Detailed Analysis of GATE 2017 Paper

GATE ME Solved 2017 Paper (Set 1) Detailed Analysis

Subject	1 Mark Questions	2 Mark Questions	Total Marks
General Aptitude	5	5	15
Engineering Mathematics	5	5	15
Heat Transfer	1	2	5
Strength of Material	3	3	9
Engineering Mechanics	1	2	5
Fluid Mechanics	4	3	10
Machine Design	2	1	4
Manufacturing Technology	5	6	17
Industrial Engineering	0	2	4
Theory of Machines	1	3	7
Thermodynamics	1	4	9
Total Marks			**100**

GATE ME Solved 2017 Paper (Set 2) Detailed Analysis

Subject	1 Mark Questions	2 Mark Questions	Total Marks
General Aptitude	5	5	15
Engineering Mathematics	5	5	15
Heat Transfer	2	2	6
Strength of Material	4	1	6
Engineering Mechanics	0	1	2
Fluid Mechanics	3	3	9
Machine Design	1	4	9
Manufacturing Technology	4	4	12
Industrial Engg.	2	2	6
Theory of Machines	2	4	10
Thermodynamics	2	4	10
Total Marks			**100**

GATE 2017 Solved Paper
ME: Mechanical Engineering
Set – I

Number of Questions: 65 **Total Marks:100.0**

Wrong answer for MCQ will result in negative marks, (–1/3) for 1 Mark Questions and (–2/3) for 2 Marks Questions.

General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Q.1 to Q.5 carry 2 mark each and Q.6 to Q.10 carry 1 marks each.

Question Number: 1 **Question Type: MCQ**

What is the sum of the missing digits in the subtraction problem below?

5 _ _ _ _
– 4 8 _ 8 9
1 1 1 1

(A) 8 (B) 10
(C) 11 (D) Cannot be determined

Solution: By hit and trial we find that the missing digit in lower number an be either 8 or 9.

If it is 8

⇒ Sum of digits = 8 + 0 + 0 + 0 + 0 = 8

If it is 9

⇒ Sum of digits = 9 + 0 + 1 + 0 + 0 = 10

Hence, the correct option is (D).

Question Number: 2 **Question Type: MCQ**

'Here, throughout the early 1820s, Stuart continued to fight his losing battle to allow his sepoys to wear their caste-marks and their own choice of facial hair on parade, being again reprimanded by the commander-in-chief. His retort that "A stronger instance than this of European prejudice with relation to this country has never come under my observations" had no effect on his superiors.'

According to this paragraph, which of the statements below is most accurate?

(A) Stuart's commander-in-chief was moved by this demonstration of his prejudice.
(B) The Europeans were accommodating of the sepoy' desire to wear their cast-marks.
(C) Stuart's 'losing battle' refers to his inability to succeed in enabling sepoys to wear cst-marks.
(D) The commander-in-chief was exempt from the European prejudice that dictated how the sepoys were to dress.

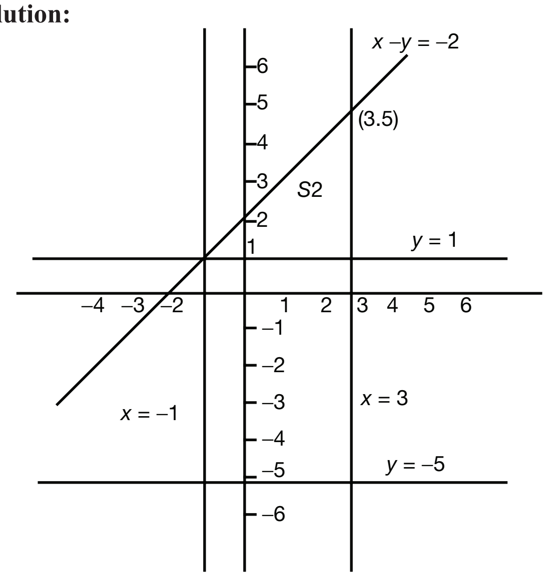
Solution: Hence, the correct option is (C).

Question Number: 3 **Question Type: MCQ**

Let S_1 be the plane figure consisting of the points (x, y) given by the inequalities $|x-1| \leq 2$ and $|y+2| \leq 3$. Let S_2 be the plane figure given by the inequalities $x - y \geq -2$, $y \geq 1$, and $x \leq 3$. Let S be the union of S_1 and S_2. The area of S is

(A) 26 (B) 28 (C) 32 (D) 34

Solution:



$|x-1| \leq 2$

$x < 1$	$x > 1$
$x - 1 = -2$	$x - 1 = 2$
$x = -1$	$x - 1$

$|y+2| \leq 3$

$y > -2$	$y < -2$
$y + 2 = 3$	$y - 2 = -3$
$y = 1$	$y = -5$

Intersection point of $x - y = -2$ and $x = 3$

$3 - y = -2$

$y = 3 + 2 = 5$

Point is (3, 5)

Area of S = Area of S Area of S_1 + Area of S_2

$$= (6 \times 4) + \frac{1}{2} \times 4 \times$$

$$= 24 + 8 = 32$$

Hence, the correct option is (D).

Question Number: 4 **Question Type: MCQ**

Two very famous sportsmen Mark and Steve happened to be brothers, and played for country *K*. Mark teased James, an opponent from country *E*, "There is no way you are good enought to play for your country." James replied, "Maybe not, but at least I am the best player in my own family."

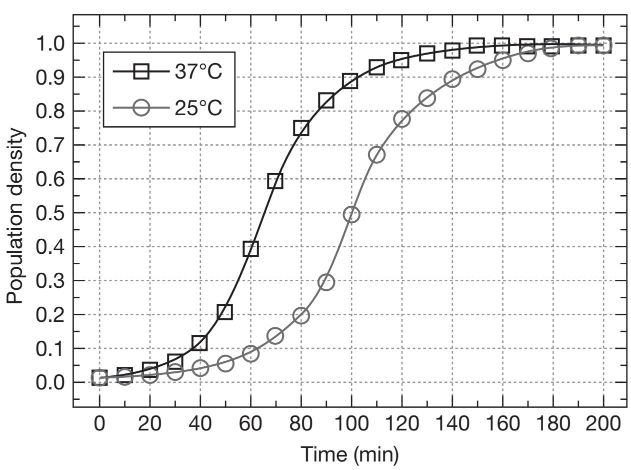
Which one of the following can be inferred from this conversation?

(A) Mark was known to play better than James
(B) Steve was known to play better than Mark
(C) James and Steve were good friends
(D) James played better than Steve

Solution: Hence, the correct option is (D).

Question Number: 5 **Question Type: MCQ**

The growth of bacteria (lactobacillus) in milk leads to curd formation A minimum bacterial population density of 0.8 (in suitable units) is needed to form curd. In the graph below, the population density of lactobacillus in 1 litre of milk is plotted as a function of time at two different temperatures, 25°C and 37°C



Consider the following statements based on the data shown above

i. The growth in bacterial population stops earlier at 37°C as compared to 25°C
ii. The time taken for curd formation at 25°C is twice the time taken at 37°C Which one of the following options is correct?

(A) Only i (B) Only ii
(C) Both i and ii (D) Neither i nor ii

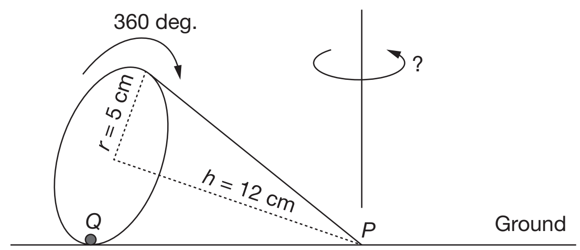
Solution:

(i) the growth in bacterial population stops almost 140 s in 37°C as compared to 180 s in 25°C.
(ii) time taken for curd formation at 25°C is approximately 90 s while it is 130 s in 37°C which is not double.

Hence, the correct option is (A).

Question Number: 6 **Question Type: NAT**

A right-angled cone (with base radius 5 cm and height 12 cm), as shown in the figure below, is rolled on the ground keeping the point *P* fixed until the point *Q* (at the base of the cone, as shown) touches the ground again

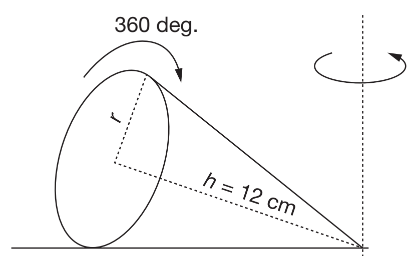


By what angle (in radians) about *P* does the cone travel?

(A) $\frac{5\pi}{12}$ (B) $\frac{5\pi}{24}$

(C) $\frac{24\pi}{5}$ (D) $\frac{10\pi}{13}$

Solution:



While rotating Q the whole cone will also rotate in a circle of radius, which will be equal to its and slant height. therefore rotating Q it will cover $2\pi R$ distance in horizontal circle. Thus angle made will be $\frac{2\pi R}{2\pi l} \times 2\pi$ radians

$$= \frac{5}{13} \times 2\pi$$

$$Q = \frac{10\pi}{13}$$

Hence, the correct option is (D).

Question Number: 7 **Question Type: MCQ**

As the two speakers became increasingly agitated, the debate became_____.

(A) lukewarm (B) poetic
(C) forgiving (D) heated

Solution: Hence, the correct option is (D).

Question Number: 8 **Question Type: MCQ**

In a company with 100 employees, 45 earn ₹ 20,000 per month 25 earn ₹ 30,000, 20 earn ₹ 40,000, 8 earn ₹ 60,000, and 2 earn ₹ 150,000. The median of the salaries is

(A) ₹ 20,000 (B) ₹ 30,000
(C) ₹ 32,300 (D) ₹ 40,000

Solution: median will be the average of two middle terms.

$$\text{Median} = \frac{30000+30000}{2} = 30000$$

Hence, the correct option is (D).

Question Number: 9 **Question Type: MCQ**

He was one of my best___and I felt his loss_____.

(A) friend, keenly (B) friends, keen
(C) friend, keener (D) friends, keenly

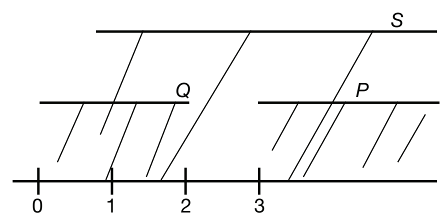
Solution: Hence, the correct option is (D).

Question Number: 10 **Question Type: MCQ**

P, Q, and R talk about S' 5 car collection P states that S has at least 3 cars. Q believes that S has been than 3 cars R indicates that to his knowledge, S has at least one car. Only one of P, Q and R is right. The number of cars owned by S is

(A) 0
(B) 1
(C) 3
(D) Cannot be determined

Solution:



As per given condition no of car according to

$P \geq 3$

$Q < 3$

$R \geq 1$

and only one is correct.

So, only Q cars is satisfying the given condition.

Hence, the correct option is (A).

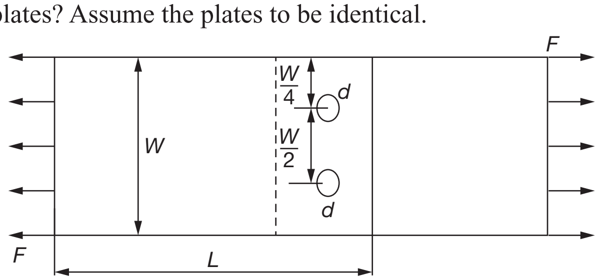
Mechanical Engineering

Number of Questions: 55 **Section marks: 85.0**

Q.11 to Q.35 carry 1 mark each and Q.36 to Q.65 carry 2 marks each.

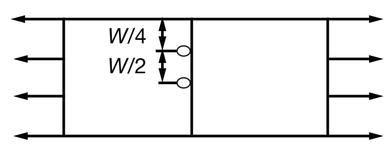
Question Number: 11 **Question Type: MCQ**

Consider the schematic of a riveted lap joint subjected to tensile load F, as shown below. Let d be the diameter of the rivets, and S_f be the maximum permissible tensile stress in the paltes. What should be the minimum value for the thickness of the plates to guard against tensile failure of the plates? Assume the plates to be identical.



(A) $\dfrac{F}{S_f(W-2d)}$ (B) $\dfrac{F}{S_f W}$
(C) $\dfrac{F}{S_f(W-d)}$ (D) $\dfrac{2F}{S_f W}$

Solution:



$$= \frac{F}{(\text{Area of shear})}$$

= Max. permissible tensile stress (S_f)

$$\Rightarrow \frac{F}{(W-2d)\times t} = S_f$$

$$\Rightarrow t = \frac{F}{S_f(W-2d)}$$

Hence, the correct option is (A).

Question Number: 12 **Question Type: MCQ**

Water (density = 1000 kg/m^3) at ambient temperature flows through a horizontal pipe of uniform corss section at the rate of 1 kg/s. If the pressure drop across the pipe is 100 kPa, the minimum power required to pump the water across the pipe, in watts, is___.

Solution:

Given data

$\Delta P = 100 \text{ kPa} = 100 \times 10^3 \text{ N/m}^2$

$Q = 1$ kg/sec

Now using relation

or, $\rho AV = 1$ kg/sec

or $A = \dfrac{1}{\rho V} = \dfrac{1}{\rho}$

$$A = \frac{1}{\rho V} = \frac{1}{\rho}$$

Hence, the correct answer is (100 Watt).

Question Number: 13 **Question Type: NAT**

Metric thread of 0.8 mm pitch is to be cut on a lathe. Pitch of the lead screw is 1.5 mm. If the spindle rotates at 1500 rpm, the speed of rotation of the lead screw (rpm) will be________.

Solution:

Given data

Pitch of thread $P_t = 0.8$ mm

RPM of spindle $N_t = 1500$ rpm

Pitch of the lead screw $P_s = 1.5$ mm

We know that

$$N_S \times P_S \times Z_S = N_t \times P_t \times Z_t \; [Z_s = Z_t = 1]$$

$$\Rightarrow N_S \times 1.5 \times 1 = 1500 \times 0.8 \times 1$$

$$\Rightarrow N_S = 800 \text{ rpm}$$

Hence, the correct answer is (800).

Question Number: 14 **Question Type: MCQ**

Match the processes with their characteristics

Process	Characteristics
P : Electrical Discharge Machining	1. No residual stress
Q: Ultrasonic machining	2. Machining of electrically conductive materials
R : Chemical machining	3. Machining of glass
S : Ion Beam Machining	4. Nano –machining

(A) P–2, Q–3, R–1, S–4 (B) P–3, Q–2, R–1, S–4
(C) P–3, Q–2, R–4, S–1 (D) P–2, Q–4, R–3, S–1

Solution:

P EdM → Machining of electronics conductive material

Q USM → Machining of glass

R Chemical Machining → No reduced stress

S Ion beam machining → Nano-machining

Hence, the correct option is (A).

Question Number: 15 **Question Type: MCQ**

Consider a beam with circular cross-section of diameter *d*. The ratio of the second moment of area about the neutral axis to the section modulus of the area is

(A) $\dfrac{d}{2}$ (B) $\dfrac{\pi d}{2}$
(C) 3 (D) *pd*

Solution:

For circular cross-section,

Second moment of area of beam $= \dfrac{\pi d^4}{64}$ (1)

Section Modulus $= \dfrac{\pi d^3}{32}$ (2)

dividing (1) and (2), we get

$\therefore$ Ratio $= \dfrac{d}{2}$

Hence, the correct option is (A).

Question Number: 16 **Question Type: MCQ**

For a steady flow, the velocity field is $\vec{V} = (-x^2 + 3y)i + (2xy)j$. The magnitude of the acceleration of a particle at (1, –1) is

(A) 2 (B) 1 (C) $2\sqrt{5}$ (D) 0

Solution: Flow filed is given as

$$\vec{V} = (-x^2 + 3y)i + (2xy)j$$

$$\vec{V} = ui + v$$

So,

$$v = 2xy$$

$$u = -x^2 + 3y$$

For steady flow acceleration is given by

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

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

$$a_x = (-x^2 + 3y)(-2x) + (2xy)(3)$$

$$a_x = 2x^3 - 6xy + 6xy$$

$$a_{(1-1)x} = +2$$

Similarly,

$$a_{(1-1)y} = 4$$

$$a_{\text{net}} = \sqrt{a_x^2 + a_y^2}$$

$$a_{\text{net}} = \sqrt{4 + 16}$$

$$a_{\text{net}} = \sqrt{20} = 2\sqrt{5} \text{ m/s}$$

Hence, the correct option is (C).

Question Number: 17 **Question Type: NAT**

Two models, P and Q, of a product earn profits of ₹ 100 and ₹ 80 per piece, respectively. Production times for P and Q are 5 hours and 3 hours, respectively, while the total production time available is 150 hours. For a total batch size of 40, to maximize profit, the number of units of P to be produced is________.

Solution:

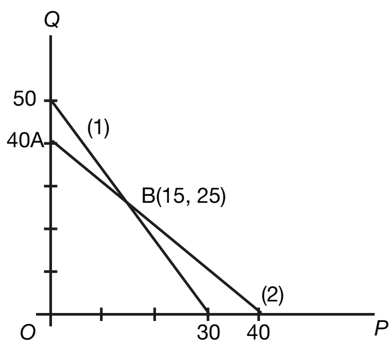
Form the given question

Profit, $Z = 100P + 80Q$

$5P + 3Q \leq 150$ [Time constraint] (i)

$P + Q = 40$ (ii)

Plotting (i) and (ii) on graph



$$Z(0, 0) = 0$$

$$Z(0, 40) = 3200$$

$$Z(15, 25) = 3500 \rightarrow \text{Maximum}$$

$$Z(30, 0) = 3000$$

So, desired quantity of P is 15 and Q is 25.

