ME GATE-05

MCQ 1.1 Stokes theorem connects

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(A) a line integral and a surface integral

(B) a surface integral and a volume integral

(C) a line integral and a volume integral

(D) gradient of a function and its surface integral

SOL 1.1 Option (A) is correct.

We know that the Stokes theorem is,

$$\oint_C \boldsymbol{F} \cdot dr = \iint_S (\nabla \times \boldsymbol{F}) \cdot \boldsymbol{n} dS = \iint_S (\text{Curl } \boldsymbol{F}) \cdot dS$$

Here we can see that the line integral $\oint_C \boldsymbol{F} \cdot dr$ & surface integral $\iint_S (\text{Curl } \boldsymbol{F}) \cdot ds$ is related to the stokes theorem.

MCQ 1.2 A lot has 10% defective items. Ten items are chosen randomly from this lot. The probability that exactly 2 of the chosen items are defective is

GATE ME 2005 ONE MARK

(A) 0.0036

(B) 0.1937

(C) 0.2234

(D) 0.3874

SOL 1.2 Option (B) is correct.

Let, $P =$ defective items

$Q =$ non-defective items

10% items are defective, then probability of defective items

$$P = 0.1$$

Probability of non-defective item

$$Q = 1 - 0.1 = 0.9$$

The Probability that exactly 2 of the chosen items are defective is

$$= {}^{10}C_2 (P)^2 (Q)^8 = \frac{10!}{8!2!} (0.1)^2 (0.9)^8$$

$$= 45 \times (0.1)^2 \times (0.9)^8 = 0.1937$$

MCQ 1.3 $\int_{-a}^{a} (\sin^6 x + \sin^7 x)\, dx$ is equal to

GATE ME 2005 ONE MARK

(A) $2\int_0^a \sin^6 x\, dx$

(B) $2\int_0^a \sin^7 x\, dx$

(C) $2\int_0^a (\sin^6 x + \sin^7 x)\, dx$ (D) zero

SOL 1.3 Option (A) is correct.

Let $$f(x) = \int_{-a}^{a} (\sin^6 x + \sin^7 x)\, dx$$

$$f(x) = \int_{-a}^{a} \sin^6 x dx + \int_{-a}^{a} \sin^7 x dx$$

We know that

$$\int_{-a}^{a} f(x)\, dx = \begin{cases} 0 & \text{when } f(-x) = -f(x); \text{odd function} \\ 2\int_0^a f(x) & \text{when } f(-x) = f(x); \text{even function} \end{cases}$$

Now, here $\sin^6 x$ is an even function & $\sin^7 x$ is an odd function. Then,

$$f(x) = 2\int_0^a \sin^6 x dx + 0 = 2\int_0^a \sin^6 x dx$$

MCQ 1.4 GATE ME 2005 ONE MARK

A is a 3×4 real matrix and $Ax = b$ is an inconsistent system of equations. The highest possible rank of A is

(A) 1 (B) 2

(C) 3 (D) 4

SOL 1.4 Option (C) is correct.

We know, from the Echelon form the rank of any matrix is equal to the Number of non zero rows.

Here order of matrix is 3×4, then, we can say that the Highest possible rank of this matrix is 3.

MCQ 1.5 GATE ME 2005 ONE MARK

Changing the order of the integration in the double integral $I = \int_0^8 \int_{\frac{x}{4}}^{2} f(x, y)\, dy dx$ leads to $I = \int_r^s \int_p^q f(x, y)\, dx dy$ What is q ?

(A) $4y$ (B) $16\ y^2$

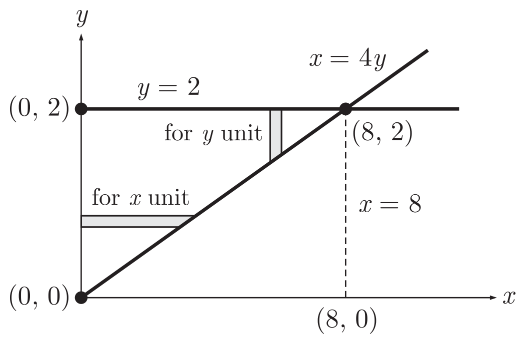
(C) x (D) 8

SOL 1.5 Option (A) is correct.

Given $$I = \int_0^8 \int_{\pi/4}^{2} f(x, y)\, dy dx$$

Here we can draw the graph from the limits of the integration, the limit of y is from $y = \frac{x}{4}$ to $y = 2$

For x the limit is $x = 0$ to $x = 8$



Here we use the changing the order of the integration. The limit of x is 0 to 8 but we have to find the limits in the form of y then $x = 0$ to $x = 4y$ & limit of y is 0 to 2

So $\int_0^8 \int_{x/4}^2 f(x,y)\,dydx = \int_0^2 \int_0^{4y} f(x,y)\,dxdy = \int_r^s \int_p^q f(x,y)\,dxdy$

Comparing the limits and get

$r = 0,\ s = 2,\ p = 0,\ q = 4y$

MCQ 1.6 GATE ME 2005 ONE MARK

The time variation of the position of a particle in rectilinear motion is given by $x = 2t^3 + t^2 + 2t$. If v is the velocity and a is the acceleration of the particle in consistent units, the motion started with

(A) $v = 0, a = 0$ (B) $v = 0, a = 2$

(C) $v = 2, a = 0$ (D) $v = 2, a = 2$

SOL 1.6 Option (D) is correct.

Given ; $x = 2t^3 + t^2 + 2t$

We know that,

$$v = \frac{dx}{dt} = \frac{d}{dt}(2t^3 + t^2 + 2t) = 6t^2 + 2t + 2 \qquad ...(i)$$

We have to find the velocity & acceleration of particle, when motion stared, So

At $t = 0$, $v = 2$

Again differentiate equation (i) w.r.t. t

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = 12t + 2$$

At $t = 0$, $a = 2$

MCQ 1.7 GATE ME 2005 ONE MARK

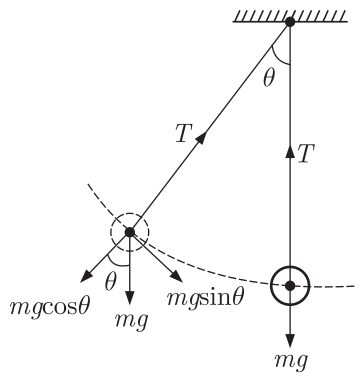
A simple pendulum of length of 5 m, with a bob of mass 1 kg, is in simple harmonic motion. As it passes through its mean position, the bob has a speed of 5 m/s. The net force on the bob at the mean position is

(A) zero (B) 2.5 N

(C) 5 N (D) 25 N

SOL 1.7 Option (A) is correct.

We have to make the diagram of simple pendulum



Here, We can see easily from the figure that tension in the string is balanced by the weight of the bob and net force at the mean position is always zero.

MCQ 1.8 GATE ME 2005 ONE MARK

A uniform, slender cylindrical rod is made of a homogeneous and isotropic material. The rod rests on a frictionless surface. The rod is heated uniformly. If the radial and longitudinal thermal stresses are represented by σ_r and σ_z, respectively, then

(A) $\sigma_r = 0, \sigma_z = 0$

(B) $\sigma_r \neq 0, \sigma_z = 0$

(C) $\sigma_r = 0, \sigma_z \neq 0$

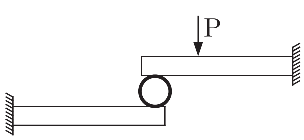
(D) $\sigma_r \neq 0, \sigma_z \neq 0$

SOL 1.8

Option (A) is correct.
We know that due to temperature changes, dimensions of the material change. If these changes in the dimensions are prevented partially or fully, stresses are generated in the material and if the changes in the dimensions are not prevented, there will be no stress set up. (Zero stresses).
Hence cylindrical rod is allowed to expand or contract freely.
So, $\sigma_r = 0$ and $\sigma_z = 0$

MCQ 1.9 GATE ME 2005 ONE MARK

Two identical cantilever beams are supported as shown , with their free ends in contact through a rigid roller. After the load P is applied, the free ends will have



(A) equal deflections but not equal slopes

(B) equal slopes but not equal deflections

(C) equal slopes as well as equal deflections

(D) neither equal slopes nor equal deflections

SOL 1.9

Option (A) is correct.
From the figure, we can say that load P applies a force on upper cantilever and the reaction force also applied on upper cantilever by the rigid roller. Due to this, deflections are occur in both the cantilever, which are equal in amount. But

because of different forces applied by the P and rigid roller, the slopes are unequal.

MCQ 1.10 GATE ME 2005 ONE MARK

The number of degrees of freedom of a planar linkage with 8 links and 9 simple revolute joints is

(A) 1 (B) 2

(C) 3 (D) 4

SOL 1.10 Option (C) is correct.

Given $l = 8$, $j = 9$

We know that, Degree of freedom,

$$n = 3(l-1) - 2j = 3(8-1) - 2\times 9 = 3$$

MCQ 1.11 GATE ME 2005 ONE MARK

There are four samples P, Q, R and S, with natural frequencies 64, 96, 128 and 256 Hz, respectively. They are mounted on test setups for conducting vibration experiments. If a loud pure note of frequency 144 Hz is produced by some instrument, which of the samples will show the most perceptible induced vibration?

(A) P (B) Q

(C) R (D) S

SOL 1.11 Option (C) is correct.

The speed of sound in air $= 332$ m/s

For frequency of instrument of 144 Hz, length of sound wave

$$L_I = \frac{332}{144} = 2.30\text{ m}$$

For sample P of 64 Hz,

$$L_P = \frac{332}{64} = 5.1875\text{ m}$$

Q of 96 Hz $$L_Q = \frac{332}{96} = 3.458\text{ m}$$

R of 128 Hz $$L_R = \frac{332}{128} = 2.593\text{ m}$$

S of 250 Hz $$L_S = \frac{332}{256} = 1.2968\text{ m}$$

Here, the length of sound wave of sample $R(L_R = 2.593\text{ m})$ is most close to the length of sound wave of Instrument ($L_I = 2.30$ m). Hence, sample R produce most perceptible induced vibration.

MCQ 1.12 GATE ME 2005 ONE MARK

Which one of the following is criterion in the design of hydrodynamic journal bearings ?

(A) Sommerfeld number (B) Rating life

(C) Specific dynamic capacity (D) Rotation factor

SOL 1.12 Option (A) is correct.

The coefficient of friction for a full lubricated journal bearing is a function of three variables, i.e.

$$\mu = \phi\left(\frac{ZN}{p}, \frac{d}{c}, \frac{l}{d}\right)$$

Here, $\frac{ZN}{p}$=Bearing characteristic Number, d=Diameter of the bearing

l=Length of the bearing, c=Diameteral clearance

$$\text{Sommerfeld Number} = \frac{ZN}{p}\left(\frac{d}{c}\right)^2$$

It is a dimensionless parameter used extensively in the design of journal bearing. i.e. sommerfeld number is also function of $\left(\frac{ZN}{p}, \frac{d}{c}\right)$. Therefore option (A) is correct.

MCQ 1.13 GATE ME 2005 ONE MARK

The velocity components in the x and y directions of a two dimensional potential flow are u and v, respectively. Then $\frac{\partial u}{\partial x}$ is equal to

(A) $\frac{\partial v}{\partial x}$ (B) $-\frac{\partial v}{\partial x}$

(C) $\frac{\partial v}{\partial y}$ (D) $-\frac{\partial v}{\partial y}$

SOL 1.13 Option (D) is correct.

We know that potential flow (ideal flow) satisfy the continuity equation.

The continuity equation for two dimensional flow for incompressible fluid is given by,

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

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

MCQ 1.14 GATE ME 2005 ONE MARK

In a case of one dimensional heat conduction in a medium with constant properties, T is the temperature at position x, at time t. Then $\frac{\partial T}{\partial t}$ is proportional to

(A) $\frac{T}{x}$ (B) $\frac{\partial T}{\partial x}$

(C) $\frac{\partial^2 T}{\partial x \partial t}$ (D) $\frac{\partial^2 T}{\partial x^2}$

SOL 1.14 Option (D) is correct.

The general heat equation in cartesian co-ordinates,

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

For one dimensional heat conduction,

$$\frac{\partial^2 T}{\partial x^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t} = \frac{\rho c_p}{k}\frac{\partial T}{\partial t} \qquad \alpha = \frac{k}{\rho c_p} = \text{Thermal Diffusitivity}$$

For constant properties of medium,

$$\frac{\partial T}{\partial t} \propto \frac{\partial^2 T}{\partial x^2}$$

MCQ 1.15
GATE ME 2005
ONE MARK

The following four figures have been drawn to represent a fictitious thermodynamic cycle, on the p-ν and T-s planes.

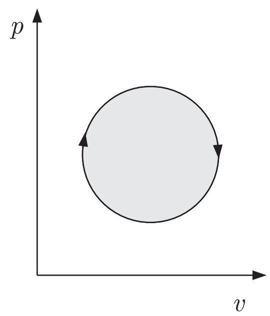


fig. 1

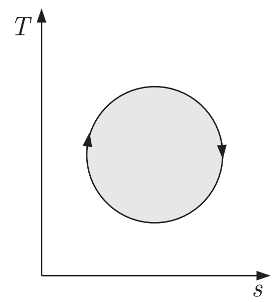


fig. 2

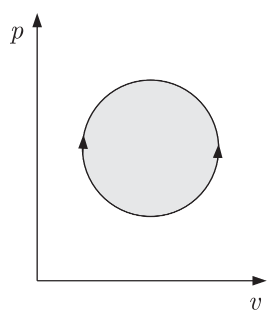


fig. 3

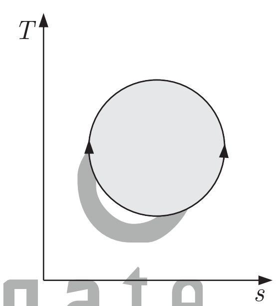


fig.4

According to the first law of thermodynamics, equal areas are enclosed by

(A) figures 1 and 2
(B) figures 1 and 3
(C) figures 1 and 4
(D) figures 2 and 3

SOL 1.15

Option (A) is correct.

From the first law of thermodynamics for a cyclic process,

$$\Delta U = 0$$

And
$$\oint \delta Q = \oint \delta W$$

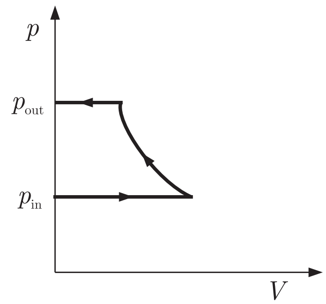
The symbol $\oint \delta Q$, which is called the cyclic integral of the heat transfer represents the heat transfer during the cycle and $\oint \delta W$, the cyclic integral of the work, represents the work during the cycle.

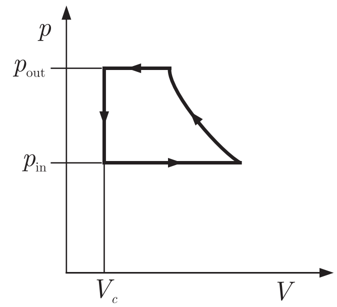
We easily see that figure 1 and 2 satisfies the first law of thermodynamics. Both the figure are in same direction (clockwise) and satisfies the relation.

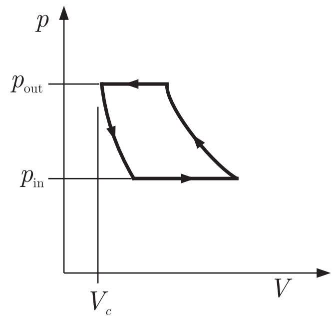
$$\oint \delta Q = \oint \delta W$$

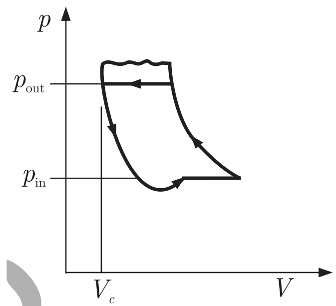
MCQ 1.16
GATE ME 2005
ONE MARK

A p-v diagram has been obtained from a test on a reciprocating compressor. Which of the following represents that diagram ?

