ACE Engineering Academy

Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad – 500001.

Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437

Hyderabad | Delhi | Bhopal | Pune | Bhubaneswar | Lucknow | Patna | Bengaluru | Chennai | Vijayawada | Vizag | Tirupati | Kukatpally | Kolkata | Ahmedabad

ESE- 2019 (Prelims) - Offline Test Series Test – 3

MECHANICAL ENGINEERING

Engineering Mechanics and Strength of Materials + Engineering Materials

SOLUTIONS

01. Ans: (b)

Sol: Shear force throughout the beam will be 10 kN and it is constant.

Bending Moment: (*Sign convention : Hogging moment is taken negative*)

$(BM)_C = 0$

$(BM)_{B_{Right}} = -10 \times 1 = -10$ kN.m

$(BM)_{B_{Left}} = -10$ kN.m $- 10$ kN.m

$= -20$ kN.m

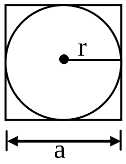
$(BM)_A = -10 \times 2 - 10 = -30$ kN.m

Thus, $|SF_{max}| = 10$ kN

and $|BM_{max}| = 30$ kN.m

02. Ans: (b)

Sol: A cubical crystal is shown below,



where, r = radius of atom.

Volume of atoms $= \frac{4}{3}\pi r^3$

Unit cell contains one atom on the average

(r) = a/2

Volume of atom in unit cell

$$(V) = \frac{4}{3}\pi(a/2)^3$$

Volume of unit cell $(\upsilon) = a^3$

Packing fraction (or density)

$$= \frac{V}{\upsilon} = \frac{4}{3}\pi\frac{a^3}{8} \times \frac{1}{a^3} = 0.52$$

03. Ans: (b)

Sol: We know that, Torque = Rate of change of angular momentum

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

$$\Rightarrow d\vec{L} = \vec{\tau}\,dt$$

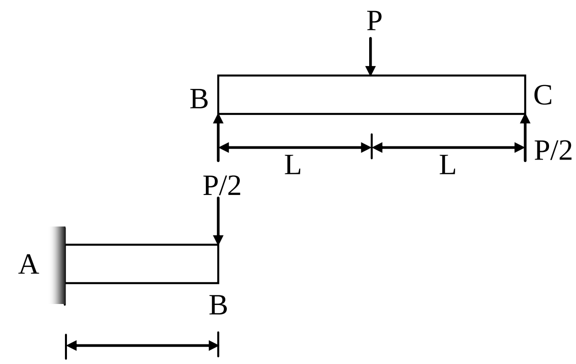
$$\Rightarrow \Delta\vec{L} = \vec{\tau}\,\Delta t$$

$$\Rightarrow I\Delta\vec{\omega} = \vec{\tau}\,\Delta t$$

$$\Rightarrow |\Delta\vec{\omega}| = \frac{\tau\Delta t}{I} = \frac{100 \times 0.1}{1} = 10\,\text{rad/s}$$

04. Ans: (b)

Sol: Compound beam ABC can be analysed as shown below.



$$(BM)_A = \frac{P}{2}\times L = \frac{PL}{2}$$

Thus, statement (1) is incorrect.

By eliminating the other options, only option (B) is correct.

- Hinge support transfers shear force only, it cannot transfer bending moment. Thus, bending moment at B is zero.
- Clearly, shear force at A is P/2.

Thus, only statements (2) and (3) are correct.

05. Ans: (b)

Sol: Dimensions of a unit cell representing a tetragonal unit are:

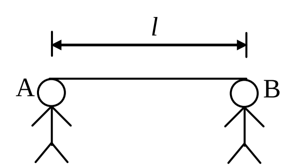
$$a = b \neq c\ ;\ \alpha = \beta = \gamma = 90^o.$$

Unit cell:

- A unit cell is a part of the material which explains whole structure of the material.
- A unit cell of three dimensional crystal lattice is formed by intercepts a, b and c along the three axes respectively i.e. x, y and z.
- The three angles α, β and γ are called the inter facial angles of the crystal. The intercepts and interfacial angles constitute the lattice parameter. A 'primitive cell' may be defined as unit cells, which possess lattice points at its corners only.

06. Ans: (c)

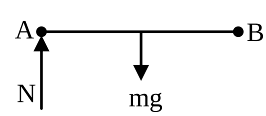
Sol:



When the beam is supported at A and B, the force exerted on each man = $\frac{mg}{2}$

Where 'm' is the mass of the beam.

When the support at B is withdrawn, the F.B.D of beam is shown below



$$\Sigma\tau_A = mg\times\frac{\ell}{2} = I\alpha = \frac{m\ell^2}{3}\alpha$$

$$\Rightarrow \alpha = \frac{3g}{2\ell}$$

The instantaneous linear acceleration of the centre of mass is

$$a_{cm} = \alpha \times \frac{\ell}{2} = \frac{3g}{2\ell} \times \frac{\ell}{2} = \frac{3g}{4}$$

Now, we know that $(\Sigma F)_{ext} = m \times a_{c.m}$

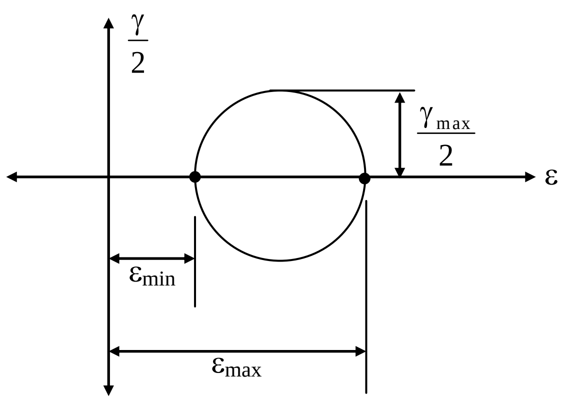
$$mg - N = m \times \frac{3g}{4}$$

$$\Rightarrow \quad N = \frac{mg}{4}$$

Thus, the force exerted by beam on man decreases.

