INSTRUCTIONAL MODULES DEMONSTRATING BUILDING ENERGY ANALYSIS USING A BUILDING INFORMATION MODEL

Module 1: Building Model Creation

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In this module:

• The design and floor plan of the building to be studied is selected.

• A tablet PC is used to generate two-dimensional concept sketches.

• Using the sketches, a three-dimensional building information model is created in Autodesk Revit Architecture. A step-by-step build strategy is included.

• A camera is added to generate a photo-realistic rendering of the final building model.
Building Selection

• the Jacobs House
• designed by Frank Lloyd Wright in 1936
• located in Madison, Wisconsin
• 1550 ft²
• two bedrooms, one bathroom

Source: http://www.dgunning.org/architecture/Wisc/jacobs1.htm
Building Selection

A floor plan of the building was found online.

Digital Sketching

The floor plan is brought into Sketchbook Pro, a digital sketching program, using a tablet PC. Here, layers can be sketched on top of the floor plan to help visualize the building’s three dimensional form. The three colors sketched here represent the building’s three different roofline elevations.


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Digital Sketching

A second layer consisting of building dimensions is added for the purpose of creating the building information model. All dimensions shown are in feet.

Finally, the original floor plan layer is turned off, leaving a clean sketch for model creation.

Autodesk Revit Architecture allows different build strategies for creating a building information model. One type of strategy is to create the building element by element, until the building realizes an overall shape. An example of this type of strategy is shown below.
Another strategy is to define the building’s overall shape first, and then add elements to building faces. In Revit, these shapes are called **conceptual masses**. This type of strategy will be used to create the building model for this study.
The private wing of the building, consisting of the bedrooms and study, can be drawn first. Select the **Massing & Site** tab and then **In-Place Mass**. Create a 2D sketch that looks like the one to the left. Exact dimensions can be found in Appendix A.
Conceptual Mass

Highlight the 2D sketch and choose **Create Solid Form, Finish Mass**.
Select a 3D view of the new block.
Once in a 3D view, select the block and choose **Edit In-Place**.
Conceptual Mass

Place your cursor toward the center of the top surface so that the entire surface is highlighted as shown.
Select the top surface, and the block’s height parameter is displayed.
Conceptual Mass

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Change the default height of 20’ to the desired height of 7 ½’.
Conceptual Mass

The block will update to reflect the new change.
The second wing, corresponding to the public space or living area, can be sketched next. This will be another conceptual massing object. The living area’s mass can be extruded to a height of 9 ½’.
Conceptual Mass

The final mass, representing the kitchen and restroom area, can be extruded to a height of 11 ½’.
Conceptual Mass

Above, an isometric view is shown of the three conceptual masses.
Masses can be edited to reflect more complex geometric features. The figure above shows a cantilevered section near the kitchen and a small recessed area toward the back of the building that need to be added to the massing model.
To modify one of the mass objects, highlight the mass and selecting **Modify → Edit In-Place**.
Select the surface that requires editing. Here, the face that will become the cantilevered section is selected.
Using the line tools, a 4’ high by 16’ wide rectangle can be sketched on the selected surface.
Using Create Void Form, a new void block can be extruded into the existing solid block.
Editing a Mass Object

The extrusion depth can be changed to 2′, resulting in the void shown here.
Selecting **Finish Mass** will subtract the void from the existing solid block.
The same process can be used to create the recessed area toward the back of the building. For dimensions, see Appendix A.
Joining Mass Objects

The individual masses can be merged into one mass using the **Join** command, found under the **Modify** tab of Revit. Blocks are joined by selecting **Join**, followed by the two blocks to be connected. Here, the private and public space masses have been joined.
Joining Mass Objects

The massing model is finished by joining the kitchen and restroom space to the public and private spaces.
The fully-joined massing model is shown above.
Three colored outlines are superimposed on top of the mass, illustrating how the three dimensional model has evolved from the original 2D concept sketch.
Adding floors to the mass object involves two steps. First, the bottom faces of the mass must be defined as “mass floors.” To do this, highlight all the bottom faces of the mass and select **Modify | Mass ➔ Mass Floors**.
Next, highlight the newly-defined mass floors and select **Massing & Site → Floor** by face. Note that the horizontal surface below the cantilevered wall must be defined as a floor element, as wall elements cannot be added to horizontal faces.
Walls can be added by applying them to mass faces. Wall material properties can be changed to be, for example, brick or wood as shown above.
Curtain walls can be added in the same way. Under wall properties, select **Curtain Wall → Exterior Glazing**.
If a wall material is not constant for an entire face, it must be split. Using **Modify → Split Element**, the indicated wall can be split into two different sections. The one section is left as a wooden exterior wall and the other section is changed to an Exterior Glazing element using the Properties window.
The default width of the Exterior Glazing elements is too wide for this building. Using the Properties window, grid sizes can be reduced. Here the vertical grid spacing has been adjusted to 2'.
Adding Elements by Face

The building is shown with all exterior walls. Since the mass objects are no longer needed they can be hidden in the view. To do this, highlight either one massing object, right-click, and select **Hide in View → Category**, or highlight all masses and select **Hide in View → Elements**.
Mullions can be added to the curtain walls by selecting curtain wall grid lines and applying a **Mullion** element.
Adding Elements by Face

Windows and exterior doors can be added in either a 2D plan view or a 3D view. Custom sizes can be created using the Properties window.
Adding Elements by Face

Interior walls and doors are added in a similar way.
Adding a Roof

Although roofs can be added directly to mass faces, due to the building’s large overhangs it is easier to sketch them separately. Select **Home → Roof → Roof by Footprint**, and draw the first roof using the line tool. Dimensions are shown in Appendix B.
Adding a Roof

Sketch the second roof over the building’s living area...
Adding a Roof

... and the third roof over the kitchen and restroom.

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A topography can be added in addition to site components, such as trees. These can both be accessed under the **Massing & Site** tab in Revit. Topography data points can be imported from a survey, or they can be created within the program.
In order to generate a more realistic view of the final geometric model, a perspective view can be generated.

First, a camera must be created. In a 3D view, Select **View → Camera** and move the camera to the desired viewing angle.
Creating a Perspective View

The camera generates the view shown above.
Perspective View of Building Construction

Click through the following slides to see a perspective view of the build process from the ground up.

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Perspective View of Building Construction
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Creating a Rendered View

To generate a realistic 2D image of the building, select View → Render.

A dialog box will pop up with many different options for the render. For the quality setting, be aware that settings higher than medium may take a significant amount of time (> 1 hour) to render.
Creating a Rendered View

Click to see a rendered view of the final geometric model.
Creating a Rendered View
Appendix A – Block Dimensions
Appendix A – Block Dimensions
Appendix A – Block Dimensions
Appendix A – Block Dimensions
Appendix A – Block Dimensions

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Appendix B – Roof Dimensions
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