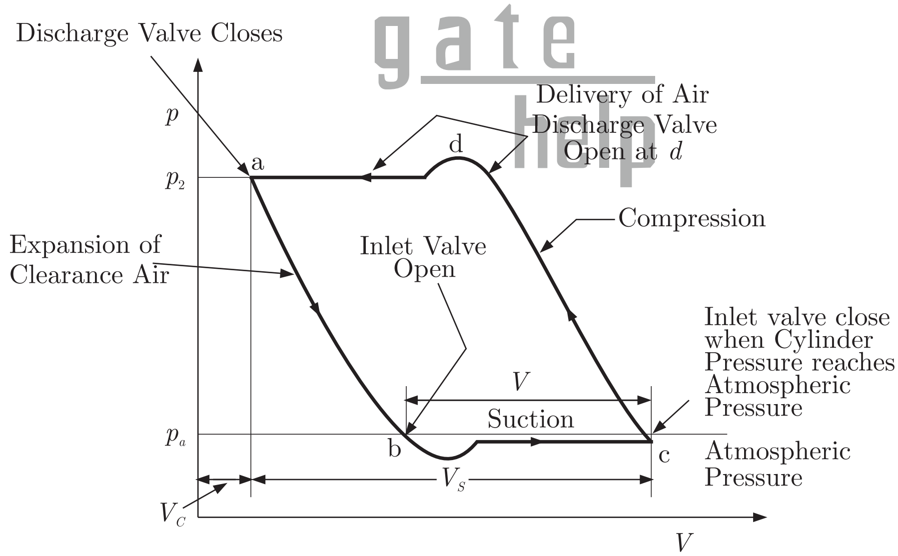
(A)


(B)


(C)


(D)


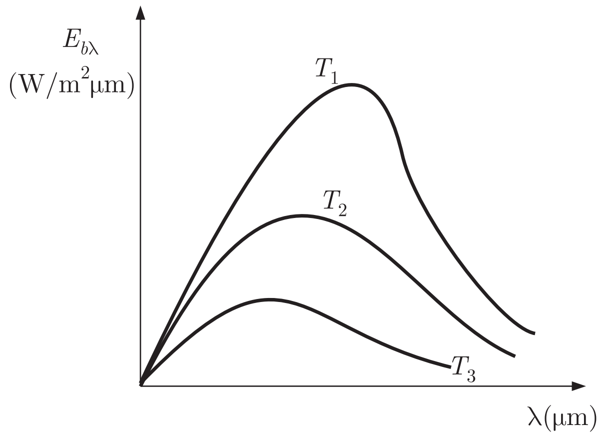
SOL 1.16 Option (D) is correct.



From above figure, we can easily see that option (D) is same.

MCQ 1.17 GATE ME 2005 ONE MARK

The following figure was generated from experimental data relating spectral black body emissive power to wavelength at three temperature T_1, T_2 and T_3 $(T_1 > T_2 > T_3)$.



The conclusion is that the measurements are

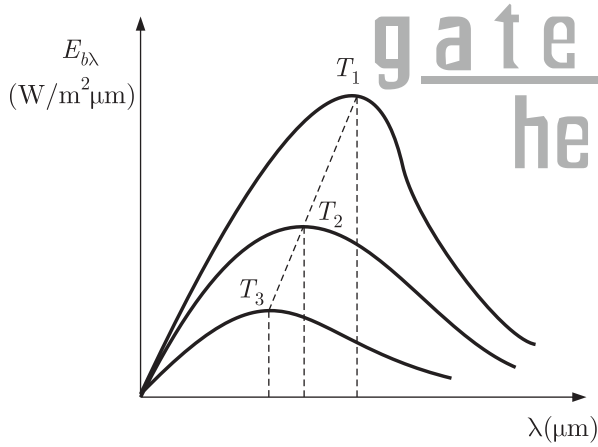
(A) correct because the maxima in $E_{b\lambda}$ show the correct trend

(B) correct because Planck's law is satisfied

(C) wrong because the Stefan Boltzmann law is not satisfied

(D) wrong because Wien's displacement law is not satisfied

SOL 1.17 Option (D) is correct.



Given : $T_1 > T_2 > T_3$

From, Wien's displacement law,

$$\lambda_{\max} T = 0.0029 \, \text{mK} = \text{Constant}$$

$$\lambda_{\max} \propto \frac{1}{T}$$

If T increase, then λ_m decrease. But according the figure, when T increases, then λ_m also increases. So, the Wien's law is not satisfied.

MCQ 1.18 GATE ME 2005 ONE MARK

For a typical sample of ambient air (at 35° C, 75% relative humidity and standard atmosphere pressure), the amount of moisture in kg per kg of dry air will be approximately

(A) 0.002

(B) 0.027

(C) 0.25 (D) 0.75

SOL 1.18 Option (B) is correct.

From steam table, saturated air pressure corresponding to dry bulb temperature of 35° C is $p_s = 0.05628\text{ bar}$.

Relative humidity,

$$\phi = \frac{p_v}{p_s} = 0.75$$

$$p_v = 0.75 \times p_s = 0.75 \times 0.05628 = 0.04221\text{ bar}$$

Now the amount of moisture in kg/kg of dry air, (Specific Humidity) is

$$W = 0.622 \times \frac{p_v}{p_b - p_v} \qquad p_b = p_{atm} = 1.01\text{ bar}$$

$$= 0.622 \times \frac{0.04221}{1.01 - 0.04221}$$

$$= 0.622 \times 0.04362$$

$$= 0.0271\text{ kg/kg of dry air}$$

MCQ 1.19 GATE ME 2005 ONE MARK

Water at 42° C is sprayed into a stream of air at atmospheric pressure, dry bulb temperature of 40° C and a wet bulb temperature of 20° C. The air leaving the spray humidifier is not saturated. Which of the following statements is true ?

(A) Air gets cooled and humidified (B) Air gets heated and humidified

(C) Air gets heated and dehumidified (D) Air gets cooled and dehumidified

SOL 1.19 Option (B) is correct.

Given : $t_{sp} = 42^\circ$ C, $t_{db} = 40^\circ$ C, $t_{wb} = 20^\circ$ C

Here we see that $t_{sp} > t_{db}$

Hence air gets heated, Also water is added to it, so it gets humidified.

MCQ 1.20 GATE ME 2005 ONE MARK

Match the items of List-I (Equipment) with the items of List-II (Process) and select the correct answer using the given codes.

	List-I (Equipment)		List-II (Process)
P.	Hot Chamber Machine	**1.**	Cleaning
Q.	Muller	**2.**	Core making
R.	Dielectric Baker	**3.**	Die casting
S.	Sand Blaster	**4.**	Annealing
		5.	Sand mixing

(A) P-2, Q-1, R-4, S-5

(B) P-4, Q-2, R-3, S-5

(C) P-4, Q-5, R-1, S-2

(D) P-3, Q-5, R-2, S-1

SOL 1.20 Option (D) is correct.

	List-I (Equipment)		List-II (Process)
P.	Hot Chamber Machine	**3.**	Die casting
Q.	Muller	**5.**	Sand mixing
R.	Dielectric Baker	**2.**	Core making
S.	Sand Blaster	**1.**	Cleaning

So, correct pairs are, P-3, Q-5, R-2, S-1

MCQ 1.21 When the temperature of a solid metal increases,

GATE ME 2005 ONE MARK

(A) strength of the metal decreases but ductility increases

(B) both strength and ductility of the metal decreases

(C) both strength and ductility of the metal increases

(D) strength of the metal increases but ductility decreases

SOL 1.21 Option (A) is correct.

When the temperature of a solid metal increases, its intramolecular bonds are brake and strength of solid metal decreases. Due to decrease its strength, the elongation of the metal increases, when we apply the load i.e. ductility increases.

MCQ 1.22 The strength of a brazed joint

GATE ME 2005 ONE MARK

(A) decreases with increase in gap between the two joining surfaces

(B) increases with increase in gap between the two joining surfaces

(C) decreases up to certain gap between the two joining surfaces beyond which it increases

(D) increases up to certain gap between the two joining surfaces beyond which it decreases

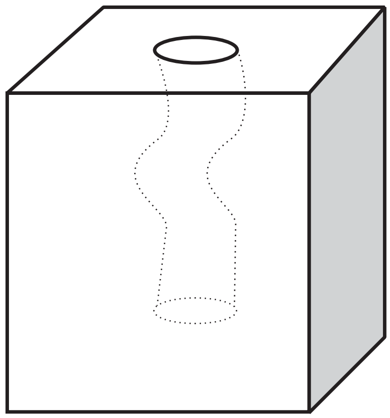
SOL 1.22 Option (D) is correct.

The strength of the brazed joint depend on (a) joint design and (b) the adhesion at the interfaces between the workpiece and the filler metal.

The strength of the brazed joint increases up to certain gap between the two joining surfaces beyond which it decreases.

MCQ 1.23 A zigzag cavity in a block of high strength alloy is to be finish machined. This can be carried out by using.

GATE ME 2005 ONE MARK



(A) electric discharge machining (B) electric-chemical machining

(C) laser beam machining (D) abrasive flow machining

SOL 1.23 Option (B) is correct.

In ECM, the principal of electrolysis is used to remove metal from the workpiece. The ECM method has also been developed for machining new hard and tough materials (for rocket and aircraft industry) and also hard refractory materials.

MCQ 1.24 In order to have interference fit, it is essential that the lower limit of the shaft should be

GATE ME 2005
ONE MARK

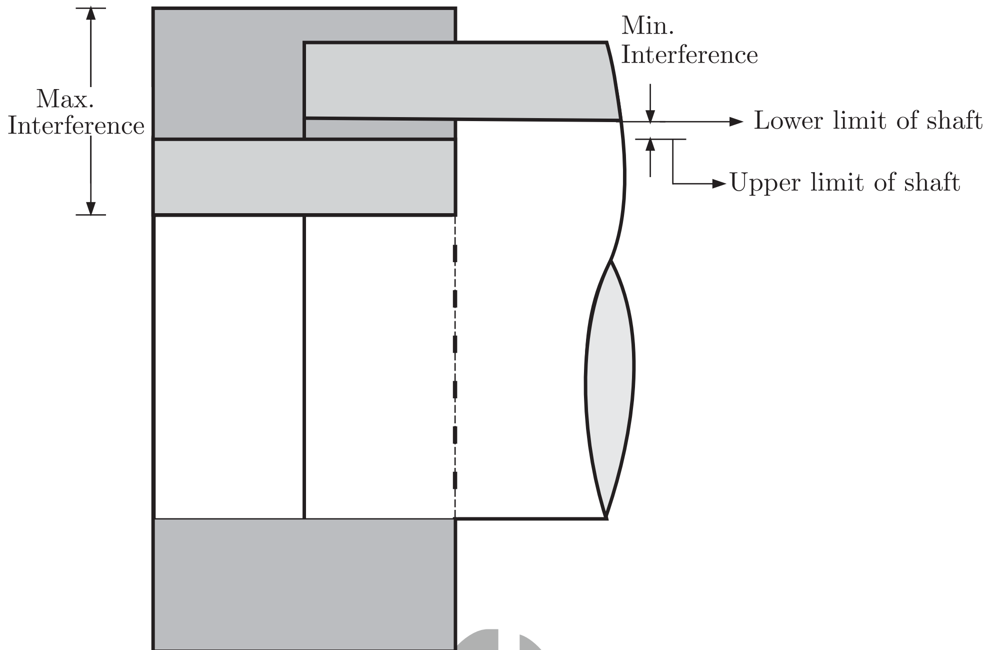
(A) greater than the upper limit of the hole

(B) lesser than the upper limit of the hole

(C) greater than the lower limit of the hole

(D) lesser than the lower limit of the hole

SOL 1.24 Option (A) is correct.



The interference is the amount by which the actual size of a shaft is larger than the actual finished size of the mating hole in an assembly.
For interference fit, lower limit of shaft should be greater than the upper limit of the hole (from figure).

MCQ 1.25 GATE ME 2005 ONE MARK

When 3-2-1 principle is used to support and locate a three dimensional work-piece during machining, the number of degrees of freedom that are restricted is

(A) 7 (B) 8

(C) 9 (D) 10

SOL 1.25 Option (C) is correct.

According to 3-2-1 principle, only the minimum locating points should be used to secure location of the work piece in any one plane.

(A) The workpiece is resting on three pins A, B, C which are inserted in the base of fixed body.

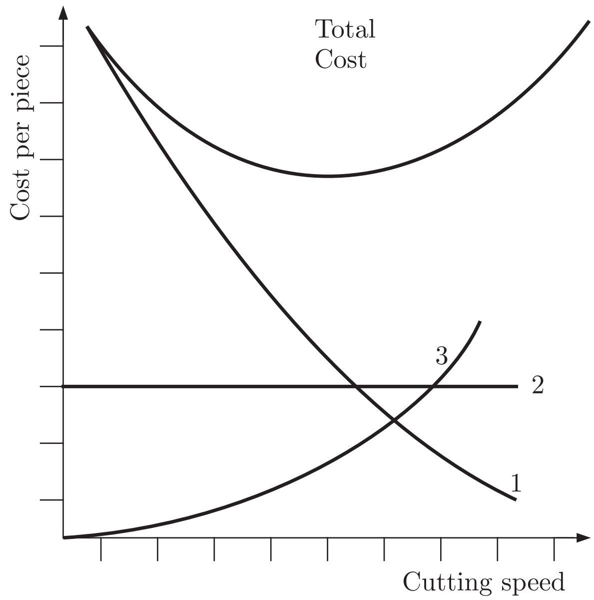
The workpiece cannot rotate about the axis XX and YY and also it cannot move downward. In this case, the five degrees of freedom have been arrested.

(B) Two more pins D and E are inserted in the fixed body, in a plane perpendicular to the plane containing, the pins A, B and C. Now the workpiece cannot rotate about the Z-axis and also it cannot move towards the left. Hence the addition of pins D and E restrict three more degrees of freedom.

(C) Another pin F in the second vertical face of the fixed body, arrests degree of freedom 9.

MCQ 1.26 GATE ME 2005 ONE MARK

The figure below shows a graph which qualitatively relates cutting speed and cost per piece produced.



The three curves 1, 2 and 3 respectively represent

(A) machining cost, non-productive cost, tool changing cost

(B) non-productive cost, machining cost, tool changing cost

(C) tool changing cost, machining cost, non-productive cost

(D) tool changing cost, non-productive cost, machining cost

SOL 1.26 Option (A) is correct.

We know,

Machining cost = Machining time $\times$ Direct labour cost.

If cutting speed increases then machining time decreases and machining cost also decreases and due to increase in cutting speed tool changing cost increases.

So, Curve 1 $\rightarrow$ Machining cost

Curve 2 $\rightarrow$ Non-productive cost

Curve 3 $\rightarrow$ Tool changing cost

MCQ 1.27 Which among the NC operations given below are continuous path operations ?

GATE ME 2005 ONE MARK

Arc Welding (AW)

Drilling (D)

Laser Cutting of Sheet Metal (LC)

Milling (M)

Punching in Sheet Metal (P)

Spot Welding (SW)

(A) AW, LC and M

(B) AW, D, LC and M

(C) D, LC, P and SW

(D) D, LC, and SW

SOL 1.27 Option (A) is correct.

Arc welding, Laser cutting of sheet and milling operations are the continuous path operations.

MCQ 1.28 An assembly activity is represented on an Operation Process Chart by the symbol

GATE ME 2005 ONE MARK

(A) □ (B) A

(C) D (D) O

SOL 1.28 Option (D) is correct.

In operation process chart an assembly activity is represented by the symbol O

MCQ 1.29 The sales of a product during the last four years were 860, 880, 870 and 890 units. The forecast for the fourth year was 876 units. If the forecast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average, the value of the exponential smoothing constant α is

GATE ME 2005 ONE MARK

(A) $\frac{1}{7}$ (B) $\frac{1}{5}$

(C) $\frac{2}{7}$ (D) $\frac{2}{5}$

SOL 1.29 Option (C) is correct.

Gives :

Sales of product during four years were 860, 880, 870 and 890 units.

Forecast for the fourth year $u_4 = 876$

Forecast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average.

So,
$$u_5 = \frac{1}{3}(880 + 870 + 890)$$
$$u_5 = 880 \text{ unit}$$

By the exponential smoothing method.
$$u_5 = u_4 + \alpha(x_4 - u_4)$$
$$880 = 876 + \alpha(890 - 876)$$
$$4 = \alpha(14)$$
$$\alpha = \frac{4}{14} = \frac{2}{7}$$

MCQ 1.30 Consider a single server queuing model with Poisson arrivals ($\lambda = 4$/hour) and exponential service ($\mu = 4$/hour). The number in the system is restricted to a maximum of 10. The probability that a person who comes in leaves without joining the queue is

GATE ME 2005 ONE MARK

(A) $\frac{1}{11}$ (B) $\frac{1}{10}$

(C) $\frac{1}{9}$ (D) $\frac{1}{2}$

SOL 1.30 Option (A) is correct.

Given : $\lambda = 4/\text{hour}, \quad \mu = 4/\text{hour}$

The sum of probability $\sum_{n=0}^{n=10} P_n = 1$ $\qquad n = 10$

$$P_0 + P_1 + P_2 ..... + P_{10} = 1$$

In the term of traffic intensity

$$\rho = \frac{\lambda}{\mu} \Rightarrow \rho = \frac{4}{4} = 1$$

So,

$$P_0 + \rho P_0 + \rho^2 P_0 + \rho^3 P_0 + ...\rho^{10} P_0 = 1 \qquad P_1 = \rho P_0, P_2 = \rho^2 P_0 \text{ and so on}$$

$$P_0(1 + 1 + 1 + ...) = 1$$

$$P_0 \times 11 = 1$$

$$P_0 = \frac{1}{11}$$

Hence,

The probability that a person who comes in leaves without joining the queue is,

$$P_{11} = \rho^{11} \cdot P_0$$

$$P_1 = 1^{11} \times \frac{1}{11}$$

$$P_1 = \frac{1}{11}$$

MCQ 1.31 Which one of the following is an eigen vector of the matrix

GATE ME 2005
TWO MARK

$$\begin{bmatrix} 5 & 0 & 0 & 0 \\ 0 & 5 & 0 & 0 \\ 0 & 0 & 2 & 1 \\ 0 & 0 & 3 & 1 \end{bmatrix}$$

(A) $\begin{bmatrix} 1 \\ -2 \\ 0 \\ 0 \end{bmatrix}$ (B) $\begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$

(C) $\begin{bmatrix} 1 \\ 0 \\ 0 \\ -2 \end{bmatrix}$ (D) $\begin{bmatrix} 1 \\ -1 \\ 2 \\ 1 \end{bmatrix}$

SOL 1.31 Option (A) is correct.

