Government of Karnataka
Department of Technical Education
Board of Technical Examinations, Bangalore

	Course Title: **MACHINE DESIGN**		
	Scheme (L:T:P) : **4:0:0**	Total Contact Hours: **52**	Course Code: **15ME53T**
	Type of Course: **Lectures, Self Study & Quiz**	Credit **:04**	Core/ Elective: **Core**
CIE- 25 Marks			SEE- 100 Marks

Prerequisites: Knowledge of Mathematics, Engineering Mechanics, Strength of Materials, Theory of Machines, Machine drawing and Workshop Processes

Course Objectives:

This course curriculum provides the knowledge of design process, as well as enables the student to design simple machine components used in small and medium scale industries.

COURSE OUTCOMES

On successful completion of the course, the students will be able to:

Course Outcome		CL	Linked PO	Teaching Hrs
CO1	Understand the concept of design and behavior of material under varying load conditions, Use of design data books while designing machine components	***R***	2	**04**
CO2	Design of bolts, nuts, and riveted joints subjected to direct stresses and analyze the type of stresses induced under different load conditions	***R/U/A/An***	1,2	**12**
CO3	Design of machine elements subjected to direct and twisting moments and analyze the type of stresses induced under different load conditions	***U/A***	1,2,	**10**
CO4	Design of machine element like Solid Muff Coupling- flange coupling subjected to direct and twisting moments and Knuckle joint-Cotter joint subjected to direct stress and analyze the various modes of failure(with numeric examples)	***A / An***	1,2	**14**
CO5	Design procedure of machine elements subjected to twisting moment and analyze the type of stresses induced in them	***R/U/A***	1,2	**08**
CO6	Know the Principles of design as per ergonomic, and Environmental considerations	***R/U***	2	**04**
		Total sessions		**52**

Legend: R; Remember, U: Understand A: Application

COURSE-PO ATTAINMENT MATRIX

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
MACHINE DESIGN	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Level 3- Highly Addressed, Level 2-Moderately Addressed, Level 1-Low Addressed.

Method is to relate the level of PO with the number of hours devoted to the COs which address the given PO.

If ≥40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 3

If 25 to 40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 2

If 5 to 25% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 1

If < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

COURSE CONTENT AND BLUE PRINT OF MARKS FOR SEE

Unit No	Unit Name	Hour	Questions to be set for SEE/MARKS			Marks weightage	weightage (%)
			R	U	A/An/Ev/cre		
1	INTRODUCTION TO DESIGN	04	05	--	--	05	6.89
2	DESIGN OF FASTENERS	12	05	05	30	40	20.68
3	DESIGN OF SHAFTS, KEYS	10	--	05	15	20	17.27
4	DESIGN OF SIMPLE MACHINE PARTS	14	---	----	50	50	34.48
5	DESIGN OF SPRINGS	08	--	05	15	20	13.79
6	ERGONOMICS & AESTHETIC CONSIDERATION IN DESIGN	04	05	05	--	10	6.89
	Total	**52**	**15**	**20**	**110**	**145**	**100**

UNIT I: INTRODUCTION TO DESIGN 04Hrs

Machine Design–Classification-General considerations-Load-stress-strain,-stress-strain diagram for mild steel- Bending and torsion stress equations - Factor of Safety and Factors governing selection of factor of Safety- Stress Concentration – Causes & Remedies- Designation of materials as per IS- using of design data book – Concept of Theory of failure-types.

UNIT II: DESIGN OF FASTENERS 12Hrs

Stresses in Screwed fasteners- bolts of Uniform Strength- Design of Bolts - Design of studs for cylinder cover-simple problems on design of bolts subjected to external force -Design of Riveted joints -classification- Important terms used in riveted joints-materials for rivets-Failures of riveted joints-Strength and efficiency of riveted joints-Simple problems on Single and Double riveted lap joint -Single and Double riveted Butt joint (with single and double strap)

UNITIII: DESIGN OF SHAFTS, KEYS 10Hrs

Types of Shafts- Shaft materials-Standard Sizes- Design of Shafts (Hollow and Solid) using strength and rigidity criteria-design for line shafts supported between bearings with one or two pulleys in between or one overhung pulley.

