GATE 2023

Mechanical Engineering

Questions & Solutions

4th Feb Afternoon Session

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GATE 2023
Exam Analysis

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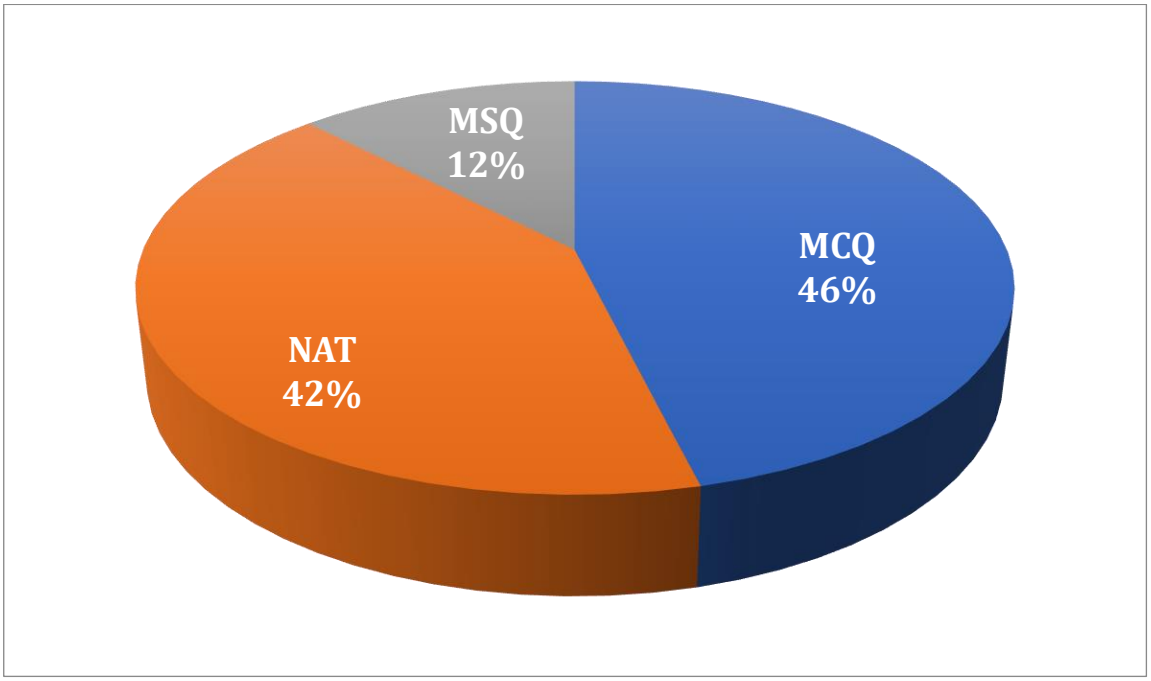
GATE 2023 Paper Analysis

Memory Based



SECTION - A GENERAL APTITUDE

1. $p^2 - 4q < 4$

   $3p + 2q < 6$

   $p + q = ?$

   (A) 3 (B) 4

   (C) 1 (D) 2

Correct Option: D **2 Mark**

2. The minute hand and second hand of a clock cross each other _____ times between 9:15:00 AM and 9:45:00 AM on a day

   (A) 15 (B) 30

   (C) 29 (D) 31

Correct Option: B **1 Mark**

3. How many pairs of sets (S, T) are possible among the subsets of {1, 2, 3, 4, 5, 6} that satisfy the condition that S is a subset of T?