Let,

$$A = \begin{bmatrix} 5 & 0 & 0 & 0 \\ 0 & 5 & 0 & 0 \\ 0 & 0 & 2 & 1 \\ 0 & 0 & 3 & 1 \end{bmatrix}$$

The characteristic equation for eigen values is given by,

$$|A - \lambda I| = 0$$

$$A = \begin{vmatrix} 5-\lambda & 0 & 0 & 0 \\ 0 & 5-\lambda & 0 & 0 \\ 0 & 0 & 2-\lambda & 1 \\ 0 & 0 & 3 & 1-\lambda \end{vmatrix} = 0$$

Solving this, we get

$$(5-\lambda)(5-\lambda)[(2-\lambda)(1-\lambda)-3]=0$$
$$(5-\lambda)^2[2-3\lambda+\lambda^2-3]=0$$
$$(5-\lambda)^2(\lambda^2-3\lambda-1)=0$$

So, $$(5-\lambda)^2=0 \Rightarrow \lambda=5,\,5 \;\&\; \lambda^2-3\lambda-1=0$$

$$\lambda=\frac{-(-3)\pm\sqrt{9+4}}{2}$$

$$\lambda=\frac{3+\sqrt{13}}{2},\ \frac{3-\sqrt{13}}{2}$$

The eigen values are $\lambda=5,\,5,\,\frac{3+\sqrt{13}}{2},\,\frac{3-\sqrt{13}}{2}$

Let $$X_1=\begin{bmatrix}x_1\\x_2\\x_3\\x_4\end{bmatrix}$$

be the eigen vector for the eigen value $\lambda=5$

Then, $$(A-\lambda I)X_1=0$$
$$(A-5I)X_1=0$$

$$\begin{bmatrix}0&0&0&0\\0&0&0&0\\0&0&-3&1\\0&0&3&-4\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\\x_4\end{bmatrix}=0$$

Multiply & get

$$-3x_3+x_4=0$$
$$3x_3-4x_4=0$$

This implies that $x_3=0,\ x_4=0$

Let $x_1=k_1$ & $x_2=k_2$

So, eigen vector, $$X_1=\begin{bmatrix}k_1\\k_2\\0\\0\end{bmatrix}$$

where $k_1,\ k_2\ \varepsilon\ R$

MCQ 1.32 With a 1 unit change in b, what is the change in x in the solution of the system of equations $x+y=2, 1.01x+0.99y=b$?

GATE ME 2005
TWO MARK

(A) zero (B) 2 units

(C) 50 units (D) 100 units

SOL 1.32 Option (C) is correct.

Given : $x + y = 2$ ...(i)

$1.01x + 0.99y = b,\ db = 1\,\text{unit}$ ...(ii)

We have to find the change in x in the solution of the system. So reduce y From the equation (i) & (ii).

Multiply equation (i) by 0.99 & subtract from equation (ii)

$$1.01x + 0.99y - (0.99x + 0.99y) = b - 1.98$$
$$1.01x - 0.99x = b - 1.98$$
$$0.02x = b - 1.98$$

Differentiating both the sides, we get

$$0.02\,dx = db$$

$$dx = \frac{1}{0.02} = 50\,\text{unit} \qquad db = 1$$

MCQ 1.33 GATE ME 2005 TWO MARK

By a change of variable $x(u,v) = uv, y(u,v) = v/u$ is double integral, the integrand $f(x,y)$ changes to $f(uv, v/u)\,\phi(u,v)$. Then, $\phi(u,v)$ is

(A) $2v/u$ (B) $2uv$

(C) v^2 (D) 1

SOL 1.33 Option (A) is correct.

Given, $x(u,v) = uv$

$$\frac{dx}{du} = v, \qquad \frac{dx}{dv} = u$$

And $y(u,v) = \dfrac{v}{u}$

$$\frac{\partial y}{\partial u} = -\frac{v}{u^2} \qquad \frac{\partial y}{\partial v} = \frac{1}{u}$$

We know that,

$$\phi(u,v) = \begin{bmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} \end{bmatrix}$$

$$\phi(u,v) = \begin{bmatrix} v & u \\ \frac{-v}{u^2} & \frac{1}{u} \end{bmatrix} = v \times \frac{1}{u} - u \times \left(-\frac{v}{u^2}\right) = \frac{v}{u} + \frac{v}{u} = \frac{2v}{u}$$

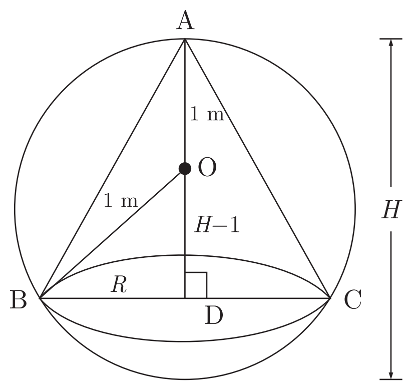
MCQ 1.34 GATE ME 2005 TWO MARK

The right circular cone of largest volume that can be enclosed by a sphere of 1 m radius has a height of

(A) 1/3 m (B) 2/3 m

(C) $\dfrac{2\sqrt{2}}{3}$m (D) 4/3 m

SOL 1.34 Option (D) is correct.



Given : Radius of sphere $r = 1$

Let, Radius of cone $= R$

Height of the cone $= H$

Finding the relation between the volume & Height of the cone

From ΔOBD, $OB^2 = OD^2 + BD^2$

$$1 = (H-1)^2 + R^2 = H^2 + 1 - 2H + R^2$$
$$R^2 + H^2 - 2H = 0$$
$$R^2 = 2H - H^2 \qquad \text{...(i)}$$

We know, the volume of the cone,

$$V = \frac{1}{3}\pi R^2 H$$

Substitute the value of R^2 from equation (i), we get

$$V = \frac{1}{3}\pi(2H - H^2)H = \frac{1}{3}\pi(2H^2 - H^3)$$

Differentiate V w.r.t to H

$$\frac{dV}{dH} = \frac{1}{3}\pi[4H - 3H^2]$$

Again differentiate

$$\frac{d^2V}{dH^2} = \frac{1}{3}\pi[4 - 6H]$$

For minimum & maximum value, using the principal of minima & maxima.

Put $\frac{dV}{dH} = 0$

$$\frac{1}{3}\pi[4H - 3H^2] = 0$$
$$H[4 - 3H] = 0$$
$$H = 0 \ \& \ H = \frac{4}{3}$$

At $H = \frac{4}{3}$,

$$\frac{d^2V}{dH^2} = \frac{1}{3}\pi\left[4 - 6 \times \frac{4}{3}\right] = \frac{1}{3}\pi[4 - 8] = -\frac{4}{3}\pi < 0 \text{ (Maxima)}$$

And at $H = 0$,

$$\frac{d^2V}{dH^2} = \frac{1}{3}\pi[4-0] = \frac{4}{3}\pi > 0 \text{ (Minima)}$$

So, for the largest volume of cone, the value of H should be $4/3$

MCQ 1.35 If $x^2\frac{dy}{dx} + 2xy = \frac{2\ln(x)}{x}$ and $y(1) = 0$, then what is $y(e)$?

GATE ME 2005 TWO MARK

(A) e

(B) 1

(C) $1/e$

(D) $1/e^2$

SOL 1.35 Option (D) is correct.

Given : $$x^2\frac{dy}{dx} + 2xy = \frac{2\ln(x)}{x}$$

$$\frac{dy}{dx} + \frac{2y}{x} = \frac{2\ln(x)}{x^3}$$

Compare this equation with the differential equation $\frac{dy}{dx} + P(y) = Q$

Then, $P = \frac{2}{x}$ & $Q = \frac{2\ln(x)}{x^3}$

The integrating factor is,

$$\text{I.F.} = e^{\int P dx} = e^{\int \frac{2}{x} dx}$$

$$e^{2\ln x} = e^{\ln x^2} = x^2$$

Then complete solution is written as,

$$y(I.F.) = \int Q(I.F.)\,dx + C$$

$$y(x^2) = \int \frac{2\ln x}{x^3} \times x^2\,dx + C = 2\int \underset{(II)}{\ln x} \times \underset{(I)}{\frac{1}{x}}\,dx + C \qquad \text{...(i)}$$

Integrating the value $\int \ln x \times \frac{1}{x}dx$ Separately

Let, $$I = \int \underset{(I)}{\ln x} \times \underset{(II)}{\frac{1}{x}}\,dx \qquad \text{...(ii)}$$

$$I = \ln x \int \frac{1}{x}dx - \int\left\{\frac{d}{dx}(\ln x) \times \int \frac{1}{x}dx\right\}dx$$

So, $$I = \ln x \ln x - \underbrace{\int \frac{1}{x} \times \ln x dx}_{I} \qquad \text{From equation(ii)}$$

$$2I = (\ln x)^2$$

$$I = \frac{(\ln x)^2}{2} \qquad \text{...(iii)}$$

Substitute the value from equation (iii) in equation (i),

$$y(x^2) = \frac{2(\ln x)^2}{2} + C$$

$$x^2 y = (\ln x)^2 + C \qquad \text{...(iv)}$$

Given $y(1) = 0$, means at $x = 1 \quad \Rightarrow y = 0$

then $\quad 0 = (\ln 1)^2 + C \Rightarrow C = 0$

So from equation (iv), we get

$$x^2 y = (\ln x)^2$$

Now at $x = e$

$$y(e) = \frac{(\ln e)^2}{e^2} = \frac{1}{e^2}$$

MCQ 1.36 GATE ME 2005 TWO MARK

The line integral $\int \boldsymbol{V} \cdot d\boldsymbol{r}$ of the vector $\boldsymbol{V} \cdot (\boldsymbol{r}) = 2xyz\boldsymbol{i} + x^2 z\boldsymbol{j} + x^2 y\boldsymbol{k}$ from the origin to the point P (1, 1, 1)

(A) is 1

(B) is zero

(C) is – 1

(D) cannot be determined without specifying the path

SOL 1.36 Option (A) is correct.

Potential function of $v = x^2 yz$ at $P(1,1,1)$ is $= 1^2 \times 1 \times 1 = 1$ and at origin $O(0,0,0)$ is 0.

Thus the integral of vector function from origin to the point (1,1,1) is

$$= [x^2 yz]_P - [x^2 yz]_O$$
$$= 1 - 0 = 1$$

MCQ 1.37 GATE ME 2005 TWO MARK

Starting from $x_0 = 1$, one step of Newton-Raphson method in solving the equation $x^3 + 3x - 7 = 0$ gives the next value (x_1) as

(A) $x_1 = 0.5$

(B) $x_1 = 1.406$

(C) $x_1 = 1.5$

(D) $x_1 = 2$

SOL 1.37 Option (C) is correct.

Let, $\quad f(x) = x^3 + 3x - 7$

From the Newton Rapson's method

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} \qquad \text{...(i)}$$

We have to find the value of x_1, so put $n = 0$ in equation (i),

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

$$f(x) = x^3 + 3x - 7$$
$$f(x_0) = 1^3 + 3 \times 1 - 7 = 1 + 3 - 7 = -3 \qquad x_0 = 1$$
$$f'(x) = 3x^2 + 3$$
$$f'(x_0) = 3 \times (1)^2 + 3 = 6$$

Then, $$x_1 = 1 - \frac{(-3)}{6} = 1 + \frac{3}{6} = 1 + \frac{1}{2} = \frac{3}{2} = 1.5$$

MCQ 1.38 A single die is thrown twice. What is the probability that the sum is neither 8 nor 9 ?

GATE ME 2005
TWO MARK

(A) 1/9 (B) 5/36

(C) 1/4 (D) 3/4

SOL 1.38 Option (D) is correct.

We know a die has 6 faces & 6 numbers so the total number of ways

$$= 6 \times 6 = 36$$

And total ways in which sum is either 8 or 9 is 9, i.e.

$(2,6),(3,6)(3,5)(4,4)(4,5)(5,4)(5,3)(6,2)(6,3)$

Total number of tosses when both the 8 or 9 numbers are not come

$$= 36 - 9 = 27$$

Then probability of not coming sum 8 or 9 is,

$$= \frac{27}{36} = \frac{3}{4}$$

MCQ 1.39 Two books of mass 1 kg each are kept on a table, one over the other. The coefficient of friction on every pair of contacting surfaces is 0.3. The lower book is pulled with a horizontal force F. The minimum value of F for which slip occurs between the two books is

GATE ME 2005
TWO MARK

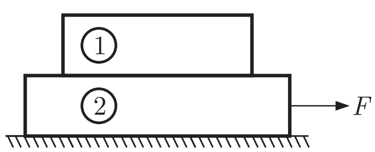
(A) zero (B) 1.06 N

(C) 5.74 N (D) 8.83 N

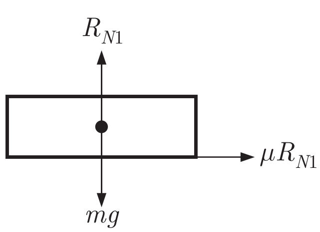
SOL 1.39 Option (D) is correct.

Given : $m_1 = m_2 = 1\,\text{kg},\ \mu = 0.3$

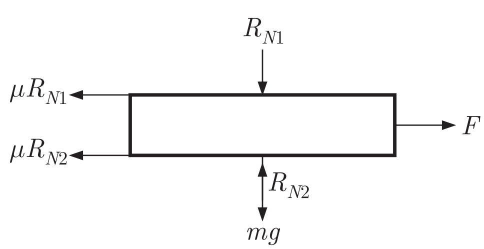
The FBD of the system is shown below :



For first book



FBD of book second



For Book (1)

$\Sigma F_y = 0$ $\qquad R_{N1} = mg$ ...(i)

Then, Friction Force $F_{N1} = \mu R_{N1} = \mu mg$

From FBD of book second

$\Sigma F_x = 0, \qquad F = \mu R_{N1} + \mu R_{N2}$

$\Sigma F_y = 0, \qquad R_{N_2} = R_{N1} + mg = mg + mg = 2\,\text{mg}$ ...(ii)

For slip occurs between the books when

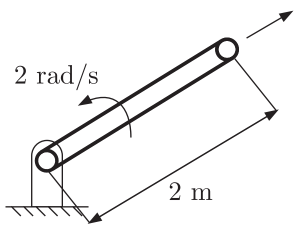
$$F \geq \mu R_{N1} + \mu R_{N2} \geq \mu mg + \mu \times 2\,\text{mg}$$
$$F \geq \mu(3\,\text{mg}) \geq 0.3(3 \times 1 \times 9.8) \geq 8.82$$

It means the value of F is always greater or equal to the 8.82, for which slip occurs between two books

So, $\qquad F = 8.83\,\text{N}$

MCQ 1.40
GATE ME 2005
TWO MARK

A shell is fired from a cannon. At the instant the shell is just about to leave the barrel, its velocity relative to the barrel is 3 m/s, while the barrel is swinging upwards with a constant angular velocity of 2 rad/s. The magnitude of the absolute velocity of the shell is



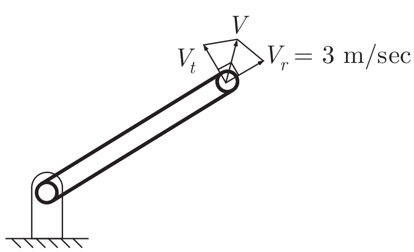
(A) 3 m/s (B) 4 m/s

(C) 5 m/s (D) 7 m/s

SOL 1.40

Option (C) is correct.

Given : $\omega = 2\,\text{rad/sec}, \; r = 2\,\text{m}$



We know that, the tangential velocity of barrel

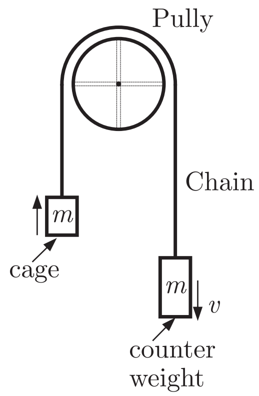
$$V_t = r\omega = 2 \times 2 = 4\,\text{m/sec}$$
$$\boldsymbol{V} = V_r\boldsymbol{i} + V_t\boldsymbol{j} = 3\boldsymbol{i} + 4\boldsymbol{j}$$

Now the resultant velocity of shell

$$|\boldsymbol{V}| = \sqrt{(3)^2 + (4)^2} = \sqrt{25} = 5\,\text{m/sec}$$

MCQ 1.41
GATE ME 2005
TWO MARK

An elevator (lift) consists of the elevator cage and a counter weight, of mass m each. The cage and the counterweight are connected by chain that passes over a pulley. The pulley is coupled to a motor. It is desired that the elevator should have a maximum stopping time of t seconds from a peak speed v. If the inertias of the pulley and the chain are neglected, the minimum power that the motor must have is



(A) $\frac{1}{2}mV^2$

(B) $\frac{mV^2}{2t}$

(C) $\frac{mV^2}{t}$

(D) $\frac{2mV^2}{t}$

SOL 1.41 Option (C) is correct.

