OR iii. The layout of an intermediate shaft of a gear box supporting two spur gears B and C is shown in Fig. 6. The shaft is mounted on two bearings A and D. The pitch circle diameters of gears B and C are 900 and 600 mm respectively. The material of the shaft is steel (S_{ut} = 770 and S_{yt} = 580 N/mm^2). The load is suddenly applied with minor shock. Determine the shaft diameter using the ASME code. Assume that the gears are connected to the shaft by means of keys. **6**

Q.5 i. What are the important functions of spring? What is the nipping phenomenon in laminated spring? **4**

ii. Design a helical compression spring for a maximum load of 1000 N for a deflection of 25 mm using the value of spring index as 5.The maximum permissible shear stress for spring wire is 420 MPa and modulus of rigidity is 84 kN/mm^2. Take- Wahl's correction factor as- K= (4C-1)/(4C-4) + 0.615/C where C= Spring Index **6**

OR iii. A locomotive semi-elliptical laminated spring has an overall length of 1 m and sustains a load of 70 kN at its centre. The spring has 3 full length leaves and 15 graduated leaves with a central band of 100 mm width. All the leaves are to be stressed to 400 MPa, when fully loaded. The ratio of the total spring depth to that of width is 2. E = 210 kN/mm2. Determine : **6**

(a) The thickness and width of the leaves.

(b) The initial gap that should be provided between the full length and graduated leaves before the band load is applied.

(c) The load exerted on the band after the spring is assembled.

Q.6 Attempt any two:

i. It is required to select a flat belt drive for a compressor running at 720 rpm which is driven by 25kW, 1440 rpm motor. The belt speed may be selected as 18 m/s. The distance centre distance available is 3m. The belt is open type. Select HI SPEED belt and power transmitting capacity as 0.0118 kW per mm width per ply. **5**

ii. The following data is given for an open-type V-belt drive: **5**
diameter of driving pulley = 200 mm; diameter of driven pulley = 600 mm ;
groove angle for sheaves = 34°; mass of belt = 0.5 kg/m
maximum permissible tension in belt = 500 N ;
coefficient of friction = 0.2 ; contact angle for smaller pulley = 157°
speed of smaller pulley = 1440 rpm ; power to be transmitted = 10 kW . How many V-belts should be used, assuming each belt takes its proportional part of the load?

iii. Explain the polygonal effect in chains. **5**

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Enrollment No....................................

Faculty of Engineering

End Sem (Even) Examination May-2018

AU3CO07/ME3CO08 Machine Design-I

Programme: B.Tech. Branch/Specialisation: AU/ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: (a) All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

(b) Use of Design Data Hand Book is permitted.

Q.1 i. Endurance limit of a component is the stress value at which the component will survive for 10^6 cycles or more during – **1**

(a) Completely reversed stress (b) Repeated stress
(c) Fluctuating stress (d) None of these

ii. Which amongst the following statements is incorrect- **1**

(a) Theoretical stress concentration factor is greater than fatigue stress concentration factor
(b) Derating factors are used to find out the corrected value of endurance limit of a component
(c) Goodman criteria is used for component is subjected to completely reversed loading
(d) Notch sensitivity `q' is numerically calculated as the ratio of increase of actual stress over nominal stress to Increase of theoretical stress over nominal stress

iii. Which of the following keys is used in a pair of two- **1**

(a) Rectangular key (b) Kennedy key (c) Round key (d) Gib headed key

iv. Which among these can transmit highest torque- **1**

(a) Bushed pin flexible coupling (b) Flanged coupling
(c) Muff coupling (d) Split muff coupling

v. Which among these is not used for making shafts - **1**

(a) Medium carbon steel (b) High carbon steel
(c) Alloy steel (d) Grey cast iron

vi. Which component among these cause axial load on the shaft- **1**

(a) Bevel and helical gears (b) Spur gears
(c) Pulleys (d) Flywheels

vii. The number of active turns for the square ended helical spring is – **1**

(a) N_t (b) N_t -1 (c) N_t - 2 (d) N_t -3
(where N_t = total no. of coils)

viii. Which among these is not correct for leaf spring- **1**

(a) The longest leaf at the top is called as `master leaf'

