

CATIA V5 Design Fundamentals

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CATIA V5 Design Fundamentals

A Step by Step Guide

ISBN-13: 978-1477689028

ISBN-10: 1477689028

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Preface

This textbook explains how to create solid models, assemblies and drawings using CATIA V5. CATIA is a three dimensional CAD/CAM/CAE software developed by Dassault Systèmes, France. This textbook is based on CATIA V5 Release 21. Users of earlier releases can use this book with minor modifications. We provide files for exercises via our website. All files are in Release 19 so readers can open the files using later releases of CATIA V5.

It is assumed that readers of this textbook have no prior experience in using CATIA V5 for modeling 3D parts. This textbook is suitable for anyone interested in learning 3D modeling using CATIA V5.

Each chapter deals with the major functions of creating 3D features using simple examples and step by step self-paced exercises. Additional drawings of 3D parts are provided at the end of each chapter for further self exercises. The final exercises are expected to be completed by readers who have fully understood the content and completed the exercises in each chapter.

Topics covered in this textbook

- Chapter 1: Basic component of CATIA V5 software, options and mouse operation.
- Chapter 2: Basic step by step modeling process of CATIA V5.
- Chapter 3 through 6: Creating sketches and sketch based features.
- Chapter 7: Usage of reference elements to create complex 3D geometry.
- Chapter 8: Dress-up features such as fillet, chamfer, draft and shell.
- Chapter 9: Modification of 3D parts to take advantage of parametric modeling concepts.
- Chapter 10: Creating complex 3D parts by creating multiple bodies and applying boolean operations.
- Chapter 11: Copying or moving geometrical bodies.
- Chapter 12 and 13: Constructing assembly structures and creating or modifying 3D parts in the context of assembly.
- Chapter 14 and 15: Creating drawings for parts or assemblies.
- Chapter 16: Advanced functions in creating a solid part such as a rib, stiffener and multi-sections solid.

Contents

Chapter 1 Starting CATIA V5

1.1 Introduction to CATIA V5	2
1.2 Workbenches in CATIA V5	3
1.3 Executing CATIA V5	3
1.3.1 File > New	5
1.3.2 Selecting Workbench in the Start Menu	6
1.4 Layout of the CATIA V5 Screen	6
1.4.1 Specification Tree	6
1.4.2 Menu Bar	7
1.4.3 Compass	7
1.4.4 Workbench	7
1.4.5 Status Bar	8
1.4.6 Base Planes	8
1.4.7 Toolbar	8
1.5 View Operations	9
1.5.1 Pan	9
1.5.2 Zoom In/Out	9
1.5.3 Rotate	9
1.5.4 Quick Pan	9
1.6 View Toolbar	10
1.6.1 Pan, Rotate, Zoom In, Zoom Out	10
1.6.2 Fit All In	11
1.6.3 Normal View	11
1.6.4 Create Multi-View	11
1.6.5 Quick View	11
1.6.6 View Mode	12
1.6.7 Hide/Show	14
1.6.8 Swap visible space	15
1.7 Short Keys	16

1.8 System Options	16
1.9 Customization	18

Chapter 2 Modeling Process with CATIA V5

2.1 Terms and Concepts	26
2.1.1 Three Dimensional Modeling	26
2.1.2 Feature Based Modeling	26
2.1.3 Sketch Based Feature	27
2.1.4 History Based Modeling	28
2.2 Introduction to CATIA V5 Modeling Process	30
2.2.1 Creating a Part File	30
Exercise 01	31
2.2.2 Creating the First Sketch	34
Exercise 02	34
2.2.3 Extruding the Sketch	39
Exercise 03	39
2.2.4 Creating the Second Feature	40
Exercise 04	40
2.2.5 Additional Modeling	45
Exercise 05	45
2.2.6 Removing the Body	48
Exercise 06	48
2.3 Summary of the Modeling Process	51
2.4 Using the Specification Tree	52
2.5 Modification of the Model	55
Exercise 07	55

Chapter 3 Sketch Fundamentals

3.1 Sketcher Workbench	60
3.1.1 Introduction	60
3.1.2 Options for Sketcher Workbench	61

3.1.3 Units	63
3.2 Sketch Elements	64
3.3 Sketch Procedure	64
3.3.1 Defining the Sketch Plane	64
3.3.2 Creating Sketch Curves	65
3.3.3 Constraint	65
3.3.4 Exit the Sketch	65
3.4 Creating a Sketch	66
3.4.1 Profile	66
Exercise 01	67
3.4.2 Sketch Tools Toolbar	68
3.4.3 Predefined Profile	69
Exercise 02	69
3.4.4 Other Sketch Commands	71
Exercise 03	71
3.5 Deleting Sketch Elements	74
3.5.1 Select Toolbar	74
3.6 Constraining Sketch Curves	75
3.6.1 Dimensional Constraint	76
3.6.2 Geometrical Constraint	77
3.6.3 Types of Constraints	79
Exercise 04	81
3.6.4 Status of Constraint	83
3.6.5 Verifying the Status of Constraint	84
Exercise 05	87
Exercise 06	89
Exercise 07	94
Exercise 08	95
 Chapter 4 Advanced Sketch	
4.1 Modifying Sketch Curves	98
4.1.1 Fillet	98

4.1.2 Chamfer	99
4.1.3 Relimitation	100
4.2 Transformation	101
4.2.1 Mirror	101
Exercise 01	101
4.2.2 Symmetry	103
4.2.3 Translate	104
4.2.4 Rotate	105
4.2.5 Scale	106
4.2.6 Offset	107
4.3 Deleting Sketch Elements	108
4.4 Creating Sketch Elements from 3D Geometry	110
Exercise 02	110
Exercise 03	113
4.5 Positioned Sketch	116
Exercise 04	117
4.6 Linking Sketch Dimensions	118
Exercise 05	119
Exercise 06	122
Exercise 07	123
Exercise 08	124
Exercise 09	125
Exercise 10	126
Exercise 11	127

Chapter 5 Sketch-Based Features I (Pad and Pocket)

5.1 Pad	130
5.2 Profile	130
Exercise 01	131
5.2.1 Characteristics of a Profile	133
5.2.2 Using an Open Profile as the First Pad Feature	135
5.2.3 Usage of Open Profile	136

Exercise 02	136
Exercise 03	138
5.3 Direction of Pad	139
Exercise 04	140
5.4 First Limit of Pad	142
Exercise 05	143
Exercise 06	144
Exercise 07	145
Exercise 08	146
5.4.1 Offset of Limit Plane or Surface	147
5.4.2 Second Limit of the Pad	148
5.5 Pad of Surface or Plane	149
5.6 Thin Pad	151
5.7 Drafted Filleted Pad	152
Exercise 09	153
5.8 Multi-Pad	154
5.9 Pocket	155
5.10 Drafted Filleted Pocket	156
5.11 Multi-Pocket	157
Exercise 10	158
Exercise 11	162
Chapter 6 Sketch Based Features II (Shaft, Groove and Hole)	
6.1 Shaft	168
6.1.1 Characteristics of Profile and Axis of Shaft	169
6.2 Groove	170
Exercise 01	170
6.3 Hole Command	172
6.3.1 Creating a General Hole	173
Exercise 02	174
6.3.2 Creating a Hole at an Existing Center	176
Exercise 03	176

6.3.3 Creating a Hole at a Distance from Existing Edges	177
Exercise 04	177
Exercise 05	179
Exercise 06	182
Exercise 07	190
Chapter 7 Reference Elements	
7.1 Reference Elements	194
7.2 Reference Plane	195
7.2.1 Usage of a Reference Plane	196
7.2.2 Offset from plane Type	198
7.2.3 Angle/Normal to plane Type	199
7.2.4 Through three points Type	201
7.2.5 Normal to curve Type	202
Exercise 01	202
7.2.6 Other Types of Reference Plane	204
7.3 Reference Point	205
7.3.1 Coordinates Type	206
7.3.2 On curve Type	208
7.3.3 On plane Type	209
7.3.4 Circle / Sphere / Ellipse center Type	210
7.3.5 Tangent on curve Type	211
7.3.6 Other Types of Reference Points	211
7.4 Reference Line	212
7.4.1 Usage of Reference Line	213
7.4.2 Point-Point Type	214
7.4.3 Point-Direction Type	215
7.4.4 Angle-Normal to curve Type	216
7.4.5 Tangent to curve Type	217
7.4.6 Other Types of Reference Lines	218
Exercise 02	219
Exercise 03	223
Exercise 04	224

Chapter 8 Dress-Up Features

8.1 Dress-Up Features	226
8.2 Fillet	227
8.2.1 Edge Fillet	227
8.2.2 Types of Edge Fillet	228
8.2.3 8.2.3 Procedure for Edge Fillets	229
Exercise 01	230
8.2.4 Setback Fillet	231
Exercise 02	231
8.2.5 Limit Fillet	233
Exercise 03	233
8.2.6 Variable Radius Fillet	234
Exercise 04	234
8.2.7 Other Options of Edge Fillets	235
Exercise 05	235
8.2.8 Face-Face Fillet	239
8.2.9 Tritangent Fillet	241
8.2.10 Guideline for Applying Fillet	242
8.3 Shell	243
8.4 Chamfer	245
8.4.1 Mode Option	246
8.5 Draft Angle	247
8.5.1 Neutral Face and Parting Face	248
Exercise 06	249
8.5.2 Variable Angle Draft	252
8.5.3 Draft Reflect Line	252
Exercise 07	253
Exercise 08	254
Exercise 09	255
Exercise 10	256
Exercise 11	258