07. Ans: (a)

Sol: Generalised Mohr's circle for strain is shown below.



Thus, $\frac{\gamma_{max}}{2}$ = Radius of Mohr's circle = R

$\therefore \gamma_{max} = 2 \times R$ = Diameter of Mohr's circle.

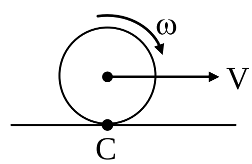
08. Ans: (b)

Sol:

- Brittleness should not equated with lack of strength, so statement (I) is incorrect.
- Brittleness is simply the absence of significant plasticity.
- Many brittle materials, such as glass and ceramics can be used to impart significant strength to reinforced composites. So statement (II) is correct.
- Toughness is defined as the work per unit volume required to fracture a material, and can be used as one measure of materials ability to absorb energy or impacts without cracking (or) breaking. So, statement (3) is also incorrect regarding brittleness. Hence the given option (b) is correct.

09. Ans: (d)

Sol:



Angular momentum about 'C' = $I_c\,\omega$

$$= \left(\frac{2}{5}mR^2 + mR^2\right) \times \omega$$

$$= \frac{7}{5}mR^2\omega$$

$$= \frac{7}{5}R \times (mV) \quad [\because V = \omega R]$$

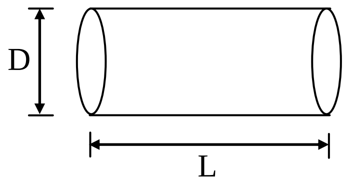
$$= \frac{7}{5}PR$$

10. Ans: (d)

Sol: Given data:

$\varepsilon_L = 0.02$,

$\mu = 0.3$



For a cylindrical rod, volumetric strain is given by

$$\varepsilon_v = \varepsilon_L + 2\varepsilon_D$$

Here, $\varepsilon_D = -\mu\varepsilon_L = -0.03\times 0.02 = -0.006$

Thus, $\varepsilon_v = 0.02 - (2\times 0.006) = 0.008$

11. Ans: (c)

Sol: In nanotechnology, surface films that self-assemble, are only one molecule thick, and in which the molecules are organized in some orderly fashion.

12. Ans: (b)

Sol: Initial velocity, u = 9 m/s,

Acceleration, $a = -2\ m/s^2$

To calculate the time when velocity is zero, we use,

$v = u + at$

$0 = 9 - 2\times t \Rightarrow t = 4.5$ sec

Let us calculate displacement (s_1) from t = 4 sec to 4.5 sec

$v^2 = u^2 + 2as_1$

$0 = 1^2 - 2\times 2\times s_1$

$[\because v|_{at\ t = 4\ sec} = u + at = 9 - 2\times 4 = 1 m/s]$

$\Rightarrow s_1 = \frac{1}{4} m$

Let us calculate displacement (s_2) from t = 4.5 sec to 5 sec

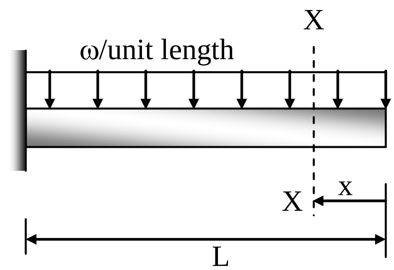
$$s_2 = ut + \frac{1}{2}at^2$$

$$s_2 = 0\times 0.5 - \frac{1}{2}\times 2\times \frac{1}{4} = -\frac{1}{4} m$$

Total distance = $|s_1| + |s_2| = \frac{1}{2} m = 0.5$ m

13. Ans: (b)

Sol: For the given beam,



Bending moment at section X-X is given by,

$$M_x = \omega\times x\times\frac{x}{2} = \frac{\omega x^2}{2}$$

Strain energy due to bending is given by,

$$U = \int_0^L \frac{M_x^2 dx}{2EI} = \int_0^L \frac{\left(\frac{\omega x^2}{2}\right)^2}{2EI} dx$$

$$= \frac{\omega^2}{8EI}\int_0^L x^4 dx = \frac{\omega^2 L^5}{40EI}$$


ACE
SUMMER
SHORT TERM BATCHES
GATE+PSUs - 2020
Admissions Open From 14th NOV 2018
HYDERABAD
29th April | 06th May | 11th May
18th May | 26th May | 02nd June 2019
DELHI
11th May | 23rd May 2019
Start Early.. Gain Surely...
EARLY BIRD OFFER :
Register on or Before 31st December 2018 : 5000/- Off | Register on or Before 31st March 2019 : 3000/- Off


ACE
TEST YOUR PREP
IN A REAL TEST ENVIRONMENT
Pre GATE - 2019
Date of Exam : 20th January 2019
Last Date to Apply : 31st December 2018
Highlights :
* Get real-time experience of GATE-2019 test pattern and environment.
* Virtual calculator will be enabled.
* Post exam learning analytics and All India Rank will be provided.
* Post GATE guidance sessions by experts.
* Encouraging awards for GATE-2019 toppers.

