PRACTICE QUESTIONS

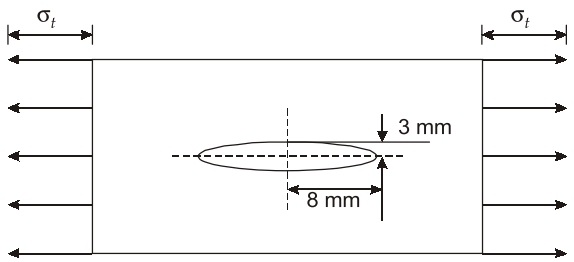
for SSC-JE : CBT-2

Machine Design

Mechanical Engineering

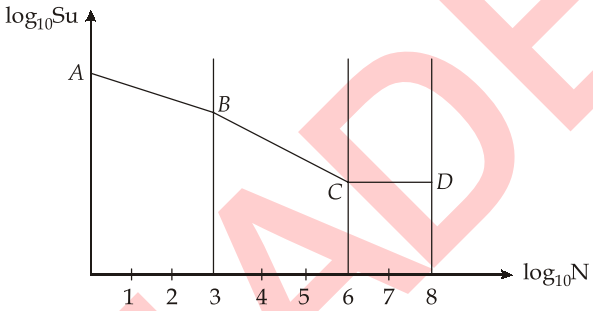
01 Machine Design

Q.1 What will be the value of theoretical stress concentration factor at the edge of the hole as shown below?



(a) 6.33 (b) 3.66
(c) 1.75 (d) 1.375

Q.2 In the given diagram, high cycle fatigue starts from



(a) Point A (b) Point B
(c) Point C (d) Point D

Q.3 A factor which is a measure of the ability of the bearing material to accommodate the frictional energy in the bearing is called:
(a) PV factor (b) Wear factor
(c) Friction coefficient (d) Embeddability factor

Q.4 The bolts in a rigid flanged coupling connecting two shafts transmitting power are subjected to
(a) shear force and bending moment
(b) axial force
(c) torsion
(d) torsion and bending moment

Q.5 Bearing characteristics number in a hydrodynamic bearing can be realized as
(a) it is closer to real life situation.
(b) it leads to a safer design.
(c) it leads to cost effective design.
(d) no other assumption is possible.

Q.6 A transmission shaft subjected to bending loads must be designed on the basis of
(a) maximum normal stress theory
(b) maximum shear stress theory
(c) maximum normal and maximum shear stress theory
(d) fatigue strength

Q.7 The design considerations for members subjected to fluctuating loads with the same factor of safety yield the most conservative estimates when using
(a) Gerber relation (b) Soderberg relation
(c) Goodman relation (d) None of the above

Q.8 Consider the following statements:
1. The severity of stress concentration is increased by drilling additional holes and using multiple notches.
2. A small under cut taken between shank and threaded portion of a component reduces the bending of force flow line, which enhances the stress concentration.

Which of the above statements is/are incorrect?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) None of these

Q.9 The diameter of rivet connecting plate of thickness $t > 8$ in mm is given by Unwin's formula

(a) $d = 6.04\sqrt{t}$ (b) $d = 4.05\sqrt{t}$

(c) $d = 1.9\sqrt{t}$ (d) $d = 1.5\sqrt{t}$

Q.10 A 20° full depth involute spur pinion of 4 mm module and 30 teeth is to transmit 16 kW at 1000 rpm, then the tangential force transmitted is

(a) 936 N (b) 1273 N

(c) 1872 N (d) 2546 N

Q.11 If a bearing has 90% reliability for life L_{90}, it means that life of 90% of the bearing will reach or exceed before fatigue failure, then life for reliability R is given by

(a) $\sqrt[3]{\dfrac{ln\left(\frac{1}{R}\right)}{ln\left(\frac{1}{R_{90}}\right)}} \times L_{90}$

(b) $1.17\sqrt{\dfrac{ln\left(\frac{1}{R}\right)}{ln\left(\frac{1}{R_{10}}\right)}} \times L_{90}$

(c) $1.17\sqrt{\dfrac{ln\left(\frac{1}{R_{90}}\right)}{ln\left(\frac{1}{R}\right)}} \times L_{90}$

(d) $\sqrt[3]{\dfrac{ln\left(\frac{1}{R_{10}}\right)}{ln\left(\frac{1}{R}\right)}} \times L_{90}$

Q.12 Deep groove ball bearings are used for

(a) heavy thrust load body.

(b) small angular displacements of shafts.

(c) radial load at high speed.

(d) combined thrust and radial loads at high speed.

Q.13 Which is not the advantage of wet friction clutch?

