GATE SOLVED PAPER
Mechanical Engineering
2013

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GATE SOLVED PAPER - ME

2013

Q. 1
GATE ME 2013 ONE MARK

Customer arrive at a ticket counter at a rate of 50 per hr and tickets are issued in the order of their arrival. The average time taken for issuing a ticket is 1 min. Assuming that customer arrivals from a Poisson process and service times and exponentially distributed, the average waiting time is queue in min is

(A) 3 (B) 4

(C) 5 (D) 6

Sol. 1

Option (C) is correct.

Average waiting time of a customer (in a queue) is given by

$$E(w) = \frac{\lambda}{\mu(\mu-\lambda)}$$

Where $\lambda = 50$ customers per hour or 0.834 customer/min

$\mu = 1$ per min

Therefore $$E(w) = \frac{0.834}{1\times(1-0.834)} = 5\text{ min}$$

Q. 2
GATE ME 2013 ONE MARK

A metric threads of pitch 2 mm and thread angle 60° is inspected for its pitch diameter using 3-wire method. The diameter of the best size wire in mm is

(A) 0.866 (B) 1.000

(C) 1.154 (D) 2.000

Sol. 2

Option (C) is correct.

For 3-wire method, the diameter of the best size wire is given by

$$d = \frac{p}{2\cos\frac{\alpha}{2}}$$

where $p = \text{pitch} = 2\text{ mm}, \ \alpha = 60^\circ$

Hence $$d_D = \frac{2}{2\cos 30^\circ} = 1.154\text{ mm}$$

Q. 3
GATE ME 2013 ONE MARK

Match the correct pairs

Processes	Characteristics/Applications
P. Friction Welding	1. Non-consumable electrode
Q. Gas Metal Arc Welding	2. Joining of thick plates
R. Tungsten Inert Gas Welding	3. Consumable electrode wire
S. Electroslag Welding	4. Joining of cylindrical dissimilar material

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

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

Sol. 3 Option (A) is correct.

Processes	Characteristics/Applications
P. Friction Welding	4. Joining of cylindrical dissimilar materials
Q. Gas Metal Arc Welding	3. Consumable electrode wire
R. Tungsten Inert Gas Welding	1. Non-consumable electrode
S. Electroslag Welding	2. Joining of thick plates

Q. 4 GATE ME 2013 ONE MARK

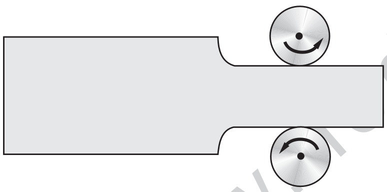
In a rolling process, the state of stress of the material undergoing deformation is

(A) pure compression (B) pure shear

(C) compression and shear (D) tension and shear

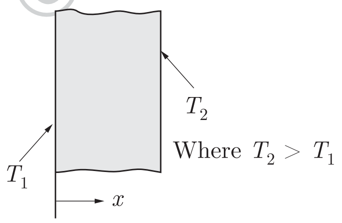
Sol. 4 Option (A) is correct.

Most metal rolling operations are similar in that the work material is plastically deformed by compressive forces between two constantly spinning rolls. Thus in a Rolling process, the material undergoing deformation is in the state of pure biaxial compression.



Q. 5 GATE ME 2013 ONE MARK

Consider one-dimensional steady state heat conduction, without heat generation in a plane wall, with boundary conditions as shown in figure below. The conductivity of the wall is given by $k = k_0 + bT$ where k_0 and b are positive constants and T is temperature.



As x increases, the temperature gradient (dT/dx) will

(A) remain constant (B) be zero

(C) increase (D) decrease

Sol. 5 Option (A) is correct.

The one-dimensional steady state heat conduction equation without heat generation is given by

$$k\frac{d^2T}{dx^2} = 0 \quad \text{where } k = k_0 + bT \quad \text{and} \quad T_2 > T_1$$

$$\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$$

Integrating both the sides

$$\int \frac{d}{dx}\left(k\frac{dT}{dx}\right) = C \quad \text{where } C \text{ is the integration constant.}$$

$$k\frac{dT}{dx} = C \quad ...(i)$$

$$\int (k_0 + bT)\,dT = \int C\,dx$$

$$k_0 T + \frac{bT^2}{2} = Cx + B$$ where B is the integration constant.

Let the boundary condition

(a) At $x = 0$, $T = 0$ and (b) At $x = 1$, $T = 100^\circ\text{C}$

From boundary condition (a), we get $B = 0$.

and from (b),

$$k_0(100) + b(5000) = C$$

Now from Eq. (i), we obtain

$$\frac{dT}{dx} = \frac{100k_0 + 5000b}{k_0 + bT} \quad ...(ii)$$

From this Eq. (ii), it is concluded that as T increases, the $\frac{dT}{dx}$ decreases because it is a function of temperature only and $T_2 > T_1$.

Q. 6

GATE ME 2013 ONE MARK

The pressure, dry bulb temperature and relative humidity of air in a room are 1 bar, 30°C and 70%, respectively. If the saturated pressure at 30°C is 4.25 kPa, the specify humidity of the room air in kg water vapour/kg dry air is

(A) 0.0083 (B) 0.0101

(C) 0.0191 (D) 0.0232

Sol. 6

Option (C) is correct.

Specific humidity is given by

$$w = 0.622 \times \frac{p_v}{p_a - p_v} \quad ...(i)$$

where p_v = Relative humidity × Saturated steam pressure $= \phi \times p_s$

$$= 0.7 \times 0.0425 = 0.02975 \text{ bar}$$

So that from equation (i), we have

$$w = 0.622 \times \frac{0.02975}{1 - 0.02975} \qquad p_a = 1 \text{ bar}$$

$$= 0.0191 \text{ kg/kg of dry air}$$

Q. 7

GATE ME 2013 ONE MARK

For steady, fully developed flow inside a straight pipe of diameter D, neglecting gravity effects, the pressure drop Δp over a length L and the wall shear stress τ_w are related by

(A) $\tau_w = \frac{\Delta pD}{4L}$ (B) $\tau_w = \frac{\Delta pD^2}{4L^2}$

(C) $\tau_w = \frac{\Delta pD}{2L}$ (D) $\tau_w = \frac{4\Delta pL}{D}$

Sol. 7

Option (A) is correct.

For steady, fully developed flow inside a straight pipe, the pressure drop and wall shear stress are related by

$$\Delta p = \frac{4L\tau_w}{D}$$

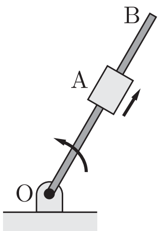
or

$$\tau_w = \frac{\Delta pD}{4L}$$

Q. 8

GATE ME 2013 ONE MARK

A link OB is rotating with a constant angular velocity of 2 rad/s in counter clockwise direction and a block is sliding radially outward on it with an uniform velocity of 0.75 m/s with respect to the rod as shown in the figure. If $OA = 1$ m, the magnitude of the absolute acceleration of the block at location A in m/s^2 is



(A) 3 (B) 4

(C) 5 (D) 6

Sol. 8

Option (C) is correct.

Absolute acceleration of given link at location A is

$$a = \sqrt{a_{radial}^2 + a_{tangential}^2} \qquad \text{...(i)}$$

Where $a_{radial} = \omega^2 r = \omega^2 \times OA$

$$= 2^2 \times 1 = 4\ \text{m/s}^2$$

$$a_{tangential} = 2v\omega = 2 \times 0.75 \times 2 = 3\ \text{m/s}^2$$

So that from equation (i), we get

$$a = \sqrt{4^2 + 3^2}$$

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

Q. 9

GATE ME 2013 ONE MARK

Two threaded bolts A and B of same material and length are subjected to identical tensile load. If the elastic strain stored in bolt A times of bolt B and the mean diameter of bolt A is 12 mm, the mean diameter of bolt B in mm is

(A) 16 (B) 24

(C) 36 (D) 48

Sol. 9

Option (B) is correct.

Stain Energy is given by

$$U = \frac{\sigma^2 V}{2E} = \frac{F^2}{A^2} \times \frac{AL}{2E}$$

$$= \frac{F^2 L}{2AE}$$

Given $U_A = 4U_B$

$$\frac{F_A^2 L_A}{2A_A E_A} = \frac{4F_B^2 L_B}{2A_B E_B}$$

Since bolts of same material and length and subjected to identical tensile load, i.e.

$$E_A = E_B,\quad L_A = L_B,\quad F_A = F_B$$

So that $\dfrac{1}{A_A} = \dfrac{4}{A_B}$

$$\frac{1}{d_A^2} = \frac{4}{d_B^2} \qquad A = \frac{\pi}{4} d^2$$

or $d_B^2 = 4d_A^2$

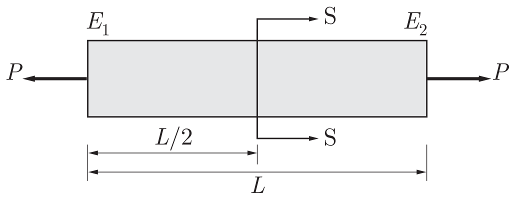
or $d_B = 2d_A$

$$= 2 \times 12 = 24\ \text{mm}$$

Q. 10

GATE ME 2013 ONE MARK

A rod of length L having uniform cross-sectional area A is subjected to a tensile force P as shown in the figure below. If the Young's modulus of the material varies linearly from E_1 to E_2 along the length of the rod, the normal stress developed at the section-SS is



(A) $\frac{P}{A}$

(B) $\frac{P(E_1 - E_2)}{A(E_1 + E_2)}$

(C) $\frac{PE_2}{AE_1}$

(D) $\frac{PE_1}{AE_2}$

Sol. 10

Option (A) is correct.

The normal stress is given by

$$\sigma = \frac{P}{A}$$

We see that normal stress only depends on force and area and it does not depends on E.