   (A) 664 (B) 729

   (C) 728 (D) 665

Correct Option: B **2 Mark**

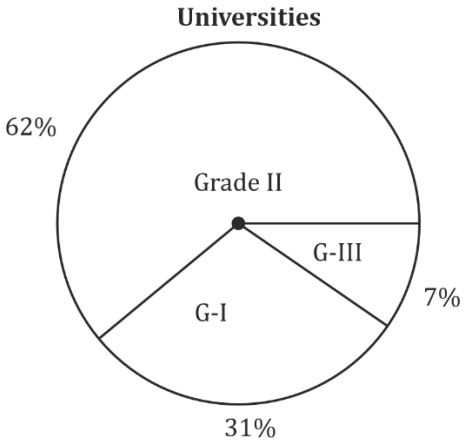
4. Planting : Seed : : Raising : _____

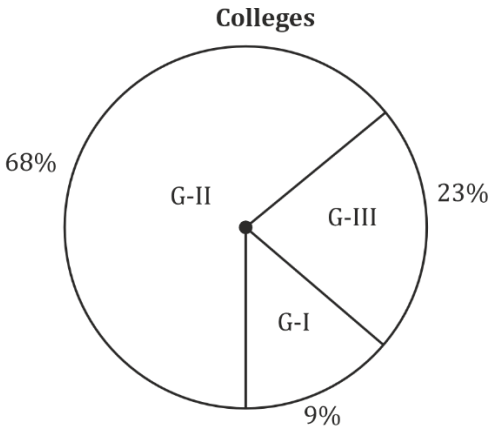
(A) Lift (B) Child

(C) Height (D) Temperature

Correct Option: B **1 Mark**

5. A certain country has 504 universities and 25951 colleges. These are categorized into Grades I, II, III.What is the percentage correct to one decimal of higher education institutions (College + university) that fall into Grade III?





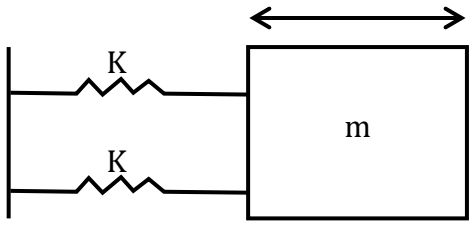
(A) 66.8% (B) 23.7%

(C) 22.7% (D) 15.0%

Correct Option: C **2 Mark**

SECTION - B TECHNICAL

1. The figure show a block of m = 20kg attached to a pair of identical linear spring, each having spring constant k = 1000N/m. The mass oscillates on a frictionless horizontal surface assuming free vibration; the time taken by the block to complete 10 oscillations is ____ sec.



Answer: 6.28 **1 Mark**

2. Mixture of ideal gases x and y

$\bar{M}x = 10$ kg/k mol, $\bar{M}y = 20$ kg. k mol,

Total pressure = 100 k pa,

Total volume = 10 m^3,

Temperature = 300 k,

Mass of x is 2 kg

Mass of y will be _____ . [R = 8314 J k mol^{-1} kg^{-1}]

Answer: 4.018 **2 Mark**

3. A HE extracts (Q_H) from a TR at T = 1000k and rejects to (Q_L) to TR at T = 100k. While producing (w) work. While combination of [Q_H, Q_L and W] is allowed.

(A) $Q_H = 2000J, Q_L = 750J, W = 1250J$

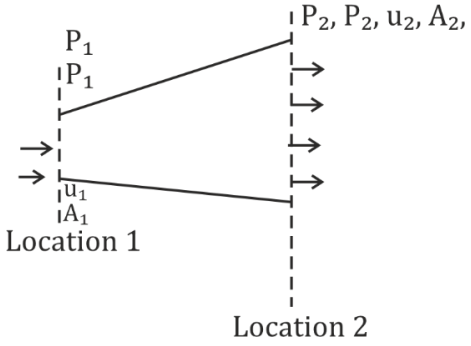
(B) $Q_H = 6000J, Q_L = 600J, W = 5500J$

(C) $Q_H = 2000J, Q_L = 500J, W = 1000J$

(D) $Q_H = 6000J, Q_L = 500J, W = 5500J$

Correct Option: A **1 Mark**

4. Consider an isentropic flow of air (ratio of specific heats = 1.4) through a duct as shown in the figure.



The variations in the flow across the cross-section are negligible. The flow condition at location 1 is given as follows:

$P_1 = 100$ kpa, $P = 1.2$ kg/m^3, $u_1 = 400$ m/s

The duct cross sectional area of location 2 is given by $A_2, = 2A_1$, where A_1 denotes the duct cross-sectional area at location 1.

