ME GATE-06

MCQ 1.1 Match the items in column I and II.

GATE ME 2006 ONE MARK

	Column I		Column II
P.	Gauss-Seidel method	**1.**	Interpolation
Q.	Forward Newton-Gauss method	**2.**	Non-linear differential equations
R.	Runge-Kutta method	**3.**	Numerical integration
S.	Trapezoidal Rule	**4.**	Linear algebraic equations

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

SOL 1.1 Option (D) is correct.

	Column I		
P.	Gauss-Seidel method	**4.**	Linear algebraic equation
Q.	Forward Newton-Gauss method	**1.**	Interpolation
R.	Runge-Kutta method	**2.**	Non-linear differential equation
S.	Trapezoidal Rule	**3.**	Numerical integration

So, correct pairs are, P-4, Q-1, R-2, S-3

MCQ 1.2 The solution of the differential equation $\frac{dy}{dx}+2xy=e^{-x^2}$ with $y(0)=1$ is

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(A) $(1+x)\,e^{+x^2}$
(B) $(1+x)\,e^{-x^2}$
(C) $(1-x)\,e^{+x^2}$
(D) $(1-x)\,e^{-x^2}$

SOL 1.2 Option (B) is correct.

Given : $\frac{dy}{dx}+2xy=e^{-x^2}$ and $y(0)=1$

It is the first order linear differential equation so its solution is

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

compare with $\frac{dy}{dx}+P(y)=Q$

So, $$I.F.=e^{\int Pdx}=e^{\int 2xdx}$$
$$=e^{2\int xdx}=e^{2\times\frac{x^2}{2}}=e^{x^2}$$

The complete solution is,

$$ye^{x^2} = \int e^{-x^2} \times e^{x^2}\, dx + C$$

$$ye^{x^2} = \int dx + C = x + C$$

$$y = \frac{x + c}{e^{x^2}} \qquad \text{...(i)}$$

Given $y(0) = 1$

At $x = 0 \Rightarrow y = 1$

Substitute in equation (i), we get

$$1 = \frac{C}{1} \Rightarrow C = 1$$

Then $y = \frac{x+1}{e^{x^2}} = (x+1)\, e^{-x^2}$

MCQ 1.3 GATE ME 2006 ONE MARK

Let x denote a real number. Find out the INCORRECT statement.

(A) $S = \{x : x > 3\}$ represents the set of all real numbers greater than 3

(B) $S = \{x : x^2 < 0\}$ represents the empty set.

(C) $S = \{x : x \in A \text{ and } x \in B\}$ represents the union of set A and set B.

(D) $S = \{x : a < x < b\}$ represents the set of all real numbers between a and b, where a and b are real numbers.

SOL 1.3

Option (C) is correct.

The incorrect statement is, $S = \{x : x \in A \text{ and } x \in B\}$ represents the union of set A and set B.

The above symbol ($\in$) denotes intersection of set A and set B. Therefore this statement is incorrect.

MCQ 1.4 GATE ME 2006 ONE MARK

A box contains 20 defective items and 80 non-defective items. If two items are selected at random without replacement, what will be the probability that both items are defective ?

(A) $\frac{1}{5}$ (B) $\frac{1}{25}$

(C) $\frac{20}{99}$ (D) $\frac{19}{495}$

SOL 1.4

Option (D) is correct.

Total number of items = 100

Number of defective items = 20

Number of Non-defective items = 80

Then the probability that both items are defective, when 2 items are selected at random is,

$$P = \frac{{}^{20}C_2\, {}^{80}C_0}{{}^{100}C_2} = \frac{\frac{20!}{18!2!}}{\frac{100!}{98!2!}}$$

$$= \frac{\frac{20 \times 19}{2}}{\frac{100 \times 99}{2}} = \frac{19}{495}$$

Alternate method

Here two items are selected without replacement.
Probability of first item being defective is

$$P_1 = \frac{20}{100} = \frac{1}{5}$$

After drawing one defective item from box, there are 19 defective items in the 99 remaining items.
Probability that second item is defective,

$$P_2 = \frac{19}{899}$$

then probability that both are defective

$$P = P_1 \times P_2$$

$$P = \frac{1}{5} \times \frac{19}{99} = \frac{19}{495}$$

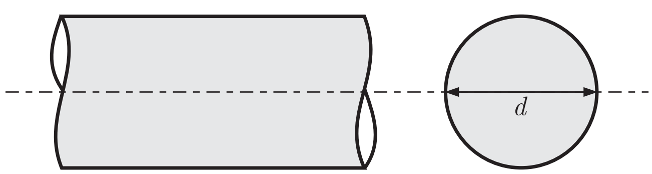
MCQ 1.5 GATE ME 2006 ONE MARK

For a circular shaft of diameter d subjected to torque T, the maximum value of the shear stress is

(A) $\frac{64T}{\pi d^3}$ (B) $\frac{32T}{\pi d^3}$

(C) $\frac{16T}{\pi d^3}$ (D) $\frac{8T}{\pi d^3}$

SOL 1.5 Option (C) is correct.



From the Torsional equation

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{l}$$

Take first two terms,

$$\frac{T}{J} = \frac{\tau}{r}$$

$$\frac{T}{\frac{\pi}{32} d^4} = \frac{\tau}{\frac{d}{2}} \qquad J = \text{Polar moment of inertia}$$

$$\tau_{max} = \frac{16T}{\pi d^3}$$

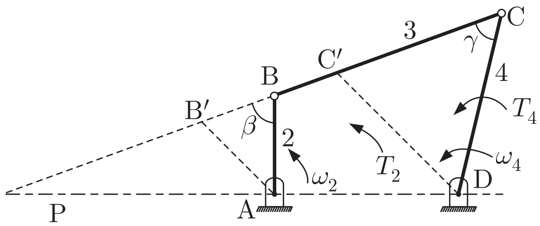
MCQ 1.6 For a four-bar linkage in toggle position, the value of mechanical advantage is

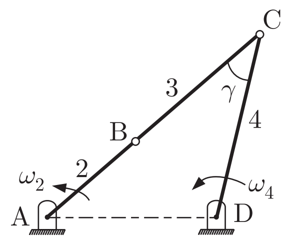
GATE ME 2006 ONE MARK

(A) 0.0 (B) 0.5

(C) 1.0 (D) ∞

SOL 1.6 Option (D) is correct.





$$M.A = \frac{T_4}{T_2} = \frac{\omega_2}{\omega_4} = \frac{R_{PD}}{R_{PA}}$$ from angular velocity ratio theorem

Construct $B'A$ and $C'D$ perpendicular to the line PBC. Also, assign lables β and γ to the acute angles made by the coupler.

$$\frac{R_{PD}}{R_{PA}} = \frac{R_{C'D}}{R_{B'A}} = \frac{R_{CD}\sin\gamma}{R_{BA}\sin\beta}$$

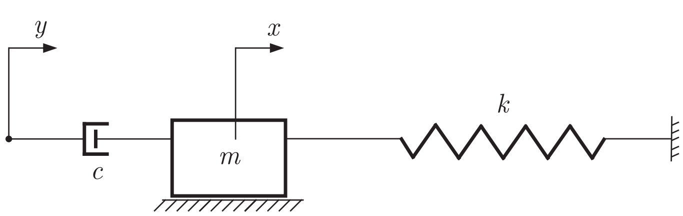
So, $$M.A. = \frac{T_4}{T_2} = \frac{\omega_2}{\omega_4} = \frac{R_{CD}\sin\gamma}{R_{BA}\sin\beta}$$

When the mechanism is toggle,then $\beta = 0^\circ$ and 180°.

So $M.A = \infty$

MCQ 1.7 The differential equation governing the vibrating system is

GATE ME 2006 ONE MARK



(A) $m\ddot{x} + c\dot{x} + k(x - y) = 0$

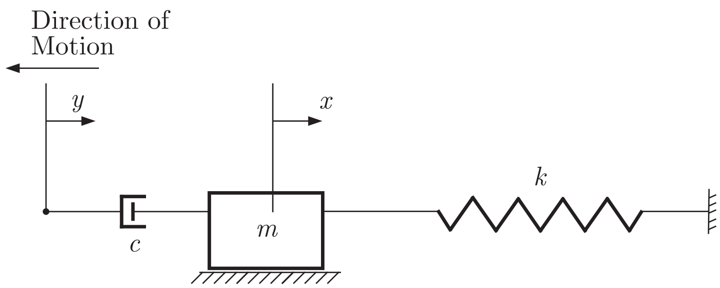
(B) $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y}) + kx = 0$

(C) $m\ddot{x} + c(\dot{x} - \dot{y}) + kx = 0$

(D) $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y}) + k(x - y) = 0$

SOL 1.7 Option (C) is correct.

Assume any arbitrary relationship between the coordinates and their first derivatives, say $x > y$ and $\dot{x} > \dot{y}$. Also assume $x > 0$ and $\dot{x} > 0$.



A small displacement gives to the system towards the left direction. Mass m is fixed, so only damper moves for both the variable x and y.
Note that these forces are acting in the negative direction.
Differential equation governing the above system is,

$$\sum F = -m\frac{d^2x}{dt^2} - c\left(\frac{dx}{dt} - \frac{dy}{dt}\right) - kx = 0$$

$$m\ddot{x} + c(\dot{x} - \dot{y}) + kx = 0$$

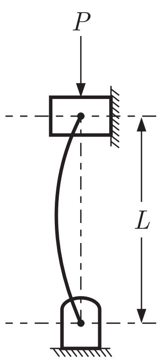
MCQ 1.8 GATE ME 2006 ONE MARK

A pin-ended column of length L, modulus of elasticity E and second moment of the cross-sectional area is I loaded eccentrically by a compressive load P. The critical buckling load (P_{cr}) is given by

(A) $P_{cr} = \frac{EI}{\pi^2 L^2}$ (B) $P_{cr} = \frac{\pi^2 EI}{3L^2}$

(C) $P_{cr} = \frac{\pi EI}{L^2}$ (D) $P_{cr} = \frac{\pi^2 EI}{L^2}$

SOL 1.8 Option (D) is correct.



According to Euler's theory, the crippling or buckling load (P_{cr}) under various end conditions is represented by a general equation,

$$P_{cr} = \frac{C\pi^2 EI}{L^2} \quad ...(i)$$

Where, E = Modulus of elasticity
I = Mass-moment of inertia
L = Length of column
C = constant, representing the end conditions of the column or end fixity coefficient.

Here both ends are hinged,

So, $C = 1$

Substitute in equation (i), we get

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

MCQ 1.9 The number of inversion for a slider crank mechanism is

GATE ME 2006 ONE MARK

(A) 6 (B) 5

(C) 4 (D) 3

SOL 1.9 Option (C) is correct.

For a 4 bar slider crank mechanism, there are the number of links or inversions are 4. These different inversions are obtained by fixing different links once at a time for one inversion. Hence, the number of inversions for a slider crank mechanism is 4.

MCQ 1.10 For a Newtonian fluid

GATE ME 2006 ONE MARK

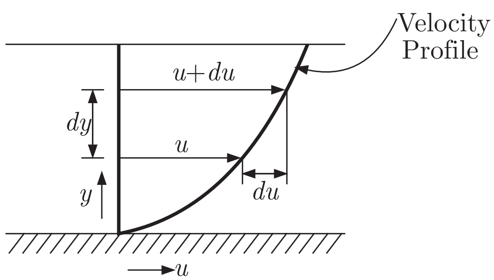
(A) Shear stress is proportional to shear strain

(B) Rate of shear stress is proportional to shear strain

(C) Shear stress is proportional to rate of shear strain

(D) Rate of shear stress is proportional to rate of shear strain

SOL 1.10 Option (C) is correct.



Velocity variation near a body

From the Newton's law of Viscosity, the shear stress (τ) is directly proportional to the rate of shear strain (du/dy).

So, $$\tau \propto \frac{du}{dy} = \mu\frac{du}{dy}$$

Where $\mu =$ Constant of proportionality and it is known as coefficient of Viscosity.

MCQ 1.11 In a two-dimensional velocity field with velocities u and v along the x and y directions respectively, the convective acceleration along the x-direction is given by

GATE ME 2006 ONE MARK

(A) $u\frac{\partial v}{\partial x} + v\frac{\partial u}{\partial y}$ (B) $u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y}$

(C) $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$ (D) $v\frac{\partial u}{\partial x} + u\frac{\partial u}{\partial y}$

SOL 1.11 Option (C) is correct.

Convective Acceleration is defined as the rate of change of velocity due to the change of position of fluid particles in a fluid flow.

In Cartesian coordinates, the components of the acceleration vector along the x -direction is given by.

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

In above equation term $\partial u/\partial t$ is known as local acceleration and terms other then this, called convective acceleration.

Hence for given flow.

Convective acceleration along x-direction.

$$a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} \qquad [w = 0]$$

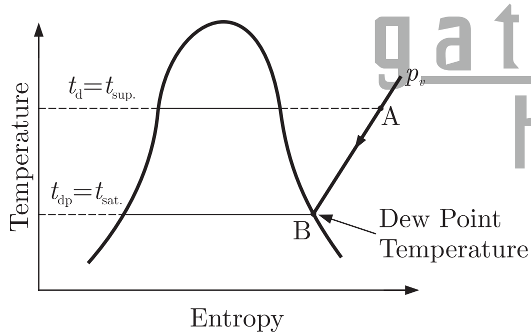
MCQ 1.12 GATE ME 2006 ONE MARK

Dew point temperature is the temperature at which condensation begins when the air is cooled at constant

(A) volume (B) entropy

(C) pressure (D) enthalpy

SOL 1.12 Option (C) is correct.

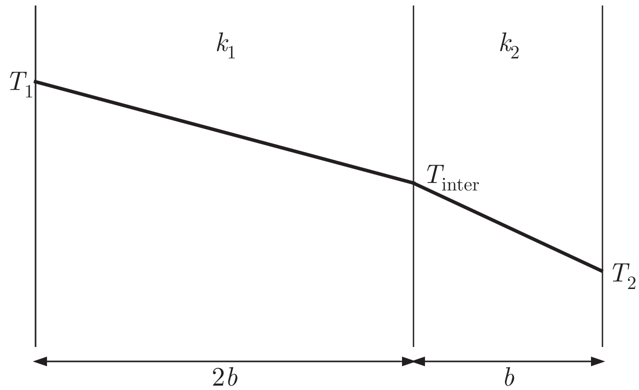


It is the temperature of air recorded by a thermometer, when the moisture (water vapour) present in it begins to condense.

If a sample of unsaturated air, containing superheated water vapour, is cooled at constant pressure, the partial pressure (p_v) of each constituent remains constant until the water vapour reaches the saturated state as shown by point B. At this point B the first drop of dew will be formed and hence the temperature at point B is called dew point temperature.

MCQ 1.13 GATE ME 2006 ONE MARK

In a composite slab, the temperature at the interface (T_{inter}) between two material is equal to the average of the temperature at the two ends. Assuming steady one-dimensional heat conduction, which of the following statements is true about the respective thermal conductivities ?



(A) $2k_1 = k_2$
(B) $k_1 = k_2$
(C) $2k_1 = 3k_2$
(D) $k_1 = 2k_2$

SOL 1.13 Option (D) is correct.

