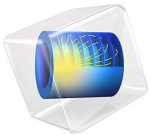

Model created in COMSOL Multiphysics 6.4

Phone Drop Test

Introduction

Drop tests are commonly performed to evaluate how consumer products respond to impacts and high accelerations. This example uses the Solid Mechanics, Explicit Dynamics interface to numerically simulate a drop test of a mobile phone. The simulation highlights the permanent plastic deformation of the aluminum case and the damage sustained by the glass screen.

Model Definition

Figure 1 shows the setup employed for drop test simulation, which consists of a mobile phone positioned just before impact with the ground.

The phone geometry includes the case, screen, and simplified internal components as shown in Figure 2.

The metal case is modeled as aluminum with an elastoplastic constitutive law incorporating linear isotropic hardening. The screen is modeled as glass, with a damage model to simulate the brittle behavior. The internal components are represented by linear elastic materials.

Contact interactions are defined both between the phone and the ground, and between the internal components and the case.

The phone is given an initial velocity of 6 m/s in the vertical direction, corresponding to a drop height of approximately 1.83 m. The ground is assumed to be perfectly rigid.

Because of the short duration of the event and the nonlinearities introduced by contact interactions and material models, an explicit time integration scheme is employed for computational efficiency.

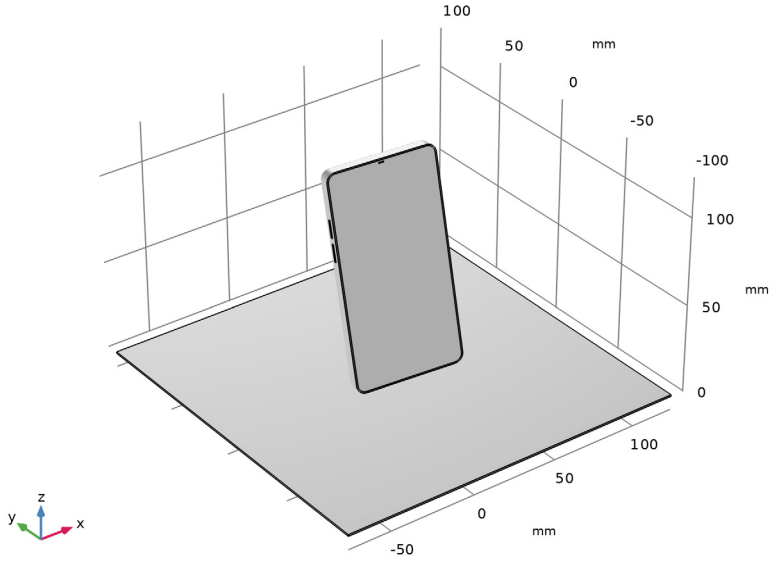

Figure 1: Geometry used as computational domain.

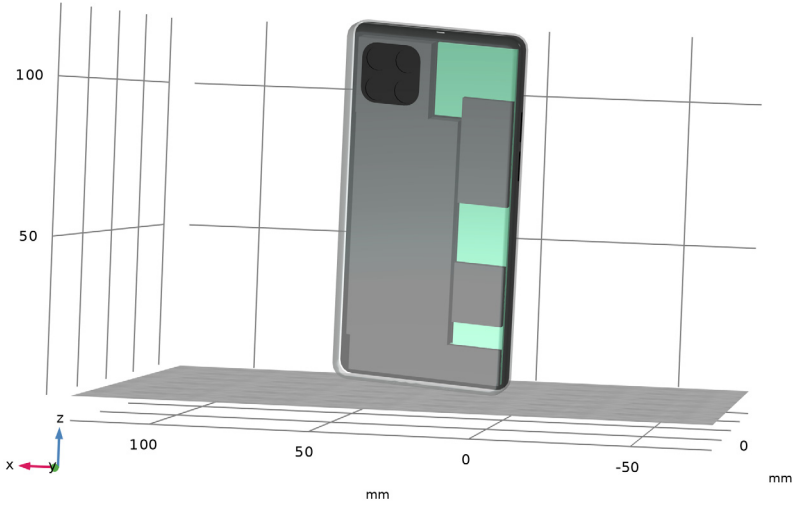

Figure 2: View on the internal components.

Results and Discussion

Figure 3 shows the permanent strain that is developed at the corner where the phone impacts the ground, whereas Figure 4 shows the crack width on the glass screen at the last computed time in the simulation.

Figure 5 shows the evolution in time of various energy quantities. Initially, the total kinetic energy (blue in the graph) quickly reduces due to the high deceleration during the impact with the ground. At the same time, part of this energy is dissipated as irrecoverable plastic deformation while the remaining part is stored as strain energy (green). As time progresses, the vibrations induced by the impact are witnessed in the plot by an exchange between kinetic and strain energy, while the dissipated energy (red) steadily increases due to crack propagation and artificial viscosity.

The graph also allows you to monitor the stabilization energy and the artificial kinetic energy, which remain low with respect to the physical ones throughout the simulation. The total contact energy shows a peak in correspondence with the impact between the phone and the ground.

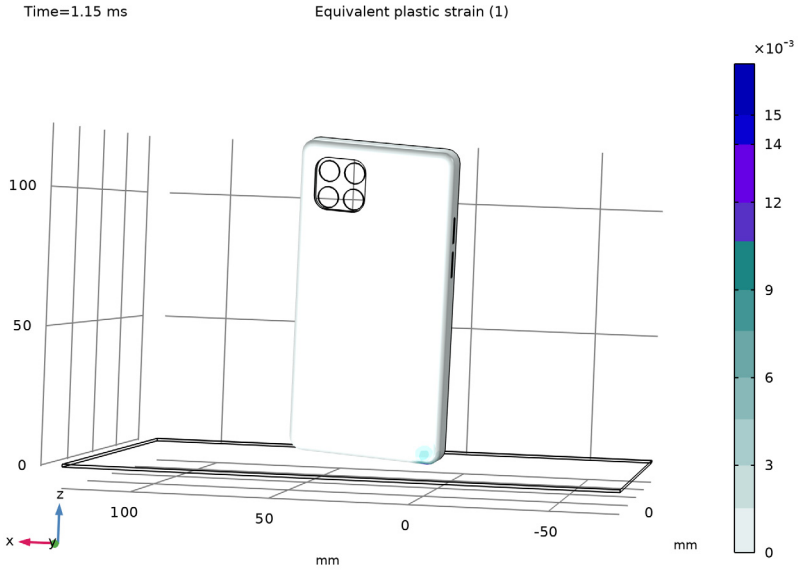

Figure 3: Permanent deformation of the aluminum case.

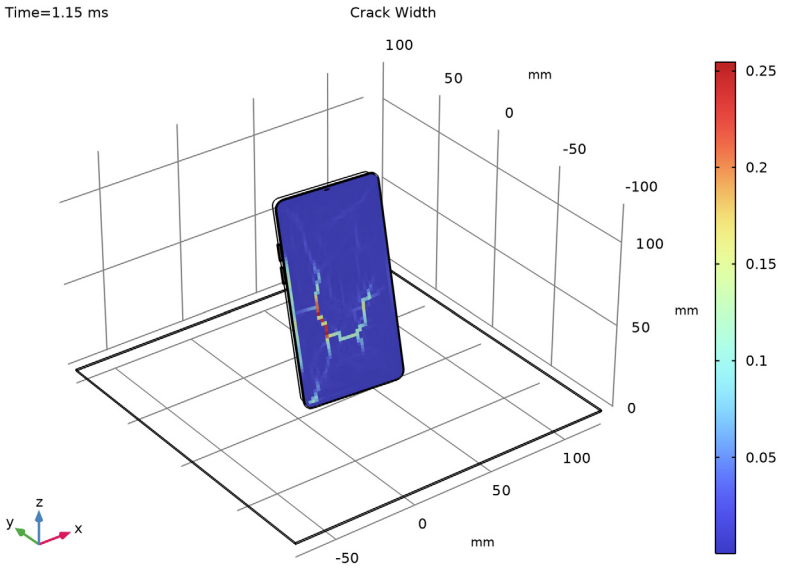

Figure 4: The crack width on the glass screen.

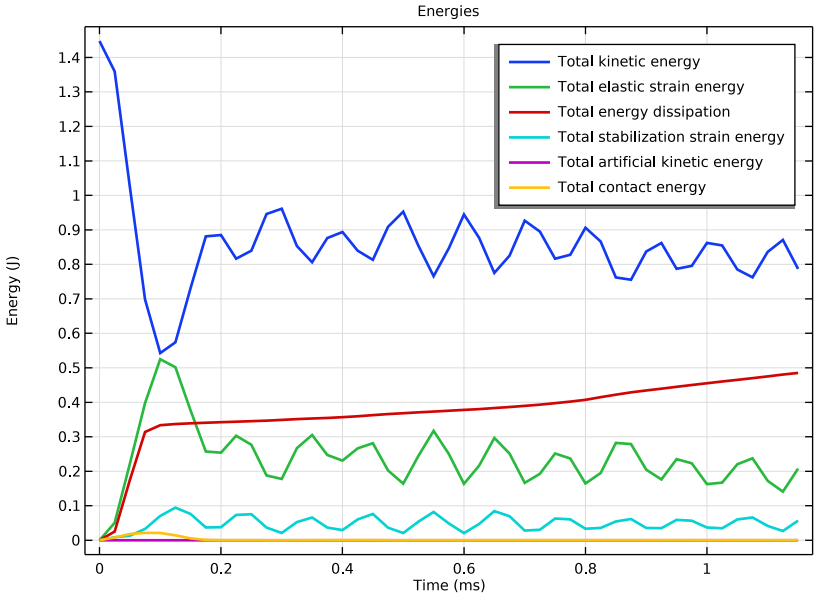

Figure 5: Time evolution of energy quantities.

Notes About the COMSOL Implementation

- The **Solid Mechanics, Explicit Dynamics** interface along with the **Explicit Dynamics** study step automatically sets up explicit time stepping and provides automatic evaluation of the stable time step.
- An **Interior Contact** node is added to model the contact between the screen and its support.
- An **Artificial Viscosity** node is added to partially damp out the energy of the impact.
- A **Mass scaling** node is added to inject localized artificial density where small elements would otherwise limit the stable time step.
- Attachments between the internal components and the case are modeled by a **Continuity** condition. This allows nonconforming meshes at each interface, which in turn makes it easier to be better control of the mesh size and quality of each component.

Application Library path: `Nonlinear_Structural_Materials_Module/Plasticity/phone_drop_test`

Modeling Instructions

From the **File** menu, choose **New**.

NEW

In the **New** window, click **Model Wizard**.

MODEL WIZARD

1. In the **Model Wizard** window, click **3D**.
2. In the **Select Physics** tree, select **Structural Mechanics** > **Explicit Dynamics** > **Solid Mechanics, Explicit Dynamics (solid)**.
3. Click **Add**.
4. Click **Study**.
5. In the **Select Study** tree, select **Preset Studies for Selected Physics Interfaces** > **Explicit Dynamics**.
6. Click **Done**.