Given : Mass of cage & counter weight $= m$ kg each

Peak speed $= V$

Initial velocity of both the cage and counter weight.

$$V_1 = V \text{ m/sec}$$

Final velocity of both objects

$$V_2 = 0$$

Initial kinetic Energy, $E_1 = \frac{1}{2}mV^2 + \frac{1}{2}mV^2 = mV^2$

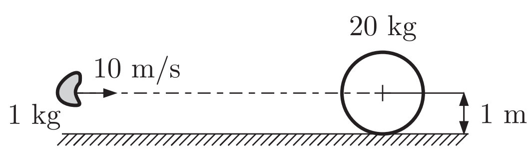
Final kinetic Energy $E_2 = \frac{1}{2}m(0)^2 + \frac{1}{2}m(0)^2 = 0$

Now, Power = Rate of change of K.E.

$$= \frac{E_1 - E_2}{t} = \frac{mV^2}{t}$$

MCQ 1.42 GATE ME 2005 TWO MARK

A 1 kg mass of clay, moving with a velocity of 10 m/s, strikes a stationary wheel and sticks to it. The solid wheel has a mass of 20 kg and a radius of 1 m. Assuming that the wheel is set into pure rolling motion, the angular velocity of the wheel immediately after the impact is approximately



(A) zero

(B) $\frac{1}{3}$ rad/s

(C) $\sqrt{\frac{10}{3}}$ rad/s (D) $\frac{10}{3}$ rad/s

SOL 1.42 Option (B) is correct.

Given : $m_1 = 1$ kg, $V_1 = 10$ m/sec, $m_2 = 20$ kg, $V_2 =$ Velocity after striking the wheel $r = 1$ meter

On applying the principal of linear momentum on the system

$$\frac{dP}{dt} = 0 \Rightarrow P = \text{constant}$$

Initial Momentum = Final Momentum

$$m_1 \times V_1 = (m_1 + m_2) V_2$$

$$V_2 = \frac{m_1 V_1}{(m_1 + m_2)} = \frac{1 \times 10}{1 + 20} = \frac{10}{21}$$

Now after the collision the wheel rolling with angular velocity ω.

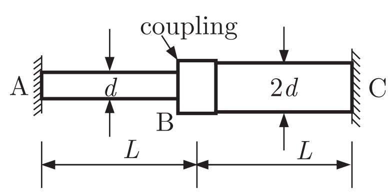
So, $V_2 = r\omega$

$$\omega = \frac{V_2}{r} = \frac{10}{21 \times 1} = 0.476$$

It is nearly equal to 1/3.

MCQ 1.43 GATE ME 2005 TWO MARK

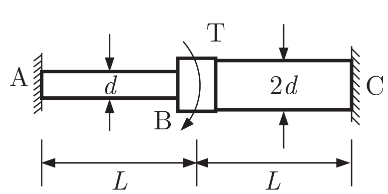
The two shafts AB and BC, of equal length and diameters d and $2d$, are made of the same material. They are joined at B through a shaft coupling, while the ends A and C are built-in (cantilevered). A twisting moment T is applied to the coupling. If T_A and T_C represent the twisting moments at the ends A and C, respectively, then



(A) $T_C = T_A$ (B) $T_C = 8T_A$

(C) $T_C = 16T_A$ (D) $T_A = 16T_C$

SOL 1.43 Option (C) is correct.



Here both the shafts AB & BC are in parallel connection.

So, deflection in both the shafts are equal.

$$\theta_{AB} = \theta_{BC} \quad \text{...(i)}$$

From Torsional formula,

$$\frac{T}{J} = \frac{G\theta}{L} \Rightarrow \theta = \frac{TL}{GJ}$$

From equation (i),

$$\frac{T_A L}{GJ_{AB}} = \frac{T_C L}{GJ_{BC}}$$

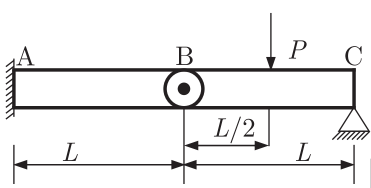
$$\frac{T_A \times L}{G \times \frac{\pi}{32} d^4} = \frac{T_C \times L}{G \times \frac{\pi}{32} (2d)^4}$$

$$\frac{T_A}{d^4} = \frac{T_C}{16 d^4}$$ For same material, $G_{AB} = G_{BC}$

$$T_C = 16 T_A$$

MCQ 1.44 GATE ME 2005 TWO MARK

A beam is made up of two identical bars AB and BC, by hinging them together at B. The end A is built-in (cantilevered) and the end C is simply-supported. With the load P acting as shown, the bending moment at A is



(A) zero

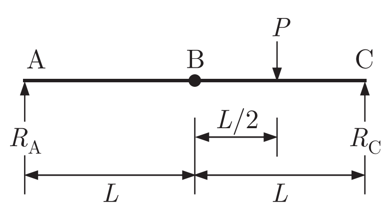
(B) $\frac{PL}{2}$

(C) $\frac{3PL}{2}$

(D) indeterminate

SOL 1.44 Option (B) is correct.

First of all we have to make a Free body diagram of the given beam.



Where, R_A & R_B are the reactions acting at point A and B

The point B is a point of contraflexure or point of inflexion or a virtual hinge. The characteristic of the point of contraflexure is that, about this point moment equal to zero.

For span BC, $M_B = 0$

$$R_C \times L = P \times \frac{L}{2}$$

$$R_C = \frac{P}{2}$$

For the equilibrium of forces on the beam,

$$R_A + R_C = P$$

$$R_A = P - \frac{P}{2} = \frac{P}{2}$$

Now for the bending moment about point A, take the moment about point A,

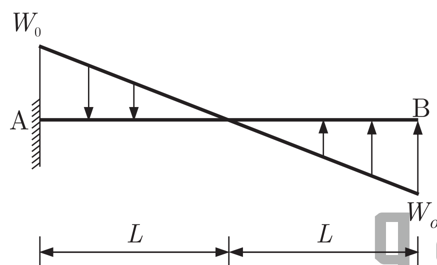
$$M_A + R_C \times 2L - P \times \left(L + \frac{L}{2}\right) = 0$$

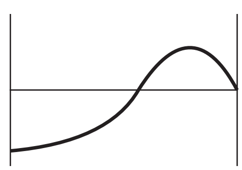
$$M_A + \frac{P}{2} \times 2L - P \times \frac{3L}{2} = 0$$

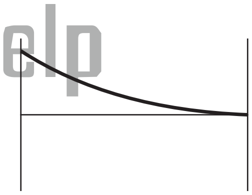
$$M_A = \frac{PL}{2}$$

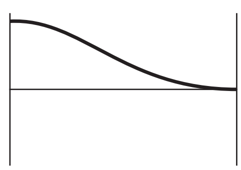
MCQ 1.45
GATE ME 2005
TWO MARK

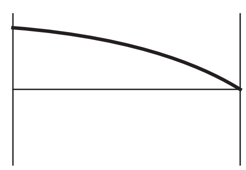
A cantilever beam carries the anti-symmetric load shown, where W_0 is the peak intensity of the distributed load. Qualitatively, the correct bending moment diagram for this beam is



(A) 

(B) 

(C) 

(D) 

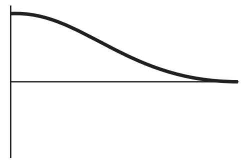
SOL 1.45

Option (C) is correct.

We know that, for a uniformly varying load bending moment will be cubic in nature.

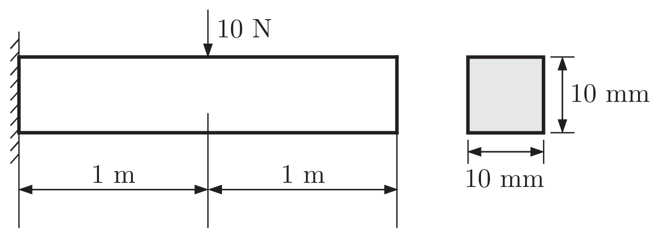
(A) We see that there is no shear force at B, so the slope of BMD at right of B must be zero and similarly on left end A there is no shear force, so slope of BMD also zero.

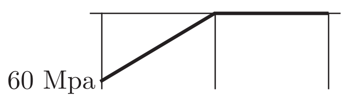
(B) Now due to triangular shape of load intensity, when we move from right to left, the rate of increase of shear force decreases and maximum at the middle & therefore it reduces.

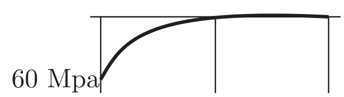


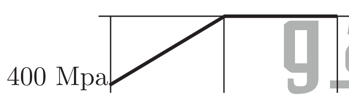
MCQ 1.46 GATE ME 2005 TWO MARK

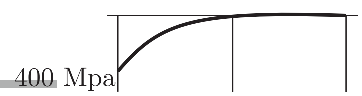
A cantilever beam has the square cross section of 10 mm × 10 mm. It carries a transverse load of 10 N. Consider only the bottom fibres of the beam, the correct representation of the longitudinal variation of the bending stress is



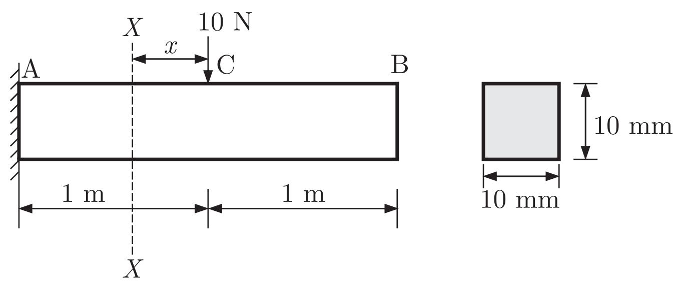
(A) 

(B) 

(C) 

(D) 

SOL 1.46 Option (A) is correct.



Taking a section XX on the beam.

Moment about this section XX

$$M_{XX} = 10 \times x = 10x \text{ N–m}$$

For a square section,

$$I = \frac{b^4}{12} = \frac{(10 \times 10^{-3})^4}{12} = \frac{10^{-8}}{12} \text{ m}^4$$

Using the bending equation,

$$\frac{M}{I} = \frac{\sigma}{y} \Rightarrow \sigma = \frac{M}{I} y$$

Substitute the values, we get

$$\sigma = \frac{10x}{\frac{10^{-8}}{12}} \times \frac{10^{-2}}{2} = 60 \times 10^6 x \qquad \text{...(i)}$$

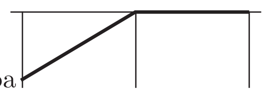
From equation (i), Bending stress at point $A\,(x = 0)$,

$$\sigma_A = 60 \times 10^6 \times 0 = 0$$

And at point C $(x = 1\,\text{m})$

$$\sigma_C = 60 \times 10^6 \times 1 = 60\,\text{MPa}$$

As no any forces are acting to the right of the point C.
So bending stress is constant after point C.



MCQ 1.47
GATE ME 2005
TWO MARK

In a cam-follower mechanism, the follower needs to rise through $20\,\text{mm}$ during $60°$ of cam rotation, the first $30°$ with a constant acceleration and then with a deceleration of the same magnitude. The initial and final speeds of the follower are zero. The cam rotates at a uniform speed of $300\,\text{rpm}$. The maximum speed of the follower is

(A) 0.60 m/s
(B) 1.20 m/s
(C) 1.68 m/s
(D) 2.40 m/s

SOL 1.47

Option (B) is correct.
Given $N = 300\,\text{r.p.m}$
Angular velocity of cam,

$$\omega = \frac{2\pi N}{60} = 10\pi\ \text{rad/sec}$$

Time taken to move $30°$ is,

$$t = \frac{\frac{\pi}{180} \times 30}{10\pi} = \frac{\frac{1}{6}}{10} = \frac{1}{60}\,\text{sec}$$

Now, Cam moves $30°$ with a constant acceleration & then with a deceleration, so maximum speed of the follower is at the end of first $30°$ rotation of the cam and during this $30°$ rotation the distance covered is $10\,\text{mm}$, with initial velocity $u = 0$.
From Newton's second law of motion,

$$S = ut + \frac{1}{2}at^2$$

$$0.01 = 0 + \frac{1}{2} \times a \times \left(\frac{1}{60}\right)^2$$

$$a = 0.01 \times 2 \times (60)^2 = 72\,\text{m/sec}^2$$

Maximum velocity,

$$v_{\max} = u + at = 72 \times \frac{1}{60} = 1.2\,\text{m/sec}$$

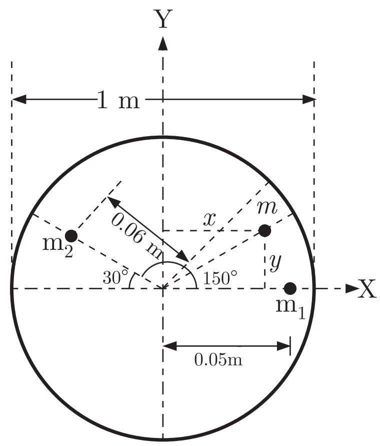
MCQ 1.48
GATE ME 2005
TWO MARK

A rotating disc of 1 m diameter has two eccentric masses of 0.5 kg each at radii of 50 mm and 60 mm at angular positions of $0°$ and $150°$, respectively. A balancing mass of 0.1 kg is to be used to balance the rotor. What is the radial position of the balancing mass ?

(A) 50 mm (B) 120 mm

(C) 150 mm (D) 280 mm

SOL 1.48 Option (C) is correct.



Given $m_1 = m_2 = 0.5\,\text{kg}$, $r_1 = 0.05\,\text{m}$, $r_2 = 0.06\,\text{m}$

Balancing mass $m = 0.1\,\text{kg}$

Let disc rotates with uniform angular velocity ω and x & y is the position of balancing mass along X & Y axis.

On resolving the forces in the x-direction, we get

$$\Sigma F_x = 0$$

$$0.5[-0.06\cos 30^\circ + 0.05\cos 0^\circ]\omega^2 = 0.1 \times x \times \omega^2$$

$$0.5 \times (-0.00196) = 0.1x \qquad F_c = mr\omega^2$$

$$x = -0.0098\,\text{m} = -9.8\,\text{mm}$$

Similarly in y-direction, $\Sigma F_y = 0$

$$0.5(0.06 \times \sin 30^\circ + 0.05 \times \sin 0)\omega^2 = 0.1 \times y \times \omega^2$$

$$0.5 \times 0.03 = 0.1 \times y$$

$$y = 0.15\,\text{m} = 150\,\text{mm}$$

Position of balancing mass is given by,

$$r = \sqrt{x^2 + y^2} = \sqrt{(-9.8)^2 + (150)^2}$$

$$= 150.31\,\text{mm} \backsimeq 150\ \text{mm}$$

MCQ 1.49 GATE ME 2005 TWO MARK

In a spring-mass system, the mass is 0.1 kg and the stiffness of the spring is 1 kN/m. By introducing a damper, the frequency of oscillation is found to be 90% of the original value. What is the damping coefficient of the damper ?

(A) 1.2 Ns/m (B) 3.4 Ns/m

(C) 8.7 Ns/m (D) 12.0 Ns/m

SOL 1.49 Option (C) is correct.

Given $m = 0.1\,\text{kg}$, $k = 1\,\text{kN/m}$

Let, ω_d be the frequency of damped vibration & ω_n be the natural frequency of spring mass system.

Hence, $\omega_d = 90\%$ of $\omega_n = 0.9\omega_n$ (Given) ...(i)

Frequency of damped vibration

$$\omega_d = \sqrt{(1-\varepsilon^2)}\,\omega_n \quad \text{...(ii)}$$

From equation (i) and equation (ii), we get

$$\sqrt{(1-\varepsilon^2)}\,\omega_n = 0.9\omega_n$$

On squaring both the sides, we get

$$1-\varepsilon^2 = (0.9)^2 = 0.81$$

$$\varepsilon^2 = 1-0.81 = 0.19$$

$$\varepsilon = \sqrt{0.19} = 0.436$$

And Damping ratio is given by,

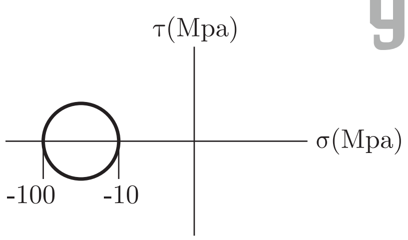
$$\varepsilon = \frac{c}{c_c} = \frac{c}{2\sqrt{km}}$$

$$c = 2\sqrt{km} \times \varepsilon$$

$$= 2\sqrt{1000 \times 0.1} \times 0.436 = 8.72\,\text{Ns/m} \backsimeq 8.7\,\text{Ns/m}$$

MCQ 1.50 GATE ME 2005 TWO MARK

The Mohr's circle of plane stress for a point in a body is shown. The design is to be done on the basis of the maximum shear stress theory for yielding. Then, yielding will just begin if the designer chooses a ductile material whose yield strength is



(A) 45 MPa (B) 50 MPa

(C) 90 MPa (D) 100 MPa

SOL 1.50 Option (C) is correct.

