

# GATE – 2015 – Mechanical Engineering (ME)

**DATE: 01/02/2015**

**Time: 9:00 AM - 12:00 PM**

01. If  $x > y > 1$ , which of the following must be true?

- (i)  $\ln x > \ln y$       (ii)  $e^x > e^y$   
 (iii)  $y^x > x^y$       (iv)  $\cos x > \cos y$

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

**01. Ans: (A)**

02. Choose the correct verb to fill in the blank below:

Let us \_\_\_\_\_

- (A) Introvert      (B) alternate  
 (C) Atheist      (D) Altruist

**02. Ans: (B)**

03. Choose the most suitable one word substitute for the following expression:

Connotation of a road or way

- (A) Pertinacious      (B) Viaticum  
 (C) Clandestine      (D) Ravenous

**03. Ans: (B)**

04. Find the missing sequence in the letter series below:

A, CD, GHI, ?, UVWXY

- (A) LMN      (B) MNO  
 (C) MNOP      (D) NOPQ

**04. Ans: (C)**

05. Choose the most appropriate word from the options given below to complete the following sentence

If the athlete had wanted to come first in the race, he \_\_\_\_\_ several hours every day.

- (A) should practise  
 (B) Should have practiced  
 (C) Practised  
 (D) Should be practicing

**05. Ans: (B)**

06. Ms. X will be in Bagdogra from 01/05/2014 to 20/05/2014 and from 22/05/2014 to 31/05/2014. On the morning of 21/05/2014, she will reach Kochi via Mumbai.

Which one of the statements below is logically valid and can be inferred from the above sentences ?

- (A) Ms. X will be in Kochi for one day, only in May.  
 (B) Ms. X will be in Kochi for only one day in May  
 (C) Ms. X will be only in Kochi for one day in May  
 (D) Only Ms. X will be in Kochi for one day in May

**06. Ans: (B)**

07.  $\log \tan 1^\circ + \log \tan 2^\circ + \dots \dots \dots \log \tan 89^\circ$  is.....

- (A) 1      (B)  $1\sqrt{2}$       (C) 0      (D) -1

**07. Ans: (C)**

08. From a circular sheet of paper of radius 30 cm, a sector of 10 % area is removed. If the remaining part is used to make a conical surface, then the ratio of the radius and height of the cone is \_\_\_\_\_.

**08. Ans: 2.06**

09. Ram and Shyam shared a secret and promised to each other that it would remain between them. Ram expressed himself in one of the following ways as given in the choices below. Identify the correct way as per standard English

- (A) It would remain between you and me
- (B) It would remain between I and you
- (C) It would remain between you and I
- (D) It would remain with me

**09. Ans: (A)**

10. In the following question, the first and the last sentence of the passage are in order and numbered 1 and 6. The rest of passage is split into 4 parts and numbered as 2,3,4 and 5. These 4 parts are not arranged in proper order. Read the sentences and arrange them in logical sequence to make a passage and

choose the correct sequence from the given options.

1. On Diwali, the family rises early in the morning
2. The whole family, including the young and old enjoy doing this.
3. Children let off fireworks later in the night with their friends.
4. At sunset, the lamps are lit and the family performs various rituals.
5. Father, mother and children visit relatives and exchange gifts and sweets.
6. Houses look so pretty with lamps all around.

- (A) 2, 5, 3, 4      (B) 5, 2, 4, 3
- (C) 3, 5, 4, 2      (D) 4, 5, 2, 3

**10. Ans: (B)**

## Mechanical Engineering

01. Curl of vector  $V(x,y,z) = 2x^2\mathbf{i} + 3z^2\mathbf{j} + y^3\mathbf{k}$  at  $x=y=z=1$  is

- (A)  $-3\mathbf{i}$  (B)  $3\mathbf{i}$   
(C)  $3\mathbf{i} - 4\mathbf{j}$  (D)  $3\mathbf{i} - 6\mathbf{k}$

