MACHINE DESIGN TEST 6

Number of Questions 25 **Time:60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. Which of these welding processes is similar to casting process?
(A) Fusion welding (B) Electric arc welding
(C) Thermit welding (D) Gas welding

2. In design of circumferential lap joint for boilers, the number of rivets can be calculated by considering
(A) Bending failure (B) Shearing failure
(C) Tearing failure (D) Crushing failure

3. The pressure angle is maximum in cycloidal teeth gears mating, at
(A) Pitch point
(B) In between pitch point and end of engagement
(C) Start of engagement
(D) In between pitch point and start of engagement.

4. The objective of providing backlash on spur gears is
(A) To compensate for thermal expansion
(B) To prevent jamming
(C) To compensate for machining errors
(D) All of the above

5. In a single block brake if the frictional force adds up to the moment applied and helps in braking then they are called as
(A) Anti lock brakes (B) Self-locking brakes
(C) Self-energizing brakes (D) Anti skid brakes

6. The actual coefficient of friction and the angle of a shoe brake are 0.4 and $\frac{7}{18}\pi$ rad. What is the equivalent coefficient of friction of the shoe brake?
(A) 0.4 (B) 0.596
(C) 0.301 (D) 0.487

7. Which of these riveted joints produces a double shear in the rivets?
(A) Single rivet lap joint
(B) Double rivet lap joint
(C) Double cover single rivet butt joint
(D) Single cover single rivet butt joint

8. The life of a ball bearing at a speed of 500 rpm is 27,000 hours. What is the life of bearing in million revolutions?
(A) 81 (B) 810
(C) 8.1 (D) 8100

9. A sliding contact bearing which has an angle of contact of 120° and the diameters of the journal and the bearing are equal is known as
(A) Full journal bearing (B) Fitted bearing
(C) Thick film bearing (D) Hydrostatic bearing

10. Which of these bearings have the least starting coefficient of friction?
(A) Full journal bearing
(B) Partial journal bearing
(C) Boundary lubricated bearing
(D) Radial ball bearing

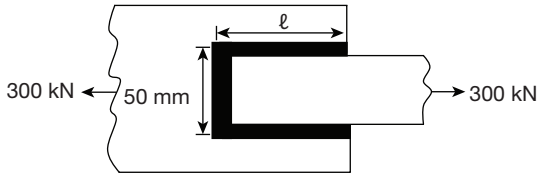
11. In riveted joints, why are butt joints preferred over lap joints for heavy load transmission?
(A) Due to the couple formed by forces in lap joints.
(B) Due to the caulking in lap joints.
(C) Due to the fullering in butt joints.
(D) Due to the couple formed by forces in butt joints.

12. The efficiency of single strap single riveted butt joint is 60% when the pitch is twice the thickness of the plate. If tearing resistance is considered as least for calculating the efficiency, what is the thickness of the plate in terms of the diameter of the rivet hole (d)?
(A) $\frac{d}{0.2}$ (B) $\frac{d}{1.2}$
(C) $\frac{d}{0.8}$ (D) $\frac{d}{1.8}$

13. In a single riveted lap joint the rivet diameter and the thickness of plates are 25 mm and 15 mm respectively. The ultimate stresses are 350 MPa in tension and 280 MPa in shear of the plate material. What is the efficiency of the riveted joint for a pitch of 80 mm, neglecting crushing of the rivets?
(A) 68.75% (B) 41.25%
(C) 60.7% (D) 65.5%

14. A metal of allowable tensile stress of 70 MPa and allowable shear stress of 50 MPa is joined in two different cases:
(1) Double transverse fillet weld.
(2) Double parallel fillet weld.
If the size and length of welds are equal for both the cases, what is the ratio of strength of the joints of the first case to the second?
(A) 1.4 (B) 0.71
(C) 0.4 (D) 2.5

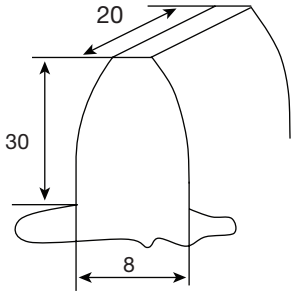
15. A single transverse and double parallel fillet weld has allowable shear load per mm as 500 N. What is the length of the parallel fillet if the size of the fillet is 7 mm?