Given : $T_{inter} = \frac{T_1 + T_2}{2}$

Heat transfer will be same for both the ends

So, $Q = -\frac{k_1 A_1 (T_1 - T_{inter})}{2b} = -\frac{k_2 A_2 (T_{inter} - T_2)}{b}$ $\qquad Q = -kA\frac{dT}{dx}$

There is no variation in the horizontal direction. Therefore, we consider portion of equal depth and height of the slab, since it is representative of the entire wall. So, $A_1 = A_2$ and $T_{inter} = \frac{T_1 + T_2}{2}$

So, we get

$$\frac{k_1\left[T_1 - \left(\frac{T_1 + T_2}{2}\right)\right]}{2} = k_2\left[\frac{T_1 + T_2}{2} - T_2\right]$$

$$k_1\left[\frac{2T_1 - T_1 - T_2}{2}\right] = 2k_2\left[\frac{T_1 + T_2 - 2T_2}{2}\right]$$

$$\frac{k_1}{2}[T_1 - T_2] = k_2[T_1 - T_2]$$

$$k_1 = 2k_2$$

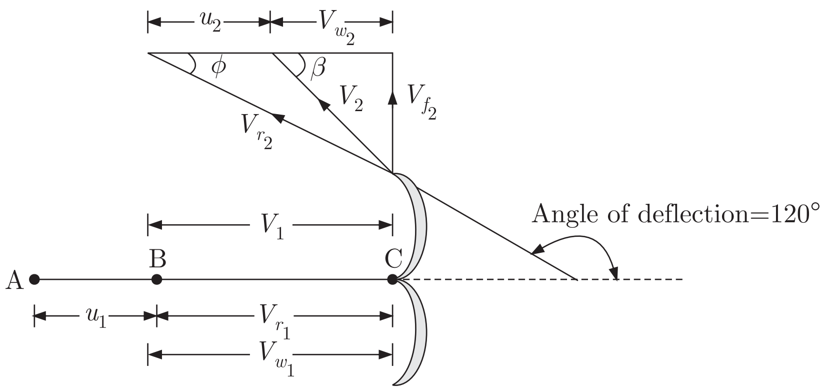
MCQ 1.14 GATE ME 2006 ONE MARK

In a Pelton wheel, the bucket peripheral speed is 10 m/s, the water jet velocity is 25 m/s and volumetric flow rate of the jet is $0.1\ m^3/s$. If the jet deflection angle is $120°$ and the flow is ideal, the power developed is

(A) 7.5 kW
(B) 15.0 kW
(C) 22.5 kW
(D) 37.5 kW

SOL 1.14 Option (C) is correct.

The velocity triangle for the pelton wheel is given below.



Given : $u = u_1 = u_2 = 10\,\text{m/sec}$, $V_1 = 25\,\text{m/sec}$, $Q = 0.1\,\text{m}^3/\text{sec}$

Jet deflection angle= 120° C

$$\phi = 180^\circ - 120^\circ = 60^\circ$$

$$P = \frac{\rho Q[V_{w_1} + V_{w_2}] \times u}{1000}\,\text{kW} \qquad ...(i)$$

From velocity triangle,

$$V_{w_1} = V_1 = 25\,\text{m/sec}$$

$$V_{w_2} = V_{r_2}\cos\phi - u_2 \qquad V_{r_2} = V_{r_1} = V_1 - u_1$$

$$= 15\cos 60^\circ - 10 \qquad = 25 - 10 = 15\,\text{m/sec}$$

$$= \frac{15}{2} - 10 = -2.5\,\text{m/sec}$$

Now put there values in equation (i)

$$P = \frac{1000 \times 0.1\,[25 - 2.5] \times 10}{1000}\,\text{kW} = 22.5\,\text{kW}$$

MCQ 1.15 An expendable pattern is used in

GATE ME 2006 ONE MARK

(A) slush casting (B) squeeze casting

(C) centrifugal casting (D) investment casting

SOL 1.15 Option (D) is correct.

Investment casting uses an expandable pattern, which is made of wax or of a plastic by molding or rapid prototyping techniques. This pattern is made by injecting molten wax or plastic into a metal die in the shape of the pattern.

MCQ 1.16 The main purpose of spheroidising treatment is to improve

GATE ME 2006 ONE MARK

(A) hardenability of low carbon steels

(B) machinability of low carbon steels

(C) hardenability of high carbon steels

(D) machinability of high carbon steels

SOL 1.16 Option (D) is correct.

Spheroidizing may be defined as any heat treatment process that produces a rounded or globular form of carbide. High carbon steels are spheroidized to improve machinability, especially in continuous cutting operations.

MCQ 1.17 NC contouring is an example of

GATE ME 2006 ONE MARK

(A) continuous path positioning
(B) point-to-point positioning
(C) absolute positioning
(D) incremental positioning

SOL 1.17 Option (A) is correct.

NC contouring is a continuous path positioning system. Its function is to synchronize the axes of motion to generate a predetermined path, generally a line or a circular arc.

MCQ 1.18 A ring gauge is used to measure

GATE ME 2006 ONE MARK

(A) outside diameter but not roundness
(B) roundness but not outside diameter
(C) both outside diameter and roundness
(D) only external threads

SOL 1.18 Option (A) is correct.

Ring gauges are used for gauging the shaft and male components i.e. measure the outside diameter. It does not able to measure the roundness of the given shaft.

MCQ 1.19 The number of customers arriving at a railway reservation counter is Poisson distributed with an arrival rate of eight customers per hour. The reservation clerk at this counter takes six minutes per customer on an average with an exponentially distributed service time. The average number of the customers in the queue will be

GATE ME 2006 ONE MARK

(A) 3
(B) 3.2
(C) 4
(D) 4.2

SOL 1.19 Option (B) is correct.

Given :

$$\lambda = 8 \text{ per hour}$$

$$\mu = 6 \text{ min per customer} = \frac{60}{6} \text{ customer/hours} = 10 \text{ customer/hour}$$

We know, for exponentially distributed service time.

Average number of customers in the queue.

$$L_q = \frac{\lambda}{\mu} \times \frac{\lambda}{(\mu - \lambda)}$$

$$L_q = \frac{8}{10} \times \frac{8}{(10 - 8)}$$

$$L_q = 3.2$$

MCQ 1.20 In an MRP system, component demand is

GATE ME 2006 ONE MARK

(A) forecasted
(B) established by the master production schedule

(C) calculated by the MRP system from the master production schedule

(D) ignored

SOL 1.20 Option (C) is correct.

MRP (Material Requirement Planning) :

MRP function is a computational technique with the help of which the master schedule for end products is converted into a detailed schedule for raw materials and components used in the end product.

Input to MRP

(i) Master production schedule.

(ii) The bill of material

(iii) Inventory records relating to raw materials.

MCQ 1.21 GATE ME 2006 TWO MARK

Eigen values of a matrix $S = \begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$ are 5 and 1. What are the eigen values of the matrix $S^2 = SS$?

(A) 1 and 25

(B) 6 and 4

(C) 5 and 1

(D) 2 and 10

SOL 1.21 Option (A) is correct.

Given : $S = \begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$

Eigen values of this matrix is 5 and 1. We can say $\lambda_1 = 1$ $\lambda_2 = 5$

Then the eigen value of the matrix

$$S^2 = S\,S \text{ is } \lambda_1^2,\ \lambda_2^2$$

Because. if $\lambda_1, \lambda_2, \lambda_3 ....$ are the eigen values of A, then eigen value of A^m are $\lambda_1^m, \lambda_2^m, \lambda_3^m ....$

Hence matrix S^2 has eigen values $(1)^2$ & $(5)^2 \Rightarrow 1$ & 25

MCQ 1.22 GATE ME 2006 TWO MARK

Equation of the line normal to function $f(x) = (x-8)^{2/3} + 1$ at $P(0,5)$ is

(A) $y = 3x - 5$

(B) $y = 3x + 5$

(C) $3y = x + 15$

(D) $3y = x - 15$

SOL 1.22 Option (B) is correct.

Given $f(x) = (x-8)^{2/3} + 1$

The equation of line normal to the function is

$$(y - y_1) = m_2(x - x_1) \qquad \text{...(i)}$$

Slope of tangent at point (0, 5) is

$$m_1 = f'(x) = \left[\frac{2}{3}(x-8)^{-1/3}\right]_{(0,5)}$$

$$m_1 = f'(x) = \frac{2}{3}(-8)^{-1/3} = -\frac{2}{3}(2^3)^{-\frac{1}{3}} = -\frac{1}{3}$$

We know the slope of two perpendicular curves is -1.

$$m_1 m_2 = -1$$
$$m_2 = -\frac{1}{m_1} = \frac{-1}{-1/3} = 3$$

The equation of line, from equation (i) is

$$(y-5) = 3(x-0)$$
$$y = 3x+5$$

MCQ 1.23 Assuming $i = \sqrt{-1}$ and t is a real number, $\int_0^{\pi/3} e^{it}\,dt$ is

GATE ME 2006 TWO MARK

(A) $\frac{\sqrt{3}}{2} + i\frac{1}{2}$ (B) $\frac{\sqrt{3}}{2} - i\frac{1}{2}$

(C) $\frac{1}{2} + i\frac{\sqrt{3}}{2}$ (D) $\frac{1}{2} + i\left(1 - \frac{\sqrt{3}}{2}\right)$

SOL 1.23 Option (A) is correct.

Let
$$f(x) = \int_0^{\pi/3} e^{it}\,dt = \left[\frac{e^{it}}{i}\right]_0^{\pi/3} \Rightarrow \frac{e^{i\pi/3}}{i} - \frac{e^0}{i}$$
$$= \frac{1}{i}\left[e^{\frac{\pi}{3}i} - 1\right] = \frac{1}{i}\left[\cos\frac{\pi}{3} + i\sin\frac{\pi}{3} - 1\right]$$
$$= \frac{1}{i}\left[\frac{1}{2} + i\frac{\sqrt{3}}{2} - 1\right] = \frac{1}{i}\left[-\frac{1}{2} + \frac{\sqrt{3}}{2}i\right]$$
$$= \frac{1}{i} \times \frac{i}{i}\left[-\frac{1}{2} + \frac{\sqrt{3}}{2}i\right]$$
$$= -i\left[-\frac{1}{2} + \frac{\sqrt{3}}{2}i\right] \qquad i^2 = -1$$
$$= i\left[\frac{1}{2} - \frac{\sqrt{3}}{2}i\right] = \frac{1}{2}i - \frac{\sqrt{3}}{2}i^2 = \frac{\sqrt{3}}{2} + \frac{1}{2}i$$

MCQ 1.24 If $f(x) = \frac{2x^2 - 7x + 3}{5x^2 - 12x - 9}$, then $\lim_{x \to 3} f(x)$ will be

GATE ME 2006 TWO MARK

(A) $-1/3$ (B) $5/18$

(C) 0 (D) $2/5$

SOL 1.24 Option (B) is correct.

Given
$$f(x) = \frac{2x^2 - 7x + 3}{5x^2 - 12x - 9}$$

Then
$$\lim_{x \to 3} f(x) = \lim_{x \to 3} \frac{2x^2 - 7x + 3}{5x^2 - 12x - 9}$$
$$= \lim_{x \to 3} \frac{4x - 7}{10x - 12} \qquad \text{Applying L – Hospital rule}$$

Substitute the limit, we get

$$= \frac{4 \times 3 - 7}{10 \times 3 - 12} = \frac{12 - 7}{30 - 12} = \frac{5}{18}$$

MCQ 1.25 Match the items in column I and II.

GATE ME 2006 TWO MARK

	Column I		Column II
P.	Singular matrix	**1.**	Determinant is not defined
Q.	Non-square matrix	**2.**	Determinant is always one
R.	Real symmetric	**3.**	Determinant is zero
S.	Orthogonal matrix	**4.**	Eigenvalues are always real
		5.	Eigenvalues are not defined

(A) P-3, Q-1, R-4, S-2 (B) P-2, Q-3, R-4, S-1

(C) P-3, Q-2, R-5, S-4 (D) P-3, Q-4, R-2, S-1

SOL 1.25 Option (A) is correct.

(P) Singular Matrix → Determinant is zero $|A| = 0$

(Q) Non-square matrix → An $m \times n$ matrix for which $m \neq n$, is called non-square matrix. Its determinant is not defined

(R) Real Symmetric Matrix → Eigen values are always real.

(S) Orthogonal Matrix → A square matrix A is said to be orthogonal if $AA^T = I$ Its determinant is always one.

MCQ 1.26 For $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 3y = 3e^{2x}$, the particular integral is

GATE ME 2006 TWO MARK

(A) $\frac{1}{15}e^{2x}$ (B) $\frac{1}{5}e^{2x}$

(C) $3e^{2x}$ (D) $C_1e^{-x} + C_2e^{-3x}$

SOL 1.26 Option (B) is correct.

Given : $$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 3y = 3e^{2x}$$

$$[D^2 + 4D + 3]y = 3e^{2x} \qquad \frac{d}{dx} = D$$

The auxiliary Equation is,

$$m^2 + 4m + 3 = 0$$
$$m(m+3) + 1(m+3) = 0$$
$$(m+3)(m+1) = 0$$
$$m = -1, -3$$

Then $$C.F. = C_1e^{-x} + C_2e^{-3x}$$

$$P.I. = \frac{3e^{2x}}{D^2 + 4D + 3} = \frac{3e^{2x}}{(D+1)(D+3)} \qquad \text{Put } D = 2$$

$$= \frac{3e^{2x}}{(2+1)(2+3)} = \frac{3e^{2x}}{3 \times 5} = \frac{e^{2x}}{5}$$

MCQ 1.27 Multiplication of matrices E and F is G. matrices E and G are

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$$E = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \text{ and } G = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

What is the matrix F ?

(A) $\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(B) $\begin{bmatrix} \cos\theta & \cos\theta & 0 \\ -\cos\theta & \sin\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(C) $\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(D) $\begin{bmatrix} \sin\theta & -\cos\theta & 0 \\ \cos\theta & \sin\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

SOL 1.27 Option (C) is correct.

Given $EF = G$ where $G = I =$ Identity matrix

$$\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \times F = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

We know that the multiplication of a matrix & its inverse be a identity matrix

$$AA^{-1} = I$$

So, we can say that F is the inverse matrix of E

$$F = E^{-1} = \frac{[\text{adj}.E]}{|E|}$$

$$\text{adj}E = \begin{bmatrix} \cos\theta & -(\sin\theta) & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}^T$$

$$= \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$|E| = [\cos\theta \times (\cos\theta - 0)] - [(-\sin\theta) \times (\sin\theta - 0)] + 0$$

$$= \cos^2\theta + \sin^2\theta = 1$$

Hence, $$F = \frac{[\text{adj}.E]}{|E|} = \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

MCQ 1.28 Consider the continuous random variable with probability density function

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$$f(t) = 1 + t \text{ for } -1 \le t \le 0$$
$$= 1 - t \text{ for } 0 \le t \le 1$$

The standard deviation of the random variable is

(A) $\frac{1}{\sqrt{3}}$

(B) $\frac{1}{\sqrt{6}}$

(C) $\frac{1}{3}$ (D) $\frac{1}{6}$

SOL 1.28 Option (B) is correct.

