K.S.R. COLLEGE OF ENGINEERING

(Autonomous)

Vision of the Institution

- We envision to achieve status as an excellent educational institution in the global knowledge hub, making self-learners, experts, ethical and responsible engineers, technologists, scientists, managers, administrators and entrepreneurs who will significantly contribute to research and environment friendly sustainable growth of the nation and the world.

Mission of the Institution

- To inculcate in the students self-learning abilities that enable them to become competitive and considerate engineers, technologists, scientists, managers, administrators and entrepreneurs by diligently imparting the best of education, nurturing environmental and social needs.
- To foster and maintain a mutually beneficial partnership with global industries and Institutions through knowledge sharing, collaborative research and innovation.

DEPARTMENT OF DEPARTMENT OF MECHANICAL ENGINEERING

Vision of the Department

- To be a centre of excellence in the field of Mechanical Engineering for providing its students and faculty with opportunities to excel in education and targeted research themes in emerging areas.

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Mission of the Department

- To excel in academic and research activities that meets the industrial and social needs.
- To develop competent, innovative and ethical Mechanical Engineers.

Programme Educational Objectives (PEOs)

- Identify, design and apply the technical skills to solve mechanical engineering problems for enhancing the quality of life.
- Apply the modern tools and techniques to face the challenges in mechanical and related engineering areas.
- Understand the responsibility, communicate and implement innovative ideas in multidisciplinary teams ethically for uplifting the society.



COURSE FACULTY **H.O.D** **PRINCIPAL**

K.S.R. COLLEGE OF ENGINEERING (Autonomous)

Department of Automobile Engineering

Subject Name: Design of Machine Elements

Subject Code: 20AU513 **Year/Semester: III / V**

Course Outcomes: On completion of this course, the student will be able to

CO1	*Examine the influence of steady and variable stresses in machine components.*
CO2	*Select the suitable shaft and coupling for a particular application.*
CO3	*Identify the basic design concepts of temporary and permanent joints.*
CO4	*Find and identify suitable springs and understand the design concepts of flywheels.*
CO5	*Acquire knowledge on bearings for engineering applications.*

Program Outcomes (POs) and Program Specific Outcomes (PSOs)

A. Program Outcomes (POs)

Engineering Graduates will be able to :

PO1 **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals; and an engineering specialization to the solution of complex engineering problems**.**

PO2 **Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences**.**

PO3 **Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations**.**

PO4 **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions**.**

PO5 **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations**.**

PO6 **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice**.**

PO7 **Environmental and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development**.**

PO8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice**.**

PO9 **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings**.**

PO10 **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions**.**

PO11 **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments**.**

PO12 **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

B. Program Specific Outcomes (PSOs)

PSO1 **Research Culture:** Read Literature, do research on new mechanical engineering problems and publish the results through patents, journals, conferences and symposium.

PSO2 **Core Values :** Contribute core universal values and social good to the community.

COURSE FACULTY **H.O.D** **PRINCIPAL**

K.S.R. COLLEGE OF ENGINEERING (Autonomous)						R 2020
SEMESTER - V						
20AU513	DESIGN OF MACHINE ELEMENTS (Use of Standard and approved Design Data Book is permitted)	L	T	P	C	
		3	1	0	4	
Prerequisite: Mechanics of Materials						
Course Outcomes : On successful completion of the course, the student will be able to						***Cognitive Level***
CO1:	*Examine the influence of steady and variable stresses in machine components.*					*Understand*
CO2:	*Select the suitable shaft and coupling for a particular application.*					*Apply*
CO3:	*Identify the basic design concepts of temporary and permanent joints.*					*Analyze*
CO4:	*Find and identify suitable springs and understand the design concepts of flywheels.*					*Apply*
CO5:	*Acquire knowledge on bearings for engineering applications.*					*Apply*
UNIT - I	**STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS**					**[12]**
Introduction to the design process – Four C's of design - factor influencing machine design, selection of materials based on mechanical properties – Preferred numbers, limits, fits and tolerances – Direct, Bending and Torsional stress equations – Calculation of principal stresses for various load combinations – eccentric loading - Factor of safety - Theories of failure – Stress concentration – Design for variable loading – Soderberg, Goodman and Gerber relations.						
UNIT - II	**DESIGN OF SHAFTS AND COUPLINGS**					**[12]**
Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways – Design of rigid flange and flexible couplings – Muff, clamp, rigid flange and bushed – pin flexible couplings.						
UNIT - III	**DESIGN OF TEMPORARY AND PERMANENT JOINTS**					**[12]**
Threaded fasteners – Design of bolted joints including eccentric loading – Design of welded joints – Axially loaded unsymmetrical welded joints – Eccentric load in the plane of welds – Welded joints subjected to bending and twisting moment – Design of riveted joints.						
UNIT - IV	**DESIGN OF SPRINGS AND FLYWHEEL**					**[12]**
Design of helical, multi- leaf and torsional springs under constant loads and varying loads – End conditions and length of springs - Stresses in Helical springs of circular wire – Wahl's stress factor – Concentric torsion springs – Design of flywheels involving stresses in rim and arm.						
UNIT - V	**DESIGN OF BEARINGS**					**[12]**
Design of bearings – Sliding contact and rolling contact types – Cubic mean load – Design of journal bearings – Mckees equation – Lubrication in journal bearings – Calculation of bearing dimensions – Fundamentals of fracture mechanics.						
Total (L= 45, T = 15) = 60 Periods						
Text Books :						
1	Bhandari.V, Design of Machine Elements, Tata McGraw–Hill Publishing Co., New Delhi, Fourth Edition, 2016.					
2	Shigley, J.E., Mischke. C.R., Mechanical Engineering Design, Tata McGraw-Hill Education, New York, Tenth Edition, 2015.					
Reference Books :						
1	Sundararajamoorthy T.V., Shanmugam. N., Machine Design, Anuradha Publications, Chennai, 2018.					
2	Gope. P.C., Machine Design - Fundamental and Application, PHI learning Pvt. Ltd., New Delhi, 2012.					
3	Juvinall. R.C., Marshek. K.M., Fundamentals of Machine Component Design, John Wiley & Sons, New Delhi, Seventh Edition, 2019.					
4	Faculty of Mechanical Engineering, PSG College of Technology, Design Data Book, M/s. Kalaikathir Achchagam, Coimbatore, 2019.					