Maximum shear stress,

$$\tau = \frac{\sigma_{\max} - \sigma_{\min}}{2}$$

Maximum shear stress at the elastic limit in simple tension (yield strength) $= \frac{\sigma_Y}{2}$

To prevent failure

$$\frac{\sigma_{\max} - \sigma_{\min}}{2} \le \frac{\sigma_Y}{2}$$

$$\sigma_{\max} - \sigma_{\min} = \sigma_Y$$

Here $\sigma_{\max} = -10\,\text{MPa}$, $\sigma_{\min} = -100\,\text{MPa}$

So, $\sigma_Y = -10 - (-100) = 90\,\text{MPa}$

MCQ 1.51 GATE ME 2005 TWO MARK

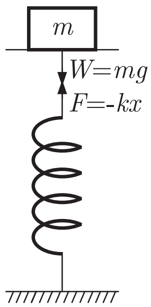
A weighing machine consist of a 2 kg pan resting on a spring. In this condition, with the pan resting on the spring, the length of the spring is 200 mm. When a mass of 20 kg is placed on the pan, the length of the spring becomes 100 mm. For the spring, the un-deformed length L and the spring constant k (stiffness) are

(A) $L = 220$ mm, $k = 1862$ N/m (B) $L = 210$ mm, $k = 1960$ N/m

(C) $L = 200$ mm, $k = 1960$ N/m (D) $L = 200$ mm, $k = 2156$ N/m

SOL 1.51 Option (B) is correct.

Initial length (un-deformed) of the spring $= L$ & spring stiffness $= k$



Let spring is deformed by an amount Δx,

then Spring force, $F = k\Delta x$

For initial condition,

$$2g = k(L - 0.2) \qquad W = mg \quad ...(i)$$

After this a mass of 20 kg is placed on the 2 kg pan. So total mass becomes 22 kg and length becomes 100 mm.

For this condition,

$$(20 + 2)\,g = k(L - 0.1) \qquad ...(ii)$$

By dividing equation (ii) by equation (i),

$$\frac{22g}{2g} = \frac{k(L - 0.1)}{k(L - 0.2)}$$

$$11 = \frac{(L - 0.1)}{(L - 0.2)}$$

$$11L - 2.2 = L - 0.1$$

$$10L = 2.1$$

$$L = \frac{2.1}{10} = 0.21\,\text{m} = 210\,\text{mm}$$

And from equation (i),

$$2g = k(0.21 - 0.2)$$

$$k = \frac{2 \times 9.8}{0.01} = 1960\,\text{N/m}$$

So, $L = 210$ mm, and $k = 1960$ N/m

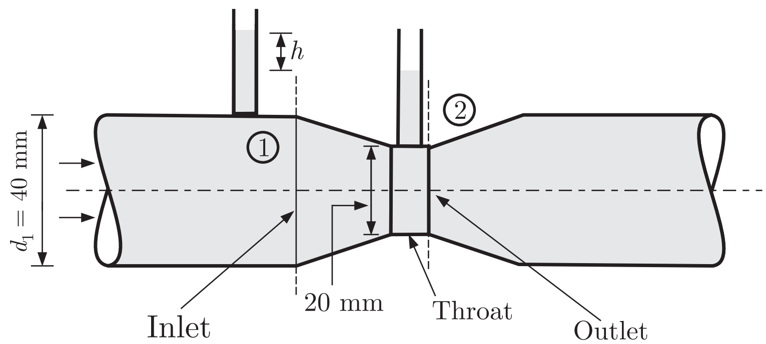
MCQ 1.52 GATE ME 2005 TWO MARK

A venturimeter of 20 mm throat diameter is used to measure the velocity of water in a horizontal pipe of 40 mm diameter. If the pressure difference between the pipe and throat sections is found to be 30 kPa then, neglecting frictional losses, the flow velocity is

(A) 0.2 m/s (B) 1.0 m/s

(C) 1.4 m/s (D) 2.0 m/s

SOL 1.52 Option (D) is correct.



Given : $d_2 = 20\text{ mm} = 0.020\text{ m}$, $d_1 = 40\text{ mm} = 0.040\text{ m}$

$$\Delta p = p_1 - p_2 = 30\text{ kPa}$$

Applying continuity equation at section (1) & (2),

$$A_1 V_1 = A_2 V_2$$

$$V_1 = \left(\frac{A_2}{A_1}\right) V_2 = \frac{\frac{\pi}{4} d_2^2}{\frac{\pi}{4} d_1^2} \times V_2$$

$$= \frac{d_2^2}{d_1^2} \times V_2 = \left(\frac{20}{40}\right)^2 V_2 = \frac{V_2}{4}$$

$$V_2 = 4 V_1 \qquad ..(i)$$

Now applying Bernoulli's equation at section (1) & (2),

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 \qquad \text{For horizontal pipe } z_1 = z_2$$

$$\frac{p_1 - p_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g}$$

$$\frac{\Delta p}{\rho} = \frac{V_2^2 - V_1^2}{2}$$

$$\frac{30 \times 10^3}{1000} = \frac{(4 V_1)^2 - V_1^2}{2} \qquad \text{From equation (i)}$$

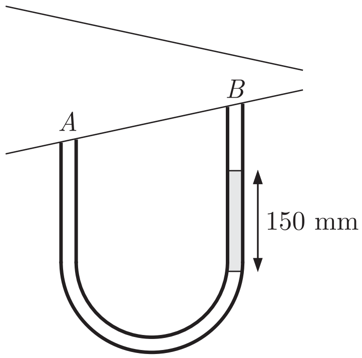
$$30 = \frac{16 V_1^2 - V_1^2}{2} = \frac{15 V_1^2}{2}$$

$$V_1^2 = \frac{30 \times 2}{15} = 4 \quad \Rightarrow V_1 = 2\text{ m/sec}$$

MCQ 1.53 GATE ME 2005 TWO MARK

A U-tube manometer with a small quantity of mercury is used to measure the static pressure difference between two locations A and B in a conical section through which an incompressible fluid flows. At a particular flow rate, the mercury column appears as shown in the figure. The density of mercury is 13600 kg/m^3 and

$g = 9.81\,\text{m/s}^2$. Which of the following is correct ?



(A) Flow direction is A to B and $p_A - p_B = 20$ kPa

(B) Flow direction is B to A and $p_A - p_B = 1.4$ kPa

(C) Flow direction is A to B and $p_B - p_A = 20$ kPa

(D) Flow direction is B to A and $p_B - p_A = 1.4$ kPa

SOL 1.53 Option (A) is correct.

It is a U-tube differential Manometer.

In this manometer A & B at different level & the liquid contain in manometer has the same specific gravity (only mercury is fill in the manometer)

Given : $\rho_{mercury} = 13600\,\text{kg/m}^3$, $g = 9.81\,\text{m/sec}^2$, $\Delta h = 150\,\text{mm} = 0.150$ meter

Static pressure difference for U-tube differential manometer is given by,

$$\begin{aligned} p_A - p_B &= \rho g (h_A - h_B) = \rho g \Delta h \\ &= 13600 \times 9.81 \times 0.150 \\ &= 20.01 \times 10^3\,\text{Pa} = 20.01\,\text{kPa} \approx 20\,\text{kPa} \end{aligned}$$

Hence $p_A - p_B$ is positive and $p_A > p_B$, Flow from A to B.

MCQ 1.54 A reversible thermodynamic cycle containing only three processes and producing work is to be constructed. The constraints are

GATE ME 2005
TWO MARK

(i) there must be one isothermal process,

(ii) there must be one isentropic process,

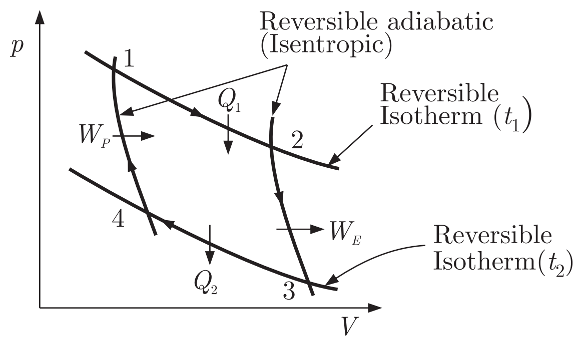
(iii) the maximum and minimum cycle pressures and the clearance volume are fixed, and

(iv) polytropic processes are not allowed. Then the number of possible cycles are

(A) 1 (B) 2

(C) 3 (D) 4

SOL 1.54 Option (A) is correct.



Now check the given processes :-

(i) Show in p-ν curve that process 1-2 & process 3-4 are Reversible isothermal process.

(ii) Show that process 2-3 & process 4-1 are Reversible adiabatic (isentropic) processes.

(iii) In carnot cycle maximum and minimum cycle pressure and the clearance volume are fixed.

(iv) From p-ν curve there is no polytropic process.

So, it consists only one cycle [carnot cycle]

MCQ 1.55 GATE ME 2005 TWO MARK

Nitrogen at an initial state of 10 bar, 1 m^3 and 300 K is expanded isothermally to a final volume of 2 m^3. The p-ν-T relation is $\left(p+\frac{a}{\nu^2}\right)\nu = RT$, where $a > 0$. The final pressure.

(A) will be slightly less than 5 bar

(B) will be slightly more than 5 bar

(C) will be exactly 5 bar

(D) cannot be ascertained in the absence of the value of a

SOL 1.55 Option (B) is correct.

Given : $p_1 = 10\text{ bar}$, $\nu_1 = 1\text{ m}^3$, $T_1 = 300\text{ K}$, $\nu_2 = 2\text{ m}^3$

Given that Nitrogen Expanded isothermally.

So, $RT = \text{Constant}$

And from given relation,

$$\left(p+\frac{a}{\nu^2}\right)\nu = RT = \text{Constant}$$

$$p_1\nu_1 + \frac{a}{\nu_1} = p_2\nu_2 + \frac{a}{\nu_2}$$

$$p_2\nu_2 = p_1\nu_1 + \frac{a}{\nu_1} - \frac{a}{\nu_2}$$

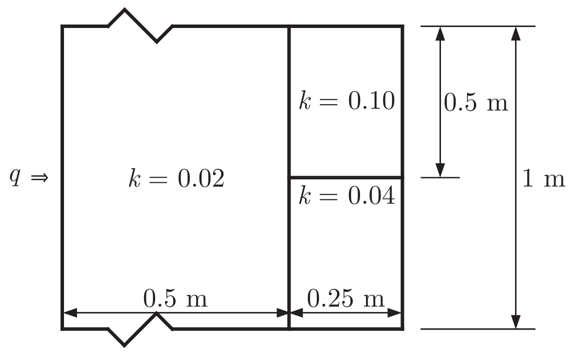
$$p_2 = p_1\left(\frac{\nu_1}{\nu_2}\right) + a\left(\frac{1}{\nu_1\nu_2} - \frac{1}{\nu_2^2}\right)$$

$$= 10\left(\frac{1}{2}\right) + a\left(\frac{1}{2} - \frac{1}{4}\right) = 5 + \frac{a}{4}$$

Here $a > 0$, so above equation shows that p_2 is greater than 5 and +ve.

MCQ 1.56 GATE ME 2005 TWO MARK

Heat flows through a composite slab, as shown below. The depth of the slab is 1 m . The k values are in W/mK. The overall thermal resistance in K/W is



(A) 17.2 (B) 21.9

(C) 28.6 (D) 39.2

SOL 1.56 Option (C) is correct.

Assumptions :

(1) Heat transfer is steady since there is no indication of change with time.

(2) Heat transfer can be approximated as being one-dimensional since it is predominantly in the x-direction.

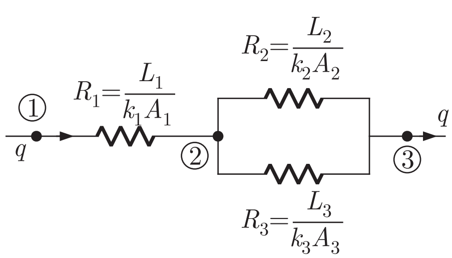
(3) Thermal conductivities are constant.

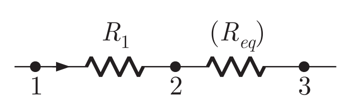
(4) Heat transfer by radiation is negligible.

Analysis :

There is no variation in the horizontal direction. Therefore, we consider a 1 m deep and 1 m high portion of the slab, since it representative of the entire wall.

Assuming any cross-section of the slab normal to the $x-$ direction to be isothermal, the thermal resistance network for the slab is shown in the figure.





$$R_1 = \frac{L_1}{k_1 A_1} = \frac{0.5}{0.02(1 \times 1)} = 25 \text{ K/W}$$

$$R_2 = \frac{L_2}{k_2 A_2} = \frac{0.25}{0.10 \times (1 \times 0.5)} = 5 \text{ K/W}$$

$$R_3 = \frac{L_3}{k_3 A_3} = \frac{0.25}{0.04 \times (1 \times 0.5)} = 12.5 \text{ K/W}$$

Resistance R_2 & R_3 are in parallel. So the equivalent resistance R_{eq} will be

$$\frac{1}{R_{eq}} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{R_3 + R_2}{R_2 R_3}$$

$$R_{eq} = \frac{R_2 R_3}{R_2 + R_3} = \frac{5 \times 12.5}{5 + 12.5} = 3.6 \text{ K/W}$$

Resistance R_1 & R_{eq} are in series. So total Resistance will be

$$R = R_1 + R_{eq} = 25 + 3.6 = 28.6 \text{ K/W}$$

MCQ 1.57 GATE ME 2005 TWO MARK

A small copper ball of 5 mm diameter at 500 K is dropped into an oil bath whose temperature is 300 K. The thermal conductivity of copper is 400 W/mK, its density 9000 kg/m^3 and its specific heat 385 J/kgK. If the heat transfer coefficient is 250 W/m^{2}K and lumped analysis is assumed to be valid, the rate of fall of the temperature of the ball at the beginning of cooling will be, in K/s,

(A) 8.7 (B) 13.9

(C) 17.3 (D) 27.7

SOL 1.57

Option (C) is correct.

Given : $D = 5\text{ mm} = 0.005\text{ m}$, $T_i = 500\text{ K}$, $T_a = 300\text{ K}$, $k = 400\text{ W/mK}$,

$\rho = 9000\text{ kg/m}^3$, $c = 385\text{ J/kg K}$, $h = 250\text{ W/m}^2\text{K}$,

Given that lumped analysis is assumed to be valid.

So, $$\frac{T - T_a}{T_i - T_a} = \exp\left(-\frac{hAt}{\rho \nu c}\right) = \exp\left(-\frac{ht}{\rho l c}\right) \qquad ...(i)$$

$$l = \frac{\nu}{A} = \frac{\text{Volume of ball}}{\text{Surface Area}} = \frac{\frac{4}{3}\pi R^3}{4\pi R^2} \qquad l = \frac{\nu}{A}$$

$$l = \frac{R}{3} = \frac{D}{6} = \frac{0.005}{6} = \frac{1}{1200}\text{ m}$$

On substituting the value of l & other parameters in equation. (i),

$$\frac{T - 300}{500 - 300} = \exp\left(-\frac{250 \times t}{9000 \times \frac{1}{1200} 385}\right)$$

$$T = 300 + 200 \times e^{-0.08658t}$$

On differentiating the above equation w.r.t. t,

$$\frac{dT}{dt} = 200 \times (-0.08658) \times e^{-0.08658t}$$

Rate of fall of temperature of the ball at the beginning of cooling is (at beginning $t = 0$)

$$\left(\frac{dT}{dt}\right)_{t=0} = 200 \times (-0.08658) \times 1 = -17.316 \text{ K/sec}$$

Negative sign shows fall of temperature.

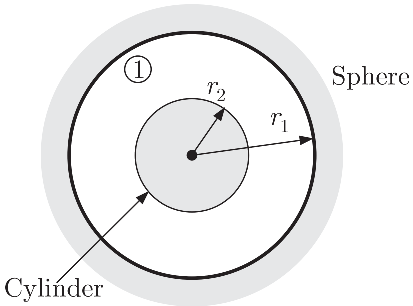
MCQ 1.58 GATE ME 2005 TWO MARK

A solid cylinder (surface 2) is located at the centre of a hollow sphere (surface 1). The diameter of the sphere is 1 m, while the cylinder has a diameter and length of 0.5 m each. The radiation configuration factor F_{11} is

(A) 0.375 (B) 0.625

(C) 0.75 (D) 1

SOL 1.58 Option (C) is correct.