(b) It also contains extra one or two full length leaves apart from master leaf
(c) The stresses in extra full length leaves are 50% more than stresses in graduated length leaves
(d) The full length leaf is given a smaller radius of curvature than the adjacent larger leaf

ix. The optimum velocity of the belt for maximum power transmission is given by- **1**

(a) $v = \sqrt{3P/m}$ (b) $v = \sqrt{P/3m}$ (c) $v = \sqrt{2P/3m}$ (d) $v = \sqrt{3P/2m}$

{where m= mass/length of belt}

x. Pick the incorrect amongst the following for designing the chain drive - **1**

(a) The number of pitches or links of the chain should always be `even'
(b) The number of teeth on the driving sprocket should always be `odd'
(c) Chain drive can transmit a constant velocity ratio if the number of teeth on sprocket increases
(d) Chain drive can transmit a constant velocity ratio if the number of teeth on sprocket decreases

Q.2 i. Explain any one theory of failure for ductile materials with failure envelop. **2**

ii. Define stress concentration. Sketch the methods to reduce the stress concentration in – (a) Threaded part (b) Stepped shoulder as shown Fig. 1 and 2 **3**

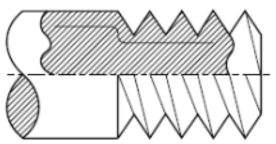
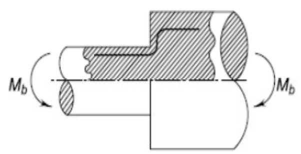
Fig. 1


Fig.2


iii. A component machined from a plate made of steel 45C8 (S_{ut} = 630 N/mm^2) is shown in Fig. 3. It is subjected to a completely reversed axial force of 50 kN. The expected reliability is 90% and the factor of safety is 2. The size factor is 0.85. Determine the plate thickness t`' for infinite life, if the notch sensitivity factor is 0.8. **5**

OR iv. A cantilever beam made of cold drawn carbon steel of circular cross-section as shown in Fig.4, is subjected to a load which varies from – F to +3F. Determine the maximum load that this member can withstand for an indefinite life using a factor of safety as 2. The theoretical stress concentration factor is 1.42 and the notch sensitivity is 0.9. Assume the following values : Ultimate stress = 550 MPa ;Yield stress = 470 MPa; **5**

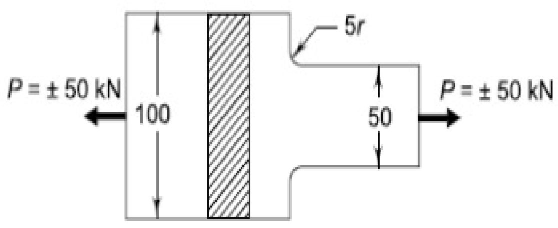


Fig. 3

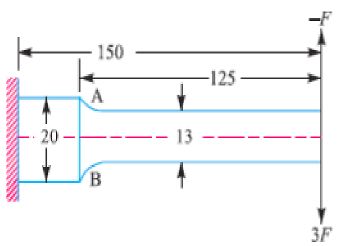


Fig. 4

Q.3 i. What is a key? Explain the stresses a key is subjected to with the help of a sketch of a rectangular key. **2**

ii. A 45 mm diameter shaft is made of steel with a yield strength (S_{yt}) 400 MPa. A parallel key of size 14 mm wide and 9 mm thick made of steel with a yield strength of 340 MPa is to be used. Find the required length of key, if the shaft is loaded to transmit the maximum permissible torque. Use maximum shear stress theory and assume a factor of safety of 2. **3**

iii. Design a muff coupling to connect two steel shafts transmitting 25 kW power at 360 rpm. The shafts and key are made of plain carbon steel 30C8 (S_{yt}=400 N/mm^2). The sleeve is made of grey cast iron FG 200. The factor of safety for the shafts and key is 4. For the sleeve, the factor of safety is 6 based on ultimate strength. **5**