14. Ans: (a)

Sol: The four single phases in the iron carbon phase diagram are:

1. *Ferrite (alpha):* Which is the room temperature body centred cubic structure.
2. *Austenite (gamma):* Which is the room temperature body centred cubic phase.
3. *Delta-ferrite (delta):* The high temperature body centred cubic phase.
4. *Cementite (Fe_3C):* The iron carbon intermetallic compound that occurs at 6.67 wt. percent carbon.

15. Ans: (d)

Sol: Work done = Increase in potential energy of one fourth of chain

$$= \frac{m}{\ell} \times \frac{\ell}{4} \times g \times \frac{\ell}{8}$$

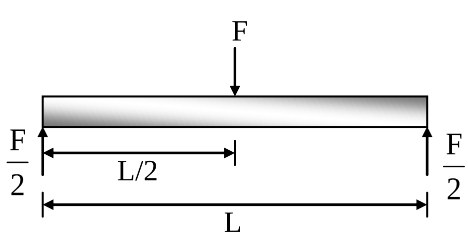
$$= \frac{mg\ell}{32}$$

16. Ans: (c)

Sol: Given data:

L = 2 m, b = d = 100 mm

σ_{allow} = 100 MPa



For the given case of simply supported beam, maximum moment occurs at mid-span.

$$M_{max} = \frac{F}{2} \times \frac{L}{2} = \frac{FL}{4}$$

Now, using flexural formula,

$$\frac{\sigma_b}{y} = \frac{M}{I} \Rightarrow \frac{\sigma_{allow} \times \frac{bd^3}{12}}{\frac{d}{2}} = \frac{FL}{4}$$

$$\Rightarrow \frac{100 \times (100)^3}{6} = \frac{F \times 2000}{4}$$

$\Rightarrow F_{safe}$ = 33.3 kN

17. Ans: (c)

Sol: White cast iron behaviour is determined to a large extent by the high iron carbide content. White cast iron is hard and brittle. Application in which minimal wear rate is required and loading is compressive are typical e.g., *Machine tool ways.*

18. Ans: (c)

Sol: $$V_{c.m} = \frac{m_1V_1 + m_2V_2}{m_1 + m_2}$$

$$= \frac{10 \times 14 + 4 \times 0}{10 + 4} = 10 \text{ ms}^{-1}$$

19. Ans: (a)

Sol: Given data:

$\delta = 10$ mm, $\theta = 0.03$ rad

For a cantilever beam subjected to point load 'P' at its free end.

$$\delta = \frac{PL^3}{3EI} \text{ and } \theta = \frac{PL^2}{2EI}$$

$$\Rightarrow \frac{\delta}{\theta} = \frac{(L/3)}{(1/2)} = \frac{2L}{3}$$

$$\Rightarrow \frac{10}{0.03} = \frac{2L}{3}$$

$\Rightarrow$ L = 500 mm = 0.5 m

20. Ans: (d)

Sol: Oils are used as quenching media. They have lower cooling rate. They cool steel more uniformly throughout thus reducing the risk of distortion.

21. Ans: (d)

Sol: Given data:

$F = 20\pi$ Kn, $\tau_{max} = 12$ MPa

For a circular section,

$$\tau_{max} = \frac{4}{3}\tau_{avg}$$

$$\Rightarrow \tau_{max} = \frac{4}{3} \times \frac{F}{A}$$

$$= \frac{4}{3} \times \frac{20\,\pi \times 10^3}{\left(\frac{\pi}{4} \times d^2\right)}$$

$\Rightarrow$ d = 94.28 mm

22. Ans: (c)

Sol: Displacement = s = kt^3 [k is constant]

$$v = \frac{ds}{dt} = 3k\,t^2$$

$$a = \frac{dv}{dt} = 6\,k\,t$$

F = ma = 6 m k t

Power = F × v = 6 mkt × 3 kt^2 = 18 $mk^2\,t^3$

$\Rightarrow$ Power $\propto t^3$

23. Ans: (d)

Sol:

- The recrystallization heat treatment used to eliminate the effect of cold working in steels with less than about 0.25% C is called a *process anneal*. So given option (a) is incorrect.
- Steels that contain a large concentration of Fe_3C have poor machining characteristics. It is possible to transform the morphology of Fe_3C using *spheroidizing*. So given option (b) is incorrect.
- The isothermal transformation heat treatment used to produce bainite is called *austempering*. So given option (c) is incorrect.
- If aluminum alloys are used, an *age hardening treatment* would most likely be required to achieve the desired mechanical strength. This would involve the stages of solution treatment, quenching and aging. So given option (d) is correct.

