ACE
Engineering Academy

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ESE- 2018 (Prelims) - Offline Test Series Test - 15

MECHANICAL ENGINEERING

SUBJECT: ENGINEERING MECHANICS & STRENGTH OF MATERIALS + MECHANISMS AND MACHINES + DESIGN OF MACHINE ELEMENTS – SOLUTIONS

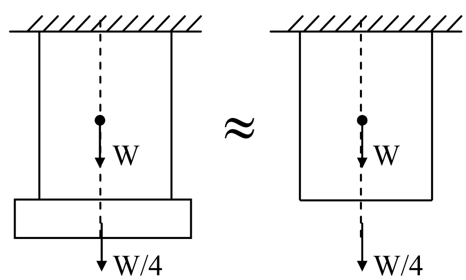
01. Ans: (a)

Sol: $\phi_{xz} = \dfrac{\partial u}{\partial z} + \dfrac{\partial w}{\partial x}$

$= (-10 + 20) \times 10^{-6} = 10\times10^{-6}$ units

02. Ans: (b)

Sol:



Strain energy stored in bar due to load = $\dfrac{W}{4}$

$$= \frac{\left(\frac{W}{4}\right)^2 L}{2AE} = \frac{W^2 L}{32\,AE}$$

Strain energy stored in bar due to it's self weight,

$$W = \frac{\gamma^2 AL^3}{6E}$$

$$= \frac{(\gamma AL)^2 L}{6AE} = \frac{W^2 L}{6AE}$$

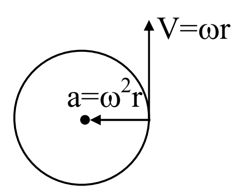
$$\text{Total S.E} = \frac{W^2 L}{32AE} + \frac{W^2 L}{6AE}$$

03. Ans: (a)

Sol: As inertia force $mr\omega^2\left(\cos\theta + \dfrac{\cos 2\theta}{n}\right)$ is continuously changing in magnitude, it is not possible to balance it completely, so it is partially balanced by counter mass which also rotate along with crank.

04. Ans: (b)

Sol:

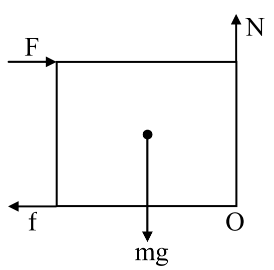


The body is moving with constant angular speed as shown in figure above.

- The velocity vector is tangent to the circle
- The tangential acceleration is zero in uniform circular motion.
- There is a centripetal acceleration of magnitude = $\omega^2 r$, which act towards centre.
- The velocity and acceleration vectors are perpendicular to each other

05. Ans: (c)

Sol: The F.B.D of cubical block at the verge of toppling is shown in figure below:



Taking moment about O

$$F \times L = mg \times \frac{L}{2}$$

$$F = \frac{mg}{2}$$

06. Ans: (c)

Sol: In cycloidal gear tooth, interference does not occurs at any instant. Pressure angle is same in involute gear. In cycloidal gear pressure angle depends on the center distance of gear and pinion. These gears are used in small scale power systems like spring driven watches and clocks.

07. Ans: (c)

Sol: $d_1 = mz_1$, $\quad \frac{z_1}{z_2} = 4.5$

$d_2 = mz_2$,

$\Rightarrow z_1 = 4.5z_2$

Centre distance $= \frac{d_1 + d_2}{2} = \frac{m}{2}(z_2 + 4.5z_2)$

$\Rightarrow 495 = \frac{6}{2}(0.5z_2)$

$\Rightarrow z_2 = 30$

$\Rightarrow z_1 = 4.5 \times 30 = 135$

$\Rightarrow z_1 + z_2 = 135 + 30 = 165$

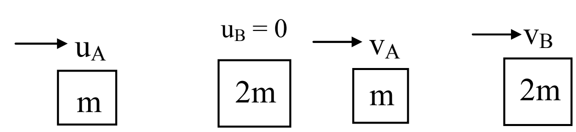
08. Ans: (b)

Sol: Friction radius, $r_f = \frac{R_1 + R_2}{2}$

$$= \frac{50 + 100}{2} = 75\,\text{mm}$$

09. Ans: (c)

Sol:



Initial position of object A and B   *Final position of object A and B*

$u_A = 9$ m/sec, $u_B = 0$

By using linear momentum conservation

$m \times 9 = m\,v_A + 2m \times v_B$

$\Rightarrow 2\,v_B + v_A = 9$ --- (1)

Coefficient of restitution = 1

(∵ elastic collision)

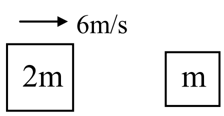
$$\frac{v_B - v_A}{u_A} = 1$$

$\Rightarrow v_B - v_A = 9$ ---- (2)

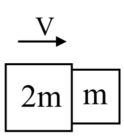
From (1) and (2)

$V_B = 6$m/sec

- When Object A collides with Object B, Object B starts moving with velocity of 6m/s as shown in figure below:



In inelastic collision (of block B and C) both masses stick together and starts moving with velocity V as shown in figure below:



By using linear momentum conservation

$2m\times6 = 3mV$

$V = 4$m/s

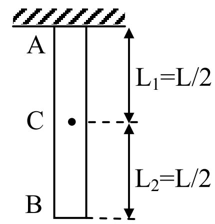
10. Ans: (b)

Sol:

- As there is no external force acting on the block, the momentum must be conserved.
- Some energy is used to break the block , thus the total kinetic energy must change.

