

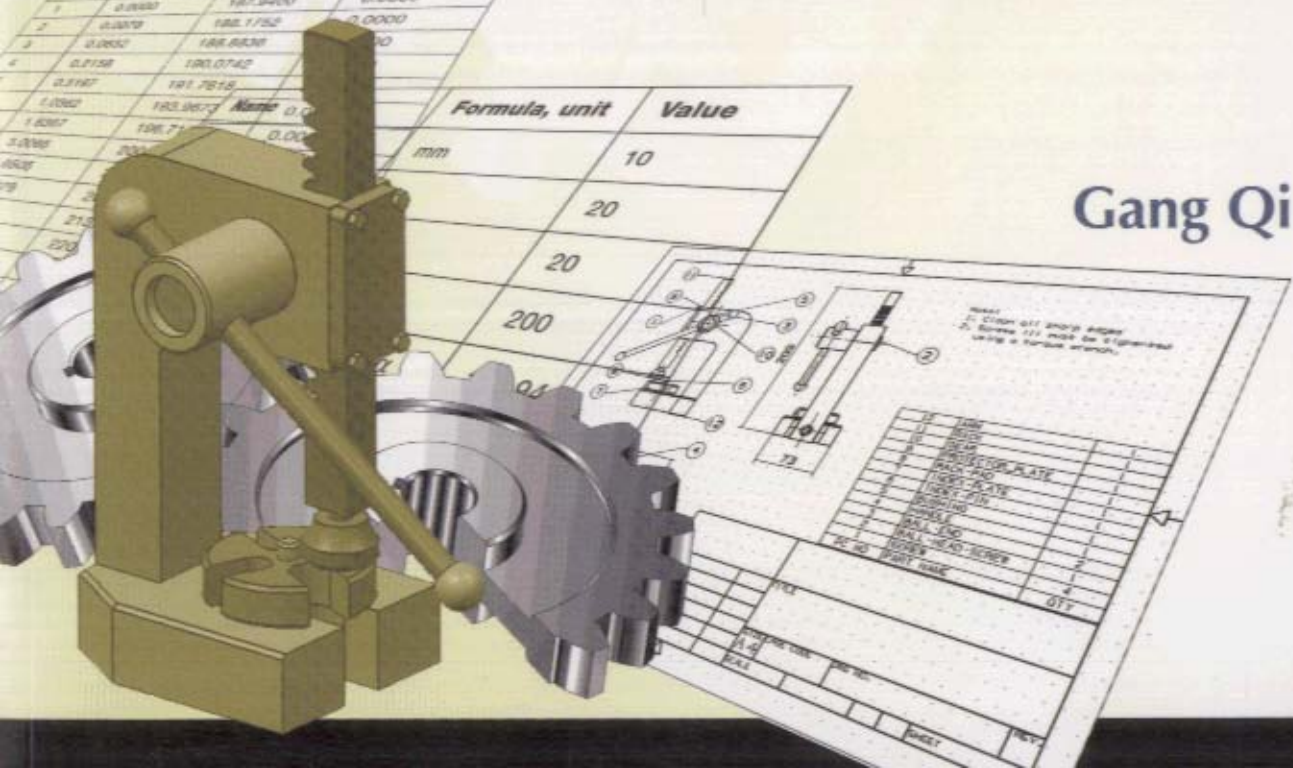
Engineering Design Communication and Modeling

Using Unigraphics® NX

| No. | coordinate | coordinate | coordinate |
|-----|------------|------------|------------|
| 1 | 0.0000 | 187.9400 | 0.0000 |
| 2 | 0.0000 | 188.1752 | 0.0000 |
| 3 | 0.0000 | 188.6838 | 0.0000 |
| 4 | 0.0158 | 190.0742 | 0.0000 |
| 5 | 0.0167 | 191.7815 | 0.0000 |
| 6 | 0.0000 | 193.9570 | 0.0000 |
| 7 | 0.0000 | 196.7100 | 0.0000 |
| 8 | 0.0000 | 200.0000 | 0.0000 |
| 9 | 0.0000 | 203.7100 | 0.0000 |
| 10 | 0.0000 | 207.9400 | 0.0000 |

| Formula, unit | Value |
|---------------|-------|
| mm | 10 |
| | 20 |
| | 20 |
| | 200 |
| | 0.5 |

Gang Qi



CONTENTS

| | |
|----------------------|----|
| PREFACE | xi |
|----------------------|----|

| | |
|------------------------------|------|
| ACKNOWLEDGMENTS | xiii |
|------------------------------|------|

