

**UNIT I****Chapter 1 : Fundamentals of Design 1-1 to 1-43****Syllabus :**

- 1.1 Machine design philosophy and phases in design, design considerations.
- 1.2 Types of loads, concepts of stresses, bearing pressure, bending and torsion stresses, principal stresses, strain, stress- strain diagram(Simple Numerical)
- 1.3 Factor of Safety, conditions for selection of F.S
- 1.4 Stress concentration meaning, causes and remedies.
- 1.5 Designation of materials as per IS and introduction to International standards, advantages of standardization, use of design data book, use of standards in design and preferred numbers in series.
- 1.6 Concept of creep, Fatigue, S-N curve, Endurance limit.
- 1.7 Maximum principal stress theory and Maximum shear stress theory.
- 1.8 Modern Design considerations Ergonomics and aesthetic considerations in design. Ecology, social consideration and Concept of Product Design.

1.1	Machine Design Philosophy .....	1-1
1.1.1	Phases of machine design (General Procedure in Machine Design).....	1-2
1.2	General Design Consideration.....	1-2
1.2.1	Consideration In Selection of Material .....	1-4
1.2.2	Mechanical Properties of Materials.....	1-5
1.3	Types of Loads.....	1-7
1.4	Concept of Stress and Strain.....	1-7
1.4.1	Types of Stresses .....	1-7
1.4.2	Principal Stress and Principal Plane.....	1-11
1.4.3	Stress-Strain Diagram for Ductile Material.....	1-11
1.4.4	Stress Strain Diagram for Brittle Material .....	1-12
1.5	Factor of Safety.....	1-16
1.6	Stress Concentration.....	1-17
1.6.1	Causes of Stress Concentration.....	1-18
1.6.2	Remedies for Reduce the Stress Concentration.....	1-18
1.6.3	Theoretical Stress Concentration Factor .....	1-20
1.6.4	Fatigue Stress Concentration Factor and Notch Sensitivity.....	1-20
1.7	Designation of materials as per Indian Standard .....	1-20

1.7.1	Types of Cast Iron.....	1-20
1.7.2	Plain Carbon Steels .....	1-22
1.7.3	Alloy Steels .....	1-24
1.7.4	Free Cutting Steel .....	1-26
1.7.5	Cast steel.....	1-27
1.7.5.1	High Speed Tool Steel .....	1-27
1.8	Standardization .....	1-28
1.8.1	Standards used in Mechanical Engineering.....	1-28
1.8.2	Advantages of Standardization.....	1-28
1.8.3	Use of Design Data Books .....	1-28
1.8.4	Types of Standards .....	1-29
1.8.5	Preferred Number Series .....	1-29
1.9	Theories of Elastic Failures .....	1-30
1.10	Concept of Creep, Creep Strain and Creep Curve.....	1-31
1.11	Fatigue .....	1-32
1.11.1	S-N Curve and Endurance Limit.....	1-32
1.12	Modern Design Consideration .....	1-33
1.13	Ergonomics of Design Consideration .....	1-33
1.13.1	Man - Machine - Relationship.....	1-34
1.13.2	Design of Equipment for Control .....	1-34
1.13.3	Design of Displays Control .....	1-35
1.13.4	Ergonomic Consideration in Design of Displays .....	1-35
1.13.5	Working Environment and Safety .....	1-36
1.14	Aesthetic Consideration in Design.....	1-36
1.14.1	Guidelines in Aesthetic Design.....	1-37
1.14.2	Aspects of Aesthetic Design.....	1-37
1.15	MSBTE Questions and Answers .....	1-40

**UNIT II****Chapter 2 : Design of Joints, Levers and Offset Links****2-1 to 2-61****Syllabus :**

- 2.1 Design of Cotter Joint, Knuckle Joint,
- 2.2 Turnbuckle.
- 2.3 Design of Levers:- Hand/Foot Lever and
- 2.4 Bell Crank Lever
- 2.5 Lever for lever safety valve
- 2.6 Design of Off-set links, C - Clamp, Overhang Crank.



