GATE 2023

Mechanical Engineering

Questions & Solutions

Memory Based

GATE 2023 Mechanical Engineering: Major Highlights

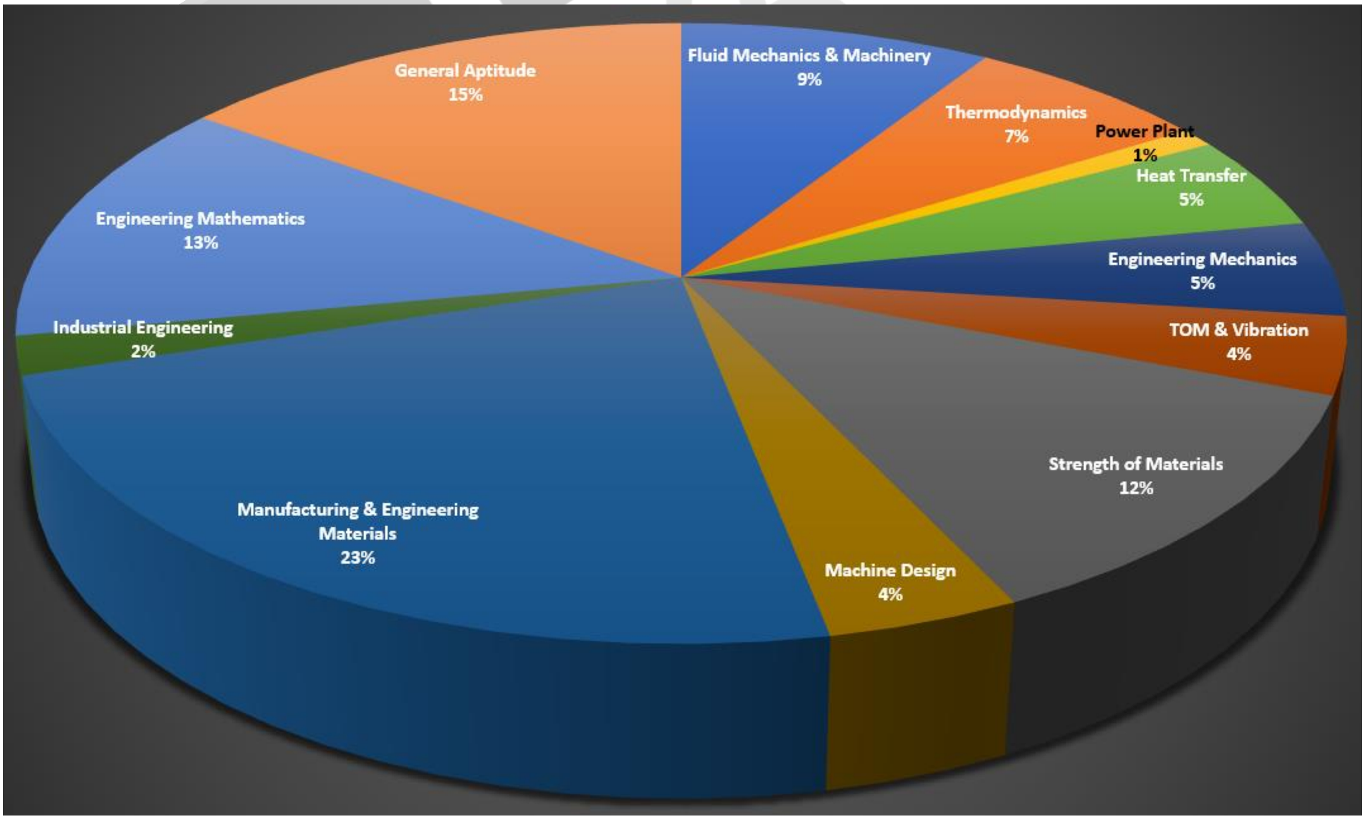
- **Overall Difficulty Level:** Moderate to tough
- **Theoretical/Numerical weightage:** Less than 10
- **MSQ weightage:** 8 Qs.
- **NAT weightage:** 25 Qs.
- **MCQ weightage:** 32 Qs.
- Questions from **General Aptitude** was easy.
- High Weightage for **Manufacturing & Engg. Materials**.

GATE 2023 Mechanical Engineering: Comparison with last 3 Years' Data

S.No.	Subjects	2023	2022	2021		2020	
				Set 1	Set 2	Set 1	Set 2
1	Fluid Mechanics & Machinery	**9**	4	6	9	8	8
2	Thermodynamics	**7**	4	6	4	4	6
3	Refrigeration & Air Conditioning	**0**	0	3	3	0	3
4	Power Plant	**1**	3	2	3	5	2
5	IC Engine	**0**	2	1	0	2	3
6	Heat Transfer	**5**	10	6	5	3	5
7	Engineering Mechanics	**5**	8	2	5	5	5
8	Theory of Machines & Vibrations	**4**	7	7	10	8	6
9	Strength of Materials	**12**	6	7	7	7	6
10	Machine Design	**4**	5	7	2	5	5
11	Manufacturing & Engineering Materials	**23**	15	18	17	18	17
12	Industrial Engineering	**2**	8	7	7	5	6
13	Engineering Mathematics	**13**	15	13	13	15	13
14	General Aptitude	**15**	15	15	15	15	15
	Total	**100**	**100**	**100**	**100**	**100**	**100**

GATE 2023 Mechanical Engineering: Subject-Wise Marks Distribution

Subjects	Questions		Total Marks
	1 Mark	2 Marks	
Fluid Mechanics & Machinery	1	4	**9**
Thermodynamics	1	3	**7**
Refrigeration & Air Conditioning	0	0	**0**
Power Plant	1	0	**1**
IC Engine	0	0	**0**
Heat Transfer	3	1	**5**
Engineering Mechanics	1	2	**5**
Theory of Machines & Vibrations	2	1	**4**
Strength of Materials	4	4	**12**
Machine Design	2	1	**4**
Manufacturing & Engineering Materials	3	10	**23**
Industrial Engineering	2	0	**2**
Engineering Mathematics	5	4	**13**
General Aptitude	5	5	**15**
Total	**30**	**35**	**100**



Section-A: General Aptitude

1. Consider the following inequalities $p^2 - 4q < 4$; $3p + 2q < 6$ where p and q are positive integers. The value of (p + q).

[MCQ, 1 Mark]

A. 1 B. 2
C. 3 D. 4

Ans. B

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

$3p + 2q < 6 \Rightarrow 6p + 4q < 12$

$4q < 12 - 6p$

$p^2 - 4 < 4q < 12 - 6p$

$p^2 + 6p - 16 < 0$

$(p + 8)(p - 2) < 0$

$-8 < p < 2$

So, p = 1

$4q < 12 - 6$

$4q < 6$

$q < 3/2$

q = 1

p + q = 2

2. 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 the subset of T?

[MCQ, 1 Mark]

A. 665 B. 664
C. 729 D. 728

Ans. A

Sol. Let $\Omega = \{1, 2, 3, 4, 5, 6\}$

(i) $T = \Omega = \{1, 2, 3, 4, 5, 6\}$

So, s can contain 1 element as 2 or 3 ...... or 6 elements.