11. Ans: (b)

Sol:



Downward displacement of point C,

$$\delta_{upper} = (\delta_{AC})_{\text{Due to its own weight}} + (\delta_{AC})_{\text{Due to external weight of BC}}$$

$$= \frac{W_1L_1}{2A_1E} + \frac{W_2L_1}{A_1E}$$

$$= \frac{(W/2)(L/2)}{2AE} + \frac{(W/2)(L/2)}{AE}$$

$$= \frac{WL}{8AE} + \frac{WL}{4AE}$$

$$= \frac{3WL}{8AE}$$

Elongation of the lower half of the bar is

$$\delta_{lower} = \frac{WL}{2AE} - \frac{3WL}{8AE} = \frac{WL}{8AE}$$

$$\therefore \frac{\delta_{upper}}{\delta_{lower}} = 3$$

12. Ans: (b)

Sol:

(i) $kx_0 = mg$

$$\therefore x_o = \frac{mg}{k} = \frac{1\times10}{500} = 0.02 \text{ m} = 2 \text{ cm}$$

So equilibrium is obtained after in extension of 2 cm of at a length of 42 cm. But it is released from a length of 45 cm

$A = 3$ cm $= 0.03$ m

(ii) $V_{max} = \omega A = \sqrt{\frac{k}{m}} A$

$= \left(\sqrt{\frac{500}{1}}\right)(0.03)$

$= 0.3\sqrt{5}\ \text{m/s} = 30\sqrt{5}\ \text{cm/s}$

(iii) $a_{max} = \omega^2 A = \left(\frac{k}{m}\right)(A)$

$= \left(\frac{500}{1}\right)(0.03) = 15\ \text{m/s}^2$

(iv) Mean position is at 42 cm length and amplitude is 3 cm. Hence block oscillates between 45 cm length and 39 cm. Natural length 40 cm lies in between these two, where elastic potential energy = 0.

13. Ans: (a)

Sol: Given data,

$\sigma_1 = 80$ MPa, $\mu = 0.3$

$\sigma_2 = 20$ MPa, $E = 200$ GPa

$\sigma_3 = -70$ MPa,

Volumetric strain is given by

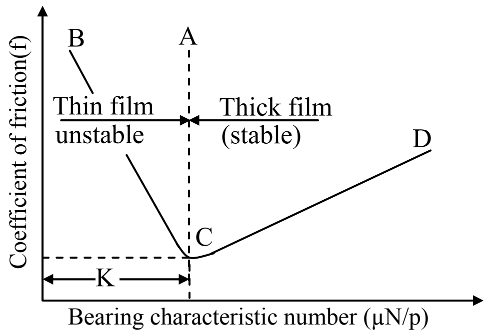
$$\varepsilon_v = \left(\frac{1-2\mu}{E}\right) \times (\sigma_1 + \sigma_2 + \sigma_3)$$

$$= \left(\frac{1-2\times0.3}{200\times10^3}\right) \times (80+20-70)$$

$$= \frac{0.4}{200\times10^3} \times 30 = 6 \times 10^{-5}$$

14. Ans: (d)

Sol:

- 

  K = bearing modulus (at minimum coefficient of friction)

- In hydrodynamic bearings, initially the journal is at rest. There is not relative motion and no hydrodynamic film. Therefore, there is metal to metal contact between the surfaces of the journal and the bearing.

15. Ans: (c)

Sol:

- Deep groove ball bearing takes a load in the radial as well as axial direction.
- Cylindrical roller bearing is not self – aligning. It cannot tolerate misalignment. It needs precise alignment between axes of the shaft and the bore of housing.
- Taper roller bearing cannot tolerant misalignment between the axes of the shaft and the housing bore.

16. Ans: (b)

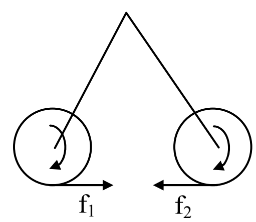
Sol: $a_{cm} = \dfrac{m_1\vec{a}_1 + m_2\vec{a}_2}{m_1 + m_2}$

$$= \frac{m_1\,\vec{a}}{m_1 + m_2}$$

$$= \frac{\vec{a}}{2} \quad (\because m_1 = m_2)$$

17. Ans: (a)

Sol:



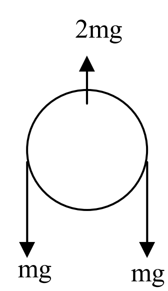
- For front wheel, friction should act in the backward direction to facilitate the angular motion of wheel.
- For rear wheel friction should at in forward direction to prevent slipping.
- Net external force is $(f_1 - f_2)$ and it provides the forward acceleration to the vehicle.

$$f_1 - f_2 > 0$$

18. Ans: (c)

Sol: $T_1 = 2\pi\sqrt{\dfrac{m}{k}}$

For case 2:



If the mass moves by x, spring moves by x/2, then

$$\frac{k}{2}x = 2mg$$

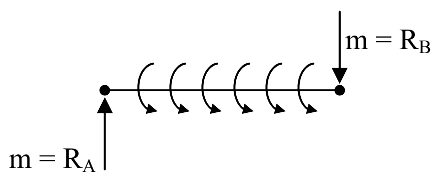
$$x = \frac{4mg}{k}$$

$$\omega_n = \sqrt{\frac{g}{\frac{4mg}{k}}}$$

$$T_2 = 2\pi\sqrt{\frac{4m}{k}}$$

19. Ans: (d)

Sol:



$\Sigma F_y = 0$

i.e., $R_A + R_B = 0$ ---- (1)

Taking momentum about point B

$R_A \times l - ml = 0$

$\therefore\ R_A = m$, $R_B = -m$

The bending moment at any distance ‘x’ from left end is given by

$M = R_A x - mx = mx - mx = 0$

$$E\frac{d^2y}{dx^2} = M = 0$$

$\therefore\ y = c_1 x + c_2$

$\Rightarrow$ The deflection curve is a straight line between points A and B i.e., horizontal line.

20. Ans: (a)

Sol: Fluctuation of energy

$$\Delta E = 8 - \frac{8}{4}\times 1 = 6\text{kJ}$$

$\omega = 60$ rad/sec

$C_S = 0.06$

$$\therefore\ I = \frac{\Delta E}{\omega^2 C_s} = \frac{6000}{60^2 \times 0.06}$$

$$= 27.78\,\text{kg} - \text{m}^2 \approx 28\ \text{kg-m}^2$$

21. Ans: (d)

Sol: *Magnitude of factor of safety depends on*

Type of load:

- For static load factor of safety is low
- for impact loads factor of safety is high.

Material of component:

- For homogenous ductile material like steel factor of safety is small.
- for cast iron which has non-homogenous structure factor of safety is high

Service condition :

- If machine element operate in corrosive atmosphere or high temperature environment high factor of safety is used.

Cost of component: Factor of safety is low for cheap machine parts.

22. Ans: (d)

Sol: For shafts connected in parallel

$\theta_A = \theta_B$ and $L_A = L_B$

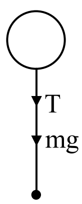
$$\frac{\tau}{r} = \frac{G\theta}{L}$$

$\therefore \tau \propto Gr$ [$\therefore$ θ & L are constant]

$$\frac{\tau_A}{\tau_B} = \frac{G_A}{G_B} \times \frac{R_A}{R_B} = \left(\frac{2}{1}\right)\times\left(\frac{1}{3}\right) = 2:3$$

23. Ans: (d)

Sol: At highest point



$$T + mg = \frac{mV^2}{R}$$

For minimum speed, T = 0

$$\frac{V^2}{R} = g$$

$$V = \sqrt{Rg}$$

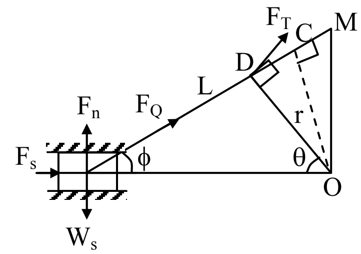
24. Ans: (c)

Sol: According to Tresca and Guest theory or maximum shear stress theory. The ratio of yield strength in shear to the yield strength in tension is

$$\frac{S_{ys}}{S_{yt}} = 0.5$$

25. Ans: (d)

Sol:



Turning moment on crank shaft.

$T = F_T \times r = F_Q \times OC$

$F_Q\cos\phi = F_s$

$$\Rightarrow F_Q = \frac{F_s}{\cos\phi}$$

$T = F_T \times r$

$= F_Q\, r \sin(\theta + \phi)$ [$\because$ OC = rsin(θ+ϕ)]

$$T = \frac{F_s}{\cos\phi} \times r\sin(\theta + \phi)$$

$T \times \omega = F_s \times V$

Where, ω = Angular velocity of crank.

V = sliding velocity of slider

$$V = r\omega\left[\sin\theta + \frac{\sin 2\theta}{2n}\right]$$

$$T\omega = F_s \times r\omega\left(\sin\theta + \frac{\sin 2\theta}{2n}\right)$$

$$\Rightarrow T = F_s \times r\left(\sin\theta + \frac{\sin 2\theta}{2n}\right)$$

$T = F_Q \times OC$

$= F_Q \times OM\cos\phi$

$$= \frac{F_s}{\cos\phi} \times OM\cos\phi = F_s \times OM$$

26. Ans: (a)

Sol: If $l + s > p + q$

Non Grashof's or Class - II

When $l + s > p + q$, in this situation, all four inversions result in a double-rocker mechanism.

