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MECHANICAL ENGINEERING

VOLUME -1

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- Engineering Mechanics
- Strength of Materials
- Theory of Machines & Vibrations
- Machine Design
- Basic Thermodynamics
- Applied Thermodynamics

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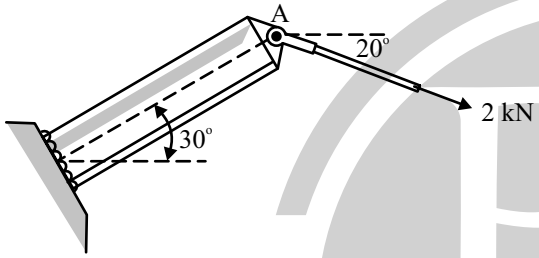
01 CHAPTER

Basic Concepts

GATE

1. [MCQ] [Level-I]

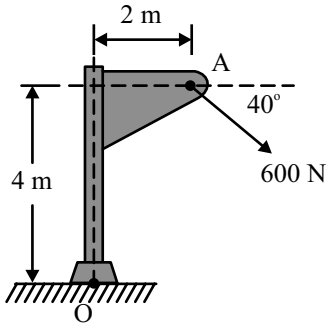
To study the effect of 2 kN tensile force in cable on the beam, it is replaced by its equivalent of two forces at A, F_t parallel and F_n perpendicular to the beam. Magnitude of F_t and F_n are



(a) 1.28 kN and 1.36 kN
(b) 1.53 kN and 1.48 kN
(c) 1.36 kN and 1.48 kN
(d) 1.28 kN and 1.53 kN

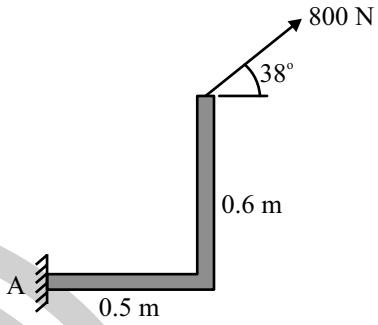
2. [NAT] [Level-I]

The magnitude of the moment of the 600 N force about point O is _____ kN-m **(Round off to two decimal places).**



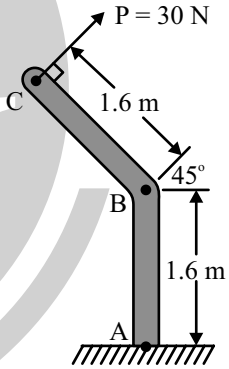
3. [NAT] [Level-I]

The magnitude of the moment of the 800 N force about point A is _____ N-m **(Round off to two decimal places).**



4. [NAT] [Level-I]

The magnitude of the moment of the 30 N force about point A is _____ N-m **(Round off to two decimal places).**



5. [MCQ] [Level-I]

A force F = 3j − 6k passes through the point A: 4i − 2j − 9k; The moment of F about the point B : 6i − 7k is

(a) 6 (3i – 2j – k)
(b) 6 (–2i – 6j – k)
(c) 6 (i + 4j + 3k)
(d) 6 (–i – 4j – 3k)

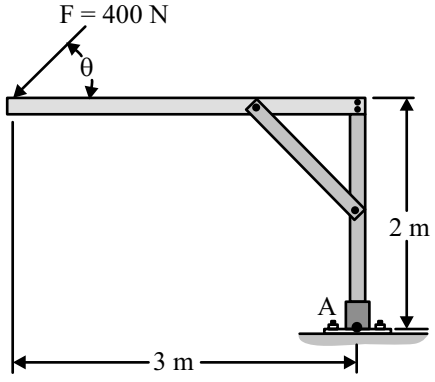
6. [MCQ] [Level-I]

The force P represented by 5i + k is acting through the point 9i – j + 2k. The moment of P about the point 3i − 2j + k is

(a) 3i + 11j + 15k
(b) – 3i – 11j –15k
(c) i – j – 5 k
(d) 3i + j + 15 k

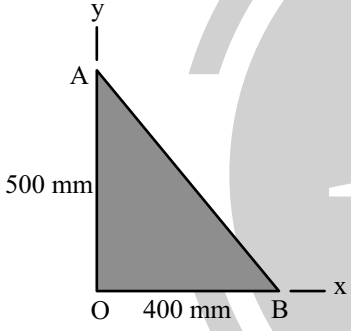
7. **[NAT]** **[Level-II]**

The maximum anticlockwise moment produced by the force F about point A is _____ N-m **(Round off to two decimal places).**



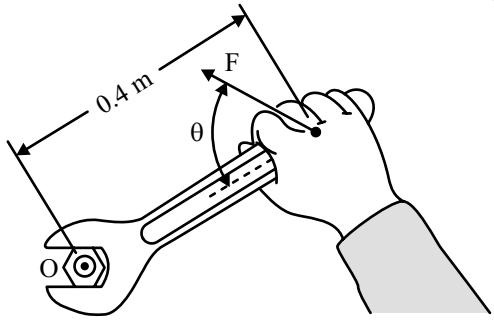
8. **[NAT]** **[Level-II]**

A force P in the xy-plane acts on the triangular plate. The moments of P about points O, A, and B are M_O = 200 N-m clockwise, $M_A = 0$, and $M_B = 0$. Magnitude of P is _____ N **(Round off to two decimal places).**



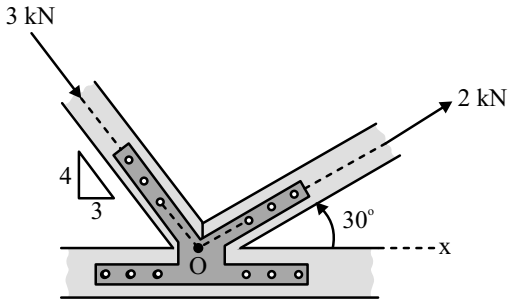
9. **[NAT]** **[Level-I]**

An anticlockwise moment of 80 N–m about O is required to loosen the nut. Determine the smallest magnitude of the force F (in N) that will turn the nut **(Round off to two decimal places).**



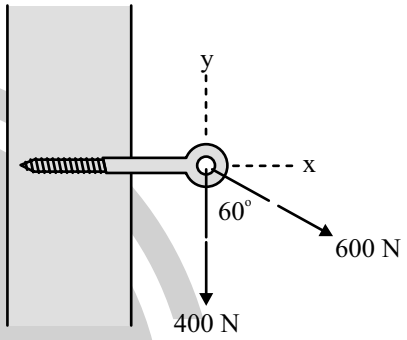
10. **[NAT]** **[Level-II]**

The two structural members, one of which is in tension and the other in compression, exert the indicated forces on joint O. The magnitude of the resultant R is _____ kN **(Round off to two decimal places).**



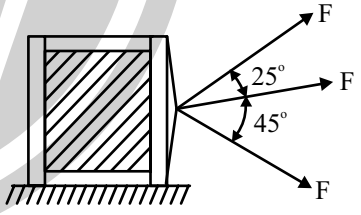
11. **[NAT]** **[Level-II]**

The angle of the resultant force of the two forces shown in figure from x axis in clockwise direction is _____ degrees **(Round off to two decimal places).**



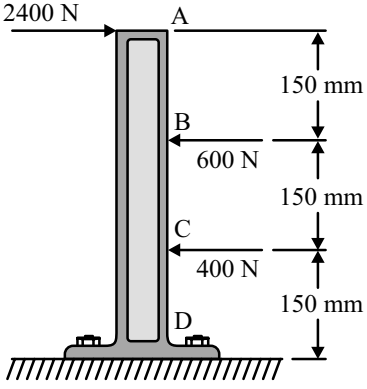
12. **[NAT]** **[Level-II]**

The three forces, each of magnitude F, are applied to the crate. If three forces are equivalent to a single 3000-N force, the magnitude of force F is _____ N **(Round off to two decimal places).**



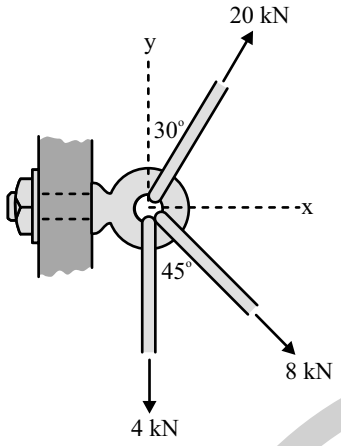
13. **[NAT]** **[Level-I]**

The resultant force of the system of three forces shown in figure acts at a distance of _____ mm from D **(Round off to two decimal places).**



14. [MSQ] [Level-II]

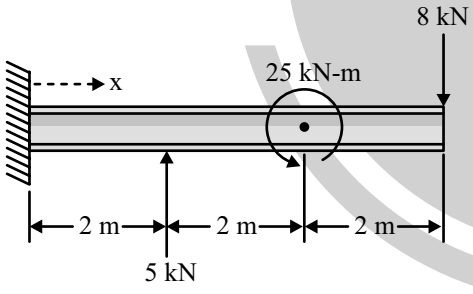
If R is the resultant of the three forces acting on the eye bolt and if θ is the angle between R and the positive x axis, which one or more of the following statement(s) is/are correct?



