

CONTENTS

<i>Preface</i>	<i>xiii</i>
<i>Visual Walkthrough</i>	<i>xvi</i>
<i>List of Symbols</i>	<i>xix</i>
1. Simple Stress and Strain	1
1.1 Introduction	1
1.2 Stress	2
1.3 Shear Stress	3
1.4 Strain	4
1.5 Modulus of Elasticity and Modulus of Rigidity	4
1.6 Elongation of A Bar	5
1.7 Principle of Superposition	5
1.8 Bars of Tapering Section	7
1.9 Elongation Due to Self Weight	9
1.10 Column of Uniform Strength	9
1.11 Statically Indeterminate Systems	10
1.12 Temperature Stresses	21
1.13 Shrinking on	29
1.14 Strain Analysis	30
1.15 Tensile Test Diagram	35
1.16 Factor of Safety	36
1.17 Elastic Constants	36
1.18 Relation Between Elastic Constants	37
<i>Summary</i>	39
<i>Review Questions</i>	40
2. Compound Stress and Strain	44
2.1 Introduction	44
2.2 Stress Analysis	44
2.3 Principal Stresses	53
2.4 Mohr's Stress Circle	55
2.5 Three Coplanar Stresses	68
2.6 Ellipse of Stress	70
2.7 Principal Stresses From Principle Strains	71
2.8 Strain Analysis	72
<i>Summary</i>	75
<i>Review Questions</i>	76
3. Strain Energy and Theories of Failures	79
3.1 Introduction	79
3.2 Strain Energy	80

3.3	Strain Energy (Three-dimensional Stress System)	81
3.4	Shear Strain Energy	82
3.5	Shear Strain Energy (Three-dimensional Stress System)	82
3.6	Stresses Due to Various Types of Loading	88
3.7	Theories of Failures	91
3.8	Graphical Representation of Theories of Failures	95
	<i>Summary</i>	97
	<i>Review Questions</i>	97
4.	Shear Force and Bending Moment	99
4.1	Introduction	99
4.2	Types of Supports and Beams	99
4.3	Shear Force	101
4.4	Bending Moment	101
4.5	Relation Between W, F and M	102
4.6	Shear Force and Bending Moment Diagrams for Cantilevers	103
4.7	Shear Force and Bending Moment Diagrams for Simply Supported Beams	108
4.8	Loading and Bending Moment Diagrams From Shear Force Diagram	125
	<i>Summary</i>	126
	<i>Review Questions</i>	127
5.	Bending Stress in Beams	129
5.1	Introduction	129
5.2	Theory of Simple Bending	130
5.3	Moment of Inertia	132
5.4	Beams With Uniform Bending Strength	142
5.5	Fitched Or Composite Beams	147
5.6	Reinforced Concrete Beams	156
5.7	Unsymmetrical Bending	157
5.8	Determination of Principal Axes	162
5.9	Ellipse of Inertia Or Momental Ellipse	170
5.10	Combined Direct and Bending Stress	171
	<i>Summary</i>	179
	<i>Review Questions</i>	181
6.	Shear Stress in Beams	184
6.1	Introduction	184
6.2	Variation of Shear Stress	184
6.3	Shear Stress Variation In Different Sections	185
6.4	Built-up Beams	197
6.5	Shear Centre	202
	<i>Summary</i>	205
	<i>Review Questions</i>	206
7.	Slope and Deflection	208
7.1	Introduction	208

7.2	Beam Differential Equation	208
7.3	Slope and Deflection At A Point	209
7.4	Double Integration Method	210
7.5	Macaulay's Method	226
7.6	Moment–Area Method	238
7.7	Strain Energy Due to Bending	244
7.8	Castigliano's First Theorem (Deflection From Strain Energy)	244
7.9	Conjugate Beam Method	251
7.10	Maxwell's Reciprocal Deflection Theorem	257
7.11	Betti's Theorem of Reciprocal Deflections	259
	<i>Summary</i>	259
	<i>Review Questions</i>	260
8.	Fixed and Continuous Beams	262
8.1	Introduction	262
8.2	Effect of Fixidity	262
8.3	Moment–Area Method	263
8.4	Macaulay's Method	270
8.5	Clapeyron's Three-moment Equation	275
8.6	Moment Distribution Method	283
	<i>Summary</i>	297
	<i>Review Questions</i>	298
9.	Bending of Curved Bars	301
9.1	Introduction	301
9.2	Bars of Small Initial Curvature	301
9.3	Bars of Large Initial Curvature (Winkler–Bach Theory)	304
9.4	Values of P2 for Various Sections	307
9.5	Stresses In A Circular Ring	315
9.6	Stresses In A Chain Link	318
9.7	Deflection of Curved Bars	320
9.8	Deflection By Strain Energy (Castigliano's Theorem)	324
	<i>Summary</i>	330
	<i>Review Questions</i>	331
10.	Torsion	333
10.1	Introduction	333
10.2	Circular Shafts	333
10.3	Power Transmission	335
10.4	Torsion of Tapered Shaft	338
10.5	Shafts In Series and Parallel	340
10.6	Strain Energy In Torsion	345
10.7	Combined Bending and Torsion	351
10.8	Thin Tubular Sections (Bredt–Batho Theory)	353
10.9	Thin-walled Sections	355
10.10	Thin Rectangular Members	357