Q. 11

GATE ME 2013 ONE MARK

Match the correct pairs:

Numerical Integration Scheme	Order of Fitting Polynomial
P. Simpson's 3/8 Rule	1. First
Q. Trapezoidal Rule	2. Second
R. Simpson's 1/3 Rule	3. Third

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

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

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

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

Sol. 11

Option (D) is correct.

Numerical Integration Scheme	Order of Fitting Polynomial
P. Simpson's 3/8 Rule	3. Third order
Q. Trapezoidal Rule	1. First order
R. Simpson's 1/3 Rule	2. Second order

Q. 12

GATE ME 2013 ONE MARK

The eigenvalues of a symmetric matrix are all

(A) Complex with non-zero positive imaginary part.

(B) Complex with non-zero negative imaginary part.

(C) real

(D) pure imaginary

Sol. 12

Option (C) is correct.

Let a square matrix

$$A = \begin{bmatrix} x & y \\ y & x \end{bmatrix}$$

The characteristic equation for the eigen value is given by

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

$$\begin{vmatrix} x-\lambda & y \\ y & x-\lambda \end{vmatrix} = 0$$

$$(x-\lambda)^2 - y^2 = 0$$

or $(x-\lambda)^2 = y^2$

or $x - \lambda = \pm y$

or $\lambda = x \pm y$ it is a real value.

So, eigen values are real if matrix is real and symmetric.

Q. 13 GATE ME 2013 ONE MARK

The partial differential equation $\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = \frac{\partial^2 u}{\partial x^2}$ is a

(A) linear equation of order 2
(B) non-linear equation of order 1
(C) linear equation of order 1
(D) non-linear equation of order 2

Sol. 13

Option (D) is correct.

We have

$$\frac{\partial^2 u}{\partial x^2} - u\frac{\partial u}{\partial x} - \frac{\partial u}{\partial t} = 0$$

Order is determined by the orders of the highest derivative present in it. So, it is a second order partial differential equation.

It is also a non-linear equation because in linear equation, the product of u with $\frac{\partial u}{\partial x}$ is not allow. Therefore, it is a second order, non-linear partial differential equation.

Q. 14 GATE ME 2013 ONE MARK

Choose the Correct set of functions, which are linearly dependent.

(A) $\sin x, \sin^2 x$ and $\cos^2 x$
(B) $\cos x, \sin x$ and $\tan x$
(C) $\cos 2x$, $\sin^2 x$ and $\cos^2 x$
(D) $\cos 2x, \sin x$ and $\cos x$

Sol. 14

Option (C) is correct.

We know

$$\cos 2x = 2\cos^2 x - 1$$

$$\cos 2x = 1 - 2\sin^2 x$$

$$\cos^2 x = 1 - \sin^2 x$$

The linear equation is given by

$$y = mx + c$$

This equation satisfy the above three equations, so that $\cos 2x$, $\sin^2 x$, $\cos^2 x$ are linearly dependent.

Q. 15 GATE ME 2013 ONE MARK

Let X be a normal random variable with mean 1 and variance 4. The probability $P\{X < 0\}$ is

(A) 0.5
(B) greater than zero and less the 0.5
(C) greater than 0.5 and less than 1.0
(D) 1.0

Sol. 15

Option (B) is correct.

The normal random variable is

$$X = N(\mu, \sigma)$$

Where $\mu = 1$ and $\sigma = 2$

Here $P(X < 0) = P\left(\frac{x-\mu}{\sigma} < \frac{0-1}{2}\right)$

$= P(z < -0.5)$

Where z = standard Normal Variable

$$= 0.5 - \phi(0.5)$$

Where value of $\phi(z)$ is always between 0.0 to 0.4999

Hence the probability

$$P\{X < 0\} = \text{greater than zero and less than } 0.5.$$

Q. 16

GATE ME 2013 ONE MARK

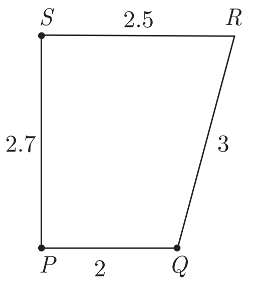
A planar closed kinematic chain is formed with rigid links $PQ = 2.0$ m, $QR = 3.0$ m, $RS = 2.5$ m and $SP = 2.7$ m with all revolute joints. The link to be fixed to obtain a double rocker (rocker-rocker) mechanism is

(A) PQ (B) QR

(C) RS (D) SP

Sol. 16

Option (C) is correct.



As given in problem, a planer closed kinematic chain is shown in above figure. In given figure, if the link opposite to the shortest link, i.e. link $RS = 2.5$ m is fixed and the shortest link PQ is made a coupler, the other two links QR and SP would oscillate. The mechanism is known as rocker-rocker or double-rocker or double lever or oscillating-oscillating converter.

Q. 17

GATE ME 2013 ONE MARK

If two nodes are observed at a frequency of 1800 rpm during whirling of a simply supported long slender rotating shaft, the first critical speed of the shaft in rpm is

(A) 200 (B) 450

(C) 600 (D) 900

Sol. 17

Option (A) is correct.

Since two nodes are observed at frequency of 1800 rpm, therefore third critical speed of shaft

$$f_3 = 1800 \text{ rpm}$$

because two nodes can be observed only in 3rd mode.

The whirling frequency of shaft

$$f = \frac{\pi}{2} \times n^2 \sqrt{\frac{g}{\delta}}$$

where n = Numbers of mode

For $n = 1$, $f_1 = \frac{\pi}{2}\sqrt{\frac{g}{\delta}}$

Therefore $f_n = n^2 \times f_1$

or $f_3 = 3^2 \times f_1$

or $f_1 = \frac{f_3}{(3)^2} = \frac{1800}{9} = 200$ rpm

Q. 18

GATE ME 2013 ONE MARK

A long thin walled cylindrical shell, closed at both the ends, is subjected to an internal pressure. The ratio of the hoop stress (circumferential stress) to longitudinal stress developed in the shell is

(A) 0.5 (B) 1.0
(C) 2.0 (D) 4.0

Sol. 18 Option (C) is correct.
Hoop stress or circumferential stress is

$$\sigma_1 = \frac{pr}{t}$$

and longitudinal or axial stress is

$$\sigma_2 = \frac{pr}{2t}$$

Ratio $$\frac{\sigma_1}{\sigma_2} = \frac{pr}{t} \times \frac{2t}{pr} = 2$$

Q. 19 A cylinder contains $5\,\mathrm{m}^3$ of an ideal gas at a pressure of 1 bar. This gas is compressed in a reversible isothermal process till its pressure increases to 5 bar. The work in kJ required for this process is

GATE ME 2013 ONE MARK

(A) 804.7 (B) 953.2
(C) 981.7 (D) 1012.2

Sol. 19 Option (A) is correct.
For Reversible isothermal Process work done is given by

$$W_{1-2} = p_1 v_1 \ln \frac{p_1}{p_2}$$
$$= 1 \times 10^5 \times 5 \times \ln\left(\frac{1}{5}\right)$$
$$= -804.7 \text{ kJ}$$

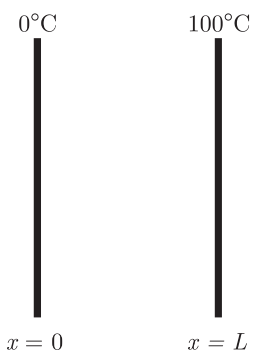
The negative sign shows that the compression process is taking place in this process.

Q. 20 Consider one-dimensional steady state heat conduction along x-axis $(0 \le x \le L)$, through a plane wall with the boundary surfaces $(x = 0 \text{ and } x = L)$ maintained at temperatures of 0°C and 100°C. Heat is generated uniformly throughout the wall. Choose the Correct statement.

GATE ME 2013 ONE MARK

(A) The direction of heat transfer will be from the surface at 100°C to the surface at 0°C.
(B) The maximum temperature inside the wall must be greater than 100°C.
(C) The temperature distribution is linear within the wall.
(D) The temperature distribution is symmetric about the mid-plane of the wall.

Sol. 20 Option (B) is correct.



The heat conduction one dimensional equation with heat generation is

$$\frac{d^2T}{dx^2} + \frac{q_g}{k} = 0$$

On integrating, we get

$$\frac{dT}{dx} = \frac{-q_g}{k}x + C_1$$

Again integrating,

$$T = -\frac{q_g}{k}\frac{x^2}{2} + C_1 x + C_2 \qquad ....(i)$$

we can see that it is a parabolic equation. Thus statement (C) is false.

Now Applying the boundary condition on Eq.(i)

$T(0) = 0$: $\quad 0 = C_1(0) + C_2 \Rightarrow C_2 = 0$ and

$T(L) = 100^\circ$C: $\quad 100 = \frac{-q_g L^2}{2k} + C_1 L$

or $\quad C_1 = \frac{100}{L} + \frac{q_g L}{2k}$

So that $\quad T = \frac{-q_g x^2}{2k} + \left(\frac{100}{L} + \frac{q_g L}{2k}\right)x$

For maximum temperature

$\frac{dT}{dx} = 0$: $\quad \frac{-q_g \times 2x}{2k} + \frac{100}{L} + \frac{q_g L}{2k} = 0$

or $\quad x = \frac{k}{q_g}\left(\frac{100}{L} + \frac{q_g L}{2k}\right)$

or $\quad x = \frac{100k}{q_g L} + \frac{L}{2} \qquad ...(ii)$

Also $\quad \frac{d^2T}{dx^2} = \frac{-q_g}{k}$ (Negative)

From Eq. (ii), it means the maximum temperature is inside the wall and it must be greater than 100°C.

Q. 21 GATE ME 2013 ONE MARK

In order to have maximum power from a Pelton turbine, the bucket speed must be

(A) equal to the jet speed

(B) equal to half of the jet speed.