(a) The magnitude of R is 21.26 kN.
(b) The magnitude of R is 17.43 kN.
(c) The magnitude of θ is 26.1°.
(d) The magnitude of θ is 44.8°.

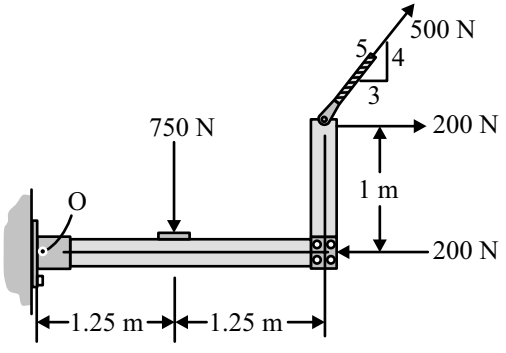
15. [NAT] [Level-I]

The resultant of the two forces and a couple shown in figure is at a distance of _____ m from the fixed end **(Round off to two decimal places).**



16. [MCQ] [Level-II]

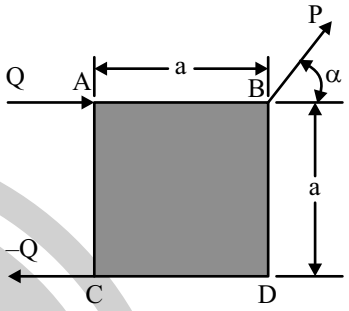
If we replace all the four forces in the force system as shown in figure with a force and a couple at point O, the magnitude of the force and the couple is



(a) 392 N and 438 N-m
(b) 461 N and 438 N-m
(c) 461 N and 525 N-m
(d) 310 N and 461 N-m

17. [NAT] [Level-I]

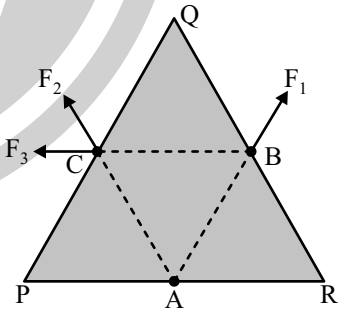
The force and couple shown are to be replaced by an equivalent single force. Knowing that P = 2Q. If the line of action of the single equivalent force is to pass through point A, the magnitude of angle α (in degrees) is _____ **(Round off to two decimal places).**



18. [MSQ] [Level-II]

Consider an equilateral triangular plate PQR subjected to three forces F_1, F_2, and F_3 as shown in Figure. The resultant force of these three forces is known to pass vertically up from point Q. Points A, B, and C are the centres of the sides of the triangular plate.

Which of the following statement(s) is/are correct about the magnitude of forces?



(a) $F_1 = F_2 + F_3$
(b) $F_1 = F_2$
(c) $3F_1 = 2F_2 + 3F_3$
(d) $2F_2 = 2F_1 + 0.5F_3$

19. [NAT] [Level-I]

The weights of two children sitting at ends A and B of a seesaw are 30 kg and 20 kg, respectively. Where should a third child sit from A (in ft) so that the resultant of the weights of the three children will pass through C if she weighs 25kg? **(Round off to two decimal places)**

ANSWER KEY

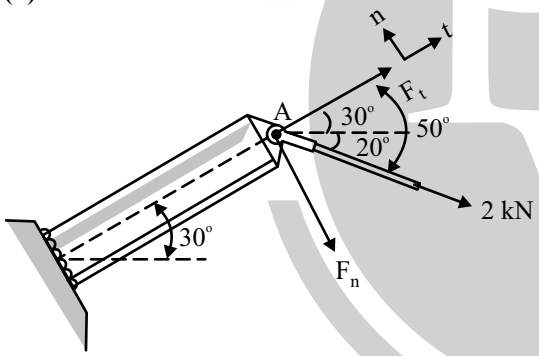
GATE

1.	(d)	**2.**	(2.58 to 2.64)	**3.**	(131.90 to 132.10)
4.	(81.80 to 82.10)	**5.**	(a)	**6.**	(c)
7.	(1442.05 to 1442.35)	**8.**	(640.20 to 640.40)	**9.**	(199.99 to 200.01)
10.	(3.70 to 3.90)	**11.**	(53.20 to 53.60)	**12.**	(1139.95 to 1140.10)
13.	(600 to 600)	**14.**	(b, c)	**15.**	(4.30 to 4.35)
16.	(b)	**17.**	(30 to 30)	**18.**	(a, b, d)
19.	(8.38 to 8.42)	**20.**	(0 to 0, 449.99 to 450.01)		

SOLUTIONS

GATE

1. (d)



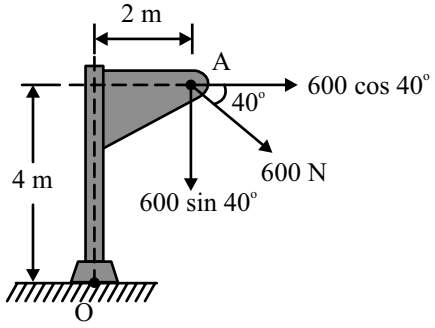
Component of force parallel to beam;

$F_t = 2 \cos 50° = 1.286$ kN

Component of force perpendicular to beam;

$F_n = 2 \sin 50° = 1.532$ kN

2. (2.58 to 2.64)



Moment about point O;

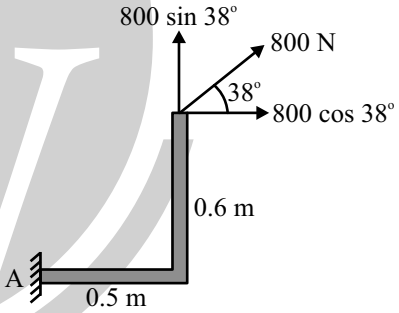
$M_o = 600 \sin 40° \times 2 + 600 \cos 40° \times 4$

$\Rightarrow M_o = 2609.85$ N-m

$\Rightarrow M_o = 2.609$ kN-m

$\Rightarrow M_o = 2.61$ kN-m

3. (131.90 to 132.10)

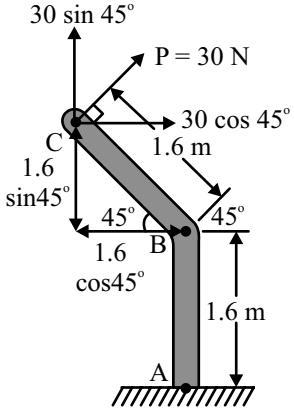


Moment about point A;

$M_A = 800 \cos 38° \times 0.6 - 800 \sin 38° \times 0.5$

$\Rightarrow M_A = 131.98$ N-m

4. (81.80 to 82.10)



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- Manufacturing Processes
- Renewable Sources of Energy
- Mechatronics
- Robotics

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01 CHAPTER

Introduction to Heat Transfer

GATE

1. **[MCQ]** **[Level-II]**

Arrange the thermal conductivity of the following materials in ascending order

Copper, silver, water, mercury

(a) Copper, silver, water, mercury

(b) Mercury, water, copper, silver

(c) Water, mercury, copper, silver

(d) Silver, copper, mercury, water

2. **[NAT]** **[Level-III]**

A brick (k = 1.2 W/m-K) wall 0.15 m thick separates combustion gases in a furnace from the atmospheric air at 30°C. The outside surface temperature is 100°C while its emissivity is 0.8 and convective heat transfer coefficient is 20 W/m^{2}K. The inner surface temperature of the brick wall is _____ (in °C) **(Enter in integer)**

3. **[MSQ]** **[Level-III]**

A hollow spherical shell [R_i = 0.5 m, R_o = 0.7 m and k = 40(1 + 0.001 T) where T is in °C] stores a liquid at 250°C inner surface temperature while the outside surface temperature of the sphere is 100°C. The ambient air is at 30°C. Which of the statements is/are correct?

(a) Rate of heat transfer is in between 154 kW to 156 kW

(b) Rate of heat transfer is in between 250 kW to 252 kW

(c) Outside heat transfer coefficient is in between 359 to 362 W/m^{2}K

(d) Outside heat transfer coefficient is in between 450 to 453 W/m^2/K

4. **[NAT]** **[Level-II]**

A steam pipe (O.D. = 10 cm, T_s = 500K, ε = 0.8) passing through a large room at 300 K. The pipe losses heat by natural convection (h = 15 W/m^{2}K) and radiation. The total rate of heat loss from the pipe per unit length is _____ kW/m. **(Round off to two decimal places)**

5. **[MCQ]** **[Level-I]**

As temperature increases, thermal conductivity of gases

(a) Increases

(b) Decreases

(c) First increases then decreases

(d) First decreases then increases

6. **[MCQ]** **[Level-II]**

At a given temperature arrange the thermal conductivity of following gases in descending order

O_2, N_2, CH_4, CO_2

(a) $k_{O_2} > k_{CH_4} > k_{CO_2} > k_{N_2}$

(b) $k_{CH_4} > k_{N_2} > k_{O_2} > k_{CO_2}$

(c) $k_{O_2} > k_{N_2} > k_{CH_4} > k_{CO_2}$

(d) None of these

7. **[MCQ]** **[Level-II]**

A composite structural wall has a thermal conductivity of 0.25 W/mK and a thickness of 100 mm. Now consider a masonry wall of thermal conductivity of 0.75 W/mK. The heat rate of masonry wall is to be 80% of the heat rate through a composite structural wall and both walls are subjected to the same temperature difference. What will be the thickness required for the masonry wall?