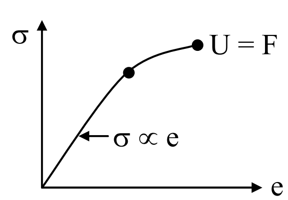
$$y = \frac{e}{\left(\frac{\omega_n}{\omega}\right)^2 - 1}$$

e = initial eccentricity of centre of mass of rotor

If the speed of the shaft is increased rapidly beyond the critical speed, $\omega > \omega_n$ or $(\omega_n/\omega)^2 < 1$ or y is negative. This means that the shaft deflects in the opposite direction. As the speed continues to increase, y approaches the value –e or the centre of mass of the rotor approaches the centre line of rotation. This principle is used in running high-speed turbines by speeding up the rotor rapidly or beyond the critical speed. When y approaches the value of –e, the rotor runs steadily.

27. Ans: (b)

Sol:



For brittle materials tested in tension

- Fracture point is equal to ultimate strength point.
- There is no necking.

28. Ans: (c)

Sol: $S = \left(\frac{r}{c}\right)^2 \times \frac{\mu N_s}{P}$

But $BCN = \frac{\mu N_s}{P}$

$$\therefore S = \left(\frac{r}{c}\right)^2 \times BCN$$

$$= \left(\frac{50}{0.05}\right)^2 \times 1.25 \times 10^{-6} = 1.25$$

29. Ans: (b)

Sol: From t = 0 sec to t = 11 sec velocity goes on increasing as acceleration is positive. So maximum velocity will occur at t = 11 sec.

$$\frac{dv}{dt} = a$$

$$dv = a\,dt$$

$$v_f - v_i = \int a\,dt$$

$$= \frac{1}{2} \times 10 \times 11 = 55$$

$$v_i = 0$$

$\Rightarrow v_f = 55$ m/s

30. Ans: (b)

Sol:

- The slope of the bending moment diagram is equal to the shear force at that point.

  $V = \dfrac{dM}{dx}$ (Where, V = shear force and M = Bending moment)

- The slope of the shear force diagram is equal to the intensity of the distributed loading of that point.

  The intensity of the distributed loading, $w = \dfrac{dV}{dx}$

  (where, V = shear force and w = intensity of distributed load)

- The second derivative of the deflection is equal to the curvature.

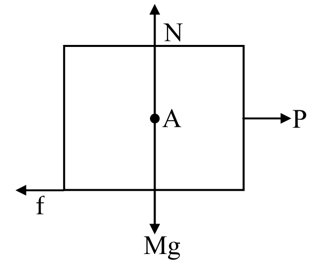
  The curvature of the beam, $\dfrac{1}{R} = \dfrac{M}{EI} = \dfrac{d^2y}{dx^2}$

- According to Castigliano's second theorem, deflection is given by

  $\delta = \dfrac{\partial u}{\partial P}$ i.e., the partial derivative of strain energy with w.r.t loads gives deflection at the point where load is acting.

31. Ans: (c)

Sol:



Force by surface on A is the resultant of friction force and normal reaction.

- When P = 0 then f = 0

  N = Mg

  Contact force = F = Mg

- When, P = f then $f = \mu N = \mu Mg$

  Contact force

  $F = \sqrt{N^2 + f^2} = Mg\sqrt{1+\mu^2}$

32. Ans: (b)

Sol:

- Ductile material are not affected by stress concentration under static load due to restribution of stresses.
- Endurance limit of components made of ductile material under fluctuating load is greatly reduced due to stress concentration because the stress at the discontinuities may exceed the endurance limit.
- The effect of stress concentration is more severe in case of brittle material subjected under static as well as fluctuating load due to their inability of plastic deformation.

33. Ans: (B)

Sol: $T_p = 16$, $T_s = 64$, $N_s = 0$ (fixed)

$N_R = 100$ rpm cw , $N_a = ?$

$$T_R = 2\left(\frac{T_s}{2} + T_P\right) = 2\left(\frac{64}{2} + 16\right) = 96$$

$$\frac{N_p - N_a}{N_R - N_a} = \frac{T_R}{T_p} \Rightarrow \frac{N_p - N_a}{100 - N_a} = \frac{96}{16} \text{ -----(i)}$$

$$\frac{N_p - N_a}{N_s - N_a} = \frac{-T_s}{T_p}$$

$$\frac{N_p - N_a}{0 - N_a} = \frac{-64}{16} = -4$$

$N_p = 4N_a + N_a = 5N_a$ --------(ii)

By solving equation (i) and (ii)

$N_a = 60$ rpm (cw)

34. Ans: (d)

Sol: The normal stress on the plane of maximum shear stress plane is given by, $\frac{\sigma_x + \sigma_y}{2}$

(1) $\frac{\sigma_x + \sigma_y}{2} = 50 \neq 0$

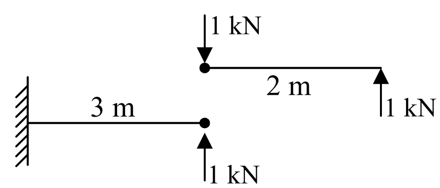
(2) $\frac{\sigma_x + \sigma_y}{2} = 100 \neq 0$

(3) $\frac{\sigma_x + \sigma_y}{2} = 0$

(4) $\frac{\sigma_x + \sigma_y}{2} = 0$

35. Ans: (c)

Sol:



$\therefore M_A = 1 \times 3 = 3$ kN-m

36. Ans: (a)

Sol: Kinetic energy of the barrel = work done on the spring.

