

# GATE - 2015 - Mechanical Engineering (ME)

**DATE: 01/02/2015**

**Time: 2:00 PM - 5:00 PM**

01. Five teams have to compete in a league, with every team playing every other team exactly once, before going to next round. How many matches will have to be held to complete the league round of matches?

(A) 20            (B) 10            (C) 8            (D) 5

**01. Ans: (B)**

02. Choose the appropriate word/phrase, out of the four options given below, to complete the following sentence:

Apparent lifelessness \_\_\_\_\_dormant life.

- (A) harbours (B) leads to  
(C) supports (D) affects

**02. Ans: (B)**

03. Choose the statement where underlined word is used correctly.

- (A) When the teacher eludes to different authors, he is being elusive.
- (B) When the thief keeps eluding the police, he is being elusive.
- (C) Matters that are difficult to understand, identify or remember are allusive.
- (D) Mirages can be allusive, but a better way to express them is illusory.

**03. Ans: (B)**

04. Fill in the blanks with the correct idiom/phrase.

That boy from the town was a \_\_\_\_\_ in the sleepy village.

- (A) dog out of herd  
(B) sheep from the heap

- (C) fish out of water  
(D) bird from the flock

**04. Ans: (C)**

05. Tanya is older than Eric.  
Cliff is older than Tanya.  
Eric is older than Cliff.

If the first two statements are true, then the third statement is:

- (A) True                      (B) False  
(C) Uncertain              (D) Data insufficient

**05. Ans: (B)**

06. Right triangle PQR is to be constructed in the xy-plane so that the right angle is at P and line PR is parallel to the x-axis. The x and y coordinates of P, Q, and R are to be integers that satisfy the inequalities:  $-4 \leq x \leq 5$  and  $6 \leq y \leq 16$ . How many different triangles could be constructed with these properties?

- (A) 110  
(B) 1,100  
(C) 9,900  
(D) 10,000

**06. Ans: (C)**

07. A coin is tossed thrice. Let  $X$  be the event that head occurs in each of the first two tosses. Let  $Y$  be the event that a tail occurs on the third toss. Let  $Z$  be the event that two tails occur in three tosses. Based on the above information, which one of the following is TRUE?

- (A) X and Y are not independent  
(B) Y and Z are dependent  
(C) Y and Z are independent  
(D) X and Z are independent

**07. Ans: (C)**

08. Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows.

**Statement:**

- I. No manager is a leader.
- II. All leaders are executives.

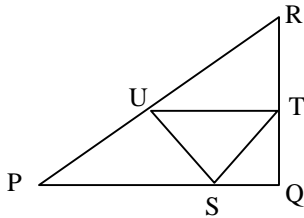
**Conclusions:**

- I. No manager is an executive.
- II. No executive is a manager.

- (A) Only conclusion I follows.
- (B) Only conclusion II follows.
- (C) Neither conclusion I nor II follows.
- (D) Both conclusions I and II follow.

**08. Ans: (D)**

09. In the given figure angle Q is a right angle,  $PS:QS=3:1$ ,  $RT:QT=5:2$  and  $PU:UR=1:1$ . If area of triangle QTS is  $20\text{cm}^2$ , then the area triangle PQR in  $\text{cm}^2$  is \_\_\_\_\_.



**09. Ans: 280**

10. Select the appropriate option in place of underlined part of the sentence.

Increased productivity necessary reflects greater efforts made by the employees.

- (A) Increase in productivity necessary
- (B) Increase productivity is necessary
- (C) Increase in productivity necessarily
- (D) No improvement required.

**10. Ans: (C)**

## Mechanical Engineering

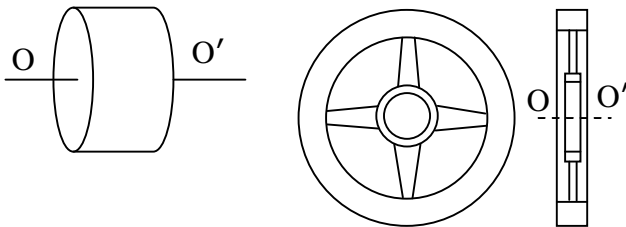
01. Three parallel pipes connected at the two ends have flow-rates  $Q_1, Q_2$ , and  $Q_3$  respectively, and the corresponding frictional head losses are  $h_{L1}$ ,  $h_{L2}$ , and  $h_{L3}$  respectively. The correct expression for total flow rate ( $Q$ ) and frictional head loss across the two ends ( $h_L$ ) are.