Chapter 9 Parametric Modification

9.1 Understanding Parametric Modification	262
9.1.1 Parent - Children Relationship of Features	263
9.1.2 Breaking Links (Isolate)	264
9.1.3 Deactivate	264
9.2 Deleting a Feature	265
9.3 Modifying a Sketch	266
9.3.1 Elements Constituting Sketches	266
Exercise 01	267
Exercise 02	269
Exercise 03	270
9.4 Modifying Feature Definition	273
9.4.1 Reselecting Target Objects	273
Exercise 04	274
Exercise 05	276
9.4.2 Modifying Profile	278
Exercise 06	279
9.5 Inserting and Reordering a Feature	282
Exercise 07	283
Exercise 08	286
Exercise 09	288
Exercise 10	290

Chapter 10 Modeling with Bodies

10.1 Modeling with Bodies	292
10.1.1 Inserting Bodies	292
10.1.2 Geometrical Set	294
Exercise 01	295
10.2 Boolean Operations	297
10.2.1 Add	297
Exercise 02	298

Exercise 03	299
Exercise 04	300
10.2.2 Union Trim	301
Exercise 05	301
10.2.3 Remove	302
Exercise 06	302
10.2.4 Remove Lump	303
Exercise 07	303
10.2.5 Intersect	304
Exercise 08	304
10.3 Reusing Bodies	307
Exercise 09	307
10.4 Graphic Properties	310
Exercise 10	311
Exercise 11	313
Exercise 12	315

Chapter 11 Copy of Objects

11.1 Transformation Features	318
11.2 Pattern	318
11.2.1 Rectangular Pattern	319
Exercise 01	320
11.2.1.1 Parameters Option	322
11.2.1.2 Keep Specifications Option	322
11.2.1.3 Patterning Several Features	323
11.2.1.4 Position of Object in Pattern Option	323
11.2.2 Circular Pattern	324
Exercise 02	325
11.2.2.1 Parameters Option in the Axial Reference Tab	326
11.2.2.2 Parameters Option in the Crown Definition Tab	326
11.2.3 User Pattern	327
Exercise 03	328

11.3 Mirror	329
Exercise 04	329
11.4 Scaling a Body	331
Exercise 05	332
Exercise 06	333
Exercise 07	334
Exercise 08	335

Chapter 12 Assembly Design I (Bottom-Up Assembly)

12.1 Introduction	338
12.2 Terms and Definitions	338
12.2.1 Part	338
12.2.2 Product	338
12.2.3 Component	339
12.2.4 Sub-assembly	339
12.2.5 Master Part	339
12.2.6 Instance	339
12.2.7 BOM(Bill of Material)	340
12.2.8 Bottom-Up Assembly Design	340
12.2.9 Top-Down Assembly Design	340
12.3 Constructing an Assembly	341
12.3.1 Invoking the Assembly Design Workbench	341
12.3.1.1 Using the Start Menu	341
12.3.1.2 Using File > New Menu	343
12.3.2 Creating a Product File	343
12.3.3 Key Functions of Assembly Design	343
12.4 Creating an Assembly	344
12.4.1 Inserting an Existing Part as a Component	345
Exercise 01	345
12.4.2 Name of Product and Instance	347
Exercise 02	348
12.5 Move Component	351

Exercise 03	351
12.6 Constraining Components	353
12.6.1 Fix	353
12.6.2 Coincidence	354
12.6.3 Contact	355
Exercise 04	355
12.6.4 Moving Components with the Snap Icon	359
12.6.5 Moving Components with the Smart Move Icon	360
12.7 Verifying Constraint Status	362
Exercise 05	364
Chapter 13 Assembly Design II (Top-Down Assembly)	
13.1 Modifying Parts	366
Exercise 01	367
13.2 Checking Interference	370
13.2.1 Types of Interference	370
13.2.1.1 Clash	370
13.2.1.2 Contact	371
13.2.1.3 Clearance	371
13.2.2 Checking Interference	372
Exercise 02	374
13.3 Modifying Parts in the Context of Assembly	375
Exercise 03	376
Exercise 04	380
13.4 Creating a New Part in an Assembly	381
Exercise 05	381
Exercise 06	384
13.5 Disassembling an Assembly	386
13.6 Display of Assembly	388
13.6.1 Display of Components	388
13.6.2 Deactivate	389
Exercise 07	389

13.6.3 Sectioning	391
Exercise 08	392
Exercise 09	396
Chapter 14 Creating Drawing Views	
14.1 Introduction	400
14.2 Terms and Definitions	400
14.2.1 Drawing View	400
14.2.2 Title Block	401
14.2.3 Drawing Sheet	401
14.3 Creating a New Drawing File	402
14.4 Drawing Sheet	403
14.4.1 Creating a Drawing Sheet	403
14.4.2 Setting a Drawing Sheet	404
14.5 Drawing Views	405
14.5.1 Projection View	405
Exercise 01	406
14.5.2 View Properties	411
Exercise 02	412
14.5.3 Section Views	413
Exercise 03	414
14.5.4 Detail View	418
14.5.5 Clipping View	419
14.5.6 Break View	420
Exercise 04	420
14.6 Modifying Part Geometry	423
Exercise 05	423
14.7 Inserting Frame and Title Block	426
14.7.1 Action	427
14.7.2 Creating a Frame for Company	427
Exercise 06	428

Chapter 15 Dimension, Annotation and Assembly Drawing

15.1 General Procedure of Creating Drawings	430
15.2 Creating Dimensions	430
15.2.1 Dimension Options	430
15.2.2 Display of Dimensions	431
Exercise 01	433
15.2.3 Tools Palette in Dimensioning	437
15.2.4 Aligning Dimensions	438
15.3 Annotations	439
15.4 Properties of Dimension and Annotation	441
15.4.1 Properties of Dimension	441
15.4.2 Properties of Annotation	442
15.4.3 Using the Manipulator	444
15.5 Center Lines	445
15.6 Assembly Drawing	447
15.6.1 Excluding Components in a View	447
15.6.2 Excluding a Component from being Sectioned	448
Exercise 02	449
15.6.3 Breakout View in an Assembly Drawing View	450
15.6.4 Inserting BOM (Bill of Material)	451
15.6.5 Inserting a Disassembled View	453
15.6.6 Balloon Annotation	455
15.7 Creating a PDF File	456
Exercise 03	457
Exercise 04	458
Exercise 05	459
Chapter 16 Sketch Based Features - Advanced	
16.1 Stiffener	462
16.1.1 From Side Mode	462
16.1.2 From Top Mode	464
Exercise 01	465

16.2 Solid Combine	466
16.3 Rib	467
16.3.1 Keep Angle Option	468
16.3.2 Pulling Direction Option	468
16.3.3 Reference Surface Option	469
16.3.4 Move Profile to Path Option	470
16.3.5 Condition of Profile and Center Curve	471
Exercise 02	471
16.3.6 Merge Rib's Ends Option	474
16.4 Slot	475
16.5 Multi-Sections Solid	475
Exercise 03	476
16.5.1 Multi-Sections Solid with Guides	477
Exercise 04	477
16.5.2 Using a Spine for Multi-Sections Solid	480
Exercise 05	480
16.5.3 Coupling and Closing Point	482
Exercise 06	483
Exercise 07	486
16.6 Removed Multi-sections Solid	488
Exercise 08	489

6

Sketch Based Features II (Shaft, Groove and Hole)

chapter

■ **After completing this chapter you will understand**

- how to create Shaft and Groove features.
- how to create a hole using the Hole command

6.1 Shaft

Using the **Shaft** command in the **Sketch-Based Features** toolbar, you can revolve a profile or surface to create a 3D geometry. The 3D geometry created with the **Shaft** command is added to the existing geometry.

Procedure

- ① Create a sketch.
- ② Choose the Shaft button from the Sketch-Based Features toolbar.
- ③ Select the profile or surface.
- ④ Select an axis of revolution.
- ⑤ Input the limit angle of the revolution and press OK.

If you press the button designated by **A** in Fig 6-1, you can invoke the **Sketcher** workbench and modify the sketch that you selected as the profile. If you did not create a sketch in advance, you can create a new sketch while running sketch based features such as **Pocket**, **Pad** and **Shaft** etc. by pressing the **Sketcher** button in the dialog box and specifying the sketch plane. After creating the sketch, you can exit the **Sketcher** as usual and the sketch is selected as the profile.

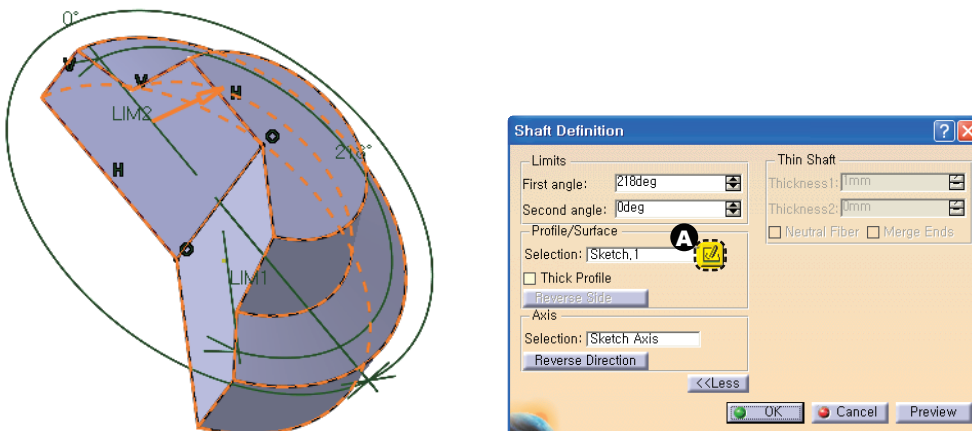


Fig 6-1 Creating a Shaft Feature

6.1.1 Characteristics of Profile and Axis of Shaft

When you define the profile and axis for the **Shaft**, you have to bear in mind the following characteristics.