CHAPTER 1 INTRODUCTION

| | |
|---|----|
| 1.1 ENGINEERING DESIGN COMMUNICATION | 1 |
| 1.2 ENGINEERING DESIGN MODELING | 3 |
| 1.3 THE RELATIONSHIP BETWEEN ENGINEERING DESIGN COMMUNICATION AND MODELING | 4 |
| 1.4 FEATURE-BASED PARAMETRIC DESIGN MODELING | 5 |
| 1.5 COMPUTER-INTEGRATED PROBLEM SOLVING IN ENGINEERING DESIGN AND MANUFACTURING..... | 8 |
| 1.6 GOOD ENGINEERING PRACTICE IN DESIGN MODELING..... | 9 |
| 1.7 MAJOR TOOLS USED IN THIS BOOK..... | 10 |
| 1.8 REFERENCES..... | 10 |

CHAPTER 2 FUNDAMENTALS OF ENGINEERING GRAPHICS

| | |
|--|----|
| 2.1 INTRODUCTION..... | 13 |
| 2.2 LEARNING OBJECTIVES | 14 |
| 2.3 MULTIVIEW PROJECTION | 14 |
| 2.3.1 Projections of Engineering Graphics..... | 14 |
| 2.3.2 First- and Third-Angle Projections | 15 |
| 2.3.3 Multiview Projection Planes | 17 |
| 2.3.4 Multiview Drawings..... | 17 |
| 2.3.5 Front View Selection | 19 |
| 2.4 AUXILIARY VIEWS..... | 21 |
| 2.5 SECTION VIEWS | 23 |
| 2.5.1 Full- and Half-Section Views..... | 23 |
| 2.5.2 Offset and Aligned Section Views | 25 |
| 2.6 DESCRIPTIVE GEOMETRY | 26 |
| 2.6.1 Determination of Point Projection..... | 26 |
| 2.6.2 Determination of Line Projection | 28 |
| 2.6.3 Determination of Plane Projection | 30 |
| 2.7 PROJECTS..... | 35 |
| 2.8 REVIEW AND DISCUSSION QUESTIONS..... | 42 |
| 2.9 ADDITIONAL PROJECTS | 43 |
| 2.10 REFERENCES..... | 47 |

CHAPTER 3 DIMENSIONING AND TOLERANCING

| | | |
|------|--|----|
| 3.1 | INTRODUCTION..... | 49 |
| 3.2 | LEARNING OBJECTIVES..... | 49 |
| 3.3 | ENGINEERING DIMENSIONING SYSTEMS..... | 50 |
| | 3.3.1 Types of Dimensions..... | 50 |
| | 3.3.2 General Rules of Dimensioning and Tolerancing..... | 51 |
| 3.4 | PREFERRED ENGINEERING PRACTICE IN DIMENSIONING..... | 53 |
| 3.5 | TOLERANCING..... | 60 |
| | 3.5.1 Manufacturing Deviations..... | 60 |
| | 3.5.2 Distribution of Manufacturing Deviations and Normal Distribution..... | 61 |
| | 3.5.3 Tolerance, Precision, and Manufacturing Costs..... | 64 |
| | 3.5.4 Standard ANSI Fits..... | 66 |
| 3.6 | GEOMETRIC DIMENSIONING AND TOLERANCING..... | 67 |
| | 3.6.1 GD&T Form Controls..... | 68 |
| | 3.6.2 GD&T Orientation Controls..... | 70 |
| | 3.6.3 GD&T Location Controls..... | 72 |
| 3.7 | PROJECTS..... | 74 |
| 3.8 | REVIEW AND DISCUSSION QUESTIONS..... | 77 |
| 3.9 | ADDITIONAL PRACTICE..... | 78 |
| 3.10 | REFERENCES..... | 81 |

CHAPTER 4 PROBLEM SOLVING IN ENGINEERING DESIGN PROJECTS

| | | |
|-----|--|-----|
| 4.1 | INTRODUCTION..... | 83 |
| 4.2 | LEARNING OBJECTIVES..... | 83 |
| 4.3 | PROBLEMS SOLVING IN ENGINEERING DESIGN..... | 84 |
| 4.4 | DESIGN PROJECT I: COMBINATION CURLING AND FLAT IRON..... | 86 |
| | 4.4.1 Problem Statement..... | 86 |
| | 4.4.2 Design Intent..... | 86 |
| | 4.4.3 Conceptual Design..... | 86 |
| | 4.4.4 Components Design..... | 87 |
| | 4.4.5 Analysis..... | 92 |
| 4.5 | DESIGN PROJECT EXAMPLE II: DESIGN MODELING OF A DE-ROTATOR..... | 95 |
| | 4.5.1 Problem Statement..... | 95 |
| | 4.5.2 Design Intent..... | 95 |
| | 4.5.3 Conceptual Design..... | 95 |
| | 4.5.4 Components Design..... | 96 |
| | 4.5.5 Operation of De-rotator..... | 100 |
| 4.6 | REVIEW AND DISCUSSION QUESTIONS..... | 102 |

