Contents

Preface  4

Chapter 1  Introduction  9
1.1  Case Study: Pneumatically Actuated PDMS Fingers  10
1.2  Structural Mechanics: A Quick Review  23
1.3  Finite Element Methods: A Conceptual Introduction  31
1.4  Failure Criteria of Materials  36
1.5  Problems  42

Chapter 2  Sketching  46
2.1  Step-by-Step: W16x50 Beam  47
2.2  Step-by-Step: Triangular Plate  58
2.3  More Details  69
2.4  Exercise: M20x2.5 Threaded Bolt  76
2.5  Exercise: Spur Gears  80
2.6  Exercise: Microgripper  86
2.7  Problems  89

Chapter 3  2D Simulations  91
3.1  Step-by-Step: Triangular Plate  92
3.2  Step-by-Step: Threaded Bolt-and-Nut  102
3.3  More Details  115
3.4  Exercise: Spur Gears  125
3.5  Exercise: Filleted Bar  130
3.6  Problems  141

Chapter 4  3D Solid Modeling  143
4.1  Step-by-Step: Beam Bracket  144
4.2  Step-by-Step: Cover of Pressure Cylinder  150
4.3  Step-by-Step: Lifting Fork  162
4.4  More Details  170
4.5  Exercise: LCD Display Support  175
4.6  Problems  180

Chapter 5  3D Simulations  182
5.1  Step-by-Step: Beam Bracket  183
5.2  Step-by-Step: Cover of Pressure Cylinder  193
5.3  More Details  200
5.4  Exercise: LCD Display Support  204
5.5  Problems  209
## Chapter 6 Surface Models  211

6.1 Step-by-Step: Bellows Joints  212  
6.2 Step-by-Step: Beam Bracket  222  
6.3 Exercise: Gearbox  232  
6.4 Problems  243

## Chapter 7 Line Models  245

7.1 Step-by-Step: Flexible Gripper  246  
7.2 Step-by-Step: 3D Truss  258  
7.3 Exercise: Two-Story Building  268  
7.4 Problems  280

## Chapter 8 Optimization  282

8.1 Step-by-Step: Flexible Gripper  283  
8.2 Exercise: Triangular Plate  296  
8.3 Problems  304

## Chapter 9 Meshing  306

9.1 Step-by-Step: Pneumatic Fingers  307  
9.2 Step-by-Step: Cover of Pressure Cylinder  326  
9.3 Exercise: 3D Solid Elements Convergence Study  338  
9.4 Problems  350

## Chapter 10 Buckling and Stress Stiffening  352

10.1 Step-by-Step: Stress Stiffening  353  
10.2 Step-by-Step: 3D Truss  364  
10.3 Exercise: Beam Bracket  368  
10.4 Problems  372

## Chapter 11 Modal Analyses  374

11.1 Step-by-Step: Gearbox  375  
11.2 Step-by-Step: Two-Story Building  380  
11.3 Exercise: Compact Disk  387  
11.4 Exercise: Guitar String  395  
11.5 Problems  402

## Chapter 12 Structural Dynamics  404

12.1 Basics of Structural Dynamics  405  
12.2 Step-by-Step: Lifting Fork  414  
12.3 Step-by-Step: Two-Story Building  426  
12.4 Exercise: Ball and Rod  433  
12.5 Exercise: Guitar String  441  
12.6 Problems  452