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

$$\frac{1}{2} \times 5 \times 10^2 = \frac{1}{2}k \times 1^2$$

$\Rightarrow k = 500$ N/m

Critical damping coefficient = $2\sqrt{km}$

$= 2\sqrt{500 \times 5} = 100$ N-sec/m

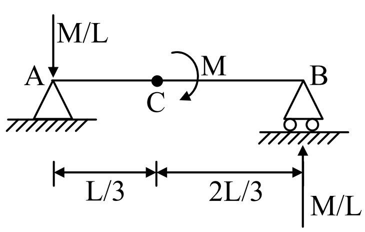
37. Ans: (d)

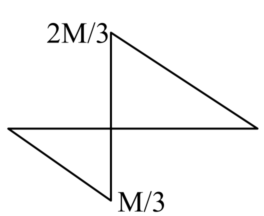
Sol:

- Mohr's first moment area theorem states that "the different of slopes between any two points on an elastic curve of a beam is equal to the net area of the bending moment diagram between these two points divided by EI (Flexural rigidity). So, statement 1 is incorrect.
- Conjugate beam is beam which has load diagram as $\frac{M}{EI}$ diagram of an actual beam. Thus statement (2) is also incorrect.
- A hinged support in a real beam remains as a hinged support in a conjugate beam. Thus statement (3) is also incorrect.

38. Ans: (a)

Sol:





The strain energy due to bending moment is calculated separately as

$$= \frac{M^2}{2EIL^2}\left[\int_0^{L/3} x^2 dx + \int_0^{2L/3} x^2 dx\right]$$

$$= \frac{M^2}{2EIL^2}\left[\frac{L^3}{27} + \frac{8L^3}{27}\right]$$

$$U = \int_0^{L/3} \frac{\left(-\frac{M}{L}x\right)^2 dx}{2EI} + \int_0^{2L/3} \frac{\left(\frac{M}{L}x\right)^2 dx}{2EI}$$

$$U = \frac{M^2L}{18EI}$$

Angular rotation at C $= \frac{dU}{dM} = \frac{ML}{9EI}$

39. Ans: (a)

Sol: Number of pairs of contact surfaces

$$= n_1 + n_2 - 1 = 10 + 9 - 1 = 18$$

40. Ans: (c)

Sol: All four points A, B, C and D are on the circumference, i.e at same radial distance from centre, hence the torsional shear stress on all these points would be same.

Axial stress (due to P_x) is uniform, hence again all four points A,B,C and D would experience same compressive shear.

B and D points lie on neutral axis, hence bending stress at these is zero.

At A bending stress is tensile while at C it is compressive.

Hence at C, bending as well axial are compressive, result into critical point.

41. Ans: (a)

Sol: $\Sigma M_A = 0$

$\therefore\ 600\times1+600\times4-R_B\times3 = 0$

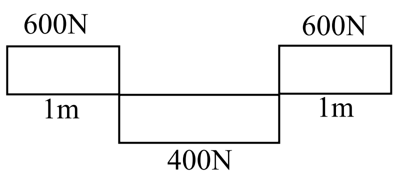
$\therefore\ R_B = 1000N$

$\Sigma F_y = 0$

$R_A+R_B = 0$

$\therefore\ R_A = -1000N$

SFD

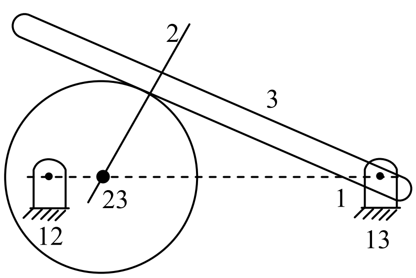


Area of SFD = 400×3 = 1200Nm

42. Ans: (d)

43. Ans: (c)

Sol:



Using instantaneous center method

$(12-23)\ \omega_2 = (13-23)\ \omega_3$

$6\omega_2 = -60\omega_3$

$$\omega_3 = \frac{-6}{60}\omega_2$$

$\omega_3 = -0.1$ rad/sec i.e., 0.1 rad/sec CW

44. Ans: (b)

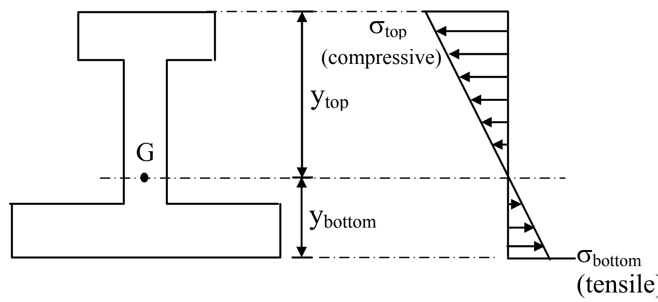
Sol: Given data,

$y_{bottom} = 53$ mm,

$y_{top} = 150 - 53 = 97$ mm

$\sigma_{bottom} = 159$ MPa

Bending stress distribution for a given beam is shown in the figure below.