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DEPARTMENT OF AUTOMOBILE ENGINEERING

DEGREE / BRANCH : B.E., AUTOMOBILE ENGINEERING
YEAR / SEMESTER : III / V
NAME OF THE STAFF: **Mr. P.VIGNESH**
SUBJECT CODE : 20AU513
SUBJECT NAME : DESIGN OF MACHINE ELEMENTS

COURSE / LESSON PLAN SCHEDULE

A) TEXT BOOK:

T1. G.K.Vijayaraghavan, "Design of Machine Elements", 3d edition, Lakshmi Publications, India, 2008
T2. R.S.Khurmi, "Machine Design", S.Chand & Company Ltd., New Delhi 1998

B) REFERENCE BOOK:

R1. Norton.R.L, "Design of Machinery:, Tata McGraw Hill, 2004
R2. Ugural.A.C, "Mechanical Design-An Integral Approach", Mc Graw Hill 2004.

C) LEGEND:

L - Lecture
T - Tutorial
OHP - Over Head Projector
T_X - Reference
PPT - Power Point
BB - Black Board
pp - Pages
Ex - Extra

Sl. No	Lecture Hour	Topics to be covered	Teaching Aid Required	Book No. /Page No
UNIT – I	**STEADY STRESSES AND VARIABLE STREESSES IN MACHINE MEMBERS**			
1.	**L1**	Introduction, design process, factors in design, selection of materials	BB	T1/PP 1.1- 1.3
2.	**L2**	Direct bending, torsional stresses, impact shock loading	BB	T1/PP 1.6-1.8
3.	**L3**	Principal stresses for various load calculations	BB	T1/PP 1.9-1.12
4.	**T1**	Solved problems on principal stresses	BB	T1/PP 1.28
5.	**L4**	Eccentric loading , problems	BB	T1/PP 1.35- 1.38 R2/PP 1.57-1.62
6.	**L5**	Curved beams, problems	BB	T1/PP 1.43-1.46
7.	**L6**	Theories of failure, types	BB	T1/PP 1.64

8.	**L7**	Problems in theories of failure	BB	T1/PP 1.64-1.67
9.	**L8, L9**	Stress concentration , design for variable loading, soderberg, goodman relations	BB	T1/PP 1.74-1.78
10.	**T2, T3**	Anna university problems in Variable stresses	BB	T1/PP 1.124-1.145
UNIT – II DESIGN OF SHAFTS AND COUPLINGS				
11.	**L10**	Introduction, types, shaft materials, design based on strength	BB	T1/PP 2.2
12.	**L11**	Critical speed, design for variable loading	BB	T1/PP 2.3-2.8
13.	**T4**	Solving problem	BB	T1/PP 2.8-2.57
14.	**L12**	Keys, types, design aspects	BB	T1/PP 2.80-2.85
15.	**L13**	Couplings, types, design aspects- box coupling	BB	T1/PP 2.98
16.	**L14, L15**	Design of clamp & flange couplings	BB	T1/PP 2.98-2.108
17.	**L16**	Design of flexible Couplings	BB	T1/PP 2.109-2.122
18.	**T5**	Solving Problem	BB	R2/PP 2.138-2.142
19.	**L17**	Design of Knuckle joint	BB	R2/PP 2.106-2.109
20.	**L18**	Steps in solving problem.	BB	R2/PP 2.110-2.111
21.	**T6**	Solving Problem	BB	R2/PP 2.111-2.113
UNIT – III DESIGN OF TEMPORARY AND PERMANENT JOINTS				
22.	**L19**	Threaded fasteners, introduction, design aspects	BB	T1/PP 3-3.3
23.	**L20**	Differential and compound screws, locking devices, washers	BB	T1/PP 3.4-3.7

24.	**L21**	Stresses, preloading , force deformation diagram	BB	T1/PP 3.13
25.	**L22**	Design of bolts, eccentric loading	BB	T1/PP 3.13-3.14
26.	**T7**	Solving problems in design of bolts	BB	T1/PP 3.21-3.57
27.	**L23**	Welded joints, introduction, and types.	BB	T1/PP 3.59-3.60
28.	**L24**	Basic weld symbols, strength of welded joints	BB	T1/PP 3.63-3.70
29.	**L25**	Eccentrically loaded joints, stress concentration factor	BB	T1/PP 3.71-3.78
30.	**L26**	Design procedure	BB	R2/PP 3.41-3.46
31.	**L27**	Bonded joints, adhesives	BB	T1/PP 3.112
32.	**T8**	Solving problems	BB	T1/PP 3.81-3.112
33.	**T9**	Solving problems	BB	T1/PP 3.81-3.112
UNIT – IV DESIGN OF SPRINGS AND FLYWHEEL				
34.	**L28**	Springs, functions, classification, design aspects	BB	T1/PP 4.1
35.	**L29**	Stresses, deflection in helical springs, stiffness of spring	BB	T1/PP 4.2-4.8
36.	**L30**	Energy stored, impact loading, end conditions	BB	T1/PP 4.2-4.10
37.	**T10**	Solving simple problems	BB	T1/PP 4.6-4.10
38.	**L31**	Buckling surge and concentric springs	BB	T1/PP 4.7-4.15
39.	**L32**	Helical springs subjected to variable loading	BB	T1/PP 4.18-4.20
40.	**L33**	Design of helical tension springs, Belleville springs	BB	T1/PP 4.20, 4.74
41.	**T11**	Solving problems	BB	T1/PP 4.24-4.29
42.	**L34,L35**	Design of laminated leaf springs, procedure	BB	T1/PP 4.85-4.92
43.	**L36**	Design of levers, procedure for cranked and foot lever	BB	T1/PP 4.109-4.118

44.	**L37**	Design of hand lever	BB	T1/PP 4.109-4.118
45.	**T12**	Solving Problems	BB	T1/PP 5.11-5.15
UNIT – V DESIGN OF BEARINGS				
46.	**L38**	Design of rolling contact bearings, introduction ,types ,components	BB	T1/PP 5.1-5.73
47.	**L39**	Roller bearings and types, bearing life, load rating	BB	R2/PP 5.8-5.15
48.	**L40**	Equivalent load, life relationship, selection of bearings	BB	R2/PP 5.16-5.19
49.	**L41**	Cyclic load and cubic mean load	BB	T1/PP 5.11
50.	**L42**	Taper roller bearings, design procedure	BB	T1/PP 5.11-5.15
51.	**T13**	Solving problems	BB	R2/PP 5.52-5.59
52.	**L43**	Design of journal bearings	BB	T1/PP 5.26-5.27
53.	**L44**	Hydrodynamic and static theory of lubrication	BB	R2/PP 5.65-5.69
54.	**L45**	Design steps	BB	T1/PP 5.29-5.35
55.	**L45**	Design of flywheels	BB	T1/PP 5.49-5.55
56.	**T14**	Solving problem	BB	T1/PP 8.27-8.36
57.	**T15**	Solving problem	BB	T1/PP 9.1-9.3

PREPARED BY
(P.VIGNESH)

H.O.D./AE
(Dr. R.VENKATACHALAM)

UNIT- I STEADY AND VARIABLE STRESSES

Part – A: 2 MARK QUESTIONS

1. **Define "Design".**

   Design is a series of activities to gather all the information necessary to realize the designer's idea into real product.