- ① You can use the **Axis** line, **Reference Element** or **Standard Element** as an axis of the **Shaft**.
- ② You can create a solid body by revolving a closed profile.
- ③ When you are using an open profile as the profile of the first **Shaft** feature, you have to choose the **Thick** option to create a solid body (except for the case of no. ⑥ below).
- ④ You cannot use an intersecting profile for a single **Shaft** feature under any circumstances.
- ⑤ You can select as many profile as you want unless they are intersecting, provided they are all closed.
- ⑥ For cases where the end points of an open profile are on the axis, you can create a solid body with an open profile.
(Refer to Fig 6-2.)
- ⑦ The axis cannot intersect the profile. (Refer to Fig 6-3.)
- ⑧ Values in the **First angle** and **Second angle** should not exceed 360° .

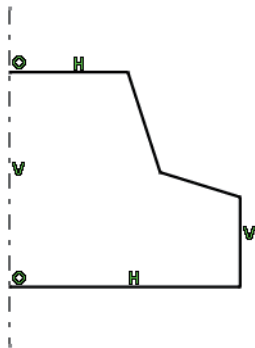


Fig 6-2 Open Profile

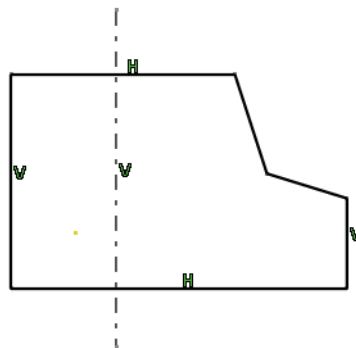


Fig 6-3 Axis Intersecting the Profile

6.2 Groove

Using the **Groove** command in the **Sketch-Based Features** toolbar, you can revolve a profile and remove material from the existing solid body. The **Groove** icon is activated only when at least one solid body exists. Therefore, you cannot create a **Groove** as the first feature.

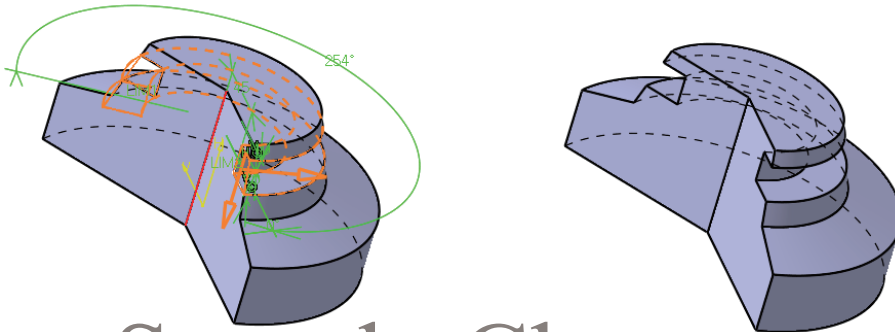


Fig 6-4 Groove Feature

Sample Chapter

Exercise 01 Creating a Groove Feature

ch06_001.CATPart

Let's create a Groove feature after creating a sketch.

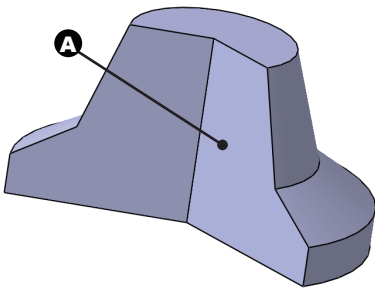


Fig 6-5 Sketch Plane

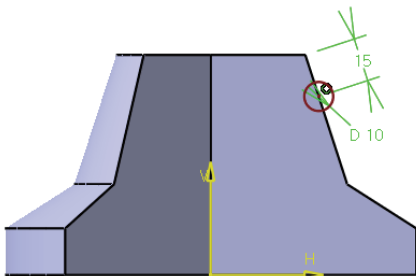


Fig 6-6 Sketch

Step 1: Sketch

1. Open the given part file. (ch06_001.CATPart)
2. Invoke the **Sketcher** workbench by specifying the plane **A** in Fig 6-5 as the sketch plane.
3. Create a circle as shown in Fig 6-6 and iso-constrain it.
4. Exit the **Sketcher**.

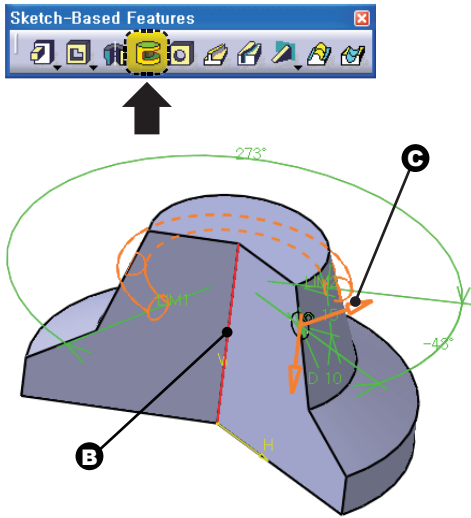


Fig 6-7 Selecting Sketch and Axis

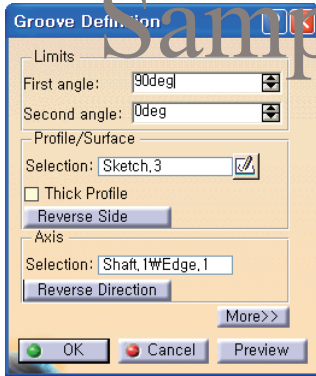


Fig 6-8 Limit Values

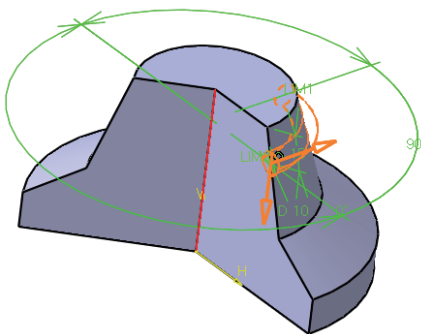


Fig 6-9 Preview

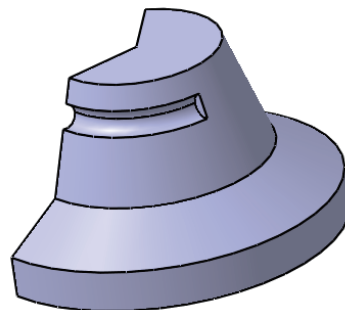


Fig 6-10 Groove Feature

Step 2: Groove

1. Choose the **Groove** button from the **Sketch-Based Features** toolbar.
2. Select the sketch created in Step 1.
3. Select the axis of revolution (**B** in Fig 6-7).
4. Press the **Reverse Direction** button in the dialog box, if required, such that the direction of the arrow appears as shown in Fig 6-8 **C**.
5. Input the limit values as shown in Fig 6-8. The preview is updated.
6. Press the **OK** button.

Sample Chapter

END of Exercise

6.3 Hole Command

Using the **Hole** command in the **Sketch-Based Features** toolbar, you can easily create standard holes that are frequently used in mechanical parts.

You can create five types of standard holes in CATIA V5.

- ① Simple Hole
- ② Tapered Hole
- ③ Counterbored Hole
- ④ Countersunk Hole
- ⑤ Counterdrilled Hole

Fig 6-11 shows the section of each standard hole

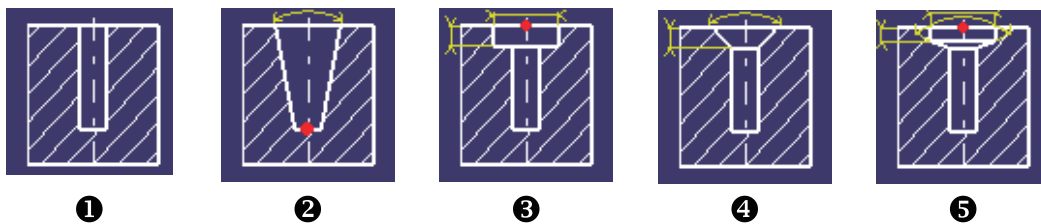


Fig 6-11 Section of Standard Holes

Remember that you can create holes by using the **Pocket** or **Groove** commands if you do not know how to use the **Hole** command.

6.3.1 Creating a General Hole

You can create a general hole according to the following procedure.

- ① Press the **Hole** button in the **Sketch-Based Features** toolbar.
- ② Select a plane onto which to create a hole.
- ③ Set the **Extension**, **Type** and **Thread Definition** in the **Hole Definition** dialog box.
- ④ Invoke the **Sketcher** by pressing the **Positioning Sketch** button and define the location of the hole center.
- ⑤ Press the **OK** button.

If you press the **Positioning Sketch** button, you can define the location of the hole center by using the sketch constraint. You may modify the location of the hole later by accessing the sketch feature in the **Spec Tree**.

