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

	Course Title: DESIGN OF MACHINE ELEMENTS		
	Scheme (L:T:P) : **4:0:0**	Total Contact Hours: **52**	Course Code: **15AT53T**
	Type of Course: **Lectures, Self**	Credit **:04**	Core/ Elective: **core 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	Explain the concept and process of Machine Design.	***R/U***	2,5,6	**02**
CO2	Understand the constructional features and Design bolts, nuts, and riveted joints subjected to direct stresses and analyze the type of stresses induced under different load conditions.	***R/U/ A***	1,2,6	**12**
CO3	Understand the constructional features and Design Shafts and keys subjected to different moments and analyze the type of stresses induced under different load conditions.	***U/A***	1,2,6	**10**
CO4	Understand the constructional features and Design Shaft couplings and joints subjected to twisting moments and analyze the various modes of failure.	***U/A***	1,2,6	**14**
CO5	Design of Engine components Subjected to combustion pressure and analyze the type of stresses induced in them.	***U/A***	1,2,6	**08**
CO6	Understand the constructional features and Design coil and leaf spring subjected to different vehicle loads.	***U/A***	1,2,6	**06**
		Total sessions		**52**

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

Course PO-attainment chart:

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
Design of Machine Elements	**1**	**3**	**0**	**0**	**1**	**3**	**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		
1	Introduction To Design	02		05	--	5	3.4
2	Design Of Fasteners	12	10	05	25	40	27.58
3	Design Of Shafts, Keys	10	--	05	20	25	17.24
4	Design Of Simple Machine Parts	14	---	----	40	40	27.58
5	Design Of Engine Parts	08	--	---	20	20	13.79
6	Design Of Springs	06	05	---	10	15	10.3
	Total	**52**	**15**	**15**	**115**	**145**	**100**

Note : Refer Design data hand book to solve the problems.
Design data hand book is to be permitted in CIE and SEE

UNIT I: INTRODUCTION TO DESIGN 02Hrs

Machine Design-Definition, Classification, General procedure and considerations.

UNIT II: DESIGN OF FASTENERS 12Hrs

Screw thread terminology, Common types of screw fastenings-Through bolts-Tap bolts-Studs-Cap screws-Set screws, forms of screw threads-V Threads-square threads- whitworth thread-sellers thread-unified standard thread-square thread-acme thread-knuckle thread-buttress thread, locking devices-Lock nut-Slotted nut-Castle nut-grooved nut-Locking by a lock plate-tab washer-spring washer, Designation of screw thread, stresses in screw fastening due to external loading- Tensile-compressive-combined tensile & shear stress, bolts of Uniform Strength, 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)

UNIT III: DESIGN OF SHAFTS, KEYS 10Hrs

Types of Shafts, Shaft materials, Standard Sizes, Design of Shafts subjected to twisting & bending moment (Hollow and Solid) using strength and rigidity criteria, Design of propeller shaft & rear axle shaft-simple problems

Keys-Purpose, Types-Taper key-parallel key-sunk key-saddle key-Gib head key-woodruff key-feather key-splines, Forces acting on sunk key-Design of Sunk Keys based on shear & crushing-Simple problems

UNIT IV: DESIGN OF SIMPLE MACHINE PARTS 14Hrs

Couplings-purpose-requirements-Types ,Design of Couplings – Solid Muff Coupling- Flange coupling (Protected and Unprotected type) –simple problems, Design of socket and spigot cotter joint-simple problem, Knuckle Joint-purpose-methods of failure-simple problems.

UNIT V: DESIGN OF ENGINE PARTS 08Hrs

Design of Engine cylinder (Thickness of cylinder wall, head thickness, bore & length of cylinder, size of studs)-simple problems, Design of piston, piston pin & piston rings-simple problems.

UNIT VI: DESIGN OF SPRINGS 06Hrs

Coil springs-Terms used in helical compression spring, stresses & deflection of helical spring, simple problems

Leaf springs- Effective & ineffective length, camber, stresses & deflection of semi elliptic leaf spring, simple problems.