Keys-Types-Design of Sunk Keys, Effect of Keyways on strength of shaft-Simple problems (excluding keyways).

UNIT IV: DESIGN OF SIMPLE MACHINE PARTS 14Hrs

Design of Couplings – Solid Muff Coupling- Flange coupling (Protected and Unprotected type) - Cotter Joint - Knuckle Joint

UNIT V: DESIGN OF SPRINGS 08Hrs

Spring – terminology, materials and specifications-Classification and Applications of Springs- Stresses in springs, Wahl's correction factor, Deflection of springs-Design of Helical compression springs subjected to uniform applied loads like I.C. engine valves, weighing balance, railway buffers and governor springs-Problems on helical compression springs only- Leaf springs – Construction and application

UNIT VI: ERGONOMICS & AESTHETIC CONSIDERATION IN DESIGN 4Hrs

Ergonomics of Design-Man-Machine relationship-Equipments for control-Ergonomics considerations in design of controls-Equipments for display-Ergonomics considerations in design of display.-Aesthetic considerations regarding shape, size, color (Morgan's code).

REFERENCES

Sl.No.	Title of Books	Author	Publication
1.	A Text book of Machine Design	R.S. Khurmi & J.K.Gupta	S. Chand publication
2.	Machine design	S G Kulkarni	McGraw Hill Education Publications
3	Introduction to Machine design	V B Bhandari	McGraw Hill Education Publications
4.	Design Of Machine Elements Vol I, Vol II	J.B.K. Das , P.L. Srinivas Murthy	Sapna Publication
5	Machine Component Design	William Orthwein	Jaico publication
6	Design Data Hand Book for Mechanical Engineers	K Mahadevan & K Balaveera Reddy	CBS publications

LIST SOFTWARES/WEBSITES

1. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_home.html
2 http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod4.html

3. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod7.html .
4. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod4.html
5. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod5.html
6. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod8.html

SPECIAL INSTRUCTIONAL STRATEGIES

UNIT NO	UNIT NAME	STARATEGIES
1	INTRODUCTION TO DESIGN	Lectures, Discussions ,cooperative learning group based learning, Think-Pair-share activities among group of students
2	DESIGN OF FASTENERS	Lectures, discussions, cooperative learning group based learning, Think-Pair-share activities among group of students
3	DESIGN OF SHAFTS, KEYS	Lectures, cooperative learning group based learning, Think-Pair-share activities among group of students
4	DESIGN OF SIMPLE MACHINE PARTS	Lectures, cooperative learning group based learning, Think-Pair-share activities among group of students Industrial visits, movies.
5	DESIGN OF SPRINGS	Lectures, cooperative learning group based learning, Think-Pair-share activities among group of students Industrial visits, movies
6	ERGONOMICS & AESTHETIC CONSIDERATION IN DESIGN	Discussions, real life industries situation, industrial visits

SUGGESTED LIST OF STUDENT ACTIVITYS

Note: the following activities or similar activities for assessing CIE (IA) for 5 marks (Any one)

- Each student should do any one of the following type activity or similar activity related to the course and before take up, get it approved from concerned Teacher and HOD.
- Each student should conduct different activity and no repeating should occur

1	The students should identify at least five applications .He should select the materials for identified applications by using design data hand book. List the mechanical properties of material selected.
2	Observe the system where transmission of power takes place through shaft, Keys, coupling, pulley and belt drive. Get the required information regarding power transmitted (power output by motoror engine etc.). By selecting suitable materials, design the shaft, key and coupling.
3	Assignments on design of Helical Springs, Screwed joints, Riveted joints [one each] with free hand sketches.
4	The student should Download and present various presentations related to design of machine elements
5	The student should Download and present various presentations related to stresses in machine elements.