- (A)  $Q = Q_1 + Q_2 + Q_3$ ;  $h_L = h_{L1} + h_{L2} + h_{L3}$   
 (B)  $Q = Q_1 + Q_2 + Q_3$ ;  $h_L = h_{L1} = h_{L2} = h_{L3}$   
 (C)  $Q = Q_1 = Q_2 = Q_3$ ;  $h_L = h_{L1} + h_{L2} + h_{L3}$   
 (D)  $Q = Q_1 = Q_2 = Q_3$ ;  $h_L = h_{L1} = h_{L2} = h_{L3}$

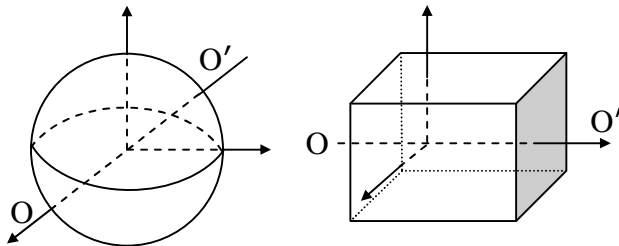
**01. Ans: (B)**

02. For the same material and the mass, which of the following configurations of flywheel will have maximum mass moment of inertia about the axis of rotation  $OO'$  passing through the center of gravity.

- (A) Solid Cylinder (B) Rimmed Wheel

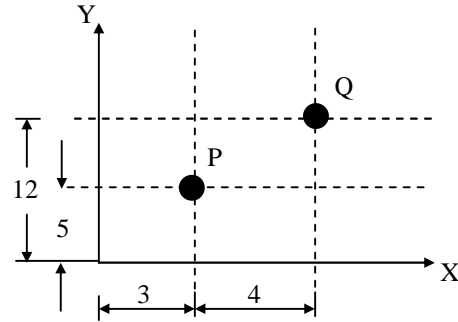


- (C) Solid Sphere (D) Solid Cube



**02. Ans: (B)**

03. A drill is positioned at point P and it has to proceed to point Q. The coordinates of point Q in the incremental system of defining position of a point in CNC part program will be.



- (A) (3, 12) (B) (5, 7)  
 (C) (7, 12) (D) (4, 7)

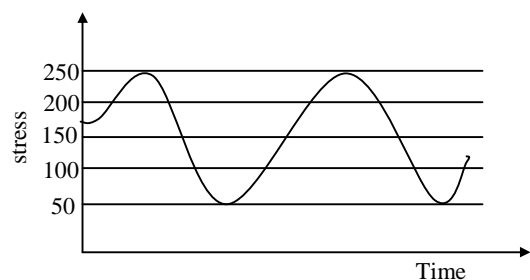
**03. Ans: (D)**

04. A rigid container of volume  $0.5 \text{ m}^3$  contains  $1.0 \text{ kg}$  of water at  $120^\circ\text{C}$  ( $\epsilon_f = 0.00106 \text{ m}^3/\text{kg}$ ,  $\epsilon_g = 0.8908 \text{ m}^3/\text{kg}$ ). The state of water is

- (A) Compressed liquid  
 (B) saturated liquid  
 (C) A mixture of saturated liquid and saturated vapor  
 (D) Superheated vapor

**04. Ans: (C)**

- 05 For the given fluctuating fatigue load, the value of stress amplitude and stress ratio are respectively.