Which one of the given statements about the velocity of u_2 at pressure P_2 at location 2 is true?

(A) $u_2 < u_1, P_2 < P_1$ (B) $u_2 > u_1, P_2 > P_1$

(C) $u_2 < u_1, P_2 > P_1$ (D) $u_2 > u_1, P_2 < P_1$

Correct Option: D **1 Mark**

5. Cylindrical bar

$L = 5$ m

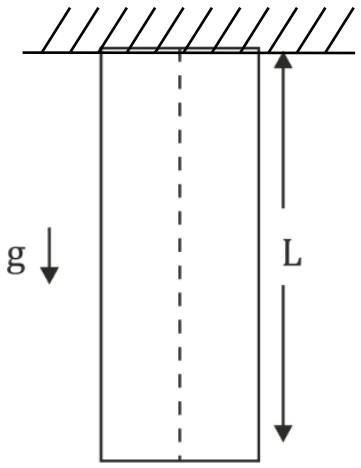
Area $= 10 m^2$

Density $= \rho = 2700$ kg/m^3

$E = 70$ GPa; $g = 9.8$ m/s^2

State of uniaxial tension due to self-weight

Elastic strain energy stored in bar _____ J.

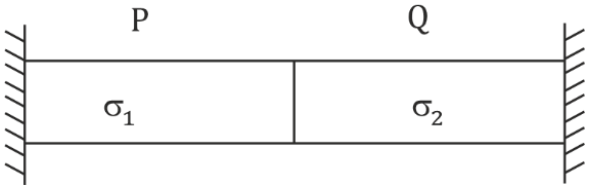


Answer: 2.083 **2 Mark**

6. Given P, Q have identical lengths and radii but different materials.

$E_Q = 2E_P$ (E → young mod)

$\alpha_Q = 2\alpha_p$ (α→ coefficient of thermal on) bars are raised by Δ T.



(A) $\sigma_1 < \sigma_2$

(B) The interface between P and Q moves to the right after heating

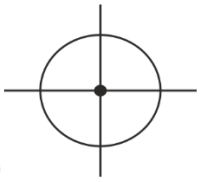
(C) $\sigma_1 = \sigma_2$

(D) The interface between P and Q moves to the left after heating

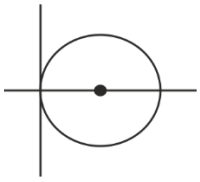
Correct Option: C, D **2 Mark**

7. Representation of a plane stress state in a material.

(A)

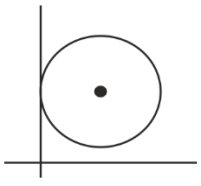


(B)



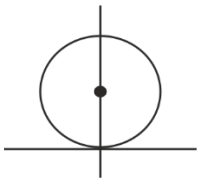
(M_1)

(C)



(M_2)

(D)



Correct Option: A, B **1 Mark**

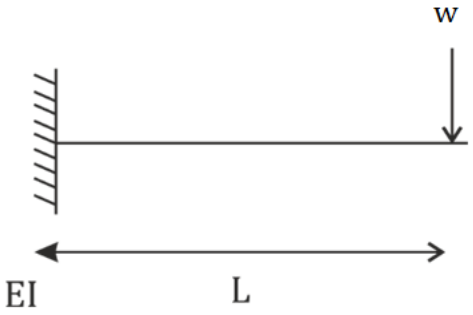
8. Calculate the stiffness of the beam shown in the figure below?