The probability density function is,

$$f(t) = \begin{cases} 1+t & \text{for} -1 \le t \le 0 \\ 1-t & \text{for } 0 \le t \le 1 \end{cases}$$

For standard deviation first we have to find the mean & variance of the function.

$$\text{Mean}\,(\bar{t}) = \int_{-1}^{\infty} t f(t)\,dt = \int_{-1}^{0} t(1+t)\,dt + \int_{0}^{1} t(1-t)\,dt$$

$$= \int_{-1}^{0} (t+t^2)\,dt + \int_{0}^{1} (t-t^2)\,dt$$

Integrating the equation and substitute the limits

$$= \left[\frac{t^2}{2} + \frac{t^3}{3}\right]_{-1}^{0} + \left[\frac{t^2}{2} - \frac{t^3}{3}\right]_{0}^{1}$$

$$= \left[-\frac{1}{2} + \frac{1}{3}\right] + \left[\frac{1}{2} - \frac{1}{3}\right] = 0$$

And variance $(\sigma^2) = \int_{-\infty}^{\infty} (t-\bar{t})^2 f(t)\,dt$ $\qquad \bar{t} = 0$

$$= \int_{-1}^{0} t^2(1+t)\,dt + \int_{0}^{1} t^2(1-t)\,dt$$

$$= \int_{-1}^{0} (t^2+t^3)\,dt + \int_{0}^{1} (t^2-t^3)\,dt$$

Integrating the equation and substitute the limits

$$= \left[\frac{t^3}{3} + \frac{t^4}{4}\right]_{-1}^{0} + \left[\frac{t^3}{3} - \frac{t^4}{4}\right]_{0}^{1}$$

$$= -\left[-\frac{1}{3} + \frac{1}{4}\right] + \left[\frac{1}{3} - \frac{1}{4} - 0\right] = \frac{1}{12} + \frac{1}{12} = \frac{1}{6}$$

Now, standard deviation

$$= \sqrt{\text{variance}\,(\sigma^2)} = \sqrt{\frac{1}{6}} = \frac{1}{\sqrt{6}}$$

MCQ 1.29 Match the item in columns I and II

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	Column I		Column II
P.	Addendum	**1.**	Cam
Q.	Instantaneous centre of velocity	**2.**	Beam
R.	Section modulus	**3.**	Linkage
S.	Prime circle	**4.**	Gear

(A) P-4, Q-2, R-3, S-1

(B) P-4, Q-3, R-2, S-1

(C) P-3, Q-2, R-1, S-4

(D) P-3, Q-4, R-1, S-2

SOL 1.29 Option (B) is correct.

	Column I		Column II
P.	Addendum	**4.**	Gear
Q.	Instantaneous centre of velocity	**3.**	Linkage
R.	Section modulus	**2.**	Beam
S.	Prime circle	**1.**	Cam

So correct pairs are, P-4, Q-3, R-2, S-1

MCQ 1.30 A disc clutch is required to transmit 5 kW at 2000 rpm. The disk has a friction lining with coefficient of friction equal to 0.25. Bore radius of friction lining is equal to 25 mm. Assume uniform contact pressure of 1 MPa. The value of outside radius of the friction lining is

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(A) 39.4 mm
(B) 49.5 mm
(C) 97.9 mm
(D) 142.9 mm

SOL 1.30 Option (A) is correct.

Given : $P = 5\,\text{kW}$, $N = 2000$ rpm, $\mu = 0.25$, $r_2 = 25\,\text{mm} = 0.025\,\text{m}$, $p = 1\,\text{MPa}$

Power transmitted, $$P = \frac{2\pi NT}{60}$$

Torque, $$T = \frac{60P}{2\pi N} = \frac{60 \times 5 \times 10^3}{2 \times 3.14 \times 2000} = 23.885\ \text{N-m}$$

When pressure is uniformly distributed over the entire area of the friction faces, then total frictional torque acting on the friction surface or on the clutch,

$$T = 2\pi\mu p\left[\frac{(r_1)^3 - (r_2)^3}{3}\right]$$

$$23.885 \times 3 = 2 \times 3.14 \times 0.25 \times 1 \times 10^6 \times [r_1^3 - (0.025)^3]$$

$$r_1^3 - (0.025)^3 = \frac{23.885 \times 3}{2 \times 3.14 \times 0.25 \times 10^6}$$

$$r_1^3 - 1.56 \times 10^{-5} = 45.64 \times 10^{-6} = 4.564 \times 10^{-5}$$

$$r_1^3 = (4.564 + 1.56) \times 10^{-5} = 6.124 \times 10^{-5}$$

$$r_1 = (6.124 \times 10^{-5})^{1/3} = 3.94 \times 10^{-2}\ \text{m}$$

$$r_1 = 39.4\ \text{mm}$$

MCQ 1.31 Twenty degree full depth involute profiled 19 tooth pinion and 37 tooth gear are in mesh. If the module is 5 mm, the centre distance between the gear pair will be

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(A) 140 mm
(B) 150 mm
(C) 280 mm
(D) 300 mm

SOL 1.31 Option (A) is correct.

Given : $Z_P = 19$, $Z_G = 37$, $m = 5\,\text{mm}$

Also, $$m = \frac{D}{Z}$$

For pinion, pitch circle diameter is,

$$D_P = m \times Z_P = 5 \times 19 = 95 \text{ mm}$$

And pitch circle diameter of the gear,

$$D_G = m \times Z_G = 5 \times 37 = 185 \text{ mm}$$

Now, centre distance between the gear pair (shafts),

$$L = \frac{D_P}{2} + \frac{D_G}{2} = \frac{95 + 185}{2} = 140 \text{ mm}$$

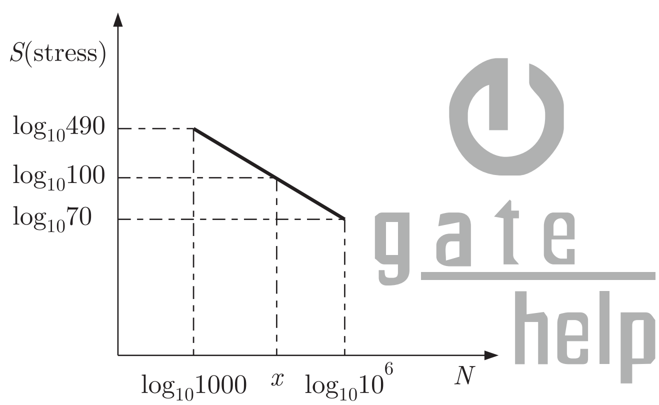
MCQ 1.32 GATE ME 2006 TWO MARK

A cylindrical shaft is subjected to an alternating stress of 100 MPa. Fatigue strength to sustain 1000 cycles is 490 MPa. If the corrected endurance strength is 70 MPa , estimated shaft life will be

(A) 1071 cycles (B) 15000 cycles

(C) 281914 cycles (D) 928643 cycles

SOL 1.32 Option (C) is correct.



We know that in S-N curve the failure occurs at 10^6 cycles (at endurance strength)

We have to make the S-N curve from the given data, on the scale of $\log_{10}$.

Now equation of line whose end point co-ordinates are

$$(\log_{10}1000, \log_{10}490) \text{ and } (\log_{10}10^6, \log_{10}70)$$

or $(3, \log_{10}490)$ and $(6, \log_{10}70)$,

$$\frac{y - \log_{10}490}{x - 3} = \frac{\log_{10}70 - \log_{10}490}{6 - 3} \qquad \left(\frac{y - y_1}{x - x_1} = \frac{y_2 - y_1}{x_2 - x_1}\right)$$

$$\frac{y - 2.69}{x - 3} = \frac{1.845 - 2.69}{3}$$

$$y - 2.69 = -0.281(x - 3) \qquad \text{...(i)}$$

Given, the shaft is subject to an alternating stress of 100 MPa

So, $y = \log_{10}100 = 2$

Substitute this value in equation (i), we get

$$2 - 2.69 = -0.281(x - 3)$$

$$-0.69 = -0.281x + 0.843$$

$$x = \frac{-0.843 - 0.69}{-0.281} = 5.455$$

And $\log_{10} N = 5.455$

$$N = 10^{5.455} = 285101$$

The nearest shaft life is 281914 cycles.

MCQ 1.33 GATE ME 2006 TWO MARK

According to Von-Mises' distortion energy theory, the distortion energy under three dimensional stress state is represented by

(A) $\frac{1}{2E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\upsilon(\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$

(B) $\frac{1-2\upsilon}{6E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + 2(\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$

(C) $\frac{1+\upsilon}{3E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - (\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$

(D) $\frac{1}{3E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - \upsilon(\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$

SOL 1.33

Option (C) is correct.

According to "VON MISES - HENKY THEORY", the elastic failure of a material occurs when the distortion energy of the material reaches the distortion energy at the elastic limit in simple tension.

Shear strain energy due to the principle stresses σ_1, σ_2 and σ_3

$$\Delta E = \frac{1+\upsilon}{6E}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]$$

$$= \frac{1+\upsilon}{6E}[2(\sigma_1^2 + \sigma_2^2 + \sigma_3^2) - 2(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)]$$

$$= \frac{1+\upsilon}{3E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - (\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_1\sigma_3)]$$

MCQ 1.34 GATE ME 2006 TWO MARK

A steel bar of 40 mm × 40 mm square cross-section is subjected to an axial compressive load of 200 kN. If the length of the bar is 2 m and $E = 200$ GPa, the elongation of the bar will be

(A) 1.25 mm (B) 2.70 mm

(C) 4.05 mm (D) 5.40 mm

SOL 1.34

Option (A) is correct.

Given : $A = (40)^2 = 1600\text{ mm}^2$, $P = -200\text{ kN}$ (Compressive)

$L = 2\text{ m} = 2000\text{ mm}$, $E = 200\text{ GPa} = 200 \times 10^3\text{ N/mm}^2$

Elongation of the bar,

$$\Delta L = \frac{PL}{AE} = \frac{-200 \times 10^3 \times 2000}{1600 \times 200 \times 10^3}$$

$$= -1.25\text{ mm} \quad \text{(Compressive)}$$

In magnitude, $\Delta L = 1.25\text{ mm}$

MCQ 1.35 GATE ME 2006 TWO MARK

If C_f is the coefficient of speed fluctuation of a flywheel then the ratio of $\omega_{max}/\omega_{min}$ will be

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

(C) $\frac{1+2C_f}{1-2C_f}$ (D) $\frac{2+C_f}{2-C_f}$

SOL 1.35 Option (D) is correct.

The ratio of the maximum fluctuation of speed to the mean speed is called the coefficient of fluctuation of speed (C_f).

Let, N_1 & N_2 = Maximum & Minimum speeds in r.p.m. during the cycle

$$N = \text{Mean speed in r.p.m.} = \frac{N_1+N_2}{2} \quad ...(i)$$

Therefore,
$$C_f = \frac{N_1-N_2}{N} = \frac{2(N_1-N_2)}{N_1+N_2} \quad \text{from equation (i)}$$

Or,
$$= \frac{\omega_1-\omega_2}{\omega} = \frac{2(\omega_1-\omega_2)}{\omega_1+\omega_2}$$

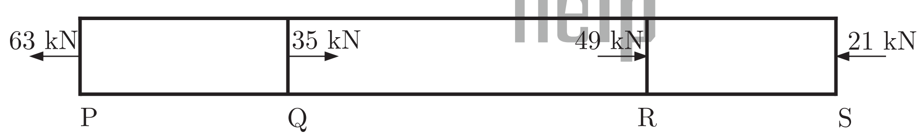
$$C_f = \frac{2(\omega_{max}-\omega_{min})}{\omega_{max}+\omega_{min}} \quad \omega_1 = \omega_{max}, \ \omega_2 = \omega_{min}$$

$$C_f\omega_{max} + C_f\omega_{min} = 2\omega_{max} - 2\omega_{min}$$
$$\omega_{max}(C_f-2) = \omega_{min}(-2-C_f)$$

Hence,
$$\frac{\omega_{max}}{\omega_{min}} = -\frac{(2+C_f)}{C_f-2} = \frac{2+C_f}{2-C_f}$$

MCQ 1.36 A bar having a cross-sectional area of 700 mm^2 is subjected to axial loads at the positions indicated. The value of stress in the segment QR is

GATE ME 2006
TWO MARK

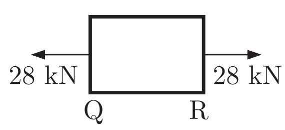


(A) 40 MPa (B) 50 MPa

(C) 70 MPa (D) 120 MPa

SOL 1.36 Option (A) is correct.

The FBD of segment QR is shown below :



FBD

Given : $A = 700\,mm^2$

From the free body diagram of the segment QR,

Force acting on QR, $P = 28\,kN$ (Tensile)

Stress in segment QR is given by,

$$\sigma = \frac{P}{\text{Area}} = \frac{28\times10^3}{700\times10^{-6}} = 40\,\text{MPa}$$

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TWO MARK

If a system is in equilibrium and the position of the system depends upon many independent variables, the principles of virtual work states that the partial derivatives of its total potential energy with respect to each of the independent variable must be

(A) -1.0 (B) 0

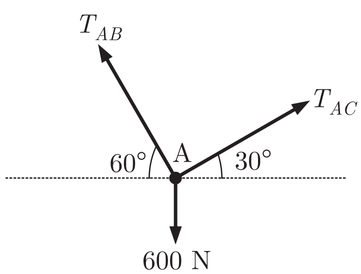
(C) 1.0 (D) ∞

SOL 1.37 Option (B) is correct.

If a system of forces acting on a body or system of bodies be in equilibrium and the system has to undergo a small displacement consistent with the geometrical conditions, then the algebraic sum of the virtual works done by all the forces of the system is zero and total potential energy with respect to each of the independent variable must be equal to zero.

MCQ 1.38 If point A is in equilibrium under the action of the applied forces, the values of tensions T_{AB} and T_{AC} are respectively

GATE ME 2006
TWO MARK



(A) 520 N and 300 N (B) 300 N and 520 N

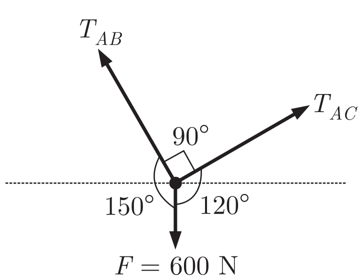
(C) 450 N and 150 N (D) 150 N and 450 N

SOL 1.38 Option (A) is correct.

We solve this problem from two ways.

From Lami's theorem

Here three forces are given. Now we have to find the angle between these forces



Applying Lami's theorem, we have

$$\frac{F}{\sin 90^\circ} = \frac{T_{AB}}{\sin 120^\circ} = \frac{T_{AC}}{\sin 150^\circ}$$

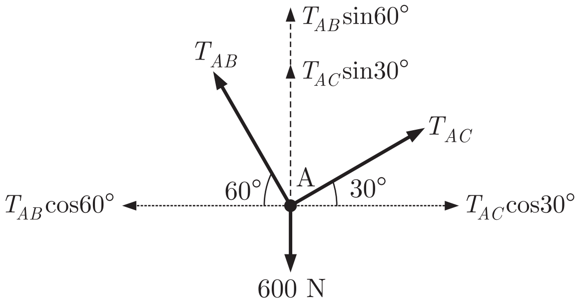
$$\frac{600}{1} = \frac{T_{AB}}{\sqrt{3}/2} = \frac{T_{AC}}{1/2}$$

$$T_{AB} = 600 \times \frac{\sqrt{3}}{2} = 300\sqrt{3} \approx 520 \text{ N}$$

$$T_{AC} = \frac{600}{2} = 300 \text{ N}$$

Alternate :

Now we using the Resolution of forces.