⇒ Possible ways

$= {}^6C_1 + {}^6C_2 + \ldots . {}^6C_6 = 2^6 - 1 = 63$

(ii) T ⇒ Any 5 out of 6 ⇒ ${}^6C_5$ Loads = 6

$S \Rightarrow {}^5C_1 + {}^5C_2 + \ldots . {}^5C_5 = 2^5 - 1 = 31$

So, by this logic, Answer is

${}^6C_6\left(2^6 - 1\right) + {}^6C_5\left(2^5 - 1\right)$

$+ {}^6C_4\left(2^4 - 1\right) + {}^6C_3\left(2^3 - 1\right)$

$+ {}^6C_2\left(2^2 - 1\right) + {}^6C_1\left(2^1 - 1\right)$

= 665

3. The minute hand and second hand of a clock cross each other.............times between 09:15:00 AM and 09:45:00 AM on a day

[MCQ, 1 Mark]

A. 29 B. 30
C. 15 D. 31

Ans. B

Sol. 9 : 15 : 00 – 9 : 45 : 00

One crossing in each minute

So, total = 30

4. The symbol O, *, Δ and □ are to be filled, one in each box as shown below. The rule for filling in the four symbols are as follow.

1. Every row and every column must contain each of the four symbol

2. Every 2 × 2 square delineated by bold lines must contain each of the four symbols.

Which symbol will occupy the box marked with '?' in particle filled figure.

[MCQ, 1 Mark]

	?		Δ
	□	*	
		□	*
*		Δ	O

A. □ B. *
C. Δ D. Δ

Ans. B

Sol.

□	*	O	Δ
Δ	□	*	□
O		□	*
*		Δ	O

Hence, * will be come at ?.

5. In a recently held parent teacher meeting, the teacher had very few complaints about Ravi. After all Ravi was a hardworking and kind student.

Incidentally, almost all Ravi's friend at school were hard working and king too. But the teacher drew attention to Ravi's complete lack of interest in sports. The teacher believed that along with some of his friends who showed similar disinterest in sports. Ravi needed to engage in some sports for his overall development, which statement is logically correct.

[MCQ, 2 Mark]

A. Some of Ravi's friends are hardworking and kind

B. None of the Ravi's friends are interested in sports.

C. All of Ravi's friends are hardworking and kind

D. No one who is not a friend of Ravi is hard working and kind

Ans. C

Sol. The given statement is exactly matching with the information given in the passage.

6. Which of the following sentence sequence in the given options creates a coherent narrative?

1. I could not bring myself to knock

2. There was a murmur of unfamiliar voice coming from the big drawing room and the door was firmly shut.

3. The passage was dark for a bit but then if suddenly opened into a bright kitchen.

4. I decided I would rather wonder down the passage

[MCQ, 2 Mark]

Ans. 1-2-4-3

Sol. Sentence-3 follows sentence-4

7. Planting : Seed :: Raising : ____ (By word meaning)

[MCQ, 1 Mark]

A. Height B. Lift

C. Temperature D. Child

Ans. D

Sol. As seed is grown into a plant through planting. Similarly, a child is grown in a nature being through raising.

8. He did not manage to fix the car himself, so he .... in the garage.

[MCQ, 2 Mark]

A. got it fixed B. got fixed

C. gets fixed D. Getting it fixed

Ans. A

Sol. The given statement is past tense.

Section-B: Technical

1. Consider the 2nd order

LDE $x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} - y = 0,\ x \ge 1$

with initial condition y(x = 1) = 6 &

$\left.\frac{dy}{dx}\right|_{x=1} = 2$ y(2) = ____. (integer)

[NAT, 2 Marks]

Ans. 9 to 9

Sol. $x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} - y = 0$

$\Rightarrow$ Euler-Cauchy form

Let, $x = e^t$

$x\frac{dy}{dx} = Dy$

$x^2 \frac{d^2y}{dx^2} = D(D-1)y$

$D(D - 1)y + Dy - y = 0$

$(D^2 - 1)y = 0$

Auxiliary Equation

$m^2 - 1 = 0$

$m = \pm 1$

$y = C_1e^t + C_2e^{-t} = C_1x + \frac{C_2}{x}$

$y(1) = 6 \qquad 6 = C_1 + C_2 \qquad ...(i)$

$y' = C_1 - \frac{C_2}{x^2}$

$y'(1) = 2 = C_1 - C_2 \qquad ...(ii)$

From equation (i) and (ii)

$C_1 = 4$

$C_2 = 2$

$y = 4x + \frac{2}{x}$

$y(2) = 8 + \frac{2}{2} = 9.$

2. The value of k that makes the complex-valued function.

$f(z) = e^{-kx}\,[\cos 2y - \mathbf{i} \sin 2y]$

analytic:

[NAT, 1 Mark]

Ans. 2 to 2

Sol. $u = e^{-kx} \cos 2y$

$v = -e^{-kx} \sin 2y$

For analytic solution

$u_x = v_y$

$-ke^{-kx} \cos xy = -e^{-kx} (2\cos 2y)$

$k = 2$

3. $L^{-1}\left(\frac{1}{s^3 - s}\right)$

Sol. $F(s) = \frac{1}{s(s^2-1)} = -\left(\frac{1}{s} - \frac{s}{s^2-1}\right)$

$= \frac{s}{s^2-1} - \frac{1}{s}$

$f(t) = \cosh t - 1 = \left(\frac{e^t + e^{-t}}{2}\right) - 1$

4. A machine produces a defective component with P = 0.015. The number of defective components in packed box = 200 follow a Poisson's distribution. The mean and variance are:

[MCQ, 1 Mark]

Sol. Mean = λ = nP = 200 × 0.015 = 3

Variance = λ = 3.

5. The initial value problem

$\frac{dy}{dt} + 2y = 0, y(0) = 1$ is solve numerically using the forward Euler's method with a constant and positive time step of Δt. Let y_n represent the numerical solution obtained after n steps. The condition $|y_{n+1}| \le |y_n|$ is satisfied if and only if Δt does not exceed ____ integer).

[NAT]

Ans. 1 to 1

Sol. $\frac{dy}{dt} + 2y = 0$

$\frac{dy}{dt} = -2y = f(x, y)$

$y_{n+1} = y_n + hf(x_n, y_n)$

$y_{n+1} = y_n + h(-2y_n)$

$y_{n+1} = y_n(1 - 2h)$

$|y_{n+1}| \le |y_n|$

$|y_n(1 - 2h)| \le |y_n|$

$|-2h| \le 1$

$-1 \le 1 - 2h \le 1$

$-2 \le -2h \le 0$

$2 \ge 2h \ge 0$

$1 \ge h \ge 0$

$0 \le h \le 1$

Hence = 1

6. A linear transformation maps a point (x, y) in the plane to point (x, y) according to rule $x = 3y, y = 2x$, then the disc $x^2 + y^2 \leq 1$ gets transformed to a region with an area____.