(A) $\frac{2\epsilon|}{L^3}$

(B) $\frac{3\epsilon|}{L^3}$

(C) $\frac{L^3}{3\epsilon}$

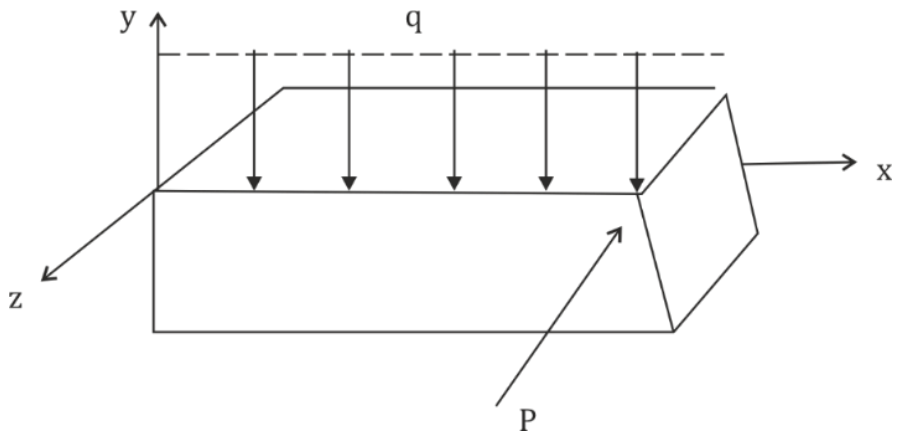
(D) $\frac{L^3}{2\epsilon|}$



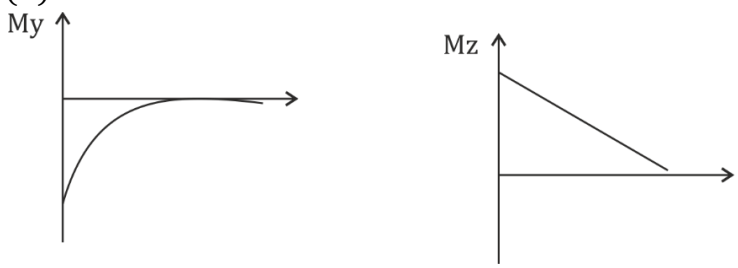
Correct Option: B **0 Mark**

9. Given a beam of length L loaded by uniformly distributed load, and by a concentrated tip load parallel to Z-axis.

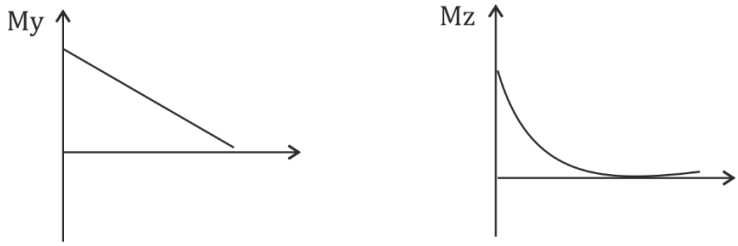
My → Bending moment about y
Mz → bending moment about z



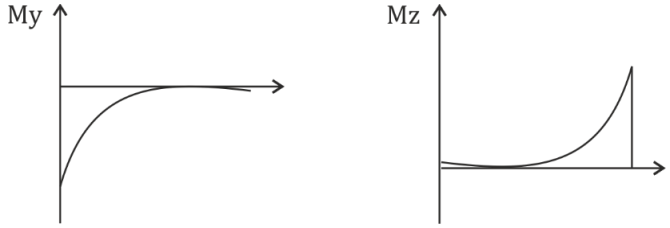
(A)



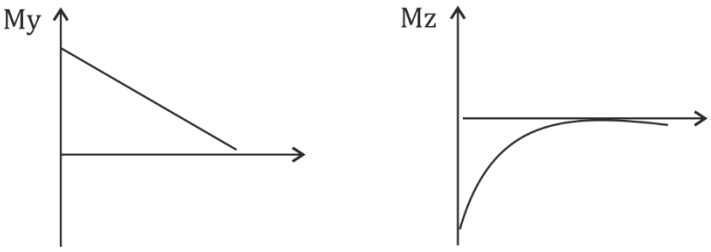
(B)



(C)

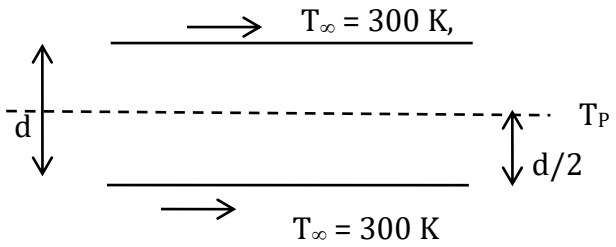


(D)