GEOMETRY 1

The geometry sequence for each component used in the geometry of the model is available in a file. If you want to create them from scratch yourself, follow the instructions in the Appendix — Geometry Modeling Instructions section. Otherwise, insert each geometry sequence as follows:

CASE AND SCREEN

1. In the **Model Builder** window, right-click **Global Definitions** and choose **Geometry Parts** > **3D Part**.
2. In the **Settings** window for **Part**, type `Case and Screen` in the **Label** text field.
3. Locate the **Advanced** section. From the **Geometry representation** list, choose **CAD kernel**.
4. In the **Geometry** toolbar, click **Insert Sequence** and choose **Insert Sequence**.
5. Browse to the model's Application Libraries folder and double-click the file `phone_drop_test_geom_sequence.mph`.

6 In the **Insert Sequence** dialog, select **Case and Screen** in the **Select geometry sequence to insert** list.

7 Click **OK**.

8 In the **Geometry** toolbar, click **Build All**.

9 In the **Model Builder** window, collapse the **Case and Screen** node.

BATTERY

1 In the **Model Builder** window, under **Global Definitions** right-click **Geometry Parts** and choose **3D Part**.

2 In the **Settings** window for **Part**, type `Battery` in the **Label** text field.

3 In the **Geometry** toolbar, click **Insert Sequence** and choose **Insert Sequence**.

4 Browse to the model's Application Libraries folder and double-click the file `phone_drop_test_geom_sequence.mph`.

5 In the **Insert Sequence** dialog, select **Battery** in the **Select geometry sequence to insert** list.

6 Click **OK**.

7 In the **Geometry** toolbar, click **Build All**.

8 In the **Model Builder** window, collapse the **Battery** node.

CAMERA

1 Right-click **Geometry Parts** and choose **3D Part**.

2 In the **Settings** window for **Part**, type `Camera` in the **Label** text field.

3 In the **Geometry** toolbar, click **Insert Sequence** and choose **Insert Sequence**.

4 Browse to the model's Application Libraries folder and double-click the file `phone_drop_test_geom_sequence.mph`.

5 In the **Insert Sequence** dialog, select **Camera** in the **Select geometry sequence to insert** list.

6 Click **OK**.

7 In the **Geometry** toolbar, click **Build All**.

8 In the **Model Builder** window, collapse the **Camera** node.

OTHER COMPONENTS

1 Right-click **Geometry Parts** and choose **3D Part**.

2 In the **Settings** window for **Part**, type `Other Components` in the **Label** text field.

3 In the **Geometry** toolbar, click **Insert Sequence** and choose **Insert Sequence**.

4 Browse to the model's Application Libraries folder and double-click the file `phone_drop_test_geom_sequence.mph`.

5 In the **Insert Sequence** dialog, select **Other Components** in the **Select geometry sequence to insert** list.

6 Click **OK**.

7 In the **Geometry** toolbar, click **Build All**.

8 In the **Model Builder** window, collapse the **Other Components** node.

GEOMETRY 1

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Geometry 1**.

2 In the **Settings** window for **Geometry**, locate the **Units** section.

3 From the **Length unit** list, choose **mm**.

4 Locate the **Advanced** section. From the **Geometry representation** list, choose **CAD kernel**.

Case and Screen 1 (pi1)

1 In the **Geometry** toolbar, click **Part Instance** and choose **Case and Screen**.

2 In the **Settings** window for **Part Instance**, click **Build Selected**.

Battery 1 (pi2)

1 In the **Geometry** toolbar, click **Part Instance** and choose **Battery**.

2 In the **Settings** window for **Part Instance**, locate the **Position and Orientation of Output** section.

3 Find the **Displacement** subsection. In the **xwi** text field, type `21`.

4 In the **ywi** text field, type `15`.

5 In the **zwi** text field, type `2.5`.

6 Click to expand the **Domain Selections** section. In the table, select the **Keep** checkbox for **Battery**.

7 Click **Build Selected**.

Camera 1 (pi3)

1 In the **Geometry** toolbar, click **Part Instance** and choose **Camera**.

2 In the **Settings** window for **Part Instance**, locate the **Position and Orientation of Output** section.

3 Find the **Displacement** subsection. In the **xwi** text field, type `31`.

4 In the **ywi** text field, type `90`.

5 In the **zwi** text field, type `1.5`.

6 Locate the **Domain Selections** section. In the table, select the **Keep** checkbox for **Camera**.

7 Click to expand the **Boundary Selections** section. In the table, select the **Keep** checkbox for **Camera - Attachments**.

8 Click **Build Selected**.

Other Components 1 (pi4)

1 In the **Geometry** toolbar, click **Part Instance** and choose **Other Components**.

2 In the **Settings** window for **Part Instance**, locate the **Position and Orientation of Output** section.

3 Find the **Displacement** subsection. In the **xwi** text field, type `3`.

4 In the **ywi** text field, type `3`.

5 In the **zwi** text field, type `5.5`.

6 Locate the **Domain Selections** section. In the table, select the **Keep** checkboxes for **Other 1**, **Other 2**, and **Other Components**.

7 Locate the **Boundary Selections** section. In the table, select the **Keep** checkbox for **Board - Attachments**.

8 Click **Build Selected**.

Rotate 1 (rot1)

1 In the **Geometry** toolbar, click **Transforms** and choose **Rotate**.

2 In the **Settings** window for **Rotate**, locate the **Input** section.

3 From the **Input objects** list, choose **All objects**.

4 Locate the **Rotation** section. From the **Axis type** list, choose **x-axis**.

5 In the **Angle** text field, type `90`.

6 Click **Build Selected**.

Rotate 2 (rot2)

1 In the **Geometry** toolbar, click **Transforms** and choose **Rotate**.

2 In the **Settings** window for **Rotate**, locate the **Input** section.

3 From the **Input objects** list, choose **All objects**.

4 Locate the **Rotation** section. From the **Specify** list, choose **Euler angles (Z-X-Z)**.

5 In the α text field, type `10`.

6 In the β text field, type `-10`.

7 In the γ text field, type `-20`.

8 Click **Build Selected**.

9 Click in the **Graphics** window and then press Ctrl+D to clear all objects.

Block 1 (blk1)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type `200`.

4 In the **Depth** text field, type `200`.

5 Locate the **Position** section. From the **Base** list, choose **Center**.

6 In the **x** text field, type `25`.

7 In the **z** text field, type `0.06`.

8 Click **Build Selected**.

Form Union (fin)

1 In the **Model Builder** window, under **Component 1 (comp1)** > **Geometry 1** click **Form Union (fin)**.

2 In the **Settings** window for **Form Union/Assembly**, locate the **Form Union/Assembly** section.

3 From the **Action** list, choose **Form an assembly**.

4 Clear the **Create pairs** checkbox.

5 Click **Build Selected**.

The geometry includes several partitions that will be useful later on to generate a regular mesh. You can mark faces, edges and domains that are used for this purpose as **Mesh Control** entities, such that they do not contribute to selections when setting up the physics.

Mesh Control Edges 1 (mce1)

1 In the **Geometry** toolbar, click **Virtual Operations** and choose **Mesh Control Edges**.

2 In the **Settings** window for **Mesh Control Edges**, locate the **Input** section.

3 Click the **Paste Selection** button for **Edges to include**.

4 In the **Paste Selection** dialog, type `22, 27, 32, 34, 42, 43, 45, 52, 57, 64, 65, 69, 70, 78, 84, 91, 95, 97, 174, 179, 181, 205, 280, 288, 295, 298, 299, 301-307, 311, 323, 330, 347, 423, 440, 445, 447` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Mesh Control Edges**, click **Build Selected**.

Mesh Control Domains 1 (mcd1)

1 In the **Geometry** toolbar, click **Virtual Operations** and choose **Mesh Control Domains**.

2 In the **Settings** window for **Mesh Control Domains**, locate the **Input** section.

3 Click the **Paste Selection** button for **Domains to include**.

4 In the **Paste Selection** dialog, type `2-41` in the **Selection** text field.

5 Click **OK**.

Mesh Control Faces 1 (mcf1)

1 In the **Geometry** toolbar, click **Virtual Operations** and choose **Mesh Control Faces**.

2 In the **Settings** window for **Mesh Control Faces**, locate the **Input** section.

3 Click the **Paste Selection** button for **Faces to include**.

4 In the **Paste Selection** dialog, type `101, 106, 108, 113, 117, 122, 123, 128` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Mesh Control Faces**, click **Build Selected**.

Mesh Control Faces 2 (mcf2)

1 In the **Geometry** toolbar, click **Virtual Operations** and choose **Mesh Control Faces**.

2 In the **Settings** window for **Mesh Control Faces**, locate the **Input** section.

3 Click the **Paste Selection** button for **Faces to include**.

4 In the **Paste Selection** dialog, type `114, 120, 161, 162, 164, 165, 173-176, 181, 182, 184, 185, 193-196` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Mesh Control Faces**, click **Build Selected**.

Ignore Edges 1 (ige1)

1 In the **Geometry** toolbar, click **Virtual Operations** and choose **Ignore Edges**.

2 In the **Settings** window for **Ignore Edges**, locate the **Input** section.

3 Click the **Paste Selection** button for **Edges to ignore**.

4 In the **Paste Selection** dialog, type `23, 25, 31, 36, 38, 43, 49, 51, 79, 82, 97, 100, 115, 118, 133, 136, 143, 164, 173, 176, 191, 194, 209, 212, 227, 230` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Ignore Edges**, click **Build Selected**.

7 Click the **Go to Default View** button in the **Graphics** toolbar.

Attachments

1 In the **Geometry** toolbar, click **Selections** and choose **Union Selection**.

2 In the **Settings** window for **Union Selection**, locate the **Geometric Entity Level** section.

3 From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog, in the **Selections to add** list, choose **Camera - Attachments (Camera 1)** and **Board - Attachments (Other Components 1)**.

6 Click **OK**.

7 In the **Settings** window for **Union Selection**, type `Attachments` in the **Label** text field.

Add a **Domain Probe** to monitor the vibration of the battery.

DEFINITIONS

Domain Probe: Battery Vibration

1 In the **Model Builder** window, expand the **Component 1 (comp1)** > **Definitions** node.

2 Right-click **Definitions** and choose **Probes** > **Domain Probe**.

3 In the **Settings** window for **Domain Probe**, type `Domain Probe: Battery Vibration` in the **Label** text field.

4 Locate the **Source Selection** section. From the **Selection** list, choose **Battery (Battery 1)**.

5 Locate the **Expression** section. In the **Expression** text field, type `solid.u_tZ`.

6 Locate the **Integration Settings** section. In the **Integration order** text field, type `1`.

Contact Pair: Phone-Ground

1 In the **Definitions** toolbar, click **Pairs** and choose **Contact Pair**.

2 In the **Settings** window for **Pair**, type `Contact Pair: Phone-Ground` in the **Label** text field.

3 Select Boundary 4 only.

4 Locate the **Destination Boundaries** section. Click to select the **Activate Selection** toggle button.

5 Select Boundary 7 only.

Contact Pair: Case-Internal Components

1 In the **Definitions** toolbar, click **Pairs** and choose **Contact Pair**.

2 In the **Settings** window for **Pair**, type `Contact Pair: Case-Internal Components` in the **Label** text field.

3 Click in the **Graphics** window and then press Ctrl+A to select all boundaries.

The wireframe rendering helps identifying surfaces inside the geometry.