Hence, the correct answer is (15).

Question Number: 18 **Question Type: NAT**

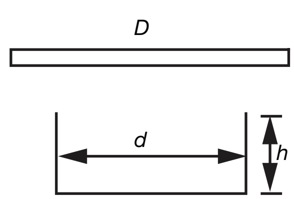
A 10 mm deep cylindrical cup with diameter of 15 mm is drawn from a circular blank. Neglecting the variation in the sheet thickness, the diameter (upto 2 decimal points accuracy) of the blank is___mm.

Solution:

Cup height, $h = 10$ mm

Cup diameter, $d = 15$ mm

Consider the figure given below



We know blank diameter D

$$D = \sqrt{d^2 + 4dh} \text{ mm}$$

$$D = \sqrt{15^2 + 4(15 \times 10)} \text{ mm}$$

$$D = 28.72 \text{ mm}$$

Hence, the correct answer is (28.72 mm).

Question Number: 19 **Question Type: MCQ**

The velocity profile inside the boundary layer for flow over a flat plate is given as $\frac{u}{U_\infty} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$, where U_∞ is the free stream velocity and δ is the local boundary layer thickness. If δ^* is the local displacement thickness, the value of $\frac{\delta^*}{\delta}$ is

(A) $\frac{2}{\pi}$ (B) $1-\frac{2}{\pi}$

(C) $1+\frac{2}{\pi}$ (D) 0

Solution: Boudnary layer thickness = δ

Given,

$$\frac{U}{U_\infty} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$$

Local displacement thickness will be

$$= \delta^+ = \int_0^\delta \left(1 - \frac{U}{U_\infty}\right) dy$$

$$\delta^* = \int_0^\delta \left[1 - \sin\left(\frac{\pi y}{25}\right)\right] dy$$

$$\delta^* = \left[y + \frac{2\delta}{\pi} x \cos\left(\frac{\pi y}{25}\right)\right]_0^\delta$$

$$\delta^* = \left[\delta + 0 - 0 - \frac{2\delta}{\pi}\right]$$

$$\delta^* = \delta\left(1 - \frac{2}{\pi}\right)$$

$$\text{So, } \frac{\delta^*}{\delta} = 1 - \frac{2}{\pi}$$

Hence, the correct option is (B).

Question Number: 20 **Question Type: MCQ**

A parametric curve defined by $x = \cos\left(\frac{\pi u}{2}\right), y = \sin\left(\frac{\pi u}{2}\right)$ in the range $0 \leq u \leq 1$ is rotated about the X-axis by 360 degrees. Area of the surface generated is

(A) $\frac{\pi}{2}$ (B) π

(C) 2π (D) 4π

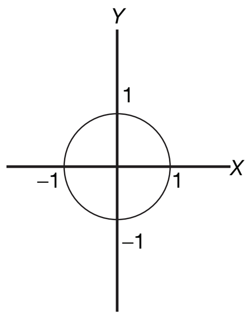
Solution:

$$x = \cos\left(\frac{\pi u}{2}\right)$$

$$y = \sin\left(\frac{\pi u}{2}\right)$$

$$x^2 + y^2 = 1$$

It represents a circle in *x*–*y* plane.



Given $0 \le u \le 1$

So, $0 \le x \le 1$, $0 \le y \le 1$

i.e., $0 \le \theta \le \frac{\pi}{2}$

So, we will get as quarter circle in *x*–*y* plane and by revolving it by 360°, we will get a hemisphere of radius unit. Area of hemisphere = $2\pi(1)^2$

$= 2\pi$

Hence, the correct option is (C).

Question Number: 21 **Question Type: NAT**

A horizontal bar, fixed at one end (x = 0), has alength of 1 m, and cross-sectional area of 100 m^2. Its elastic modulus varies along its length as given by $E(x) = 100e^{-x}$ GPa, where x is the length coordinate (in m) along the axis of the bar. An axial tensile load of 10 kN is applied at the free end (x = 1). The axial displacement of the free end is___mm.

Solution: length, L = 1 m

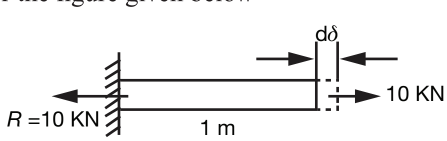
Area, A = 100 mm^2

Elastic modulus, $E(x) = 100e^{-x}$ GPa

Tensile load, P = 10 KN

Reaction, R = 10 KN

Consider the figure given below



So elongation is given by

$$d\delta = \int_0^x \frac{P(x)}{A(x)E(x)}dx$$

here $P(x)$ = constant = 10 KN

$A(x)$ = constant = 100 mm^2

$E(x) = 100e^{-x}$ GPa

$$d\delta = \frac{P}{A}\int_0^x \frac{1}{100e^{-x}}dx$$

$$d\delta = \frac{10\times10^3[e^1 - e^0]}{100\times10^{-6}\times100\times10^9}$$

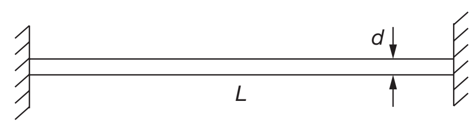
$$d\delta = 1.718\times10^{-3}\text{ m}$$

Axial displacement = $d\delta$ = 1.718 mm

Hence, the correct answer is (1.718).

Question Number: 22 **Question Type: MCQ**

An initially stress-free massless elastic beam of length L and circular cross-section with diameter $d(d << L)$ is held fixed between two walls as shown. The beam material has Young's modulus E and coefficient of thermal expansion α.



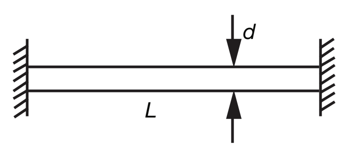
If the beam is slowly and uniformly heated, the temperature rise required to cause the beam to buckle is proportional to

(A) d (B) d2

(C) d3 (D) d4

Solution:

Consider the figure given below



On increasing temperature thermal stress will be

$$\sigma = E\alpha\Delta T$$

Using buckling condition buckling load will be

$$P = \frac{\pi EI_{\text{im}}}{L_{\text{eff}}^2}$$

Here $I_{\min}$ for a circular cross-section

$$= \frac{\pi d^4}{64}$$

Buckoing stress, $\sigma = \frac{P}{A} = \frac{\pi^2 E\pi d^4 \times 4}{L_{\text{eff}}^2 \times 64\times\pi d^2}$

Equating thermal stress and buckling stress

$$E\alpha\Delta T = \frac{\pi^2 E\pi d^2}{16L_{\text{eff}}^2}$$

So, ΔT is directly proportional to d^2

Hence, the correct option is (B).

Question Number: 23 **Question Type: NAT**

Two cutting tools with tool life equations given below are being compared:

Tool 1 : $VT^{0.1} = 150$

Tool 2 : $VT^{0.3} = 300$

where V is cutting speed in m/minute and T is tool life in minutes. The breakdown cutting speed beyond which Tool 2 will have a higher tool life is ___ m/minute.

Solution:

The given tool life equations are

Tool 1,

$$VT^{0.1} = 150 \quad (1)$$

Tool 2,

$$VT^{0.3} = 300 \quad (2)$$

For break even velocity from (1)

$$T = \left(\frac{150}{V}\right)^{10}$$

Substituting the above value in equation (2) we

$$\text{have } V \times \left(\frac{150}{v}\right)^3 = 300$$

$$V = 106.07 \text{ m/s}$$

Hence, the correct answer is (106.07).

Question Number: 24 **Question Type: MCQ**

Two disks A and B with identical mass (m) and radius (R) are initially at rest. They roll down from the top of identical inclined planes without slipping. Disk A has all of its mass concentrated at the rim, while Disk B has its mass uniformly distributed. At the bottom of the plane, the ratio of velocity of the center of disk A to the velocity of the center of disk B is

(A) $\sqrt{\frac{3}{4}}$

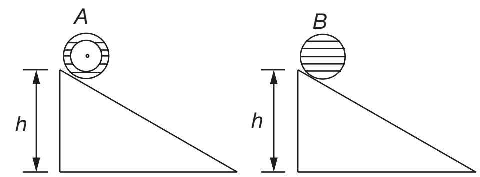
(B) $\sqrt{\frac{3}{2}}$

(C) 1

(D) $\sqrt{2}$

Solution:

Consider the figure given below



Mass of both disks = m

Radius of both disks = R

Initially both have same potential energy finally they will also have same energy.

So,

$$\frac{1}{2} I_A w_A^2 = \frac{1}{2} I_B w_B^2 \quad (1)$$

Where I_A and I_B are moment of inertia about point of contact.

So,

$$I_A = 2\ mR^2$$

$$I_B = \frac{3}{2} mR^2$$

So using equation (1), we get

$$\frac{w_A}{w_B} = \sqrt{\frac{I_B}{I_A}}$$

$$\therefore \frac{w_A}{w_B} = \frac{V_A}{V_B} = \sqrt{\frac{3}{4}}$$

Hence, the correct option is (A).

Question Number: 25 **Question Type: NAT**

For the vector $\vec{V} = 2yz\hat{i} + 3xz\hat{j} + 4xy\,\hat{k}$, the value of $\nabla \cdot (\nabla \times \vec{V})$ is ___.

Solution:

The given vector is

$$\vec{V} = 2yz\hat{i} + 3xz\hat{j} + 4xy\hat{k}$$

$$\nabla \times \vec{V} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 2yz & 3xz & 4xy \end{vmatrix}$$

$$= x\hat{i} - 2y\hat{j} + z\hat{k}$$

$$\nabla(\nabla\times\vec{V}) = \frac{\partial x}{\partial x} + \frac{\partial}{\partial y}(-2y) + \frac{\partial}{\partial z}(z)$$

$$= 1 - 2 + 1$$

$$\nabla(\nabla\times\vec{V}) = 0$$

Also we know that divergence of a curl is always zero.

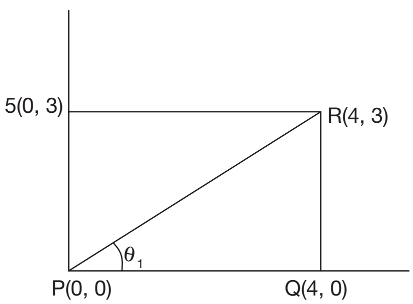
Hence, the correct answer is (0).

Question Number: 26 **Question Type: NAT**

A rectangular region in a solid is in a state of plane strain. The (x, y) coordinates of the corners of the underformed rectangle are given by P(0, 0), Q(4, 0), R(4, 3) S(0.3). The rectangle is subjected to uniform strains, ε_{xx} = 0.001, ε_{yy} = 0.002, γ_{xy} = 0.003. The deformed length of the elongated diagonal, upto three decimal places. is ___ units.

Solution:

Consider the figure given below



From above figure, we get

$$\cos\theta_1 = \frac{4}{5}$$

$$\sin\theta_1 = \frac{3}{5}$$

$$\varepsilon_{xx} = 0.001$$

$$\varepsilon_{yy} = 0.002$$

$$\gamma_{xy} = 0.003$$

$$\frac{\Delta PR}{PR} = \varepsilon_1(\text{along } PR)$$

$$= \varepsilon_{xx}\cos^2\theta_1 + \varepsilon_{yy}\sin\theta_1 + \gamma_{yy}\sin\theta_1\cos\theta_1$$

$$\Rightarrow \frac{\Delta PR}{PR} = \frac{7}{2500}\text{ mm}$$

$$\Rightarrow \Delta PR = 0.014 \text{ mm}$$

Length of elongated diagonal = $PR + DPR$

= 5.014 mm

Hence, the correct answer is (5.014 mm).

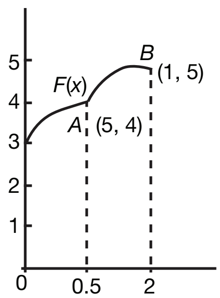
Question Number: 27 **Question Type: MCQ**

P(0, 3), Q(0.5. 4), and R(1, 5) are three points on the curve defined by $f(x)$. Numerical integration is carried out using both Trapezoidal rule and Simpson's rule within limits x = 0 and x = 1 for the curve. The difference between the two results will be

(A) 0 (B) 0.25
(C) 0.5 (D) 1

Solution:

Consider the figure given below



Using β trapezoidal rule, we get

$$\int_a^h f(x)dx = \frac{h}{2}\left[\left(y_0 + y_n\right) + 2(y_1 + y_2 + \ldots)\right]$$

$$= \frac{1}{2}\times(3+4)\times 0.5 + \frac{1}{2}\times(4+5)\times 0.5$$

Using simpson 1/3rd rule we get

$$\int_a^b f(x)dx = \frac{h}{3}\left[\left(y_0 + y_n\right) + 4(y_1 + y_3 + \ldots) + 2(y_2 + y_a + \ldots)\right]$$

$$= \frac{0.5}{3}\times[(3+5) + 4\times 4]$$

$$= 4$$

Difference between result = 4 – 4 = 0

Hence, the correct option is (A).

Question Number: 28 **Question Type: NAT**

Air contains 79% to N_2 and 21% O_2 on a molar basis. Methane (CH_4) is burned with 50% excess air than required stoichiometrically. Assuming complete combustion of methane, the molar percentage of N_2 in the products is ____.

Solution:

The combustion of m ethane is

$CH_4 + 1.5 \times 2(O_2 + 3.76N_2) \rightarrow CO_2 + 2H_2O + O_2 + 3 \times 3.76N_2$

∴ % of N_2 is product

$$= \frac{3\times 3.76}{3\times 3.76+1+2+1}\times 100$$
$$= 73.821\%$$

Hence, the correct answer is (73.821).

Question Number: 29 **Question Type: NAT**

Moist air is treated as an ideal gas mixture of water vapor and dry air (molecular weight of air = 28.84 and molecular weight of water = 18). At a location, the total pressure is 100 kPa, the temperature is 30°C and the relative humidity is 55%. Given that the saturation pressure of water at 30°C is 4246 Pa, the mass of water vapor per kg of dry air is___ grams.

Solution:

Relative humidity, $\phi = 55\%$

Total pressure, $P = 100$ kPa

Temperature, $T = 30°C$

Saturation pressure of water, $P_{VS} = 4246$ Pa

P_V = Vapour pressure

We know that Relative humidity,

$$\phi = \frac{Pv}{Pvs}$$

where

Vapour pressure at saturated is P_{VS}

$$\text{So, } 0.55 = \frac{Pv}{4246}$$
$$P_V = 2335.5 \text{ Pa}$$

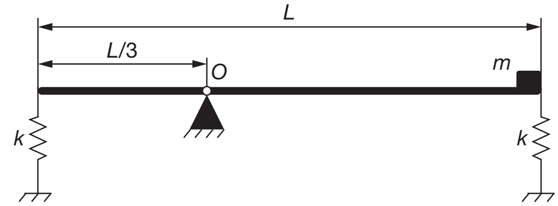
Mass of water vapour per kg of dry air is called specific humidity and given by

$$w = \frac{0.622Pv}{P-P_V}$$
$$\omega = \frac{0.622P_V \times 2335.3}{\left[(100\times 10^3)-2335.3\right]}$$
$$\omega = 14.872 \text{ gm per kg of dry air}$$

Hence, the correct answer is (14.872).

Question Number: 30 **Question Type: MCQ**

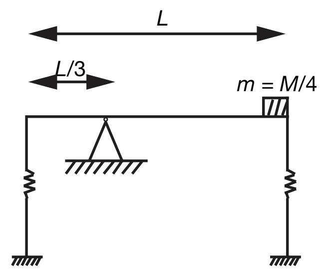
A thin uniform rigid bnar of length L and mass M is hinged at point O, located at a distance of $\frac{L}{3}$ from one of its ends. The bar is further supported using springs, each of stiffness k, located at the two ends. A particle of mass $m = \frac{M}{4}$ is fixed at one end of the bar, as shown in the figure. For small rotations of the bar about O, the natural frequencyof the system is



(A) $\sqrt{\frac{5K}{M}}$ (B) $\sqrt{\frac{5K}{2M}}$

(C) $\sqrt{\frac{3K}{2M}}$ (D) $\sqrt{\frac{3K}{M}}$

Solution:



Mass moment of inertia about O,

$$I = \frac{Ml^2}{12} + M\left(\frac{l}{2}-\frac{l}{3}\right)^2 + m\times\left(\frac{2l}{3}\right)^2$$
$$= \frac{Ml^2}{12}+\frac{Ml^2}{36}+\frac{4ml^2}{9}$$
$$= \frac{Ml^2}{9}+\frac{4Ml^2}{4\times 9}$$
$$= \frac{2Ml^2}{9}$$

Now balancing torque about 0, we get

$$I\alpha = K\times\frac{2L}{3}\times\left(\frac{2L}{3}\theta\right)+K\times\frac{L}{3}\times\left(\frac{L}{3}\theta\right)$$
$$\Rightarrow \frac{2Ml^2}{9}\frac{d^2\theta}{dt} = \frac{5K}{2M} = \omega_n^2\theta$$
$$\therefore \omega_n = \sqrt{\frac{5K}{2M}}$$

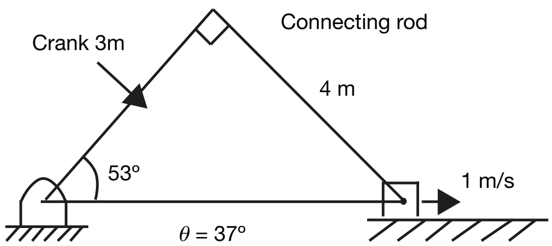
Question Number: 31 **Question Type: NAT**

For an inline slider-crank mechanism, the lengths of the crank and connecting rod are 3 m and 4 m, respectively. At the instant when the connecting rod is perpendicular to the crank, if the velocity of the slider is 1 m/s, the magnitude of angular velocity (upto 3 decimal points accuracy) of the crank is ___ radian/s.

