S.No. : 06 GH1_ME_T_180719
Machine Design

MADE EASY
India's Best Institute for IES, GATE & PSUs

Delhi | **Noida** | **Bhopal** | **Hyderabad** | **Jaipur** | **Lucknow** | **Indore** | **Pune** | **Bhubaneswar** | **Kolkata** | **Patna**

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

CLASS TEST 2019-2020

MECHANICAL ENGINEERING

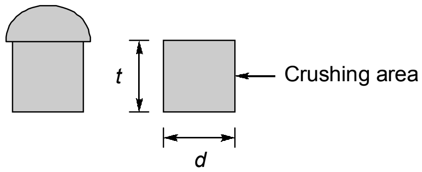
Date of Test : 18/07/2019

ANSWER KEY ➤ Machine Design

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

DETAILED EXPLANATIONS

1. (b)



$$(P_{max})_{crushing} = dt\sigma_{per}$$
$$(P_{max})_{solid} = bt\sigma_{per}$$
$$\text{Crushing efficiency} = \frac{dt\sigma_{per}}{bt\sigma_{per}} = \frac{18}{50} = 36\%$$ ss

2. (c)

$$P = \mu WV = \mu W.\frac{\pi DN}{60}$$
$$= 0.002 \times 30 \times 10^3 \times \frac{\pi \times 45 \times 10^{-3} \times 500}{60} = 70.68 \text{ W}$$

3. (b)

$$\frac{D}{C} = 80$$
$$z = 30 \times 10^{-3} \text{ Pa-s}$$
$$n = \frac{2500}{60} \text{ rps}$$
$$s = \frac{zn}{p}\left(\frac{D}{C}\right)^2 = \frac{30 \times 10^{-3} \times 2500}{60 \times 1.6 \times 10^6}(80)^2 = 0.005$$

5. (c)

$$T_{min} = \frac{2A_r}{\sin^2\phi} = \frac{2 \times 1}{\sin^2 14.5°} = 31.9 \simeq 31.9$$

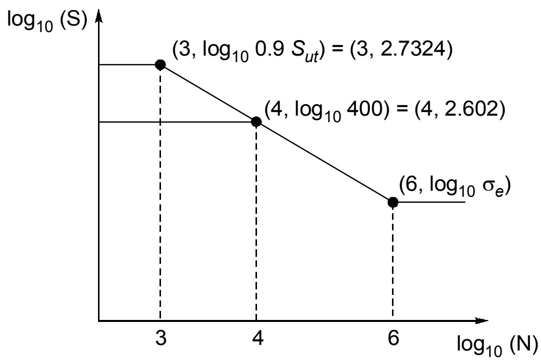
7. (b)

$$k_t = 1 + \frac{2b}{a} = 1 + 2 \times \frac{1}{3} = 1 + \frac{2}{3} = \frac{5}{3}$$

8. (b)

$$\tau_{max} = \frac{5.66M}{\pi d^2 t}$$
$$M = 6 \times 10^3 \times 120 = 72 \times 10^4 \text{ N-mm}$$
$$t = \frac{566 \times 72 \times 10^4}{105 \times \pi \times 28^2} = 15.75 \text{ mm}$$

10. (a)



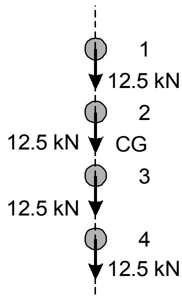
$$\frac{2.602 - 2.7324}{4 - 3} = \frac{\log_{10}\sigma_e - 2.602}{6 - 4}$$

$$\sigma_e = 219.3814 \text{ MPa}$$

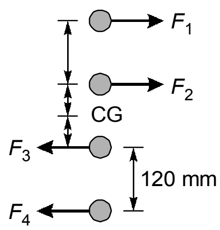
11. (d)

Primary force

$$P_1 = P_2 = P_3 = P_4 = \frac{50}{4} = 12.5 \text{ kN}$$



Secondary force



$$F_1 \times 180 + F_2 \times 60 + F_3 \times 60 + F_4 \times 180 = 50 \times 10^3 \times 150 \quad \text{...(i)}$$

$$\frac{F_1}{180} = \frac{F_2}{60} = \frac{F_3}{60} = \frac{F_4}{180} = k \quad \text{...(ii)}$$

From (i) and (ii),

$$k(180^2 + 60^2 + 60^2 + 180^2) = 50 \times 10^3 \times 150$$

$$k = 104.16$$

From (ii),

$$F_1 = 180 \times 104.166 = F_4 = 18750 \text{ N}$$
$$F_2 = 60 \times 104.166 = F_3 = 6250 \text{ N}$$