**01. Ans: (A)**

02. A rope brake dynamometer attached to the crank shaft of an I.C. engine measures a brake power of 10 kW when the speed of rotation of the shaft is 400 rad/s. The shaft torque (in N-m) sensed by the dynamometer is \_\_\_\_\_

**02. Ans: 25**

03. If the fluid velocity for a potential flow is given by  $V(x,y) = u(x,y)\mathbf{i} + v(x,y)\mathbf{j}$  with usual notations, then the slope of potential line at  $(x,y)$  is

- (A)  $\frac{v}{u}$  (B)  $-\frac{u}{v}$   
(C)  $\frac{v^2}{u^2}$  (D)  $\frac{u}{v}$

**03. Ans: (B)**

04. In a spring-mass system the mass is  $m$  and the spring constant is  $k$ . The critical damping coefficient of the system is  $0.1 \text{ kg/s}$ . In another spring mass system, the mass is  $2m$  and the spring constant is  $8k$ . The critical damping coefficient (in  $\text{kg/s}$ ) of this system is \_\_\_\_\_

**04. Ans: 0.4**

05. The Laplace transform of  $e^{i5t}$  where  $i = \sqrt{-1}$ , is

- (A)  $\frac{s-5i}{s^2-25}$  (B)  $\frac{s+5i}{s^2+25}$

- (C)  $\frac{s+5i}{s^2-25}$  (D)  $\frac{s-5i}{s^2+25}$

**05. Ans: (B)**

06. A gas is stored in a cylindrical tank of inner radius 7 m and wall thickness 50 mm. The gage pressure of the gas is 2 MPa. The maximum shear stress (in MPa) in the wall is  
(A) 35 (B) 70 (C) 140 (D) 280

**06. Ans: (C)**

07. Which of the following statements regarding a Rankine cycle with reheating are **TRUE** ?

- (i) Increase in average temperature of heat addition  
(ii) reduction in thermal efficiency  
(iii) drier steam at the turbine exit.  
(A) only (i) and (ii) are correct  
(B) only (ii) and (iii) are correct  
(C) only (i) and (iii) are correct  
(D) (i), (ii) and (iii) are correct

**07. Ans: (C)**

08. A small ball of mass 1 kg moving with a velocity of 12 m/s undergoes a direct central impact with a stationary ball of mass 2 kg. The impact is perfectly elastic. The speed (in m/s) of 2 kg mass ball after the impact will be \_\_\_\_\_

**08. Ans: 8**

09. The primary mechanism of material removal in electrochemical machining (ECM) is

- (A) chemical corrosion  
(B) etching  
(C) ionic dissolution  
(D) spark erosion

**09. Ans: (C)**

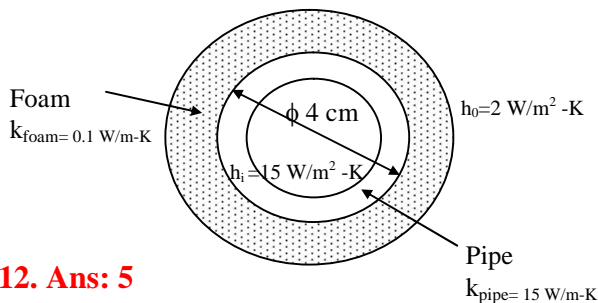
10. Within a boundary layer for a steady incompressible flow, the Bernoulli equation  
 (A) holds because the flow is steady  
 (B) holds because the flow is incompressible  
 (C) holds because the flow is transitional  
 (D) does not hold because the flow is frictional

**10. Ans: (D)**

11. The Van der Waals equation of state is  $\left(p + \frac{a}{v^2}\right)(v-b) = RT$ , where  $p$  is pressure,  $v$  is specific volume,  $T$  is temperature and  $R$  is characteristic gas constant. The SI unit of  $a$  is  
 (A) J/kg-K (B) m<sup>3</sup>/kg  
 (C) m<sup>5</sup>/kg-s<sup>2</sup> (D) Pa/kg

**11. Ans: (C)**

12. If a foam insulation is added to a 4cm outer diameter pipe as shown as figure, the critical radius of insulation (in cm) is \_\_\_\_\_