24. Ans: (b)

Sol: Given data:

Solid shaft	***Hollow shaft***
$L_s = 500$ mm,	$L_H = 500$ mm,
$D_s = 100$ mm,	$D_o = 100$ mm,
	$D_i = 50$ mm

We know that,

$$\frac{T}{J} = \frac{G\theta}{L}$$

Thus, torsional stiffness, $K_T = \frac{T}{\theta} = \frac{GJ}{L}$

For same material and same length, $K_T \propto J$

$$\Rightarrow \frac{(K_T)_H}{(K_T)_S} = \frac{J_H}{J_S} = \frac{\frac{\pi}{32}\times\left(D_0^4 - D_i^4\right)}{\frac{\pi}{32}\times D_s^4}$$

$$= \frac{D_0^4\left(1-\left(\frac{D_i}{D_o}\right)^4\right)}{D_s^4}$$

$$= \left(1-\left(\frac{50}{100}\right)^4\right) \quad (\because D_o = D_s)$$

$$= 1-\frac{1}{16} = \frac{15}{16}$$

25. Ans: (c)

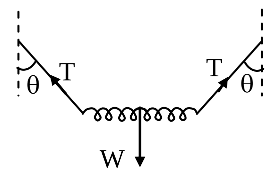
Sol: Alloying elements are added to improve the mechanical, chemical, electrical and magnetic properties.

Alloying elements are added to steels to

- provide solid-solution strengthening of ferrite.
- cause the precipitation of alloy carbides rather than that of Fe_3C.
- improve corrosion resistance and other special characteristics of the steel.
- improve hardenability.

26. Ans: (b)

Sol: F.B.D of spring is shown below.



T is the tension in each string.

$\Sigma F_y = 0 \Rightarrow 2\,T\cos\theta = W$

Extension in spring,

$$\delta = \frac{T\sin\theta}{k} = \frac{W}{2\cos\theta}\times\frac{\sin\theta}{k}$$

$$\delta = \frac{W\tan\theta}{2k}$$

27. Ans: (a)

Sol: Modulus of resilience

$$= \frac{\text{Strain energy stored up to the yield point}}{\text{Volume of the specimen}}$$

For the same size of specimens,

$R \propto U_{elastic}$

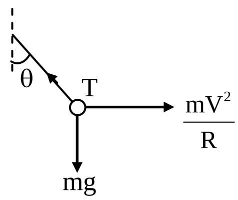
$\therefore R_A > R_B \quad (\because U_A > U_B)$

28. Ans: (b)

Sol: Top-down processing approaches: In fabricating nanoscale structures include *electron-beam lithography*, x-ray lithography, and micro or nano imprint lithography.

29. Ans: (c)

Sol: F.B.D of bob is shown below :



$\Sigma F_y = 0 \Rightarrow T\cos\theta = mg$

$\Sigma F_x = 0 \Rightarrow T\sin\theta = \frac{mV^2}{R}$

$\Rightarrow \tan\theta = \frac{V^2}{Rg} = \frac{10^2}{10\times 10} = 1$

$\Rightarrow \theta = 45°$

30. Ans: (d)

Sol: $I_x = (I_x)_{semi-circle} - (I_x)_{rectangle} = \frac{\pi r^4}{8} - \frac{bh^3}{3}$

31. Ans: (a)

Sol: The decomposition of martensite in steels causes *the strength and hardness of the steel to decrease while the ductility and impact properties to improve.*

32. Ans: (d)

Sol: In rolling without slip, at constant speed on horizontal surface, there is no force of friction between the surfaces (sphere and plank). So, removing the pin causes no change in system and P will still be at rest.

33. Ans: (d)

Sol: If w = intensity of load,

V = shear force and

M = bending moment, then,

$$w = \frac{dV}{dx} = \frac{d^2M}{dx^2}$$

Also, $V = \frac{dM}{dx}$

Thus, option (d) is correct.

34. Ans: (d)

Sol:

- *Pearlite* is a microconstituent consisting of a lamellar mixture of ferrite and cementite.
- In *Bainite*, which is obtained by transformation of austenite at a large undercooling, the cementite is more rounded than in pearlite.
- *Tempered martensite*, a mixture of very fine and nearly round cementite in ferrite, forms when martensite is reheated following its formation.

35. Ans: (d)

Sol: Torque about an axis = Rate of change of angular momentum about the same axis.

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

$\because \vec{\tau} = 0 \Rightarrow \vec{L}$ is constant

$\Rightarrow I\omega$ = constant ----- (i)

Kinetic energy

$= \frac{1}{2} I\omega^2$

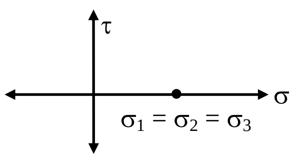
$= \frac{1}{2} \times I \times \left(\frac{\text{constant}}{I}\right)^2 = \frac{(\text{constant})^2}{2I}$ -----(ii)

When man brings weights inwards, I decreases

- ω increases [from (i)].
- kinetic energy increases [from (ii)].

36. Ans: (c)

Sol: Given that, $\sigma_1 = \sigma_2 = \sigma_3$. Mohr's circle for a given case is shown below:



Thus, Mohr's circle is a point having principal planes in every direction.

37. Ans: (d)

Sol:

- Initially friction opposes motion so block is at rest
- After some time a constant friction (limiting friction) acts, but force increases linearly. Hence, acceleration is increasing thus the plot of V against t will be a curve.