2.1	Cotter Joint (Socket and Spigot Joint).....	1-1	3.1	Introduction .....	3-1
2.1.1	Applications of Cotter Joint .....	1-1	3.1.1	Types of Shaft.....	3-1
2.1.2	Difference between Key and Cotter .....	1-2	3.2	Difference between Shaft, Axle and Spindle.....	3-2
2.1.3	Design of Cotter Joint.....	1-2	3.3	Standard Sizes of Shaft.....	3-2
2.1.4	Sleeve and Cotter Joint .....	1-6	3.4	Material for Shaft.....	3-2
2.2	Knuckle Joint.....	1-7	3.5	Design of Solid and Hollow Shaft .....	3-3
2.2.1	Applications of knuckle joint .....	2-8	3.5.1	Design of Solid and Hollow Shaft on the Strength Basis.....	3-3
2.2.2	Difference between Knuckle joint and Cotter joint .....	2-8	3.5.2	Design of Hollow Shaft on the Basis of Strength .....	3-6
2.2.3	Design of Knuckle Joint.....	2-8	3.5.3	Design of Shaft on the Basis of Rigidity and Deflection .....	3-8
2.3	Turn Buckle.....	2-11	3.5.4	Summary of Design of Shaft .....	3-9
2.3.1	Applications of Turn Buckle.....	2-11	3.6	Keys.....	3-27
2.3.2	Design of Turn Buckle .....	2-11	3.6.1	Introduction to Key .....	3-27
2.4	Levers .....	2-32	3.6.2	Types of Keys .....	3-27
2.4.1	Types of Levers.....	2-32	3.6.3	Sunk Key.....	3-27
2.4.2	Design of Hand Lever.....	2-33	3.6.4	Design of Sunk Key.....	3-28
2.4.3	Foot Lever.....	2-34	3.6.5	Effect of Keyways on Strength of Shaft .....	3-29
2.5	Design of Two Arm Levers(Bell Crank Lever).....	2-41	3.7	Couplings .....	3-31
2.5.1	Design of Lever Safety Valve .....	2-46	3.7.1	Introduction to Couplings.....	3-31
2.6	Design of 'C' Clamp Offset Link.....	2-49	3.7.1.1	Requirements coupling.....	3-32
2.6.1	Design Procedure.....	2-49	3.7.1.2	Factors consider in selection of coupling.....	3-32
2.6.2	Design of Overhang Crank .....	2-49	3.7.1.3	Difference between coupling and clutch .....	3-32
2.7	MSBTE Questions and Answers .....	2-59	3.7.2	Types of Couplings .....	3-32

### UNIT III

#### Chapter 3 : Design of Shaft, Keys and Couplings

**3-1 to 3-63**

##### Syllabus :

- 3.1 Types of Shafts, Shaft materials, Standard Sizes, Design of solid and hollow shafts based on strength and rigidity criteria.
- 3.2 Design of hollow and solid shaft for combined bending and twisting moments and considering the effect of shock and fatigue. ASME code of design for line shafts supported between bearings with one or two pulleys in between or one overhung pulley.
- 3.3 Types of keys, effect of keyway on the strength of shaft, Design of rectangular and square sunk key.
- 3.4 Types of couplings, Design of muff coupling, flanged couplings(protected and unprotected) and Bushed pin type flexible coupling

3.1	Introduction .....	3-1
3.1.1	Types of Shaft.....	3-1
3.2	Difference between Shaft, Axle and Spindle.....	3-2
3.3	Standard Sizes of Shaft.....	3-2
3.4	Material for Shaft.....	3-2
3.5	Design of Solid and Hollow Shaft .....	3-3
3.5.1	Design of Solid and Hollow Shaft on the Strength Basis.....	3-3
3.5.2	Design of Hollow Shaft on the Basis of Strength .....	3-6
3.5.3	Design of Shaft on the Basis of Rigidity and Deflection .....	3-8
3.5.4	Summary of Design of Shaft .....	3-9
3.6	Keys.....	3-27
3.6.1	Introduction to Key .....	3-27
3.6.2	Types of Keys .....	3-27
3.6.3	Sunk Key.....	3-27
3.6.4	Design of Sunk Key.....	3-28
3.6.5	Effect of Keyways on Strength of Shaft .....	3-29
3.7	Couplings .....	3-31
3.7.1	Introduction to Couplings.....	3-31
3.7.1.1	Requirements coupling.....	3-32
3.7.1.2	Factors consider in selection of coupling.....	3-32
3.7.1.3	Difference between coupling and clutch .....	3-32
3.7.2	Types of Couplings .....	3-32
3.7.3	Comparison of Rigid and Flexible Coupling .....	3-33
3.7.4	Muff or Sleeve Coupling .....	3-33
3.7.4.1	Advantages and disadvantages of Muff or sleeve coupling .....	3-33
3.7.4.2	Design of Muff Coupling .....	3-33
3.7.5	Split muff Coupling : [Clamp or Compression Coupling].....	3-35
3.7.5.1	Design procedure .....	3-35
3.7.6	Flange Coupling .....	3-36
3.7.6.1	Design of Unprotected Type Flange Coupling .....	3-36
3.7.6.2	Design of Protected Type Flange Coupling .....	3-37
3.7.7	Bushed Pin Type Flexible Coupling .....	3-40
3.7.7.1	Design of Bushed - Pin Type Flexible Flange Coupling .....	3-41
3.8	MSBTE Questions and Answers .....	3-60

