

GATE-2015

Question Paper

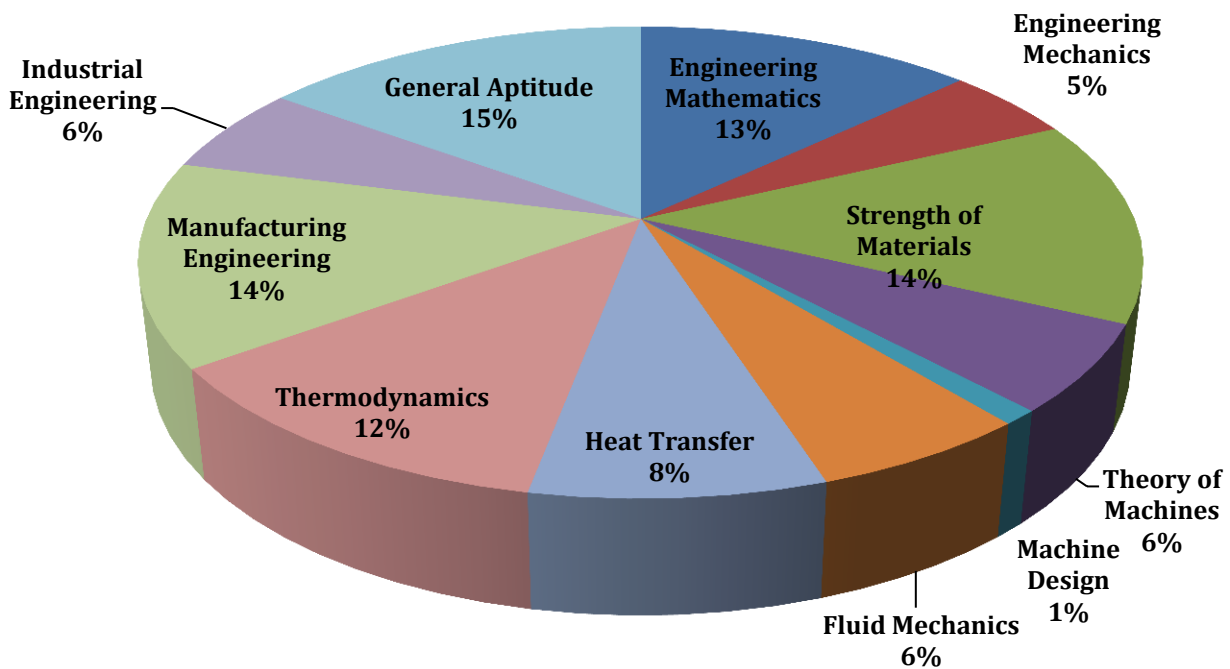
&

Answer Keys

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ANALYSIS OF GATE 2015 Mechanical Engineering



GATE-2015- ME

SUBJECT	NO OF QUESTION	Topics Asked in Paper	Total Marks
Engineering Mathematics	1M:5 2M:4	Calculus Vector calculus Linear Algebra Laplace Transform Probability and Distribution Numerical Method Differential Equation	13
Engineering Mechanics	1M:1 2M:2	Statics Dynamics	5
Strength of Materials	1M:2 2M:6	Simple Stress & Strain Torsion Mohr's Circle Slope & Deflection of beams Shear Force & Bending Moment Deflection of beams	14
Theory of Machines	1M:2 2M:2	Mechanism Vibration Gear Trains	6
Machine Design	1M:1 2M:0	Theories of failure	1
Fluid Mechanics	1M:2 2M:2	Fluid Kinematics Flow Through pipes Fluid dynamic	6
Heat Transfer	1M:2 2M:3	Convection Conduction Radiation Heat Exchanger	8
Thermodynamics	1M:4 2M:4	Refrigeration; IC Engine Basic Thermodynamics IC Engine Thermodynamic Cycle and property Relations Power Engineering	12
Manufacturing Engineering	1M:4 2M:5	Advanced Machining Engg Materials Metrology and inspection Computer integrated Manufacturing Casting; Metal Cutting Forming Process; Joining Process	14
Industrial Engineering	1M:2 2M:2	Operational Research Inventory Control	6
General Aptitude	1M:5 2M:5	Verbal Ability Numerical Ability	15
Total	65		100

GATE 2015 Examination
MECHANICAL ENGINEERING

Test Date: 1/02/2015
Test Time: 9:00 AM 12:00 PM
Subject Name: ME MECHANICAL ENGINEERING

Section: General Aptitude

1. 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 practice (C) practiced
(B) should have practiced (D) should be practicing

[Ans. B]

2. 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 (C) iii and iv
(B) i and iii (D) ii and iv

[Ans. A]

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

Let us _____.