4 Click the **Wireframe Rendering** button in the **Graphics** toolbar.

5 Locate the **Source Boundaries** section. Click **Paste Selection**.

6 In the **Paste Selection** dialog, type `17, 20, 64` in the **Selection** text field.

7 Click **OK**.

8 In the **Settings** window for **Pair**, locate the **Destination Boundaries** section.

9 Click to select the **Activate Selection** toggle button.

10 Click **Paste Selection**.

11 In the **Paste Selection** dialog, type `81-87, 91, 93-97, 99-103, 105-108, 111-114, 116, 117, 119, 120, 122, 123, 126, 149` in the **Selection** text field.

12 Click **OK**.

Identity Boundary Pair: Board-Internal Components

1 In the **Definitions** toolbar, click **Pairs** and choose **Identity Boundary Pair**.

2 In the **Settings** window for **Pair**, type `Identity Boundary Pair: Board-Internal Components` in the **Label** text field.

3 Select Boundary 85 only.

4 Locate the **Destination Boundaries** section. Click to select the **Activate Selection** toggle button.

5 Select Boundaries 98, 104, and 110 only.

6 Locate the **Frame** section. From the **Source frame** list, choose **Material (X, Y, Z)**.

7 From the **Destination frame** list, choose **Material (X, Y, Z)**.

Identity Boundary Pair: Case-Screen

1 In the **Definitions** toolbar, click **Pairs** and choose **Identity Boundary Pair**.

2 In the **Settings** window for **Pair**, type `Identity Boundary Pair: Case-Screen` in the **Label** text field.

3 Locate the **Source Boundaries** section. Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `58, 59, 61, 62, 64-70, 75-80` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Pair**, locate the **Destination Boundaries** section.

7 Click **Paste Selection**.

8 In the **Paste Selection** dialog, type `9, 10` in the **Selection** text field.

9 Click **OK**.

10 In the **Settings** window for **Pair**, locate the **Frame** section.

11 From the **Source frame** list, choose **Material (X, Y, Z)**.

12 From the **Destination frame** list, choose **Material (X, Y, Z)**.

Identity Boundary Pair: Attachments

1 In the **Definitions** toolbar, click **Pairs** and choose **Identity Boundary Pair**.

2 In the **Settings** window for **Pair**, type `Identity Boundary Pair: Attachments` in the **Label** text field.

3 Locate the **Source Boundaries** section. From the **Selection** list, choose **Attachments**.

4 Locate the **Destination Boundaries** section. Click to select the **Activate Selection** toggle button.

5 Select Boundary 64 only.

6 Locate the **Frame** section. From the **Source frame** list, choose **Material (X, Y, Z)**.

7 From the **Destination frame** list, choose **Material (X, Y, Z)**.

Identity Boundary Pair: Battery Attachment

1 In the **Definitions** toolbar, click **Pairs** and choose **Identity Boundary Pair**.

2 In the **Settings** window for **Pair**, type `Identity Boundary Pair: Battery Attachment` in the **Label** text field.

3 Locate the **Source Boundaries** section. Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `90 125` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Pair**, locate the **Destination Boundaries** section.

7 Click to select the **Activate Selection** toggle button.

8 Click **Paste Selection**.

9 In the **Paste Selection** dialog, type `115 118` in the **Selection** text field.

10 Click **OK**.

11 In the **Settings** window for **Pair**, locate the **Frame** section.

12 From the **Source frame** list, choose **Material (X, Y, Z)**.

13 From the **Destination frame** list, choose **Material (X, Y, Z)**.

ADD MATERIAL

1 In the **Materials** toolbar, click **Add Material** to open the **Add Material** window.

2 Go to the **Add Material** window.

3 In the tree, select **Built-in** > **Aluminum**.

4 Click the **Add to Component** button in the window toolbar.

MATERIALS

Aluminum (mat1)

1 In the **Settings** window for **Material**, locate the **Geometric Entity Selection** section.

2 Click  **Clear Selection**.

3 Select Domain 2 only.

ADD MATERIAL

1 Go to the **Add Material** window.

2 In the tree, select **Built-in** > **Glass (quartz)**.

3 Click the **Add to Component** button in the window toolbar.

MATERIALS

Glass (quartz) (mat2)

1 Select Domain 3 only.

2 In the **Settings** window for **Material**, locate the **Material Contents** section.

3 In the table, enter the following settings:

Property	Variable	Value	Unit	Property group
Young's modulus	E	70[GPa]	Pa	Young's modulus and Poisson's ratio
Poisson's ratio	nu	0.22	1	Young's modulus and Poisson's ratio

ADD MATERIAL

1 Go to the **Add Material** window.

2 In the tree, select **Built-in** > **FR4 (Circuit Board)**.

3 Click the **Add to Component** button in the window toolbar.

MATERIALS

FR4 (Circuit Board) (mat3)

1 In the **Settings** window for **Material**, locate the **Geometric Entity Selection** section.

2 From the **Selection** list, choose **Other 1 (Other Components 1)**.

ADD MATERIAL

1 Go to the **Add Material** window.

2 In the tree, select **Built-in** > **Silica glass**.

3 Click the **Add to Component** button in the window toolbar.

MATERIALS

Silica glass (mat4)
Select Domain 4 only.

ADD MATERIAL

1 Go to the **Add Material** window.

2 In the tree, select **Built-in** > **Acrylic plastic**.

3 Click the **Add to Component** button in the window toolbar.

MATERIALS

Acrylic plastic (mat5)
Select Domains 8 and 10 only.

ADD MATERIAL

1 Go to the **Add Material** window.

2 In the tree, select **Built-in** > **Silicon**.

3 Click the **Add to Component** button in the window toolbar.

4 In the **Materials** toolbar, click **Add Material** to close the **Add Material** window.

MATERIALS

Silicon (mat6)
Select Domains 6 and 7 only.

Battery

1 In the **Model Builder** window, right-click **Materials** and choose **Blank Material**.

2 In the **Settings** window for **Material**, type `Battery` in the **Label** text field.

3 Locate the **Geometric Entity Selection** section. From the **Selection** list, choose **Battery (Battery 1)**.

4 Locate the **Material Contents** section. In the table, enter the following settings:

Property	Variable	Value	Unit	Property group
Young's modulus	E	5[GPa]	Pa	Young's modulus and Poisson's ratio
Poisson's ratio	nu	0.2	1	Young's modulus and Poisson's ratio
Density	rho	1000	kg/m³	Basic

SOLID MECHANICS, EXPLICIT DYNAMICS (SOLID)

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Solid Mechanics, Explicit Dynamics (solid)**.

2 Select Domains 2–10 only.

3 In the **Settings** window for **Solid Mechanics, Explicit Dynamics**, click to expand the **Energy Dissipation** section.

4 From the **Store dissipation** list, choose **Total**.

Initial Values 1

1 In the **Model Builder** window, under **Component 1 (comp1)** > **Solid Mechanics, Explicit Dynamics (solid)** click **Initial Values 1**.

2 In the **Settings** window for **Initial Values**, locate the **Initial Values** section.

3 In the **structural velocity field** vector, enter

-6	Z

Gravity 1

In the **Physics** toolbar, click **Global** and choose **Gravity**.

Linear Elastic Material 1

In the **Model Builder** window, click **Linear Elastic Material 1**.

Plasticity 1

1 In the **Physics** toolbar, click **Attributes** and choose **Plasticity**.

2 In the **Settings** window for **Plasticity**, locate the **Domain Selection** section.

3 Click **Clear Selection**.

4 Select Domain 2 only.

MATERIALS

Aluminum (mat1)

1 In the **Model Builder** window, under **Component 1 (comp1)** > **Materials** click **Aluminum (mat1)**.

2 In the **Settings** window for **Material**, locate the **Material Contents** section.

3 In the table, enter the following settings:

Property	Variable	Value	Unit	Property group
Initial yield stress	sigmags	`150[MPa]`	Pa	Elastoplastic material model
Isotropic tangent modulus	Et	`20[GPa]`	Pa	Elastoplastic material model

SOLID MECHANICS, EXPLICIT DYNAMICS (SOLID)

Linear Elastic Material 1

In the **Model Builder** window, under **Component 1 (comp1)** > **Solid Mechanics, Explicit Dynamics (solid)** click **Linear Elastic Material 1**.

Damage 1

1 In the **Physics** toolbar, click **Attributes** and choose **Damage**.

2 In the **Settings** window for **Damage**, locate the **Damage** section.

3 Find the **Damage evolution** subsection. From the σ_p list, choose **User defined**. In the associated text field, type `14e6`.

4 From the G_f list, choose **User defined**. In the associated text field, type `100`.

5 Locate the **Domain Selection** section. Click **Clear Selection**.

6 Select Domain 3 only.

Interior Contact 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Interior Contact**.

2 Select Boundary 63 only.

Friction 1

1 In the **Physics** toolbar, click **Attributes** and choose **Friction**.

2 In the **Settings** window for **Friction**, locate the **Friction Parameters** section.

3 In the μ text field, type `0.5`.

4 In the T_{cohe} text field, type `1e3`.

Artificial Viscosity 1

1 In the **Physics** toolbar, click **Domains** and choose **Artificial Viscosity**.

2 In the **Settings** window for **Artificial Viscosity**, locate the **Domain Selection** section.

3 From the **Selection** list, choose **All domains**.

MESH 1

Free Quad 1

1 In the **Mesh** toolbar, click **More Generators** and choose **Free Quad**.

2 In the **Settings** window for **Free Quad**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `157, 163, 174, 178, 196, 199, 201` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Free Quad**, click to expand the **Mesh Generation** section.

7 From the **Method** list, choose **Quad**.

Size

1 In the **Model Builder** window, click **Size**.

2 In the **Settings** window for **Size**, locate the **Element Size** section.

3 Click the **Custom** button.

4 Locate the **Element Size Parameters** section. In the **Maximum element size** text field, type `2`.

5 In the **Minimum element size** text field, type `0.5`.

6 In the **Maximum element growth rate** text field, type `1.2`.

7 In the **Curvature factor** text field, type `0.4`.

8 In the **Resolution of narrow regions** text field, type `0.7`.

Distribution 1

1 In the **Model Builder** window, right-click **Free Quad 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Edge Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `458` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Distribution**, locate the **Distribution** section.

7 In the **Number of elements** text field, type `1`.

Distribution 2

1 Right-click **Free Quad 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Edge Selection** section.

3 Click  **Paste Selection**.

4 In the **Paste Selection** dialog, type `455, 460` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Distribution**, locate the **Distribution** section.

7 In the **Number of elements** text field, type `2`.

Distribution 3

1 Right-click **Free Quad 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Edge Selection** section.

3 Click  **Paste Selection**.

4 In the **Paste Selection** dialog, type `493, 504` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Distribution**, locate the **Distribution** section.

7 In the **Number of elements** text field, type `3`.

8 Click  **Build Selected**.

Distribution 4

1 Right-click **Free Quad 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Edge Selection** section.

3 Click  **Paste Selection**.

4 In the **Paste Selection** dialog, type `489-491, 497` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Distribution**, locate the **Distribution** section.