**UNIT IV****Chapter 4 : Design of Power Screws and Fasteners****4-1 to 4-66****Syllabus :**

- 4.1 Basic concepts of power screws, thread profiles used for power Screws, relative merits and demerits of each, Self locking and overhauling properties, Torque required to overcome thread friction, efficiency of power screws, types of stresses induced.
- 4.2 Design of Screw Jack, Toggle Jack (only screw and nut).
- 4.3 Stresses in Screwed fasteners, bolts of Uniform Strength, Design of Bolted Joints subjected to eccentric loading.
- 4.4 Design of parallel and transverse fillet welds, axially loaded symmetrical section.

4.1	Introduction .....	4-1
4.1.1	Advantages of Power Screws .....	4-1
4.1.2	Disadvantages of Power Screws .....	4-1
4.2	Types of Threads Profile used for Power Screw .....	4-1
4.3	Torque Required to Overcome Thread Friction .....	4-3
4.3.1	Torque Required to Raise the Load by Square Thread .....	4-4
4.3.2	Torque Required to Lower the Load .....	4-4
4.4	Self-Locking and Over-Hauling Screws .....	4-5
4.5	Efficiency of Square Thread Screw .....	4-5
4.5.1	Maximum Efficiency of Square Thread Screw .....	4-6
4.5.2	Efficiency of Self Locking Screw .....	4-6
4.6	Torque Required to Overcome Thread Friction in Trapezoidal Thread .....	4-6
4.7	Types of Stresses in Power Screw .....	4-7
4.8	Design of Screw Jack .....	4-8
4.9	Design of Toggle Jack .....	4-11
4.10	Numericals .....	4-12
4.11	Screwed Fasteners .....	4-33
4.11.1	Different terms used in screw threads .....	4-34
4.11.2	Screwed joints are preferred over welded joints .....	4-34
4.12	Forms of Thread .....	4-34
4.12.1	Advantages of 'V' Thread Over Square Thread .....	4-35
4.12.2	Forms of Threads .....	4-35
4.13	Stresses in Screw Fasteners .....	4-36
4.14	Bolts with Uniform Strength .....	4-38
4.15	Design of Bolted Joints Subjected to Eccentric Loading .....	4-38

4.15.1	Eccentric Load Acting Parallel to The Axis of Bolts .....	4-39
4.15.2	Eccentric Load Perpendicular to Axis of Bolt .....	4-39
4.16	Solved Examples .....	4-41
4.17	Welded Joints .....	4-54
4.17.1	Advantages and Disadvantages of Welded Joints Over Riveted Joint .....	4-54
4.17.2	Comparison welded joints with screwed joints .....	4-54
4.17.3	Types of Welded Joints .....	4-54
4.17.4	Butt Joint .....	4-55
4.17.5	Strength of Transverse Fillet Welded Joint .....	4-55
4.17.6	Strength of Parallel Fillet Weld .....	4-56
4.18	Solved Examples .....	4-58
4.19	MSBTE Questions and Answers .....	4-61

**UNIT V****Chapter 5 : Design of Springs****5-1 to 5-30****Syllabus :**

- 5.1 Classification and Applications of Springs, Spring - terminology, materials specifications. Stresses in helical tension and compression springs, Wahl's correction factor, Deflection of springs, Energy stored in springs.
- 5.2 Design of Helical tension and compression springs subjected to concentric applied loads like I.C. engine valves, weighing balance, railway buffers .
- 5.3 Leaf springs - construction and applications.