Resolve the T_{AB} & T_{AC} in x & y direction (horizontal & vertical components)

We use the Resolution of forces in x & y direction

$\Sigma F_x = 0,$ $\quad T_{AB}\cos 60^\circ = T_{AC}\cos 30^\circ$

$$\frac{T_{AB}}{T_{AC}} = \frac{\sqrt{3}}{2} \times \frac{2}{1} = \sqrt{3} \qquad \text{...(i)}$$

$\Sigma F_y = 0, \quad T_{AB}\sin 60^\circ + T_{AC}\sin 30^\circ = 600 \text{ N}$

$$\frac{\sqrt{3}}{2} T_{AB} + \frac{1}{2} T_{AC} = 600 \text{ N}$$

$$\sqrt{3}\, T_{AB} + T_{AC} = 1200 \text{ N} \qquad T_{AC} = \frac{T_{AB}}{\sqrt{3}} \text{ From equation (i)}$$

Now, $$\sqrt{3}\, T_{AB} + \frac{T_{AB}}{\sqrt{3}} = 1200 \text{ N}$$

$$4\,T_{AB} = 1200\sqrt{3}$$

$$T_{AB} = \frac{1200\sqrt{3}}{4} = 520 \text{ N}$$

and $$T_{AC} = \frac{T_{AB}}{\sqrt{3}} = \frac{520}{\sqrt{3}} = 300 \text{ N}$$

MCQ 1.39 Match the items in columns I and II

GATE ME 2006 TWO MARK

	Column I		ColumnII
P.	Higher Kinematic Pair	**1.**	Grubler's Equation
Q.	Lower Kinemation Pair	**2.**	Line contact
R.	Quick Return Mechanism	**3.**	Euler's Equation
S.	Mobility of a Linkage	**4.**	Planar
		5.	Shaper

6. Surface contact

(A) P-2, Q-6, R-4, S-3 (B) P-6, Q-2, R-4, S-1

(C) P-6, Q-2, R-5, S-3 (D) P-2, Q-6, R-5, S-1

SOL 1.39 Option (D) is correct.

In this question pair or mechanism is related to contact & machine related to it.

	Column I		Column II
P.	Higher Kinematic Pair	**2.**	Line Contact
Q.	Lower Kinematic Pair	**6.**	Surface Contact
R.	Quick Return Mechanism	**5.**	Shaper
S.	Mobility of a Linkage	**1.**	Grubler's Equation

So correct pairs are, P-2, Q-6, R-5, S-1

MCQ 1.40 A machine of 250 kg mass is supported on springs of total stiffness 100 kN/m. Machine has an unbalanced rotating force of 350 N at speed of 3600 rpm. Assuming a damping factor of 0.15, the value of transmissibility ratio is

GATE ME 2006 TWO MARK

(A) 0.0531 (B) 0.9922

(C) 0.0162 (D) 0.0028

SOL 1.40 Option (C) is correct.

Given $m = 250\,\text{kg}$, $k = 100\,\text{kN/m}$, $N = 3600\,\text{rpm}$, $\varepsilon = \frac{c}{c_c} = 0.15$

$$\omega = \frac{2\pi N}{60}$$

$$= \frac{2 \times 3.14 \times 3600}{60} = 376.8\,\text{rad/sec}$$

Natural frequency of spring mass system,

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{100 \times 1000}{250}} = 20\,\text{rad/sec}$$

So,
$$\frac{\omega}{\omega_n} = \frac{376.8}{20} = 18.84$$

$$T.R. = \frac{F_T}{F} = \sqrt{\frac{1 + \left(2\varepsilon\frac{\omega}{\omega_n}\right)^2}{\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left[2\varepsilon\frac{\omega}{\omega_n}\right]^2}}$$

$$T.R. = \sqrt{\frac{1 + (2 \times 0.15 \times 18.84)^2}{[1 - (18.84)^2]^2 + [2 \times 0.15 \times 18.84]^2}}$$

$$= \sqrt{\frac{1 + 31.945}{[1 - 354.945]^2 + 31.945}} = \sqrt{\frac{32.945}{125309}} = 0.0162$$

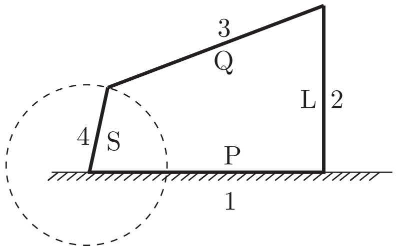
MCQ 1.41 In a four-bar linkage, S denotes the shortest link length, L is the longest link length, P and Q are the lengths of other two links. At least one of the three moving links will rotate by 360° if

GATE ME 2006 TWO MARK

(A) $S+L \le P+Q$ (B) $S+L > P+Q$

(C) $S+P \le L+Q$ (D) $S+P > L+Q$

SOL 1.41 Option (A) is correct.



Here P, Q, R, & S are the lengths of the links.

According to Grashof's law : "For a four bar mechanism, the sum of the shortest and longest link lengths should not be greater than the sum of remaining two link lengths, if there is to be continuous relative motion between the two links

$$S+L \leqslant P+Q$$

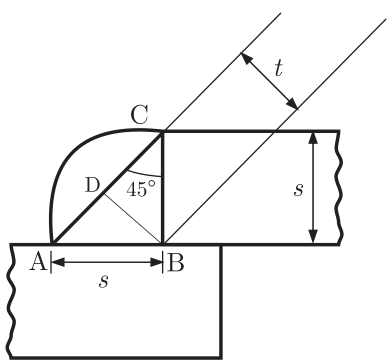
MCQ 1.42 GATE ME 2006 TWO MARK

A 60 mm long and 6 mm thick fillet weld carries a steady load of 15 kN along the weld. The shear strength of the weld material is equal to 200 MPa. The factor of safety is

(A) 2.4 (B) 3.4

(C) 4.8 (D) 6.8

SOL 1.42 Option (B) is correct.



Given : $l = 60\text{ mm} = 0.06\text{ m}$, $s = 6\text{ mm} = 0.006\text{ m}$, $P = 15\text{ kN} = 15 \times 10^3\text{ N}$

Shear strength $= 200\text{ MPa}$

We know that, if τ is the allowable shear stress for the weld metal, then the shear strength of the joint for single parallel fillet weld,

$$P = \text{Throat Area} \times \text{Allowable shear stress} = t \times l \times \tau$$

$$P = 0.707s \times l \times \tau \qquad t = s\sin 45^\circ = 0.707s$$

$$\tau = \frac{P}{0.707 \times s \times l}$$

$$= \frac{15 \times 10^3}{0.707 \times 0.006 \times 0.06} = 58.93 \text{ MPa}$$

Factor of Safety, $FOS = \frac{\text{Shear strength}}{\text{Allowable shear stress}}$

$$= \frac{200 \text{ MPa}}{58.93 \text{ MPa}} = 3.39 \simeq 3.4$$

MCQ 1.43 GATE ME 2006 TWO MARK

A two-dimensional flow field has velocities along the x and y directions given by $u = x^2 t$ and $v = -2xyt$ respectively, where t is time. The equation of stream line is

(A) $x^2 y =$ constant (B) $xy^2 =$ constant

(C) $xy =$ constant (D) not possible to determine

SOL 1.43 Option (D) is correct.

Given : $u = x^2 t$, $v = -2xyt$

The velocity component in terms of stream function are

$$\frac{\partial \psi}{\partial x} = v = -2xyt \quad \text{...(i)}$$

$$\frac{\partial \psi}{\partial y} = -u = -x^2 t \quad \text{...(ii)}$$

Integrating equation (i), w.r.t 'x', we get

$$\psi = \int (-2xyt)\, dx$$

$$= -x^2 yt + K \quad \text{...(iii)}$$

Where, K is a constant of integration which is independent of 'x' but can be a function of 'y'

Differentiate equation (iii) w.r.t y, we get

$$\frac{\partial \psi}{\partial y} = -x^2 t + \frac{\partial K}{\partial y}$$

But from equation (ii),

$$\frac{\partial \psi}{\partial y} = -x^2 t$$

Comparing the value of $\frac{\partial \psi}{\partial y}$, we get

$$-x^2 t + \frac{\partial K}{\partial y} = -x^2 t$$

$$\frac{\partial K}{\partial y} = 0$$

$$K = \text{Constant}(K_1)$$

From equation (iii)

$$\psi = -x^2 yt + K_1$$

The line for which stream function ψ is zero called as stream line.

So, $-x^2 yt + K_1 = 0$

$$K_1 = x^2 yt$$

If 't' is constant then equation of stream line is,

$$x^2 y = \frac{K_1}{t} = K_2$$

But in the question, there is no condition for t is constant. Hence, it is not possible to determine equation of stream line.

MCQ 1.44 GATE ME 2006 TWO MARK

The velocity profile in fully developed laminar flow in a pipe of diameter D is given by $u = u_0(1 - 4r^2/D^2)$, where r is the radial distance from the center. If the viscosity of the fluid is μ, the pressure drop across a length L of the pipe is

(A) $\frac{\mu u_0 L}{D^2}$ (B) $\frac{4\mu u_0 L}{D^2}$

(C) $\frac{8\mu u_0 L}{D^2}$ (D) $\frac{16\mu u_0 L}{D^2}$

SOL 1.44 Option (D) is correct.

Given : $$u = u_o\left(1 - \frac{4r^2}{D^2}\right) = u_o\left(1 - \frac{r^2}{R^2}\right)$$

Drop of pressure for a given length (L) of a pipe is given by,

$$\Delta p = p_1 - p_2 = \frac{32\mu\bar{u}L}{D^2} \quad ..(i)$$

(From the Hagen poiseuille formula)

Where $\bar{u}$ = average velocity

And
$$\bar{u} = \frac{2}{R^2}\int_0^R u(r)\,rdr$$
$$= \frac{2}{R^2}\int_0^R u_o\left(1 - \frac{r^2}{R^2}\right) rdr$$
$$= \frac{2u_o}{R^2}\int_0^R \left(r - \frac{r^3}{R^2}\right) dr$$
$$= \frac{2u_o}{R^2}\left[\frac{r^2}{2} - \frac{r^4}{4R^2}\right]_0^R$$
$$= \frac{2u_o}{R^2}\left[\frac{R^2}{2} - \frac{R^4}{4R^2}\right]_0^R$$
$$= \frac{2u_o}{R^2}\left[\frac{R^2}{4}\right]$$
$$\overline{u} = \frac{u_o}{2}$$

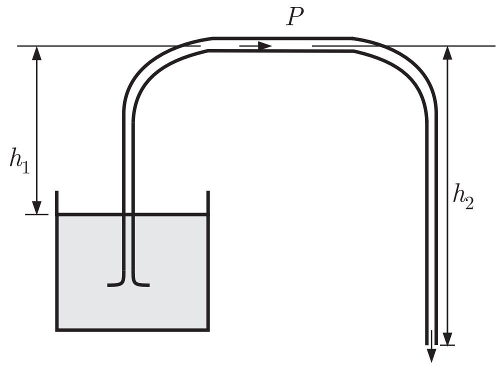
Substitute the value of $\overline{u}$ in equation(1)

So, $$\Delta p = \frac{32\mu L}{D^2} \times \frac{u_o}{2} = \frac{16\mu u_o L}{D^2}$$

Note : The average velocity in fully developed laminar pipe flow is one-half of the maximum velocity.

MCQ 1.45 GATE ME 2006 TWO MARK

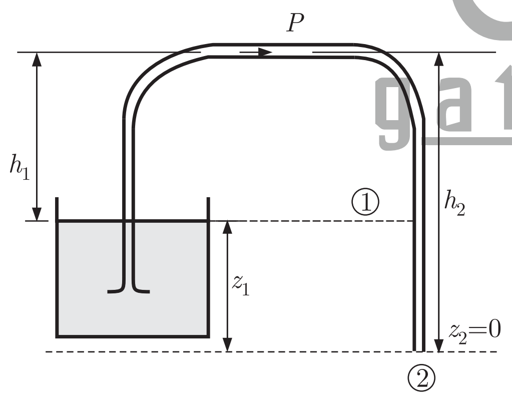
A siphon draws water from a reservoir and discharge it out at atmospheric pressure. Assuming ideal fluid and the reservoir is large, the velocity at point P in the siphon tube is



(A) $\sqrt{2gh_1}$ (B) $\sqrt{2gh_2}$

(C) $\sqrt{2g(h_2-h_1)}$ (D) $\sqrt{2g(h_2+h_1)}$

SOL 1.45 Option (C) is correct.



In a steady & ideal flow of incompressible fluid, the total energy at any point of the fluid is constant. So applying the Bernoulli's Equation at section (1) and (2)

$$\frac{p_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{p_2}{\rho g}+\frac{V_2^2}{2g}+Z_2$$

$V_1 = 0=$ Initial velocity at point (1)

$Z_2 = 0=$ At the bottom surface

$p_1 = p_2 = p_{atm}$

And $z_1 = h_2 - h_1$

So, $$h_2-h_1=\frac{V_2^2}{2g}$$

$$V_2^2 = 2g(h_2-h_1)$$

$$V_2=\sqrt{2g(h_2-h_1)}$$

So, velocity of fluid is same inside the tube

$$V_p = V_2 = \sqrt{2g(h_2-h_1)}$$

MCQ 1.46 GATE ME 2006 TWO MARK

A large hydraulic turbine is to generate 300 kW at 1000 rpm under a head of 40 m. For initial testing, a 1 : 4 scale model of the turbine operates under a head of 10 m . The power generated by the model (in kW) will be

(A) 2.34 (B) 4.68

(C) 9.38 (D) 18.75

SOL 1.46 Option (A) is correct.

Given : $P_1 = 300\,\text{kW},\ N_1 = 1000\,\text{rpm},\ H_1 = 40\,\text{m}$

$$\frac{d_2}{d_1} = \frac{1}{4},\ H_2 = 10\,\text{m}$$

Specific power for similar turbine is same. So from the relation, we have

$$\frac{P}{d^2 H^{3/2}} = \text{Constant}$$

For both the cases,

$$\frac{P_1}{d_1^2 H_1^{3/2}} = \frac{P_2}{d_2^2 H_2^{3/2}}$$

$$P_2 = \left(\frac{d_2}{d_1}\right)^2 \left(\frac{H_2}{H_1}\right)^{3/2} \times P_1 = \left(\frac{1}{4}\right)^2 \left(\frac{10}{40}\right)^{3/2} \times 300 = 2.34$$

MCQ 1.47 GATE ME 2006 TWO MARK

The statements concern psychrometric chart.

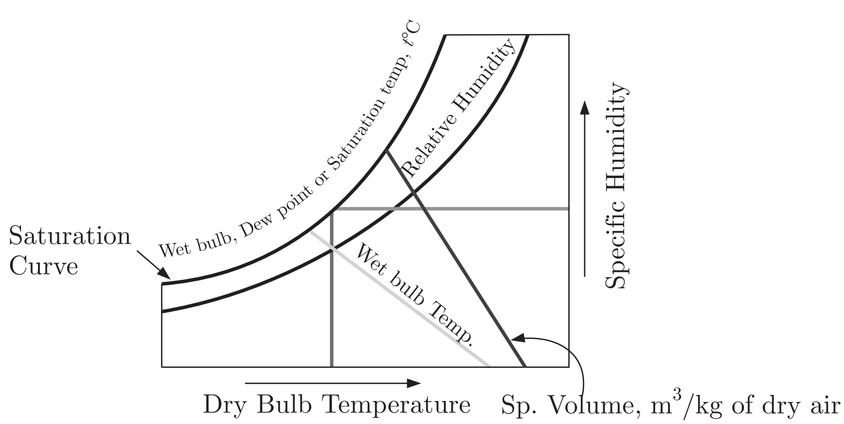
1. Constant relative humidity lines are uphill straight lines to the right
2. Constant wet bulb temperature lines are downhill straight lines to the right
3. Constant specific volume lines are downhill straight lines to the right
4. Constant enthalpy lines are coincident with constant wet bulb temperature lines

Which of the statements are correct ?

