GATE 2018

Set-2

Mechanical Engineering

Questions & Solutions

SECTION: GENERAL APTITUDE

1. A rectangle becomes a square when its length and breadth are reduced by 10 m and 5 m, respectively. During this process, the rectangle loses $650\ m^2$. What is the area of the original rectangle in square meters?

A. 1125 B. 2250

C 2924 D. 4500

Ans. B

Sol. Let 'a' be the side of square, then length and breadth of rectangle are 'a+10 and 'a+5' respectively.

Given that,

Area of rectangle= Area of Square+650

$$(a+10)(a+5) = a^2 + 650$$

$$a^2 + 15a + 50 = a^2 + 650$$

$$15a = 600$$

$$a = 40$$

Area of rectangle=$a^2 + 650$

Area of rectangle=1600+650=2250

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2. A number consists of two digits. The sum of the digits is 9. If 45 is subtracted from the number. Its digits are interchanged. What is the number?

A. 63 B. 72

C. 81 D. 90

Ans. B

Sol. Let one's digit is y and ten's digit is x

Hence the number becomes '10x +y' and the reverse number will be '10y+x'

$$x + y = 9 \quad \ldots(i)$$

$$10x + y - 10y - x = 45$$

$$x - y = 5 \quad \ldots.(ii)$$

Adding (i) and (ii)

x = 7

Subtracting (i) and (ii)

y = 2

Therefore the number is 72.

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3. Seven machines take 7 minutes to make 7 identical toys. At the same rate, how many minutes would it take for 100 machines to make 100 toys?

A. 1 B. 7

C. 100 D. 700

Ans. B

Sol. Time taken by a machine to make a toy will be independent of how many machines are making toys in parallel.

From given data, it takes 7 minutes for a machine to make a toy. If hundred such machines are running parallel to make a toy each, the time will remain same 7 minutes.

7 machine → 7 toys → 7 minutes

1 machine → 1 toy → 7 minutes

Because one machine takes 7 minute for making 1 toy.

So, 100 machines will take 7 minute for making 100 toys.

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4. "Her _______ should not be confused with miserliness, she is ever willing to assist those in need."

The word that best fills the bank in the above sentence is :

A. Cleanliness

B. punctuality

C. frugality

D. greatness

Ans. C

Sol. The statement suggests that some weak condition of the person is depicted. And this weak condition should not be taken as being miser.

Miser: A person reluctant to spend.

Frugal: A person who is economically weak.

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5. Going by the __________ that many hands make light work, the school __________ involved all the students in the task.”

A. principle, principal

B. principal, principle

C. principle, principle

D. principal, principal

Ans. A

Sol. Principle – Truth/Proposition serving as foundation of person’s belief.

Principal – The most important person in an organization. Here it refers to school Principal

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6. Given that a and b are integers and $a + a^2b^3$ is odd, which one of the following statements is correct?

A. a and b are both odd

B. a and b are both even

C. a is even and b is odd

D. a is odd and b is even

Ans. D

Sol. Given: a and b are integers

$a + a^2b^3$ is odd

Taking a common

$a\left(1 + ab^3\right)$ is odd

Odd number is obtained after multiplication if both numbers multiplied are odd.

Hence, a is odd and $1 + ab^3$ is also odd.

$1 + ab^3$ is odd, so ab^3 will be even. (odd-1= even quantity)

Because a is odd so for ab^3 to be even b must be even.

So, a is odd and b is even.

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7. Consider the following three statements:

1. Some roses are red

2. All red flowers fade quickly.

3. Some roses fade quickly.

Which of the following statements can be logically inferred from the above statements?

A. If (i) is true and (ii) is false, then (iii) is false.

B. If (i) is true and (ii) is false, then (iii) is true.

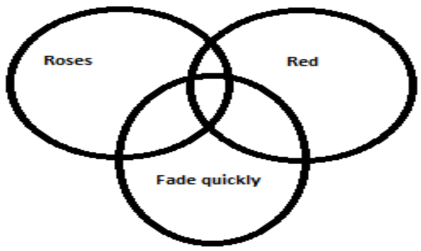
C. If (i) and (ii) are true, then (iii) is true.

D. If (i) and (ii) are false, then (iii) is false.

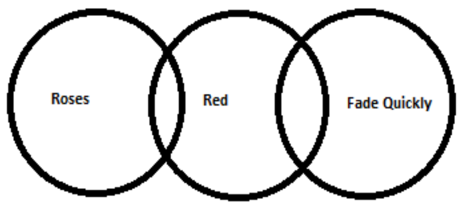
Ans. C

Sol. Solving by options

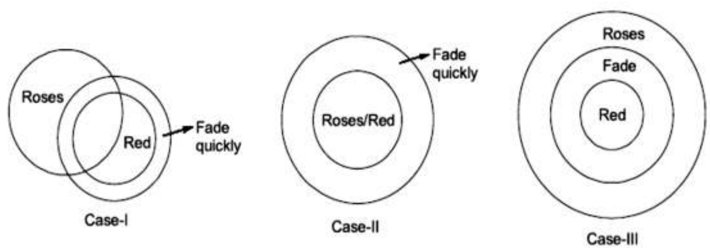
Option A: Even if statement 2[nd] is false, i.e. All red flowers do not fade quickly, that does not mean that some roses won’t fade quickly.



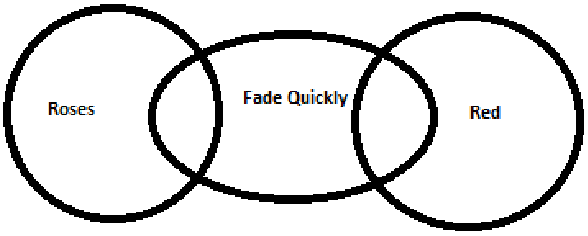
Option B: There can be a possibility that no rose fade quickly



Option C: This is true in all possibilities.



Option D: There can be a possibility that some roses do fade quickly.



Hence option C is the only correct option.

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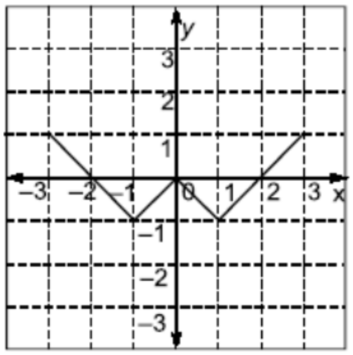
8. Which of the following functions describe the graph shows in the below figure.



A. $y = ||x|+1|-2$ B. $y = ||x|-1|-1$

C. $y = ||x|+1|-1$ D. $y = ||x-1|-1|$

Ans. B

Sol.

x	0	± 1	± 2
y	0	-1	0

	X=2	X=1	X=-1	X=-2
$y = ||x|+1|-2$	1(option fails)			
$y = ||x|-1|-1$	0	-1	-1	0
$y = ||x|+1|-1$	2(option fails)			
$y = ||x-1|-1|$	0	1(option fails)		

Hence only B option prevails.

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9. For integers a, b and c, what would be the minimum and maximum values respectively of $a+b+c$ if $\log|a|+\log|b|+\log|c|=0$

A. -3 and 3

B. -1 and 1

C. -1 and 3

D. 1 and 3

Ans. A

Sol. $\log|a|+\log|b|+\log|c|=0$

It is possible only,

If $|a|,|b|$ and $|c|$ all are equal to 1.

So, a, b, c may be respectively

'+1' or '-1'.

For minimum value all three will be negative.

So, minimum value = - 3

For maximum value all three will be positive.

So, maximum value = + 3.

Search Tag- GATE18

10. From the time the front of a train enters a platform, it takes 25 seconds for the back of the train to leave the platform, while travelling at a constant speed of 54 km/h. At the same speed, it takes 14 seconds to pass a man running at 9 km/h in the same direction as the train. What is the length of the train and that of the platform in meter, respectively?

A. 210 and 140 B. 162.5 and 187.5

C. 245 and 130 D. 175 and 200

Ans. D

Sol. Train speed = 54 km/h

Time = 25 sec for travelling length of train and length of platform

Man speed = 9 km/h

Relative speed of train with respect to man = 45 km/h

Time = 14 sec

So, length of train $= \text{time} \times \text{speed}$

$$= 14 \times 45 \times \frac{5}{18}$$

Length of train $= 35 \times 5 \text{ m} = 175 \text{ m}$

Length of platform + length of train

$= \text{speed} \times \text{time}$

$$= 54 \times \frac{5}{18} \times 25 = 15 \times 25 = 375 \text{ m}$$

Length of platform = 375−175=200 m

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MECHANICAL ENGINEERING

1. For a two-dimensional incompressible flow field given by $\vec{u} = A\left(x\hat{i} - y\hat{j}\right)$, where $A > 0$, which one of the following statements is FALSE?

A. It satisfies continuity equation

B. It is unidirectional when $x \to 0$ and $y \to \infty$.

C. Its streamlines are given by $x = y$.

D. It is irrotational

Ans. C

Sol. This has to be solved through options

Continuity equation for 2D incompressible flow

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial (Ax)}{\partial x} + \frac{\partial (-Ay)}{\partial y} = 0$$

$A - A = 0$

It satisfies continuity equation.