OR iv It is required to design a rigid type of flange coupling to connect two shafts. The input shaft transmits 37.5 kW power at 180 rpm to the output shaft through the coupling. The service factor for the application is 1.5, i.e., the design torque is 1.5 times of the rated torque. The permissible torsional stress in shaft = 76 N/mm^2, the permissible torsional stresses in keys and bolts = 80 N/mm^2, the permissible compressive stresses for keys and bolts = 240 N/mm^2 and the permissible torsional stresses in flanges = 17 N/mm^2 **5**

Q.4 i. What is a shaft? Explain the types of loads it is subjected to during working with help of simple sketches. **4**

ii. The layout of a shaft carrying two pulleys 1 and 2, and supported on two bearings A and B is shown in Fig. 5. The shaft transmits 7.5 kW power at 360 rpm from the pulley 1 to the pulley 2. The diameters of pulleys 1 and 2 are 250 mm and 500 mm respectively. The masses of pulleys 1 and 2 are 10 kg and 30 kg respectively. The belt tensions act vertically downward and the ratio of belt tensions on the tight side to slack side for each pulley is 2.5:1. The shaft is made of plain carbon steel 40C8 (S_{yt} = 380 N/mm^2) and the factor of safety is 3. Estimate suitable diameter of shaft. If the permissible angle of twist is 0.5° per metre length, calculate the shaft diameter on the basis of torsional rigidity. Assume G = 79300 N/mm^2. **6**

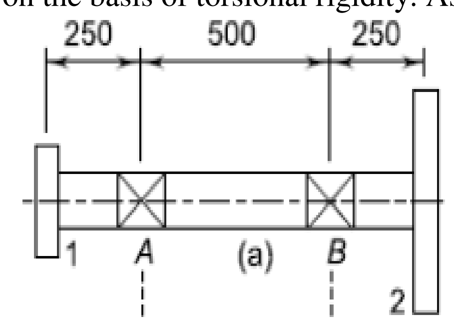


Fig. 5

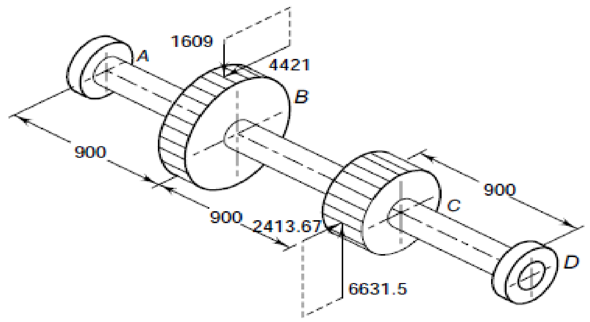


Fig. 6

Marking Scheme
AU3CO07/ME3CO08 Machine Design-I

Q.1 i. Endurance limit of a component is the stress value at which the component will survive for 10^6 cycles or more during – **1**
(a) Completely reversed stress

ii. Which amongst the following statements is incorrect- **1**
(c) Goodman criteria is used for component is subjected to completely reversed loading

iii. Which of the following keys is used in a pair of two- **1**
(b) Kennedy key

iv. Which among these can transmit highest torque- **1**
(b) Flanged coupling

v. Which among these is not used for making shafts **1**
(d) Grey cast iron

vi. Which component among these cause axial load on the shaft- **1**
(a) Bevel and helical gears

vii. The number of active turns for the square ended helical spring is **1**
(c) N_t - 2

viii Which among these is not correct for leaf spring- **1**
(d) The full length leaf is given a smaller radius of curvature than the adjacent larger leaf

ix. The optimum velocity of the belt for maximum power transmission is given by- **1**
(b) $v = \sqrt{P/3m}$

x. Pick the incorrect amongst the following for designing the chain drive - **1**
(d) Chain drive can transmit a constant velocity ratio if the number of teeth on sprocket decreases

Q.2 i. Any one theory of failure for ductile materials with failure envelop. **2**

ii. Stress concentration. 1 mark **3**
(a) Threaded part 1 mark
(b) Stepped shoulder 1 mark

iii. (a) Determination of surface finish factor (K_a=0.86; DB-pg.32) 1 mark **5**
(b) Determination of K_t=2.27; K_f=2.016; K_f'= 0.496 1 mark
(c) Determination of endurance limit of component (S_e=102.45 N/mm^2) 1 mark
(d) Determination of permissible stress amplitude (σ_a=41 N/mm^2) 1 mark
(e) Determination of thickness of plate t=24.4mm 1 mark

