ME GATE-04

MCQ 1.1 If $x = a(\theta + \sin\theta)$ and $y = a(1 - \cos\theta)$, then $\frac{dy}{dx}$ will be equal to

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(A) $\sin\left(\frac{\theta}{2}\right)$ (B) $\cos\left(\frac{\theta}{2}\right)$

(C) $\tan\left(\frac{\theta}{2}\right)$ (D) $\cot\left(\frac{\theta}{2}\right)$

SOL 1.1 Option (C) is correct.

Given : $x = a(\theta + \sin\theta),\ y = a(1 - \cos\theta)$

First differentiate x w.r.t. θ,

$$\frac{dx}{d\theta} = a[1 + \cos\theta]$$

And differentiate y w.r.t. θ

$$\frac{dy}{d\theta} = a[0 - (-\sin\theta)] = a\sin\theta$$

We know,

$$\frac{dy}{dx} = \frac{dy}{d\theta} \times \frac{d\theta}{dx} = \frac{dy/d\theta}{dx/d\theta}$$

Substitute the values of $\frac{dy}{d\theta}$ & $\frac{dx}{d\theta}$

$$\frac{dy}{dx} = a\sin\theta \times \frac{1}{a[1 + \cos\theta]} = \frac{\sin\theta}{1 + \cos\theta} = \frac{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}}{2\cos^2\frac{\theta}{2}}$$

$$= \frac{\sin\frac{\theta}{2}}{\cos\frac{\theta}{2}} = \tan\frac{\theta}{2} \qquad \cos\theta + 1 = 2\cos^2\frac{\theta}{2}$$

MCQ 1.2 The angle between two unit-magnitude coplanar vectors $P(0.866, 0.500, 0)$ and $Q(0.259, 0.966, 0)$ will be

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(A) 0° (B) 30°

(C) 45° (D) 60°

SOL 1.2 Option (C) is correct.

Given : $P(0.866, 0.500, 0)$, so we can write

$$\boldsymbol{P} = 0.866\boldsymbol{i} + 0.5\boldsymbol{j} + 0\boldsymbol{k}$$

$Q = (0.259, 0.966, 0)$, so we can write

$$\boldsymbol{Q} = 0.259\boldsymbol{i} + 0.966\boldsymbol{j} + 0\boldsymbol{k}$$

We know that for the coplanar vectors

$$\boldsymbol{P} \cdot \boldsymbol{Q} = |\boldsymbol{P}||\boldsymbol{Q}|\cos\theta$$

$$\cos\theta = \frac{\boldsymbol{P} \cdot \boldsymbol{Q}}{|\boldsymbol{P}||\boldsymbol{Q}|}$$

$$\boldsymbol{P} \cdot \boldsymbol{Q} = (0.866\boldsymbol{i} + 0.5\boldsymbol{j} + 0\boldsymbol{k}) \cdot (0.259\boldsymbol{i} + 0.966\boldsymbol{j} + 0\boldsymbol{k})$$

$$= 0.866 \times 0.259 + 0.5 \times 0.966$$

So,

$$\cos\theta = \frac{0.866 \times 0.259 + 0.5 \times 0.966}{\sqrt{(0.866)^2 + (0.5)^2} + \sqrt{(0.259)^2 + (0.966)^2}}$$

$$= \frac{0.22429 + 0.483}{\sqrt{0.99} \times \sqrt{1.001}} = \frac{0.70729}{\sqrt{0.99} \times \sqrt{1.001}} = 0.707$$

$$\theta = \cos^{-1}(0.707) = 45^\circ$$

MCQ 1.3 The sum of the eigen values of the matrix given below is

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

(A) 5
(B) 7
(C) 9
(D) 18

SOL 1.3 Option (B) is correct.

Let

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

We know that the sum of the eigen value of a matrix is equal to the sum of the diagonal elements of the matrix

So, the sum of eigen values is,

$$1+5+1 = 7$$

MCQ 1.4 The figure shows a pin-jointed plane truss loaded at the point M by hanging a mass of 100 kg. The member LN of the truss is subjected to a load of

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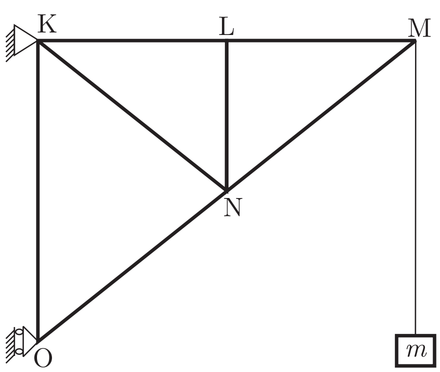
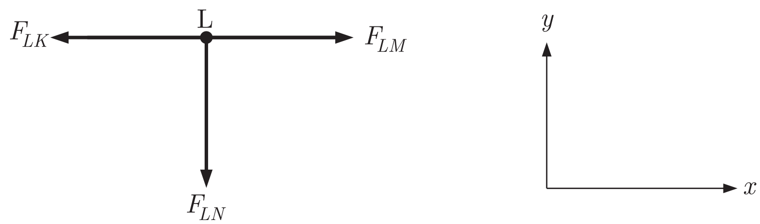


(A) 0 Newton (B) 490 Newtons in compression
(C) 981 Newtons in compression (D) 981 Newtons in tension

SOL 1.4 Option (A) is correct.

First of all we consider all the forces, which are acting at point L.



Now sum all the forces which are acting along x direction,

$$F_{LK} = F_{LM}$$ Both are acting in opposite direction

Also summation of all the forces, which are acting along y-direction.

$$F_{LN} = 0$$ Only one forces acting in y-direction

So the member LN is subjected to zero load.

MCQ 1.5 In terms of Poisson's ratio (υ) the ratio of Young's Modulus (E) to Shear Modulus (G) of elastic materials is

GATE ME 2004 ONE MARK

(A) $2(1+\upsilon)$ (B) $2(1-\upsilon)$

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

SOL 1.5 Option (A) is correct.

We know that, relation between E, G & υ is given by,

$$E = 2G(1+\upsilon)$$

Where E = young's modulus

G = Shear Modulus

υ = Poisson's ratio

Now, $$\frac{E}{G} = 2(1+\upsilon)$$

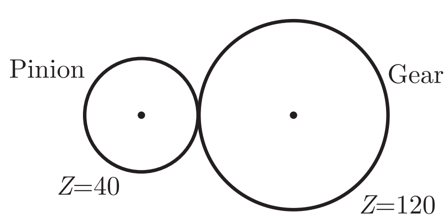
MCQ 1.6 Two mating spur gears have 40 and 120 teeth respectively. The pinion rotates at 1200 rpm and transmits a torque of 20 Nm. The torque transmitted by the gear is

GATE ME 2004 ONE MARK

(A) 6.6 Nm (B) 20 Nm

(C) 40 Nm (D) 60 Nm

SOL 1.6 Option (D) is correct.



Given : $Z_P = 40$ teeth, $Z_G = 120$ teeth, $N_P = 1200$ rpm, $T_P = 20$ N-m

Velocity Ratio, $\dfrac{Z_P}{Z_G} = \dfrac{N_G}{N_P}$

$$N_G = \frac{Z_P}{Z_G} \times N_P$$

$$N_G = \frac{40}{120} \times 1200 = 400 \text{ rpm}$$

Power transmitted is same for both pinion & Gear.

$$P = \frac{2\pi N_P T_P}{60} = \frac{2\pi N_G T_G}{60}$$

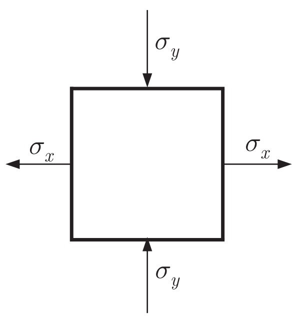
$$N_P T_P = N_G T_G$$

$$T_G = \frac{N_P T_P}{N_G} = \frac{1200}{400} \times 20 = 60 \text{ N-m}$$

So, the torque transmitted by the Gear is 60 N-m

MCQ 1.7 GATE ME 2004 ONE MARK

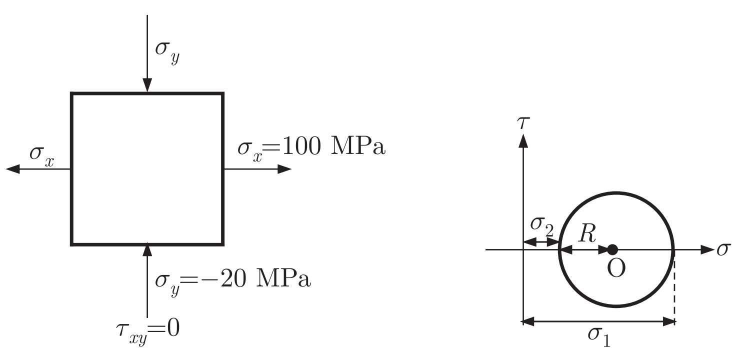
The figure shows the state of stress at a certain point in a stressed body. The magnitudes of normal stresses in x and y directions are 100 MPa and 20 MPa respectively. The radius of Mohr's stress circle representing this state of stress is



(A) 120 (B) 80

(C) 60 (D) 40

SOL 1.7 Option (C) is correct.



$\sigma_x = 100$ MPa (Tensile), $\sigma_y = -20$ MPa (Compressive)

We know that, $\sigma_1 = \dfrac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

From the figure, Radius of Mohr's circle,

$$R = \frac{\sigma_1 - \sigma_2}{2}$$

$$= \frac{1}{2} \times 2\sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Substitute the values, we get

$$R = \sqrt{\left[\frac{100 - (-20)}{2}\right]^2} = 60$$

MCQ 1.8 For a mechanism shown below, the mechanical advantage for the given configuration is

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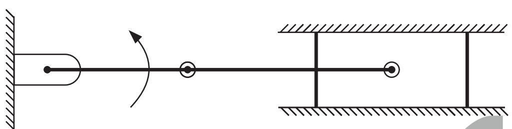

(A) 0 (B) 0.5

(C) 1.0 (D) ∞

SOL 1.8 Option (D) is correct.

Mechanical advantage in the form of torque is given by,

$$M.A. = \frac{T_{output}}{T_{input}} = \frac{\omega_{input}}{\omega_{output}}$$

Here output link is a slider, So, $\omega_{output} = 0$

Therefore, $M.A. = \infty$

MCQ 1.9 A vibrating machine is isolated from the floor using springs. If the ratio of excitation frequency of vibration of machine to the natural frequency of the isolation system is equal to 0.5, then transmissibility ratio of isolation is

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

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

SOL 1.9 Option (C) is correct.

Given $\frac{\omega}{\omega_n} = r = 0.5$

And due to isolation damping ratio,

$$\varepsilon = \frac{c}{c_c} = 0 \qquad \text{For isolation } c = 0$$

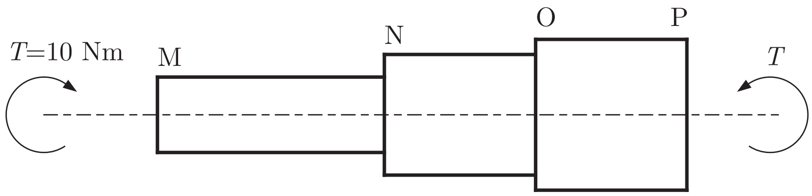
We know the transmissibility ratio of isolation is given by,

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

$$= \frac{\sqrt{1+0}}{\sqrt{[1-(0.5)^2]^2+0}} = \frac{1}{0.75} = \frac{4}{3}$$

MCQ 1.10 GATE ME 2004 ONE MARK

A torque of 10 Nm is transmitted through a stepped shaft as shown in figure. The torsional stiffness of individual sections of length MN, NO and OP are 20 Nm/ rad, 30 Nm/rad and 60 Nm/rad respectively. The angular deflection between the ends M and P of the shaft is



(A) 0.5 rad (B) 1.0 rad

(C) 5.0 rad (D) 10.0 rad

SOL 1.10 Option (B) is correct.

Given : $T = 10$ N-m, $k_{MN} = 20$ N-m/rad, $k_{NO} = 30$ N-m/rad, $k_{OP} = 60$ N-m/rad

We know that angular deflection,

$$\theta = \frac{T}{k}$$

For section MN, NO or OP,

$$\theta_{MN} = \frac{10}{20}\text{ rad}, \; \theta_{NO} = \frac{10}{30}\text{ rad}, \; \theta_{OP} = \frac{10}{60}\text{ rad}$$

Since MN, NO & OP are connected in series combination. So angular deflection between the ends M and P of the shaft is,

$$\theta_{MP} = \theta_{MN} + \theta_{NO} + \theta_{OP} = \frac{10}{20} + \frac{10}{30} + \frac{10}{60} = 1\text{ radian}$$

MCQ 1.11 GATE ME 2004 ONE MARK

In terms of theoretical stress concentration factor (K_t) and fatigue stress concentration factor (K_f), the notch sensitivity 'q' is expressed as

(A) $\frac{(K_f-1)}{(K_t-1)}$ (B) $\frac{(K_f-1)}{(K_t+1)}$

(C) $\frac{(K_t-1)}{(K_f-1)}$ (D) $\frac{(K_f+1)}{(K_t+1)}$

SOL 1.11 Option (A) is correct.

When the notch sensitivity factor q is used in cyclic loading, then fatigue stress concentration factor may be obtained from the following relation.

$$K_f = 1 + q(K_t - 1)$$

$$K_f - 1 = q(K_t - 1)$$

$$q = \frac{K_f - 1}{K_t - 1}$$

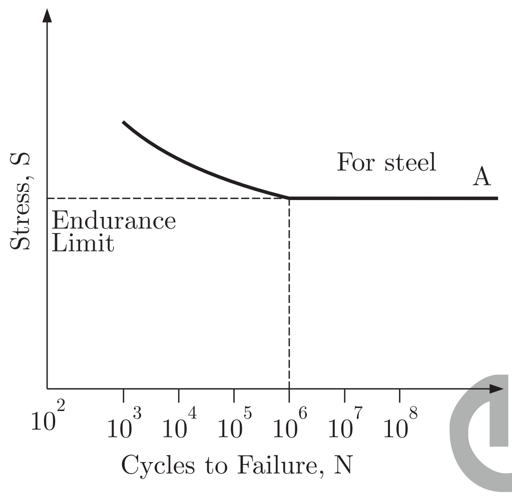
MCQ 1.12 The S-N curve for steel becomes asymptotic nearly at

GATE ME 2004 ONE MARK

(A) 10^3 cycles
(B) 10^4 cycles
(C) 10^6 cycles
(D) 10^9 cycles

SOL 1.12 Option (C) is correct.

The S-N curve for the steel is shown below :



We can easily see from the S-N curve that, steel becomes asymptotic nearly at 10^6 cycles.

MCQ 1.13 In the window air conditioner, the expansion device used is

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(A) capillary tube
(B) thermostatic expansion valve
(C) automatic expansion valve
(D) float valve

SOL 1.13 Option (A) is correct.

Air conditioner mounted in a window or through the wall are self-contained units of small capacity of 1 TR to 3 TR. The capillary tube is used as an expansion device in small capacity refrigeration units.

MCQ 1.14 During the chemical dehumidification process of air

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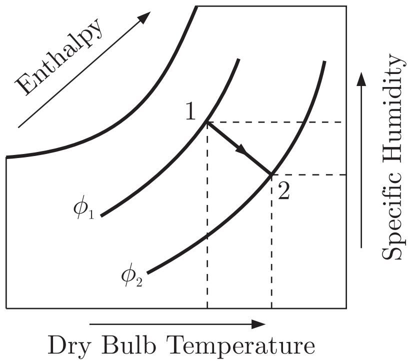
(A) dry bulb temperature and specific humidity decreases
(B) dry bulb temperature increases and specific humidity decreases
(C) dry bulb temperature decreases and specific humidity increases
(D) dry bulb temperature and specific humidity increases

SOL 1.14 Option (B) is correct.



In the process of chemical dehumidification of air , the air is passed over chemicals which have an affinity for moisture and the moisture of air gets condensed out and gives up its latent heat. Due to the condensation, the specific humidity decreases and the heat of condensation supplies sensible heat for heating the air and thus increasing its dry bulb temperature.

So chemical dehumidification increase dry bulb temperature & decreases specific humidity.

MCQ 1.15 At the time of starting, idling and low speed operation, the carburretor supplies a mixture which can be termed as

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(A) Lean (B) slightly leaner than stoichiometric

(C) stoichiometric (D) rich

SOL 1.15 Option (C) is correct.

Stoichiometric mixture :

The S.M. is one in which there is just enough air for complete combustion of fuel.