$\Rightarrow$ As $\vec{V} = Ax\,\hat{i} - Ay\,\hat{j}$

As $y \to \infty$ velocity vector field will not be defined along y axis.

So flow will be along x-axis i.e. 1-D flow.

$\Rightarrow$ Stream line equation for 2D

$$\frac{dx}{u} = \frac{dy}{v}$$

$$\frac{dx}{Ax} = \frac{dy}{-Ay}$$

$$\text{In}\, x = -\text{In}\, y + \text{In}\, c$$

$$\text{In}\, xy = \text{In}\, c$$

$xy = c \to$ streamline equation

Search Tag- GATE19

2. An ideal gas undergoes a process from state 1 $(T_1 = 300\text{ K}, p_1 = 100\text{ kPa})$ to state 2 $(T_2 = 600\text{ K}, p_2 = 500\text{ kPa})$. The specific heats of the ideal gas are: $c_p = 1$ kJ/kg-K and $C_v = 0.7$ kJ/kg-K. The change in specific entropy of the ideal gas from state 1 to state 2 (in kJ/kg-K) is ________ (correct to two decimal places)

Ans. (0.21)

Sol. Ideal gas

State 1 : $T_1 = 300$ K, $P_1 = 100$ kPa

State 2 : $T_2 = 600$ K, $P_2 = 500$ kPa

$c_p = 1$ kJ/kg-K, $c_p - c_v = R$, $c_v = 0.7$ kJ/kg-K

$\Rightarrow$ $c_p - c_v = 1 - 0.7 = R$

$R = 0.3$ kJ/kg-K

Change in specific entropy

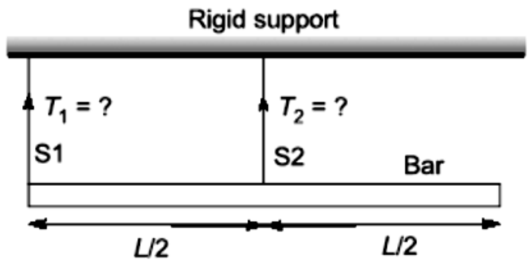
$$s_2 - s_1 = c_p \,\text{In}\frac{T_2}{T_1} - R\,\text{In}\frac{P_2}{P_1}$$

$$= 1 \times \text{In}\frac{600}{300} - 0.3\,\text{In}\frac{500}{100}$$

$$= 0.21 \text{ kJ/kg-K}$$

Search Tag- GATE18

3. A bar of uniform cross section and weighing 100 N is held horizontally using two massless and inextensible strings S_1 and S_2 as shows in the figure.



Tension in the springs are

A. $T_1 = 100$ N and $T_2 = 0$ N

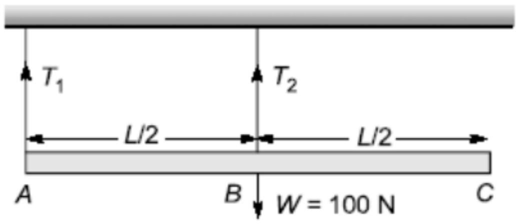
B. $T_1 = 0$ N and $T_2 = 100$ N

C. $T_1 = 75$ N and $T_2 = 25$ N

D. $T_1 = 25$ N and $T_2 = 75$ N

Ans. B

Sol.



$$T_1 + T_2 = 100 \text{ N} \quad ...(i)$$
$$\Sigma M_A = 0$$
$$T_2 \cdot \frac{L}{2} = 100 \times \frac{L}{2}$$
$$\therefore T_2 = 100 \text{ N}$$
$$T_1 = 0 \text{ N}$$

Comments: This can also be inferred from fact that if T_1 is finite then the bar will not remain horizontal.

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4. For a Pelton wheel with a given water jet velocity, the maximum output power from the Pelton wheel is obtained when the ratio of the bucket speed to the water jet speed is ________ (correct to two decimal places).

Ans. (0.50)

Sol. In Pelton wheel turbine for maximum efficiency,

$$\eta_{max} = \frac{u}{v_1} = \frac{1}{2} = 0.50$$

Search Tag- GATE18

5. A six- faced fair dice is rolled five times. The probability (in%)of obtaining "ONE" at least four times is

A. 33.3

B. 3.33

C. 0.33

D. 0.0033

Ans. C

Sol. A dice is rolled 5 times

$n = 5$

$P = (\text{Probability of getting } 1) = \frac{1}{6}$

$q = 1 - \frac{1}{6} = \frac{5}{6}$

Probability of getting 1 'at least' 4 times will include probability of getting 1- "4 times+5times"

The probability distribution is binomial distribution.

$$P(x \geq 4) = P(x = 4) + P(x = 5)$$
$$= {}^nC_4 p^4 q^{n-4} + {}^nC_5 p^5 q^{n-5}$$
$$= {}^5C_4 p^4 q^1 + {}^5C_5 p^5 q^0$$
$$= 5 \times \left(\frac{1}{6}\right)^4 \left(\frac{5}{6}\right)^1 + 1 \times \left(\frac{1}{6}\right)^5 \times \left(\frac{5}{6}\right)^0$$
$$= \frac{25}{(6)^5} + \frac{1}{(6)^5} = \frac{26}{(6)^5} = 0.0033$$

% probability = 0.33%

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6. Using the Taylors tool life equation with exponent $n = 0.5$, if the cutting speed is reduced by 50% the ratio of new tool life to original tool life is

A. 4 B. 2

C. 1 D. 0.5

Ans. A

Sol. Taylor's Tool life equation is VT^n=Constant

Let subscript 1 represent the initial conditions and subscript 2 represent the final conditions.

$$V_2 = \frac{V_1}{2}$$
$$V_1 T_1^{0.5} = V_2 T_2^{0.5}$$
$$V_1 T_1^{0.5} = \frac{V_1}{2} . T_2^{0.5}$$
$$\left(\frac{T_2}{T_1}\right)^{0.5} = 2$$
$$\frac{T_2}{T_1} = 2^{\frac{1}{0.5}} = 4$$

Search Tag- GATE18

7. A grinding ratio of 200 implies that the

A. grinding wheel wears 200 times the volume of the material removed.

B. grinding wheel wears 0.005 times the volume of the material removed.

C. aspect ratio of abrasive particles used in the grinding wheel is 200

D. ratio of volume of abrasive particle to that of grinding wheel is 200

Ans. B

Sol. Grinding ratio is defined as ratio of Volume of work material removed to the ratio of wheel material removed.

$$= \frac{\text{Volume of work material removed}(V_m)}{\text{Volume of wheel wear}(V_w)}$$

$$200 = \frac{\text{Volume of work material removed}(V_m)}{\text{Volume of wheel wear}(V_w)}$$

Grinding wheel wears 1/200 (= 0.005) times the volume of material removed.

Search Tag- GATE18

8. The number of atoms per unit cell and the number of slip systems, respectively, for a face-centered cubic (FCC) crystal are

A. 3, 3   B. 3, 12

C. 4, 12   D. 4, 48

Ans. C

Sol.

Unit cell	N	CN	a/R	APF	Number of Slip Systems
Simple cubic	1	6	2	0.52	
Body centered cubic	2	8	$\frac{4}{\sqrt{3}}$	0.68	48
Face centered cubic	4	12	$\frac{4}{\sqrt{2}}$	0.74	12
Hexagonal close packed	6	12	a/R=2 c/a=1.633	0.74	3

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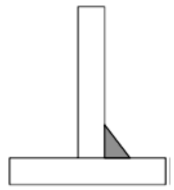
9. The type of weld represented by the shaded region in the figure is

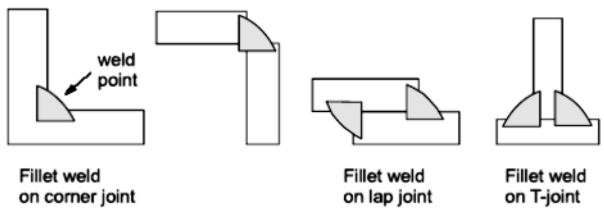


A. groove   B. spot

C. fillet   D. plug

Ans. C

The figure represents fillet weld on T joint.



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10. The height (in mm) for a 125 mm sine bar to measure a taper of 27°32′ on a flat work piece is ___________ (correct to three decimal places).

Ans. (57.782)

Sol. $\theta = 27°32'$

$$= 27 + \left(\frac{32}{60}\right)^{\circ} = 27.533^{\circ}$$

In sine bar, $\sin\theta = \frac{H}{L}$

Where H= height of specimen and L= Length of Sine bar (length between center of two rollers)

$$\therefore \quad \sin 27.533^{\circ} = \frac{H}{125}$$

$$H = 57.782427$$

$$H \approx 57.782 \text{ mm}$$

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11. Interpolator in a CNC machine

A. controls spindle speed

B. coordinates axes movements

C. operates tool changer

D. commands canned cycle

Ans. B

Sol. As interpolator provides two functions:

1. It computes individual axis velocities to drive the tool along the programmed path at given feed rate.

2. It generates intermediate coordinate positions along the programmed path.

Search Tag- GATE18

12. If the wire diameter of a compressive helical spring is increased by 2% the change in spring stiffness (in %) is __________ (correct to two decimal places)

Ans. (8.242)

Sol. Stiffness of helical spring

$K = \frac{Gd^4}{8D^3 n}$

Where, d=Spring Wire diameter

D= Mean Coil diameter

n= Number of coils

G= Shear Modulus

d increased by 2% i.e. $d' = 1.02d$

$$\frac{k'}{k} = \left(\frac{d'}{d}\right)^4$$

$$\frac{k'}{k} = \left.\frac{1.02d}{d}\right)^4 = 1.02^4 = 1.08242$$

Percentage change in spring Stiffness=

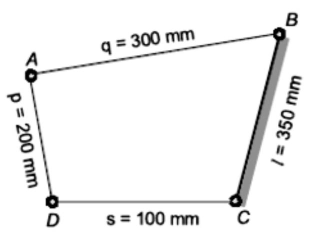
$\frac{k'-k}{k} \times 100$=8.242%

Search Tag- GATE18

13. A four bar mechanism is made up of links of length 100,200,300 and 350 mm. if the 350 mm link is fixed, the number of links that can rotate fully is _________

Ans. (1)

Sol.