OR iv. (a) Determination of surface finish factor (K_a=0.88; DB-pg.32) 1 mark **5**
(b) Determination of size factor (K_b =0.85) & K_f'=0.725 1 mark
(c) Determination of endurance limit of component (S_e=151N/mm^2) 1 mark
(d) Determination of mean bending stress = σ_m = 0.58F and variable bending stresses σ_v =1.16F 1 mark
(e) Determination of force `F' (57.3N) 1 mark

Q.3 i. Key 1 mark **2**
Stresses a key 1 mark

ii. (a) Determination of permissible stresses in shaft and key and max. torque (τ_{max}. (shaft)= 100N/mm2); . τ_{max}. (key) =85N/mm2 Torque M_t= 1.8X106 N.mm) 1 mark **3**
(b) Determination of key length under shear stress .(l=67.2mm) 1 mark
(c) Determination of key length under compression (l=104.6mm) 1 mark

iii. (a) Calculation of permissible stresses for shaft and keys and sleeve. (For keys & shafts σ_t = 100N/mm^2 ; σ_y =100N/mm^2; τ=50N/mm^2)(For sleeve of FG200; S_{ut}.=200N/mm^2 from DB. Pg-461 & so τ = 16.67N/mm^2) 1 mark **5**
(b) Calculation of diameter of shaft `d=40.73mm =45mm rounded off) 1 mark
(c) Calculations of dimensions of sleeve D=105mm; L=160mm; J=11530626.79 mm^4 and τ(induced) = 3 N/mm^2 <16.67N/mm^2 1 mark
(d) Calculation of dimensions of key (l=160/2=80mm) and c/s=14X9 (from Table 4.1;DB. Pg. 69) 1 mark
(e) Check for stresses in key (τ(induced) =26.32 N/mm^2 <50 N/mm^2 and, σ_c (induced) = 81.87 N/mm^2 <100 N/mm^2 1 mark

OR (a) Determination of diameter of shaft (d=58.48= 60mm) 1 mark **5**
(b) Determination of flange dimensions (d_h=2d=120mm; l_h=1.5d=90 mm ; D=3d=180mm; t=0.5d= 30mm; t1=0.25d= 15mm d_r =1.5d =90mm; D_o= 4d=240mm [From DB-Pg.252] 1 mark
(c) Check for torsional stresses in hub and at the junction of hub and flange [J (hub) =19085175.37N/mm2] τ(induced)=9.38<17 N/mm2 and Shear stress in flange at the junction of hub = 4.40 N/mm^2 < 17 N/mm2 1 mark
(d) Diameter of bolts (d1=11.5=12mm [Eq.13.2 (c) pg.252 DB] ; σ_c(induced) =23N/mm2 <240 N/mm2) 1 mark
(e) Dimension of key and the check for stresses l=l_h= 90mm (τ(induced) =61.4 N/mm^2 <80 N/mm^2 and, σ_c (induced) = 201 N/mm^2 <240 N/mm^2 1 mark

Q.4 i. Shaft 1 mark **4**

Types of loads 3 marks

ii. (a) Determination of permissible shear stress (τ_{max}. (shaft)= 63.33N/mm2) 1 mark **6**

(b) Determination of torsional moment (Mt=198943.68 N.mm) 1 mark

(c) Determination of belt tensions (P1=2652.58N;P2=1061 N; P3=1326.3 N and P4= 530.52N; 1 mark

(d) Determination of bending moment $(M_b)_A$= 952927.5 N.mm); $(M_b)_B$ = 537777.5N 1 mark

(e) Determination of shaft diameter on strength basis (d=42.78 mm) 1 mark

(f) Determination of shaft diameter on torsional rigidity basis using. $d^4 = 584 M_t\, l / G\theta$ is d=41.37mm 1 mark

OR iii. (a) Determination of permissible stresses [$\tau = 0.3(S_{yt}) = 174$ N/mm^2]; τ = 0.18(Sut)= 138.6 N/mm^2 so we take lower value 138.6 N/mm^2 and as key way is present we take $\tau_{max.}$ 0.75(138.6)=103.95N/mm^2] 1 mark **6**