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
3	Introduction to Machine design	V B Bhandari	McGraw Hill Education
4	Automotive Mechanics	Dr N K Giri	Khanna Publishers
4.	Design Of Machine Elements Vol I, Vol II	J.B.K. Das , P.L. Srinivas Murthy	Sapna Publication
5	Auto Design	R B Gupta	Satya Prakashan
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

SUGGESTED LIST OF STUDENT ACTIVITIES

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 machine components .He should select the materials for identified machine components by using design data hand book. List the mechanical properties of material selected.
2	Observe the mechanisms where transmission of power takes place through shaft, Keys, coupling, pulley and belt drive. Get the required information regarding power transmitted (power output by motor engine etc.).
3	The students can visit nearby workshops/garages and collect information like material, design features etc on different fasteners and machine components.
4	Assignments on design of Screwed joints, Riveted joints [one each] With free hand sketches.
5	The student should Download and present various presentations related to design of machine elements.
6	The student should Download and present various presentations related to stresses in Machine elements.
7	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 3 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

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

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MODEL OF RUBRICS /CRITERIA FOR ASSESSING STUDENT ACTIVITY

RUBRICS MODEL

Student Name :				Reg No:		
RUBRICS FOR ACTIVITY(5 Marks)						
Dimension	**Unsatisfactory**	**Developing**	**Satisfactor y**	**Good**	**Exemplary**	**Student Score**
	1Mark	**2 Mark**	**3 Mark**	**4 Mark**	**5 Mark**	
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	Collects some basic information; most refer to the	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	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

1. Blue books (20 marks)
2. Student suggested activities report for 5 marks
3. 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	V SEM	DESIGN OF MACHINE ELEMENTS	20
	Year: 2016-17	Course code: 15AT53T	

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

Note: Design data hand book is permitted
Answer all questions

Q. No	Questions	Mark	CL	CO	PO
1	**a.** Explain any five considerations in Machine Design b. Explain Whitworth thread with its profile **OR** a. Define Machine Design. b. Define efficiency of riveted joint	5 5 5 5	R/U	1,2	1,2,5,6
2	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. **OR** 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.	10 10	A	2	1,2,6

MODEL QUESTION PAPER (SEE)

V Semester Diploma Examination

DESIGN OF MACHINE ELEMENTS

Time: **3 Hours**] [Max Marks**: 100**

NOTE:

1. Use of Design data hand book is permitted
2. Answer **any six** questions from PART-A and each question carry **five** marks.
3. Answer **any seven** questions from PART-B and each question carry **ten** marks.

PART-A

1. List out the classification of Machine Design.
2. Explain woodruff key with sketch
3. Explain Whitworth thread with its profile.
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. Explain sunk key with sketch.
6. Design 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.
7. Classify the fasteners.
8. Define the following terms used in coil spring.
   a. solid length b. Free length c. Spring index
9. Explain castle nut with a sketch

PART-B

1. An electric motor weighing 10KN is lifted by means of an eye bolt. The eye bolt is screwed into the frame of the motor. The eye bolt has coarse threads. It is made of plain carbon steel having ultimate tensile stress of 400N/mm^2 and factor of safety is 6. Determine the size of the bolt.

2. 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 allowable tensile stress in the plate 115 MPa ; compressive stress 160 MPa; and shear stress in the rivet 80 MPa.

3. A solid shaft is transmitting 1 MW at 240rpm determine the diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20%. Take the maximum allowable shear stress as 60MPa.

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4. Design a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 rpm. 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.

5. 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 15MPa. Assume that the maximum torque transmitted is 25 per cent greater than the mean torque.

6. 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.

7. 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.

8. Design an aluminum alloy piston with a flat head for an I C engine having 100mm bore. The maximum explosion pressure is 4.5 N/mm^2. Given that
Permissible stress for aluminum alloy piston= 70 N/mm^2
Permissible stress for piston ring= 100 N/mm^2
Cylinder wall pressure = 0.04 N/mm^2
Permissible bearing pressure on piston barrel= 0.45 N/mm^2
Permissible bearing pressure for piston pin= 70 N/mm^2

9. A four stroke internal combustion engine has the following specifications.
Brake power=5KW, Speed=1200 rpm, Mean effective pressure=0.35N/mm^2
Mechanical efficiency=80%, Maximum gas pressure=3.15 N/mm^2, Determine
Bore and length of the cylinder, if stroke length is 1.5 times cylinder bore.
Thickness of the cylinder head if permissible stress for head material is 42N/mm^2
Size of studs for the cylinder head, if permissible stress for stud material is 65N/mm^2.