[NAT, 1 Mark]

Ans. 17.5 to 19.5

Sol. $x = 3y$

$y = 2x$

$x^2 + y^2 \leq 1$

$$\Rightarrow \left(\frac{y}{2}\right)^2 + \left(\frac{x}{3}\right)^2 \leq 1$$

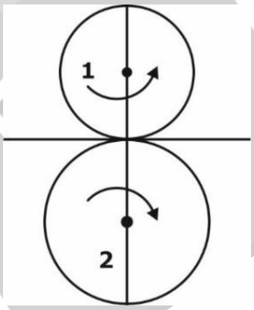
$$\frac{(x)^2}{3^2} + \frac{(y)^2}{2^2} \leq 1$$

→ Area of ellipse = πab

$= \pi(3)(2) = 6\pi$

$= 18.84$

7. Two machine spur gear 1, and 2 with diametral pitch of 8 teeth per mm and an angular velocity $\frac{\omega_2}{\omega_1} = \frac{1}{4}$ have their centres 30 mm apart. The number of teeth on driver (gear 1) is

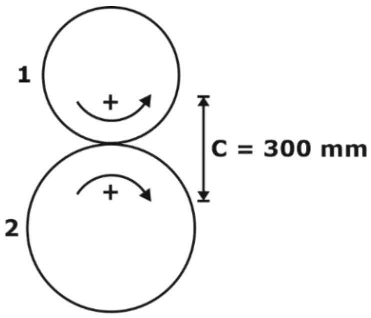


[NAT]

Ans. 96

Sol. P_d = 8 teeth/mm

$$\frac{\omega_2}{\omega_1} = \frac{1}{4}$$



$$\boxed{P_d = \frac{T}{D}}$$

$$\frac{T_1}{D_1} = \frac{T_2}{D_2}$$

$$C = \frac{D_1 + D_2}{2}$$

$60 = D_1 + D_2$

$D_1 = 12$

$D_2 = 48$

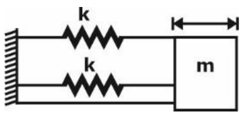
$$\frac{\omega_2}{\omega_1} = \frac{T_1}{T_2} = \frac{D_1}{D_2}$$

$$\frac{1}{4} = \frac{D_1}{D_2} \Rightarrow \boxed{D_2 = 4D_1}$$

$$\frac{T_1}{D_1} = 8$$

$T_1 = 96$

8. The figure shows a block of m = 20 kg attached to a pair of identical linear spring, each having spring constant k = 1000N/m. The clock oscillates on a frictionless horizontal surface assuming free vibration, the time taken by the block to complete 10 oscillation is $\pi = 3.14$ ______ sec.



[NAT]

Ans. 6.0 to 6.4

Sol. m = 20 kg

K = 1000 N/m

$$\omega_n = \sqrt{\frac{k_{eq}}{m}}$$

$$= \sqrt{\frac{2k}{m}}$$

$$= \sqrt{\frac{2 \times 1000}{20}} = 10 \text{ rad/s}$$

$$T = \frac{2\pi}{\omega_n}$$

$$= \frac{2\pi}{10} \text{ sec/ oscillation}$$

For 10 oscillations

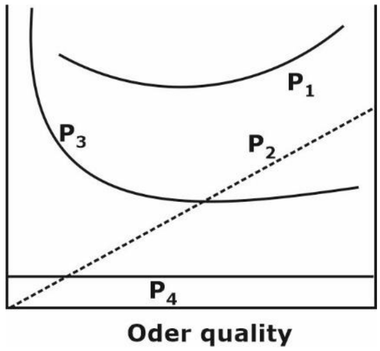
$$= 10 \times \frac{2\pi}{10} \text{ sec}$$

$= 2\pi$

$= 6.28$ sec

9. With reference to the EOQ model, which are of the options given is correct?

[MCQ, 1 Mark]



A. Curve P_1 total cost, P_2 Holding cost, P_3: setup cost, P_4: production cost

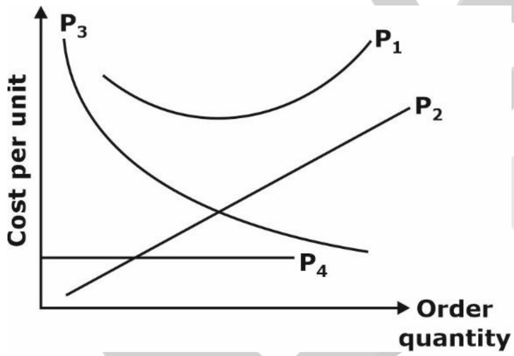
B. P_1: Production cost, P_2 Holding cost, P_3: Total cost, P_4 setup cost

C. P_1 Holding cost, P_2 setup cost, P_3 production cost, P4 total cost

D. P_1 total cost, P_2 production cost, P_3 Holding cost, P_4 setup cost.

Ans. A

Sol.



Curve P_1 = Total cost

Curve P_2 = Holding cost

$\because$ Holding $= \frac{Q}{2}C_h$

Holding $\text{cost} \propto Q$

Curve P_3 = Setup cost

$\text{Cost} = \frac{D}{Q} \times C_0$

$\boxed{\text{Setup cost} \propto \frac{1}{Q}}$

Curve P_4 = Production cost

10. Which one of the option given represent the feasible region of the linear program model:

$Z_{Max} = 45x_1 + 60x_2$

$x_1 \leq 45$

$x_2 \leq 50$

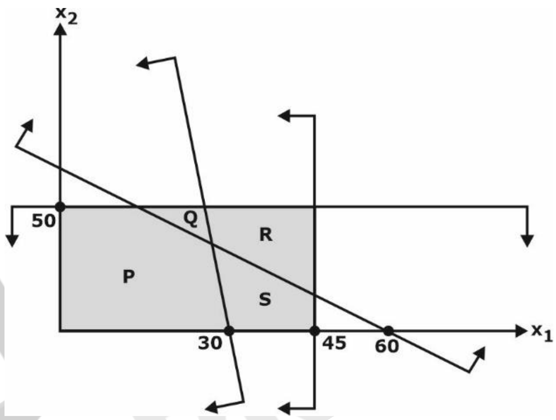
$10x_1 + 10x_2 \geq 600$

$25x_1 + 5x_2 \leq 750$

A. P   B. Q

C. R   D. S

[MCQ]



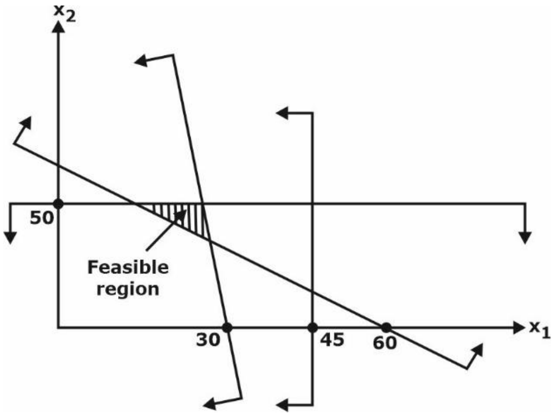
Ans. B

Sol. $x_1 \leq 45$

$x_2 \leq 50$

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

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



11. Consider incompressible laminar fluid flow of constant property Newtonian fluid in an isothermal circular tube. The flow is steady with fully developed temperature and velocity profiles. The Nusselt number for this flow depends on

A. the Prandtl number but not the Reynold number

B. the Reynold number but not the Prandtl number

C. neither the Reynold number not the Prandtl number

D. both the Reynold number and Prandtl number

[MCQ, 1 Marks]

Ans. C

Sol. For laminar flow in pipe Nusselt number remains constant which is independent of Prandtl number and Reynold number.