Solution:

Length of crank = 3 m

Length of connecting rod = 4 m



From the above figure, we get

$$V_{\text{connecting rod}} = 1\cos\theta = \frac{4}{5}\text{ m/s}$$

$$V_{\text{connecting rod}} = \omega_{\text{crank}} \times r$$

$$\Rightarrow \frac{4}{5} = \omega_{\text{crank}} \times 3$$

$$\Rightarrow \omega_{\text{crank}} \frac{4}{5} = 0.266 \text{ rad/s}$$

Hence, the correct answer is (0.266).

Question Number: 32 **Question Type: MCQ**

Consider steady flow of an incompressible fluid through two long and straight pipes of diameters d_1 and d_2 arranged in series. Both pipes are of equal length and the flow is turbulent in both pipes. The friction factor for turbulent flow though pipes is of the form, $f = K(\text{Re})^{-n}$, where K and p are known positive constants and Re is the Reynolds number. Neglecting minor losses, the ratio of the frictional pressure drop in pipe 1 to that in pipe 2 $\left(\frac{\Delta P_1}{\Delta P_2}\right)$, is given by

(A) $\left(\frac{d_2}{d_1}\right)^{(5-n)}$ (B) $\left(\frac{d_2}{d_1}\right)^{5}$

(C) $\left(\frac{d_2}{d_1}\right)^{(3-n)}$ (D) $\left(\frac{d_2}{d_1}\right)^{(5+n)}$

Solution:

The friction factor for turbulent flow though pipes is of the form,

$$f = K(\text{Re})^{-n}$$

Now we know that

$$\frac{\Delta P_1}{\Delta P_2} = \frac{\rho g h_{f1}}{\rho g h_{f2}} = \frac{h_{f1}}{h_{f2}}$$

$$= \frac{\frac{f_1 l V_1^2}{2gd_1}}{\frac{f_2 l V_2^2}{2gd_2}}$$

$$= \frac{\frac{f_1 Q^2}{d_1^5}}{\frac{f_2 Q^2}{d_2^5}}$$

$$= \left(\frac{d_2}{d_1}\right)^5 \times \frac{K \times \left(\frac{\rho V d_1}{\mu}\right)^{-n}}{K \times \left(\frac{\rho V d_2}{\mu}\right)^{-n}}$$

$$[f = KR_e^{-n}]$$

$$= \frac{d_2^5}{d_1^5} \times \frac{d_1^n}{d_2^n}$$

$$= \left(\frac{d_2}{d_1}\right)^{5-n}$$

Hence, the correct option is (A).

Question Number: 33 **Question Type: NAT**

One kg of an ideal gas (gas constant, $R = 400$ J/kg.K: specific heat at constant volume, $c_v = 1000$ J/kg.K) at 1 bar, and 300 K is contained in a sealed rigid cylinder. During an adiabatic process, 100 kJ of work is done on the system by a stirrer. The increase in entropy of the system is ____ J/K.

Solution:

Mass, $m = 1$ Kg

Gas constant, $R = 400$ J KgK

Specific heat at constant volume, C_V=1000 J KgK

Temperature, $T_1 = 300$ K

Work done during adiabatic process, $W = 100$ KJ

Rigid cylinder, adiabatic process

Applying first law of thermodynamics

$$dQ = dU + dW$$

[$\because$ $dQ = 0$ adiabatic and $dU = MC_V dT$ for constant volume]

$$V\, mC_V dT = dW$$

$$dT = \frac{100 \times 10^3}{1 \times 1000}$$
$$dT = 100$$
$$T_2 = T_1 + dT = 400 \text{ K}$$

For ideal gas

$$S_2 - S_1 = mC_V \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}$$
$$[\because V_2 = V_1 \text{ rigid cylinder}]$$
$$S_2 - S_1 = m \times 1000 \times \ln\left(\frac{400}{300}\right) + 0$$
$$(\Delta S)_{\text{system}} = S_2 - S_1 = 287.68 \text{ J/K}$$

Hence, the correct answer is (287.68).

Question Number: 34 **Question Type: NAT**

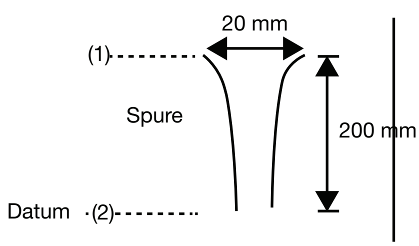
A sprue in a sand mould has a top diameter of 20 mm and height of 200 mm. The velocity of the molten metal at entry of the sprue is 0.5 m/s. Assume acceleration due to gravity as 9.8 m/s^2 and neglect all losses. If the mould is well ventilated the velocity (upto 3 decimal points accuracy) of the molten metal at the bottom of the sprue is ____m/s.

Solution:

Velocity of the molten metal at entry of the sprue V_1 = 0.5 m/s

Height h_1 = 200 mm

Height h_2 = 0



Applying bernaulli's equation between (1) and (2).

$P_1 = P_2 = P$ atm.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + h_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_2$$

V_2 = 2.042 m/s

Hence, the correct answer is (2.042).

Question Number: 35 **Question Type: NAT**

A block of length 200 mm is machined by a slab milling cutter 34 mm in diameter. The depth of cut and table feed are set at 2 mm and 18 mm/minute, respectively. Considering the approach and the over travel of the cutter to be same, the minimum estimated machining time per pass in___minutes.

Solution:

Block length = 200 mm

Diameter of slab milling cutter, D = 34 mm

Depth of cut, d = 2 mm

Approach = over travel

$$= \sqrt{d(D-d)}$$
$$= \sqrt{2 \times (34-2)}$$
$$= 8 \text{ mm}$$

Estimated machine time per pass

= Block length+ Approach + Over travel table feed

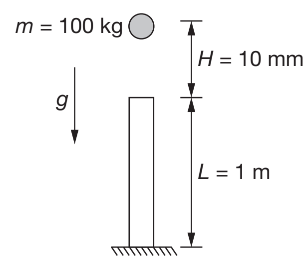
$$= \frac{200+8+8}{18} \text{ minute}$$

=12 minute

Hence, the correct answer is (12).

Question Number: 36 **Question Type: NAT**

A point mass of 100 kg is dropped onto a massless elastic bar (cross-sectional area = 100 mm^2, length = 1 m, Young's modulus = 100 GPa) from a height H of 10 mm as shown (figure is not to scale). If g = 10 m/s^2, the maximum compression of the elastic bar is___mm.



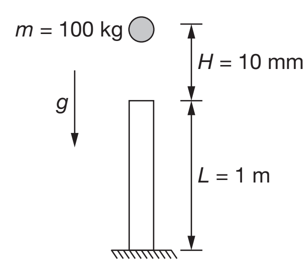
Solution:

Mass m = 100 kg

Cross-sectional area = 100 mm^2,

Length = 1 m,

Young's modulus = 100 GPa



$$mg(h+x) = \frac{1}{2} K_{\text{bar}} x^2$$

[By energy conserved]

$$K_{bar} = \frac{EA}{L}$$
$$= \frac{100\times10^9\times100\times10^{-6}}{1}\ \text{N/m}$$
$$= 10^7\ \text{N/m}$$

Solving quadratic equation in, x we get

$$x = 1.317 \text{ mm}$$

Hence, the correct answer is (1.517 mm).

Question Number: 37 **Question Type: NAT**

Following data refers to the jobs (P, Q, R, S) which have arrived at a machine for scheduling. The shortest possible average flow time is ___ days.

Job	Processing Time (days)
P	15
Q	9
R	22
S	12

Solution:

According to shortest possible time sequencing the job sequence will be

$Q\rightarrow S\rightarrow P\rightarrow R$

Job Processing Job flow time

Q	9	9
S	12	21
P	15	36
R	22	58

Total job flow time = 124

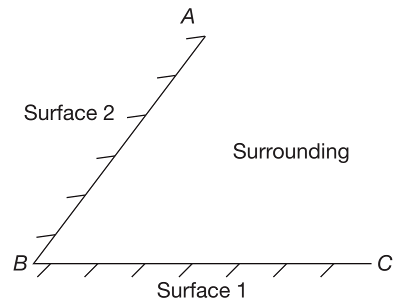
Average job flow time = Total job flow time no of jobs

$$= \frac{124}{4}$$
$$= 31 \text{ days}$$

Hence, the correct answer is (31).

Question Number: 38 **Question Type: NAT**

Two black surfaces, AB and BC, of lengths 5 m and 6 m, respectively, are oriented as shown. Both surfaces extend infinitely into the third dimension. Given that view factor F_{12} = 0.5, T_1 = 800 K. T_2 = 600 K, $T_{surrounding}$ = 300 K and Stefan Boltzmann constant, $\sigma = 5.64 \times 10^{-8}$ W/(m^2K^4), the heat transfer rate from Surface 2 to the surrounding environment is ___kW.



Solution:

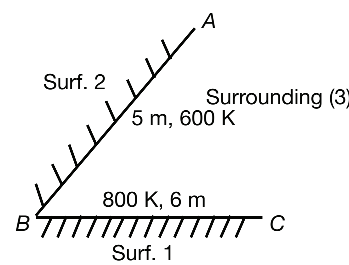
View factor, F_{12} = 0.5,

Temperature, T_1 = 800 K.

Temperature, T_2 = 600 K,

Temperature, $T_{surrounding}$ = 300 K

Stefan Boltzmann constant, $\sigma = 5.64 \times 10^{-8}$ W/(m^2K^4)



From the above figure

$$AB = 5 \text{ m}$$
$$BC = 6 \text{ m}$$
$$F_{12} = 0.5$$
$$A_1F_{12} = A_2F_{21} \text{ [Reciprocity relation]}$$
$$\Rightarrow (2 \times 6) \times 0.5 = (L \times 5) \times F_{21}$$
$$\Rightarrow F_{21} = 0.6$$
$$F_{21} + F_{22} + F_{23} = 1$$
$$\Rightarrow 0.6 + 0 + F_{23} = 1$$
$$\Rightarrow F_{23} = 0.4$$

Heat transfer rate from surface to surrounding can be calculated as

$$q_{1-2} = F_{23}\sigma A_2(T_2^4 - T_{surr}^4)$$
$$= 0.4\times(5.67\times10^{-8})\times(5\times1)\times(600^4 - 300^4)\text{W}$$
$$= 13.778 \text{ KW}$$

Hence, the correct answer is (14.696).

Question Number: 39 **Question Type: NAT**

Heat is generated uniformly in a long solid cylindrical rod (diameter = 10 mm) at the rate of 4×10^7 W/m^3. the thermal conductivity of the rod material is 25 W/mK. Under steady state conditions, the temperature difference between the centre and the surface of the rod is ___°C.

Solution:

Rate of heat generation $q_g = 4 \times 10^7$ W/m^3

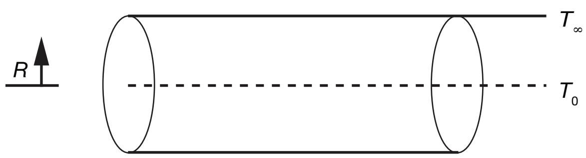
Thermal conductivity, $K = 25$ WmK

Cylindrical rod dia = 10 mm

Temperature distribution in a cylindrical rod with uniform heat generation under steady state is given by

$$T_0 - T_\infty = \frac{qgR^2}{4K}\left(1-\left(\frac{r}{R}\right)^2\right)$$

[$T_0 \rightarrow$ Centre temperature]



For $T = T_0 = T_{\text{centre}}$ means $r = 0$

$$\text{So, } T_0 - T_\infty = \frac{q_g R^2}{4K}$$

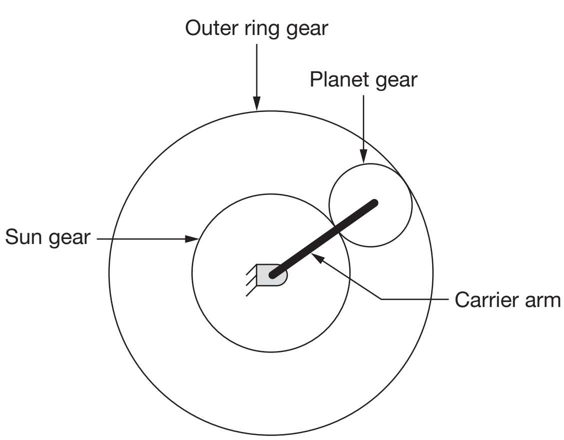
$$T_0 - T_{\text{wall}} = \frac{4\times 10^7 \times (0.005)^2}{4\times 25}$$

$$T_{\text{centre}} - T_{\text{wall}} = 10$$

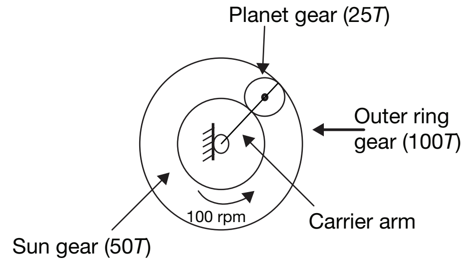
Hence, the correct answer is (10).

Question Number: 40 **Question Type: NAT**

In an epicyclic gear train, shown in the figure, the outer ring gear is fixed, while the sun gear rotates counterclockwise at 100 rpm. Let the number of teeth on the sun, planet and outer gears to be 50, 25, and 100, respectively. The ratio of magnitudes of angular velocity of the planet gear to the angular velocity of the carrier arm is ___.



Solution:



	Sun (S)	Planet (P)	Outer ring
Wihtout (orpm) arm	X	$-x\times\frac{50}{25}=-2x$	$-x\times\frac{50}{25}\times\frac{25}{100}=\frac{-x}{2}$
Witharm (y rpm)	$x + y = 100$	$-2x + y$	$-\frac{x}{2}+y=0$

$$x + y = 100 \quad (1)$$

$$-\frac{x}{2} + y = 0 \quad (2)$$

Eqn. (1) and (2), we get

$$\frac{3x}{2} = 100$$

$$\Rightarrow x = \frac{200}{3}$$

$$y = \frac{100}{3}$$

ω_p, (Angular vel. of plant gear) = $-2x + y$

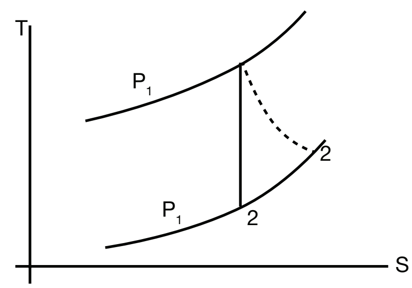
$$= \frac{-400}{3} + \frac{100}{3} = -100$$

$$\frac{|\omega_p|}{|\omega_{\text{arm}}|} = \frac{|-100|}{\left|\frac{100}{3}\right|} = 3$$

Question Number: 41 **Question Type: NAT**

The pressure ratio across a gas turbine (for air, specific heat of constant pressure, $cp = 1040$ J/kg. K and ratio of specific heats, γ=1.4 is 10. If the inelt temperature to the turbine is 1200 K and the isentropic efficiency is 09, the gas temperature at turbine exit is ___K.

Solution:



$$\frac{P_1}{P_2} = 10$$

$$C_p = 1040 \text{ J/kg}$$

$$Y = 1.4$$

$$T_1 = 1200 \text{ K}$$

$$\eta_{\text{isentropic}} = 0.9$$

For process 1 – 2, we have

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\therefore T_2 = 1200\left(\frac{1}{10}\right)^{0.4/1.4}$$

$$T_2 = 621.54 \text{ K}$$

Now, we know

$$\eta_{\text{isentropic}} = \frac{T_1 - T_2'}{T_1 - T_2}$$

$$0.9 = \frac{1200 - T_2'}{1200 - 621.54}$$

$$T_2' = 679.38 \text{ K}$$

Hence, the correct answer is (679.38).

Question Number: 42 **Question Type: MCQ**

Consider the matrix $P = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{-1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$

Which one of the following statements about P is INCORRECT?

(A) Determinant of P is equal to 1.
(B) P is orthogonal
(C) Inverse of P is equal to its transpose.
(D) All eigenvalues of P are real numbers

Solution:

$$P = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{-1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$$

(i) $|P| = 1$

(ii) $P = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{-1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$

$$P.P^T = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{-1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}\begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{-1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = I$$

Hence P is orthogonal as $P.P^T = I$

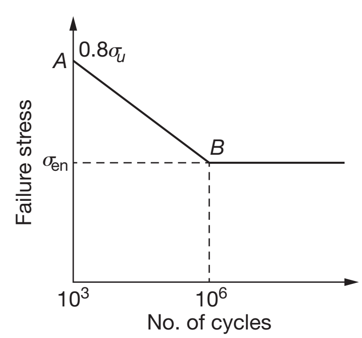
(iii) $P^{-1} = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{-1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{-1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix} = P^T$

Hence (iv) is wrong.

Hence, the correct option is (D).

Question Number: 43 **Question Type: NAT**

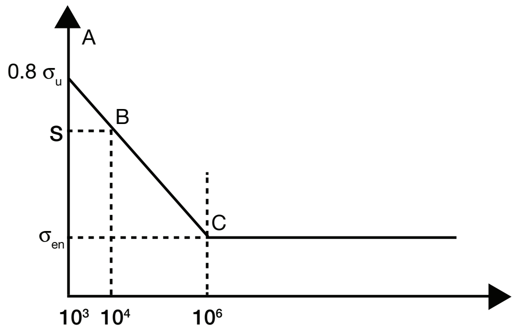
A machine element has an ultimate strength (σ_u) of 600 N/mm^2, and endurnace limit (σ_{en}) of 250 N/mm^2. The fatigue curve for the element on a log-log plot is shown below. If the element is to be designed for a finite life of 10000 cycles, the maximum amplitude of a completely reversed operating stress is ___ N/mm^2.