- (A) 100 MPa and 5
- (B) 250 MPa and 5
- (C) 100 MPa and 0.20
- (D) 250 MPa and 0.20

**05. Ans: (C)**

06. In full mould (cavity-less) casting process,

Pattern is made of

- (A) Expanded polystyrene
- (B) Wax
- (C) Epoxy
- (D) Plaster of Paris

**06. Ans: (A)**

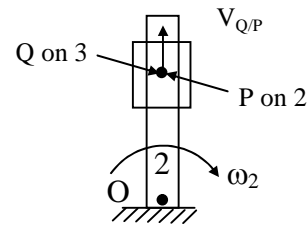
07. Which of the following statements are TRUE for damped vibrations?

- P. For a system having critical damping, the value of damping ratio is unity and system does not undergo a vibratory motion.
- Q. Logarithmic decrement method is used to determine the amount of damping in a physical system.
- R. In case of damping due to dry friction between moving surfaces resisting force of constant magnitude acts opposite to the relative motion.
- S. For the case of viscous damping, drag force is directly proportional to the square of relative velocity.

- (A) P and Q only
- (B) P and S only
- (C) P, Q and R only
- (D) Q and S only

**07. Ans: (C)**

08. In the figure, link 2 rotates with constant angular velocity  $\omega_2$ . A slider link 3 moves outwards with a constant relative velocity  $V_{Q/P}$ , where Q is a point on slider 3 and p is a point on link 2. The magnitude and direction of Coriolis component of acceleration is given by



- (A)  $2\omega_2 V_{Q/P}$ ; direction of  $V_{Q/P}$  rotated by  $90^\circ$  in the direction of  $\vec{S}_2$ .
- (B)  $\omega_2 V_{Q/P}$ ; direction of  $V_{Q/P}$  rotated by  $90^\circ$  in the direction of  $\vec{S}_2$ .
- (C)  $2\omega_2 V_{Q/P}$ ; direction of  $V_{Q/P}$  rotated by  $90^\circ$  Opposite to the direction of  $\vec{S}_2$ .
- (D)  $\omega_2 V_{Q/P}$ ; direction of  $V_{Q/P}$  rotated by  $90^\circ$  Opposite to the direction of  $\vec{S}_2$ .

**08. Ans: (A)**

09. An air-standard Diesel cycle consists of the following process:

- 1-2: Air is compressed isentropically.
- 2-3: Heat is added at constant pressure.
- 3-4: Air expands isentropically to the original volume.
- 4-5: Heat is rejected at constant volume.

If  $\gamma$  and  $T$  denote the specific heat ratio and temperature, respectively, the efficiency of the cycle is

- (A)  $1 - \frac{T_4 - T_1}{T_3 - T_2}$
- (B)  $1 - \frac{T_4 - T_1}{\gamma(T_3 - T_2)}$
- (C)  $1 - \frac{\gamma(T_4 - T_1)}{T_3 - T_2}$
- (D)  $1 - \frac{T_4 - T_1}{(\gamma - 1)(T_3 - T_2)}$

**09. Ans: (B)**

10. If  $P(X) = 1/4$ ,  $P(Y) = 1/3$ , and  $P(X \cap Y) = 1/12$ , the value of  $P(Y/X)$  is

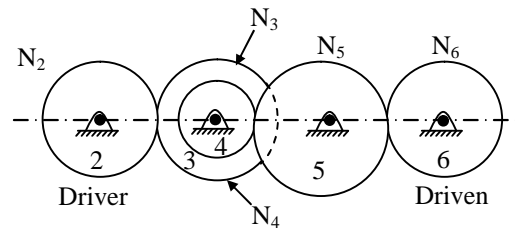
- (A)  $\frac{1}{4}$       (B)  $\frac{4}{25}$       (C)  $\frac{1}{3}$       (D)  $\frac{29}{50}$

**10. Ans: (C)**

11. A cylindrical tank with closed ends is filled with compressed air at a pressure of 500kPa, the inner radius of the tank is 2m, and it has wall thickness of 10 mm. The magnitude of maximum in-plane shear stress (in MPa) is \_\_\_\_

**11. Ans: 25**

12. A gear train is made up of five spur gears as shown in the figure. Gear 2 is driver and gear 6 is driven member.  $N_2$ ,  $N_3$ ,  $N_4$ ,  $N_5$  and  $N_6$  represent number of teeth on gears 2, 3, 4, 5, and 6 respectively. The gear(s) which act(s) as idler(s) is/ are