Correct Option: A **2 Mark**

10. In which of the following cases Lumped analysis is applicable:



(A) $h = 1000\ W/m^2K, d = 1m, k = 1\ W/mK, T_P = 350K$

(B) $h = 100\ W/m^2K, d = 1m, k = 100\ W/mK, T_P = 325K$

(C) $h = 10\ W/m^2K, d = 1mm, k = 100\ W/mK, T_P = 350K$

(D) $h = 100\ W/m^2K, d = 1mm, k = 1000\ W/mK, T_P = 325K$

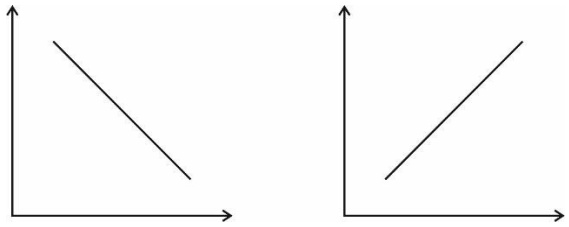
Correct Option: C, D **2 Mark**

11. Given a Counter flow Heat exchanger with inlet temperature of both the fluids 1 and 2 as 350 K and 300 K respectively. The heat capacity rates of both the fluids are $C_1 = 1000\ W/K$ and $C_2 = 400\ W/K$. The effectiveness of the heat exchanger is 0.5. The actual heat transfer is _____ kW.

Answer: 10 **1 Mark**

12. Consider 1-D steady state Heat transfer through a plane slab without heat generation. Which of the following temperature profiles is/are correct?

(A) (B)



Correct Option: A,B **1 Mark**

13. Given, $\frac{x^2d^2y}{dx^2} + \frac{xdy}{dx} - y = 0, x \geq 1$

Initial conditions $y(x=1) = 6, \frac{dy}{dx}|_{x=1}^{=2}$

The value of y at $x = 2$ equal _____.

Answer: 9 **2 Mark**

14. The initial value problem $\frac{dy}{dt} + 2y = 0, y(0) = 1$ is solved using forward Euler's method with a constant and positive time step of Δ t.

Let y_n represent the numerical solution obtained after 'n' steps. The condition $|y_{n+1}| \leq |y_n|$ is satisfied iff Δt does not exceed _____.

Answer: * **2 Mark**

15. The smallest perimeter that a rectangle with area of 4 square units can have is _____ units.

Answer: 8 **2 Mark**

16. Which of the option given is the inverse Laplace transform of $\frac{1}{S^3-S}$? U (t)→ unit step function.

(A) $\left(\frac{1}{3}e^{-t}-e^{t}\right)u(t)$

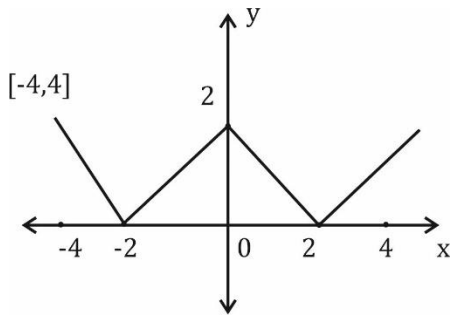
(B) $\left(-1+\frac{1}{2}e^{-t}+\frac{1}{2}e^{t}\right)u(t)$