(a) 375 mm

(b) 325 mm

(c) 285 mm

(d) 425 mm

8. **[MCQ]** **[Level-I]**

A solar radiant flux of 800 W/m^2 is absorbed by the roof of a car and the underside of the car is perfectly insulated. The convection coefficient between the roof and the ambient air is 12 W/m^{2}K. If radiation exchange with the surroundings is neglected and the ambient air temperature is 20°C, what will be the temperature of the roof under steady-state conditions?

(a) 69.4 °C (b) 86.7 °C

(c) 52.5 °C (d) 99.7 °C

9. **[NAT]** **[Level-III]**

A hot fluid pipeline runs above the ground and are supported by a vertical steel shaft (k = 25 W/mK) that are 1 m long and have a cross-sectional area of 0.005 m^2. Under normal operating conditions, the temperature variation along the length of a shaft is known to be governed by an expression of the form $T = 100 – 150x + 10x^2$, where T and x have unit of °C and meters respectively. Temperature variations are small over the shaft cross-section. Rate of heat loss from the side of the shaft _____ (in W). **(Round off to two decimal places)**

10. **[NAT]** **[Level-III]**

The temperature variation across a wall 0.3 m thick at a certain instant of time is $T(x) = a + bx + cx^2$ where T is in °C and x is in meter. a = 200°C, b = –200°C/m and c = 30°C/m^2. The wall has thermal conductivity of 1 W/mK. If the cold surface is exposed to a fluid at 100°C. Convective heat transfer coefficient (in W/m^2K) is _____. **(Round off to two decimal places)**

11. **[MCQ]** **[Level-I]**

In an equation of Fourier law of heat conduction, heat flow through a body per unit time is the $Q = -kA\frac{dT}{dx}$

negative sign of k in this equation is to take care of

(a) Decreasing temperature along the direction of increasing thickness

(b) Increasing temperature along the direction of increasing thickness

(c) Constant temperature along the direction with constant thickness

(d) All of the above

12. **[MCQ]** **[Level-I]**

A flat wall with a thermal conductivity of 0.2 kW/mK has its inner and outer surface temperature 600°C and 200°C respectively. If the heat flux through the wall is 200 kW/m^2 what is the thickness of the wall?

(a) 10 cm (b) 20 cm

(c) 30 cm (d) 40 cm

13. **[MCQ]** **[Level-II]**

The external surface of a wall of 3 m height, 5 m width and 0.5 m thickness is at a temperature of 2°C. If a heat loss of 150 W from the room is measured across the wall, find the inner wall temperature? The thermal conductivity of wall material can be taken as 1 W/m.K

(a) 280 K (b) 285 K

(c) 268 K (d) 282 K

14. **[MCQ]** **[Level-I]**

Which of the following has maximum value of thermal conductivity?

(a) Steel (b) Copper

(c) Brass (d) Aluminium

15. **[MCQ]** **[Level-I]**

For a given heat flow and for the same thickness, the temperature drop across the material will be maximum for

(a) Copper

(b) Steel

(c) Glass-wool

(d) Refractory brick

16. **[MCQ]** **[Level-I]**

In descending order of magnitude, the thermal conductivity of

(a) pure iron,

(b) liquid water,

(c) saturated water vapour

(d) aluminum

can be arranged as

(a) a, b, c, d (b) b, c, a, d

(c) d, a, b, c (d) d, c, b, a

ESE & PSUs

1. Which law forms the basis of the concept of heat transfer, indicating that heat flows from a high to a low temperature region?

(a) Zeroth law of thermodynamics

(b) First law of thermodynamics

(c) Second law of thermodynamics

(d) Newton's law of cooling

2. In a one-dimensional steady-state heat conduction, which factor influences the rate of heat transfer the most according to Fourier's law?

(a) Length of the medium

(b) Thermal conductivity of the material

(c) Specific heat of the material

(d) Heat capacity of the medium

3. With rise in temperature, thermal conductivity of solid material

(a) Decreases

(b) Increases

(c) Remains constant

(d) Cannot be predicted

4. Match the following terms with their correct descriptions:

	Term		Description
A.	Convection	1.	Transfer of heat through a solid
B.	Conduction	2.	Heat transfer with fluid motion
C.	Radiation	3.	Heat transfer without medium

(a) A-1, B-3, C-2 (b) A-2, B-3, C-1
(c) A-1, B-2, C-3 (d) A-2, B-1, C-3

5. A composite wall is made up of two materials with thermal conductivities k_1 = 0.5 W/m.K and k_2 = 1.0 W/m.K. If the thickness of both layers is 0.1 m, and the temperature difference across the composite wall is 30°C, the overall heat transfer rate per unit area is
(a) 80 W/m^2 (b) 100 W/m^2
(c) 72 W/m^2 (d) 40 W/m^2

6. Calculate the internal energy change for a 2 kg iron block (specific heat c = 0.45 kJ/kg.K) cooled from 900°C to 100°C
(a) 640 kJ (b) 120 kJ
(c) 720 kJ (d) 550 kJ

7. For a given heat flow and for the same thickness, the temperature drop across the material will be maximum for
(a) copper (b) steel
(c) silver (d) refractory brick

8. Which material has the highest thermal conductivity?
(a) Air (b) Glass
(c) Copper (d) Water

9. **Statement I:** The driving force for heat transfer is the temperature gradient.
Statement II: Higher the conductivity higher the temperature difference across the slab.
(a) Statement I is correct & statement II is wrong.
(b) Statement I is wrong & statement II is correct.
(c) Both the statements are correct.
(d) Both the statements are wrong.

10. Which of the following enhances heat transfer in natural convection?
(a) Thermal resistance
(b) Buoyancy force
(c) Specific heat
(d) Heat capacity

11. A metal rod is heated at one end while the other end is kept at a lower temperature. The heat travels through the rod by conduction. Which of the following is true about the process of heat transfer in the rod?
(a) Heat transfer occurs as the particles of the metal physically move from the hot end to the cold end.
(b) The metal's particles at the hot end vibrate more vigorously, transferring energy to adjacent particles without a net movement of particles along the rod.
(c) Electrons within the metal rod move uniformly from the cold end to the hot end, carrying heat with them.
(d) Heat transfer occurs instantaneously across the rod because metals are perfect conductors.

12. Which of the following materials has the lowest thermal conductivity?
(a) Glass wool (b) Copper
(c) Aluminium (d) Iron

13. Which material shows a **decrease** in thermal conductivity with an increase in temperature?
(a) Metals
(b) Gases
(c) Polymers
(d) Liquids

ANSWER KEY

GATE

1.	(c)	**2.**	(335 to 338)	**3.**	(a & c)
4.	(1.65 to 1.75)	**5.**	(a)	**6.**	(b)
7.	(a)	**8.**	(b)	**9.**	(2.5 to 2.5)
10.	(4.2 to 4.3)	**11.**	(a)	**12.**	(d)
13.	(a)	**14.**	(b)	**15.**	(c)
16.	(c)				

ESE & PSUs

1.	(c)	**2.**	(b)	**3.**	(d)
4.	(d)	**5.**	(b)	**6.**	(c)
7.	(d)	**8.**	(c)	**9.**	(a)
10.	(b)	**11.**	(b)	**12.**	(a)
13.	(a)				

SOLUTIONS

GATE

1. (c)

Ascending order i.e. increasing order

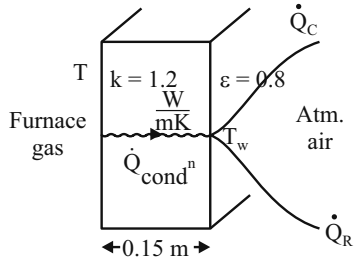
Water, mercury, copper, silver

2. (335 to 338)

$T_w = 100°C$

$T_\infty = 30°C = 303\ K$

$h_0 = 20\dfrac{W}{m^2K}$



Energy Balance:

$\dot{Q}_{cond} = \dot{Q}_C + \dot{Q}_R$

$$-kA\left[\frac{T_w - T}{\delta}\right] = hA[T_w - T_\infty] + \varepsilon A\sigma_b(T_w^4 - T_\infty^4)$$

$$\frac{k(T - T_w)}{\delta} = h[T_w - T_\infty] + \varepsilon\sigma_b(T_w^4 - T_\infty^4)$$

$$\frac{1.2(T - 373)}{0.15} = 20[373 - 303] + 0.8 \times 5.67 \times 10^{-8}$$

$[373^4 - 303^4]$

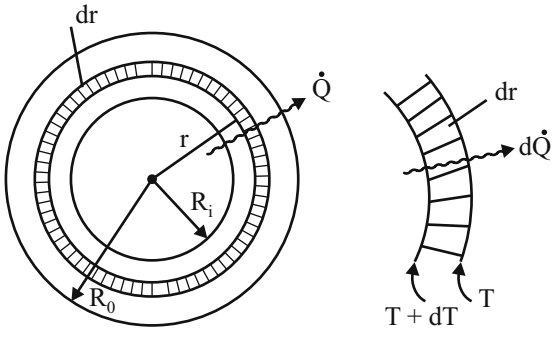
$T = 609.96\ K$

$T = 336.96°C$

3. (a & c)

$k = 40\ [1 + 0.001\ T]$

$T_\infty = 30°C$



At $r = R_i$, $T_i = 250°C$

$r = R_0$, $T_0 = 100°C$

From Fourier's law of heat condition

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CONTENTS

ENGINEERING MATHEMATICS

GENERAL APTITUDE

❐❐❐

01 CHAPTER

Linear Algebra

Topic 1: Basics of Determinants

1. **[MCQ]**

If the determinant of a 4 × 4 matrix 'A' is 2, then the value of determinant of adj(adj(A)) is

(a) 1024 (b) 256

(c) 32 (d) 512

2. **[MSQ]**

If the adjoint of 3 × 3 matrix P is $\begin{bmatrix} 1 & 4 & 4 \\ 2 & 1 & 7 \\ 1 & 1 & 3 \end{bmatrix}$ then the determinant of P is (are)

(a) 2 (b) –2

(c) –1 (d) 1

3. **[MCQ]**

A matrix $A = \begin{bmatrix} p & q & r \\ q & r & p \\ r & p & q \end{bmatrix}$, where p, q and r are real positive numbers. If $pqr = 2$ and $A^TA = I$, then the value of $p^3 + q^3 + r^3$ should be equal to _____.

(a) 3 (b) 4

(c) 7 (d) 10

4. **[MCQ]**

If $ax^4 + bx^3 + cx^2 + dx + e = \begin{vmatrix} 2x & x-1 & x+1 \\ x+1 & x^2-x & x-1 \\ x-1 & x+1 & 3x \end{vmatrix}$

Then the value of e, is:

(a) 2 (b) 1.5

(c) 1 (d) 0

5. **[MCQ]**

The value of the determinant is:

$$\begin{vmatrix} \lim\limits_{x\to 0} \frac{\sin x}{x} & 2 & 4 \\ \lim\limits_{x\to 0} x^2 \cdot \frac{\sin x}{x} & \int_0^{\pi/2} \sin x\, dx & -8 \\ \lim\limits_{x\to \infty} \frac{\sin x}{x} & 0 & \left(\frac{1}{2}\right) \end{vmatrix}$$

(a) $\frac{\sqrt{\pi}}{2}$ (b) $\sqrt{\pi}$

(c) $2\sqrt{\pi}$ (d) π

6. **[NAT]**

Let $A = \begin{bmatrix} 9 & 2 & 7 & 1 \\ 0 & 7 & 2 & 1 \\ 0 & 0 & 11 & 6 \\ 0 & 0 & -5 & 0 \end{bmatrix}$

Then the value of $|\det (8I - A)^3|$ is _____. (Enter in integer)

7. **[NAT]**

If $f(x) = \begin{vmatrix} 1 & x & x+1 \\ 2x & x(x+1) & x(x+1) \\ 3x(x-1) & x(x-1)(x-2) & x(x+1)(x-1) \end{vmatrix}$

Then f (100) is equal to_____.

(Enter in integer)

8. **[MCQ]**

If the matrix, $M = \left[M_{ij}\right] \forall \begin{matrix} 1 \le i \le 2025, \\ 1 \le j \le 2025 \end{matrix}$

Such that $M_{ij} = \int_i^j \frac{x^2 \ln x}{2x} dx + \lim\limits_{x\to\infty} \frac{\sin(i+j)x}{x}$

Then the determinant of the matrix 'M' is _____.

(a) 1 (b) –1

(c) 2025 (d) 0

9. **[MCQ]**

Let A be a 4 × 4 matrix with real entries. you are given the following information.

- det (A) = 6
- B is a matrix obtained by interchanging two rows of A
- C is obtained by multiplying one row of A by 3
- D is a matrix obtained by adding a multiple of one row of A to another row.

What are determinants of B, C & D?

(a) det $(B) = -6$, det $(C) = 18$, det $(D) = 6$
(b) det $(B) = 6$, det $(C) = 18$, det $(D) = 6$
(c) det $(B) = -6$, det $(C) = 2$, det $(D) = 6$
(d) det $(B) = 6$, det $(C) = 2$, det $(D) = 6$

10. [MCQ]

Let $A \in R^{4\times4}$ be partitioned as: $A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}$

Where, $A_{11} = \begin{bmatrix} 2 & 1 \\ 1 & 3 \end{bmatrix}$, $A_{12} = \begin{bmatrix} 0 & 1 \\ 2 & 0 \end{bmatrix}$, $A_{21} = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$, $A_{22} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$

What will be det (A)?

(a) 12 (b) 13
(c) 8 (d) 6

11. [NAT]

Given the matrix $B = \begin{bmatrix} a & 1 & 2 & 3 \\ 0 & b & 4 & 5 \\ 0 & 0 & c & 6 \\ 0 & 0 & 0 & d \end{bmatrix}$, the determinant is 120 and the trace is 14. The value of $|a - d|$ if $(a < b < c < d)$ are positive integers with , will be ____. (Enter in integer)

12. [NAT]

If matrix 'A' = $[a_{ij}]$ is defined by the element $a_{ij} = \int_i^j \sin^{(j+i)} x\,dx$ where $1 \le i \le 3$; $1 \le j \le 3$.

The determinant of the matrix A is_____. (Round off to one decimal places)

Topic 2: Basics of Matrices

13. [MCQ]

Let $B = \begin{bmatrix} 1+2i & 3 \\ 4 & 2-i \end{bmatrix}$. If the inverse of B exists then which of the following is correct form of B^{-1}?

(a) $\frac{1}{15}\begin{bmatrix} 2-i & -3 \\ -4 & 1+2i \end{bmatrix}$ (b) $\frac{1}{-8+3i}\begin{bmatrix} 2-i & -3 \\ -4 & 1+2i \end{bmatrix}$

(c) $\frac{1}{10}\begin{bmatrix} 2-i & -3 \\ -4 & 1+2i \end{bmatrix}$ (d) $\frac{1}{10}\begin{bmatrix} 2+i & 3 \\ 4 & 1-2i \end{bmatrix}$

14. [MCQ]

If a matrix 'A' shifts the vector $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ to $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$ and $\begin{bmatrix} 2 \\ 0 \end{bmatrix}$ to $\begin{bmatrix} 0 \\ 2 \end{bmatrix}$, then $A^2 \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ is:

(a) $\begin{bmatrix} -1 \\ 0 \end{bmatrix}$ (b) $\begin{bmatrix} -2 \\ 0 \end{bmatrix}$
(c) $\begin{bmatrix} 0 \\ -1 \end{bmatrix}$ (d) $\begin{bmatrix} 0 \\ -2 \end{bmatrix}$

15. [NAT]

The minimum number of multiplications required to calculate the product ABC where $A_{3\times4}$, $B_{4\times5}$, $C_{5\times3}$ are the matrices, is _____ (Enter in integer).

16. [NAT]

If $A = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 2 \\ 0 & 2 & 4 \end{bmatrix}$ and $A^{-1} = \begin{bmatrix} 0 & a & 1 \\ b & 3 & -2 \\ -1 & -1 & c \end{bmatrix}$ then $\frac{a+b}{c} =$ _____. (Enter in integer)

17. [MSQ]

Let $[M]$ be a square matrix of order 3 × 3 such that $a_{ij} = \begin{cases} 0, & i \ne j \\ \int_0^{\pi/2} \sin^i x\,dx & i = j \end{cases}$ then which of the following is/are true?