Maximum force will be at rivet 1 and 4 i.e. these are critical rivets

$$\text{diameter} = d$$

$$\tau = \frac{\text{Net force on 1 or 4}}{\text{Sheared area}}$$

$$\text{Net force} = \sqrt{12.5^2 + 18.75^2} = 22.534 \text{ kN}$$

$$\tau = \frac{22.534 \times 10^3}{\frac{\pi}{4} \times d^2}$$

$$\Rightarrow \quad d = \sqrt{\frac{22.534 \times 10^3 \times 4}{\pi \times 80}}$$

$$d = 18.938 \text{ mm}$$

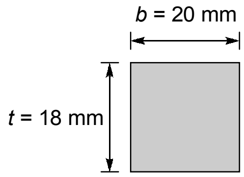
12. (d)

$$F_r = 10 \times 10^3 \text{ N}$$
$$L_{90} = 9000 \times 60 \times 1200 = 648 \times 10^6 \text{ revolutions}$$
$$L_{90} = \left(\frac{C}{P_e}\right)^k, \; P_e = F_r$$
$$648 = \left(\frac{C}{10 \times 10^3}\right)^3$$
$$C = 10000 \times 648^{1/3} = 86534.97 \text{ N} = 86.53 \text{ kN}$$

13. (a)

$$\text{Equivalent load} = P_e$$
$$P_e^{\,3} = \frac{18000^3 \times 0.3 \times 600 + 12000^3 \times 0.4 \times 800 + 6000^3 \times 0.3 \times 400}{0.3 \times 600 + 0.4 \times 800 + 0.3 \times 400}$$
$$= 13797.84 \text{ N}$$
$$P_e = 13797.84 \text{ N}$$
$$L_{90} = \left(\frac{45000}{13797.84}\right)^3 = 34.69 \text{ million revolutions}$$

14. (a)



$$P = \frac{2\pi NT}{60}$$

$$\Rightarrow \quad T = \frac{60 \times 35 \times 10^3}{2 \times \pi \times 800} = 417.781 \text{ N-m}$$

$$T = F_t \times R$$

$$\Rightarrow \quad F_t = \frac{T}{R} = \frac{417.781}{0.02} = 20889.05 \text{ N}$$

$$\tau_{ind} = \frac{F}{bl}$$

$$\Rightarrow \quad 90 \times 0.577 = \frac{20889.05}{20 \times l}$$

$$l = \frac{20889.05}{90 \times 0.577 \times 20} = 20.11 \text{ mm}$$

15. (b)

$$\text{Power} = 2\pi N T_f/60$$

$$T_f = n \,.\, 2\pi\, R_i\, \mu\, (R_o^2 - R_i^2)\, P$$

$$= 1 \times 2 \times \pi \times \frac{0.15}{2} \times 0.3\left(0.15^2 - 0.075^2\right) \times 20 \times 10^3$$

$$= 47.71 \text{ N-m}$$

$$\text{Power} = \frac{2 \times \pi \times 600}{60} \times 47.71 = 2997.89 \text{ W} = 2.998 \text{ kW} \simeq 3 \text{ kW}$$

16. (c)

$$\omega_1 = \frac{2\pi \times 0.8 \times 1000}{60} = 83.7758 \text{ rad/s}$$

$$\omega_2 = \frac{2\pi \times 1000}{60} = 104.7197 \text{ rad/s}$$

$$r_g = 0.15 \text{ m}$$

$$r_d = 0.18 \text{ m}$$

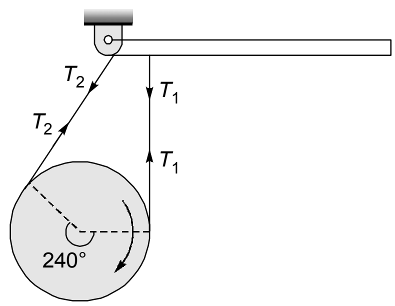
$$T_f = \frac{60 \times 10^6 \times (\text{kW})}{2\pi N_2} = \frac{60 \times 10^6 \times 25}{2 \times \pi \times 1000}$$

$$= 238732.41 \text{ N-mm} = 238.732 \text{ N-m}$$

$$T_f = n\,\mu\, r_g\, r_d\, m\, (\omega_2^2 - \omega_1^2)$$

$$m = 1.86 \text{ kg}$$

17. (d)



$$\frac{T_1}{T_2} = e^{\mu\theta} \qquad \text{...(i)}$$

$$T_f = (T_1 - T_2)R \qquad \text{...(ii)}$$

$$T_2 = 1000 \text{ N}$$

$$\mu = ?$$

$$\theta = \frac{240°}{180°} \times \pi = \frac{4\pi}{3}$$

$$P = \frac{2\pi N T_f}{60}$$

$$T_f = 891.267 \text{ N-m}$$

From (ii)

$$891.267 = (T_1 - 1000) \times \frac{0.35}{2}$$

$$T_1 = 6092.93 \text{ N}$$

From (i)

