Register Number:……..

KUMARAGURU college of technology
character is life

B.E DEGREE EXAMINATIONS: MAY 2018

(Regulation 2015)

Sixth Semester

MECHATRONICS ENGINEERING

U15MCT602**:** Design of Machine Elements

(Use of approved Design Data Book is permitted)

COURSE OUTCOMES

CO1: Recognize the design process and the factors influencing it and design the simple components for static loading
CO2: Estimate the life of the components subjected to varying loads
CO3: Design the circular shafts based on strength and rigidity, keys and couplings for power transmission
CO4: Design the welded joints and threaded joints subjected to static loads
CO5: Design the springs subjected to static and dynamic loads
CO6: Select the rolling contact bearings for static and cyclic loads
CO7: Select the lubricants and bearing dimensions for hydrodynamic bearings

Time: Three Hours **Maximum Marks: 100**

Answer ALL the Questions:-

PART A (10 x 1 = 10 Marks)

1. Match list I items with list II and select the correct answer using the codes given below. CO1 [K_1]

List I	List II
A. Machine design	i. hyperbolic variation of bending stresses
B. Curved beam	ii. use of scientific principles
C. Distortion- energy theory	iii. one of the theories of failure
D. Factor influencing design	iv. strength

	A	B	C	D
a)	ii	i	iii	iv
b)	iii	iv	ii	i
c)	ii	iv	iii	i
d)	iii	i	ii	iv

2. A bolt diameter of 30 mm, having safe tensile stress 100 N/mm^2 can safely carry a load of CO1 [K_5]
   a) 100 kN b) 70.7 kN
   c) 120 kN d) 150 kN
3. Select the statements related to stress concentration CO2 [K_2]
   1. Stress distribution caused by abrupt changes of form
   2. Stress concentration factor is the ratio of maximum stress to nominal stress
   3. Stress distribution caused by uniform shape of form
   4. Stress concentration factor is the ratio of nominal stress to tensile stress

   a) 1,3 b) 1,4
   c) 1,2 d) 2,3
4. Failure of a material is called fatigue when it fails CO2 [K_3]
   a) at the elastic limit b) below elastic limit
   c) at the yield point d) below the yield point
5. Assertion (A): Two shafts will have equal strength if twisting moment of both the shafts is same CO3 [K_4]
   Reason (R) : Two shafts will have equal strength if diameter of both the shafts is same

a) Both A and R are Individually true and R is the correct explanation of A
b) Both A and R are Individually true but R is not the correct explanation of A
c) A is true but R is false
d) A is false but R is true

6. For a square key made of mild steel, the shear and crushing strengths are related as CO3 [K_1]
a) shear strength = crushing strength
b) shear strength > crushing strength
c) shear strength < crushing strength
d) shear strength × crushing strength

7. Consider the following in the order of increasing magnitude in threaded fasteners CO4 [K_2]
1. Major diameter 2. Pitch 3. Minor diameter 4. Pitch diameter
a) 2-3-4-1
b) 1-3-2-4
c) 3-4-2-1
d) 4-1-3-2

8. When helical compression spring is cut into halves, the stiffness of the resulting spring will be CO5 [K_4]
a) same
b) double
c) one-half
d) one-fourth

9. Assertion (A): Ball and roller bearings in comparison to sliding bearings have more accuracy in alignment CO6 [K_3]
Reason (R): Ball and roller bearings in comparison to sliding bearings have small overall dimensions
a) Both A and R are Individually true and R is the correct explanation of A
b) Both A and R are Individually true but R is not the correct explanation of A
c) A is true but R is false
d) A is false but R is true

10. In a full journal bearing, the contact of the bearing with the journal is CO7 [K_2]
a) 120^o
b) 180^o
c) 360^o
d) 270^o

PART B (10 x 2 = 20 Marks)
(Answer not more than 40 words)

11. Define factor of safety. CO1 [K_1]
12. List the stages of the design of individual components in a design process. CO1 [K_2]
13. Define fluctuating stress. CO2 [K_2]
14. Tell what is the Gerber curve. CO2 [K_1]
15. A shaft designed for maximum strength failed to satisfy the rigidity criterion. Tell what alteration will satisfy strength and rigidity criteria. CO3 [K_2]
16. List the advantages of bushed pin flexible coupling. CO3 [K_2]
17. Tell the disadvantages of bonded joints compared to welded joints. CO4 [K_1]
18. Tell why crack developed at the inner side of helical springs used in railways. CO5 [K_2]
19. Determine the expected life of a ball bearing with the dynamic load capacity of 37.5 kN and is subjected a radial load of 17 kN. CO6 [K_4]
20. Define hydrodynamic lubrication. CO7 [K_2]

Answer any FIVE Questions:-
PART C (5 x 14 = 70 Marks)
(Answer not more than 300 words)

Q.No. 21 is Compulsory

21. A transmission shaft supporting a spur gears B and the pulley D is shown in Fig 1.The shaft is mounted on two bearings A and C. The diameter of the pulley and the pitch circle diameter of the gear are 450 mm and 300 mm respectively. The pulley transmits 20 kW power at 500 rpm to the gear. P_1 and P_2 are belt tensions in the tight and loose sides, while P_t and P_r are tangential and radial components of gear tooth force. Assume CO3 [K_3]

$$P_1 = 3P_2 \text{ and } P_r = P_t \tan(20^o)$$

The gear and pulley are keyed to the shaft. The material of the shaft is steel $50C_4$ (ultimate stress = 700 460 N/mm^2 and yield stress = 460 N/mm^2). The shock factor k_b and fatigue factor k_t of the ASME code are 1.5 each. Determine the shaft diameter using ASME code.