12. A cylinder of diameter d and height h is placed inside the cube of side L. What is view factor F_{ss}? If S denote the inner surface of cube.

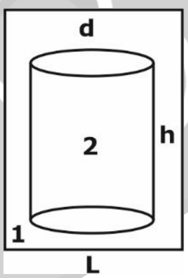
A. 0 B. 1

C. $\dfrac{\frac{\pi}{2}d^2 + \pi dh}{6L^2}$ D. $1 - \left(\dfrac{\frac{\pi}{2}d^2 + \pi dh}{6L^2}\right)$

[MCQ, 1 Marks]

Ans. D

Sol.



$F_{21} + F_{22} = 1$ (Enclosed theorem)

$\Rightarrow F_{21} = 1$

($F_{22} = 0$: Convex and flat surface)

Also $F_{11} + F_{12} = 1$ (Enclosure theorem)

$\Rightarrow F_{11} = 1 - F_{12}$

$= 1 - \dfrac{A_2F_{21}}{A_1}$ (reciprocity theorem)

$= 1 - \dfrac{A_2}{A_1}$

$= 1 - \dfrac{\left(2 \times \frac{\pi}{4}d^2 + \pi dh\right)}{6L^2}$

$= 1 - \left(\dfrac{\frac{\pi}{2}d^2 + \pi dh}{6L^2}\right)$

13. Consider a counter flow heat exchanger with inlet temperatures of two fluids as 300 K and 350 K. The heat capacity rates are 1000 W/K and 400 W/K and effectiveness as 0.5. What is actual heat transfer rate is _______ kW.

[NAT - 1 Marks]

Ans. 9.99 – 10.01

Sol. We know that,

$\in = \dfrac{q_{act}}{q_{max}}$

$\Rightarrow q_{act} = \in \times q_{max}$

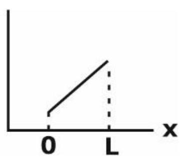
$= \in \times C_{min}(T_{h_1} - T_{C_1})$

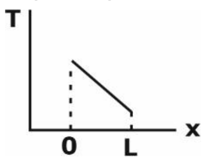
$= 0.5 \times 400(350 - 300)$ ($C_{min} = 400$ W/k)

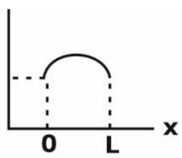
$= 10000$ W

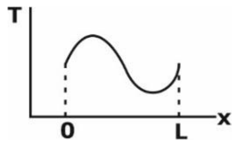
$= 10$ kW

14. The lateral surface of a rod is insulated. The thermal conductivity of material is constant. For steady heat flow and without heat generation, which of the following temperature graph is possible.

A. 

B. 

C. 

D. 

[MSQ, 2 Marks]

Ans. A, B

Sol. Temperature profile is linear for steady state conduction without heat generation.

15. A very large metal plate of thickness (d) and thermal conductivity (K) is cooled by stream of air (T = 300 K). T_p (center line temperature). In which case lumped parameter model is used to study the heat transfer in metal plate.

A. h = 100 W/m^{2}K, k = 1000 W/mK, d = 1 mm, T_p = 325 K

B. h = 100 W/m^{2}K, k = 100 W/mK, d = 1 m, T_p = 325 K

C. h = 1000 W/m^{2}K, k = 1 W/mK, d = 1 m, T_p = 350 K

D. h = 10 W/m^{2}K, k = 100 W/mK, d = 1 mm, T_p = 350 K

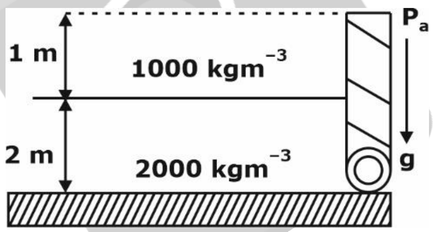
[MSQ, 2 Marks]

Ans. A, D

Sol. For lumped system analysis to be valid biot number ≤ 0.1.

16. 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 _______ kN-m/m. (Round off to decimal places).

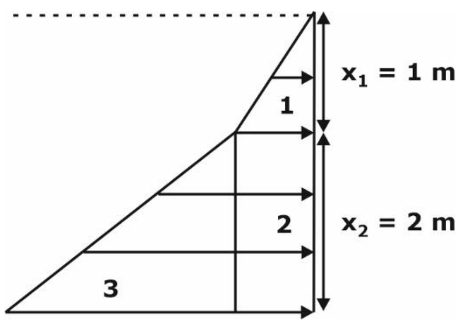
Assume acceleration due to gravity, g = 9.8 m/s^2.



[NAT, 1 Mark]

Ans. 83 – 84

Sol.



$F_H = \frac{1}{2} r_1 g x_1 \times x_1 + r_1 g x_1 \times x_2 + \frac{1}{2} r_2 g x_2 \times x_2$

$= \left(\frac{1}{2}\times 1\times 1+1\times 1\times 2+\frac{1}{2}\times 2\times 2\times 2\right)g$

$= \left(\frac{1}{2}+2+4\right)g$

F_H = 6.5g kN

For depth of C_p from free surface equate moment about free surface.

$F_H \times h_{c_p} = \left[\frac{1}{2}\times\frac{2}{3}+2\times(1+1)+4\times\left(1+\frac{2}{3}\right)\right]g$

$6.5\times h_{c_p} = \left(\frac{1}{3}+4+4\times\frac{5}{3}\right)$

$h_{c_p} = 1.69$ m

Moment about bottom

$M_B = F_H \times (3 - 1.69)$

= 6.5 × 9.81 × 1.308

M_B = 83.42 kN-m/m

17. 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 τ_w. What is wall shear stress at a location 30 mm from the leading edge is

A. $\frac{\tau_w}{\sqrt{2}}$

B. $2\tau_w$

C. $\frac{\tau_w}{2}$

D. $\sqrt{2}\tau_w$

[MCQ, 1 Mark]

Ans. A

Sol. For laminar boundary layer over a flat plate $\tau_0 \propto \frac{1}{\sqrt{x}}$

So, $\frac{\tau_{0_2}}{\tau_{0_1}} = \sqrt{\frac{x_1}{x_2}}$

$\Rightarrow \tau_{0_2} = \tau_w \times \sqrt{\frac{15}{30}}$

$\tau_{0_2} = \frac{\tau_w}{\sqrt{2}}$

18. Consider a unidirectional flow with velocity field is given by V(x, y, z, t) = $u(x,t)\hat{i}$ where, u(0, t) = 1. If spatially homogeneous density varies with time as r(t) = 1 + $0.2e^{-t}$. The value of u(2, 1) = __________ (Round off to two decimal places). Assuming all dimensionless quantities.

[NAT, 2 Marks]

Ans. 1.08 – 1.15

Sol. Continuity equation for 1D compressible flow.

