

CLASS TEST

S.No. : 03 GH1_ME_B_080619

Machine Design



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CLASS TEST 2019-2020

MECHANICAL ENGINEERING

Date of Test : 08/06/2019

ANSWER KEY ➤ Machine Design

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

DETAILED EXPLANATIONS

1. (a)

$$\tau_{\max} = \frac{2T}{\pi d^2 h}$$

$$T = 1500 \text{ Nm}, d = 60 \text{ mm}, \tau_{\max} = \tau_{\text{per}} = 80 \text{ N/mm}^2$$

$$h = \frac{2 \times 1500 \times 10^3}{\pi \times 60^2 \times 80} = 3.31 \text{ mm}$$

2. (b)

$$\begin{aligned} \text{Safe load} &= \text{no. of rivets} \times \text{projected area of rivet on one plate} \\ &\quad \times \text{bearing stress} \\ &= 2 \times 20 \times 25 \times 150 = 150000 \text{ N} = 150 \text{ kN} \end{aligned}$$

3. (b)

$$\begin{aligned} L_{10} &= 10000 \times 300 \times 60 = 180 \times 10^6 \text{ rev} \\ C &= 30 \text{ kN} \end{aligned}$$

$$L_{10} = \left(\frac{C}{Pe} \right)^k$$

$$180 = \left(\frac{30000}{Pe} \right)^{10/3}$$

$$\Rightarrow Pe = \frac{30000}{(180)^{3/10}} = 6317.41 \text{ N}$$

4. (a)

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

$$l = 40 \text{ mm}$$

$$D = 50 \text{ mm}$$

$$\sigma_{\text{ind}} = 90 = \frac{F_t}{lt} = \frac{4T}{Dt l} \quad \left[T = F_t \times \frac{D}{2} \right]$$

$$T = \frac{90 \times 50 \times 40 \times 15}{4} \text{ N-mm} = 675000 \text{ N-mm} = 675 \text{ N-m}$$

5. (b)

Taper roller bearing of heavy series having 25 mm diameter.

6. (d)

Worm gearing. For higher reduction (more than 20), worm gears are used.

$$\text{Here, Gear ratio} = \frac{72 \times 60}{36} = 120$$

7. (a)

$$\delta = \frac{8WD^3n}{Gd^4}, \delta \propto n$$

$$\frac{\delta_1}{\delta_2} = \frac{n_1}{n_2} = \frac{32}{16} = 2$$

8. (b)

9. (d)

$$\text{Bending stress} = \frac{32M}{\pi d^3}$$

$$\text{Maximum bending stress} = k_t \frac{32M}{\pi d^3}$$

$$= 1.35 \times \frac{32 \times 180 \times 10^3}{\pi \times 25^3} = 158.41 \text{ MPa}$$

10. (d)

$$V = \frac{\pi DN}{60} = \frac{\pi \times 0.25 \times 1200}{60} = 15.708 \text{ m/s}$$

$$\begin{aligned} \sigma_{\max} &= \rho V^2 = 6500 \times 15.708^2 \\ &= 1603.810 \text{ kPa} \end{aligned}$$

11. (d)

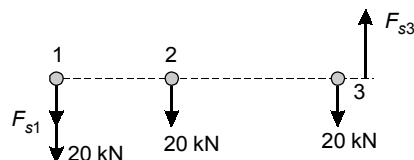
For single parallel fillet weld

$$P = 0.707 t l \tau_{\text{per}}$$

for double parallel fillet weld

$$\begin{aligned} P &= 2 \times 0.707 t l \tau_{\text{per}} \\ 75 \times 10^3 &= 2 \times 0.707 \times 12.5 \times l \times 90 \\ l &= 47.15 \text{ mm} \end{aligned}$$

12. (c)



CG of system of rivets is at rivet 2.

Transferring the force at rivet 2.

Primary force = 20 kN at each rivet

Eccentricity = 120 mm

$$F_{s1} \times 120 + F_{s2} \times 0 + F_{s3} \times 120 = 60 \times 120 \quad \dots(i)$$

$$F_{s1} = K \times 120 \quad \dots(ii)$$

$$F_{s3} = K \times 120 \quad \dots(iii)$$

From (i) and (ii)

$$K(120^2 + 120^2) = 60 \times 120$$

⇒

$$K = 0.25$$

$$F_{s1} = 120 \times 0.25 = 30 \text{ kN}$$

$$F_{s3} = 120 \times 0.25 = 30 \text{ kN}$$

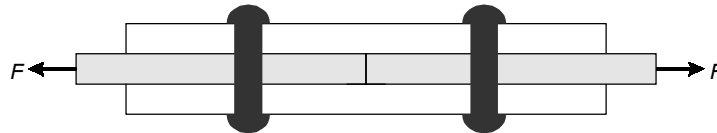
Rivet 1 has maximum amount of force

$$\tau = \frac{F}{\frac{\pi}{4}d^2}$$

$$\Rightarrow \frac{(20 + 30) \times 10^3}{\frac{\pi}{4}d^2} = 80$$

$$\Rightarrow d = 28.21 \text{ mm}$$

13. (a)



