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Memory Based Questions of

GATE 2020

Mechanical Engineering

Detailed Solutions

Date of Exam : 1/2/2020

Forenoon Session

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GENERAL APTITUDE

Q.1 8 + 88 + 888 + ... Sum of the series is

(a) $\frac{80}{81}\left(10^n-1\right)+\frac{8}{9}n$ (b) $\frac{80}{81}\left(10^n-1\right)-\frac{8}{9}n$

(c) $\frac{81}{80}\left(10^n-1\right)+\frac{8}{9}n$ (d) $\frac{81}{80}\left(10^n-1\right)-\frac{8}{9}n$

Ans. (b)

End of Solution

Q.2 Build : Building : : Grow : _____

(a) Grown (b) Growth

(c) Grow (d)

Ans. ()

Options are incomplete

End of Solution

Q.3 If *P* is coded as αα, *Q* as αβ then *R* and *S* in terms of α, β is coaded as?

(a) βα, ββ (b) αβ, ββ

(c) αα, βα (d) αα, ββ

Ans. (a)

End of Solution

Q.4 Jofra archer is a bowler. He is _____ then accurate

(a) more fast (b) less faster

(c) faster (d) fast

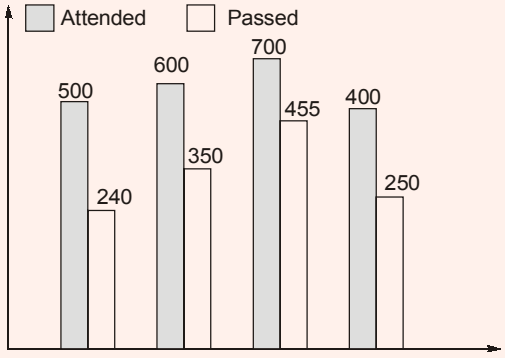
Ans. (a)

Jofra Archer is a bowler. He is more fast than accurate.

when different qualities of the same noun are compared, we use more + positive degree adjective,not comparative degree adjective. Hence use of 'faster' is incorrect here.

End of Solution

Q.5 A bar graph is shown in which number of students in 4 schools are given and also number of students passing in respective school is also given; then calculate average passing percentage of students.



Ans. (58.86)

$$\text{Average percentage of passing students} = \frac{\text{Total no. of passed students}}{\text{Total no. of students}}$$

$$= \frac{240+350+455+250}{500+600+700+400} \times 100$$

$$= \frac{1295}{2200} \times 100 = 58.86$$

End of Solution

Q.6 I do not think, you know that cause well enough to have opinion having said that I agree with your other point.
What does "having said that" means.

(a) Contrary to what I have said
(b) Despite what I have said
(c) As oppose to what I have said
(d) In addition to what I have said

Ans. (d)

End of Solution

Q.7 Fill in the blanks
He is known for his unscrupulary ways. He always _____ tears to decieve people.

(a) Fox
(b) Fox's
(c) Crocodile's
(d) Crocodile

Ans. (d)

End of Solution

MECHANICAL ENGINEERING

Q.1 For a bead of 1 mm diameter, initial temperature of 100°C and surrounding temperature of 20°C. After 4.35 seconds, temperature is 28°C. Calculate heat transfer coefficient, $\rho = 8500\ kg/m^3$.

Ans. **(299.95)**

$r = 0.5$ mm; $c_p = 400$ J/kgk; $\rho = 8500\ kg/m^3$; $t = 4.35$ sec

$$\because \quad \frac{V}{A} = \frac{\frac{4}{3}\pi R^3}{4\pi R^2} = \frac{R}{3}$$

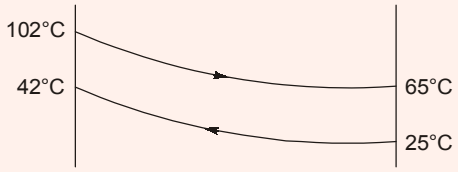
$$\because \quad \frac{T - T_\infty}{T_i - T_\infty} = e^{\frac{-hA}{rC_pV} \times \tau}$$

$$\Rightarrow \quad \frac{28 - 20}{100 - 20} = e^{-\left(\frac{h \cdot 3000}{0.5 \times 8500 \times 400}\right) \times 4.35}$$

$$\Rightarrow \quad h = 299.95\ W/m^2K$$

End of Solution

Q.2 LMTD of counter flow heat exchanger:



Oil enters in a concentric heat exchanger at 102°C and exit at 65°C and water enters at 25°C and exits at 42°C, What is the logarithmic mean temperature difference of heat exchanger.

Ans. **(49.33)**

$T_{hi} = 102°C, \quad T_{he} = 65°C$

$T_{c,i} = 25°C, \quad T_{ce} = 42°C$

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}; \qquad \Delta T_1 = 102° - 42° = 60°C; \Delta T_2 = 65° - 25°C = 40°C;$$

$$= \frac{60 - 40}{\ln\left(\frac{60}{40}\right)} = \frac{20}{0.4054} = 49.33°C$$

End of Solution

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Q.3 Match the following:

List-I	List-II
A. Prandlt number	1. $\frac{\text{Bouyancy force}}{\text{Viscous force}}$
B. Grashoff number	2. $\frac{\text{Momentum diffusivity}}{\text{Thermal diffusivity}}$
C. Reynold number	3. $\frac{\text{Inertia force}}{\text{Viscous force}}$
D. Nusselt number	4. $\frac{\text{Convective Heat Transfer}}{\text{Conductive Heat Transfer}}$

	A	B	C	D
(a)	2	1	3	4
(b)	1	2	3	4
(c)	4	3	2	1
(d)	3	1	2	4

Ans. (a)

End of Solution

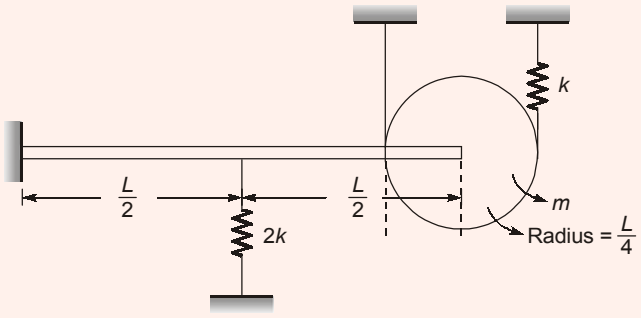
Q.4 Froude number is the ratio of

(a) Viscous force and inertia force
(b) Inertia force and buoyancy force
(c) Viscous force and buoyancy force
(d) Inertia force and gravity force