6	The student should Download and present various presentations related to failure of machine elements.

Course Assessment and Evaluation Scheme:

	What		To whom	When/Where (Frequency in the course)	Max Marks	Evidence collected	Course outcomes
Direct Assessment	CIE	IA	Students	Three IA tests(Average of three tests will be computed)	20	Blue books	1,2,3,4,5,6
				Student Activities	05	Activity sheets	
	SEE	End Exam		End of the course	100	Answer scripts at BTE	1,2,3,4,5,6
Indirect Assessment	Student Feedback on course		Students	Middle of the course		Feedback forms	1,2,3 Delivery of course
	End of Course Survey			End of the course		Questionnaires	1,2,3,4,5,6 Effectiveness of Delivery of instructions & Assessment Methods

CIE- Continuous Internal Evaluation SEE- Semester End Examination

Note: I.A. test shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

Note to IA verifier*: *The following documents to be verified by CIE verifier at the end of semester

1. Blue books (20 marks)
2. Student suggested activities report for 5 marks evaluated through appropriate rubrics.
3. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Methods

- **MODEL OF RUBRICS /CRITERIA FOR ASSESSING STUDENT ACTIVITY**

RUBRICS MODEL

RUBRICS FOR ACTIVITY(5 Marks)						
Dimension	**Unsatisfactory**	**Developing**	**Satisfactory**	**Good**	**Exemplary**	**Student Score**
	1	**2**	**3**	**4**	**5**	
Collection of data	Does not collect any information relating to the topic	Collects very limited information; some relate to the topic	Collect much information; but very limited relate to the topic	Collects some basic information; most refer to the topic	Collects a great deal of information; all refer to the topic	Ex: 4
Fulfill team's roles & duties	Does not perform any duties assigned to the team role	Performs very little duties but unreliable.	Performs very little duties	Performs nearly all duties	Performs all duties of assigned team roles	5
Shares work equally	Always relies on others to do the work	Rarely does the assigned work; often needs reminding	Usually does the assigned work; rarely needs reminding	Normally does the assigned work	Always does the assigned work without having to be reminded.	3
Listen to other Team mates	Is always talking; never allows anyone else to speak	Usually does most of the talking; rarely allows others to speak	Talks good; but never show interest in listening others	Listens, but sometimes talk too much	Listens and speaks a fair amount	2
Average / Total marks=(4+5+3+2)/4=14/4=3.5=4						

Note: This is only an example. Appropriate rubrics/criteria may be devised by the concerned faculty (Course Coordinator) for assessing the given activity.

Note to IA verifier: ***The following documents to be verified by CIE verifier at the end of semester***

4. Blue books (20 marks)
5. Student suggested activities report for 5 marks
6. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Method

MODEL QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks
Ex: I test/6 th week of sem 10-11 Am	VSEM	**MACHINE DESIGN**	20
	Year: 2016-17	Course code:15ME53T	

Name of Course coordinator : Units:1,2 Co: 1,2

Note: Answer all questions

Question no	Question	MARKS	CL	CO	PO
1	Define factor of safety. List and explain the factors to be considered while selecting Factor of safety. **OR** Explain stress strain diagram of mild steel is differing from that of cast iron with necessary sketches.	10	R/U	1	2
2	A steam engine cylinder has an effective diameter of 350 mm and the maximum steam pressure acting on the cylinder cover is 1.25 N/mm2. Calculate the number and size of studs required to fix the cylinder cover, assuming the permissible stress in the studs as 33 MPa. **OR** The cylinder head of a steam engine is subjected to a steam pressure of 0.7 N/mm2. It is held in position by means of 12 bolts. A soft copper gasket is used to make the joint leak-proof. The effective diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa.	10	A	2	1,2

MODEL QUESTION PAPER (SEE)

V- Semester Diploma Examination		
MACHINE DESIGN		
Time: **3 Hours**]	**Note: Answer all questions**	[Max Marks**: 100**
	PART-A	
1	List the general Considerations in machine design	5
2	Explain man-machine joint system	5
3	List with examples five basic forms for shape of product	5
	PART-B	
4- a	List the different types of riveted joints and rivets.	5
B	Two plates of 10 mm thickness each are to be joined by means of a single riveted double strap butt joint. Determine the rivet diameter; rivet pitch, strap thickness and efficiency of the joint. Take the working stresses in tension and shearing as 80 MPa and 60 MPa respectively.	15
	OR	
4- a	Discuss the stresses induced in the Screw fasteners when it is subjected to static loading.	5
b	The cylinder head of a steam engine is subjected to a steam pressure of 0.7 N/mm2. It is held in position by means of 12 bolts. A soft copper gasket is used to make the joint leak-proof. The effective diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa.	15
5- a	Explain the effect of keyway cut into the shaft.	5
b	Select the diameter of a solid steel shaft to transmit 20kw at 200 rpm. The ultimate shear stress for the steel may be taken as 360mpa and factor of safety as 8. If a hallow shaft is to be used in place of solid shaft , finds the inside and outside diameter when the ratio of inside to outside is 0.5.	15
	OR	
5- a	Explain how the shafts are designed when it is subjected to twisting moment only on stiffness/strength basis.	5
b	Select the diameter of a solid steel shaft for a pair of wheels of a railway wagon carries a load of 50KN on each axle box acting at a distance of 100mm outside the wheel base. The gauge of the rails is 1.4 m ,if the stress is not to exceed 100Mpa.	15
6- a	Explain the applications of spring	5
b	Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity, G = 84 kN/mm2. Neglect the effect of stress concentration.	15
	OR	
6- a	Classify the springs.	5
	Design the spring for the buffers of a rail wagon of mass 20 tonnes is	8