Maximum shear force resisted by rivets

$$(P_{\max})_{\text{shear}} = 2 \times \frac{\pi}{4}d^2 \times \tau_{\text{per}}$$

Strength of solid plate, $(P_{\max})_{\text{solid}} = b t \sigma_{\text{per}}$

$$\eta = \frac{(P_{\max})_{\text{shear}}}{(P_{\max})_{\text{solid}}} = \frac{2 \times \frac{\pi}{4} \times 20^2 \times 90}{30 \times 100 \times 150} = 0.1256 = 12.56\%$$

14. (b)

$$\text{Effective length of bolt} = 3 \times 20 = 60 \text{ mm}$$

$$\text{Core area of the bolt} = \frac{\pi}{4} \times d_c^2 = \frac{\pi}{4} \times 25^2 = 490.874 \text{ mm}^2$$

$$\text{Stiffness of the bolt} = \frac{EA}{L} = \frac{180 \times 10^3 \times 490.874}{60} = 1.4726 \times 10^6 \text{ N/mm}$$

15. (d)

$$P_e = s(XVFr + YFa)$$

$$= 1(0.56 \times 1 \times 10 + 1 \times 5) = 10.6 \text{ kN}$$

$$L_{50} = 15000 \times 60 \times 1000 = 900 \text{ mR}$$

$$L_{50} = 5 L_{10}$$

$$L_{10} = \frac{900}{5} = 180 \text{ mR}$$

$$L_{10} = \left(\frac{C}{P_e} \right)^k$$

$$\Rightarrow C = 180^{1/3} \times 10.6 \times 10^3 = 59.894 \text{ kN}$$

16. (a)

$$\tau = \frac{\mu V}{C}$$

$$= \frac{22 \times 10^{-3} \times 30 \times 22.5 \times 10^{-3}}{0.0225 \times 10^{-3}} = 660 \text{ N/m}^2$$

Force,

$$F = \tau A = 660 \times \pi \times 0.045 \times 0.045 \quad (\because A = \pi d l)$$

$$= 4.1987 \text{ N}$$

Torque = $F \times r$

$$= 4.1987 \times 22.5 \times 10^{-3}$$

$$= 0.09447 \text{ N-m} = 94.47 \text{ N-mm}$$

17. (b)

$$z = 16 \times 10^{-3} \text{ Pa-s}$$

$$n = \frac{1500}{60} \text{ rps} = 25 \text{ rps}$$

$$\rho = \frac{W}{ld} = \frac{60 \times 10^3}{0.1 \times 0.1} = 60 \times 10^5 \text{ N/m}^2$$

$$\mu = 2\pi^2 \left(\frac{zn}{\rho} \right) \left(\frac{r}{c} \right)$$

$$= 2\pi^2 \times \frac{16 \times 10^{-3} \times 25}{60 \times 10^5} \times \left(\frac{50}{0.12} \right)$$

$$= 5.4831 \times 10^{-4}$$

$$\text{Power loss} = \mu W v$$

$$= 5.4831 \times 10^{-4} \times 60 \times 10^3 \times \frac{\pi \times 0.1 \times 1500}{60}$$

$$= 258.38 \text{ W}$$

18. (c)

$$\text{Sum of pitch circle radius} = r_P + r_G = \frac{mz_P + mz_G}{2} = 480$$

$$z_P + z_G = 160 \quad \dots(i)$$

$$\text{Speed reduction} = \frac{4}{1} = \frac{z_G}{z_P}$$

$$\Rightarrow z_G = 4 z_P \quad \dots(ii)$$

From (i) and (ii)

$$5 z_P = 160$$

$$z_P = 32$$

19. (b)

$$P = 3500 \text{ W}$$

$$N = 800 \text{ rpm}$$

$$y = \text{form factor} = 0.25$$

$$b = \text{face width} = 44 \text{ mm}$$

$$C_v = \text{velocity factor} = 1.4$$

$$m = 4 \text{ mm}$$

$$z = 20$$

$$F_t = \frac{2T}{D}$$

$$D = mz = 4 \times 20 = 80 \text{ mm}$$

$$P = 2\pi NT = 2\pi \times \frac{800}{60} \times T = 3500$$

$$T = 41.778 \text{ N-m} = 41.778 \times 10^3 \text{ N-mm}$$

$$F_{\text{dynamic}} = F_t \cdot C_v \cdot s$$

$$= \frac{2T}{D} \times 1.4 \times 1$$

(Assuming, $s = 1$)

$$= \frac{2 \times 41.778 \times 10^3}{80} \times 1.4 = 1462.236 \text{ N}$$

$$F_{\text{dynamic}} \leq (F_t)_{\text{max}}$$

$$1462.236 \leq bmy(\sigma_b)_{\text{permissible}}$$

$$(\sigma_b)_{\text{permissible}} = \frac{1462.236}{44 \times 4 \times 0.25} = 33.23 \text{ MPa}$$