(C) equal to twice the jet speed

(D) independent of the jet speed.

Sol. 21

Option (B) is correct.

The force imposed by the jet on the runner is equal but opposite to the rate of momentum change of the fluid.

$$\begin{aligned} F &= -m(V_f - V_i) \\ &= -\rho Q[(-V_i + 2u) - V_i] \\ &= -\rho Q(-2V_i + 2u) \\ &= 2\rho Q(V_i - u) \end{aligned}$$

where u is the bucket speed and V_i is the jet speed.

Power $\quad P = Fu$

$$= 2\rho Q(V_i - u)u$$

For maximum power

$$\frac{dP}{du} = 2\rho Q(V_i - 2u) = 0$$

or $\quad u = \frac{V_i}{2} \qquad 2\rho Q \neq 0$

Hence bucket speed (u) must be equal to half of the jet speed.

Q. 22 GATE ME 2013 ONE MARK

For a ductile material, toughness is a measure of

(A) resistance to scratching

(B) ability to absorb energy up to fracture

(C) ability to absorb energy till elastic limit

(D) resistance to indentation.

Sol. 22

Option (B) is correct.

For ductile material, toughness is a measure of ability to absorb energy of impact loading up to fracture.

Q. 23 GATE ME 2013 ONE MARK

A cube shaped solidifies in 5 min. The solidification time in min for a cube of the same material, which is 8 times heavier than the original casting, will be

(A) 10 (B) 20

(C) 24 (D) 40

Sol. 23

Option (B) is correct.

From Can's relation, Solidification time

$$t_s = C\left(\frac{\text{volume}}{\text{Surface Area}}\right)^2$$

where C = constant

Case I :

$$t_{s1} = \left(\frac{a^3}{6a^2}\right)^2 = \left(\frac{a}{6}\right)^2 \quad \text{...(i)}$$

volume of cube $= a^3$

Surface Area of cube $= 6a^2$

Case II :

$$\text{volume} = 8 \text{ times}$$
$$= 8a^3 = 2a \times 2a \times 2a$$

area of one surface $= 2a \times 2a$

$$= 4a^2$$

where $2a$ = side of cube

So that

$$t_{s2} = \left(\frac{8a^3}{6 \times 4a^2}\right)^2$$
$$= \left(\frac{2a}{6}\right)^2 = 4\left(\frac{a}{6}\right)^2 \quad \text{...(ii)}$$

From Eq. (i) and (ii), the desired ratio is given by

$$\frac{t_{s1}}{t_{s2}} = \frac{(a/6)^2}{4(a/6)^2} = \frac{1}{4}$$

or $t_{s2} = 4t_{s1} = 4 \times 5 = 20$ min

Q. 24 GATE ME 2013 ONE MARK

A steel bar 200 mm in diameter is turned at a feed of 0.25 mm/rev with a depth of cut of 4 mm. The rotational speed of the workpiece is 160 rpm. The material removal rate in mm^3/s is

(A) 160 (B) 167.6

(C) 1600 (D) 1675.5

Sol. 24

Option (D) is correct.

$$\text{MRR } (mm^3/s) = \text{feed} \times \text{depth} \times \text{cutting speed}$$
$$= f \times d \times V_C$$

where

$$V_C = \omega \times r = \frac{2\pi N}{60} \times r$$

Therefore $\text{MRR} = f \times d \times r \times \frac{2\pi N}{60}$

$$= 0.25 \times 4 \times \frac{200}{2} \times \frac{2\pi \times 160}{60}$$

$$= 1675.5 \text{ mm}^3/\text{s}$$

Q. 25

GATE ME 2013 ONE MARK

In simple exponential smoothing forecasting, to give higher weightage to recent demand information, the smoothing constant must be close to

(A) –1

(B) zero

(C) 0.5

(D) 1.0

Sol. 25

Option (D) is correct.

Higher weightage given to recent demand, therefore $F_t = D_t$

$$F_t = F_{t-1} + \alpha(D_t - F_{t-1})$$

or $$= F_{t-1}(1-\alpha) + D_t$$

Thus from the given condition

$$F_{t-1}(1-\alpha) = 0$$

or $$\alpha = 1$$

The values of smoothing constant (α) lie between 0 and 1. A low value of α gives more weightage to the past series and less weightage to the recent demand information. Hence, in simple exponential smoothing forecasting, higher value of α, i.e. 1, gives higher weightage to recent demand information and less weightage to the past series.

Q. 26

GATE ME 2013 TWO MARK

A linear programming problem is shown below.

Maximize $3x + 7y$

Subject to $3x + 7y \le 10$

$4x + 6y \le 8$

$x, y \ge 0$

It has

(A) an unbounded objective function

(B) exactly one optimal solution.

(C) exactly two optimal solutions.

(D) infinitely many optimal solutions

Sol. 26

Option (B) is correct.

We have

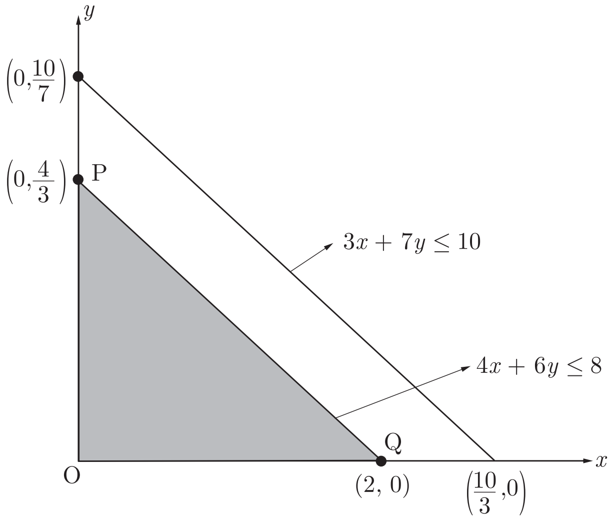
Maximize $3x + 7y$

Subject to $3x + 7y \le 10$

$4x + 6y \le 8$

$x, y \ge 0$

From these equation, we have



The solution of the given problem must lie in the shaded area. One of the points O, P and Q of shaded area must give the optimum solution of problem. So

At $P(0, 4/3)$, $\quad Z = 3 \times 0 + 7 \times \frac{4}{3} = \frac{28}{3} = 9.33$

and at $Q(2, 0)$, $\quad Z = 3 \times 2 + 7 \times 0 = 6$

Hence, there is only a single optimal solution of the problem which is at point $P(0, 4/3)$.

Q. 27
GATE ME 2013 TWO MARK

In a CAD package, mirror image of a 2D point $P(5, 10)$ is to be obtained about a line which passes through the origin and makes an angle of 45° counterclockwise with the X-axis. The coordinates of the transformed point will be

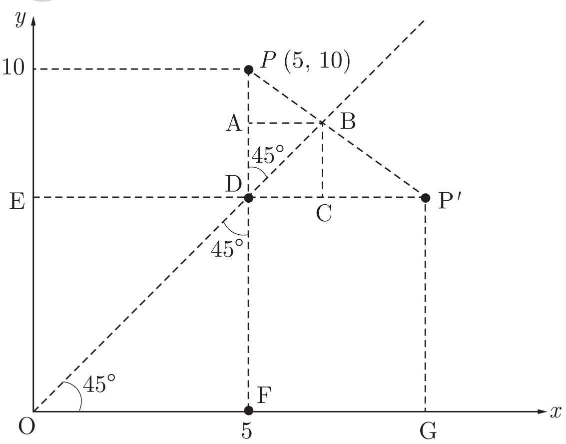
(A) (7.5, 5) (B) (10, 5)

(C) (7.5, –5) (D) (10, –5)

Sol. 27

Option (B) is correct.

From the given condition the 2D point is shown below:



The mirror image of point P is P'. From the figure

$$DE = OF = 5 \text{ and } DP = 5$$

Now $\quad PB = PD \sin 45^\circ = \frac{5}{\sqrt{2}}$

and $\quad BD = PD \cos 45^\circ = \frac{5}{\sqrt{2}}$

Now Because of mirror image

$$BP = BP' = \frac{5}{\sqrt{2}}$$

From the triangle BDP'

$$DP' = \sqrt{BD^2 + P'B^2}$$
$$= \sqrt{\frac{25}{2} + \frac{25}{2}}$$
$$= 5$$

Similarly for y coordinate of P', the symmetricity gives

$$P'G = 5$$

Hence the coordinates of P' becomes

$$P'(5+5, 5)$$
$$P'(10, 5)$$

Q. 28 GATE ME 2013 TWO MARK

Two cutting tools are being compared for a machining operation. The tool life equations are:

Carbide tool : $VT^{1.6} = 3000$

HSS tool: $VT^{0.6} = 200$

where V is the cutting speed in m/min and T is the tool life in min. The carbide tool will provide higher tool life if the cutting speed in m/min exceeds

(A) 15.0 (B) 39.4

(C) 49.3 (D) 60.0

Sol. 28

Option (B) is correct.

We have

For carbide tool : $VT^{1.6} = 3000$ ....(i)

For HSS tool : $VT^{0.6} = 200$ ...(ii)

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

$$\frac{VT^{1.6}}{VT^{0.6}} = \frac{3000}{200}$$

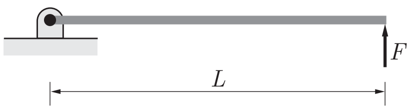
or $T = 15\,\text{min}$

Now for carbide tool

$$V = \frac{3000}{T^{1.6}}$$
$$= \frac{3000}{(15)^{1.6}} = 39.4\ \text{m/min}$$

Q. 29 GATE ME 2013 TWO MARK

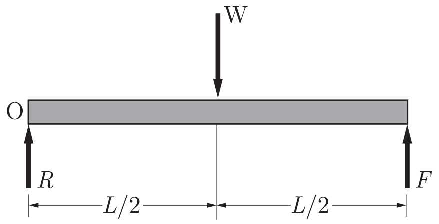
A pin joined uniform rigid rod of weight W and length L is supported horizontally by an external force F as shown in figure below. The force F is suddenly removed. At the instant of force removal, the magnitude of vertical reaction developed at the support is



(A) zero (B) $W/4$

(C) $W/2$ (D) W

Sol. 29 Option (B) is correct.