MCQ 1.16 One dimensional unsteady state heat transfer equation for a sphere with heat generation at the rate of 'q' can be written as

GATE ME 2004 ONE MARK

(A) $\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$ (B) $\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(C) $\frac{\partial^2 T}{\partial r^2}+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$ (D) $\frac{\partial^2}{\partial r^2}(rT)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

SOL 1.16 Option (B) is correct.

The one dimensional time dependent heat conduction equation can be written more compactly as a simple equation,

$$\frac{1}{r^n}\frac{\partial}{\partial r}\left[r^n\frac{\partial T}{\partial r}\right]+\frac{q}{k}=\frac{\rho c}{k}\frac{\partial T}{\partial t} \qquad ...(i)$$

Where, $n=0$, For rectangular coordinates

$n=1$, For cylindrical coordinates

$n=2$, For spherical coordinates

Further, while using rectangular coordinates it is customary to replace the r -variable by the x-variable.

For sphere, substitute $r = 2$ in equation (i)

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left[r^2\frac{\partial T}{\partial r}\right] + \frac{q}{k} = \frac{\rho c}{k}\frac{\partial T}{\partial t}$$

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left[r^2\frac{\partial T}{\partial r}\right] + \frac{q}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t} \qquad \alpha = \frac{k}{\rho c} = \text{thermal diffusivity}$$

MCQ 1.17
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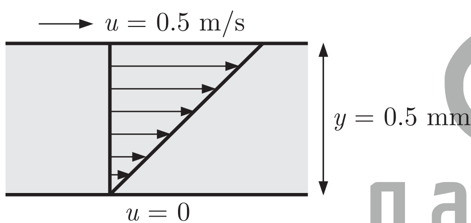
ONE MARK

An incompressible fluid (kinematic viscosity, 7.4×10^{-7} m^2/s, specific gravity, 0.88) is held between two parallel plates. If the top plate is moved with a velocity of 0.5 m/s while the bottom one is held stationary, the fluid attains a linear velocity profile in the gap of 0.5 mm between these plates; the shear stress in Pascals on the surfaces of top plate is

(A) 0.651×10^{-3}
(B) 0.651
(C) 6.51
(D) 0.651×10^{3}

SOL 1.17

Option (B) is correct.



Given : $\upsilon = 7.4 \times 10^{-7}$ m^2/sec, $S = 0.88$, $y = 0.5$ mm $= 0.5 \times 10^{-3}$ meter

Density of liquid $= S \times$ density of water

$= 0.88 \times 1000 = 880$ kg/m^3

Kinematic Viscosity $\qquad \upsilon = \dfrac{\mu}{\rho} = \dfrac{\text{Dynamic viscosity}}{\text{Density of liquid}}$

$$\mu = \upsilon \times \rho = 7.4 \times 10^{-7} \times 880 = 6.512 \times 10^{-4} \text{ Pa-s}$$

From the Newton's law of viscosity,

$$\tau = \mu \times \frac{u}{y}$$

$$= 6.512 \times 10^{-4} \times \frac{0.5}{0.5 \times 10^{-3}} = 0.6512 \text{ N/m}^2$$

$$= 0.651 \text{ Pa}$$

MCQ 1.18
GATE ME 2004
ONE MARK

Environment friendly refrigerant R134 is used in the new generation domestic refrigerators. Its chemical formula is

(A) $CHClF_2$
(B) $C_2Cl_3F_3$
(C) $C_2Cl_2F_4$
(D) $C_2H_2F_4$

SOL 1.18

Option (D) is correct.

If a refrigerant is written in the from of $Rabc$.

The first digit on the right (c) is the number of fluorine (F) atoms, the second digit from the right (b) is one more than the number of hydrogen (H) atoms required &

third digit from the right (a) is one less than the Number of carbon (C) atoms in the refrigerant. So, For R134

First digit from the Right = 4 = Number of Fluorine atoms

Second digit from the right = 3 − 1 = 2 = Number of hydrogen atoms

Third digit from the right = 1 + 1 = 2 = Number of carbon atoms

Hence, Chemical formula is $C_2H_2F_4$

MCQ 1.19
GATE ME 2004
ONE MARK

A fluid flow is represented by the velocity field $\boldsymbol{V} = ax\boldsymbol{i} + ay\boldsymbol{j}$, where a is a constant. The equation of stream line passing through a point (1, 2) is

(A) $x - 2y = 0$ (B) $2x + y = 0$

(C) $2x - y = 0$ (D) $x + 2y = 0$

SOL 1.19

Option (C) is correct.

Given : $\boldsymbol{V} = ax\boldsymbol{i} + ay\boldsymbol{j}$ ...(i)

The equation of stream line is,

$$\frac{dx}{u_x} = \frac{dy}{u_y} = \frac{dz}{u_z} \quad \text{...(ii)}$$

From equation (i), $u_x = ax$, $u_y = ay$ and $u_z = 0$

Substitute there values in equation (ii), we get

$$\frac{dx}{ax} = \frac{dy}{ay}$$

$$\frac{dx}{x} = \frac{dy}{y}$$

Integrating both sides, we get

$$\int \frac{dx}{x} = \int \frac{dy}{y}$$

$$\log x = \log y + \log c = \log yc \Rightarrow x = yc \quad \text{...(iii)}$$

At point (1, 2),

$$1 = 2c \Rightarrow c = \frac{1}{2}$$

From equation (iii),

$$x = \frac{y}{2} \Rightarrow 2x - y = 0$$

MCQ 1.20
GATE ME 2004
ONE MARK

A gas contained in a cylinder is compressed, the work required for compression being 5000 kJ. During the process, heat interaction of 2000 kJ causes the surroundings to be heated. The changes in internal energy of the gas during the process is

(A) −7000 kJ (B) −3000 kJ

(C) +3000 kJ (D) +7000 kJ

SOL 1.20

Option (C) is correct.

Given : $W = -5000$ kJ (Negative sign shows that work is done on the system)

& $Q = -2000$ kJ (Negative sign shows that heat rejected by the system)

From the first law of thermodynamics,

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

So, $$\Delta U = \Delta Q - \Delta W = -2000 - (-5000)$$
$$= -2000 + 5000 = 3000 \text{ kJ}$$

MCQ 1.21 GATE ME 2004 ONE MARK

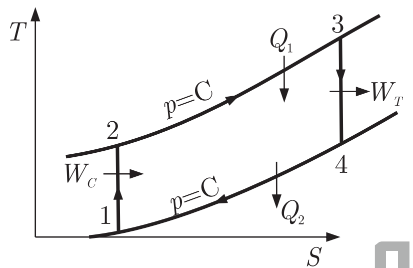
The compression ratio of a gas power plant cycle corresponding to maximum work output for the given temperature limits of T_{min} and T_{max} will be

(A) $\left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}}$ (B) $\left(\frac{T_{min}}{T_{max}}\right)^{\frac{\gamma}{2(\gamma-1)}}$

(C) $\left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma-1}{\gamma}}$ (D) $\left(\frac{T_{min}}{T_{max}}\right)^{\frac{\gamma-1}{\gamma}}$

SOL 1.21 Option (A) is correct.

The T-s curve for simple gas power plant cycle (Brayton cycle) is shown below :



From the T-s diagram, Net work output for Unit Mass,

$$W_{net} = W_T - W_c = c_p[(T_3 - T_4) - (T_2 - T_1)] \qquad ...(i)$$

And from the T-s diagram,

$$T_3 = T_{max} \text{ and } T_1 = T_{min}$$

Apply the general relation for reversible adiabatic process, for process 3-4 and 1-2,

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

$$T_4 = T_3(r_p)^{-\left(\frac{\gamma-1}{\gamma}\right)} \qquad \frac{p_3}{p_4} = \frac{p_2}{p_1} = r_p = \text{Pressure ratio}$$

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

$$T_2 = T_1(r_p)^{\frac{\gamma-1}{\gamma}}$$

$$W_{net} = c_p\left[T_3 - T_3(r_p)^{-\left(\frac{\gamma-1}{\gamma}\right)} - T_1(r_p)^{\frac{\gamma-1}{\gamma}} + T_1\right] \qquad ...(ii)$$

Differentiating equation (ii) w.r.t. (r_p) and on equating it to the zero, we get

$$\frac{dW_{net}}{dr_p} = c_p\left[-T_3\left(-\frac{\gamma-1}{\gamma}\right)r_p^{-\left(\frac{\gamma-1}{\gamma}\right)-1} - T_1\left(\frac{\gamma-1}{\gamma}\right)r_p^{\left(\frac{\gamma-1}{\gamma}-1\right)}\right]$$

$$= c_p\left[-T_3\left(-\frac{\gamma-1}{\gamma}\right)r_p^{\left(\frac{-\gamma+1-\gamma}{\gamma}\right)} - T_1\left(\frac{\gamma-1}{\gamma}\right)r_p^{\left(-\frac{1}{\gamma}\right)}\right]$$

$$= c_p\left[-T_3\left(-\frac{\gamma-1}{\gamma}\right)r_p^{\left(\frac{1-2\gamma}{\gamma}\right)} - T_1\left(\frac{\gamma-1}{\gamma}\right)r_p^{\left(-\frac{1}{\gamma}\right)}\right]$$

$$T_3 r_p^{\left(\frac{1}{\gamma}-2\right)} - T_1 r_p^{\left(-\frac{1}{\gamma}\right)} = 0$$

$$T_3 r_p^{\left(\frac{1}{\gamma}-2\right)} = T_1 r_p^{-\frac{1}{\gamma}}$$

$$\frac{T_3}{T_1} = \frac{(r_p)^{-\frac{1}{\gamma}}}{r_p^{\frac{1}{\gamma}-2}} = (r_p)^{-\frac{1}{\gamma}-\frac{1}{\gamma}+2} = r_p^{\frac{2(\gamma-1)}{\gamma}}$$

So, $$(r_p)_{opt} = \left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}} = \left(\frac{T_{\max}}{T_{\min}}\right)^{\frac{\gamma}{2(\gamma-1)}}$$

MCQ 1.22 In an interchangeable assembly, shafts of size $25.000^{+0.040}_{-0.0100}$ mm mate with holes of size $25.000^{+0.020}_{-0.000}$ mm. The maximum possible clearance in the assembly will be

GATE ME 2004 ONE MARK

(A) 10 microns (B) 20 microns

(C) 30 microns (D) 60 microns

SOL 1.22 Option (C) is correct.

We know that maximum possible clearance occurs between minimum shaft size and maximum hole size.

Maximum size of shaft $= 25 + 0.040 = 25.040$ mm

Minimum size of shaft $= 25 - 0.100 = 24.99$ mm

Maximum size of hole $= 25 + 0.020 = 25.020$ mm

Minimum size of hole $= 25 - 0.000 = 25.00$ mm

$25.020 - 24.99 = 0.03$ mm $= 30$ microns

MCQ 1.23 During the execution of a CNC part program block

GATE ME 2004 ONE MARK

$N020\ G02\ X45.0\ Y25.0\ R5.0$

the type of tool motion will be

(A) circular Interpolation − clockwise

(B) circular Interpolation − counterclockwise

(C) linear Interpolation

(D) rapid feed

SOL 1.23 Option (A) is correct.

Given:- $N020\ G02\ X45.0\ Y25.0\ R5.0$

Here term $X45.0\ Y25.0\ R5.0$ will produce circular motion because radius is consider in this term and $G02$ will produce clockwise motion of the tool.

MCQ 1.24 The mechanism of material removal in EDM process is

GATE ME 2004 ONE MARK

(A) Melting and Evaporation (B) Melting and Corrosion

(C) Erosion and Cavitation (D) Cavitation and Evaporation

SOL 1.24 Option (A) is correct

In EDM, the thermal energy is employed to melt and vaporize tiny particles of work material by concentrating the heat energy on a small area of the work-piece.

MCQ 1.25 Two 1 mm thick steel sheets are to be spot welded at a current of 5000 A. Assuming effective resistance to be 200 μm and current flow time of 0.2 second, heat generated during the process will be

GATE ME 2004 ONE MARK

(A) 0.2 Joule (B) 1 Joule

(C) 5 Joule (D) 1000 Joule

SOL 1.25 Option (D) is correct

Given : $I = 5000\text{ A},\ R = 200\,\mu\Omega = 200\times10^{-6}\,\Omega,\ \Delta t = 0.2$ second

Heat generated, $H_g = I^2(R\,\Delta\,t)$

$$H_g = (5000)^2\times200\times10^{-6}\times0.2$$

$$= 25\times10^6\times40\times10^{-6} = 1000\text{ Joule}$$

MCQ 1.26 In PERT analysis a critical activity has

GATE ME 2004 ONE MARK

(A) maximum Float (B) zero Float

(C) maximum Cost (D) minimum Cost

SOL 1.26 Option (B) is correct.

PERT (Programme Evaluation and Review Technique) uses even oriented network in which successive events are joined by arrows.

Float is the difference between the maximum time available to perform the activity and the activity duration. In PERT analysis a critical activity has zero float.

MCQ 1.27 For a product, the forecast and the actual sales for December 2002 were 25 and 20 respectively. If the exponential smoothing constant (α) is taken as 0.2, then forecast sales for January 2003 would be

GATE ME 2004 ONE MARK

(A) 21 (B) 23

(C) 24 (D) 27

SOL 1.27 Option (C) is correct.

Given :

Forecast sales for December $u_t = 25$

Actual sales for December $X_t = 20$

Exponential smoothing constant $\alpha = 0.2$

We know that, Forecast sales for January is given by

$$u_{t+1} = u_t + \alpha[X_t - u_t]$$

$$u_{t+1} = 25 + 0.2(20 - 25)$$

$$= 25 + 0.2\times(-5)$$

$$= 25 - 1$$

$$= 24$$

Hence, Forecast sales for January 2003 would be 24.

MCQ 1.28 There are two products P and Q with the following characteristics

GATE ME 2004 ONE MARK

Product	Demand (Units)	Order cost (Rs/order)	Holding Cost (Rs./ unit/ year)
P	100	50	4
Q	400	50	1

The economic order quantity (EOQ) of products P and Q will be in the ratio

(A) 1 : 1 (B) 1 : 2

(C) 1 : 4 (D) 1 : 8

SOL 1.28 Option (C) is correct.

For product P : $D = 100\text{ units}, \quad C_o = 50\text{ Rs./order}, \quad C_h = 4\text{ Rs./unit/year}$

Economic order quantity (EOQ) for product P,

$$(\text{EOQ})_P = \sqrt{\frac{2C_oD}{C_h}}$$

$$(\text{EOQ})_P = \sqrt{\frac{2\times 50\times 100}{4}} = \sqrt{2500} = 50 \qquad ...(i)$$

For product Q :

$$D = 400\text{ Units} \quad C_o = 50\text{ Rs. order}, \quad C_h = 1\text{ Rs. Unit/year}$$

EOQ For Product Q,

$$(\text{EOQ})_Q = \sqrt{\frac{2C_oD}{C_h}}$$

$$= \sqrt{\frac{2\times 50\times 400}{1}} = \sqrt{40000} = 200 \qquad ...(ii)$$

From equation (i) & (ii),

$$\frac{(\text{EOQ})_P}{(\text{EOQ})_Q} = \frac{50}{200} = \frac{1}{4}$$

$$(\text{EOQ})_P : (\text{EOQ})_Q = 1:4$$

MCQ 1.29 Misrun is a casting defect which occurs due to

GATE ME 2004 ONE MARK

(A) very high pouring temperature of the metal

(B) insufficient fluidity of the molten metal

(C) absorption of gases by the liquid metal

(D) improper alignment of the mould flasks

SOL 1.29 Option (B) is correct

Two streams of liquid metal which are not hot enough to fuse properly result into a casting defect, known as Misrun/cold shut.

It occurs due to insufficient fluidity of the molten metal.

MCQ 1.30 The percentage of carbon in gray cast iron is in the range of

GATE ME 2004 ONE MARK

(A) 0.25 to 0.75 percent (B) 1.25 to 1.75 percent

(C) 3 to 4 percent (D) 8 to 10 percent

SOL 1.30 Option (C) is correct.

Gray cast iron is the most widely used of all cast irons. In fact, it is common to speak of gray cast iron just as cast iron.
It contains 3 to 4% C and 2.5 % Si.