(a) Trace of the matrix M is $\frac{\pi}{4} + \frac{5}{3}$
(b) Trace of the matrix M is $\frac{7\pi}{12} + 1$
(c) Determinant of matrix M is $\frac{\pi^2}{12}$
(d) Determinant of the matrix M is $\frac{\pi}{6}$

18. [MCQ]

If matrix A such that $A^2 = 2A - I$, where I is the identity matrix then for $n \ge 2$, An is equal to

(a) $nA - (n-1)I$ (b) $nA - I$
(c) $2^{n-1}A - (n-1)I$ (d) $2^{n-1}A - I$

19. [MCQ]

For $\alpha, \beta, \gamma \in R$ let $A = \begin{bmatrix} \alpha^2 & 6 & 8 \\ 3 & \beta^2 & 9 \\ 4 & 5 & \gamma^2 \end{bmatrix}$

and $B = \begin{bmatrix} 2\alpha & 3 & 5 \\ 2 & 2\beta & 6 \\ 1 & 4 & 2\gamma - 3 \end{bmatrix}$

If $\text{tr}(A) = \text{tr}(B)$, then the value of $\alpha^{-1} + \beta^{-1} + \gamma^{-1}$ is:

(a) 1 (b) 2
(c) 4 (d) 3

20. [MCQ]

Let A and B be two matrices such that AB exists. Consider the following statements regarding the existence of BA:

1. BA must exist if A and B are both invertible.
2. If AB exists, then BA always exists.
3. If A and B are square matrices of the same order then BA exists.
4. If A has dimensions $m \times n$ and B has deminsion $n \times p$, then BA exists if and only if $p = m$

Which of the above statements is/are correct?

(a) Only 1 and 3 (b) Only 1 and 4
(c) Only 2, 3 and 4 (d) Only 1, 3 and 4

21. [MCQ]

A matrix 'A' is defined by $a_{ij} = i^2 - j^2 \ \forall \ \begin{matrix} 1 \le i \le 2013 \\ 1 \le j \le 2013 \end{matrix}$

The value of sum of all the elements in the matrix is

(a) 1 (b) –1
(c) 0 (d) 5

22. [MCQ]

If a matrix $A = [a_{ij}]$ where $a_{ij} = i^j - j^i$ where $1 \le i \le 3$, $1 \le j \le 3$, then the value of $\sum_{i=1}^{3}\sum_{j=1}^{3} a_{ij}$ is

(a) 207 (b) 0
(c) 217 (d) 343

23. [MCQ]

If $A = A^T$ and $B = -B^T$ then the matrix '$AB + BA$' always is:

(a) Symmetric (b) Skew-Symmetric
(c) Orthogonal (d) Singular

24. [MCQ]

If $A = (a_{ij})_{n\times n}$, where $a_{ij} = i^2 - j^2$ is a square matrix of even order then

(a) A is symmetric and $|A|$ is a perfect square
(b) A is symmetric and $|A| = 0$
(c) A is a skew-symmetric matrix and $|A| = 0$
(d) None of these

Topic 3: Rank of Matrix

25. [MCQ]

Let $v_1 = \begin{bmatrix} 3 \\ 1 \\ 4 \end{bmatrix}$ and $v_2 = \begin{bmatrix} 1 \\ 2 \\ 2 \end{bmatrix}$. Find the value of the coefficient in the expression $v_1 = v_2 + e$, which minimizes the length of the error.

(a) 13/9 (b) 11/9
(c) 17/9 (d) 2/9

26. [NAT]

Let $v_1 = \begin{bmatrix} 2 \\ 4 \\ 6 \end{bmatrix}$ & $v_2 = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$. The error vector $\vec{e} = v_1 - \alpha v_2$ has the modulus $||e||$. Then, at what value of α $||e||$ is minimized?

27. [NAT]

If 'A' $= \begin{bmatrix} 1/9 & 8/9 & -4/9 \\ 4/9 & -4/9 & -7/9 \\ 8/9 & 1/9 & 4/9 \end{bmatrix}$ is an orthogonal matrix and $\vec{x} = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$ is a vector, then the length of the vector $A\vec{x}$ is_____. (Round off to two decimals)

28. [MCQ]

What will be the value of 'a' such that the rank of 4×4 matrix $A = \begin{bmatrix} 1 & 1 & -1 & 0 \\ 4 & 4 & -3 & 1 \\ a & 2 & 2 & 2 \\ 9 & 9 & a & 3 \end{bmatrix}$ is 3?

(a) $a = \{2, -6\}$ (b) $a = \{1, -6\}$
(c) $a = \{2, 6\}$ (d) $a = \{2, 1\}$

29. [MCQ]

The rank of the matrix $[A]_{3\times 3} = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \\ 1 & 3 & 5 \end{bmatrix}$ will be :

(a) 1 (b) 2
(c) 3
(d) The rank cannot be determined

30. [MCQ]

Let A be an $n \times m$ matrix. Consider the following statements:

1. The rank of A is equal to the maximum number of linearly independent rows.
2. The rank of A is equal to the maxinaun number of linearly independent columns.
3. If A is an $n \times m$ matrix with $n > m$ then the rank of A can never exceed m.
4. If A is a Singular Square matrix, then its rank is equal to its size.

Which of the above statement is/are correct?

(a) only 1 and 2 (b) Only 1, 2 and 3
(c) Only 1, 2 and 4 (d) 1, 2, 3 and 4

Topic 4: Non-Homogeneous System

31. [MCQ]

Consider the following system of equations:

$x + y + z = 3$

$2x + 3y + z = 7$

$3x + 4y + 2z = 10$

Which of the following statement is correct?

(a) The system has a unique solution

(b) The system has no solution

(c) The system has infinitely many solutions

(d) The system has exactly two soultion

32. [MCQ]

Which of the following ordered pair (m, n) of the lienar equations:

$x + 2y + 3z = 4$

$3x + 4y + 5z = m$

$4x + 9y + 9z = n$

is consistent.

(a) (4, 1) (b) (5, 2)

(c) (6, 3) (d) For any values of m, n

33. [MCQ]

Consider the following system of linear equations?

$x + 2y + z = 4$

$2x + 4y + 2z = 8$

$3x + 6y + kz = 12$

Which of the following statement is correct?

(a) The system has infinitely many solution for $k = 2$.

(b) The system has no. solution for $k = 3$.

(c) The system has unique solution for $k = 1$

(d) The rank of confined matrix is always 2 regardless of k.

34. [MCQ]

A system of linear equation given below.

$x + 2y + \mu z = \lambda$

$x + y + z = 6$

$x + 2y + 3z = 10$

The system has no solution if

(a) $\lambda = 10, \mu = 3$

(b) $\mu \neq 3, \lambda = 10$

(c) $\mu = 3, \lambda \neq 10$

(d) $\mu \neq 3$

35. [NAT]

A d.c circuit involves 3 closed loops. Applying Kirchoff's laws to the closed loops give the following equations for current flow in milliamperes.

$2I_1 + 3I_2 - 4I_3 = 26$

$I_1 - 5I_2 - 3I_3 = -87$

$-7I_1 + 2I_2 + 6I_3 = 12$

The value of 'I_3' in milli amperes is _____. (Enter an integer)

36. [MCQ]

Consider the system of equations:

$4x - 2y + 6z = 5$

$2x + 2y + 4z = 3$

$10x - 2y + \lambda z = b$

If the system has infinitely many solutions, then the values of λ & b will be:

(a) $\lambda = 14, b = 13$ (b) $\lambda = 13, b = 12$

(c) $\lambda = 14, b = 10$ (d) $\lambda = 16, b = 13$

37. [MCQ]

Consider the following linear system of equations:

$2x + 4y - 6z = p$

$4x + 6y + 6z = q$

$10x + 18y - 12z = r$

Which of the following option is correct?

(a) The system is consistent for all values of p, q, r

(b) The system is consistent if $p + q + r = 0$

(c) The system is consistent if $p - q + 2r = 0$

(d) The system is consistent if $3p + q - r = 0$

38. [MCQ]

A company needs to allocate n resources to m tasks. The allocation is modeled as a system of linear equations with m equations and n variables. Consider the following scenarios.

1. If the number of task m is less than the number of resources n, then there may exist infinitely many ways to allocate recourses.
2. If $m > n$, the allocation becomes impossible for any configuration.
3. If $m = n$, the allocation can be determined uniquely if the allocation matrix is invertible.

Which of the following is correct?

(a) Only 1 is correct

(b) Only 3 is correct

(c) Both 1 and 3 are correct

(d) None of these are correct

39. [MCQ]

Consider the system of equations:

$x + y - z = 4$

$x + 3y + z = 10$

$x - y + 2z = 3$

Which of the following statement is correct?

(a) The system has no solutions
(b) The system has infinitely many solutions
(c) The system has a unique solutions
(d) The system has inconsistent equations

40. [MCQ]

For what value of λ, the given system have a solution:

$2x + y + z = 1$

$2x + 2y + 4z = \lambda$

$6x + 6y + 12z = \lambda^2$

(a) $\frac{7 \pm \sqrt{17}}{2}$ (b) $\frac{5 \pm \sqrt{17}}{2}$

(c) $\frac{1 \pm \sqrt{17}}{2}$ (d) 0, 3

41. [MCQ]

Consider the following equations:

$x + 2y - z = 4$

$2x + 5y + kz = 10$

$3x + 7y + 3z = 14$

For what value of 'k' the above system of equation has infinitely many solutions?