2. **What is 'Adaptive design' Where is it used? Give examples.**

   It is a process where a new product is developed just by making small changes to the existing product. It is used where no or limited scope is available to go for an entirely new design. Ex: Geared bicycle.

3. **What are the various phases of Design process?**

   i) Recognition of need.
   ii) Definition of the problem.
   iii) Synthesis.
   iv) Analysis and optimization.
   v) Evaluation and presentation.

4. **List some factors that influence machine design.**

   1. Strength and stiffness.
   2. Surface finish and tolerance.
   3. Manufacturability.
   4. Ergonomics and aesthetics.
   5. Working atmosphere.
   6. Safety and reliability.
   7. Cost.

5. **Explain "Design for Manufacture".**

   Design for manufacture means designing is done so that manufacturing in the shop floor is possible. It includes prescribing available materials, possible manufacturing methods and achievable tolerances.

6. **Define "Optimization".**

   It is the process of maximizing a desired quantity or minimizing the unwanted one.

7. **Describe the material properties hardness, stiffness and resilience.**

   Harness is the ability of material to resist stretching and indentation.
   Stiffness is the ability of material to resist deformation under loading.
   Resilience is the ability of the material to absorb energy and to resist shock and impact load.

8. **Identify the steel designated as 50 C 4 as per BIS.**

   i. It is a plain carbon steel.
   ii. Average percentage of carbon= 50/100 = 0.5%
   iii. Average percentage of manganese =4=0.04%

9. Determine the composition of the steel designated as 17 Mn Cr 95.

i. It is an alloy steel.

ii. Average %ge of carbon = 0.17

iii. Manganese is the principal alloying element with average 1%

iv. Average %ge of chromium is 0.95%

10. What is an Impact load? Give an Example.

If the time load application is less than one third of the lowest national period of vibration of the part, the load is called an impact load.

11. Define principal planes and principal stress.

A plane where only normal stresses act, with no shear stress acting is called principal plane. The normal stress acting on this plane is called principal stress.

12. What is the difference between straight beam and curved beams?

Feature	Straight beam	Curved beam
Centroidal axis and neutral axis	Are coincident	Are not coincident. Neutral axis is shifted towards the centre of curvature
Stress developed	Same throughout the section.	Different at inner and outer radii of the section.

13. Define 'Factor of safety'

The ratio between maximum stresses to working stress is known as factor of safety.

14. How is factor of safety defined for brittle and ductile materials?

For ductile materials, F.O.S is taken as Yield stress/working stress.

For brittle material , F.O.S is taken as Ultimate stress/working stress.

15. What are the various factors to be considered in designing factor of safety?

i) Material properties.

ii) Nature of load.

iii) Presence of localized stresses.

iv) Presence of initial stresses.

v) Mode of failure.

16. What are the various factors to be considered in selecting the materials for machine elements?

i) Required material properties,

ii) Manufacturing ease,

iii) Material availability,

iv) Cost.

17. Why normal stress theory is not suitable for ductile materials?

Ductile materials mostly fail by shearing. But this theory considers only tensile and compressive stresses. So this is not suitable for ductile materials.

18. Explain St. venant's theory of failure

According to this theory, failure occurs when the maximum strain in the material equals the tensile yield strain.

(i.e.), σ1-γ$(\sigma_2 + \sigma_3)$ $or\ \sigma_2 - \gamma(\sigma_3 + \sigma_1)$ or $\sigma_3 - (\sigma_1 + \sigma_2) = \sigma_y$ whichever is maximum

Where, γ is Poisson's ratio

19. Explain notch sensitivity. State the relationship between stress concentration factor, fatigue stress concentration factor and notch sensitivity.

Notch sensitivity (q) is the degree to which the theoretical effect of stress concentration is actually reached. The relation is, $K_f = 1+q(K_f-1)$

20. Differentiate between static and variable stresses.

Static stress does not change in magnitude and in direction. Variable stress changes in magnitude or direction or both.

21. Differentiate between alternating and fluctuating stress.

Alternating stress varying from a minimum value of one nature to a maximum of opposite nature.

Fluctuating stress vary from a minimum to a maximum of same nature.

For diagram, fig.1.69 on page no 1.143 in text book

22. What are the various theories of failure?

i) Maximum principal stress theory,

ii) Maximum shear stress theory,

iii) Maximum principal strain theory ,

iv) Maximum strain energy theory.

23. Draw Goodman & Soderberg diagrams and locate the salient points.

Refer Fig.1.70 in the page no 1.144 in the text book.

24. What is an S-N curve?

An S-N curve has failure stress on Y-axis and number of loading cycle in X axis. It is used to find the fatigue stress value corresponding to a given number of cycles.

25. Define endurance limit. What are the factors affecting endurance strength.

Endurance limit is the maximum value of completely reversed stress that the standard specimen can sustain an infinite number (10^6) of cycles without failure.

26. Differentiate between endurance limit and endurance strength.

The word 'Endurance limit' is used for infinite (10^6) of cycles and 'Endurance strength' can be used for any number of cycles.