$s = 100,\ p = 200, l = 350,\ q = 300$

$$(s + l) = 350 + 100 = 450 < (p + q)$$

$$450 < 200 + 300$$

$$450 < 500$$

Grashoff's law is satisfied.

350 mm link is fixed, i.e. adjacent to shortest link is fixed.

The mechanism obtained will be crank rocker mechanism, it means only one link (crank) will fully rotate.

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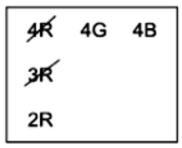
14. Four red balls, four green balls and four blue balls are put in a box. Three balls are pulled out of the box at random one after another without replacement. The probability that all the three balls are red is

A. 1/72 B. 1/55

C. 1/36 D. 1/27

Ans. B

Sol. Probability that all the three balls are red is



P=R.R.R

$$P = \frac{4}{12} \times \frac{3}{11} \times \frac{2}{10} = \frac{24}{1320} = \frac{1}{55}$$

Alter:

The required probability can also be obtained as,

Probability=

$\frac{4C_3}{12C_3} = \frac{4\times3\times2}{3\times2\times1} \times \frac{3\times2\times1}{12\times11\times10} = \frac{1}{55}$

Search Tag- GATE18

15. The rank of the matrix $\begin{bmatrix} -4 & 1 & -1 \\ -1 & -1 & -1 \\ 7 & -3 & 1 \end{bmatrix}$ is

A. 1 B. 2

C. 3 D. 4

Ans. B

Sol. Converting the matrix into Echelon form,

$$\begin{bmatrix} -4 & 1 & -1 \\ -1 & -1 & -1 \\ 7 & -3 & 1 \end{bmatrix}$$

$R_1 \longleftrightarrow R_2$
$$\begin{bmatrix} -1 & -1 & -1 \\ -4 & 1 & -1 \\ 7 & -3 & 1 \end{bmatrix}$$

$R_2 - 4R_1, R_3 + 7R_1$
$$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 5 & 3 \\ 0 & -10 & -6 \end{bmatrix}$$

$R_3 + 2R_2$
$$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 5 & 3 \\ 0 & 0 & 0 \end{bmatrix}$$

Now since the matrix is in Echelon

Rank=Number of non-zero rows=2

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16. According to the Mean Value Theorem for a continuous function $f(x)$ in the interval $[a, b]$, there exists a value ξ in this interval such that $\int_a^b f(x)dx =$

A. $f(\xi)(b-a)$ B. $f(b)(\xi-a)$

C. $f(a)(b-\xi)$ D. 0

Ans. A

Sol. $\int_a^b f(x)dx = b.f(b) - a.f(a)$ ..(1)

This implies that within interval [a,b] there exists a value ξ such that

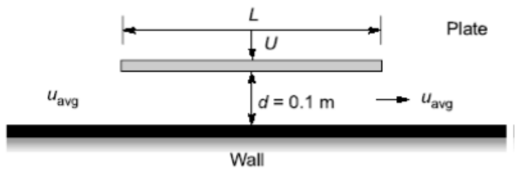
$$f(\xi) = \frac{b.f(b) - a.f(a)}{b-a}$$

$$f(\xi)(b-a) = b.f(b) - a.f(a) \quad ..(2)$$

$$From\ (1) and\ (2), \int_a^b f(x)dx = f(\xi)(b-a)$$

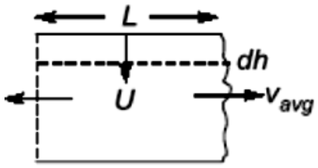
Search tag- GATE18

17. A flat plate of width $L = 1$ m is pushed down with a velocity $U = 0.01$ m/s towards a wall resulting in the drainage of the fluid between the plate and the wall as shown in the figure. Assume two-dimensional incompressible flow and that the plate remains parallel to the wall. The average velocity, U_{avg} of the fluid (in m/s) draining out at the instant shows in the figure is ____________ (correct to three decimal places).



Ans. (0.05)

Sol.



Assuming length of plate as B

Let in infinitely small time 'dt' the plate is displaced with 'dh'

So, $\frac{dh}{dt} = U$

As per continuity,

Rate of mass displaced through plate= Rate of mass displaced between plates and wall

$LBdh = 2 \times U_{avg} \times d \times Bdt$

$L\frac{dh}{dt} = 2\ U_{avg}\ d$

$U_{avg} = \frac{LU}{2d} = \frac{1 \times 0.01}{2 \times 0.1} = 0.05$ m/s

$A_1U_1 = A_2u_{avg}$

$$L \times B \times U = 2 \times d \times B \times u_{avg}$$

Since the flow is 2D the velocity of flow in direction perpendicular to plane of paper is zero.

$$1 \times 0.01 = 2 \times 0.1 \times u_{avg}$$

$$u_{avg} = 0.05\ m/sec$$

Search Tag- GATE18

18. $F(z)$ is a function of the complex variable $z = x + iy$ given by

$F(z) = iz + k\ \text{Re}(z) + i\,\text{Im}(z)$

For what value of k will f(z) satisfy the Cauchy-Riemann equations?

A. 0 B. 1

C. -1 D. y

Ans. B

Sol. $F(z) = i.z + k.Re(z) + i.Im(z)$

$$F(z) = i.(x + iy) + kx + iy$$

$$F(z) = (kx - y) + i(x + y)$$

$$F(z) = u + iv$$

Where $u = (kx - y)$ and $v = (x + y)$

According to Cauchy Riemann Equations,

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}\ and\ \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$$

From first condition k=1.

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19. If σ_1 and σ_3 are the algebraically largest and smallest principal stresses respectively the value of the maximum shear stress is.

A. $\frac{\sigma_1 + \sigma_3}{2}$ B. $\frac{\sigma_1 - \sigma_3}{2}$

C. $\sqrt{\frac{\sigma_1 + \sigma_3}{2}}$ D. $\sqrt{\frac{\sigma_1 - \sigma_3}{2}}$

Ans. B

Sol. Maximum shear stress at a point is given by = $\frac{\sigma_1 - \sigma_3}{2}$

Search Tag- GATE18

20. The time series forecasting method that gives equal weightage to each of the M most recent observation is

A. Moving average method

B. Exponential smoothing with linear trend.

C. Triple Exponential smoothing

D. Kalman Filter

Ans. A

Sol. 'Simple moving average method' is generally also called 'Moving average method' which gives equal weightage to all data points for period 'M' on which it is defined.

Search Tag- GATE18

21. In a linearly hardening plastic material. The true stress beyond initial yielding

A. increases linearly with the true strain

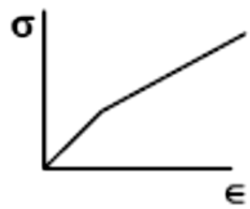
B. decreases linearly with the true stain

C. first increases linearly and then decreases linearly with the true stain

D. remain constant

Ans. A

Sol. Given that the strain hardening is linear, the true stress will increase linearly after yield point.



Search Tag- GATE18

22. A steel column of rectangular section $(15\text{ mm} \times 10\text{ mm})$ and length 1.5 m is simply supported at both ends. Assuming modulus of elasticity, $E = 200\text{ GPa}$ for steel, the critical axial load (in kN) is ________ (correct to two decimal places)

Ans. (1.097)

Sol. For Simply Supported column at both ends,

Buckling load $= \frac{\pi^2 EI_{min}}{L^2}$

$= \frac{\pi^2 \times 200 \times 10^3 \times \frac{15 \times 10^3}{12}}{1500^2} = 1096.62\text{ N}$

$= 1.097\text{ kN}$

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23. Which one of the following statement is correct for a superheated vapour?

A. Its pressure is less than the saturation pressure at a given temperature.

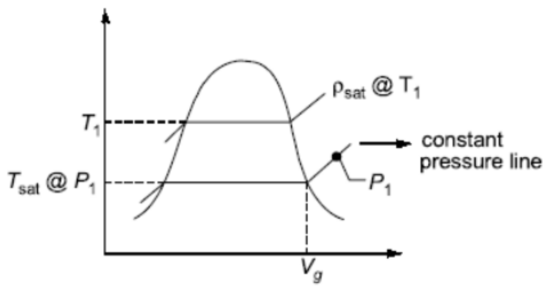
B. Its temperature is less than the saturation temperature at a given pressure.