- (A) introvert (C) atheist
(B) alternate (D) altruist

[Ans. B]

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

A, CD, GHI, ?, UVWXYZ

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

[Ans. C]

5. Choose the most suitable one word substitute for the following expression.

Connotation of a road or way

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

[Ans. A]

6. $\log \tan 1^\circ + \log \tan 2^\circ + \dots + \log \tan 89^\circ$ is _____.
 (A) 1 (B) $1/\sqrt{2}$ (C) 0 (D) -1

[Ans. C]

7. In the following questions, the first and the last sentence of the passage are in order and numbered 1 and 6. The rest of the 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 a 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 the 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 exchanges gifts and sweets.
6. Houses look so pretty with lighted lamps all around.

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

[Ans. B]

8. 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

[Ans. A]

9. 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 _____.

[Ans. *] Range: 13.08 to 13.08

10. 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 statement 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.

[Ans. A]

Section: Mechanical Engineering

Q.1 to Q. 25 carry one marks each.

1. Curl of vector $V(x, y, z) = 2x^2i + 3z^2j + y^3k$ at $x = y = z = 1$ is
 (A) $-3i$ (C) $3i - 4j$
 (B) $3i$ (D) $3i - 6k$

[Ans. A]

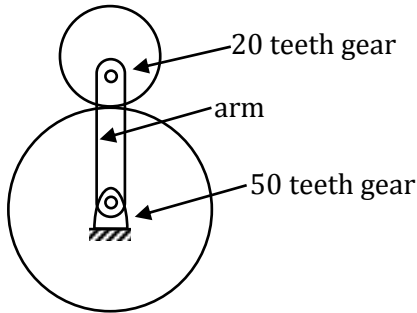
2. Which of the following statements regarding a Rankine cycle with reheating are TRUE?
- (i) Increase in average temperature of heat addition
 - (ii) Reduction in thermal efficiency
 - (iii) Drier steam at the turbine exit
- (A) only (i) and (ii) are correct
(B) only (ii) and (iii) are correct
(C) only (i) and (iii) are correct
(D) (i), (ii) and (iii) are correct

[Ans. C]

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

[Ans. *] Range: 10 to 10

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



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

[Ans. C]

5. 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.

[Ans. B]

6. Annual demand of a product is 50000 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 _____

[Ans. *] Range: 35000 to 35000

7. 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 kg/s. In another spring – mass system, the mass is $2m$ and the spring constant is $8k$. The critical damping coefficient (in kg/s) of the system is _____

[Ans. *] Range: 1.6 to 1.6

8. The Van der Waals equation of state is $\left(p + \frac{a}{v^3}\right)(v - b) = RT$, 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 (C) $\text{m}^5/\text{kg} - \text{s}^2$
(B) m^3/kg (D) Pa/kg

[Ans. C]

9. A rope-brake dynamometer attached to the crank shaft of an I.C. engine measure 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 _____

[Ans. *] Range: 25 to 25

10. A rod is subjected to a uni-axial 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 _____.

[Ans. *] Range: 77 to 77

11. At least one eigenvalue of a singular matrix is

- (A) Positive (C) Negative
(B) Zero (D) Imaginary

[Ans. B]

12. 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 _____.

