ME GATE-11

MCQ 1.1 Green sand mould indicates that

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(A) polymeric mould has been cured (B) mould has been totally dried

(C) mould is green in color (D) mould contains moisture

SOL 1.1 Option (D) is correct.

A green sand mould is composed of a mixture of sand (silica sand, SiO_2), clay (which acts as binder) and water.

The word green is associated with the condition of wetness or freshness and because the mould is left in the damp condition, hence the name " green sand mould".

MCQ 1.2 Eigen values of a real symmetric matrix are always

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(A) positive (B) negative

(C) real (D) complex

SOL 1.2 Option (C) is correct

Let a square matrix

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

We know that the characteristic equation for the eigen values is given by

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

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

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

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

$$x - \lambda = \pm y \Rightarrow \lambda = x \pm y$$

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

MCQ 1.3 A series expansion for the function $\sin\theta$ is

GATE ME 2011 ONE MARK

(A) $1 - \frac{\theta^2}{2!} + \frac{\theta^4}{4!} - \ldots$ (B) $\theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \ldots$

(C) $1 + \theta + \frac{\theta^2}{2!} + \frac{\theta^3}{3!} + \ldots$ (D) $\theta + \frac{\theta^3}{3!} + \frac{\theta^5}{5!} + \ldots$

SOL 1.3 Option (B) is correct.

We know the series expansion of

$$\sin\theta = \theta - \frac{\theta^3}{\lfloor 3} + \frac{\theta^5}{\lfloor 5} - \frac{\theta^7}{\lfloor 7} + ...$$

MCQ 1.4 A column has a rectangular cross-section of 10×20 mm and a length of 1 m. The slenderness ratio of the column is close to

GATE ME 2011 ONE MARK

(A) 200 (B) 346

(C) 477 (D) 1000

SOL 1.4 Option (B) is correct.

Given : $l = 1$ meter, $b = 20$ mm, $h = 10$ mm

We know that, Slenderness ratio $= \frac{l}{k}$

Where, $$k = \sqrt{\frac{I}{A}} = \sqrt{\frac{bh^3/12}{b \times h}}$$

Substitute the values, we get

$$k = \sqrt{\frac{\frac{1}{12} \times 20 \times (10)^3 \times 10^{-12}}{10 \times 20 \times 10^{-6}}} = \sqrt{\frac{20 \times 10^{-3}}{12 \times 10 \times 20}}$$

$$= \sqrt{8.33 \times 10^{-6}} = 2.88 \times 10^{-3}\text{ m}$$

$$\text{Slenderness ratio} = \frac{1}{2.88 \times 10^{-3}} = 347.22 \simeq 346$$

MCQ 1.5 Heat and work are

GATE ME 2011 ONE MARK

(A) intensive properties (B) extensive properties

(B) point functions (D) path functions

SOL 1.5 Option (D) is correct.

Work done is a quasi-static process between two given states depends on the path followed. Therefore,

$$\int_1^2 dW \neq W_2 - W_1 \qquad dW \text{ shows the inexact differential}$$

But, $$\int_1^2 dW = W_{1-2} \text{ or } {}_1W_2$$

So, Work is a path function and Heat transfer is also a path function. The amount of heat transferred when a system changes from state 1 to state 2 depends on the intermediate states through which the system passes i.e. the path.

$$\int_1^2 dQ = Q_{1-2} \text{ or } {}_1Q_2$$

dQ shows the inexact differential. So, Heat & work are path functions.

MCQ 1.6 A hole is of dimension $\phi 9^{+0.015}_{+0}$ mm. The corresponding shaft is of dimension $\phi 9^{+0.010}_{+0.001}$ mm. The resulting assembly has

GATE ME 2011 ONE MARK

(A) loose running fit (B) close running fit

(C) transition fit (D) interference fit

SOL 1.6 Option (C) is correct.

In transition fit, the tolerance zones of holes and shaft overlap.

Upper limit of hole $= 9 + 0.015 = 9.015\text{ mm}$

Lower limit of hole $= 9 + 0.000 = 9.000\text{ mm}$

Upper limit of shaft $= 9 + 0.010 = 9.010\text{ mm}$

Lower limit of shaft $= 9 + 0.001 = 9.001\text{ mm}$

Fig. Fig.

Now, we can easily see from figure dimensions that it is a transition fit

MCQ 1.7 The operation in which oil is permeated into the pores of a powder metallurgy product is known as

GATE ME 2011 ONE MARK

(A) mixing (B) sintering

(C) impregnation (D) infiltration

SOL 1.7 Option (C) is correct.

If the pores in a sintered compact are filled with an oil, the operation is called as impregnation. The lubricants are added to the porous bearings, gears and pump rotors etc.

MCQ 1.8 The maximum possible draft in cold rolling of sheet increases with the

GATE ME 2011 ONE MARK

(A) increase in coefficient of friction (B) decrease in coefficient of friction

(C) decrease in roll radius (D) increase in roll velocity

SOL 1.8 Option (A) is correct.

The main objective in rolling is to decrease the thickness of the metal.

The relation for the rolling is given by

$$F = \mu P_r$$

Where ; F = tangential frictional force

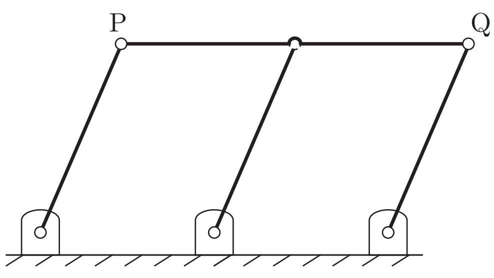
μ = Coefficient of friction

P_r = Normal force between the roll and work piece

Now, from the increase in μ, the draft in cold rolling of sheet increases.

MCQ 1.9 A double-parallelogram mechanism is shown in the figure. Note that PQ is a single link. The mobility of the mechanism is

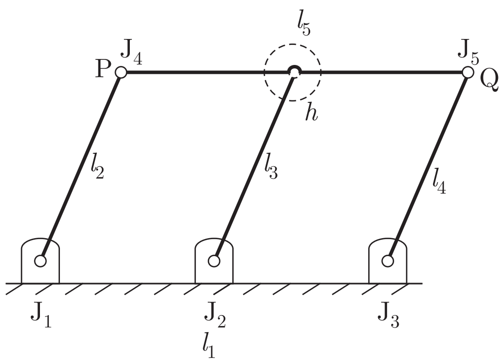
GATE ME 2011 ONE MARK



(A) -1 (B) 0

(C) 1 (D) 2

SOL 1.9 Option (C) is correct.

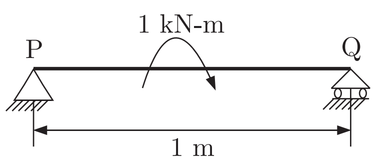


Given that PQ is a single link.
Hence : $l = 5,\ j = 5,\ h = 1$
It has been assumed that slipping is possible between the link l_5 & l_1. From the kutzbach criterion for a plane mechanism,
Numbers of degree of freedom or movability.

$$n = 3(l-1) - 2j - h = 3(5-1) - 2\times 5 - 1 = 1$$

MCQ 1.10 GATE ME 2011 ONE MARK

A simply supported beam PQ is loaded by a moment of 1 kNm at the mid-span of the beam as shown in the figure The reaction forces R_P and R_Q at supports P and Q respectively are



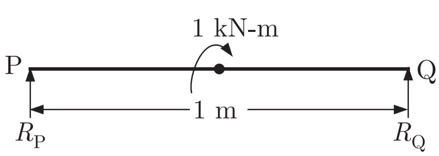
(A) 1 kN downward, 1 kN upward

(B) 0.5 kN upward, 0.5 kN downward

(C) 0.5 kN downward, 0.5 kN upward

(D) 1 kN upward, 1 kN upward

SOL 1.10 Option (A) is correct.
First of all we have to make a free body diagram of the given beam.



Here R_P & R_Q are the reaction forces acting at P & Q.
For equilibrium of forces on the beam,

$$R_P + R_Q = 0 \qquad \text{...(i)}$$

Taking the moment about the point P,

$$R_Q \times 1 = 1\,\text{kN-m} \Rightarrow R_Q = 1\,\text{kN-m}$$

From equation (i),

$$R_P = -R_Q = -1\,\text{kN-m}$$

Since, our assumption that R_P acting in the upward direction, is wrong,
So, R_P acting in downward direction & R_Q acting in upward direction.

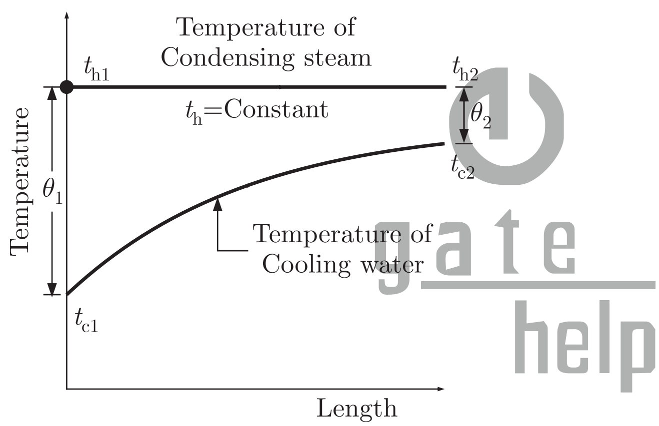
MCQ 1.11 GATE ME 2011 ONE MARK

In a condenser of a power plant, the steam condenses at a temperatures of 60°C. The cooling water enters at 30°C and leaves at 45°C. The logarithmic mean temperature difference (LMTD) of the condenser is

(A) 16.2°C (B) 21.6°C

(C) 30°C (D) 37.5°C

SOL 1.11 Option (B) is correct.