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$\Rightarrow$
$$\frac{6092.93}{1000} = e^{\mu \cdot \frac{4\pi}{3}}$$

$$\mu = 0.431$$

18. (d)

$$\tau_{max} = \frac{8WD}{\pi d^3} K_w\ , \quad c = 8 = \frac{D}{d}$$

$$K_w = \frac{4c-1}{4c-4} + \frac{0.615}{c} = \frac{4 \times 8 - 1}{4 \times 8 - 4} + \frac{0.615}{8} = 1.184$$

$$\tau_{max} = \frac{8 \times 2 \times 10^3 \times 8d \times 1.184}{\pi \times d^3}$$

$$d^2 = \frac{8 \times 2 \times 10^3 \times 8 \times 1.184}{\pi \times 80}$$

$$d = 24.55 \text{ mm}$$

19. (d)

$$T = 60 \text{ N-m} = 60 \times 10^3 \text{ N-mm}$$

$$\sigma_{max} = 180 \text{ MPa} = 180 \text{ N/mm}^2$$

$$C = \frac{D}{d} = 10$$

$$D = 10\text{ d}$$

$$\tau = \frac{16T}{\pi d^3} \quad \text{and} \quad \tau = \frac{\sigma_{max}}{2}$$

So,
$$\sigma_{max} = \frac{32T}{\pi d^3}$$

$\Rightarrow$
$$d^3 = \frac{32 \times 60 \times 10^3}{\pi \times 180}$$

$$d = 15 \text{ mm}$$

$$\text{Mean coil diameter} = 10 \times 15 = 150 \text{ mm}$$

20. (a)

Wahl's factor,

$$K_w = \frac{4c-1}{4c-4} + \frac{0.615}{c}$$

$$= \frac{4\times9-1}{4\times9-4} + \frac{0.615}{9} = 1.162$$

$$d = \frac{D}{c} = \frac{36}{9} = 4 \text{ mm}$$

$$W_{max} = \frac{\pi d^3}{8DK_w} \times \tau_{per}$$

$$W_{max} = \frac{\pi \times 4^3}{8\times36\times1.162} \times 60 = 36.04 \text{ N}$$

21. (b)

$$P = \frac{2\pi NT}{60}$$

$$\Rightarrow \quad T = \frac{60\times5\times10^6}{2\pi\times600} = 79577.47 \text{ N-mm}$$

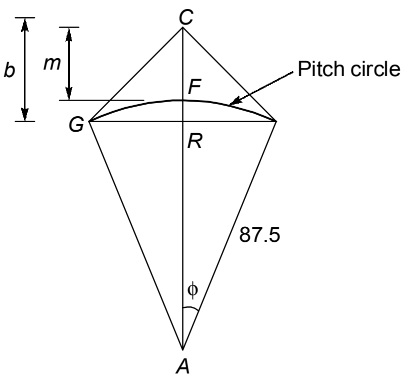
$$T = F_t \times R$$

$$\Rightarrow \quad F_t = \frac{2T}{mZ} = \frac{2\times29577.47}{4\times24} = 1657.864 \text{ N}$$

$$F_n = \frac{F_t}{\cos\phi} = \frac{1657.864}{\cos20°} = 1764.262 \text{ N}$$

22. (c)

$m = 5$, $Z = 35$, $D = mZ = 5 \times 35 = 175$ mm



$$P_c = \frac{\pi D}{Z} = \frac{\pi\times175}{35} = 15.7079 \text{ mm}$$

$P_c = a + a = 2a$ (tooth thickness = tooth space)

$2a = 15.7079$

$a = 7.854$ mm

$$\phi = \frac{360°}{35\times4} = 2.571°$$

$AR = 87.5 \cos 2.571$

$= 87.412$ mm

$b = m + FR = m + AF - AR$

$= 5 + 87.5 - 87.412 = 5.088$ mm

23. (b)

Wear strength of gear tooth

$F_w = D_P \,.\, b \,.\, Q \,.\, K$

$D_P = mz_p = 4 \times 32 = 128$ mm

$b = 10\text{ m} = 10 \times 4 = 40$ mm

$$Q = \frac{2G}{G-1} \quad \text{(for internal gearing arrangement)}$$

$$= \frac{2\times 4}{4-1} = \frac{8}{3} \quad (\because G = 4)$$

$$K = \frac{0.16(BHN)^2}{100^2} = \frac{0.16\times 60^2}{100^2} = 0.0576$$

$$F_w = 128\times 40\times \frac{8}{3}\times 0.0576 = 786.432 \text{ N}$$

24. (b)