When the Force F is suddenly remove, then due to W, the rod is in rotating condition with angular acceleration α.
Thus equation of motion

$$\Sigma M_O = I_O \alpha$$

$$\frac{WL}{2} = I_O \alpha = \frac{mL^2}{3}\alpha$$

or $$\frac{mgL}{2} = \frac{mL^2}{3}\alpha$$

or $$\alpha = \frac{3g}{2L}$$

Also the centre of the rod accelerate with linear acceleration a. Thus from FBD of rod

$$W - R = ma$$

$$mg - R = ma \qquad \text{...(i)}$$

From the relation of linear and angular acceleration, we have

$$a = r\alpha$$

$$= \frac{L}{2} \times \frac{3g}{2L} = \frac{3g}{4}$$

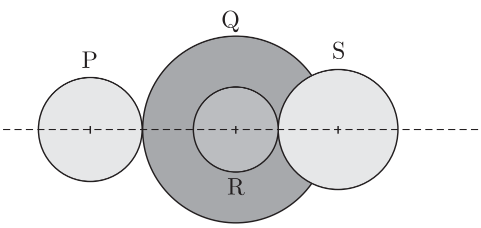
Substitute this value in equation (i), we obtain

$$R = mg - m \times \frac{3g}{4}$$

$$R = \frac{mg}{4} = \frac{W}{4}$$

Q. 30 GATE ME 2013 TWO MARK

A compound gear train with gears P, Q, R and S has number of teeth 20, 40, 15 and 20, respectively. Gears Q and R are mounted on the same shaft as shown in the figure below. The diameter of the gear Q is twice that of the gear R. If the module of the gear R is 2 mm, the center distance in mm between gears P and S is.



(A) 40
(B) 80
(C) 120
(D) 160

Sol. 30 Option (B) is correct.
We have
$Z_P = 20,\ Z_Q = 40,\ Z_R = 15,\ Z_S = 20,\ D_Q = 2D_R,\ m_R = 2\text{ mm}$

module $m_R = \frac{D_R}{Z_R}$

or $D_R = 2 \times 15 = 30$ mm

and $D_Q = 2 \times 30 = 60$ mm

Also $\frac{D_P}{D_Q} = \frac{Z_P}{Z_Q}$

or $D_P = \frac{20}{40} \times 60 = 30$ mm

Again $D_S = \frac{Z_S}{Z_R} \times D_R$

$= \frac{20}{15} \times 30 = 40$ mm

Thus the centre distance between P and S is

$$d_{PS} = \frac{D_P}{2} + \frac{D_Q}{2} + \frac{D_R}{2} + \frac{D_S}{2}$$

$$= 15 + 30 + 15 + 20 = 80 \text{ mm}$$

Q. 31 GATE ME 2013 TWO MARK

A flywheel connected to a punching machine has to supply energy of 400 Nm while running at a mean angular speed of 20 rad/s. If the total fluctuation of speed is not to exceed $\pm 2\%$, the mass moment of inertia of the flywheel in kg-m^2 is

(A) 25 (B) 50

(C) 100 (D) 125

Sol. 31

Option (A) is correct.

We have $E = 400$ N-m, $\omega = 20$ rad/ sec, $C_s = 0.04$

The energy of flywheel is given by

$$E = I\omega^2 C_s$$

or $I = \frac{E}{\omega^2 C_s}$

$$= \frac{400}{(20)^2 \times 0.04} = 25 \text{ kg-m}^2$$

Q. 32 GATE ME 2013 TWO MARK

A steel ball of diameter 60 mm is initially in thermal equilibrium at 1030°C in a furnace. It is suddenly removed from the furnace and cooled in ambient air at 30°C, with convective heat transfer cofficient $h = 20$ W/m^{2}K. The thermo-physical properties of steel are: density $\rho = 7800$ kg/m^2, conductivity $k = 40$ W/m^{2}K and specific heat $c = 600$ J/kg K. The time required in seconds to cool the steel ball in air from 1030°C to 430°C is

(A) 519 (B) 931

(C) 1195 (D) 2144

Sol. 32

Option (D) is correct.

We have $d = 60$ mm, $T_i = 1030$ °C, $T_a = 30$ °C, $h = 20$ W/m^{2}K, $T = 430$ °C

$\rho = 7800$ kg/m^2, $k = 40$ W/m^{2}K, $c = 600$ J/kg K

The characteristic length is

$$l = \frac{\text{Volume}}{\text{Surface area}}$$

$$= \frac{\frac{4}{3}\pi r^3}{4\pi r^2} = \frac{r}{3} = \frac{0.030}{3} = 0.010 \text{ m}$$

Biot number $Bi = \frac{hl}{k} = \frac{(20)(0.01)}{40} = 0.005 < 0.1$

Thus, applying the lumped analysis formula

$$\frac{T-T_a}{T_i-T_a} = \exp\left(\frac{-hAt}{\rho vc}\right) = \exp\left(\frac{-ht}{\rho lc}\right)$$

or $$\frac{430-30}{1030-30} = \exp\left(\frac{-20t}{7800\times 0.01\times 600}\right)$$

or $$\frac{2}{5} = \exp\left(\frac{-t}{2340}\right)$$

or $$\ln\left(\frac{2}{5}\right) = \frac{-t}{2340}$$

or $$t = 2144 \text{ sec}$$

Q. 33

GATE ME 2013 TWO MARK

Specific enthalpy and velocity of steam at inlet and exit of a steam turbine, running under steady state, are as given below:

	Specific enthalpy (kJ/kg)	Velocity (m/s)
Inlet steam condition	3250	180
Exit steam condition	2360	5

The rate of heat loss from the turbine per kg of steam flow rate is 5 kW. Neglecting changes in potential energy of steam, the power developed in kW by the steam turbine per kg of steam flow rate is

(A) 901.2 (B) 911.2

(C) 17072.5 (D) 17082.5

Sol. 33

Option (A) is correct.

From energy balance equation for steady flow system

$$E_{in} = E_{out}$$

$$h_1 + \frac{V_1^2}{2} + gz_1 + dQ = h_2 + \frac{V_2^2}{2} + gz_2 + dW \quad \text{For negligible P.E. } gz_1 = gz_2 = 0$$

or $$dW = (h_1 - h_2) + \frac{V_1^2 - V_2^2}{2\times 1000} + dQ$$

$$= (3250-2360) + \frac{[(180)^2-(5)^2]}{2\times 1000} - 5$$

$$= 890 + 16.1875 - 5$$

$$= 901.2 \text{ kW/kg}$$

Q. 34

GATE ME 2013 TWO MARK

Water is coming out from a tap and falls vertically downwards. At the tap opening, the stream diameter is 20 mm with uniform velocity of 2 m/s. Acceleration due to gravity is 9.81 m/s^2. Assuming steady, inviscid flow, constant atmospheric pressure everywhere and neglecting curvature and surface tension effects, the diameter in mm of the stream 0.5 m below the tap is approximately.

(A) 10 (B) 15

(C) 20 (D) 25

Sol. 34

Option (B) is correct.

Applying the bernoulli's equation at the tap opening and the 0.5 m below the tap

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

or $$\frac{V_2^2 - V_1^2}{2g} = Z_1 - Z_2 \qquad (p_1 = p_2)$$

or $V_2^2 - V_1^2 = (Z_1 - Z_2)2g$ $\quad Z_1 - Z_2 = 0.5\text{ m}$

or $V_2^2 = 2 \times 9.81 \times 0.5 + (2)^2$ $\quad V_1 = 2\text{ m/sec}$

or $V_2 = 3.72\text{ m/sec}$

Now applying the continuity equation

$$A_1 V_1 = A_2 V_2$$

$$\frac{\pi}{4} d_1^2 V_1 = \frac{\pi}{4} d_2^2 V_2$$

or $$d_2^2 = \frac{V_1}{V_2} d_1^2 = \frac{2}{3.72} \times (20)^2$$

$$d_2 = 15\text{ mm}$$

Q. 35 GATE ME 2013 TWO MARK

The function $f(t)$ satisfies the differential equation $\frac{d^2f}{dt^2} + f = 0$ and the auxillary conditions, $f(0) = 0, \frac{df}{dt}(0) = 4$. The Laplace Transform of $f(t)$ is given by

(A) $\frac{2}{s+1}$ (B) $\frac{4}{s+1}$

(C) $\frac{4}{s^2+1}$ (D) $\frac{2}{s^4+1}$

Sol. 35

Option (C) is correct.

We have $$\frac{d^2f}{dt^2} + f = 0$$

$$(D^2 + 1)f = 0$$

The auxiliary equation is

$$m^2 + 1 = 0$$

$$m = \pm 1$$

Thus the solution of this equation becomes

$$f(t) = C_1 \cos x + C_2 \sin x$$

and $$\frac{df}{dt} = - C_1 \sin x + C_2 \cos x$$

From given conditions $f(0) = 0$

$$C_1 = 0$$

and $$\frac{df}{dt}(0) = 4$$

$$4 = C_2 + 0 \Rightarrow C_2 = 4$$

So that $f(t) = 4 \sin x$

Hence, the laplace transform is

$$L\, f(t) = 4L[\sin x]$$

$$= \frac{4}{s^2+1}$$

Q. 36 GATE ME 2013 TWO MARK

The following surface integral is to be evaluated over a sphere for the given steady velocity vector field $F = xi + yj + zk$ defined with respect to a Cartesian coordinate system having i, j and k as unit base vectors.

$$\iint_S \frac{1}{4}(F \cdot n)\, dA$$

where S is the sphere, $x^2 + y^2 + z^2 = 1$ and n is the outward unit normal vector to the sphere. The value of the surface integral is

(A) π (B) 2π

(C) $3\pi/4$ (D) 4π

Sol. 36 Option (A) is correct.