Given : $t_{h1} = t_{h2} = 60^\circ\text{C},\ t_{c1} = 30^\circ\text{C},\ t_{c2} = 45^\circ\text{C}$

From diagram, we have

$$\theta_1 = t_{h1} - t_{c1} = 60 - 30 = 30^\circ\text{C}$$

And $$\theta_2 = t_{h2} - t_{c2} = 60 - 45 = 15^\circ\text{C}$$

Now LMTD, $$\theta_m = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{30 - 15}{\ln\left(\frac{30}{15}\right)} = 21.6^\circ\text{C}$$

MCQ 1.12 GATE ME 2011 ONE MARK

If a mass of moist air in an airtight vessel is heated to a higher temperature, then

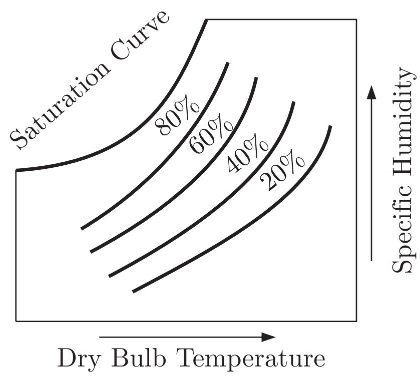
(A) specific humidity of the air increases

(B) specific humidity of the air decreases

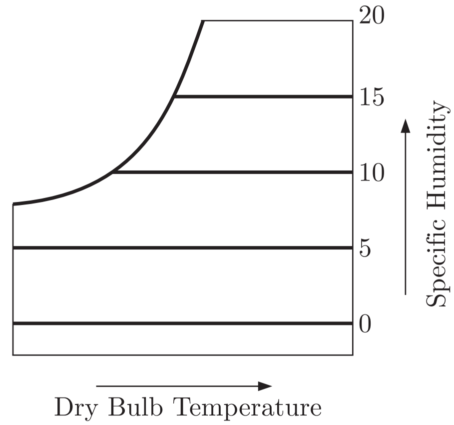
(C) relative humidity of the air increases

(D) relative humidity of the air decreases

SOL 1.12 Option (D) is correct.



Relative Humidity Lines



Specific Humidity Lines

From the given curve, we easily see that relative humidity of air decreases, when temperature of moist air in an airtight vessel increases. So, option (C) is correct. Specific humidity remain constant with temperature increase, so option *a* & *b* are incorrect.

MCQ 1.13 A streamline and an equipotential line in a flow field

GATE ME 2011 ONE MARK

(A) are parallel to each other (B) are perpendicular to each other

(C) intersect at an acute angle (D) are identical

SOL 1.13 Option (B) is correct.

For Equipotential line, $\frac{dy}{dx} = -\frac{u}{v}$ = Slope of equipotential line ...(i)

For stream function,

$$\frac{dy}{dx} = \frac{v}{u} = \text{Slope of stream line} \qquad ...(ii)$$

It is clear from equation (i) & (ii) that the product of slope of equipotential line & slope of the stream line at the point of intersection is equal to -1.

$$-\frac{u}{v} \times \frac{v}{u} = -1$$

And, when $m_1 m_2 = -1$, Then lines are perpendicular, therefore the stream line and an equipotential line in a flow field are perpendicular to each other.

MCQ 1.14 The crystal structure of austenite is

GATE ME 2011 ONE MARK

(A) body centered cubic (B) face centered cubic

(C) hexagonal closed packed (D) body centered tetragonal

SOL 1.14 Option (B) is correct.

Austenite is a solid solution of carbon in γ-iron. It has F.C.C structure. It has a solid solubility of upto 2% C at 1130°C.

MCQ 1.15 Which one among the following welding processes uses non-consumable electrode ?

GATE ME 2011 ONE MARK

(A) Gas metal arc welding (B) Submerged arc welding

(C) Gas tungsten arc welding (D) Flux coated arc welding

SOL 1.15 Option (C) is correct.
GTAW is also called as Tungsten Inert Gas Welding (TIG). The arc is maintained between the work piece and a tungsten electrode by an inert gas. The electrode is non-consumable since its melting point is about 3400°C.

MCQ 1.16 A thin cylinder of inner radius 500 mm and thickness 10 mm is subjected to an internal pressure of 5 MPa. The average circumferential (hoop) stress in MPa is

GATE ME 2011 ONE MARK

(A) 100 (B) 250

(C) 500 (D) 1000

SOL 1.16 Option (B) is correct.
Given : $r = 500\,\text{mm},\ t = 10\,\text{mm},\ p = 5\,\text{MPa}$
We know that average circumferential (hoop) stress is given by,

$$\sigma_h = \frac{pd}{2t}$$

$$\sigma_h = \frac{5\times(2\times 500)}{2\times 10} = 250\,\text{MPa}$$

MCQ 1.17 The coefficient of restitution of a perfectly plastic impact is

GATE ME 2011 ONE MARK

(A) 0 (B) 1

(C) 2 (D) ∞

SOL 1.17 Option (A) is correct.
From the Newton's Law of collision of Elastic bodies.

Velocity of separation = $e\times$ Velocity of approach

$$(V_2 - V_1) = e(U_1 - U_2)$$

Where e is a constant of proportionality & it is called the coefficient of restitution. And its value lies between 0 to 1.
The coefficient of restitution of a perfectly plastic impact is zero, because all the K.E. will be absorbed during perfectly plastic impact.

MCQ 1.18 If $f(x)$ is an even function and a is a positive real number, then $\int_{-a}^{a} f(x)\,dx$ equals

(A) 0 (B) a

(C) $2a$ (D) $2\int_0^a f(x)\,dx$

SOL 1.18 Option (D) is correct.
For a function, whose limits bounded between $-a$ to a and a is a positive real number. The solution is given by

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

MCQ 1.19 The word 'kanban' is most appropriately associated with

GATE ME 2011 ONE MARK

(A) economic order quantity (B) just-in-time production

(C) capacity planning (D) product design

SOL 1.19 Option (B) is correct.
Kanban Literally, a "Visual record"; a method of controlling materials flow through a Just-in-time manufacturing system by using cards to authorize a work station to transfer or produce materials

MCQ 1.20 GATE ME 2011 ONE MARK

Cars arrive at a service station according to Poisson's distribution with a mean rate of 5 per hour. The service time per car is exponential with a mean of 10 minutes. At steady state, the average waiting time in the queue is

(A) 10 minutes (B) 20 minutes

(C) 25 minutes (D) 50 minutes

SOL 1.20 Option (D) is correct.

Given : $\lambda = 5$ per hour, $\mu = \frac{1}{10} \times 60$ per hour $= 6$ per hour

Average waiting time of an arrival

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)} = \frac{5}{6(6-5)}$$
$$= \frac{5}{6} \text{ hours } = 50 \text{ min}$$

MCQ 1.21 GATE ME 2011 ONE MARK

The product of two complex numbers $1+i$ and $2-5i$ is

(A) $7-3i$ (B) $3-4i$

(C) $-3-4i$ (D) $7+3i$

SOL 1.21 Option (A) is correct.

Let, $z_1 = (1+i)$, $z_2 = (2-5i)$

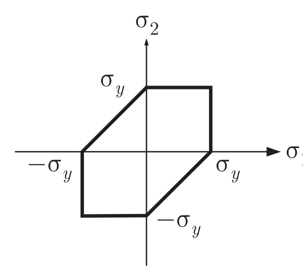
$$z = z_1 \times z_2 = (1+i)(2-5i)$$
$$= 2 - 5i + 2i - 5i^2 = 2 - 3i + 5 = 7 - 3i \qquad i^2 = -1$$

MCQ 1.22 GATE ME 2011 ONE MARK

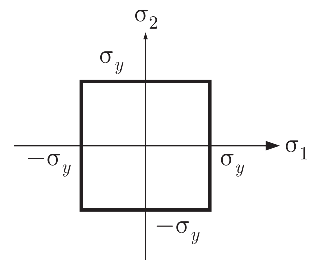
Match the following criteria of material failure, under biaxial stresses σ_1 and σ_2 and yield stress σ_y, with their corresponding graphic representations.

P. Maximum-normal-stress criterion

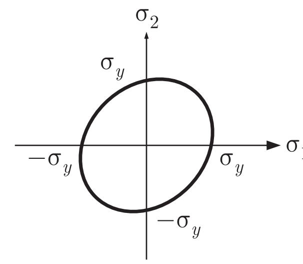
L.



Q. Maximum-distortion-energy criterion

M. 

R. Maximum-shear-stress criterion

N. 

(A) P-M, Q-L, R-N
(B) P-N, Q-M, R-L
(C) P-M, Q-N, R-L
(D) P-N, Q-L, R-M

SOL 1.22 Option (C) is correct.