38. Ans: (a)

Sol:

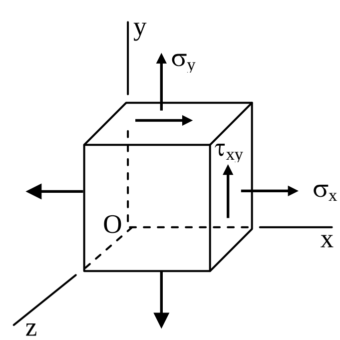
- *Eutectic* reaction is a three-phase invariant reaction in which *one liquid phase solidifies to produce two solid phases.*
- *Eutectoid* reaction is a three-phase invariant reaction in which one solid phase transforms to two different solid phases.
- *Peritectic* reaction is a three-phase reaction in which a solid and a liquid combine to produce a second solid on cooling.
- *Monotectic* reaction is a three-phase reaction in which one liquid transforms to a solid and a second liquid on cooling.

39. Ans: (c)

Sol: Ceramic materials fail at stresses much lower than their theoretical strength *due to presence of voids.*

40. Ans: (D)

Sol: For a plane stress condition:



Stress: $\sigma_z = 0, \tau_{xz} = 0, \tau_{yz} = 0$

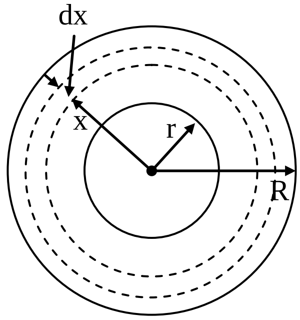
σ_x, σ_y and τ_{xy} may have nonzero values.

Strains: $\gamma_{xz} = 0, \gamma_{yz} = 0$

$\varepsilon_x, \varepsilon_y, \varepsilon_z$ and γ_{xy} may have nonzero values.

41. Ans: (d)

Sol:



Take an elemental ring of radius x and thickness dx

$$dI = (dm) \times x^2$$

$$= \frac{m}{\pi(R^2 - r^2)} \times 2\pi x \times dx \times x^2$$

$$dI = \frac{2m}{R^2 - r^2} x^3 dx$$

$$I = \int_r^R dI = \frac{2m}{R^2 - r^2} \times \left[\frac{x^4}{4}\right]_r^R$$

$$= \frac{2m}{4(R^2 - r^2)} \times (R^2 + r^2)(R^2 - r^2)$$

$$= \frac{1}{2} m (R^2 + r^2)$$

42. Ans: (a)

Sol:

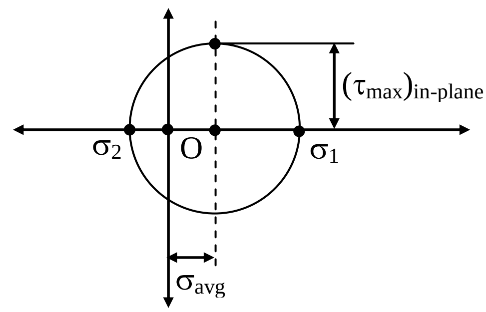
- Polyamide: Bearings, gears, fibres, rope, automotive components, electrical components
- Butadiene-styrene: Tires
- Silicones: Gaskets and seals

43. Ans: (a)

Sol: Given data:

$\sigma_x = 150$ MPa, $\sigma_y = 30$ MPa,

$\tau_{xy} = 80$ MPa



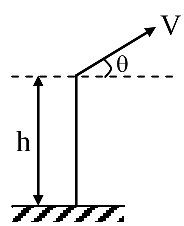
Normal stress on maximum in-plane shear stress plane is given by,

$$\sigma_{avg} = \frac{\sigma_1 + \sigma_2}{2} = \frac{\sigma_x + \sigma_y}{2}$$

$$= \frac{150 + 30}{2} = 90 \text{ MPa}$$

44. Ans: (c)

Sol:



Let the stone is thrown with velocity V at an angle θ to the horizontal and let the stone reaches the ground with speed V′.

By conservation of Mechanical energy.

$$mgh + \frac{1}{2}mV^2 = \frac{1}{2}mV'^2$$

Thus, we see that,

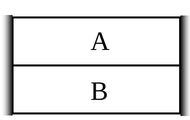
- V' depends on V
- V' is always greater than V .

45. Ans: (a)

Sol: Many types of reinforcing materials are employed. Straw has been used to strengthen mud bricks for centuries. Steel-reinforcing bars are introduced into concrete structures. Glass fibres in a polymer matrix produce fibre glass for transportation and aerospace applications. Fibres made of boron, carbon, polymers and ceramics provide exceptional reinforcement in advanced composites based on matrices of polymers, metals, ceramics, and even inter-metallic compounds.

46. Ans: (a)

Sol: For the given bars A and B which are fixed at both the ends,



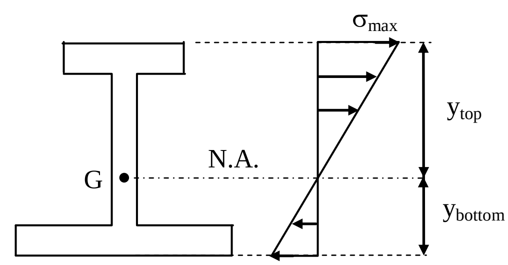
If temperature is decreased, both the bars would like to contract. The rigid supports prevent the contraction; therefore both the bars are under tension.

47. Ans: (a)

Sol: Addition of titanium or niobium to a stainless steel prevents intergranular corrosion.

