue is (GATE PI 2010)

a) 1 b) 2 c) 3 d) 5

19) if $f(x) = \sin|x|$, then the value of $\frac{df}{dx}$ at $x = -\frac{\pi}{4}$ is (GATE PI 2010)

a) 0 b) $\frac{1}{\sqrt{2}}$ c) $-\frac{1}{\sqrt{2}}$ d) 1

20) Which one of the following differential equations has a solution given by the function $y = 5\sin\left(3x + \frac{\pi}{3}\right)$ (GATE PI 2010)

a) $\frac{dy}{dx} - \frac{5}{3}\cos(3x) = 0$
b) $\frac{dy}{dx} + \frac{5}{3}\cos(3x) = 0$
c) $\frac{d^2y}{dx^2} + 9y = 0$
d) $\frac{d^2y}{dx^2} - 9y = 0$

21) If $f(x + iy) = x^3 - 3xy^2 + i\varphi(x, y)$ where $i = \sqrt{-1}$ and $f(x + iy)$ is an analytic function, then $\varphi(x, y)$ is (GATE PI 2010)

a) $y^3 - 3x^2y$ b) $3x^2y - y^3$ c) $x^4 - 4x^3y$ d) $xy - y^2$

22) If a complex number ω satisfies the equation $\omega^3 = 1$ then the value of $1 + \omega + \frac{1}{\omega}$ is (GATE PI 2010)

a) 0 b) 1 c) 2 d) 4

23) If a random variable X satisfies the Poisson's distribution with a mean value of 2, then the probability that $X \geq 2$ is (GATE PI 2010)

a) $2e^{-2}$ b) $1 - 2e^{-2}$ c) $3e^{-2}$ d) $1 - 3e^{-2}$

24) The integral $\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} e^{-\frac{x^2}{2}}dx$ is equal to (GATE PI 2010)

a) $\frac{1}{2}$ b) $\frac{1}{\sqrt{2}}$ c) 1 d) ∞

25) The following algorithm computes the integral $J = \int_a^b f(x)\,dx$ from the given values $f_j = f\left(x_j\right)$ at equidistant points: $x_0 = a$; $x_j = x_{j-1} + h$; $x_{2m} = x_0 + 2mh = b$.

$$\text{Compute } S_0 = f_0 + f_{2m}$$
$$S_1 = f_1 + f_3 + \cdots + f_{2m-1}$$
$$S_2 = f_2 + f_4 + \cdots + f_{2m-2}$$
$$J = \frac{h}{3}\left(S_0 + 4S_1 + 2S_2\right)$$

The rule of numerical integration, which uses the above algorithm, is (GATE PI 2010)

a) Rectangular rule
b) Trapezoidal rule
c) Four-point rule
d) Simpson's rule

26) During open die forging process using two flat and parallel dies, a solid circular steel disc of initial radius (R_{IN}) 200 mm and initial height (H_{IN}) 50 mm attains a height (H_{FN}) of 30 mm and radius of R_{FN}. Along the die-disc interfaces,

i. the coefficient of friction (μ) is: $\mu = 0.35\left(1 + e^{-\frac{R_{FN}}{R_{IN}}}\right)$.

ii. in the region $R_{SS} \le r \le R_{FN}$, sliding friction prevails, and $P = \sqrt{3}Ke^{\frac{2\mu}{H_{FN}}(R_{FN}-r)}$ and $\tau = \mu p$, where p and τ are the normal an d the shear stresses, respectively; K is the shear yield strength of steel and r is the radial distance of any point.

iii. in the region $0 \le r \le R_{SS}$, sticking condition prevails.