$$\text{Thus, } \frac{\sigma_{top}}{\sigma_{bottom}} = \frac{y_{top}}{y_{bottom}}$$

$$\Rightarrow \sigma_{top} = 159\times\frac{97}{53}$$

$= 291$ MPa (compressive)

45. Ans: (d)

Sol: $$y = \frac{PL^3}{3EI}$$

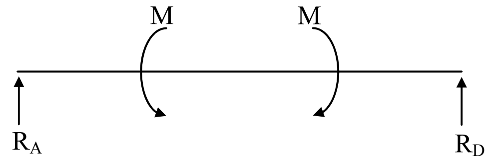
$$y_I = \frac{PL^3}{3EI}\times\frac{12}{(2B)\times B^3} = \frac{PL^3}{3E}\times\frac{12}{2B^4}$$

$$y_{II} = \frac{PL^3}{3EI} = \frac{PL^3}{3E}\times\frac{12}{B\times(2B)^3} = \frac{PL^3}{3E}\times\frac{12}{8\times B^3}$$

$$\therefore \frac{y_I}{y_{II}} = 4$$

46. Ans: (d)

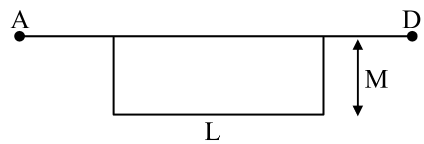
Sol: FBD



$R_A + R_D = 0$, $\Sigma M_A = 0$

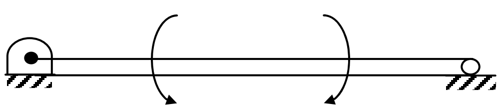
$\therefore$ $R_D = 0$; $R_A = 0$

BMD



Strain $U_{AB} = U_{DC} = 0$

$$U_{BC} = \int \frac{M^2.dx}{2EI} = \frac{M^2}{2EI}.\int_0^L dx = \frac{M^2L}{2EI}$$



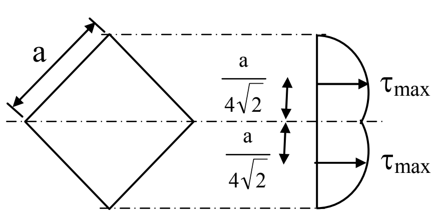
Let, L = length of beam, d = dia of shaft

47. Ans: (a)

Sol: Given data,

F = 80 kN, a = 300 mm

Shear stress distribution for a given case is shown in the figure below.



Maximum shear stress occurs at a point located at a distance of $\frac{a}{4\sqrt{2}}$ from the neutral axis.

It is equal to $\tau_{max} = \frac{9}{8}\tau_{avg}$

$$\tau_{max} = \frac{9}{8}\left(\frac{F}{a^2}\right)$$

$$= \frac{9}{8} \times \frac{80\times10^3}{300\times300} = 1 \text{ MPa}$$

48. Ans: (d)

Sol: $\theta_{AB} = \theta_{BC}$

$$\therefore \left(\frac{TL}{GJ}\right)_{AB} = \left(\frac{TL}{GJ}\right)_{BC}$$

$$\therefore \frac{T_{AB} \times L/3}{\frac{\pi}{32}\times d^4} = \frac{T_{BC}\times\frac{2L}{3}}{\frac{\pi}{32}\times(2d)^4}$$

$$\therefore T_{AB} = T_{BC} \times \frac{2}{16}$$

$$\therefore \frac{T_{AB}}{T_{BC}} = \frac{1}{8}$$

49. Ans: (d)

Sol: $$\tau_{max} = \max.\left\{\left|\frac{\sigma_1-\sigma_2}{2}\right|, \left|\frac{\sigma_1-\sigma_3}{2}\right|, \left|\frac{\sigma_2-\sigma_3}{2}\right|\right\}$$

$$= \max\left\{\left|\frac{150-75}{2}\right|, \left|\frac{150-(-30)}{2}\right|, \left|\frac{75-(-30)}{2}\right|\right\}$$

$$= \max\ \{37.5, 90, 52.5\}$$

$\therefore$ $\tau_{max} = 90$

According to maximum shear stress theory.

$$\tau_{max} = \frac{S_{sy}}{Fos}$$

$$S_{sy} = \frac{PL}{2} = \frac{300}{2} = 150$$

$$\therefore 90 = \frac{150}{Fos}$$

$$\therefore \text{FOS} = 1.67$$

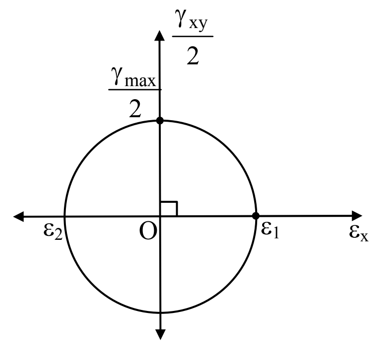
50. Ans: (c)

Sol: $$\sigma = \frac{M \times y}{I} = \frac{M \times d/2}{\pi t r^3}$$

$$= \frac{M \times r}{\pi t r^3} = \frac{M}{\pi t r^2} = \frac{4M}{\pi t d^2}$$

51. Ans: (a)

Sol: Mohr circle for a plane strain condition, in case of pure shear is shown in the figure below. To draw a Mohr circle for a plane strain condition, σ_x, σ_y and τ_{xy} are replaced by ε_x, ε_y and $\frac{\gamma_{xy}}{2}$, respectively.