48. Ans: (a)

Sol: Bending stress distribution across the unsymmetrical I-section is shown in figure below.



Cross section *Bending stress distribution*

As, $\sigma_b = \frac{M}{I}y \Rightarrow \sigma_b \propto y$

Since, $y_{top} > y_{bottom} \Rightarrow (\sigma_b)_{top} \propto (\sigma_b)_{bottom}$

As top fibre is farthest from neutral axis, it always experiences maximum bending stress.

49. Ans: (a)

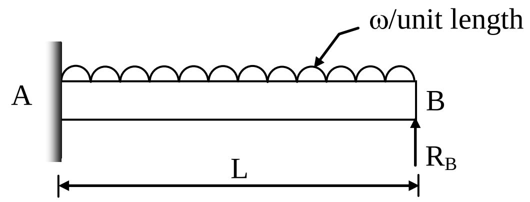
Sol:

- *Stress-corrosion cracking* is an example of the effect of a corrosive environment on the integrity of a product that, as manufactured, had residual stresses. Cold-worked metals are likely to have residual stresses; hence, they are more susceptible to corrosion than are hot-worked or annealed metals.

- Corrosion can also occur along grain boundaries of metals as *intergranular corrosion*, and at the interface of bolted or riveted joints as *crevice corrosion.*
- Corrosion can occur over an entire surface, or it can be localized, called *pitting.*
- Two dissimilar metals may form a galvanic cell that is, two electrodes in an electrolyte in a corrosive environment that includes moisture-and cause *galvanic corrosion.*

50. Ans: (c)

Sol: For the given beam,



Downward deflection of B due to UDL = Upward deflection of B due to R_B

$$\therefore \frac{\omega L^4}{8EI} = \frac{R_B L^3}{3EI}$$

$$\Rightarrow R_B = \frac{3\omega L}{8}$$

51. Ans: (b)

Sol: In a real beam at the fixed support, there is a zero deflection. So, there should be zero bending moment at converted support in conjugate beam.

- Also in real beam at the fixed support, there will be zero slope. So, in conjugate beam, shear force should be zero at converted support.
- Hence, the fixed support of a real beam is assumed to be free end in a conjugate beam to satisfy above criteria.

52. Ans: (d)

Sol: Resistance to corrosion depends on the *composition of the material and on the particular environment.* Corrosive media may be chemicals (acids, alkalis, and salts), the environment (oxygen, moisture, pollution, and acid rain), and water (fresh or salt water).

Non-ferrous metals, stainless steels, and nonmetallic materials generally have high corrosion resistance. Steels and cast irons generally have poor resistance and must be protected by various coatings and surface treatments.

53. Ans: (a)

Sol: Increase in width (b) of the beam section causes decrease in shear stress (as shear stress is inversely proportional to width of the beam).

Shear stress, $\tau = \frac{FAy}{Ib}$

54. Ans: (c)

Sol:

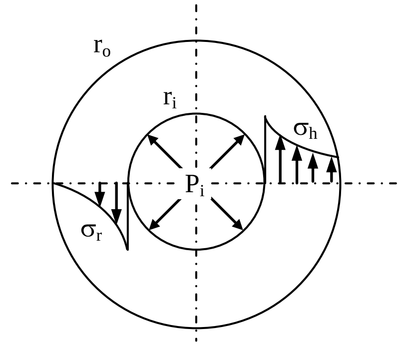
- *Molybdenum (Mo)* has a high melting point, high modulus of elasticity, *good resistance to thermal shock*, and good electrical and thermal conductivity.
- *Niobium* (Nb) it is also referred to as columbium. Niobium possesses *good ductility and formability* and has greater oxidation resistance than other refractory metals.
- *Tungsten*(W) has the *highest melting point of any metal* (3410°C). As a result, it is notable for its high strength at elevated temperatures.
- *Silicon(Si)* is most commonly used as *deoxidizing agent.* If added in higher percent to steel then produces electrical resistance and gives high magnetic permeability.

55. Ans: (c)

Sol:

In case of thick cylinder subjected to internal pressure:

- The element on outer wall is uni-directional only as 'σ_h' is acting along circumferential direction. ($\sigma_l = 0$ and $\sigma_R = 0$)



Hence, statement (1) is true.

- For internal pressure Lame's constants are always positive.

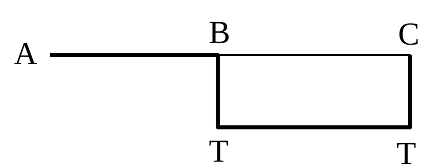
According to Lame's equation for thick cylinders hoop stress, $\sigma_h = \dfrac{b}{x^2} + a$

here, $b = \dfrac{Pr_1^2 r_2^2}{(r_1^2 - r_2^2)}$ and $a = \dfrac{Pr_2^2}{(r_1^2 - r_2^2)}$

Therefore, for internal pressure a, b are positive and for external pressure 'P' is negative; a, b are negative. Hence, statement- 2 is also true.

56. Ans: (c)

Sol: Torsional moment diagram for a given shaft is shown below.