MCQ 1.31 GATE ME 2004 TWO MARK

The following data about the flow of liquid was observed in a continuous chemical process plant :

Flow rate (litres / sec)	7.5 to 7.7	7.7 to 7.9	7.9 to 8.1	8.1 to 8.3	8.3 to 8.5	8.5 to 8.7
Frequency	1	5	35	17	12	10

Mean flow rate of the liquid is

(A) 8.00 litres/sec
(B) 8.06 litres/sec
(C) 8.16 litres/sec
(D) 8.26 litres/sec

SOL 1.31

Option (C) is correct.
In this question we have to make the table for calculate mean flow rate :

Flow rate litres/sec.	Mean flow rate $x = \left(\frac{x_i + x_f}{2}\right)$	Frequency f	fx
7.5 to 7.7	7.6	1	7.6
7.7 to 7.9	7.8	5	39
7.9 to 8.1	8.0	35	280
8.1 to 8.3	8.2	17	139.4
8.3 to 8.5	8.4	12	100.8
8.5 to 8.7	8.6	10	86
		$\Sigma f = 80$	$\Sigma fx = 652.8$

Mean flow rate, $\overline{x} = \frac{\Sigma fx}{\Sigma f} = \frac{652.8}{80} = 8.16 \text{ litres/ sec}$

MCQ 1.32 GATE ME 2004 TWO MARK

From a pack of regular playing cards, two cards are drawn at random. What is the probability that both cards will be Kings, if first card in NOT replaced ?

(A) $\frac{1}{26}$
(B) $\frac{1}{52}$
(C) $\frac{1}{169}$
(D) $\frac{1}{221}$

SOL 1.32

Option (D) is correct.
Given : Total number of cards = 52 and two cards are drawn at random.
Number of kings in playing cards = 4
So the probability that both cards will be king is given by,

$$P = \frac{^4C_1}{^{52}C_1} \times \frac{^3C_1}{^{51}C_1} \qquad {}^nC_r = \frac{\lfloor n}{\lfloor r \lfloor n-r}$$

Solving this we get,

$$P = \frac{4}{52} \times \frac{3}{51} = \frac{1}{221}$$

MCQ 1.33 GATE ME 2004 TWO MARK

A delayed unit step function is defined as $U(t-a) = \begin{cases} 0, \text{ for } t < a \\ 1, \text{ for } t \geq a \end{cases}$ Its Laplace transform is

(A) ae^{-as} (B) $\frac{e^{-as}}{s}$

(C) $\frac{e^{as}}{s}$ (D) $\frac{e^{as}}{a}$

SOL 1.33 Option (B) is correct.

Given : $U(t-a) = \begin{cases} 0, & \text{for } t < a \\ 1, & \text{for } t \geq a \end{cases}$

From the definition of Laplace Transform

$$\mathcal{L}[F(t)] = \int_0^\infty e^{-st} f(t)\, dt$$

$$\mathcal{L}[U(t-a)] = \int_0^\infty e^{-st}\, U(t-a)\, dt$$

$$= \int_0^a e^{-st}(0) + \int_a^\infty e^{-st}(1)\, dt = 0 + \int_a^\infty e^{-st}\, dt$$

$$\mathcal{L}[U(t-a)] = \left[\frac{e^{-st}}{-s}\right]_a^\infty = 0 - \left[\frac{e^{-as}}{-s}\right] = \frac{e^{-as}}{s}$$

MCQ 1.34 GATE ME 2004 TWO MARK

The values of a function $f(x)$ are tabulated below

x	$f(x)$
0	1
1	2
2	1
3	10

Using Newton's forward difference formula, the cubic polynomial that can be fitted to the above data, is

(A) $2x^3 + 7x^2 - 6x + 2$ (B) $2x^3 - 7x^2 + 6x - 2$

(C) $x^3 - 7x^2 - 6x^2 + 1$ (D) $2x^3 - 7x^2 + 6x + 1$

SOL 1.34 Option (D) is correct.

First we have to make the table from the given data

x	$f(x)$	$\Delta f(x)$	$\Delta^2 f(x)$	$\Delta^3 f(x)$
0	1	1	-2	12
1	2	-1	10	
2	1	9		
3	10			

Take $x_0 = 0$ and $h = 1$

Then $P = \frac{x - x_0}{h} = x$

From Newton's forward Formula

$$f(x) = f(x_0) + \frac{P}{\lfloor 1}\Delta f(0) + \frac{P(P-1)}{\lfloor 2}\Delta^2 f(0) + \frac{P(P-1)(P-2)}{\lfloor 3}\Delta^3 f(0)$$

$$= f(0) + x\Delta f(0) + \frac{x(x-1)}{2}\Delta^2 f(0) + \frac{x(x-1)(x-2)}{6}\Delta^3 f(0)$$

$$= 1 + x(1) + \frac{x(x-1)}{2}(-2) + \frac{x(x-1)(x-2)}{6}(12)$$

$$= 1 + x - x(x-1) + 2x(x-1)(x-2)$$

$$f(x) = 2x^3 - 7x^2 + 6x + 1$$

MCQ 1.35 The volume of an object expressed in spherical co-ordinates is given by

GATE ME 2004
TWO MARK

$$V = \int_0^{2\pi}\int_0^{\pi/3}\int_0^1 r^2 \sin\phi\, dr d\phi d\theta$$

The value of the integral is

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

(B) $\frac{\pi}{6}$

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

(D) $\frac{\pi}{4}$

SOL 1.35 Option (A) is correct.

Given : $$V = \int_0^{2\pi}\int_0^{\pi/3}\int_0^1 r^2 \sin\phi\, dr d\phi d\theta$$

First integrating the term of r, we get

$$V = \int_0^{2\pi}\int_0^{\pi/3}\left[\frac{r^3}{3}\right]_0^1 \sin\phi\, d\phi d\theta = \int_0^{2\pi}\int_0^{\pi/3}\frac{1}{3}\sin\phi\, d\phi d\theta$$

Integrating the term of ϕ, we have

$$V = \frac{1}{3}\int_0^{2\pi}[-\cos\phi]_0^{\pi/3} d\theta$$

$$= -\frac{1}{3}\int_0^{2\pi}\left[\cos\frac{\pi}{3} - \cos 0\right]d\theta = -\frac{1}{3}\int_0^{2\pi}\left[\frac{1}{2} - 1\right]d\theta$$

$$= -\frac{1}{3}\int_0^{2\pi}\left(-\frac{1}{2}\right)d\theta = -\frac{1}{3}\times\left(-\frac{1}{2}\right)\int_0^{2\pi}d\theta$$

Now, integrating the term of θ, we have

$$V = \frac{1}{6}[\theta]_0^{2\pi} = \frac{1}{6}[2\pi - 0] = \frac{\pi}{3}$$

MCQ 1.36 For which value of x will the matrix given below become singular ?

GATE ME 2004
TWO MARK

$$= \begin{bmatrix} 8 & x & 0 \\ 4 & 0 & 2 \\ 12 & 6 & 0 \end{bmatrix}$$

(A) 4
(B) 6
(C) 8
(D) 12

SOL 1.36 Option (A) is correct.

Let, $$A = \begin{bmatrix} 8 & x & 0 \\ 4 & 0 & 2 \\ 12 & 6 & 0 \end{bmatrix}$$

For singularity of the matrix $|A| = 0$

$$\begin{vmatrix} 8 & x & 0 \\ 4 & 0 & 2 \\ 12 & 6 & 0 \end{vmatrix} = 0$$

$$8[0 - 2 \times 6] - x[0 - 24] + 0[24 - 0] = 0$$
$$8 \times (-12) + 24x = 0$$
$$-96 + 24x = 0$$
$$24x = 96$$
$$x = \frac{96}{24} = 4$$

MCQ 1.37 In the figure shown, the relative velocity of link 1 with respect to link 2 is 12 m/sec. Link 2 rotates at a constant speed of 120 rpm. The magnitude of Coriolis component of acceleration of link 1 is

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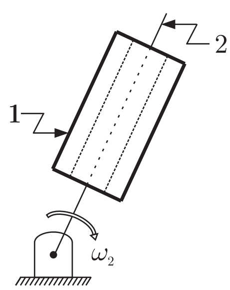
TWO MARK



(A) 302 m/s^2
(B) 604 m/s^2
(C) 906 m/s^2
(D) 1208 m/s^2

SOL 1.37 Option (A) is correct.

Given $N_2 = 120$ rpm, $v_1 = 12$ m/sec

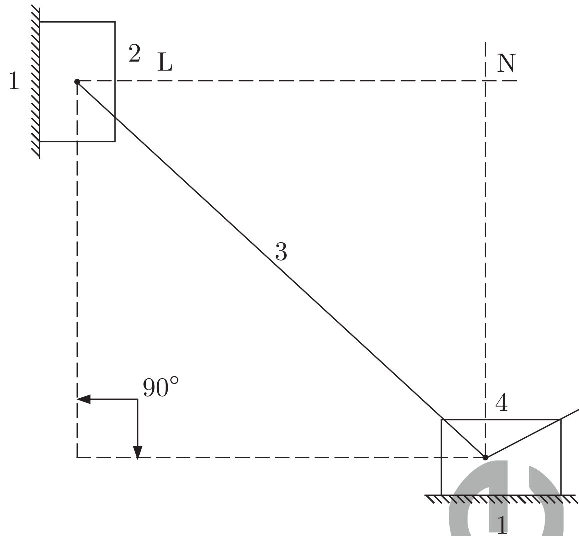
So, coriolis component of the acceleration of link 1 is,

$$a_{12}^c = 2\omega_2 v_1 = 2 \times \frac{2\pi \times 120}{60} \times 12$$

$$= 301.44\ \text{m/s}^2 \simeq 302\ \text{m/s}^2$$

MCQ 1.38 GATE ME 2004 TWO MARK

The figure below shows a planar mechanism with single degree of freedom. The instant centre 24 for the given configuration is located at a position



(A) L (B) M

(C) N (D) ∞

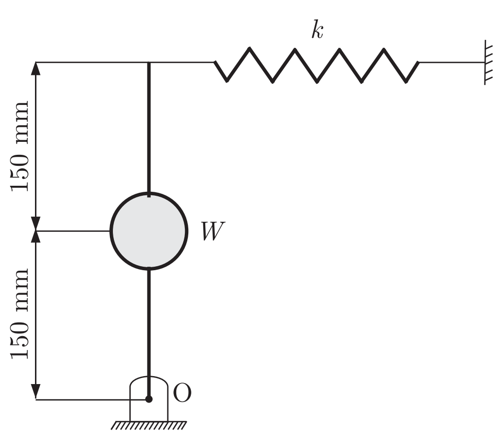
SOL 1.38 Option (D) is correct.

Given planar mechanism has degree of freedom, $N = 1$ and two infinite parallel lines meet at infinity. So, the instantaneous centre I_{24} will be at N, but for single degree of freedom, system moves only in one direction.

Hence, I_{24} is located at infinity(∞).

MCQ 1.39 GATE ME 2004 TWO MARK

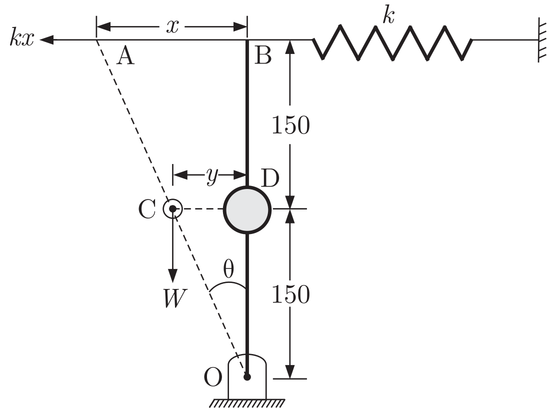
A uniform stiff rod of length 300 mm and having a weight of 300 N is pivoted at one end and connected to a spring at the other end. For keeping the rod vertical in a stable position the minimum value of spring constant k needed is

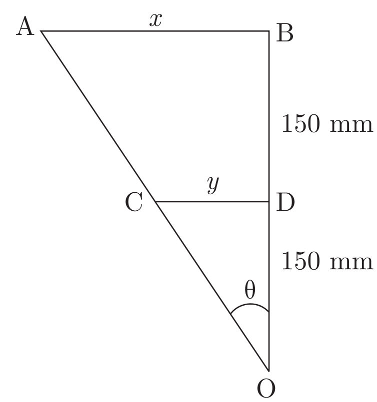


(A) 300 N/m (B) 400 N/m

(C) 500 N/m (D) 1000 N/m

SOL 1.39 Option (C) is correct.





Given $l = 300\text{ mm} = 0.3\text{ m}$, $W = 300\text{ N}$

Let, rod is twisted to the left, through an angle θ.

From the similar triangle OCD & OAB,

$$\tan\theta = \frac{y}{0.15} = \frac{x}{0.30}$$

If θ is very very small, than

$$\tan\theta \simeq \theta = \frac{y}{0.15} = \frac{x}{0.30}$$

$x = 0.30\theta$ and $y = 0.15\theta$ ..(i)

On taking moment about the hinged point "O",

$$kx \times 300 + W \times y = 0$$

$$k = -\frac{Wy}{300x} = -\frac{300}{300} \times \left(\frac{y}{x}\right)$$

$$k = -\frac{1}{2} = -0.5\text{ N/mm}$$ From equation (i) $y/x = 0.15\theta/0.30\theta$

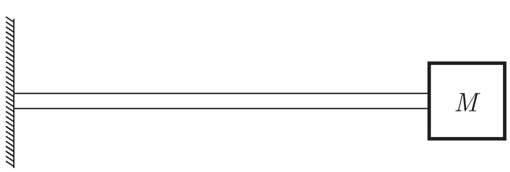
$$= -500\text{ N/m}$$

Negative sign shows that the spring tends to move to the point B.

In magnitude, $k = 500\text{ N/m}$

MCQ 1.40 GATE ME 2004 TWO MARK

A mass M, of 20 kg is attached to the free end of a steel cantilever beam of length 1000 mm having a cross-section of 25 × 25 mm. Assume the mass of the cantilever to be negligible and $E_{steel} = 200$ GPa. If the lateral vibration of this system is critically damped using a viscous damper, then damping constant of the damper is



(A) 1250 Ns/m (B) 625 Ns/m
(C) 312.50 Ns/m (D) 156.25 Ns/m

SOL 1.40 Option (A) is correct.

Given $M = 20\,\text{kg}$, $l = 1000\,\text{mm} = 1\,\text{m}$, $A = 25 \times 25\,\text{mm}^2$

$E_{steel} = 200\,\text{GPa} = 200 \times 10^9\,\text{Pa}$

Mass moment of inertia of a square section is given by,

$$I = \frac{b^4}{12} = \frac{(25 \times 10^{-3})^4}{12} = 3.25 \times 10^{-8}\,\text{m}^4$$

Deflection of a cantilever, Loaded with a point load placed at the free end is,

$$\delta = \frac{Wl^3}{3EI} = \frac{mgl^3}{3EI}$$

$$= \frac{20 \times 9.81 \times (1)^3}{3 \times 200 \times 10^9 \times 3.25 \times 10^{-8}} = \frac{196.2}{19500} = 0.01\,\text{m}$$

$$\omega_n = \sqrt{\frac{g}{\delta}} = \sqrt{\frac{9.81}{0.01}} = 31.32\,\text{rad/sec}$$

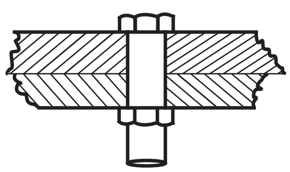
Therefore, critical damping constant

$$c_c = 2\,M\omega_n = 2 \times 20 \times 31.32$$

$$= 1252.8\,\text{Ns/m} \simeq 1250\,\text{Ns/m}$$

MCQ 1.41 GATE ME 2004 TWO MARK

In a bolted joint two members are connected with an axial tightening force of 2200 N. If the bolt used has metric threads of 4 mm pitch, the torque required for achieving the tightening force is



(A) 0.7 Nm (B) 1.0 Nm
(C) 1.4 Nm (D) 2.8 Nm

SOL 1.41 Option (C) is correct.

Given : $F_t = 2200\,\text{N}$, $p = 4\,\text{mm} = 0.004\,\text{m}$

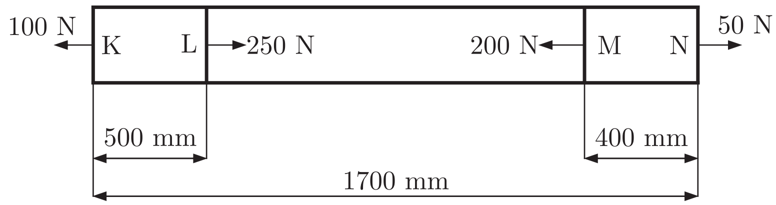
Torque required for achieving the tightening force is,

$$T = F_t \times r = F_t \times \frac{\text{Pitch}}{2\pi}$$

$$= 2200 \times \frac{0.004}{2 \times 3.14} = 1.4\,\text{N-m}$$

MCQ 1.42 GATE ME 2004 TWO MARK

The figure below shows a steel rod of 25 mm² cross sectional area. It is loaded at four points, K, L, M and N. Assume $E_{\text{steel}} = 200$ GPa. The total change in length of the rod due to loading is



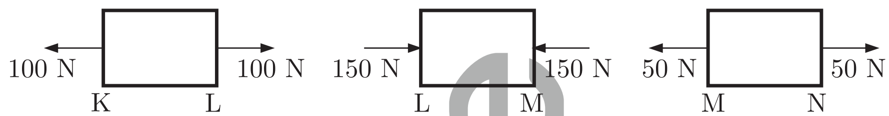
(A) 1 μm (B) – 10 μm

(C) 16 μm (D) – 20 μm

SOL 1.42 Option (B) is correct.