b	moving with a velocity of 2 m/s. It is brought to rest by two buffers with springs of 300 mm diameter. The maximum deflection of springs is 250 mm. The allowable shear stress in the spring material is 600 MPa.	15
	PART C	
7	Design a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing. **OR**	25
8	Design a rigid flange coupling to transmit a torque of 250 N-m between two coaxial shafts. The shaft is made of alloy steel, flanges out of cast iron and bolts out of steel. Four bolts are used to couple the flanges. The shafts are keyed to the flange hub. The permissible stresses are given below: Shear stress on shaft =100 MPa Bearing or crushing stress on shaft =250 MPa Shear stress on keys =100 MPa Bearing stress on keys =250 MPa Shearing stress on cast iron =200 MPa Shear stress on bolts =100 MPa	25

MODEL QUESTION BANK

V- Semester Diploma Examination

MACHINE DESIGN

Note: ***The paper setter is of liberty to set the questions on his/her desecration based on cognitive levels notified for that unit. They have to follow only blue print of SEE question paper format. The model question bank is only for reference to students/course coordinator to initiate the process of teaching-learning only.***

CO-1: Understand the concept of design and behaviour of material under varying load conditions, Use of design data books while designing machine components

Remember

1) Define machine Design.
2) List out the classification of machine design.
3) List general considerations in machine design.
4) Define the following terms a) Load b) Stress c) strain
6) Define factor of safety.
7) Recall the equation for bending.
8) Recall the equation for Torsion.
9) List the various factors to be considered in deciding the factor of safety.
10) Label the salient features of stress- strain diagram for mild steel.
11) List the different types of failure theories.

CO-2: **Design of bolts, nuts, and riveted joints subjected to direct stresses and analyze the type of stresses induced under different load conditions**

Remember

1. Define fastener.
2. Define Riveted joint.
3. List the different types of riveted joints and rivets.
4. Define efficiency of riveted joint.

Understanding

1. Classify the fasteners.
2. Compare Bolt, stud and Nut.
3. Explain bolt of uniform strength. Where it is preferably used.
4. Explain the stresses induced in the Screw fasteners when it is subjected to static loading.
5. Interpret the reasons for "Initial tightening of bolts is essential".
6. Interpret the reasons for "Excessive tightening of bolts is avoided".
7. Explain the necessity of riveted joint.

8. List the applications of riveted joint in modern equipments.
9. Explain the types of failures in riveted joint with sketch.

a. Problems on bolts

Analysis/Application

1. A steam engine cylinder has an effective diameter of 350 mm and the maximum steam pressure acting on the cylinder cover is 1.25 N/mm2. Calculate the number and size of studs required to fix the cylinder cover, assuming the permissible stress in the studs as 33 MPa.

2. A mild steel cover plate is to be designed for an inspection hole in the shell of a pressure vessel. The hole is 120 mm in diameter and the pressure inside the vessel is 6 N/mm2. Design the cover plate along with the bolts. Assume allowable tensile stress for mild steel as 60 MPa and for bolt material as 40 MPa.

3. The cylinder head of a steam engine is subjected to a steam pressure of 0.7 N/mm2. It is held in position by means of 12 bolts. A soft copper gasket is used to make the joint leak-proof. The effective diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa.

4. An eye bolt is to be used for lifting a load of 60 kN. Find the nominal diameter of the bolt, if the tensile stress is not to exceed 100 MPa. Assume coarse threads.