(a) $k \neq 4$ (b) $k = 4$
(c) $k = 2$ (d) $k \neq 2$

42. [MCQ]

Given the matrix A as follows:

$$A = \begin{bmatrix} 1 & 2 & 1 \\ 3 & 6 & 3 \\ 2 & 4 & 2 \end{bmatrix}$$

What can be concluded about the system $Ax = b$ for any vector b?

(a) The system has a unique solution for any b.
(b) The system has no solution for any b.
(c) The system has infinitely many solutions for any b.
(d) The system may have no solutions or infinitely many solutions depending on b.

43. [MCQ]

Consider the system of equations:

$x + 3z = 5$

$-2x + 5y - z = 0$

$-x + 4y + z = 4$

Which of the following statements is correct about the consistency of the system?

(a) The system is consistent with a unique solution.
(b) The system is inconsistent and has no solution.
(c) The system is consistent and has infinitely many solution.
(d) The system has a solution only if $x = 0$.

44. [MSQ]

Consider the following system of equation:

$x + y + z = 1$

$x + 2y + 4z = n$

$x + 4y + 10z = n^2$

For what values of 'n' does the system have infinite solutions and what is the corresponding general solution for x, y and z?

(a) $n = 1$, with the solution $x = 1 + 2z$, $y = -3z$, $z = z$
(b) $n = 1$, with the solution $x = 2z$, $y = 1 - 3z$, $z = z$
(c) $n = 2$, with the solution $x = 1 + 2z$, $y = -3z$, $z = z$
(d) $n = 2$, with the solution $x = 2z$, $y = 1 - 3z$, $z = z$

45. [MCQ]

If A is 4×5 matrix and the system of equations $AX = B$ is inconsistent then the highest possible rank of A will be

(a) $\rho(A) \leq 2$ (b) $\rho(A) \leq 3$
(c) $\rho(A) \leq 4$ (d) $\rho(A) \leq 5$

Topic 5: Homogeneous System

46. [MCQ]

Consider a 3×5 matrix A defined as follows

$$A = \begin{bmatrix} 1 & 4 & 5 & a & 18 \\ 0 & 1 & 7 & 19 & b \\ 0 & 0 & 1 & 11 & 15 \end{bmatrix}$$

Where a and b are real numbers. Choose the correct statement regarding the matrix A based on values of a and b.

(a) There are specific values of a and b for which the columns of A become linearly independent.
(b) There are values of a and b for which the equation $Ax = 0$ has only the trivial solution $x = 0$.
(c) For any values of a and b, the rows of A span a 3-d subspace in R^5.
(d) There exist values of a and b such that the rank A is equal to 2.

47. [MCQ]

Consider the following system of linear equations:

$2x + 2py + pz = 0$

$2x + 2qy + qz = 0$

$2x + 2ry + rz = 0$

where $p, q, r \in R$ are non-zero and distinct: has a non-zero solution, then choose correct option.

(a) $p + q + r = 0$
(b) $p + q + r = 1$
(c) p, q, r can be any combination except 0
(d) $\frac{1}{p}, \frac{1}{q}, \frac{1}{r}$ are in $A.P.$

ANSWER KEY

1. (d)
2. (a, b)
3. (c)
4. (d)
5. (b)
6. (216)
7. **(0)**
8. (d)
9. (a)
10. (b)
11. (3)
12. (–0.001 to 0.001)
13. (b)
14. (a)
15. (96)
16. (–0.001 to 0.001)
17. (a, d)
18. (a)
19. (d)
20. (d)
21. (c)
22. (b)
23. (b)
24. (d)
25. (a)
26. **(2)**
27. (3.7 to 3.78)
28. (a)
29. (b)
30. (b)
31. (c)
32. (d)
33. (a)
34. (c)
35. (8 to 10)
36. (d)
37. (d)
38. (c)
39. (c)
40. (d)
41. (b)
42. (d)
43. (b)
44. (a, d)
45. (b)
46. (c)
47. (c)
48. (a, d)
49. (a)
50. (c)
51. (1)
52. (a)
53. (d)
54. (0)
55. (a, b)
56. (c)
57. (12)
58. (b)
59. (a)
60. (a)
61. (d)
62. (a)
63. (d)
64. (a)
65. (b)
66. (a)
67. (a)
68. (c)
69. (a)
70. (a, c)
71. (c)
72. (d)
73. (–0.3 to –0.4)
74. (b)
75. (c)
76. (56)
77. (b)
78. (a)
79. (d)
80. (a)
81. (c)
82. (16)
83. (a)
84. (b)
85. (c)
86. (a)
87. (c)
88. (a)
89. (d)
90. (a)
91. (b)
92. (a)
93. (a, b, c)
94. (a, b, c, d)
95. (c)
96. (a)
97. (d)
98. (c)
99. (c)
100. (d)
101. (37)
102. (a, b, c)
103. (b)
104. (c)
105. (d)
106. (a)
107. (b)
108. (a)
109. (c, d)
110. (c)
111. (b)
112. (a)
113. (d)
114. (b)
115. (d)
116. (4)
117. (b, d)
118. (b)
119. (b)
120. (a)
121. (a)
122. (b)
123. (b)
124. (a, b, d)
125. (4)
126. (d)
127. (c)
128. (b)
129. (c)

130. (a) **131.** (b) **132.** (d)
133. (a) **134.** (d) **135.** (a, b)
136. (b) **137.** (a) **138.** (a)
139. (a, d) **140.** (a) **141.** (a)
142. (a, d) **143.** (12) **144.** (c)
145. (20) **146.** (a) **147.** (–6)
148. (b) **149.** (d) **150.** (d)
151. (a) **152.** (b, d) **153.** (a, c)

SOLUTIONS

1. **(d)**

Given, $|A| = 2$ and $n = 4$

For a matrix $A_{n\times n}$

$|\text{adj A}| = |A|^{n-1}$ and $|\text{adj (adj } A)| = |A|^{(n-1)^2}$

$\Rightarrow \quad |\text{adj (adj } A)| = 2^{(4-1)^2} = 2^9 = 512$

$\therefore \quad |\text{adj (adj } A)| = 512$

2. **(a, b)**

Given:

$$\text{Adj } P = \begin{bmatrix} 1 & 4 & 4 \\ 2 & 1 & 7 \\ 1 & 1 & 3 \end{bmatrix}$$

$$|\text{Adj } P| = \begin{vmatrix} 1 & 4 & 4 \\ 2 & 1 & 7 \\ 1 & 1 & 3 \end{vmatrix} \qquad R_2 \to R_2 - 2R_1,\ R_3 \to R_3 - R_1$$

$$|\text{Adj } P| = \begin{vmatrix} 1 & 4 & 4 \\ 0 & -7 & -1 \\ 0 & -3 & -1 \end{vmatrix} = 1(7-3) = 4$$

$\because \quad |\text{Adj } P|_{3\times 3} = |P|^{3-1}$ (Property of Adjoint)

On comparing it, $|P|^2 = 4 \Rightarrow |P| = \pm 2$

3. **(c)**

Given, $A = \begin{bmatrix} p & q & r \\ q & r & p \\ r & p & q \end{bmatrix} \to$ Symmetric matrix $(A = A^T)$

$p, q, r \in \text{R}^+$; $p\,q\,r = 2$

$A^T A = I \Rightarrow A^2 = I$

$\Rightarrow |A|^2 = |I| = 1$

$$\begin{vmatrix} p & q & r \\ q & r & p \\ r & p & q \end{vmatrix}^2 = 1$$

$$\left(p\left(qr - p^2\right) - q\left(q^2 - rp\right) + r\left(pq - r^2\right)\right)^2 = 1$$

$$\left(3pqr - \left(p^3 + q^3 + r^3\right)\right)^2 = 1$$

$6 - (p^3 + q^3 + r^3) = \pm 1$

$p^3 + q^3 + r^3 = 5$ (or) 7

4. **(d)**

Given:

$$ax^4 + bx^3 + cx^2 + dx + e = \begin{vmatrix} 2x & x-1 & x+1 \\ x+1 & x^2 - x & x-1 \\ x-1 & x+1 & 3x \end{vmatrix}$$

Put $x = 0$

$$e = \begin{vmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{vmatrix}$$

Using $C_2 \to C_2 + C_3$

$$e = \begin{vmatrix} 0 & 0 & 1 \\ 1 & -1 & -1 \\ -1 & 1 & 0 \end{vmatrix}$$

$\Rightarrow \quad e = 1 - 1 = 0$

5. **(b)**

$$\begin{vmatrix} \underset{x\to 0}{Lt}\ \dfrac{\sin x}{x} & 2 & 4 \\ \underset{x\to 0}{Lt}\ x^2 \dfrac{\sin x}{x} & \displaystyle\int_0^{\pi/2} \sin x\,dx & -8 \\ \underset{x\to \infty}{Lt}\ \dfrac{\sin x}{x} & 0 & \sqrt{\dfrac{1}{2}} \end{vmatrix}$$

$$= \begin{vmatrix} 1 & 2 & 4 \\ 0 & 1 & -8 \\ 0 & 0 & \sqrt{\pi} \end{vmatrix} = 1(\sqrt{\pi} - 0) = \sqrt{\pi}$$