CHAPTER 5 BASE DESIGN FEATURES

| | |
|--|-----|
| 5.1 INTRODUCTION | 103 |
| 5.2 LEARNING OBJECTIVES..... | 105 |
| 5.3 STOCK TYPES OF BASE FEATURES | 105 |
| 5.3.1 Block..... | 105 |
| 5.3.2 Cylinder | 108 |
| 5.3.3 Cone..... | 110 |
| 5.3.4 Sphere..... | 111 |
| 5.4 MODIFYING MODELS | 111 |
| 5.5 MODELING BY COMBINING STANDARD BASE FEATURES..... | 114 |
| 5.5.1 The Work Coordinate System..... | 114 |
| 5.5.2 Manipulating the Work Coordinate System..... | 116 |
| 5.5.3 Modeling by Combining Standard Base Features | 116 |
| 5.6 PROJECTS..... | 124 |
| 5.7 REVIEW AND DISCUSSION QUESTIONS | 126 |
| 5.8 ADDITIONAL PRACTICE | 126 |

CHAPTER 6 BASIC FUNCTIONAL ELEMENT FEATURES

| | |
|--|-----|
| 6.1 INTRODUCTION | 131 |
| 6.2 LEARNING OBJECTIVES..... | 132 |
| 6.3 BASIC FUNCTIONAL ELEMENT FEATURES AND THEIR USAGE | 133 |
| 6.3.1 Basic Functional Features | 133 |
| 6.3.2 General Feature Placement Requirements | 138 |
| 6.3.3 Define a Placement Plane..... | 138 |
| 6.3.4 Define a Horizontal Reference | 141 |
| 6.3.5 Position Basic Features | 142 |
| 6.4 BASIC FUNCTIONAL FEATURE MODELING | 143 |
| 6.4.1 Models with Holes and Bosses..... | 143 |
| 6.4.2 Models with Pockets, Slots, and Pads | 147 |
| 6.4.3 Models with Grooves and Threads | 151 |
| 6.5 FEATURE MODIFICATION | 154 |
| 6.5.1 Feature Resize..... | 154 |
| 6.5.2 Feature Reposition..... | 157 |
| 6.6 PROJECTS..... | 159 |
| 6.7 REVIEW AND DISCUSSION QUESTIONS | 162 |
| 6.8 ADDITIONAL PRACTICE | 163 |

CHAPTER 7 FEATURE DATUM REFERENCES

| | |
|---|-----|
| 7.1 INTRODUCTION | 167 |
| 7.2 LEARNING OBJECTIVES..... | 167 |
| 7.3 BASIC DATUM REFERENCES..... | 168 |
| 7.3.1 Datums as Initial Features..... | 169 |
| 7.3.2 Datums on Existing Solid Surface..... | 171 |

| | |
|--|------------|
| 7.3.3 Parallel and Perpendicular Datum Planes..... | 173 |
| 7.3.4 Mixed Datum Axes and Planes..... | 176 |
| 7.4 ADVANCED PLACEMENT OF DATUM REFERENCES..... | 179 |
| 7.4.1 Advanced Datum Plane Placement..... | 179 |
| 7.4.2 Advanced Datum Axis Placement..... | 183 |
| 7.5 PROJECTS..... | 186 |
| 7.6 REVIEW AND DISCUSSION QUESTIONS..... | 189 |
| 7.7 ADDITIONAL PRACTICE..... | 189 |

CHAPTER 8 DESIGN MODELING FROM TWO-DIMENSIONAL SKETCHES

| | |
|---|------------|
| 8.1 INTRODUCTION..... | 193 |
| 8.2 LEARNING OBJECTIVES..... | 194 |
| 8.3 APPLICATIONS OF SKETCHING..... | 195 |
| 8.4 BASIC SKETCHING..... | 197 |
| 8.4.1 Creating a Simple Sketch..... | 198 |
| 8.4.2 Profiling Sketches..... | 204 |
| 8.4.3 Profiling Sketches with Splines..... | 207 |
| 8.4.4 Manipulating Sketches..... | 208 |
| 8.5 SKETCHING TO FACILITATE MODELING..... | 214 |
| 8.5.1 Creating Sketches—Define a Sketching Plane..... | 214 |
| 8.5.2 Constraining Sketches..... | 220 |
| 8.5.3 Dimensioning Sketches..... | 225 |
| 8.6 SKETCH ANIMATION..... | 230 |
| 8.7 PROJECTS..... | 233 |
| 8.8 REVIEW QUESTIONS..... | 236 |
| 8.9 ADDITIONAL PRACTICE..... | 237 |

