

# CONTENTS

	<b>CONTENTS</b>	<b>3</b>
<b>1</b>	<b>OVERVIEW</b>	<b>7</b>
1.1	Preface	7
1.2	Acknowledgements	7
1.3	Role of Mechanics of Materials and Solid Mechanics in Design	7
<b>2</b>	<b>SIMPLE STRESS AND STRAIN</b>	<b>14</b>
2.1	Load	14
2.2	Direct or Normal Stress ( $\sigma$ )	16
2.3	Direct or Normal Strain ( $\varepsilon$ )	16
2.4	Sign Convention for Direct Stress and Strain	17
2.5	Saint-Venant's Principle	17
2.6	Elastic materials - Hooke's Law for Direct Stress and Strain	18
2.7	Modulus of Elasticity - Young's Modulus for Direct Stress and Strain	19
2.8	Tensile Test	20
2.9	Ductile Materials	23
2.10	Brittle Materials	24
2.11	Hyper-Elastic Materials (Elastomers) and Cellular Materials	24
2.12	Normal Forces (N.F.)	25
2.13	Reactions	26
	Example 2.1	26
2.14	Stress, Strain and Elongation in Pure Tension or Compression	27
2.15	Temperature Stresses, Strains and Elongations	29
2.16	Gravity Load in Axial Direction	31
	Example 2.2	31
2.17	Poisson's Ratio	33
2.18	Application of Poisson's Ratio to a Two-Dimensional Stress System	34
2.19	Volume Change	35
2.20	Strain Energy	36
2.21	Shear Stress	38
2.22	Shear Strain.	38
2.23	Modulus of Rigidity - Shear Modulus	39
2.24	Allowable Working Stress - Factor of Safety	39
2.25	Stress Concentrations	41
2.26	Stress-Concentration Factors in Pure Tension or Compression	41
	Example 2.3	42
	Example 2.4	43
2.27	Trusses	45
2.28	Ideal Plane Trusses	46
	Example 2.5	47
2.29	Castigliano's Theorem in Pure Tension or Compression	49
	Example 2.6	50
2.30	Theory of 1 <sup>st</sup> and 2 <sup>nd</sup> Order for Small Deformations	52

2.31	Examples	53
	Example 2.7	53
	Example 2.8	56
	Example 2.9	59
	Example 2.10	61
	Example 2.11	63
	Example 2.12	66
	Example 2.13	67
	Example 2.14	69
	Example 2.15	72
	Example 2.16	73
	Example 2.17	75
<b>3</b>	<b>SHEARING FORCE AND BENDING MOMENT DIAGRAMS</b>	<b>77</b>
3.1	Summary	77
3.2	Beams	78
3.3	Supports	80
3.4	Reactions	82
	Example 3.1	82
	Example 3.2	83
	Example 3.3	84
	Example 3.4	84
3.5	Shearing Force (S.F.) and Bending Moment (B.M.)	85
3.6	(S.F.) Sign Convention	86
3.7	(B.M.) Sign Convention	87
3.8	(S.F.) and (B.M.) Diagrams	87
3.9	(S.F.) and (B.M.) Diagrams for Cantilever Beams	88
	Example 3.5	88
	Example 3.6	89
3.10	(S.F.) and (B.M.) Diagrams for Simple Supported Beams	90
	Example 3.7	90
	Example 3.8	92
	Example 3.9	94
3.11	Relationship between (S.F.), (B.M.) and Intensities $q$ and $m$	95
3.12	Gerber-Girder (Continuous Beam Divided by Pin-Joints)	98
3.13	Examples	99
	Example 3.10	99
	Example 3.11	103
	Example 3.12	104
	Example 3.13	105
	Example 3.14	106
	Example 3.15	106
	Example 3.16	107
	Example 3.17	109

**4 SIMPLE BENDING OF STRAIGHT BEAMS 111**

4.1	Summary	111
4.2	Introduction	115
4.3	Centroids and First Moments of Plane Areas	116
	Example 4.1	117
4.4	Simple Bending Theory	118
4.5	Neutral Axis (N.A.)	121
4.6	Maximal Stress and Section Modulus $W_o$	123
4.7	Second Moments and Products of Inertia of Areas	124
	Example 4.2	125
	Example 4.3	126
	Example 4.4	126
	Example 4.5	127
4.8	Parallel Axis Theorem	128
	Example 4.6	129
4.9	Principal Second Moments of Areas	130
	Example 4.7	133
4.10	Strain Energy in Simple Bending	136
4.11	Stress-Concentrations in Bending	137
4.12	Stress-Concentration Factors in Bending	137
	Example 4.8	139
4.13	Examples	141
	Example 4.9	141
	Example 4.10	142

**5 SLOPE AND DEFLECTION OF STRAIGHT BEAMS 144**

5.1	Summary	144
5.2	Introduction	145
5.3	Relationship between Slope, Deflection and Curvature of Beams	145
5.4	Differential Equations for Deflection of Beams	147
5.5	Direct integration Method	149
	Example 5.1	151
	Example 5.2	153
	Example 5.3	156
	Example 5.4	157
5.6	Direct Integration Method Applied for Statically Indeterminate Beams	161
	Example 5.5	162
5.7	Principle of Superposition	166
	Example 5.6	166
5.8	Maxwell's Theorems of Reciprocal Displacements	168
	Example 5.7	170
5.9	Energy methods	171
5.10	Castigliano's Theorems	171
5.11	Castigliano's First Theorem for Deflection of Beams	172
	Example 5.8	176
5.12	Castigliano's Second Theorem for Slope of Beams	177
	Example 5.9	177

5.13	Use of Fictitious Force and Fictitious Moment in the Castigliano's Theorems	178
	Example 5.10	179
5.14	Castigliano's Theorems Applied for Statically Indeterminate Beams	181
	Example 5.11	181
	Example 5.12	183
5.15	Examples	185
	Example 5.13	185
	Example 5.14	186
	Example 5.15	187
	Example 5.16	188
<b>6</b>	<b>APPENDIX</b>	<b>191</b>
6.1	Solution of the Supported Beam via FEM Software ANSYS	191
6.2	Printout of the Programme (for ANSYS Software)	192
6.3	Calculation of Maximal Bending Stress (Probabilistic Assessment) via AntHill Software	193
6.4	Printout of the Programme (for AntHill Software)	197
6.5	English Czech Dictionary (Basic Words Used in this Book)	198
	<b>REFERENCES</b>	<b>200</b>