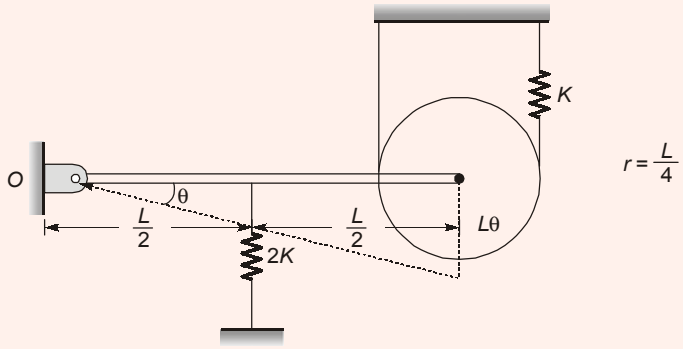
Ans. (d)

End of Solution

Q.5 System is a massless rod, hinged at one end and on the other end a disk of mass 'm' and radius $\left(\frac{L}{4}\right)$ is attached as shown in figure. Assuming no-slip condition. Find the natural frequency of the system.



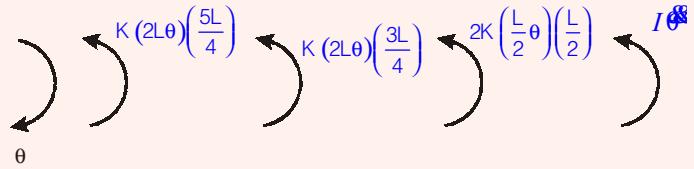
Ans. $\left(\frac{12}{\sqrt{33}}\sqrt{\frac{K}{m}}\right)$



MI about point *O*,

$$I = \frac{mr^2}{2} + mL^2$$

$$= \frac{m}{2}\frac{L^2}{16} + mL^2 = \frac{33mL^2}{32}$$



$$I\ddot{\theta} + K(2L\theta)\left(\frac{8L}{4}\right) + 2K\left(\frac{L}{2}\times\frac{L}{2}\right)\theta = 0$$

$$I\ddot{\theta} + 4KL^2\theta + \frac{KL^2}{2}\cdot\theta = 0$$

$$I\ddot{\theta} + \frac{9KL^2}{2}\cdot\theta = 0$$

$$\frac{33mL^2\ddot{\theta}}{32} + \frac{9KL^2}{2}\cdot\theta = 0$$

$$\frac{33m\ddot{\theta}}{16} + 9K\cdot\theta = 0$$

$$\ddot{\theta} + \frac{16\times 9K}{33\ m}\cdot\theta = 0$$

$$\omega_n^2 = \frac{16\times 9}{33}\frac{K}{m}$$

$$\Rightarrow \quad \omega_n = \frac{12}{\sqrt{33}}\sqrt{\frac{K}{m}}$$

End of Solution

Q.6 For given flat face follower motion given by
$y(0) = 4(2\pi\theta - \theta^2) \quad 0 \le \theta \le 2\pi$
If radius of curvature due to contact stresses should not be less than 40 mm then determine the minimum radius of base circle?

Ans. **(8.52)**

Flat face follower

Displacement equation:

$$y = 4\left(2\pi\theta - \theta^2\right)$$

$$\frac{dy}{d\theta} = V = 4(2\pi - 2\theta)$$

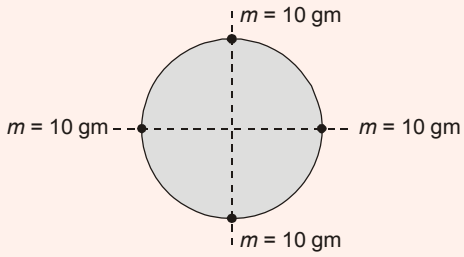
$$= 8(\pi - \theta) \qquad \text{(For } y \text{ to be max } \frac{dy}{d\theta} = 0 \Rightarrow \theta = \pi\text{)}$$

$$a = \frac{dv}{d\theta} = -8$$

$$(R_{curvature})_{Min} = R_{Base} + (y + a)_{min}$$
$$40 = R_{Base} + [4(2\pi\theta - \theta^2) - 8]_{Min}$$
$$40 = R_{Base} + [4\pi^2 - 8]$$
$$R_{Base} = 40 + [4\pi^2 - 8]$$
$$= 40 - 31.478$$
$$= 8.5215 \text{ mm}$$

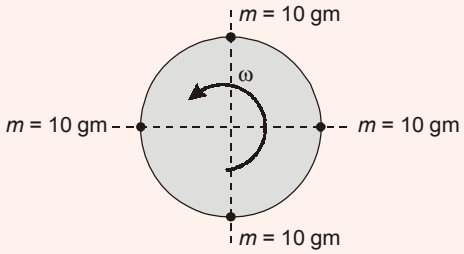
End of Solution

Q.7 If one mass is deattached. Find unbalanced force.



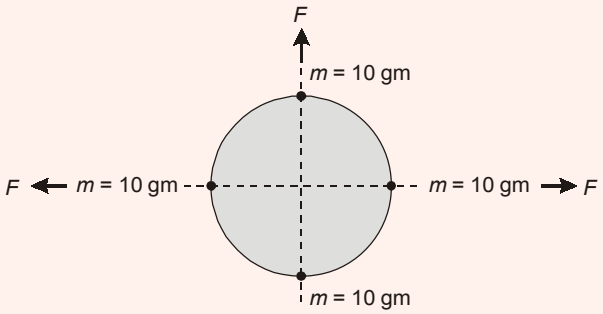
$\omega = 10$ rad/s
$r = 100$ mm

Ans. **(0.1)**



$\omega = 10$ rad/s, $r = 100$ mm $= 0.1$ m

If one mass is deattached then



Now, unbalance tone, $F = mr\omega^2$

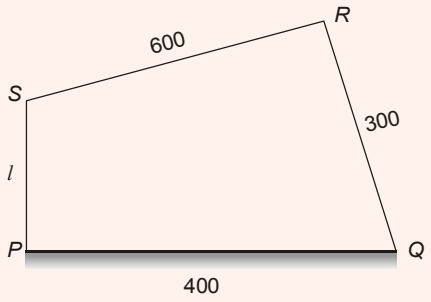
$$= \frac{10}{1000} \times 0.1 \times (10)^2$$