CHAPTER 9 ADDITIONAL MODELING FEATURES

| | |
|--|------------|
| 9.1 INTRODUCTION..... | 241 |
| 9.2 LEARNING OBJECTIVES..... | 241 |
| 9.3 EDGE AND FACE FEATURES..... | 241 |
| 9.3.1 Rounds..... | 244 |
| 9.3.2 Chamfers..... | 247 |
| 9.3.3 Face Tapers..... | 248 |
| 9.4 MODELS WITH PATTERNED FEATURES..... | 251 |
| 9.4.1 Linear Patterned Features..... | 252 |
| 9.4.2 Radial Patterned Features..... | 254 |
| 9.4.3 Models with Symmetry..... | 256 |
| 9.5 MODELS WITH HOLLOW FEATURES..... | 259 |
| 9.5.1 Models with a Simple Hollow..... | 259 |
| 9.5.2 Models with Regional Hollows..... | 260 |
| 9.6 PROJECTS..... | 263 |

| | |
|---|-----|
| 9.7 REVIEW AND DISCUSSION QUESTIONS | 266 |
| 9.8 ADDITIONAL PRACTICES..... | 267 |

CHAPTER 10 ADVANCED DESIGN MODELING

| | |
|---|-----|
| 10.1 INTRODUCTION | 271 |
| 10.2 LEARNING OBJECTIVES..... | 271 |
| 10.3 SURFACE PROFILES | 272 |
| 10.3.1 Creating Surface Profiles Using Least-Square Regression..... | 273 |
| 10.3.2 Surface Profiles Using Spline Functions | 277 |
| 10.4 SURFACE MODELS | 279 |
| 10.4.1 Surface Models by a Single Revolved Curve | 280 |
| 10.4.2 Surface Models by One Group of Profile Curves..... | 281 |
| 10.4.3 Surface Models by Two Groups of Profile Curves..... | 288 |
| 10.4.4 Surface Models by Three Groups of Profile Curves | 294 |
| 10.5 SOLID MODELS | 297 |
| 10.6 MECHANICAL COMPONENT DESIGNS | 305 |
| 10.6.1 Joukowski Airfoil | 305 |
| 10.6.2 Femoral Prosthetic Device..... | 310 |
| 10.6.3 Plate Cam with Reciprocating Planar Face Follower | 313 |
| 10.6.4 Gear Tooth with Involute Profile..... | 317 |
| 10.7 PROJECTS..... | 322 |
| 10.8 REVIEW AND DISCUSSION QUESTIONS | 327 |
| 10.9 REFERENCES..... | 328 |

CHAPTER 11 ACQUIRING MODEL INFORMATION

| | |
|--|-----|
| 11.1 INTRODUCTION | 329 |
| 11.2 LEARNING OBJECTIVES..... | 329 |
| 11.3 ASSIGNMENT OF MATERIAL PROPERTIES | 329 |
| 11.4 MODEL GEOMETRIC PROPERTIES | 332 |
| 11.4.1 Distance..... | 332 |
| 11.4.2 Angle..... | 335 |
| 11.4.3 Arc Radius and Length..... | 336 |
| 11.4.4 Surface Area and Solid Volume..... | 338 |
| 11.5 MODEL MECHANICAL PROPERTIES..... | 339 |
| 11.5.1 Mechanical Properties of Areas | 339 |
| 11.5.2 Mechanical Properties of Mass | 345 |
| 11.6 PROJECTS..... | 348 |
| 11.7 REVIEW AND DISCUSSION QUESTIONS | 349 |
| 11.8 REFERENCES..... | 349 |