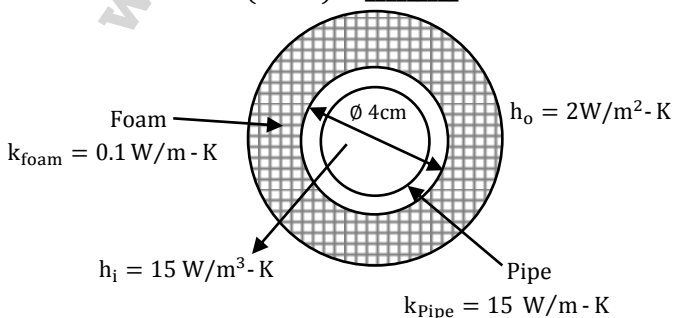
[Ans. *] Range: 0.97 to 0.97

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

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

[Ans. D]

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



[Ans. *] Range: 5 to 5

15. The Laplace transform of e^{i5t} where $i = \sqrt{-1}$, is
- (A) $\frac{s - 5i}{s^2 - 25}$ (C) $\frac{s + 5i}{s^2 - 25}$
 (B) $\frac{s + 5i}{s^2 + 25}$ (D) $\frac{s - 5i}{s^2 + 25}$
[Ans. A]
16. The primary mechanism of material removal in electrochemical machining (ECM) is
- (A) chemical corrosion (C) ionic dissolution
 (B) etching (D) spark erosion
[Ans. B]
17. 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 _____
[Ans. *] Range: 8 to 8
18. In the laminar flow of air ($Pr = 0.7$) over a heated plate, if δ and δ_T denote, respectively, the hydrodynamic and thermal boundary layer thickness, then
- (A) $\delta = \delta_T$ (C) $\delta < \delta_T$
 (B) $\delta > \delta_T$ (D) $\delta = 0$ but $\delta_T \neq 0$
[Ans. C]
19. 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
[Ans. D]
20. The atomic packing factor for a material with body centered cubic structure is _____
[Ans. *] Range: 0.64 to 0.64
21. 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 limits of a hole
[Ans. A]
22. The uniaxial yield stress of a material is 300 MPa. According to von Mises criterion, the shear yield stress (in MPa) of the material is ____
[Ans. *] Range: 173.28 to 173.28

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

[Ans. D]

24. 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 (C) 140
(B) 70 (D) 280

[Ans. B]

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

[Ans. A]

Q. 26 - Q. 55 carry two marks each.

26. The total emissive power of a surface is 500 W/m^2 at a temperature T_1 and 1200 W/m^2 at a temperature T_2 , where the temperatures 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 (C) 0.803
(B) 0.416 (D) 0.874

[Ans. C]

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

[Ans. B]

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

[Ans. C]

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

[Ans. *] Range: 70000 to 70000

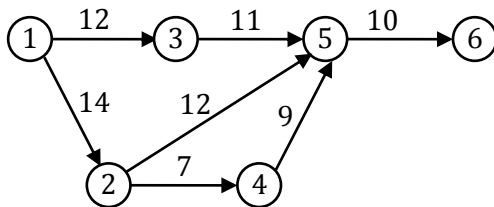
30. The initial velocity of an object is 40 m/s. The acceleration a of the object is given by the following expression:

$$a = -0.1v,$$

Where v is the instantaneous velocity of the object. The velocity of the object after 3 second will be _____

[Ans. *] Range: 29.632 to 29.632

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



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

[Ans. *] Range: 40 to 40

32. Consider the following differential equations:

The value of y at $t = 3$ is

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

(A) $-5e^{-10}$

(B) $2e^{-10}$

(C) $2e^{-15}$

(D) $-15e^{-2}$

[Ans. C]

33. One kg of air ($R = 287 \text{ J/kg-K}$) undergoes an 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 _____

[Ans. *] Range: -116.36 to -116.36

34. For a fully developed laminar flow of water (dynamic viscosity 0.001 Pa-s) through a pipe 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 _____

[Ans. *] Range: 6.24 to 6.24

35. A cube and a sphere made of cast iron (each of volume 1000 cm^3) were cast under identical conditions. The time taken for solidifying the cube was 4 s . The solidification time (in second) for the sphere is _____.