Given : $A = 25\,\text{mm}^2$, $E_{steel} = 200\,\text{GPa} = 200 \times 10^9\,\text{N/m}^2 = 200 \times 10^3\,\text{N/mm}^2$

First of all we have to make the F.B.D of the sections KL, LM & MN separately.



Now, From the F.B.D,

$$P_{KL} = 100\,\text{N (Tensile)}$$
$$P_{LM} = -150\,\text{N (Compressive)}$$
$$P_{MN} = 50\,\text{N (Tensile)}$$

or $L_{KL} = 500\,\text{mm},\ L_{LM} = 800\,\text{mm},\ L_{MN} = 400\,\text{mm}$

Total change in length,

$$\Delta L = \Delta L_{KL} + \Delta L_{LM} + \Delta L_{MN}$$

$$= \frac{P_{KL}L_{KL}}{AE} + \frac{P_{LM}L_{LM}}{AE} + \frac{P_{MN}L_{MN}}{AE} \qquad \Delta L = \frac{PL}{AE}$$

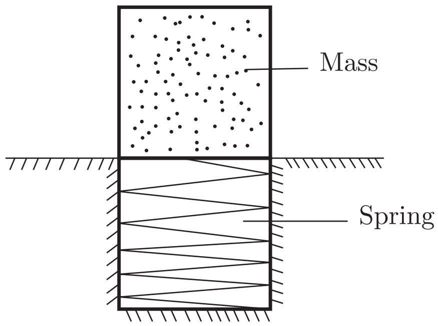
Substitute the values, we get

$$\Delta L = \frac{1}{25 \times 200 \times 10^3}[100 \times 500 - 150 \times 800 + 50 \times 400]$$

$$= \frac{1}{5000 \times 10^3}[-50000] = -10000 \times 10^{-6}\,\text{mm} = -10\,\mu\text{m}$$

MCQ 1.43 GATE ME 2004 TWO MARK

An ejector mechanism consists of a helical compression spring having a spring constant of $k = 981 \times 10^3\,\text{N/m}$. It is pre-compressed by 100 mm from its free state. If it is used to eject a mass of 100 kg held on it, the mass will move up through a distance of



(A) 100 mm (B) 500 mm

(C) 581 mm (D) 1000 mm

SOL 1.43 Option (A) is correct.

Given : $k = 981 \times 10^3$ N/m, $x_i = 100$mm=0.1 m, $m = 100$ kg

Let, when mass $m = 100$ kg is put on the spring then spring compressed by x mm.

From the conservation of energy :

Energy stored in free state = Energy stored after the mass is attach.

$$(\text{K.E.})_i = (\text{K.E.})_f + (\text{P.E.})_f$$

$$\frac{1}{2}kx_i^2 = \frac{1}{2}kx^2 + mg(x+0.1)$$

$$kx_i^2 = kx^2 + 2mg(x+0.1)$$

Substitute the values, we get

$$981 \times 10^3 \times (0.1)^2 = (981 \times 10^3 \times x^2) + [2 \times 100 \times 9.81 \times (x+0.1)]$$

$$10^3 \times 10^{-2} = 10^3 x^2 + 2(x+0.1)$$

$$10 = 1000x^2 + 2x + 0.2$$

$$1000x^2 + 2x - 9.8 = 0$$

So, on solving above equation, we get

$$x = \frac{-2 \pm \sqrt{(2)^2 - 4 \times 1000(-9.8)}}{2 \times 1000}$$

$$= \frac{-2 \pm \sqrt{4 + 39200}}{2000} = \frac{-2 \pm 198}{2000}$$

On taking -ve sign, we get

$$x = \frac{-2 - 198}{2000} = -\frac{1}{10}\text{m=-100 mm}$$

(-ve sign shows the compression of the spring)

MCQ 1.44 GATE ME 2004 TWO MARK

A rigid body shown in the figure (a) has a mass of 10 kg. It rotates with a uniform angular velocity 'ω'. A balancing mass of 20 kg is attached as shown in figure (b). The percentage increase in mass moment of inertia as a result of this addition is

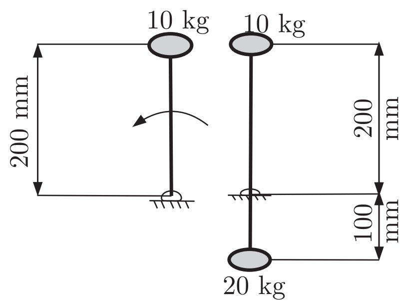


fig. (a) fig. (b)

(A) 25% (B) 50%

(C) 100% (D) 200%

SOL 1.44 Option (B) is correct.

Given : First Mass, $m_1 = 10\,\text{kg}$

Balancing Mass, $m_2 = 20\,\text{kg}$

We know the mass moment of inertia, $I = mk^2$

Where, k = Radius of gyration

Case (I) : When mass of 10 kg is rotates with uniform angular velocity 'ω'

The moment of inertia $I_1 = m_1 k_1^2$

$$I_1 = 10 \times (0.2)^2 \qquad k_1 = 200\,\text{mm} = 0.2\,\text{meter}$$

$$= 10 \times 0.04 = 0.4\,\text{kg m}^2$$

Case (II) : When balancing mass of 20 kg is attached then moment of inertia

$$I_2 = 10 \times (0.2)^2 + 20 \times (0.1)^2 \qquad \text{Here } k_1 = 0.2\,\text{m}$$

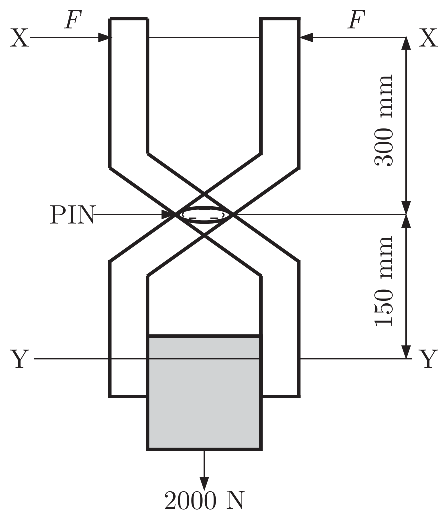
$$= 0.4 + 0.2 = 0.6 \qquad \text{and } k_2 = 0.1\,\text{m}$$

Percent increase in mass moment of inertia,

$$I = \frac{I_2 - I_1}{I_1} \times 100 = \frac{0.6 - 0.4}{0.4} \times 100 = \frac{1}{2} \times 100 = 50\%$$

MCQ 1.45 GATE ME 2004 TWO MARK

The figure shows a pair of pin-jointed gripper-tongs holding an object weighting 2000 N. The coefficient of friction (μ) at the gripping surface is 0.1 XX is the line of action of the input force and YY is the line of application of gripping force. If the pin-joint is assumed to be frictionless, the magnitude of force F required to hold the weight is



(A) 1000 N (B) 2000 N

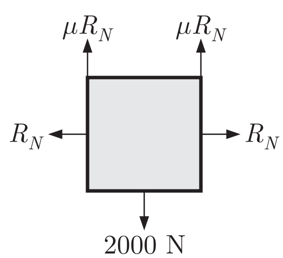
(C) 2500 N (D) 5000 N

SOL 1.45 Option (D) is correct.

Given : Weight of object $W = 2000$ N

Coefficient of Friction $\mu = 0.1$

First of all we have to make the FBD of the system.



Here, R_N = Normal reaction force acting by the pin joint.

$F = \mu R_N$ = Friction force

In equilibrium condition of all the forces which are acting in y direction.

$$\mu R_N + \mu R_N = 2000 \text{ N}$$

$$\mu R_N = 1000 \text{ N}$$

$$R_N = \frac{1000}{0.1} = 10000 \text{ N} \qquad \mu = 0.1$$

By taking the moment about the pin, we get

$$10000 \times 150 = F \times 300$$

$$F = 5000 \text{ N}$$

MCQ 1.46 GATE ME 2004 TWO MARK

A solid circular shaft of 60 mm diameter transmits a torque of 1600 N.m. The value of maximum shear stress developed is

(A) 37.72 MPa (B) 47.72 MPa

(C) 57.72 MPa (D) 67.72 MPa

SOL 1.46 Option (A) is correct.

Given : $d = 60\text{ mm},\ T = 1600\text{ N–m}$

From the torsional formula,

$$\frac{T}{J} = \frac{\tau}{r} \qquad r = \frac{d}{2} \text{ and } J = \frac{\pi}{32}d^4$$

So,

$$\tau_{max} = \frac{T}{\frac{\pi}{32}d^4} \times \frac{d}{2} = \frac{16T}{\pi d^3}$$

Substitute the values, we get

$$\tau_{max} = \frac{16 \times 1600}{3.14 \times (60 \times 10^{-3})^3} = \frac{8152.866}{(60)^3} \times 10^9$$

$$= 0.03774 \times 10^9\text{ Pa} = 37.74\text{ MPa} \simeq 37.72\text{ MPa}$$

MCQ 1.47 GATE ME 2004 TWO MARK

For a fluid flow through a divergent pipe of length L having inlet and outlet radii of R_1 and R_2 respectively and a constant flow rate of Q, assuming the velocity to be axial and uniform at any cross-section, the acceleration at the exit is

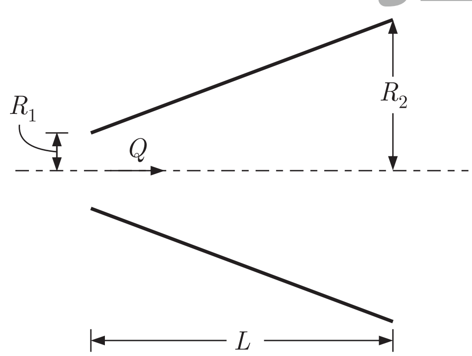
(A) $\frac{2Q(R_1 - R_2)}{\pi L R_2^3}$

(B) $\frac{2Q^2(R_1 - R_2)}{\pi L R_2^3}$

(C) $\frac{2Q^2(R_1 - R_2)}{\pi^2 L R_2^5}$

(D) $\frac{2Q^2(R_2 - R_1)}{\pi^2 L R_2^5}$

SOL 1.47 Option (C) is correct.



Flow rate, $Q = AV$

Inlet velocity, $$V_1 = \frac{Q}{A_1} = \frac{Q}{\frac{\pi}{4}(2R_1)^2} = \frac{Q}{\pi R_1^2} \qquad A_1 = \frac{\pi}{4}d_1^2$$

Outlet Velocity, $$V_2 = \frac{Q}{A_2} = \frac{Q}{\pi R_2^2}$$

Therefore, resultant velocity will be,

$$dV = V_2 - V_1 = \frac{Q}{\pi}\left[\frac{1}{R_2^2} - \frac{1}{R_1^2}\right]$$

Acceleration at the exit section,

$$a = \frac{dV}{dt} = V\frac{dV}{dx}$$

In this case $dV = V_2 - V_1$

$V = V_2$

And $dx = L$

So, $$a = \frac{Q}{\pi R_2^2} \times \frac{Q}{\pi L}\left[\frac{1}{R_2^2} - \frac{1}{R_1^2}\right] = \frac{Q^2}{\pi^2 R_2^2 L}\left[\frac{R_1^2 - R_2^2}{R_1^2 R_2^2}\right]$$

$$= \frac{Q^2}{\pi^2 R_2^2 L}\left[\frac{(R_1 + R_2)(R_1 - R_2)}{R_1^2 R_2^2}\right]$$

Considering limiting case $R_1 \to R_2$

Then, $$a = \frac{Q^2}{\pi^2 R_2^2 L}\left[\frac{(R_1 - R_2)\,2R_2}{R_2^2 R_2^2}\right]$$

$$= \frac{2Q^2}{\pi^2 R_2^5 L}[R_1 - R_2] = \frac{2Q^2(R_1 - R_2)}{\pi^2 R_2^5 L}$$

MCQ 1.48 A closed cylinder having a radius R and height H is filled with oil of density ρ. If the cylinder is rotated about its axis at an angular velocity of ω, then thrust at the bottom of the cylinder is

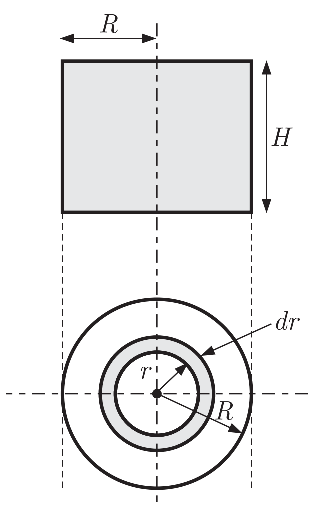
(A) $\pi R^2 \rho g H$

(B) $\pi R^2 \frac{\rho\omega^2 R^2}{4}$

(C) $\pi R^2 (\rho\omega^2 R^2 + \rho g H)$

(D) $\pi R^2 \left(\frac{\rho\omega^2 R^2}{4} + \rho g H\right)$

SOL 1.48 Option (D) is correct.



Total thrust at the bottom of cylinder = Weight of water in cylinder + Pressure force on the cylinder

For rotating motion,

$$\frac{\partial p}{\partial r} = \frac{\rho V^2}{r} = \frac{\rho r^2 \omega^2}{r} = \rho\omega^2 r \qquad p = \text{Pressure}, V = r\omega$$

And $\partial p = \rho\omega^2 r dr$

Integrating both the sides within limits p between 0 to p & r between 0 to r,

$$\int_0^p \partial\, p = \int_0^r \rho\omega^2 r dr$$

$$[p]_0^p = \rho\omega^2\left[\frac{r^2}{2}\right]_0^r$$

For calculating the total pressure on the cylinder,

$$p = \rho\omega^2 \times \left[\frac{r^2}{2} - 0\right] = \frac{\rho\omega^2 r^2}{2}$$

On dividing whole area of cylinder in the infinite small rings with thickness dr,
Force on elementary ring

$$= \text{Pressure intensity} \times \text{Area of ring}$$

$$= \frac{\rho\omega^2 r^2}{2} \times 2\pi r dr$$

Total force, $$F = \int_0^R \frac{\rho\omega^2 r^2}{2} \times 2\pi r dr = \pi\rho\omega^2 \int_0^R r^3 dr$$

$$= \pi\rho\omega^2\left[\frac{r^4}{4}\right]_0^R = \pi\rho\omega^2 \frac{R^4}{4}$$

Weight of water $= mg = \rho\nu g$ $\qquad m = \rho\nu$

$= \rho\pi R^2 \times Hg = \rho g H\pi R^2$ $\qquad A = \pi R^2$

So, Net force $= \rho g H\pi R^2 + \rho\omega^2 \dfrac{\pi R^4}{4} = \pi R^2\left[\dfrac{\rho\omega^2 R^2}{4} + \rho g H\right]$

MCQ 1.49 GATE ME 2004 TWO MARK

For air flow over a flat plate, velocity (U) and boundary layer thickness (δ) can be expressed respectively, as

$$\frac{U}{U_\infty} = \frac{3y}{2\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3;\ \delta = \frac{4.64x}{\sqrt{\mathrm{Re}_x}}$$

If the free stream velocity is 2 m/s, and air has kinematic viscosity of 1.5×10^{-5} m^2/s and density of 1.23 kg/m^3, the wall shear stress at $x = 1$ m, is

(A) 2.36×10^2 N/m^2 (B) 43.6×10^{-3} N/m^2

(C) 4.36×10^{-3} N/m^2 (D) 2.18×10^{-3} N/m^2

SOL 1.49 Option (C) is correct.

