

Table of Contents

1 Stress	3
Chapter Objectives	3
1.1 Introduction	3
1.2 Equilibrium of a Deformable Body	4
1.3 Stress	22
1.4 Average Normal Stress in an Axially Loaded Bar	24
1.5 Average Shear Stress	32
1.6 Allowable Stress Design	46
1.7 Limit State Design	48
2 Strain	67
Chapter Objectives	67
2.1 Deformation	67
2.2 Strain	68
3 Mechanical Properties of Materials	83
Chapter Objectives	83
3.1 The Tension and Compression Test	83
3.2 The Stress—Strain Diagram	85
3.3 Stress—Strain Behavior of Ductile and Brittle Materials	89
3.4 Hooke's Law	92
3.5 Strain Energy	94
3.6 Poisson's Ratio	104

3.7 The Shear Stress—Strain Diagram	106
*3.8 Failure of Materials Due to Creep and Fatigue	109
4 Axial Load	121
Chapter Objectives	121
4.1 Saint-Venant's Principle	121
4.2 Elastic Deformation of an Axially Loaded Member	124
4.3 Principle of Superposition	138
4.4 Statically Indeterminate Axially Loaded Member	139
4.5 The Force Method of Analysis for Axially Loaded Members	145
4.6 Thermal Stress	153
4.7 Stress Concentrations	160
*4.8 Inelastic Axial Deformation	164
*4.9 Residual Stress	166
5 Torsion	181
Chapter Objectives	181
5.1 Torsional Deformation of a Circular Shaft	181
5.2 The Torsion Formula	184
5.3 Power Transmission	192
5.4 Angle of Twist	204
5.5 Statically Indeterminate Torque-Loaded Members	218
*5.6 Solid Noncircular Shafts	225
*5.7 Thin-Walled Tubes Having Closed Cross Sections	228
5.8 Stress Concentration	238

*5.9 Inelastic Torsion	241
*5.10 Residual Stress	243
6 Bending	259
Chapter Objectives	259
6.1 Shear and Moment Diagrams	259
6.2 Graphical Method for Constructing Shear and Moment Diagrams	266
6.3 Bending Deformation of a Straight Member	285
6.4 The Flexure Formula	289
6.5 Unsymmetric Bending	306
*6.6 Composite Beams	316
*6.7 Reinforced Concrete Beams	319
*6.8 Curved Beams	323
6.9 Stress Concentrations	330
*6.10 Inelastic Bending	339
7 Transverse Shear	363
Chapter Objectives	363
7.1 Shear in Straight Members	363
7.2 The Shear Formula	365
7.3 Shear Flow in Built-Up Members	382
7.4 Shear Flow in Thin-Walled Members	391
*7.5 Shear Center for Open Thin-Walled Members	396
8 Combined Loadings	409
Chapter Objectives	409

8.1 Thin-Walled Pressure Vessels	409
8.2 State of Stress Caused by Combined Loadings	416
9 Stress Transformation	441
Chapter Objectives	441
9.1 Plane-Stress Transformation	441
9.2 General Equations of Plane-Stress Transformation	446
9.3 Principal Stresses and Maximum In-Plane Shear Stress	449
9.4 Mohr's Circle—Plane Stress	465
9.5 Absolute Maximum Shear Stress	477
10 Strain Transformation	489
Chapter Objectives	489
10.1 Plane Strain	489
10.2 General Equations of Plane-Strain Transformation	490
*10.3 Mohr's Circle—Plane Strain	498
*10.4 Absolute Maximum Shear Strain	506
10.5 Strain Rosettes	508
10.6 Material-Property Relationships	512
*10.7 Theories of Failure	524
11 Design of Beams and Shafts	541
Chapter Objectives	541
11.1 Basis for Beam Design	541
11.2 Prismatic Beam Design	544
11.3 Fully Stressed Beams	558

11.4 Shaft Design	562
12 Deflection of Beams and Shafts	573
Chapter Objectives	573
12.1 The Elastic Curve	573
12.2 Slope and Displacement by Integration	577
*12.3 Discontinuity Functions	597
*12.4 Slope and Displacement by the Moment-Area Method	608
12.5 Method of Superposition	623
12.6 Statically Indeterminate Beams and Shafts	631
12.7 Statically Indeterminate Beams and Shafts–Method of Integration	632
*12.8 Statically Indeterminate Beams and Shafts–Moment-Area Method	637
12.9 Statically Indeterminate Beams and Shafts–Method of Superposition	643
13 Buckling of Columns	661
Chapter Objectives	661
13.1 Critical Load	661
13.2 Ideal Column with Pin Supports	664
13.3 Columns Having Various Types of Supports	670
*13.4 The Secant Formula	682
*13.5 Inelastic Buckling	688
*13.6 Design of Columns for Concentric Loading	696
*13.7 Design of Columns for Eccentric Loading	707
14 Energy Methods	719
Chapter Objectives	719

14.1 External Work and Strain Energy	719
14.2 Elastic Strain Energy for Various Types of Loading	724
14.3 Conservation of Energy	737
14.4 Impact Loading	744
*14.5 Principle of Virtual Work	755
*14.6 Method of Virtual Forces Applied to Trusses	759
*14.7 Method of Virtual Forces Applied to Beams	766
*14.8 Castigliano's Theorem	775
*14.9 Castigliano's Theorem Applied to Trusses	777
*14.10 Castigliano's Theorem Applied to Beams	780

Appendix

A. Geometric Properties of an Area

B. Geometric Properties of Structural Shapes

C. Slopes and Deflections of Beams

Fundamental Problems Partial Solutions and Answers

Answers for Selected Problems

Index