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) = 0$$

$$\Rightarrow -0.2e^{-t} + (1 + 0.2e^{-t})\frac{\partial u}{\partial x} = 0$$

$$\Rightarrow \frac{\partial u}{\partial x} = \frac{0.2e^{-t}}{1+0.2e^{-t}}$$

Integrate

$$\Rightarrow u = \left(\frac{0.2e^{-t}}{1+0.2e^{-t}}\right)x + C$$

At x = 0 ⇒ u = 1 ⇒ C = 1

$$\Rightarrow u = \left(\frac{0.2e^{-t}}{1+0.2e^{-t}}\right)x + 1$$

At x = 2, t = 1

$$u = \left(\frac{0.2e^{-1}}{1+0.2e^{-1}}\right)\times 2 + 1$$

= 1.137 m/s

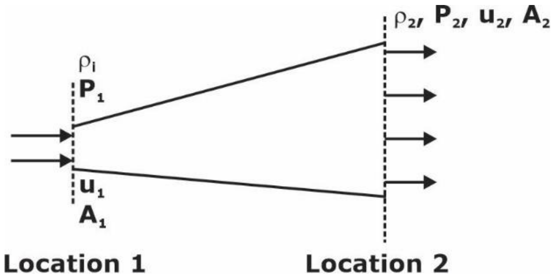
19. Consider an isentropic flow of air (ratio of specific heats = 1.4) through a duct as shown in the figure.

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

P_1 = 100 kPa, ρ = 1.2 kg/m³, u_1 = 400 m/s

The duct cross-sectional area at 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 u_2 and pressure P_2 at location 2 is TRUE?

[MCQ, 1 Mark]



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. $u_2 > u_1$, $P_2 < P_1$

Ans. A

Sol. p_1 = 100 KPa ρ_1 = 1.2

u_1 = 400 m/s

The ideal gas equation is

$P_1 = \rho_1 R T_1$

$$T_1 = \frac{100}{1.2\times 0.287} = 290.36\text{ K}$$

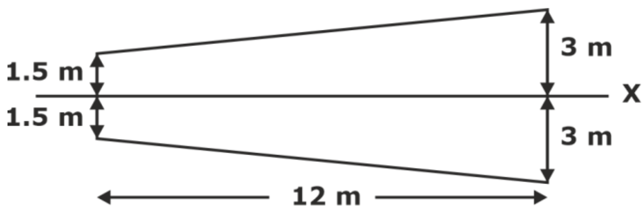
Mach number at inlet is

$$M = \frac{400}{\sqrt{1.4\times 287\times 290.36}} = 1.17$$

Mach number at the inlet of duct is greater than one so flow is supersonic. And divergent cross section area behave like a nozzle so velocity increase and pressure decreases.

20. The area moment of inertia about the Y-axis of a linearly tapered section shown in fig. is ____ m⁴.

[NAT]



Ans. 3020 to 3030

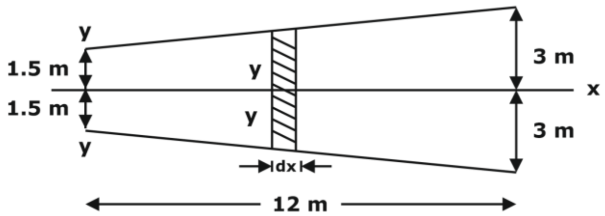
Sol. Let us consider a small strip of length dx as shown in the figure.

The area of small strip can be given as

dA = 2y.dx

area moment of inertia of small strip about y axis can be given as

$dI_y = x^2 \cdot 2y \cdot dx$



y can be given as

$$y=\left(\frac{3-1.5}{12}\right)x+1.5$$

$$\Rightarrow \frac{1.5}{12}x+1.5=\frac{x}{8}+1.5$$

So the area moment of inertia is

$$dI_y=2\left(\frac{x}{8}+1.5\right)\times x^2\cdot dx$$

$$\Rightarrow x^2\left(\frac{2x}{8}+3\right)dx=\left(\frac{x^3}{4}+3x^2\right)dx$$

Total moment of inertia about y axis is

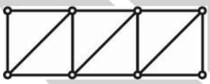
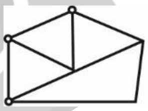
$$I_y=\int_0^{12}\left(\frac{x^3}{4}+3x^2\right)dx=\left[\frac{x^4}{16}+\frac{3x^3}{3}\right]_0^{12}$$

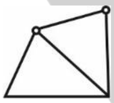
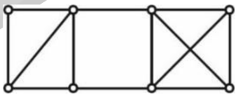
$$=\frac{12\times12\times12\times12}{16}+12\times12\times12$$

$= 1296 + 1728 \Rightarrow 3024\ m^4$

21. The options show frames consistory of rigid bar connected by pin joints. Which one of the frames is non rigid?

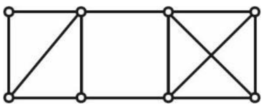
[MCQ]

A.  B. 

C.  D. 

Ans. D

Sol.



22. Which of the following not correct?

A. Any real gas behaves as an ideal gas at low pressure high temperature.

B. For real gas going through adiabatic reversible process (PV^{γ} = C (is the process equation)

C. For ideal gas h ≠ f(p)

D. Ideal gas polytropic process ($PV^{1.5}$=C)

$\frac{P}{R}=\frac{mT}{V}$ is the equation connecting P1V and T at any point along to the process.

[MCQ, 1 Mark]

Ans. B

Sol. PV^{γ} = C is valid for reversible adiabatic process of the ideal gas. so this statement is not correct and the correct answer is B.

23. 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.

[MCQ, 1 Mark]

A. Q_H = 2000 J, Q_L = 750 J, W = 1250 J

B. Q_H = 6000 J, Q_2 = 600J, W = 5500 J

C. Q_H = 2000 J, Q_L = 500J, W = 1000J

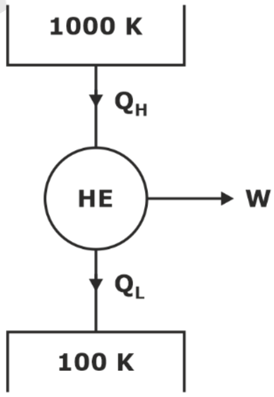
D. Q_H = 6000 J, Q_L = 500J, W = 5500 J

Ans. A

Sol. Given,

T_H = 1000 K

T_L = 100 K



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

We know that,

W = Q_H – Q_L = 2000 – 750 = 1250 J

$$(\eta_{carnot})_{HE}=1-\frac{T_L}{T_H}=1-\frac{100}{1000}=0.9 \text{ or } 90\%$$

$$(\eta)_{\text{for this option}}=\frac{W}{Q_H}=\frac{1250}{2000}=62.5\%$$

∴ This is the correct option.

B) ∵ Q_H – Q_L = 6000 – 600

= 5400 ≠ W(5500 J)

So, option B is incorrect.

C) $\because Q_H - Q_L = 2000 - 500$
$= 1500\text{ J} \neq W(1000\text{ J})$
So, option C is incorrect.
D) $Q_H - Q_L = 6000 - 500$
$= 5500\text{ J} = W(5500\text{ J})$
Now,

$$\eta = \frac{5500}{6000} = 0.9166 \text{ or } 91.67\% > (\eta)_{\text{carnot efficiency}}$$

So, option D is incorrect.