Solution:

Ultimate strength (σ_u) of 600 N/mm^2,

Endurnace limit (σ_{en}) of 250 N/mm^2



Coordinates of points are :

$A \rightarrow A \rightarrow$ (log $(0.8\sigma_u)$, 3)

$B \rightarrow$(log$S$, 4)

$C \rightarrow$(log σ_{en}, 6)

Equating slope of ine-segment A-B-C

$$\frac{\log(0.8\sigma_u) - \log S}{3-4} = \frac{\log(0.8\sigma_u) - \log(\sigma_{en})}{3-6}$$

$$\Rightarrow \log S = \log(0.8\sigma_u) - \frac{\log(0.8\sigma_u) - \log(\sigma_n)}{3}$$

$$\Rightarrow S = 386.34$$

Hence, the correct answer is (386.19 MPa).

Question Number: 44 **Question Type: MCQ**

Assume that the surface roughness profile is triangular as shown schematically in the figure. If the peak to valley height is 20 μm, the central line average surface roughness Ra (in mm) is

(A) 5 (B) 6.67
(C) 10 (D) 20

Solution:

Average surface roughness,

$$R_a = Z_1 + Z_2 \_\_\_\_ + \frac{Z_n}{n}$$

$$= \frac{h}{4}$$

$$= \frac{20}{4}$$

$$= 5 \text{ mm}$$

Hence, the correct option is (A).

Question Number: 45 **Question Type: MCQ**

Circular arc on a part profile is being machined on a vertical CNC milling machine, CNC part program using metric units with absolute dimensins is listed below:

N60 G01 X 30 Y 55 Z-5 F50

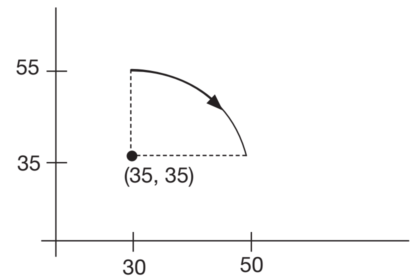
N70 G02 X 50 Y 35 R 20

N80 G01 Z 5

The coordinates of the centre of the circular arc are:

(A) (30, 55) (B) (50, 55)
(C) (50, 35) (D) (30, 35)

Solution:



Two possible centre are (30, 35) $\rightarrow$ For $R \rightarrow$ +ve $\rightarrow$ (50, 55) $\rightarrow$ for $R \rightarrow$ –ve.

Hence, the correct option is (D).

Question Number: 46 **Question Type: MCQ**

A particle of unit mass is moving on a plane. Its trajectory in polar coordinates is given by 2 $r(t) = t^2, \phi(t) = t$ where t is time. The kinetic of the particle at time t = 2 is

(A) 4 (B) 12 (C) 16 (D) 24

Solution:

$$\frac{dr}{dt} = V = 2t = 2 \times 2 \text{ for } t = 2$$

$$= 4$$

$$r(t) = t^2$$

$$r(2) = (2) \times 2 = 4$$

$$\frac{d\theta}{dt} = \omega = \frac{dt}{dt} = 1$$

So, $$K,E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$I = mr^2 = 1 \times 4 \Big| \text{ at } t = 2$$

So, $$K,E = \frac{1}{2} \times 1(4)^2 + \frac{1}{2} 1 \times (4)^2 \times 1$$

$$= 16$$

Hence, the correct option is (C).

Question Number: 47 **Question Type: MCQ**

Cylindrical pins of diameter $15^{\pm 0.020}$ mm are being produced on a machine. Statistical quality control tests show a mean of 14.995 mm and standard deviation of 0.04 mm. The process capability index C_p is

(A) 0.833 (B) 1.667
(C) 3.333 (D) 3.750

Solution:

The process capability index can be calculated as

$$C_p = \frac{USL - LSL}{6\sigma}$$
$$= \frac{15.02 - 14.98}{6 \times 0.004}$$
$$= 1.667$$

Hence, the correct option is (B).

Question Number: 48 **Question Type: MCQ**

Which one of the following is NOT a rotating machine?

(A) Centrifugal pump (B) Gear pump
(C) Jet pump (D) Vane pump

Solution:

Centrifugal pump has rotating part, e.g., impeller, Vane.

In Gear Pump there is gear mechanism which is rotating part.

In Jet Pump the pump utilizing ejecter principle which have nozzle and difusses not rotating parts.

Vane Pump consist of rotating disc which called as rotor in which number of radial slots are there where sliding vanes is inserted

Hence, the correct option is (C).

Question Number: 49 **Question Type: NAT**

A six-face fair dice is rolled a large number of times. The mean value of the outcomes is ____.4. A six-face fair dice is rolled a large number of times. The mean value of the outcomes is ____.

Solution:

$$\text{Mean outcome} = \sum_{i=1}^{6} n_i p_i$$
$$= \frac{1+2+3+4+5+6}{6}\left[p_i = \frac{1}{6}\right]$$
$$= 3.5$$

Hence, the correct answer is (3.5).

Question Number: 50 **Question Type: MCQ**

In an arc welding process, welding speed is doubled. Assuming all other process parameters to be constant, the cross sectional area of the weld bead will

(A) increase by 25%
(B) increase by 50%
(C) reduce by 25%
(D) reduce by 50%

Solution:

Since, all process parameter are constant Material deposition rate = constant

= Area of weld (A_w) × welding speed (V_w)

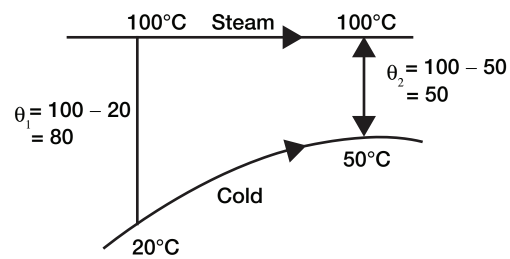
$$\because V_w' = 2V_w$$
$$\because A_w' = A_w \times \frac{V_w}{V_w'} = \frac{A_w}{2}$$
$$\%\,\text{change} = \frac{A_w' - A_w}{A_w} \times 100 = -50\%$$

Hence, the correct option is (D).

Question Number: 51 **Question Type: NAT**

Saturated steam at 100°C condenses on the outside of a tube. Cold fluid enters the tube at 20°C and exits at 50°C. The value of the Log Mean Temperature Difference (LMTD) is _____°C.

Solution:



Log Mean Temperature Difference can be calculated as

$$(\Delta T_m) = \frac{\theta_1 - \theta_2}{\ln\left(\dfrac{\Delta\theta_1}{\Delta\theta_2}\right)}$$

For parallel as well as counter flow heat exchanger.

Considering it as parallel flour heat exchanger.

$$\Delta T_i = 100 - 20 = 80°C$$
$$\Delta T_e = 100 - 50 = 50°C$$
$$(\Delta T_m) = \frac{80 - 50}{\ln\left(\dfrac{80}{50}\right)}$$
$$(\Delta T_m) = 63.82°C$$

Hence, the correct answer is (63.82°C).

Question Number: 52 **Question Type: MCQ**

The damping ratio for a viscously damped spring mass system, governed by the relationship $m\frac{d^2x}{dt^2} + c\frac{dx}{dt^2} + kx = F(t)$, is given by

(A) $\sqrt{\dfrac{c}{mk}}$ (B) $\dfrac{c}{2\sqrt{km}}$

(C) $\dfrac{c}{\sqrt{km}}$ (D) $\sqrt{\dfrac{c}{2mk}}$

Solution:

The damping ratio for a viscously damped spring mass system is

$$\frac{md^2x}{dt^2}+\frac{Cdx}{dt}+kx=F(t)$$

or, $m\ddot{x}+c\ddot{x}+kx=0$

(By considering sum of the inertia force and external forces on a body in a direction in to be zero)

or, $k=Ae^{\alpha t}+Be^{\alpha t}$

i.e., $\alpha^2+\dfrac{c}{m}\alpha^2+\dfrac{k}{m}=0$

$$\alpha_{1,2}=\frac{C}{2m}+\sqrt{\left(\frac{C}{2m}\right)^2-\left(\frac{k}{m}\right)}$$

The ratio of $\left(\dfrac{C}{2m}\right)^2$ to $\dfrac{s}{m}$ gives the degree of dumpness and square root of those termed as damping ratio.

$$\varepsilon=\sqrt{\frac{\left(\frac{C}{2m}\right)^2}{\frac{k}{m}}}=\frac{C}{2\sqrt{km}}$$

$$\frac{T}{J}=\frac{T_{max}}{r_a}$$

Hence, the correct option is (B).

Question Number: 53 **Question Type: NAT**

A motor driving a solid circular steel shaft transmits 40 kW of power at 500 rpm. If the diameter of the shaft is 40mm, the maximum shear stress in the shaft is ___MPa.

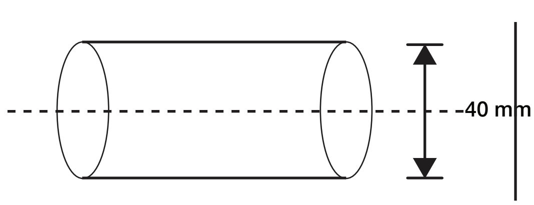
Solution:

Power transmitted, P 40 KW

Speed of shaft, $N = 500$ rpm

Diameter, $a = 40$ mm

Consider the figure given below



We know that

$$P=\frac{2\pi NT}{60}\text{[Where } T\text{-Torque]}$$

So, $T=\dfrac{60P}{2\pi N}$

$$T=\frac{60\times 40\times 10^3}{2\times\pi\times 500}\text{ N-m}$$

$$T = 763.44 \text{ N-m}$$

Maximum shear stress after applying Torque, T will be at a distance d/2 from neutral axis and will be given by

$$\frac{T}{J}=\frac{\tau_{max}}{r_{max}}$$

[Where T_{min} = Shear Stress J = Polar moment of inertia rmax = d/2

$$\tau_{max}\ \frac{T\times d\times 32}{\pi d^4\times 2}$$

$$\tau_{min}=60.792 \text{ MPa}$$

Hence, the correct answer is (60.792 MPa).

Question Number: 54 **Question Type: MCQ**

Consider the following partial differential equation $u(x, y)$ with the constant $c > 1$:

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

Solution of this equation is

(A) $u(x, y) = f(x + cy)$ (B) $u(x, y) = f(x - cy)$

(C) $u(x, y) = f(cx + y)$ (D) $u(x, y) = f(cx - y)$

Solution:

Let $u = f(ax + by)$

$$\therefore \frac{\partial u}{\partial(ax+by)}=f'(ax+by)$$

Now $\dfrac{\partial u}{\partial y}+C\dfrac{\partial u}{\partial x}=0$

$$\frac{\partial u}{\partial(ax+by)}\times\frac{\partial(ax+by)}{\partial y}+C\frac{du}{\partial(ax+by)}\times\frac{\partial(ax+by)}{\partial x}$$

$= 0$

$\Rightarrow b+c\times a=0$

$\Rightarrow b=-ac$

If $a=1$

$b=-c$

$\therefore\ u=f(1x-cy)$

$=f(1x-cy)$

Hence, the correct option is (B).

Question Number: 55 **Question Type: MCQ**

Consider the two-dimensional velocity field given by $\vec{V} = (5 + a_1x + b_1y)i + (4 + a_2x + b_2y)j$. where a_1,b_1a_2 and b_2 are constants. Which one of the following conditions needs to be satisfied for the flow to be incompressible?

(A) $a_1 + b_1 = 0$ (B) $a_1 + b_2 = 0$
(C) $a_2 + b_2 = 0$ (D) $a_2 + b_2 = 0$

Solution:

Two-dimensional velocity field

$$\vec{V} = (5 + a_1x + b_1y)i + (\overline{4} + a_2x + b_2y)j$$
$$= u_i + V_j$$

For, incompressible flow,

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$
$$a_1 + b_2 = 0$$

Hence, the correct option is (B).

Question Number: 56 **Question Type: MCQ**

The product of eignvalues of the matrix P is

$$P = \begin{bmatrix} 2 & 0 & 1 \\ 4 & -3 & 3 \\ 0 & 2 & -1 \end{bmatrix}$$

(A) –6 (B) 2
(C) 6 (D) –2

Solution:

Product of eigen value = $|P|$

$$\begin{bmatrix} 2 & 0 & 1 \\ 4 & -3 & 3 \\ 0 & 2 & -1 \end{bmatrix}$$
$$= 2\,(3 - 6) + 1\,(8 - 0)$$
$$= 2$$

Hence, the correct option is (B).

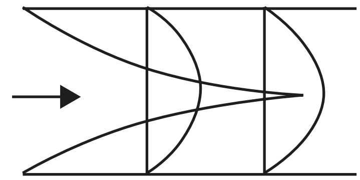
Question Number: 57 **Question Type: MCQ**

For steady flow of a viscous incompressible fluid through a circular pipe of constant diameter, the average velocity in the fully developed region is constant. Which one of the folloiwng statements about the average velocityin the developing region is TRUE?

(A) It increases until the flow is fully developed.
(B) It is constant and is equal to the average velocity in the fully developed region.
(C) It decreases until the flow is fully developed
(D) It is constant but is always lower than the average velocity in the fully developed region.

Solution:

Consider the figure given below



Retardation goes on increasing as the distance from leading edge increases, and hence average velocity goes on decreasing.

Hence, the correct option is (C).

Question Number: 58 **Question Type: MCQ**

The Poisson's rati for a perfectly incompressible linear elastic material is

(A) 1 (B) 0.5
(C) 0 (D) infinity

Solution:

Volumetric strain for linear elastic material,

$$\varepsilon_v = \frac{\Delta V}{V} = \frac{(1 - 2\mu)}{E}(\sigma_x + \sigma_y + \sigma_z)$$

For incompressible flow

$$\Delta V = 0$$
$$\therefore\ 1 - 2\,\mu = 0$$
$$\Rightarrow \mu = 0.5$$

Hence, the correct option is (B).

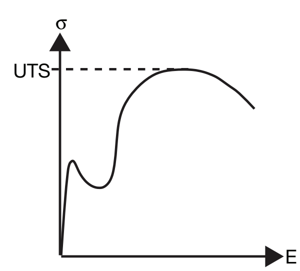
Question Number: 59 **Question Type: MCQ**

In the engineering stress-strain curve for mild steel, the Ultimate Tensile Strength (UTS) refers to

(A) Yield stress (B) Proportional limit
(C) Maximum stress (D) Fracture stress

Solution:

stress-strain curve for mild steel is shown below



Hence, the correct option is (C).

Question Number: 60 **Question Type: NAT**

The molar specific heat at constant volume of an ideal gas is equal to 2.5 times the universal gas constant (8.314 J/mol.K).

When the temperature increases by 100 K, the change in molar specific enthalpy is _____J/mol.

Solution:

We know that specific enthalpy can be calculated by relation

$$\Delta h = C_P\, \Delta T$$
$$= (C_V + R)\Delta R$$
$$= (2.5R + R)\ \Delta T$$
$$= 3.5 \times 8.314 \times 100 \text{ J/mol}$$
$$= 2909.9$$

Hence, the correct answer is (2909.9 J/mol).

Question Number: 61 **Question Type: NAT**

A heat pump absorbs 10 kW of heat from outside environment at 250 K while absorbing 15 kW of work. It delivers the heat to a room that must be kept warm at 300 K. The Coefficient of Performance (COP) of the heat pump is _____.

Solution:

The Coefficient of Performance can be calculated as

C.O.P = Head delivered to room work input

$$= \frac{25 \text{ Kw}}{15 \text{ Kw}} = 1.67$$

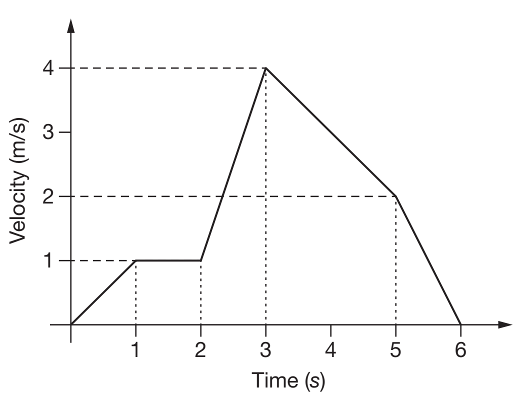
Here,

Heat delivered = Heat taken + work input

Hence, the correct answer is (1.67).

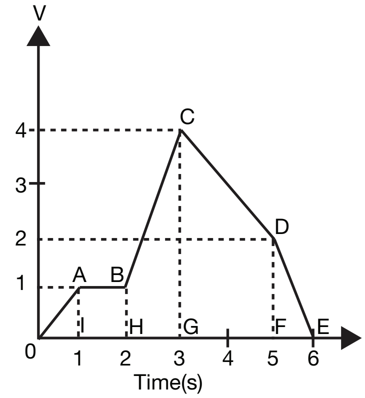
Question Number: 62 **Question Type: MCQ**

The following figure shows the velocity-time plot for a particle travelling along a straight line. The distance covered by the particle from $t = 0$ to $5 = 5$ s is ___m.



Solution:

Since, $\frac{D}{t} = V$



Distance covered

= Area under the curve from $t = 0$ to $t = 5$ sec.

= Ar[ΔAOI + □$ABHI$ + Trapezoidal $BCGH$ + Trapezoidal CDFG}

$$= \frac{1}{2}\times 1\times 1 + 1\times(2-1) + \frac{1}{2}\times(1+4)\times(3-2)$$
$$+ \frac{1}{2}\times(4+2)\times(5-3)$$
$$= 10$$

Hence, the correct answer is (10).