(a) High coefficient of friction.

(b) Simplicity of sealing.

(c) Greater operating life.

(d) Smoothness in operation and engagement.

Q.14 Consider the following statements regarding caulking:

1. Caulking and fullering processes are used to obtain leak proof riveted joints in pressure vessels and boilers.
2. The caulking process is applied to the edge of plates in a lap joint and edges of strap in plate in a bolt joint.
3. Caulking is applied to plates with less than 6 mm thickness.
4. In caulking process, the edges are first bevelled to approximately 30 to 45°.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1, 3 and 4 only

(c) 2 and 3 only (d) 1, 2, 3 and 4

Q.15 If the uniaxial yield stress of a material is 450 MPa, then the shear yield strength of the material according to Von-Mises criterion, will be

(a) 225 MPa (b) 259.8 MPa

(c) 112.5 MPa (d) 318.2 MPa

Q.16 Consider the following statements regarding clutches:

1. Positive contact clutches are used in power presses and rolling mills.
2. Jaw clutches can be engaged only if both shafts are stationary.
3. Electromagnetic clutches have rapid response time, ease of control and smooth start and stop.

Which of the above statements are correct?

(a) 1 and 2 (b) 2 and 3

(c) 1 and 3 (d) 1, 2 and 3

Q.17 Match List-I (**Parts**) with List-II (**Function**) and select the correct answer using the codes given below:

List-I

A. Bearing

B. Key

C. Screw fastening

D. Power screw

List-II

1. To produce uniform and slow motion and to transmit the force
2. To hold two or more machine parts together
3. To transmit torque between shaft and pulley
4. To support rotating shaft

Codes:

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

Q.18 A fillet weld is loaded parallel to its length of 15 cm by a load of 50 kN. If the weld leg is 2.5 mm, the average shear stress on the throat area will be

(a) 94.27 MPa (b) 141.4 MPa
(c) 188.53 MPa (d) 212.34 MPa

Q.19 The life of ball bearings in millions of revolutions, if the radial load on bearing is 9.2 kN and dynamic load capacity of bearing is 184 kN, is given by

(a) 400 (b) 4600
(c) 8000 (d) 800

Q.20 In a multiple disc clutch, the axial pressure is not to exceed 0.35 MPa. The inner radius of the disc is 80 mm and outer radius is 150 mm. The axial force as per uniform wear theory will be

(a) 13345 N (b) 12320 N
(c) 11830 N (d) 120121 N

Q.21 If pitch circle diameter of pinion is 500 mm, width of pinion is 200 mm, material combination factor is 0.5 N/mm^2 and gear ratio is 6 for an internal gear arrangement, then wear strength of the pinion is

(a) 60 kN (b) 72 kN
(c) 52 kN (d) 144 kN

Q.22 If a shaft is subjected to a bending moment of 40 kN-m and a twisting moment of 40 kN-m, then equivalent moment on the shaft according to MDET is

(a) 57 kN-m (b) 48 kN-m
(c) 50 kN-m (d) 53 kN-m

Q.23 A steel connecting rod having S_{ut} = 100 MPa S_{yt} = 90 MPa is subjected to completely reversed axial load of 30 kN, if the values of
K_a = Size factor = 0.90
K_b = Surface finish factor = 0.95
K_c = Load factor = 0.75
Then endurance limit of the bar is

(a) 50 MPa (b) 32 MPa
(c) 29 MPa (d) 45 MPa

Q.24 A bearing is subjected under 6 MPa pressure when running at 3000 rpm. If $z = 28 \times 10^{-3}$ Pa.s, D = 500 mm and diametral clearance is 5 mm then, sommerfeld number of the bearing is

(a) 0.14 (b) 2.34×10^{-3}
(c) 1.4×10^{-3} (d) 2.34×10^{-5}

Q.25 If actual coefficient of friction for a shoe brake is 'μ', then equivalent coefficient of friction for long shoe is
[Assume: $2\theta \geq 45°$]

(a) $\mu_{eq} = \dfrac{2\mu \sin 2\theta}{2\theta + \sin\theta}$

(b) $\mu_{eq} = \dfrac{4\mu \sin 2\theta}{2\theta + \sin 2\theta}$

(c) $\mu_{eq} = \dfrac{4\mu \sin 2\theta}{2\theta + \sin\theta}$

(d) $\mu_{eq} = \dfrac{4\mu \sin\theta}{2\theta + \sin\theta}$

Q.26 A band brake acts on the circumference of the drum of 250 mm diameter and half of the circumference of the drum is covered by the band, if band provides a braking torque of 200 N-m, then tension on slack side is

[Take $\mu = \dfrac{1}{\pi}$]

(a) 1600 N (b) 2535.67 N
(c) 935.67 N (d) None of these

Q.27 The expected life of a ball bearing subjected to a load of 10000 N and working at 800 rpm is 4000 hours. What is the expected life of same bearing for a similar load of 5000 N and speed of 2400 rpm?