[Ans. *] Range: 6.15 to 6.15

36. A balanced counter flow heat exchanger has a surface area of 20 m^2 and overall heat transfer coefficient of $20 \text{ W/m}^2\text{-K}$. Air ($C_p = 1000 \text{ J/kg-K}$) 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

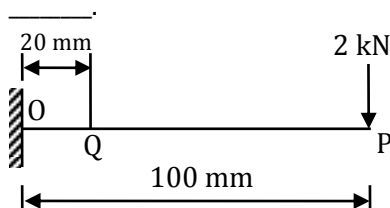
(D) 350

[Ans. A]

37. 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°C . At steady state, the surface temperature (in K) of the rod is
- (A) 308 (C) 418
(B) 398 (D) 448

[Ans. B]

38. 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 the 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



[Ans. *] Range: 0.1587 to 0.1587

39. 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 _____.

[Ans. *] Range: 3.71 to 3.71

40. A single point cutting tool with 0° rake angle is used in an orthogonal machining process. At a cutting speed of 180 m/min, the thrust force is 490 N. 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 _____.

[Ans. *] Range: 2.1 to 2.1

41. In a certain slider – crank mechanism, length 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 m/s^2) is _____.

[Ans. *] Range: 117.6 to 117.6

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

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

[Ans. B]

43. 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 (C) 8
(B) 4 (D) 16

[Ans. C]

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

[Ans. *] Range: 4.5 to 4.5

45. The flow stress (in MPa) of a material is given by

$$\sigma = 500\epsilon^{0.1},$$

Where ϵ 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 _____.

[Ans. *] Range: 95.18 to 95.18

46. 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) $1/18$

(C) $2/9$

(B) $1/4$

(D) $5/18$

[Ans. B]

47. 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 μs , the average power input required is 1 kW. The capacitance (in μF) in the circuit is

(A) 2.5

(C) 7.5

(B) 5.0

(D) 10.0

[Ans. A]

48. 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) $\eta_{\text{Otto}} > \eta_{\text{Dual}} > \eta_{\text{Diesel}}$

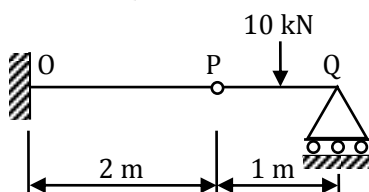
(C) $\eta_{\text{Dual}} > \eta_{\text{Diesel}} > \eta_{\text{Otto}}$

(B) $\eta_{\text{Diesel}} > \eta_{\text{Dual}} > \eta_{\text{Otto}}$

(D) $\eta_{\text{Diesel}} > \eta_{\text{Otto}} > \eta_{\text{Dual}}$

[Ans. B]

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



(A) 2.5

(C) 10

(B) 5

(D) 25

[Ans. B]

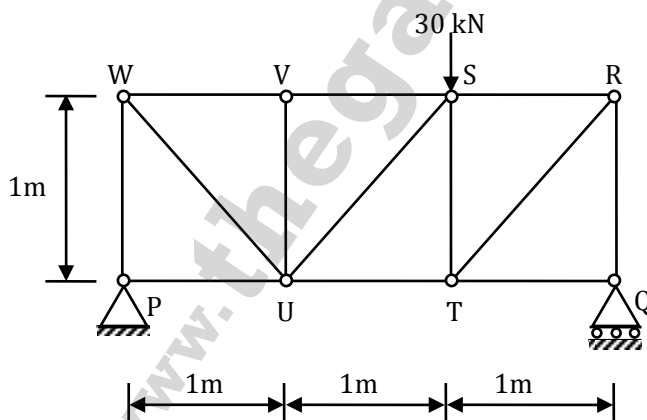
50. The surface integral $\iint_S \frac{1}{\pi} (9xi - 3yj) \cdot ndS$ over the sphere given by $x^2 + y^2 + z^2 = 9$ is _____
[Ans. *] Range: 216 to 216

51. 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 (C) 0.60
(B) 0.58 (D) 1.00
[Ans. A]

52. 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 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 (C) 55.90
(B) 44.72 (D) 62.25
[Ans. A]

53. 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° . 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 _____.
[Ans. *] Range: 44.52 to 44.52

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



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

[Ans. C]

55. The value 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 $\int_0^{0.4} f(x) dx$ is _____

[Ans. *] Range: 22 to 22