C. Its volume is less than the volume of the saturated vapour at a given temperature.

D. Its enthalpy is less than enthalpy of the saturated vapour at a given pressure.

Ans. A

Sol.



P_1, T_1 represent the state of superheated vapours.

Let P_2 be the saturation pressure at T_1 temperature.

Conclusions (According to options)

A. Pressure will be less than saturation Pressure at given temperature.

B. Temperature will be higher than saturation temperature at given pressure (superheated state).

C. Volume is more than the volume of the saturated vapour at a given temperature (Volume is more in superheated state at same temperature).

D. Its enthalpy is higher than enthalpy of the saturated vapour at a given pressure (superheated vapours have more enthalpy than saturated vapours).

Hence only option A is correct.

Search tag- GATE18

24. The equation of motion for a spring-mass system excited by a harmonic force is

$M\ddot{x} + Kx = F\cos(\omega t)$

Where M is the mass, K is the spring stiffness, F is the force amplitude and ω is the angular frequency of excitation. Resonance occurs when ω is equal to.

A. $\sqrt{\frac{M}{K}}$ B. $\frac{1}{2\pi}\sqrt{\frac{K}{M}}$

C. $2\pi\sqrt{\frac{K}{M}}$ D. $\sqrt{\frac{K}{M}}$

Ans. D

Sol. $M\ddot{x} + Kx = F\cos(\omega t)$

Resonance is when $\omega = \omega_n = \sqrt{\frac{K}{M}}$

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25. For an Oldham coupling used between two shafts, which among the following statements are correct?

I. Torsional load is transferred along shaft axis.

II. A velocity ratio of 1:2 between shafts is obtained without using gears

III. Bending load is transferred transverse to shaft axis.

IV. Rotation is transferred along shaft axis.

A. I and II

B. I and IV

C. II and III

D. II and IV

Ans. B

Sol. Oldham's coupling is used to transmit power between two shafts having small angular misalignment. There is no bending load or reduction/increase of speed criterion.

Hence only I and IV statements are correct.

Search Tag- GATE18

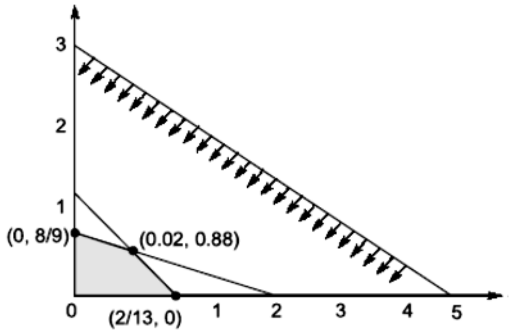
26. The minimum value of $3x+5y$ such that:

$3x+5y \le 15$
$4x+9y \le 8$
$13x+2y \le 2$
$x \ge 0,\ y \ge 0$

is ___________.

Ans. (0)

Sol. Z= 3x+5y



$Z = 3x+5y$

Feasible region will be as shown in figure.

Since the minimum value of objective function is to be found and both the coefficients in objective function are zero.

Z will be zero at point (0,0).

Search Tag- GATE18

27. A bar is compressed to half of its original length. The magnitude of true strain produced in the deformed bar is _________ (correct to two decimal places).

Ans. (0.693)

Sol. $L_0 \rightarrow$ Initial length

$L = \frac{L_0}{2} \rightarrow$ Final length

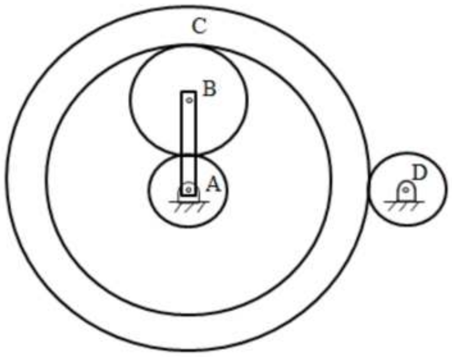
$$\text{true strain} = \epsilon_T = \ln\frac{L}{L_0} = \ln\left[\frac{\left(\frac{L_0}{2}\right)}{L_0}\right] = \ln\frac{1}{2}$$

$= -0.693$

As examiner mentioned "magnitude" only magnitude will be given 0.693.

Search Tag- GATE18

28. An epicyclic gear train is shown in the figure below. The number of teeth on the gears A, B and D are 20, 30 and 20, respectively. Gear C has 80 teeth on the inner surface and 100 teeth on the outer surface. If the carrier arm AB is fixed and the sun gear A rotates at 300 rpm in the clockwise direction, then the rpm of D in the clockwise direction is



A. 240 B. -240

C. 375 D. -375

Ans. C

Sol. Arm is fixed, no epicyclic nature. Taking clockwise direction as positive.

$$N_A = +300$$

$$(A, B) \qquad N_B = -\frac{300\times 20}{30} = -200$$

$$(B, C) \qquad N_C = -200 \times \frac{30}{80} = -75$$

$$(C, D) \qquad N_D = +75 \times \frac{100}{20} = +375$$

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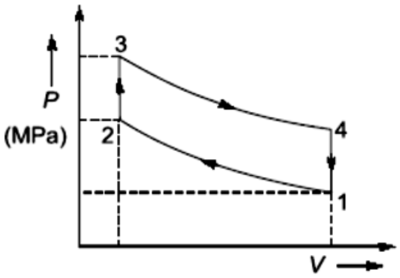
29. An engine working on air standard Otto cycle is supplied with air at 0.1 MPa and 35°C. The compression ratio is 8. The heat supplied is 500 kJ/kg. Property data for air:

$c_p = 1.005\,\text{kJ/kgK}, c_v 0.718\,\text{kJ/kgK}, R = 0.287$ kJ/kgK. The maximum temperature (in K) of the cycle is __________ (correct to one decimal place).

Ans. (1403.97)

Sol.



$P_1 = 0.1$ MPa, $T_1 = 35°C = 308$ K

$$\frac{V_1}{V_2} = n = 8$$
$$Q_s = 500 \text{ kJ/kg}$$
$$c_p = 1.005 \text{ kJ/kgK}$$
$$c_v = 0.718 \text{ kJ/kgK}$$
$$R = 0.287 \text{ kJ/kgK}$$
$$\gamma = \frac{c_p}{c_v} = 1.399 \simeq 1.40$$
$$T_3 = T_{max} = ?$$

For process 1-2

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 8^{0.4}$$

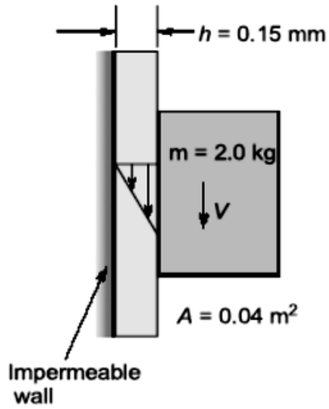
$T_2 = 707.6K$

For process 2 → 3

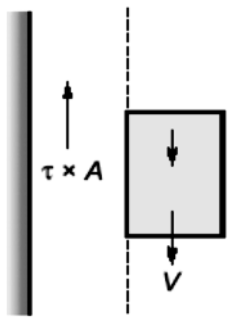
$$Q_s = C_V(T_3 - T_2) = 500 \text{ kJ/kg}$$
$$0.718(T_3 - 707.6) = 500$$
$$T_3 = 1403.97 \text{ K}$$

Search Tag- GATE18

30. A solid block of 2.0 kg mass slides steadily at a velocity V along a vertical wall as shown in the figure below. A thin oil film of thickness h=0.15mm provides lubrication between the block and the wall. The surface area of the face of the block in contact with the oil film is 0.04 m^2. The velocity distribution within the oil film gap is linear as shown in the figure. Take dynamic viscosity of oil as 7×10^{-3} Pa-s and acceleration due to gravity as 10 m/s^2 Neglect weight of the oil. The terminal velocity V (in m/s) of the block is __________ (correct to one decimal place).



Ans. (10.714)



Terminal velocity is a constant velocity i.e. the net acceleration is zero.

So, $\Sigma F_{net} = ma$

$$mg - \tau A = 0$$
$$\tau A = mg$$
$$\mu\frac{V}{h}A = mg$$
$$7\times10^{-3}\times\frac{V}{0.15\times10^{-3}}\times0.04 = 2\times10$$
$$V = 10.714 \text{ m/s}$$

Search Tag- GATE18

31. A self-aligning ball bearing has a basic dynamic load rating (C_{10}, for 10^6 revolutions) of 35 kN. If the equivalent radial load on the bearing is 45 kN, the expected life (in 10^6 revolutions) is

A. below 0.5

B. 0.5 to 0.8

C. 0.8 to 1.0

D. above 1.0

Ans. A

Sol. C = 35 kN

P_C = 45 kN

$$L_{90} = \left(\frac{C}{P_C}\right)^3 = \left(\frac{35}{45}\right)^3 = 0.4705\ \text{MR}$$

Search Tag- Gate18

32. The maximum reduction in cross-sectional area per pass (R) of a cold wire drawing process is

$R = 1 - e^{-(n+1)}$

where n represents the strain hardening coefficient. For the case of a perfectly plastic material, R is

A. 0.865 B. 0.826

C. 0.777 D. 0.632

Ans. D

Sol. Perfectly plastic material implies that strain hardening coefficient n is zero.