Given relation is,

$$\frac{U}{U_\infty} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3 \text{ and } \delta = \frac{4.64x}{\sqrt{\mathrm{Re}_x}} \qquad \text{...(i)}$$

$U_\infty = U = 2$ m/sec, $v = 1.5 \times 10^{-5}$ m^2/s, $\rho = 1.23$ kg/m^3, $L = x = 1$

Kinematic viscosity,

$$v = \frac{\mu}{\rho}$$

$$\mu = v \times \rho = 1.5 \times 10^{-5} \times 1.23$$

$$= 1.845 \times 10^{-5} \text{ kg/m sec}$$

Reynolds Number is given as,

$$\mathrm{Re}_x = \frac{\rho U x}{\mu} = \frac{1.23 \times 2 \times 1}{1.845 \times 10^{-5}} = 1.33 \times 10^5$$

$$\delta = \frac{4.64 \times 1}{\sqrt{1.33 \times 10^5}} = 0.0127$$

And

$$\frac{U}{U_\infty} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

$$\frac{dU}{dy} = U_\infty \frac{d}{dy}\left[\frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3\right] = U_\infty\left[\frac{3}{2} \times \frac{1}{\delta} - \frac{3}{2}\frac{y^2}{\delta^3}\right]$$

where U_∞ =Free stream velocity= U

$$\left(\frac{dU}{dy}\right)_{y=0} = U_\infty\left[\frac{3}{2\delta}\right] = \frac{3U_\infty}{2\delta}$$

We know that shear stress by the Newton's law of viscosity,

$$\tau_0 = \mu\left(\frac{dU}{dy}\right)_{y=0} = 1.845 \times 10^{-5} \times \frac{3U_\infty}{2\delta}$$

Substitute the values of U_∞ and δ, we get

$$= 1.845 \times 10^{-5} \times \frac{3 \times 2}{2 \times 0.0127}$$

$$= 435.82 \times 10^{-5}\ \mathrm{N/m^2} = 4.36 \times 10^{-3}\ \mathrm{N/m^2}$$

MCQ 1.50

GATE ME 2004 TWO MARK

A centrifugal pump is required to pump water to an open water tank situated 4 km away from the location of the pump through a pipe of diameter 0.2 m having Darcy's friction factor of 0.01. The average speed of water in the pipe is 2 m/s. If it is to maintain a constant head of 5 m in the tank, neglecting other minor losses, then absolute discharge pressure at the pump exit is

(A) 0.449 bar (B) 5.503 bar

(C) 44.911 bar (D) 55.203 bar

SOL 1.50

Option (B) is correct.

Given : $L = 4\ \mathrm{km} = 4 \times 1000 = 4000\ \mathrm{m},\ d = 0.2\ \mathrm{m}$

$f = 0.01,\ V = 2\ \mathrm{m/sec},\ H = 5\ \mathrm{meter}$

Head loss due to friction in the pipe,

$$h_f = \frac{fLV^2}{2gd}$$

$$= \frac{0.01 \times 4000 \times (2)^2}{2 \times 9.81 \times 0.2} = 40.77 \text{ m of water}$$

Now total pressure (absolute discharge pressure) to be supplied by the pump at exit = Pressure loss by pipe + Head pressure of tank + Atmospheric pressure head

Total pressure, $p = \rho g h_f + \rho g H + \rho g h_{atm}$

$$p = \rho g[h_f + H + h_{atm}] \qquad \text{Pressure head}, \frac{p}{\rho g} = H \Rightarrow p = H\rho g$$

$$= 1000 \times 9.81[40.77 + 5 + 10.3]$$

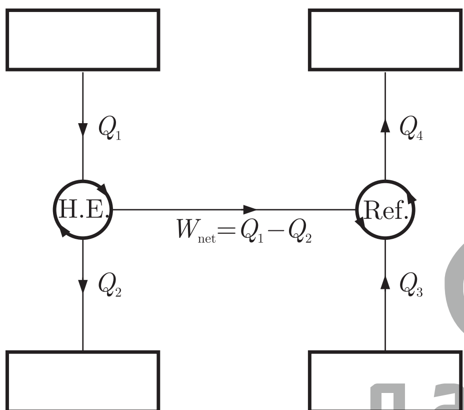
$= 5.5 \times 10^5 \text{ N/m}^2 = 5.5 \text{ bar}$ For water $h_{atm} = 10.3 \text{ m}$

MCQ 1.51 GATE ME 2004 TWO MARK

A heat engine having an efficiency of 70% is used to drive a refrigerator having a coefficient of performance of 5. The energy absorbed from low temperature reservoir by the refrigerator for each kJ of energy absorbed from high temperature source by the engine is

(A) 0.14 kJ
(B) 0.71 kJ
(C) 3.5 kJ
(D) 7.1 kJ

SOL 1.51 Option (C) is correct.



Given : $(COP)_{refrigerator} = 5$, $(\eta)_{H.E.} = 70\% = 0.7$

$$(COP)_{ref.} = \frac{Q_3}{W} = 5 \quad \text{...(i)}$$

$$(\eta)_{H.E.} = \frac{W}{Q_1} = 0.7 \quad \text{...(ii)}$$

By multiplying equation (i) & (ii),

$$\frac{Q_3}{W} \times \frac{W}{Q_1} = 5 \times 0.7 \Rightarrow \frac{Q_3}{Q_1} = 3.5$$

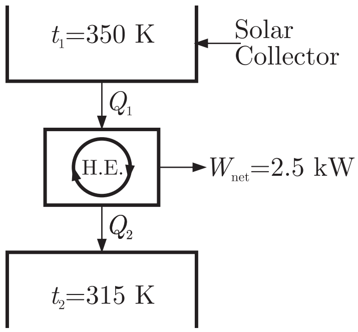
Hence, Energy absorbed (Q_3) from low temperature reservoir by the refrigerator for each kJ of energy absorbed (Q_1) from high temperature source by the engine $= 3.5 \text{ kJ}$

MCQ 1.52 GATE ME 2004 TWO MARK

A solar collector receiving solar radiation at the rate of 0.6 kW/m^2 transforms it to the internal energy of a fluid at an overall efficiency of 50%. The fluid heated to 250 K is used to run a heat engine which rejects heat at 315 K. If the heat engine is to deliver 2.5 kW power, the minimum area of the solar collector required would be

(A) 83.33 m^2
(B) 16.66 m^2
(C) 39.68 m^2
(D) 79.36 m^2

SOL 1.52 Option (A) is correct.



Solar collector receiving solar radiation at the rate of $0.6\,\text{kW/m}^2$. This radiation is stored in the form of internal energy. Internal energy of fluid after absorbing

Solar radiation, $\Delta U = \frac{1}{2} \times 0.6$ Efficiency of absorbing radiation is 50%

$$= 0.3\,\text{kW/m}^2$$

$$\eta_{Engine} = 1 - \frac{T_2}{T_1} = \frac{W_{net}}{Q_1}$$

$$Q_1 = \frac{W_{net} \times T_1}{T_1 - T_2} = \frac{2.5 \times 350}{350 - 315} = 25 \text{ kW}$$

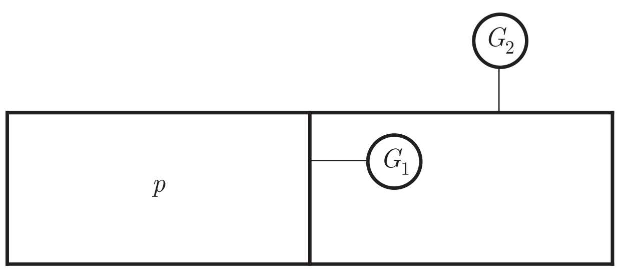
Let, A is the minimum area of the solar collector.

So, $$Q_1 = A \times \Delta U = A \times 0.3\,\text{kW/m}^2$$

$$A = \frac{Q_1}{0.3} = \frac{25}{0.3} = \frac{250}{3} = 83.33\,\text{m}^2$$

MCQ 1.53 GATE ME 2004 TWO MARK

The pressure gauges G_1 and G_2 installed on the system show pressure of $p_{G1} = 5.00$ bar and $p_{G2} = 1.00$ bar. The value of unknown pressure p is



Q.15.

(A) 1.01 bar (B) 2.01 bar

(C) 5.00 bar (D) 7.01 bar

SOL 1.53 Option (D) is correct.

Given : $p_{G_1} = 5.00\,\text{bar},\ p_{G_2} = 1.00\,\text{bar},\ p_{atm} = 1.01\,\text{bar}$

Absolute pressure of G_2 = Atmospheric pressure + Gauge pressure

$$= 1.01 + 1.00 = 2.01\,\text{bar}$$

Absolute pressure of $G_1 = p_{G_1} + p_{abs(G_2)} = 5.00 + 2.01 = 7.01\,\text{bar}$

MCQ 1.54 GATE ME 2004 TWO MARK

A steel billet of $2000\,\text{kg}$ mass is to be cooled from $1250\,\text{K}$ to $450\,\text{K}$. The heat released during this process is to be used as a source of energy. The ambient temperature is 303 K and specific heat of steel is 0.5 kJ/kg K. The available energy of this billet is

(A) 490.44 MJ (B) 30.95 MJ

(C) 10.35 MJ (D) 0.10 MJ

SOL 1.54 Option (A) is correct.

Given : $m = 2000$ kg, $T_1 = 1250$ K, $T_2 = 450$ K, $T_0 = 303$ K, $c = 0.5$ kJ/kg K

$$Q_1 = \text{Available Energy} + \text{Unavailable energy}$$

$$A.E. = Q_1 - U.E. \qquad \text{...(i)}$$

And

$$Q_1 = mc\Delta T$$

$$= 2000 \times 0.5 \times 10^3 \times (1250 - 450)$$

$$Q_1 = 800 \times 10^6 = 800 \text{ MJoule}$$

We know

$$U.E. = T_0(\Delta s) \qquad \text{...(ii)}$$

$$\Delta S = mc\ln\frac{T_1}{T_2} = 2000 \times 0.5 \times 10^3 \ln\frac{1250}{450}$$

$$= 10^6 \ln\frac{1250}{450} = 1.021 \times 10^6 \text{ J/kg}$$

Now, Substitute the value of Q_1 and $U.E.$ in equation (i),

$$A.E. = 800 \times 10^6 - 303 \times 1.021 \times 10^6 \qquad \text{From equation (ii)}$$

$$= 10^6 \times [800 - 309.363]$$

$$= 490.637 \times 10^6 = 490.637 \backsimeq 490.44 \text{ MJ}$$

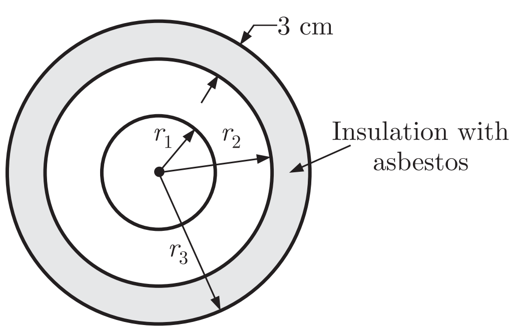
MCQ 1.55 GATE ME 2004 TWO MARK

A stainless steel tube $(k_s = 19 \text{ W/m K})$ of 2 cm ID and 5 cm OD is insulated with 3 cm thick asbestos $(k_a = 0.2 \text{ W/m K})$. If the temperature difference between the innermost and outermost surfaces is 600°C, the heat transfer rate per unit length is

(A) 0.94 W/m (B) 9.44 W/m

(C) 944.72 W/m (D) 9447.21 W/m

SOL 1.55 Option (C) is correct.



Let Length of the tube $= l$

Given : $r_1 = \frac{d_1}{2} = 2/2 \text{ cm} = 1 \text{ cm}$, $r_2 = \frac{5}{2} \text{ cm} = 2.5 \text{ cm}$

Radius of asbestos surface, $r_3 = \frac{d_2}{2} + 3 = 2.5 + 3 = 5.5\,\text{cm}$

$k_s = 19\,\text{W/mK},\ k_a = 0.2\,\text{W/mK}$

And $T_1 - T_2 = 600^\circ\,\text{C}$

From the given diagram heat is transferred from r_1 to r_2 & from r_2 to r_3. So Equivalent thermal resistance,

$$\Sigma R = \frac{1}{2\pi k_s l}\ln\left(\frac{r_2}{r_1}\right) + \frac{1}{2\pi k_a l}\ln\left(\frac{r_3}{r_2}\right)$$

For hollow cylinder $R_t = \frac{\log_e(r_2/r_1)}{2\pi kl}$

$$\Sigma R \times l = \frac{1}{2\pi k_s}\ln\left(\frac{r_2}{r_1}\right) + \frac{1}{2\pi k_a}\ln\left(\frac{r_3}{r_2}\right)$$

$$= \frac{1}{2\times 3.14 \times 19}\ln\left(\frac{2.5}{1}\right) + \frac{1}{2\times 3.14\times 0.2}\ln\left(\frac{5.5}{2.5}\right)$$

$$= \frac{0.916}{119.32} + \frac{0.788}{1.256} = 0.00767 + 0.627 = 0.635\,\text{mK/W} \qquad \text{...(i)}$$

Heat transfer per unit length,

$$Q = \frac{T_1 - T_2}{(\Sigma R \times l)} = \frac{600}{0.635} = 944.88 \simeq 944.72\,\text{W/m}$$

MCQ 1.56

GATE ME 2004
TWO MARK

A spherical thermocouple junction of diameter $0.706\,\text{mm}$ is to be used for the measurement of temperature of a gas stream. The convective heat transfer co-efficient on the bead surface is $400\,\text{W/m}^2\text{K}$. Thermo-physical properties of thermocouple material are $k = 20\,\text{W/mK}$, $c = 400\,\text{J/kg K}$ and $\rho = 8500\,\text{kg/m}^3$. If the thermocouple initially at 30°C is placed in a hot stream of 300°C, then time taken by the bead to reach 298°C, is

(A) 2.35 s
(B) 4.9 s
(C) 14.7 s
(D) 29.4 s

SOL 1.56

Option (B) is correct.

Given : $h = 400\,\text{W/m}^2\text{K},\ k = 20\,\text{W/mK},\ c = 400\,\text{J/kg K},\ \rho = 8500\,\text{kg/m}^3$

$T_i = 30^\circ\,\text{C},\ D = 0.706\ \text{mm},\ T_a = 300^\circ\,\text{C},\ T = 298^\circ\,\text{C}$

Biot Number, $B_i = \frac{hl}{k}$ ..(i)

And $$l = \frac{\text{Volume}}{\text{Surface Area}} = \frac{\frac{4}{3}\pi R^3}{4\pi R^2} = \frac{\frac{1}{6}\pi D^3}{\pi D^2}$$

$$= \frac{D}{6} = \frac{0.706\times 10^{-3}}{6} = 1.176\times 10^{-4}\,\text{m}$$

From equation (i), we have

$$Bi = \frac{hl}{k} = \frac{400\times 1.176\times 10^{-4}}{20} = 0.0023$$

$$Bi < 0.1$$

The value of Biot Number is less than one. So the lumped parameter solution for transient conduction can be conveniently stated as

$$\frac{T - T_a}{T_i - T_a} = e^{-\left(\frac{hAt}{\rho c\nu}\right)} = e^{-\left(\frac{ht}{\rho cl}\right)} \qquad \frac{\nu}{A} = l$$

$$\frac{298-300}{30-300} = \exp\left(\frac{-400t}{8500\times 400\times 1.176\times 10^{-4}}\right)$$

$$\frac{-2}{-270} = e^{-t}$$

$$\frac{2}{270} = e^{-t}$$

Take natural logarithm both sides, we get

$$\ln\left(\frac{2}{270}\right) =- t$$

$$t = 4.90 \text{ sec}$$

MCQ 1.57 GATE ME 2004 TWO MARK

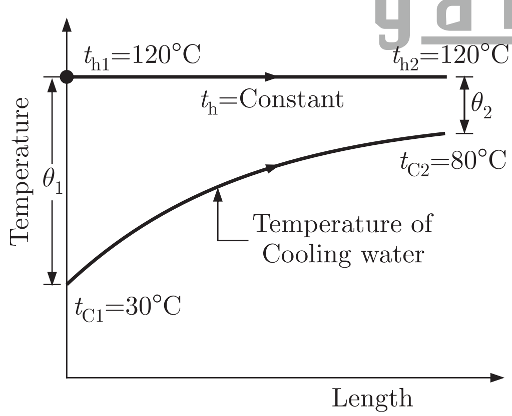
In a condenser, water enters at 30°C and flows at the rate 1500 kg/hr. The condensing steam is at a temperature of 120°C and cooling water leaves the condenser at 80°C . Specific heat of water is 4.187 kJ/kgK. If the overall heat transfer coefficient is 2000 W/m^2K, then heat transfer area is

(A) 0.707 m^2 (B) 7.07 m^2

(C) 70.7 m^2 (D) 141.4 m^2

SOL 1.57 Option (A) is correct.