**12. Ans: 5**

13. The COP of a Carnot heat pump operating between 6°C and 37°C is \_\_\_\_\_

**13. Ans: 10**

14. Which one of the following statements is **TRUE**?

- (A) The 'GO' gage controls the upper limit of a hole  
 (B) The 'NO GO' gage controls the lower limit of a shaft  
 (C) The 'GO' gage controls the lower limit of a hole  
 (D) The 'NO GO' gage controls the lower limit of a hole

**14. Ans: (B & C)**

15. A rod is subjected to a uniaxial load within linear elastic limit. When the change in the stress is 200 MPa, the change in the strain is 0.001. If the Poisson's ratio of the rod is 0.3 the modulus of rigidity (in GPa) is \_\_\_\_\_

**15. Ans: 76.92**

16. In the laminar flow of air ( $Pr = 0.7$ ) over a heated plate, if  $\delta$  and  $\delta_T$  denote, respectively the hydrodynamic and thermal boundary layer thickness, then

- (A)  $\delta = \delta_T$  (B)  $\delta > \delta_T$   
 (C)  $\delta < \delta_T$  (D)  $\delta = 0$  but  $\delta_T \neq 0$

**16. Ans: (C)**

17. Sales data of a product is given in the following table:

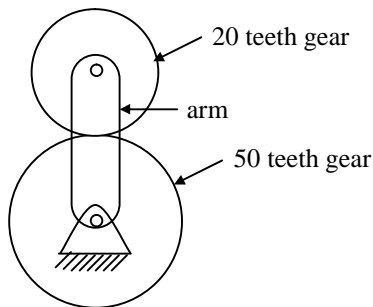
Month	January	February	March	April	May
Number of units sold	10	11	16	19	25

Regarding forecast for the month of June, which one of the following statements is TRUE?

- (A) Moving average will forecast a higher value compared to regression
- (B) Higher the value of order N, the greater will be the forecast value by moving average
- (C) Exponential smoothing will forecast a higher value compared to regression
- (D) Regression will forecast a higher value compared to moving average

**17. Ans: (D)**

18. The number of degrees of freedom of the planetary gear train shown in the figure is



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

**18. Ans: (C)**

19. The atomic packing factor for a material with body centered cubic structure is \_\_\_\_\_

**19. Ans: 0.68**

20. Three vendors were asked to supply a very high precision component. The respective

probabilities of their meeting the strict design specifications are 0.8, 0.7 and 0.5. Each vendor supplies one component. The probability that out of total three components supplied by the vendors, at least one will meet the design specification is \_\_\_\_\_

**20. Ans: 0.97**

21. At least one eigenvalue of a singular matrix is  
(A) Positive      (B) Zero  
(C) Negative      (D) Imaginary

**21. Ans: (B)**

22. At  $x = 0$ , the function  $f(x) = |x|$  has  
(A) a minimum  
(B) a maximum  
(C) a point of inflexion  
(D) neither a maximum nor minimum

**22. Ans: (A)**

23. At uniaxial yield stress of a material is 300 MPa. According to Von mises criterion, the shear yield stress (in MPa) of the material is \_\_\_\_\_

**23. Ans: 173.1**

24. Annual demand of a product is 5000 units and the ordering cost is Rs.7000 per order. Considering the basic economic order quantity model, the economic order quantity is 10000 units. When the annual inventory cost is minimized, the annual inventory holding cost (in Rs.) is \_\_\_\_\_

**24. Ans: 35000**

25. During the development of a product, an entirely new process plan is made based on design logic, examination of geometry and tolerance information. This type of process planning is known as  
(A) retrieval      (B) Generative  
(C) Variant      (D) Group technology based

**25. Ans: (B)**

26. A cube and a sphere made of cast iron (each volume  $1000 \text{ cm}^3$ ) were cast under identical conditions. The time taken for solidifying the cube was 4 s. The solidification time (in s) for the sphere is \_\_\_\_\_