10. 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.

MODEL QUESTION BANK

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: Explain the concept and process of Machine Design.

05 Marks

1) Define Machine Design.(R)
2) List out the classification of Machine Design.(R)
3) State general considerations in Machine Design.(R)

10 Marks

1. Explain general procedure in Machine Design (U).
2. Explain general considerations in Machine Design.(U)

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

05 Marks

1. Define a fastener.(R)
2. Define a screwed joint.(R)
3. Explain Whitworth thread with its profile. .(U)
4. Explain Sellers thread with its profile.(U)
5. Explain Unified standard thread with its profile.(U)
6. Explain square thread with its profile.(U)
7. Explain acme thread with its profile.(U)
8. Explain Knuckle thread with its profile.(U)
9. Explain Buttress thread with its profile.(U)
10. Explain Through bolt with a sketch.(U)
11. Explain Tap bolt with a sketch.(U)
12. Explain Studs with a sketch (U).
13. Explain Cap screws with sketch.(U)
14. Explain set screws with sketch.(U)
15. State the necessity of locking a bolt.(R)
16. Explain Lock nut with a sketch.(U)
17. Explain slotted nut with a sketch.(U)
18. Explain castle nut with a sketch.(U)
19. Explain grooved nut with a sketch.(U)
20. Define a Riveted joint.(R)
21. Enumerate the different types of riveted joints.(R)
22. Define efficiency of riveted joint.(R)
23. Define the following terms used in riveted joints. (R)

a. Pitch b. Back pitch c. Diagonal pitch d. Margin

24. Define the following terms used in riveted joints. (R)

a. Major diameter b. Minor diameter c. Pitch diameter d. Lead e. Crest

25. List the different forms of screw thread. (R)
26. List the common types of screw fastenings. (R)
27. List the different types of locking devices. (R)
28. Describe how a screw thread is specified. (U)
29. Classify the fasteners. (A)
30. Differentiate between Bolt & stud. (A)
31. Discuss bolt of uniform strength. Where it is preferably used. (A)
32. Discuss the stresses induced in the Screw fasteners when it is subjected to external loading. (A)
33. Explain the necessity of riveted joint. (U)
34. Discuss applications of riveted joint in modern equipments. (A)
35. Explain the types of failures in riveted joint with sketch. (U)

10 Marks

Bolts

1. Two shafts are connected by means of a flange coupling to transmit torque of 25 N-m. The flanges of the coupling are fastened by four bolts of the same material at a radius of 30mm. Find the size of the bolts if the allowable shear stress for the bolt material is 30 MPa.(A)
2. Two plates are fastened by means of two bolts. The bolts are made of plain carbon steel 30C8 of ultimate shear stress 200N/mm^2 and factor of safety is 5. Determine the size of bolts if shear load is 5KN. (A)
3. 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 (A)
4. 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. (A)
5. A lever loaded safety valve has a diameter of 100mm and the blow off pressure is 1.6N/mm^2. The fulcrum of the lever is screwed into the cast-iron body of the cover. Find the diameter of the threaded part of the fulcrum if the permissible tensile stress is limited to 50 MPa and the leverage ratio is 8.(A)
6. An electric motor weighing 10KN is lifted by means of an eye bolt. The eye bolt is screwed into the frame of the motor. The eye bolt has coarse threads. It is made of plain carbon steel having ultimate tensile stress of 400N/mm^2 and factor of safety is 6. Determine the size of the bolt.(A)

Rivets

1. A double riveted lap joint with zigzag riveting is to be designed for 13 mm thick plates. Assume allowable tensile stress in the plate 80 MPa; compressive stress 120 MPa; and shear stress in the rivet 60 MPa. State how the joint will fail and find the efficiency of the joint. (A)

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 (A).

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 (A).

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 allowable tensile stress in the plate 120 MPa; compressive stress 160 MPa; and shear stress in the rivet 90 MPa (A)

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. Take allowable tensile stress in the plate 140 MPa; compressive stress 240 MPa and shear stress in the rivet 110 MPa. Find the efficiency of the joint.(A)

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 allowable tensile stress in the plate 100 MPa ; compressive stress 160 MPa; and shear stress in the rivet 80 MPa .(A)

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 allowable tensile stress in the plate 115 MPa; compressive stress 160 MPa; and shear stress in the rivet 80 MPa.(A)

CO-3: Understand the constructional features and Design Shafts and keys subjected to different moments and analyze the type of stresses induced under different load conditions.