24. Two ideal gases (x, y) its weight $\bar{M}_x = \frac{10\text{kg}}{\text{k-mol}}$, $\bar{M}_y = \frac{20\text{kg}}{\text{k-mol}}$

Total pressure in the chamber P_T = 10 kPa, $V_T = 10\text{ m}^3$, Temperature of contents of the container 300K, Mass of X is 2 kg, find the mass of y in kg

Take $\bar{R} = \frac{8314\text{ J}}{\text{k-mol.K}}$

[NAT, 2 Marks]

Ans. 3.95 to 4.1

Sol. Given data,

$\bar{M}_x = 10\text{ kg/k-mol}$

$\bar{M}_y = 20\text{ kg/k-mol}$

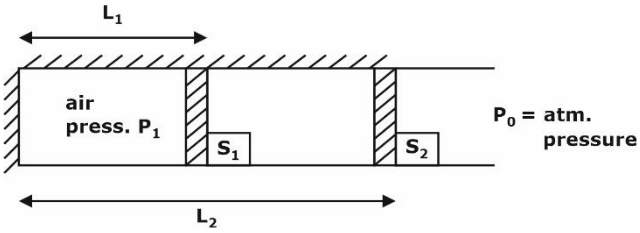
P = 100 kPa
$V = 10\text{ m}^3$
T = 300 K
$m_x = 2$ kg
$m_y = ?$
Ideal gas equation for the gas mixture can be given as
PV = mRT
$PV = n\bar{R}T$
By substituting the value of total number of moles we get ideal gas equation

$$100 \times 10 = \left(\frac{m_x}{M_x} + \frac{m_y}{M_y}\right) 8.314 \times 300$$

$$1000 = \left(\frac{2}{10} + \frac{m_y}{20}\right) 8.314 \times 300$$

$m_y = 4.02$ kg

25. $P_1 \gg P_0$, $P_2 \gg P_0$, P_2 is pressure at location 2.



Area of distance = A
Find the W.D. by piston on the atm. _____.

A. $P_1AL_1 \ln\left(\frac{L_1}{L_2}\right)$ B. $\frac{(P_2L_2 - P_1L_1)A}{(1-y)}$

C. $P_0 A(L_2 - L_1)$ D. 0

[MCQ, 2 Marks]

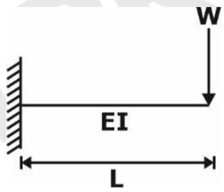
Ans. C

Sol. The work done by the gas can be given as

$$W_{1-2} = \int p_{ex}.dv = P_o \int_1^2 dv = P_o (V_2 - V_1)$$

$$W_{1-2} = P_o (AL_2 - AL_1) = P_o A (L_2 - L_1)$$

26. Find stiffness



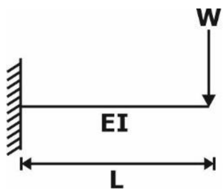
[MCQ, 1 Mark]

A. $\frac{EI}{3L^3}$ B. $\frac{3EI}{L^3}$

C. $\frac{L^3}{3EI}$ D. $\frac{3L^3}{EI}$

Ans. B

Sol. Given a cantilever beam with point load W at free and deflection at free end,



$\delta = \frac{WL^3}{3EI}$

We know, $k\delta = W$

$k \times \frac{WL^3}{3EI} = W$

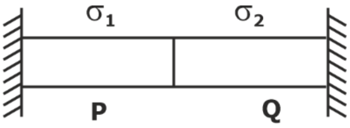
$k = \frac{3EI}{L^3}$

27. $L_P = L_Q$

$R_P = R_Q$

$\alpha_Q = 2\alpha_P$

$E_Q = 2E_P$



A. $\sigma_1 = \sigma_2$

B. $\sigma_1 < \sigma_2$

C. Interface between P & Q moves right.

D. Interface between P & Q moves left.

[MSQ, 2 Marks]

Ans. A, D

Sol. Given,

$L_P = L_Q$

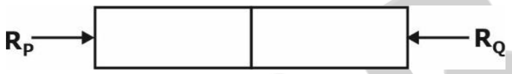
$A_P = A_Q$

$\alpha_Q = 2\alpha_P$

$E_Q = 2E_P$

For equilibrium

$R_P = R_Q = R$



$\sigma_1 = \frac{R}{A}$ and $\sigma_2 = \frac{R}{A}$

Hence, $\sigma_1 = \sigma_2$

$\Delta L_P = L(\alpha)\Delta T - \frac{RL}{AE}$

$\Delta L_Q = L(2\alpha)\Delta T - \frac{RL}{2AE}$

From above two values

$\Delta L_Q > \Delta L_P$

Hence, interface between P and Q moves left.

28. The principal stress at a point P in a solid are 70 MPa, −70 MPa, o, The s_y of material is 100 MPa. Which prediction about material failure at P is/are correct

A. Maximum normal stress theory predicts that material does not fail.

B. MSST predicts material does not fail.

C. Maximum normal stress theory predicts material fail.

D. MSST predicts material fail.

[MSQ, 1 Mark]

Ans. A, D

Sol. Given principal stresses.

$\sigma_1 = 70$ MPa

$\sigma_2 = -70$ MPa

$\sigma_3 = 0$

Yield stress $\sigma_y = 100$ MPa

According to maximum shear stress theory

$$\left|\frac{\sigma_1 - \sigma_2}{2}\right| \le \frac{\sigma_y}{2}$$

$$\left|\frac{70 + 70}{2}\right| \le \frac{100}{2}$$

$70 \le 50$

Hence material fails.

According maximum normal stress

$\sigma_1 \le \sigma_y$

$70 \le 100$

Hence material does not fail.

29. Consider the stress & shear relationship is

$\sigma = 400\ \varepsilon^{0.3}$ MPa

σ = True stress

ε = True strain

Find Engineering Ultimate tensile strength value of this material in MPa.

[NAT, 2 Marks]

Ans. 277.8 to 278.5

Sol. $\sigma_T = 400 \epsilon_T^n$

As we know that

$\sigma_T = \sigma_E (1 + \epsilon_E)$

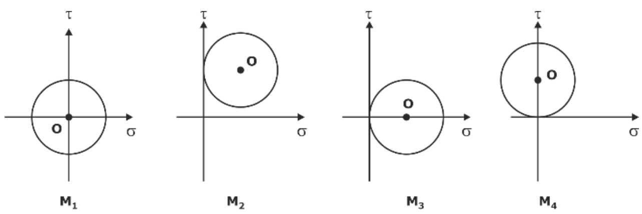
$\epsilon_T = \ln(1 + \epsilon_E)$

And for UTS = engineering ultimate stress

$\boxed{\epsilon = n}$

$\sigma_{ult} = 206.38$ MPa

30. Representation of a plane stress state in a material



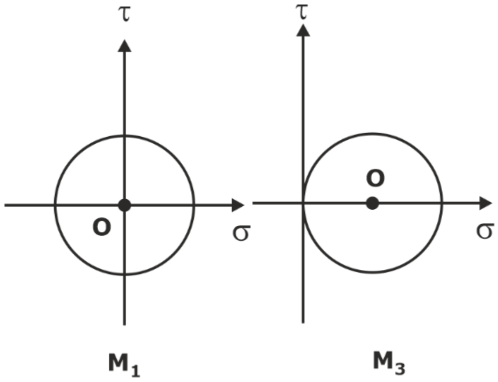
A. M_1 B. M_2

C. M_3 D. M_4

[MSQ, 1 Mark]

Ans. A, C

Sol. Centre of Mohr's circle always lies on σ-axis. Hence M_1 and M_3 is correct representation of a plane stress state.