Question Number: 63 **Question Type: MCQ**

The differential equation $\frac{d^2y}{dx^2} + 16y = 0$ for $y(x)$ with the two boundary conditions $\left.\frac{dy}{dx}\right|_{x=0} = 1$ and $\left.\frac{dy}{dx}\right|_{x=\frac{x}{2}} = -1$ has

(A) no solution
(B) exactly two solutions
(C) exactly one solution
(D) infinitely many solutions

Solution:

$$\frac{d^2y}{dx^2} + 16y = 0$$
$$(D^2 + 16)y = 0$$

Let $D^2 = m^2$

$m^2 + 16 = 0$ (this is a complex equation)

$m = \pm 4i - 0 \pm 4i$

$y = (C_1 \cos 4x + C_2 \sin 4x)\, e^{ox}$

$\Rightarrow y = C_1 \cos 4x + C_2 \sin 4x$

$\Rightarrow y' = -4C_1 \sin 4x + 4C_2 \cos 4x$

$y'(0) = 4C_2 = 1$

$$C_2 = \frac{1}{4}$$

$$y'(0) = \left(\frac{\pi}{2}\right) = -1 = -4C_1 \sin 2\pi + 4C_2 \cos 2\pi$$

$$-1 = 4C_2$$

$$C_2 = \frac{1}{4}$$

Hence, the correct option is (A).

Question Number: 64 **Question Type: NAT**

In a metal forming operation when the material has just started yielding, the principal stresses are σ_1 = 180 MPa, σ_2 = 100 MPa, σ_3 = 0. Following von Mises' criterion the yield stress is ____MPa.

Solution:

According to Von-misces, yield stress (σ_{yt}) is given by

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \leq \left(\frac{\sigma_{yt}}{N}\right)^2$$

Given,

$$\sigma_1 = +180 \text{ MPa}$$
$$\sigma_2 = -100 \text{ MPa}$$
$$\sigma_3 = 0$$
$$N = 1$$

$$\sigma_{yt} = \frac{\sqrt{(\sigma_1 - \sigma_2) + \sigma_2^2 + \sigma_1^2}}{\sqrt{2}}$$

$$= 245.76 \text{ MPa}$$

Hence, the correct answer is (245.76).

Question Number: 65 **Question Type: MCQ**

The value of $\lim_{x\to 0} \frac{x^3 - \sin(x)}{x}$ is

(A) 0 (B) 3 (C) 1 (D) –1

Solution:

$$\lim_{x\to 0} \frac{x^3 - \sin(x)}{x} = \lim_{x\to 0} \frac{3x^2 - \cos}{1}$$

[Using L Hospital Rule]

$$= -1$$

Hence, the correct option is (D).

GATE 2017 Solved Paper
ME: Mechanical Engineering
Set – 2

Number of Questions: 65 **Total Marks:100.0**

Wrong answer for MCQ will result in negative marks, (−1/3) for 1 Mark Questions and (−2/3) for 2 Marks Questions.

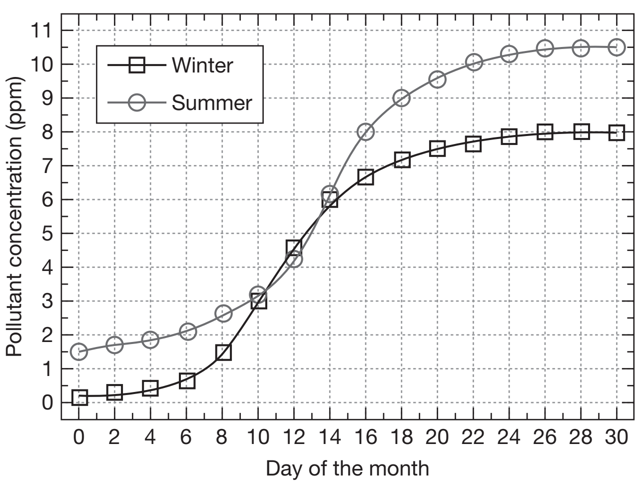
General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Q.1 to Q.5 carry 2 mark each and Q.6 to Q.10 carry 1 marks each.

Question Number: 1 **Question Type: MCQ**

In the graph below, the concentration of a particular pollutant in a lake is plotted over (alternate) days of a month in winter (average temperature 10°C) and a month in summer (average temperature 30°C).



Consider the following statements based on the data shown above:

i. Over the given months, the difference between the maximum and the minimum

ii. There are at least four days in the summer month such that the pollutant concentrations on those days are within 1 ppm of the pollutant concentrations on the corresponding days in the winter month.

Which one of the following options is correct?

(A) Only i (B) Only ii

(C) Both i and ii (D) Neither i nor ii

Solution:

Diffrence in pollutant concentration

Insummer Inwinter

10.5 1.5 8.0 0.25

= 9.0 = 7.75

Hence, the correct option is (B).

Question Number: 2 **Question Type: MCQ**

All people in a certain island are either 'Knights' or 'Knaves' and each person knows every other person's identity. Knights NEVER lie, and knaves ALWAYS lie.

P says "Both of us are knights". *Q* says "None of us are knaves"

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

(A) Both *P* and *Q* are knights

(B) *P* is a knight; *Q* is a knave

(C) Both *P* and *Q* are knaves

(D) The identities of *P*, *Q* cannot be determined

Solution:

There can be more than one possibilities. So identities of *P*, *Q* can not be.

Hence, the correct option is (D).

Question Number: 3 **Question Type: MCQ**

There are 4 women *P*, *Q*, *R*, *S* and 5 men *V*, *W*, *X*, *Y*, *Z* in a group. We are required to form pairs each consisting of one woman and one man. *P* is not to be paired with *Z*, and *Y* must necessarily be paired with someone. In how many ways can 4 such pairs be formed?

(A) 74 (B) 76

(C) 78 (D) 80

Solution:

P, *Q*, *R*, *S*, *V*, *W*, *X*, *Y*, *Z*

Women Men

Probability in which '*p*' not paired with '*z*'

$$= 4 \times 4 \times 3 \times 2 = 96 = (P1)$$

Probability in which '*P*' not paired with '*z*' and also '*y*' is not paired with anyone ($P2$) = 3 × 3 × 2×1 =18.

Probability in which 'P' is not a paired with 'z' and also 'y' is necessarily pasied = $P_1 - P_2$.

$$= 96 - 18$$
$$= 78$$

Hence, the correct option is (C).

Question Number: 4 **Question Type: MCQ**

X bullocks and Y tractores take 8 days to plough a field. If we halve the number of bullocks and double the number of tractors, it takes 5 days to plough the same field. How many days will it take X bullocks alone to plough the field?

(A) 30 (B) 35
(C) 40 (D) 45

Solution:

If b is the work per day per bullock and t is the work per day per tractor, then we have

$$8bx + 8ty = 1 \quad \text{(i)}$$

$$5b\left(\frac{x}{2}\right) + 5t(2t) = 1 \quad \text{(ii)}$$

$$40bx + 40ty = 5$$
$$10bx + 40ty = 4$$
$$bx = \frac{1}{30}$$

bx. (no. of days) = 1

No. of days $= \frac{1}{bx} - \frac{1}{1/30} = 30$ days

Hence, the correct option is (A).

Question Number: 5 **Question Type: MCQ**

"If you are looking for history of India, or for an account of the rise and fall of the British Raj, or for the reason of the cleaving of the subcontinent into two mutually antagonistic parts and the effects this mutilation will have in the respective sections, and ultiamtely on Asia, you will not find it in these pages; for though I have spent a lifetime in the country, I lived too near the seat of events, and was too intimately associated with the actors, to get the prespective needed for the impartial recording of these matters."

Which of the following is closest in meaning to 'cleaving'?

(A) deteriorating
(B) arguing
(C) departing
(D) splitting

Solution:

Cleaving = spliting, separating.

Hence, the correct option is (D).

Question Number: 6 **Question Type: MCQ**

A couple has 2 children. The probability that both children are boys if the older one is a boy is

(A) $\frac{1}{4}$ (B) $\frac{1}{3}$
(C) $\frac{1}{2}$ (D) 1

Solution:

Possibel Outcomes:

1st Child	IInd Child
B	B
B	G
G	B
G	G

If older one is boy (i.e., 1st child is boy)

Possible Outcomes:

1st Child	IInd Child
B	B
B	G

Probability (both are boys) $= \frac{1}{2}$

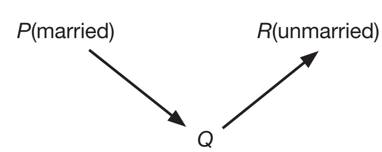
Hence, the correct option is (C).

Question Number: 7 **Question Type: MCQ**

P looks at Q while Q looks at R. P is married, R is not. The number of pairs of people in which a married person is looking at an unmarried person is

(A) 0
(B) 1
(C) 2
(D) Cannot be determined

Solution:



Only one case possible

Hence, the correct option is (B).

Question Number: 8 **Question Type: MCQ**

The ways in which this game can be played___potentially infinite.

(A) is
(B) is being
(C) are
(D) are being

Solution:

Subject here is ‘The ways’. So ‘are’ is used.

Hence, the correct option is (C).

Question Number: 9 **Question Type: MCQ**

If a and b are integers and $a - b$ is even, which of the following must always be even?

(A) ab
(B) $a^2 + b^2 + 1$
(C) $a^2 + b + 1$
(D) $ab - b$

Solution:

Given, a – b = even

Case = I Case = II

a = odd a = even

b = odd b = even

Option A, ab

in Case I:ab = odd

in Case II:ab = even [Not always even]

Option B

$a^2 + b^2 + 1$

In case I : $(\text{odd})^2 + (\text{odd})^2 + 1$ = even

$(\text{even})^2 + (\text{even})^2 + 1$ = odd

Option C: $a^2 + b$ 61

Case I : $(\text{odd})^2$ + odd +1 = even

Case II : $(\text{even})^2$ ++even + 1 = odd

Option D: $ab - b$

Case I : (odd)(odd) – odd = even

Case II : (even)(even) – even = even

Hence, the correct option is (D).

Question Number: 10 **Question Type: MCQ**

If you choose plan P, you will have to ___plan Q, as these two are mutually_____.

(A) forgo, exclusive (B) forget inclusive
(C) accept, exhaustive (D) adopt, intrusive

Solution: Hence, the correct option is (C).

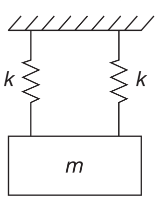
Mechanical Engineering

Number of Questions: 55 **Section marks: 85.0**

Q.11 to Q.25 carry 1 mark each and Q.36 to Q.65 carry 2 marks each.

Question Number: 11 **Question Type: MCQ**

A mass m is attached to two identical springs having spring constant k as shown in the figure. The natural frequency ω of this angle degree of freedom system is

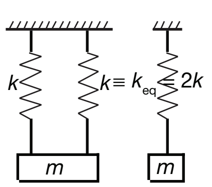


(A) $\sqrt{\frac{2k}{m}}$ (B) $\sqrt{\frac{k}{m}}$ (C) $\sqrt{\frac{k}{2m}}$ (D) $\sqrt{\frac{4k}{m}}$

Solution:

The natural frequency ω can be calculated using relation

$$\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{2K}{m}}$$



The arrangement shown consists of parallel connection of springs.

Hence, the correct option is (A).

Question Number: 12 **Question Type: MCQ**

Which one of the following statements is TRUE?

(A) Both Pelton and Francis turbines are impulse turbines.
(B) Francis turbine is a reaction turbine but Kaplan turbine is an impulse turbine.
(C) Francis turbine is an axial-flow reaction turbine.
(D) Kaplan turbine is an axial-flow reaction turbine.

Solution:

Both Pelton and Francis turbines are impulse turbines, this statement is Wrong because Petton = Impulse; Frances = Reaction turbine

Francis turbine is a reaction turbine but Kaplan turbine is an impulse turbine., this statement is Wrong : because Francis = Reaction; Kaplan = Reaction turbine

Francis turbine is an axial-flow reaction turbine., this statement is Wrong because Francis = Mixed flow reaction turbine

Kaplan turbine is an axial-flow reaction turbine, this statement is Correct because Kaplan = Axial flow reaction turbine

Hence, the correct option is (D).

Question Number: 13 **Question Type: MCQ**

For a single server with Poisson arrival and exponential service time, the arrival rate is 12 per hour. Which one of the following service rates will provide a steady state finite queue length?

(A) 6 per hour
(B) 10 per hour
(C) 12 per hour
(D) 24 per hour

Solution:

We know that

$$L_q = \text{queue length} = \frac{\rho^2}{1-\rho}$$

$$\text{where} \quad \rho = \frac{\text{Arrival rate}}{\text{Service rate}} = \frac{12}{24} = \frac{1}{2}$$

Also it is given that L_q = Finite, therefore

$\rho < 1$ otherwise L_q can't be defined

Hence, the correct option is (D).

Question Number: 14 **Question Type: MCQ**

It is desired to make a product having Tshaped cross-section from a rectangular aluminium block. Which one of the following processes is expected to provide the highest strength of the product?

(A) Welding (B) Casting
(C) Metal forming (D) Machining

Solution:

Highest strength is obtained through metal forming processes because due to continuous application of force work hardening occurs.

Hence, the correct option is (C).

Question Number: 15 **Question Type: MCQ**

A mass m of a perfect gas at pressure p_1 and volume V_1 undergoes an isothermal process. The final pressure is p_2 and volume is V_2. The work done on the system is considered positive. If R is the gas constant and T is the temperture, then the work done in the process is

(A) $p_1V_1 \ln\frac{V_2}{V_1}$ (B) $-p_1V_1 \ln\frac{p_1}{p_2}$

(C) $RT \ln\frac{V_2}{V_1}$ (D) $-mRT \ln\frac{p_2}{p_1}$

Solution:

We know that in a Isothermal Process

PV = constant

$\Rightarrow$ Work done by system

$$= \int PdV = \int_{V_1}^{V_2} \frac{C}{V} dV = [C \ln V]_{V_1}^{V_2}$$

$$\Rightarrow C \ln\frac{V_2}{V_1}$$

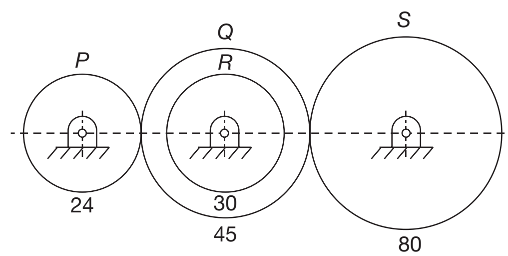
$$\Rightarrow P_1V_1 \ln\frac{V_2}{V_1} = P_1V_1 \ln\left(\frac{C/P_2}{C/P_1}\right) = P_1V_1 \ln\frac{P_1}{P_2}$$

Since, it is given that work done at system is positive but in this processes work is done by system. So work done will be negative.

Hence, the correct option is (B).

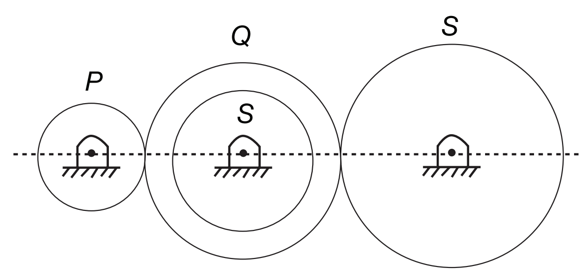
Question Number: 16 **Question Type: NAT**

A gear train shown in the figure consists of gears P, Q, R and S. Gear Q and gear R are mounted on the same shaft. All the gears are mounted on parallel shafts and the number of teeth of P, Q, R and S are 24, 45, 30 and 80, respectively. Gear P is rotating at 400 rpm. The speed (in rpm) of the gear S is_______.



Solution:

Consider the figure given below



It is given that Q is Idle

$$T_S N_S = T_P N_P$$

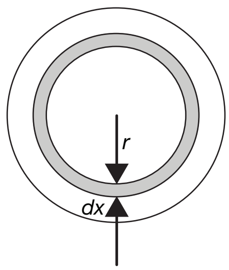
$$N_S = \frac{24}{80} \times 400 = 120 \text{ rpm}$$

Hence, the correct answer is (120).

Question Number: 17 **Question Type: NAT**

A single-plate clutch has a friction disc with inner and outer radii of 20 mm and 40 mm respectively. The friction lining in the disc is made in such a way that the coefficient of friction μ varies radially as $\mu = 0.01$ r, where r is in mm. The clutch needs to transmit a friction torque of 18.85 kN-mm. As per uniform pressure theory, the pressure (in MPa) on the disc is ______.

Solution:



We know that

$W = p(2\pi r)dr$

The torque can be calculated as

Torque = $d\tau = (\mu w)r$

$= \mu[p(2\pi r)dr]r$

$\Rightarrow \quad \mu = 0.01$ r

$d\tau = 2\pi p(0.01 \text{ r})\text{r.rdr}$

$\int d\tau = 2\pi p(0.01) \int r^2 \, d\pi$

$$(18.85\times10^3)\text{N-m} = (0.02\pi p)\left[\frac{r^4}{4}\right]_{20}^{40}$$

$$\frac{18.85\times10^3\times4}{0.02\pi(40^4-20^4)} = p(\text{in MPa})$$

$p = 0.5$ MPa

Hence, the correct answer is (0.5).

Question Number: 18 **Question Type: NAT**

In an orthogonal machining with a tool of 9° orthogonal rake angle, the uncut chip thickness is 0.2 mm. The chip thickness fluctuates between 0.25 mm and 0.4 mm. The ratio of the maximum shear angle to the minimum shear angle during machining is____.