We have $F = xi + yj + zk$

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

We know, the Gauss divergence theorem is

$$\iint_S (F \cdot n) dA = \iiint_V (\nabla \cdot F) dV$$

Thus the gauss theorem transformed surface integral to volume integral.

$$\nabla \cdot F = \left(\frac{\partial}{\partial x} i + \frac{\partial}{\partial y} j + \frac{\partial}{\partial y} k\right) \cdot (xi + yj + zk)$$

$$= 1 + 1 + 1 = 3$$

So that $$\iiint_V (\nabla \cdot F) dV = \iiint_V 3dV$$

$$= 3 \times \text{volume of sphere}$$

$$= 3 \times \frac{4}{3}\pi \times (1)^3 = 4\pi$$

Hence the given integral becomes

$$\iint_S \frac{1}{4}(F \cdot n) dA = \frac{1}{4} \times 4\pi = \pi$$

Q. 37 The value of the definite integral $\int_1^e \sqrt{x} \ln(x) dx$ is

GATE ME 2013 TWO MARK

(A) $\frac{4}{9}\sqrt{e^3} + \frac{2}{9}$ (B) $\frac{2}{9}\sqrt{e^3} - \frac{4}{9}$

(C) $\frac{2}{9}\sqrt{e^3} + \frac{4}{9}$ (D) $\frac{4}{9}\sqrt{e^3} - \frac{2}{9}$

Sol. 37 Option (C) is correct.

Let $I = \int_1^e \sqrt{x} \ln(x) dx$

From ILATE, consider $\ln(x)$ as first and $\sqrt{x}$ as second function.

$$I = \ln(x) \int_1^e \sqrt{x}\, dx - \int_1^e \left[\frac{d}{dx} \ln(x) \int_1^e \sqrt{x}\, dx\right] dx$$

$$= \left[\ln(x) \times \frac{2}{3} x^{3/2}\right]_1^e - \int_1^e \frac{1}{x} \times \frac{2}{3} x^{3/2} dx$$

$$= \left[\frac{2}{3} e^{3/2} - 0\right] - \left[\frac{2}{3} \times \frac{2}{3} x^{3/2}\right]_1^e$$

$$= \frac{2}{3} e^{3/2} - \frac{4}{9}[e^{3/2} - 1]$$

$$= \frac{2}{3} e^{3/2} - \frac{4}{9} e^{3/2} + \frac{4}{9}$$

$$= \frac{2}{9} e^{3/2} + \frac{4}{9} = \frac{2}{9}\sqrt{e^3} + \frac{4}{9}$$

Q. 38 The solution of the differential equation $\frac{d^2u}{dx^2} - k\frac{du}{dx} = 0$ where k is a constant, subjected to the boundary conditions $u(0) = 0$ and $u(L) = U$, is

GATE ME 2013 TWO MARK

(A) $u = U\frac{x}{L}$ (B) $u = U\left(\frac{1 - e^{kx}}{1 - e^{kL}}\right)$

(C) $u = U\left(\frac{1 - e^{-kx}}{1 - e^{-kL}}\right)$ (D) $u = U\left(\frac{1 + e^{kx}}{1 + e^{kL}}\right)$

Sol. 38 Option (B) is correct.

We have $$\frac{d^2u}{dx^2} - k\frac{du}{dx} = 0$$

or $(D^2 - kD)u = 0$

The auxiliary equation is

$$m^2 - km = 0$$

$$m(m-k) = 0$$

or $m = 0, k$

Thus the complete solution is

$$u = C_1 e^{0x} + C_2 e^{kx}$$

or $u = C_1 + C_2 e^{kx}$

From the given condition

$u(0) = 0$: $0 = C_1 + C_2$

$$C_1 + C_2 = 0 \qquad \text{....(i)}$$

and

$u(L) = U$: $U = C_1 + C_2 e^{kL}$ ....(ii)

Subtracting equation (i) from (ii), we get

$$U = C_2(e^{kL} - 1)$$

or $C_2 = \dfrac{U}{(e^{kL} - 1)}$

From equation (i), we have

$$C_1 = -C_2 = \frac{-U}{(e^{kL} - 1)}$$

Substitute these values in the expression for u, we get

$$u = \frac{-U}{(e^{kL} - 1)} + \frac{U}{(e^{kL} - 1)} e^{kx}$$

or $u = U\left(\dfrac{1 - e^{kx}}{1 - e^{kL}}\right)$

Q. 39

GATE ME 2013 TWO MARK

The probability that a student knows the correct answer to a multiple choice question is $\frac{2}{3}$. If the student does not know the answer, then the student guesses the answer. The probability of the guessed answer being correct is $\frac{1}{4}$. Given that the student has answered the question correctly, the conditional probability that the student knows the correct answer is

(A) $\frac{2}{3}$

(B) $\frac{3}{4}$

(C) $\frac{5}{6}$

(D) $\frac{8}{9}$

Sol. 39

Option (D) is correct.

Let A be the event when student knows the answer and B be the event when student guesses the answer. Therefore

$$P(A) = P(A \cap B) = \frac{2}{3}$$

and $P(B) = \dfrac{2}{3} + \dfrac{1}{3} \times \dfrac{1}{4} = \dfrac{9}{12}$

where $\frac{2}{3}$ is the probability of correct answer and $\frac{1}{3}$ is the probability that student does not know the answer. So guesses the answer and probability of correct guess is $\frac{1}{4}$. Therefore total probability of correct answer

$$= \frac{2}{3} + \frac{1}{3} \times \frac{1}{4} = \frac{9}{12}$$

Conditional probability that student knows the correct answer

$$P(A/B) = \frac{P(A \cap B)}{P(B)}$$
$$= \frac{2}{3} \div \frac{9}{12} = \frac{8}{9}$$

Q. 40

GATE ME 2013 TWO MARK

The pressure, temperature and velocity of air flowing in a pipe are 5 bar, 500 K and 50 m/s, respectively. The specific heats of air at constant pressure and at constant volume are 1.005 kJ/kg K and 0.718 kJ/kg K, respectively. Neglect potential energy. If the pressure and temperature of the surrounding are 1 bar and 300 K, respectively, the available energy in kJ/kg of the air stream is

(A) 170 (B) 187

(C) 191 (D) 213

Sol. 40

Option (B) is correct.

We have, in pipe

$$p = 5\text{ bar} = 5 \times 10^5\text{ Pa},\ T = 500\text{ K},\ V = 50\text{ m/sec}$$
$$c_p = 1.005\text{ kJ/kg K},\ c_v = 0.718\text{ kJ/kg K}$$

For surrounding air

$$p_0 = 1\text{ bar} = 1 \times 10^5\text{ Pa},\ T_0 = 300\text{ K}$$

Available energy function is

$$\psi = (h - h_0) - T_0(S - S_0) + \frac{V^2}{2} + gz$$

Given, the potential energy is negligible. Thus

$$\psi = (h - h_0) - T_0(S - S_0) + \frac{V^2}{2}$$

The entropy is given by

$$S = c_p \ln T - R\ln p \text{ and } h = c_p T$$

So that
$$\psi = c_p(T - T_0) - T_0\left[c_p \ln T - R\ln p - c_p \ln T_0 + R\ln p_0 + \frac{V^2}{2}\right]$$

$$\psi = c_p(T - T_0) - T_0\left[c_p \ln\left(\frac{T}{T_0}\right) - R\ln\left(\frac{p}{p_0}\right)\right] + \frac{V^2}{2}$$

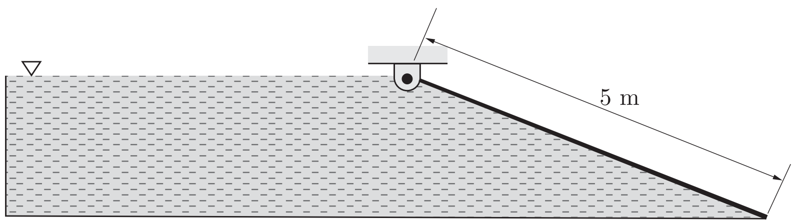
$$= 1.005(500 - 300) - 300\left[1.005 \times \ln\left(\frac{500}{300}\right) - 0.287 \times \ln\left(\frac{5}{1}\right)\right] + \frac{(50)^2}{2 \times 1000}$$

$$= 187\text{ kJ/kg}$$

Q. 41

GATE ME 2013 TWO MARK

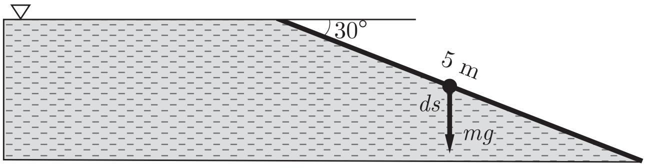
A hinged gate of length 5 m, inclined at 30° with the horizontal and with water mass on its left, is shown in the figure below. Density of water is 1000 kg/m^3. The minimum mass of the gate in kg per unit width (perpendicular to the plane of paper), required to keep it closed is



(A) 5000 (B) 6600

(C) 7546 (D) 9623

Sol. 41 Option (D) is correct.



Here mg shows the weight of the gate, where m is the mass of the gate.