Note that you can create only one hole in a single operation. If you have to create a hole recursively, you can copy or pattern the hole using the commands in the **Patterns** toolbar.

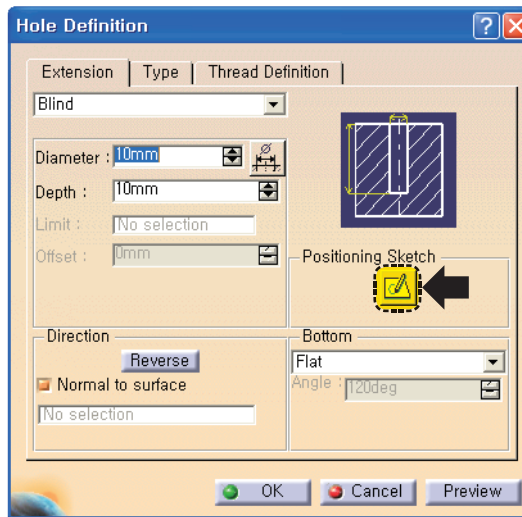


Fig 6-12 Hole Definition Dialog Box

Exercise 02 Creating a General Hole

ch06_002.CATPart

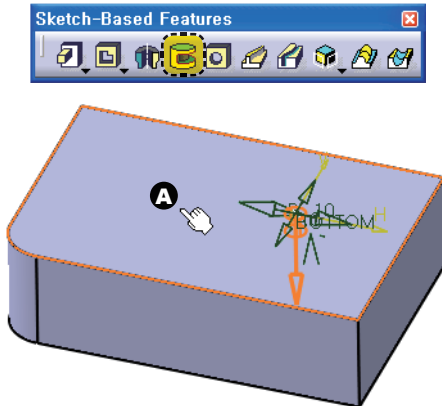


Fig 6-13 Plane for Hole

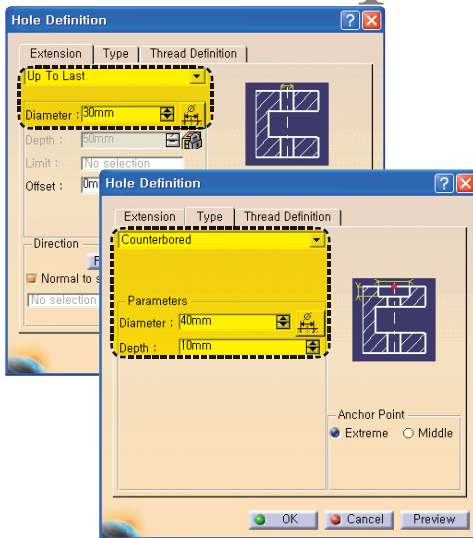


Fig 6-14 Options

1. Open the given part file. (ch06_002.CATPart)
2. Choose the **Hole** button from the **Sketch-Based Features** toolbar.
Read the message in the status bar.
3. Select the face **A** shown in Fig 6-13.
4. Set the options in the **Extension** and **Type** tab in the **Hole Definition** dialog box as shown in Fig 6-14 and press **OK**.

A counter bored hole is created at an arbitrary location as shown in Fig 6-15.

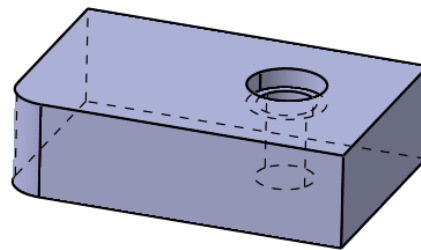


Fig 6-15 Counterbored Hole Created

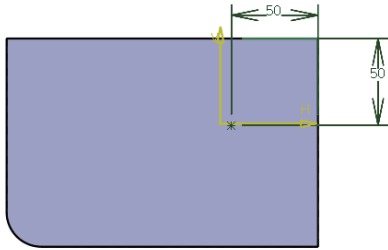


Fig 6-16 Define the Location

5. Double click the **Sketch** feature under the **Hole** feature in the Spec Tree. The **Sketcher** workbench is invoked.

6. Press the **Constraint** button and define the location of the point as shown in Fig 6-16.

7. Exit the **Sketcher**.

The location of the hole is updated.

END of Exercise

Sample Chapter

! Anchor Point

The **Anchor Point** option in the **Type** tab of **Hole Definition** dialog box defines the location of the base point in the hole section.

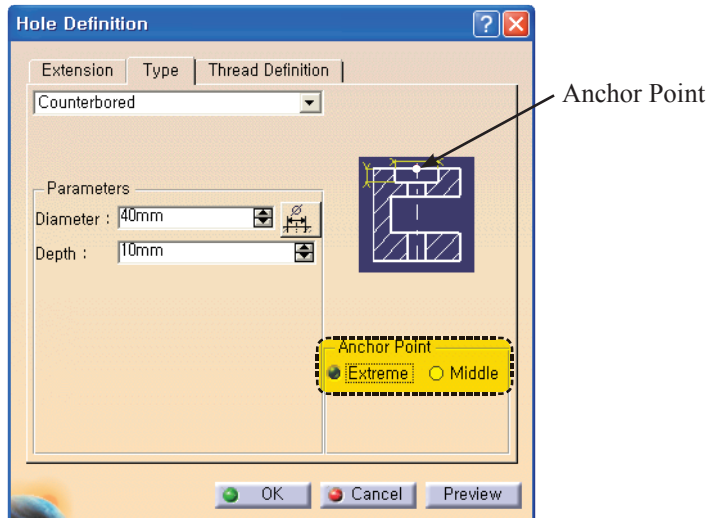


Fig 6-17 Anchor Point Option

6.3.2 Creating a Hole at an Existing Center

You can create a hole at the center of an existing circle or arc according to the following procedure.

- ① Press the Hole button.
- ② Select a circle or an arc whose center will be coincident with the center of the hole.
- ③ Select a plane.
- ④ Set the Extension, Type and Thread Definition in the Hole Definition dialog box.
- ⑤ Press the OK button.

Exercise 03 Creating a Hole at an Existing Center

ch06_003.CATPart

Open the part file ch06_003.CATPart and create a simple hole whose center is coincident with the center of an existing arc. The number in Fig 6-18 corresponds to the procedure explained above.

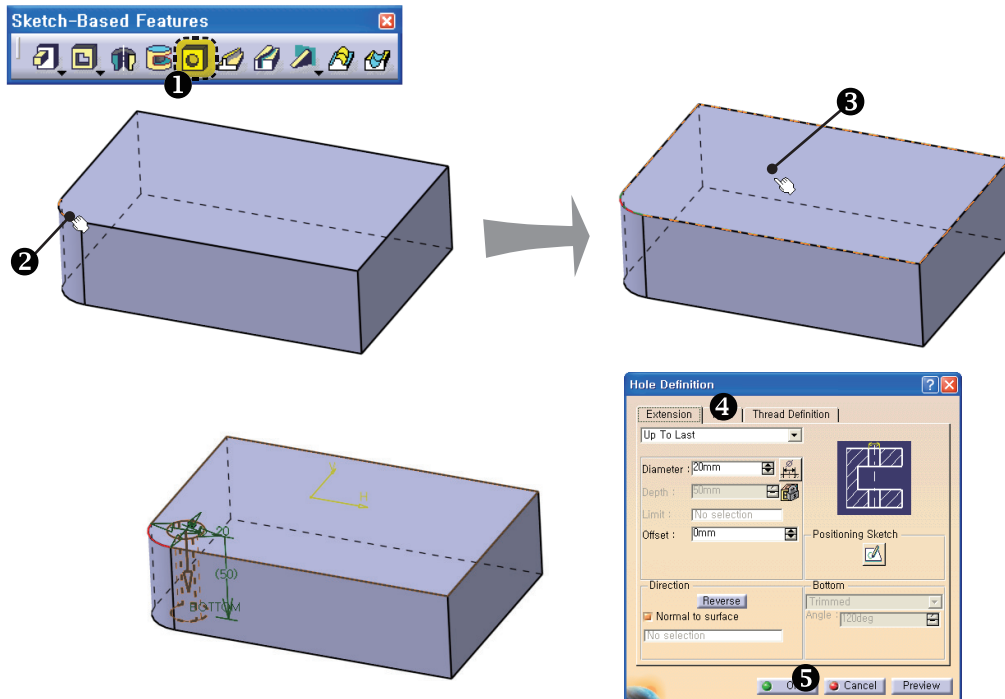


Fig 6-18 Creating a Simple Hole

END of Exercise

6.3.3 Creating a Hole at a Distance from Existing Edges

You can create a hole at a distance from the existing linear edge(s) according to the following procedure.

- ① Press the Hole button.
- ② Select one or two linear edge(s).
- ③ Select a plane.
- ④ Set the Extension, Type and **Thread Definition** in the **Hole Definition** dialog box.
- ⑤ Press the **OK** button.

ch06_003.CATPart

Creating a Hole at a Distance from Existing Edges

Exercise 04

Using the part file in Exercise 03, create a countersunk hole at a location measured from the existing edges.