From the Mohr circle, it can be concluded that,

$$\varepsilon_1 = \varepsilon_{max} = \frac{\gamma_{max}}{2} = \frac{600}{2} = 300 \text{ micron}$$

52. Ans: (c)

Sol: $\left(\frac{\delta}{P}\right)_{bolt} = \frac{1}{4}\times\left(\frac{\delta}{P}\right)_{plates}$

But $\frac{\delta}{P} = \frac{1}{k}$

$\therefore \frac{1}{k_{bolt}} = \frac{1}{4}\times\frac{1}{k_{cm}}$

$(k_{cm} = \text{stiffness of connected members})$

$\therefore \frac{k_{bolt}}{k_{cm}} = 4$

$\therefore c = \frac{k_{bolt}}{k_{bolt}+k_{cm}} = \frac{k_{bolt}/k_{cm}}{k_{bolt}/k_{cm}+1}$

$= \frac{4}{4+1} = 0.8 = 80\%$

53. Ans: (a)

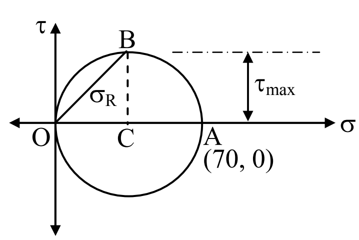
Sol: Spring force at lowest position is the required initial compression.

Initial compression of the spring = $\frac{F_{s2}}{k}$

$= \frac{130}{10} = 13$ mm

54. Ans: (c)

Sol: For a given state of stress, Mohr circle is shown in the figure below.



Resultant stress (σ_R) is given by

$\sigma_R = \sqrt{OC^2 + BC^2}$

$= \sqrt{\left(\frac{70}{2}\right)^2 + \left(\frac{70}{2}\right)^2} = 35\sqrt{2}$ MPa

55. Ans: (c)

Sol: $L = \left(\frac{C}{P}\right)^2 = \frac{L_n \times N \times 60}{10^6}$

$\therefore P^3 \times L_h \times .N$ = constant

$\therefore P_1^3 \times L_h \times N$ = constant

[Where L_h = Life in hours]

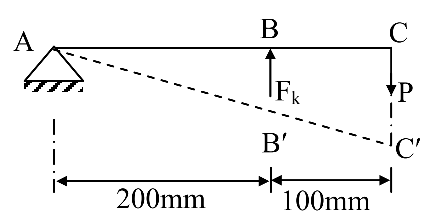
$\therefore 5000^3 \times 4 \times 2000 = P_2^3 \times 1000 \times 1$

$\Rightarrow P_2 = 10000$ N

56. Ans: (d)

Sol: Given data, P = 1000 N, k = 500 N/mm

When the rigid bar is displaced by δ_e at point B in the downward direction ,



Here,

$BB' = \delta_B$

$CC' = \delta_C$

Take, $\Sigma M_A = 0$

$\therefore F_k \times 200 - P \times 300 = 0$

$$F_k = \frac{3P}{2} = \frac{3\times1000}{2} = 1500\,\text{N}$$

Deflection of spring,

$$\delta_B = \frac{F_k}{k} = \frac{1500}{500} = 3\,\text{mm}$$

From similarity of triangles ABB′ and ACC′

$$\frac{CC'}{AC} = \frac{BB'}{AB}$$

$$\Rightarrow \delta_C = \delta_B \times \frac{300}{200} = 4.5 \text{ mm downward}$$

57. Ans: (b)

Sol: Uniform wear theory assumption gives lower torque capacity, the designing based on uniform wear theory for higher torque capacity will need bigger clutch dimensions.

58. Ans: (d)

59. Ans: (a)

Sol: For static balance, $\sum F_x = 0$ and $\sum F_y = 0$

$m_1 = 6$ kg, $m_2 = 4$ kg and $m_3 = 10$ kg

$m_1r_1 + m_2r_2 = m_3r_3$

$6 \times 0.2 + 4 \times 0.2 = 10 \times 0.2$

So it is statically balanced but not dynamically balanced because the couple created by the forces is not balanced which will cause reaction at the bearings.

60. Ans: (a)

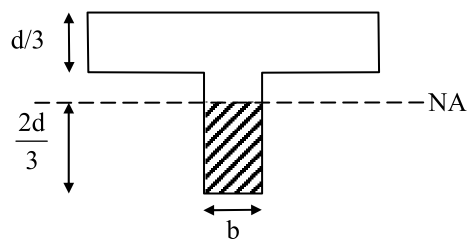
Sol: When crank is perpendicular to line of stroke, velocity of slider = $r\omega_2$ and $\omega_3 = 0$

Variation in centre distance does not influence velocity ratio in involute gears.

In a crank rocker mechanism, if the rocker is parallel to crank angular velocity of coupler is zero.