(C) $\left(-1+\frac{1}{2}e^{-(t-1)}+\frac{1}{2}e^{(t-1)}\right)u(t-1)$

(D) $\left(-1-\frac{1}{2}e^{-(t-1)}-\frac{1}{2}e^{(t-1)}\right)u(t-1)$

Correct Option: B **2 Mark**

17. Which of the following represents the plot shown below between the range -4 to 4?



(A) 2 – |x|

(B) |2 – x|

(C) |2 + |x||

(D) |2–|x||

Correct Option: D **1 Mark**

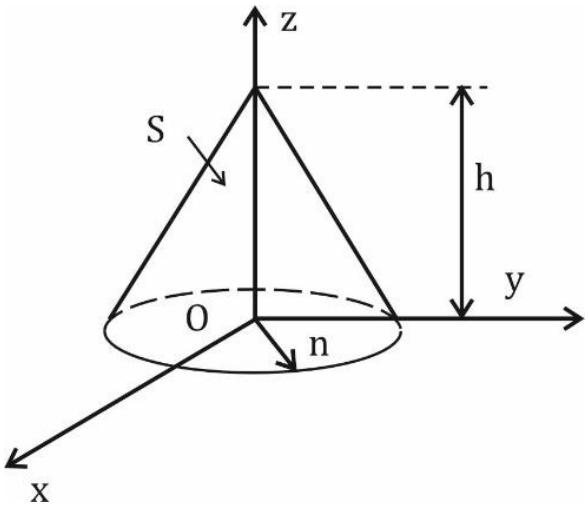
18. Given, Analytic complex valued function

$f(z) = e^{-kx}(\cos 2y - i \sin 2y)$, where $z = x + iy$ $R = ?$

The value of 'k' is _____.

Answer: 2 **1 Mark**

19. Given, a vector field $B(x, y, z) = x\hat{\imath} + y\hat{\jmath} - 2z\hat{k}$ is defined over a conical region having height $h = 2$, Base radius $r = 3$ and axis along Z, as shown. The base of the cone lies in the x-y plane and is centered at origin. If 'n' denotes the unit outward normal to the curved surface 'S' of the cone, the value of the integral $\int_S B.n\, ds =$ _____.



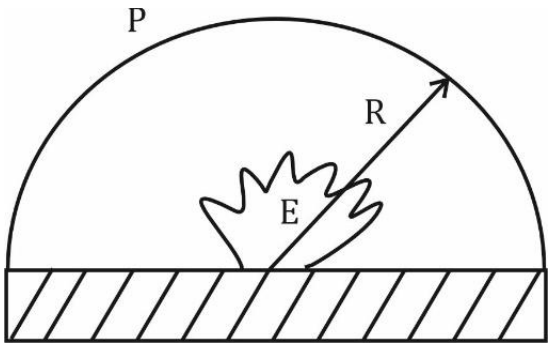
Answer: 0 **1 Mark**

20. A linear transformation maps a point (x, y) in the plane to the point $(\hat{x}, \hat{y})$ as per $\hat{x} = 35, \hat{y} = 2x$. Then the disc $x^2 + y^2 \leq 1$ gets transformed to a region with an area equal to_____.

Answer: 18.84 **1 Mark**

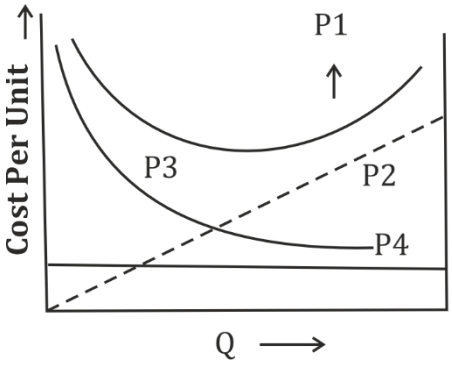
21. An explosion at time $t = 0$ releases energy E at the origin in a space filled with a gas of density P. Subsequently, a hemispherical blast wave propagates radically outwards as shown. Let R denote the radius of the front of the hemispherical blast wave. The radius 'R' follows the relationship.