5.1	Introduction to Spring .....	5-1
5.1.1	Functions/Applications of springs .....	5-1
5.2	Classification of Springs .....	5-1
5.3	Terminology for Helical Compression Spring .....	5-4
5.4	Desirable Properties of Spring Material .....	5-5
5.4.1	Material for Spring .....	5-5
5.5	Stresses in Spring .....	5-7
5.6	WAHL'S Correction Factor ( $K_w$ ) .....	5-8
5.7	Deflection in Helical Spring .....	5-8
5.8	Energy Stored in Helical Spring .....	5-9
5.9	Design of Helical Tension and Compression Spring .....	5-10
5.9.1	Types of Ends for Helical Compression Springs .....	5-10
5.9.2	Types of Ends for Helical Tension Springs .....	5-11
5.10	Arrangement of Spring for Stiffness and Deflection .....	5-11
5.11	Leaf Spring .....	5-13
5.12	MSBTE Questions and Answers .....	5-28



**UNIT VI**

**Chapter 6 : Selection of Antifriction Bearings and Gears 6-1 to 6-25**

**Syllabus :**

- 6.1 Classification of Bearings – Sliding contact and rolling contact.
- 6.2 Terminology of Ball bearings – life load relationship, basic static load rating and basic dynamic load rating.
- 6.3 Selection of ball bearings using manufacturer’s catalogue
- 6.4 Design of spur gear using Lewis and Buckingham’s equation, (Simple Numerical), selection of gears from standard sizes

6.1 Introduction to Bearing ..... 6-1

6.1.1 Functions of Bearing ..... 6-1

6.2 Classification of Bearing ..... 6-1

6.2.1 According to Nature of Relative Motion Between Two Contacting Surface ..... 6-2

6.3 Classification of Sliding Contact Bearing ..... 6-3

6.3.1 Classification according to mode of Lubrication ..... 6-3

6.3.2 Classification according to Relative Motion Between Two Surfaces ..... 6-4

6.3.3 Applications of sliding contact bearings ..... 6-5

6.3.4 Advantages and disadvantages of plain bearings when compared with antifriction bearings ..... 6-5

6.3.5 Properties of Sliding Contact Bearing Materials ..... 6-5

6.4 Rolling Contact Bearing or Antifriction Bearing ..... 6-6

6.4.1 Terminology of Ball Bearings ..... 6-6

6.4.2 Classification of Roller Contact bearing or Antifriction Bearing ..... 6-7

6.4.2.1 Ball Bearing ..... 6-7

6.4.2.2 Classification of Roller Bearings ..... 6-9

6.4.3 Different Terms Related to Bearings ..... 6-11

6.5 Comparison between Ball and Roller Bearings ..... 6-12

6.5.1 Applications of Rolling Contact Bearings ..... 6-12

6.5.2 Comparison of Rolling Contact and Sliding Contact Bearing ..... 6-13

6.6 Bearing Life ..... 6-14

6.6.1 Rating Life ( $L_{10}$ ) ..... 6-14

6.7 Life Load Relationship ..... 6-14

6.8 Basic Static Load Rating,  $C_0$  (Basic Static Capacity) ..... 6-14

6.8.1 Static Equivalent Load ..... 6-15

6.9 Basic Dynamic Load Rating (C) ..... 6-15

6.9.1 Equivalent Dynamic Load ..... 6-15

6.10 Selection of Bearing from Manufacturer’s Catalogue ..... 6-16

6.11 Spur Gears ..... 6-17

6.11.1 Design Consideration for a Gear Drive ..... 6-17

6.11.2 Design of spur gear using Lewis Equation for Static Beam Strength of Spur Gear Teeth ..... 6-17

6.11.3 Permissible Working Stress (bending stress) for Gear Teeth in the Lewis Equation ..... 6-19

6.11.4 Power Transmission Capacity of Spur Gear in Bending ..... 6-19

6.11.5 Design of spur gear using Buckingham’s equation ..... 6-19

6.11.5.1 Buckingham’s Dynamic Load Equation ..... 6-20

6.11.5.2 Selection of gear from standard size ..... 6-20

6.12 MSBTE Questions and Answers ..... 6-24