7 In the **Number of elements** text field, type `2`.

8 Click  **Build Selected**.

Copy Face 1

1 In the **Mesh** toolbar, click  **Copy** and choose **Copy Face**.

2 In the **Settings** window for **Copy Face**, locate the **Source Boundaries** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `199` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Copy Face**, locate the **Destination Boundaries** section.

7 Click **Paste Selection**.

8 In the **Paste Selection** dialog, type `198` in the **Selection** text field.

9 Click **OK**.

10 In the **Settings** window for **Copy Face**, click **Build Selected**.

Copy Face 2

1 In the **Mesh** toolbar, click **Copy** and choose **Copy Face**.

2 In the **Settings** window for **Copy Face**, locate the **Source Boundaries** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `196, 198, 199, 201` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Copy Face**, locate the **Destination Boundaries** section.

7 Click **Paste Selection**.

8 In the **Paste Selection** dialog, type `189, 191, 192, 194` in the **Selection** text field.

9 Click **OK**.

10 In the **Settings** window for **Copy Face**, click **Build Selected**.

Mapped 1

1 In the **Mesh** toolbar, click **More Generators** and choose **Mapped**.

2 In the **Settings** window for **Mapped**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `150-156, 158-162, 164-173, 175-177, 179-184, 186-188, 190, 193, 195, 197, 200, 202-208, 211, 215-219` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Mapped**, click to expand the **Reduce Element Skewness** section.

7 Select the **Adjust edge mesh** checkbox.

Distribution 1

1 Right-click **Mapped 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Edge Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `487` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Distribution**, locate the **Distribution** section.

7 In the **Number of elements** text field, type `1`.

8 Click **Build Selected**.

Mapped 2

1 In the **Mesh** toolbar, click **More Generators** and choose **Mapped**.

2 In the **Settings** window for **Mapped**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `7, 185, 214` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Mapped**, locate the **Reduce Element Skewness** section.

7 Select the **Adjust edge mesh** checkbox.

8 Click **Build Selected**.

Free Quad 2

1 In the **Mesh** toolbar, click **More Generators** and choose **Free Quad**.

2 In the **Settings** window for **Free Quad**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `212, 213` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Free Quad**, locate the **Mesh Generation** section.

7 From the **Method** list, choose **Quad**.

Size 1

1 Right-click **Free Quad 2** and choose **Size**.

2 Select Boundary 213 only.

3 In the **Settings** window for **Size**, locate the **Element Size** section.

4 From the **Predefined** list, choose **Coarser**.

5 Click **Build Selected**.

Copy Face 3

1 In the **Mesh** toolbar, click  **Copy** and choose **Copy Face**.

2 In the **Settings** window for **Copy Face**, locate the **Source Boundaries** section.

3 Click  **Paste Selection**.

4 In the **Paste Selection** dialog, type `212, 213` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Copy Face**, locate the **Destination Boundaries** section.

7 Click  **Paste Selection**.

8 In the **Paste Selection** dialog, type `209, 210` in the **Selection** text field.

9 Click **OK**.

10 In the **Settings** window for **Copy Face**, click  **Build Selected**.

Swept 1

1 In the **Mesh** toolbar, click  **Swept**.

2 In the **Settings** window for **Swept**, locate the **Domain Selection** section.

3 From the **Geometric entity level** list, choose **Domain**.

4 Click  **Paste Selection**.

5 In the **Paste Selection** dialog, type `2, 23-25, 28-31, 33, 34, 36-43, 45-51, 53-59` in the **Selection** text field.

6 Click **OK**.

Distribution 1

1 Right-click **Swept 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Domain Selection** section.

3 Click  **Clear Selection**.

4 Click  **Paste Selection**.

5 In the **Paste Selection** dialog, type `2 23 28 29 30 33 36 37 38 39 40 41 43 45 46 47 48 49 51 53 54 55 58 59` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Distribution**, locate the **Distribution** section.

8 In the **Number of elements** text field, type `2`.

9 Click  **Build Selected**.

Free Quad 3

1 In the **Mesh** toolbar, click  **More Generators** and choose **Free Quad**.

2 In the **Settings** window for **Free Quad**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `340` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Free Quad**, click **Build Selected**.

Swept 2

1 In the **Mesh** toolbar, click **Swept**.

2 In the **Settings** window for **Swept**, locate the **Domain Selection** section.

3 From the **Geometric entity level** list, choose **Domain**.

4 Click **Paste Selection**.

5 In the **Paste Selection** dialog, type `26, 27, 32, 35, 44, 52, 60, 61` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Swept**, click **Build Selected**.

Mapped 3

1 In the **Mesh** toolbar, click **More Generators** and choose **Mapped**.

2 In the **Settings** window for **Mapped**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `270, 272` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Mapped**, click **Build Selected**.

Free Quad 4

1 In the **Mesh** toolbar, click **More Generators** and choose **Free Quad**.

2 In the **Settings** window for **Free Quad**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog, type `60, 271` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Free Quad**, click **Build Selected**.

Swept 3

1 In the **Mesh** toolbar, click **Swept**.

2 In the **Settings** window for **Swept**, locate the **Domain Selection** section.

3 From the **Geometric entity level** list, choose **Domain**.

4 Click  **Paste Selection**.

5 In the **Paste Selection** dialog, type `3, 4, 17-22, 32` in the **Selection** text field.

6 Click **OK**.

Distribution 1

1 Right-click **Swept 3** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Distribution** section.

3 In the **Number of elements** text field, type `2`.

4 Click  **Build Selected**.

Swept 4

1 In the **Mesh** toolbar, click  **Swept**.

2 In the **Settings** window for **Swept**, locate the **Domain Selection** section.

3 From the **Geometric entity level** list, choose **Domain**.

4 Click  **Paste Selection**.

5 In the **Paste Selection** dialog, type `5-11, 13-16` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Swept**, locate the **Mesh Generation** section.

8 From the **Elements** list, choose **Hexahedra**.

Distribution 1

1 Right-click **Swept 4** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Domain Selection** section.

3 Click  **Clear Selection**.

4 Click  **Paste Selection**.

5 In the **Paste Selection** dialog, type `5, 8` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Distribution**, locate the **Distribution** section.

8 In the **Number of elements** text field, type `2`.

9 Click  **Build Selected**.

Swept 5

1 In the **Mesh** toolbar, click  **Swept**.

2 In the **Settings** window for **Swept**, click  **Build All**.

STUDY 1

1 In the **Model Builder** window, click **Study 1**.

2 In the **Settings** window for **Study**, locate the **Study Settings** section.

3 Clear the **Generate default plots** checkbox.

Step 1: Explicit Dynamics

1 In the **Model Builder** window, under **Study 1** click **Step 1: Explicit Dynamics**.

2 In the **Settings** window for **Explicit Dynamics**, locate the **Study Settings** section.

3 From the **Time unit** list, choose **ms**.

4 In the **Output times** text field, type `range(0,0.025,1.15)`.

5 Click to expand the **Results While Solving** section. From the **Update at** list, choose **Time steps taken by solver**.

The time step is automatically computed from the material properties and the size of the mesh elements. To locate critical mesh elements, use **Get Initial Value** in order to get access to **Result Templates**.

6 In the **Study** toolbar, click **Get Initial Value**.

Add a plot of the cell time from **Result Templates**.

RESULT TEMPLATES

1 In the **Home** toolbar, click **Result Templates** to open the **Result Templates** window.

2 Go to the **Result Templates** window.

3 In the tree, select **Study 1/Solution 1 (sol1)** > **Solid Mechanics, Explicit Dynamics** > **Cell Time (solid)**.

4 Click the **Add Result Template** button in the window toolbar.

5 In the **Home** toolbar, click **Result Templates** to close the **Result Templates** window.

RESULTS

Probe Plot Group 1

A few small elements are limiting the size of the time step. You can remedy this by adding a **Mass Scaling** node to inject artificial mass in those elements.

SOLID MECHANICS, EXPLICIT DYNAMICS (SOLID)

Mass Scaling 1

1 In the **Physics** toolbar, click **Domains** and choose **Mass Scaling**.

2 Select Domain 2 only.

3 In the **Settings** window for **Mass Scaling**, locate the **Mass Scaling** section.

4 In the $\Delta t_{\text{cell}}{}^{0}$ text field, type `1.5E-8`.

STUDY 1

In the **Study** toolbar, click **Compute**.

RESULTS

Battery Vibration

1 In the **Model Builder** window, under **Results** click **Probe Plot Group 1**.

2 In the **Settings** window for **1D Plot Group**, type `Battery Vibration` in the **Label** text field.

3 Locate the **Legend** section. Clear the **Show legends** checkbox.

4 Click to expand the **Title** section. From the **Title type** list, choose **Label**.

Add a plot of the equivalent plastic strain from **Result Templates**.

RESULT TEMPLATES

1 In the **Home** toolbar, click **Result Templates** to open the **Result Templates** window.

2 Go to the **Result Templates** window.

3 In the tree, select **Study 1/Solution 1 (sol1)** > **Solid Mechanics, Explicit Dynamics** > **Equivalent Plastic Strain (solid)**.

4 Click the **Add Result Template** button in the window toolbar.

5 In the **Home** toolbar, click **Result Templates** to close the **Result Templates** window.

RESULTS

Equivalent Plastic Strain (solid)

1 Click the **Show More Options** button in the **Model Builder** toolbar.

2 In the **Show More Options** dialog, select **Results** > **Views** in the tree.

3 In the tree, select the checkbox for the node **Results** > **Views**.

4 Click **OK**.

View 3D 27

In the **Model Builder** window, under **Results** right-click **Views** and choose **View 3D**.