05 Marks

1) Classify shafts. (U/A)
2) Discuss the reasons for rectangular keys are preferred over square keys. (U)
3) Explain how the shafts are designed when it is subjected to twisting moment only on stiffness/strength basis. (U)
4) Explain how the shafts are designed when it is subjected to Bending moment only on stiffness/strength basis. (U)
6) State the properties of materials used for shafts. (R/U)
7) Classify Sunk keys.(U/A)
8) Explain sunk-key with sketch. (U/A)
9) Explain saddle key with sketch. (U/A)
10) Explain Gib head key with sketch. (U/A)
11) Explain woodruff key with sketch. (U/A)
12) Discus the forces acting on sunk key. (U)
13) Discuss the standard sizes of Transmission shafts. (U)
14) Explain how the shafts are designed on Rigidity basis. (U)

10 Marks

Shafts

1) A line shaft rotating at 200 rpm is to transmit 20kW. The shaft may be assumed to be made of mild steel with an allowable shear stress of 42MPa. Determine the diameter of the shaft, neglecting bending moment on the shaft.(A)

2) A solid shaft is transmitting 1 MW at 240rpm determine the diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20%. Take the maximum allowable shear stress as 60MPa (A)

3) Find 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. (A)

4) 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 find the diameter of the axle between the wheels, if the stress is not to exceed 100Mpa. (A)

5) A hollow shaft of diameter ratio 3/5 is to transmit 600 KW at 110 rpm. The maximum torque is 12% greater than the mean torque. If the shear stress is not to exceed 60 N/mm^2, determine the minimum external diameter. (A)

6) A solid circular shaft is used to transmit a torque of 9.6 N-m, the angle of twist over a length of a 2m is 2^o. Estimate the required diameter of shaft. Take C= $0.8x10^5$ N/mm^2.(A)

7) A shaft is required to transmit 1 MW at 240 rpm. The shaft must not twist more than 1^o on a length of 15 diameters. If the modulus of rigidity for the shaft material is 80 KN/mm^2, find the diameter of the shaft. (A)

8) A mild steel shaft has to transmit 75 KW at 210 rpm. The allowable shear stress in the shaft is limited to 42 N/mm^2. The angle of twist is not to exceed 1^o for a length of 20 diameters. Calculate the suitable diameter of the shaft. (A)

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

Keys

1) Design 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. (A)

2) A 45 mm diameter shaft is made of steel with yield strength of 400 MPa. A parallel key of size 14 mm wide and 9 mm thick made of steel with 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. (A)

3) Design a square key for a gear shaft of diameter 25mm, 20KW power at 1000 rpm is transmitted from the shaft to gear. The yield strength of key material in tension is 450 MPa and factor of safety is 3. The yield strength in compression can be assumed to be equal to the yield strength in tension. (A)

4) A rectangular sunk key 14mmX10mm thick,75mm long is required to transmit 1200 N-m torque from 50mm diameter solid shaft. Determine whether the length is sufficient or not if

permissible shear stress and crushing stresses are limited to 56MPa and 168 MPa respectively. (A)

5) A square key is to be used to key a gear to a 35mm diameter shaft. The hub length of gear is 60mm. Both shaft and key are to be made of the same material having an allowable shear stress of 55MPa. What are the minimum dimensions for the sides of the square key if 395 N-m of torque is to be transmitted? (A)

CO-4: Understand the constructional features and Design Shaft couplings and joints subjected to twisting moments and analyze the various modes of failure.

05 Marks

1. List the purposes of couplings.(R)
2. List the requirements of a good coupling.(R)
3. Classify couplings.(A)
4. Discus the various methods of failure of knuckle joint.(U/A)

10 Marks

Muff coupling

1) Design a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 rpm. 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. (A)

2) Design a muff coupling to connect two shafts transmitting 40 kW at 120 rpm. 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. (A)

Flange coupling

1) Design a cast iron protective type flange coupling to transmit 15 kW at 900 rpm 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 rpm 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. (A)

3) Design a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 rpm. 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. (A)

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 (A)

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 flange, 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 (A)

Cotter joint

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. (A)

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. (A)

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.(A)

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= 90MPa. (A)

Knuckle Joint

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.(A)

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.(A)

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.(A)

4. A knuckle joint is required to withstand a tensile load of 25 kN. Design the joint if the permissible stresses are 56 MPa in tension ; 40 MPa in shear and 70 MPa in crushing(A).