**26. Ans: 6.16**

27. A manufacturer has the following data regarding a product:  
 Fixed cost per month = Rs 50000  
 Variable cost per unit = Rs 200  
 Selling price per unit = Rs 300  
 Production capacity = 1500 units per month  
 If the production is carried out at 80 % of the rated capacity, then the monthly profit (in Rs) is \_\_\_\_\_

**27. Ans: 70000**

28. The initial velocity of an object is 40 m/s. The acceleration  $a$  of the object is given by the following expression:  
 $a = -0.1 v$   
 Where  $v$  is the instantaneous velocity of the object. The velocity of the object after 3 seconds will be \_\_\_\_\_

**28. Ans: 29.37**

29. The surface integral  $\iint_s \frac{1}{\pi} (9xi - 3yj) \cdot n \, dS$  over the sphere given by  $x^2 + y^2 + z^2 = 9$  is \_\_\_\_\_

**29. Ans: 216**

30. In a Rankine cycle, the enthalpies at turbine entry and outlet are 3159 kJ/kg and 2187 kJ/kg respectively. If the specific pump work is 2 kJ/kg, the specific steam consumption (in kg/kW-h) of the cycle based on net output is \_\_\_\_\_

**30. Ans: 3.711**

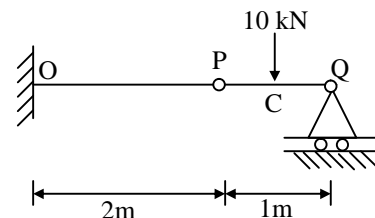
31. In a two stage wire drawing operation, the fractional reduction (ratio of change in cross sectional area to initial cross sectional area) in the first stage is 0.4. The fractional reduction in the second stage is 0.3. The overall fractional reduction is  
 (A) 0.24 (B) 0.58 (C) 0.60 (D) 1.00

**31. Ans: (B)**

32. For a fully developed laminar flow of water (dynamic viscosity 0.001 Pa-s) through a pipe of radius 5 cm, the axial pressure gradient is -10 Pa/m. The magnitude of axial velocity (in m/s) at a radial location of 0.2 cm is \_\_\_\_\_

**32. Ans: 6.24**

33. A cantilever beam OP is connected to another beam PQ with a pin joint as shown in figure. A load of 10 kN is applied at the mid-point of PQ. The magnitude of bending movement (in kN-m) at fixed end O is



- (A) 2.5 (B) 5 (C) 10 (D) 25

**33. Ans: (C)**

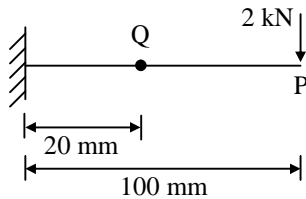
34. During a TIG welding process, the arc current and arc voltage were 50 A and 60 V, respectively, when the welding speed was 150 mm/min. In another process, the TIG welding is carried out at a welding speed of 120 mm/min at the same arc welding voltage

and heat input to the material so that weld quality remains the same. The welding current (in A) for this process is

- (A) 40.00 (B) 44.72  
(C) 55.90 (D) 62.25

**34. Ans: (A)**

35. A cantilever beam with square cross section of 6 mm side is subjected to a load of 2 kN normal to the top surface as shown in figure. The Young's modulus of elasticity of the material of the beam is 210 GPa. The magnitude of slope (in radian) at Q (20 mm from the fixed end) is \_\_\_\_\_



**35. Ans: 0.158**

36. In a certain slider crank mechanism, lengths of crank and connecting rod are equal. If the crank rotates with a uniform angular speed of 14 rad/s and the crank length is 300 mm, the maximum acceleration of the slider (in  $\text{m/s}^2$ ) is \_\_\_\_\_