The value of R_{SS} (in mm), where sticking condition changes to sliding friction, is (GATE PI 2010)

a) 241.76 b) 254.55 c) 265.45 d) 278.20

27) Two steel bars, each of diameter 10 mm, are coaxially friction welded, end to end, at an axial pressure of 200 MPa and at a rotational speed of 4000 rpm. The coefficient of friction between the mating faces of the rotating bars is 0.50. The torque is assumed to act at the $3/4^{th}$ radius of the rotating bar. The power (in kW) consumed at the interface for welding is (GATE PI 2010)

a) 12.33 b) 16.44 c) 18.50 d) 24.66

28) During a steady gas metal arc welding with direct current electrode positive polarity, the welding current, voltage and weld speed are 150 A, 30 V and 6 m/min, respectively. A metallic wire electrode of diameter 1.2 mm is being fed at a constant rate of 12 m/min. The density, specific heat and melting temperature of the wire electrode are 7000 kg/m^3, 500 J/kg°C and 1530°C, respectively. Assume the ambient temperature to be 30°C and neglect the latent heat of melting. Further, consider that two-third of the total electrical power is available for melting of the wire electrode. The melting efficiency (in percentage) of the wire electrode is (GATE PI 2010)

a) 39.58 b) 45.25 c) 49.38 d) 54.98

29) The tool geometry of a single point right handed turning tool is provided in the orthogonal rake system (*ORS*). The sum of the principal (*major*) cutting edge angle and the auxiliary (*minor*) cutting edge angle of the above tool is 90°. The inclination angles of the principal and the auxiliary cutting edges are both 0°. The principal and auxiliary orthogonal clearance angles are 10° and 8°, respectively. The rake angle (in degree) measured on the orthogonal plane is (GATE PI 2010)

a) 0 b) 2 c) 8 d) 10

30) Keeping all other parameters unchanged, the tool wear in electrical discharge machining (*EDM*) would be less if the tool material has (GATE PI 2010)

a) high thermal conductivity and high specific heat
b) high thermal conductivity and low specific heat
c) low thermal conductivity and low specific heat
d) low thermal conductivity and high specific heat

31) For a 3-axes CNC table, the slide along the vertical axis of the table is driven by a DC servo motor via a lead screw-nut mechanism. The lead screw has a pitch of 5 mm. This lead screw is fitted with a relative (*incremental*) circular encoder. The basic length unit (*BLU*) of the slide along the vertical axis of the table is 0.005 mm. When the table moves along the vertical axis by 9 mm, the corresponding number of pulses generated by the encoder is (GATE PI 2010)

a) 1400
b) 1800
c) 4200
d) 9000

32) A small bore is designated as 25H7. The lower (*minimum*) and upper (*maximum*) limits of the bore are 25.000 mm and 25.021 mm, respectively. When the bore is designated as 25H8, then the upper (*maximum*) limit is 25.033 mm. When the bore is designated as 25H6, then the upper (*maximum*) limit of the bore (in mm) is (GATE PI 2010)

a) 25.001 b) 25.005 c) 25.009 d) 25.013

33) A gear with involute tooth profile has 50 teeth and module 2. It is in mesh with a pinion having 20 teeth. The pressure angle is 20°. The base circle diameter (in mm) of the pinion is (GATE PI 2010)

a) 33.828
b) 37.587
c) 42.567
d) 93.969

34) The length of time, during which a particular piece of equipment operates before failure, is a random variable with the distribution function given as: $F(t) = 1 - e^{-0.5t}$. Assume 100 pieces of the equipment are placed into service in year 0. Out of the units, which survive the first 4 years, the units (in percentage) that will fail during year 5 is (GATE PI 2010)

a) 37 b) 39 c) 41 d) 43

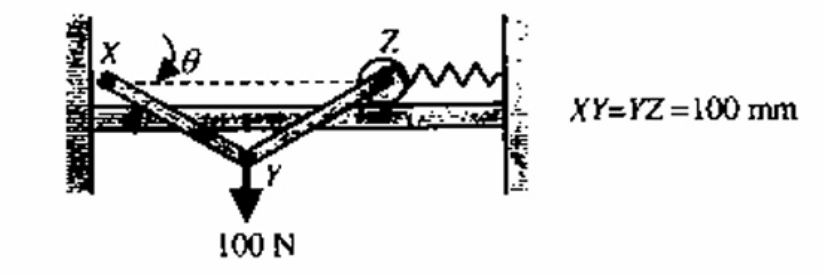
35) Euler's method of integration is applied to the initial value problem: $y(0) = 0$.

$$\frac{dy}{dx} = 2x$$

If the step size $h = 0.2$, then the error in computation (*inpercentage*) after 5 steps would be (GATE PI 2010)