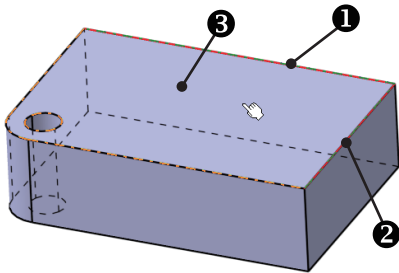


Fig 6-19 Selecting Edges and Plane

1. Press the **Hole** button and select the edges **1**, **2** and plane **3** in order as shown in Fig 6-19.

2. Double click the dimension **A** and **B** shown in Fig 6-20 and modify each value to 40mm.

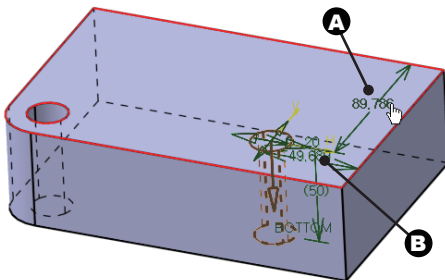


Fig 6-20 Modifying the Dimensions

! Message in the Status Bar

Note that the status bar message after pressing the Hole button is as follows.

“Select a face or a plane. Optionally select a point or line first to position the sketch.”

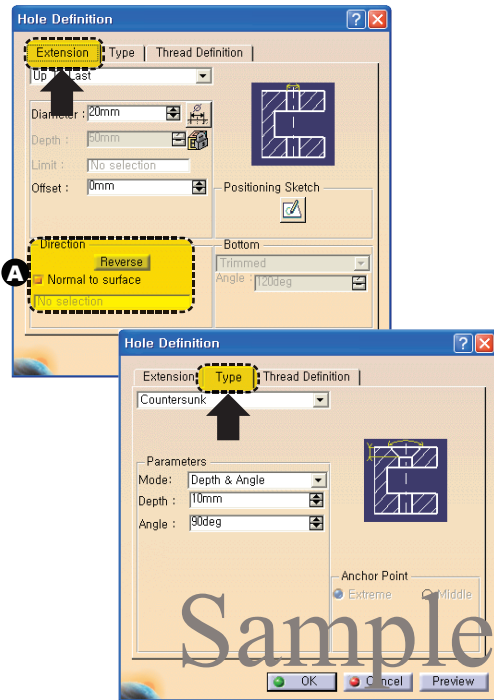


Fig 6-21 Type and Extension Option

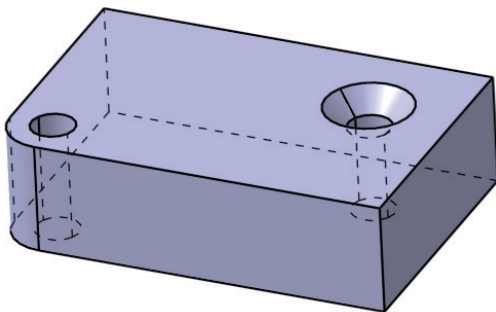


Fig 6-22 Countersunk Hole Created

3. Set the **Extension** and **Type** option in the dialog box as shown in Fig 6-21.

Fig 6-22 shows the countersunk hole created at a specified location from the existing edges.

! Direction of the Hole

With the **Direction** option designated by **A** in Fig 6-21, you can specify the direction of the hole not normal to the sketch plane.

! Creating Points in Advance

You can create points in advance at which to create holes. If you want to create holes at several points, you have to run the **Hole** command for each hole.

When you are creating several holes with the same section and options but at different locations, you may create a hole first and use the **User Pattern** command which will be explained further in Chapter 11.

END of Exercise

Let's create the **Shaft** and **Groove** feature according to the following steps.

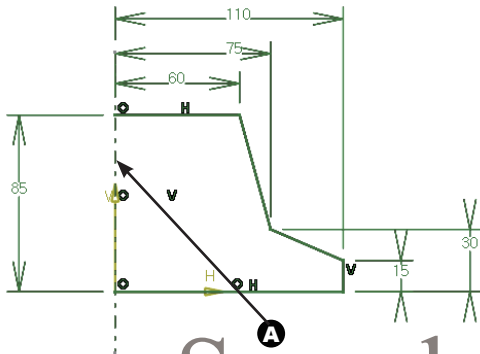


Fig 6-23 The First Sketch

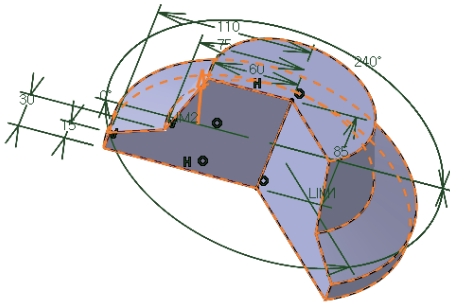


Fig 6-24 Preview of the Shaft Feature

Step 1: Create a Shaft

1. Create a sketch on the xy plane as shown in Fig 6-23. The axis **A** is created with the **Axis** command in the **Profile** toolbar.

2. Exit the **Sketcher** and press the **Shaft** button.

3. Select the sketch created above as the profile.

4. Input 240 deg in the **First angle** input box and press the **Preview** button. The preview is shown in Fig 6-24.

5. Press the **OK** button to create the first **Shaft** feature.

Step 2: Second Sketch

1. Choose the **Positioned Sketch** button from the **Sketcher** toolbar and select the plane **B** shown in Fig 6-25. Align the H and V axis as it appears in the figure.

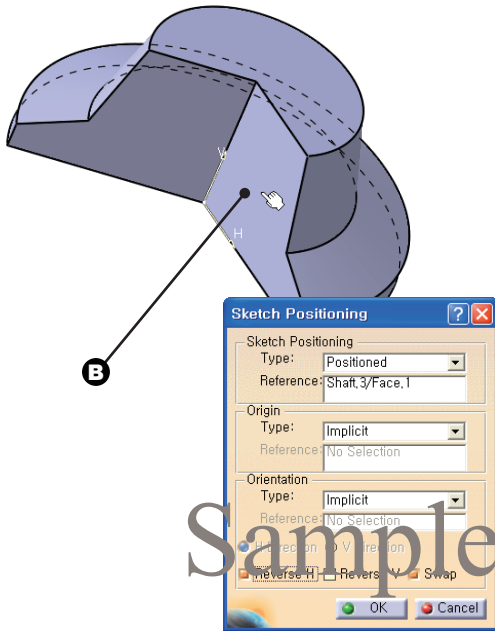


Fig 6-25 The Second Sketch Plane

2. Use the **Project 3D Elements** command in the **Operation** toolbar to project the curves **C** and **D** shown in Fig 6-26 on the sketch plane.

3. Offset the projected curve 10mm inside the geometry as shown in fig 6-27 **E**.

4. Create an additional line located 35mm above the bottom edge as shown in Fig 6-27 **F**.

5. Convert the projected curve **C** and **D** shown in Fig 6-26 as the construction elements.

6. Trim out the unnecessary portion of the curves using the **Quick Trim** command.

7. Exit the **Sketcher**.

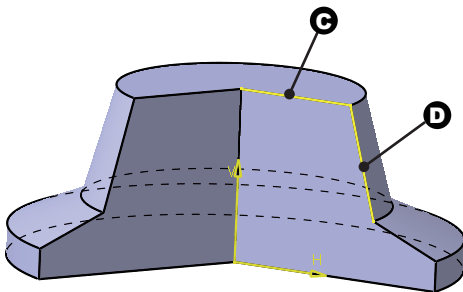


Fig 6-26 Project

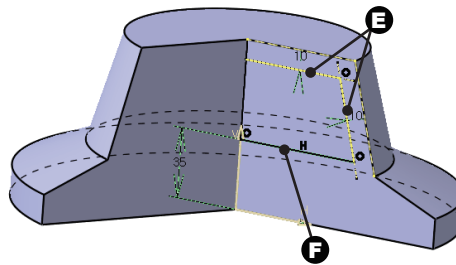


Fig 6-27 The Second Sketch Completed

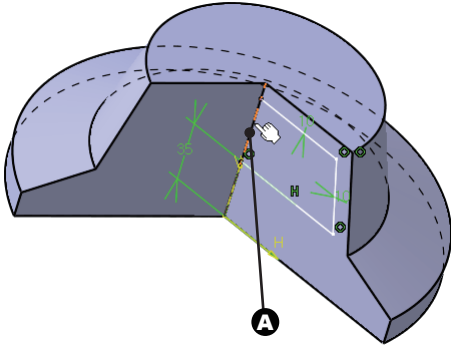


Fig 6-28 Axis

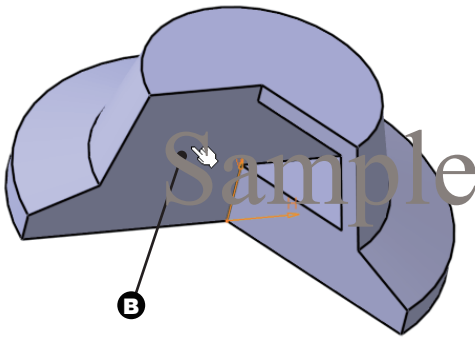


Fig 6-29 The Third Sketch Plane

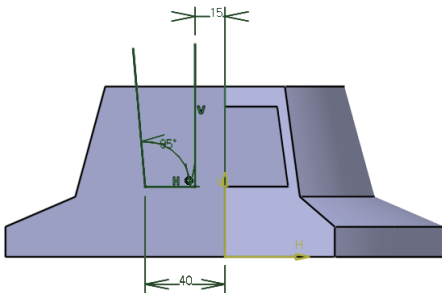


Fig 6-30 The Third Sketch

Step 3: Create a Groove

1. Choose the **Groove** button from the **Sketch-Based Features** toolbar and select the sketch that was created in Step 2.