(P) Maximum-normal stress criterion → (M)

(Q) Maximum-distortion energy criterion → (N)

(R) Maximum-shear-stress criterion → (L)

So correct pairs are, P-M, Q-N, R-L

MCQ 1.23 GATE ME 2011 ONE MARK

The contents of a well-insulated tank are heated by a resistor of $23\,\Omega$ in which 10 A current is flowing. Consider the tank along with its contents as a thermodynamic system. The work done by the system and the heat transfer to the system are positive. The rates of heat (Q), work (W) and change in internal energy (ΔU) during the process in kW are

(A) $Q = 0, W = -2.3, \Delta U = +2.3$
(B) $Q = +2.3, W = 0, \Delta U + 2.3$
(C) $Q = -2.3, W = 0, \Delta U = -2.3$
(D) $Q = 0, W = +2.3, \Delta U = -2.3$

SOL 1.23 Option (A) is correct.

Given : $R = 23\,\Omega,\ i = 10\text{ A}$

Since work is done on the system. So,

$$W_{electrical} = -i^2 R = -(10)^2 \times 23 = -2300\text{ W} = -2.3\text{ kW}$$

Here given that tank is well-insulated.

So, $\Delta Q = 0$

Applying the First law of thermodynamics,

$$\Delta Q = \Delta U + \Delta W$$
$$\Delta U + \Delta W = 0$$
$$\Delta W = -\Delta U$$

And $\Delta U = +2.3\,\text{kW}$

Heat is transferred to the system

MCQ 1.24 GATE ME 2011 ONE MARK

A pipe of 25 mm outer diameter carries steam. The heat transfer coefficient between the cylinder and surroundings is $5\,\text{W/m}^2\,\text{K}$. It is proposed to reduce the heat loss from the pipe by adding insulation having a thermal conductivity of $0.05\,\text{W/m K}$. Which one of the following statements is TRUE ?

(A) The outer radius of the pipe is equal to the critical radius.

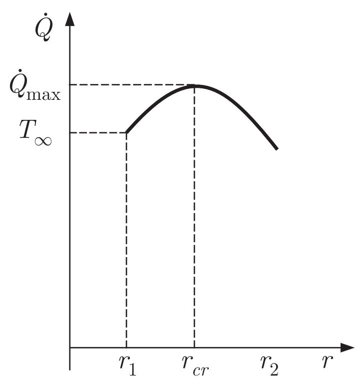
(B) The outer radius of the pipe is less than the critical radius.

(C) Adding the insulation will reduce the heat loss.

(D) Adding the insulation will increases the heat loss.

SOL 1.24 Option (C) is correct.

Given : $d_0 = 25\,\text{mm} = 0.025\,\text{m}$, $r_0 = \frac{0.025}{2} = 0.0125$ m, $h = 5\,\text{W/m}^2\,\text{K}$, $k = 0.05\,\text{W/mK}$



Hence, Critical radius of insulation for the pipe is given by,

$$r_c = \frac{k}{h} = \frac{0.05}{5} = 0.01\,\text{m}$$

$$r_c < r_0 \text{ or } r_0 > r_c \qquad \text{...(i)}$$

So, from equation (i) option a & b is incorrect. The critical radius is less than the outer radius of the pipe and adding the insulation will not increase the heat loss. Hence the correct statement is adding the insulation will reduce the heat loss.

MCQ 1.25 GATE ME 2011 ONE MARK

What is $\lim_{\theta \to 0} \frac{\sin\theta}{\theta}$ equal to ?

(A) θ (B) $\sin\theta$

(C) 0 (D) 1

SOL 1.25 Option (D) is correct.

Let $$y = \lim_{\theta \to 0} \frac{\sin\theta}{\theta}$$

$$y = \lim_{\theta \to 0} \frac{\frac{d}{d\theta}(\sin\theta)}{\frac{d}{d\theta}(\theta)} = \lim_{\theta \to 0} \frac{\cos\theta}{1}$$ Applying L-Hospital rule

Substitute the limits, we get

$$= \frac{\cos 0}{1} = 1$$

MCQ 1.26 GATE ME 2011 TWO MARK

The shear strength of a sheet metal is 300 MPa. The blanking force required to produce a blank of 100 mm diameter from a 1.5 mm thick sheet is close to

(A) 45 kN (B) 70 kN

(C) 141 kN (D) 3500 kN

SOL 1.26 Option (C) is correct.

Given : $\tau = 300\,\text{MPa},\ D = 100\,\text{mm},\ t = 1.5\,\text{mm}$

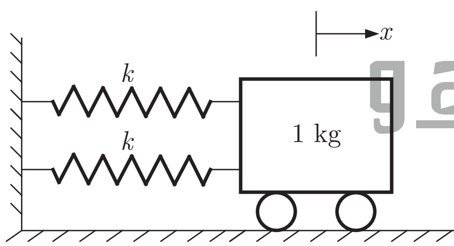
Blanking force $F_b = \tau \times \text{Area} = \tau \times \pi D t$

$$F_b = 300 \times 10^6 \times 3.14 \times 100 \times 1.5 \times 10^{-6}$$

$$= 141300\,\text{N} = 141.3\,\text{kN} \simeq 141\,\text{kN}$$

MCQ 1.27 GATE ME 2011 TWO MARK

A mass of 1 kg is attached to two identical springs each with stiffness $k = 20$ kN/m as shown in the figure. Under the frictionless conditions, the natural frequency of the system in Hz is close to



(A) 32 (B) 23

(C) 16 (D) 11

SOL 1.27 Option (A) is correct.

Given $k = 20\,\text{kN/m},\ m = 1\,\text{kg}$

From the Givenspring mass system, springs are in parallel combination. So,

$$k_{eq} = k + k = 2k$$

We know natural Frequency of spring mass system is,

$$\omega_n = \sqrt{\frac{k_{eq}}{m}}$$

$$2\pi f_n = \sqrt{\frac{k_{eq}}{m}} \qquad f_n = \text{Natural Frequency in Hz.}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k_{eq}}{m}} = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$$

$$= \frac{1}{2 \times 3.14}\sqrt{\frac{2 \times 20 \times 1000}{1}}$$

$$= \frac{200}{6.28} = 31.84\,\text{Hz} \simeq 32\,\text{Hz}$$

MCQ 1.28 GATE ME 2011 TWO MARK

An unbiased coin is tossed five times. The outcome of each toss is either a head or a tail. The probability of getting at least one head is

(A) $\frac{1}{32}$ (B) $\frac{13}{32}$

(C) $\frac{16}{32}$ (D) $\frac{31}{32}$

SOL 1.28 Option (D) is correct.

The probability of getting head $p = \frac{1}{2}$

And the probability of getting tail $q = 1 - \frac{1}{2} = \frac{1}{2}$

The probability of getting at least one head is

$$P(x \geq 1) = 1 - {}^5C_0 (p)^5 (q)^0 = 1 - 1 \times \left(\frac{1}{2}\right)^5 \left(\frac{1}{2}\right)^0$$

$$= 1 - \frac{1}{2^5} = \frac{31}{32}$$

MCQ 1.29 GATE ME 2011 TWO MARK

Consider the differential equation $\frac{dy}{dx} = (1 + y^2) x$. The general solution with constant c is

(A) $y = \tan \frac{x^2}{2} + \tan c$ (B) $y = \tan^2 \left(\frac{x}{2} + c\right)$

(C) $y = \tan^2 \left(\frac{x}{2}\right) + c$ (D) $y = \tan\left(\frac{x^2}{2} + c\right)$

SOL 1.29 Option (D) is correct.

Given : $$\frac{dy}{dx} = (1 + y^2) x$$

$$\frac{dy}{(1 + y^2)} = x dx$$

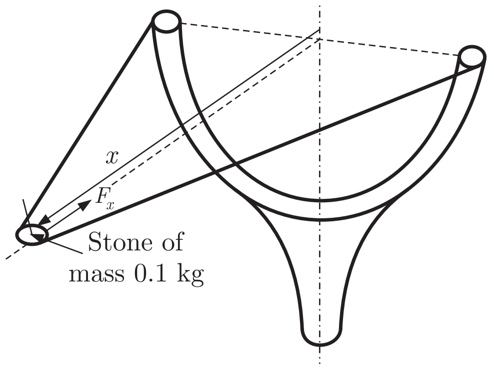
Integrating both the sides, we get

$$\int \frac{dy}{1 + y^2} = \int x dx$$

$$\tan^{-1} y = \frac{x^2}{2} + c \Rightarrow y = \tan\left(\frac{x^2}{2} + c\right)$$

MCQ 1.30 GATE ME 2011 ONE MARK

A stone with mass of 0.1 kg is catapulted as shown in the figure. The total force F_x (in N) exerted by the rubber band as a function of distance x (in m) is given by $F_x = 300x^2$. If the stone is displaced by 0.1 m from the un-stretched position $(x = 0)$ of the rubber band, the energy stored in the rubber band is



(A) 0.01 J
(B) 0.1 J
(C) 1 J
(D) 10 J

SOL 1.30 Option (B) is correct.

Given : $F_x = 300x^2$

Position of x is, $x = 0$ to $x = 0.1$

We know that,

Energy stored in the rubber band = Work done by the stone

Hence $dE = F_x\,dx$

Integrating both the sides & put the value of F & limits

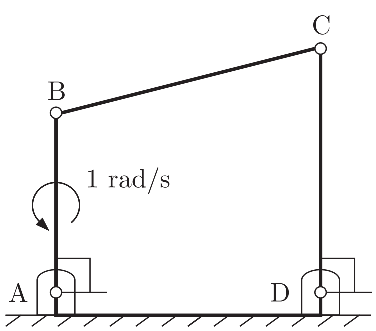
$$\int_0^E dE = \int_0^{0.1} 300x^2\,dx$$

$$E = 300\left[\frac{x^3}{3}\right]_0^{0.1}$$

$$E = 300\left[\frac{(0.1)^3}{3}\right] = 0.1\,\text{Joule}$$

MCQ 1.31 GATE ME 2011 TWO MARK

For the four-bar linkage shown in the figure, the angular velocity of link AB is 1 rad/s. The length of link CD is 1.5 times the length of link AB. In the configuration shown, the angular velocity of link CD in rad/s is



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

SOL 1.31 Option (D) is correct.