$$= \frac{10 \times 0.1 \times 100}{1000}$$

$= 0.1$ N Answer

End of Solution

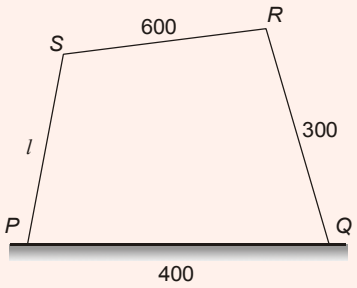
Q.8 What will be the value of l for crank-rocker mechanism?



(a) 350 (b) 80

(c) 200 (d) 300

Ans. (b)



For Crank-Rocker mechanism, shortest link must be crank and adjacent to fixed as well

as grashoffs law must be satisfied.

If $l = 80$ mm

then shortest will be $= 80$ mm

as well as $(80 + 600) < (400 + 300)$

$680 < 700$

There for law is satisfied.

$\Rightarrow$ $l = 80$ mm

End of Solution

Q.9 A simple arrangement of block of mass *'m'* attached with spring '*k*' and damper '*c*' is under the influence of force $F = F_0 \cos \omega t$. If $\omega \neq 0$ then the value of ω for which amplitude transmitted is F_0 is

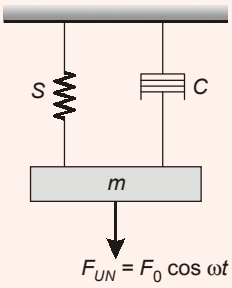
(a) $\omega = \sqrt{\frac{k}{m}}$

(b) $\omega = \sqrt{\frac{2k}{m}}$

(c) $\omega = \sqrt{\frac{k}{2m}}$

(d) $\omega = 2\sqrt{\frac{k}{m}}$

Ans. (b)



Given,

$$F_T = F_0$$

Then transmissibility

$$\epsilon = \frac{F_T}{F_0} = \frac{F_0}{F_0} = 1$$

$$\frac{\sqrt{1+\left(\frac{2\pi\omega}{\omega_n}\right)^2}}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2+\left(\frac{2\xi\omega}{\omega_n}\right)^2}} = 1$$

$$1+\left(\frac{2\xi\omega}{\omega_n}\right)^2 = \left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2+\left(\frac{2\xi\omega}{\omega_n}\right)^2$$

$$1-\left(\frac{\omega}{\omega_n}\right)^2 = \pm 1$$

Taking (–ve) sign

$$\Rightarrow \quad 1-\left(\frac{\omega}{\omega_n}\right)^2 = 2$$

$$\Rightarrow \quad \left(\frac{\omega}{\omega_n}\right)^2 = \sqrt{2}$$

$$\Rightarrow \quad \frac{\omega}{\omega_n} = \sqrt{2} = \sqrt{2}\omega_n = \sqrt{\frac{2k}{m}}$$

End of Solution

Q.10 If $\omega_1 = 100$ rad/s, $\omega_2 = 110$ rad/s is and $\Delta KE = 1.05$ kJ. The moment of inertia of flywheel in kg-m^2.

Ans. **(1)**

$$\Delta KE = \frac{1}{2} I\left(\omega_L^2 - \omega_1^2\right)$$

$$\therefore \quad 1.05 \times 10^3 \times 2 = I\left(110^2 - 100^2\right)$$

$$I = 1 \text{ kg.m}^2$$

Q.11 $z = x + iy$, $f(z) = x^2 - y^2 + i\psi\ (x, y)$, find the value of imaginary part of $f(z)$ at $z = 1 + i$

(a) (b)

(c) (d)

Ans. **(2)**

$$F(z) = x^2 + y^2 + \phi\ \psi\ (x, y)$$

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

$$d\psi = \frac{d\psi}{dx}dx + \frac{d\psi}{dy}dy$$

$$= \frac{-d\phi}{dy}dx + \frac{d\phi}{dx}dy$$

$$= -(-2y)dx + 2xdy$$

$$\psi = 2xy$$

At $Z = 1 + i = x + iy$

$x = 1,\ y = 1$

So, $\psi = 2 \times 1 \times 1 = 2$

End of Solution

Q.12 $\lim\limits_{x\to 1} \dfrac{1-e^{-C(1-x)}}{1-xe^{-C(1-x)}}$

(a) $\dfrac{2C}{1+C}$ (b) $\dfrac{1+C}{C}$

(c) $\dfrac{C}{1+C}$ (d) $\dfrac{1+C}{2C}$

Ans. **(c)**

By L Hospital rule,

$$= \lim_{x\to 1} \frac{1-e^{-C(1-x)}(-C(-1))}{1-e^{-C(1-x)}-xe^{-C(1-x)}\times(-C(0-1))}$$

$$= \lim_{x\to 1} \frac{-Ce^{-C(1-x)}}{-e^{-C(1-x)}-xCe^{-C(1-x)}}$$

$$= \frac{-C}{-1-1\times C\times 1} = \frac{-C}{-1-C} = \frac{C}{1+C}$$

End of Solution

Q.13 x and y are exponential distribution function of random variable. If, $z = x + y$ and mean of x and y are 0.5 each, variance of $z = 0$.
The co-relation between x and y is _____.