The status bar message prompts you to select an axis.

2. Select the edge **A** shown in Fig 6-28 as the axis.

3. Input 60 deg in the **First angle** input box and press **OK**.

Step 4: The Third Sketch

1. Choose the **Positioned Sketch** button from the **Sketcher** toolbar and select the plane **B** shown in Fig 6-29 as the sketch plane.

2. Create an open sketch as shown in Fig 6-30.

3. Exit the **Sketcher** workbench.

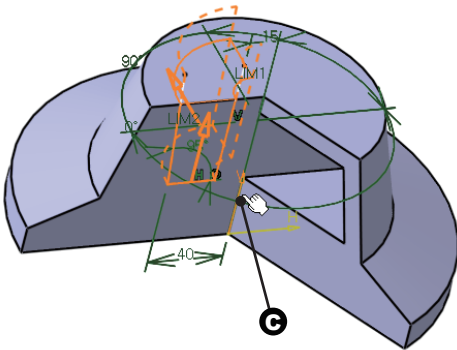


Fig 6-31 Preview of the Groove

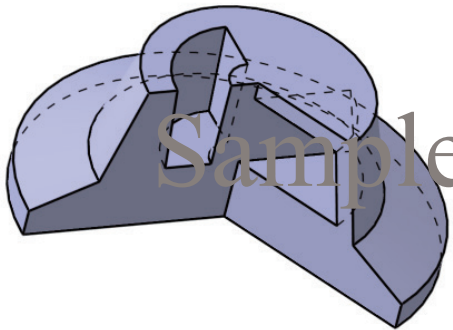


Fig 6-32 Completed Model

Step 5: Create a Groove

1. Choose the **Groove** button from the **Sketch-Based Features** toolbar and select the sketch that is created in Step 4.

2. Select the edge **C** in Fig 6-31 as the axis and set the **Reverse side** and/or **Reverse direction** options so that the arrows point as shown in Fig 6-31. You can reverse the direction by clicking the arrow head in the preview.

3. Input the angle to 90 deg.

4. Press the **OK** button.

Fig 6-32 shows the completed model.

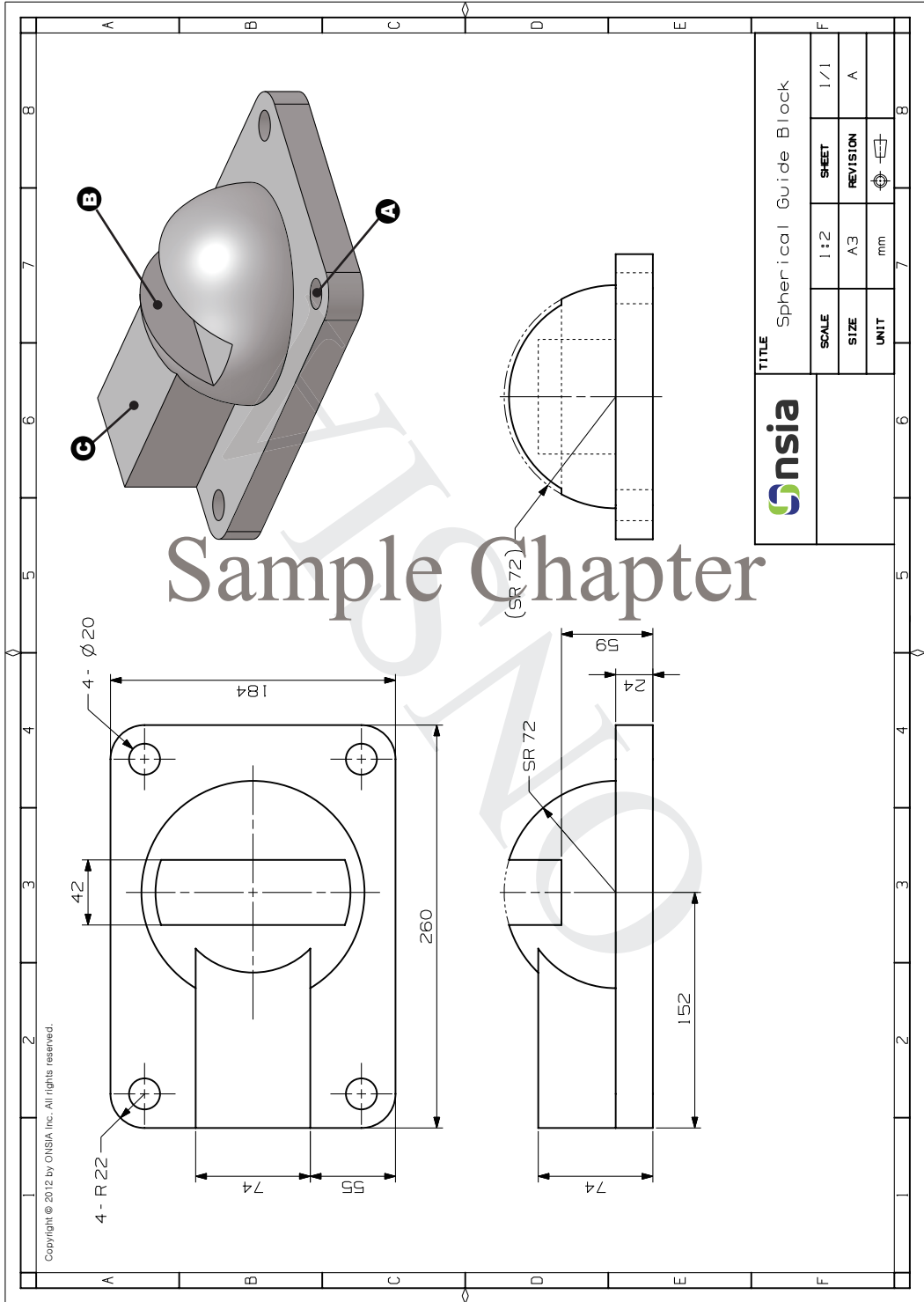
FND of Exercise

Exercise 06 Spherical Guide Block

Create a spherical guide block referring to the drawing in Fig 6-33.

Requirements

- ① The diameter of the four holes specified by **A** are linked such that if you modify one, all other holes are updated.
- ② The **Pocket** feature designated by **B** in Fig 6-33 has to remove the sphere completely regardless of the radius of the sphere.
- ③ The **Pad** feature designated by **C** has to end on the spherical surface.



Sample Chapter

Fig 6-33 Spherical Guide Block

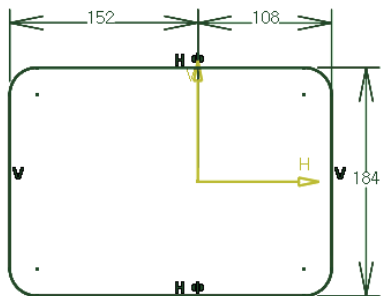


Fig 6-34 Base Sketch

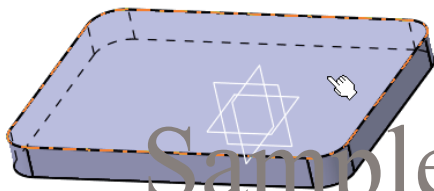


Fig 6-35 Sketch Plane

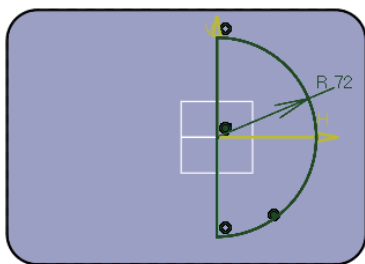


Fig 6-36 Half Circle

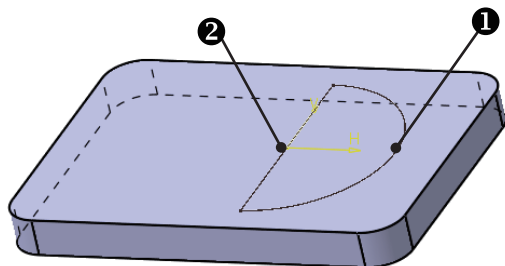


Fig 6-37 Selecting Profile and Axis

Step 1: Bottom Plate

1. Create a sketch for the bottom plate on the xy plane as shown in Fig 6-34.
2. Pad it by 24mm along the Z axis.

Step 2: Creating a Hemisphere

1. Define a sketch on the upper plane of the bottom plate as shown in Fig 6-35.
2. Create a half circle as shown in Fig 6-36 and iso-constrain it. The line passing through the center of the circle will be used as the axis. You may create the line with the **Axis** command because the end points of the half circle are on the axis.
3. Press the **Shaft** button.
4. Select the sketch designated by ① in Fig 6-37 as the profile. The **Selection** area of the **Axis** option is activated and the status bar message prompts you to select an axis.
5. Select the line ② shown in Fig 6-37 as the axis.
6. Input 180 deg in the **First angle** input area and press **OK**.