5. Determine the safe tensile load for bolts of M 20 and M 36. Assume that the bolts are not initially stressed and take the safe tensile stress as 200 MPa.

6. An eye bolt carries a tensile load of 20 kN. Find the size of the bolt, if the tensile stress is not to exceed 100 MPa..

7. An engine cylinder is 300 mm in diameter and the steam pressure is 0.7 N/mm2. If the cylinder head is held by 12 studs, find the size. Assume safe tensile stress as 28 MPa.

B. Problems on rivets

Applications/evaluating/creating

1. A double riveted lap joint with zig-zag riveting is to be designed for 13 mm thick plates. Assume σt = 80 MPa ; τ = 60 MPa ; and σc = 120 MPa. State how the joint will fail and find the efficiency of the joint.

2. Two plates of 10 mm thickness each are to be joined by means of a single riveted double strap butt joint. Determine the rivet diameter; rivet pitch, strap thickness and efficiency of the joint. Take the working stresses in tension and shearing as 80 MPa and 60 MPa respectively.

3. Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5 m in diameter subjected to a steam pressure of 0.95 N/mm2. Assume joint efficiency as 75%, allowable tensile stress in the plate 90 MPa ; compressive stress 140 MPa ; and shear stress in the rivet 56 MPa.

4. A single riveted lap joint is made in 15 mm thick plates with 20 mm diameter rivets. Determine the strength of the joint, if the pitch of rivets is 60 mm. Take σt = 120 MPa; τ = 90 MPa and σc = 160 MPa.

5. Two plates 16 mm thick are joined by a double riveted lap joint. The pitch of each row of rivets is 90mm. The rivets are 25 mm in diameter. The permissible stresses are as +follows: σt = 140 MPa ; τ = 110 MPa and σc = 240 MPa Find the efficiency of the joint.

6. A single riveted double cover butt joint is made in 10 mm thick plates with 20 mm diameter rivets
with a pitch of 60 mm. Calculate the efficiency of the joint, if σt = 100 MPa ; τ = 80 MPa and σc = 160 MPa.

7. A double riveted double cover butt joint is made in 12 mm thick plates with 18 mm diameter rivets. Find the efficiency of the joint for a pitch of 80 mm, if σt = 115 MPa ; τ = 80 MPa and σc = 160 MPa.

CO-3: Design of machine elements subjected to direct and twisting moments and analyzes the type of stresses induced under different load conditions

Understand

1) Explain the effect of keyway cut into the shaft.
2) List the reasons for rectangular keys are preferred over square keys.
3) Explain how the shafts are designed when it is subjected to twisting moment only on stiffness/strength basis.
4) Explain how the shafts are designed when it is subjected to Bending moment only on stiffness/strength basis.
5) Explain how the shafts are designed when it is subjected to combined twisting moment and bending moment on stiffness/strength basis.
6) List the properties of materials used for shafts.
7) Classify Sunk keys.
8) List he standard sizes of Transmission shafts.
9) Explain how the shafts are designed on Rigidity basis.

Problems on shafts

Applications

1) Select the diameter of the shaft for a mild steel rotating at 200 rpm, transmiting 20kW with a allowable shear stress of 42MPa.

2) Select the diameter of the shaft for a mild steel rotating at 240rpm, is transmitting 1 MW The maximum torque transmitted exceeds the mean torque by 20%. The allowable shear stress as 60mpa.

3) Select the diameter of a solid steel shaft to transmit 20kw at 200 rpm. The ultimate shear stress for the steel may be taken as 360mpa and factor of safety as 8. If a hallow shaft is to be used in place of solid shaft , finds the inside and outside diameter when the ratio of inside to outside is 0.5.

4) Select the diameter of a solid steel shaft for a pair of wheels of a railway wagon carries a load of 50KN on each axle box acting at a distance of 100mm outside the wheel base. The gauge of the rails is 1.4 m ,if the stress is not to exceed 100Mpa.

5) Select the diameter of a solid steel shaft is subjected to bending moment of 3000N-m and a torque of 10000N-m. The shaft is made of 45 c 8 steel having ultimate tensile stress of 700Mpa and Ultimate shear stress of 500Mpa. Assuming factor of safety as 6.