In equilibrium condition

Torque due to pressure of water = Torque due to weight of the plate

Now Torque due to pressure at distance s for infinitesimal length (pressure force acts normal to the surface)

$$T_0 = (pgy\,ds)s$$
$$= \rho g s^2 \sin\theta ds$$
$$= \rho g \sin\theta s^2 ds$$

Torque due to weight of the gate is

$$= mg \times \frac{L}{2}\cos\theta$$

Thus $$\int_0^L \rho g \sin\theta s^2 ds = mg \times \frac{L}{2}\cos\theta$$

or $$m = \frac{2\rho L^2 \tan\theta}{3}$$
$$= \frac{2}{3}\times 10^3 \times (5)^2 \times \tan 30^\circ$$
$$= 9623\text{ kg}$$

Q. 42 GATE ME 2013 TWO MARK

Two large diffuse gray parallel plates, separated by a small distance, have surface temperatures of 400 K and 300 K. If the emissivities of the surface are 0.8 and the Stefan-Boltzmann constant is $5.67 \times 10^{-8}\text{ W/m}^2\text{K}^4$, the net radiation heat exchanges rate in kW/m^2 between the two plates is

(A) 0.66 (B) 0.79

(C) 0.99 (D) 3.96

Sol. 42 Option (A) is correct.

As both the plates are gray, the net radiation heat exchange between the two plates is

$$Q_{12} = \frac{\varepsilon_1\varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1\varepsilon_2}\sigma_b(T_1^4 - T_2^4)$$
$$= \frac{0.8\times 0.8}{0.8 + 0.8 - 0.8\times 0.8}\times 5.67\times 10^{-8}[(400)^4 - (300)^4]$$
$$= 661\text{ W/m}^2$$
$$= 0.66\text{ kW/m}^2$$

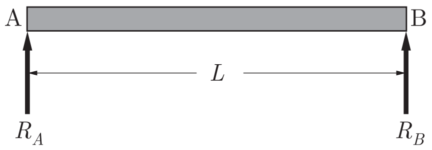
Q. 43 GATE ME 2013 TWO MARK

A simply supported beam of length L is subjected to a varying distributed load $\sin(3\pi x/L)\text{ Nm}^{-1}$, where the distance x is measured from the left support. The magnitude of the vertical reaction force in N at the left support is

(A) zero (B) $L/3\pi$

(C) L/π (D) $2L/\pi$

Sol. 43 Option (B) is correct.



Total load on the beam

$$F = \int_0^L \sin\left(\frac{3\pi x}{L}\right)dx$$

$$= \left[-\cos\left(\frac{3\pi x}{L}\right) \times \frac{L}{3\pi}\right]_0^L$$

$$= -\left[\frac{-L}{3\pi} - \frac{L}{3\pi}\right] = \frac{2L}{3\pi}$$

This load acting at the centre of the beam because of the sin function. Now taking the moment about point B, we have

$$\Sigma M_B = 0$$

$$R_A \times L = \frac{2L}{3\pi} \times \frac{L}{2}$$

$$R_A = \frac{L}{3\pi}$$

Q. 44 A bar is subjected to fluctuating tensile load from 20 kN to 100 kN. The material has yield strength of 240 MPa and endurance limit in reversed bending is 160 MPa. According to the Soderberg principle, the area of cross-section in mm^2 of the bar for a factor of safety of 2 is

GATE ME 2013 TWO MARK

(A) 400
(B) 600
(C) 750
(D) 1000

Sol. 44 Option (D) is correct.

Given $F_{min} = 20$ kN, $F_{max} = 100$ kN, $\sigma_y = 240$ MPa $= 240$ N/mm^2, $FOS = 2$

$\sigma_e = 160$ MPa $= 160$ N/mm^2

$$\sigma_{min} = \frac{F_{min}}{\text{Area}} = \frac{20 \times 10^3}{A}$$

$$\sigma_{max} = \frac{F_{max}}{\text{Area}} = \frac{100 \times 10^3}{A}$$

Now $$\sigma_{mean} = \frac{\sigma_{max} + \sigma_{min}}{2}$$

$$= \frac{120 \times 10^3}{2A} = \frac{60 \times 10^3}{A}$$

and $$\sigma_v = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$= \frac{80 \times 10^3}{2A} = \frac{40 \times 10^3}{A}$$

According to soderberg's criterion

$$\frac{1}{FOS} = \frac{\sigma_m}{\sigma_y} + \frac{\sigma_v}{\sigma_e}$$

or $$\frac{1}{2} = \frac{60 \times 10^3}{240A} + \frac{40 \times 10^3}{160A}$$

or $$\frac{1}{2} = \frac{10^3}{4A} + \frac{10^3}{4A}$$

or $$A = 1000\text{ mm}^2$$

Q. 45
GATE ME 2013 TWO MARK

A single degree of freedom system having mass 1 kg and stiffness 10 kN/m initially at rest is subjected to an impulse force of magnitude 5 kN for 10^{-4} sec. The amplitude in mm of the resulting free vibration is

(A) 0.5 (B) 1.0

(C) 5.0 (D) 10.0

Sol. 45

Option (C) is correct.

Given $m = 1\text{ kg}, k = 10\text{ kN/m}, u = 0, F = 5\text{ kN}, t = 10^{-4}\text{sec}$

Here the time duration is very less.

The acceleration is calculated by

$$F = ma$$

$$a = \frac{F}{m} = \frac{5000}{1} = 5000\text{ m/sec}^2$$

Also from law of motion

$$v = u + at$$

$$v = 0 + 5000 \times 10^{-4}$$

$$= 0.5\text{ m/sec}$$

Now equating the energies of the system and spring by using conservation law.

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

or $$x^2 = \frac{mv^2}{k} = \frac{1 \times (0.5)^2}{10000}$$

or $$x = 5 \times 10^{-3}\text{ m} = 5\text{ mm}$$

Q. 46
GATE ME 2013 TWO MARK

During the electrochemical machining (ECM) of iron (atomic weight $= 56$, valency $= 2$) at current of 1000 A with 90% current efficiency, the material removal rate was observed to be 0.26 gm/s. If Titanium (atomic weight $= 48$, valency $= 3$) is machined by the ECM process at the current of 2000 A with 90% current efficiency, the expected material removal rate in gm/s will be

(A) 0.11 (B) 0.23

(C) 0.30 (D) 0.52

Sol. 46

Option (C) is correct.

The material removal rate is given by

$$MRR = \frac{IA}{FV} \times \eta$$

where for titanium

$$I = \text{current} = 2000\text{ A}$$

$$A = \text{Atomic weight} = 48$$

$$F = \text{Faradays constant} = 96500\text{ coulombs}$$

$$V = \text{valency} = 3$$

$$\eta = \text{Efficiency} = 90\% = 0.90$$

So that $$MRR = \frac{2000 \times 48}{96500 \times 3} \times 0.90$$

$$= 0.30$$

Q. 47

GATE ME 2013 TWO MARK

Cylindrical pins of $25^{+0.020}_{+0.010}$ mm diameter are electroplated in a shop. Thickness of the plating is $30^{\pm 2.0}$ micron. Neglecting gage tolerances, the size of the GO gage in mm to inspect the plated components is

(A) 25.042 (B) 25.052

(C) 25.074 (D) 25.084

Sol. 47

Option (D) is correct.

Go gauge is always entered into acceptable component, so that it is always made for the maximum material unit of the component.

We have

$$\text{Cylinderical pin} = 25^{+0.020}_{+0.010}\,\text{mm}$$
$$\text{plating} = 30^{\pm 2.0}\,\text{microns}$$

Thus maximum thickness of plating

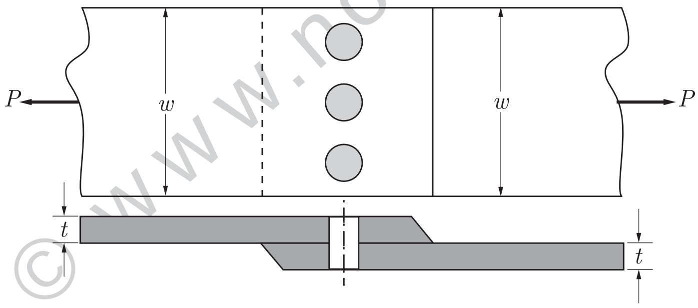
$$= 0.03 + 0.002 = 0.032\,\text{mm}$$

Thus size of GO-gauge is

$$= 25.02 + 0.032 \times 2$$
$$= 25.084\,\text{mm}$$

Common Data For Q.Common Data for Question 48 and 49

A single riveted lap joint of two similar plates as shown in the figure below has the following geometrical and material details.



width of the plate $w = 200$ mm, thickness of the plate $t = 5$ mm, number of rivets $n = 3$, diameter of the rivet $d_r = 10$ mm, diameter of the rivet hole $d_h = 11$ mm, allowable tensile stress of the plate $\sigma_p = 200$ MPa, allowable shear stress of the rivet $\sigma_s = 100$ MPa and allowable stress of the rivet $\sigma_c = 150$ MPa.

Q. 48

GATE ME 2013 TWO MARK

If the plates are to be designed to avoid tearing failure, the maximum permissible load P in kN is

(A) 83 (B) 125

(C) 167 (D) 501

Sol. 48

Option (C) is correct.

If the rivets are to be designed to avoid crushing failure, maximum permissible load

$$P = \sigma_p \times A$$

where for crushing failure $A = (w - 3d_{hole}) \times t$

So that
$$P = (w - 3d_{hole}) \times t \times \sigma_p$$
$$= (200 - 3 \times 11) \times 5 \times 200$$
$$= 167000\,\text{N} = 167\,\text{kN}$$

Q. 49 GATE ME 2013 TWO MARK

If the rivets are to be designed to avoid crushing failure, the maximum permissible load P in kN is

(A) 7.50 (B) 15.00

(C) 22.50 (D) 30.00

Sol. 49

Option (C) is correct.