Given $\omega_{AB} = 1\,\text{rad/sec}$, $l_{CD} = 1.5 l_{AB}$. $\Rightarrow \frac{l_{CD}}{l_{AB}} = 1.5$

Let angular velocity of link CD is ω_{CD}

From angular velocity ratio theorem,

$$\frac{\omega_{AB}}{\omega_{CD}} = \frac{l_{CD}}{l_{AB}}$$

$$\omega_{CD} = \omega_{AB} \times \frac{l_{AB}}{l_{CD}} = 1 \times \frac{1}{1.5} = \frac{2}{3}\,\text{rad/sec}$$

MCQ 1.32 GATE ME 2011 TWO MARK

Two identical ball bearings P and Q are operating at loads 30 kN and 45 kN respectively. The ratio of the life of bearing P to the life of bearing Q is

(A) $\frac{81}{16}$ (B) $\frac{27}{8}$

(C) $\frac{9}{4}$ (D) $\frac{3}{2}$

SOL 1.32 Option (B) is correct.

Given : $W_P = 30\,\text{kN}$, $W_Q = 45\,\text{kN}$

Life of bearing, $L = \left(\frac{C}{W}\right)^k \times 10^6$ revolutions

C = Basic dynamic load rating = Constant

For ball bearing, $k = 3$

So, $L = \left(\frac{C}{W}\right)^3 \times 10^6$ revolutions

These are the identical bearings. So for the Life of P and Q.

$$\left(\frac{L_P}{L_Q}\right) = \left(\frac{W_Q}{W_P}\right)^3 = \left(\frac{45}{30}\right)^3 = \left(\frac{3}{2}\right)^3 = \frac{27}{8}$$

MCQ 1.33 GATE ME 2011 TWO MARK

The integral $\int_1^3 \frac{1}{x}\,dx$, when evaluated by using Simpson's 1/3 rule on two equal sub-intervals each of length 1, equals

(A) 1.000 (B) 1.098

(C) 1.111 (D) 1.120

SOL 1.33 Option (C) is correct.

Let, $f(x) = \int_1^3 \frac{1}{x}\,dx$

From this function we get $a = 1$, $b = 3$ & $n = 3 - 1 = 2$

So, $h = \frac{b-a}{n} = \frac{3-1}{2} = 1$

We make the table from the given function

$$y = f(x) = \frac{1}{x}$$

$\boldsymbol{x}$	$\boldsymbol{f(x) = y = \frac{1}{x}}$

$x = 1$	$y_1 = \frac{1}{1} = 1$
$x = 2$	$y_2 = \frac{1}{2} = 0.5$
$x = 3$	$y_3 = \frac{1}{3} = 0.333$

Applying the Simpson's $1/3^{rd}$ formula

$$\int_1^3 \frac{1}{x}dx = \frac{h}{3}[(y_1 + y_3) + 4y_2] = \frac{1}{3}[(1 + 0.333) + 4 \times 0.5]$$

$$= \frac{1}{3}[1.333 + 2] = \frac{3.333}{3} = 1.111$$

MCQ 1.34 GATE ME 2011 TWO MARK

The values of enthalpy of steam at the inlet and outlet of a steam turbine in a Rankine cycle are 2800 kJ/kg and 1800 kJ/kg respectively. Neglecting pump work, the specific steam consumption in kg/kW hour is

(A) 3.60 (B) 0.36

(C) 0.06 (D) 0.01

SOL 1.34 Option (A) is correct.

Given : $h_1 = 2800\,\text{kJ/kg}$ = Enthalpy at the inlet of steam turbine

$h_2 = 1800\,\text{kJ/kg}$ = Enthalpy at the outlet of a steam turbine

Steam rate or specific steam consumption

$$= \frac{3600}{W_T - W_p}\,\text{kg/kWh}$$

Pump work W_p is negligible, therefore

$$\text{Steam rate} = \frac{3600}{W_T}\,\text{kg/kWh}$$

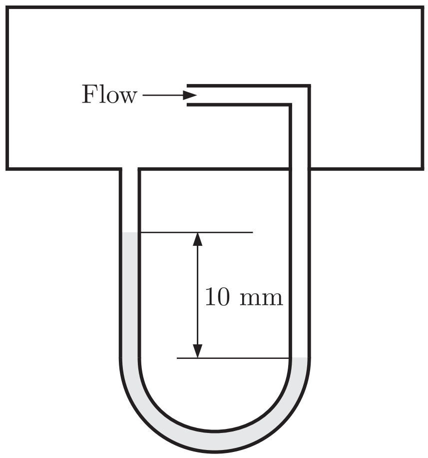
And $W_T = h_1 - h_2$ From Rankine cycle

$$\text{Steam rate} = \frac{3600}{h_1 - h_2}\,\text{kg/kWh}$$

$$= \frac{3600}{2800 - 1800} = 3.60\,\text{kg/kWh}$$

MCQ 1.35 GATE ME 2011 TWO MARK

Figure shows the schematic for the measurement of velocity of air (density $= 1.2\,\text{kg/m}^3$) through a constant area duct using a pitot tube and a water tube manometer. The differential head of water (density $= 1000\,\text{kg/m}^3$) in the two columns of the manometer is 10 mm. Take acceleration due to gravity as $9.8\,\text{m/s}^2$. The velocity of air in m/s is



(A) 6.4
(B) 9.0
(C) 12.8
(D) 25.6

SOL 1.35 Option (C) is correct.

Given : $\rho_a = 1.2\,\text{kg/m}^3,\ \rho_w = 1000\,\text{kg/m}^3,\ x = 10\times10^{-3}\,\text{m},\ g = 9.8\,\text{m/sec}^2$

If the difference of pressure head 'h' is measured by knowing the difference of the level of the manometer liquid say x. Then

$$h = x\left[\frac{S.G_w}{S.G_a} - 1\right] = x\left[\frac{\rho_w}{\rho_a} - 1\right]$$

$$= 10\times10^{-3}\left[\frac{1000}{1.2} - 1\right] = 8.32\,\text{m}$$

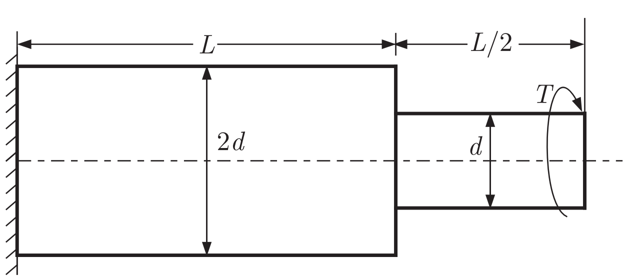
Where $$S.G = \frac{\text{Weight density of liquid}}{\text{Weight density of water}}$$

$$S.G \propto \text{Density of Liquid}$$

Velocity of air $$V = \sqrt{2gh} = \sqrt{2\times9.8\times8.32} = 12.8\,\text{m/sec}$$

MCQ 1.36 GATE ME 2011 TWO MARK

A torque T is applied at the free end of a stepped rod of circular cross-section as shown in the figure. The shear modulus of material of the rod is G. The expression for d to produce an angular twist θ at the free end is



(A) $\left(\frac{32TL}{\pi\theta G}\right)^{\frac{1}{4}}$
(B) $\left(\frac{18TL}{\pi\theta G}\right)^{\frac{1}{4}}$
(C) $\left(\frac{16TL}{\pi\theta G}\right)^{\frac{1}{4}}$
(D) $\left(\frac{2TL}{\pi\theta G}\right)^{\frac{1}{4}}$

SOL 1.36 Option (B) is correct.

Here we see that shafts are in series combination. For series combination Total angular twist,

$$\theta = \theta_1 + \theta_2 \qquad ...(i)$$

From the torsional equation,

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{l} \Rightarrow \theta = \frac{Tl}{GJ} \qquad J = \frac{\pi}{32}d^4$$

$$\theta = \frac{32Tl}{\pi d^4 G}$$

Now, from equation (i),

$$\theta = \frac{32T(L)}{\pi(2d)^4 G} + \frac{32T\left(\frac{L}{2}\right)}{\pi d^4 G} = \frac{32TL}{\pi d^4 G}\left[\frac{1}{16} + \frac{1}{2}\right]$$

$$= \frac{32TL}{\pi d^4 G} \times \frac{9}{16} = \frac{18TL}{\pi d^4 G}$$

$$d = \left(\frac{18TL}{\pi\theta G}\right)^{\frac{1}{4}}$$

MCQ 1.37 GATE ME 2011 TWO MARK

A cubic casting of 50 mm side undergoes volumetric solidification shrinkage and volumetric solid contraction of 4% and 6% respectively. No riser is used. Assume uniform cooling in all directions. The side of the cube after solidification and contraction is

(A) 48.32 mm (B) 49.90 mm

(C) 49.94 mm (D) 49.96 mm

SOL 1.37 Option (A) is correct.