**36. Ans: 117.6**

37. The values of function  $f(x)$  at 5 discrete points are given below:

X	0	0.1	0.2	0.3	0.4
f(x)	0	10	40	90	160

Using Trapezoidal rule with step size of 0.1,

the value of  $\int_0^{0.4} f(x) dx$  is \_\_\_\_\_

**37. Ans: 22**



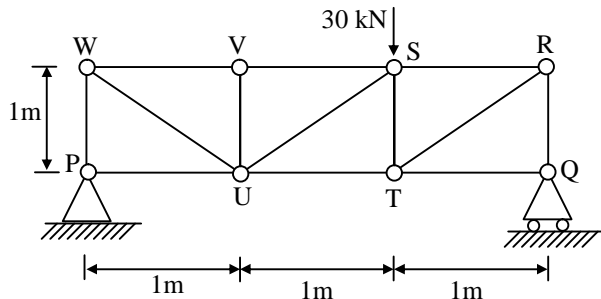
38. A hollow shaft ( $d_o = 2d_i$  where  $d_o$  and  $d_i$  are the outer and inner diameters respectively) needs to transmit 20 kW power at 3000 RPM. If the maximum permissible shear stress is 30 MPa,  $d_o$  is
- (A) 11.29 mm (B) 22.58 mm  
(C) 33.87 mm (D) 45.16 mm

**38. Ans: (B)**

39. The head loss for a laminar incompressible flow through a horizontal circular pipe is  $h_1$ . Pipe length and fluid remaining the same, if the average flow velocity doubles and the pipe diameter reduces to half its previous value, the head loss is  $h_2$ . The ratio  $h_2/h_1$  is
- (A) 1 (B) 4 (C) 8 (D) 16

**39. Ans: (C)**

40. For the truss shown in figure, the magnitude of the force (in kN) in the member SR is



- (A) 10 (B) 14.14  
(C) 20 (D) 28.28

**40. Ans: (C)**

41. For the same values of peak pressure, peak temperature and heat rejection, the correct order of efficiencies for Otto, dual and diesel cycles is
- (A)  $\eta_{\text{otto}} > \eta_{\text{dual}} > \eta_{\text{Diesel}}$   
(B)  $\eta_{\text{diesel}} > \eta_{\text{Dual}} > \eta_{\text{otto}}$   
(C)  $\eta_{\text{Dual}} > \eta_{\text{Diesel}} > \eta_{\text{otto}}$   
(D)  $\eta_{\text{diesel}} > \eta_{\text{otto}} > \eta_{\text{dual}}$

**41. Ans: (B)**

42. A cylindrical uranium fuel rod of radius 5 mm in a nuclear reactor is generating heat at the rate of  $4 \times 10^7 \text{ W/m}^3$ . The rod is cooled by a liquid (convective heat transfer coefficient  $1000 \text{ W/m}^2\text{-K}$ ) at  $25^\circ \text{C}$ . At steady state, the surface temperature (in K) of the rod is
- (A) 308 (B) 398  
(C) 418 (D) 448

**42. Ans: (B)**

43. Consider the following differential equation

$$\frac{dy}{dt} = -5y; \text{ initial condition: } y = 2 \text{ at } t = 0.$$

The value of  $y$  at  $t = 3$  is

- (A)  $-5e^{-10}$  (B)  $2e^{-10}$   
(C)  $2e^{-15}$  (D)  $-15e^2$

**43. Ans: (C)**

44. The flowing stress (in MPa) of a material is given by  $\sigma = 500 \varepsilon^{0.1}$ , When  $\varepsilon$  is true strain. The Young's modulus of elasticity of the material is 200 GPa. A block of thickness 100 mm made of this material is compressed to 95 mm thickness and then the load is removed. The final dimension of the block (in mm) is \_\_\_\_

**44. Ans: 99.81**

45. Work is done on a adiabatic system due to which its velocity changes from 10 m/s to 20 m/s elevation increase by 20 m and temperature increases by 1K. The mass of the system is 10 kg,  $C_v = 100 \text{ J/(kg.K)}$  and gravitational acceleration is  $10 \text{ m/s}^2$ . If there is no change in any other component of the energy of the system, the magnitude of total work (in kJ) on the system is \_\_\_\_

**45. Ans: 4.5**



46. In a plane stress condition, the components of stress at a point are  $\sigma_x = 20$  MPa,  $\sigma_y = 80$  MPa and  $\tau_{xy} = 40$  MPa. The maximum shear stress (in MPa) at the point is  
(A) 20 (B) 25 (C) 50 (D) 100