CO-5: Design of Engine components Subjected to combustion pressure and analyze the type of stresses induced in them.

10 Marks

Piston, Piston rings and piston pin.

1. Design an aluminum alloy piston with a flat head for an I C engine having 100mm bore. The maximum explosion pressure is 4.5 N/mm^2. Given that
Permissible stress for aluminum alloy piston= 70 N/mm^2
Permissible stress for piston ring= 100 N/mm^2
Cylinder wall pressure = 0.04 N/mm^2
Permissible bearing pressure on piston barrel= 0.45 N/mm^2
Permissible bearing pressure for piston pin= 70 N/mm^2

2. Design a cast iron piston for a single acting four stroke engine for the following data:
Cylinder bore=100mm, Stroke=125mm. Maximum gas pressure= 5N/mm^2, Indicated mean effective pressure=0.75N/mm^2, Mechanical efficiency=80%, Fuel consumption=0.15 kg per brake power per hour, Higher calorific value of fuel= $42x10^3$ Kj/Kg, speed=2000 rpm, Assume
Permissible stress for cast iron piston= 38 N/mm^2
Permissible stress for piston ring= 100 N/mm^2
Cylinder wall pressure = 0.035 N/mm^2
Permissible bearing pressure on piston barrel= 0.45 N/mm^2
Permissible bearing pressure for piston pin= 25 N/mm^2

Engine Cylinder

1. A four stroke internal combustion engine has the following specifications.
Brake power=7.5KW, Speed=1000 rpm, Mean effective pressure=0.35N/mm^2
Maximum gas pressure=3.5 N/mm^2, Mechanical efficiency=80%, Determine
   a. The dimensions of cylinder, if the length of stroke is 1.4 times the cylinder bore.
   b. Cylinder wall thickness, if the hoop stress is 35MPa
   c. Thickness of the cylinder head and the size of studs when the permissible stresses for the cylinder head and stud materials are 45MPa and 65MPa respectively.

2. A four stroke internal combustion engine has the following specifications.
Brake power=5KW, Speed=1200 rpm, Mean effective pressure=0.35N/mm^2
Mechanical efficiency=80%, Maximum gas pressure=3.15 N/mm^2, Determine
   a. Bore and length of the cylinder, if stroke length is 1.5 times cylinder bore.
   b. Thickness of the cylinder head if permissible stress for head material is 42N/mm^2
   c. Size of studs for the cylinder head, if permissible stress for stud material is 65N/mm^2.

CO-6: Understand the constructional features and Design coil and leaf spring subjected to different vehicle loads.

05 Marks

1. Define the following terms used in coil spring. (R)

a. solid length b. Free length c. Spring index d. Spring rate e. Pitch

2. Define the following terms used in leaf spring.(R)

a. Effective length b. Ineffective length c. camber

10 Marks

1) A helical spring is made from a wire of 6mm diameter and has outside diameter of 75mm. If the permissible shear stress is 350MPa and modulus of rigidity 84 KN/mm^2, find the axial load which the spring can carry and the deflection per active turns.

2) 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,with considering whal's factor.

3) A typical coil suspension spring has 10 effective coils of a mean diameter 125mm and made out of wires of diameter 15mm. The spring is designed to carry a maximum static load of 3531.6 N. Calculate the shear stress and the deflection under the above loading.

If a maximum shear stress of 637650 kPa is allowable in the material, then what is the possible clearance in the spring? Take the value of G=73575x10^3 kPa.

4) A vehicle spring of semi-elliptic type has leaves of 75mm width and 10mm thickness and effective length 900mm. If the stress is not to exceed 220725kPa when the spring is loaded to 4905 N, estimate the required number of leaves and the deflection undr this condition. If the spring is just flat under load, what is the initial radius. Take E=196.2x10^{6}kPa.

5) Design a leaf spring for the following specifications:

Total load=140KN: Number of springs supporting the load=4: Maximum number of leaves=10:

Span of the spring=1000mm:Permissible deflection=80mm.

Take Young's modulus, E=200KN/mm^2 and allowable stress in spring material as 600MPa.

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