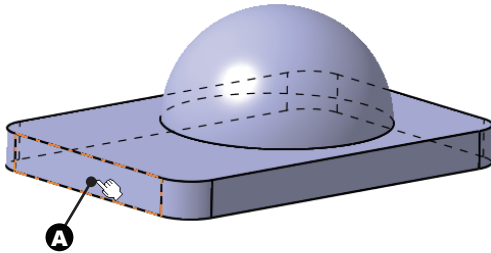


Fig 6-38 Sketch Plane

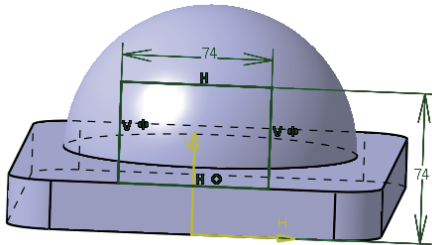
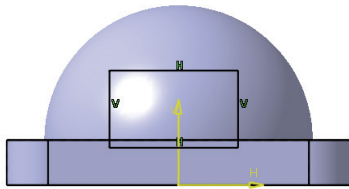


Fig 6-39 Rectangle

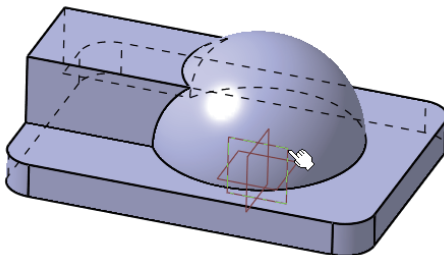


Fig 6-40 Sketch Plane

Step 3: Pad Feature **in Fig 6-33**

1. Press the **Sketch** button and select the plane **A** shown in fig 6-38 as the sketch plane. Be careful not to select the other side of the base plate because the hemisphere is one-sided.

2. Create the sketch as shown in Fig 6-39.

3. Exit the sketcher and press the **Pad** button.

4. Select the sketch in Fig 6-39 as the profile.

5. Select the type of the **First limit** as **Up to surface**.

6. Select the surface of the hemisphere.

7. Confirm the preview and press **OK**.

Step 4: Pocket Feature **in Fig 6-33**

1. Press the **Sketch** button and select the xz plane as the sketch plane as shown in Fig 6-40. You can select the zx plane in the Spec Tree.

Sample Chapter

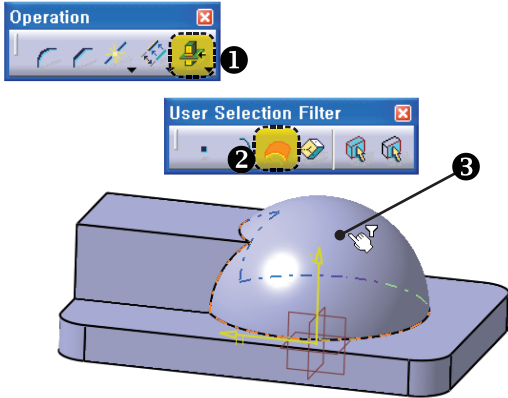


Fig 6-41 Selecting the Surface

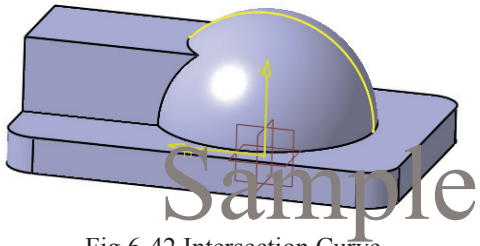


Fig 6-42 Intersection Curve

2. Choose the **Intersect 3D Elements** button (1 in Fig 6-41) from the **Operation** toolbar.

3. Click the **Surface Filter** button (2 in Fig 6-41) from the **User Selection Filter** to turn it on.

4. Select the spherical surface (3 shown in Fig 6-41).

A yellow intersection curve is created as shown in Fig 6-42.

5. Click the **Surface Filter** button from the **User Selection Filter** to turn it off.

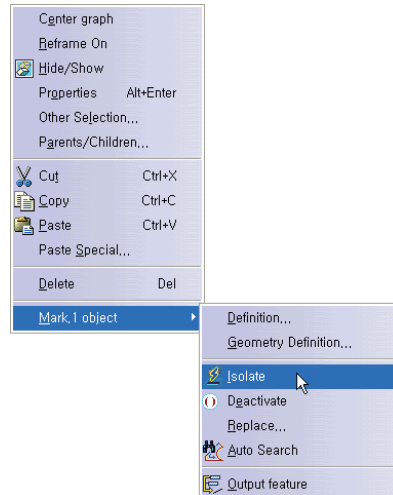
! Yellow Intersection Curve

If the yellow intersection curve is not obtained, check the option as follows.

- ① Choose **Tools > Options** from the menu bar.
- ② The “**Keep link with selected object**” option in the **General** tab of **Infrastructure > Part Infrastructure** has to be checked.

The yellow curve implies that the curve is linked to another geometric element. If the source element is modified, the linked element is updated.

If you want to break the link, place the mouse cursor on the curve and press MB3. The **Isolate** menu is available in the pop-up menu of the linked object.



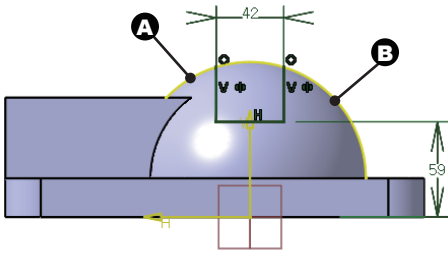


Fig 6-43 Sketch

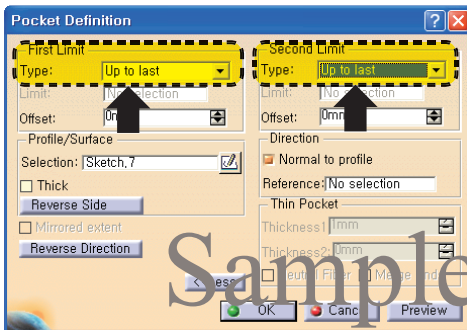


Fig 6-44 Limits Options

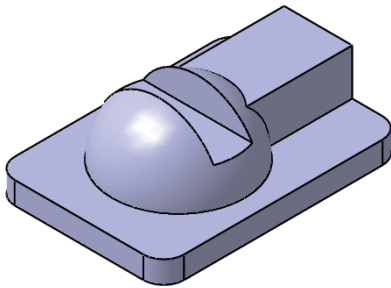


Fig 6-45 Pocket Feature

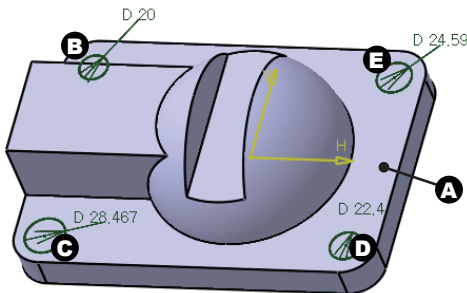


Fig 6-46 Sketch for Holes

6. Align the sketch plane by pressing the **Normal View** button in the **View** toolbar. Note that the normal view is reversed if you click the button one more time.

7. Create a sketch as shown in Fig 6-43. Trim out the portion **A** and **B** of the intersection curve.

8. Exit the **Sketcher**.

9. Press the **Pocket** button.

10. Press the **More** button in the **Pocket Definition** dialog box. Set the **First limit** and the **Second limit** as shown in Fig 6-44 and press **OK**.

This is to fulfill the second requirement of this exercise.

Fig 6-45 shows the model at this point.

Step 5: Pocket Feature **A in Fig 6-33**

1. Define the sketch plane on **A** in Fig 6-46 and create 4 circles as shown.
2. Apply the **Concentricity** constraint between the circular edge and the circle.
3. Create the diametral dimension for each circle.

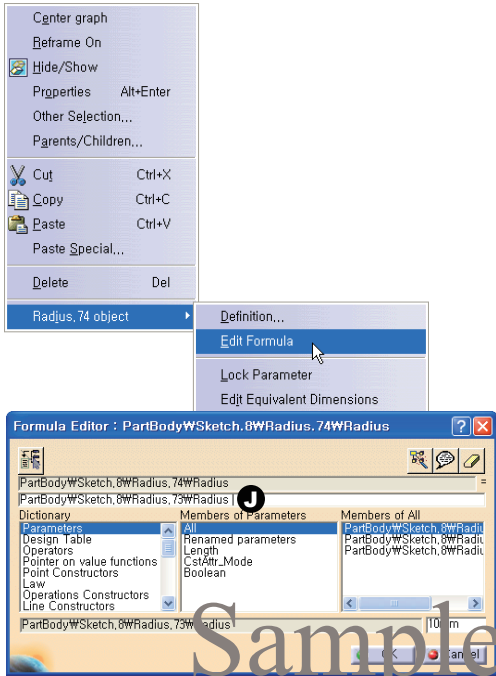


Fig 6-47 Applying Formula

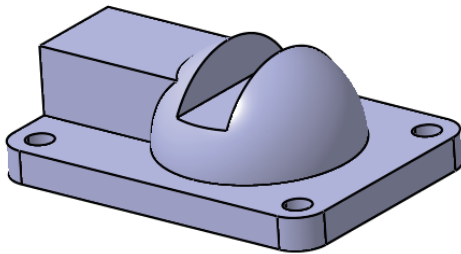


Fig 6-48 Completed Model

4. Modify the dimension designated by **B** in Fig 6-46 as 20mm

5. Press MB3 on the dimension **C** in Fig 6-46.

6. Select **Edit Formula** from the pop-up menu of the object.

7. Select the dimension **B** in Fig 6-45. The selected dimension variable appears in the input area **J** in Fig 6-47.

8. Press **OK**. The dimension **C** in Fig 6-46 is modified to 20 and the function symbol $\text{f}(\text{C})$ is applied.