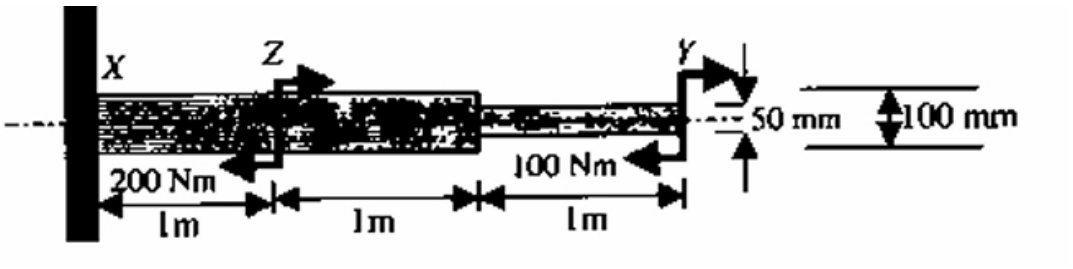
a) 0 b) 10 c) 20 d) 30

36) A rigid massless link YZ of length 100 mm is connected at one end to another massless link XY of the same length by means of a frictionless hinge at Y and at the other end to a frictionless roller, as shown in the following figure. The link XY is connected to the wall by means of a frictionless hinge at point X. The roller is connected to a massless linear spring with a spring constant 10 kN/m. A point force of 100 N is applied at point Y as shown in the figure. At equilibrium, each of the links XY and YZ makes an angle $\theta = 30°$ with the horizontal. Under this situation, the stretch of the spring (in mm) is (GATE PI 2010)



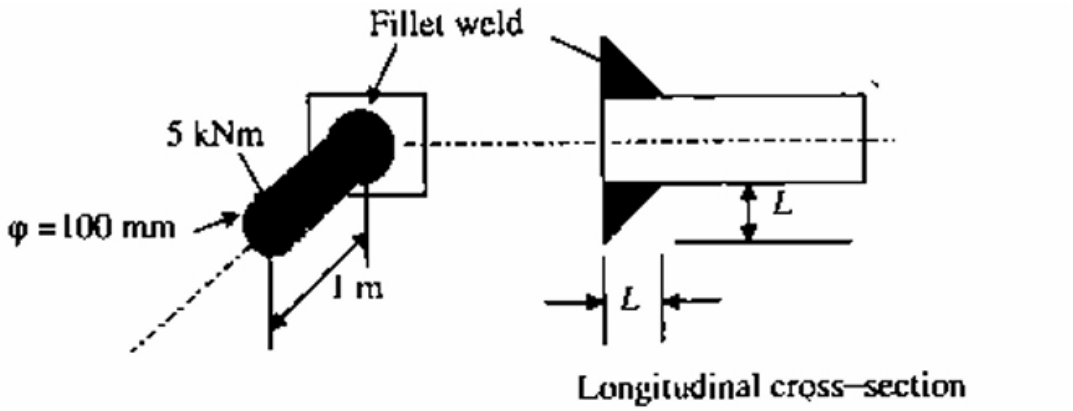
a) $\frac{5}{3}\sqrt{3}$
b) $\frac{5}{2}\sqrt{3}$
c) $5\sqrt{3}$
d) $10\sqrt{3}$

37) A cantilever beam XY is made of a stepped circular shaft of diameters 100 mm and 50 mm, as shown in the following figure. The cantilever is subjected to two concentrated bending moments, one of 100 Nm at point Y and another of 200 Nm at point Z. The maximum bending stress (in MPa) experienced by the cantilever is (GATE PI 2010)



a) 1.02
b) 3.06
c) 8.15
d) 16.30

38) A 1 m long cylindrical shaft of diameter 100 mm is joined to the wall by means of fillet weld as shown in the following figure. The shaft is designed to carry a torque of 5 kNm at the free end. If the allowable shear stress of the weld material is 80 MPa, then the minimum value of the size, L (shown in the following figure), of the fillet (in mm) is