For Design against tearing failure, maximum permissible load

$$P = n.d_{rivet} \times t \times \sigma_c$$
$$= 3 \times 10 \times 5 \times 150$$
$$= 22500 \text{ N} = 22.5 \text{ kN}$$

Common Data Question 50 and 51

Water (specific heat, $c_p = 4.18$ kJ/kg-K) enters a pipe at a rate of 0.01 kg/s and a temperature of 20°C. The pipe of diameter 50 mm and length 3 m, is subjected to a wall heat flux q_w'' in W/m^2

Q. 50 GATE ME 2013 TWO MARK

If $q_w''= 5000$ and the convection heat transfer coefficient at the pipe outlet is 1000 W/m^{2}K, the temperature in °C at the inner surface of the pipe at the outlet is

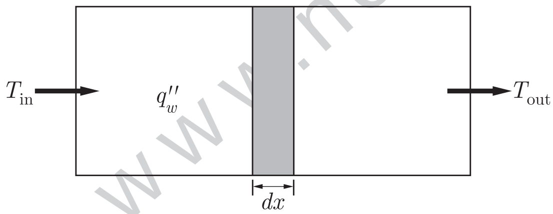
(A) 71 (B) 76

(C) 79 (D) 81

Sol. 50

Option (D) is correct.

We have $d = 0.05$ m, $L = 3$ m, $c_p = 4.18$ kJ/kg K, $h = 1000$ W/m^{2}K



Now $\int_0^L q''_w \, 2\pi r dx = q_w'' 2\pi r L = \dot{m} c_p (T_{out} - T_{in})$

or $\dfrac{q_w'' \pi d L}{\dot{m} c_p} + T_{in} = T_{out}$

or $T_{out} = 20 + \dfrac{5000 \times 3.14 \times 0.05 \times 3}{0.01 \times 4.18 \times 10^3}$

$= 76.36$ K

Now for wall temperature at outlet

$$q_w'' = h(T_\omega - T_{out})$$

or $T_\omega = \dfrac{q_w''}{h} + T_{out} = \dfrac{5000}{1000} + 76.36$

$= 81.36°\text{C} \backsimeq 81°\text{C}$

Q. 51 GATE ME 2013 TWO MARK

If $q_w''= 2500x$, where x is in m and in the direction of flow ($x = 0$ at the inlet), the bulk mean temperature of the water leaving the pipe in °C is

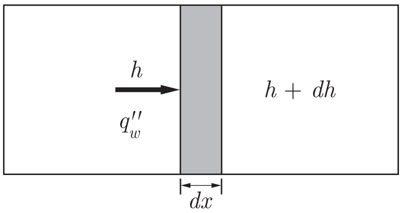
(A) 42 (B) 62

(C) 74 (D) 104

Sol. 51 Option (B) is correct.

We have

$$q_w'' = 2500\,x$$



Due to heat transfer from wall, the enthalpy changes, from inlet to outlet.

Now $$q_w'' dA = \dot{m} c_p dT_m$$

Where $$dT_m = \text{Bulk mean Temperature}$$

$$2500x \times 2\pi r dx = \dot{m} c_p dT_m$$

Integrating both the sides, we get

$$5000\pi r \int_0^L x dx = \dot{m} c_p \int dT_m$$

$$= \dot{m} c_p (T_{out,m} - T_{in,m})$$

or $$\frac{5000}{2} \frac{\pi d L^2}{2} = \dot{m} c_p (T_{out,m} - 20)$$

or $$T_{out,m} = 20 + \frac{1250 \times \pi \times 0.05 \times (3)^2}{(0.01 \times 4.18 \times 10^3)}$$

$$= 20 + 42.27$$

$$= 62.27^\circ\text{C} \simeq 62^\circ\text{C}$$

Statement for Linked Answer Question 52 and 53

In orthogonal turning of a bar of 100 mm diameter with a feed of 0.25 mm/rev, depth of cut of 4 mm and cutting velocity of 90 m/min, it is observed that the main (tangential) cutting force is perpendicular to the friction force acting at the chip-tool interface. The main (tangential) cutting force is 1500 N.

Q. 52 The orthogonal rake angle of the cutting tool in degree is

GATE ME 2013 TWO MARK

(A) zero (B) 3.58

(C) 5 (D) 7.16

Sol. 52 Option (A) is correct.

Since it is given that the main (tangential) cutting force is perpendicular to friction force acting at the chip-tool interface, therefore rake angle

$$\alpha = 0^\circ$$

Q. 53 The normal force acting at the chip-tool interface in N is

GATE ME 2013 TWO MARK

(A) 1000 (B) 1500

(C) 2000 (D) 2500

Sol. 53 Option (B) is correct.

Since normal force is given by

$$N = F_C \cos\alpha - F_r \sin\alpha$$

and $\alpha = 0^\circ$ (from previous question)

$$N = F_C \cos\alpha$$

or $$N = F_C = 1500\text{ N}$$

Statement for Linked Answer Question 54 and 55

In a simple Brayton cycle, the pressure ratio is 8 and temperatures at the entrance of compressor and turbine are 300 K and 1400 K, respectively. Both compressor and gas turbine have isentropic efficiencies equal to 0.8. For the gas, assume a constant value of c_p (specific heat at constant pressure) equal to 1 kJ/kg-K and ratio of specific heats as 1.4. Neglect changes in kinetic and potential energies.

Q. 54 The power required by the compressor in kW/kg of gas flow rate is

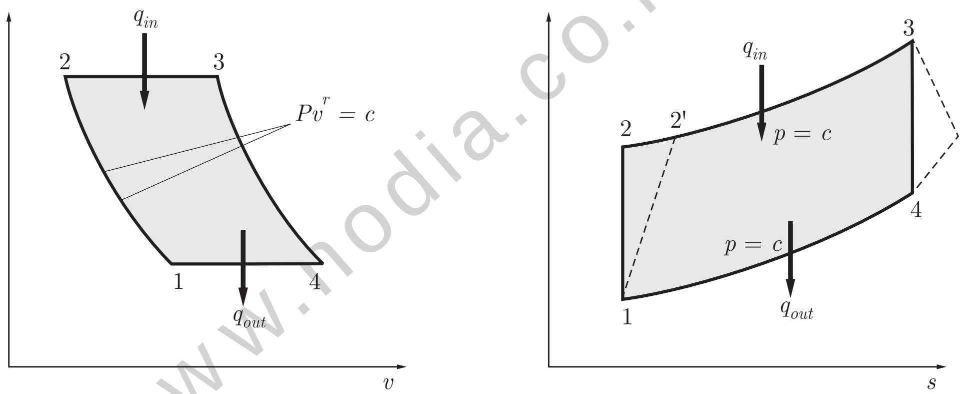
GATE ME 2013 TWO MARK

(A) 194.7 (B) 243.4

(C) 304.3 (D) 378.5

Sol. 54 Option (C) is correct.

The $p-v$ and $T-s$ diagram of brayton cycle is shown below:



Given $r_p = \dfrac{p_2}{p_1} = 8,\ \gamma = 1.4,\ T_1 = 300\text{ K},\ T_3 = 1400\text{ K},\ c_p = 1\text{ kJ/kg-K},\ \eta_{\text{isen}} = 0.8$

The process $1-2$ (Isentropic compression)

Process $1-2'$ (Actual compression)

Process $3-4$ (Isentropic expansion)

Process $3-4'$ (Actual expansion)

For reversible adiabatic compression process $1-2$

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = (8)^{\frac{2}{7}}$$

or $$T_2 = 300 \times (8)^{\frac{2}{7}} = 543.43\text{ K}$$

Now

$$\eta_{\text{isen}} = \frac{\text{Isentropic compressor work}}{\text{Actual compressor work}}$$

$$W_{actual} = \frac{\dot{m} c_p (T_2 - T_1)}{\eta_{\text{isen}}}$$

$$\frac{W_{net}}{\dot{m}} = \frac{1 \times (543.43 - 300)}{0.8}$$

$$= 304.3\text{ kW/kg}$$

Q. 55 The thermal efficiency of the cycle in percentage (%) is

GATE ME 2013 TWO MARK

(A) 24.8 (B) 38.6

(C) 44.8 (D) 53.1

Sol. 55 Option (A) is correct.

For process 2 – 3 (p = constant)

$$\frac{V_2}{T_2} = \frac{V_3}{T_3}$$

Heat supplied $Q_{in} = c_p(T_3 - T_2')$

Now $\eta_{\text{isen}} = \frac{W_{\text{actual}}}{W_{\text{isen}}} = \frac{h_2 - h_1}{h_2' - h_1}$

$$= \frac{c_p(T_2 - T_1)}{c_p(T_2' - T_1)}$$

$$= \frac{T_2 - T_1}{T_2' - T_1}$$

or $$0.8 = \frac{543.43 - 300}{T_2' - 300}$$

$$0.8\,T_2' - 240 = 243.43$$

$$T_2' = 604.3\text{ K}$$

So that $Q_{in} = 1 \times (1400 - 604.3)$

$$= 795.7\text{ kJ/kg}$$

For process 3 – 4 (p = constant)

$$\frac{T_3}{T_4} = \left(\frac{p_3}{p_4}\right)^{\frac{\gamma-1}{\gamma}} = (r_p)^{\frac{\gamma-1}{\gamma}}$$

or $$T_4 = \frac{T_3}{(r_p)^{\frac{\gamma-1}{\gamma}}} = \frac{1400}{(8)^{\frac{1.4-1}{1.4}}} = 772.86\text{ K}$$

Now $\eta_{\text{isen}} = \frac{W_{\text{actual}}}{W_{\text{isen}}}$

$$= \frac{h_3 - h_4'}{h_3 - h_4} = \frac{T_3 - T_4'}{T_3 - T_4}$$

$$0.8 = \frac{1400 - T_4'}{1400 - 772.86}$$

or $T_4' = 898.288\text{ K}$

Now $W_{act} = c_p(T_3 - T_4')$

$$= 1(1400 - 898.288)$$

$$= 501.712\text{ kJ/kg}$$

Hence $n_{thermal} = \frac{W_{act} - W_{comp}}{Q_{in}}$

$$= \left(\frac{501.712 - 304.3}{795.7}\right) \times 100$$

$$= 24.8\%$$

Q. 56 Choose the grammatically INCORRECT sentence

GATE ME 2013 ONE MARK

(A) He is of Asian origin (B) They belonged to Africa

(C) She is an European (D) They migrated from India to Australia

Sol. 56 Option (C) is correct.