61. Ans: (b)

Sol:



$$\tau = \frac{fA\bar{y}}{It}$$

$$= \frac{P}{2}.\frac{1}{I.b} \times \frac{2d}{3} \times b \times \frac{1}{2}.\frac{2d}{3}$$

$$\tau = \frac{P.d^2}{9I}$$

62. Ans: (b)

Sol:

- The work done by all the forces (external and internal) on a system equals the change in kinetic energy (By work energy principle).
- The work done by the external forces on a system equals the change in total energy.

63. Ans: (b)

Sol: Tangential acceleration occurs due to change in magnitude of velocity, which is zero during uniform circular motion.

64. Ans: (a)

Sol: Area moment method assumes continues slope. For internal hinge slope is not continues at hinge, therefore area moment method is not suitable for beams with internal hinges.

65. Ans: (c)

Sol: For long columns, crushing load is very high as compared to buckling load and hence it fails because of buckling, prior to getting crushed.

66. Ans: (a)

Sol: Thus, $\Delta V = 0$

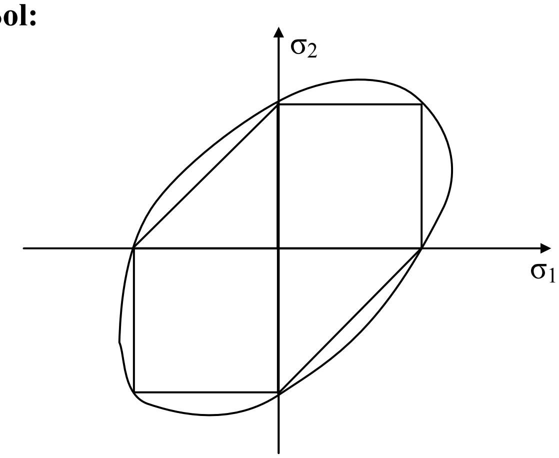
Also, $\frac{\Delta V}{V_o} = (1-2\mu)\varepsilon$

$\Rightarrow 1 - 2\mu = 0$

$\Rightarrow \mu = 0.5$

67. Ans: (d)

Sol:



Area of the hexagon represent safe zone as per Tresca's theory and the area of ellipse represent the safe zone as per von Mises theory.

Some of the loading conditions which are safe von-Mises theory are not safe by Tresca's theory. Thus Tresca's theory predicts larger dimensions for given loading than von-mises theory i.e., it gives more conservative dimensions.

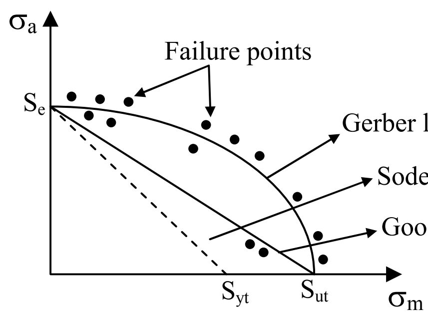
68. Ans:(b)

Sol: In partial bearings, the angle of contact between the bush and the journal is always less than 180°. Most of the partial bearings in practice have 120° angle of contact. Partial bearing can take loads in only one radial direction. Partial bearings are used in railroad-cars. The advantages of partial bearings compared to full journal bearing are as follows:

- Partial bearing is simple in construction.
- It is easy to supply lubricating oil to the partial bearing.
- The frictional loss in partial bearing is less. Therefore, temperature rise is low.

69. Ans: (b)

Sol:



- Theories based on soderberg line or the Goodman line as failure criteria are conservative theories. This results in increased dimensions of components.
- The Gerber curve fits the failure points of test data in best possible way. It takes mean path through failure points. It is therefore more accurate in predicting fatigue failure.

70. Ans: (c)

Sol: Strain energy is negative work done by stress resultant as displacement is opposite to the direction stress. Strain energy is the area under the load-deformation plot.

71. Ans: (b)

Sol: Compatibility condition can be used for statically indeterminate shafts and composite shafts.

72. Ans: (a)

Sol: During idle stroke the speed of flywheel increases. During punching stroke the extra energy for punching comes from the kinetic energy of flywheel.

73. Ans: (d)

Sol: In a rolling pair, one element undergoes undergoes rolling motion with respect to one another.

A pair of gears gives a positive drive but rolling pair does not give positive drive because there is no sufficient friction or slip may occur.

74. Ans: (d)

Sol: F = –kx for all displacements from the mean positions, whether they are small or large.

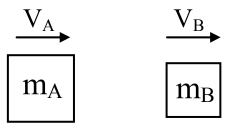
$F = -kx^n$

where n = 1, 3, 5, ... is equation of oscillation.

if n = 1 then this oscillation equation represents simple harmonic motion.

75. Ans: (a)

Sol:



- Two particles of masses m_A and m_B are moving with velocities V_A and V_B respectively.

  After completely inelastic collision (e=0) both the masses stick together and let, they start moving with a common velocity V.

  For principal of conservation of linear momentum

  $$m_A V_A + m_B V_B = (m_A + m_B)V$$

  $$V = \frac{m_A V_A + m_B V_B}{m_A + m_B}$$

  So, kinetic energy is not completely lost.

- The principle of conservation of linear momentum holds true for all type of collision.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7
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