(A) 2 and 3 (B) 1 and 2

(C) 1 and 3 (D) 2 and 4

SOL 1.47 Option (A) is correct.



Hence, the statement 2 & 3 are correct.

MCQ 1.48 GATE ME 2006 TWO MARK

A 100 W electric bulb was switched on in a $2.5\,\text{m} \times 3\,\text{m} \times 3\,\text{m}$ size thermally insulated room having a temperature of 20°C. The room temperature at the end of 24 hours will be

(A) 321°C (B) 341°C

(C) 450°C (D) 470°C

SOL 1.48 Option (D) is correct.

Given : $P = 100\,\text{W},\ \nu = 2.5 \times 3 \times 3 = 22.5\,\text{m}^3,\ T_i = 20^\circ\,\text{C}$

Now Heat generated by the bulb in 24 hours,

$$Q = 100 \times 24 \times 60 \times 60 = 8.64\,\text{MJ} \qquad ...(i)$$

Volume of the room remains constant.

Heat dissipated, $Q = mc_v\,dT = \rho\nu c_v(T_f - T_i)$ $\qquad m = \rho v$

Where, T_f = Final temperature of room

ρ = Density of air = $1.2\,\text{kg/m}^3$

c_v of air = $0.717\,\text{kJ/kg K}$

Substitute the value of Q from equation (i), we get

$$8640000 = 1.2 \times 22.5 \times 0.717 \times 10^3(T_f - 20)$$
$$8640 = 1.2 \times 22.5 \times 0.717(T_f - 20)$$
$$(T_f - 20) = 446.30$$
$$T_f = 446.30 + 20 = 466.30^\circ\,\text{C} \simeq 470^\circ\,\text{C}$$

MCQ 1.49 GATE ME 2006 TWO MARK

A thin layer of water in a field is formed after a farmer has watered it. The ambient air conditions are : temperature 20°C and relative humidity 5%. An extract of steam tables is given below.

Temp($^\circ$C)	-15	-10	-5	0.01	5	10	15	20
Saturation Pressure (kPa)	0.10	0.26	0.40	0.61	0.87	1.23	1.71	2.34

Neglecting the heat transfer between the water and the ground, the water temperature in the field after phase equilibrium is reached equals

(A) 10.3°C (B) $-10.3^\circ\,\text{C}$

(C) $-14.5^\circ\,\text{C}$ (D) $14.5^\circ\,\text{C}$

SOL 1.49 Option (C) is correct.

Given : Relation humidity= 5% at temperature $20^\circ\,\text{C}$

Relative humidity, $\phi = \dfrac{\text{Actual mass of water vapour in a given volume of moist air}}{\text{mass of water vapour in the same volume of saturated air at same temperature \& pressure}}$

$$\phi = \frac{m_v}{m_s} = \frac{p_v}{p_s} = 0.05 \qquad ...(i)$$

Where, p_v = Partial pressure of vapor at $20^\circ\,\text{C}$

From given table at $T = 20^\circ\text{C},\ p_s = 2.34\,\text{kPa}$

From equation (i),

$$p_v = 0.05 \times p_s = 0.05 \times 2.34 = 0.117 \text{ kPa}$$

Phase equilibrium means, $p_s = p_v$

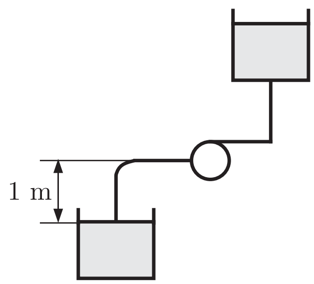
The temperature at which p_v becomes saturated pressure can be found by interpolation of values from table, for $p_s = 0.10$ to $p_s = 0.26$

$$T = -15 + \left[\frac{-10-(-15)}{0.26-0.10}\right](0.117-0.10)$$

$$= -15 + \frac{5}{0.16} \times 0.017 = -14.47 \simeq -14.5^\circ \text{C}$$

MCQ 1.50 GATE ME 2006 TWO MARK

A horizontal-shaft centrifugal pump lifts water at 65°C. The suction nozzle is one meter below pump center line. The pressure at this point equals 200 kPa gauge and velocity is 3 m/s. Steam tables show saturation pressure at 65°C is 25 kPa, and specific volume of the saturated liquid is 0.001020 m^3/kg. The pump Net Positive Suction Head (NPSH) in meters is



(A) 24 (B) 26

(C) 28 (D) 30

SOL 1.50

Option (A) is correct.

Net positive suction head, (NPSH)= Pressure head + static head

Pressure difference, $\Delta p = 200 - (-25) = 225 \text{ kPa}$

(Negative sign shows that the pressure acts on liquid in opposite direction)

$$\Delta p = 225 \times 10^3 \text{ Pa} = 2.25 \text{ bar}$$

$$= \frac{2.25 \times 10.33}{1.013} \text{ m} = 22.95 \text{ m of water}$$

Static head = 1 m (Given)

Now, NPSH = 22.95 + 1 = 23.95 ≃ 24 m of water

MCQ 1.51 GATE ME 2006 TWO MARK

Given below is an extract from steam tables.

Temperature in °C	p_{sat} (Bar)	Specific volume m^3/kg		Enthalpy (kJ/ kg)	
		Saturated Liquid	Saturated vapour	Saturated liquid	Saturated vapour
45	0.09593	0.001010	15.26	188.45	2394.8
342.24	150	0.001658	0.010337	1610.5	2610.5

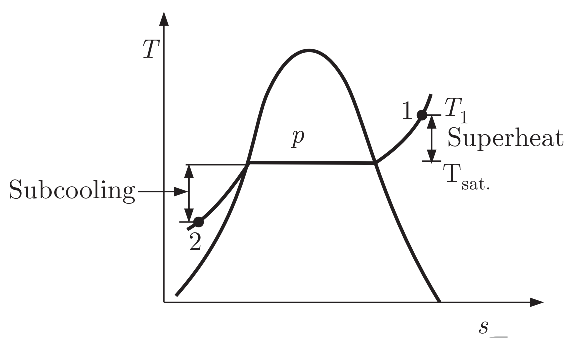
Specific enthalpy of water in kJ/kg at 150 bar and 45°C is

(A) 203.60 (B) 200.53

(C) 196.38 (D) 188.45

SOL 1.51 Option (D) is correct.

When the temperature of a liquid is less than the saturation temperature at the given pressure, the liquid is called compressed liquid (state 2 in figure).



The pressure & temperature of compressed liquid may vary independently and a table of properties like the superheated vapor table could be arranged, to give the properties at any p & T.

The properties of liquids vary little with pressure. Hence, the properties are taken from the saturation table at the temperature of the compressed liquid.

So, from the given table at $T = 45^\circ$ C, Specific enthalpy of water $= 188.45\,\text{kJ/kg}$.

MCQ 1.52 Determine the correctness or otherwise **Assertion (A)** and the **Reason (R)**

GATE ME 2006 TWO MARK

Assertion (A) : In a power plant working on a Rankine cycle, the regenerative feed water heating improves the efficiency of the steam turbine.

Reason (R) : The regenerative feed water heating raises the average temperature of heat addition in the Rankine cycle.

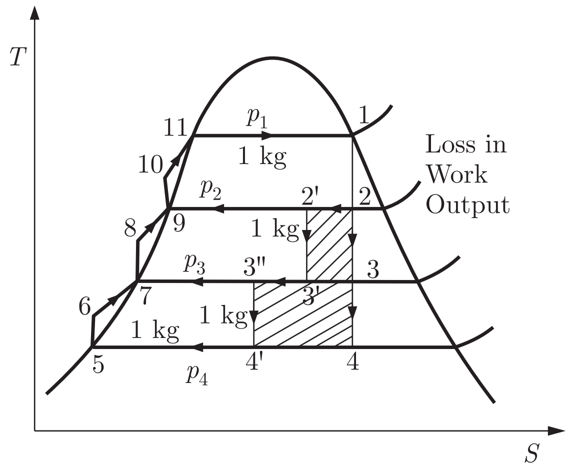
(A) Both (A) and (R) are true and (R) is the correct reason for (A)

(B) Both (A) and (R) are true but (R) is NOT the correct reason for (A)

(C) Both (A) and (R) are false

(D) (A) is false but (R) is true

SOL 1.52 Option (A) is correct.



The thermal efficiency of a power plant cycle increases by increase the average temperature at which heat is transferred to the working fluid in the boiler or decrease the average temperature at which heat is rejected from the working fluid in the condenser. Heat is transferred to the working fluid with the help of the feed water heater.

So, (A) and (R) are true and (R) is the correct reason of (A).

MCQ 1.53 GATE ME 2006 TWO MARK

Determine the correctness or otherwise of the following **Assertion (A)** and the **Reason (R)**.

Assertion (A) : Condenser is an essential equipment in a steam power plant.

Reason (R) : For the same mass flow rate and the same pressure rise, a water pump requires substantially less power than a steam compressor.

(A) Both (A) and (R) are true and (R) is the correct reason for (A)

(B) Both (A) and (R) are true and (R) is NOT the correct reason for (A)

(C) Both (A) and (R) are false

(D) (A) is false but (R) is true

SOL 1.53 Option (D) is correct.

(A) Condenser is an essential equipment in a steam power plant because when steam expands in the turbine & leaves the turbine in the form of super saturated steam. It is not economical to feed this steam directly to the boiler.

So, condenser is used to condensed the steam into water.

And condenser is a essential part (equipment) in steam power plant.

Assertion (A) is correct.

(R) The compressor and pumps require power input. The compressor is capable of compressing the gas to very high pressures. Pump work very much like compressor except that they handle liquid instead of gases. Now for same mass flow rate and the same pressure rise, a water pump require very less power because the specific volume of liquid is very less as compare to specific volume of vapour.

MCQ 1.54 Match items from groups I, II, III, IV and V.

GATE ME 2006 TWO MARK

Group I	Group II	Group III	Group IV	Group V
	When added to the system is	Differential	Function	Phenomenon
E Heat	G Positive	I Exact	K Path	M Transient
F Work	H Negative	J Inexact	L Point	N Boundary

(A) F-G-J-K-M
E-G-I-K-N

(B) E-G-I-K-M
F-H-I-K-N

(C) F-H-J-L-N
E-H-I-L-M

(D) E-G-J-K-N
F-H-J-K-M

SOL 1.54 Option (D) is correct

Group (I)	Group (II)	Group (III)	Group (IV)	Group (V)
	When added to the system	**Differential**	**Function**	**Phenomenon**
E	G	J	K	N
F	H	J	K	M

So correct pairs are
E-G-J-K-N and F-H-J-K-M

MCQ 1.55 Group I shows different heat addition process in power cycles. Likewise, Group II shows different heat removal processes. Group III lists power cycles. Match items from Groups I, II and III.

GATE ME 2006 TWO MARK

Group I	Group II	Group III
P. Pressure constant	S. Pressure constant	1. Rankine Cycle
Q. Volume Constant	T. Volume Constant	2. Otto cycle
R. Temperature constant	U. Temperature Constant	3. Carnot cycle
		4. Diesel cycle
		5. Brayton cycle

(A) P-S-5
R-U-3
P-S-1
Q-T-2

(B) P-S-1
R-U-3
P-S-4
P-T-2

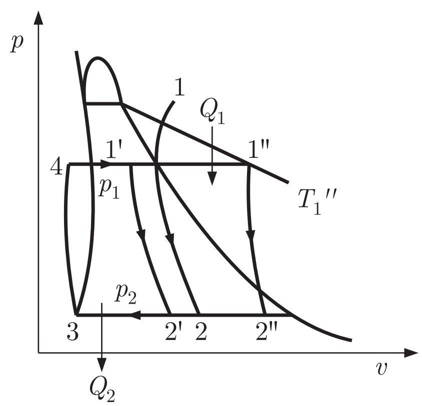
(C) R-T-3
P-S-1
P-T-4
Q-S-5

(D) P-T-4
R-S-3
P-S-1
P-S-5

SOL 1.55 Option (A) is correct.

We draw p - v diagram for the cycles.

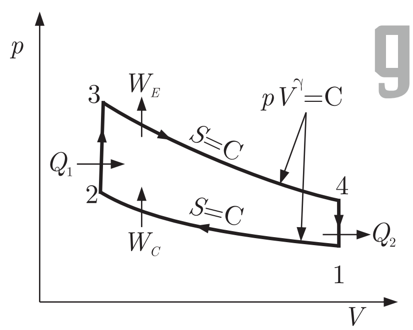
(a) Rankine cycle



Constant Pressure Process

Q_1 = Heat addition at constant p and Q_2 = Heat Rejection at constant p

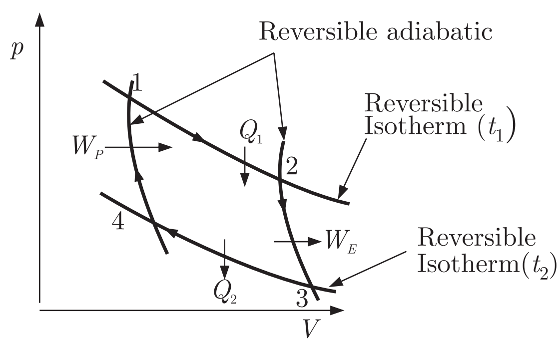
(b) Otto cycle



Constant Volume Process

Q_1 = Heat addition at constant ν and Q_2 = Heat Rejection at constant ν

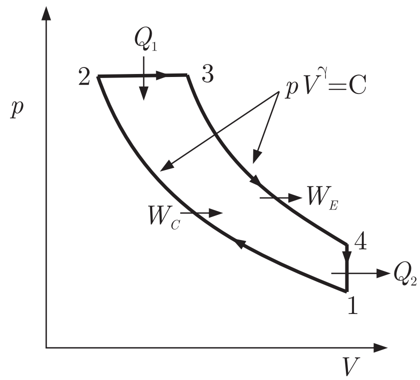
(c) Carnot cycle



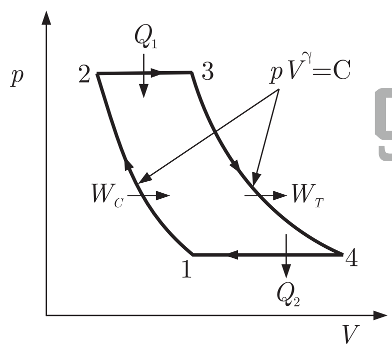
Constant Temperature Process (Isothermal)

$Q_1 =$ Heat addition at constant T and $Q_2 =$ Heat Rejection at constant T

(d) Diesel cycle



Constant Pressure & constant volume process
$Q_1 =$ Heat addition at constant p and $Q_2 =$ Heat rejection at constant V
(e) Brayton cycle



Constant pressure Process
$Q_1 =$ Heat addition at constant p and $Q_2 =$ Heat rejection at constant p
From the Five cycles, we see that $P-S-5, R-U-3, P-S-1, Q-T-2$ are the correct pairs.

