

---

## Contents

---

<b>Preface</b> . . . . .	ix
<b>Chapter 1. Elasticity, Rigidity</b> . . . . .	1
1.1. Elasticity and rigidity tensors . . . . .	1
1.1.1. Hooke's law . . . . .	1
1.1.2. Matrix notation . . . . .	2
1.1.3. Relationships between stresses and strains for isotropic bodies . . . . .	2
1.1.4. Tensors $[\sigma]$ and $[\varepsilon]$ and deviators . . . . .	4
1.2. Elastic energy . . . . .	30
1.2.1. Elastic energy of a body subjected to stresses . . . . .	30
1.2.2. Expansion energies $W_\theta$ and distortion $W_D$ . . . . .	31
1.3. Generalized stresses and strains . . . . .	33
1.3.1. Generalized or equivalent Von Mises stress . . . . .	33
1.3.2. Generalized or equivalent Von Mises strain . . . . .	35
<b>Chapter 2. Scaling Criteria: Tresca, Von Mises, Hill</b> . . . . .	37
2.1. Isotropic criteria . . . . .	37
2.1.1. Tresca criterion . . . . .	37
2.1.2. Von Mises criterion . . . . .	41
2.1.3. Load surfaces . . . . .	47
2.2. Anisotropic criteria . . . . .	82
2.2.1. Influence of anisotropy on the elastic limit . . . . .	82
2.2.2. The Hill criterion for anisotropic materials . . . . .	85
2.2.3. Hill's criterion, scaling of composites . . . . .	89

<b>Chapter 3. Elastic Mechanics of Parts and Structures: Rigidity, Strength, Scaling . . . . .</b>	115
3.1. Statics of solids, basic concepts . . . . .	116
3.1.1. Load on a solid S . . . . .	116
3.1.2. Bonds: inventory of the primary bonds and cases of a spatial problem . . . . .	117
3.1.3. Equilibrium of a solid S . . . . .	119
3.1.4. Internal stresses . . . . .	119
3.1.5. Isostatic or hyperstatic pieces and structures . . . . .	125
3.2. Elasticity of parts and structures: method for calculating the three moments. . . . .	130
3.2.1. Calculation of rotations . . . . .	131
3.2.2. Generalization, equation of the three moments . . . . .	138
3.3. The force method . . . . .	140
3.3.1. Example of associated isostatic systems . . . . .	141
3.3.2. Castigliano's theorem . . . . .	142
3.3.3. Manabrea's theorem . . . . .	143
3.3.4. Maxwell's influence coefficients. . . . .	146
3.4. Mohr integrals . . . . .	149
3.4.1. Application to the force method . . . . .	153
3.5. Movement method: application of Castigliano's theorem to the calculation of elastic movements at a point of a part or a structure . . . . .	162
3.5.1. Calculation of the movements on a bending planar structure . . . . .	164
3.6. Matrix method, elastic stiffness [K] . . . . .	168
3.6.1. Lattice structures with flat articulated nodes . . . . .	168
 <b>Chapter 4. Tension, Torsion, Bending, Shearing: Static and Dynamic . . . . .</b>	207
4.1. Introduction: static and dynamic tensions . . . . .	207
4.2. Torsion: basic concepts . . . . .	214
4.2.1. Stress for any section that does not have an angular point . . . . .	221
4.2.2. The case of a prism-shaped beam with rectangular section . . . . .	222
4.2.3. The case of a prism-shaped beam with a hollow section . . . . .	224
4.2.4. The case of a prism-shaped beam with a straight section in profile . . . . .	226
4.2.5. Internal energy of torsion strain . . . . .	227
4.2.6. Dynamic torsion . . . . .	228
4.3. Bending . . . . .	231
4.3.1. Planar bending . . . . .	231
4.3.2. Pure bending, $T = 0$ . . . . .	232

---

4.3.3. Non-symmetrical bending . . . . .	236
4.3.4. Bending of curved beams . . . . .	239
4.3.5. Single bending, $T \neq 0$ . . . . .	242
4.4. Elastic deflection of beams . . . . .	242
4.4.1. The diagram method . . . . .	243
4.4.2. Double integration method and deflection curve . . . . .	255
4.4.3. Deformation energy method . . . . .	267
<b>Chapter 5. Plastic Hinge . . . . .</b>	281
5.1. Elastic limit deflection . . . . .	281
5.1.1. Any potential section with double symmetry . . . . .	282
5.1.2. A beam with symmetry only on its vertical axis . . . . .	287
5.1.3. Plastic ball joint . . . . .	290
5.2. Dynamic deflection . . . . .	299
5.2.1. Localized loading of beams and sheets . . . . .	299
5.2.2. Distributed loading of beams and sheets . . . . .	303
5.3. Bending of circular plates: elastic limit, bending of symmetrically loaded circular plates . . . . .	314
5.3.1. Circumferential and radial extensions, stresses and moments . . . . .	314
<b>Chapter 6. Cutting Force, Shearing . . . . .</b>	333
6.1. Distribution of shear stresses . . . . .	333
6.1.1. Full section: extent of boundary conditions . . . . .	333
6.1.2. Calculation of the distribution of stresses . . . . .	334
6.2. Balance of a beam element: balance of a solid (ABC A'B'C') . . . . .	335
6.2.1. Resulting breakdown of forces $O_x$ . . . . .	335
6.2.2. Balance of forces on $O_x$ . . . . .	336
6.3. Thin-walled section . . . . .	337
6.3.1. Torsion moment and shear center . . . . .	340
6.4. Shear in bending beams . . . . .	342
6.5. Shear flux . . . . .	343
6.6. Bredt's formula . . . . .	344
6.6.1. Applications . . . . .	345
6.7. Deformation energy and strain: introduction of reduced sections and sag . . . . .	355

<b>Appendix. Page Numbers of the One Hundred Examples Examined with Their Solutions . . . . .</b>	363
<b>References . . . . .</b>	367
<b>Index . . . . .</b>	369