Figure for condensation is given below :



Given : $t_{c1} = 30^\circ$C, $\frac{dm}{dt} = \dot{m} = 1500 \text{ kg/hr} = \frac{1500}{3600} \text{ kg/sec} = 0.4167 \text{ kg/sec}$

$t_{h2} = t_{h1} = 120^\circ$ C, $t_{c2}t_{c2} = 80^\circ$C, $c_w = 4.187$ kJ/kg K, $U = 2000$ W/m^2K

Hence, $\theta_1 = t_{h1} - t_{c1} = 120 - 30 = 90^\circ$ C

And $\theta_2 = t_{h2} - t_{c2} = 120 - 80 = 40^\circ$ C

So, Log mean temperature difference (LMTD) is,

$$\theta_m = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{90-40}{\ln\left(\frac{90}{40}\right)} = 61.66^\circ \text{ C}$$

Energy transferred is given by,

$$Q = \dot{m}c_w \Delta T = UA\theta_m$$

$$A = \frac{\dot{m}c_w \Delta T}{U\theta_m}$$

$$= \frac{0.4167 \times 4.187 \times 1000 \times 50}{2000 \times 61.66} = 0.707 \text{ m}^2$$

MCQ 1.58 GATE ME 2004 TWO MARK

During a Morse test on a 4 cylinder engine, the following measurements of brake power were taken at constant speed.

All cylinders firing	3037 kW
Number 1 cylinder not firing	2102 kW
Number 2 cylinder not firing	2102 kW
Number 3 cylinder not firing	2100 kW
Number 4 cylinder not firing	2098 kW

The mechanical efficiency of the engine is

(A) 91.53% (B) 85.07%

(C) 81.07% (D) 61.22%

SOL 1.58

Option (C) is correct.

When all cylinders are firing then, power is 3037 kW = Brake Power

Power supplied by cylinders (Indicated power) is given below :

Cylinder No.	Power supplied (I.P.)
1.	$I.P._1 = 3037 - 2102 = 935$ kW
2.	$I.P._2 = 3037 - 2102 = 935$ kW
3.	$I.P._3 = 3037 - 2100 = 937$ kW
4.	$I.P._4 = 3037 - 2098 = 939$ kW

$$I.P._{Total} = I.P._1 + I.P._2 + I.P._3 + I.P._4$$
$$= 935 + 935 + 937 + 939 = 3746 \text{ kW}$$

And, $$\eta_{mech} = \frac{B.P.}{I.P.} = \frac{3037}{3746} = 0.8107 \text{ or } 81.07\%$$

MCQ 1.59 GATE ME 2004 TWO MARK

An engine working on air standard Otto cycle has a cylinder diameter of 10 cm and stroke length of 15 cm. The ratio of specific heats for air is 1.4. If the clearance volume is 196.3 cc and the heat supplied per kg of air per cycle is 1800 kJ/kg, the work output per cycle per kg of air is

(A) 879.1 kJ (B) 890.2 kJ

(C) 895.3 kJ (D) 973.5 kJ

SOL 1.59

Option (D) is correct.

Given : $D = 10$ cm $= 0.1$ meter, $L = 15$ cm $= 0.15$ meter

$\gamma = \frac{c_p}{c_v} = 1.4$, $\nu_c = 196.3$ cc, $Q = 1800$ kJ/kg

$$\nu_s = A \times L = \frac{\pi}{4} D^2 \times L$$
$$= \frac{\pi}{4} \times (10)^2 \times 15 = \frac{1500\pi}{4} = 1177.5 \text{ cc}$$

And Compression ratio, $r = \frac{\nu_T}{\nu_c} = \frac{\nu_c + \nu_s}{\nu_c}$

$$= \frac{196.3 + 1177.5}{196.3} = 6.998 \simeq 7$$

Cycle efficiency, $\eta_{Otto} = 1 - \frac{1}{(r)^{\gamma-1}} = 1 - \frac{1}{(7)^{1.4-1}}$

$$= 1 - \frac{1}{2.1779} = 1 - 0.4591 = 0.5409$$

$$\eta_{Otto} = 54.09\%$$

We know that, $\eta = \frac{\text{Work output}}{\text{Heat Supplied}}$

$$\text{Work output} = \eta \times \text{Heat supplied}$$

$$= 0.5409 \times 1800 = 973.62\,\text{kJ} \simeq 973.5\,\text{kJ}$$

MCQ 1.60 GATE ME 2004 TWO MARK

At a hydro electric power plant site, available head and flow rate are 24.5 m and 10.1 m^3/s respectively. If the turbine to be installed is required to run at 4.0 revolution per second (rps) with an overall efficiency of 90%, the suitable type of turbine for this site is

(A) Francis (B) Kaplan

(C) Pelton (D) Propeller

SOL 1.60

Option (A) is correct.

Given : $H = 24.5\,\text{m}$, $Q = 10.1\,\text{m}^3/\text{sec}$, $\eta_0 = 90\%$, $N = 4\,\text{rps} = 4 \times 60 = 240\,\text{rpm}$

$$\eta_0 = \frac{\text{Shaft Power in kW}}{\text{Water Power in kW}} = \frac{P}{\left(\frac{\rho \times g \times Q \times H}{1000}\right)}$$

$$P = \frac{\eta_0 \times \rho \times g \times Q \times H}{1000}$$

$$= \frac{0.90 \times 1000 \times 9.81 \times 10.1 \times 24.5}{1000}$$

$$= 2184.74\,\text{kW} \qquad \rho_{water} = 1000\,\text{kg/m}^3$$

For turbine Specific speed,

$$N_S = \frac{N\sqrt{P}}{H^{5/4}} = \frac{240\sqrt{2184.74}}{(24.5)^{5/4}} = 205.80\,\text{rpm}$$

Hence, $51 < N_S < 255$ for francis turbine.

MCQ 1.61 GATE ME 2004 TWO MARK

Dew point temperature of air at one atmospheric pressure (1.013 bar) is 18° C. The air dry bulb temperature is 30° C. The saturation pressure of water at 18° C and 30° C are 0.02062 bar and 0.04241 bar respectively. The specific heat of air and water vapour respectively are 1.005 and 1.88 kJ/kg K and the latent heat of vaporization of water at 0° C is 2500 kJ/kg. The specific humidity (kg/kg of dry air) and enthalpy (kJ/kg or dry air) of this moist air respectively, are

(A) 0.01051, 52.64 (B) 0.01291, 63.15

(C) 0.01481, 78.60 (D) 0.01532, 81.40

SOL 1.61 Option (B) is correct.

Given : $t_{dp} = 18^\circ\text{C} = (273 + 18)\text{K} = 291\text{K},\ p = p_{atm} = 1.013\text{ bar}$

$t_{db} = 30^\circ\text{C} = (273 + 30)\text{K} = 303\text{K}$

$p_v = 0.02062$ bar (for water vapour at dew point).

$c_{air} = 1.005\text{ kJ/kg K},\ c_{water} = 1.88\text{ kJ/kg K}$

Latent heat of vaporization of water at 0°C.

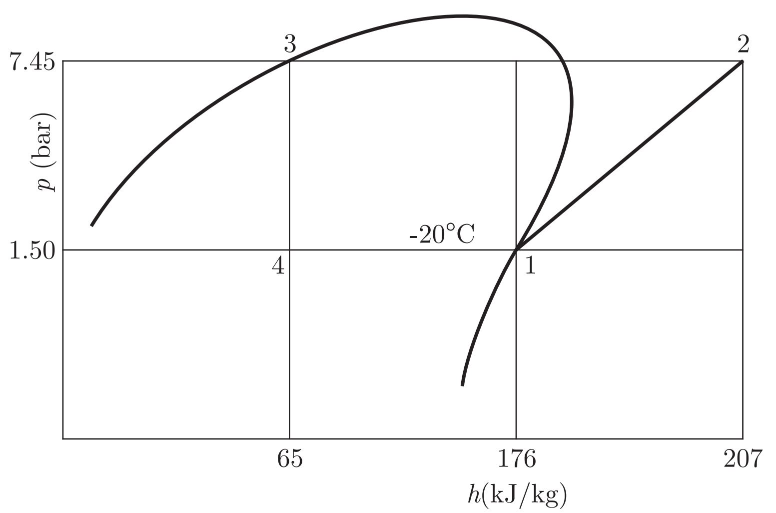
$$h_{fgdp} = 2500\text{ kJ/kg}$$

Specific humidity,
$$W = \frac{0.622 \times p_v}{p - p_v} = \frac{0.622 \times 0.02062}{1.013 - 0.02062}$$
$$= \frac{0.01282}{0.99238} = 0.01291\text{ kg/kg of dry air}$$

Enthalpy of moist air is given by,
$$h = 1.022t_{db} + W(h_{fgdp} + 2.3t_{dp})\text{ kJ/kg}$$
$$h = 1.022 \times 30 + 0.01291[2500 + 2.3 \times 18]$$
$$= 30.66 + 0.01291 \times 2541.4$$
$$= 63.46\text{ kJ/kg} \simeq 63.15\text{ kJ/Kg}$$

MCQ 1.62 GATE ME 2004 TWO MARK

A R-12 refrigerant reciprocating compressor operates between the condensing temperature of 30°C and evaporator temperature of -20°C. The clearance volume ratio of the compressor is 0.03. Specific heat ratio of the vapour is 1.15 and the specific volume at the suction is 0.1089 m^3/kg. Other properties at various states are given in the figure. To realize 2 tons of refrigeration, the actual volume displacement rate considering the effect of clearance is



(A) $6.35 \times 10^{-3}\text{ m}^3/\text{s}$ (B) $63.5 \times 10^{-3}\text{ m}^3/\text{s}$

(C) $635 \times 10^{-3}\text{ m}^3/\text{s}$ (D) $4.88 \times 10^{-3}\text{ m}^3/\text{s}$

SOL 1.62 Option (A) is correct.

Given : $C = 0.03,\ \ n = 1.15$, Specific volume at suction $= 0.1089\text{ m}^3/\text{kg}$

$$\text{Net refrigeration effect} = 2 \text{ ton}$$

$$1 \text{ TR} = 1000 \times 335 \text{ kJ in 24 hr}$$

$$= \frac{2 \times 1000 \times 335}{24 \times 60 \times 60} = 7.75 \text{ kJ/sec}$$

$$\text{Let net mass flow rate} = \dot{m}$$

$$\text{Net refrigeration effect} = \dot{m}(h_1 - h_4)$$

Substitute the values from equation (i), and from the $p - h$ curve,

$$7.75 = \dot{m}(176 - 65)$$

$$m = \frac{7.75}{111} = 0.06981 \text{ kg/sec}$$

Specific volume, $\frac{\nu}{\dot{m}} = 0.1089$

$$\nu = 0.1089 \times 0.06981 = 0.00760$$

$$= 7.60 \times 10^{-3} \text{ m}^3/\text{sec}$$

We know that volumetric efficiency,

$$\eta_v = 1 + C - C\left(\frac{p_2}{p_1}\right)^{\frac{1}{n}}$$

Where, p_1 is the suction pressure and p_2 is the discharge pressure.

$$= 1 + 0.03 - 0.03 \times \left(\frac{7.45}{1.50}\right)^{\frac{1}{1.15}}$$

$$= 1.03 - 0.12089 = 0.909$$

Now actual volume displacement rate is,

$$\nu_{actual} = \nu \times \eta_v = 7.60 \times 10^{-3} \times 0.909$$

$$= 6.90 \times 10^{-3} \simeq 6.35 \times 10^{-3} \text{ m}^3/\text{sec}$$

MCQ 1.63 GATE ME 2004 TWO MARK

GO and NO-GO plug gauges are to be designed for a hole $20.000^{+0.050}_{+0.010}$ mm. Gauge tolerances can be taken as 10% of the hole tolerance. Following ISO system of gauge design, sizes of GO and NO-GO gauge will be respectively

(A) 20.010 mm and 20.050 mm
(B) 20.014 mm and 20.046 mm
(C) 20.006 mm and 20.054 mm
(D) 20.014 mm and 20.054 mm

SOL 1.63 Option (B) is correct.

$$\text{For hole size} = 20.000^{+0.050}_{+0.010} \text{ mm}$$

$$\text{Maximum hole size} = 20.000 + 0.050 = 20.050 \text{ mm}$$

$$\text{Minimum hole size} = 20.000 + 0.010 = 20.010$$

So, $\text{Hole tolerance} = \text{Maximum hole size} - \text{Minimum hole size}$

$$= 20.050 - 20.010 = 0.040 \text{ mm}$$

Gauge tolerance can be 10% of the hole tolerance (Given).

So, $\text{Gauge tolerance} = 10\% \text{ of } 0.040$

$$= \frac{10}{100} \times 0.040 = 0.0040 \text{ mm}$$

$$\begin{aligned}\text{Size of Go Gauge} &= \text{Minimum hole size} + \text{Gauge tolerance}\\ &= 20.010 + 0.0040 = 20.014 \text{ mm}\\ \text{Size of NO-GO Gauge} &= \text{Maximum hole size} - \text{Gauge tolerance}\\ &= 20.050 - 0.004 = 20.046 \text{ mm}\end{aligned}$$

MCQ 1.64 GATE ME 2004 TWO MARK

A standard machine tool and an automatic machine tool are being compared for the production of a component. Following data refers to the two machines.

	Standard Machine Tool	Automatic Machine Tool
Setup time	30 min	2 hours
Machining time per piece	22 min	5 min
Machine rate	Rs. 200 per hour	Rs. 800 per hour

The break even production batch size above which the automatic machine tool will be economical to use, will be

(A) 4 (B) 5

(C) 24 (D) 225

SOL 1.64 Option (D) is correct.

Let, The standard machine tool produce x_1 number of components.

For standard machine tool,

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

$$(TC)_{SMT} = \left[\frac{30}{60} + \frac{22}{60} \times x_1\right] \times 200$$

$$= \frac{30}{60} \times 200 + \frac{22}{60} \times x_1 \times 200$$

$$= 100 + \frac{220}{3} x_1 \qquad \text{...(i)}$$

If automatic machine tool produce x_2 Number of components, then the total cost for automatic machine tool is

$$(TC)_{AMT} = \left(2 + \frac{5}{60} x_2\right) 800$$

$$= 1600 + \frac{200}{3} x_2 \qquad \text{....(ii)}$$

Let, at the breakeven production batch size is x and at breakeven point.

$$(TC)_{SMT} = (TC)_{AMT}$$

$$100 + \frac{220x}{3} = 1600 + \frac{200x}{3}$$

$$\frac{220x}{3} - \frac{200x}{3} = 1600 - 100$$

$$\frac{20x}{3} = 1500$$

$$x = \frac{1500 \times 3}{20}$$

$$x = 225$$

So, breakeven production batch size is 225.

MCQ 1.65 GATE ME 2004 TWO MARK

10 mm diameter holes are to be punched in a steel sheet of 3 mm thickness. Shear strength of the material is 400 N/mm^2 and penetration is 40%. Shear provided on the punch is 2 mm. The blanking force during the operation will be

(A) 22.6 kN (B) 37.7 kN

(C) 61.6 kN (D) 94. 3 kN

SOL 1.65

Option (A) is correct.