Option (C) is grammatically incorrect because 'European' pronunciate with consonent sound although starts with vowel 'E'. Therefore the article 'a' should be used instead of 'an'.

Q. 57 What will be the maximum sum of 44, 42, 40,........?

GATE ME 2013 ONE MARK

(A) 502 (B) 504

(C) 506 (D) 500

Sol. 57 Option (C) is correct.

Series may be written as $0+2+4+.......+44$

In A.P. the number of term

$$n^{th} = a+(n-1)d$$

where a = 1st term in series = 0

n^{th} = n^{th} term = 44

d = difference = 2

So that

$$n^{th} = a+(n-1)d$$

$$44 = 0+(n-1)(2)$$

or $n = 23$

And the sum of these numbers in $A.P$

$$\text{sum} = \frac{n}{2}[2a+(n-1)d]$$

$$= \frac{23}{2}[2\times 0+(23-1)\times 2]$$

$$= \frac{23}{2}\times 44 = 23\times 22 = 506$$

Q. 58 Were you a bird, you...................... in the sky.

GATE ME 2013 ONE MARK

(A) would fly (B) shall fly

(C) should fly (D) shall have flown

Sol. 58 Option (A) is correct.

This is a conditional sentence, in which if sentence starts with 'were' or 'should' then the second part of the sentence after comma. uses 'would + Ist form of verbs'.

Q. 59 Which one of the following options is the closest in meaning to the word given below ?

GATE ME 2013 ONE MARK

Nadir

(A) Highest (B) Lowest

(C) Medium (D) Integration

Sol. 59 Option (B) is correct.

Nadir – means the lowest point in the fortunes of a person or organization.

Q. 60 Complete the sentence:

GATE ME 2013 ONE MARK

Universalism is the particularism as diffuseness is to................

(A) specificity (B) neutrality

(C) generality (D) adaptation

Sol. 60 Option (A) is correct.

'Particularism' is the opposite of Universalism' Therefore the opposite of diffuseness is 'specificity'.

Q. 61

GATE ME 2013 TWO MARK

The current erection cost of a structure is Rs. 13,200. If the labour wages per day increase by 1/5 of the current wages and the working hours decrease by 1/24 of the current period, then the new cost of erection in Rs. is

(A) 16,500 (B) 15,180

(C) 11,000 (D) 10,120

Sol. 61

Option (B) is correct.

(i) Since labour wages per day increase by $1/5$ of the current wages. Hence new labour wages per day

$$= 1 + \frac{1}{5} = \frac{6}{5} \text{ per day}$$

(ii) The working hours decrease by $1/24$ of the current period. Hence new working period

$$= 1 - \frac{1}{24} = \frac{23}{24}$$

Therefore the commulative factor which affect the current erection cost of structure due to above condition is

$$= \frac{6}{5} \times \frac{23}{24} = 1.15 \text{ times}$$

Now, the new cost of erection

$$= 1.15 \times 13200$$
$$= \text{Rs.}\,15180$$

Q. 62

GATE ME 2013 ONE MARK

After several defeats in wars, Robert Bruce went in exile and wanted to commit suicide. Just before committing suicide, he came across a spider attempting tirelessly to have its net. Time and again, the spider failed but that did not deter it to refrain from making attempts. Such attempts by the spider made Bruce curious. Thus, Bruce started observing the near-impossible goal of the spider to have the net. Ultimately, the spider succeeded in having its new despite several failures. Such act of the spider encouraged Bruce not to commit suicide. And then, Bruce went back again and won many a battle and the rest is history.

Which of the following assertions is best supported by the above information ?

(A) Failure is the pillar of success

(B) Honesty is the best policy

(C) Life begins and ends with adventures

(D) No adversity justifies giving up hope.

Sol. 62

Option (D) is correct.

In given paragraph, spider makes repeated efforts even after failure. It means spider did not give up hope after adversity of failure. Hence assertion ‘No adversity justifies giving up hope” is best supported by the above information.

Q. 63

GATE ME 2013 TWO MARK

A tourist covers half of his journey by train at 60 km/h, half of the remainder by bus at 30 km/h and the rest by cycle at 10 km/h. The average speed of the tourist in km/h during the entire journey is

(A) 36 (B) 30

(C) 24 (D) 18

Sol. 63

Option (C) is correct.

Let total distance travelled $= d$ km

Distance $\frac{d}{2}$ travelled with 60 km/h

So the time taken to travel $d/2$ distance is

$$t_1 = \frac{d}{2\times 60} = \frac{d}{120} \text{ hours}$$

Distance $\frac{d}{4}$ travelled with 30 km/h

So the time taken to travel $d/4$ distance is

$$t_2 = \frac{d}{4\times 30} = \frac{d}{120} \text{ hours}$$

and rest of distance $\left(\frac{d}{4}\right)$ is travelled with 10 km/h

So the time taken to travel $d/4$ distance is

$$t_3 = \frac{d}{4\times 10} = \frac{d}{40} \text{ hour}$$

Total time of journey

$$= \frac{d}{120} + \frac{d}{120} + \frac{d}{40} = \frac{5d}{120} = \frac{d}{24} \text{ hours}$$

Total distance travelled $= d$ km

Therefore average speed of journey

$$= \frac{d}{d}\times 24 = 24 \text{ km/h}$$

Q. 64 Find the sum of the expression

GATE ME 2013 TWO MARK

$$\frac{1}{\sqrt{1}+\sqrt{2}} + \frac{1}{\sqrt{2}+\sqrt{3}} + \frac{1}{\sqrt{3}+\sqrt{4}} + \dots\dots\dots\dots + \frac{1}{\sqrt{80}+\sqrt{81}}$$

(A) 7 (B) 8

(C) 9 (D) 10

Sol. 64 Option (B) is correct.

Given Series is

$$\frac{1}{\sqrt{1}+\sqrt{2}} + \frac{1}{\sqrt{2}+\sqrt{3}} + \frac{1}{\sqrt{3}+\sqrt{4}} + \dots\dots\dots\dots + \frac{1}{\sqrt{80}+\sqrt{81}}$$

By multiplying and dividing each term of series with their opposite sign denominator, we have

$$= \frac{1}{(\sqrt{1}+\sqrt{2})}\times\frac{\sqrt{2}-\sqrt{1}}{(\sqrt{2}-\sqrt{1})} + \frac{1}{\sqrt{2}+\sqrt{3}}\times\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}-2} + \dots\dots\dots + \frac{1}{\sqrt{80}+\sqrt{81}}\times\frac{\sqrt{81}-\sqrt{80}}{\sqrt{81}-\sqrt{80}}$$

or $$= \frac{\sqrt{2}-\sqrt{1}}{2-1} + \frac{\sqrt{3}-\sqrt{2}}{3-2} + \dots\dots\dots\dots \frac{\sqrt{81}-\sqrt{80}}{81-80}$$

$$= \frac{\sqrt{2}-\sqrt{1}+\sqrt{3}-\sqrt{2}+\sqrt{4}-\sqrt{3}\dots\dots\dots+\sqrt{81}-\sqrt{80}}{1}$$

or $$\frac{\sqrt{81}-\sqrt{1}}{1} = 9-1 = 8$$

Q. 65 Out of all the 2-digit integers between 1 and 100, a 2-digit number has to be selected at random. What is the probability that the selected number is not divisible by 7?

GATE ME 2013 TWO MARK

(A) 13/90 (B) 12/90

(C) 78/90 (D) 77/90

Sol. 65 Option (D) is correct.

There are total 90, 2-digit integers between 1 and 100.

Therefore Total condition for this sample

$$n = 90$$

Out of there conditions, there are only 13 condition which are divisible by 7.
Hence the total favorable condition which are not divisible by 7 are

$$n - 13 = 90 - 13 = 77$$

Therefore the probability that the selected number is not divisible by 7 is

$$= \frac{\text{conditions which are not divisible by 7}}{\text{Total conditions } (n)}$$

$$= \frac{77}{90}$$

****

Answer Sheet									
1.	(D)	14.	(B)	27.	(C)	40.	(A)	53.	(D)
2.	(A)	15.	(B)	28.	(A)	41.	(C)	54.	(C)
3.	(C)	16.	(D)	29.	(D)	42.	(A)	55.	(A)
4.	(C)	17.	(C)	30.	(C)	43.	(B)	56.	(A)
5.	(A)	18.	(A)	31.	(D)	44.	(B)	57.	(A)
6.	(C)	19.	(B)	32.	(C)	45.	(D)	58.	(B)
7.	(B)	20.	(B)	33.	(D)	46.	(A)	59.	(A)
8.	(B)	21.	(B)	34.	(B)	47.	(C)	60.	(A)
9.	(D)	22.	(A)	35.	(D)	48.	(A)	61.	(A)
10.	(D)	23.	(C)	36.	(B)	49.	(B)	62.	(D)
11.	(A)	24.	(D)	37.	(A)	50.	(A)	63.	(B)
12.	(C)	25.	(A)	38.	(C)	51.	(C)	64.	(B)
13.	(A)	26.	(B)	39.	(C)	52.	(C)	65.	(C)