(GATE PI 2010)

a) 3.97 b) 5.63 c) 7.95 d) 11.45

39) In a steam power plant, the turbine power output is 1 MW while the boiler heat input is at the rate of 2.5 MW. The pump power input is negligibly small. In the condenser, exhaust steam from the turbine rejects heat to a steady flow of cooling water, which enters the condenser at 25°C and leaves at 40°C. Ignore kinetic and potential energy effects for the cooling water. The specific heat of cooling water is 4 kJ/kgK. The required mass flow rate (in kg/s) of cooling water is (GATE PI 2010)

a) 1.5 b) 2.5 c) 15 d) 25

40) Nitrogen gas flows over a flat surface, which is maintained at a temperature (T_w) of 300 K. The temperature distribution within the boundary layer is expressed as:

$$\frac{T - T_w}{T_\infty - T_w} = 1 - e^{-3500y}$$

where y (in m) is the distance normal to the surface, the free stream nitrogen gas temperature (T_∞) is 400 K, and T is the Nitrogen gas temperature within the boundary layer at a given y. The thermal conductivity of nitrogen is 0.03 W/mK. The resulting average convective heat transfer coefficient $\left(\text{in W/m}^2\text{K}\right)$ is (GATE PI 2010)

a) 52 b) 105 c) 1050 d) 3500

41) Consider steady and incompressible flow of water through a tapered pipe from section 1 to section 2. The pipe has a diameter of 0.25 m and a centre-line elevation of 25 m at section 1 and a diameter of 0.35 m and a centre-line elevation of 20 m at section 2. Consider head loss between section 1 and section 2 to be negligibly small. Pressure at section 1 is 120 kPa. The acceleration due to gravity is 10 m/s^2 and density of water is 1000 kg/m^3. For a flow rate of 0.2 m^3/s, the pressure at section 2 (*inkPa*) is (GATE PI 2010)

a) 56 b) 112 c) 176 d) 232

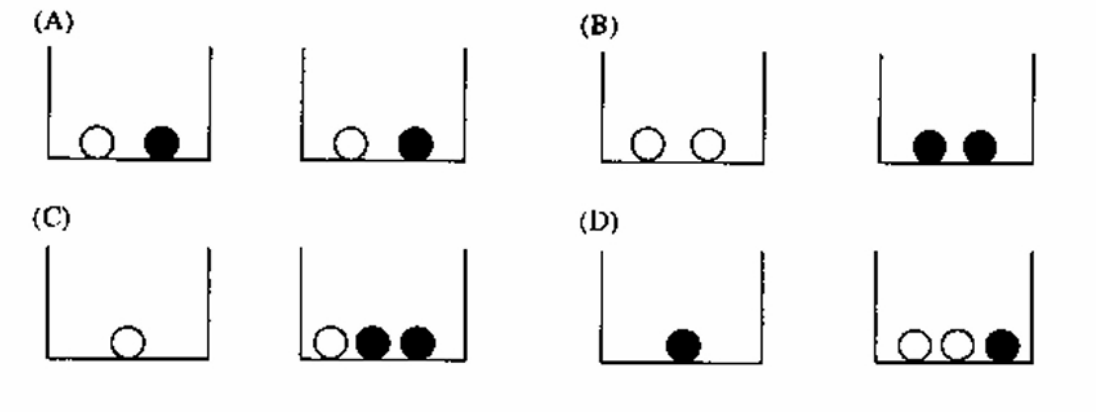
42) If annual demand, ordering cost and carrying cost become four times of their respective original values, then the economic order quantity (EOQ) (GATE PI 2010)

a) remains the same b) gets halved c) gets doubled d) becomes four times

43) The solution of the differential equation $\frac{dy}{dx} - y^2 = 1$ satisfying the condition $y(0) = 1$ is (GATE PI 2010)