MCQ 1.56 GATE ME 2006 TWO MARK

With an increase in the thickness of insulation around a circular pipe, heat loss to surrounding due to

(A) convection increase, while that the due to conduction decreases

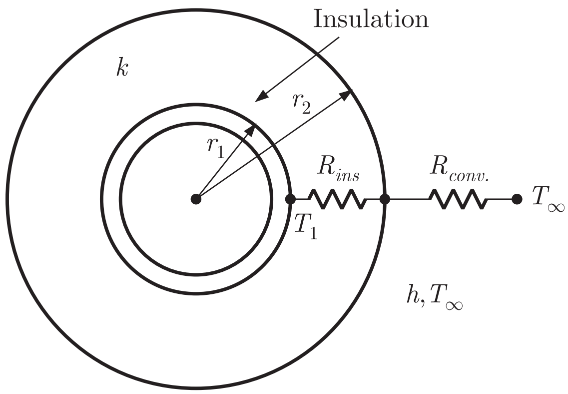
(B) convection decrease, while that due to conduction increases

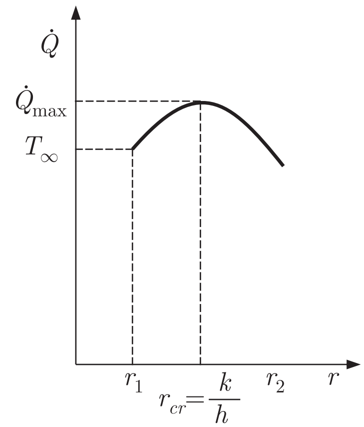
(C) convection and conduction decreases

(D) convection and conduction increases

SOL 1.56 Option (B) is correct.

The variation of heat transfer with the outer radius of the insulation r_2, when $r_1 < r_{cr}$





The rate of heat transfer from the insulated pipe to the surrounding air can be expressed as

$$\dot{Q} = \frac{T_1 - T_\infty}{R_{ins} + R_{conv.}} = \frac{T_1 - T_\infty}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi Lk} + \frac{1}{h(2\pi r_2 L)}}$$

The value of r_2 at which $\dot{Q}$ reaches a maximum is determined from the requirement that $\frac{d\dot{Q}}{dr_2} = 0$. By solving this we get,

$$r_{cr,pipe} = \frac{k}{h} \qquad \text{...(i)}$$

From equation (i), we easily see that by increasing the thickness of insulation, the value of thermal conductivity increases and heat loss by the conduction also increases.
But by increasing the thickness of insulation, the convection heat transfer co-efficient decreases and heat loss by the convection also decreases. These both cases are limited for the critical thickness of insulation.

MCQ 1.57 GATE ME 2006 TWO MARK

The ultimate tensile strength of a material is 400 MPa and the elongation up to maximum load is 35%. If the material obeys power law of hardening, then the true stress-true strain relation (stress in MPa) in the plastic deformation range is

(A) $\sigma = 540\varepsilon^{0.30}$
(B) $\sigma = 775\varepsilon^{0.30}$
(C) $\sigma = 540\varepsilon^{0.35}$
(D) $\sigma = 775\varepsilon^{0.35}$

SOL 1.57 Option (B) is correct.

Given : $\sigma_u = 400\,\text{MPa}, \ \frac{\Delta L}{L} = 35\% = 0.35 = \varepsilon_0$

Let, true stress is σ and true strain is ε.

True strain, $\varepsilon = \ln(1+\varepsilon_0) = \ln(1+0.35) = 0.30$

True stress, $\sigma = \sigma_u(1+\varepsilon_0) = 400(1+0.35) = 540\,\text{MPa}$

We know, at Ultimate tensile strength,

$$n = \varepsilon = 0.3$$

Relation between true stress and true strain is given by,

$$\sigma = K\varepsilon^n \quad ...(i)$$

$$K = \frac{\sigma}{\varepsilon^n} = \frac{540}{(0.30)^{0.30}} = 774.92 \simeq 775$$

So, From equation (i) $\sigma = 775\varepsilon^{0.3}$

MCQ 1.58 GATE ME 2006 TWO MARK

In a sand casting operation, the total liquid head is maintained constant such that it is equal to the mould height. The time taken to fill the mould with a top gate is t_A. If the same mould is filled with a bottom gate, then the time taken is t_B. Ignore the time required to fill the runner and frictional effects. Assume atmospheric pressure at the top molten metal surfaces. The relation between t_A and t_B is

(A) $t_B = \sqrt{2}\, t_A$

(B) $t_B = 2t_A$

(C) $t_B = \frac{t_A}{\sqrt{2}}$

(D) $t_B = 2\sqrt{2}\, t_A$

SOL 1.58 Option (B) is correct.

We know that,Time taken to fill the mould with top gate is given by,

$$t_A = \frac{A_m H_m}{A_g\sqrt{2gH_g}}$$

Where
A_m = Area of mould
H_m = Height of mould
A_g = Area of gate
H_g = Height of gate

Given that, total liquid head is maintained constant and it is equal to the mould height.

So, $H_m = H_g$

$$t_A = \frac{A_m\sqrt{H_m}}{A_g\sqrt{2g}} \quad ...(i)$$

Time taken to fill with the bottom gate is given by,

$$t_B = \frac{2A_m}{A_g\sqrt{2g}} \times (\sqrt{H_g} - \sqrt{H_g - H_m})$$

$$t_B = \frac{2A_m}{A_g\sqrt{2g}} \times \sqrt{H_m} \qquad H_m = H_g \quad ...(ii)$$

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

$$\frac{t_B}{t_A} = 2$$

$$t_B = 2t_A$$

MCQ 1.59 GATE ME 2006 TWO MARK

A 4 mm thick sheet is rolled with 300 mm diameter roll to reduce thickness without any change in its width. The friction coefficient at the work-roll interface is 0.1. The minimum possible thickness of the sheet that can be produced in a single pass is

(A) 1.0 mm

(B) 1.5 mm

(C) 2.5 mm

(D) 3.7 mm

SOL 1.59 Option (C) is correct.

Given : $t_i = 4\text{ mm}$, $D = 300\text{ mm}$, $\mu = 0.1$, $t_f = ?$

We know that,

For single pass without slipping, minimum possible thickness is given by the relation.

$$(t_i - t_f) = \mu^2 R$$

$$t_f = t_i - \mu^2 R$$

$$t_f = 4 - (0.1)^2 \times 150 = 2.5\text{ mm}$$

MCQ 1.60 GATE ME 2006 TWO MARK

In a wire drawing operation, diameter of a steel wire is reduced from 10 mm to 8 mm. The mean flow stress of the material is 400 MPa. The ideal force required for drawing (ignoring friction and redundant work) is

(A) 4.48 kN (B) 8.97 kN

(C) 20.11 kN (D) 31.41 kN

SOL 1.60 Option (B) is correct.

Given, $d_i = 10\text{ mm}$, $d_f = 8\text{ mm}$, $\sigma_0 = 400\text{ MPa}$

The expression for the drawing force under frictionless condition is given by

$$F = \sigma_{mean} A_f \ln\left(\frac{A_i}{A_f}\right)$$

$$= 400 \times 10^6 \times \frac{\pi}{4} \times (0.008)^2 \ln\left[\frac{\frac{\pi}{4}(0.001)^2}{\frac{\pi}{4}(0.008)^2}\right]$$

$$= 20096 \times \ln(1.5625)$$

$$= 8.968\text{ kN} \simeq 8.97\text{ kN}$$

MCQ 1.61 GATE ME 2006 TWO MARK

Match the item in columns I and II

	Column I		Column II
P.	Wrinkling	**1.**	Yield point elongation
Q.	Orange peel	**2.**	Anisotropy
R.	Stretcher strains	**3.**	Large grain size
S.	Earing	**4.**	Insufficient blank holding force
		5.	Fine grain size
		6.	Excessive blank holding force

(A) P-6, Q-3, R-1, S-2

(B) P-4, Q-5, R-6, S-1

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

(D) P-4, Q-3, R-1, S-2

SOL 1.61 Option (D) is correct.

Column I	Column II

P.	Wrinkling	**4.**	Insufficient blank holding force
Q.	Orange peel	**3.**	Large grain size
R.	Stretcher strains	**1.**	Yield point elongation
S.	Earing	**2.**	Anisotropy

So correct pairs are, P-4, Q-3, R-1, S-2

MCQ 1.62 GATE ME 2006 TWO MARK

In an arc welding process, the voltage and current are 25 V and 300 A respectively. The arc heat transfer efficiency is 0.85 and welding speed is 8 mm/sec. The net heat input (in J/mm) is

(A) 64 (B) 797

(C) 1103 (D) 79700

SOL 1.62

Option (B) is correct.

Given, $V = 25\text{ Volt}, \quad I = 300\text{ A}, \quad \eta = 0.85, \quad V = 8\text{ mm/sec}$

We know that the power input by the heat source is given by,

$$\text{Voltage} = 25\text{ Volt}$$

$$P = \text{Voltage} \times I$$

Heat input into the work piece $= P \times$ efficiency of heat transfer

$$H_i = \text{Voltage} \times I \times \eta = 25 \times 300 \times 0.85 = 6375\text{ J/sec}$$

$$\text{Heat energy input (J/mm)} = \frac{H_i}{V}$$

$$H_i(\text{J/mm}) = \frac{6375}{8} = 796.9 \simeq 797\text{ J/mm}$$

MCQ 1.63 GATE ME 2006 TWO MARK

If each abrasive grain is viewed as a cutting tool, then which of the following represents the cutting parameters in common grinding operations ?

(A) Large negative rake angle, low shear angle and high cutting speed

(B) Large positive rake angle, low shear angle and high cutting speed

(C) Large negative rake angle, high shear angle and low cutting speed

(D) Zero rake angle, high shear angle and high cutting speed

SOL 1.63

Option (A) is correct.

In common grinding operation, the average rake angle of the grains is highly negative, such as $-60°$ or even lower and smaller the shear angle. From this, grinding chips under go much larger deformation than they do in other cutting process. The cutting speeds are very high, typically 30 m/s

MCQ 1.64 GATE ME 2006 TWO MARK

Arrange the processes in the increasing order of their maximum material removal rate.

Electrochemical Machining (ECM)

Ultrasonic Machining (USM)

Electron Beam Machining (EBM)

Laser Beam Machining (LBM) and

Electric Discharge Machining (EDM)

(A) USM, LBM, EBM, EDM, ECM

(B) EBM, LBM, USM, ECM, EDM

(C) LBM, EBM, USM, ECM, EDM

(D) LBM, EBM, USM, EDM, ECM

SOL 1.64 Option (D) is correct.

	Process	**Metal Removal Rate(MRR)** (in mm^3/sec)
1.	LBM	0.10
2.	EBM	0.15
3.	USM	14.0
4.	EDM	14.10
5.	ECM	2700

So the processes which has maximum MRR in increasing order is,
LBM, EBM, USM, EDM, ECM

MCQ 1.65 Match the items in columns I and II.

GATE ME 2006 TWO MARK

	Column I		**Column II**
P.	Charpy test	**1.**	Fluidity
Q.	Knoop test	**2.**	Microhardness
R.	Spiral test	**3.**	Formability
S.	Cupping test	**4.**	Toughness
		5.	Permeability

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

(B) P-3, Q-5, R-1, S-4

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

(D) P-4, Q-2, R-1, S-3

SOL 1.65 Option (D) is correct.

	Column I		**Column II**
P.	Charpy test	**4.**	Toughness
Q.	Knoop test	**2.**	Microhardness
R.	Spiral test	**1.**	Fluidity
S.	Cupping test	**3.**	Formability

So, correct pairs are, P-4, Q-2, R-1, S-3

GATE ME 2006 TWO MARK

An manufacturing shop processes sheet metal jobs, wherein each job must pass through two machines ($M1$ and $M2$, in that order). The processing time (in hours) for these jobs is

Machine	Jobs					
	P	Q	R	S	T	U
$M1$	15	32	8	27	11	16
$M2$	6	19	13	20	14	7

The optimal make-span (in-hours) of the shop is

(A) 120 (B) 115

(C) 109 (D) 79

SOL 1.66 Option (B) is correct.

First finding the sequence of jobs, which are entering in the machine. The solution procedure is described below :

By examining the rows, the smallest machining time of 6 hours on machine $M2$. Then scheduled Job P last for machine $M2$

					P

After entering this value, the next smallest time of 7 hours for job U on machine $M2$. Thus we schedule job U second last for machine $M2$ as shown below

				U	P

After entering this value, the next smallest time of 8 hours for job R on machine $M1$. Thus we schedule job R first as shown below.

R				U	P

After entering this value the next smallest time of 11 hours for job T on machine $M1$. Thus we schedule job T after the job R.

R	T			U	P

After this the next smallest time of 19 hours for job Q on machine $M2$. Thus schedule job Q left to the U and remaining job in the blank block.

Now the optimal sequence as :

R	T	S	Q	U	P

Then calculating the elapsed time corresponding to the optimal sequence, using the individual processing time given in the problem.

The detailed are shown in table.

Jobs	$M1$		$M2$	
	In	**Out**	**In**	**Out**
R	0	8	8	$8+13=21$
T	8	$8+11=19$	21	$21+14=35$
S	19	$19+27=46$	46	$46+20=66$
Q	46	$46+32=78$	78	$78+19=97$
U	78	$78+16=94$	97	$97+7=104$
P	94	$94+15=109$	109	$109+6=115$

We can see from the table that all the operations (on machine 1st and machine 2nd) complete in 115 hours. So the optimal make-span of the shop is 115 hours.

MCQ 1.67 GATE ME 2006 TWO MARK

Consider the following data for an item.
Annual demand : 2500 units per year, Ordering cost : Rs. 100 per order, Inventory holding rate : 25% of unit price
Price quoted by a supplier

Order quantity (units)	Unit price (Rs.)
< 500	10
≥ 500	9

The optimum order quantity (in units) is

(A) 447 (B) 471

(C) 500 (D) ≥ 600

SOL 1.67

Option (C) is correct.

Given :
$$D = 2500 \text{ units per year}$$
$$C_o = \text{Rs. } 100 \text{ per order}$$
$$C_h = 25\% \text{ of unit price}$$

Case (I) : When order quantity is less than 500 units.

Then, Unit price $= 10$ Rs.

and $C_h = 25\%$ of $10 = 2.5$ Rs.

$$EOQ = \sqrt{\frac{2C_0 D}{C_h}} = \sqrt{\frac{2 \times 100 \times 2500}{2.5}}$$

$$Q = 447.21 \simeq 447 \text{ units}$$

$$\text{Total cost} = D \times \text{unit cost} + \frac{Q}{2} \times c_h + \frac{D}{Q} \times c_o$$

$$= 2500 \times 10 + \frac{447}{2} \times 2.5 + \frac{2500}{447} \times 100$$

$= 25000 + 558.75 + 559.75$
$= 26118$ Rs.

Case (II) : when order Quantity is 500 units. Then unit prize $= 9$ Rs.

and $c_h = 25\%$ of $9 = 2.25$ Rs.