According to Soderberg

$$\frac{\sigma_m}{\sigma_{yt}} + \frac{\sigma_a}{\sigma_e} = \frac{1}{N}$$

$$\sigma_{max} = \frac{210\times 10^3}{A} \text{ N/mm}^2$$

$$\sigma_{min} = \frac{-80\times 10^3}{A} \text{ N/mm}^2$$

Stress amplitude,
$$\sigma_a = \frac{\sigma_{max}-\sigma_{min}}{2} = \frac{210+80}{2}\times\frac{10^3}{A} \text{ N/mm}^2$$

$$= \frac{145\times 10^3}{A} \text{ N/mm}^2$$

Mean stress,
$$\sigma_m = \frac{\sigma_{max}-\sigma_{min}}{2} = \frac{210-80}{2}\times\frac{10^3}{A} \text{ N/mm}^2$$

$$= \frac{65\times 10^3}{A} \text{ N/mm}^2$$

By soderberg,
$$\frac{65\times 10^3}{A\times 500} + \frac{145\times 10^3}{A\times 280} = \frac{1}{2.5}$$

$$A = 259.14 \text{ mm}^2$$

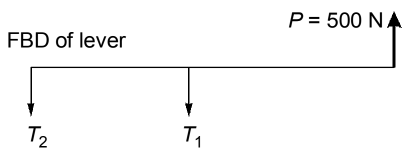
25. (b)

For uniform pressure theory intensity of pressure is constant.

$$\text{Friction torque} = \frac{2}{3}\mu\pi P\left(R_o^3 - R_i^3\right)\times n = \frac{2}{3}\times 0.32\times\pi\times 0.5\,(130^3 - 65^3)\times 2$$

$$= 1288388.1 \text{ N-mm} = 1288.39 \text{ N-m}$$

26. (c)



T_1 is tight and

T_2 is slack

$$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.3\times\pi}$$

$$\Rightarrow \quad T_1 = 2.566\, T_2 \qquad \text{...(i)}$$

Taking moment about hinge

$$T_2 \times 50 - T_1 \times 200 + 500 \times 500 = 0$$

$$4T_1 - T_2 = 5000 \qquad \text{...(ii)}$$

From (i) and (ii)

$$T_1 = 1384.9 \text{ N}$$

$$T_2 = 539.6 \text{ N}$$

$$\text{Breaking torque} = (T_1 - T_2)\times\frac{D}{2} = (1384.9 - 539.6)\times\frac{0.25}{2} = 105.66 \text{ N-m}$$

27. (b)

$$V = \frac{\pi DN}{60} = \frac{\pi\times 200\times 1000}{60} = 10.472 \text{ m/s}$$

$$\sigma_{max} = \frac{\rho v^2(\mu+3)}{8} = \frac{8000\times 10.472^2\times 3.3}{8} = 361885.5 \text{ pa}$$

$$= 361.88 \text{ kPa}$$

28. (a)

$$\sigma_{max} = \frac{\rho v^2(\mu+3)}{8}$$

$$20\times 10^6 = \frac{9200\times v^2(3+0.28)}{8}$$

$$v = 72.81 \text{ m/s}$$

$$\omega_{max} = \frac{v_{max}}{R} = \frac{72.81}{0.25} = 291.26 \text{ rad/s}$$

$$E_{max} = \frac{1}{2}I\,\omega_{max}^2 = \frac{1}{2}\times 2\times(291.26)^2 = 84.835 \text{ kJ}$$

29. (d)

$$\sigma_{max} = -\sigma_{min} = \sigma$$

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{\sigma-(-\sigma)}{2} = \sigma$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2} = \frac{\sigma-\sigma}{2} = 0$$

According to Goodman's criteria

$$\frac{\sigma_m}{\sigma_{ut}} + \frac{\sigma_a}{\sigma_e} = \frac{1}{N}$$

$$\sigma_e = 0.5\,\sigma_{ut} = 0.5\times 1000 = 500 \text{ MPa}$$

$$\frac{\sigma}{500} = \frac{1}{2}$$

$$\Rightarrow \quad \sigma = 250 \text{ MPa}$$

$$\sigma = \frac{100 \times 10^3}{\frac{\pi}{4} d^2}$$

$$d^2 = \frac{100 \times 10^3}{\frac{\pi}{4} \times 250}$$

$$d = 22.567 \text{ mm}$$

30. (c)

$$P = 2 \times 0.707 \times t\, l\, \tau_{per} + 0.707\, t\, l\, \sigma_{per}$$

$$30 \times 10^3 = 2 \times 0.707 \times 12\, l \times 60\ _{per} + 0.707 \times 12\, l \times 90$$

$$l = \frac{30 \times 10^3}{2 \times 0.707 \times 12 \times 60 + 0.707 \times 12 \times 90} = 16.84 \text{ mm}$$

■■■■