Hence

$$R = \frac{A_o}{A_f} = 1 - e^{-1} = 1 - \frac{1}{e} = 0.6321$$

Search Tag- GATE18

33. The value of integral

$\oiint_S \vec{r}.\vec{n}\, dS$

over the closed surface S bounding a volume, where $\vec{r} = x\hat{i} + y\hat{i} + z\hat{k}$ is the position vector and $\vec{n}$ is the normal to the surface S, is

A. V B. 2 V

C. 3 V D. 4 V

Ans. C

By Gauss Divergence Theorem

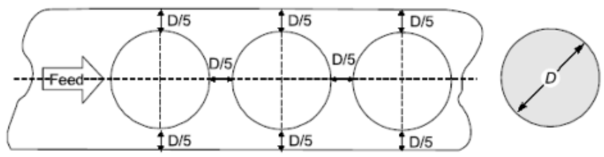
$$\oiint_S \vec{r}.\vec{n}\, dS = \iiint_V (\nabla.\vec{r})\, dV$$

$$(\nabla.\vec{r}) = 3$$

Hence, $\oiint_S \vec{r}.\vec{n}\, dS = 3\iiint_V dV = 3V$

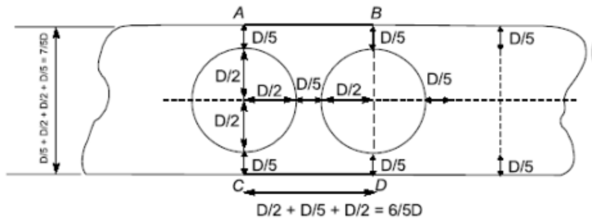
Search Tag-GATE18

34. The percentage scrap in a sheet metal blanking operation of a continuous strip of sheet metal as shown in the figure _______ (correct to two decimal places)



Ans. (53.25)

Sol.



This rectangle ABCD will be repeated again and again.

Sides of this rectangle are (D+D/5) and (D+2D/5)

$$A_t = \text{Total Area} = \frac{7}{5}D \times \frac{6}{5}D = \frac{42}{25}D^2$$

$$A_u = \text{Area of blanking Disc} = \frac{\pi D^2}{4}$$

$$\%\ \text{of scrap} = \frac{A_t - A_u}{A_t} \times 100\%$$

$$= \left[1 - \frac{\left(\frac{\pi}{4}\right)}{\left(\frac{42}{25}\right)}\right] \times 100\% = 53.25\%$$

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35. An orthogonal cutting operations is being carried out in which uncut thickness is 0.010 mm, cutting speed is 130 m/min, rake angle is 15° and width of cut is 6 mm. It is observed that the chip thickness is 0.015 mm, the cutting force is 60 N and the thrust force is 25 N. The ratio of friction energy to total energy is ___________ (correct to two decimal places)

Ans. (0.4408)

$t = 0.010$ mm
$v = 130$ m/min
$\alpha = 15^\circ$
$b = 6$ mm
$t_c = 0.015$ mm
$F_c = 60$ N
$F_t = 25$ N
$F = F_c \sin\alpha + F_t \cos\alpha$
$= 60 \sin 15 + 25 \cos 15 = 39.6773$ N

Where F represents frictional force

Ratio of frictional energy to total energy

$$= \frac{F}{F_c} \cdot \frac{V_c}{V} = \frac{F}{F_c}\left(\frac{t}{t_c}\right)$$

$$\left[\because \frac{t}{t_c} = \frac{V_c}{V} = r\right]$$

$$= \frac{39.6773}{60} \times \frac{0.010}{0.015} = 0.4408$$

Search Tag- GATE18

36. Let X_1, X_2 be two independent normal random variables with means μ_1, μ_2 and standard deviations σ_1, σ_2 respectively. Consider $Y = X_1 - X_2$; $\mu_1 = \mu_2 = 1$, $\sigma_1 = 1$; $\sigma_2 = 2$,

Then,

A. Y is normal distributed with mean 0 and variance 1

B. Y is normally distributed with mean 0 and variance 5

C. Y has mean 0 and variance 5, but is NOT normally distributed

D. Y has mean 0 and variance 1, but is NOT normally distributed

Ans. B

Sol. $\mu_1 = 1$, $\mu_2 = 1$, $\sigma_1 = 1$, $\sigma_2 = 2$

x_1 and x_2 are two independent random variables

$$Y = X_1 - X_2$$

$$\mu(Y) = \mu(X_1 - X_2)$$

$$= \mu(X_1) - \mu(X_2) = \mu_1 - \mu_2 = 1 - 1 = 0$$

$$Var(Y) = Var(X_1 - X_2)$$

$$= Var(X_1) + Var(X_2) - Cov(X_1, X_2)$$

Since X_1 and X_2 are independent variables

$$Var(Y) = Var(X_1) + Var(X_2)$$

$$= \sigma_1^2 + \sigma_2^2 = 1 + 4$$

$$Var(Y) = 5$$

Search Tag-GATE18

37. An electrochemical machining (ECM) is to be used to cut a through hole into a 12 mm thick aluminium plate. The hole has a rectangular cross-section, 10 mm × 30 mm The ECM operation will be accomplished in 2 minutes, with efficiency of 90%. Assuming specific removal rate for aluminium as 3.44×10^{-2} mm^3 /(As), the current (in A) required is __________(correct to two decimal places).

Ans. (968.992)

Sol. Volume of metal to be removed

$$= (10 \times 30) \times 12 \text{ mm}^3 = 3600 \text{ mm}^3$$

Ideal energy required

$$== \frac{3600 \text{ mm}^3}{3.44 \times 10^{-2} \frac{\text{mm}^3}{(\text{A s})}} = 104651.163 \text{ As}$$

Actual energy required

$$= \frac{104651.163}{0.9} \text{As}$$

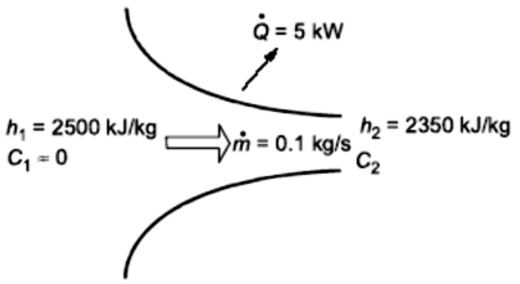
$$= 116279.07 \text{ As}$$

Time is 2 min $= 120$ s

$$\therefore \text{Current} = \frac{116279.07}{120} \text{A} = 968.992 \text{ A}$$

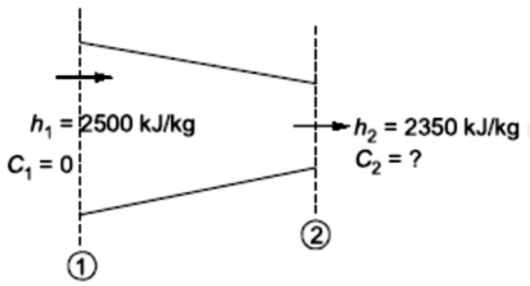
Search Tag- GATE18

38. Steam flows through a nozzle at mass flow rate of $\dot{m} = 0.1$ kg/s with a heat loss of 5 kW. The enthalpies at inlet and exit are 2500 kJ/kg and 2350 kJ/kg, respectively. Assuming negligible velocity at inlet $(C_1 \approx 0)$, the velocity (C_2) of steam (in m/s) at the nozzle exit is __________ (correct to two decimal places)



Ans. (447.213)

Sol.



$\dot{m} = 0.1$ kg/s, $Q = 5$ kW (heat loss)

Applying SFEE

$$\dot{m}\left(h_1 + \frac{1}{2}c_1^2 + gz_1\right) + \dot{Q}$$
$$= \dot{m}\left(h_2 + \frac{1}{2}c_2^2 + gz_2\right) + \dot{w}_{cv}$$

$c_1 = 0$ and $\dot{w}_{cv} = 0$

$$z_1 = z_2 \text{ (assume)}$$

$$\dot{m}h_1 + \dot{Q} = \dot{m}h_2 + \dot{m}\frac{1}{2}c_2^2$$

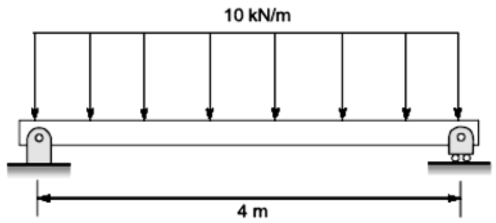
$$\Rightarrow \quad \dot{m} \times \frac{1}{2}c_2^2 = \dot{m}(h_1 - h_2) + \dot{Q}$$

$$\Rightarrow \quad 0.1 \times \frac{1}{2}c_2^2 \times 10^{-3} = 0.1(2500 - 2350) - 5$$

$$c_2 = 447.213 \text{ m/s}$$

Search Tag- GATE18

39. A simply supported beam of width 100 mm, height 200 mm and length 4 m is carrying a uniformly distributed load of intensity 10 kN/m. The maximum bending stress (in MPa) in the beam is __________ (correct to one decimal place)



Ans. (30)

Sol. Maximum bending moment will be at centre.