Given : $a = 50\,\text{mm}$, $V = a^3 = (50)^3 = 125000\,\text{mm}^3$

Firstly side undergoes volumetric solidification shrinkage of 4%.

So, Volume after shrinkage,

$$V_1 = 125000 - 125000 \times \frac{4}{100} = 120000\,\text{mm}^3$$

After this, side undergoes a volumetric solid contraction of 6%.

So, volume after contraction,

$$V_2 = 120000 - 120000 \times \frac{6}{100} = 112800\,\text{mm}^3$$

Here V_2 is the combined volume after shrinkage and contraction.

Let at volume V_2, side of cube is b.

So, $$b^3 = 112800 = \sqrt[3]{112800} = 48.32\,\text{mm}$$

MCQ 1.38 GATE ME 2011 TWO MARK

Match the following non-traditional machining processes with the corresponding material removal mechanisms :

	Machining process		Mechanism of material removal
P.	Chemical machining	**1.**	Erosion

Q.	Electro-chemical machining	**2.**	Corrosive reaction
R.	Electro-discharge machining	**3.**	Ion displacement
S.	Ultrasonic machining	**4.**	Fusion and vaporization

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

SOL 1.38 Option (A) is correct.

	Machining process		**Mechanism of material removal**
P.	Chemical machining	**2.**	Corrosive reaction
Q.	Electro-chemical machining	**3.**	Ion displacement
R.	Electro-discharge machining	**4.**	Fusion and vaporization
S.	Ultrasonic machining	**1.**	Erosion

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

MCQ 1.39 GATE ME 2011 TWO MARK

A single-point cutting tool with 12° rake angle is used to machine a steel work-piece. The depth of cut, i.e., uncut thickness is 0.81 mm. The chip thickness under orthogonal machining condition is 1.8 mm. The shear angle is approximately

(A) 22°
(B) 26°
(C) 56°
(D) 76°

SOL 1.39 Option (B) is correct.

Given : $\alpha = 12^\circ$, $t = 0.81\,\text{mm}$, $t_c = 1.8\,\text{mm}$

Shear angle, $$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} \qquad \text{...(i)}$$

Chip thickness ratio, $$r = \frac{t}{t_c} = \frac{0.81}{1.8} = 0.45$$

From equation (i),

$$\tan\phi = \frac{0.45\cos 12^\circ}{1 - 0.45\sin 12^\circ}$$

$$\phi = \tan^{-1}(0.486) = 25.91^\circ \simeq 26^\circ$$

MCQ 1.40 GATE ME 2011 TWO MARK

Consider the following system of equations

$$2x_1 + x_2 + x_3 = 0$$
$$x_2 - x_3 = 0$$
$$x_1 + x_2 = 0$$

This system has

(A) a unique solution
(B) no solution
(C) infinite number of solutions
(D) five solutions

SOL 1.40 Option (C) is correct.

Given system of equations are,

$$2x_1 + x_2 + x_3 = 0 \quad ...(i)$$
$$x_2 - x_3 = 0 \quad ...(ii)$$
$$x_1 + x_2 = 0 \quad ...(iii)$$

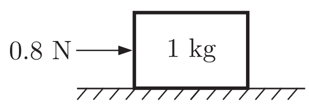
Adding the equation (i) & (ii)

$$2x_1 + 2x_2 = 0$$
$$x_1 + x_2 = 0 \quad ...(iv)$$

We see that the equation (iii) & (iv) is same and they will meet at infinite points. So we can say that this system of equations have infinite number of solutions.

MCQ 1.41 GATE ME 2011 TWO MARK

A 1 kg block is resting on a surface with coefficient of friction $\mu = 0.1$. A force of 0.8 N is applied to the block as shown in the figure. The friction force is



(A) 0 (B) 0.8 N

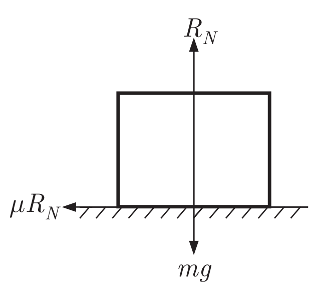
(C) 0.98 N (D) 1.2 N

SOL 1.41 Option (B) is correct.

Given : $m = 1\,\text{kg}$, $\mu = 0.1$

Draw the FBD of the system

From FBD : $R_N = mg$



Now static friction force,

$$f_S = \mu R_N = \mu mg = 0.1 \times 1 \times 9.8 = 0.98\,\text{N}$$

Applied force $F = 0.8\,\text{N}$ is less then, the static friction $f_S = 0.98\,\text{N}$

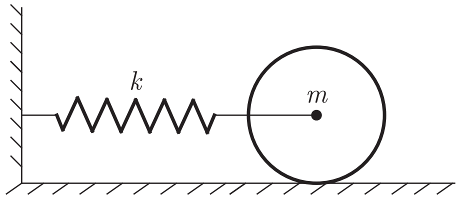
$$F < f_S$$

So, we can say that the friction developed will equal to the applied force

$$F = 0.8\,\text{N}$$

MCQ 1.42 GATE ME 2011 TWO MARK

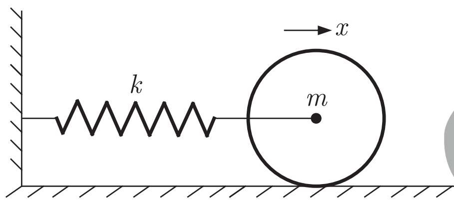
A disc of mass m is attached to a spring of stiffness k as shown in the figure The disc rolls without slipping on a horizontal surface. The natural frequency of vibration of the system is

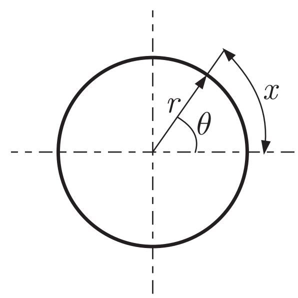


(A) $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$

(C) $\frac{1}{2\pi}\sqrt{\frac{2k}{3m}}$ (D) $\frac{1}{2\pi}\sqrt{\frac{3k}{2m}}$

SOL 1.42 Option (C) is correct.





$$\theta = \frac{x}{r} \Rightarrow x = r\theta \qquad \text{...(i)}$$

Total energy of the system remains constant.

So, T.E. = K.E. due to translatory motion + K.E. due to rotary motion + P.E. of spring

$$\text{T.E.} = \frac{1}{2}m\dot{x}^2 + \frac{1}{2}I\dot{\theta}^2 + \frac{1}{2}kx^2$$

$$= \frac{1}{2}mr^2\dot{\theta}^2 + \frac{1}{2}I\dot{\theta}^2 + \frac{1}{2}kr^2\theta^2 \qquad \text{From equation (i) } \dot{x} = r\dot{\theta}$$

$$= \frac{1}{2}mr^2\dot{\theta}^2 + \frac{1}{2}\times\frac{1}{2}mr^2\dot{\theta}^2 + \frac{1}{2}kr^2\theta^2 \qquad \text{For a disc } I = \frac{mr^2}{2}$$

$$= \frac{3}{4}mr^2\dot{\theta}^2 + \frac{1}{2}kr^2\theta^2 = \text{Constant}$$

On differentiating above equation w.r.t. t, we get

$$\frac{3}{4}mr^2 \times (2\dot{\theta}\ddot{\theta}) + \frac{1}{2}kr^2(2\theta\dot{\theta}) = 0$$

$$\frac{3}{2}mr^2\ddot{\theta} + kr^2\theta = 0$$

$$\ddot{\theta} + \frac{2k}{3m}\theta = 0$$

$$\omega_n^2 = \frac{2k}{3m}$$

So, $$\omega_n = \sqrt{\frac{2k}{3m}}$$

Therefore, natural frequency of vibration of the system is,

$$f_n = \frac{\omega_n}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{2k}{3m}}$$

MCQ 1.43 GATE ME 2011 TWO MARK

An ideal Brayton cycle, operating between the pressure limits of 1 bar and 6 bar, has minimum and maximum temperature of 300 K and 1500 K. The ratio of specific heats of the working fluid is 1.4. The approximate final temperatures in Kelvin at the end of compression and expansion processes are respectively

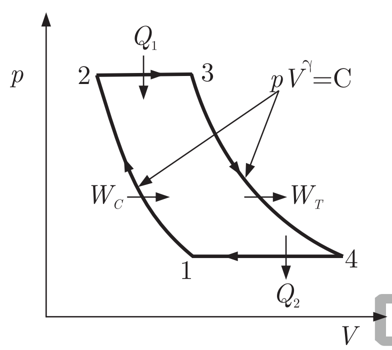
(A) 500 and 900 (B) 900 and 500

(C) 500 and 500 (D) 900 and 900

SOL 1.43

Option (A) is correct.

Given p - ν curve shows the Brayton Cycle.