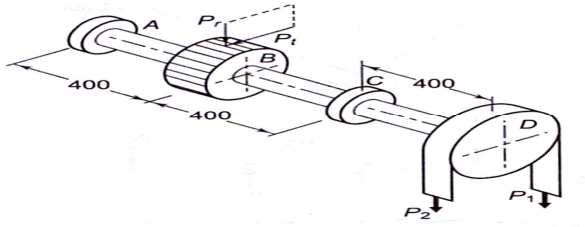

Fig 1

22. i) A pull of 80 kN is transmitted from a bar X to the bar Y through a pin as shown in Fig 2. If the maximum permissible tensile stress in the bars is 100 N/mm^2 and the permissible shear stress in the pin is 80 N/mm^2, calculate the diameter of bars and of the pin. (7) CO1 [K_3]

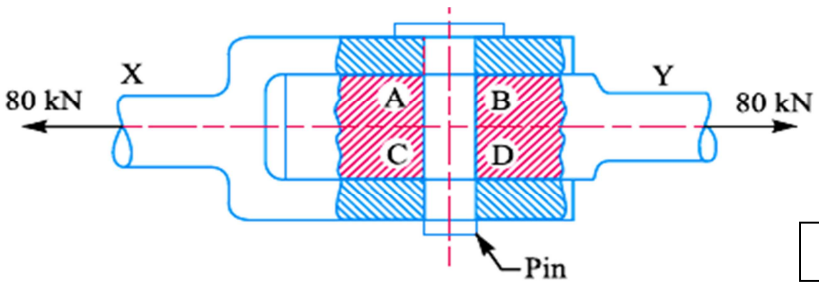

Fig 2

ii) The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Determine the diameter of bolt required according to maximum shear stress theory. Take permissible tensile stress at elastic limit = 100 MPa (7) CO1 [K_3]

23. i) Determine the maximum stress induced in a rectangular plate 60 mm × 10 mm with a hole 12 diameter as shown in Fig.3 and subjected to a tensile load of 12 kN. Consider the stress concentration. (5) CO2 [K_3]

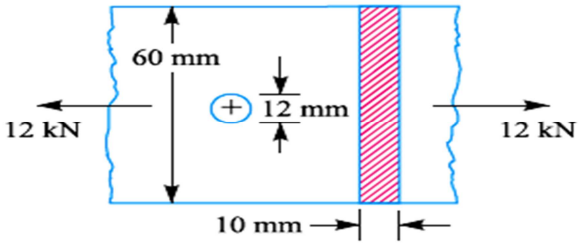

Fig 3

ii) A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 20 kN and a maximum value of 50 kN. Determine the diameter of bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar is given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa. Use Soderberg relation (9) CO2 [K_3]

24. A rectangular steel plate is welded as cantilever to a vertical column and supports a single concentrated load P, as shown in Fig 4. Determine the weld size if the shear stress in the same is not to exceed 140 MPa. CO4 [K_6]

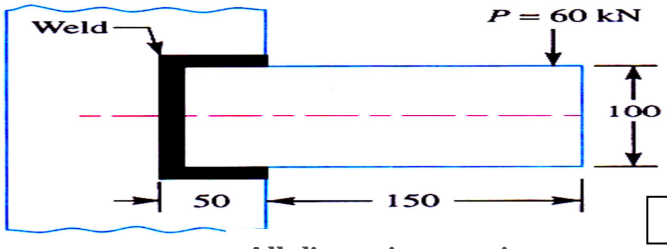

Fig 4

All dimensions are in mm

25. A safety valve operated by a helical spring through lever mechanism is schematically illustrated in Fig 5. The diameter of the valve is 50 mm. In normal operating conditions, the valve is closed and the pressure inside the chamber is 0.5 N/mm^2. The valve is opened when the pressure inside the chamber increases to 0.6 N/mm^2. The maximum lift of the valve is 5 mm. The spring index can be taken as 8. The spring is made of patented and cold-drawn steel wire with ultimate tensile strength of 1200 N/mm^2 and modulus of rigidity of 81370 N/mm^2. CO5 [K_6]

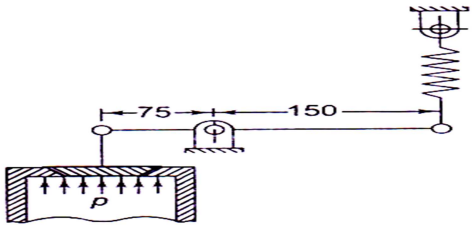

Fig 5

The permissible shear stress for the spring wire can be taken as 30% of the ultimate tensile strength. Design the spring and determine its all dimensions. Draw a neat sketch showing various dimensions.

26. A ball bearing is operating on a work cycle consisting of three parts – a radial load of 3000 N at 1440 rpm for one quarter cycle, a radial load of 5000 N at 720 rpm for one half cycle, and a radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of bearing is 10000 h. Estimate the cubic mean load on the bearing. (6) CO6 [K_3]

ii) Design a journal bearing for a centrifugal pump from the following data: (8) CO7 [K_3]

Load on the journal = 20000 N
Speed of the journal = 900 rpm
Type of oil is SAE 10, for which the absolute viscosity at 55^{o}C = 0.017 kg/m.s
Maximum bearing pressure for the pump = 1.5 N/mm^2.

27. Design a bushed pin type flexible coupling to connect a pump shaft to a motor shaft transmitting 32 kW at 960 rpm. The overall torque is 20 percent more than mean torque. The material properties are as follows: CO3 [K_3]

- The allowable shear and crushing stress for shaft and key material is 40 MPA and 80 MPa respectively.
- The allowable shear stress for cast iron is 15 MPA
- The allowable bearing pressure for rubber bush is 0.8 N/mm^2
- The material of the pin is same as that of shaft and key

Draw neat sketch of the coupling.

****