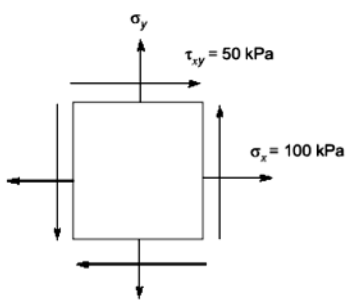
$$\text{Maximum B.M.M} = \frac{wL^2}{8} = \frac{10 \times 16}{8}$$
$$= 20 \text{ kNm}$$
$$(L = 4)$$

Maximum Bending Stress

$$\sigma_{max} = \frac{M}{I}y_{max} = \frac{20 \times 10^3}{\left(\frac{0.1 \times 0.2^3}{12}\right)} \times 0.1$$
$$= 30 \times 10^6 \text{ N/m}^2 = 30 \text{ MPa}$$

Search Tag- GATE18

40. The state of stress at a point, for a body in place stress, is shown in the figure below. If the minimum principal stress is 10 kPa, then the normal stress σ_y (in kPa) is



A. 9.45 B. 18.88

C. 37.78 D. 75.50

Ans. C

Sol. $\sigma_x = 100$ kPa, $\tau_{xy} = 50$ kPa

Minimum principal stress

$$= \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$10 = \frac{100 + \sigma_y}{2} - \sqrt{\left(\frac{100 - \sigma_y}{2}\right)^2 + 50^2}$$

$$\therefore \quad \sqrt{\left(\frac{100 - \sigma_y}{2}\right)^2 + 50^2} = 50 + \frac{\sigma_y}{2} - 10$$

$$= 40 + \frac{\sigma_y}{2}$$

By squaring

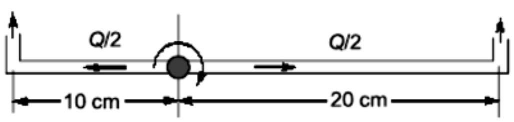
$$2500 + \frac{\sigma_y^2}{4} - 50\,\sigma_y + 2500 = 1600 + \frac{\sigma_y^2}{4} + 40\sigma_y$$

$$\therefore \quad 90\sigma_y = 3400$$

$$\sigma_y = 37.78 \text{ MPa}$$

Search Tag- GATE18

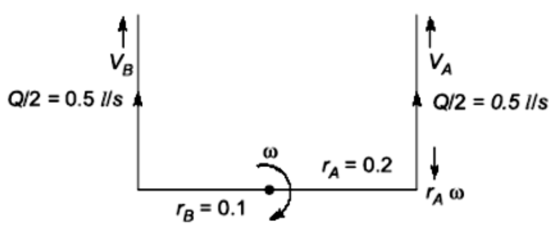
41. A sprinkler shown in the figure rotates about its hinge point in a horizontal plane due to water flow discharged through its two exit nozzles.



The total flow rate Q through the sprinkler is 1 litre/sec and the cross-sectional area of each exit nozzle is $1cm^2$. Assuming equal flow rate through both arms and a frictionless hinge, the steady state angular speed of rotation (rad/s) of the sprinkler is __________ (correct to two decimal places).

Ans. (10)

Sol.



Relative velocities of water with sprinkler

$$V_A = \frac{Q/2}{A} = \frac{1 \times 10^{-3}}{2 \times 10^{-4}} = 5 \text{ m/s}$$

$$V_B = 5 \text{ m/s}$$

Absolute velocity from B side

$$V'_{Abs} - (+r_B\omega) = V_B$$

$$V'_{Abs} = V_B + r_B\omega$$

$$= 5 + 0.1\,\omega$$

Absolute velocity from A side

$$V_{Abs} - (-r_A\omega) = V_A$$

$$V_{Abs} = V_A + r_A\omega$$

$$V_{Abs} = 5 - 0.2\,\omega$$

The external torque to the sprinkler is zero.

So, $\Sigma T = 0$

$$\dot{m}_A V_{Abs} r_A - \dot{m}_B V'_{Abs} r_B = 0$$

$$\rho\left(\frac{Q}{2}\right)\{5 - 0.2\,\omega\}\,0.2 - \rho\frac{Q}{2}\{5 + 0.1\,\omega\}\,0.1 = 0$$

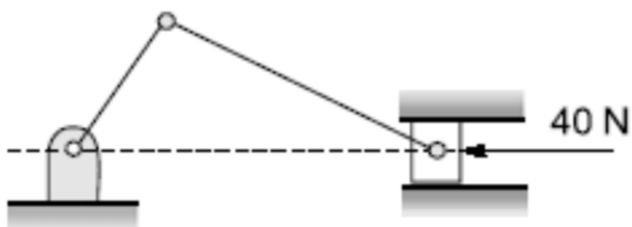
$$1 - 0.04\,\omega - 0.5 - 0.01\,\omega = 0$$

$$0.05\,\omega = 0.5$$

$$\omega = 10 \text{ rad/s}$$

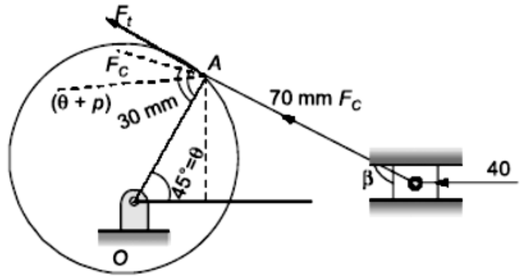
Search Tag- GATE18

42. A slider crank mechanism is shown in the figure. At some instant, the crank angle is 45° and a force of 40 N is acting towards the left on the slider. The length of the crank is 30 mm and the connecting rod is 70 mm. Ignoring the effect of gravity, friction and inertial forces, the magnitude of the crankshaft torque (in Nm) needed to keep the mechanism in equilibrium is _________(correct to two decimal places).



Ans. (1.12)

Sol.



$$30 \sin 45° = 70 \sin\beta$$

$$\sin\beta = \frac{30 \sin 45}{70} = 0.303045$$

$$\beta = 17.6406°$$

$$F_C \cos\beta = 40$$

$$F_C = \frac{40}{\cos\beta} = 41.9737 \text{ N}$$

$$F_t = F_C \sin(\theta + \beta)$$

$$= 41.9737 \times \sin(17.6406° + 45°)$$

$$F_t = 37.2785 \text{ N}$$

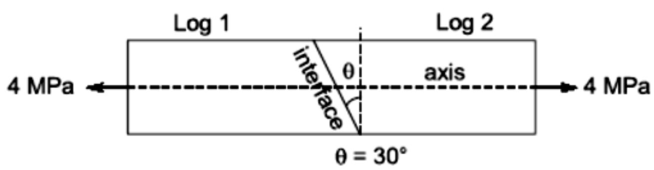
$$T = F_t \times r = 47.2785 \times 0.030$$

$$= 1.1183 \text{ N-m} = 1.118 \text{ N-m}$$

$$= 1.12 \text{ N-m}$$

Search Tag- GATE18

43. A carpenter glues a pair of cylindrical wooden logs by bonding their end faces at an angle of as shown in the figure.



The glue used at the interface fails if

Criterion 1 : the maximum normal stress exceeds 2.5 MPa

Criterion 2 : the maximum shear stress exceeds 1.5 MPa

Assume that the interface fails before the logs fail. When a uniform tensile stress of 4 MPa is applied, the interface

A. fails only because of criterion 1

B. fails only because of criterion 2

C. fails because of both criteria 1 and 2

D. does not fail.

Ans. C

Sol. General equation learned for

Normal stress on inclined plane

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} cos\, 2\theta + \tau_{xy} \sin 2\theta$$

And shear stress for inclined plane

$$\tau_n = -\frac{\sigma_x - \sigma_y}{2} sin\, 2\theta + \tau_{xy} \cos 2\theta$$

when ϴ is measured clockwise from left face. Hence θ must be replaced by (- θ) in above equations and $\sigma_y = 0$, $\tau_{xy} = 0$

$$\sigma_n = \frac{\sigma_x}{2} + \frac{\sigma_x}{2} cos\, 2(-30) + 0$$

$$\sigma_n = \frac{4}{2} + \frac{4}{2} cos(-60)$$

$$\sigma_n = 3\ MPa$$

$$\tau_n = -\frac{\sigma_x}{2} sin\, 2(-\theta)$$

$$\tau_n = \frac{\sigma_x}{2} sin(2\theta)$$

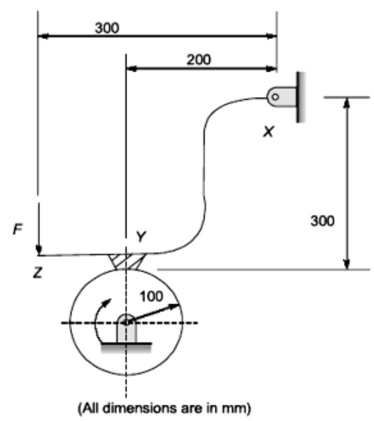
$$\tau_n = \frac{4}{2} sin(60)$$

$$\tau_n = 1.73$$

Since both the stress exceeds the given limits, answer is option (C).