6) Select the diameter of a solid steel shaft made of mild steel is required to transmit 100 kW at 300 r.p.m. The supported length of the shaft is 3 metres. It carries two pulleys each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe value of stresses

7) Select the diameter of a solid steel shaft by considering two different theories of failure made of steel of yield strength 700 MPa is subjected to static loads consisting of a bending moment of 10 kN-m and a torsional moment of 30 kN-m. and assuming a factor of safety of 2.

8) Choose the outside and inside diameter of a hollow steel shaft transmits 600 kW at 500 r.p.m. The maximum shear stress is 62.4 MPa. The outer diameter is twice of inside diameter, assuming that the maximum torque is 20% greater than the mean torque.

Problems on keys

Application/Evaluation

1) Recommend the rectangular key for a shaft of 50 mm diameter. The shearing and crushing stresses for the key material are 42 MPa and 70 MPa.

2) Recommend 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 for a 45 mm diameter shaft is made of steel with a yield strength of 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.

3) A 15 kW, 960 r.p.m. motor has a mild steel shaft of 40 mm diameter and the extension being 75 mm. The permissible shear and crushing stresses for the mild steel key are 56 MPa and 112 MPa. Design the keyway in the motor shaft extension. Check the shear strength of the key against the normal strength of the shaft.

4) Select the length of a 20 mm wide key required to mount a pulley on the shaft so that the stress in the key does not exceed 42MPa. A shaft 80 mm diameter transmits power at maximum shear stress of 63 MPa.

5) Select the dimensions of the key so that A shaft 30 mm diameter is transmitting power at a maximum shear stress of 80 MPa. If a pulley is connected to the shaft by means of a key, the stress in the key is not to exceed 50 MPa and length of the key is 4 times the width.

6) Select a suitable key for the gear having a steel shaft has a diameter of 25 mm. The shaft rotates at a speed of 600 r.p.m. and transmits 30 kW through a gear. The tensile and yield strength of the material of shaft are 650 MPa and 353 MPa respectively. Take a factor of safety 3. Assume that the key and shaft are made of the same material.

CO-4: Design of machine element like Solid Muff Coupling- flange coupling subjected to direct and twisting moments and Knuckle joint-Cotter joint subjected to direct stress and analyze the various modes of failure(with numeric examples)

Apply/ Analysis

Muff coupling

1) Design a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 r.p.m. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa.

2) Design a muff coupling to connect two shafts transmitting 40 kW at 120 r.p.m. The permissible shear and crushing stress for the shaft and key material (mild steel) are 30 MPa and 80 MPa respectively. The material of muff is cast iron with permissible shear stress of 15 MPa. Assume that the maximum torque transmitted is 25 per cent greater than the mean torque.

Problems on flange coupling

Apply/ Analysis

1) Design a cast iron protective type flange coupling to transmit 15 kW at 900
r.p.m. from an electric motor to a compressor. The service factor may be assumed as 1.35. The
Following permissible stresses may be used :
Shear stress for shaft, bolt and key material = 40 MPa
Crushing stress for bolt and key = 80 MPa
Shear stress for cast iron = 8 MPa
2) Design a protective type of cast iron flange coupling for a steel shaft
transmitting 15 kW at 200 r.p.m. and having an allowable shear stress of 40 MPa. The working stress in the bolts should not exceed 30 MPa. Assume that the same material is used for shaft and key and that the crushing stress is twice the value of its shear stress. The maximum torque is 25% greater than the full load torque. The shear stress for cast iron is 14 MPa.

3) Design a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 r.p.m. The allowable shear stress in the shaft is 40 MPa and the angle of twist is not to exceed 1° in a length of 20 diameters. The allowable shear stress in the coupling bolts is 30 MPa.