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CONTENTS

❐❐❐

01 Basics of Energy and Environment

Ecology and Environment

1. Match the following types of ecological pyramids (List I) with their correct characteristics (List II):

List I (Ecological Pyramid)	List II (Characteristic)
A. Pyramid of Numbers	1. Always upright
B. Pyramid of Biomass	2. Can be inverted in parasitic ecosystems
C. Pyramid of Energy	3. Can be upright or inverted
D. Pyramid of Numbers (Grassland)	4. Producer > Herbivore > Carnivore

Select the correct code:

(a) A-3, B-2, C-1, D-4
(b) A-2, B-3, C-1, D-4
(c) A-3, B-1, C-2, D-4
(d) A-3, B-2, C-4, D-1

2. Match the following ecosystems (List I) with the type of biomass pyramid they usually exhibit (List II):

List I (Ecosystem)	List II (Pyramid of biomass Type)
A. Forest ecosystem	1. Inverted
B. Aquatic ecosystem	2. Upright
C. Grassland ecosystem	3. Generally upright
D. Oceanic food chain	4. Biomass of zooplankton > phytoplankton

Select the correct code:

(a) A-2, B-1, C-3, D-4
(b) A-2, B-4, C-1, D-3
(c) A-3, B-4, C-2, D-1
(d) A-3, B-1, C-2, D-4

3. Match the Trophic Level with its Description.

List I (Trophic Level)	List II (Description)
A. Producers	1. Always at the base of ecological pyramids
B. Primary Consumers	2. Herbivores
C. Secondary Consumers	3. Feed on herbivores
D. Decomposers	4. Operate at all trophic levels

Select the correct code:

(a) A-1, B-2, C-3, D-4
(b) A-2, B-1, C-4, D-3
(c) A-1, B-4, C-2, D-3
(d) A-4, B-2, C-3, D-1

4. Match the Type of Succession with its Description.

List I (Type of Succession)	List II (Description)
A. Primary Succession	1. Begins in areas with no previous life (e.g., lava)
B. Secondary Succession	2. Occurs in areas with pre-existing life but disturbed
C. Autogenic Succession	3. Driven by organisms within the ecosystem itself
D. Allogenic Succession	4. Driven by external factors like fire or flood

Select the correct code:

(a) A-1, B-2, C-3, D-4
(b) A-2, B-1, C-4, D-3
(c) A-1, B-3, C-2, D-4
(d) A-1, B-2, C-4, D-3

5. Match the Stage of Succession with its Key Features.

List I (Succession Stage)	List II (Feature)
A. Nudation	1. Exposure of a bare area
B. Invasion	2. Arrival and establishment of species
C. Competition & Coaction	3. Interaction and struggle for resources
D. Stabilization/Climax	4. Formation of a stable and mature community

Select the correct code:

(a) A-1, B-2, C-3, D-4
(b) A-2, B-1, C-3, D-4
(c) A-1, B-3, C-2, D-4
(d) A-1, B-2, C-4, D-3

6. Match the Succession Type with suitable example.

List I (Succession Type)	List II (Example)
A. Hydrarch Succession	1. Pond turning into forest over time
B. Xerarch Succession	2. Rocky surface gradually becoming forest
C. Lithosere	3. Succession on bare rock surface
D. Psammosere	4. Succession on sandy habitat like sea coasts

Select the correct code:

(a) A-1, B-2, C-3, D-4

(b) A-2, B-1, C-4, D-3

(c) A-1, B-4, C-3, D-2

(d) A-4, B-2, C-1, D-3

7. **Assertion (A):** The carbon footprint of an individual includes direct as well as indirect greenhouse gas emissions.

Reason (R): Emissions from electricity usage and transportation are direct emissions, while emissions from goods and services consumed are indirect.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

8. **Assertion (A):** Carbon handprint focuses on minimizing the harmful effects of human actions on the environment.

Reason (R): It quantifies the greenhouse gases added to the atmosphere by human activities.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

9. **Assertion (A):** Adopting lifestyle changes such as reducing meat consumption and using public transport can lower an individual's carbon footprint.

Reason (R): These lifestyle changes contribute to the net-zero emission goals of countries.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

10. Which one of the following is the best description of the term "ecosystem"?

(a) A community of organisms interacting with one another.

(b) That part of the Earth which is inhabited by living organisms.

(c) A community of organisms together with the environment in which they live.

(d) The flora and fauna of a geographical area.

11. Which of the following best defines the concept of "ecotone"?

(a) A region where sunlight penetration is highest in an ecosystem

(b) A transitional zone between two distinct ecosystems with high species diversity

(c) A part of an ecosystem where only detritivores survive

(d) A nutrient-poor, stable ecosystem zone

12. Which of the following are considered "ecosystem services"?

1. Pollination
2. Climate regulation
3. Food and fiber production
4. Carbon sequestration

The correct option is:

(a) 1 and 2 only (b) 3 and 4 only

(c) 1, 2 and 3 only (d) All of the above

13. Which one of the following terms describes not only the physical space occupied by an organism, but also its functional role in the community of organisms?

(a) Ecotone (b) Ecological niche

(c) Habitat (d) Home range

14. Which one of the following is the process involved in photosynthesis?

(a) Potential energy is released to form free energy

(b) Free energy is converted into potential energy and stored

(c) Food is oxidized to release carbon dioxide and water

(d) Oxygen is taken, and carbon dioxide and water vapour are given out

15. Consider the following statements regarding 'Earth Hour':

1. It is an initiative of UNEP and UNESCO.
2. It is a movement in which the participants switch off the lights for one hour on a certain day every year.
3. It is a movement to raise awareness about climate change and the need to save the planet.

Which of the statements given above is/are correct?

(a) 1 and 3 only (b) 2 only
(c) 2 and 3 only (d) 1, 2 and 3

16. In the context of ecosystem productivity, marine upwelling zones are important as they increase the marine productivity by bringing the:

1. Decomposer microorganisms to the surface.
2. Nutrients to the surface.
3. Bottom-dwelling organisms to- the surface.

Which of the statements given above is/are correct?

(a) 1 and 2 (b) 2 only
(c) 2 and 3 (d) 3 only

17. In the grasslands, trees do not replace the grasses as a part of an ecological succession because of :

(a) Insects and Fungi
(b) Limited sunlight and paucity of nutrients
(c) Water limits and fire
(d) None of the above

18. Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity?

(a) Oceans, lakes, grasslands, mangroves
(b) Mangroves, oceans, grasslands, lakes
(c) Mangroves, grasslands, lakes, oceans
(d) Oceans, mangroves, lakes, grasslands

19. Consider the following statements about ecological succession:

1. Primary succession occurs on newly exposed surfaces like lava or sand.
2. Secondary succession takes place in areas where a previous community existed.
3. Climax community is always a forest ecosystem.

Which of the above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

20. Which one of the following ecosystems has the highest gross primary productivity (GPP) but lower net primary productivity (NPP) due to high respiration loss?

(a) Ocean (b) Tropical rainforest
(c) Desert (d) Grassland

21. With reference to food chains in ecosystems, consider the following statements:

1. A food chain illustrates the order in which a chain of organisms feed upon each other.
2. Food chains are found within the populations of a species.
3 A food chain illustrates the numbers of each organism which are eaten by others.

Which of the statements given above is / are correct?

(a) 1 only (b) 1 and 2 only
(c) 1, 2 and 3 (d) None

22. Arrange the following in the correct sequence in an aquatic food chain:

1. Small fishes
2. Zooplankton
3. Large carnivorous fishes
4. Phytoplankton

(a) $4 \rightarrow 2 \rightarrow 1 \rightarrow 3$ (b) $1 \rightarrow 2 \rightarrow 3 \rightarrow 4$
(c) $4 \rightarrow 1 \rightarrow 2 \rightarrow 3$ (d) $2 \rightarrow 4 \rightarrow 1 \rightarrow 3$

23. Which of the following is correct regarding ecological pyramids?

(a) Pyramid of biomass is always upright
(b) Pyramid of energy can be inverted in aquatic ecosystems
(c) Pyramid of numbers can be both upright and inverted
(d) Pyramid of energy may not follow 10% law

24. Which of the following statements regarding food chains is/are correct?

1. Energy transfer is efficient and continuous.
2. Longer food chains are more stable.
3. Bioaccumulation increases as we go up trophic levels.