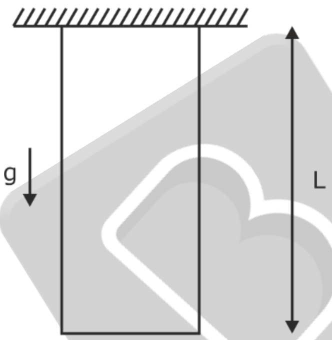
31. L = 5 m

A = 10 m^2

E = 70 GPa

ρ = 2700 kg/m^3

Elastic strain energy due to self-weight



[NAT, 2 Mark]

Ans. 2.083 J

Sol. Given,

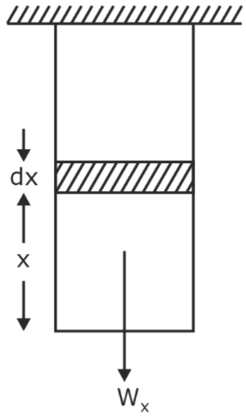
L = 5 m

A = 10 m^2

E = 70 GPa

ρ = 2700 kg/m^3

Consider a strip dx at a distance x form the bottom



Total load W = ρgAL

Strain energy

$$U = \int_0^L \frac{(W_x)^2\,dx}{2AE}$$

$$U = \int_0^L \frac{(\rho gAx)^2\,dx}{2AE}$$

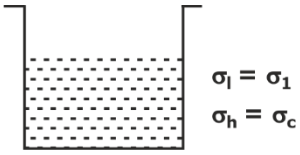
$$U = \frac{(\rho g)^2 A}{2E}\left[\frac{x^3}{3}\right]_0^L = \frac{(\rho g)^2 A}{2E}\left(\frac{L^3}{3}\right)$$

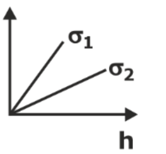
$$U = \frac{(2700\times 9.8)^2\times 10}{2\times 70\times 10^9}\times\left(\frac{5^3}{3}\right)$$

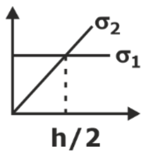
U = 2.083 J

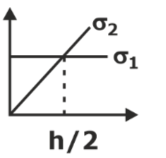
32. Which of the following represent the correct relation

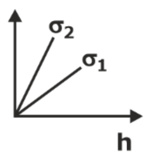
$\sigma_1 = \sigma_2$



A. 

B. 

C. 

D. 

[MCQ, 2 Marks]

Ans. C

Sol. As we all know that

$$\sigma_L = \frac{p_{max}\cdot r}{2t} \qquad p_{max} = \rho gh$$

$$(\sigma_h)_{x-x} = \frac{p_{x-x} r}{t} = \frac{\rho gx\cdot r}{t}$$

When n = h/2

$$\boxed{(\sigma_h) = \frac{\rho ghr}{t}}$$

So, C is correct

33. In a metal casting process to manufacture parts, both patterns & mould provide shape by dictating where the material should or should not go. Which of the option given correctly describe mould and pattern?

A. Pattern walls indicates boundaries within which the molten part material is allowed, while mould walls indicate boundaries of region where mould material is not allowed.

B. Mould wall indicates boundaries within which the molten part material is allowed while pattern wall indicate boundaries where mould material is not allowed.

C. Mould can be used to make pattern.

D. Pattern can be used to make mould.

[MSQ, 2 Marks]

Ans. B, D

Sol. Mould wall indicates boundaries within which the molten part material is allowed while pattern wall indicate boundaries where mould material is not allowed.
Pattern can be used to make mould.

34. To surfaces P & Q are to joined together. Which of given operation, there is no melting of two surfaces P & Q for creating joint?

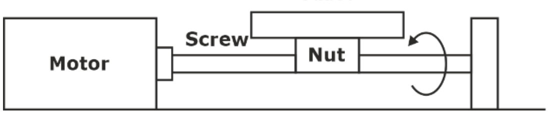
A. Brazing B. Adhesive bonding
C. Spot welding D. Arc welding

[MSQ, 1 Mark]

Ans. A, B

Sol. Brazing, Adhesive bonding

35. The motor moves in discrete rotational steps of 50 steps per revolution. The pitch of lead screw is 5 mm and total horizontal transverse length of table is 100 mm what is total number of controllable locations at which the table can be positioned?



A. 1000 B. 5000
C. 2 D. 100

[MCQ, 2 Marks]

Ans. A

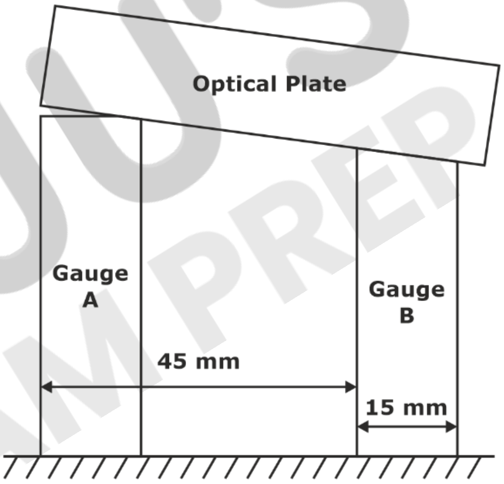
Sol. Number of steps per revolution, n_s = 50
Pitch = 5 mm

$$BLU = \frac{5}{50} = \frac{1}{10} mm$$

Length of the table = 100 mm
Number of controllable positions

$$= \frac{100}{BLU} = \frac{100}{(1/10)} = 1000$$

36. Consider
λ = 0.5 μm
n = 12 fringes
Find the height difference of gauge in mm ________



[NAT, 2 Marks]

Ans. 0.0078 to 0.0095

Sol. λ = 0.5 μm
G = 45 mm

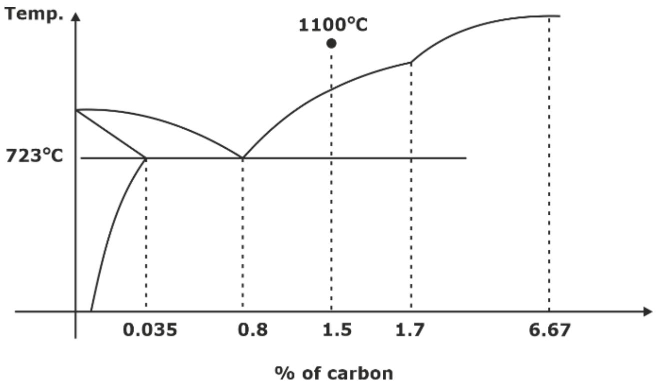
$$\Delta h = \left(\frac{n\lambda}{2}\right)\left(\frac{G}{L}\right)$$

$$= \left(\frac{12 \times 0.5 \times 10^{-3}}{2}\right)\left(\frac{45}{15}\right)$$