CHAPTER 12 MACHINE ASSEMBLY DESIGN MODELING

| | |
|-------------------------------|-----|
| 12.1 INTRODUCTION | 351 |
| 12.2 LEARNING OBJECTIVES..... | 351 |

| | | |
|--|--|-----|
| 12.3 | CONCEPTS OF ENGINEERING DESIGN..... | 352 |
| 12.4 | TYPES OF INSTALLATION RELATIONSHIPS BETWEEN MACHINE COMPONENTS..... | 356 |
| 12.4.1 | Surface Contact..... | 356 |
| 12.4.2 | Linear and Face Alignment..... | 361 |
| 12.4.3 | Center Placement..... | 363 |
| 12.4.4 | Distance Placement..... | 366 |
| 12.4.5 | Tangent Placement..... | 368 |
| 12.5 | COMBINED PLACEMENT RELATIONSHIPS..... | 370 |
| 12.5.1 | Combination of Alignment and Center..... | 370 |
| 12.5.2 | Combination of Surface Contact and Center..... | 371 |
| 12.5.3 | Combination of Surface Contact and Distance..... | 372 |
| 12.5.4 | Combination of Surface Tangent and Center..... | 373 |
| 12.5.5 | Combination of Linear Alignment and Angle..... | 374 |
| 12.5.6 | Combination of Multiple Placement Constraints Between Components..... | 375 |
| 12.6 | DESIGN ASSEMBLY MODELS WITH PATTERNED COMPONENTS..... | 380 |
| 12.6.1 | Assembly Models with Linearly Patterned Components..... | 380 |
| 12.6.2 | Assembly Models with Cylindrically Patterned Components..... | 383 |
| 12.7 | PROJECTS..... | 385 |
| 12.8 | REVIEW AND DISCUSSION QUESTIONS..... | 392 |
| CHAPTER 13 ENGINEERING WORKING DRAWINGS | | |
| 13.1 | INTRODUCTION..... | 393 |
| 13.2 | LEARNING OBJECTIVES..... | 395 |
| 13.3 | ENGINEERING WORKING DRAWING BASICS..... | 395 |
| 13.3.1 | Drawing Sheet Format..... | 395 |
| 13.3.2 | Working Drawing Contents..... | 396 |
| 13.4 | GENERATING VIEWS ON WORKING DRAWINGS..... | 398 |
| 13.4.1 | Generating Multiview Projections..... | 398 |
| 13.4.2 | Methods of Modifying Views..... | 404 |
| 13.4.3 | Generating Auxiliary Views..... | 406 |
| 13.4.4 | Generating Section Views..... | 408 |
| 13.4.5 | Generating Detail Views..... | 417 |
| 13.5 | DIMENSIONING..... | 419 |
| 13.5.1 | Basic Dimensioning Methods..... | 419 |
| 13.5.2 | Dimensioning for Manufacturing and Quality Control..... | 422 |
| 13.6 | GEOMETRIC DIMENSIONING AND TOLERANCING..... | 423 |
| 13.7 | GENERATING DESIGN ASSEMBLY DRAWINGS..... | 427 |
| 13.8 | PROJECTS..... | 429 |
| 13.9 | REVIEW AND DISCUSSION QUESTIONS..... | 429 |
| 13.10 | ADDITIONAL PRACTICE..... | 430 |

APPENDIX

| | | |
|------|--|-----|
| A.1 | FILE NAMING CONVENTIONS IN UNIGRAPHICS NX | 431 |
| A.2 | UNIGRAPHICS NX INTERFACE | 431 |
| A.3 | INTRODUCTION TO MENU FUNCTIONS | 434 |
| A.4 | BASIC MODEL VISUALIZATION OPERATIONS WITH THE MOUSE | 435 |
| A.5 | CUSTOMIZING THE UNIGRAPHICS NX INTERFACE FOR YOUR OWN PREFERENCE | 435 |
| A.6 | CUSTOMIZING MODEL PREFERENCE | 438 |
| | A.6.1 Visualization Preferences | 438 |
| | A.6.2 Annotation Preferences | 439 |
| A.7 | CUSTOMIZING VIEW SETTINGS | 442 |
| A.8 | CUSTOMIZING DRAFTING SETTINGS | 444 |
| | A.8.1 Modifying Content Visibility in Specific View(s) | 444 |
| | A.8.2 Modifying Datum Reference Visibility in Specific View(s) | 444 |
| | A.8.3 Modifying Utility Symbols in Dimensioning | 446 |
| | A.8.4 Hiding View Borders | 448 |
| A.9 | CUSTOMIZING ASSEMBLY SETTINGS | 449 |
| | A.9.1 Component Color Settings | 449 |
| | A.9.2 Component Translucency Setting | 450 |
| A.10 | UNIGRAPHICS NX STRUCTURAL ANALYSIS INTERFACE AND BASIC OPERATIONAL STEPS | 450 |
| | A.10.1 UG NX Structural Analysis Interface | 451 |
| | A.10.2 Creating a Finite Element Model and Post Presentation of the Results | 452 |
| | INDEX | 459 |