Solution:

$$\tan\phi = \frac{r\cos\alpha}{1-r\sin\,\alpha}$$

$\alpha = 9°$

$t = 0.2$ mm = Uncut thickness

$0.25 \text{ m} \le t_c \le 0.4$ mm

For $r =$ $\quad r = \frac{0.2}{0.25} = 0.8$

$$\tan\phi = \frac{0.8\times\cos 9}{1-0.8\,\sin\,9}$$

$= 0.903$

$\phi = 42.087°$

$$r = \frac{0.2}{0.4} = 0.5$$

$$\text{or } \tan\phi = \frac{0.5\times\cos 9}{1-0.5\,\sin\,9}$$

$= 0.5357$

$\phi = 28.18°$

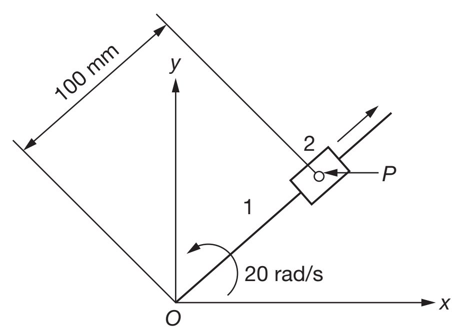
$$\text{Ratio} = \frac{42.087}{28.18}$$

$= 1.49$

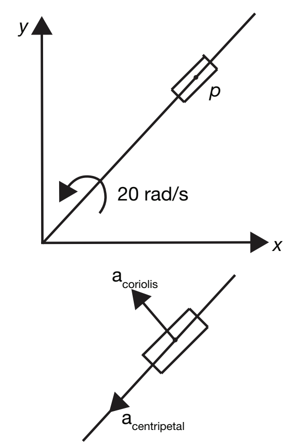
Hence, the correct answer is (1.49).

Question Number: 19 **Question Type: NAT**

Block 2 slides outward on link 1 at a uniform velocity of 6 m/s as shown in the figure. Link 1 is rotating at a constant angular velocity of 20 radian/s counter-clockwise. The magnitude of the total acceleration (in m/s^2) of point *P* of the block with respect to fixed point O is _____.



Solution:



Coriolis acceleration = $2V\omega$

$= 2 \times 6 \times 20$

$= 240 \frac{m}{s^2}$

Centripetal acc. = $\omega^2 r = 400 \times 0.1$

$$= 40 \text{ m s}^2$$

$$a_{\text{Resultant}} = \sqrt{(240)^2 + (40)^2}$$

$$= 243.31 \text{ ms}^2$$

Hence, the correct answer is (243.31).

Question Number: 20 **Question Type: MCQ**

During the turning of a 20 mm-diameter steel bar at a spindle speed of 400 rpm, a tool life of 20 minute is obtained. When the same bar is turned at 200 rpm, the tool life becomes 60 minute. Assume that Taylor's tool life equation is valid. When the bar is turned at 300 rpm, the tool life (in minute) is approximately

(A) 25 (B) 32
(C) 40 (D) 50

Solution:

We know that

$$V = \pi DN\left(\frac{m}{\min}\right)$$

Where T = in minutes

$$(\pi D_1 N_1)T_1^n = (\pi D_2 N_2)T_2^n$$

$$\Rightarrow N_1 T_1^n = N_2 T_2^n$$

$$\Rightarrow 400(20)^n = 200 \times (60)^n = 300T^n$$

$$\Rightarrow \frac{400}{200} = \left(\frac{60}{20}\right)^n$$

$$2 = 3^n \Rightarrow n = 0.6309$$

$$400 \times 20^n = 300 \times T^n$$

$$\left(\frac{400}{300}\right)^{1/n} \times 20 = T$$

$$T = 31.55 \text{ minutes}$$

Hence, the correct option is (B).

Question Number: 21 **Question Type: NCQ**

A metal ball of diameter 60 mm is initially at 220°C. The ball is suddenly cooled by an air jet of 20°C. The heat transfer coefficient is 200 W/m^2.K. The specific heat, thermal conductivity and density of the metal ball are 400 J/kg.K, 400 W/m-K and 9000 kg/m^3, respectively. The ball temperature (in °C) after 90 seconds will be approximately.

(A) 141 (B) 163
(C) 189 (D) 210

Solution:

As we know that

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-hAt/\rho VC_p}$$

$$\frac{hA}{\rho VCp} = \frac{h}{\rho\left(\frac{R}{3}\right)C_p}$$

$$= \frac{200}{9000 \times \left(\frac{30}{3 \times 1000}\right) \times 400}$$

$$= \frac{1}{180}$$

$$\frac{T - 20}{220 - 20} = e^{-90/180}$$

$$T = 141.306°\text{C}$$

Hence, the correct option is (A).

Question Number: 22 **Question Type: MCQ**

A product made in two factories, P and Q, is transported to two destinations, R and S. The per unit costs of transportation (in Rupees) from factories to destinations are as per the following matrix:

Destination	Factory	*R*	*S*
P		10	7
Q		3	4

Factory P produces 7 units and factory Q produces 9 units of the product. Each destination requires 8 units. If the north-west corner method provides the total transportation cost as X (in Rupees) and the optimized (the minimum) total transportation cost is Y (in Rupees), then (X–Y), in Rupees, is

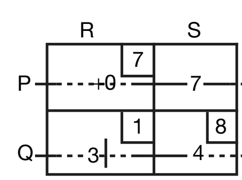
(A) 0 (B) 15
(C) 35 (D) 105

Solution: (28). None of the option is correct

Consider the table given below

Destination	Factory	*R*	*S*
P		10	7
Q		3	4

i) Applying *N*-*W* method and allocating.



So total cost $X = (10 \times 7) + (3 \times 1) + (4 \times 8)$

$X = 105$ Rs

ii) For minimized optimal cost first we will apply Vogel's approximation method to find allocation.

	R	S	Penalty
P	10	(7) 7	3
Q	(8) 3	(1) 4	1

Allocation Matrix:

	R	S
P	10	(7) 7
Q	(8) 3	(1) 4

No of allocation= $2 = m + n - 1$

Optimally can be performed.

Cost-matrix for allocated cell

	V_1R	S V_2
U_1P	·	7
U_2Q	3	4

$$U_1 + V_2 = 1$$
$$U_1 + V_1 = 3$$
$$U_2 + V_2 = 4$$

Let 1 $V_1 = 0 \Rightarrow U_2 = 3;\ V_2 = 1;\ U_1 = 6$

Now $U_i + V_j$ matrix for unallocated cell.

	R_0	S_1
P 6	6	
Q 3		

Cell evaluation matrix

	R_0	S_1
P 6	4	
Q 3		

Since name of allocation is negative, the solution is optimal total optimized minimum cost Y,

$$Y = (7 \times 7) + (8 \times 3) + (4 \times 1)$$
$$Y = 77$$
$$X - Y = 105 - 77$$
$$= 28\ ₹.$$

Question Number: 23 **Question Type: NAT**

A cylindrical pin of $25^{+0.020}_{+0.010}$ mm iameter is electroplated. Plating thickness is $2.0^{\pm 0.005}$ mm. Neglecting the gauge tolerance, the diameter (in mm. up to 3 decimal points accuracy) of the GO ring gauge to insepct the plated pin is ______.

Solution:

GO ring gauge is used to check upper limit of shaft/pin in ring gauge.

Maximum diameter of pin will be 25.020 mm.

On electroplating, thickness increases on both sides so after electroplating maximum diameter

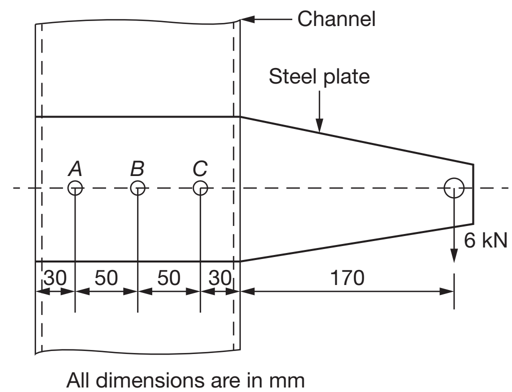
$$= 25.020 + (2.005) \times 2$$

And since GO ring gauge is used to check upper limit of shaft, so, GO gauge dimension should be 29.030 mm.

Hence, the correct answer is (29.030).

Question Number: 24 **Question Type: NAT**

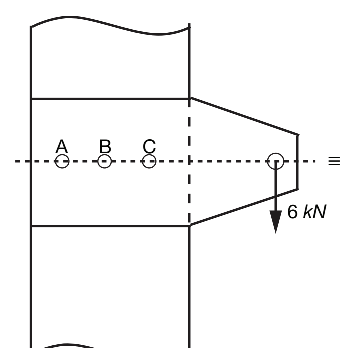
A steel plate, connected to a fixed channel using three identical bolts A, B and C, carries a load of 6 kN as shown in the figure. Considering the effect of direct load and moment, the magnitude of resultant shear force (in kN) on bolt C is

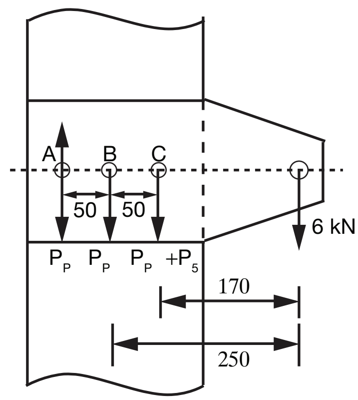


(A) 13 (B) 15 (C) 17 (D) 30

Solution:

Consider the figure given below





$$P_P = \frac{6}{3} = 2\text{KN}\{P_P = \text{Primary shear force}\}$$

$$\{P_s = \text{ secondary shear force}\}$$

By taking moment about *B*.

$$6 \times 250 = (P_S \times 50) \times 2$$

$$P_S = 15 \text{ KN}$$

At *C*:

Resultant shear force on '*C*'

$$= P_S + P_P = 15 + 2 = 17 \text{ KN}$$

Hence, the correct option is (C).

Question Number: 25 Question Type: MCQ

The volume and temperature of air (assumed to be an ideal gas) in a closed vessel is 2.87 m^3 and 300 K, respectively. The gauge pressure indicated by a manometer fitted to the wall of the vessel is 0.5 bar. If the gas constant of air is R = 287 J/kg-K and the atmospheric pressure is 1 bar, the mass of air (in kg) in the vessel is

(A) 1.67 (B) 3.33
(C) 5.00 (D) 6.66

Solution:

We know that for an Ideal gas

$PV = mRT$

Also

$P_{abs} = P_{atm} + P_g = 1 + 0.5$

$= 1.5 \times 101.3 = 151.95$ kPa

Volume = 2.87 m^3

$R = 0.287$ kPa

$T = 300$ K

Substituting the values, we get

$$151.95 \times 2.87 = m \times 0.287 \times 300$$

$$m = 5.065 \text{ kg}$$

Hence, the correct option is (C).

Question Number: 26 Question Type: NAT

Consider the matrix $A = \begin{bmatrix} 50 & 70 \\ 70 & 80 \end{bmatrix}$ whose eigenvectors corresponding to eigenvalues λ_1 and λ_2 are $x_1 = \begin{bmatrix} 70 \\ \lambda_1 - 50 \end{bmatrix}$ and $x_2 = \begin{bmatrix} \lambda_2 - 70 \\ 70 \end{bmatrix}$, respectively. The value of $x_1 x_2$ is _____.

Solution:

$$\begin{bmatrix} 50-\lambda & 70 \\ 70 & 80-\lambda \end{bmatrix} = 0$$

$$(50-\lambda)(80-\lambda) - 4900 = 0$$

Solving quadratic egn. :

$$\lambda = -6.589 + 136.589$$

$$[A - \lambda I][x] = 0$$

For $\lambda = -6.589$

$$\begin{bmatrix} 56.589 & 70 \\ 70 & 86.589 \end{bmatrix}\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$56.589a + 70b = 0$$

$$\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} -1.237 \\ 1 \end{bmatrix} = [x_1]$$

For $\lambda = 136.589$

$$\begin{bmatrix} -86.589 & 70 \\ 70 & -56.589 \end{bmatrix}\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$-86.589a + 70b = 0$$

$$\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 1 \\ 1.237 \end{bmatrix} = [x_2]$$

$$X_1^T X_2 = [-1.2371][11.237]$$

$$= [0]$$

Hence, the correct answer is (0).

Question Number: 27 Question Type: NAT

The surface integral $\iint_S F \times n dS$ over the surface S of the sphere $x^2 + y^2 + z^2 = 9$, where $F = (x + y)i + (x + z)j + (y + z)k$ and n is the unit outward surface normal, yields___.

Solution:

$$\iint_S F \times n dS = \int_S div.F dV \quad \text{[Stoke's Law]}$$

$$= \int_s \nabla[(x+y)\hat{i} + (x+z)\hat{j} + (y+z)\hat{k}] dV$$

$$= \int_s (1+0+1)dV$$

$$= 2\int dV = 2V$$

$$V = \frac{4}{3}\pi.(3)^3 = 36\pi$$

$$2\times 36\pi = 226.19$$

Hence, the correct answer is (226.19).

Question Number: 28 **Question Type: NAT**

One kg of an ideal gas (gas constant R = 287 J/kgK) undergoes an irreversible process from state-1 (1 bar, 300 K) to state-2 (2 bar, 300 K). The change in specific entropy $(s_2 - s_1)$ of the gas (in J/kg.K) in the process is _____.

Solution:

$$\begin{array}{ccc} \text{State-1} & & \text{State-2} \\ & \rightarrow & \\ \text{1 bar, 300 K} & & \text{2 bar, 300 K} \end{array}$$

$$S_2 - S_1 = mC_p \ln\frac{T_2}{T_1} + mR\ln\frac{p_1}{p_2}$$

$$= m\left[C_p \ln\frac{300}{300} + 287\ln\frac{1}{2}\right]$$

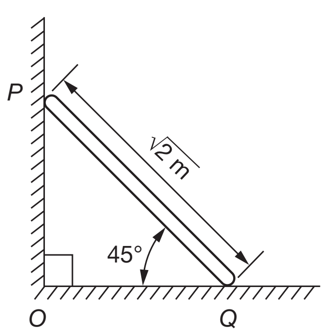
$$\frac{(S_2 - S_1)}{m} = -287\ln 2 = -198.93$$

= change in specific entropy

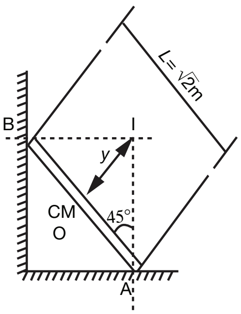
Hence, the correct answer is (–198.93).

Question Number: 29 **Question Type: NAT**

The rod PQ of length $L = \sqrt{2}$ m, and uniformly distributed mass of M = 10 kg, is released from rest at position shown in the figure. The ends slide along the frictionless faces OP and OQ. Assume acceleration due to gravity, g = 10 m/s^2. The mass moment of inetia of the rod about its centre of mass andan axis perpendicular to the plane of the figure is (ML_2/12). At this instant, the magnitude of angular acceleration (in radian/s_2) of the rod is ____.



Solution:



Moment of Inertia about

$$I_1 = \frac{ML^2}{12} + My^2$$

Now, in ΔIOA

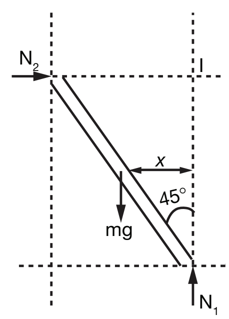
$$\frac{y}{(\sqrt{2}/2)} = \tan 45°$$

$$y = \frac{1}{\sqrt{2}}\text{ m}$$

$$I_1 = \frac{M}{12}(\sqrt{2})^2 + M\left(\frac{1}{\sqrt{2}}\right)^2$$

$$= 10\left(\frac{2}{12} + \frac{1}{2}\right) = 6.67\text{ kg} - \text{m}^2$$

F.B.D. of Rod



Moment balance about point I

$$\text{mg}.x = I_1\alpha$$

$$\alpha = \frac{\text{mg}x}{I_1}$$

$$\because \sin 45° = \frac{x}{\frac{y}{2}} = \frac{x}{\frac{\sqrt{2}}{2}}$$

$$\frac{\sqrt{2}}{2}\frac{1}{\sqrt{2}} = x \Rightarrow = 0.5\text{ m}$$

$$\alpha = \frac{10\times 10\times 0.5}{6.67}$$

$$\alpha = 7.5\text{ rad/s}^2$$

Hence, the correct answer is (7.5).

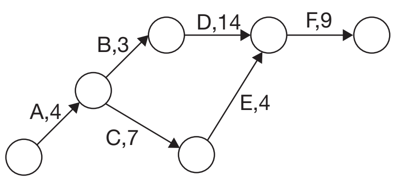
Question Number: 30 Question Type: NAT

A project starts with activity A and ends with activity F. The precedence relation and durations of the activities are as per the following table:

Activity	Immediate Predecessor	Duration (days)
A	–	4
B	A	3
C	A	7
D	B	14
E	C	4
F	D, E	9

The minimum project completion time (in days) is _____.

Solution:



Critical path = $A \rightarrow B \rightarrow D \rightarrow F$ [Longest path]

$$T_C = 4 ++ 3 +14 + 9$$
$$= 30 \text{ days}$$

Hence, the correct answer is (30).