	<i>Summary</i>	360	
	<i>Review Questions</i>	361	
11.	Springs		364
11.1	Introduction	364	
11.2	Close-coiled Helical Springs	364	
11.3	Springs In Series and Parallel	370	
11.4	Concentric (Cluster) Springs	371	
11.5	Open-coiled Helical Springs	373	
11.6	Flat Spiral Springs	378	
11.7	Leaf Or Laminated Springs	380	
	<i>Summary</i>	384	
	<i>Review Questions</i>	385	
12.	Columns and Struts		388
12.1	Introduction	388	
12.2	Euler's Theory	388	
12.3	Equivalent Length	391	
12.4	Limitations of Euler's Formula	391	
12.5	Rankine's Formula	396	
12.6	Other Formulae	397	
12.7	Strut With Eccentric Load (Secant Formula)	399	
12.8	Strut With Initial Curvature	402	
12.9	Strut With Lateral Loading	405	
12.10	Tie With Lateral Loading	411	
12.11	Struts of Varying Cross-section	413	
	<i>Summary</i>	415	
	<i>Review Questions</i>	416	
13.	Cylinders and Spheres		419
13.1	Introduction	419	
13.2	Thin Cylinder	419	
13.3	Thin Spherical Shell	421	
13.4	Thin Cylinder With Spherical Ends	421	
13.5	Volumetric Strain	422	
13.6	Wire Winding of Thin Cylinders	430	
13.7	Thick Cylinders	433	
13.8	Compound Tubes	439	
13.9	Hub on Solid Shaft	444	
13.10	Wire Winding of Thick Cylinders	447	
13.11	Design of a Thick Cylindrical Shell	451	
13.12	Thick Spherical Shells	454	
	<i>Summary</i>	457	
	<i>Review Questions</i>	458	
14.	Rotating Discs and Cylinders		461
14.1	Introduction	461	

14.2	Rotating Ring	461	
14.3	Disc of Uniform Thickness	463	
14.4	Long Cylinder	476	
14.5	Disc of Uniform Strength	481	
14.6	Collapse Speed	482	
	<i>Summary</i>	484	
	<i>Review Questions</i>	485	
15.	Circular Plates		487
15.1	Introduction	487	
15.2	Symmetrically Loaded Circular Plates	487	
15.3	Uniformly Distributed Load on A Solid Plate	491	
15.4	Central Point Load on Solid Plate	497	
15.5	Load Round A Circle on A Solid Plate	503	
15.6	Annular Ring, Load Round An Inner Edge	508	
	<i>Summary</i>	511	
	<i>Review Questions</i>	512	
16.	Plastic Bending and Torsion		513
16.1	Introduction	513	
16.2	Plastic Theory of Bending	513	
16.3	Moment of Resistance At Plastic Hinge	514	
16.4	Symmetrical Bending	515	
16.5	Unsymmetrical Bending	516	
16.6	Collapse Load	523	
16.7	Torsion of Circular Shafts	525	
16.8	Combined Direct and Bending Stress	528	
	<i>Summary</i>	529	
	<i>Review Questions</i>	530	
17.	Plane Frame Structures		532
17.1	Introduction	532	
17.2	Perfect Frames	532	
17.3	Reactions At the Supports	533	
17.4	Statically Determinate Frames	533	
17.5	Assumptions In the Analysis of Frames	534	
17.6	Sign Convention	534	
17.7	Methods of Analysis	535	
17.8	Method of Joints	535	
17.9	Method of Sections	540	
	<i>Summary</i>	544	
	<i>Review Questions</i>	545	
18.	Properties and Testing of Materials		548
18.1	Introduction	548	
18.2	Mechanical Properties	548	
18.3	Factor of Safety	549	

18.4	Tensile Testing	550
18.5	Compression Testing	552
18.6	Torsion Testing	552
18.7	Hardness Testing	553
18.8	Impact Testing	554
18.9	Column Testing	555
18.10	Creep Testing	555
18.11	Fatigue Testing	556
	<i>Summary</i>	558
	<i>Review Questions</i>	558
	<i>Appendix I</i>	560
	<i>Appendix II</i>	578
	<i>Index</i>	581