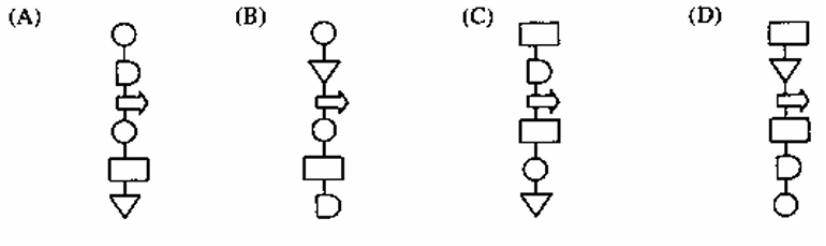
a) $y = e^{x^2}$ b) $y = \sqrt{x}$ c) $y = \cot\left(x + \frac{\pi}{4}\right)$ d) $y = \tan\left(x + \frac{\pi}{4}\right)$

44) Two white and two black balls, kept in two bins, are arranged in four ways as shown below. In each arrangement, a bin has to be chosen randomly and only one ball needs to be picked randomly from the chosen bin. Which one of the following arrangements has the highest probability for getting a white ball picked? (GATE PI 2010)



45) An industrial process consists of the following six activities
1. Casting
2. Wait
3. To Buffing
4. Buffing
5. Inspection
6. Store

The correct flow process chart for this process is (GATE PI 2010)



46) A batch of $10,000$ raw work units is processed through 20 operations, each of which has a fraction defect rate of 0.05. The defect-free units and the number of defects in the final batch are, respectively, (GATE PI 2010)

a) 3285 and 6715 b) 3385 and 6615 c) 3485 and 6515 d) 3585 and 6415

47) Match the following groups most appropriately. (GATE PI 2010)

Group I		**Group II**	
E.	Strategic decision	1.	Production scheduling
F.	Bullwhip effect	2.	Reduce manufacturing lead time
G.	Flexible manufacturing system	3.	Plant layout
H.	Tactical decision	4.	Price fluctuations
I.	Operational decision	5.	Inventory policies

a) E-3, F-4, G-2, H-5, I-1
b) E-4, F-5, G-1, H-2, I-3
c) E-4, F-1, G-5, H-3, I-2
d) E-3, F-1, G-2, H-5, I-4

Common Data for Questions 48 and 49:

A machine shop processes custom orders from a variety of clients. A machining centre in a job shop for a local manufacturing company has five unprocessed jobs remaining at a particular point in time. The jobs are labelled J_1, J_2, J_3, J_4, and J_5 in the order they entered the shop. The respective processing times and due dates are given in the table below:

Job	Processing time (in days)	Due date (in days)
J_1	13	65
J_2	32	48
J_3	34	34
J_4	4	36
J_5	5	35

48) When the jobs are assumed to enter the shop in the sequence of SPT (Shortest Processing Time), the mean flow time and average tardiness, respectively, are (GATE PI 2010)

a) 35.4 and 12
b) 37.4 and 13
c) 39.4 and 14
d) 41.4 and 15

49) When the jobs are assumed to enter in the sequence of EDD (Earliest Due Date), the number of tardy jobs is (GATE PI 2010)

a) 0 b) 1 c) 3 d) 4

Common Data for Questions 50 and 51:

A company is engaged in producing and selling a single product. The fixed cost of the product is F per period. The selling price for the product is S per unit. The variable cost is V per unit, which is half of the selling price, i.e., $S/2$ per unit. The company has computed its Break Even Sales in monetary units. Not being satisfied with this Break Even Sales, the company has decided to increase its selling price from S to $1.5S$. The company has again computed the new Break Even Sales in monetary units keeping the fixed cost (F) and variable cost ($S/2$ per unit) of the product same.

50) The ratio of new to old Break Even Sales is (GATE PI 2010)

a) 0.25 b) 0.50 c) 0.75 d) 1.50

51) The firm desires to make a profit equal to the fixed cost of the product. In this scenario, the ratio of new to old Required Sales Volume is (GATE PI 2010)

a) 0.25 b) 0.50 c) 0.75 d) 1.50

Linked Answer Questions

Statement for Linked Answer Questions 52 and 53:

Consider the following Linear Programming problem:

$$\begin{aligned} \text{Maximize} \quad & Z = 3x_1 + 5x_2 + 8x_3 \\ \text{Subject to:} \quad & x_1 + 5x_2 \leq 10 \\ & x_3 \leq 20 \\ & x_1 \geq 0;\ x_2 \geq 0;\ x_3 \geq 0 \end{aligned}$$