(A) 250 mm (B) 275 mm
(C) 300 mm (D) 325 mm

16. The interference points of two involute gears in motion (mating) lie on the
(A) Common tangent of the base circles
(B) Common tangent of the pitch circles
(C) Common tangent of the Maximum addendum circles.
(D) Common normat at the pitch point.

17. The permissible bending stress of a gear material is 150 MPa with a radial load of 100 N acting upon it. What is the magnitude of the resultant load acting on the tooth for the given dimensions?



(A) 1066.67 N (B) 1166.67 N
(C) 1071.34 N (D) 1171.34 N

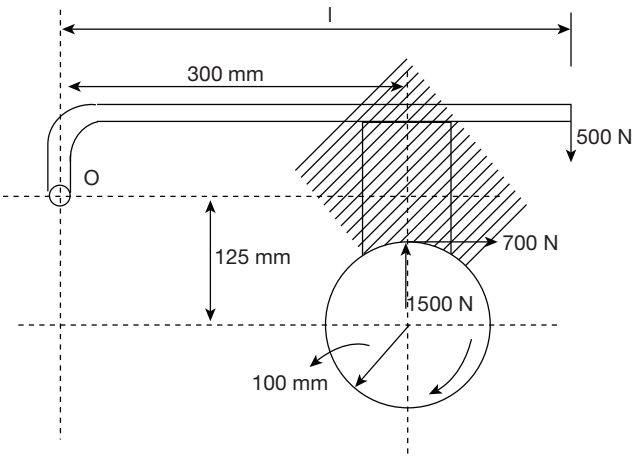
18. Match List-I with List-II

List-I	List-II
P. Static load	1. Minimum number of teeth on pinion
Q. Contact ratio	2. Deflections of teeth on loading
R. Interference	3. Arc of contact, Circular pitch
S. Dynamic load on teeth	4. Lewis equation

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

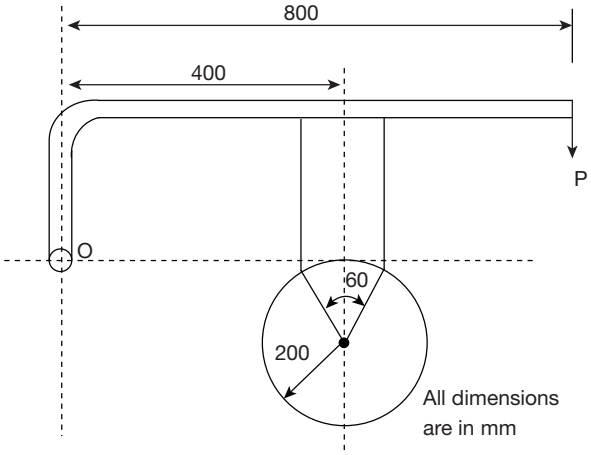
19. A motorcycle moving on an inclined road with a velocity of 30 m/s is of total mass 300 kg. The change in inclination of the vehicle when it comes to rest within a distance of 100 m is 5 m. What is the minimum coefficient of friction between the tyres and the road so that the tyres do not skid if the vehicle is moving downhill? (Assume that total energy is observed by the brake)
(A) 0.5 (B) 0.46
(C) 0.4 (D) 0.56

20. A single block brake has the dimensions as given in the figure. What is the length of the lever when there is uniform normal pressure acting in between the block and the wheel?



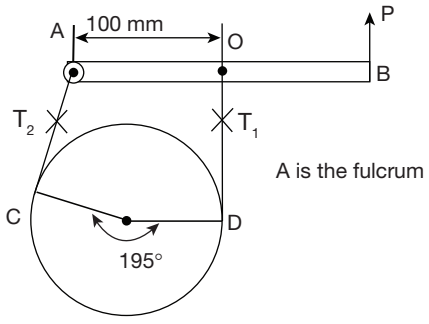
(A) 900 mm (B) 935 mm
(C) 865 mm (D) 820 mm

21. A shoe brake of shoe width 150 mm has a bearing pressure on shoe of 3 bar. What is the amount of the force P for the given dimensions in the figure?