$Q = 500$ units

Total cost $= 2500 \times 9 + \frac{500}{2} \times 2.25 + \frac{2500}{500} \times 100$

$= 22500 + 562.5 + 500$
$= 23562.5$ Rs.

So, we may conclude from both cases that the optimum order quantity must be equal to 500 units.

MCQ 1.68 GATE ME 2006 TWO MARK

A firm is required to procure three items (P, Q, and R). The prices quoted for these items (in Rs.) by suppliers $S1$, $S2$ and $S3$ are given in table. The management policy requires that each item has to be supplied by only one supplier and one supplier supply only one item. The minimum total cost (in Rs.) of procurement to the firm is

Item	Suppliers		
	$S1$	$S2$	$S3$
P	110	120	130
Q	115	140	140
R	125	145	165

(A) 350
(B) 360
(C) 385
(D) 395

SOL 1.68 Option (C) is correct.

Given, In figure

	$S1$	$S2$	$S3$
P	110	120	130
Q	115	140	140
R	125	145	165

Step (I) : Reduce the matrix :

In the effectiveness matrix, subtract the minimum element of each row from all the element of that row. The resulting matrix will have at least one zero element in each row.

	$S1$	$S2$	$S3$
P	0	10	20
Q	0	25	25
R	0	20	40

Step (II) : Mark the column that do not have zero element. Now substract the minimum element of each such column for all the elements of that column.

	$S1$	$S2$	$S3$
P	0	0	0
Q	0	15	5
R	0	10	20

Step (III) : Check whether an optimal assignment can be made in the reduced matrix or not.

For this, Examine rows successively until a row with exactly one unmarked zero is obtained. Making square (□) around it, cross (×) all other zeros in the same column as they will not be considered for making any more assignment in that column. Proceed in this way until all rows have been examined.

	$S1$	$S2$	$S3$
P	[0]	~~0~~	~~0~~
Q	~~0~~	15	5
R	~~0~~	10	20

In this there is not one assignment in each row and in each column.

Step (IV) : Find the minimum number of lines crossing all zeros. This consists of following substep

(A) Right marked ( ) the rows that do not have assignment.

(B) Right marked ( ) the column that have zeros in marked column (not already marked).

(C) Draw straight lines through all unmarked rows and marked columns.

	$S1$	$S2$	$S3$	
P	[0]	~~0~~	~~0~~	
Q	~~0~~	15	5	✓
R	~~0~~	10	20	✓
	✓			

Step (V) : Now take smallest element & add, where two lines intersect.

No change, where single line & subtract this where no lines in the block.

	$S1$	$S2$	$S3$	
P	5	[0]	~~0~~	
Q	~~0~~	10	[0]	✓
R	[0]	5	15	✓
	✓			

So, minimum cost is

$$= 120 + 140 + 125$$
$$= 385$$

MCQ 1.69 GATE ME 2006 TWO MARK

A stockist wishes to optimize the number of perishable items he needs to stock in any month in his store. The demand distribution for this perishable item is

Demand (in units)	2	3	4	5
Probability	0.10	0.35	0.35	0.20

The stockist pays Rs. 70 for each item and he sells each at Rs. 90. If the stock is left unsold in any month, he can sell the item at Rs. 50 each. There is no penalty for unfulfilled demand. To maximize the expected profit, the optimal stock level is

(A) 5 units (B) 4 units

(C) 3 units (D) 2 units

SOL 1.69 Option (A) is correct.

$$\text{Profit per unit sold} = 90 - 70 = 20\,\text{Rs.}$$
$$\text{Loss per unit unsold item} = 70 - 50 = 20\,\text{Rs.}$$

Now consider all the options :

Cases	**Units in stock**	**Unit sold (Demand)**	**Profit**	**Probability**	**Total profit**
Option (D)	2	2	$2 \times 20 = 40$	0.1	4
Option (C)	3	2	$2 \times 20 - 1 \times 20 = 20$	0.1	2
	3	3	$3 \times 20 = 60$	0.35	21
					23
Option (B)	4	2	$2 \times 20 - 2 \times 20 = 0$	0	0
	4	3	$3 \times 20 - 1 \times 20 = 40$	0.35	14
	4	4	$4 \times 20 = 80$	0.35	28
					42
Option (A)	5	2	$2 \times 20 - 3 \times 20 = -20$	0.10	-2

	5	3	$3 \times 20 - 2 \times 20 = 20$	0.35	7
	5	4	$4 \times 20 - 1 \times 20 = 60$	0.35	21
	5	5	$5 \times 20 = 100$	0.20	20
					46

Thus, For stock level of 5 units, profit is maximum.

MCQ 1.70 The table gives details of an assembly line.

GATE ME 2006 TWO MARK

Work station	I	II	III	IV	V	VI
Total task time at the workstation (in minutes)	7	9	7	10	9	6

What is the line efficiency of the assembly line ?

(A) 70%
(B) 75%
(C) 80%
(D) 85%

SOL 1.70 Option (C) is correct.

$$\text{Total time used} = 7 + 9 + 7 + 10 + 9 + 6 = 48 \text{ min}$$

$$\text{Number of work stations} = 6$$

Maximum time per work station (cycle time) = 10 min

We know,

$$\text{Line efficiency } \eta_L = \frac{\text{Total time used}}{\text{Number of work stations} \times \text{cycle time}}$$

$$\eta_L = \frac{48}{6 \times 10} = 0.8 = 80\%$$

Common Data for Question 71, 72 & 73

In an orthogonal machining operation :

Uncut thickness = 0.5 mm
Cutting speed = 20 m/min
Rake angel = 15°
Width of cut = 5 mm Chip thickness = 0.7 mm
Thrust force = 200 N Cutting force = 1200 N
Assume Merchant's theory.

MCQ 1.71 The values of shear angle and shear strain, respectively, are

GATE ME 2006 TWO MARK

(A) 30.3° and 1.98
(B) 30.3° and 4.23
(C) 40.2° and 2.97
(D) 40.2° and 1.65

SOL 1.71 Option (D) is correct.

Given : $t = 0.5\,\text{mm}$, $V = 20\,\text{m/min}$, $\alpha = 15^\circ$

$w = 5\text{ mm}, \quad t_c = 0.7\text{ mm}, \quad F_t = 200\text{ N}, \quad F_c = 1200\text{ N}$

We know, from the merchant's theory

Chip thickness ratio, $r = \dfrac{t}{t_c} = \dfrac{0.5}{0.7} = 0.714$

For shear angle, $\tan\phi = \dfrac{r\cos\alpha}{1 - r\sin\alpha}$

Substitute the values, we get

$$\tan\phi = \frac{0.714\cos 15^\circ}{1 - 0.714\sin 15^\circ} = \frac{0.689}{0.815} = 0.845$$

$$\phi = \tan^{-1}(0.845) = 40.2^\circ$$

Shear strain, $s = \cot\phi + \tan(\phi - \alpha)$

$$s = \cot(40.2^\circ) + \tan(40.2^\circ - 15^\circ)$$
$$= \cot 40.2^\circ + \tan 25.2 = 1.183 + 0.470 = 1.65$$

MCQ 1.72 The coefficient of friction at the tool-chip interface is

GATE ME 2006
TWO MARK

(A) 0.23 (B) 0.46

(C) 0.85 (D) 0.95

SOL 1.72 Option (B) is correct.

From merchants, theory

$$\mu = \frac{F}{N} = \frac{F_c\sin\alpha + F_t\cos\alpha}{F_c\cos\alpha - F_t\sin\alpha} = \frac{F_c\tan\alpha + F_t}{F_c - F_t\tan\alpha}$$

$$\mu = \frac{1200\tan 15^\circ + 200}{1200 - 200\times\tan 15^\circ} = \frac{521.539}{1146.41}$$

$$= 0.455 \simeq 0.46$$

MCQ 1.73 The percentage of total energy dissipated due to friction at the tool-chip interface is

GATE ME 2006
TWO MARK

(A) 30% (B) 42%

(C) 58% (D) 70%

SOL 1.73 Option (A) is correct.

We know, from merchant's theory, frictional force of the tool acting on the tool-chip interface is

$$F = F_c\sin\alpha + F_t\cos\alpha$$
$$= 1200\sin 15^\circ + 200\cos 15^\circ = 503.77\text{ N}$$

Chip velocity, $V_c = \dfrac{\sin\phi}{\cos(\phi - \alpha)} \times V$

$$= \frac{\sin(40.2^\circ)}{\cos(40.2^\circ - 15^\circ)} \times 20 = 14.27\text{ m/min}$$

Total energy required per unit time during metal cutting is given by,

$$E = F_c \times V$$
$$= 1200 \times \frac{20}{60} = 400\text{ Nm/sec}$$

Energy consumption due to friction force F,

$$E_f = F \times V_c = 503.77 \times \frac{14.27}{60} \text{ Nm/sec}$$

$$= 119.81 \text{ Nm/sec}$$

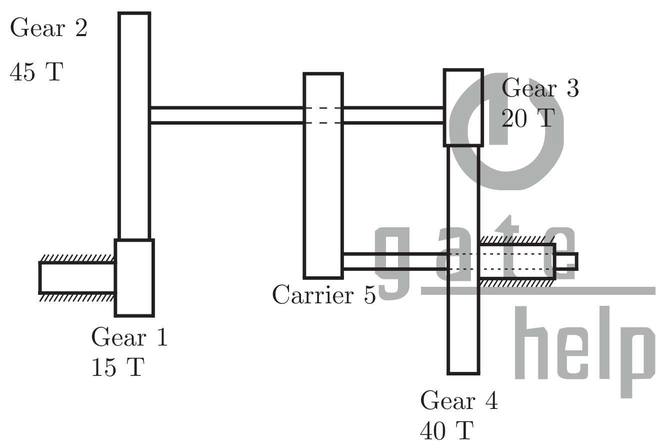
Percentage of total energy dissipated due to friction at tool-chip interface is

$$E_d = \frac{E_f}{E} \times 100$$

$$= \frac{119.81}{400} \times 100 \simeq 30\%$$

Common Data For Q. 74 & 75

A planetary gear train has four gears and one carrier. Angular velocities of the gears are $\omega_1, \omega_2, \omega_3$ and ω_4, respectively. The carrier rotates with angular velocity ω_5.



MCQ 1.74 What is the relation between the angular velocities of Gear 1 and Gear 4 ?

GATE ME 2006
TWO MARK

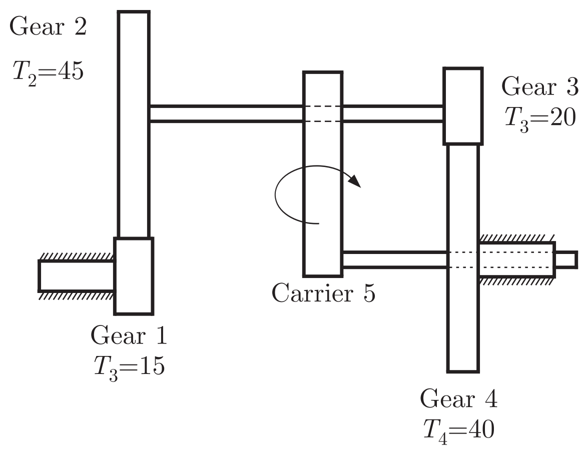
(A) $\frac{\omega_1 - \omega_5}{\omega_4 - \omega_5} = 6$

(B) $\frac{\omega_4 - \omega_5}{\omega_1 - \omega_5} = 6$

(C) $\frac{\omega_1 - \omega_2}{\omega_4 - \omega_5} = -\left(\frac{2}{3}\right)$

(D) $\frac{\omega_2 - \omega_5}{\omega_4 - \omega_5} = \frac{8}{9}$

SOL 1.74 Option (A) is correct.



The table of motions is given below :
Take CW $=+ve$, CCW $=-ve$

S. No.	Condition of Motion	Revolution of elements			
		Gear 1 N_1	Compound Gear 2-3, $N_2 = N_3$	Gear 4 N_4	Carrier N_5
1.	Carrier 5 is fixed & Gear 1 rotates +1 rpm (CW)	+1	$-\frac{Z_1}{Z_2}$	$\frac{Z_1}{Z_2}\times\frac{Z_3}{Z_4}$	0
2.	Gear 1 rotates through $+x$ rpm (CW)	$+x$	$-x\frac{Z_1}{Z_2}$	$x\frac{Z_1Z_3}{Z_2Z_4}$	0
3.	Add $+y$ revolutions to all elements	$+y$	$+y$	$+y$	$+y$
4.	Total motion.	$x+y$	$y-x\frac{Z_1}{Z_2}$	$y+x\times\frac{Z_1Z_3}{Z_2Z_4}$	$+y$

Note

(i) Speed ratio $=\frac{\text{Speed of driver}}{\text{Speed of driven}}=\frac{\text{No. of teeth on driven}}{\text{No.of teeth on driver}}$

i.e. $\frac{N_1}{N_2}=\frac{Z_2}{Z_1}$

CCW = Counter clock wise direction (– ve)

CW = Clock wise direction (+ ve)

(ii) Gear 2 & Gear 3 mounted on the same shaft (Compound Gears)

So, $N_2 = N_3$

We know, $\omega = \frac{2\pi N}{60}$, $\Rightarrow \omega \propto N$

Hence, $$\frac{N_1-N_5}{N_4-N_5}=\frac{\omega_1-\omega_5}{\omega_4-\omega_5}=\frac{(x+y)-y}{y+x\times\frac{Z_1Z_3}{Z_2Z_4}-y}$$

$$\frac{\omega_1 - \omega_5}{\omega_4 - \omega_5} = \frac{x}{x \times \frac{Z_1 Z_3}{Z_2 Z_4}} = \frac{Z_2 Z_4}{Z_1 Z_3}$$

$$\frac{\omega_1 - \omega_5}{\omega_4 - \omega_5} = \frac{45 \times 40}{15 \times 20} = 3 \times 2 = 6$$

MCQ 1.75 GATE ME 2006 TWO MARK

For $\omega_1 = 60$ rpm clockwise (CW) when looked from the left, what is the angular velocity of the carrier and its direction so that Gear 4 rotates in counterclockwise (CCW)direction at twice the angular velocity of Gear 1 when looked from the left ?

(A) 130 rpm, CW
(B) 223 rpm, CCW
(C) 256 rpm, CW
(D) 156 rpm, CCW

SOL 1.75 Option (D) is correct.

Given $\omega_1 = 60\,\text{rpm}$ (CW), $\omega_4 = -2 \times 60$ (CCW) $= -120\,\text{rpm}$

From the previous part,

$$\frac{\omega_1 - \omega_5}{\omega_4 - \omega_5} = 6$$

$$\frac{60 - \omega_5}{-120 - \omega_5} = 6$$

$$60 - \omega_5 = -720 - 6\omega_5$$

$$\omega_5 = -\frac{780}{5} = -156\,\text{rpm}$$

Negative sign show the counter clock wise direction.

So, $\omega_5 = 156\,\text{rpm}$, CCW

Statement for linked Answer Questions 76 and 77 :

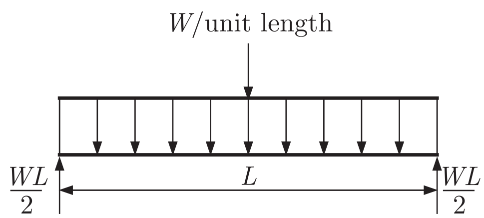
A simply supported beam of span length 6 m and 75 mm diameter carries a uniformly distributed load of 1.5 kN/m

MCQ 1.76 GATE ME 2006 TWO MARK

What is the maximum value of bending moment ?