UNIT- I STEADY AND VARIABLE STRESSES

Part – B: 16 MARK QUESTIONS

1. A cylindrical bar 60mm diameter and 200mm long is fixed at one end. At the free end it is loaded as shown in fig, with an axial load of 12kN, a downward transverse load of 5kN and a torque of 1.4kN.m. Calculate the maximum stress at the point B of the bar.
[ANNA University- Apr'96] [Refer Text Book Page no 1.33 & fig1.18]

2. A bolt is subjected to a tensile load of 25kN and a shear load of 10kN. Determine the diameter of the bolt according to
a) Maximum principal stress theory
b) Maximum principal strain theory
c) Maximum shear stress theory
Assume factor of safety as 2.5, yield point stress in simple tension = 300N/mm^2, poison's ratio = 0.25 [ANNA University- Apr'98] [Refer Text Book Page no 1.69]

3. A transmission shaft is subjected to a fluctuating torque that varies from -120N.m to+500N.m. Let the stress concentration factor be 1.5 and factor of safety be 2. Determine the required diameter of the shaft. The shaft material is C45 steel. [ANNA University- Apr'98] [Refer Text Book Page no 1.88]

4. A shaft is subjected to a bending moment varying from -200N.m to 500N.m and a twisting moment varying from 50N.m to 175N.m. the material has Su = 600MPa, Se = 300MPa, Ka = 0.76, Kb=0.85, Kc=0.897, and q= 0.95. Find the diameter of the shaft by Von Mices Henky theory. Factor of safety is 1.5. [A.U-Nov'2002] [Refer Text Book Page no 1.124]

5. A transmission shaft made of C45 steel is subjected to a fluctuating toque from -100N.m to +500N.m. Also a fluctuating bending moment varying from +500N.m to -500N.m. Let the stress concentration factor be 2. The shaft is machined for a factor of safety of 1.5. Determine the required diameter of the shaft.[A.U-Nov2004] [Refer Text Book Page no 1.134]

6. A mild steel bracket is as shown in fig. It is subjected to a pull of 5000N acting at 45^0 to the horizontal axis. The bracket has a rectangular section whose depth is twice the thickness. Find the cross sectional dimensions of the bracket if the permissible stress in the material is 50N/mm^2. [A.U-Apr'2005] [Refer Text Book Page no 1.137 & fig1.66]

7. A cantilever rod of circular cross section is subjected to a cyclic transverse load varying from -100N to +300N as shown in fig. Determine the diameter of the rod by (i) Goodman method, (ii) Soderberg method using the following data.
Factor of safety = 2.

Stress concentration factor = 1.4
Notch sensitivity factor = 0.9
Ultimate strength = 550MPa
Yield strength = 320MPa
Endurance strength = 275MPa
Size correction factor = 0.85
Surface correction factor = 0.9 [A.U Nov.2004]
[Refer Text Book Page no1.132 & fig1.65 (a)]

UNIT- II DESIGN OF SHAFTS & COUPLINGS

Part – A: 2 MARK QUESTIONS

1. **Define shaft.**

   A shaft is a rotating element , which transmits power from one point to another point.

2. **Explain the various types of shafts used in power transmission**.
   1. Line shaft.
   2. Spindle.
   3. Stub shaft.
   4. Counter shaft.

3. **What is simple torsion?**

   When a shaft is subjected to pure torsional moment Mt , the shaft diameter can be found from torsional shear strength equation, which is given by,

   Shear strength τ, $= \frac{16M_t}{\pi d^3}$ .....for solid shaft

   $= \frac{16M_t D_0}{\pi(D_0^4 - D_i^4)}$..... for hollow shaft

   Where, Mt – torque in N.mm

   d- diameter of the shaft

   D_0 – outside diameter of the hollow shaft

   D_i – inside diameter of the hollow shaft

4. **What is simple bending moment?**

   When a shaft is subjected to a pure bending load, principal stresses induced in the shaft are tension and compression. The maximum stress induced in the shaft can be determined by the theory of simple bending. It is given by the relation

   $\sigma_b = \frac{32M_b}{\pi d^3}$

   $\sigma_b = \frac{32M_b d_0}{\pi(d_0^4 - d_i^4)}$ Where, M_b = bending moment. d_0 is outer diameter,

   d_i is inner diameter

5. **Write down the formula for finding Equivalent Bending Moment.**

   The expression $\sqrt{M_b^2 + M_t^2}$ is called equivalent twisting moment denoted by M_{te}

   $$M_{te} = \sqrt{M_b^2 + M_t^2}$$

6. Define the term 'critical speed'

The speed at which the shaft runs so that the additional defection of the shaft from the axis of rotation becomes infinite, is known as critical or whirling speed.

7. Write down Dunkerley's equation for the critical speed of the shaft.

When a shaft carries n pulleys or gears, the critical speed of the shaft may be found by Dunkerley's equation.

$$\frac{1}{\omega_c^2} = \frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} + \cdots\cdots + \frac{1}{\omega_n^2}$$

Where, $\omega_1 \ \omega_2 \ \cdots\cdots\cdots \omega_n$ are critical speeds of the shaft when each mass is considered.

8. What is a key? And write down types of keys.

A key is a device which is used for connecting two machine parts for preventing relatice motion with respect to each other.

Types of keys i) saddle key, ii) tangent key, iii) sunk key, iv) Round key and taper pins

9. Differentiate between keys and splines.

S.No	KEYS	SPLINES
1.	A shaft which is having single keyway	A shaft which is having multiple keyways
2.	Keys are used in couplings	Used in automobiles and machine tools.

10. What is the function of a coupling between two shafts?

Couplings are used to connect sections of long transmission shafts to connect the shaft of a driving machine to the shaft of a driven machine.

11. Under what circumferences flexible couplings are used?

They are used to join the abutting ends of shafts when they are not in exact alignment.

They are used to permit an axial misalignment of the shafts without under absorption of the of the power, which the shafts are transmitting.

12. How a coupling is specified?

It is specified by

a) Diameter of the shaft
b) Diameter of the sleeve or muff
c) Length of the muff or sleeve
d) Nominal diameter of the bolt

e) Diameter of the bolt circle.

13. Name any two of the rigid and flexible couplings?

1. Rigid coupling

i) Sleeve coupling
ii) Flange coupling
iii) Clamp coupling

2. flexible coupling

i) Universal coupling
ii) Oldham's coupling
iii) Pushed pin type coupling

14. What is the material used for flange or flange coupling?

Cast iron

15. What is the advantage of Gear coupling?

- It is a rigid coupling with some flexibility because of using curved external teeth.
- Strength of gear coupling is very high.
- Most compact coupling for high power transmission.

16. Differentiate between a cotter and knuckle joint.

	Cotter joint	Knuckle joint
1	Rods are rigidly connected.	Small angular moment is possible between rods
2	Subjected to tensile or compressive forces.	Mostly tensile loads only, compressive loads are applied only if guidance is provided.