(A) 2250 N (B) 4500 N
(C) 9000 N (D) 7795 N

22. A band brake operates a drum of 300 mm diameter using a lever (*AB*) of 500 mm long. What is the ratio of tensions in the band *AC* when the drum rotates clockwise and anticlockwise for a coefficient of friction of 0.25?



(A) 0.182 (B) 5.48
(C) 0.463 (D) 0.364

23. The angle of contact of a square bearing of 50 mm diameter is 360° which is rotating at 900 rpm. If the coefficient of friction is 0.005 and the bearing pressure is 1.5 N/mm^2 what is the amount of heat generated?
(A) 44.178 W (B) 34.698 W
(C) 4.417 W (D) 3.469 W

24. Sommerfeld number of a hydrodynamic journal bearing is 14.3×10^6. The viscosity of the lubricant at a bearing pressure of 2 N/m^2 is 0.018 kg/m-s. What is the coefficient of friction if the journal is rotating at 900 rpm? (Neglect the end leakage factor)
(A) 0.0055 (B) 0.0045
(C) 0.0035 (D) None

25. A roller bearing and a ball bearing have the dynamic load rating and equivalent dynamic load as 80 kN and 7.5 kN. What is the ratio of working life in hours of the ball bearing to the roller bearing?
(A) 2.201 (B) 0.454
(C) 1.082 (D) 0.924

Answer Keys

1. C	**2.** B	**3.** C	**4.** D	**5.** C	**6.** D	**7.** C	**8.** B	**9.** B	**10.** D
11. A	**12.** C	**13.** D	**14.** A	**15.** B	**16.** A	**17.** C	**18.** C	**19.** A	**20.** B
21. B	**22.** A	**23.** A	**24.** C	**25.** B					

Hints and Explanations

1. A mixture called thermit is ignited and poured into a mould made around the joint in thermit welding which is similar to melting and casting process. Choice (C)

2. Since it is a lap joint the rivets will be in single shear. Choice (B)

3. The pressure angle is maximum at the beginning of engagement, reduces to zero at the pitch point and again becomes maximum at the end of engagement. Choice (C)

4. Choice (D)

5. Choice (C)

6. As the angle of contact is $\left(\frac{7}{18}\pi = 70^o\right) > 60^o$ uniform wear of the brake lining occurs.
The equivalent coefficient of friction is

$$\mu^1 = \frac{4\mu \operatorname{Sin}\theta}{2\theta + \operatorname{Sin} 2\theta}$$

$\mu = 0.4$, $\theta = \frac{7}{18}\pi$

$\Rightarrow$ $2\theta = 140^o \Rightarrow \theta = 70^o$

$\therefore$ $\mu^1 = \frac{4 \times 0.4 \times \operatorname{Sin} 70}{\frac{7}{9}\pi + \operatorname{Sin} 140} = 0.487$ Choice (D)

7. The shearing takes place at two cross-sections of a rivet in double cover butt joint. Choice (C)

8. $L = 60\, N\, L_H$
$L_H = 27000$ hours, $N = 500$ rpm
$\therefore$ $L = 60 \times 500 \times 27000$
$L = 810 \times 10^6$ revolutions Choice (B)

9. Choice (B)

10. The rolling contact bearings offer low starting friction, ball bearings are a type of rolling contact bearings. Choice (D)

11. In lap joint, the forces acting are not in the same straight line. These forces form a couple which may bend the joint. On the other hand, the forces act in a same straight line in butt joint, therefore there will be no couple. Hence butt joints are preferred for heavy loads. Choice (A)

12. Tearing resistance = $P_t = (P - d).t\, \sigma_t$

Efficiency, $\eta = \frac{P_t}{P.t.\sigma_t} = \frac{(P-d)t.\sigma_t}{P.t.\sigma_t}$

$\therefore$ $\eta = 0.6 = \frac{(2t-d)t}{2t^2}$ $(\because P = 2t)$

$\therefore$ $1.2t^2 = 2t^2 - dt$

$\Rightarrow$ $dt = 0.8\, t^2$

$\Rightarrow$ $t = \frac{d}{0.8}$ Choice (C)