Given : $p_1 = 1\,\text{bar} = p_4,\; p_2 = 6\,\text{bar} = p_3,\; T_{minimum} = 300\,\text{K},\; T_{maximum} = 1500\,\text{K}$

$$\frac{c_p}{c_v} = \gamma = 1.4$$

We have to find T_2 (temperature at the end of compression) or T_4 (temperature at the end of expansion)

Applying adiabatic equation for process 1-2, we get

$$\frac{T_1}{T_2} = \left(\frac{p_1}{p_2}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{1}{6}\right)^{\frac{1.4-1}{1.4}}$$

$$\frac{300}{T_2} = \left(\frac{1}{6}\right)^{0.286} \qquad T_1 = T_{minimum}$$

$$T_2 = \frac{300}{\left(\frac{1}{6}\right)^{0.286}} = 500.5\,\text{K} \simeq 500\,\text{K}$$

Again applying for the Process 3-4,

$$\frac{T_4}{T_3} = \left(\frac{p_4}{p_3}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{p_1}{p_2}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{1}{6}\right)^{\frac{1.4-1}{1.4}} = \left(\frac{1}{6}\right)^{0.286}$$

So,

$$T_4 = T_3 \times \left(\frac{1}{6}\right)^{0.286} = 1500 \times \left(\frac{1}{6}\right)^{0.286} = 900\,\text{K} \qquad T_3 = T_{maximum}$$

MCQ 1.44 GATE ME 2011 TWO MARK

A spherical steel ball of 12 mm diameter is initially at 1000 K. It is slowly cooled in surrounding of 300 K. The heat transfer coefficient between the steel ball and the surrounding is 5 W/m^2 K. The thermal conductivity of steel is 20 W/mK. The temperature difference between the centre and the surface of the steel ball is

(A) large because conduction resistance is far higher than the convective resistance.

(B) large because conduction resistance is far less than the convective resistance.

(C) small because conduction resistance is far higher than the convective resistance.

(D) small because conduction resistance is far less than the convective resistance.

SOL 1.44 Option (D) is correct.

Given : $D = 12\,\text{mm} = 12 \times 10^{-3}\,\text{m},\ h = 5\,\text{W/m}^2\,\text{K},\ k = 20\,\text{W/m K}$

For spherical ball, $= \dfrac{12 \times 10^{-3}}{6} = 2 \times 10^{-3}\,\text{m}$

$$l = \frac{\text{volume}}{\text{surface area}} = \frac{\frac{4}{3}\pi R^3}{4\pi R^2} = \frac{D}{6}$$

The non-dimensional factor (hl/k) is called biot Number. It gives an indication of the ratio of internal (conduction) resistance to the surface (convection) resistance. A small value of Bi implies that the system has a small conduction resistance i.e., relatively small temperature gradient or the existence of a practically uniform temperature within the system.

Biot Number, $Bi = \dfrac{hl}{k} = \dfrac{5 \times 2 \times 10^{-3}}{20} = 0.0005$

Since, Value of Biot Number is very less. Hence, conduction resistance is much less than convection resistance.

MCQ 1.45 GATE ME 2011 TWO MARK

A pump handing a liquid raises its pressure from 1 bar to 30 bar. Take the density of the liquid as $990\,\text{kg/m}^3$. The isentropic specific work done by the pump in kJ/kg is

(A) 0.10 (B) 0.30

(C) 2.50 (D) 2.93

SOL 1.45 Option (D) is correct.

Given : $p_1 = 1\,\text{bar},\ p_2 = 30\,\text{bar},\ \rho = 990\,\text{kg/m}^3$

Isentropic work down by the pump is given by,

$$W = \nu dp = \frac{m}{\rho} dp \qquad \nu = \frac{m}{\rho}$$

$$\frac{W}{m} = \frac{1}{\rho} dp = \frac{1}{990} \times (30 - 1) \times 10^5 \text{ pascal}$$

$$= 2929.29\,\text{J/kg} = 2.93\,\text{kJ/kg}$$

MCQ 1.46 GATE ME 2011 TWO MARK

The crank radius of a single-cylinder I.C. engine is 60 mm and the diameter of the cylinder is 80 mm. The swept volume of the cylinder in cm^3 is

(A) 48 (B) 96

(C) 302 (D) 603

SOL 1.46 Option (D) is correct.

Given : $r = 60\,\text{mm},\ D = 80\,\text{mm}$

Stroke length, $L = 2r = 2 \times 60 = 120\,\text{mm}$ (cylinder diameter)

Swept Volume, $\nu_s = A \times L$

$$= \frac{\pi}{4} D^2 \times L = \frac{\pi}{4}(8.0)^2 \times 12.0$$

$$= \frac{\pi}{4}(8 \times 8) \times 12 = 602.88 \simeq 603\,\text{cm}^3$$

MCQ 1.47

GATE ME 2011 TWO MARK

The ratios of the laminar hydrodynamic boundary layer thickness to thermal boundary layer thickness of flows of two fluids P and Q on a flat plate are 1/2 and 2 respectively. The Reynolds number based on the plate length for both the flows is 10^4. The Prandtl and Nusselt numbers for P are 1/8 and 35 respectively. The Prandtl and Nusselt numbers for Q are respectively

(A) 8 and 140 (B) 8 and 70

(C) 4 and 40 (D) 4 and 35

SOL 1.47

Option (A) is correct.

Given : $\left(\frac{\delta_H}{\delta_{Th}}\right)_P = \frac{1}{2}$ and $\left(\frac{\delta_H}{\delta_{Th}}\right)_Q = 2$

Here, δ_H →Thickness of laminar hydrodynamic boundary layer

And δ_{Th} →Thickness of thermal boundary layer

$$(\text{Re})_P = (\text{Re})_Q = 10^4$$

$$(\text{Pr})_P = \frac{1}{8}$$

$$(\text{Nu})_P = 35$$

For thermal boundary layer prandtl Number is given by, (For fluid Q)

$$(\text{Pr})_Q^{1/3} = \left(\frac{\delta_H}{\delta_{Th}}\right)_Q = 2$$

$$(\text{Pr})_Q = (2)^3 = 8$$

For laminar boundary layer on flat plate, relation between Reynolds Number, Prandtl Number & Nusselt Number is given by,

$$\text{Nu} = \frac{hl}{k} = (\text{Re})^{1/2}(\text{Pr})^{1/3}$$

Since, Reynolds Number is same for both P & Q.

So, $$\frac{(\text{Nu})_P}{(\text{Nu})_Q} = \frac{(\text{Pr})_P^{1/3}}{(\text{Pr})_Q^{1/3}}$$

$$(\text{Nu})_Q = \frac{(\text{Pr})_Q^{1/3}}{(\text{Pr})_P^{1/3}} \times (\text{Nu})_P = \frac{(8)^{1/3}}{(1/8)^{1/3}} \times (35)$$

$$= \frac{2}{1/2} \times 35 = 140$$

Common Data for Questions 48 and 49 :

One unit of product P_1 requires 3 kg of resources R_1 and 1 kg of resources R_2. One unit of product P_2 requires 2 kg of resources R_1 and 2 kg of resources R_2. The profits per unit by selling product P_1 and P_2 are Rs. 2000 and Rs. 3000 respectively.

The manufacturer has 90 kg of resources R_1 and 100 kg of resources R_2.

MCQ 1.48 The unit worth of resources R_2, i.e., dual price of resources R_2 in Rs. per kg is

GATE ME 2011 TWO MARK

(A) 0 (B) 1350

(C) 1500 (D) 2000

SOL 1.48 Option (A) is correct.

Since, in Z_j Row of final (second) obtimum table the value of slack variable S_2 showns the unit worth or dual price of Resource R_2 and the value of S_2 in given below table is zero. Hence the dual Price of Resource R_2 is zero.

$$\text{Max } Z = 2000P_1 + 3000P_2$$

S.T.

$$3P_1 + 2P_2 \le 90 \quad \rightarrow R_1 - \text{Resource}$$

$$P_1 + 2P_2 \le 100 \quad \rightarrow R_2 - \text{Resource}$$

$$P_1,\ P_2 \ge 0$$

Solution :

$$Z = 2000P_1 + 3000P_2 + 0.S_1 + 0.S_2$$

S.T.

$$3P_1 + 2P_2 + S_1 = 90$$

$$P_1 + 2P_2 + S_2 = 100$$

$$P_1 \ge 0,\ P_2 \ge 0,\ S_1 \ge 0,\ S_2 \ge 0$$

First table :-

		C_j	2000	3000	0	0
C_B	S_B	P_B	P_1	P_2	S_1	S_2
0	S_1	90	3	$\boxed{2}$ →	1	0
0	S_2	100	1	2	0	1
	Z_j		0	0	0	0
	$Z_j - C_j$		-2000	-3000 ↑	0	0

Second Table :-

		C_j	2000	3000	0	0
C_B	S_B	P_B	P_1	P_2	S_1	S_2
3000	P_2	$\boxed{45}$	3/2	1	1/2	0
0	S_2	10	-2	0	-1	1
		Z_j	4500	3000	1500	$\boxed{0}$ → unit worth of R_2
		$Z_j - C_j$	2500	0	1500	0

MCQ 1.49 The manufacturer can make a maximum profit of Rs.

GATE ME 2011 TWO MARK

(A) 60000 (B) 135000

(C) 150000 (D) 200000

SOL 1.49 Option (B) is correct.

Since all $Z_j - C_j \geq 0$, an optimal basic feasible solution has been attained. Thus, the optimum solution to the given LPP is

$$\text{Max}\, Z = 2000 \times 0 + 3000 \times 45$$
$$= \text{Rs.}135000 \text{ with } P_1 = 0 \text{ and } P_2 = 45$$

Common data Question 50 and 51 :

In an experimental set up, air flows between two stations P and Q adiabatically. The direction of flow depends on the pressure and temperature conditions maintained at P and Q. The conditions at station P are 150 kPa and 350 K. The temperature at station Q is 300 K.