Camera

1 In the **Model Builder** window, expand the **View 3D 27** node, then click **Camera**.

2 In the **Settings** window for **Camera**, locate the **Camera** section.

3 In the **Zoom angle** text field, type `14.4`.

4 Locate the **Position** section. In the **x** text field, type `-166`.

5 In the **y** text field, type `1604`.

6 In the **z** text field, type `92`.

7 Locate the **Target** section. In the **x** text field, type `25`.

8 In the **z** text field, type `60`.

9 Locate the **Up Vector** section. In the **x** text field, type `0.04`.

10 Locate the **Center of Rotation** section. In the **y** text field, type `-0.01`.

11 Locate the **Up Vector** section. In the **y** text field, type `-0.01`.

12 In the **z** text field, type `1`.

13 Locate the **Center of Rotation** section. In the **y** text field, type `0`.

14 Locate the **View Offset** section. In the **x** text field, type `0.01`.

15 In the **y** text field, type `0.04`.

Equivalent Plastic Strain (solid)

1 In the **Model Builder** window, under **Results** click **Equivalent Plastic Strain (solid)**.

2 In the **Settings** window for **3D Plot Group**, locate the **Plot Settings** section.

3 From the **View** list, choose **View 3D 27**.

4 In the **Equivalent Plastic Strain (solid)** toolbar, click **Plot**.

Crack Width

1 In the **Results** toolbar, click **3D Plot Group**.

2 In the **Settings** window for **3D Plot Group**, type `Crack Width` in the **Label** text field.

3 Click to expand the **Title** section. From the **Title type** list, choose **Label**.

Surface 1

1 Right-click **Crack Width** and choose **Surface**.

2 In the **Settings** window for **Surface**, locate the **Expression** section.

3 In the **Expression** text field, type `solid.kappadmgGp*solid.hcb`.

4 Click to expand the **Quality** section. From the **Evaluation settings** list, choose **Manual**.

5 From the **Resolution** list, choose **No refinement**.

6 From the **Smoothing** list, choose **None**.

7 Locate the **Coloring and Style** section. From the **Color table** list, choose **RainbowLight**.

8 In the **Crack Width** toolbar, click **Plot**.

Energies

1 In the **Results** toolbar, click **1D Plot Group**.

2 In the **Settings** window for **1D Plot Group**, type `Energies` in the **Label** text field.

3 Locate the **Plot Settings** section.

4 Select the **y-axis label** checkbox. In the associated text field, type `Energy (J)`.

5 Locate the **Title** section. From the **Title type** list, choose **Label**.

Global 1

1 Right-click **Energies** and choose **Global**.

2 In the **Settings** window for **Global**, locate the **y-Axis Data** section.

3 In the table, enter the following settings:

Expression	Unit	Description
`solid.Wk_tot`	J	`Total kinetic energy`
`solid.Ws_tot`	J	`Total elastic strain energy`
`solid.Wd_tot`	J	`Total energy dissipation`
`solid.Wstb_tot`	J	`Total stabilization strain energy`
`solid.Wka_tot`	J	`Total artificial kinetic energy`
`solid.Wcnt_tot`	J	`Total contact energy`

4 Click to expand the **Coloring and Style** section. From the **Width** list, choose **2**.

5 In the **Energies** toolbar, click **Plot**.

Thumbnail

1 In the **Results** toolbar, click **3D Plot Group**.

2 In the **Settings** window for **3D Plot Group**, type `Thumbnail` in the **Label** text field.

3 Locate the **Title** section. From the **Title type** list, choose **None**.

4 Locate the **Plot Settings** section. Clear the **Plot dataset edges** checkbox.

5 Locate the **Color Legend** section. Clear the **Show legends** checkbox.

Case

1 Right-click **Thumbnail** and choose **Surface**.

2 In the **Settings** window for **Surface**, type `Case` in the **Label** text field.

3 Locate the **Expression** section. In the **Expression** text field, type `1`.

Selection 1

1. Right-click **Case** and choose **Selection**.
2. Select Boundary 7 only.

Material Appearance 1

1. In the **Model Builder** window, right-click **Case** and choose **Material Appearance**.
2. In the **Settings** window for **Material Appearance**, locate the **Appearance** section.
3. From the **Appearance** list, choose **Custom**.
4. From the **Material type** list, choose **Aluminum (polished)**.

Deformation 1

1. Right-click **Case** and choose **Deformation**.
2. In the **Settings** window for **Deformation**, locate the **Scale** section.
3. Select the **Scale factor** checkbox. In the associated text field, type `1`.

Crack Width

1. In the **Model Builder** window, right-click **Thumbnail** and choose **Surface**.
2. In the **Settings** window for **Surface**, type `Crack Width` in the **Label** text field.
3. Locate the **Expression** section. In the **Expression** text field, type `solid.kappadmgGp* solid.hcb`.
4. Locate the **Coloring and Style** section. From the **Color table** list, choose **GrayScale**.
5. From the **Color table transformation** list, choose **Nonlinear**.
6. In the **Color calibration parameter** text field, type `-1.5`.
7. Locate the **Quality** section. From the **Evaluation settings** list, choose **Manual**.
8. From the **Smoothing** list, choose **None**.

Deformation 1

In the **Model Builder** window, under **Results** > **Thumbnail** > **Case** right-click **Deformation 1** and choose **Copy**.

Deformation 1

In the **Model Builder** window, right-click **Crack Width** and choose **Paste Deformation**.

Floor

1. In the **Model Builder** window, right-click **Thumbnail** and choose **Surface**.
2. In the **Settings** window for **Surface**, type `Floor` in the **Label** text field.
3. Locate the **Expression** section. In the **Expression** text field, type `1`.

Selection 1

1. Right-click **Floor** and choose **Selection**.
2. Select Boundary 4 only.

Material Appearance 1

1. In the **Model Builder** window, right-click **Floor** and choose **Material Appearance**.
2. In the **Settings** window for **Material Appearance**, locate the **Appearance** section.
3. From the **Appearance** list, choose **Custom**.
4. From the **Material type** list, choose **Concrete**.

Visual Effects 1

1. Right-click **Floor** and choose **Visual Effects**.
2. In the **Settings** window for **Visual Effects**, locate the **Visual Effects** section.
3. Find the **Direct shadows** subsection. From the **Mode** list, choose **Manual**.
4. Clear the **Casts shadows** checkbox.

Circuit Board

1. In the **Model Builder** window, right-click **Thumbnail** and choose **Volume**.
2. In the **Settings** window for **Volume**, type `Circuit Board` in the **Label** text field.
3. Locate the **Expression** section. In the **Expression** text field, type `1`.

Selection 1

1. Right-click **Circuit Board** and choose **Selection**.
2. In the **Settings** window for **Selection**, locate the **Selection** section.
3. From the **Selection** list, choose **Other 1 (Other Components 1)**.

Material Appearance 1

1. In the **Model Builder** window, right-click **Circuit Board** and choose **Material Appearance**.
2. In the **Settings** window for **Material Appearance**, locate the **Appearance** section.
3. From the **Material** list, choose **FR4 (Circuit Board) (mat3)**.

Deformation 1

In the **Model Builder** window, under **Results** > **Thumbnail** > **Crack Width** right-click **Deformation 1** and choose **Copy**.

Deformation 1

In the **Model Builder** window, right-click **Circuit Board** and choose **Paste Deformation**.

Battery and Internal Components

1 In the **Model Builder** window, right-click **Thumbnail** and choose **Volume**.

2 In the **Settings** window for **Volume**, type `Battery and Internal Components` in the **Label** text field.

3 Locate the **Expression** section. In the **Expression** text field, type `1`.

Selection 1

1 Right-click **Battery and Internal Components** and choose **Selection**.

2 Select Domains 6–10 only.

Material Appearance 1

1 In the **Model Builder** window, right-click **Battery and Internal Components** and choose **Material Appearance**.

2 In the **Settings** window for **Material Appearance**, locate the **Appearance** section.

3 From the **Appearance** list, choose **Custom**.

4 From the **Color** list, choose **Black**.

Deformation 1

In the **Model Builder** window, under **Results** > **Thumbnail** > **Circuit Board** right-click **Deformation 1** and choose **Copy**.

Deformation 1

In the **Model Builder** window, right-click **Battery and Internal Components** and choose **Paste Deformation**.

Thumbnail

1 Click the  **Show Grid** button in the **Graphics** toolbar.

2 Click the  **Zoom Extents** button in the **Graphics** toolbar.

3 Click the  **Go to Default View** button in the **Graphics** toolbar.

Appendix — Geometry Modeling Instructions

From the **File** menu, choose **New**.

NEW

In the **New** window, click  **Model Wizard**.

MODEL WIZARD

1 In the **Model Wizard** window, click **3D**.

2 Click **Done**.

CASE AND SCREEN

1 In the **Model Builder** window, right-click **Global Definitions** and choose **Geometry Parts** > **3D Part**.

2 In the **Settings** window for **Part**, type `Case and Screen` in the **Label** text field.

3 Locate the **Units** section. From the **Length unit** list, choose **mm**.

4 Locate the **Advanced** section. From the **Geometry representation** list, choose **CAD kernel**.

Work Plane 1 (wp1)

In the **Geometry** toolbar, click **Work Plane**.

Work Plane 1 (wp1) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 1 (wp1) > Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Object Type** section.

3 From the **Type** list, choose **Curve**.

4 Locate the **Size and Shape** section. In the **Width** text field, type `60`.

5 In the **Height** text field, type `120`.

6 Click **Build Selected**.

Work Plane 1 (wp1) > Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **r1**, select Points 1–4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `5`.

5 Click **Build Selected**.

Work Plane 1 (wp1) > Thicken 1 (thi1)

1 In the **Work Plane** toolbar, click **Conversions** and choose **Thicken**.

2 Select the object **fil1** only.

3 In the **Settings** window for **Thicken**, locate the **Options** section.

4 From the **Offset** list, choose **Asymmetric**.

5 In the **Upside thickness** text field, type `1.5`.

6 Click **Build Selected**.

Extrude 1 (ext1)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
8

4 Click **Build Selected**.

5 Click the **Go to Default View** button in the **Graphics** toolbar.

Work Plane 2 (wp2)

In the **Geometry** toolbar, click **Work Plane**.

Work Plane 2 (wp2) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 2 (wp2) > Projection 1 (proj1)

1 In the **Work Plane** toolbar, click **Projection**.

2 In the **Settings** window for **Projection**, locate the **Projection** section.

3 From the **Projection** list, choose **Selected edges**.

4 Click the **Paste Selection** button for **Entities to project**.

5 In the **Paste Selection** dialog, type `ext1: 10, 11, 15, 21, 24, 33, 36, 42` in the **Selection** text field.

6 Click **OK**.

Work Plane 2 (wp2) > Convert to Solid 1 (csol1)

1 In the **Work Plane** toolbar, click **Conversions** and choose **Convert to Solid**.

2 Select the object **proj1** only.

Work Plane 2 (wp2)

1 In the **Model Builder** window, under **Global Definitions** > **Geometry Parts** > **Case and Screen** click **Work Plane 2 (wp2)**.

2 In the **Settings** window for **Work Plane**, click **Build Selected**.

Extrude 2 (ext2)

1 In the **Geometry** toolbar, click **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
1.5

4 Click **Build Selected**.

Fillet 1 (fil1)

1 In the **Geometry** toolbar, click **Editing** and choose **Fillet**.

2 In the **Settings** window for **Fillet**, locate the **Edges** section.

3 Click the **Paste Selection** button for **Edges to fillet**.

4 In the **Paste Selection** dialog, type `ext1: 2, 3, 7, 18, 27, 30, 39, 46` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Fillet**, locate the **Radius** section.

7 In the **Radius** text field, type `1.5`.

8 Click **Build Selected**.

Union 1 (uni1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Union**.

2 Click in the **Graphics** window and then press Ctrl+A to select both objects.

3 In the **Settings** window for **Union**, click **Build Selected**.

Work Plane 3 (wp3)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **uni1**, select Boundary 5 only.

Work Plane 3 (wp3) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 3 (wp3) > Projection 1 (proj1)

1 In the **Work Plane** toolbar, click **Projection**.

2 In the **Settings** window for **Projection**, locate the **Projection** section.

3 From the **Project** list, choose **Selected edges**.

4 Click the **Paste Selection** button for **Entities to project**.

5 In the **Paste Selection** dialog, type `uni1: 17, 18, 23, 32, 38, 50, 56, 65` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Projection**, click **Build Selected**.