20. (b)

Stiffness of spring, $k = \frac{Gd^4}{8D^3N}$

Deflection of spring, $\delta = \frac{P}{k} = \frac{8PD^3N}{Gd^4}$... (i)

Here in question, $d_2 = d_1 + 0.08 d_1 = 1.08 d_1$

Since from (i), $\delta \propto \frac{1}{d^4}$

$$\frac{\delta_2}{\delta_1} = \left(\frac{d_1}{d_2}\right)^4 = \left(\frac{1}{1.08}\right)^4 = 0.735$$

$$\text{Change in deflection} = \frac{\delta_2 - \delta_1}{\delta_1} = \frac{0.735 - 1}{1} = -0.265$$

$$\% \text{ change} = -26.5\%$$

21. (b)

$$(\tau_{\max})_1 = \frac{8W_1D_1}{\pi d_1^3} K_w$$

$$(\tau_{\max})_2 = \frac{8W_2D_2}{\pi d_2^3} K_w$$

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

$$c = \frac{D}{d}$$

Since c remains unchanged, K_w will be same in both cases.

$$(\tau_{\max})_2 = \frac{8(2W_1)(2D_1)}{\pi(2d_1)^3} K_w$$

$$\frac{(\tau_{\max})_2}{(\tau_{\max})_1} = \frac{2 \times 2}{8} = \frac{1}{2}$$

$$\% \text{ change} = 100 \frac{(\tau_{\max})_2 - (\tau_{\max})_1}{(\tau_{\max})_1} = \frac{1/2 - 1}{1} \times 100 = -50\%$$

22. (c)

Here,

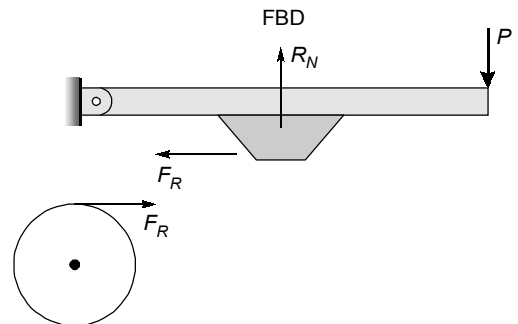
$$F_R = \mu R_N$$

$$\begin{aligned} \text{Torque of drum} &= 400 \text{ N-m} \\ &= 400 \times 10^3 \text{ N-mm} \end{aligned}$$

$$\begin{aligned} \text{Torque} &= F_R \times R \\ &= \mu R_N \times R \end{aligned}$$

$$400 \times 10^3 = 0.25 \times R_N \times 250$$

$$R_N = 6400 \text{ N}$$



23. (a)

$$\omega_1 = \frac{2\pi N_1}{60} = \frac{2 \times \pi \times 600}{60} = 62.8318 \text{ rad/s}$$

$$\omega_2 = \frac{2\pi N_2}{60} = \frac{2 \times \pi \times 900}{60} = 94.278 \text{ rad/s}$$

$$r_d = 160 \text{ mm} = 0.160 \text{ m}$$

$$r_g = 130 \text{ mm} = 0.130 \text{ m}$$

$$n = 4$$

$$T_f = \frac{60 \times 10^6 \times (\text{kW})}{2\pi N_2} = \frac{60 \times 10^6 \times 30}{2 \times \pi \times 900} = 318309.88 \text{ N-mm}$$

$$= 318.3099 \text{ N-m}$$

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

$$318.3099 = 4 \times 0.35 \times 0.130 \times 0.160 \times m (94.278^2 - 62.8318^2)$$

$$m = 2.21 \text{ kg}$$

24. (b)

$$\text{Power} = \frac{2\pi NT_f}{60} \quad \dots(i)$$

$$T_f = n \times \frac{2}{3} \mu \pi \rho_{\text{perm}} (R_0^3 - R_i^3)$$

$$= n \times \frac{2}{3} \times 0.25 \times \pi \times 2 \times 10^6 \times (0.1^3 - 0.06^3) = 821 \text{ N-m}$$