UNIT- II DESIG NOF SHAFTS & COUPLINGS

Part – B: 16 MARK QUESTIONS

1. A feed pump of a binary vapour cycle of centrifugal type and delivers 20m3/min at 750rpm against a dynamic head of 8m. Determine the power required to drive the motor, if the pump efficiency is 90%. If the maximum torque on the motor shaft is 30% more than the average torque, determine the diameter of the motor shaft. The permissible shear stress in the shaft material should not exceed 50MPa. [Refer Text Book Page no 2.10]

2. The propeller shaft of marine engine is to transmit 500kW at 1000rpm, without a significant bending. The efficiency of the propeller is 75% at 20knots (1knot = 1085km/hr). If the slenderness ratio is less than 40 and the permissible shear stress should not exceed 55MPa, determine the diameter of the shaft. [Refer Text Book Page no 2.11]

3. A solid shaft is to transmit 1000kW at 120rpm. Find the shaft diameter if the design shear stress is 80N/mm^2. If the shaft is made hollow with internal diameter is

0.6times the external diameter, find the % of saving in material [Refer Text Book Page no 2.18]

4. A line shaft rotating at 200rpm is to transmit 20kW power. The allowable shear stress for the material is 42N/mm^2. If the shaft carries a central load of 900Nand is simply supported between bearings 3 meters apart determine the diameter the diameter of the shaft. The maximum tensile or compressive stress is not to exceed 56MPa. [A.U.-May '99] [Refer Text Book Page no 2.57]

5. A solid shaft transmits power from an electric motor to a machine through a pulley by means of a vertical belt drive with unit speed ratio. The pulley weighs 250N and is overhanging at a distance of 120mm from a bearing. Diameter of the pulley is 200mm. maximum power transmitted at 150rpm is 3kW. Co efficient of friction between the belt and pulley is 0.25. Combined shock and fatigue factor in torsion is 1.5 and in bending is 2.0, permissible shear stress for the shaft material is 40MPa [A.U.May'01] [Refer Text Book Page no 12.63]

6. A shaft is to transmit 50kW at 1200rpm. It is also subjected to a bending moment of 275N.m. allowable shear stress is 60MPa. The shaft is not to twist more than 2^o in a length of 2m. G = 80x 10^3 N/mm^2. Design the shaft. [A.U.Nov2005] [Refer Text Book Page no 2.77]

7. A rigid type of coupling is used to connect two shafts transmitting 15kW at 200rpm. The shaft, keys, bolts are made of C45 steel and the couplings is of cast iron. Design the coupling. [M.U-Apr'99] [Refer Text Book Page no 2.105]

8. Design a protected type flange coupling fro the following requirements
Power transmitted = 10kW
Speed of the shaft = 960rpm
Select suitable materials [M.U.Apr'97] [Refer Text Book Page no 2.118]

9. A marine type flange coupling is used to transmit 3.75kW at 150rpm. The allowable shear stress in the shaft and bolt material is taken as 50MPa. Determine the shaft diameter and the diameter of the bolts as per Indian standard.[M.K.U –Apr'96] [Refer Text Book Page no 2.127]

10. A knuckle joint is to transmit a force of 140kN. Allowable stresses in tension, shear and compression are 75MPa, 65MPa and 140MPa respectively. Design the joint. [AU – CBE Nov'2004] [Refer Text Book Page no 2.138]

11. Design a bushed pin type of flange coupling for connecting a motor and pump shaft for the following data
Power = 20kW;
speed = 1000rpm;
Shaft diameter = 50mm
Bearing pressure for the rubber bush = 0.3N/mm^2. [M.U – Apr'03] [Refer Text Book Page no 2.131]

UNIT- III DESIGN OF FASTENERS &WELDED JOINTS

Part – A: 2 MARK QUESTIONS

1. **What are the purposes of screws?**
   - i) To secure members
   - ii) To transmit power
2. **Define: pitch, lead.**

   Pitch is the axial distance from a point on one third to corresponding point on next thread.

   Lead is the distance the screw moves in one turn.
3. **List some types of commonly used thread forms.**

   i) Square ii) ISO metric iii) ACME iv) BSW v) BA
4. **How is a bolt designated?**

   A bolt is designated by a letter M followed by nominal diameter and pitch in mm.
5. **State the advantages of threaded joints.**
   a) High clamping.
   b) Small tightening force requirement.
   c) Easy manufacturing.
   d) Simple design.
6. **What are differential and compound screws?**

   A differential screw gives a motion equal to the difference of two pitches. Compound screw gives a motion equal to the sum of two pitches.
7. **What is blot of uniform strength?**

   It has equal strength at the thread and shank portion.
8. **What stresses acts on screw fastening?**
   a) Initial stresses due to screw up,
   b) Stresses due to external forces,
   c) Combined stresses.
9. **Define the term 'self locking' of power screws.**

   If the friction angle is greater than the helix angle of the power screw, the torque required to lower the load will be positive, indicating that an effort is applied to lower the load. This type of screw is known as self locking screws which have efficiency less than 50%.
10. **Why welded joints are preferred over riveted joints?**

    Material is saved in welding joints and hence the machine element will be light if welded joints are used instead of riveted joints. Leak proof joints can be easily obtained by welded joints.
11. **How is welding classified?**

    i)Forge welding, ii) Electrical resistance welding and iii) Fusion welding.

12. State the advantages of welding?

1. Lighter in weight and having good joint efficiency.
2. These are leak proof and economical in cost.
3. Welded joint assemblies can be easily modified depending on the change in product requirement.

13. Write down the formula for strength of single fillet and double fillet.

For a single fillet P =Aτ $= 0.707hl\tau$

For a double fillet P = 2A $1.414hl\tau$

Where h - weld size, L –length of weld, - tensile stress.

14. Differentiate with a neat sketch the fillet welds subjected to parallel loading and transverse loading.

15. When will be the weld deposit is weaker?

When the components are made of high carbon steels or alloy steel, the weld becomes weaker.

16. Define eccentrically loaded welded joints.

The external loaded where applied may not pass through geometric centre in structural joints called as eccentrically loaded joints.

17. What are the two types of stresses induced in eccentrically loaded welded joints?

a) Welded connections subjected to moment in a plane of the weld.
b) Welded connections subjected to moment in a plane normal to the plane of the weld.

18. What is a stress concentration factor? How does it occur?

Due to the abrupt change in cross section, some stress concentration will be formed. It occurs at toe and heel points.

19. What are the main indications of complete weld symbol?

a) A basic symbol is to specify the type of weld.
b) An arrow and a reference line to indicate the location of the weld.
c) Supplementary symbols to indicate special instructions.
d) Dimensions of the weld in cross section and length.