- (A) Only 3      (B) Only 4  
(C) Only 5      (D) both 3 and 5

**12. Ans: (C)**

13. The ratio of momentum diffusivity ( $\nu$ ) to thermal diffusivity ( $\alpha$ ), is called

- (A) Prandtl number (B) Nusselt number  
(C) Biot number (D) Lewis number

**13. Ans: (A)**

14. The lowest eigen value of the  $2 \times 2$  matrix

$$\begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix} \text{ is } \underline{\hspace{2cm}}$$

**14. Ans: 2**

15. Which two of the following joining processes are autogenous?

- (i) Diffusion welding  
(ii) Electro slag welding  
(iii) Tungsten inert gas welding  
(iv) Friction welding

- (A) (i) and (iv) (B) (ii) and (iii)  
(C) (ii) and (iv) (D) (i) and (iii)

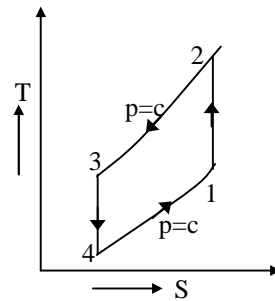
**15. Ans: (A)**

16. Couette flow is characterized by

- (A) Steady, incompressible, laminar flow through a straight circular pipe  
(B) Fully developed turbulent flow through a straight circular pipe  
(C) Steady, incompressible, laminar flow between two fixed parallel plates  
(D) Steady, incompressible, laminar flow between one fixed plate and the other moving with a constant velocity

**16. Ans: (D)**

17. The thermodynamic cycle shown in figure ( $T$ - $s$  diagram) indicates.



- (A) Reversed Carnot cycle  
(B) Reversed Brayton cycle  
(C) Vapor compression cycle  
(D) Vapor absorption cycle

**17. Ans: (B)**

18. In the notation (a/b/c) : (d/e/f) for summarizing the characteristics of queuing situation, the letters 'b' and 'd' respectively for

- (A) Service time distribution and queue discipline  
(B) Number of servers and size of calling source  
(C) Number of servers and queue discipline  
(D) Service time distribution and maximum number allowed in system

**18. Ans: (A)**

19. In a machining operation, if the generatrix and directrix both are straight lines, the surface obtained is

- (A) Cylindrical (B) helical  
(C) Plane (D) Surface of revolution

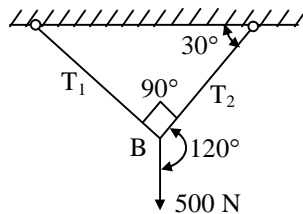
**19. Ans: (C)**

20. Let  $w$  be an arbitrary smooth real valued scalar function and  $\vec{V}$  be an arbitrary smooth vector valued function in a three-dimensional space. Which one of the following is an identity?

- (A)  $\text{Curl}(\phi \vec{V}) = \nabla(w \text{Div} \vec{V})$   
 (B)  $\text{Div} \vec{V} = 0$   
 (C)  $\text{Div} \text{Curl} \vec{V} = 0$   
 (D)  $\text{Div} (w \vec{V}) = w \text{Div} \vec{V}$

**20. Ans: (C)**

21. A weight of 500N is supported by two metallic ropes as shown in the figure. The values of tensions  $T_1$  and  $T_2$  are respectively.



- (A) 433N and 250N  
 (B) 250N and 433N  
 (C) 353.5N and 250N  
 (D) 250N and 353.5N

**21. Ans: (A)**

22. Saturated vapor is condensed to saturated liquid in a condenser. The heat capacity ratio is  $c_r = \frac{c_{\min}}{c_{\max}}$ . The effectiveness (s) of the condenser is.