Given : $d_1 = 1\,\text{m},\ d_2 = 0.5\,\text{m},\ L = 0.5\,\text{m}$

The cylinder surface cannot see itself and the radiation emitted by this surface falls on the enclosing sphere. So, from the conservation principle (summation rule) for surface 2,

$$F_{21} + F_{22} = 1$$

$$F_{21} = 1 \qquad F_{22} = 0$$

From the reciprocity theorem,

$$A_1 F_{12} = A_2 F_{21}$$

$$F_{12} = \frac{A_2}{A_1} \times F_{21} = \frac{A_2}{A_1} \qquad ...(ii)$$

For sphere, $F_{11} + F_{12} = 1$

$$F_{11} = 1 - F_{12} \qquad ...(iii)$$

From equation (ii) and (iii), we get

$$F_{11} = 1 - \frac{A_2}{A_1} = 1 - \frac{2\pi r_2 l}{\pi d_1^2} = 1 - \frac{2 r_2 l}{d_1^2}$$

$$= 1 - \frac{2 \times 0.250 \times 0.5}{1^2} = 1 - \frac{1}{4} = 0.75$$

MCQ 1.59 GATE ME 2005 TWO MARK

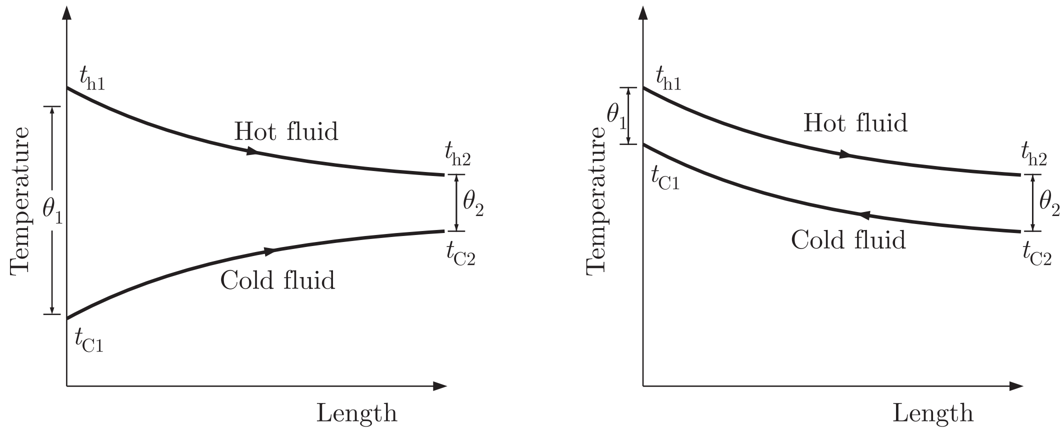
Hot oil is cooled from 80 to 50°C in an oil cooler which uses air as the coolant. The air temperature rises from 30 to 40°C. The designer uses a LMTD value of 26°C. The type of heat exchange is

(A) parallel flow (B) double pipe

(C) counter flow (D) cross flow

SOL 1.59 Option (D) is correct.

The figure shown below are of parallel flow and counter flow respectively.



For parallel flow,

$t_{h1} = 80^\circ\text{C},\ t_{h2} = 50^\circ\text{C},\ t_{c1} = 30^\circ\text{C},\ t_{c2} = 40^\circ\text{C}$

$$\theta_{mp} = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{(t_{h1} - t_{c1}) - (t_{h2} - t_{c2})}{\ln\left(\frac{t_{h1} - t_{c1}}{t_{h2} - t_{c2}}\right)}$$

Where, θ_{mp} denotes the LMTD for parallel flow.

$$\theta_{mp} = \frac{(80 - 30) - (50 - 40)}{\ln\left(\frac{50}{10}\right)} = \frac{40}{\ln(5)} = 24.85^\circ\text{C}$$

For counter flow arrangement

$t_{h1} = 80^\circ\text{C},\ t_{h2} = 50^\circ\text{C},\ t_{c1} = 40^\circ\text{C},\ t_{c2} = 30^\circ\text{C}$

Where, θ_{mc} denotes the LMTD for counter flow.

$$\theta_{mc} = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{(t_{h1} - t_{c2}) - (t_{h2} - t_{c1})}{\ln\left(\frac{t_{h1} - t_{c2}}{t_{h2} - t_{c1}}\right)}$$

$$= \frac{(80 - 30) - (50 - 40)}{\ln\left(\frac{50}{10}\right)} = \frac{40}{\ln(5)} = 28.85^\circ\text{C}$$

Now for defining the type of flow, we use the correction factor.

$$\theta_m = F\theta_{mc} = F\theta_{mp} \qquad \text{...(i)}$$

Where $F =$ correction factor, which depends on the geometry of the heat exchanger and the inlet and outlet temperatures of the of the hot & cold streams.

$F < 1$, for cross flow and $F = 1$, for counter & parallel flow

So, From equation (i),

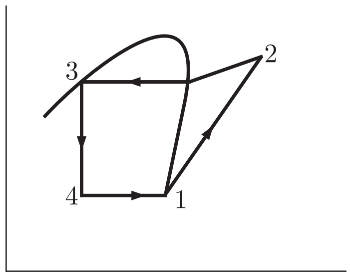
$$F = \frac{\theta_m}{\theta_{mc}} = \frac{26}{28.85} = 0.90 < 1$$

and also $$F = \frac{\theta_m}{\theta_{mp}} = \frac{26}{24.85} = 1.04 > 1$$

So, cross flow in better for this problem.

MCQ 1.60
GATE ME 2005
TWO MARK

The vapour compression refrigeration cycle is represented as shown in the figure below, with state 1 being the exit of the evaporator. The coordinate system used in this figure is

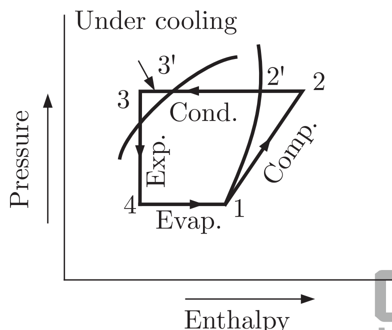


(A) p-h (B) T-s

(C) p-s (D) T-h

SOL 1.60 Option (A) is correct.

Given curve is the theoretical p-h curve for vapour compression refrigeration cycle.

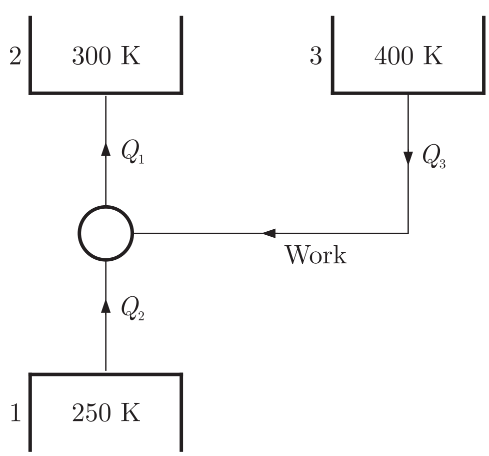


(Theoretical p-h diagram)

Hence, curve given in question is a ideal $p-h$ curve for vapour compression refrigeration cycle.

MCQ 1.61 GATE ME 2005 TWO MARK

A vapour absorption refrigeration system is a heat pump with three thermal reservoirs as shown in the figure. A refrigeration effect of 100 W is required at 250 K when the heat source available is at 400 K. Heat rejection occurs at 300 K. The minimum value of heat required (in W) is



(A) 167 (B) 100

(C) 80 (D) 20

SOL 1.61 Option (C) is correct.

$$(COP)_{ref.} = \frac{\text{Refrigeration Effect}}{\text{Work done}} = \frac{T_1}{T_2 - T_1}$$

$$\frac{100}{W} = \frac{250}{300 - 250}$$

$$W = \frac{100}{250} \times 50 = 20 \text{ Watt}$$

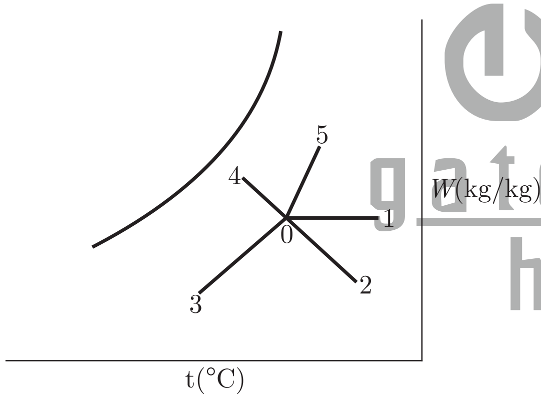
For supply this work, heat is taken from reservoir 3 & rejected to sink 2.
So efficiency,

$$\eta = \frac{W}{Q_3} = \frac{T_3 - T_2}{T_3}$$ It works as a heat engine.

$$\frac{20}{Q_3} = \frac{400 - 300}{400} \Rightarrow Q_3 = 80 \text{ Watt}$$

MCQ 1.62 Various psychometric processes are shown in the figure below.

GATE ME 2005
TWO MARK



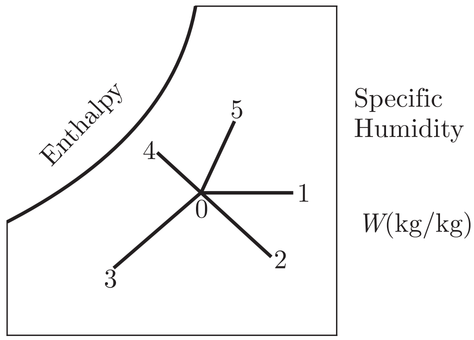
	Process in Figure		**Name of the process**
P.	0 - 1	**(i).**	Chemical dehumidification
Q.	0 - 2	**(ii).**	Sensible heating
R.	0 - 3	**(iii).**	Cooling and dehumidification
S.	0 - 4	**(iv).**	Humidification with steam injection
T.	0 - 5	**(v).**	Humidification with water injection

The matching pairs are

(A) P-(i), Q-(ii), R-(iii), S-(iv), T-(v) (B) P-(ii), Q-(i), R-(iii), S-(v), T-(iv)

(C) P-(ii), Q-(i), R-(iii), S-(iv), T-(v) (D) P-(iii), Q-(iv), R-(v), S-(i), T-(ii)

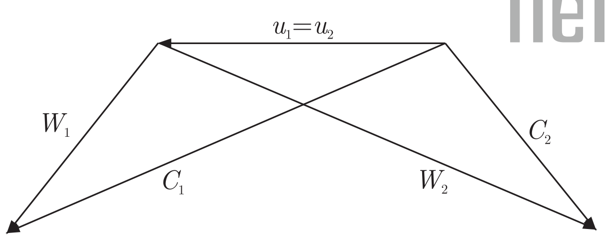
SOL 1.62 Option (B) is correct.



Process	Process Name	t_{DBT}	W
0-1	Sensible Heating	Increase	Constant
0-2	Chemical dehumidification	Increase	Decrease
0-3	Cooling and dehumidification	Decrease	Decrease
0-4	Humidification with water injection	Decrease	Increase
0-5	Humidification with steam injection	Increase	Increase

MCQ 1.63
GATE ME 2005
TWO MARK

In the velocity diagram shown below, u = blade velocity, C = absolute fluid velocity and W = relative velocity of fluid and the subscripts 1 and 2 refer to inlet and outlet. This diagram is for



(A) an impulse turbine (B) a reaction turbine
(C) a centrifugal compressor (D) an axial flow compressor

SOL 1.63

Option (B) is correct.
Velocity of flow, $u = u_1 = u_2 =$ constant
& $W_2 >> W_1$ $W =$ Whirl velocity
Hence, it is a diagram of reaction turbine.

MCQ 1.64
GATE ME 2005
TWO MARK

A leaf is caught in a whirlpool. At a given instant, the leaf is at a distance of 120 m from the centre of the whirlpool. The whirlpool can be described by the following velocity distribution:

$$V_r = -\left(\frac{60 \times 10^3}{2\pi r}\right) \text{ m/s and } V_\theta = \frac{300 \times 10^3}{2\pi r} \text{ m/s}$$

Where r (in metres) is the distance from the centre of the whirlpool. What will be the distance of the leaf from the centre when it has moved through half a revolution ?

(A) 48 m (B) 64 m

(C) 120 m (D) 142 m

SOL 1.64 Option (B) is correct.

Given : $$V_r = -\left(\frac{60 \times 10^3}{2\pi r}\right) \text{m/sec} \quad \text{...(i)}$$

And $$V_\theta = \frac{300 \times 10^3}{2\pi r} \text{m/sec} \quad \text{...(ii)}$$

Dividing equation (i) by equation (ii), we get

$$\frac{V_r}{V_\theta} = -\frac{60 \times 10^3}{2\pi r} \times \frac{2\pi r}{300 \times 10^3} = -\frac{1}{5}$$

$$V_r = -\frac{V_\theta}{5} \quad \text{...(iii)}$$

In this equation (iii)

$$V_r = \text{Radial Velocity} = \frac{dr}{dt}$$

$$V_\theta = \text{Angular Velocity} = r\omega = r\frac{d\theta}{dt}$$

So, $$\frac{dr}{dt} = -\frac{1}{5}r\frac{d\theta}{dt}$$

$$\frac{dr}{r} = -\frac{1}{5}d\theta$$

On integrating both the sides and put limits, between $r \Rightarrow 120$ to r and $\theta \Rightarrow 0$ to π (for half revolution).

$$\int_{120}^{r}\frac{dr}{r} = -\frac{1}{5}\int_0^{\pi} d\theta$$

$$[\ln r]_{120}^{r} = -\frac{1}{5}[\theta]_0^{\pi}$$

$$\ln r - \ln 120 = -\frac{1}{5}[\pi - 0] = -\frac{\pi}{5}$$

$$\ln\frac{r}{120} = -\frac{\pi}{5}$$

$$\frac{r}{120} = e^{-\pi/5} = 0.533$$

$$r = 0.533 \times 120 = 64 \text{ meter}$$

MCQ 1.65 GATE ME 2005 TWO MARK

A mould has a downsprue whose length is 20 cm and the cross sectional area at the base of the downsprue is 1 cm^2. The downsprue feeds a horizontal runner leading into the mould cavity of volume 1000 cm^3. The time required to fill the mould cavity will be

(A) 4.05 s (B) 5.05 s

(C) 6.05 s (D) 7.25 s

SOL 1.65 Option (B) is correct.

Given : $l = 20\text{ cm} = 0.2\text{ m},\ A = 1\text{ cm}^2 = 10^{-4}\text{ m}^2$

$V = 1000\text{ cm}^3 = 1000\times10^{-6}\text{ m}^3 = 10^{-3}\text{ m}^3$

Velocity at the base of sprue is,

$$V = \sqrt{2gh} = \sqrt{2\times9.8\times0.2} = 1.98\text{ m/sec}$$

From the continuity equation flow rate to fill the mould cavity is,

Filling rate $\dot{Q} = \text{Area}\times\text{Velocity} = AV$

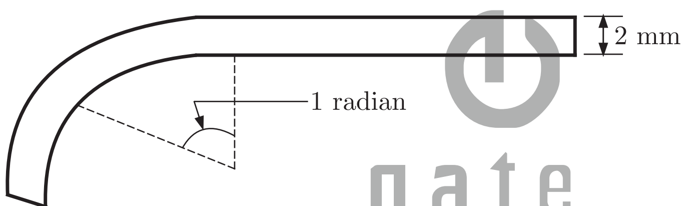
$$\frac{v}{t} = AV \qquad v = \text{Volume}$$

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

$$t = \frac{10^{-3}}{10^{-4}\times1.98} = \frac{10}{1.98} = 5.05\text{ sec.}$$

MCQ 1.66 A 2 mm thick metal sheet is to be bent at an angle of one radian with a bend radius of 100 mm. If the stretch factor is 0.5, the bend allowance is

GATE ME 2005
TWO MARK



(A) 99 mm (B) 100 mm

(C) 101 mm (D) 102 mm

SOL 1.66 Option (C) is correct.

Given : $\alpha = 1\text{ radian}\times\frac{180}{\pi} = \left(\frac{180}{\pi}\right)^{\circ},\ r = 100\text{ mm},\ k = 0.5,\ t = 2\text{ mm}$

Here, $r > 2t$

So, $k = 0.5t$

Bend allowance $B = \frac{\alpha}{360}\times2\pi(r+k)$

$$B = \frac{180}{\pi}\times\frac{2\pi}{360}(100+0.5\times2) = 101\text{ mm}$$

MCQ 1.67 Spot welding of two 1 mm thick sheets of steel (density $= 8000\text{ kg/m}^3$) is carried out successfully by passing a certain amount of current for 0.1 second through the electrodes. The resultant weld nugget formed is 5 mm in diameter and 1.5 mm thick. If the latent heat of fusion of steel is 1400 kJ/kg and the effective resistance in the welding operation is 200 $\mu\Omega$, the current passing through the electrodes is approximately

GATE ME 2005
TWO MARK

(A) 1480 A (B) 3300 A

(C) 4060 A (D) 9400 A

SOL 1.67 Option (C) is correct.