Ans. **(–1)**

$X \sim E(\lambda_1)$; $\quad$ mean $= \dfrac{1}{\lambda_1} = 0.5$

$\Rightarrow \quad \lambda_1 = 2$

Variance, $x = \dfrac{1}{\lambda_1^2} = \dfrac{1}{4} = 0.25$

$Y \sim E(\lambda_2)$; $\quad$ Mean $= \dfrac{1}{\lambda_2} = 0.5$

$\Rightarrow \quad \lambda_2 = 2$

Variance, $y = 0.25$

Given Var (Z) = Var$(x + y)$ + Var (y) + 2 COV (x, y)

$0 = 0.25 + 0.25 + 2$ COV (x, y)

$$\text{COV}(x, y) = -\frac{0.5}{2} = -0.25$$

Correlation, $\quad \rho = \dfrac{COV(x,y)}{\sigma_x\sigma_y} = \dfrac{-0.25}{\sqrt{(0.25)}\sqrt{(0.25)}} = -1$

End of Solution

Q.14 Solve the following integration by simpson's 1/3 rule,

$$I = \int_{-1}^{1.4} x|x|\,dx, \qquad h = 0.6$$

$$h = \frac{b-a}{n}, \qquad n = \frac{1.4+1}{0.6} = 4$$

	y_0	y_1	y_2	y_3	y_4
x	–1	–0.4	0.2	0.8	1.4
$f(x)$	–1	–0.16	0.04	0.64	1.92

Ans. **(0.584)**

By simpson's 1/3 rules,

$$I = \frac{h}{3}\left[(y_o + y_4) + 4(y_1 + y_3) + 2(y_2)\right]$$

$$= \frac{0.6}{3}\left[(-1+1.92) + 4(-0.16+0.64) + 2(0.04)\right]$$

$$I = 0.2\ [0.92 + 1.92 + 0.08] = 0.584$$

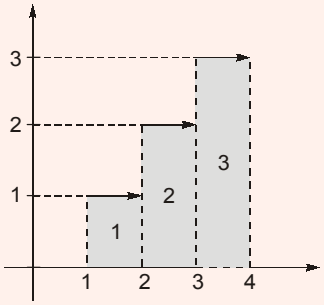
End of Solution

Q.15 Find the area under the curve, $y = [x]$, $x \in [1, 4]$

(a) 4 (b) 1

(c) 3 (d) 6

Ans. **(d)**



Area = 1 × 1 + 1 × 2 + 1 × 3

= 1 + 2 + 3 = 6

End of Solution

Q.16 Laplace inverse of $F(s)=\dfrac{1}{\left(s^2+\omega^2\right)}$

(a) $\dfrac{1}{\omega^2}(1-\omega\sin\omega t)$

(b) $\dfrac{1}{\omega^2}(1-\sin\omega t)$

(c) $\dfrac{1}{\omega}\cos\omega t$

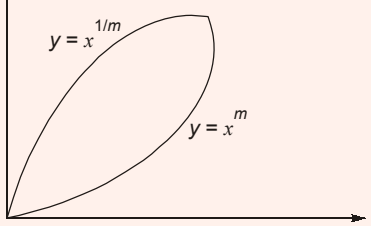
(d) $\dfrac{1}{\omega}\sin\omega t$

Ans. (d)

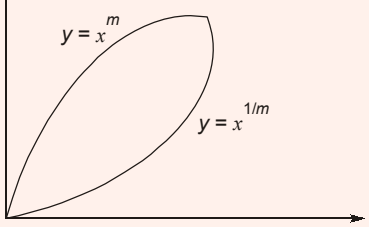
End of Solution

Q.17 For $0 \le x \le 1$ and $n > 1$. graph of $y = x^{1/m}$ and $y = x^m$ will be

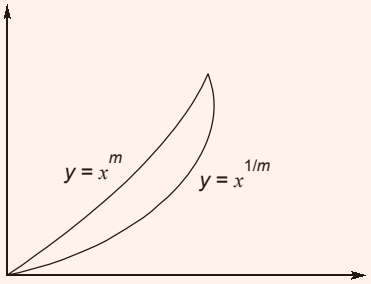
(a)



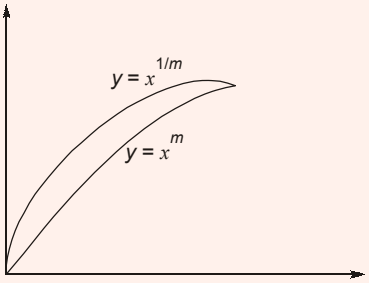
(b)



(c)



(d)



Ans. (a)

End of Solution

Q.18 A vector, $F=\dfrac{x}{\left(x^2+y^2+z^2\right)^{3/2}}i+\dfrac{y}{\left(x^2+y^2+z^2\right)^{3/2}}j+\dfrac{z}{\left(x^2+y^2+z^2\right)^{3/2}}k$. $\iint\vec{F}\cdot ds$ is obtained over hollow sphere of raddi 2 m and 1 m. What is the ratio of inner radi to outer raddi.

(a) 2π

(b) 4π

(c) 3π

(d) 0

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Morning :

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EE : 18th Feb, 2020
EC : 6th Apr, 2020

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ME : 9th Feb, 2020
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EC : 22nd Feb, 2020

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Kolkata : 25-01-2020
Jaipur : 16-02-2020

Ans. (d)

$$\vec{F} = \frac{\vec{r}}{r^3}$$

$$\nabla \cdot \vec{F} = \nabla \cdot \frac{\vec{r}}{r^3} = 0$$

$$\iint_{S_1} \vec{F} \cdot \hat{N} dS = 4$$

By div theorem,

$$\iint_{S_1} \vec{F} \cdot \hat{N} dS = \iiint_R (\nabla \cdot \vec{F}) dx\, dy\, dz = 0$$

End of Solution

Q.19 Which of the following is not analytic function?

(a) e^z (b) $\sin z$

(c) $\log z$ (d) z^2

Ans. (c)

End of Solution

Q.20 It two real valued square matrices of same order are multiplied, then product will be?

(a) associative (b) commutative

(c) can't be evaluated (d) will be a positive matrix

Ans. (a)

End of Solution

Q.21 What is crystalline structure of γ-iron?

(a) BCC (b) HCP

(c) HCT (d) FCC

Ans. (d)

α - iron - BCC → α - Ferrite

γ - iron - FCC → Austenite

δ - iron - BCC → δ - Ferrite

End of Solution

Q.22 Match the following:

Effects	Heat treatment
A. Hardening	1. Tempering
B. Softening	2. Quenching
C. Toughing	3. Annealing
D. Strengthening	4. Normalising

	A	B	C	D
(a)	2	1	3	4
(b)	2	3	1	4
(c)	4	1	3	2
(d)	2	4	1	3

Ans. **(b)**

1 - C decrease hardness and increase ductility and toughness.
2 - A increases in wear resistance strength and hardness.
3 - B remove or relieve strains or stresses induced by cold working.
4 - D improved mechanical properties (tensile strength, ductility).