$R = ktaEbPc$, $k \rightarrow$ dimensionless constant. The value of a _____



Answer: 0.4 **2 Mark**

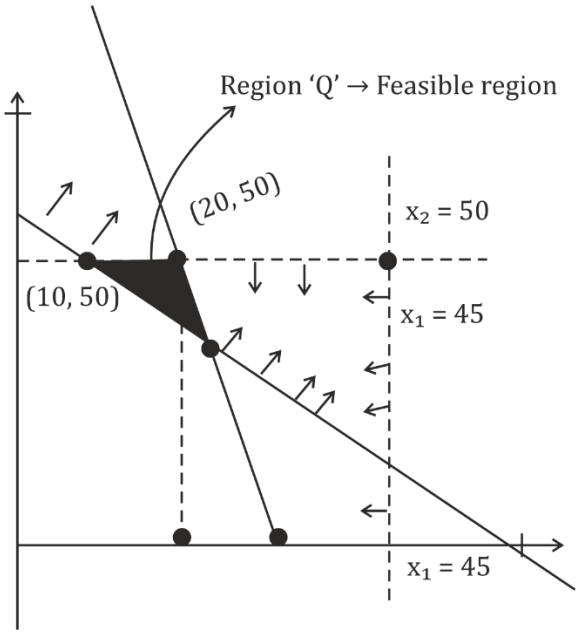
22. Which of the following options correctly represents the curves as shown in the diagram below?



P1 → Total Cost
P2 → Holding Cost
P3 → Set up Cost
P4 → Production Cost

Correct Option: B **1 Mark**

23.



$x_1 \le 45$

$x_2 \le 50$

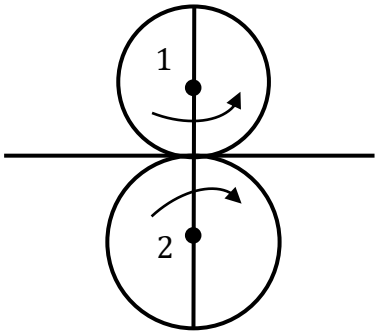
$\frac{x_1}{60} + \frac{x_2}{60} \ge 1$

$\frac{x_1}{30} + \frac{x_2}{150} \le 1$

$10x_1 + 10 \times 50 = 600$
$10x_1 + 500 = 600$
$10x_1 = 100$
$x_1 = 10$
$25x_1 + 5 \times 50 = 750$
$25x_1 + 250 = 750$
$25x_1 = 500$
$x_1 = 20$

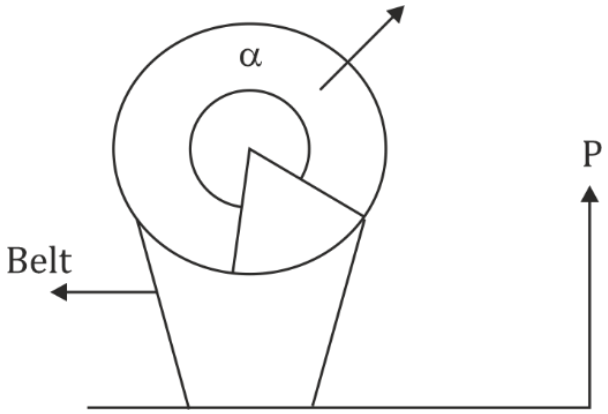
Correct Option: Q **1 Mark**

24. Two machine spur gear 1, and 2 with diametric pitch of 8 teeth per mm and an angular velocity $\frac{w_2}{w_1} = \frac{1}{4}$ have their centers 30 mm apart. The number of teeth on driver (geari) is



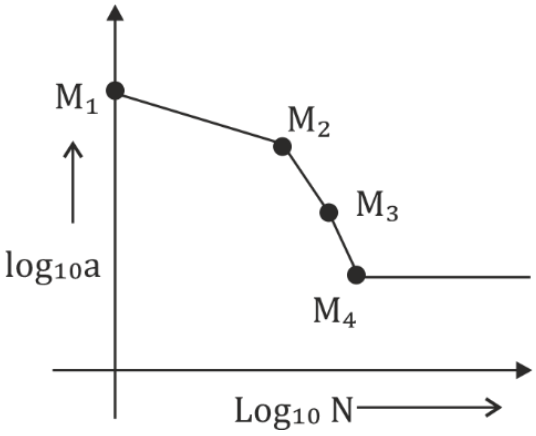
Answer: 96 **1 Mark**

25. Find the value of $\mu = 0.3, \alpha = 270^0$ T_1/T_2 =?



Answer: 4.11 **1 Mark**

26. Which point tells about the endurance unit _____?



(A) M_1 (B) M_2
(C) M_3 (D) M_4

Correct Option: D **1 Mark**

27. Mixture of ideal gases, X and Y $\bar{M}y = 20$ kg/kmol
Total pressure = 100 KPa, Total volume = $10m^3$
Temperature = 300 k mass of x is 2 kg.
Mass of Y is? [R = 8314 J kmol^{-1} n^{-1}]