From (i),

$$\text{Power} = 68780.17 \text{ kW} = 68.78 \text{ kW}$$

25. (d)

$$\omega_1 = \frac{2\pi N_1}{60} = \frac{2 \times \pi \times 1200}{60} = 125.60 \text{ rad/s}$$

$$P = 2000 \text{ W}$$

$$T = \frac{P}{\omega} = 15.915 \text{ N-m}$$

$$I_q = mk^2 = 15 \times 0.2^2 = 0.6$$

$$\frac{-T_1}{I_1} t + \omega_1 = \frac{-T_2}{I_2} t + \omega_2$$

Initial speed of flywheel is zero and assuming motor is running at constant speed.

$$\omega_1 = \frac{T_2}{I_2} t$$

$$t = \frac{I_2 \omega_1}{T} = \frac{0.6 \times 125.66}{15.915} = 4.74 \text{ sec}$$

26. (a)

$$\mu = 0.3$$

$$2\theta = 80^\circ$$

⇒

$$\theta = 40^\circ$$

$$2\theta = \frac{80}{180} \times \pi = 1.3962$$

$$\mu' = \mu \times \frac{4 \sin \theta}{2\theta + \sin 2\theta}$$

$$= 0.28 \times \frac{4 \sin 40^\circ}{1.3962 + \sin 80^\circ} = 0.30$$

27. (b)

$$N = 2, \mu = 0.25, P_{\max} = 100 \text{ KPa}, R/r = 1.5$$

$$T_f = N \times \mu \times W \left(\frac{R+r}{2} \right)$$

$$P_{\max} \times r = \frac{W}{2\pi(R-r)}$$

$$0.1 \times r = \frac{W}{2\pi(1.5r-r)}$$

$$W = 0.31416 r^2$$

$$T_f = 2 \times 0.25 \times 0.31416 r^2 \left(\frac{r+1.5r}{2} \right)$$

$$120 \times 10^3 = 0.19635 r^3$$

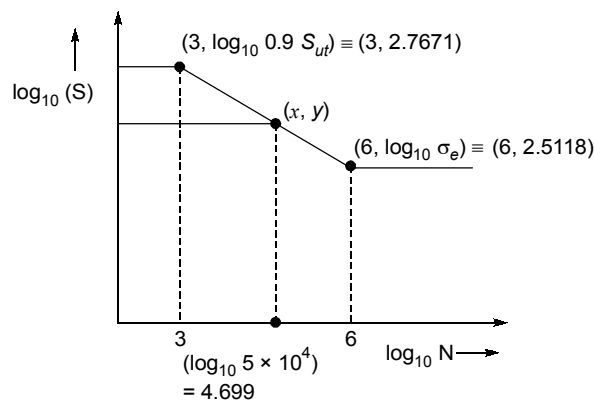
$$r^3 = 611153.55 \text{ mm}^3$$

$$r = 84.862 \text{ mm}$$

$$R = 127.294 \text{ mm}$$

$$\text{diameter} = 254.588 \text{ mm}$$

28. (c)



$$(y - 2.7671) = \frac{2.5118 - 2.7671}{6 - 3} \times (4.699 - 3)$$

$$y = 2.6225$$

$$y = \log_{10} \sigma_f$$

$$\sigma_f = 419.29 \text{ MPa}$$

29. (b)

According to Goodman,

$$\frac{\sigma_m}{S_{ut}} + \frac{\sigma_a}{S_e} \leq \frac{1}{N} \quad \dots(i)$$

Given,

$$\sigma_{\max} = 350 \text{ MPa}$$

$$\sigma_{\min} = -150 \text{ MPa}$$

$$\sigma_m = \frac{\sigma_{\max} + \sigma_{\min}}{2} = \frac{350 - 150}{2} = 100 \text{ MPa}$$

$$\sigma_a = \frac{\sigma_{\max} - \sigma_{\min}}{2} = \frac{350 + 150}{2} = 250 \text{ MPa}$$

From equation (i),

$$\frac{100}{S_{ut}} + \frac{250}{0.5S_{ut}} = \frac{1}{2.5}$$

$$S_{ut} = 1500 \text{ MPa}$$

30. (b)

$$(\sigma)_{\max} = \frac{\sigma v^2 (\mu + 3)}{10^6 \cdot 8}$$

$$25 = \frac{8000 \times v^2 \times (3 + 0.26)}{8 \times 10^6}$$

$$v = 87.57 \text{ m/s}$$

$$v = R \times \omega$$

$$\omega = 437.856 \text{ rad/s}$$

$$E_{\max} = \frac{1}{2} I \times \omega^2 = 143.785 \text{ kJ}$$

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