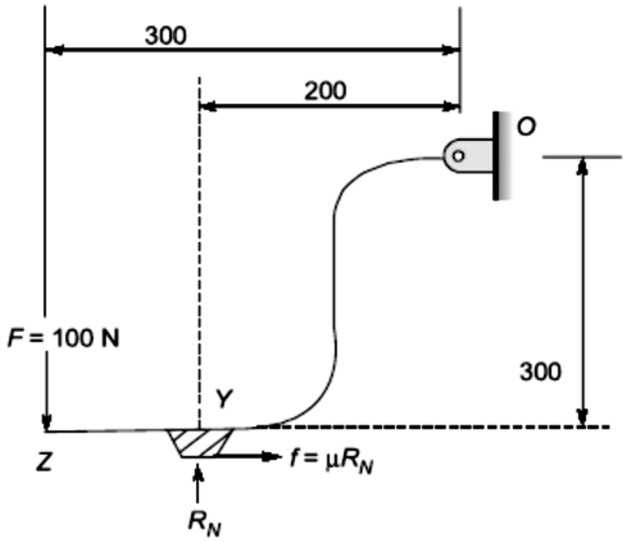
Search Tag- GATE18

44. The schematic of an external drum rotating clockwise engaging with a short shoe is shown in the figure. The shoe is mounted at point Y on a rigid lever XYZ hinged at point X. A force F = 10 N is applied at the free end of the lever as shown. Given that the coefficient of friction between the shoe and the drum is 0.3, the braking torque (in Nm) applied on the drum is ______________ (correct to two decimal places).



Ans. (8.18)

Sol.



$\Sigma M_0 = 0$

$F \times 300 + f \times 300 = RN \times 200$

$100 \times 300 + \mu R_N \times 300 = R_N \times 200$

$100 \times 300 + 0.3 \times R_N \times 300 = R_N \times 200$

$300 = 1.1\ R_N$

$R_N = 272.72$ N

Braking torque $= \mu R_N \times R = 0.3 \times 272.72 \times 0.100 = 8.18$ Nm

Search Tag- GATE18

45. Processing times (including step times) and due dates for six jobs waiting to be processed at a work centre are given in the table. The average tardiness (in days) using shortest processing time rule is __________(correct to two decimal places).

Job	Processing time (days)	Due date (days)
A	3	8
B	7	16
C	4	4
D	9	18
E	5	17
F	13	19

Ans. (6.33)

Sol. By SPT Rule

Job	P.T.	D.D.	Job Flow Time	Tardiness
A	3	8	0 + 3 = 3	0
C	4	4	3 + 4 = 7	3
E	5	17	7 + 5 = 12	0
B	7	16	12 + 7 = 19	3
D	9	18	19 + 9 = 28	10
F	13	19	28 + 13 = 41	22
				38

Total tardiness = 38

Average tardiness per job

$$= \frac{\text{Total tardiness}}{\text{No. of Jobs}} = \frac{38}{6} = 6.33 \text{ days}$$

Search Tag- GATE18

46. An explicit forward Euler method is used to numerically integrate the differential equation

$$\frac{dy}{dt} = y$$

Using a time step of 0.1. With the initial condition $y(0) = 1$, the value of $y(1)$ computed by this method is ____________ (correct to two decimal places).

Ans. (2.5937)

Sol. $y_1 = y_0 + h_f(t_0, y_0)$

$= y_0 + hy_0$

$= 1 + 0.1(1)$

$y_1 = 1.1$

$y_2 = y_1 + h_f(t_1, y_1)$

$= y_1 + h.y_1$

$= 1.1 + 0.1(1.1)$

$y_2 = 1.21$

$y_3 = y_2 + h_f(t_2, y_2)$

$= y_2 + h.y_2$

$= 1.21 + 0.1 \times 1.21$

$y_3 = 1.331$

$y_4 = y_3 + h.f(t_3, y_3)$

$= y_3 + h.y_3$

$= 1.331 + 0.1 \times 1.331$

$y_4 = 1.4641$

$y_5 = y_4 + h.f(t_4, y_4)$

$= y_4 + h.y_4$

$= 1.4641 + 0.1 \times (1.4641)$

$y_5 = 1.61051$

$y_6 = y_5 + h.f(t_5, y_5)$

$= y_5 + h.y_5$

$= 1.61051 + 0.1 \times 1.61051$

$y_6 = 1.771561$

$y_7 = y_6 + h.f(t_6, y_6)$

$= y_6 + h \times y_6$

$= 1.771561 + 0.1 \times 1.771561 = 1.9487$

$y_8 = y_7 + h.f(t_7, y_7)$

$= y_7 + h.y_7$

$= 1.9487 + 0.1 \times (1.9487)$

$y_8 = 2.14357$

$y_9 = y_8 + h.f(t_8, y_8)$

$= y_8 + h.y_8$

$= 2.14357 + 0.1 \times 2.14357$

$y_9 = 2.3579$

$y_{10} = y_9 + h.f(t_9, y_9)$

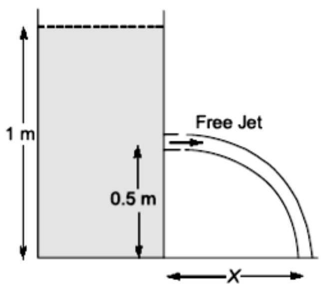
$= y_9 + h.y_9$

$= 2.3579 + 0.1 \times (2.3579)$

$y_{10} = 2.5937$

Search Tag- GATE18

47. A tank open at the top with a water level of 1 m, as shown in the figure, has a hole at a height of 0.5 m. A free jet leaves horizontally from the smooth hole. The distance X (in m) where the jet strikes the floor is



A. 0.5 B. 1.0

C. 2.0 D. 4.0

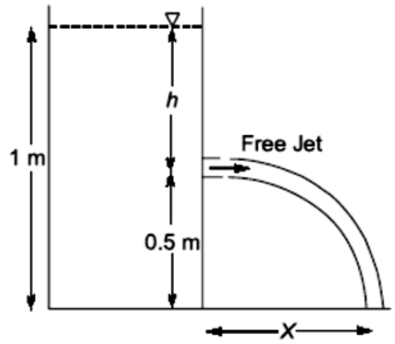
Ans. B

Sol. Let free jet velocity is x displacement

$t = \frac{x}{v}$

Velocity of jet coming from the orifice in X direction, $V = \sqrt{2gh}$

$t = \frac{x}{\sqrt{2gh}}$ ...(i)



To calculate time 't', using equation of motion for y direction,

By second law of motion equation

$s = ut + \frac{1}{2}gt^2$

For free fall u=0, s=0.5m

$t = \sqrt{\frac{2s}{g}}$

$$t = \sqrt{\frac{2 \times 0.5}{g}} = \frac{1}{\sqrt{g}} \quad ..(ii)$$

is the time of free fall of object

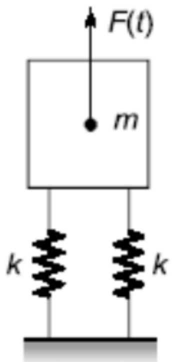
By equation (i) and (ii)

$$\frac{x}{\sqrt{2 \times g \times 0.5}} = \frac{1}{\sqrt{g}}$$

x=1 m.

Search Tag- GATE18

48. A machine of mass $m = 200$ kg is supported on two mounts, each of stiffness $k = 10$ kN/m. The machine is subjected to an external force (in N) $F(t) = 50 \cos 5t$. Assuming only vertical translator motion, the magnitude of the dynamic force (in N) transmitted from each mount to the ground is __________(correct to two decimal places).



Ans. (33.333)

Sol.

$m = 200$ kg, $k = 10$ kN/m $= 10000$ N/m

$K_{eq} = K + K = 10000 + 10000 = 20000$ N/m

$F_t = 50 \cos 5t$

$F_0 = 50$ N

$\omega = 5$ rad/s

$$\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{20000}{200}} = \sqrt{100} = 10 \text{ rad/s}$$

$$\frac{\omega}{\omega_n} = \frac{5}{10} = \frac{1}{2}$$

No damping $\Rightarrow c = 0 \Rightarrow \xi = 0$

Transmissibility

$$\epsilon = \frac{\sqrt{1 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}{\sqrt{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}} \qquad (\xi = 0)$$

$$= \frac{1}{\sqrt{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2}} = \frac{1}{\sqrt{\left\{1 - \left(\frac{1}{2}\right)^2\right\}^2}}$$

$$= \frac{1}{1 - \frac{1}{4}} = \frac{1}{\frac{3}{4}} = \left(\frac{4}{3}\right)$$

$$\epsilon = \frac{F_t}{F_0}$$

$$\frac{4}{3} = \frac{F_t}{50}$$

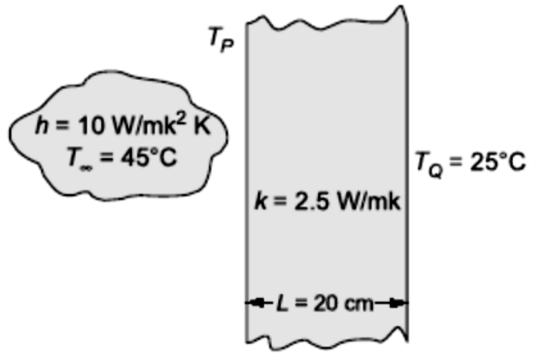
$$F_t = \frac{200}{3} = 66.66\text{N}$$

Force from each mount $= \frac{F_t}{2} = \frac{66.666}{2}$

$= 33.333$N

Search Tag- GATE18

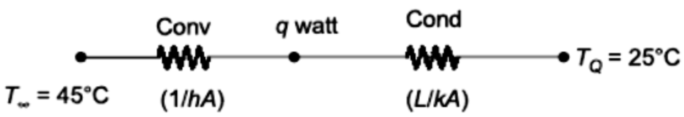
49. A plane slab of thickness L and thermal conductivity k is heated with a fluid on one side (P), and the other side (Q) is maintained at a constant temperature, T_Q of 25°C, as shown in the figure. The fluid is at 45°C and the surface heat transfer coefficient, h, is 10 W/m^{2}K. The steady state temperature. T_P (in °C) of the side which is exposed to the fluid is __________ (correct to two decimal places).