(b) Determination of bending moments in vertical direction with BM diagram $(M_b)_B$= 1024056 N.mm $(M_b)_C$ =3496203 N.mm 1 mark

(c) Determination of bending moment in horizontal direction with BM diagram $(M_b)_B$= 1928493 N.mm $(M_b)_C$ =121905 N.mm So max. B.M. occurs at C (BM)c=3498327.4 N.mm 1 mark

(d) Determination of torsional moment Mt=1989450 N.mm 1 mark

(e) Selection of shock and fatigue factors for BM and TM [C_m=1.5-2.0 and C_t=1.0-1.5 from DB.Pg-56] Selecting C_m=1.5 and C_t=1] 1 mark

(f) Determination of shaft diameter $d^3 = 16/\pi\, \tau_{max} [\sqrt{(C_m M_b)^2 + (C_t M_t)^2}]$ gives d= 65mm 1 mark

Q.5 i. Important functions of spring 2 marks **4**

Nipping phenomenon in laminated spring. 2 marks

ii. (a) Determination of mean diameter of coil K=1.31 and τ =K [(8WC)/(πd^2) eq.11.1 DB. Pg. 169 gives d=6.3 mm; D=31.5mm 2 marks **6**

(b) Determination of turns of coil [using deflection equation we get n=13.23 =14mm] and total no. of turns = N=n+2 =16 for squared and ground ends. 2 marks

(c) Determination of free length L_f= Nd+δ_{max}. +0.15 δ_{max}= 131.2 mm 1 mark

(d) Determination of pitch = p= L_f /(N-1) = 8.75mm 1 mark

OR iii. (a) Determination of thickness and width of the leaves. Total leaves =n=N_F+N_G =3=15=18; nt/b =2 (Given) and so b= 9t 2L=2L1-l = 1000-100=900 mm and so L=900/2 =450mm; Using σ =6WL/nbt^2 we get t=11.34 =12 mm and b= 9(12)=108mm 2 marks **6**

(b) Determination of initial gap C=2WL3/(nEbt^3) =9.0 mm 2 marks

(c) Determination of load exerted on the band

$W_b = 2N_F.N_G / n(2 N_G + 3 N_F) = 4487$N 2 marks

Q.6 Attempt any two:

i. (a) Determination of pulley diameter and belt speed Selecting v=18m/s d= 238.73 =250mm and so D= 2(250)=500mm Recalculating belt velocity for above diameters give v=18.85 m/s 1 mark **5**

(b) Determination of maximum power Correction Factor=1.3 DB.PSGPg. 7.52; So Max. power = 1.3(25)=32.5 kW 1 mark

(c) Determination of arc of contact factor

Arc of contact = α_c = 180-2sin^{-1} [(D-d)/2C]=175.23° ; F_d=1.019 by linear interpolation 1 mark

(d) Determination of corrected power and belt rating

Corrected power = 1.019(32.5) = 33.12 kW and selecting HI SPEED belt, the corrected rating at 18.85m/s is given by- 0.0118(18.85)/5.08=0.0438kW 1 mark

(e) Selection of belt plies and the length of belt 1 mark

Width X No. of plies = (corrected power/corrected belt rating)

= 33.12/0.0438 = 756.17

Belt widths for 4 plies = w= 756.17/4 =189mm

Belt widths for 5 plies = w= 756.17/5 =151.23 mm

Belt widths for 4 plies = w= 756.17/6 =126.03mm

Selecting HISPEED belt of 152.23 mm width and 5 plies

Belt length = 2C+π(D+d)/2+ (D-d)^2/4C = 7183.31mm =7.2 m

ii. (a) Determination of belt tensions **5**

Using $(P_1 - mv^2)/(P_2 - mv^2) = e^{\mu\theta/\sin\alpha}$ and

By power relation , kW= $(P_1 - P_2)$v /1000 2.5 marks

We get P1= 896.96 N and P2= 233.83 N

Number of belts = (max. tension in belt)/(Allowable belt load)

= 896.96/500 = 1.79 =2 2.5 marks

iii. Polygonal effect in chains. **5**

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