9. Link the dimensions **D**, **E** and **F** to the dimension **B** in the same way.

11. Exit the **Sketcher** and create holes using the **Pocket** command.

Fig 6-48 shows the completed model.

END of Exercise

! Verifying the Requirement ②

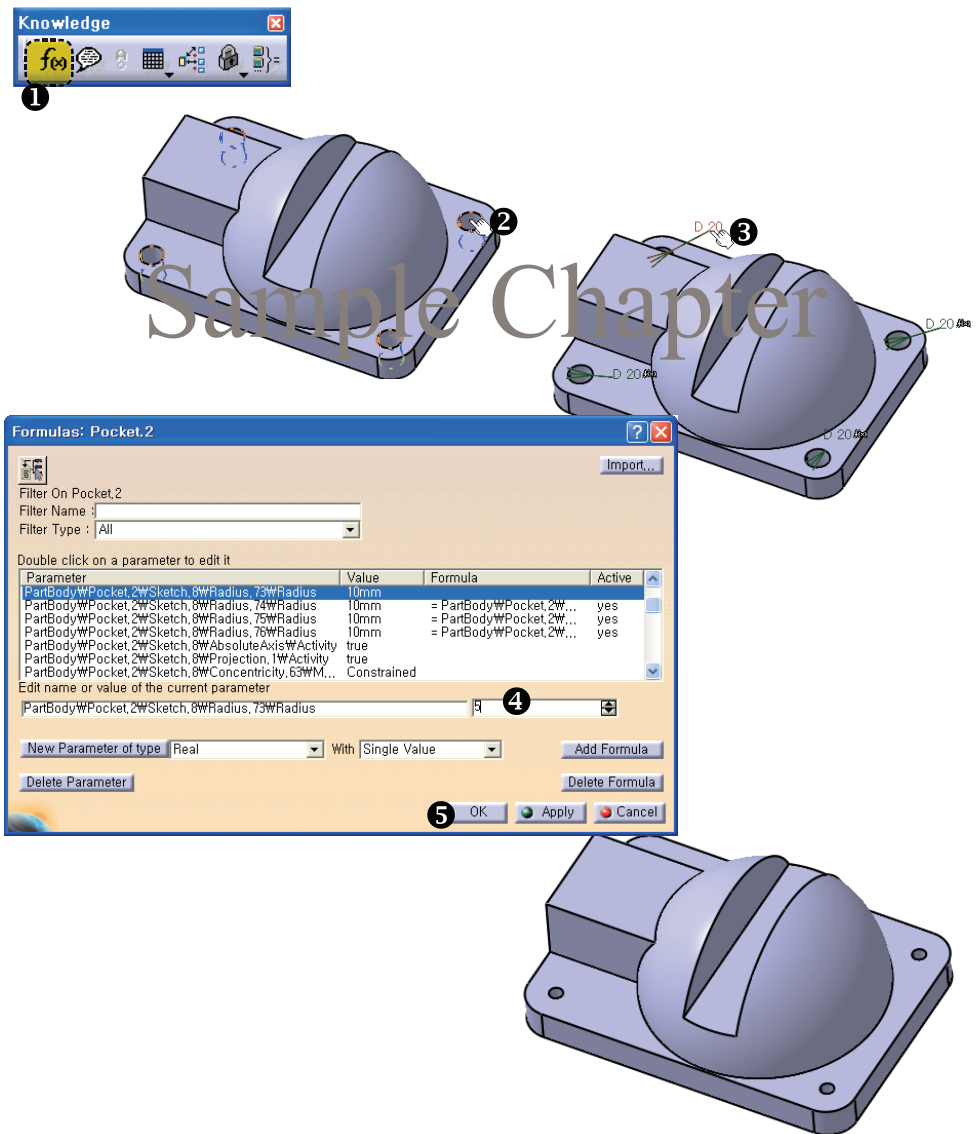
- ① Double click the sketch of the hemisphere.
- ② Modify the radius to 90mm.
- ③ Exit the **Sketcher**.

The **Shaft** feature **B** in Fig 6-33 is created successfully because we have created an intersection curve with the spherical surface.

! Verifying the Requirement ③

- ① Method 1: Modify the sketch dimension **B** in Fig 6-46.
- ② Method 2: Use the **Formula** icon in the **Knowledge** toolbar.

The following figure shows the procedure to modify the dimension value using the **Formula** icon. Input a new value in the input box ④ and press **OK**.



Exercise 07 Guide Bracket

Create a guide bracket referring to the drawing in Fig 6-49.

General Modeling Procedure (Refer to p.51)

- ① Create the features that add material.
- ② Create the features that remove material.
- ③ Complete the model by applying detailed features.

! Fillet

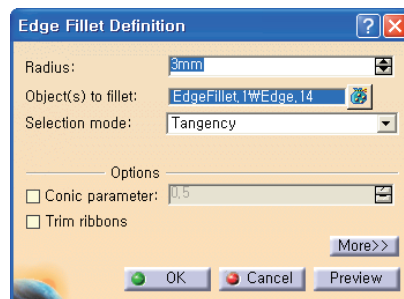
A fillet makes sharp edges rounded.

Sample Chapter

A convex fillet is a measure to make an exterior look aesthetic. If you manufacture a part from a mold, convex fillets are naturally generated because the mold cavity is machined with a rounded drill. If you want to generate a sharp edge with a mold, you have to finish the rounded toolpath with a flat end mill.

A concave fillet is used to relieve stress concentration to avoid fracture of a part.

The **Fillet** feature designated by **A** in Fig 6-49 can be created by using the **Edge Fillet** command available in the **Dress-Up Features** toolbar.



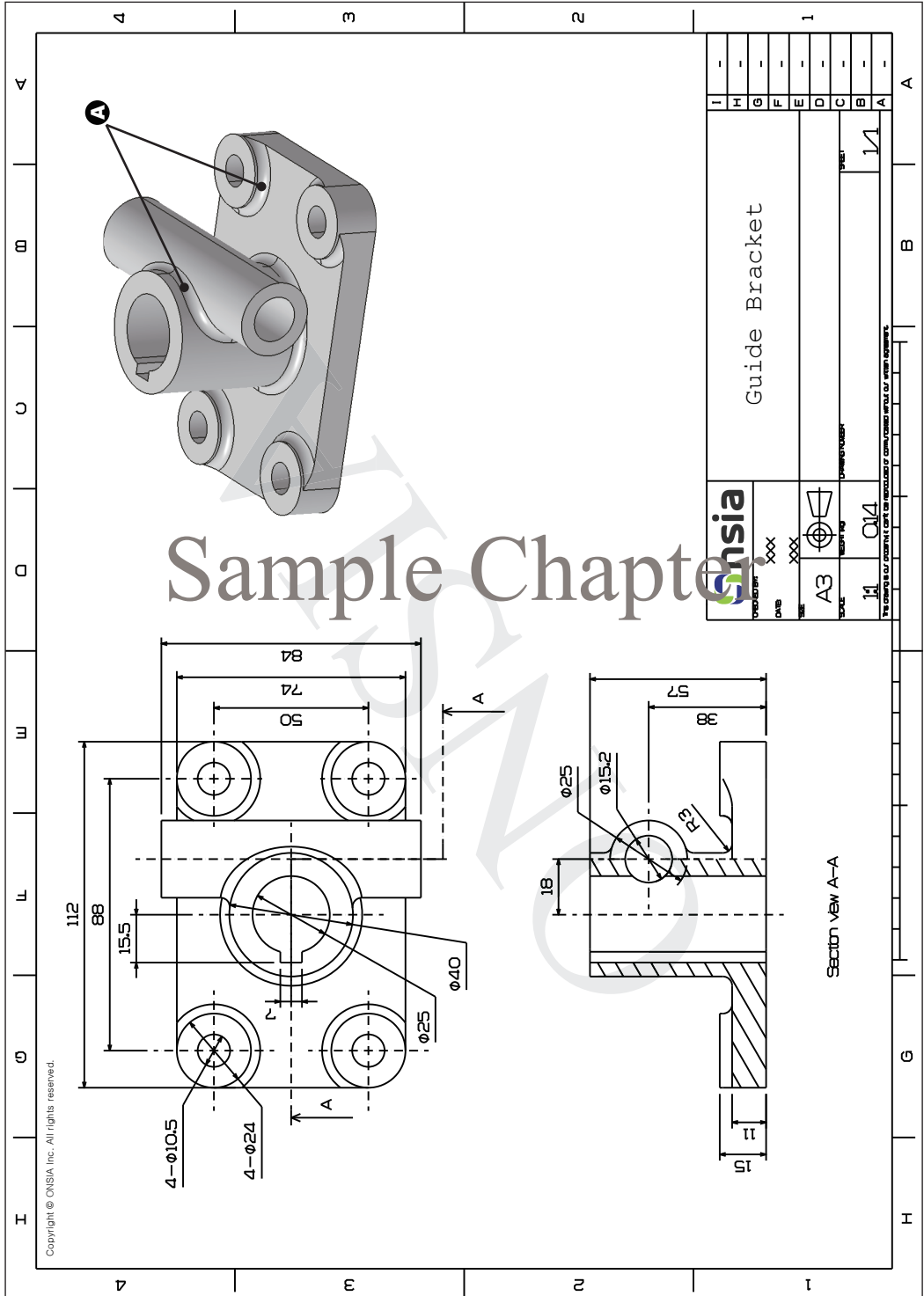


Fig 6-49 Guide Bracket

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Sample Chapter