Given : $d = 10\,\text{mm},\ t = 3\,\text{mm},\ \tau_s = 400\,\text{N/mm}^2,\ t_1 = 2\,\text{mm},\ p = 40\% = 0.4$

We know that, when shear is applied on the punch, the blanking force is given by,

$$F_B = \pi dt\left(\frac{t \times p}{t_1}\right) \times \tau_s \qquad \text{Where } t \times p = \text{Punch travel}$$

Substitute the values, we get

$$F_B = 3.14 \times 10 \times 3\left(\frac{3 \times 0.4}{2}\right) \times 400$$

$$= 94.2 \times 0.6 \times 400 = 22.6\,\text{kN}$$

MCQ 1.66 GATE ME 2004 TWO MARK

Through holes of 10 mm diameter are to be drilled in a steel plate of 20 mm thickness. Drill spindle speed is 300 rpm, feed 0.2 mm/rev and drill point angle is 120°. Assuming drill overtravel of 2 mm, the time for producing a hole will be

(A) 4 seconds (B) 25 seconds

(C) 100 seconds (D) 110 seconds

SOL 1.66

Option (B) is correct

Given : $D = 10\,\text{mm},\ t = 20\,\text{mm},\ N = 300\,\text{rpm},\ f = 0.2\,\text{mm/rev.}$

Point angle of drill, $2\alpha_p = 120^\circ \qquad \Rightarrow \alpha_p = 60^\circ$

Drill over-travel $= 2\,\text{mm}$

We know that, break through distance,

$$A = \frac{D}{2\tan\alpha_p} = \frac{10}{2\tan 60^\circ} = 2.89\,\text{mm}$$

Total length travelled by the tool,

$$L = t + A + 2$$

$$= 20 + 2.89 + 2 = 24.89\,\text{mm}$$

So, time for drilling,

$$t = \frac{L}{f \cdot N} = \frac{24.89}{0.2 \times 300} = 0.415\,\text{min}$$

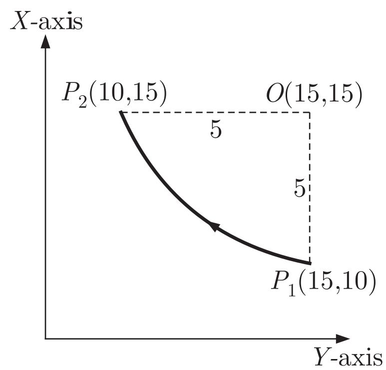
$$= 0.415 \times 60\,\text{sec} = 24.9 \simeq 25\,\text{sec}$$

MCQ 1.67 GATE ME 2004 TWO MARK

In a 2-D CAD package, clockwise circular arc of radius 5, specified from $P_1(15, 10)$ to $P_2(10, 15)$ will have its centre at

(A) (10, 10) (B) (15, 10)
(C) (15, 15) (D) (10, 15)

SOL 1.67 Option (C) is correct



From the figure, the centre of circular arc with radius 5 is

$$[15, (10+5)] = [15, 15] \qquad \text{From point } P_1$$

$$[(10+5), 15] = [15, 15] \qquad \text{From point } P_2$$

MCQ 1.68 Gray cast iron blocks 200 × 100 × 10 mm are to be cast in sand moulds. Shrinkage allowance for pattern making is 1%. The ratio of the volume of pattern to that of the casting will be

GATE ME 2004
TWO MARK

(A) 0.97 (B) 0.99
(C) 1.01 (D) 1.03

SOL 1.68 Option (D) is correct.

Given : Dimension of block $= 200 \times 100 \times 10\,\text{mm}$

Shrinkage allowance, $X = 1\%$

We know that, since metal shrinks on solidification and contracts further on cooling to room temperature, linear dimensions of patterns are increased in respect of those of the finished casting to be obtained.

So, $v_c = 200 \times 100 \times 10 = 2 \times 10^5\,\text{mm}^2$

Shrinkage allowance along length,

$$S_L = LX = 200 \times 0.01 = 2\,\text{mm}$$

Shrinkage allowance along breadth,

$$S_B = 100 \times 0.01 = 1\,\text{mm}$$

or Shrinkage allowance along height,

$$S_H = 10 \times 0.01 = 0.1\,\text{mm}$$

Volume of pattern will be

$$v_p = [(L+S_L)(B+S_B)(S+S_H)]\,\text{mm}^3$$

$$= 202 \times 101 \times 10.01\,\text{mm}^3 = 2.06 \times 10^5\,\text{mm}^3$$

So, $$\frac{\text{Volume of Pattern } v_p}{\text{Volume of Casting } v_c} = \frac{2.06 \times 10^5}{2 \times 10^5} = 1.03$$

MCQ 1.69 GATE ME 2004 TWO MARK

In an orthogonal cutting test on mild steel, the following data were obtained

Cutting speed	:	40 m/min
Depth of cut	:	0.3 mm
Tool rake angle	:	$+5^\circ$
Chip thickness	:	1.5 mm
Cutting force	:	900 N
Thrust force	:	450 N

Using Merchant's analysis, the friction angle during the machining will be

(A) 26.6° (B) 31.5°

(C) 45° (D) 63.4°

SOL 1.69 Option (B) is correct.

Given : $V = 40\,\text{m/min}$, $d = 0.3\,\text{mm}$, $\alpha = 5^\circ$

$t = 1.5\,\text{mm}$, $F_c = 900\,\text{N}$, $F_t = 450\,\text{N}$

We know from the merchant's analysis

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

Where F= Frictional resistance of the tool acting on the chip.

N= Force at the tool chip interface acting normal to the cutting face of the tool.

$$\mu = \frac{900\tan 5^\circ + 450}{900 - 450\tan 5^\circ}$$

$$= \frac{528.74}{860.63} = 0.614$$

Now, Frictional angle, $\beta = \tan^{-1}\mu = \tan^{-1}(0.614) = 31.5^\circ$

MCQ 1.70 GATE ME 2004 TWO MARK

In a rolling process, sheet of 25 mm thickness is rolled to 20 mm thickness. Roll is of diameter 600 mm and it rotates at 100 rpm. The roll strip contact length will be

(A) 5 mm (B) 39 mm

(C) 78 mm (D) 120 mm

SOL 1.70 Option (B) is correct.

Given : $t_i = 25\,\text{mm}$, $t_f = 20\,\text{mm}$, $D = 600\,\text{mm}$, $N = 100\,\text{rpm}$

Let, Angle substended by the deformation zone at the roll centre is θ in radian and it is given by the relation.

$$\theta(\text{radian}) = \sqrt{\frac{t_i - t_f}{R}}$$

$$= \sqrt{\frac{25-20}{300}} = \sqrt{0.0166} = 0.129\text{ radian}$$

Roll strip contact length is

$$L = \theta \times R \qquad \text{Angle} = \frac{\text{Arc}}{R}$$

$$L = 0.129 \times 300 = 38.73\,\text{mm} \simeq 39\,\text{mm}$$

MCQ 1.71 In a machining operation, doubling the cutting speed reduces the tool life to $\frac{1}{8}$th of the original value. The exponent n in Taylor's tool life equation $VT^n = C$, is

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(A) $\frac{1}{8}$
(B) $\frac{1}{4}$
(C) $\frac{1}{3}$
(D) $\frac{1}{2}$

SOL 1.71 Option (C) is correct.

Given : $VT^n = C$

Let V and T are the initial cutting speed & tool life respectively.

Case (I) : The relation between cutting speed and tool life is,

$$VT^n = C \quad ...(i)$$

Case (II) : In this case doubling the cutting speed and tool life reduces to $1/8^{th}$ of original values.

So,
$$(2V) \times \left(\frac{T}{8}\right)^n = C \quad ...(ii)$$

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

$$\frac{VT^n}{2V\left(\frac{T}{8}\right)^n} = 1$$

$$T^n = 2\left(\frac{T}{8}\right)^n$$

$$\frac{1}{2} = \left(\frac{1}{8}\right)^n$$

$$\left(\frac{1}{2}\right)^1 = \left(\frac{1}{2}\right)^{3n}$$

Compare powers both the sides,

$$1 = 3n \qquad \Rightarrow n = \frac{1}{3}$$

MCQ 1.72 A soldering operation was work-sampled over two days (16 hours) during which an employee soldered 108 joints. Actual working time was 90% of the total time and the performance rating was estimated to be 120 per cent. If the contract provides allowance of 20 percent of the time available, the standard time for the operation would be

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TWO MARK

(A) 8 min
(B) 8.9 min
(C) 10 min
(D) 12 min

SOL 1.72 Option (D) is correct.

Given :

$$\text{Total time } T = 16 \text{ hours}$$
$$= 16 \times 60 = 960 \text{ min}$$

Actual working time was 90% of total time

So,
$$\text{Actual time, } T_{actual} = 90\% \text{ of } 960$$
$$= \frac{90}{100} \times 960, \; T_{actual} = 864 \text{ min}$$

Performance rating was 120 percent.

So, Normal time, $T_{normal} = 120\%$ of 864

$$T_{normal} = \frac{120}{100} \times 864$$

$$= 1036.8 \text{ min}$$

Allowance is 20% of the total available time.

$$\text{So total standard time } T_{standard} = \frac{T_{normal}}{\left(1 - \frac{20}{100}\right)}$$

$$= \frac{1036.8}{1 - 0.2} = \frac{1036.8}{0.8}$$

$$= 1296 \text{ min}$$

Number of joints soldered, $N = 108$

Hence,

$$\text{Standard time for operation} = \frac{1296}{108}$$

$$= 12 \text{ min}$$

MCQ 1.73
GATE ME 2004
TWO MARK

An electronic equipment manufacturer has decided to add a component sub-assembly operation that can produce 80 units during a regular 8-hours shift. This operation consist of three activities as below

Activity	Standard time (min)
M. Mechanical assembly	12
E. Electric wiring	16
T. Test	3

For line balancing the number of work stations required for the activities M, E and T would respectively be

(A) 2, 3, 1
(B) 3, 2, 1
(C) 2, 4, 2
(D) 2, 1, 3

SOL 1.73

Option (A) is correct.

Given :

Number of units produced in a day = 80 units

Working hours in a day = 8 hours

Now, Time taken to produce one unit is,

$$T = \frac{8}{80} \times 60$$

$$= 6 \text{ min}$$

Activity	Standard time (min)	No. of work stations $(S.T/T)$

M. Mechanical assembly	12	$12/6 = 2$
E. Electric wiring	16	$16/6 = 2.666 = 3$
T. Test	3	$3/6 = 0.5 = 1$

Number of work stations are the whole numbers, not the fractions.
So, number of work stations required for the activities M, E and T would be 2, 3 and 1, respectively.

MCQ 1.74 GATE ME 2004 TWO MARK

A maintenance service facility has Poisson arrival rates, negative exponential service time and operates on a 'first come first served' queue discipline. Breakdowns occur on an average of 3 per day with a range of zero to eight. The maintenance crew can service an average of 6 machines per day with a range of zero to seven. The mean waiting time for an item to be serviced would be

(A) $\frac{1}{6}$ day (B) $\frac{1}{3}$ day

(C) 1 day (D) 3 day

SOL 1.74

Option (A) is correct.
Given :

Mean arrival rate $\lambda = 3$ per day

Mean service rate $\mu = 6$ per day

We know that, for first come first serve queue.
Mean waiting time of an arrival,

$$t = \frac{\lambda}{\mu(\mu - \lambda)}$$

$$t = \frac{3}{6(6-3)} = \frac{1}{6} \text{ day}$$

MCQ 1.75 GATE ME 2004 TWO MARK

A company has an annual demand of 1000 units, ordering cost of Rs. 100/ order and carrying cost of Rs. 100/ unit/year. If the stock-out cost are estimated to be nearly Rs. 400 each time the company runs out-of-stock, then safety stock justified by the carrying cost will be

(A) 4 (B) 20

(C) 40 (D) 100

SOL 1.75

Option (C) is correct.
Given : $D = 1000$ units, $C_o = 100$/order, $C_h = 100$ unit/year $C_s = 400$ Rs.
We know that, optimum level of stock out will be,

$$\text{S.O} = \sqrt{\frac{2DC_o}{C_h}} \times \sqrt{\frac{C_s}{C_h + C_s}}$$

$$\text{S.O} = \sqrt{\frac{2 \times 1000 \times 100}{100}} \times \sqrt{\frac{400}{100 + 400}}$$

$$= 44.72 \times 0.895$$

$$= 40$$

MCQ 1.76
GATE ME 2004
TWO MARK

A company produces two types of toys : P and Q. Production time of Q is twice that of P and the company has a maximum of 2000 time units per day. The supply of raw material is just sufficient to produce 1500 toys (of any type) per day. Toy type Q requires an electric switch which is available @ 600 pieces per day only. The company makes a profit of Rs. 3 and Rs. 5 on type P and Q respectively. For maximization of profits, the daily production quantities of P and Q toys should respectively be

(A) 1000, 500
(B) 500, 1000
(C) 800, 600
(D) 1000, 1000

SOL 1.76

Option (A) is correct.
Solve this problem, by the linear programming model.
We have to make the constraints from the given conditions.
For production conditions

$$P + 2Q \le 2000 \quad ...(i)$$

For raw material

$$P + Q \le 1500 \quad ...(ii)$$

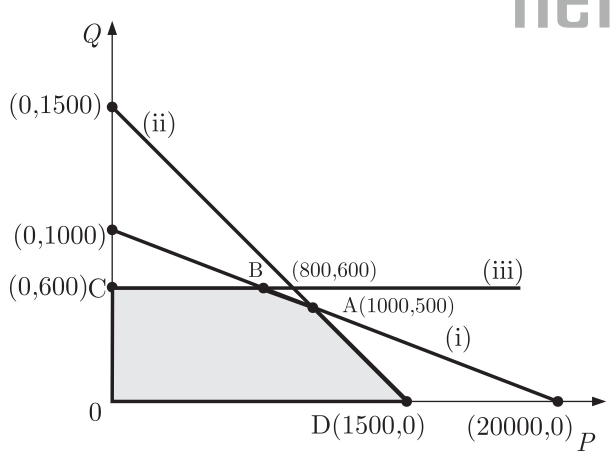
For electric switch

$$Q \le 600 \quad ...(iii)$$

For maximization of profit, objective function

$$Z = 3P + 5Q \quad ...(iv)$$

From the equations (i), (ii) & (iii), draw a graph for toy P and Q



Line (i) and line (ii) intersects at point A, we have to calculate the intersection point.

$$P + 2Q = 2000$$
$$P + Q = 1500$$

After solving there equations, we get $A(1000, 500)$
For point B,

$$P + 2Q = 2000$$
$$Q = 600$$

$$P = 2000 - 1200 = 800$$

So, $B(800, 600)$

Here shaded area shows the area bounded by the three line equations (common area)

This shaded area have five vertices.

	Vertices	Profit $Z = 3P + 5Q$
(i)	0(0, 0)	$Z = 0$
(ii)	$A(1000, 500)$	$Z = 3000 + 2500 = 5500$
(iii)	$B(800, 600)$	$Z = 2400 + 3000 = 5400$
(iv)	$C(0, 600)$	$Z = 3000$
(v)	$D(1500, 0)$	$Z = 4500$

So, for maximization of profit

$$P = 1000 \qquad \text{from point(ii)}$$
$$Q = 500$$

MCQ 1.77 Match the following

GATE ME 2004
TWO MARK

	Type of Mechanism		Motion achieved
P.	Scott-Russel Mechanism	**1.**	Intermittent Motion
Q.	Geneva Mechanism	**2.**	Quick return Motion
R.	Off-set slider-crank Mechanism	**3.**	Simple Harmonic Motion
S.	Scotch Yoke Mechanism	**4.**	Straight Line Motion

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

SOL 1.77 Option (C) is correct.

	Types of Mechanisms		Motion Achieved
P.	Scott-Russel Mechanism	**4.**	Straight Line Motion
Q.	Geneva Mechanism	**1.**	Intermittent Motion
R.	Off-set slider-crank Mechanism	**2.**	Quick Return Mechanism
S.	Scotch Yoke Mechanism	**3.**	Simple Harmonic Motion

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

MCQ 1.78 Match the following

GATE ME 2004
TWO MARK

Type of gears **Arrangement of shafts**

P.	Bevel gears	**1.**	Non-parallel off-set shafts
Q.	Worm gears	**2.**	Non-parallel intersecting shafts
R.	Herringbone gears	**3.**	Non-parallel, non-intersecting shafts
S.	Hypoid gears	**4.**	Parallel shafts

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

SOL 1.78 Option (B) is correct.

	Type of Gears		Arrangement of shafts
P.	Bevel gears	**2.**	Non-parallel intersecting shafts
Q.	Worm gears	**3.**	Non-parallel, non-intersecting shafts
R.	Herringbone gears	**4.**	Parallel shafts
S.	Hypoid gears	**1.**	Non-parallel off-set shafts

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

MCQ 1.79 Match the following with respect to spatial mechanisms.

GATE ME 2004
TWO MARK

	Types of Joint		Degree of constraints
P.	Revolute	**1.**	Three
Q.	Cylindrical	**2.**	Five
R.	Spherical	**3.**	Four
		4.	Two
		5.	Zero

(A) P-1 Q-3 R-3
(B) P-5 Q-4 R-3
(C) P-2 Q-3 R-1
(D) P-4 Q-5 R-3

SOL 1.79 Option (C) is correct.

	Types of Joint		Degree of constraints
P.	Revolute	**2.**	Five
Q.	Cylindrical	**3.**	Four
R.	Spherical	**1.**	Three

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

MCQ 1.80 Match List-I with List-II and select the correct answer using the codes given below the lists :

GATE ME 2004
TWO MARK

	List-I		List-II
P.	Reciprocating pump	**1.**	Plant with power output below 100 kW
Q.	Axial flow pump	**2.**	Plant with power output between 100 kW to 1 MW
R.	Microhydel plant	**3.**	Positive displacement
S.	Backward curved vanes	**4.**	Draft tube
		5.	High flow rate, low pressure ratio
		6.	Centrifugal pump impeller

Codes :

	P	Q	R	S
(A)	3	5	6	2
(B)	3	5	2	6
(C)	3	5	1	6
(D)	4	5	1	6

SOL 1.80 Option (B) is correct.