Work Plane 3 (wp3) > Thicken 1 (thi1)

1 In the **Work Plane** toolbar, click **Conversions** and choose **Thicken**.

2 Select the object **proj1** only.

3 In the **Settings** window for **Thicken**, locate the **Options** section.

4 In the **Total thickness** text field, type `1.5`.

5 Click **Build Selected**.

Extrude 3 (ext3)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 Select the **Reverse direction** checkbox.

4 Click **Build Selected**.

Difference 1 (dif1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **uni1** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Click to select the **Activate Selection** toggle button for **Objects to subtract**.

5 Select the object **ext3** only.

6 Click **Build Selected**.

Work Plane 4 (wp4)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 In the **z-coordinate** text field, type `8`.

Work Plane 4 (wp4) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 4 (wp4) > Projection 1 (proj1)

1 In the **Work Plane** toolbar, click **Projection**.

2 In the **Settings** window for **Projection**, locate the **Projection** section.

3 From the **Project** list, choose **Selected edges**.

4 Click the **Paste Selection** button for **Entities to project**.

5 In the **Paste Selection** dialog, type `dif1: 14, 15, 18, 38, 52, 62, 76, 91` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Projection**, click **Build Selected**.

Work Plane 4 (wp4) > Convert to Solid 1 (csol1)

1 In the **Work Plane** toolbar, click **Conversions** and choose **Convert to Solid**.

2 Select the object **proj1** only.

3 In the **Settings** window for **Convert to Solid**, click **Build Selected**.

Extrude 4 (ext4)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
0.5
1

4 Select the **Reverse direction** checkbox.

5 Click **Build Selected**.

Work Plane 5 (wp5)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **dif1**, select Boundary 20 only.

Work Plane 5 (wp5) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 5 (wp5) > Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `0.8`.

4 In the **Height** text field, type `2`.

5 Locate the **Position** section. From the **Base** list, choose **Center**.

6 In the **xw** text field, type `8`.

7 In the **yw** text field, type `-0.5`.

8 Click **Build Selected**.

Work Plane 5 (wp5) > Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **r1**, select Points 1–4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `0.4`.

5 Click **Build Selected**.

Work Plane 5 (wp5) > Array 1 (arr1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Array**.

2 Select the object **fil1** only.

3 In the **Settings** window for **Array**, locate the **Size** section.

4 In the **xw size** text field, type `4`.

5 Locate the **Displacement** section. In the **xw** text field, type `1.2`.

6 Click **Build Selected**.

Work Plane 5 (wp5) > Mirror 1 (mir1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Mirror**.

2 Click in the **Graphics** window and then press Ctrl+A to select all objects.

3 In the **Settings** window for **Mirror**, locate the **Input** section.

4 Select the **Keep input objects** checkbox.

5 Click **Build Selected**.

Work Plane 5 (wp5) > Rectangle 2 (r2)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `5`.

4 In the **Height** text field, type `1.5`.

5 Locate the **Position** section. In the **yw** text field, type `-0.5`.

6 From the **Base** list, choose **Center**.

7 Click **Build Selected**.

Work Plane 5 (wp5) > Fillet 2 (fil2)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **r2**, select Points 1–4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `0.75`.

5 Click **Build Selected**.

Extrude 5 (ext5)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
2

4 Select the **Reverse direction** checkbox.

5 Click **Build Selected**.

Difference 2 (dif2)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **dif1** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Click to select the **Activate Selection** toggle button for **Objects to subtract**.

5 Select the object **ext5** only.

6 Click **Build Selected**.

Work Plane 6 (wp6)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **dif2**, select Boundary 1 only.

Work Plane 6 (wp6) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 6 (wp6) > Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `10`.

4 In the **Height** text field, type `1.5`.

5 Locate the **Position** section. In the **xw** text field, type `-30`.

6 In the **yw** text field, type `-0.5`.

7 From the **Base** list, choose **Center**.

8 Click **Build Selected**.

Work Plane 6 (wp6) > Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **r1**, select Points 1–4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `0.5`.

5 Click **Build Selected**.

Work Plane 6 (wp6) > Array 1 (arr1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Array**.

2 Select the object **fil1** only.

3 In the **Settings** window for **Array**, locate the **Size** section.

4 In the **xw size** text field, type `2`.

5 Locate the **Displacement** section. In the **xw** text field, type `13`.

6 Click **Build Selected**.

Extrude 6 (ext6)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
2

4 Select the **Reverse direction** checkbox.

5 Click **Build Selected**.

Difference 3 (dif3)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **dif2** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Click to select the **Activate Selection** toggle button for **Objects to subtract**.

5 Select the object **ext6** only.

6 Click **Build Selected**.

Work Plane 7 (wp7)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **ext4**, select Boundary 7 only.

Work Plane 7 (wp7) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 7 (wp7) > Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type `3`.

4 In the **Height** text field, type `0.4`.

5 Locate the **Position** section. From the **Base** list, choose **Center**.

6 In the **yw** text field, type `58`.

7 Click **Build Selected**.

Work Plane 7 (wp7) > Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click **Fillet**.

2 On the object **r1**, select Points 1–4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type `0.2`.

5 Click **Build Selected**.

Extrude 7 (ext7)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 Select the **Reverse direction** checkbox.

4 Click **Build Selected**.

Difference 4 (dif4)

1 In the **Geometry** toolbar, click  **Booleans and Partitions** and choose **Difference**.

2 Select the object **ext4** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Click to select the  **Activate Selection** toggle button for **Objects to subtract**.

5 Select the object **ext7** only.

6 Click  **Build Selected**.

Work Plane 8 (wp8)

1 In the **Geometry** toolbar, click  **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **dif3**, select Boundary 30 only.

Work Plane 8 (wp8) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 8 (wp8) > Rectangle 1 (r1)

1 In the **Work Plane** toolbar, click  **Rectangle**.

2 In the **Settings** window for **Rectangle**, locate the **Size and Shape** section.

3 In the **Width** text field, type 20.

4 In the **Height** text field, type 20.

5 Locate the **Position** section. From the **Base** list, choose **Center**.

6 In the **xw** text field, type 14.

7 In the **yw** text field, type -44.

8 Click  **Build Selected**.

Work Plane 8 (wp8) > Fillet 1 (fil1)

1 In the **Work Plane** toolbar, click  **Fillet**.

2 On the object **r1**, select Points 1–4 only.

3 In the **Settings** window for **Fillet**, locate the **Radius** section.

4 In the **Radius** text field, type 5.

5 Click  **Build Selected**.

Extrude 8 (ext8)

1 In the **Model Builder** window, right-click **Case and Screen** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
2

4 Select the **Reverse direction** checkbox.

5 Click **Build Selected**.

Difference 5 (dif5)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **dif3** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Click to select the **Activate Selection** toggle button for **Objects to subtract**.

5 Select the object **ext8** only.

6 Click **Build Selected**.

Partition Domains 1 (pard1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 On the object **dif5**, select Domain 1 only.

3 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

4 From the **Partition with** list, choose **Extended faces**.

5 Click the **Paste Selection** button for **Planar, cylindrical, or spherical faces**.

6 In the **Paste Selection** dialog, type `dif5: 26, 33 dif4: 7` in the **Selection** text field.

7 Click **OK**.

8 In the **Settings** window for **Partition Domains**, click **Build Selected**.

Work Plane 9 (wp9)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard1**, select Point 3 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard1**, select Point 1 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 Click the **Wireframe Rendering** button in the **Graphics** toolbar.

9 On the object **pard1**, select Point 29 only.

Work Plane 10 (wp10)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard1**, select Point 21 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard1**, select Point 20 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard1**, select Point 48 only.

Partition Domains 2 (pard2)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 Click the **Paste Selection** button for **Domains to partition**.

4 In the **Paste Selection** dialog, type `pard1: 1-4` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

7 From the **Work plane** list, choose **Work Plane 9 (wp9)**.

8 Click **Build Selected**.

Partition Domains 3 (pard3)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 Click the **Paste Selection** button for **Domains to partition**.

4 In the **Paste Selection** dialog, type `pard2: 1, 3, 5, 7` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Partition Domains**, click **Build Selected**.

Work Plane 11 (wp11)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard3**, select Point 50 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard3**, select Point 49 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard3**, select Point 56 only.

9 Click **Build Selected**.

Work Plane 12 (wp12)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard3**, select Point 190 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard3**, select Point 189 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard3**, select Point 195 only.

9 Click **Build Selected**.

Work Plane 11 (wp11)

In the **Model Builder** window, collapse the **Global Definitions** > **Geometry Parts** > **Case and Screen** > **Work Plane 11 (wp11)** node.

Partition Domains 4 (pard4)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 Click the **Paste Selection** button for **Domains to partition**.

4 In the **Paste Selection** dialog, type `pard3: 2, 4, 6-12` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Partition Domains**, click **Build Selected**.

Partition Domains 5 (pard5)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 Click the **Paste Selection** button for **Domains to partition**.

4 In the **Paste Selection** dialog, type `pard4: 2, 4, 6-12, 16` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

7 From the **Work plane** list, choose **Work Plane 11 (wp11)**.

8 Click **Build Selected**.

Work Plane 13 (wp13)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard5**, select Point 188 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard5**, select Point 186 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard5**, select Point 187 only.

Work Plane 14 (wp14)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard5**, select Point 152 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard5**, select Point 150 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard5**, select Point 151 only.

Partition Domains 6 (pard6)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 From the **Work plane** list, choose **Work Plane 13 (wp13)**.

4 On the object **pard5**, select Domain 17 only.

5 Click **Build Selected**.

Partition Domains 7 (pard7)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 On the object **pard6**, select Domain 17 only.

3 In the **Settings** window for **Partition Domains**, click **Build Selected**.

Work Plane 15 (wp15)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard7**, select Point 200 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard7**, select Point 199 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard7**, select Point 132 only.

Work Plane 16 (wp16)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **pard7**, select Point 198 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **pard7**, select Point 197 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **pard7**, select Point 130 only.

Partition Domains 8 (pard8)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 From the **Work plane** list, choose **Work Plane 15 (wp15)**.

4 On the object **pard7**, select Domains 17 and 24 only.

5 Click **Build Selected**.

Partition Domains 9 (pard9)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 On the object **pard8**, select Domains 17 and 25 only.

3 In the **Settings** window for **Partition Domains**, click **Build Selected**.

Work Plane 17 (wp17)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **dif4**, select Point 27 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **dif4**, select Point 25 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **dif4**, select Point 22 only.

Work Plane 18 (wp18)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Vertices**.

4 On the object **dif4**, select Point 21 only.

5 Click to select the **Activate Selection** toggle button for **Second vertex**.

6 On the object **dif4**, select Point 19 only.

7 Click to select the **Activate Selection** toggle button for **Third vertex**.

8 On the object **dif4**, select Point 16 only.

Partition Domains 10 (pard10)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 In the **Settings** window for **Partition Domains**, locate the **Partition Domains** section.

3 From the **Work plane** list, choose **Work Plane 17 (wp17)**.

4 On the object **dif4**, select Domains 1 and 2 only.

5 Click **Build Selected**.

Partition Domains 11 (pard11)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Domains**.