- (A)  $\frac{1 - \exp[-NTU(1 + C_r)]}{1 + C_r}$

- (B)  $\frac{1 - \exp[-NTU(1 - C_r)]}{1 - c_r \exp[-NTU(1 - C_r)]}$   
 (C)  $\frac{NTU}{1 + NTU}$   
 (D)  $1 - \exp(-NTU)$

**22. Ans: (D)**

23. The value of

$$\lim_{x \rightarrow 0} \left( \frac{-\sin x}{2 \sin x + x \cos x} \right) \text{ is } \underline{\hspace{2cm}}$$

**23. Ans: - 0.333**

24. The strain hardening exponent  $n$  of stainless steel SS 304 with distinct yield and UTS values undergoing plastic deformation is

- (A)  $n < 0$  (B)  $n = 0$   
 (C)  $0 < n < 1$  (D)  $n = 1$

**24. Ans: (C)**

25. Using a unit step size, the value of integral

$$\int_1^2 x \ln x dx \text{ by trapezoidal rule is } \underline{\hspace{2cm}}$$

**25. Ans: 0.6931**

26. Steam enters a turbine at 30bar,  $300^\circ\text{C}$  ( $u=2750\text{kJ/kg}$ ,  $h=2993\text{ kJ/kg}$ ) and exits the turbine as saturated liquid at 15kPa ( $u=225\text{kJ/kg}$ ,  $h=226\text{kJ/kg}$ ). Heat loss to the surrounding is 50Kj/kg of steam flowing through the turbine. Neglecting changes in kinetic energy and potential energy, the work output of the turbine (in kJ/kg of steam) is \_\_\_\_\_

**26. Ans: 2717**

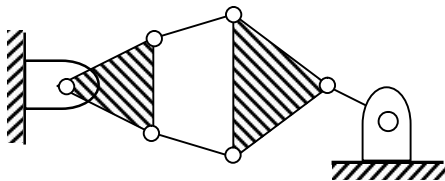
27. Refrigerant vapor enters into the compressor of a standard vapor compression cycle at  $-10^{\circ}\text{C}$  ( $h=402\text{kJ/kg}$ ) and leaves the compressor at  $50^{\circ}\text{C}$  ( $h = 432\text{kJ/kg}$ ). It leaves the condenser at  $30^{\circ}\text{C}$  ( $h=237\text{kJ/kg}$ ). The COP of the cycle is \_\_\_\_\_

**27. Ans: 5.5**

28. For ball bearings, the fatigue life  $L$  measured in number of revolutions and the radial load  $F$  are related by  $FL^{1/3} = K$ , where  $K$  is a constant. It withstands a radial load of 2 kN for a life of 540 million revolutions. The load (in kN) for a life of one million revolutions is

**28. Ans: 16.286**

29. The number of degree of freedom of the linkage shown in figure is



(A) -3      (B) 0      (C) 1      (D) 2

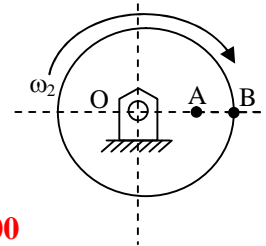
**29. Ans: (C)**

30. The dimensions of a cylindrical side riser (height = diameter) for a 25cm × 15cm × 5cm steel casting are to be determined. For the tabulated shape factor values given below, the diameter of the riser (in cm) is \_\_\_\_\_

Shape factor	2	4	6	8	10	12
Riser volume/ Casting volume	1.0	0.70	0.55	0.50	0.40	0.35

**30. Ans: 10.6**

31. Figure shows a wheel rotating about  $O_2$ . Two points A and B located along the radius of wheel have speeds of 80m/s and 140 m/s respectively. The distance between the points A and B is 300 mm. The diameter of the wheel (in mm) is \_\_\_\_\_



**31. Ans: 1400**

32. In a CNC milling operation, the tool has to machine the circular arc from point (20,20) to (10,10) at sequence number 5 of the CNC part program. If the center of the arc is at (20,10) and the machine has incremental mode of defining position coordinates, the correct tool path command is

(A) N 05 G90 G01 X-10 Y-10 R10  
(B) N 05 G91 G03 X-10 Y-10 R10  
(C) N 05 G90 G03 X20 Y20 R 10  
(D) N 05 G91 G02 X20 Y20 R10