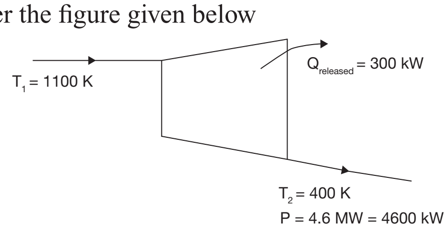
Question Number: 31 Question Type: MCQ

A calorically perfect gas (specific heat at constant pressure 1000 J/kg.K) enters and leaves a gas turbine with the same velocity. The temperatures of the gas at turbine entry and exit are 1100 K and 400 K. respectively. The power produced is 4.6 MW and heat escapes at the rate of 300 kJ/s through the turbine casing. The power produced is 4.6 MW and heat escapes at the rate of 300 kJ/s through the turbine casing. The mass flow rate of gas (in kg/s) through the turbine is

(A) 6.14 (B) 7.00 (C) 7.50 (D) 8.00

Solution:

Consider the figure given below



Also it is given that

$V_{\text{entry}} = V_{\text{exit}}$

Applying SFEE,

$mc_pT_1 = mc_pT_2 + P + Q\text{released}$

$10^{-3} \times m \times 1000 \times (1100 - 400) = 4600 + 300$

$$10^{-3} m = \frac{4000}{1000 \times 700} = 7 \times 10^{-3}$$
$$m = 7 \text{ kg/s}$$

Hence, the correct option is (B).

Question Number: 32 Question Type: NAT

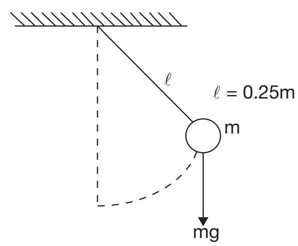
The radius of gyration of a compound pendulum about the point of suspension is 100 mm. The distance between the point of suspension and the centre of mass is 250 mm. Considering the acceleration due to gravity as 9.81 m/s^2, the natural frequency (in radian/s) of the compound pendulum is _____.

Solution:

Mass moment inertia = $m(0.1)^2$ kg–m^2

Radius of gyration (K) = 0.1 m

Consider the figure given below



$$I\ddot{\theta} + mg \sin\theta l = 0$$

Assuming $\theta \approx 0$ (very small [$\sin\theta \approx \theta$]

$$\ddot{\theta} + \frac{mg}{I} l\theta = 0$$

$$\ddot{\theta} + \frac{m \times 9.81 \times 0.25}{m \times (0.1)^2}\theta = 0$$

$$\omega_n = \sqrt{\frac{9.81 \times 0.25}{(0.1)^2}} = 15.66 \text{ rad/s}$$

Hence, the correct answer is (15.66).

Question Number: 33 Question Type: MCQ

If $f(z) = (x^2 + ay^2) + ibxy$ is a complex analytic function $z = x + iy$, where $i = \sqrt{-1}$, then

(A) $a = -1, b = -1$ (B) $a = -1, b = 2$

(C) $a = 1, b = 2$ (D) $a = 2, b = 2$

Solution:

$$f(z) = (x^2 + ay^2) + ib \times y = u(x, y) + i(x, y)$$

$$u(x, y) = x^2ay^2$$

$$V(x,y) = bxy$$

$$\frac{\partial u}{\partial x} = 2x$$

$$\frac{\partial u}{\partial x} = 2ay$$

$$\frac{\partial V}{\partial x} = by$$
$$\frac{\partial V}{\partial y} = bx$$

Using Cauchy Reimann Theorem :

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \Rightarrow 2x = bx$$

and $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$, by this, we have

$$a = -1$$
$$b = 2$$

Hence, the correct option is (B).

Question Number: 34 **Question Type: NAT**

A strip of 120 mm width and 8mm thickness is rolled between two 300 mm-diameter rolls to get a strip of 120 mm width and 7.2 mm thickness. The speed of the strip at the exit is 30 m/min. There is no front or back tension. Assuming uniform roll pressure of 200 MPa in the roll bite and 100% mechanical efficiency, the minimum total power (in kW) required to drive the two rolls is____.

Solution:

Radius of roll = 150 mm

Change in thickens (Δh) = 8 – 7.2

= 0.8 mm

Contact length can be calculated using relation

$$(L_p) = \sqrt{R\Delta h}$$
$$= \sqrt{150 \times 0.8}$$
$$= 10.954 \text{ mm}$$

Also we know that Width (b) = 120 mm

The force can be calculated using relation

Force = σ_0 ($L_p \times b$)

= 200(10.954 ×120)

= 262.896 kN

Assuming hot rolling:
arm length (a) = 0.5 L_p

= 5.477 mm

Now the torque can be calculated using

Torque = F.a = 262.896 × 5.477

= 1439.881 kN-mm

= 1439.881 (N-m)

⇒ Power = 2.T.w

[Because there are two rolls]

= 2 ×1439.881× ω

for 100% mechanical efficiency:

$$r.\omega = \frac{30}{60} \text{ m/s}$$
$$\omega = \frac{0.5}{0.15} = 3.33 \text{ rad/s}$$

Power = 2 ×1439.881×3.33

= 9.6

Hence, the correct answer is (9.6).

Question Number: 35 **Question Type: NAT**

Maximize $Z = 5x_1 + 3x_2$,

subject to

$$x_1 + 2x_2 \le 10;$$
$$x_1 - x_2 \le 8,$$
$$x_1, x_2 \ge 0.$$

In the starting simplex tableau, x_1 and x_2 non-basic variables and the value of Z is zero. The value of Z in the next simplex tableau is ____.

Solution:

Maximize, $Z = 5x_1 + 3x_2$

$$x_1 + 2x_2 \le 10$$
$$x_1 - x_2 \le 8$$
$$x_1, x_2 \ge 0$$

For simplex

$$x_1 + 2x_2 + s_1 = 10$$
$$x_1 - x_2 + s_2 = 8$$

and maximize $z = 5x_1 + 3x_2 + 0S_1 + 0S_2$

where S_1 and S_2 are slack variable.

First simplex table:

C_i → / Besis ↓	5 X_1	3 X_2	0 a_1	0 a_2	b 10	$\theta - \frac{b}{C_i}$ 10
0 S_1	1	5	1	0	8	8 ←
← 0 S_2	[1]*	–1	0	1		
E_j	0	5	0	0		
$E_j - C_i$	–5 ↑	–3	0	0		

So, S_2 leaving x_1 incoming and applying

$R_{1new} = R_{1old} - R_{2old}$

C_i → / Besis ↓	5 X_1	3 X_2	0 a_1	0 a_2	b	0
0 S_1	1	3	–1	–1	2	
← 5 S_2	1	–1	0	1	8	
E_j	0	–5	0	0		

So, from second table value can be rad as

$$\begin{bmatrix} S_1 = 2 \\ x_1 = 8 \end{bmatrix}$$

So maximum, Z = $5x_1 + 3x_2 + 0S_1 + 0S_2$

Max, $Z = 5 \times 8$

$= 40$

Hence, the correct answer is (40).

Question Number: 36 **Question Type: NAT**

For the laminar flow of water over a sphere, the drag coefficient C_F is defined as $C_F = F/(\rho U^2 D^2)$, where F is the drag force, ρ is the fluid density, U is the fluid velocity and D is the diameter of the sphere. The density of water is 1000 kg/m^3. When the diameter of the sphere is 100 mm and the fluid velocity is 2 m/s, the drag coefficient is 0.5. If water now flows over another sphere of diameter 200 mm under dynamically similar conditions, the drag force (in N) on this sphere is _____.

Solution:

Equating Reynold's number for both, we get

$$\text{Re}\,\frac{\rho VD}{\mu}$$

$$\frac{1000 \times 2 \times D}{\mu} = \frac{100 \times V_1 \times (2D)}{\mu}$$

$$2\,D = V_1\,(2D)$$

$$V_1 = 1 \text{ m/s}$$

$$F = C_F\,(/(\rho U^2 V^2)$$

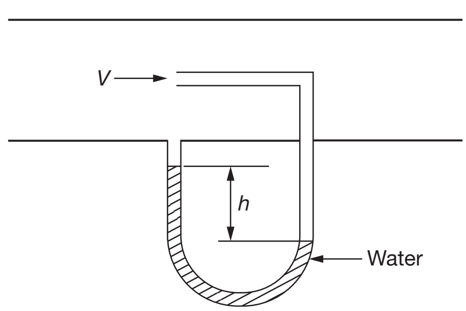
$$F = 0.5 \times 1000 \times 1^2 \times (0.2)^2$$

$$= 20 \text{ N}$$

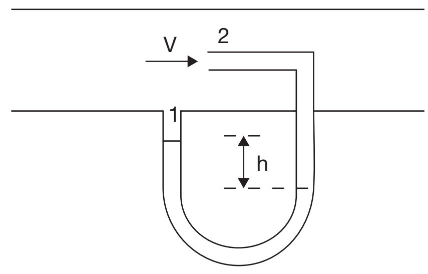
Hence, the correct answer is (20).

Question Number: 37 **Question Type: NAT**

The arrangement shown in the figure measures the velocity V of a gas of density 1 kg/m^3 flowing through a pipe. The acceleration due to gravity is 9.81 m/s^2. If the manometric fluid is water (density 1000 kg/m^3) and the velocity V is 20 m/s, the differential head h (in mm) between the two arms of the manometer is ______.



Solution:



Assume the velocity at point '2' is zero

Applying Bernoulli's equation between '1' and '2'.

$$\Rightarrow p_1 + \frac{\rho V_1^2}{2} = p_2 + \frac{\rho V_2^2}{2} [\rho = \text{gas density}]$$

$$-P_1 + P_2 = \frac{\rho}{2}(-V_1^2 + V_1^2)[V_2 \approx 0]$$

$$P_2 - P_1 = \frac{P}{2}(V_1^2 - 0)$$

$$P_2 - P_1 = \frac{\rho}{2} V_1^2 \quad \text{(i)}$$

Also $P_2 - P_1 = \rho g h \left(\frac{\rho_w}{\rho} - 1 \right)$

$[\rho_w = \text{water density}]$

$$P_2 - P_1 = 1 \times 9.81 \times h \left(\frac{1000}{1} - 1 \right) \quad \text{(ii)}$$

$$\frac{\rho}{2} V_1^2 = 9.81h(999)$$

$$h = \frac{1}{2} \cdot \frac{(20)^2}{9.81 \times 999}$$

$$= 0.020467 \text{ m}$$

$$h(\text{in mm}) = 20.408 \text{ mm}$$

Hence, the correct answer is (20.408).

Question Number: 38 **Question Type: NAT**

A helical compression spring made of a wire of circular cross-section is subjected to a compressive load. The maximum shear stress induced in the cross-section of the wire is 24 MPa. For the same compressive load, if both the wire diameter and the mean coil diameter are doubled, the maximum shear stress (in MPa) induced in the cross-section of the wire is ____.

Solution:

Given :

Diameter $d_2 = 2d$

Diameter $D_2 = 2D_0$

C = spring compliance $= \dfrac{D}{d}$

Now using relation

$$(\tau_{\text{shear}})_1 = \frac{8\text{ W}}{\pi d^2}C = 24\text{ MPa}$$

$$C_2 = \frac{2D}{2d} = \frac{D}{d} = C$$

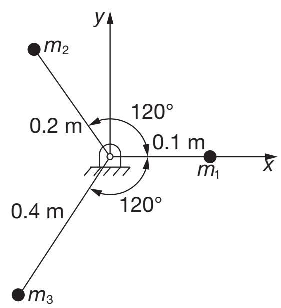
Then, $(\tau_{\text{shear}})_2 = \frac{8\text{ W}}{\pi(2d)^2}C = \frac{(\tau_{\text{shear}})_1}{4} = 6\text{ MPa}$

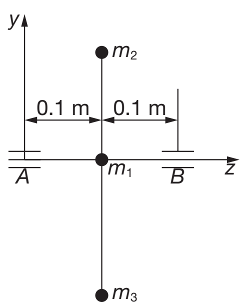
$$\tau_{\text{shear}} = 6\text{ MPa}$$

Hence, the correct answer is (6).

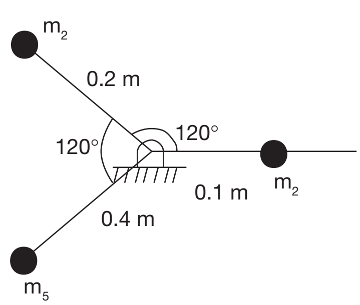
Question Number: 39 **Question Type: NAT**

Three masses are connected to a rotating shaft supported on bearings A and B as shown in the figure. The system is in a space where the gravitational effect is absent. Neglect the mass of the shaft and rods connecting the masses. For $m_1 = 10$ kg, $m_2 = 5$ kg and $m_3 = 2.5$ kg and for a shaft angular speed of 1000 radian/s, the magnitude of the bearing reaction (in N) at location B is _____.





Solution:



$$\sum F_x = \sum mr\omega^2 \cos\theta$$

$$= [10\times 0.1\times \omega^2 \times \cos 0°] - [5\times 0.2\times \omega^2 \times \cos 60°]$$

$$-[2.5\times 0.4\times \omega^2 \times \cos 60°] = 0$$

$$\sum F_y = \sum mr\omega^2 \sin\theta$$

$$= 5\times 0.2\times \omega^2 \sin 60° - 2.5\times 0.4\times \omega^2 \sin 60° = 0$$

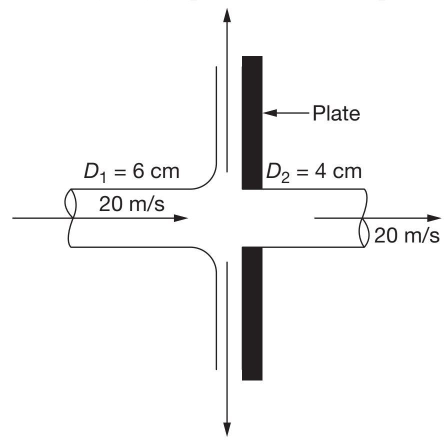
$$F_{\text{resultant}} = \sqrt{(\sum F_x)^2 + (\sum F_y)^2} = 0$$

Since, this is a balanced system so, net force on bearing is zero.

Hence, the correct answer is (0).

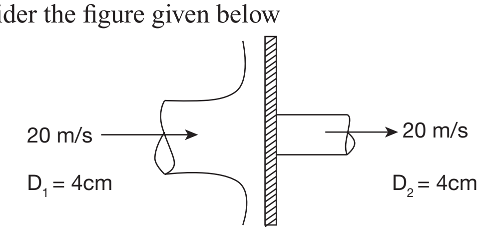
Question Number: 40 **Question Type: NAT**

A 60 mm-diameter water jet strikes a plate containing a hole of 40 mm diameter as shown in the figure. Part of the jet passes through the hole horizontally, and the remaining is deflected vertically. The density of water is 1000 kg/m^3. If velocities are as indicated in the figure, the magnitude of horizontal force (in N) required to hold the plate is ____.



Solution:

Consider the figure given below



Force in x-direction = Rate of change in momentum

$$= (\rho A_1 V_1)V_1 - (\rho A_2 V_2)V_2$$

$$= \rho\left[\frac{\pi}{4}(0.6)^2.20^2 - \frac{\pi}{4}(0.4)^2.20^2\right]$$

$$= 1000\times\frac{\pi}{4}400[0.06^2 - 0.04^2]$$

$$= 628.32\text{ N}$$

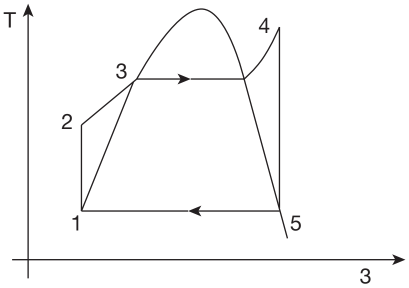
Hence, the correct answer is (628.32).

Question Number: 41 **Question Type: NAT**

In the Rankine cycle for a steam power plant the turbine entry and exit enthalpies are 2803 kJ/kg and 1800 kJ/kg, respectively. The enthalpies of water at pump entry and exit are 121 kJ/kg and 124 kJ/kg, respectively. The specific steam consumption (in kg/kW.h) of the cycle is______.

Solution:

Consider the figure given below



$$h_2 - h_r = W_{\text{pump}} = 124 - 121 = \tfrac{3\text{ kJ}}{\text{kg}}$$

$$h_4 - h_\delta = 2809 - 1800$$

$$= 1003 \text{ KJ/Kg}$$

$$W_{\text{net}} = 1003 - 3$$

$$= 1000 \text{ KJ/Kg}$$

Specific steam consumption will be

$$= \frac{3600}{\text{W}_{\text{net}}} (\text{Kg/kW} - h)$$

$$= 3.6 (\text{kg/Kw.h})$$

Hence, the correct answer is (3.6).

Question Number: 42 **Question Type: NAT**

Consider the differential equation $3y'(x) + 27y(x) = 0$ with initial conditions $y(0) = 0$ and $y'(0) = 2000$. The value of y at $x = 1$ is _____.

Solution:

$$3'y + (x) + 27y(x) = 0$$

$$y''(x) + 9y(x) = 0$$

$$(D^2 + 9)y = 0$$

So characteristic equation is given by:

$$m^2 + 9 = 0$$

$$m = \pm 3i = 0 \pm 3i$$

$$y = (C_1 \cos 3x + C_2 \sin x)e^{0x}$$

$$y = C_1 \text{Cos} 3x + C_2 \sin 3x$$

$$y' = -3 \sin 3x + C_2 \cos 3x$$

$$y'(0) = 3C_2 = 2000$$

$$C_2 = \frac{2000}{3}$$

$$y(0) = 0 = C_1(1) + C_2(0)$$

$$C_1 = 0$$

$$y = \frac{2000}{3} \sin 3x$$

$$y(1) = \frac{2000}{3} \sin 3 = 94.08$$

Hence, the correct answer is (94.08).