52) Apart from the non-negativity criteria, the dual problem for the given Linear Programming problem consists of (GATE PI 2010)

a) 2 constraints and both of them are of $\leq$ type
b) 2 constraints and both of them are of $\geq$ type
c) 3 constraints and all of them are of $\leq$ type
d) 3 constraints and all of them are of $\geq$ type

53) The value of the objective function after solving the dual problem is (GATE PI 2010)

a) 160 b) 170 c) 190 d) 210

Statement for Linked Answer Questions 54 and 55:

In orthogonal turning of an engineering alloy, it has been observed that the friction force acting at the chip-tool interface is 402.5 N and the friction force is also perpendicular to the cutting velocity vector. The feed velocity is negligibly small with respect to the cutting velocity. The ratio of friction force to normal force associated with the chip-tool interface is 1. The uncut chip thickness is 0.2 mm and the chip thickness is 0.4 mm. The cutting velocity is 2 m/s.

54) The shear force (in N) acting along the primary shear plane is (GATE PI 2010)

a) 180.0 b) 240.0 c) 360.5 d) 402.5

55) Assume that the energy expended during machining is completely converted to heat. The rate of heat generation (in W) at the primary shear plane is (GATE PI 2010)

a) 180.5 b) 200.5 c) 302.5 d) 402.5

56) Choose the most appropriate word from the options given below to complete the following sentence: His rather casual remarks on politics _____ his lack of seriousness about the subject. (GATE GA 2010)

a) masked
b) belied
c) betrayed
d) suppressed

57) Which of the following options is the closest in meaning to the word below: Circuitous (GATE GA 2010)

a) cyclic
b) indirect
c) confusing
d) crooked

58) Choose the most appropriate word from the options given below to complete the following sentence: If we manage to _____ our natural resources, we would leave a better planet for our children. (GATE GA 2010)

a) uphold
b) restrain
c) cherish
d) conserve

59) 25 persons are in a room. 15 of them play hockey, 17 of them play football and 10 of them play both hockey and football. Then the number of persons playing neither hockey nor football is (GATE GA 2010)

a) 2 b) 17 c) 13 d) 3

60) The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair. Unemployed : Worker (GATE GA 2010)

a) fallow : land
b) unaware : sleeper
c) wit : jester
d) renovated : house

61) If 137 + 276 = 435 how much is 731 + 672? (GATE GA 2010)

a) 534 b) 1403 c) 1623 d) 1513

62) Hari (H), Gita (G), Irfan (I) and Saira (S) are siblings (i.e. brothers and sisters). All were born on 1^{st} January. The age difference between any two successive siblings ($thatisbornoneafteranother$) is less than 3 years. Given the following facts:

i. Hari's age + Gita's age ¿ Irfan's age + Saira's age.
ii. The age difference between Gita and Saira is 1 year. However, Gita is not the oldest and Saira is not the youngest.
iii. There are no twins.

In what order were they born (oldest first)? (GATE GA 2010)

a) HSIG b) SGHI c) IGSH d) IHSG

63) Modern warfare has changed from large scale clashes of armies to suppression of civilian populations. Chemical agents that do their work silently appear to be suited to such warfare; and regretfully there exist people in military establishments who think that chemical agents are useful tools for their cause. Which of the following statements best sums up the meaning of the above passage: (GATE GA 2010)

a) Modern warfare has resulted in civil strife.
b) Chemical agents are useful in modern warfare.
c) Use of chemical agents in warfare would be undesirable.
d) People in military establishments like to use chemical agents in war.

64) 5 skilled workers can build a wall in 20 days; 8 semi-skilled workers can build a wall in 25 days; 10 unskilled workers can build a wall in 30 days. If a team has 2 skilled, 6 semi-skilled and 5 unskilled workers, how long will it take to build the wall? (GATE GA 2010)

a) 20 days b) 18 days c) 16 days d) 15 days

65) Given digits $2, 2, 3, 3, 3, 4, 4, 4, 4$ how many distinct 4 digit numbers greater than 3000 can be formed? (GATE GA 2010)

a) 50 b) 51 c) 52 d) 54