(a) 1 only (b) 2 and 3 only
(c) 3 only (d) 1 and 3 only

25. Which of the following are keystone species in their ecosystems?

1. Tiger in a forest
2. Sea otter in kelp forests
3. Coral in coral reefs
4. Grass in grassland

The correct option is:

(a) 1, 2 and 3 only (b) 2, 3 and 4 only
(c) 1 and 4 only (d) All of the above

26. In ecological niche theory, if two species occupy the same niche:

(a) Both can coexist without competition
(b) One species will be eliminated
(c) The environment adapts to accommodate both
(d) They evolve into similar species

27. Which of the following ecosystems has the lowest net primary productivity (NPP)?

(a) Desert (b) Estuary
(c) Grassland (d) Tropical forest

28. The concept of "trophic cascade" is associated with:
(a) Collapse of primary producers
(b) Progressive increase in biomass at higher levels
(c) Impact of top predators on ecosystem structure
(d) Herbivore-plant mutualism

29. Detritus food chain differs from grazing food chain in that:
(a) It begins with herbivores
(b) It includes photosynthetic producers
(c) It starts with dead organic matter
(d) It doesn't involve energy flow

30. Lichens, which are capable of initiating ecological succession even on a bare rock, are actually a symbiotic association of
(a) Algae and bacteria
(b) Algae and fungi
(c) Bacteria and fungi
(d) Fungi and mosses

Environmental Pollution and Degradation

1. **Assertion (A):** Coal - based thermal power stations contribute to acid-rain.
Reason (R): Oxides of carbon are emitted when coal burns.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

2. Which of the following statements correctly describe Black Carbon?
1. It is a greenhouse gas with a long atmospheric lifetime.
2. It is produced by incomplete combustion of fossil fuels and biomass.
3. It contributes to glacial melt in the Himalayas.
4. It is the same as soot particles.
Select the correct code:
(a) 1 and 2 only (b) 2, 3 and 4 only
(c) 1, 2, and 3 only (d) 1, 3, and 4 only

3. With reference to Blue Carbon, consider the following statements:
1. It refers to the carbon stored in coastal and marine ecosystems.
2. Mangroves, seagrasses, and salt marshes are important blue carbon sinks.
3. Oceans store more carbon than terrestrial forests.
Which of the above statements is/are correct?
(a) 1 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

4. Match the Type of Carbon with its Description.

Type of Carbon	Description
A. Green Carbon	1. Carbon stored in plants and terrestrial ecosystems
B. Brown Carbon	2. Organic carbon released from biomass burning
C. Grey Carbon	3. Carbon emissions from industrial processes
D. Black Carbon	4. Strong light-absorbing component of PM2.5

Select the correct code:
(a) A-1, B-2, C-3, D-4
(b) A-1, B-4, C-2, D-3
(c) A-2, B-1, C-3, D-4
(d) A-3, B-1, C-4, D-2

5. Which of the following are some important pollutants released by the steel industry in India?
1. Oxides of sulphur 2. Oxides of nitrogen
3. Carbon monoxide 4. Carbon dioxide
Select the correct answer using the code given below.
(a) 1, 3 and 4 only (b) 2 and 3 only
(c) 1 and 4 only (d) 1,2, 3 and 4

6. With reference to furnace oil, consider the following statements:
1. It is a product of oil refineries.
2. Some industries use it to generate power.
3. Its use causes sulphur emissions into environment.
Which of the statements given above are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

7. Which of the following are the reason/factors for exposure to benzene pollution?
1. Automobile exhaust
2. Tobacco smoke
3. Wood burning
4. Using varnished wooden furniture
5. Using products made of polyurethane
Select the correct answer using the code given below:
(a) 1, 2 and 3 only (b) 2 and 4 only
(c) 1, 3 and 4 only (d) 1, 2, 3, 4 and 5

8. Which of the following types of hydrogen is considered the cleanest and most sustainable?
(a) Grey Hydrogen (b) Blue Hydrogen
(c) Green Hydrogen (d) Turquoise Hydrogen

ANSWER KEY

Ecology and Environment

1.	(a)	**2.**	(a)	**3.**	(a)
4.	(a)	**5.**	(a)	**6.**	(a)
7.	(a)	**8.**	(c)	**9.**	(a)
10.	(c)	**11.**	(b)	**12.**	(d)
13.	(b)	**14.**	(b)	**15.**	(c)
16.	(b)	**17.**	(c)	**18.**	(c)
19.	(a)	**20.**	(b)	**21.**	(a)
22.	(a)	**23.**	(c)	**24.**	(c)
25.	(a)	**26.**	(b)	**27.**	(a)
28.	(c)	**29.**	(c)	**30.**	(b)

Environmental Pollution and Degradation

1.	(b)	**2.**	(b)	**3.**	(d)
4.	(a)	**5.**	(d)	**6.**	(d)
7.	(d)	**8.**	(c)	**9.**	(d)
10.	(c)	**11.**	(a)	**12.**	(c)
13.	(b)	**14.**	(d)	**15.**	(a)
16.	(b)	**17.**	(d)	**18.**	(d)
19.	(d)	**20.**	(a)	**21.**	(a)
22.	(a)	**23.**	(a)	**24.**	(a)
25.	(a)	**26.**	(a)	**27.**	(a)
28.	(a)	**29.**	(a)		

Environmental Issues

1.	(c)	**2.**	(a)	**3.**	(a)
4.	(a)	**5.**	(d)	**6.**	(a)
7.	(a)	**8.**	(a)	**9.**	(c)
10.	(d)	**11.**	(d)	**12.**	(a)
13.	(d)	**14.**	(a)	**15.**	(a)
16.	(d)	**17.**	(a)	**18.**	(a)
19.	(a)	**20.**	(c)		

Climate Change

1.	(a)	**2.**	(c)	**3.**	(a)
4.	(c)	**5.**	(a)	**6.**	(c)
7.	(a)	**8.**	(a)	**9.**	(a)
10.	(a)	**11.**	(a)	**12.**	(a)
13.	(d)	**14.**	(c)	**15.**	(a)
16.	(d)	**17.**	(a)	**18.**	(d)

7.	(a)	**8.**	(c)	**9.**	(a)
10.	(a)	**11.**	(a)	**12.**	(a)
13.	(d)	**14.**	(a)	**15.**	(a)
16.	(b)	**17.**	(c)	**18.**	(b)
19.	(a)	**20.**	(b)	**21.**	(a)
22.	(d)	**23.**	(b)	**24.**	(c)
25.	(b)	**26.**	(b)	**27.**	(b)
28.	(a)	**29.**	(b)	**30.**	(a)
31.	(a)	**32.**	(a)	**33.**	(a)
34.	(a)	**35.**	(a)	**36.**	(a)
37.	(c)	**38.**	(a)	**39.**	(a)

SOLUTIONS

Ecology and Environment

1. (a)

A. Pyramid of Numbers – 3:

This can be upright (grasslands) or inverted (Parasitic food chain, where one tree supports many parasites).

B. Pyramid of Biomass – 2:

In forests, biomass decreases at higher trophic levels (can be inverted). In aquatic ecosystems, producers (phytoplankton) have less biomass than consumers – so inverted.

C. Pyramid of Energy – 1:

Always upright because energy is lost at each trophic level (10% law).

D. Pyramid of Numbers (Grassland) – 4:

A classic example of upright pyramid: many grasses → fewer herbivores (e.g., grasshoppers) → even fewer carnivores.

2. (a)

A. Forest ecosystem – 2 (Upright): Producers (trees) have large biomass, decreasing toward top carnivores.

B. Aquatic ecosystem – 1 (Inverted): Tiny phytoplankton (low biomass) support larger biomass of zooplankton.

C. Grassland ecosystem – 3 (Generally upright): Herbaceous plants have more biomass than herbivores/carnivores.

D. Oceanic food chain – 4: Due to fast turnover of phytoplankton, biomass of consumers may exceed producers.

3. (a)

A. Producers – 1: Form the base of all ecological pyramids by converting solar energy into biomass.

B. Primary Consumers – 2: Herbivores feeding directly on producers.

C. Secondary Consumers – 3: Feed on primary consumers (e.g., frogs, small carnivores).

D. Decomposers – 4: Operate at all levels, breaking down organic matter and recycling nutrients.

4. (a)

A. Primary Succession – 1: Begins on barren areas (e.g., lava rocks, sand dunes) with no initial biotic community.

B. Secondary Succession – 2: Occurs where a biological community has been removed due to disturbance (e.g., forest fire, agriculture).

C. Autogenic Succession – 3: Driven by biotic components of the system (e.g., shade-tolerant plants replacing pioneers).

D. Allogenic Succession – 4: Caused by abiotic external forces (e.g., flood, drought, volcanic eruption).

5. (a)

A. Nudation – 1: First stage where a bare area is formed due to volcanic eruption, landslide, retreat of glaciers, etc.

B. Invasion – 2: Dispersal and colonization by pioneer species such as lichens, algae, or grasses.

C. Competition & Coaction – 3: Organisms compete for light, nutrients, space, influencing further succession.

D. Stabilization (Climax) – 4: A stable, self-sustaining climax community is formed (e.g., deciduous forest in humid regions).