= 0.009

37. Find the ratio of

$$\frac{\text{Proeutectoid Cementite}}{\text{Total Cementite}} = ?$$



[NAT, 2 Marks]

Ans. 0.48 to 0.57

Sol. $m_{pro-Fe_3C} = \frac{1.5-0.8}{6.67-0.8} = 0.1192$

$m_{total-Fe_3C} = \frac{1.5-0.02}{6.67-0.02} = 0.2225$

$\therefore \frac{m_{pro-Fe_3C}}{m_{total-Fe_3C}} = \frac{0.1192}{0.2225} = 0.53$

38. Atomic radius of FCC $= \frac{\sqrt{2}}{10}$ mm

Atomic weight = 24.092 g/mol

Avogadro Number (A.N) = 6.023×10^{23} atm/mol

Find the density of material = ________ kg/m^3

[NAT, 2 Marks]

Ans. 2499 to 2501

Sol. Given,

Atomic radius of FCC material, $r = \frac{\sqrt{2}}{10}$ nm

Atomic weight (W) = 24.092 g/mole

Avogadro number (N)

= 6.023×10^{23} atoms/mole

Find density = ?

We know, $\rho = \frac{N_{avg} \times \text{Atomic weight}}{6.023 \times 10^{23} \times (a)^3}$

For FCC, $a = 2\sqrt{2}\,r$ & $N_{avg} = 4$

$$\therefore \rho = \frac{4 \times 24.092 \times 10^{-3}}{6.023 \times 10^{23} \times \left(2\sqrt{2} \times \frac{\sqrt{2}}{10} \times 10^{-9}\right)^3}$$

= 2500 kg/m^3

39. Find strain rate (s^{-1}) if shear angle 45° and rake angle is 5°, mean thickness is 5 micrometer if cutting velocity = 1 m/sec

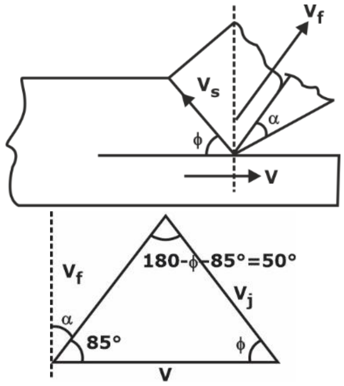
A. 1.84×10^{-4} B. 1.54×10^{-4}

C. 2.6×10^{5} D. 6.2×10^{4}

[MCQ, 2 Marks]

Ans. C

Sol.



$\frac{V_s}{\sin 85°} = \frac{V_C}{\sin 50°}$

$V_s = 1.3$ m/sec

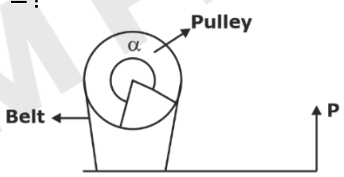
Strain rate $= \frac{V_s}{t_s}$

$= \frac{1.3}{5 \times 10^{-6}}$

$= 2.6 \times 10^{5}\ \text{sec}^{-1}$

40. Find the value of μ = 0.3, α = 270°

T_1/T_2 =?



[NAT - 1 Mark]

Ans. 3.95 - 4.3

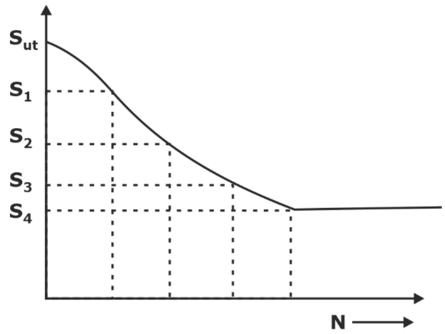
Sol. Given,

m = 0.3

$\theta = 270° = 270 \times \frac{\pi}{100} = \frac{3\pi}{2}$

$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.3 \times 3\pi/2} = 4.11$

41. Which of the following represents the correct endurance limit?



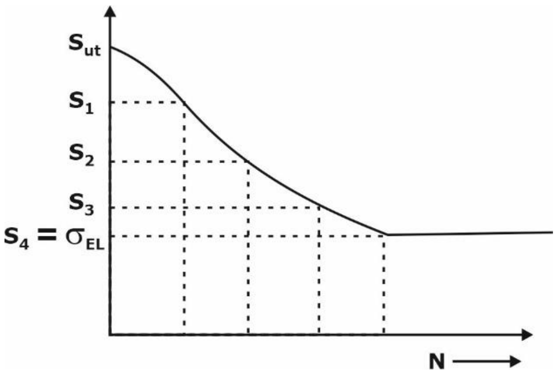
A. S_1 B. S_2

C. S_3 D. S_4

[MCQ, 1 Mark]

Ans. D

Sol. Correct endurance limit is S_4.



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GATE 2023 Mechanical Engineering: Expected Topper's Marks

- **80+/100 Marks Expected for AIR under 10**
- **75+/100 Marks Expected for AIR under 100**

GATE 2023 Mechanical Engineering: Expected Cut-Off

Category	2021	2022	Expected 2023
General	33	28.1	31
OBC	29.7	25.2	29
SC/ST	22	18.7	23

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Rank 02
Poojasree (EC)


Rank 03
Manoj (EC)


Rank 03
Munish (ME)


Rank 06
Parag (EC)


Rank 07
Vatsal (ME)


Rank 08
Rahul (CE)


Rank 08
Hemant (EE)


Rank 08
Rajat (ME)


Rank 09
Vamsi (EC)


Rank 13
Shashwat (CE)

50+ Students under AIR-100 — 2020


Rank 06
Ghanendra (EC)


Rank 09
Avinash (ME)


Rank 09
Himanshu (EE)


Rank 26
Kartikay (CE)


Rank 30
Raja (EC)


Rank 39
Akash Singh (CS)


Rank 39
Navneet (CS)


Rank 54
Rishi (EE)


Rank 56
Apurv Mittal (ME)


Rank 56
Nikhil (ME)

Our Success Stories

Our Outstanding GATE Results

80+

Students under AIR-100

2022

Rank 01
Ram (EC)

Rank 02
Amit (CE)

Rank 02
Vandit (EE)

Rank 03
Parvinder (ME)

Rank 06
Abhishek (ME)

Rank 06
Vivek (CE)

Rank 08
Kiran (CS)

Rank 09
Shivam (EC)

Rank 09
Tushar (EE)

Rank 10
Mitesh (CS)

Rank 11
Kaustav (ME)

Rank 11
Souvik (ME)

Rank 12
Himanshu (CE)

Rank 15
Surya (CS)

Rank 18
Swastik (CE)

Rank 20
Lakshay (ME)

Rank 21
Tathagata (CS)

Rank 22
Ayush (CE)

Rank 29
Piyush (EE)

Rank 38
Rajat (EE)