13. Tearing resistance = $P_t = (P - d).t.\, \sigma_t$
$P_t = (80 - 25).15.350 = 288750$ N

Shearing resistance = $P_s = n \times \frac{\pi}{4} d^2 \times \tau$

$n = 2$

$\because$ Single riveted lap joint

$\therefore$ $P_s = 2 \times \frac{\pi}{4} \times 25^2 \times 280 = 274889.3572$ N

$\therefore$ Efficiency of the joint $= \frac{Least\ of\ P_t, P_s}{P.t.\sigma_t}$

$\therefore$ $\eta = \frac{274889.3572}{80 \times 15 \times 350} = 0.655$

$\therefore$ $\eta = 65.5\%$ Choice (D)

14. 1. Double transverse fillet weld.
P_1 = strength = $1.414 \times s \times t \times \sigma_t$
$\therefore$ $P_1 = 1.414 \times s \times t \times 70\ MN$
2. Double parallel fillet weld
P_2 = strength = $1.414 \times s \times t \times \tau$
$\therefore$ $P_2 = 1.414 \times s \times t \times 50\ MN$
$\therefore$ $P_1 : P_2 = \frac{70}{50} = 1.4$ Choice (A)

15. Total length of weld = $2\ell + 50$ mm
Allowable load on the weld = $(2\ell + 50) \times 500$ N
$\therefore$ $300 \times 10^3 = (2\ell + 50)500$
$\ell = 275$ mm Choice (B)

16. The points on the common tangent to the base circles of the two mating gears upto which the diameters of the addendum circles can be increased without interference are called interference points. Choice (A)

17. $\sigma = 150$ MPa = 150 N/mm^2
By Lewis equation
$W_t = \sigma.b.t^2/6.h$
Here, $b = 20$ mm, $t = 8$ mm, $h = 30$ mm
$\therefore$ $W_t = \frac{150 \times 20 \times 8^2}{6 \times 30} = 1066.67$ N
W_r = radial load = 100 N
$\therefore$ Resultant load = $\sqrt{W_t^2 + W_r^2} = \sqrt{1066.67^2 + 100^2}$
= 1071.344 N Choice (C)

18. Choice (C)

19. As the motor cycle is moving downhill the energy absorbed $E = E_k + E_p$
$E_k = \frac{1}{2} mv^2$
$m = 300$ kg, $v = 30$ m/s
$\therefore$ $E_k = \frac{1}{2} \times 300 \times 30^2 = 135000$ J
$E_P = mgh = 300 \times 9.81 \times 5 = 14715$ J
$\therefore$ $E = 135000 + 14715 = 149715$ J
The vehicle is stopped in a distance of 100 m, therefore tangential braking force is
$F_t = \frac{E}{100} = 1497.15$ N
$\therefore$ Tangential force = μR_N
μ = coefficient of friction between the tyres and the road.
R_N = Normal force/weight of the motor cycle
$\therefore$ $1497.15 = \mu \times 300 \times 9.81 \Rightarrow \mu = 0.509$
Choice (A)

20. As there is uniform pressure between the wheel and the block by considering moments about point 0 we get
$R_N = 1500$ N, $F_t = 700$ N, $P = 500$ N, $a = 25$ mm
$x = 300$ mm, $a = (125 - 100) = 25$ mm
$\therefore$ $R_N \times x + F_t \times a = P \times l$
Frictional force $F_t = \mu \times R_N \Rightarrow \mu = 0.467$
$\therefore$ $(1500 \times 0.3) + (700 \times 0.025) = 500 \times l$
$\Rightarrow$ $l = 0.935 \Rightarrow l = 935$ mm Choice (B)