End of Solution

Q.23 In a rolling operation, thickness of strip is reduced to 15 mm from initial thickness of 20 mm. If width is 120 mm and roller radius is 450 mm. Calculate the Roll seperating force if strength of strip is 210 MPa and σ_0 = Strength $\times \frac{(\epsilon_T)^n}{n+1}$. Where, n = Strain hardening coefficient = 0.25.

Ans. **(700.356)**

Given: h_o = 20 mm, h_f = 15 mm, $\epsilon_T = \ln\frac{h_f}{h_o} = \ln\left(\frac{15}{20}\right) = -0.287682 \approx -0.2877$

$$\bar{\sigma}_o = \frac{k \times \epsilon_T^n}{1+n} = \frac{210 \times 0.2877^{0.25}}{1+0.25} = 123.04\ \text{MPa}$$

$$F = \bar{\sigma}_o \sqrt{R\Delta h} \times b = 123.04 \times \sqrt{450 \times (20-15)} \times 120\ \text{N}$$

$$= 700355.96\ \text{N}$$

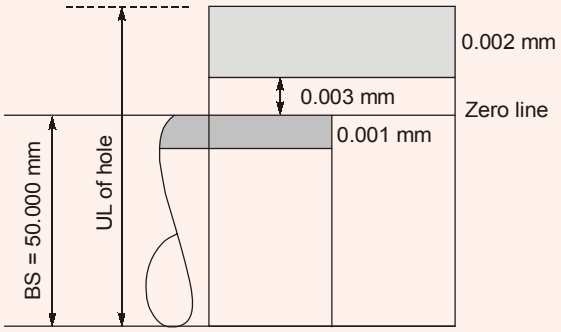
$$\approx 700.356\ \text{kN}$$

End of Solution

Q.24 For basic size of 50 mm, hole tolerance of 0.002 mm, allowance of 0.003 mm and shaft tolerance of 0.001 mm. Determine the maximum hole size according to shaft basis system.

Ans. (50.005)

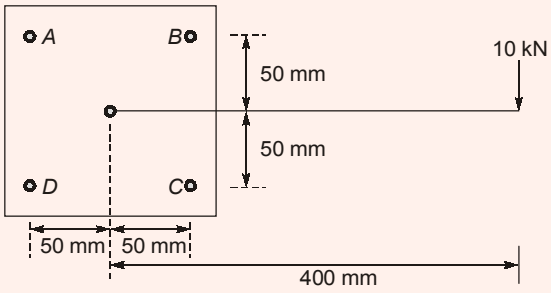
Using diagram method



UL of hole = BS + 0.003 + 0.002 mm
= 50.005 mm

End of Solution

Q.25 What is the resultant shear load in B?



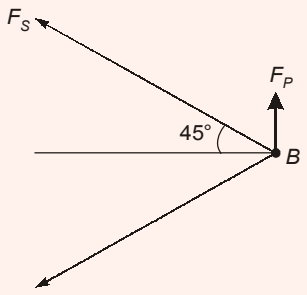
Ans. (16)

Primary shear force, $F_P = \frac{10}{4} = 2.5$ kN

Secondary shear force F_s

$$\frac{F_s}{50\sqrt{2}}\left[\left(50\sqrt{2}\right)^2 + \left(50\sqrt{2}\right)^2\right] = 10 \times 400$$

$$F_s \times 50\sqrt{2} \times 4 = 10 \times 400$$



Resultant force on B

$$F_B = (2.5 + 14.142 \sin 45) + (14.142 \cos 45)^2$$
$$= 16.0 \text{ kN}$$

End of Solution

Q.26 A disc-plate type clutch having outer radius 250 mm and inner radius 50 mm. The torque transmitted by new clutch is equal to torque transmitted by the old clutch, then find the ratio of force of new clutch to old clutch? [μ same in both cases] $\frac{F_{new}}{F_{old}} = ?$

Ans. (0.871)

$$T = \mu W \times R_m$$
$$T_{new} = \mu \times W \times R_{new}$$
$$T_{new} = \mu \times W_{new} \times \frac{2}{3}\frac{(R_0^3 - R_i^3)}{R_0^2 - R_i^2}$$
$$T_{old} = \mu \times W \times R_{old}$$
$$T_{new} = T_{old}$$
$$W_{new} \times \frac{2}{5}\frac{(R_0^3 - R_i^3)}{R_0^2 - R_i^2} = W_{old} \times \frac{(R_0 + R_i)}{2}$$
$$\frac{W_{new}}{W_{old}} = 0.871$$

End of Solution

Q.27 Two helical gears of helix angle 30° and pressure angle 20° is at middle of which is supported by bearing at both ends shaft is subjected to

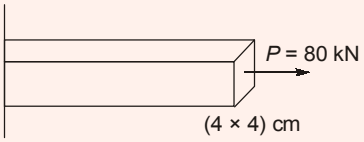
(a) Bending stress in two plane, torsional stress
(b) Bending stress in two plane, axial stress and torsional stress
(c) Torsional stress and axial stress
(d) Axial and bending stresses

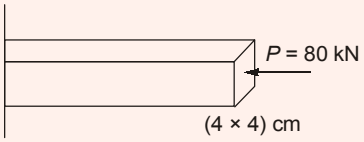
Ans. (a)

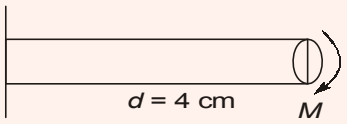
End of Solution

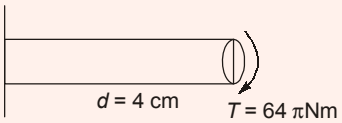
Q.28 Which of the above component will fail according to maximum shear stress theory?

Given permissible shear stress = 20 MPa.

1.


2.


3. 

4. 