We know that,

$$\frac{T}{J} = \frac{G\theta}{L} \Rightarrow \theta = \frac{TL}{GJ}$$

$$\theta_{C/A} = \theta_{C/B} + \theta_{B/A}$$

Here, $\theta_{B/A} = 0$ as $T_{AB} = 0$

and $\theta_{C/B} = \dfrac{T_{BC}L_{BC}}{GJ}$

$$= \frac{TL}{GJ}$$

$$\Rightarrow \theta_{C/A} = \theta_{C/B} = \frac{TL}{GJ}$$

57. Ans: (d)

Sol:

- In an elastic collision, kinetic energy and linear momentum are conserved.
- In an inelastic collision only linear momentum is conserved.

Hence we can say that in general linear momentum is conserved in a collision.

58. Ans: (b)

Sol: Given data: E = 2K

We know that,

$$E = 3K(1-2\mu)$$

$$\therefore 2K = 3K(1-2\mu)$$

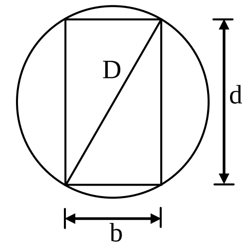
$$\therefore \frac{2}{3} = 1-2\mu$$

$$\therefore 2\mu = 1-\frac{2}{3} = \frac{1}{3}$$

$$\Rightarrow \mu = \frac{1}{6}$$

59. Ans: (b)

Sol:



Strongest beam is the one for which section modulus z is maximum.

Let rectangular section will be of width b and depth d. Diameter of cylindrical log, D = 300 mm

So, $b^2 + d^2 = D^2$

$$z = \frac{bd^2}{6} = \frac{b\times(D^2-b^2)}{6} = \frac{bD^2-b^3}{6}$$

For maximum z,

$$\frac{\partial z}{\partial b} = 0 \Rightarrow \frac{D^2-3b^2}{6} = 0 \Rightarrow D^2 = 3b^2$$

$$\Rightarrow b^2 = \frac{D^2}{3}$$

$$\Rightarrow b = \frac{D}{\sqrt{3}} = \frac{300}{\sqrt{3}}$$

$$= 100\sqrt{3} = 100\times1.73 = 173 \text{ mm}$$

60. Ans: (c)

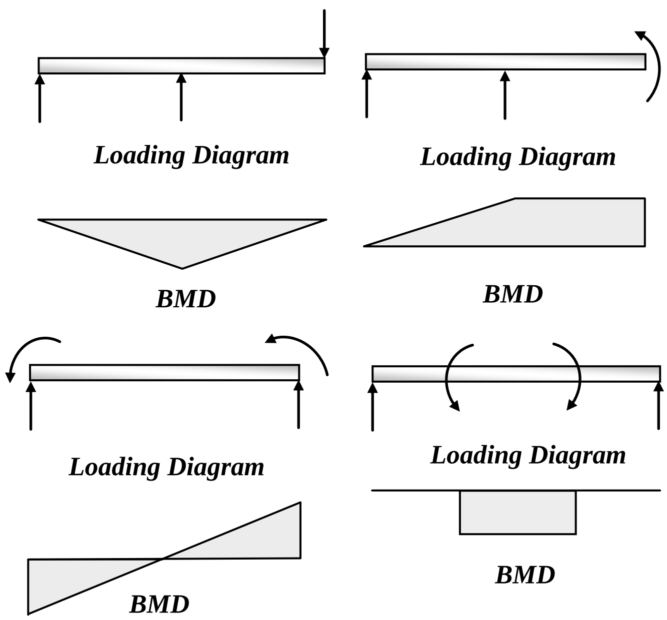
Sol: $W = \dfrac{1}{2}Kx_2^2 - \dfrac{1}{2}Kx_1^2$

$$= \frac{1}{2}K\left(x_2^2 - x_1^2\right)$$

$$= \frac{1}{2}1000\times\left[\left(\frac{10}{100}\right)^2 - \left(\frac{1}{100}\right)^2\right] \cong 5J$$

61. Ans: (c)

Sol: Knowing the fact that, if the beam is subjected to concentrated moment at certain location, then in BMD diagram there will be sudden rise or fall. Also all the beams given in the problem are subjected to either concentrated moment or point load due to the reaction at the supports. Bu considering this, BMD of the beams are shown below.

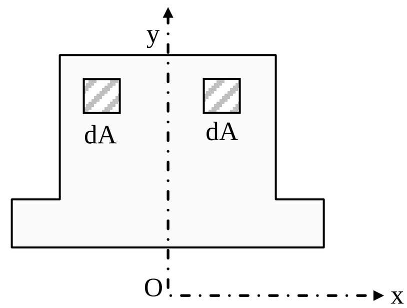


62. Ans: (c)

Sol: Product of inertia with respect to the x and y axes is given by,

$$I_{xy} = \int xy\,dA \text{..........Eq.(1)}$$

A special case arises when one of the axes is an axis of symmetry of the area. For instance, consider the area shown in figure, which is symmetric about the y axis.



For every element dA having coordinates x and y, there exists an equal and symmetrically located element dA having the same y coordinate but an x coordinate of opposite sign. Therefore, the products xy.dA cancel each other and the integral in Eq. (1) vanishes. Thus, the product of inertia of an area is zero with respect to any pair of axes in which at least one axis is an axis of symmetry of the area. Thus, statement (I) is correct.