**32. Ans: (B)**

33. A brick wall  $\left(k = 0.9 \frac{\text{W}}{\text{m.K}}\right)$  of thickness

0.18m separates the warm air in a room the cold ambient air. On a particular winter day, the outside air temperature is  $-5^{\circ}\text{C}$  and the room needs to be maintained at  $27^{\circ}\text{C}$ . The heat transfer coefficient associated with outside air is  $20 \frac{\text{W}}{\text{m}^2\text{K}}$ . Neglecting the convective resistance of the air inside the room, the heat loss in  $\left(\frac{\text{W}}{\text{m}^2}\right)$  is.

(A) 88      (B) 110      (C) 128      (D) 160

**33. Ans: (C)**



34. Air in a room is at  $35^{\circ}\text{C}$  and 60% relative humidity (RH). The pressure in the room is 0.1 MPa. The saturation pressure of water at  $35^{\circ}\text{C}$  is 5.63 kPa. The humidity ratio of the air (in gram/kg of dry air) is \_\_\_\_\_

**34. Ans: 21.745**

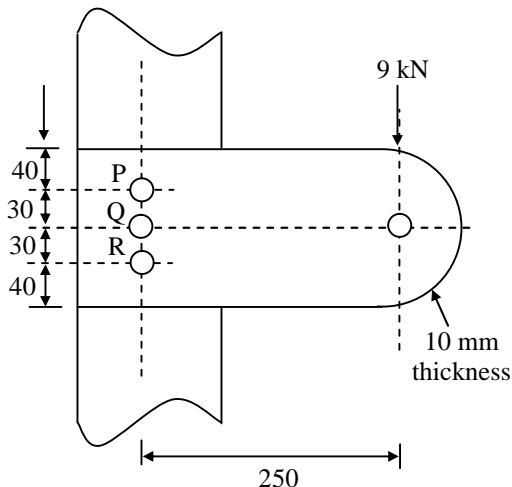
35. A mixture of ideal gases has the following composition by mass:

$\text{N}_2$	$\text{O}_2$	$\text{CO}_2$
60%	30%	10%

If the universal gas constant is  $8314 \text{ J/kmol}\cdot\text{K}$ , the characteristic gas constant of the mixture (in  $\text{J/kg}\cdot\text{K}$ ) is \_\_\_\_\_

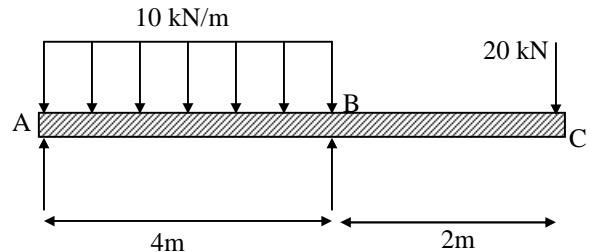
**35. Ans: 274.996**

36. A cantilever bracket is bolted to a column using three M12 $\times$ 1.75 bolts P, Q and R. The value of maximum shear stress developed in the bolt P (in MPa) is \_\_\_\_\_



**36. Ans: 332.54**

37. For the overhanging beam shown in figure, the magnitude of maximum bending moment (in kN-m) is \_\_\_\_\_



**37. Ans: 40**

38. The annual requirement of rivets at a ship manufacturing company is 2000 kg. The rivets are supplied in units of 1 kg costing Rs. 25 each. If it costs Rs. 100 to place an order and the annual cost of carrying one unit is 9% of its purchase cost, the cycle length of the order (in days) will be \_\_\_\_\_

**38. Ans: 76.996**

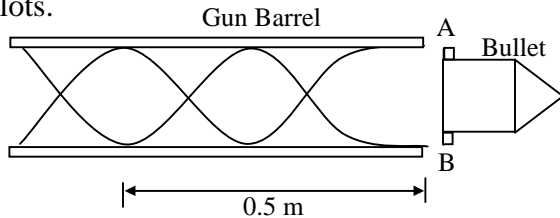
39. Ratio of solidification time of a cylindrical casting (height = radius) to that of a cubic casting of side two times the height of cylindrical casting is \_\_\_\_\_

**39. Ans: 0.5625**

40. One side of a wall is maintained at 400K and the other at 300K. The rate of heat transfer through the wall is 1000W and the surrounding temperature is  $25^{\circ}\text{C}$ . Assuming no generation of heat within the wall, the irreversibility (in W) due to heat transfer through the wall is \_\_\_\_\_

**40. Ans: 248.33**

41. A bullet spin as the shot is fired from a gun. For this purpose, two helical slots as shown in the figure are cut in the barrel. Projections A and B on the bullet engage in each of the slots.