Given :
$\rho = 8000\,\text{kg/m}^3$, $t = 0.1\,\text{sec.}$, $d = 5\,\text{mm}$, $w = 1.5\,\text{mm}$, $L_f = 1400\,\text{kJ/kg}$, $R = 200\,\mu\Omega$
First of all calculate the mass,

$$\rho = \frac{m}{V}$$

$$m = \rho \times V = \rho \times \frac{\pi}{4} d^2 \times t$$

$$= 8000 \times \frac{\pi}{4} \times (5 \times 10^{-3})^2 \times 1.5 \times 10^{-3}$$

$$= 235.5 \times 10^{-6}\,\text{kg} = 2.35 \times 10^{-4}\,\text{kg}$$

Total heat for fusion,

$$Q = mL_f \qquad L = \text{Latent heat}$$

$$= 2.35 \times 10^{-4} \times 1400 \times 10^3 = 329\,\text{J} \qquad \text{...(i)}$$

We also know that, the amount of heat generated at the contacting area of the element to be welded is,

$$Q = I^2 Rt$$

$$329 = I^2 \times 200 \times 10^{-6} \times 0.1 \qquad \text{From equation (i)}$$

$$I^2 = \frac{329}{200 \times 10^{-7}} = 16.45 \times 10^6$$

$$I = \sqrt{16.45 \times 10^6} = 4056\,\text{A} \simeq 4060\,\text{A}$$

MCQ 1.68 A $600\,\text{mm} \times 30\,\text{mm}$ flat surface of a plate is to be finish machined on a shaper. The plate has been fixed with the 600 mm side along the tool travel direction. If the tool over-travel at each end of the plate is 20 mm, average cutting speed is 8 m/min., feed rate is 0.3 mm/ stroke and the ratio of return time to cutting time of the tool is 1:2, the time required for machining will be

GATE ME 2005 TWO MARK

(A) 8 minutes (B) 12 minutes

(C) 16 minutes (D) 20 minutes

SOL 1.68 Option (B) is correct.
Given : Side of the plate= 600 mm, $V = 8\,\text{m/min}$, $f = 0.3\,\text{mm/stroke}$

$$\frac{\text{Return time}}{\text{Cutting time}} = \frac{1}{2}$$

The tool over travel at each end of the plate is 20 mm. So length travelled by the tool in forward stroke,

$$L = 600 + 20 + 20 = 640\,\text{mm}$$

$$\text{Number of stroke required} = \frac{\text{Thickness of flat plate}}{\text{Feed rate/stroke}}$$

$$= \frac{30}{0.3} = 100\,\text{strokes}$$

Distance travelled in 100 strokes is,

$$d = 640 \times 100$$

$$= 64000 \text{ mm} = 64 \text{ m}$$

So, Time required for forward stroke

$$t = \frac{d}{V} = \frac{64}{8} = 8 \text{ min}$$

$$\text{Return time} = \frac{1}{2} \times 8 = 4 \text{ min}$$

Machining time, T_M = Cutting time + Return time

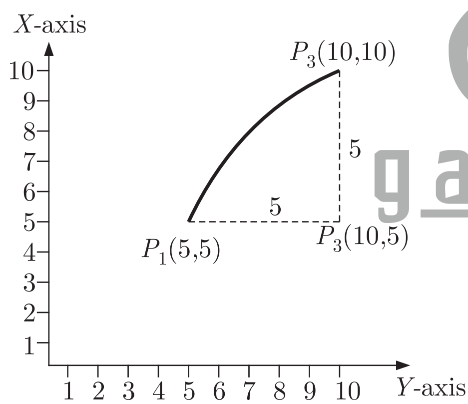
$$= 8 + 4 = 12 \text{ min}$$

MCQ 1.69
GATE ME 2005
TWO MARK

The tool of an NC machine has to move along a circular arc from (5, 5) to (10, 10) while performing an operation. The centre of the arc is at (10, 5). Which one of the following NC tool path command performs the above mentioned operation ?

(A) N010 G02 X10 Y10 X5 Y5 R5
(B) N010 G03 X10 Y10 X5 Y5 R5
(C) N010 G01 X5 Y5 X10 Y10 R5
(D) N010 G02 X5 Y5 X10 Y10 R5

SOL 1.69 Option (A) is correct.



So,
N010 →represent start the operation
G02 →represent circular (clock wise) interpolation
X10Y10 →represent final coordinates
X5Y5 →represent starting coordinate
R5 →represent radius of the arc

So, NC tool path command is, N010 G02 X10 Y10 X5 Y5 R5

MCQ 1.70
GATE ME 2005
TWO MARK

A component can be produced by any of the four processes I, II, III and IV. Process I has a fixed cost of Rs. 20 and variable cost of Rs. 3 per piece. Process II has a fixed cost Rs. 50 and variable cost of Rs. 1 per piece. Process III has a fixed cost of Rs. 40 and variable cost of Rs. 2 per piece. Process IV has a fixed cost of Rs. 10 and variable cost of Rs. 4 per piece. If the company wishes to produce 100 pieces of the component, form economic point of view it should choose

(A) Process I
(B) Process II
(C) Process III
(D) Process IV

SOL 1.70 Option (B) is correct.

For economic point of view, we should calculate the total cost for all the four processes.

$$\text{Total cost} = \text{Fixed cost} + \text{Variable cost} \times \text{Number of piece}$$

For process (I) :

$$\text{Fixed cost} = 20\,\text{Rs.}$$
$$\text{Variable cost} = 3\,\text{Rs. per piece}$$
$$\text{Number of pieces} = 100$$
$$\text{Total cost} = 20 + 3 \times 100 = 320\,\text{Rs.}$$

For process (II) :

$$\text{Total cost} = 50 + 1 \times 100 = 150\,\text{Rs.}$$

For process (III) :

$$\text{Total cost} = 40 + 2 \times 100 = 240\,\text{Rs.}$$

For process (IV) :

$$\text{Total cost} = 10 + 4 \times 100 = 410\,\text{Rs.}$$

Now, we can see that total cost is minimum for process (II). So process (II) should choose for economic point of view.

MCQ 1.71

GATE ME 2005 TWO MARK

A welding operation is time-studied during which an operator was pace-rated as 120%. The operator took, on an average, 8 minutes for producing the weld-joint. If a total of 10% allowances are allowed for this operation. The expected standard production rate of the weld-joint (in units per 8 hour day) is

(A) 45 (B) 50

(C) 55 (D) 60

SOL 1.71

Option (A) is correct.

Given : Rating factor $= 120\%$

$$\text{Actual time } T_{actual} = 8\,\text{min}$$
$$\text{Normal time } T_{normal} = \text{actual time} \times \text{Rating factor}$$
$$T_{normal} = 8 \times \frac{120}{100} = 9.6\,\text{min}$$

10% allowance is allowed for this operation.

So, standard time,

$$T_{standard} = \frac{T_{normal}}{1 - \frac{10}{100}} = \frac{9.6}{0.9} = 10.67\,\text{min}$$

Hence, standard production rate of the weld joint

$$= \frac{8 \times 60}{10.67}$$

$$= 45 \text{ units}$$

MCQ 1.72 The distribution of lead time demand for an item is as follows:

GATE ME 2005 TWO MARK

Lead time demand	Probability
80	0.20
100	0.25
120	0.30
140	0.25

The reorder level is 1.25 times the expected value of the lead time demand. The service level is

(A) 25% (B) 50%

(C) 75% (D) 100%

SOL 1.72 Option (D) is correct.

The expected value of the lead time demand

$$= 80 \times 0.20 + 100 \times 0.25 + 120 \times 0.30 + 140 \times 0.25$$

$$= 112$$

Reorder level is 1.25 time the lead time demand.

So,

$$\text{Reorder value} = 1.25 \times 112$$

$$= 140$$

Here we can see that both the maximum demand or the reorder value is equal.

Hence, $\text{service level} = 100\%$

MCQ 1.73 A project has six activities (A to F) with respective activity duration 7, 5, 6, 6, 8, 4 days. The network has three paths A-B, C-D and E-F. All the activities can be crashed with the same crash cost per day. The number of activities that need to be crashed to reduce the project duration by 1 day is

GATE ME 2005 TWO MARK

(A) 1 (B) 2

(C) 3 (D) 6

SOL 1.73 Option (C) is correct.

The 3 activity need to be crashed to reduce the project duration by 1 day.

MCQ 1.74 A company has two factories $S1$, $S2$, and two warehouses $D1$, $D2$. The supplies from $S1$ and $S2$ are 50 and 40 units respectively. Warehouse $D1$ requires a minimum of 20 units and a maximum of 40 units. Warehouse $D2$ requires a minimum of 20 units and, over and above, it can take as much as can be supplied. A balanced transportation problem is to be formulated for the above situation. The number

GATE ME 2005 TWO MARK

of supply points, the number of demand points, and the total supply (or total demand) in the balanced transportation problem respectively are

(A) 2, 4, 90 (B) 2, 4, 110

(C) 3, 4, 90 (D) 3, 4, 110

SOL 1.74 Option (C) is correct.

First we have to make a transportation model from the given details.

	Factories S_1	S_2	Supply
Warehouse D_1			20 to 40 units
D_2			≥ 20
Demand	50	40	

We know,

Basic condition for transportation model is balanced, if it contains no more than $m+n-1$ non-negative allocations, where m is the number of rows and n is the number of columns of the transportation problem.

So, Number of supply point (allocations) $= m+n-1$

$$= 2+2-1 = 3$$

$$\text{Number of demand points} = 4 \,(\text{No. of blank blocks})$$

$$\text{Total supply or demand} = 50+40 = 90$$

MCQ 1.75 GATE ME 2005 TWO MARK

Two tools P and Q have signatures 5°-5°-6°-6°-8°-30°-0 and 5°-5°-7°-7°-8°-15°-0 (both ASA) respectively. They are used to turn components under the same machining conditions. If h_P and h_Q denote the peak-to-valley heights of surfaces produced by the tools P and Q, the ratio h_P/h_Q will be

(A) $\dfrac{\tan 8^\circ + \cot 15^\circ}{\tan 8^\circ + \cot 30^\circ}$ (B) $\dfrac{\tan 15^\circ + \cot 8^\circ}{\tan 30^\circ + \cot 8^\circ}$

(C) $\dfrac{\tan 15^\circ + \cot 7^\circ}{\tan 30^\circ + \cot 7^\circ}$ (D) $\dfrac{\tan 7^\circ + \cot 15^\circ}{\tan 7^\circ + \cot 30^\circ}$

SOL 1.75 Option (B) is correct.

Tool designation or tool signature under ASA, system is given in the order.

Back rake, Side rake, End relief, Side relief, End cutting edge angle, Side cutting edge angle and nose radius that is

$$\alpha_b\text{-}\alpha_s\text{-}\theta_e\text{-}\theta_s\text{-}C_e\text{-}C_s\text{-}R$$

Given : For tool P, tool signature,

$$5^\circ\text{-}5^\circ\text{-}6^\circ\text{-}6^\circ\text{-}8^\circ\text{-}30^\circ\text{-}0$$

For tool Q

$$5^\circ\text{-}5^\circ\text{-}7^\circ\text{-}7^\circ\text{-}8^\circ\text{-}15^\circ\text{-}0$$

We know that,

$$h = \frac{\text{feed}}{\tan(\text{SCEA}) + \cot(\text{ECEA})} = \frac{f}{\tan(C_s) + \cot(C_e)}$$

For tool P, $\quad h_P = \dfrac{f_P}{\tan 30^\circ + \cot 8^\circ}$

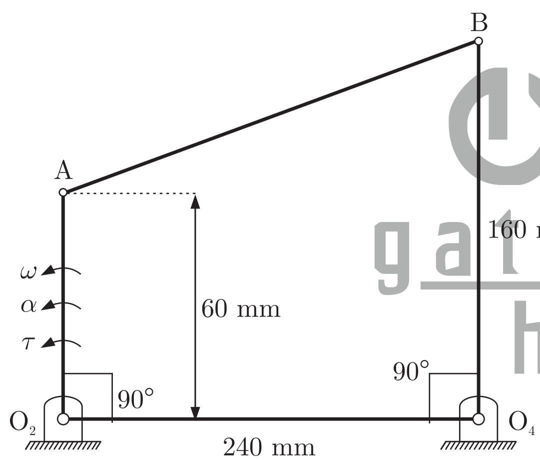
For tool Q $\quad h_Q = \dfrac{f_Q}{\tan 15^\circ + \cot 8^\circ}$

for same machining condition $f_P = f_Q$

Hence, $\quad \dfrac{h_P}{h_Q} = \dfrac{\tan 15^\circ + \cot 8^\circ}{\tan 30^\circ + \cot 8^\circ}$

Common Data for Questions 76, 77, and 78 :

An instantaneous configuration of a four-bar mechanism, whose plane is horizontal is shown in the figure below. At this instant, the angular velocity and angular acceleration of link O_2 A are $\omega = 8$ rad/s and $\alpha = 0$, respectively, and the driving torque (τ) is zero. The link O_2 A is balanced so that its centre of mass falls at O_2.

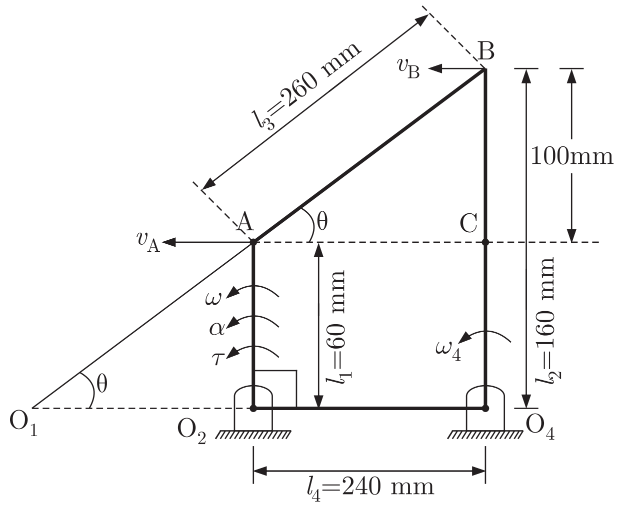


MCQ 1.76 Which kind of 4-bar mechanism is O_2ABO_4 ?

GATE ME 2005 TWO MARK

(A) Double-crank mechanism
(B) Crank-rocker mechanism
(C) Double-rocker mechanism
(D) Parallelogram mechanism

SOL 1.76 Option (B) is correct.



From Triangle ABC,

$$AB = \sqrt{(100)^2 + (240)^2} = \sqrt{67600} = 260\text{ mm}$$

$$\text{Length of shortest link } l_1 = 60\text{ mm}$$

$$\text{Length of longest link } l_3 = 260\text{ mm}$$

From the Grashof's law,

$$l_1 + l_3 \not> l_2 + l_4$$

$$60 + 260 \not> 160 + 240$$

$$320 \not> 400$$

So, $\quad l_1 + l_3 < l_2 + l_4$

Also, when the shortest link O_2A will make a complete revolution relative to other three links, if it satisfies the Grashof's law. Such a link is known as crank. The link O_4B which makes a partial rotation or oscillates is known as rocker. So, crank rocker mechanism is obtained.

Here, $\quad O_2A = l_1 = 60\text{ mm}$ is crank (fixed link)

Adjacent link, $O_2O_4 = 240\text{ mm}$ is fixed

So, crank rocker mechanism will be obtained.

MCQ 1.77 At the instant considered, what is the magnitude of the angular velocity of O_4B?

GATE ME 2005 TWO MARK

(A) 1 rad/s (B) 3 rad/s

(C) 8 rad/s (D) $\frac{64}{3}$ rad/s

SOL 1.77 Option (B) is correct.

Let, ω_4 is the angular velocity of link O_4B

From the triangle ABC,

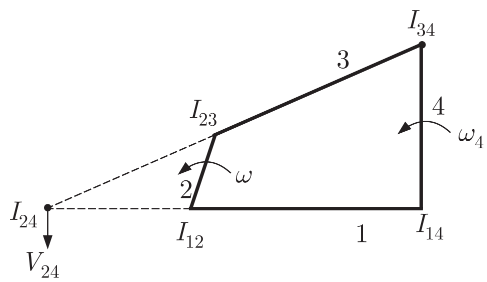
$$\tan\theta = \frac{100}{240} = \frac{5}{12} \qquad \text{...(i)}$$

$$\theta = \tan^{-1}\left(\frac{5}{12}\right) = 22.62^\circ$$

Also from the triangle O_1O_2A,

$$\tan\theta = \frac{O_2A}{O_1O_2}$$

$$O_1O_2 = \frac{O_2A}{\tan\theta} = \frac{60}{\frac{5}{12}} = 144\text{ mm}$$



From the angular velocity ratio theorem.

$$V_{24} = \omega_4 \times I_{24}I_{14} = \omega \times I_{24}I_{12}$$

$$\omega_4 = \frac{I_{24}I_{12}}{I_{24}I_{14}} \times \omega$$

$$\omega_4 = \frac{144}{(240+144)} \times 8 = \frac{144}{384} \times 8 = 3\text{ rad/sec}$$

MCQ 1.78 GATE ME 2005 TWO MARK

At the same instant, if the component of the force at joint A along AB is 30 N, then the magnitude of the joint reaction at O_2

(A) is zero

(B) is 30 N

(C) is 78 N

(D) cannot be determined from the given data

SOL 1.78 Option (D) is correct.

From the given data the component of force at joint A along AO_2 is necessary to find the joint reaction at O_2. So, it is not possible to find the magnitude of the joint reaction at O_2.

Common Data for Question 79 and 80

In two air standard cycles-one operating in the Otto and the other on the Brayton cycle-air is isentropically compressed from 300 to 450 K. Heat is added to raise the temperature to 600 K in the Otto cycle and to 550 K in the Brayton cycle.

MCQ 1.79 GATE ME 2005 TWO MARK

In η_O and η_B are the efficiencies of the Otto and Brayton cycles, then

(A) $\eta_O = 0.25, \eta_B = 0.18$

(B) $\eta_O = \eta_B = 0.33$

(C) $\eta_O = 0.5, \eta_B = 0.45$

(D) it is not possible to calculate the efficiencies unless the temperature after the expansion is given

SOL 1.79 Option (B) is correct.