We know that,

$$I_{x_1y_1} = \frac{I_x - I_y}{2}\sin 2\theta + I_{xy}\cos 2\theta$$

If the product of inertia is zero, then,

$$\frac{I_x - I_y}{2}\sin 2\theta + I_{xy}\cos 2\theta = 0$$

$$\therefore \quad \tan 2\theta = -\frac{2I_{xy}}{I_x - I_y}$$

This equation is different then the equation given in statement (II) for orientation (θ_p) of principal axes. Thus, statement (II) is incorrect.

63. Ans: (b)

Sol: Many low-carbon steels weld easily. Welding of medium- and high-carbon steels is comparatively more difficult since martensite can form in the heat-affected zone rather easily, thereby causing a weldment with poor toughness.

64. Ans: (a)

Sol: The Young's modulus which is represented by the slope of the stress-strain curve in its linear portion is the same in tension and compression.

Thus, according to Hook's law,

$\Rightarrow \sigma = E\varepsilon$

$$\Rightarrow \varepsilon = \frac{\sigma}{E} \quad \Rightarrow \quad \varepsilon \propto \sigma$$

Hence, both the statements are correct and statement (II) is the correct explanation of statement (I).

65. Ans: (a)

Sol: The strain-hardening mechanism is not effective at elevated temperatures, because above recrystalisation temperature grain reformation and grain growth takes place without residual stresses.

66. Ans: (a)

Sol: The dispersed phase particles should be round, rather than needle-like or sharp edged, because the rounded shape is less likely to initiate a crack or to act as a notch.

67. Ans: (d)

Sol: According to flexural formula,

$$\frac{\sigma_b}{y} = \frac{M}{I} = \frac{E}{R} \Rightarrow \sigma_b = \frac{M}{I} y$$

- For a given bending moment (M) maximum bending stress developed will be the same as bending stress developed for a given bending moment is independent of material properties. However, the maximum bending moment taken by aluminium beam at failure is less, as the maximum stress taken by aluminium beam is lesser. Hence, statement (I) is incorrect.
- Thus, bending stress does not depend on Young's modulus of the material. Hence, statement (II) is correct.

68. Ans: (b)

Sol: Annealing, involving a slow furnace cool after austenitizing, produces a coarse pearlitic structure containing lamellar Fe_3C. Normalizing, involving an air cool after austenitizing, produces a fine pearlitic structure and higher strength compared with annealing.

69. Ans: (b)

Sol: **Elastomers** are known as rubbers. They sustain elastic deformations greater than 200%. These may be thermoplastics or lightly cross-linked thermosets. The polymer chains consist of coil-like molecules that can reversibly stretch by applying a force.

70. Ans: (a)

Sol: For a thin spherical vessel,

$$\sigma_h = \sigma_\ell = \frac{Pr}{2t}$$

- Since the principal stresses σ_1 , σ_2 are equal, Mohr's circle for transformations of stress within the plane tangent to the surface of the vessel reduces to a point. The in - plane normal stress is constant, and the in-plane maximum shearing stress is zero.

71. Ans: (d)

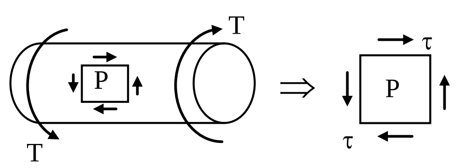
Sol: Superalloys are nickel, iron-nickel, and cobalt alloys that contain large amounts of alloying elements intended to produce a combination of high strength at elevated temperatures, resistance to creep at temperatures up to 1000°C, and resistance to corrosion. These excellent high-temperature properties are obtained even though the melting temperatures of the alloys are about the same as that for steels. Typical applications include vanes and blades for turbine and jet engines, heat exchangers, chemical reaction vessel components, and heat-treating equipment.

72. Ans: (d)

Sol: In hypereutectoid alloys, the primary phase is Fe_3C, which forms at the austenite grain boundaries. After the austenite cools through the eutectoid reaction, the steel contains hard, brittle cementite surrounding islands of pearlite. Now, because the hard, brittle microconstituent is continuous, the steel is also brittle.

73. Ans: (a)

Sol: Mild steel is a ductile material. Ductile material is weaker in shear. In pure torsion, maximum shear stress occurs at angle 90° to the axis of the rod.



Thus, both the statements are correct and statement (II) is the correct explanation of statement (I).

74. Ans: (b)

Sol: In an elastic collision :

- Linear momentum is conserved.
- Initial kinetic energy is equal to final kinetic energy.

75. Ans: (a)

Sol: Grey cast iron consist of graphite flakes so it is exhibits low ductility, the graphite component produces stress concentration, crack initiation sites and resulting brittleness.


OUR GATE - 2018 TOP RANKERS
AIR 1 AKASH CHOUKSEY CE
AIR 1 NAMITA KALRA CSIT
EC TOP 10 9 TOP 100 74
EE TOP 10 7 TOP 100 69
CE TOP 10 7 TOP 100 42
ME TOP 10 4 TOP 100 54
CSIT TOP 10 6 TOP 100 31
IN TOP 10 11 TOP 100 78
PI TOP 10 5 TOP 100 50
OUR ESE - 2017 TOP RANKERS
TOTAL SELECTIONS 196
CE 86
ME 44
EE 36
E&T 30
ACE ENGINEERING ACADEMY
Since 1995
ACE
Engineering Academy
Leading Institute for ESE/GATE/PSUs
43
ALL INDIA 1st RANKS IN GATE
7
ALL INDIA 1st RANKS IN ESE