4) Design a rigid flange coupling to transmit a torque of 250 N-m between two coaxial shafts. The shaft is made of alloy steel, flanges out of cast iron and bolts out of steel. Four bolts are used to couple the flanges. The shafts are keyed to the flange hub. The permissible stresses are given below:

Shear stress on shaft =100 MPa
Bearing or crushing stress on shaft =250 MPa
Shear stress on keys =100 MPa
Bearing stress on keys =250 MPa
Shearing stress on cast iron =200 MPa
Shear stress on bolts =100 MPa

5) Two 35 mm shafts are connected by a flanged coupling. The flanges are fitted with 6 bolts on 125 mm bolt circle. The shafts transmit a torque of 800 N-m at 350 r.p.m. For the safe stresses mentioned below, calculate 1. diameter of bolts ; 2. thickness of flanges ; 3. key dimensions ;4. hub length; and 5. power transmitted.
Safe shear stress for shaft material = 63 MPa
Safe stress for bolt material = 56 MPa
Safe stress for cast iron coupling = 10 MPa
Safe stress for key material = 46 MPa

Problems on cotter joint

Apply/ Analysis

1. Design a cotter joint to connect two mild steel rods for a pull of 30 kN. The maximum permissible stresses are 55 MPa in tension; 40 MPa in shear and 70 MPa in crushing. Draw a neat sketch of the joint designed.

2.Two rod ends of a pump are joined by means of a cotter and spigot and socket at the ends. Design the joint for an axial load of 100 kN which alternately changes from tensile to compressive. The allowable stresses for the material used are 50 MPa in tension, 40 MPa in shear and 100 MPa in crushing.

3. Two mild steel rods 40 mm diameter are to be connected by a cotter joint. The thickness of the cotter is 12 mm. Calculate the dimensions of the joint, if the maximum permissible stresses are: 46 MPa in tension ; 35 MPa in shear and 70 MPa in crushing.

4. Design a cotter joint to support a load varying from 30 kN in compression to 30 kN in tension. The material used is carbon steel for which the following allowable stresses may be used. The load is applied statically. Tensile stress = compressive stress 50 MPa ; shear stress 35 MPa and crushing stress= 90 MPa.

Problems on Knuckle Joint

Apply/ Analysis

1. Design a knuckle joint to transmit 150 kN. The design stresses may be taken as 75 MPa in tension, 60 MPa in shear and 150 MPa in compression.

2. Design a knuckle joint for a tie rod of a circular section to sustain a maximum pull of 70 kN. The ultimate strength of the material of the rod against tearing is 420 MPa. The ultimate tensile and shearing strength of the pin material are 510 MPa and 396 MPa respectively. Determine the tie rod section and pin section. Take factor of safety = 6.
3. Design a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing.
4. A knuckle joint is required to withstand a tensile load of 25 kN. Design the joint if the permissible stresses are :σt = 56 MPa ; τ = 40 MPa and σc = 70 MPa.

CO-5: Design procedure of machine elements subjected to twisting moment and analyzes the type of stresses induced in them

Remember

1) List the applications of spring
3) List materials used in Springs.
4) Define the terms used in springs.
5) Name the springs used in a) Spring balance b)Ball Pen c) Door Hinges d) Truck Chassis e)Clock

Understand

1) Classify the springs.
2) Explain the significance of Whal's factor
3) Expline the applications of spring
4) List the materials used in Springs.

Problems on springs

Apply/ Analysis

1) Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity, G = 84 kN/mm2. Neglect the effect of stress concentration.

2) Design and draw a valve spring of a petrol engine for the following operating conditions:
Spring load when the valve is open = 400 N
Spring load when the valve is closed = 250 N
Maximum inside diameter of spring = 25 mm
Length of the spring when the valve is open= 40 mm
Length of the spring when the valve is closed= 50 mm
Maximum permissible shear stress = 400 MPa

3) Design the spring for the buffers of a rail wagon of mass 20 tonnes is moving with a velocity of 2 m/s. It is brought to rest by two buffers with springs of 300 mm diameter. The

maximum deflection of springs is 250 mm. The allowable shear stress in the spring material is 600 MPa.
4) 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/mm2,with considering whal's factor.

CO-6: Know the Principles of design as per ergonomic, and Environmental considerations

Remember

1) Define Ergonomics.
2) List with examples five basic forms for the shape of Product.
3) List the types of controls.
4) List the types of Display.

Understand

1) Explain the relationship between functional requirement and external appearance of the Product.
2) Explain the scope of ergonomics in product design.
3) Explain the meaning of different colors as per morgan's code.
4) Explain man – machine joint system.
5)Explain the ergonomics considerations in design of controls.
6) Explain the ergonomics considerations in design of Display.