21. The angle of contact, $2\theta = 60^o$
$\Rightarrow$ $\theta = 30^o < 60^o$
$\therefore$ Uniform pressure is acting between the block and the wheel.
$\therefore$ $P_b = 3$ bar $= 3 \times 10^5\ Pa = \frac{R_N}{A}$
$A = w\ (2r \sin \theta)$
w = width of shoe = 150 mm = 0.15 m
r = radius of wheel = 200 mm = 0.2 m
$\therefore$ $A = 0.15 \times 2 \times 0.2 \times \sin 30 = 0.03$ m^2
$\therefore$ $R_N = P_b \times A = 3 \times 10^5 \times 0.03 = 9000$ N
$\therefore$ By taking moments around 0.
$R_N \times 0.4 = P \times 0.8 \Rightarrow P = \frac{R_N \times 0.4}{0.8}$
$\therefore$ $P = 4500$ N Choice (B)

22. $\mu = 0.25$, $\theta = 195^o = 3.403$ rad
$\therefore \frac{T_1}{T_2} = e^{\mu\theta}$, when the drum is rotating clockwise
$\therefore$ $T_1 = T_2\ e^{0.25 \times 3.403}$
$\Rightarrow$ $T_1 = 2.341.T_2$
Taking moments about A,
$T_1 \times 0.1 = P \times 0.5$
$\Rightarrow$ $T_1 = 5P$
$\Rightarrow$ Tension in band $AC = T_2 = 2.136.P$
When the drum rotates anticlockwise
$T_2 > T_1$
$\Rightarrow$ $\frac{T_2}{T_1} = e^{\mu\theta} \Rightarrow T_2 = 2.341.T_1$
Taking moments about A,
$T_1 \times 0.1 = P \times 0.5 \Rightarrow T_1 = 5P$
$\Rightarrow$ $T_2 = 11.705.P$ (anti clockwise)
$\therefore$ $\frac{T_{clock}}{T_{anticlock}} = \frac{2.136}{11.705} = 0.1825$ Choice (A)

23. A square bearing has the journal diameter equal to the journal length.
$\therefore$ W = Load on the bearing = $P.(d \times l) = P.d^2$
$P = 1.5$ N/mm^2, d = 50 mm
$\therefore$ $W = 1.5 \times 50^2 = 3.75$ kN
H_g = Heat generated = $\mu.W.V$
$V = \frac{\pi dN}{60} = \frac{\pi \times 50 \times 10^{-3} \times 900}{60} = 2.3562$ m/s
$\therefore$ $H_g = 0.005 \times 3.75 \times 10^3 \times 2.3562$
$H_g = 44.178$ W Choice (A)

24. Sommerfeld number = $\left(\frac{ZN}{P}\right)\left(\frac{d}{C}\right)^2$
$Z = 0.018$ kg/m-s, $N = 900$ rpm, $P = 2$ N/m^2

$$\therefore \quad \frac{0.018\times900}{2}\left(\frac{d}{C}\right)^2 = 14.3 \times 10^6$$

$$\therefore \quad \frac{d}{C}=1328.7$$

The coefficient of friction is given by the Mckee equation:

$$\mu = \frac{33}{10^8}\left(\frac{ZN}{P}\right)\left(\frac{d}{C}\right)+k$$

$$\therefore \quad \mu=\frac{33}{10^8}\times\frac{0.018\times900}{2}\times1328.7 \qquad \text{(here, } k=0\text{)}$$

$\mu = 3.55 \times 10^{-3} = 0.0035$ Choice (C)

25. Bearing life in revolutions is

$$L=\left(\frac{C}{W}\right)^k\times10^6$$

where $k = 3$ for ball bearings
$k = 10/3$ for roller bearings.
$C = 80$ kN, $W = 7.5$ kN
Working life in hours is

$$L_H=\frac{L}{60.N}$$

$$\therefore \quad (L_H)_{\text{ball}}=\frac{L_{ball}}{60.N}$$

$$(L_H)_{\text{roller}}=\frac{L_{roller}}{60.N}$$

$$\therefore \quad (L_H)_{\text{ball}}:(L_H)_{\text{roller}} = L_{\text{ball}}:L_{\text{roller}}$$

$$=\left(\frac{C}{W}\right)^3:\left(\frac{C}{W}\right)^{\frac{10}{3}}$$

$$=\left(\frac{80}{7.5}\right)^3:\left(\frac{80}{7.5}\right)^{\frac{10}{3}} = 0.4543$$ Choice (B)