Question Number: 43 **Question Type: MCQ**

The principal stresses at a point in a critical section of a machine component are σ_1 = 60 MPa, σ_2 = 5 MPa and σ_3 = 40 MPa. For the material of the component, the tensile yield strength is σ_y = 200 MPa. According to the maximum shear stress theory, the factor of safety is

(A) 1.67 (B) 2.00 (C) 3.60 (D) 4.00

Solution:

principal stresses σ_1 = 60 MPa

principal stresses σ_2 = 5 MPa

principal stresses σ_3 = –40 MPa

$$\text{Absolute } \tau_{\max} = \frac{60 - (-40)}{2} = 50 \text{ MPa}$$

$$50 \text{ MPa} \le \frac{\sigma_{yT}}{2N} [\text{Shear stress theory}]$$

$$50 \le \frac{200}{2 \times N}$$

$$N = \frac{200}{50 \times 2}$$

$$N = 2$$

Hence, the correct option is (B).

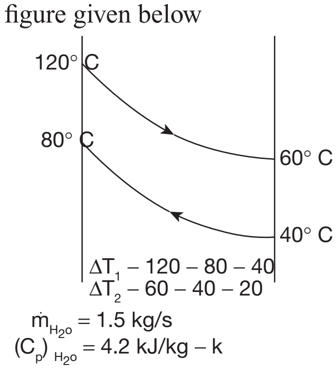
Question Number: 44 **Question Type: MCQ**

In a counter-flow heat exchanger, water is heated at the rate of 1.5 kg/s from 40°C to 80°C by an oil entering at 120°C and leaving at 60°C. The specific heats of water and oil are 4.2 kJ/kgK and 2 kJ/kgK respectively. The overall heat transfer coefficient is 400 W/m^2.K. The required heat transfer surface area (in m^2) is

(A) 0.104 (B) 0.022 (C) 10.4 (D) 21.84

Solution:

Consider the figure given below



$$\Delta T_m = \frac{40-20}{ln\left(\frac{40}{20}\right)} = 28.86°C$$

$$U_{overall} = 400 \text{ W/m}^2 - K$$

$$U_{overall}.A\Delta T_m = m_{H_2O}(C_P)_{H_2O}.(80-40)$$

$$A = \frac{1.5\times 40(4.2\times 10^3)}{400\times 28.86}$$

$$= 21.83 \text{ m}^2$$

Hence, the correct option is (D).

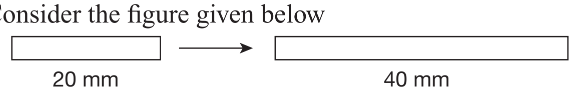
Question Number: 45 **Question Type: MCQ**

A rod of length 20 mm is stretched to make a rod of length 40 mm. Subsequently, it is compressed to make a rod of final length 10 mm. Consider the longitudinal tensile strain as positive and compressive strain as negative. The total true longitudinal strain in the rod is

(A) –0.5 (B) –0.69
(C) –0.75 (D) –1.0

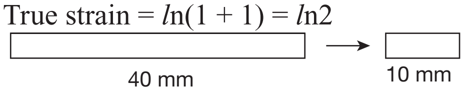
Solution:

Consider the figure given below



$$\text{Engineering strain} = \frac{\Delta L}{L} = \frac{40-20}{20} = 1$$

True strain = $ln(1 + 1) = ln2$



$$\text{Engineering strain} = -\frac{(40-10)}{40} = -\frac{3}{4}$$

$$\text{True strain ln}\left(1-\frac{3}{4}\right) = ln(0.25)$$

$$\text{Total true strain} = ln^2 + ln(0.25)$$

$$= -0.693$$

Hence, the correct option is (B).

Question Number: 46 **Question Type: NAT**

Given the atomic weight of Fe is 56 and that of C is 12, the weight percentage of carbon in cementite (Fe_3C) is _____.

Solution:

Weight of carbon in Fe_3C = 1 × 12 = 12

Molecular weight of Fe_3C = (3 × 56 + 12 = 180)

$$\% \text{ weight of carbon} = \frac{12}{180}\times 00$$

$$= 6.67\%$$

Hence, the correct answer is (6.67%).

Question Number: 47 **Question Type: MCQ**

Which one of the folloiwng TRUE for the ultrasonic machining (USM) process?

(A) In USM, the tool vibrates at subsonic frequency
(B) USM does not employ magnetostrictive transducer
(C) USM is an excellent process for machining ductile materials
(D) USM often uses a slurry comprising abrasive-particles and water

Solution:

In USM, the tool vibrates at high may be sonic frequency, therefore statement (a) is wrong.

USM uses transducers so as to produce low amplitude vibration, therefore statement (b) is wrong.

USM is an excellent process for machining hard and brittle materials, therefore statement (c) is wrong.

In USM slurry comprising abrasiveparticles and water are often uses to remove material from the workpiece by abrasion or impact grinding action, thus statement (d) is correct.

Hence, the correct option is (D).

Question Number: 48 **Question Type: MCQ**

The crystal structure of aluminium is

(A) body-centred cubic
(B) face-centred cubic
(C) close-paced hexagonal
(D) body-centred tetragonal

Solution:

Crystal structure of aluminium is FCC that is face centered cubic.

Hence, the correct option is (B).

Question Number: 49 **Question Type: MCQ**

A sample of 15 data is as follows 17, 18, 17, 17, 13, 18, 5, 5, 6, 7, 8, 9, 20, 17, 3. The mode of the data is

(A) 4 (B) 13
(C) 17 (D) 20

Solution:

Mode refers to value that appears most frequently in a set of data.

17, 18, 17, 17, 13, 18, 5, 5, 6, 7, 8, 9, 20, 17, 3

The data which is repeated for maximum number of times, i.e., four times is 17.

Hence, the correct option is (C).

Question Number: 50 **Question Type: MCQ**

If a mass of moist air contained in a closed metallic vessel is heated, then its

(A) relative humidity decreases
(B) relative humidity increases
(C) specific humidity increases
(D) specific humidity decreases

Solution:

Mass of moist air is constant because moist air is contained in CLOSED VESSEL, so we cay say that

ω = specific humidity = $\dfrac{m_v}{m_{d.a.}}$

[$M_{d.a.}$ = dry air mass

ω = constant

Since container is heated, so

temperature (increases) ⇒ saturation pressure increases

⇒ mass at saturation pressure increase

So,

$$\phi = \frac{m_v}{m_{vs}}$$
= decreases

Hence, the correct option is (A).

Question Number: 51 **Question Type: NAT**

For a loaded cantilever beam of uniform crosssection, the bending moment (in N-mm) along the length is $M(x) = 5x^2 + 10x$, where x is the distance (in mm) measured from the free end of the beam. The magnitude of shear force (in N) in the cross-section at x = 10 mm is _____.

Solution:

Consider the figure given below

Shear force $= \dfrac{dM}{dx} = 10x + 10$

at x = 10 mm

SF = 100 + 10 = 110 N

Hence, the correct answer is (110).

Question Number: 52 **Question Type: NAT**

A machine component made of a ductile material is subjected to a variable loading with σ_{min} = –50 MPa and σ_{max} = 50 MPa. If the corrected endurnace limit and the yield strength for the material are eσ'_e = 100 MPa and σ_y = 300 MPa, respectively, the factor of safety is ____.

Solution:

Since the machine component is ductile, so using soderberg criterion:

$$\frac{1}{N} = \frac{\sigma_{\text{mean}}}{\sigma_{\text{yield}}} + \frac{\sigma_v}{\sigma_{\text{enduranec}}}$$

$$\sigma_{\text{mean}} = 0$$

$$\sigma_{\text{variable}} = \frac{50-(-50)}{2} = 50 \text{ MPa}$$

$$\frac{1}{N} = \frac{0}{\sigma_{\text{yield}}} + \frac{50}{100}$$

$$N = 2$$

Hence, the correct answer is (2).

Question Number: 53 **Question Type: MCQ**

For the stability of a floating body the

(A) centre of buoyancy must coincide with the centre of gravity
(B) centre of buoyancy must be above the centre gravity
(C) centre of gravity must be above the centre of buoyancy
(D) metacentre must be above the centre of gravity

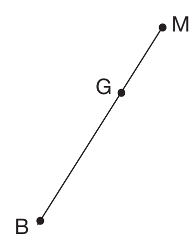
Solution:

∵ $GM = BM - BG$

(i) $GM > 0$, stable equilibrium

(ii) $GM = 0$, Neutral equilibirum

(iii) $GM < 0$, unstable



For stability of floating body : GM > 0 So, metacenter must be above the centre of gravity.

Hence, the correct option is (D).

Question Number: 54 **Question Type: MCQ**

The Laplace transform of tet is

(A) $\dfrac{s}{(s+1)^2}$ (B) $\dfrac{s}{(s-1)^2}$

(C) $\dfrac{s}{(s+1)^2}$ (D) $\dfrac{s}{s-1}$

Solution:

$F(t) = t.e^t$

$F(t) = g(t).e^{at}$ and if $\angle g(t) = G(s)$

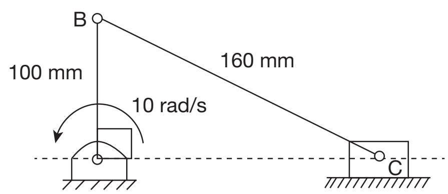
$\angle F(t) = F(s) = G(s-a)$

$$\angle F(t) = \angle te^t = \frac{s}{(s-1)^2}$$

Hence, the correct answer is (B).

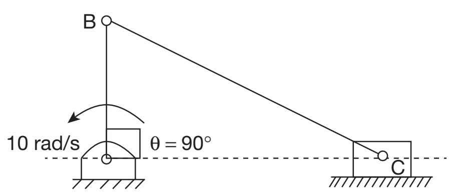
Question Number: 55 **Question Type: NAT**

In a slider-crank mechanism, the lengths of the crank and the connecting rod are 100 mm and 160 mm, respectively. The crank is rotating with an angular velocity of 10 radian/s counter-clockwise. The magnitude of linear velocity (in m/s) of the piston at the instant corresponding to the configuration shown in the figure is ____.



Solution:

Consider the figure given below



$$V = r\omega\left[\sin\theta + \frac{\sin 2\theta}{2n}\right]$$

$$n = \frac{l}{r} = \frac{160}{100} = 1.6$$

$\theta = 90°$

r = crank length = 100 mm = 0.1 m

$$V = r\omega\left[\sin 90° + \frac{\sin 180°}{2n}\right]$$

$V = 0.1 \times 10 = 1 m/s$

Hence, the correct answer is (1).

Question Number: 56 **Question Type: NAT**

The determinant of a 2 × 2 matrix is 50. If one eigenvalue of the matrix is 10, the other eigenvalue is______.

Solution:

Product of eigne values = Determinant of matrix

$10 \times \lambda = 50$

$\lambda = 5$

Hence, the correct answer is (5).

Question Number: 57 **Question Type: NAT**

Two coins are tossed simultaneously. The probability (upto two decimal points accuracy) of getting at least one head is ____.

Solution:

outcomes (H, H) (H, T) (T, H) (T, T)

$$P(\text{at least one head}) = = \frac{3}{4} = 0.75$$

Hence, the correct answer is (0.75).

Question Number: 58 **Question Type: MCQ**

Consider the laminar flow at zero incidence over a flat plate. The shear stress at the wall is denoted by τ_w. The axial positions x_1 and x_2 on the plate are measured from the leading edge in the direction of flow. If $x_2 > x_1$

t hen

(A) $\tau_w|_{x_1} = \tau_w|_{x_2} = 0$

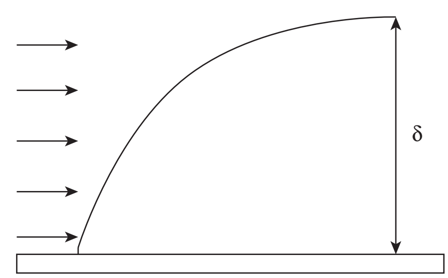
(B) $\tau_w|_{x_1} = \tau_w|_{x_2} \neq 0$

(C) $\tau_w|_{x_1} = \tau_w|_{x_2}$

(D) $\tau_w|_{x_1} < \tau_w|_{x_2}$

Solution:

Consider the figure given below



Now we have

$$\frac{u}{u_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{4}{\delta}\right)^3$$

$$\tau_{\text{wall}} = \mu\left(\frac{du}{dy}\right)_{y=0}$$

$$\tau_{\text{wall}} = \frac{3\mu}{2\delta}$$

$$\text{Since, } \delta = \frac{4.65x}{\sqrt{\text{Re}_x}}$$

$$\delta \propto x^{1/2}$$

$$\tau_{\text{wall}} \infty x^{-1/2}$$

So as 'x' increases, τ_{wall} decreases.

$\tau_w|_{x1} > \tau_w|_{x2}$

Hence, the correct answer is (C).

Question Number: 59 **Question Type: NAT**

The divergence of the vector $-yi + xj$ is____.

Solution:

$$-y\hat{i} + x\hat{j}$$
$$\Rightarrow div.(-y\hat{i} + x\hat{j})$$
$$\Rightarrow \nabla.(-y\hat{i} + xj6) = 0 + 00$$

[Dot product of vector quantity is zero]

Hence, the correct answer is (0).

Question Number: 60 **Question Type: NAT**

The standard deviation of linear dimensions P and Q are 3 μm and 4 μm respectively. When assembled, the standard deviation (inμm) of the resulting linear dimension $(P + Q)$ is ______.

Solution:

Standard deviation $\sigma_P = 3$ mμ

Standard deviation $\sigma_Q = 4$ μm

Variance $\sigma^2{}_P = 9$

Variance $\sigma^2{}_Q = 16$

Now we know that variance can be added therefore

$\sigma^2{}_{(P+Q)} = = 9 + 16 = 25$

$\sigma_{(p+q)} = 5$

Hence, the correct answer is (5).

Question Number: 61 **Question Type: MCQ**

The emissive power of a blackbody is P. If its absolute temperature is doubled, the emissive power becomes

(A) 2P (B) 4P
(C) 8P (D) 16P

Solution:

Emissive power = $\sigma A.T^4$

Power ∞ T^4

Absolute temperature increases by two fold, so power becomes 2^4.P =16P.

Hence, the correct answer is (D).

Question Number: 62 **Question Type: NAT**

The state of stress at a point is $\sigma_x = \sigma_y = \sigma_z = \tau_{xz} = y_z = \tau_{zy} = 0$ and $\tau_{xy} = \tau_{yx} = 50$ MPa. The maximum normal stress (in MPa) at the point is____.

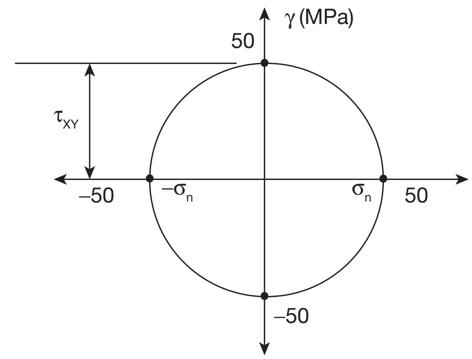
Solution:

$\sigma_x = \sigma_y = \sigma_z$

$\tau_{xz} = \tau_{zx} = \tau_{yz} = \tau_{zy}$

This is case of Biaxial pure shear.

Mohr' circle



Maximum normal stress at the point = 50 MPc.

Hence, the correct answer is (50).

Question Number: 63 **Question Type: MCQ**

A cantilever beam of length L and flexural modulus EI is subjected to a point load P at the free end. The elastic strain energy stored in the beam due to bending (neglecting transverse shear) is

(A) $\frac{P^2L^3}{6EI}$

(B) $\frac{P^2L^3}{3EI}$

(C) $\frac{PL^3}{3EI}$

(D) $\frac{PL^3}{6EI}$

Solution: (A)

$$M_{x\text{-}x} = P_x$$
$$U = \frac{M^2L}{3EI}$$
$$U_{x\text{-}x} = \int_0^2 \frac{(Px)^2\,dx}{2EI} - \frac{P^2}{2EI}\int_0^L x^2dx$$
$$= \frac{P^2}{2EI}\left[\frac{x^3}{3}\right]_0^2 = \frac{P^2L^3}{6EI}$$

Hence, the correct answer is (A).

Question Number: 64 **Question Type: NAT**

A steel bar is held by two fixed supports as shown in the figure and is subjected to an increase of temperature ΔT = 100°C. If the coefficient of thermal expansion and Young's modulus of elasticity of steel are 11×10^{-6}/ C and 200 GPa, respectively, the magnitude of thermal stress (in MPa) induced in the bar is ___.

Solution:

For Indeterminate Structure :

$\Delta T = 100°C$

$\alpha = 11 \times 10^{-6}/°C$

$E = 200$ GPc

For Indeterminate Structure :

$$\Delta L = 0$$

$$\frac{RL}{AE} + L\alpha\Delta T = 0$$

$$\frac{R}{A} = \frac{-L\alpha\Delta T}{L}.E$$

$$\frac{R}{A} = \sigma = \alpha\Delta TE$$

$$\sigma = (11.10^{-6}) \times (100).200.10^{3}$$

$$= 220\,MPa$$

Hence, the correct answer is (220 MPa).

Question Number: 65 **Question Type: NAT**

The heat loss from a fin is 6 W. The effectiveness and efficiencyof the fin are 3 and 0.75 respectively. The heat loss (in W) from the fin, keeping the entire fin surface at base temperature, is _____.

Solution:

$$\text{Efficiency} = \frac{\text{Heat loss from the fin}}{\text{Maximum HeatDissipated if the entire fin surface were at base temperature.}}$$

$$0.75 = \frac{6}{Q}$$

$$Q = \frac{6}{0.75} = 8W$$

Hence, the correct answer is (8).