

## Contents

Preface, V

Introduction, 1

Chapter 1. Kinematics, 11

- 1.1. Motion of a single particle, 11
- 1.2. Description of the motion of a rigid body, 26
- 1.3. Relative motion, 40
- 1.4. Plane motion of a rigid body, 48
- 1.5. Examples of the determination of velocities and accelerations in the motion of plane mechanisms, 55

Chapter 2. The dynamics of a particle, 69

- 2.1. Fundamental definitions and theorems, 69
- 2.2. Motion of a particle, 72
- 2.3. Centre of mass and centre of gravity of a particle system, 80
- 2.4. Law of variation of momentum, 86
- 2.5. Law of variation of angular momentum, 92

Chapter 3. Statics, 95

- 3.1. Equations of equilibrium, 95
- 3.2. Couple, 96
- 3.3. Spatial system of forces. Wrench, 97
- 3.4. Analytical and graphical methods in the statics of plane systems, 99  
Analytical methods, 99  
Graphical methods (funicular polygon), 101

- 3.5. Examples, 106
  - Triple-jointed system, 106
  - Free-ends beam, 114
  - Plane trusses, 117
- 3.6. The distributive character of transverse loads in simple rods, 121
- 3.7. The equilibrium of rods loaded with transverse forces, 127
- 3.8. Friction, 136
  - Friction on an inclined plane, 138
  - Bearing friction, 140
  - Friction of rope against wheel, 141
  - Problem of friction in the case of a cylinder rolling on plane surface, 142

#### Chapter 4. The statics of elastic systems, 144

- 4.1. Hooke's law, 144
- 4.2. Safety factor, 149
- 4.3. Statically indeterminate systems, 151
- 4.4. Problems of simple beam-bending, 155
- 4.5. Geometric moments of inertia, 159
- 4.6. Strength calculations of beams, 166
- 4.7. The equation for the axis of a deflected beam, 169
- 4.8. Graphical methods of determining deflections of simple beams (Mohr's analogy), 173
- 4.9. Oblique bending, 176
- 4.10. Some special problems of bending theory, 177
- 4.11. Clapeyron's systems, 185
- 4.12. Buckling problems of axially compressed rods, 199
- 4.13. Highly curved rods, 203
- 4.14. Torsion of rods with circular cross-section, 209
- 4.15. Springs, 212
- 4.16. Simultaneous bending and torsion of rods with circular cross-section, 217

#### Chapter 5. The dynamics of rigid bodies, 220

- 5.1. Moments of inertia of rigid bodies, 220
- 5.2. The angular momentum of a rigid body in general motion, 226

- 5.3. Angular momentum in circular motion, 228
- 5.4. Euler's equations, 230
- 5.5. The kinetic energy of rigid bodies in general motion, 235

Chapter 6. Dynamics in relative motion, 241

- 6.1. Differential equation of the motion of a particle in a non-inertial system, 241
- 6.2. The dynamics of rigid bodies in relative motion, 243

Chapter 7. Fundamentals of analytical mechanics, 249

- 7.1. Generalized coordinates and degrees of freedom of a mechanical system, 249
- 7.2. D'Alembert's principle, 255
- 7.3. Hamilton's principle, 258
- 7.4. Lagrange equations of the first order, 261
- 7.5. Lagrange equations of the second order, 265
- 7.6. Kinetic energy of a system, 272
- 7.7. Impulsive motion, 272
- 7.8. Gyroscopic and dissipative forces, 276
- 7.9. The Lagrange equations for electromechanical systems, 279
- 7.10. Hamilton's canonical equations, 283
- 7.11. The total energy of a mechanical system, 284
- 7.12. Configurational space, 286
- 7.13. The stability of mechanical systems, 293

Chapter 8. Vibrations of systems with one degree of freedom, 307

- 8.1. Preliminary discussion, 307
- 8.2. Free vibrations of harmonic oscillators, 310
- 8.3. The influence of dissipative forces in the free vibrations of harmonic oscillators, 319
- 8.4. Forced vibrations of harmonic oscillators, 323
- 8.5. Vibrations of harmonic oscillators with kinematical input, 332
- 8.6. Vibrations of harmonic oscillators under periodic input forces, 333
- 8.7. Vibrations of non-linear systems, 336

|   |  |
|---|--|
| Chapter 9. Vibrations of systems with many degrees of freedom, 351              |  |
| 9.1. Preliminary discussion, 351  |  |
| 9.2. Problems of linearization of the equations, 352                            |  |
| 9.3. Free vibrations of conservative systems, 356                               |  |
| 9.4. Normal coordinates, 362  |  |
| 9.5. Forced vibrations of a system, 363   |  |
| 9.6. Free vibrations of dissipative systems, 364                                |  |
| 9.7. Forced vibrations in dissipative systems, 366                              |  |
| 9.8. Vibrations of Clapeyron's systems, 367                                     |  |
| <br>  |  |
| Chapter 10. Some methods of describing random phenomena in mechanics, 371       |  |
| 10.1. Basic concepts, 371   |  |
| 10.2. Methods of describing stochastic processes, 381                           |  |
| 10.3. Stochastic linearization, 387   |  |
| 10.4. Random vibrations of linear systems with one degree of freedom, 389       |  |
| 10.5. Random vibrations of systems with many degrees of freedom, 397            |  |
| 10.6. The problem of departures, 400  |  |
| 10.7. Fokker–Planck–Kolmogorov equations, 415                                   |  |
| 10.8. Proposal for a method of direct determination of probability density, 420 |  |
| <br>  |  |
| Bibliography, 425   |  |
| Subject index, 429  |  |