UNIT- III DESIGN OF FASTENERS &WELDED JOINTS

Part – B: 16 MARK QUESTIONS

1. The cylinder head of a steam engine with 250mm bore is fastened by eight stud bolts made of 30C8 steel. Maximum pressure inside the cylinder is 1MPa. Determine the bolt size and approximate tightening torque. Take 20% overload. Assume yield strength = 300MPa fro bolt materials.
[Refer Text Book Page no 3.19]

2. A plate 100mm wide and 12.5mm thick is to be welded to another plate by means of two parallel fillet welds. The plates are subjected to a tensile load of 50kN. Find the length of the weld so that the maximum stress does not exceed 56N/mm^2. (Do the calculations under static loading). [MKU – Apr'96] [Refer Text Book Page no 3.83 & fig3.48]

3. A plate 100mm wide and 12.5mm thick is to be welded to another plate by means of single transverse and double parallel fillet welds. Determine the length of the weld run in each case, if the joint is to varying loads. The recommended design stress in tension is not exceed 70N/mm^2 and in shear 56N/mm^2 for static loading [MU – Oct'99] [Refer Text Book Page no 3.84 & fig3.49]

4. A 50mm diameter solid shaft is welded to a flat plate by 8mm fillet weld. Determine the maximum torque that the welded joint can sustain if the permissible shear stress of material is not to exceed 70MPa.
[Refer Text Book Page no 3.86 & fig3.51]

5. A circular shaft 60mm in diameter, is welded to a support plate by means of a fillet weld as shown in fig. determine the size of the weld, if the permissible shear stress in the weld is limited to 85Mpa.
[Refer Text Book Page no 3.87 & fig3.52]

6. A bracket shown in fig. carries a load of 10kN. Find the size of the weld if the allowable shear stress is not to exceed 75N/mm^2. [M.U – Apr'97] [Refer Text Book Page no 3.100 & fig3.62]

7. A bracket shown in fig. carries a load of 'P'. Calculate the value of P, if the weld size is 15mm and the allowable stress is not to exceed 80MPa. [MU- Oct'97] [Refer Text Book Page no 3.103 & fig.3.64]

8. A rectangular beam is to be welded to a plate. The maximum load of 14kN is applied repetitively. Determine the size of the weld required for 10,000,000 cycles. Assume the shear load is distributed uniformly over the entire weld. [AU-Apr'04] [Refer Text Book Page no 3.120 &fig3.76]

9. An eccentrically loaded plate is welded to a frame as shown in fig.7. design the welded joints if the tensile stress in the plate should not exceed 100MPa and that in weld is 80MPa. [AU – Nov-2004] [Refer Text Book Page no 3.122 & fig3.77]

UNIT- IV DESIGN OF SPRINGS AND LEVERS

Part – A: 2 MARK QUESTIONS

1. What is a spring?

A spring is an elastic member which deflects or distorts under the action of load and regains its original shape after the load is removed.

2. What are the applications of spring?

i) Automobiles.
ii) Railway wagons.
iii) Values and vehicles.

3. State any two functions of a spring.

i) To measure the forces in a spring balance, meters and engine indicators,
ii) To store energy.

4. What are the various types of springs?

i) Helical springs,
ii) Spiral springs,
iii) Leaf springs,
iv) Disc spring or Belleville spring.

5. How will you find whether the given helical spring is a compression spring or tension spring?[AU – Nov'03]

Ends of the compression springs are flat whereas for the tension spring, the hooks will be provided at the ends.
Coils will be slightly opened to facilitate compression in compression spring whereas in tension spring, coils are very close.

6. Define leaf springs.

A leaf spring consist of flat bars of varying lengths clamped together and supported at both ends, thus acting as a simply supported beam.

7. Define Belleville springs.

They are made in the form of a cone disc to carry a high compressive force. In order to improve their load carrying capacity, they may be stacked up together. The major stresses are tensile and compressive.

8. What is spring index? Or spring rate? [AU – Nov'05]

The ratio of the mean or pitch diameter of the wire for the spring is called spring index.

9. What are active and inactive coils?

The coils which are free to deflect under the load are called active coils.
The coils which do not take part in deflection of the spring, are known as inactive coils.

10. What is pitch in a spring?

The axial distance between adjacent coils in uncompressed state is called pitch.

11. What is solid length?

The length of the spring under the maximum compression is called solid length. It is the product of total number of coils and the diameter of the wire.

$$Ls = n_t \times d.$$

12. What are the requirements of spring while designing?

a) Spring must carry the service load without the stress exceeding the safe level.
b) The spring rate must be satisfactory for given applications.

13. Write down the formula for shear stress of a helical spring.

$$\tau_s = K_s \times \frac{8PD}{\pi d^3}$$

Where, - shear stress,
D – Diameter of the shaft,
d – Diameter of the wire,
P – Axial force.

14. Write down the formula for shear stress correction factor.

$$K_s = 1 + \frac{1}{2C}$$

Where C – spring index.

15. What is shear stress correction factor according to Wahl's hypothesis?

$$K_s = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$$

Where C – spring index.

16. Write down the formula for deflection of a helical spring.

$$y = \frac{8PC^3n}{Gd}$$

Where P –axial force,

C – Spring index,

N – no of coils.

17. What is stiffness of spring?

This is the ratio of load to deflection of the spring.

Stiffness q = P/y

18. Define 'Energy stored in spring'.

Strain energy stored in spring or resilience.

$$U = \frac{\tau^2}{4K_s^2G} \times V$$

Where, τ – shear stress,

Ks – Shear stress correction factor,

G – Rigidity modulus,

V – Volume of the spring $= \pi Dn \times \frac{\pi}{4} d^2$

19. What are the end conditions of the springs?

a. Plain end,
b. Plain and ground end,
c. Squared end,
d. Squared and ground end

20. What is buckling of springs?

The helical spring behaves like a column and buckles at a comparative small load when the length of the spring is more than 4 times the mean coil diameter.

21. What is surge in springs?

The material is subjected to higher stresses, which may cause early fatigue failure. This effect is called as spring surge.

22. For springs in series, the spring rates (stiffness) add reciprocally – prove.

When springs are connected in series then total deflection produced by the spring is equal to the sum of the deflections of the individual springs.

23. What are the various spring materials?

a. High carbon steels,
b. Medium carbon alloy steels,
c. Phosphor bronze and brass.