(A) 9 kN-m
(B) 13.5 kN-m
(C) 81 kN-m
(D) 125 kN-m

SOL 1.76 Option none of these is correct.



Given : $L = 6\,\text{m}$, $W = 1.5\,\text{kN/m}$, $d = 75\,\text{mm}$

We know that for a uniformly distributed load, maximum bending moment at the centre is given by,

$$B.M. = \frac{WL^2}{8} = \frac{1.5 \times 10^3 \times (6)^2}{8}$$

$$B.M. = 6750 \text{ N–m} = 6.75 \text{ kN–m}$$

MCQ 1.77 What is the maximum value of bending stress ?

GATE ME 2006 TWO MARK

(A) 162.98 MPa (B) 325.95 MPa

(C) 625.95 MPa (D) 651.90 MPa

SOL 1.77 Option (A) is correct.

From the bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

Where M = Bending moment acting at the given section = 6.75 kN–m

I = Moment of inertia = $\frac{\pi}{64} d^4$

y = Distance from the neutral axis to the external fibre = $\frac{d}{2}$

σ_b = Bending stress

So,

$$\sigma_b = \frac{M}{I} \times y$$

Substitute the values, we get

$$\sigma_b = \frac{6.75 \times 10^6}{\frac{\pi}{64}(75)^4} \times \frac{75}{2} = \frac{32400}{\pi \times 2 \times (75)^4} \times 10^6$$

$$\sigma_b = 1.6305 \times 10^{-4} \times 10^6 = 163.05 \text{ MPa} \simeq 162.98 \text{ MPa}$$

Statement for linked Answer Question 78 and 79 :

A vibratory system consists of a mass 12.5 kg, a spring of stiffness 1000 N/m, and a dash-pot with damping coefficient of 15 Ns/m.

MCQ 1.78 The value of critical damping of the system is

GATE ME 2006 TWO MARK

(A) 0.223 Ns/m (B) 17.88 Ns/m

(C) 71.4 Ns/m (D) 223.6 Ns/m

SOL 1.78 Option (D) is correct.

Given $m = 12.5$ kg, $k = 1000$ N/m, $c = 15$ Ns/m

Critical Damping,

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

On substituting the values, we get

$$c_c = 2\sqrt{1000 \times 12.5} = 223.6 \text{ Ns/m}$$

MCQ 1.79 The value of logarithmic decrement is

GATE ME 2006 TWO MARK

(A) 1.35 (B) 1.32

(C) 0.68 (D) 0.66

SOL 1.79 None of these

We know logarithmic decrement,

$$\delta = \frac{2\pi\varepsilon}{\sqrt{1-\varepsilon^2}} \quad \text{...(i)}$$

And $\varepsilon = \frac{c}{c_c} = \frac{15}{223.6} = 0.0671$ $c_c = 223.6$ Ns/m

Now, from equation (i), we get

$$\delta = \frac{2 \times 3.14 \times 0.0671}{\sqrt{1-(0.0671)^2}} = 0.422$$

Statement for Linked Answer Questions 80 & 81 :

A football was inflated to a gauge pressure of 1 bar when the ambient temperature was 15° C. When the game started next day, the air temperature at the stadium was 5° C. Assume that the volume of the football remains constant at 2500 cm^3.

MCQ 1.80 The amount of heat lost by the air in the football and the gauge pressure of air in the football at the stadium respectively equal

GATE ME 2006 TWO MARK

(A) 30.6 J, 1.94 bar (B) 21.8 J, 0.93 bar

(C) 61.1 J, 1.94 bar (D) 43.7 J, 0.93 bar

SOL 1.80 Option (D) is correct.

Given :

$$p_{gauge} = 1 \text{ bar}$$

$$p_{absolute} = p_{atm} + p_{gauge}$$

So,

$$p_{abs} = 1.013 + 1 = 2.013 \text{ bar} \qquad p_{atm} = 1.013 \text{ bar}$$

$$T_1 = 15^\circ \text{C} = (273+15)\text{ K} = 288\text{ K}$$

$$T_2 = 5^\circ \text{C} = (273+5)\text{ K} = 278\text{ K}$$

$$\text{Volume} = \text{Constant}$$

$$\nu_1 = \nu_2 = 2500\text{ cm}^3 = 2500 \times (10^{-2})^3\text{ m}^3$$

From the perfect gas equation,

$$p\nu = mRT$$

$$2.013 \times 10^5 \times 2500 \times (10^{-2})^3 = m \times 287 \times 288$$

$$2.013 \times 2500 \times 10^{-1} = m \times 287 \times 288$$

$$m = \frac{2.013 \times 250}{287 \times 288} = 0.0060\text{ kg}$$

For constant Volume, relation is given by,

$$Q = mc_v dT \qquad c_v = 0.718\text{ J/kg K}$$

$$= 0.0060 \times 0.718 \times (278 - 288) \qquad dT = T_2 - T_1$$

$$Q = -0.0437 = -43.7 \times 10^{-3}\text{ kJ}$$

$$= -43.7\text{ Joule}$$ Negative sign shows the heat lost

As the process is isochoric i.e. constant volume, So from the prefect gas equation,

$$\frac{p}{T} = \text{Constant}$$

And $$\frac{p_1}{T_1} = \frac{p_2}{T_2}$$

$$p_2 = \frac{T_2}{T_1} \times p_1 = \frac{278}{288} \times 2.013 = 1.943 \text{ bar} \qquad p_1 = p_{abs}$$

So, Gauge Pressure = Absolute pressure – atmospheric pressure

$$p_{gauge} = 1.943 - 1.013 = 0.93 \text{ bar}$$

MCQ 1.81 Gauge pressure of air to which the ball must have been originally inflated so that it would be equal 1 bar gauge at the stadium is

GATE ME 2006 TWO MARK

(A) 2.23 bar (B) 1.94 bar

(C) 1.07 bar (D) 1.00 bar

SOL 1.81 Option (C) is correct.

It is a constant volume process, it means

$$\frac{p}{T} = \text{Constant}$$

$$\frac{p_1}{p_2} = \frac{T_1}{T_2}$$

Substitute, $T_1 = 288$ and $T_2 = 278$

$$p_2 = p_{2,gauge} + p_{atm.} = 1 + 1.013$$

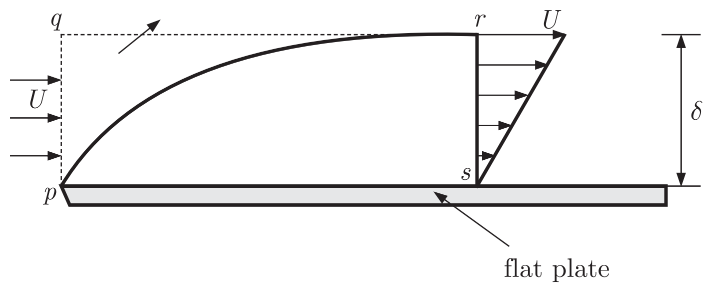
$$p_2 = 2.013 \text{ bar}$$

So, $$p_1 = \frac{T_1}{T_2} \times p_2 = \frac{288}{278} \times 2.013 = 2.08 \text{ bar}$$

Gauge pressure, $$p_{gauge} = 2.08 - 1.013 = 1.067 \simeq 1.07 \text{ bar}$$

Statement for Linked Answer Questions 82 & 83 :

A smooth flat plate with a sharp leading edge is placed along a gas stream flowing at $U = 10$ m/s. The thickness of the boundary layer at section r-s is 10 mm, the breadth of the plate is 1 m (into the paper) and the density of the gas $\rho = 1.0 \text{ kg/m}^3$. Assume that the boundary layer is thin, two-dimensional, and follows a linear velocity distribution, $u = U(y/\delta)$, at the section r-s, where y is the height from plate.



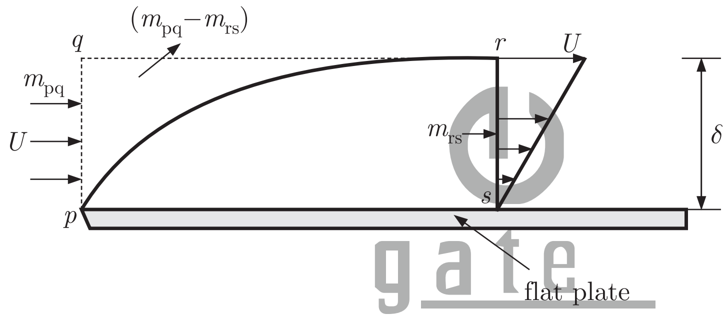
MCQ 1.82 The mass flow rate (in kg/s) across the section $q-r$ is

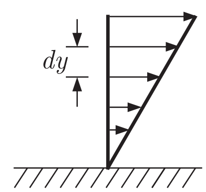
GATE ME 2006
TWO MARK

(A) zero (B) 0.05

(C) 0.10 (D) 0.15

SOL 1.82 Option (B) is correct.





Given : $U = 10\,\text{m/sec}$, $\delta = 10\,\text{mm} = 10^{-2}$ meter, $\rho = 1.0\,\text{kg/m}^3$,

$B = 1\,\text{m}$ and $u = U\left(\frac{y}{\delta}\right)$

From the figure we easily find that mass entering from the side qp

=Mass leaving from the side qr + Mass Leaving from the side rs

$$m_{pq} = (m_{pq} - m_{rs}) + m_{rs}$$

So, firstly Mass flow rate entering from the side pq is

$$\dot{m}_{pq} = \rho \times \text{Volume} = \rho \times (A \times U)$$

$$= 1 \times (B \times \delta) \times U$$

Substitute the values, we get

$$\dot{m}_{pq} = 1 \times (1 \times 10^{-2}) \times 10 = 0.1\,\text{kg/sec}$$

For mass flow through section r - s, we have to take small element of dy thickness. Then Mass flow rate through this element,

$$d\dot{m} = \rho \times \text{Volume} = \rho \times (A \times u)$$

$$= \rho \times u \times B \times (dy) = \rho B U\left(\frac{y}{\delta}\right) dy$$

For total Mass leaving from rs, integrating both sides within the limits,

$$dm \Rightarrow 0 \text{ to } m$$

$$y \Rightarrow 0 \text{ to } \delta$$

$$\int_0^m d\dot{m} = \int_0^\delta y\left(\frac{\rho U B}{\delta}\right) dy$$

$$[\dot{m}]_0^m = \frac{\rho UB}{\delta}\left[\frac{y^2}{2}\right]_0^\delta$$

$$\dot{m} = \frac{\rho UB}{\delta} \times \frac{\delta^2}{2} = \frac{1}{2}\rho UB\delta$$

So, $$\dot{m}_{rs} = \frac{1}{2} \times 10^{-2} \times 10 \times 1 \times 1 = 5 \times 10^{-2} = 0.05 \text{ kg/sec}$$

Mass leaving from qr

$$\dot{m}_{qr} = \dot{m}_{pq} - \dot{m}_{rs} = 0.1 - 0.05 = 0.05 \text{ kg/sec}$$

MCQ 1.83 The integrated drag force (in N) on the plate, between p-s, is

GATE ME 2006 TWO MARK

(A) 0.67 (B) 0.33

(C) 0.17 (D) zero

SOL 1.83 Option (D) is correct.

Von Karman momentum Integral equation for boundary layer flows is,

$$\frac{\tau_o}{\rho U^2} = \frac{\partial \theta}{\partial x}$$

and $$\theta = \text{momentum thickness}$$

$$= \int_0^\delta \frac{u}{U}\left[1 - \frac{u}{U}\right]dy$$

So,

$$\frac{\tau_o}{\rho U^2} = \frac{\partial}{\partial x}\left[\int_0^\delta \frac{u}{U}\left(1 - \frac{u}{U}\right)dy\right] \qquad \frac{u}{U} = \frac{y}{\delta}$$

$$= \frac{\partial}{\partial x}\left[\int_0^\delta \frac{y}{\delta}\left(1 - \frac{y}{\delta}\right)dy\right]$$

$$= \frac{\partial}{\partial x}\left[\int_0^\delta \left(\frac{y}{\delta} - \frac{y^2}{\delta^2}\right)dy\right]$$

Integrating this equation, we get

$$= \frac{\partial}{\partial x}\left[\left(\frac{y^2}{2\delta} - \frac{y^3}{3\delta^2}\right)_0^\delta\right]$$

$$= \frac{\partial}{\partial x}\left[\left(\frac{\delta^2}{2\delta} - \frac{\delta^3}{3\delta^2}\right)\right] = \frac{\partial}{\partial x}\left[\frac{\delta}{6}\right] = 0$$

$$\tau_o = 0$$

And drag force on the plate of length L is,

$$F_D = \int_0^L \tau_o \times b \times dx = 0$$

Statement for Linked Answer Questions 84 & 85 :

Consider a PERT network for a project involving six tasks (a to f)

Task	Predecessor	Expected task time (in days)	Variance of the task time (in days^2)
a	-	30	25
b	a	40	64
c	a	60	81
d	b	25	9
e	b, c	45	36
f	d, e	20	9

MCQ 1.84 The expected completion time of the project is

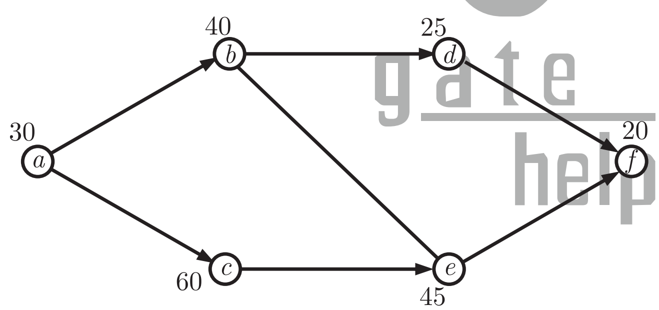
GATE ME 2006 TWO MARK

(A) 238 days (B) 224 days

(C) 171 days (D) 155 days

SOL 1.84 Option (D) is correct.

We have to make a network diagram from the given data.



For simple projects, the critical path can be determined quite quickly by enumerating all paths and evaluating the time required to complete each.

There are three paths between a and f. The total time along each path is

(i) For path a-b-d-f

$$T_{abdf} = 30 + 40 + 25 + 20 = 115 \text{ days}$$

(ii) For path a-c-e-f

$$T_{acef} = 30 + 60 + 45 + 20 = 155 \text{ days}$$

(iii) For path a-b-e-f

$$T_{abef} = 30 + 40 + 45 + 20 = 135 \text{ days}$$

Now, path a-c-e-f be the critical path time or maximum excepted completion time $T = 155$ days

MCQ 1.85 The standard deviation of the critical path of the project is

GATE ME 2006 TWO MARK

(A) $\sqrt{151}$ days (B) $\sqrt{155}$ days

(C) $\sqrt{200}$ days (D) $\sqrt{238}$ days

SOL 1.85 Option (A) is correct.

The critical path of the network is a-c-e-f.

Now, for variance.

Task	Variance (days^2)
a	25
c	81
e	36
f	9

Total variance for the critical path

$$V_{critical} = 25 + 81 + 36 + 9$$

$$= 151\ \text{days}^2$$

We know the standard deviation of critical path is

$$\sigma = \sqrt{V_{critical}}$$

$$= \sqrt{151}\ \text{days}$$

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

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