The following are the properties and relations pertaining to air :

Specific heat at constant pressure, $c_p = 1.005$ kJ/kgK;
Specific heat at constant volume, $c_v = 0.718$ kJ/kgK;
Characteristic gas constant, $R = 0.287$ kJ/kgK
Enthalpy, $h = c_p T$
Internal energy, $u = c_v T$

MCQ 1.50 GATE ME 2011 TWO MARK

If the air has to flow from station P to station Q, the maximum possible value of pressure in kPa at station Q is close to

(A) 50 (B) 87

(C) 128 (D) 150

SOL 1.50 Option (B) is correct.

Given : At station p :

$p_1 = 150$ kPa, $T_1 = 350$ K

At station Q :

$p_2 = ?$, $T_2 = 300$ K

We know, $$\gamma = \frac{c_p}{c_v} = \frac{1.005}{0.718} = 1.39$$

Applying adiabatic equation for station P & Q,

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

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

$$p_2 = \frac{p_1}{\left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{\gamma-1}}} = \frac{150}{\left(\frac{350}{300}\right)^{\frac{1.39}{1.39-1}}}$$

$$= \frac{150}{1.732} = 86.60 \text{ kPa} \simeq 87 \text{ kPa}$$

MCQ 1.51 GATE ME 2011 TWO MARK

If the pressure at station Q is 50 kPa, the change in entropy $(s_Q - s_P)$ in kJ/kgK is

(A) -0.155 (B) 0

(C) 0.160 (D) 0.355

SOL 1.51 Option (C) is correct.

Given :

Pressure at Q $p_2 = 50\,\text{kPa}$

By using the general relation to find the entropy changes between P and Q

$$Tds = dh - \nu dp$$

$$ds = \frac{dh}{T} - \frac{\nu}{T}dp \quad \text{...(i)}$$

Given in the previous part of the question

$$h = c_p T$$

Differentiating both the sides, we get

$$dh = c_p dT$$

Put the value of dh in equation (i),

$$ds = c_p \frac{dT}{T} - \frac{\nu}{T}dp$$

From the gas equation $\nu/T = R/p$

So,
$$= c_p \frac{dT}{T} - R\frac{dp}{p}$$

Integrating both the sides and put the limits

$$\int_P^Q ds = c_p \int_P^Q \frac{dT}{T} - R\int_P^Q \frac{dp}{p}$$

$$[s]_P^Q = c_p[\ln T]_P^Q - R[\ln P]_P^Q$$

$$s_Q - s_P = c_p[\ln T_Q - \ln T_P] - R[\ln p_Q - \ln p_P]$$

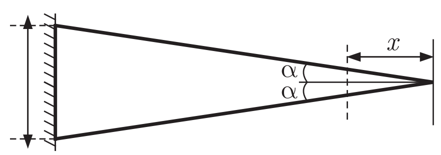
$$= c_p \ln\left(\frac{T_Q}{T_P}\right) - R\ln\left(\frac{p_Q}{p_P}\right)$$

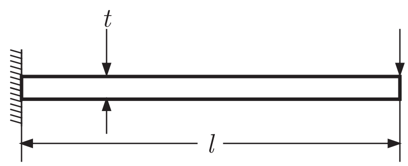
$$= 1.005\ln\left(\frac{300}{350}\right) - 0.287\ln\left(\frac{50}{150}\right)$$

$$= 1.005 \times (-0.1541) - 0.287 \times (-1.099) = 0.160\,\text{kJ/kg K}$$

Linked Data Question 52 and 53 :

A triangular-shaped cantilever beam of uniform-thickness is shown in the figure The Young's modulus of the material of the beam is E. A concentrated load P is applied at the free end of the beam.





MCQ 1.52 GATE ME 2011 TWO MARK

The area moment of inertia about the neutral axis of a cross-section at a distance x measured from the free end is

(A) $\frac{bxt^3}{6l}$

(B) $\frac{bxt^3}{12l}$

(C) $\frac{bxt^3}{24l}$

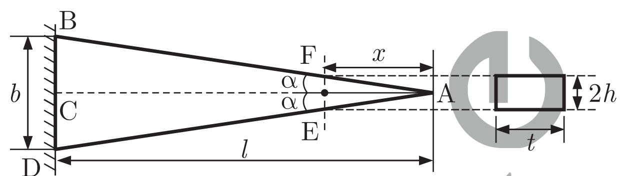
(D) $\frac{xt^3}{12l}$

SOL 1.52

Option (B) is correct.

Let, b = width of the base of triangle $ABD = BD$

t = thickness of conilever beam



From the similar triangle (Figure (i)) ΔABC or ΔAFE

$$\frac{b/2}{l} = \frac{h}{x} \qquad \text{let } OE = h$$

$$h = \frac{bx}{2l} \qquad ...(i)$$

Now from figure (ii), For a rectangular cross section,

$$I = \frac{(2h)\,t^3}{12} = 2 \times \frac{bx}{2l} \times \frac{t^3}{12} \qquad \text{From equation (i)}$$

$$I = \frac{bxt^3}{12l}$$

MCQ 1.53 GATE ME 2011 TWO MARK

The maximum deflection of the beam is

(A) $\frac{24Pl^3}{Ebt^3}$

(B) $\frac{12Pl^3}{Ebt^3}$

(C) $\frac{3Pl^3}{Ebt^3}$

(D) $\frac{6Pl^3}{Ebt^3}$

SOL 1.53

Option (D) is correct.

We know that deflection equation is

$$EI\frac{d^2t}{dx^2} = M = P \times x$$

$$\frac{d^2y}{dx^2} = \frac{1}{EI}P \times x$$

From previous part of the question

$$\frac{d^2y}{dx^2} = \frac{1}{E \times \frac{bxt^3}{12L}} \times Px = \frac{12PL}{Ebt^3}$$

On Integrating, we get

$$\frac{dy}{dx} = \frac{12PLx}{Ebt^3} + C_1 \qquad ...(i)$$

When $x = L$, $\frac{dy}{dx} = 0$

So, $$0 = \frac{12PL^2}{Ebt^3} + C_1 \Rightarrow C_1 = -\frac{12PL^2}{Ebt^3}$$

Again integrating equation (i),

$$y = \frac{12PL}{Ebt^3} \times \frac{x^2}{2} + C_1x + C_2 \qquad ...(ii)$$

When $x = L$, $y = 0$

So,

$$0 = \frac{12PL}{2Ebt^3} \times L^2 + C_1L + C_2$$

$$= \frac{6PL^3}{Ebt^3} - \frac{12PL^3}{Ebt^3} + C_2$$

$$C_2 = \frac{6PL^3}{Ebt^3}$$

From equation (ii),

$$y = \frac{6PLx^2}{Ebt^3} - \frac{12PL^2x}{Ebt^3} + \frac{6PL^3}{Ebt^3} \qquad ...(iii)$$

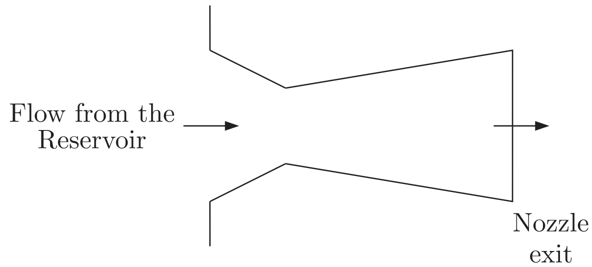
The maximum deflection occurs at $x = 0$, from equation (iii),

$$y_{\max} = 0 + 0 + \frac{6PL^3}{Ebt^3}$$

$$y_{\max} = \frac{6PL^3}{Ebt^3}$$

Statement for Linked Answer Questions 54 and 55 :

The temperature and pressure of air in a large reservoir are 400 K and 3 bar respectively. A converging diverging nozzle of exit area 0.005 m^2 is fitted to the wall of the reservoir as shown in the figure. The static pressure of air at the exit section for isentropic flow through the nozzle is 50 kPa. The characteristic gas constant and the ratio of specific heats of air are 0.287 kJ/kgK and 1.4 respectively.



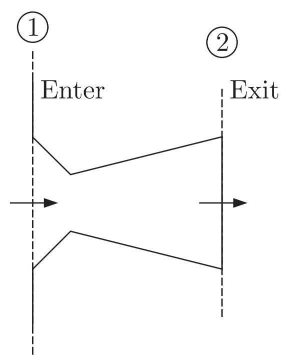
MCQ 1.54 The density of air in kg/m^3 at the nozzle exit is

GATE ME 2011 TWO MARK

(A) 0.560 (B) 0.600

(C) 0.727 (D) 0.800

SOL 1.54 Option (C) is correct.



Given : $T_1 = 400\,\text{K},\ p_1 = 3\,\text{bar}$

$A_2 = 0.005\,\text{m}^2,\ p_2 = 50\,\text{kPa} = 0.5\,\text{bar},\ R = 0.287\ \text{kJ/kg K}$

$\gamma = \frac{c_p}{c_v} = 1.4,\ T_2 = ?$

Applying adiabatic equation for isentropic (reversible adiabatic) flow at section (1) and (2), we get

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

$$T_2 = T_1\left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = 400\left(\frac{0.5}{3}\right)^{\frac{1.4-1}{1.4}}$$

$$= 400 \times (0.166)^{0.286} = 239.73\ \text{K}$$

Apply perfect Gas equation at the exit,

$$p_2\nu_2 = m_2RT_2$$

$$p_2 = \frac{m_2}{\nu_2}RT_2 = \rho_2RT_2 \qquad \left(\frac{m}{\nu} = \rho\right)$$

$$\rho_2 = \frac{p_2}{RT_2} = \frac{50 \times 10^3}{0.287 \times 10^3 \times 239.73} = 0.727\ \text{kg/m}^3$$

MCQ 1.55 The mass flow rate of air through the nozzle in kg/s is

GATE ME 2011 TWO MARK

(A) 1.30 (B) 1.77

(C) 1.85 (D) 2.06

SOL 1.55 Option (D) is correct.