Ans. (33.889)

Sol. Assuming steady state conditions

Thermal circuit



Assuming steady state, heat transferred from fluid will be equal to heat transferred from wall.

$$q = \text{Rate of heat transfer} = \frac{45 - T_P}{1/hA} = \frac{T_p - 25}{L/kA}$$

$$\Rightarrow \quad \frac{45 - T_P}{\left(\frac{1}{10}\right)} = \frac{T_P - 25}{\frac{0.2}{2.5}}$$

$$T_P = 33.889°\text{C}$$

Search Tag- GATE18

50. $F(s)$ is the Laplace transform of the function

$f(t) = 2t^2e^{-t}$

F(1) is ___________ (correct to two decimal places).

Ans. (0.5)

Sol. $L(t^n) = \frac{n!}{s^{n+1}}$

$$L(t^2) = \frac{2!}{s^{2+1}} = \frac{2}{s^3}$$

$$L(2t^2) = 2L(t^2) = \frac{4}{s^3}$$

$$L(2t^2e^{-\alpha t})$$

$$= \frac{4}{(s+\alpha)^3}$$

$$L(2t^2e^{-t}) = \frac{4}{(s+1)^3}$$

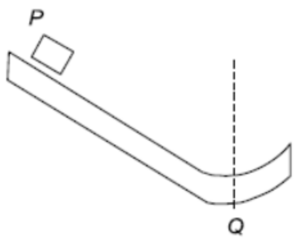
$$= F(s)$$

$$Hence\ F(1) = \frac{4}{2^3}$$

$$= 0.5$$

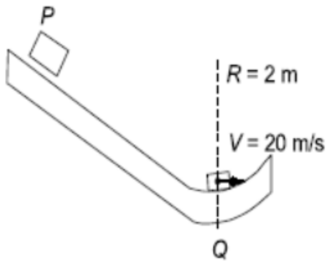
Search Tag- GATE18

51. Block P of mass 2 kg slides down the surface and has a speed 20 m/s at the lowest point, Q where the local radius of curvature is 2 m as shown in the figure. Assuming $g = 10\ m/s^2$, the normal force (in N) at Q is _________ (correct to two decimal places).



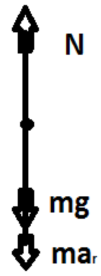
Ans. (420)

Sol.



$m = 2$ kg, $g = 10\ m/s^2$

FBD of mass P at Point Q



$N - mg = ma_r$ at no slip condition.

$$N = mg + \frac{mv^2}{R} = 2\times10 + \frac{2\times20\times20}{2} = 420N$$

Search Tag- GATE18

52. In a Lagrangian system, the position of a fluid particle in a flow is described as $x = x_0e^{-kt}$ and $y = y_0e^{kt}$ where t is the time while x_0, y_0, and k are constants. The flow is

A. unsteady and one-dimensional

B. steady and two-dimensional

C. steady and one-dimensional

D. unsteady and two-dimensional

Ans. B

Sol. x direction scalar of velocity field,

$$u = \frac{dx}{dt} = -kx_oe^{-kt} = -kx$$

y direction scalar of velocity field

$$v = \frac{dy}{dt} = ky_oe^{kt} = ky$$

u & v are non zero scalar $t \geq 0$ so it is 2D flow.

Continuity equation for steady flow,

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$$

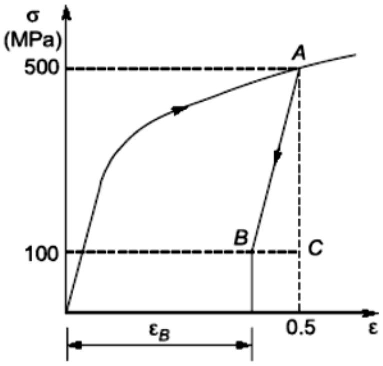
$$\frac{\partial}{\partial x}\left(-kx_0e^{-kt}\right)+\frac{\partial}{\partial y}\left(ky_0e^{kt}\right)=0$$

$0+0=0$ Continuity is satisfied.

Hence flow is 2D and steady.

Search Tag- GATE19

53. The true stress (σ), true strain (ε) diagram of a strain hardening material is shown in figure. First, there is loading up to point A, i.e. up to stress of 500 MPa and strain of 0.5. then from point A, there is unloading up to point B, i.e. to stress of 100 MPa, Given that the Young's modulus $E=200$ GPa, the natural strain at point B (ε_B) ________ (correct to two decimal places).



Ans. (0.498)

Sol. BC is the elastic recovery related strain.

Recovered strain $\varepsilon_{recovered}=\frac{change\ in\ stress}{Elastic\ \ modulus}$

$$\varepsilon_{recovered}=\frac{400}{200\times10^3}=0.002$$

$$\varepsilon_B=\varepsilon_C-\varepsilon_{recovered}$$

$$\varepsilon_B=0.5-0.002$$

$$\varepsilon_B=0.498$$

Search Tag- GATE18

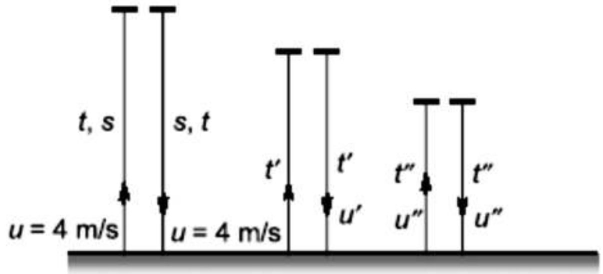
54. A point mass is shot vertically up from ground level with a velocity of 4 m/s at time, $t=0$. It loses 20% of its impact velocity after each collision with the ground. Assuming that the acceleration due to gravity is 10 m/s^2 and that air resistance is negligible, the mass stops bouncing and comes to complete rest on the ground after a total time (in seconds) of

A. 1 B. 2

C. 4 D. ∞

Ans. C

Sol.



(1)→ $t=?$

$v=u+at$

$0=4-10t$

$t=\frac{4}{10}=0.4s$

(2)→ $t'=?$

$u'=0.8\times u$

$=0.8\times4=3.2$ m/s

$v'=u'+at'$

$0=3.2-10t'$

$t'=\frac{3.2}{10}=0.32s$

(3)→ $t'=?$

$u'=0.8\ u'$

$=0.8\times3.2=2.56$ m/s

$v''=u''+at''$

$0=2.56-10t''$

$t''=0.256s$

So, t, t', t'' are forming a GP series

So, total time

$=2\left(t+t'+t''+......0\right)$

$=2\left[0.4+0.32+0.256+....0\right]$

$=2\times\frac{0.4}{1-0.8}=2\times2=4s$

Search Tag- GATE18

55. A tank of volume $0.05\ m^3$ contains a mixture of saturated water and saturated steam at 200°C. The mass of the liquid present is 8 kg. The entropy (in kJ/kg/K) of the mixture is ___________ (correct of two decimal places)

Property data for saturated steam and water are:

At 200°C, $Psat = 1.5538$ MPa

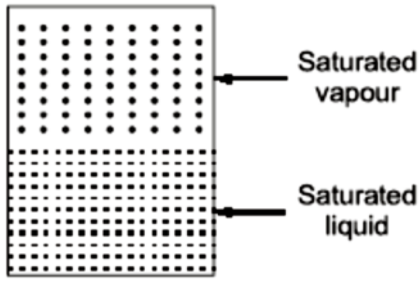
v_f = 0.001157 m3/kg, v_g = 0.12736 m3/kg

s_{fg}=4.1014 kJ/kg K, sf =2.3309 kJ/kg K

Ans. (2.488)

Sol. Total volume of tank $(V) = 0.05\ m^3$

Means of liquid $(m_2) = 8$ kg



Volume occupied by liquid in tank= $m \times v_f$

$V_L = 8 \times 0.001157\ m^3$

$V_L = 0.009256$

$V_v = V - V_L$

$V_v = 0.05 - 0.009256 = 4.990744$

$m_v = \frac{V_v}{v_g} = \frac{0.04990744}{0.12736} = 0.3198\ kg$

$$x = \frac{m_v}{m_v + m_L} = 0.0384$$

Specific entropy of mixture (s)

$s = s_f + x s_{fg}$

$s = 2.3309 + 0.0384 \times 4.1014$

$s = 2.4884$ kJ/kg-K

Search Tag- GATE18

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