(a) 12000 hours (b) 6000 hours
(c) 10666.67 hours (d) 16000 hours

Q.28 A 10 cm diameter solid shaft is welded to a flat plate by 2 cm fillet weld, if permissible shear stress in weld metal is not to exceed $\frac{10}{\pi}$ kN/cm^2, then maximum torque that the welded joint can sustain is

(a) 5 kN-m (b) 6 kN-m
(c) 7 kN-m (d) 8 kN-m

Q.29 A stepped shaft has theoretical stress concentration factor of 1.95 and notch sensitivity of 0.80. The fatigue stress concentration factor for the shaft is

(a) 1.81 (b) 1.76
(c) 1.56 (d) 2.18

Q.30 A rotating shaft carrying a unidirectional transverse load is subjected to

(a) constant bending stress
(b) variable shear stress
(c) variable bending stress
(d) constant shear stress

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Answer Keys

1.	(a)	2.	(b)	3.	(a)	4.	(a)	5.	(b)	6.	(a)	7.	(b)
8.	(c)	9.	(a)	10.	(d)	11.	(b)	12.	(d)	13.	(a)	14.	(a)
15.	(b)	16.	(c)	17.	(d)	18.	(c)	19.	(c)	20.	(b)	21.	(b)
22.	(d)	23.	(b)	24.	(b)	25.	(b)	26.	(c)	27.	(c)	28.	(c)
29.	(b)	30.	(c)										

Detailed Solutions

1. (a)

Theoretical stress concentration factor,

$$k_t = 1 + 2\left(\frac{a}{b}\right)$$

Here, a = 8 mm and b = 3 mm

$$k_t = 1 + 2\left(\frac{8}{3}\right) = 6.33$$

2. (b)

High cycle fatigue failure occurs if the number of stress cycles are more than 1000.

3. (a)

The PV value the pressure (P) multiplied by the speed of operation (V) - measures the ability of the bearing material to accommodate the temperature limit generated by the frictional energy during operation.

4. (a)

A rigid flange coupling consists of two flanges one keyed to the driving shaft and other keyed to the driven shaft. These two flanges are connected together by means of bolts. Bolts of flange dcoupling fail under two modes of failure.

(i) Shearing of bolts.
(ii) Crushing or bending of bolts.

7. (b)

A straight line joining σ_e on the ordinate and σ_y on the abscissa is called Soderberg line, which is most conservative criterion.

8. (c)
- A small undercut between the shank and the threaded portion of the component and a fillet radius provided for this under cut, reduces bending of the force flow line and consequently reduces stress concentration.
- The severity of stress concentration is reduced by using multiple notches, drilling additional holes and removal of undesired materials.

9. (a)
For plate thickness ($t > 8$ mm), Unwin's formula is given by $d = 6.04\sqrt{t}$.

10. (d)
Radius of pinion,

$$r = \frac{mt}{2} = \frac{4\times10^{-3}\times30}{2} = 60\times10^{-3}\ \text{m}$$

$$\text{Tangential force } F_t = \frac{P}{R\times\frac{2\pi N}{60}}$$

$$= \frac{16\times10^{3}}{60\times10^{-3}\times\frac{2\times\pi\times1000}{60}} = \frac{8\times10^{3}}{\pi}\text{N}$$

$= 2546.48$ N

11. (b)

$$\text{Life at any reliability, } \frac{L}{L_{90}} = \left[\frac{\ln\left(\frac{1}{R}\right)}{\ln\left(\frac{1}{E_{90}}\right)}\right]^{\frac{1}{1.17}}$$

12. (d)
Deep groove ball bearings are able to bear thrust and radial loads at high speed.

13. (a)
(i) The wet friction is about one third of dry friction clutch.
(ii) The torque capacity of dry clutch is more as compared with the torque capacity of wet clutch of the same dimensions.
(iii) In wet clutches, the lubricating oil carries away the friction heat.

14. (a)
- Caulking cannot be applied to plates with less than 6 mm thickness.
- Edges are beveled to approximately 70° to 75°.

15. (b)
As per Von-Mises theory,

$$\tau_y = \frac{\sigma_y}{\sqrt{3}} = \frac{450}{\sqrt{3}} = 150\sqrt{3} = 150\times1.732$$

$\tau_y = 259.8$ MPa

16. (c)
Jaw clutches can be engaged only when both shafts are stationary or rotate with very small speed difference.