24. What are semi elliptical leaf springs?

The spring consists of number of leaves, which are held together by U clips. The long leaf fastened to the supported is called master leaf. Remaining leaves are called as graduated leaves.

25. What is nipping of laminated leaf spring? Discuss the role in spring design.

For economical use of the materials, design the spring such that all the leaves should be equally stressed, otherwise the master leaf will fail. This condition can be obtained if the full length leaves are given a greater radius of curvature than that used in the graduated leaves before the leaves are assembled to form a spring. This will create an initial gap(x) between the leaves called the 'nip'. When the central bolt is tightened, the full length leaf will bend back and have an initial stress in a direction opposite to that of the normal load. When the load is gradually applied to the spring, the full length leaf is first relieved of this initial stress and then stressed in opposite direction. Such a pre-stressing obtained by a difference of radii of curvature is known as nipping.

26. Why Wahl's factor is to be considered in the design of helical compression springs?

When a wire is wound in the form of helix, the length of the inner fiber of wire is reduced in comparison to the length of the outer fiber. This results in stress concentration at the inner fiber. Wahl's factor takes into account the effect of curvature as well as shear stress correction factor.

27. For springs in series, the spring rates (stiffness) add reciprocally – prove. [AU – Apr'04]

When the springs are connected in series then total deflection produced by the spring is equal to the sum of the deflections of the deflections of the individual springs.

$$y_{equ} = y_1 + y_2$$

$$\frac{P}{q_{equ}} = \frac{P}{q_1} + \frac{P}{q_2}$$

$$\frac{1}{q_{equ}} = \frac{1}{q_1} + \frac{1}{q_2}$$

UNIT- IV DESIGN OF SPRINGS AND LEVERS

Part – B: 16 MARK QUESTIONS

1. A spring made from a wire of 1.25mm diameter and 750N/mm^2 as its yield strength has a mean diameter of 12.5mm and 14 active coils. Find (i) stiffness of the spring, (ii) solid height assuming that the ends are squared and ground. Take G = 0.85 x 10^5 N/mm^2. [MU –Oct'2000] [Refer Text Book Page no 4.23]

2. A helical valve spring is to be designed for an operating load range of 90N to 135N. The deflection of the spring for this load range is 7.5mm, assuming a spring index of 10, a permissible shear stress of 480MPa and G = 80GPa for the material, determine the dimensions of the spring. [BHU – Apr'97] [Refer Text Book Page no 4.27]

3. A safety valve of 70mm diameter is to blow off at a pressure of 1.1MPa. It is placed on its seat by a close coiled helical spring of circular steel bar. The mean diameter of each coil is 150mm and compression of the spring is 25mm. find the diameter of the spring bar and the number of active turns required, if the shearing stress allowed is 130MPa and G = 0.084 x 10^6 MPa. [BHU – Apr'1996] [Refer Text Book Page no 4.39]

4. A solenoid brake is to be actuated by a helical compression spring. The spring should have a free length of 450mm and is exert a maximum force of 14000N when compressed to a length of 375mm. the outside diameter must not exceed 175mm. selecting the suitable material , design the spring. [MU – Apr'97] [Refer Text Book Page no 4.43]

5. A railway wagon weighing 300kN is moving with a velocity of 2.5m/s. It is brought to rest by two buffers with coil spring of 300mm diameter. The maximum deflection of the springs is 350mm. The allowable shear stress in the spring material is 600MPa and G is 8.2 x 10^6 N/cm^2. Design the coil spring for the buffers. [BHU – Apr'1996] [Refer Text Book Page no 4.46]

6. A torsion spring made of 6mm monel metal wire wound with an inside diameter of 45mm. assuming a safety factor, find: (a) the maximum force which can be applied with a 55mm leverage(b) corresponding deflection in degrees, if n =4.5 [Refer Text Book Page no 4.83]

7. A safety valve of 60mm diameter is to blow off at pressure of 1.2MPa.it is placed on its seat by a close- coiled helical spring. The maximum lift of the valve is 10 mm. Design a suitable compression spring of spring index 5 and providing an initial compression of 35mm. the maximum shear stress in the material of the wire is limited to 500N/mm^2. G is taken as 0.80 x 10^5 MPa. Calculate,

(i) Diameter of the spring wire,
(ii) Mean coil diameter,
(iii) Number of active turns,
(iv) Pitch of the coil [AU – May'99 & MSU – Apr'96] [Refer Text Book Page no 4.146]

8. A relief valve must blow off at a pressure of 1.25MPa and should lift by 6mm for a 6% increase in pressure. The valve diameter is 65mm. take the C as 8. Maximum allowable shear stress of the spring material is 600MPa. The diameter of the available spring wires in mm is 13, 14, 15, 16 and 18. Modulus of rigidity is 81370N/mm^2. Consider the Wahl's correction factor. Take inactive number of turns as 1. Design the valve spring. [AU- May'2000] [Refer Text Book Page no 4.148]

9. A semi elliptic leaf spring of 1m long and is required to resist a load of 50kN. The spring has 15 leaves, of which three are full length. The width of the central band is 100mm. all the leaves are to be stressed to 420MPa. The ratio of total depth to width is 3. Take E = 2.1 x 10^5 MPa. Determine,

(i) The thickness and width of the leaves.

(ii) The initial gap that should be provided between the full length and graduated leaves before assembly and

(iii) The load exerted on the band for the assembly. [AU – Nov'04] [Refer Text Book Page no 4.157]

UNIT- V DESIGN OF BEARINGS AND FLYWHEELS

Part – A: 2 MARK QUESTIONS

1. Define anti friction bearings.

The contact between the bearings elements are rolling, this type has very small friction.

2. What are the types of rolling contact bearings?

(i) Depending upon the type of rolling element,

a. Ball bearing
b. Roller bearing.

(ii) Depending upon the load is carried,

a. Radial
b. b. Angular contact bearing,
c. c. Thrust bearing

3. Define the term 'Bearing life'.

The life of a radial ball bearing is the number of revolutions or hours at a given constant speed that the bearing runs before the first evidence of fatigue develops in the material of either ring or in a ball.

4. What is load rating?

The load carrying capacity of a rolling element bearing is called 'load rating'.

5. What is basic static load rating?

It is defined as load acting on a non- rotating bearing under which permanent deformation is 0.0001 times the ball or roller diameter.

6. Explain the term 'Dynamic load carrying capacity' of rolling contact bearings.[AU –Nov'04]

It is defined as the radial load in radial bearings (or thrust load in thrust bearings) that can be carried for a minimum life of one million revolutions.