We know that efficiency,

$$\eta_{Otto} = \eta_{Brayton} = 1 - \frac{T_1}{T_2}$$

$$\eta_{Otto} = \eta_{Brayton} = 1 - \frac{300}{450}$$

$$= 1 - \frac{6}{9} = 0.33$$

So, $$\eta_{Otto} = \eta_{Brayton} = 33\%$$

MCQ 1.80 If W_O and W_B are work outputs per unit mass, then

GATE ME 2005
TWO MARK

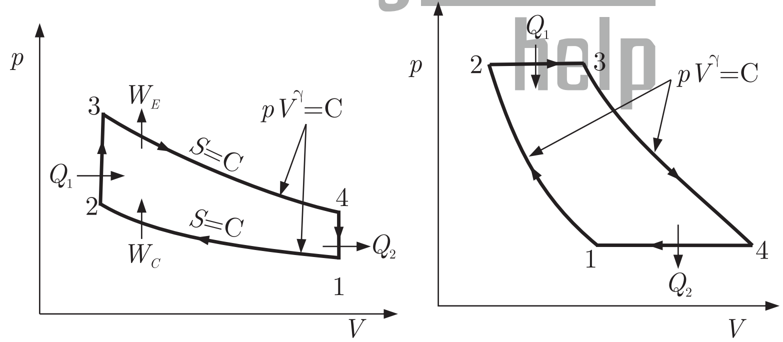
(A) $W_O > W_B$

(B) $W_O < W_B$

(C) $W_O = W_B$

(D) it is not possible to calculate the work outputs unless the temperature after the expansion is given

SOL 1.80 Option (A) is correct.



From the previous part of the question

$T_{3(Otto)} = 600\,\text{K},\ T_{3(Brayton)} = 550\,\text{K}$

From the p-v diagram of Otto cycle, we have

$$W_O = Q_1 - Q_2 = c_v(T_3 - T_2) - c_v(T_4 - T_1) \qquad \text{...(i)}$$

For process 3 - 4,

$$\frac{T_3}{T_4} = \left(\frac{\nu_4}{\nu_3}\right)^{\gamma-1} = \left(\frac{\nu_1}{\nu_2}\right)^{\gamma-1} \qquad \nu_4 = \nu_1,\ \nu_3 = \nu_2$$

For process 1 - 2,

$$\frac{T_2}{T_1} = \left(\frac{\nu_1}{\nu_2}\right)^{\gamma-1}$$

So, $$\frac{T_3}{T_4} = \frac{T_2}{T_1}$$

$$T_4 = \frac{T_3}{T_2} \times T_1 = \frac{600}{450} \times 300 = 400\,\text{K}$$

And $W_O = c_v(600 - 450) - c_v(400 - 300)$

$= c_v(150) - 100c_v = 50c_v$ ...(ii)

From p-ν diagram of brayton cycle, work done is,

$$W_B = Q_1 - Q_2 = c_p(T_3 - T_2) - c_p(T_4 - T_1)$$

And $T_4 = \dfrac{T_1}{T_2} \times T_3 = \dfrac{300}{450} \times 550 = 366.67\,\text{K}$

$W_B = c_p(550 - 450) - c_p(366.67 - 300) = 33.33c_p$ ...(iii)

Dividing equation (ii) by (iii), we get

$$\frac{W_O}{W_B} = \frac{50c_v}{33.33c_p} = \frac{50}{33.33\gamma} \qquad \frac{c_p}{c_v} = \gamma, \gamma = 1.4$$

$$= \frac{50}{33.33 \times 1.4} = \frac{50}{46.662} > 1$$

From this, we see that,

$$W_O > W_B$$

Statement for Linked Answer Question 81 & 82 :

The complete solution of the ordinary differential equation

$\dfrac{d^2y}{dx^2} + p\dfrac{dy}{dx} + qy = 0$ is $y = c_1e^{-x} + c_2e^{-3x}$

MCQ 1.81 Then p and q are

GATE ME 2005 TWO MARK

(A) $p = 3, q = 3$ (B) $p = 3, q = 4$

(C) $p = 4, q = 3$ (D) $p = 4, q = 4$

SOL 1.81 Option (C) is correct.

Given :

$$\frac{d^2y}{dx^2} + p\frac{dy}{dx} + qy = 0$$

We know that the solution of this equation is given by,

$$y = c_1e^{mx} + c_2e^{nx} \qquad ...(i)$$

Here m & n are the roots of ordinary differential equation

Given solution is,

$$y = c_1e^{-x} + c_2e^{-3x} \qquad ...(ii)$$

On comparing equation (i) & (ii), we get

$m = -1 \qquad n = -3$

Sum of roots, $m + n = -p$

$-1 - 3 = -p$

$-4 = -p$

$p = 4$

$$\text{\& Product of roots,} \quad mn = q$$
$$(-1)(-3) = q$$
$$q = 3$$

MCQ 1.82 Which of the following is a solution of the differential equation

GATE ME 2005 TWO MARK

$$\frac{d^2y}{dx^2} + p\frac{dy}{dx} + (q+1)\,y = 0$$

(A) e^{-3x} (B) xe^{-x}

(C) xe^{-2x} (D) x^2e^{-2x}

SOL 1.82 Option (C) is correct.

Given : $$\frac{d^2y}{dx^2} + p\frac{dy}{dx} + (q+1)\,y = 0$$

$$[D^2 + pD + (q+1)]\,y = 0 \qquad \frac{d}{dx} = D$$

From the previous question, put $p = 4$ & $m = 3$

$$[D^2 + 4D + 4]\,y = 0 \qquad \text{...(i)}$$

The auxilliary equation of equation (i) is written as

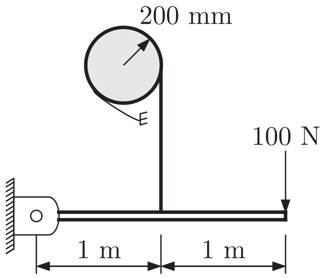
$$m^2 + 4m + 4 = 0$$
$$(m+2)^2 = 0$$
$$m = -2, -2$$

Here the roots of auxiliary equation are same then the solution is

$$y = (c_1 + c_2 x)\,e^{mx} = xe^{-2x} \qquad \begin{pmatrix}\text{Let } c_1 = 0 \\ c_2 = 1\end{pmatrix}$$

Statement for Linked Answer Questions 83 and 84 :

A band brake consists of a lever attached to one end of the band. The other end of the band is fixed to the ground. The wheel has a radius of 200 mm and the wrap angle of the band is 270°. The braking force applied to the lever is limited to 100 N and the coefficient of friction between the band and the wheel is 0.5. No other information is given.



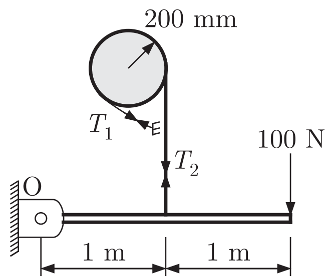
MCQ 1.83 The maximum tension that can be generated in the band during braking is

GATE ME 2005 TWO MARK

(A) 1200 N (B) 2110 N

(C) 3224 N (D) 4420 N

SOL 1.83 Option (B) is correct.



Given : $r = 200\,\text{mm} = 0.2\,\text{m}$, $\theta = 270° = 270 \times \frac{\pi}{180} = \frac{3\pi}{2}$ radian, $\mu = 0.5$

At the time of braking, maximum tension is generated at the fixed end of band near the wheel.

Let, $T_2 \to$ Tension in the slack side of band

$T_1 \to$ Tension in the tight side of band at the fixed end

Taking the moment about the point O,

$$T_2 \times 1 = 100 \times 2 \qquad \Rightarrow \quad T_2 = 200\,\text{N}$$

For the band brake, the limiting ratio of the tension is given by the relation

$$\frac{T_1}{T_2} = e^{\mu\theta} \qquad \Rightarrow T_1 = T_2 \times e^{\mu\theta}$$

$$T_1 = 200 \times e^{0.5 \times \frac{3\pi}{2}} = 200 \times 10.54 = 2108\,\text{N} \simeq 2110\,\text{N}$$

So, maximum tension that can be generated in the band during braking is equal to 2110 N

MCQ 1.84 The maximum wheel torque that can be completely braked is

GATE ME 2005 TWO MARK

(A) 200 Nm (B) 382 Nm

(C) 604 Nm (D) 844 Nm

SOL 1.84 Option (B) is correct.

Maximum wheel torque or braking torque is given by,

$$T_W = (T_1 - T_2)\,r = (2110 - 200) \times 0.2 = 382\,\text{N-m}$$

Statement for Linked Answer Question 85 and 86 :

Consider a linear programming problem with two variables and two constraints. The objective function is : Maximize $X_1 + X_2$. The corner points of the feasible region are (0, 0), (0, 2), (2, 0) and (4/3, 4/3)

MCQ 1.85 If an additional constraint $X_1 + X_2 \le 5$ is added, the optimal solution is

GATE ME 2005 TWO MARK

(A) $\left(\frac{5}{3}, \frac{5}{3}\right)$ (B) $\left(\frac{4}{3}, \frac{4}{3}\right)$

(C) $\left(\frac{5}{2},\frac{5}{2}\right)$ (D) (5, 0)

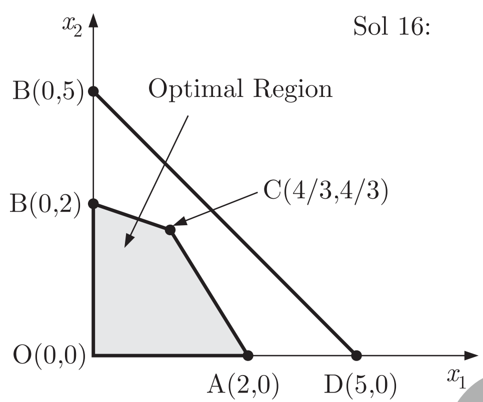
SOL 1.85 Option (B) is correct.

Given : Objective function

$$Z = X_1 + X_2$$

From the given corners we have to make a graph for X_1 and X_2

Sol 16:



From the graph, the constraint $X_1 + X_2 \leq 5$ has no effect on optimal region.

Now, checking for optimal solution

	Point	$Z = X_1 + X_2$
(i)	$O(0,0)$	$Z = 0$
(ii)	$A(2,0)$	$Z = 2+0 = 2$
(iii)	$B(0,2)$	$Z = 0+2 = 2$
(iv)	$C(4/3,4/3)$	$Z = 4/3+4/3 = 8/3$

The optimal solution occurs at point $C(4/3,4/3)$

MCQ 1.86 GATE ME 2005 TWO MARK

Let Y_1 and Y_2 be the decision variables of the dual and v_1 and v_2 be the slack variables of the dual of the given linear programming problem. The optimum dual variables are

(A) Y_1 and Y_2 (B) Y_1 and v_1

(C) Y_1 and v_2 (D) v_1 and v_2

SOL 1.86 Option (D) is correct.

We know,

The inequality constraints are changed to equality constraints by adding or subtracting a non-negative variable from the left-hand sides of such constraints. These variable is called slack variables or simply slacks.

They are added if the constraints are $(\leq)$ and subtracted if the constraints are $(\geq)$. These variables can remain positive throughout the process of solution and their values in the optimal solution given useful information about the problem.

Hence, Optimum dual variables are v_1 and v_2.

Statement for Linked Answer Questions 87 and 88 :

The following table of properties was printed out for saturated liquid and saturated vapour of ammonia. The title for only the first two columns are available. All that we know that the other columns (column 3 to 8) contain data on specific properties, namely, internal energy (kJ/kg), enthalpy (kJ/kg) and entropy (kJ/kg.K)

$t(^\circ C)$	p(kPa)						
-20	190.2	88.76	0.3657	89.05	5.6155	1299.5	1418.0
0	429.6	179.69	0.7114	180.36	5.3309	1318.0	1442.2
20	587.5	272.89	1.0408	274.30	5.0860	1332.2	1460.2
40	1554.9	368.74	1.3574	371.43	4.8662	1341.0	1470.2

MCQ 1.87 The specific enthalpy data are in columns

GATE ME 2005 TWO MARK

(A) 3 and 7
(B) 3 and 8
(C) 5 and 7
(D) 5 and 8

SOL 1.87 Option (D) is correct.

From saturated ammonia table column 5 and 8 are the specific enthalpy data column.

MCQ 1.88 When saturated liquid at 40°C is throttled to -20°C, the quality at exit will be

GATE ME 2005 TWO MARK

(A) 0.189
(B) 0.212
(C) 0.231
(D) 0.788

SOL 1.88 Option (B) is correct.

The enthalpy of the fluid before throttling is equal to the enthalpy of fluid after throttling because in throttling process enthalpy remains constant.

$$h_1 = h_2$$

$$371.43 = 89.05 + x(1418 - 89.05) \qquad h = h_f + x(h_g - h_f)$$

$$= 89.05 + x(1328.95)$$

$$x = \frac{282.38}{1328.95} = 0.212$$

Statement for Linked Answer Question 89 and 90 :

An uninsulated air conditioning duct of rectangular cross section $1\,\text{m} \times 0.5\,\text{m}$, carrying air at 20°C with a velocity of $10\,\text{m/s}$, is exposed to an ambient of 30°C. Neglect the effect of duct construction material. For air in the range of 20 - 30°C, data are as follows; thermal conductivity $= 0.025\,\text{W/mK}$; viscosity $= 18\,\mu\text{Pas}$, Prandtl number $= 0.73$; density $= 1.2\,\text{kg/m}^3$. The laminar flow Nusselt number is 3.4 for constant wall temperature conditions and for turbulent flow, $\text{Nu} = 0.023\,\text{Re}^{0.8}\text{Pr}^{0.33}$

MCQ 1.89 The Reynolds number for the flow is

GATE ME 2005 TWO MARK

(A) 444 (B) 890

(C) 4.44×10^5 (D) 5.33×10^5

SOL 1.89 Option (C) is correct.

Given : A duct of rectangular cross section. For which sides are

$a = 1\,\text{m}$ & $b = 0.5\,\text{m}$

$T_1 = 30^\circ\text{C},\ T_2 = 20^\circ\text{C},\ V = 10\,\text{m/sec},\ k = 0.025\,\text{W/m K}$

Viscosity $= 18\,\mu\text{Pas},\ \text{Pr} = 0.73,\ \rho = 1.2\,\text{kg/m}^3,\ \text{Nu} = 0.023\,\text{Re}^{0.8}\text{Pr}^{0.33}$

Hence, For a rectangular conduit of sides a & b,

Hydraulic diameter, $D_H = \dfrac{4A}{p}$

Where, A is the flow cross sectional area & p the wetted perimeter

$$D_H = \frac{4ab}{2(a+b)} = \frac{2ab}{(a+b)}$$
$$= \frac{2 \times 1 \times 0.5}{(1+0.5)} = \frac{1}{1.5} = 0.666\,\text{m}$$

Reynolds Number, $\text{Re} = \dfrac{\rho V D_H}{\mu}$

$$= \frac{1.2 \times 10 \times 0.666}{18 \times 10^{-6}} = 4.44 \times 10^5$$

MCQ 1.90 The heat transfer per meter length of the duct, in watts is

GATE ME 2005 TWO MARK

(A) 3.8 (B) 5.3

(C) 89 (D) 769

SOL 1.90 Option (D) is correct.

From the first part of the question,

$$\text{Re} = 4.44 \times 10^5$$

Which is greater than 3×10^5. So, flow is turbulent flow.

Therefore, $\text{Nu} = 0.023\,\text{Re}^{0.8}\text{Pr}^{0.33}$

$$\frac{hL}{k} = 0.023(4.44 \times 10^5)^{0.8} \times (0.73)^{0.33} \qquad \text{Nu} = \frac{hL}{k}$$
$$= 0.023 \times 32954 \times 0.9013 = 683.133$$
$$h = 683.133 \times \frac{k}{L}$$
$$= 683.133 \times \frac{0.025}{0.666} = 25.64\,\text{W/m}^2\,\text{K} \qquad D_H = L = 0.666\,\text{m}$$

Total Area, $A = 2(a+b)L = 2(1+0.5)L = 3L$

Heat transfer by convection is given by,

$$Q = hA(T_1 - T_2) = 25.64 \times 3L \times [(273+30) - (273+20)]$$

Heat transfer per meter length of the duct is given by

$$\frac{Q}{L} = 25.64 \times 3 \times 10 = 769.2 \text{ W} \simeq 769 \text{ W}$$

Answer Sheet									
1.	(A)	19.	(B)	37.	(C)	55.	(B)	73.	(C)
2.	(B)	20.	(D)	38.	(D)	56.	(C)	74.	(C)
3.	(A)	21.	(A)	39.	(D)	57.	(C)	75.	(B)
4.	(C)	22.	(D)	40.	(C)	58.	(C)	76.	(B)
5.	(A)	23.	(B)	41.	(C)	59.	(D)	77.	(B)
6.	(D)	24.	(A)	42.	(B)	60.	(A)	78.	(D)
7.	(A)	25.	(C)	43.	(C)	61.	(C)	79.	(B)
8.	(A)	26.	(A)	44.	(B)	62.	(B)	80.	(A)
9.	(A)	27.	(A)	45.	(C)	63.	(B)	81.	(C)
10.	(C)	28.	(D)	46.	(A)	64.	(B)	82.	(C)
11.	(C)	29.	(C)	47.	(B)	65.	(B)	83.	(B)
12.	(A)	30.	(A)	48.	(C)	66.	(C)	84.	(B)
13.	(D)	31.	(A)	49.	(C)	67.	(C)	85.	(B)
14.	(D)	32.	(C)	50.	(C)	68.	(B)	86.	(D)
15.	(A)	33.	(A)	51.	(B)	69.	(A)	87.	(D)
16.	(D)	34.	(D)	52.	(D)	70.	(B)	88.	(B)
17.	(D)	35.	(D)	53.	(A)	71.	(A)	89.	(C)
18.	(B)	36.	(A)	54.	(A)	72.	(D)	90.	(D)

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