Helical slots are such that one turn of helix is completed over a distance of 0.5m. If velocity of bullet when it exits the barrel is 20m/s, its spinning speed in rad/s is \_\_\_\_\_

**41. Ans: 251.32**

42. The torque (in N-m) exerted on the crank shaft of a two stroke engine can be described as  $T = 10000 + 1000 \sin 2\theta - 1200 \cos \theta$ , where  $\theta$  is the crank angle as measured from inner dead center position. Assuming the resisting torque to be constant, the power (in kW) developed by the engine at 100 rpm is \_\_\_\_\_

**42. Ans: 104.32**

43. A shaft of length 90 mm has a tapered portion of length 55 mm. The diameter of the taper is 80 mm at one end and 65 mm at the other. If the taper is made by tailstock set over method, the taper angle and the set over respectively are.

- (A)  $15^\circ 32'$  and 12.16 mm
- (B)  $18^\circ 32'$  and 15.66 mm
- (C)  $11^\circ 22'$  and 10.26 mm
- (D)  $10^\circ 32'$  and 14.46 mm

**43. Ans: (A)**

44. Which of the following statement are TRUE, when the cavitation parameter  $\sigma = 0$ ?

- (i) The local pressure is reduced to vapor pressure.
  - (ii) Cavitations starts
  - (iii) Boiling of liquid starts
  - (iv) Cavitations stops
- (A) (i),(ii) and (iv)
  - (B) only (ii) and (iii)
  - (C) only (i) and (iii)
  - (D) (i), (ii) and (iii)

**44. Ans: (D)**

45. For the linear programming problem:

$$\text{Maximize } Z=3X_1+2X_2$$

Subject to

$$-2X_1+3X_2 \leq 9$$

$$X_1-5X_2 \geq -20$$

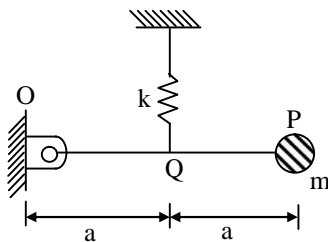
$$X_1, X_2 \geq 0$$

The above problem has

- (A) Unbounded solution
- (B) Infeasible solution
- (C) alternative optimum solution
- (D) degenerate solution

**45. Ans: (A)**

46. Figure shows a single degree of freedom system. The system consists of a mass less rigid bar OP hinged at O and a mass  $m$  at end P. The natural frequency of vibration of the system is



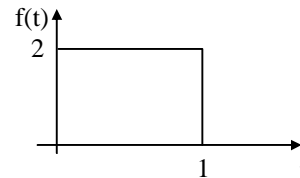
- (A)  $f_n = \frac{1}{2f} \sqrt{\frac{k}{4m}}$
- (B)  $f_n = \frac{1}{2f} \sqrt{\frac{k}{2m}}$
- (C)  $f_n = \frac{1}{2f} \sqrt{\frac{k}{m}}$
- (D)  $f_n = \frac{1}{2f} \sqrt{\frac{2k}{m}}$

**46. Ans: (A)**

47. Laplace transform of the function  $f(t)$  is

$$\text{given by } f(s) = \mathcal{L}\{f(t)\} = \int_0^{\infty} f(t)e^{-st} dt.$$

Laplace transform of the function shown below is given by.