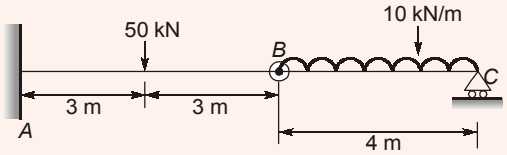
(a) 1 and 2
(b) 1 only
(c) 2 and 3
(d) 1 and 4

Ans. ()

Question incomplete

End of Solution

Q.29 A beam as shown below having hinge at B. What is the reaction at C.



(a) 20 kN
(b) 40 kN
(c) 30 kN
(d) 50 kN

Ans. (a)

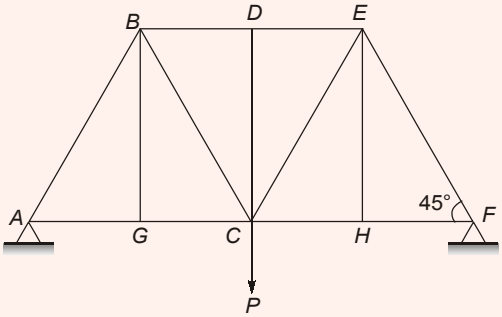
In BC, $\Sigma M_B = 0$

$R_C \times 4 = 10 \times 4 \times 2$

$R_C = 20$ kN

End of Solution

Q.30 Which member is subjected to zero force?



(a) BG, EH, CD, BE, DE
(b) BG, EH, CD, AB, EF
(c) BG and EH only
(d) BG, EH and CD

Ans. (d)

End of Solution

Q.31 A ball of 250 BHN is used to shear a sheet metal. The clearance of die and punch is 1 mm. If hardness is increased to 400 BHN then what is the clearance?

(a) 1.25 mm
(b) 1.5 mm
(c) 1 mm
(d) 0.75 mm

Ans. **(a)**

Tensile strength $\propto$ BHN

[Formula available in my PPT slide NO. 7, hardness test material science]

$\therefore$ Shear strength $\propto$ BHN

and $$C = 0.0032t\sqrt{\tau}$$

$$C \propto \sqrt{\text{Shear strength}} \propto \sqrt{BHN}$$

$$\frac{C_2}{C_1} = \sqrt{\frac{(BHN)_2}{(BHN)_1}}$$

or $$C_2 = C_1 \times \sqrt{\frac{(BHN)_2}{(BHN)_1}} = 1 \times \sqrt{\frac{400}{250}} = 1.265 \text{ mm}$$

End of Solution

Q.32 In rolling process, initial thickness 40 mm and final thickness is 20 mm. If roller diameter is 200 mm. Find coefficient of friction and projected length.

Ans. **(0.4472)**

$h_0 = 40$ mm, $h_f = 20$ mm, $\Delta h = 40 - 20 = 20$ mm, $D = 200$ mm, $R = 100$ mm

Projected length, $$L = \sqrt{R\Delta h} = \sqrt{100 \times 20} = \sqrt{2000} = 44.7213 \text{ mm}$$

$$\Delta h = \mu^2 R$$

$\therefore$ $$20 = \mu^2 \cdot 100$$

$\therefore$ $$0.2 = \mu^2$$

$$\mu = 0.4472$$

End of Solution

Q.33 In a rankine cycle, workdone by turbine is 903 kJ/kg and workdone of pump is 3 kJ/kg. Specific steam consumption in kg/kW-hr is _____?

Ans. **(4)**

$(WD)_{\text{turbine}} = 903$ kJ/kg

$(WD)_{\text{pump}} = 3$ kJ/kg

Specific steam consumption = ? (kg/kW-hr)

$$\text{SSC} = \frac{3600}{W_T - W_C}$$

$$= \frac{3600}{903 - 3} = 4 \text{ kg/kW-hr}$$

End of Solution

Q.34 Overall pressure ratio of 2 stage adiabatic compressor is 6. At the inlet of first compressor, temperature is 300 K and pressure is 100 kPa. Determine the intermediate pressure.

(a) 244.94 kPa (b) 300 kPa
(c) 250 kPa (d) 344.5 kPa

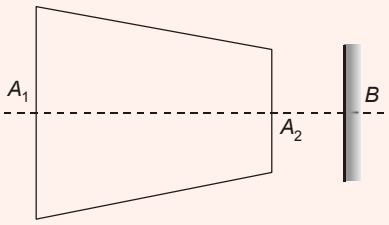
Ans. (a)

$$\frac{P_3}{P_1} = 6 \qquad \Rightarrow P_3 = 600 \text{ kPa}$$

$$\text{Intermediate pressure} = \sqrt{P_3 P_1} = \sqrt{600 \times 100} = 244.94 \text{ kPa}$$

End of Solution

Q.35 Air is passing through a nozzle of inlet and exit area of 0.1 m^2 and 0.02 m^2 respectively. Inlet pressure of air is 0.36 MPa (gauge). If after pasing through nozzle, air is striking a vertical wall as shown. Determine the gauge pressure at *B*. (Assumeing density to be constant).



Ans. (0.375)

On applying continuity equation,

$$\dot{m} = \rho_1 \cdot A_1 \cdot v_1 = \rho_2 \cdot A_2 \cdot v_2$$

$$\Rightarrow \quad 0.1 V_1 = 0.02 V_2$$

$$\Rightarrow \quad V_2 = \frac{10}{2} V_1 = 5 V_1$$

Now on applying Bernoulli between 1 and 2 section

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g}^{0} + \frac{V_2^2}{2g} + z_2$$

$$\Rightarrow \quad \frac{0.36 \times 10^3}{1.21 \times 9.81} + \frac{V_1^2}{2g} = \frac{25 V_1^2}{2g}$$

$$\Rightarrow \quad V_1 = 4.98 \text{ m/s}$$

$$\Rightarrow \quad V_2 = 24.89 \text{ m/s}$$

On applying Bernoulli between 2 and 3 sections

$$\frac{P_2}{\rho g}^{0} + \frac{V_2^2}{2g} + z_2 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g}^{0} + z_3$$

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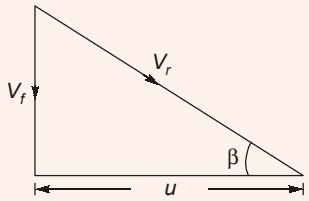
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$$P_3 = \frac{\rho g \cdot V_2^2}{2g} = \frac{1.21 \times (24.89)^2}{2} = 375\ \text{Pa}$$
$$= 0.375\ \text{kPa (gauge)}$$