Answer: 4.018 **2 Mark**

28. Cylinder shaft of length 1.5 m and diameter 100 mm, G = 80 GPA, N = 500 rpm, $\theta = 0.5$ degree power transmitted by shaft is _____ kW.

Answer: 239.24 **1 Mark**

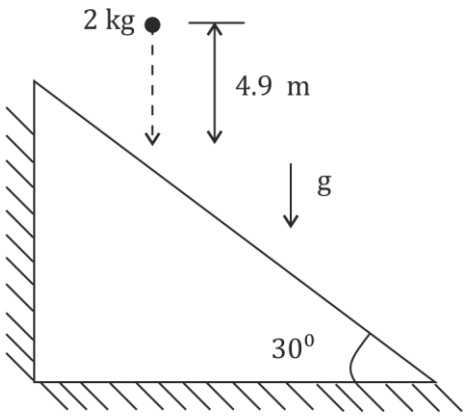
29. True stress vs true strain. $\sigma = 400 \in^{0.3}$ MPa. Engineering ultimate tensile strength value _____ MPa.

Answer: 278.74 **1 Mark**

30. Atomic radius of a hypothetical FCC is $(\sqrt{2}/10)$ nm. Atomic weight = 24. 0.92 g/mol. Avogadro No = 6.023×10^{23} atoms/mol, density of metal _____ kg/m^3.

Answer: 17.6 **2 Mark**

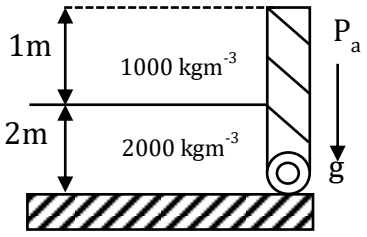
31. Spherical ball of mass 2 kg dropped from a height of 4.9 m. If the collision is perfectly elastic, what is the momentum vector of the ball just after impact ? [g = 9.8 m/s^2].



(A) $9.8\,\hat{i} + 17\,\hat{j}$
(B) $17\,\hat{i} + 9.8\,\hat{j}$
(C) $19.6\,\hat{j}$
(D) $6\,\hat{j}$

Correct Option: B **2 Mark**

32. The figure shows two fluids held by a hinged gate. The atmospheric pressure is 100 KPa. Moment per unit width about the base of hinge is _____ kNm/m. (Round off to decimal places). Assume acceleration due to gravity, g = 9.8m/s^2.



Answer: 57.34 **2 Mark**

33. Air (density = 1.2 kg/m^3, Kinematic viscosity = 1.5×10^{-5}m^2/s) flows over a flat plate with free stream velocity of 2 m/s. The wall shear stress at a location 15 mm from leading edge is Tw. What is wall shear stress at a location 30 mm from the leading edge is

(A) $\frac{T_w}{\sqrt{2}}$ (B) $2T_w$

(C) $\frac{T_w}{2}$ (D) $\sqrt{2}T_w$

Correct Option: A **2 Mark**

34. The true stress vs true strain relationship is $\sigma = 400 \in^{0.3}$ MPa

Find engineering ultimate tensile strength value of this material in _____ MPa.

Answer: 278.74 **1 Mark**

35. The velocity field of a certain two dimensional flow is given by $V(x, y) = k(x\hat{i} - y\hat{j})$ where $k = 2s^{-1}$. The coordinates x and y are in meters. Assume gravitational effect to be negligible. If the density of the fluid is 1000 kg/m^3 and the pressure at the origin is 100 KPa, the pressure at the location (2m, 2m) is KPa.

Answer: 64 **1 Mark**