	List-I		List-II
P.	Reciprocating pump	**3.**	Positive Displacement
Q.	Axial flow pump	**5.**	High Flow rate, low pressure ratio
R.	Microhydel plant	**2.**	Plant with power output between 100 kW to 1 MW
S.	Backward curved vanes	**6.**	Centrifugal pump impeller

So, correct pairs are P-3, Q-5, R-2, S-6

MCQ 1.81 Match the following

GATE ME 2004
TWO MARK

	Feature to be inspected		Instrument
P.	Pitch and Angle errors of screw thread	**1.**	Auto Collimator
Q.	Flatness error of a surface	**2.**	Optical Interferometer
R.	Alignment error of a machine slideway	**3.**	Dividing Head and Dial Gauge
S.	Profile of a cam	**4.**	Spirit Level
		5.	Sine bar
		6.	Tool maker's Microscope

(A)	P-6	Q-2	R-4	S-6
(B)	P-5	Q-2	R-1	S-6
(C)	P-6	Q-4	R-1	S-3
(D)	P-1	Q-4	R-5	S-2

SOL 1.81 Option (B) is correct.

	Feature to be inspected		Instrument
P.	Pitch and Angle errors of screw thread	**5.**	Sine bar
Q.	Flatness error of a surface	**2.**	Optical Interferometer
R.	Alignment error of a machine slideway	**1.**	Auto collimator
S.	Profile of a cam	**6.**	Tool maker's Microscope

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

MCQ 1.82 Match the following

GATE ME 2004 TWO MARK

	Product		Process
P.	Molded luggage	**1.**	Injection molding
Q.	Packaging containers for Liquid	**2.**	Hot rolling
R.	Long structural shapes	**3.**	Impact extrusion
S.	Collapsible tubes	**4.**	Transfer molding
		5.	Blow molding
		6.	Coining

(A) P-1 Q-4 R-6 S-3
(B) P-4 Q-5 R-2 S-3
(C) P-1 Q-5 R-3 S-2
(D) P-5 Q-1 R-2 S-4

SOL 1.82 Option (B) is correct.

	Product		Process
P.	Molded luggage	**4.**	Transfer molding
Q.	Packaging containers for Liquid	**5.**	Blow molding
R.	Long structural shapes	**2.**	Hot rolling
S.	Collapsible tubes	**3.**	Impact extrusion

So, correct pairs are, P-4 Q-5 R-2 S-3

MCQ 1.83 Typical machining operations are to be performed on hard-to-machine materials by using the processes listed below. Choose the best set of Operation-Process combinations

GATE ME 2004 TWO MARK

	Operation		Process
P.	Deburring (internal surface)	**1.**	Plasma Arc Machining
Q.	Die sinking	**2.**	Abrasive Flow Machining
R.	Fine hole drilling in thin sheets	**3.**	Electric Discharge Machining
S.	Tool sharpening	**4.**	Ultrasonic Machining
		5.	Laser beam Machining

6. Electrochemical Grinding

(A) P-1 Q-5 R-3 S-4
(B) P-1 Q-4 R-1 S-2
(C) P-5 Q-1 R-2 S-6
(D) P-2 Q-3 R-5 S-6

SOL 1.83 Option (D) is correct.

	Operation		Process
P.	Deburring (internal surface)	**2.**	Abrasive Flow Machining
Q.	Die sinking	**3.**	Electric Discharge Machining
R.	Fine hole drilling in thin sheets	**5.**	Laser beam Machining
S.	Tool sharpening	**6.**	Electrochemical Grinding

So, Correct pairs are, P-2, Q-3, R-5, S-6

MCQ 1.84 From the lists given below choose the most appropriate set of heat treatment process and the corresponding process characteristics

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TWO MARK

	Process		Characteristics
P.	Tempering	**1.**	Austenite is converted into bainite
Q.	Austempering	**2.**	Austenite is converted into martensite
R.	Martempering	**3.**	Cementite is converted into globular structure
		4.	Both hardness and brittleness are reduced
		5.	Carbon is absorbed into the metal

(A) P-3 Q-1 R-5
(B) P-4 Q-3 R-2
(C) P-4 Q-1 R-2
(D) P-1 Q-5 R-4

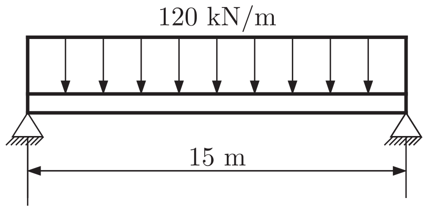
SOL 1.84 Option (C) is correct.

	Process		Characteristics
P.	Tempering	**4.**	Both hardness and brittleness are reduced
Q.	Austempering	**1.**	Austenite is converted into bainite
R.	Martempering	**2.**	Austenite is converted into martensite

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

Data for Q. 85 and 86 are given below. Solve the problems and choose correct answers.

A steel beam of breadth 120 mm and height 750 mm is loaded as shown in the figure. Assume $E_{steel} = 200$ GPa.



MCQ 1.85 The beam is subjected to a maximum bending moment of

GATE ME 2004 TWO MARK

(A) 3375 kN-m (B) 4750 kN-m

(C) 6750 kN-m (D) 8750 kN-m

SOL 1.85 Option (A) is correct.

Given : $b = 120\,\text{mm},\ h = 750\,\text{mm},\ E_{steel} = 200\,\text{GPa} = 200 \times 10^3\,\text{N/mm}^2$,

$W = 120\,\text{kN/m},\ L = 15\,\text{m}$

It is a uniformly distributed load.

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

$$B.M. = \frac{WL^2}{8}$$

Substitute the values, we get

$$B.M. = \frac{120 \times 15 \times 15}{8} = 3375\,\text{kN-m}$$

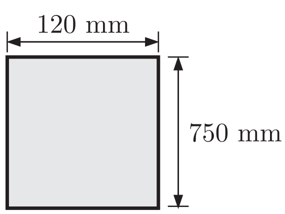
MCQ 1.86 The value of maximum deflection of the beam is

GATE ME 2004 TWO MARK

(A) 93.75 mm (B) 83.75 mm

(C) 73.75 mm (D) 63.75 mm

SOL 1.86 Option (A) is correct.



We know that maximum deflection at the centre of uniformly distributed load is given by,

$$\delta_{max} = \frac{5}{384} \times \frac{WL^4}{EI}$$

For rectangular cross-section,

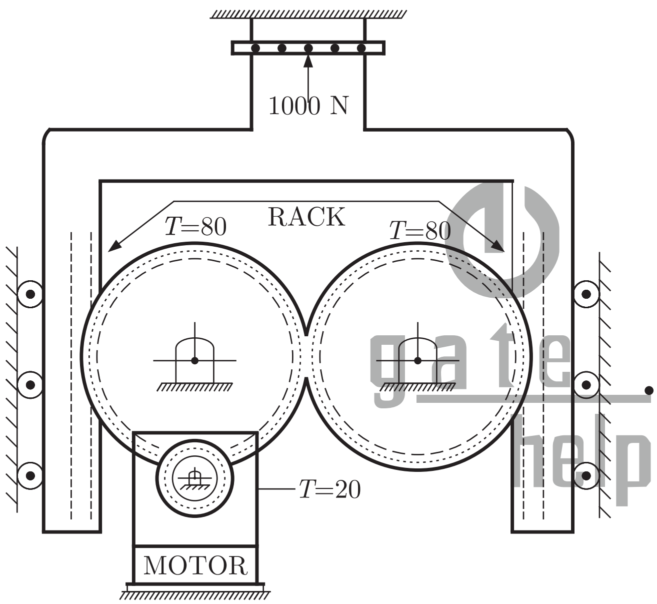
$$I = \frac{bh^3}{12} = \frac{(120) \times (750)^3}{12}$$

$$= 4.21875 \times 10^9\,\text{mm}^4 = 4.21875 \times 10^{-3}\,\text{m}^4$$

So, $$\delta_{max} = \frac{5}{384} \times \frac{120 \times 10^3 \times (15)^4}{200 \times 10^9 \times 4.21875 \times 10^{-3}}$$
$$= \frac{5}{384} \times 7200 \times 10^{-3} = 0.09375\,\text{m} = 93.75\,\text{mm}$$

Data for Q. 87 and 88 are given below. Solve the problems and choose correct answer.

A compacting machine shown in the figure below is used to create a desired thrust force by using a rack and pinion arrangement. The input gear is mounted on the motor shaft. The gears have involute teeth of 2 mm module.



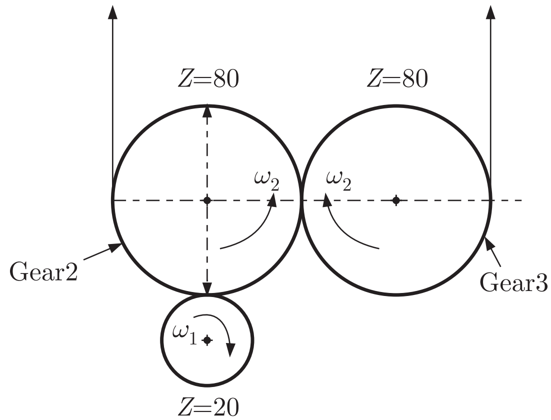
MCQ 1.87 If the drive efficiency is 80%, the torque required on the input shaft to create 1000 N output thrust is

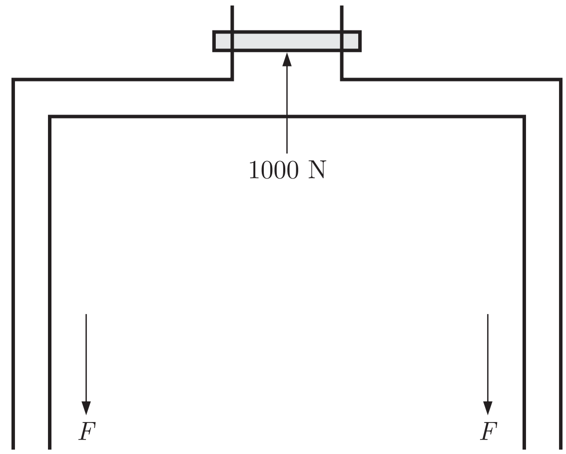
GATE ME 2004
TWO MARK

(A) 20 Nm (B) 25 Nm

(C) 32 Nm (D) 50 Nm

SOL 1.87 Option (B) is correct.





Let, Z is the number of teeth and motor rotates with an angular velocity ω_1 in clockwise direction & develops a torque T_1.
Due to the rotation of motor, the gear 2 rotates in anti-clockwise direction & gear 3 rotates in clock wise direction with the same angular speed.
Let, T_2 is the torque developed by gear.
Now, for two equal size big gears,

Module $$m = \frac{D}{Z} = \frac{\text{(Pitch circle diameter)}}{\text{(No.of teeths)}}$$

$$D = mZ = 2 \times 80 = 160 \text{ mm}$$

(Due to rotation of gear 2 & gear 3 an equal force (F) is generated in the downward direction because teeth are same for both the gears)
For equilibrium condition, we have

$$\text{Downward force} = \text{upward force}$$

$$F + F = 1000$$

$$F = 500 \text{ N}$$

And $$\eta = \frac{\text{Power Output}}{\text{Power Input}} = \frac{2 \times T_2\omega_2}{T_1\omega_1}$$

Output power is generated by the two gears

$$\eta = \frac{2 \times \left(F \times \frac{D}{2}\right)\omega_2}{T_1\omega_1} \quad \text{...(i)}$$

We know velocity ratio is given by

$$\frac{N_1}{N_2} = \frac{\omega_1}{\omega_2} = \frac{Z_2}{Z_1} \qquad \omega = \frac{2\pi N}{60}$$

From equation (i),

$$\eta = \frac{2 \times \left(F \times \frac{D}{2}\right)}{T_1} \times \frac{Z_1}{Z_2}$$

$$T_1 = \frac{F \times D}{\eta} \times \left(\frac{Z_1}{Z_2}\right)$$

$$= \frac{500 \times 0.160}{0.8} \times \frac{20}{80} = 25\ \text{N-m}$$

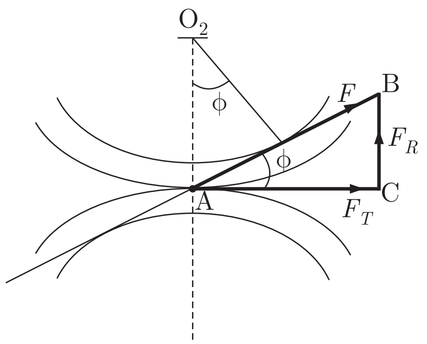
MCQ 1.88 If the pressure angle of the rack is 20°, then force acting along the line of action between the rack and the gear teeth is

GATE ME 2004 TWO MARK

(A) 250 N (B) 342 N

(C) 532 N (D) 600 N

SOL 1.88 Option (C) is correct.



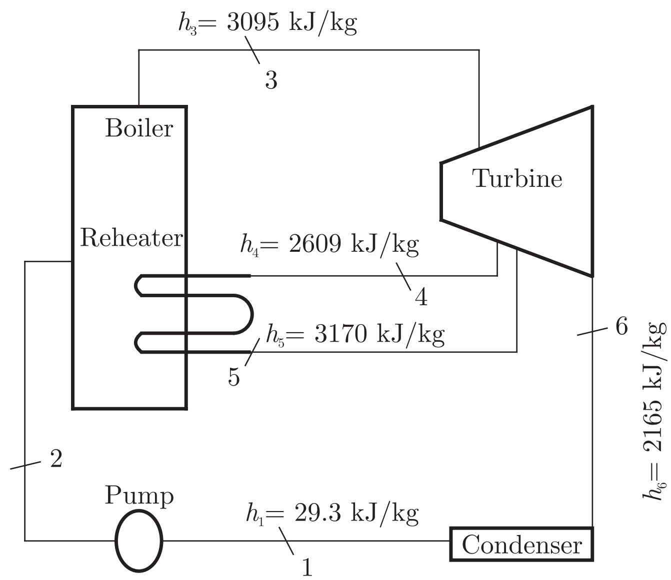
Given pressure angle $\phi = 20^\circ$, $F_T = 500\,\text{N}$ from previous question.
From the given figure we easily see that force action along the line of action is F.
From the triangle ABC,

$$\cos\phi = \frac{F_T}{F}$$

$$F = \frac{F_T}{\cos\phi} = \frac{500}{\cos 20^\circ} = 532\ \text{N}$$

Data for Q. 89 and 90 are given below. Solve the problem and choose correct answers.

Consider a steam power plant using a reheat cycle as shown . Steam leaves the boiler and enters the turbine at 4 MPa, 350° C ($h_3 = 3095\,\text{kJ/kg}$). After expansion in the turbine to $400\,\text{kPa}$ ($h_4 = 2609$ kJ/kg), and then expanded in a low pressure turbine to $10\,\text{kPa}$ ($h_6 = 2165$ kJ/kg). The specific volume of liquid handled by the pump can be assumed to be



MCQ 1.89 The thermal efficiency of the plant neglecting pump work is

GATE ME 2004 TWO MARK

(A) 15.8% (B) 41.1%

(C) 48.5% (D) 58.6%

SOL 1.89 Option (B) is correct.

Given : $h_1 = 29.3\,\text{kJ/kg}$, $h_3 = 3095\,\text{kJ/kg}$, $h_4 = 2609\,\text{kJ/kg}$, $h_5 = 3170\,\text{kJ/kg}$
$h_6 = 2165\,\text{kJ/kg}$

Heat supplied to the plant,

$$Q_S = (h_3 - h_1) + (h_5 - h_4) \qquad \text{At boiler \& reheater}$$
$$= (3095 - 29.3) + (3170 - 2609) = 3626.7\,\text{kJ}$$

Work output from the plant,

$$W_T = (h_3 - h_4) + (h_5 - h_6)$$
$$= (3095 - 2609) + (3170 - 2165) = 1491\,\text{kJ}$$

Now,
$$\eta_{thermal} = \frac{W_T - W_p}{Q_s} = \frac{W_T}{Q_s} \qquad \text{Given, } W_p = 0$$
$$= \frac{1491}{3626.7} = 0.411 = 41.1\%$$

MCQ 1.90 The enthalpy at the pump discharge (h_2) is

GATE ME 2004 TWO MARK

(A) 0.33 kJ/kg (B) 3.33 kJ/kg

(C) 4.0 kJ/k (D) 33.3 kJ/kg

SOL 1.90 Option (D) is correct.

From the figure, we have enthalpy at exit of the pump must be greater than at inlet of pump because the pump supplies energy to the fluid.

$$h_2 > h_1$$

So, from the given four options only one option is greater than h_1

$$h_2 = 33.3\,\text{kJ/kg}$$

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

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