End of Solution

Q.36 In a axial turbine, diameter of tip is 4 m and diameter of hub is 2 m. If discharge is 100 m^3/s and speed of turbine is 300 rpm find the blade outlet angle of turbine.
D_{hub} = 2 m, D_{tip} = 4 m, N = 300 rpm, D_{mean} = 3 m, Q = 100 m^3/s



(a) 12.67°C
(b) 12.33°C
(c) 11.67°C
(d) 11.33°C

Ans. **(a)**

$$Q = \frac{\pi}{4}(D_{tip}^2 - D_{hub}^2) \cdot v_f$$

$$\Rightarrow \quad 100 = \frac{\pi}{4}(4^2 - 2^2) \times v_f = 10.61\,\text{m/s}$$

$$V = \frac{\pi DN}{60} = \frac{p \times 3 \times 300}{600} = 47.21$$

$$\tan\beta = \frac{V_f}{u}$$

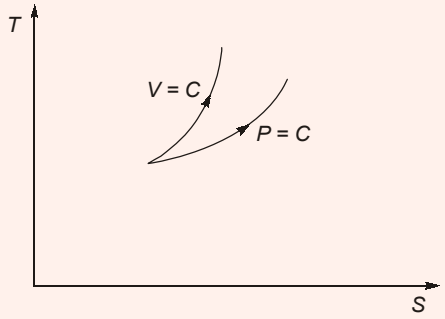
$$\Rightarrow \quad \beta = \tan^{-1}\left(\frac{10.61}{47.21}\right) = 12.67$$

End of Solution

Q.37 In T-s diagram, constant volume curve and constant pressure curve intersect at point, find ratio of the slope of constant pressure to constant volume?

(a) $\frac{C_p}{C_v}$
(b) $\frac{C_p}{C_p + C_v}$
(c) $\frac{C_v}{C_p}$
(d) None of these

Ans. (c)



If $V = C$

$$Tds = du + pdv$$

$$Tds = du$$

$$du = WdT \qquad [\because V = C]$$

$$\left(\frac{dT}{ds}\right)_V = \frac{T}{C_v}$$

If $P = C$

$$Tds = dh - Vdp$$

$$dh = C_P dT \qquad [\because P = C]$$

$$Tds = C_P dT$$

$$\left(\frac{dT}{ds}\right)_P = \frac{T}{C_P}$$

Ratio, $$\frac{(dT/ds)_P}{(dT/ds)_V} = \frac{(T/C_P)_P}{(T/C_V)_V} = \frac{C_V}{C_P}$$

End of Solution

Q.38 Value of Joule Thomson coefficient for ideal gas is _____

(a) positive (b) zero

(c) negative (d) indeterminate

Ans. (0)

Value of joule thompson coefficient for ideal gas,

$$\mu = \left(\frac{\partial T}{\partial P}\right)_h = 0$$

End of Solution

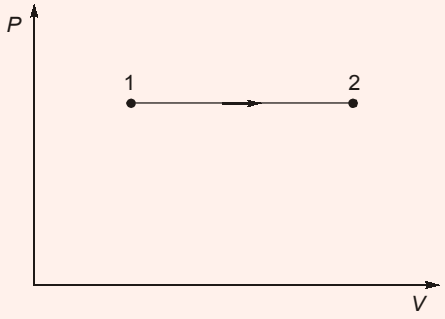
Q.39 1 kg of ideal gas at temperature 127°C is expanded at constant pressure when till its volume is doubled. For ideal gas, $R = 0.287$ kJ/kgK. Find work transfer is process in kJ?

(a) 110 (b) 120.5

(c) 114.8 (d) 115.3

Ans. **(c)**

$m = 1$ kg, $T_1 = 127°C = 400$ k; $P = C$, $V_2 = 2V_1$; $R = 0.287$ kJ/kgK



$$W = P_1(V_2 - V_1)$$

$$= P_1(2V_1 - V_1) = P_1V_1 = mRT_1$$

$$= 114.8 \text{ kJ}$$

End of Solution

Q.40 What is the brake power of Otto cycle 10 kW heat is added, given $r_c = 8$, $n_m = 80\%$?

(a) 5.64 kW (b) 4.52 kW

(c) 6.32 kW (d) 3.64 kW

Ans. **(b)**

$$\frac{W}{Q_1} = 0.5647$$

$$W = 10 \times 5647 = 5.647 \text{ kW}$$

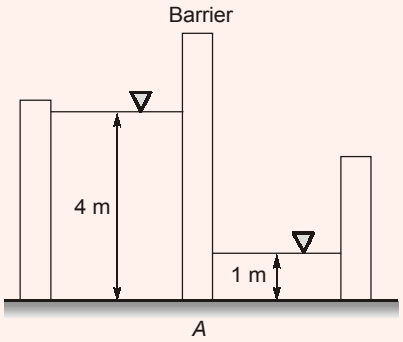
$$\eta = 1 - \frac{1}{r_c^{\gamma-1}} = 1 - \frac{1}{8^{0.4}} = 0.5647$$

$$\text{BP} = \eta_m \times W = 0.8 \times 5.617$$

$$= 4.5175 \text{ kW}$$

End of Solution

Q.41 In a tank barrier which act as a cantilever separates water as shown.



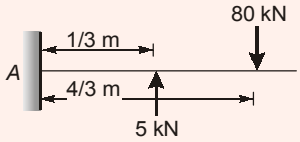
ρ = 1000 kg/m^3, g = 10 m/s^2

What is the net bending moment in barrier. Take unit width.

(a) 90 kN-m (b) 80 kN-m

(c) 100 kN-m (d) 50 kN-m

Ans. (c)



$$F_1 = \rho g A \cdot \bar{x}_1$$
$$= 1000 \times 10 \times (1 \times 4) \times 2 = 80 \text{ kN}$$
$$F_2 = \rho g A \cdot \bar{x}_2$$
$$= 1000 \times 10 \times (1 \times 1) \times 0.5 = 5 \text{ kN}$$
$$CP_1 = 4 \times \frac{1}{3} = \frac{4}{3} \text{ m}$$
$$CP_2 = 1 \times \frac{1}{3} = \frac{1}{3} \text{ m}$$

So, $$M_A = 80 \times \frac{4}{3} - 5 \times \frac{4}{3}$$
$$= 100 \text{ kN-m}$$

End of Solution

Q.42 Which of the following is correct for cost slope in crashing?