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

**47. Ans: (C)**

48. The value of

$$\int_C [(3x-8y^2)dx + (4y-6xy)dy], \text{ (where C is the region bounded by } x=0, y=0 \text{ and } x+y=1) \text{ is}$$

**48. Ans: 1.666**

49. Orthogonal turning of a mild steel tube with a tool of rake angle  $10^\circ$  is carried out at a feed of 0.14 mm/rev. If the thickness of the chip produced is 0.28mm, the values of shear angle and shear strain will be respectively.

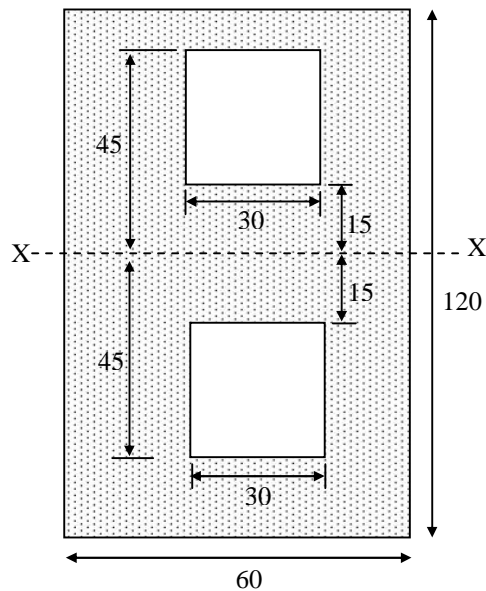
- (A)  $28^\circ 20'$  and 2.19
- (B)  $22^\circ 20'$  and 3.53
- (C)  $24^\circ 30'$  and 4.19
- (D)  $37^\circ 20'$  and 5.19

**49. Ans: (A)**

50. Newton-Raphson method is used to find the roots of the equation,  $x^3+2x^2+3x-1=0$ . If the initial guess is  $x_0=1$ , then the value of  $x$  after 2<sup>nd</sup> iteration is \_\_\_\_\_

**50. Ans: 0.3044**

51. The value of moment of inertia of the section shown in the figure about the axis-XX is



All dimensions are in 'mm'

- (A)  $8.5050 \times 10^6 \text{ mm}^4$   
 (B)  $6.8850 \times 10^6 \text{ mm}^4$   
 (C)  $7.7625 \times 10^6 \text{ mm}^4$   
 (D)  $8.5725 \times 10^6 \text{ mm}^4$

**51. Ans: (B)**

52. For a given matrix  $P = \begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$ ,

where  $i = \sqrt{-1}$ , the inverse of matrix P is

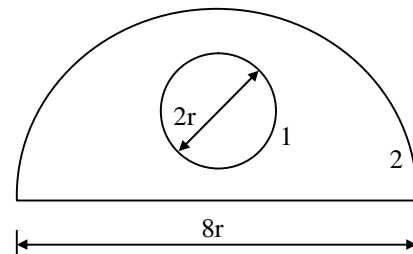
- (A)  $\frac{1}{24} \begin{bmatrix} 4-3i & i \\ -i & 4+3i \end{bmatrix}$   
 (B)  $\frac{1}{25} \begin{bmatrix} i & 4-3i \\ 4+3i & -i \end{bmatrix}$   
 (C)  $\frac{1}{24} \begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$   
 (D)  $\frac{1}{25} \begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$

**52. Ans: (A)**

53. A Prandtl tube (Pitot-static tube with  $C=1$ ) is used to measure the velocity of water. The differential manometer reading is 10 mm of liquid column with a relative density of 10. Assuming  $g=9.8 \text{ m/s}^2$ , the velocity of water (in m/s) is \_\_\_\_\_

**53. Ans: 1.328**

54. A solid sphere 1 of radius 'r' is placed inside a hollow, closed hemispherical surface 2 of radius '4r'. The shape factor  $F_{2-1}$  is.



- (A)  $1/12$  (B)  $1/2$  (C) 2 (D) 12

**54. Ans: (A)**

55. In a rolling operation using rolls of diameter 500mm, if a thick plate cannot be reduced to less than 20mm in one pass, the coefficient of friction between the roll and the plate is \_\_\_\_\_.

**55. Ans: 0.1414**