2 On the object **pard10**, select Domains 1 and 2 only.

3 In the **Settings** window for **Partition Domains**, click **Build Selected**.

Partition Edges 1 (pare1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pard9**, select Edge 351 only.

3 In the **Settings** window for **Partition Edges**, click **Build Selected**.

Partition Faces 1 (parf1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare1**, select Boundary 180 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare1**, select Points 201 and 220 only.

6 Click **Build Selected**.

Partition Edges 2 (pare2)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf1**, select Edge 129 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 In the table, enter the following settings:

Relative arc length parameters
0.05

5 Click **Build Selected**.

Partition Edges 3 (pare3)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare2**, select Edges 124 and 134 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **pare2**, select Point 133 only.

6 Click **Build Selected**.

Partition Edges 4 (pare4)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare3**, select Edge 283 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 In the table, enter the following settings:

Relative arc length parameters
0.98

5 Click **Build Selected**.

Partition Edges 5 (pare5)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare4**, select Edges 118, 346, and 392 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **pare4**, select Point 158 only.

6 Click **Build Selected**.

Partition Faces 2 (parf2)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare5**, select Boundaries 79, 150, and 175 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare5**, select Points 59, 159, 200, and 222 only.

6 Click **Build Selected**.

Partition Faces 3 (parf3)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **parf2**, select Boundaries 84 and 88 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **parf2**, select Points 134–136 only.

6 Click **Build Selected**.

Partition Edges 6 (pare6)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf3**, select Edges 119 and 123 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **parf3**, select Point 134 only.

6 Click **Build Selected**.

Partition Faces 4 (parf4)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare6**, select Boundaries 79 and 81 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare6**, select Points 134–136 only.

6 Click **Build Selected**.

Partition Edges 7 (pare7)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf4**, select Edges 258, 262, and 362 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **parf4**, select Points 135, 138, and 224 only.

6 Click **Build Selected**.

Partition Faces 5 (parf5)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare7**, select Boundaries 138, 140, and 183 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare7**, select Points 135, 138, 143, 144, 211, and 227 only.

6 Click **Build Selected**.

Partition Edges 8 (pare8)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.
2 On the object **parf5**, select Edge 7 only.
3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.
4 From the **Type of specification** list, choose **Vertex projection**.
5 On the object **parf5**, select Points 6, 8, 14, and 16 only.
6 Click **Build Selected**.

Partition Edges 9 (pare9)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.
2 On the object **pare8**, select Edge 2 only.
3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.
4 From the **Type of specification** list, choose **Vertex projection**.
5 On the object **pare8**, select Points 6, 9, 16, and 19 only.
6 Click **Build Selected**.

Partition Faces 6 (parf6)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.
2 On the object **pare9**, select Boundary 1 only.
3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.
4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.
5 On the object **pare9**, select Points 6 and 9 only.
6 Click **Build Selected**.

Partition Faces 7 (parf7)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.
2 On the object **parf6**, select Boundary 19 only.
3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.
4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.
5 On the object **parf6**, select Points 10 and 13 only.
6 Click **Build Selected**.

Partition Faces 8 (parf8)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **parf7**, select Boundary 23 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **parf7**, select Points 18 and 21 only.

6 Click **Build Selected**.

Partition Faces 9 (parf9)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **parf8**, select Boundary 30 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **parf8**, select Points 22 and 25 only.

6 Click **Build Selected**.

Partition Edges 10 (pare10)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf9**, select Edges 13, 34, 37, and 58 only.

3 In the **Settings** window for **Partition Edges**, click **Build Selected**.

Partition Faces 10 (parf10)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare10**, select Boundary 23 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare10**, select Points 16 and 19 only.

6 Click **Build Selected**.

Partition Edges 11 (pare11)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf10**, select Edges 28, 34, and 38 only.

3 In the **Settings** window for **Partition Edges**, click **Build Selected**.

Partition Faces 11 (parf11)

1 In the **Geometry** toolbar, click  **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare11**, select Boundaries 23 and 25 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the  **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare11**, select Points 18–20 only.

6 Click  **Build Selected**.

Partition Edges 12 (pare12)

1 In the **Geometry** toolbar, click  **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf11**, select Edge 7 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 In the table, enter the following settings:

Relative arc length parameters
0.93

5 Click  **Build Selected**.

Partition Edges 13 (pare13)

1 In the **Geometry** toolbar, click  **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare12**, select Edge 67 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 In the table, enter the following settings:

Relative arc length parameters
0.18

5 Click  **Build Selected**.

Partition Edges 14 (pare14)

1 In the **Geometry** toolbar, click  **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare13**, select Edges 2 and 61 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **pare13**, select Points 4 and 36 only.

6 Click **Build Selected**.

Partition Faces 12 (parf12)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare14**, select Boundaries 1 and 37 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare14**, select Points 4, 5, 37, and 38 only.

6 Click **Build Selected**.

Partition Edges 15 (pare15)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf12**, select Edges 13 and 74 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **parf12**, select Points 7 and 35 only.

6 Click **Build Selected**.

Partition Faces 13 (parf13)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare15**, select Boundaries 16 and 38 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare15**, select Points 5, 8, 36, and 39 only.

6 Click **Build Selected**.

Partition Edges 16 (pare16)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf13**, select Edges 136 and 139 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 In the table, enter the following settings:

Relative arc length parameters
0.2

5 Click **Build Selected**.

Partition Edges 17 (pare17)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare16**, select Edges 139 and 193 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **pare16**, select Points 95 and 224 only.

6 Click **Build Selected**.

Partition Faces 14 (parf14)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare17**, select Boundary 75 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare17**, select Points 95, 96, 225, and 226 only.

6 Click **Build Selected**.

Partition Edges 18 (pare18)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf14**, select Edge 194 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **parf14**, select Points 147 and 151 only.

6 Click **Build Selected**.

Partition Edges 19 (pare19)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare18**, select Edge 195 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **pare18**, select Points 149 and 154 only.

6 Click **Build Selected**.

Partition Faces 15 (parf15)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare19**, select Boundary 120 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare19**, select Points 147, 150, 153, and 156 only.

6 Click **Build Selected**.

Partition Edges 20 (pare20)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **parf15**, select Edges 195 and 284 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 In the table, enter the following settings:

Relative arc length parameters
0.28

5 Click **Build Selected**.

Partition Edges 21 (pare21)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Edges**.

2 On the object **pare20**, select Edges 194 and 291 only.

3 In the **Settings** window for **Partition Edges**, locate the **Positions** section.

4 From the **Type of specification** list, choose **Vertex projection**.

5 On the object **pare20**, select Points 145 and 172 only.

6 Click **Build Selected**.

Partition Faces 16 (parf16)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Partition Faces**.

2 On the object **pare21**, select Boundaries 120 and 151 only.

3 In the **Settings** window for **Partition Faces**, locate the **Partition Faces** section.

4 Click to select the **Activate Selection** toggle button for **Vertices defining curve segments**.

5 On the object **pare21**, select Points 145, 146, 173, and 174 only.

6 Click **Build Selected**.

Partition Domains 1 (pard1), Partition Domains 10 (pard10), Partition Domains 11 (pard11), Partition Domains 2 (pard2), Partition Domains 3 (pard3), Partition Domains 4 (pard4), Partition Domains 5 (pard5), Partition Domains 6 (pard6), Partition Domains 7 (pard7), Partition Domains 8 (pard8), Partition Domains 9 (pard9), Partition Edges 1 (pare1), Partition Edges 10 (pare10), Partition Edges 11 (pare11), Partition Edges 12 (pare12), Partition Edges 13 (pare13), Partition Edges 14 (pare14), Partition Edges 15 (pare15), Partition Edges 16 (pare16), Partition Edges 17 (pare17), Partition Edges 18 (pare18), Partition Edges 19 (pare19), Partition Edges 2 (pare2), Partition Edges 20 (pare20), Partition Edges 21 (pare21), Partition Edges 3 (pare3), Partition Edges 4 (pare4), Partition Edges 5 (pare5), Partition Edges 6 (pare6), Partition Edges 7 (pare7), Partition Edges 8 (pare8), Partition Edges 9 (pare9), Partition Faces 1 (parf1), Partition Faces 10 (parf10), Partition Faces 11 (parf11), Partition Faces 12 (parf12), Partition Faces 13 (parf13), Partition Faces 14 (parf14), Partition Faces 15 (parf15), Partition Faces 16 (parf16), Partition Faces 2 (parf2), Partition Faces 3 (parf3), Partition Faces 4 (parf4), Partition Faces 5 (parf5), Partition Faces 6 (parf6), Partition Faces 7 (parf7), Partition Faces 8 (parf8), Partition Faces 9 (parf9), Work Plane 10 (wp10), Work Plane 11 (wp11), Work Plane 12 (wp12), Work Plane 13 (wp13), Work Plane 14 (wp14), Work Plane 15 (wp15), Work Plane 16 (wp16), Work Plane 17 (wp17), Work Plane 18 (wp18), Work Plane 9 (wp9)

1 In the **Model Builder** window, under **Global Definitions** > **Geometry Parts** > **Case and Screen**, Ctrl-click to select **Partition Domains 1 (pard1)**, **Work Plane 9 (wp9)**, **Work Plane 10 (wp10)**, **Partition Domains 2 (pard2)**, **Partition Domains 3 (pard3)**, **Work Plane 11 (wp11)**, **Work Plane 12 (wp12)**, **Partition Domains 4 (pard4)**, **Partition Domains 5 (pard5)**, **Work Plane 13 (wp13)**, **Work Plane 14 (wp14)**, **Partition Domains 6 (pard6)**, **Partition Domains 7 (pard7)**, **Work Plane 15 (wp15)**, **Work Plane 16 (wp16)**, **Partition Domains 8 (pard8)**, **Partition Domains 9 (pard9)**, **Work Plane 17 (wp17)**, **Work Plane 18 (wp18)**, **Partition Domains 10 (pard10)**, **Partition Domains 11 (pard11)**, **Partition Edges 1 (pare1)**, **Partition Faces 1 (parf1)**, **Partition Edges 2 (pare2)**, **Partition Edges 3 (pare3)**, **Partition Edges 4 (pare4)**, **Partition Edges 5 (pare5)**, **Partition Faces 2 (parf2)**, **Partition Faces 3 (parf3)**, **Partition Edges 6 (pare6)**, **Partition Faces 4 (parf4)**, **Partition Edges 7 (pare7)**, **Partition Faces 5 (parf5)**, **Partition Edges 8 (pare8)**, **Partition Edges 9 (pare9)**, **Partition Faces 6 (parf6)**, **Partition Faces 7 (parf7)**, **Partition Faces 8 (parf8)**, **Partition Faces 9 (parf9)**, **Partition Edges 10 (pare10)**, **Partition Faces 10 (parf10)**, **Partition Edges 11 (pare11)**, **Partition Faces 11 (parf11)**, **Partition Edges 12 (pare12)**, **Partition Edges 13 (pare13)**, **Partition Edges 14 (pare14)**, **Partition Faces 12 (parf12)**, **Partition Edges 15 (pare15)**, **Partition Faces 13 (parf13)**, **Partition Edges 16 (pare16)**, **Partition Edges 17 (pare17)**, **Partition Faces 14 (parf14)**, **Partition Edges 18 (pare18)**,

Partition Edges 19 (pare19), **Partition Faces 15 (parf15)**, **Partition Edges 20 (pare20)**, **Partition Edges 21 (pare21)**, and **Partition Faces 16 (parf16)**.