17. (d)
- Bearing is a machine element that supports a rotating shaft and it guides and confines its motion.
- Key is used to transmit torque between shaft and pulley.
- Screw fastening is used to hold two or more machine parts together.
- Power screw is used to produce uniform and slow motion and to transmit the force.

18. (c)
Average shear stress,

$$\tau_{avg} = \frac{P}{lt}$$

At throat, $t = \frac{h}{\sqrt{2}}$

$$\therefore \quad \tau_{avg} = \frac{\sqrt{2}\times P}{lh}$$

$$\tau_{avg} = \frac{1.414\times50000}{150\times2.5} = 188.53\ \text{MPa}$$

19. (c)

$$\text{For ball bearings, } L = \left(\frac{C}{P}\right)^3 = \left(\frac{184}{9.2}\right)^3 = 8000$$

20. (b)

According to uniform wear theory,

$F = 2\pi R_i (R_o - R_i) \times P$

$F = 2 \times \frac{22}{7} \times 0.08(0.150 - 0.08) \times 0.35 \times 10^6$

$F = 12320\ \text{N}$

21. (b)

$F_w = D_p \cdot b \cdot Q \cdot K = (500)(200)\left(\frac{2(6)}{6-1}\right)(0.5)$

$F_w = 72000\ \text{N}$

$F_w = 72\ \text{kN}$

22. (d)

According to MDET,

$M_e = \sqrt{M^2 + \frac{3}{4}T^2} = \sqrt{(40)^2 + \frac{3}{4}(40)^2}$

$M_e = \sqrt{2800}$

$M_e = 52.92 \approx 53\ \text{kN-m}$

23. (b)

$\left(\sigma_e^*\right) = 0.5\ S_{ut} = 0.5\ (100) = 50\ \text{MPa}$

Now, $\sigma_e = K_a\ K_b\ K_c \left(\sigma_e^*\right) = 0.90(0.95)(0.75)50$

$\sigma_e \approx 32\ \text{MPa}$

24. (b)

$\Rightarrow \quad S = \left(\frac{Zn}{P}\right)\left(\frac{D}{C}\right)^2$

$S = \left\{\frac{\left(28 \times 10^{-3} \times \frac{3000}{60}\right)}{6 \times 10^6}\right\} \times \left(\frac{500}{5}\right)^2$

$S = \frac{28 \times 50}{6} \times 10^{-9} \times 10^4$

$S = 233.33 \times 10^{-5} \approx 2.34 \times 10^{-3}$

25. (b)

For long shoe brake,

$\mu_{eq} = \frac{4\mu \sin\theta}{2\theta + \sin 2\theta}, \quad 2\theta \geq 45°$

26. (c)

$\frac{T_1}{T_2} = e^{\mu\theta} = e^{\left(\frac{1}{\pi}\right)\left(180\left(\frac{\pi}{180}\right)\right)} = e^1 = 2.71 \ldots (i)$

Torque

$= (T_1 - T_2)(r) \Rightarrow 200 = (T_1 - T_2)\left(\frac{250}{2} \times 10^{-3}\right)$

$T_1 - T_2 = 1600 \quad \ldots (ii)$

From equation (i) and (ii)

We get, $T_1 = 2535.67\ \text{N}$

$T_2 = 935.67\ \text{N}$

27. (c)

For bearings:

$L(P)^3 = \text{constant}$

$\Rightarrow \quad \frac{L_1}{L_2} = \left(\frac{P_2}{P_1}\right)^3$

$\Rightarrow \quad \frac{800 \times 60 \times 4000}{2400 \times 60 \times t_2} = \left(\frac{5000}{10000}\right)^3$

$t_2 = \frac{8 \times 800 \times 60 \times 4000}{2400 \times 60} = 10666.67\ \text{hours}$

28. (c)

$h = 2\ \text{cm};\ d = 10\ \text{cm};\ \tau = \frac{10}{\pi}\ \text{kN/cm}^2$

For circular fillet weld, $\tau = \frac{2.83\ T}{\pi d^2\ h}$

$\Rightarrow T = \frac{\left(\frac{10}{\pi}\right)(\pi)(10^2)(2)}{2.83}$

$T = 706.71\ \text{kN - cm} \approx 7\ \text{kN-m}$

29. (b)

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

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

$= 1 + 0.8\ (1.95 - 1) = 1 + 0.8\ (0.95) = 1.76$

30. (c)

Some fibres will be subjected to tensile stress and some will be subjected to bending stress.

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