7. How can be equivalent bearing loads computed?

If a bearing is to be chosen to withstand a combination of radial load (Fr) & thrust load (Fa), on equivalent static load (P) , which causes the square deformation as the combined loads, can be computed by the formula

$$P = (XF_r + YF_a)S$$

Where, X – Radial factor, Y – Thrust factor, S – service factor

8. State any points to be considered for selection of bearings.

a) Calculate the radial & axial forces acting on the bearing.
b) Calculate the Shaft diameter.
c) Determine the radial load factor(X) and thrust load factor(Y).

9. What is bearing?

It is a stationary machine element which supports a rotating shafts or axles and confines its motion.

10. Classify the types of bearings.

a. Depending upon the type of load coming upon the shaft:
   1. Radial bearing
   2. Thrust bearings
b. Depending upon the nature of contact:
   1. Sliding contact
   2. Rolling contact bearings or anti friction bearings.

11. What are the required properties of bearing materials?

1. High compressive strength
2. Low coefficient of friction
3. High thermal conductivity
4. High resistance to corrosion.

12. Define a journal bearing.

It is a sliding contact bearing which gives lateral support to the rotating shaft.

13. What is known as self acting bearings?

The pressure is created within the system due to rotation of the shaft is known as self acting bearing.

14. State the theory of lubrication.

a. Hydrostatic theory of lubrication
b. Hydrodynamic theory of lubrication

15. Define kinematic viscosity.

It is defined as the ratio of absolute viscosity to the density of oil. It is denoted as

Kinematic viscosity, = $\gamma = \frac{Absolute\ \ viscosity}{Density}$

16. What is bearing characteristics number?

The combination of term $\left(\frac{Zn}{p}\right)\left(\frac{D}{C}\right)$ is called as bearing characteristics number.

17. How the Sommerfield number is calculated?

It is given by the expressions,

$$S=\frac{Zn}{p}\left(\frac{D}{C}\right)^2$$

Where, Z – absolute viscosity,
n – Revolution per second,
p – Bearing pressure.

18. What is critical pressure?

The minimum operating pressure is known as critical pressure. It is the pressure at which the oil film breaks down and metal to metal contact begins. It is given empirically

$$P = \frac{Zn}{4.75\times10^6}\left(\frac{D}{C}\right)^2\left(\frac{L}{D+L}\right) \text{ N/mm}^2$$

19. What is flywheel?

It is a machine element used to minimize the fluctuation of speed in an engine.

20. What are the functions of the flywheel? [Anna. Univ. – Nov ' 03]

A flywheel used in machine serves as a reservoir which stores energy during the period when the supply of energy is more than the requirements and releases it dulling the period when the requirement of the energy is more than the supply.

21. Define co efficient of fluctuation of speed in case of flywheels.

It is the ratio of maximum change of speed to mean speed of the flywheel.

$$\text{Ks} = \frac{w_{max} - w_{min}}{w_{mean}} \text{ or } 2\frac{(w_{max} - w_{min})}{w_{max} + w_{min}}$$

22. Define the term fluctuation of energy.

The ratio of fluctuation of energy to the mean energy is called co- efficient of fluctuation of energy.

23. How a flywheel differs from governor?

A governor regulates mean speed of an engine when there are variations in the mean loads. It automatically controls the supply of working fluid to engine with the varying load condition and keeps the mean speed within the limits. It does not control the speed variation caused by the varying load. A flywheel does not maintain constant speed.

UNIT- V DESIGN OF BEARINGS AND FLYWHEELS

Part – B: 16 MARK QUESTIONS

1. If a ball bearing is subjected to a radial load of 10kN and the expected life for 90% of the bearing is 6000hr, calculate the dynamic load carrying capacity of the bearing, when the shaft rotates at 1250rpm. [Refer Text Book Page no 5.16]

2. Select a bearing for a 40mm diameter shaft rotates at 400rpm. Due to bevel gear mounted on the shaft, the bearing will have to withstand a 5000N radial load and 3000N thrust load. The life of the bearing is expected to be at least 1000hrs. [Refer Text Book Page no 5.17]

3. Select a roller bearing having a life of 10000hrs for a spindle of a drilling machine with journal of 50mm diameter and carrying an axial load 8000N at 500rpm. [Refer Text Book Page no 5.23]

4. Select a suitable ball bearing for a drilling machine spindle of diameter 40mm rotating at 3000rpm. It is subjected to a radial load of 2000N and axial thrust of 1000N. It is to work for 15hours a week for one year. [AU –Nov'03] [Refer Text Book Page no 5.97]

5. A sleeve bearing is 10mm in diameter and 10mm long. SAE 10 oil at an inlet temperature of 50^0C is used to lubricate the bearing. The radial clearance is 0.0076mm. If the journal speed is 3600rpm and the load on the bearing is 68N, find the temperature rise of the lubricant and the minimum film thickness. [AU-May'99] [Refer Text Book Page no 5.99]

6. Design a journal bearing for a centrifugal pump to the following specifications.
Diameter of the journal = 75mm.
Speed of the journal = 1140rpm.
Load on each journal = 11500N [AU – Nov'04] [Refer Text Book Page no 5.102]

7. A single cylinder double acting steam engine delivers 185kW at 100rpm. The maximum fluctuation of energy per revolution is 15% of energy developed per revolution. The speed variation is limited to 1% either from the mean. The mean diameter of the rim is 2.4m. Design a cast iron flywheel for the engine.[AU-Apr'01] [Refer Text Book Page no 5.104]

8. Design a CI flywheel for a four stroke engine developing 150kW at 200rpm. Calculate the mean diameter of the flywheel if the hoop stress is not to exceed 4MPa. Total fluctuation of the speed is to be 4% of mean speed. Work done during power stroke is 1.5times average work done during the cycle. Density of CI is 7200kg/m^3. [Anna. Univ. – Nov'03] [Refer Text Book Page no 5.108]

9. A multi cylinder engine is to run at a constant load at a speed of 500rpm on drawing the crank effort diagram to scale of 1cm = 2500N.m and 1cm = 60^0 , the area above and below the mean torque line were measured and found to be in order +1.60, -1.72 , +1.68 , - 1.91 , +1.97 and -1.62. If the speed to be kept within limits of ± 1% of the mean speed, design the suitable type of flywheel. [B.H.U-Nov.'96] [Refer Text Book Page no 5.93]