2 Right-click and choose **Group**.

Partitions

In the **Settings** window for **Group**, type `Partitions` in the **Label** text field.

CASE AND SCREEN

In the **Model Builder** window, collapse the **Global Definitions** > **Geometry Parts** > **Case and Screen** node.

BATTERY

1 In the **Model Builder** window, under **Global Definitions** right-click **Geometry Parts** and choose **3D Part**.

2 In the **Settings** window for **Part**, type `Battery` in the **Label** text field.

3 Locate the **Units** section. From the **Length unit** list, choose **mm**.

Block 1 (blk1)

1 In the **Geometry** toolbar, click  **Block**.

2 In the **Model Builder** window, expand the **Battery** node, then click **Block 1 (blk1)**.

3 In the **Settings** window for **Block**, locate the **Size and Shape** section.

4 In the **Width** text field, type `35`.

5 In the **Depth** text field, type `75`.

6 In the **Height** text field, type `4.5`.

Battery

1 In the **Geometry** toolbar, click  **Selections** and choose **Explicit Selection**.

2 On the object **blk1**, select Domain 1 only.

3 In the **Settings** window for **Explicit Selection**, type `Battery` in the **Label** text field.

4 Locate the **Color** section. From the **Color** list, choose **Color 19**.

CAMERA

1 In the **Model Builder** window, under **Global Definitions** right-click **Geometry Parts** and choose **3D Part**.

2 In the **Settings** window for **Part**, type `Camera` in the **Label** text field.

3 Locate the **Units** section. From the **Length unit** list, choose **mm**.

Block 1 (blk1)

1 In the **Geometry** toolbar, click  **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type `25`.

4 In the **Depth** text field, type `25`.

5 In the **Height** text field, type `5.5`.

6 Click  **Build Selected**.

Work Plane 1 (wp1)

In the **Geometry** toolbar, click  **Work Plane**.

Work Plane 1 (wp1) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 1 (wp1) > Circle 1 (c1)

1 In the **Work Plane** toolbar, click  **Circle**.

2 In the **Settings** window for **Circle**, locate the **Size and Shape** section.

3 In the **Radius** text field, type `4`.

4 Locate the **Position** section. In the **xw** text field, type `8`.

5 In the **yw** text field, type `8.5`.

Work Plane 1 (wp1) > Array 1 (arr1)

1 In the **Work Plane** toolbar, click  **Transforms** and choose **Array**.

2 Select the object **c1** only.

3 In the **Settings** window for **Array**, locate the **Size** section.

4 In the **xw size** text field, type `2`.

5 In the **yw size** text field, type `2`.

6 Locate the **Displacement** section. In the **xw** text field, type `10`.

7 In the **yw** text field, type `10`.

8 Click  **Build Selected**.

Extrude 1 (ext1)

1 In the **Model Builder** window, right-click **Camera** and choose **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **Distances** section.

3 In the table, enter the following settings:

Distances (mm)
0.5

4 Click **Build Selected**.

Difference 1 (dif1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Difference**.

2 Select the object **blk1** only.

3 In the **Settings** window for **Difference**, locate the **Difference** section.

4 Click to select the **Activate Selection** toggle button for **Objects to subtract**.

5 Select the object **ext1** only.

6 Click **Build Selected**.

Extrude 2 (ext2)

1 In the **Geometry** toolbar, click **Extrude**.

2 In the **Settings** window for **Extrude**, locate the **General** section.

3 From the **Extrude from** list, choose **Faces**.

4 On the object **dif1**, select Boundaries 8, 11, 18, and 21 only.

5 Locate the **Distances** section. In the table, enter the following settings:

Distances (mm)
5

6 Select the **Reverse direction** checkbox.

7 Click **Build Selected**.

Work Plane 2 (wp2)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **ext2**, select Boundary 4 only.

Work Plane 2 (wp2) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 2 (wp2) > Square 1 (sq1)

1 In the **Work Plane** toolbar, click **Square**.

2 In the **Settings** window for **Square**, locate the **Size** section.

3 In the **Side length** text field, type 2.

4 Locate the **Position** section. In the **xw** text field, type -12.5.

5 In the **yw** text field, type -12.5.

6 Click **Build Selected**.

Work Plane 2 (wp2) > Array 1 (arr1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Array**.

2 Select the object **sq1** only.

3 In the **Settings** window for **Array**, locate the **Size** section.

4 In the **xw size** text field, type 2.

5 In the **yw size** text field, type 2.

6 Locate the **Displacement** section. In the **xw** text field, type 23.

7 In the **yw** text field, type 23.

8 Click **Build Selected**.

9 Click **Build Selected**.

Union 1 (uni1)

1 In the **Model Builder** window, right-click **Camera** and choose **Booleans and Partitions** > **Union**.

2 Click in the **Graphics** window and then press Ctrl+A to select both objects.

3 In the **Settings** window for **Union**, click **Build Selected**.

Camera

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type Camera in the **Label** text field.

3 Click the **Select All** button in the **Graphics** toolbar.

4 Locate the **Color** section. From the **Color** list, choose **Color 6**.

Camera - Attachments

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type Camera - Attachments in the **Label** text field.

3 Locate the **Entities to Select** section. From the **Geometric entity level** list, choose **Boundary**.

4 On the object **uni1**, select Boundaries 4, 6, 48, and 49 only.

OTHER COMPONENTS

1 In the **Model Builder** window, under **Global Definitions** right-click **Geometry Parts** and choose **3D Part**.

2 In the **Settings** window for **Part**, type `Other Components` in the **Label** text field.

3 Locate the **Units** section. From the **Length unit** list, choose **mm**.

Block 1 (blk1)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type `17`.

4 In the **Depth** text field, type `112`.

5 In the **Height** text field, type `1.5`.

Block 2 (blk2)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type `35`.

4 In the **Depth** text field, type `12`.

5 In the **Height** text field, type `1.5`.

6 Locate the **Position** section. In the **x** text field, type `17`.

Block 3 (blk3)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type `10`.

4 In the **Depth** text field, type `24`.

5 In the **Height** text field, type `1.5`.

6 Locate the **Position** section. In the **x** text field, type `17`.

7 In the **y** text field, type `88`.

Block 4 (blk4)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type `52`.

4 In the **Depth** text field, type `12`.

5 In the **Height** text field, type 2.

6 Locate the **Position** section. In the **z** text field, type -2.

7 Click **Build Selected**.

Block 5 (blk5)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type 17.

4 In the **Depth** text field, type 20.

5 In the **Height** text field, type 2.5.

6 Locate the **Position** section. In the **y** text field, type 20.

7 In the **z** text field, type -2.5.

Block 6 (blk6)

1 In the **Geometry** toolbar, click **Block**.

2 In the **Settings** window for **Block**, locate the **Size and Shape** section.

3 In the **Width** text field, type 17.

4 In the **Depth** text field, type 35.

5 In the **Height** text field, type 2.5.

6 Locate the **Position** section. In the **y** text field, type 60.

7 In the **z** text field, type -2.5.

8 Click **Build Selected**.

Work Plane 1 (wp1)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane type** list, choose **Face parallel**.

4 On the object **blk1**, select Boundary 4 only.

Work Plane 1 (wp1) > Plane Geometry

In the **Model Builder** window, click **Plane Geometry**.

Work Plane 1 (wp1) > Square 1 (sq1)

1 In the **Work Plane** toolbar, click **Square**.

2 In the **Settings** window for **Square**, locate the **Size** section.

3 In the **Side length** text field, type 2.

4 Locate the **Position** section. In the **xw** text field, type `-18.5`.

5 In the **yw** text field, type `-56`.

Work Plane 1 (wp1) > Square 2 (sq2)

1 In the **Work Plane** toolbar, click  **Square**.

2 In the **Settings** window for **Square**, locate the **Size** section.

3 In the **Side length** text field, type `2`.

4 Locate the **Position** section. In the **xw** text field, type `6.5`.

5 In the **yw** text field, type `-56`.

Work Plane 1 (wp1) > Square 3 (sq3)

1 In the **Work Plane** toolbar, click  **Square**.

2 In the **Settings** window for **Square**, locate the **Size** section.

3 In the **Side length** text field, type `2`.

4 Locate the **Position** section. In the **xw** text field, type `6.5`.

5 In the **yw** text field, type `54`.

Work Plane 1 (wp1) > Square 4 (sq4)

1 In the **Work Plane** toolbar, click  **Square**.

2 In the **Settings** window for **Square**, locate the **Size** section.

3 In the **Side length** text field, type `2`.

4 Locate the **Position** section. In the **xw** text field, type `-43.5`.

5 In the **yw** text field, type `54`.

Work Plane 1 (wp1) > Square 5 (sq5)

1 In the **Work Plane** toolbar, click  **Square**.

2 In the **Settings** window for **Square**, locate the **Size** section.

3 In the **Side length** text field, type `2`.

4 Locate the **Position** section. In the **xw** text field, type `-43.5`.

5 In the **yw** text field, type `44`.

6 Click  **Build Selected**.

Work Plane 1 (wp1)

1 In the **Model Builder** window, under **Global Definitions** > **Geometry Parts** > **Other Components** click **Work Plane 1 (wp1)**.

2 In the **Settings** window for **Work Plane**, click  **Build Selected**.

Other 1

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type `Other 1` in the **Label** text field.

3 On the object **blk1**, select Domain 1 only.

4 On the object **blk2**, select Domain 1 only.

5 On the object **blk3**, select Domain 1 only.

6 Locate the **Color** section. From the **Color** list, choose **Color 11**.

Other 2

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type `Other 2` in the **Label** text field.

3 On the object **blk4**, select Domain 1 only.

4 On the object **blk5**, select Domain 1 only.

5 On the object **blk6**, select Domain 1 only.

6 Locate the **Color** section. From the **Color** list, choose **Color 9**.

Other Components

1 In the **Geometry** toolbar, click **Selections** and choose **Union Selection**.

2 In the **Settings** window for **Union Selection**, type `Other Components` in the **Label** text field.

3 Locate the **Input Entities** section. Click **Add**.

4 In the **Add** dialog, in the **Selections to add** list, choose **Other 1** and **Other 2**.

5 Click **OK**.

Union 1 (uni1)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Union**.

2 Select the objects **blk1**, **blk2**, **blk3**, and **wp1** only.

3 In the **Settings** window for **Union**, click **Build Selected**.

Form Assembly (fin)

1 In the **Geometry** toolbar, click **Booleans and Partitions** and choose **Form Assembly**.

2 Click **Build All**.

Board - Attachments

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type `Board - Attachments` in the **Label** text field.

3 Locate the **Entities to Select** section. From the **Geometric entity level** list, choose **Boundary**.

4 On the object **fin**, select Boundaries 10, 12, 25, 27, and 28 only.