**46. Ans: (C)**

47. The chance of a student passing an exam is 20%. The chance of a student passing the exam and getting above 90 % marks in it is 5%. Given that a student passes the examination, the probability that the student gets above 90 % marks is

- (A)  $\frac{1}{18}$  (B)  $\frac{1}{4}$   
(C)  $\frac{2}{9}$  (D)  $\frac{5}{18}$

**47. Ans: (B)**

48. A resistance capacitance relaxation circuit is used in an electrical discharge machining process. The discharge voltage is 100 V. at a spark cycle time of 25  $\mu$ s the average power input required is 1 kW. The capacitance (in  $\mu$ F) in the circuit is

- (A) 2.5 (B) 5.0  
(C) 7.5 (D) 10.0

**48. Ans: (B)**

49. A balanced counter-flow heat exchanger has a surface area of 20  $\text{m}^2$  and overall heat transfer coefficient of 20  $\text{W/m}^2\text{-K}$ . Air ( $C_p = 1000$  J/kg-K) entering at 0.4 kg/s and 280 K is to be preheated by the air leaving the system at 0.4 kg/s and 300 K. the outlet temperature (in K) of the preheated air is

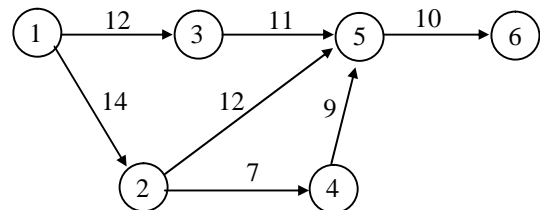
- (A) 290 (B) 300 (C) 320 (D) 350

**49. Ans: (A)**

50. A single point cutting tool with  $0^\circ$  rake angle is used in an orthogonal machining process. At a cutting speed of 180 m/min the thrust force is 490N. If the coefficient of friction between the tool and the chip is 0.7, Then the power consumption (in kW) for the machining operation is \_\_\_\_

**50. Ans: 2.1**

51. A project consists of 7 activities. The network along with the time durations ( in days) for various activities is shown in figure



The minimum time( in days) for completion of the project is \_\_\_\_

**51. Ans: 40**

52. One kg of air ( $R = 287$  J/kg-K) under goes irreversible process between equilibrium state 1 ( $20^\circ\text{C}$ ,  $0.9 \text{ m}^3$ ) and equilibrium state 2 ( $20^\circ\text{C}$ ,  $0.6 \text{ m}^3$ ). The change in entropy  $s_2 - s_1$  (in J/kg-K) is \_\_\_\_

**52. Ans: -116.22**

53. A single degree freedom spring mass is subjected to a sinusoidal force of 10 N amplitude and frequency  $\omega$  along the axis of the spring. The stiffness of the spring is 150N/m, damping factor is 0.2 and undamped natural frequency is  $10 \omega$ . At steady state, the amplitude of vibration (in m) is approximately

- (A) 0.05 (B) 0.07  
(C) 0.70 (D) 0.90

**53. Ans: (B)**

54. A hollow shaft of 1 m length is designed to transmit a power of 30 kW at 700 rpm. The maximum permissible angle of twist in the shaft is  $1^\circ$ . The inner diameter of the shaft is 0.7 times the outer diameter. The modulus of rigidity is 80 GPa. The outside diameter (in mm) of the shaft is \_\_\_\_\_

**54. Ans: 44.52**

55. The total emissive power of a surface is  $500 \text{ W/m}^2$  at a temperature  $T_1$  and  $1200 \text{ W/m}^2$  at a temperature  $T_2$ , where the temperature are in Kelvin. Assuming the emissivity of the surface to be constant, the ratio of the temperatures  $\frac{T_1}{T_2}$  is

- (A) 0.308                                      (B) 0.416  
(C) 0.803                                      (D) 0.874

**55. Ans: (C)**