(a) $\text{Cost slope} = \dfrac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$

(b) $\text{Cost slope} = \dfrac{\text{Crash cost}}{\text{Normal time} - \text{Crash time}}$

(c) $\text{Cost slope} = \dfrac{\text{Normal cost}}{\text{Normal time} - \text{Crash time}}$

(d) $\text{Cost slope} = \dfrac{\text{Crash cost} - \text{Normal cost}}{\text{Crash time}}$

Ans. (a)

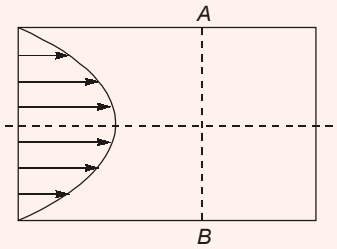
End of Solution

Q.43 Production rate is 4 pieces/hr and operation time is 60 min. If operation time is decresed by 30%, then keeping prduction rate constant, work in process will be
(a) increase by 30% (b)
(c) (d)

Ans. ()
Options are incomplete

End of Solution

Q.44 Velocity distribution in pipe is given as $V = -C\left[r^2 - \frac{D^2}{4}\right]$. The rate of kinetic energy at section AB is proportional to D^n. What is the value of n.



Ans. (8)

$$v = -C\left[r^2 - \frac{D^2}{4}\right] = -C\left[r^2 - R^2\right]$$

$$v = C\left[R^2 - r^2\right] = CR^2\left[1 - \frac{r^2}{R^2}\right]$$

$$\left(\overset{0}{KE}\right) = \frac{1}{2}\int_0^R \rho v^3 dA$$

$$= \rho\int_0^R C^3R^6\left[1 - \frac{r^2}{R^2}\right]^3 \cdot 2\pi r \cdot dr$$

$$= \rho C^3R^6 2\pi\int_0^R\left[1 - \frac{r^2}{R^2}\right]^3 \cdot r \cdot dr$$

$$= \rho C^3R^6 2\pi\int_0^R\left[1 - \frac{r^6}{R^6} - \frac{3r^2}{R^2}\left[1 - \frac{r^2}{R^2}\right]\right]\cdot r \cdot dr$$

$$= \rho C^3R^6 2\pi\int_0^R\left[1 - \frac{r^6}{R^6} - \frac{3r^2}{R^2} - \frac{3r^4}{R^4}\right]\cdot r \cdot dr$$

$$= \rho C^3 2\pi R^6 \left[\frac{R^2}{2} - \frac{R^2}{8} - \frac{3R^2}{4} + \frac{R^2}{2}\right]$$

$$= \rho C^3 2\pi R^6 \left[R^2 - \frac{R^2}{8} - \frac{3R^2}{4}\right]$$

$$= \rho C^3 2\pi R^6 \left[\frac{R^2}{8}\right]$$

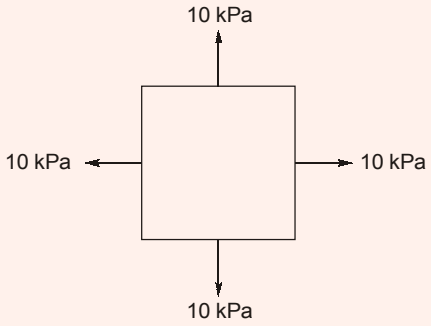
$$= \frac{\rho C^3 2\pi}{8} R^8$$

$$= \frac{\rho C^3 2\pi}{8 \times (2)^8} \times D^8$$

n = 8 Answer

End of Solution

Q.45 Mohr circle is represented by

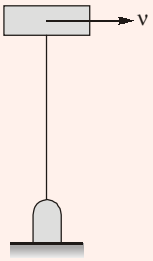


(a) A point 10 cm away from origin on σ axis
(b) A point 10 cm away from origin on τ axis
(c) A circle with origin as center and 10 cm radius
(d) A circle with 10 cm radius and at 10 cm from origin in σ axis

Ans. (a)

End of Solution

Q.46 Initially rod is unstretched, and velocity is given 1.5 m/s. What is the value of velocity (m/s) when rod is stretched by 0.4 m?



m = 2 kg, Stiffness = 5 N/m

(a) 1.26 (b) 1.06
(c) 0.26 (d) 1.36

Ans. **(d)**

Energy conservation,

$$\frac{1}{2}mV_1^2 = \frac{1}{2}mV_0^2 + \frac{1}{2}kx^2$$

$$\Rightarrow \quad 2 \times 1.5^2 = 2 \times V_0^2 + 5 \times 0.4^2$$

$$V_0 = 1.360 \text{ m/s}$$

End of Solution

Q.47 A 25 mm × 25 mm slot is milled having length of 300 mm using face and end mill cutter width 25 mm, diameter 100 mm and 20 teeth cutting speed is given as 35 m/min, feed per tooth is 0.1, approach and over travel are 5 mm, what is the machining time of slot?

Ans. **(96.94)**

$$V = \pi DN$$

or $$35 = \pi \times 0.100 \times N \quad \Rightarrow N = 111.408 \text{ rpm}$$

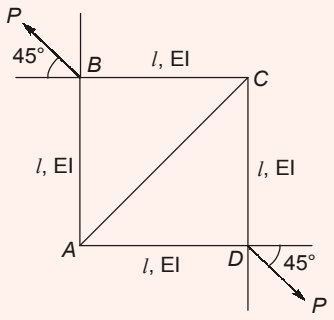
$$t = \frac{L + A + O + \frac{D}{2}}{fZN} = \frac{300 + 5 + 5 + \frac{100}{2}}{0.1 \times 20 \times 111.408} \text{ min}$$

$$= 1.615 \text{ min}$$

$$= 96.94 \text{ sec}$$

End of Solution

Q.48 A square frame *ABCD* with only 1 diagonal member *AC* which is 4 times more elastically stiff than 4 side members. Which member will buckle?



Ans. **()**

Data is incomplete

End of Solution

■■■■