Given : $\rho_2 = 0.727\ \text{kg/m}^3$, $A_2 = 0.005\ \text{m}^2$, $V_2 = ?$

For isentropic expansion,

$$V_2 = \sqrt{2c_p(T_1 - T_2)} = \sqrt{2 \times 1.005 \times 10^3 \times (400 - 239.73)}$$

for air $c_p = 1.005\ \text{kJ/kg K}$

$$= \sqrt{322142.7} = 567.58\ \text{m/sec}$$

Mass flow rate at exit,

$$\dot{m} = \rho_2 A_2 V_2 = 0.727 \times 0.005 \times 567.58 = 2.06\ \text{kg/sec}$$

MCQ 1.56 GATE ME 2011 ONE MARK

Choose the most appropriate word from the options given below to complete the following sentence.

If you are trying to make a strong impression on your audience, you cannot do so by being understated, tentative or

(A) hyperbolic (B) restrained

(C) argumentative (D) indifferent

SOL 1.56 Option (B) is correct.

The mean of the sentence indicates a word that is similar to understand is needed for the blank place.

Therefore, the best option is restrained which means controlled or reserved.

MCQ 1.57 GATE ME 2011 ONE MARK

If $\log(P) = (1/2)\log(Q) = (1/3)\log(R)$, then which of the following options is TRUE ?

(A) $P^2 = Q^3 R^2$ (B) $Q^2 = PR$

(C) $Q^2 = R^3 P$ (D) $R = P^2 Q^2$

SOL 1.57 Option (B) is correct.

We have

$$\log(P) = \frac{1}{2}\log(Q) = \frac{1}{3}\log(R)$$

or $\log(P) = \log(Q)^{1/2} = \log(R)^{1/3} = \log C$

Where $\log C$ is a constant.

or $P = C$, $Q = C^2$, $R = C^3$

Now From option (ii),

$$Q^2 = PR$$
$$(C^2)^2 = C \times C^3$$
$$C^4 = C^4$$

Equation (ii) satisfies.

MCQ 1.58 GATE ME 2011 ONE MARK

Choose the word from the options given below that is most nearly opposite in meaning to the given word :

Amalgamate

(A) merge (B) split

(C) collect (D) separate

SOL 1.58 Option (B) is correct.

Amalgamate means combine into a unified or integrated whole unit. The word split is nearly opposite in meaning to the Amalgamate.

MCQ 1.59 GATE ME 2011 ONE MARK

Choose the most appropriate word from the options given below to complete the following sentence.

In contemplated................Singapore for my vacation but decided against it.

(A) to visit (B) having to visit

(C) visiting (D) for a visit

SOL 1.59 Option (C) is correct.

The correct usage of contemplate is verb + ing form. It is a transitive verb. The most appropriate work is visiting.

MCQ 1.60 GATE ME 2011 ONE MARK

Which of the following options is the closest in the meaning to the word below :

Inexplicable

(A) Incomprehensible (B) Indelible

(C) Inextricable (D) Infallible

SOL 1.60 Option (A) is correct.

Inexplicable means incapable of being explained or accounted. So, the best synonym here is incomprehensible.

MCQ 1.61 GATE ME 2011 TWO MARK

A transporter receives the same number of orders each day. Currently, he has some pending orders (backlog) to be shipped. If he uses 7 trucks, then at the end of the 4th day he can clear all the orders. Alternatively, if he uses only 3 trucks, then all the orders are cleared at the end of the 10th day. What is the minimum number of trucks required so that there will be no pending order at the end of the 5th day ?

(A) 4 (B) 5

(C) 6 (D) 7

SOL 1.61 Option (C) is correct.

Let 'x' be the number of orders each day and y be the backlogs.

So, From the given conditions

$$4x+y = 4\times 7 = 28$$

and $$10x+y = 3\times 10 = 30$$

After solving these two equations, we get

$$x = \frac{1}{3}, \qquad y = \frac{80}{3}$$

Now determine the number of trucks, so that no pending order will be left end of the 5th day.

$$5x + y = 5n$$

Where n = Number of trucks

$$n = \frac{5 \times \frac{1}{3} + \frac{80}{3}}{5} = \frac{\frac{85}{3}}{5} = 5.56$$

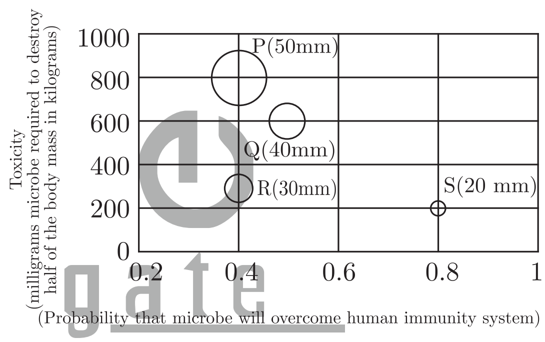
Hence number of trucks have to be natural number,

$$n = 6$$

MCQ 1.62

GATE ME 2011 TWO MARK

P, Q, R and S are four types of dangerous microbes recently found in a human habitat. The area of each circle with its diameter printed in brackets represents the growth of a single microbe surviving human immunity system within 24 hours of entering the body. The danger to human beings varies proportionately with the toxicity, potency and growth attributed to a microbe shown in the figure below :



A pharmaceutical company is contemplating the development of a vaccine against the most dangerous microbe. Which microbe should the company target in its first attempt ?

(A) P (B) Q

(C) R (D) S

SOL 1.62

Option (D) is correct.

The danger of a microbe to human being will be directly proportional to potency and growth and inversely proportional to the toxicity.

So, level of dangerous $\propto \dfrac{\text{Potency} \times \text{growth}}{\text{Toxicity}}$

$$D = C\frac{PG}{T} \text{ Where } C = \text{constant of proportionality}$$

For P, $D_P = \dfrac{0.4 \times \pi \times (25)^2}{800} = 0.98$

For Q, $D_Q = \dfrac{0.5 \times \pi \times (20)^2}{600} = 1.047$

For R, $D_R = \dfrac{0.4 \times \pi \times (15)^2}{300} = 0.94$

For S, $D_S = \dfrac{0.8 \times \pi \times (10)^2}{200} = 1.25$

Thus D_S is maximum and it is most dangerous among them and it is targeted in first attempt.

MCQ 1.63 GATE ME 2011 TWO MARK

A container originally contains 10 litres of pure spirit. From this container 1 litre of spirit is replaced with 1 litre of water. Subsequently, 1 litre of the mixture is again replaced with 1 litre of water and this processes is repeated one more time. How much spirit is now left in the container ?

(A) 7.58 litres (B) 7.84 litres

(C) 7 litres (D) 7.29 litres

SOL 1.63

Option (D) is correct.

We know

Quantity of spirit left after n^{th} operation $= a \times \left(\frac{a-b}{a}\right)^n$

Where a = initial quantity of pure spirit

and b = quantity taken out and replaced every time

Now after three $(n = 3)$ operations,

Left quantity of spirit after 3^{rd} operation

$$= 10\left(\frac{10-1}{10}\right)^3 = 10\left(\frac{9}{10}\right)^3$$
$$= 7.29 \text{ litre}$$

MCQ 1.64 GATE ME 2011 TWO MARK

The variable cost (V) of manufacturing a product varies according to the equation $V = 4q$, where q is the quantity produced. The fixed cost (F) of production of same product reduces with q according to the equation $F = 100/q$. How many units should be produced to minimize the total cost $(V + F)$?

(A) 5 (B) 4

(C) 7 (D) 6

SOL 1.64

Option (A) is correct.

Total cost = Variable cost + Fixed Cost

$$T.C. = V + F$$
$$= 4q + \frac{100}{q}$$

Not for minimize the total cost, using the options.

(A) For $q = 5, T.C.$ $= 4 \times 5 + \frac{100}{5} = 40$

(B) For $q = 4, T.C.$ $= 4 \times 4 + \frac{100}{4} = 41$

(C) For $q = 7, T.C.$ $= 4 \times 7 + \frac{100}{7} = 42.28$

(D) For $q = 6, T.C.$ $= 4 \times 6 + \frac{100}{6} = 40.66$

Hence, option (A) gives the minimum cost.

MCQ 1.65 GATE ME 2011 TWO MARK

Few school curricula include a unit on how to deal with bereavement and grief, and yet all students at some point in their lives suffer from losses through death and parting.

Based on the above passage which topic would not be included in a unit on bereavement ?

(A) how to write a letter of condolence

(B) what emotional stages are passed through in the healing process

(C) what the leading causes of death are

(D) how to give support to a grieving friend

SOL 1.65 Option (C) is correct.

This passage deals with how to deal with bereavement and grief. So, after the tragedy occurs and it is not about precautions. Thus option (C), what the leading causes of death are, not be included in a unit of bereavement. Rest all are important in dealing with grief.

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

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Design of patterns, moulds and cores; solidification and cooling; riser and gating design, design considerations.

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Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy.

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