**TinkerCad Course – Instructors’ Notes**

1. Course goals (15 minutes)
   1. Introduce TinkerCad and 3D design concepts
   2. Establish an ongoing “support network” for graduates of the course.
   3. Provide a “Glossary of Terms” for TinkerCad users as a “reference resource.”
2. Introduction to TinkerCad (60 minutes)
   1. The User Interface, Logging In
      1. <https://www.lynda.com/Tinkercad-tutorials/Using-exercise-files/371319/420571-4.html>
      2. Requires the Chrome Web browser.
      3. Log into: [www.tinkercad.com](http://www.tinkercad.com) and log in.
      4. Click on “Start Tinkering Now.”
      5. When you begin, you will be invited to view a series of Tinkercad course videos. We recommend you view them.
      6. To start Tinkercad, click on the Tinkercad Logo in the upper left corner.
      7. Click on “Create a New Design” to get started with a blank grid.
      8. Other
   2. Navigation Around the Work Area
      1. The Workplane.
      2. File name is assigned by the software.
      3. View Controls: Zoom-in, Zoom-out, Plane orientation.
      4. Tool Bar on top: File Functions, Edit, Help, Un-Do, Re-Do, Adjust, Group, Un-Group, & Shapes Panel.
      5. Add an object to the Workplane.
      6. Use the navigation icons to move around object, zoom, select, etc.
      7. Alternatively: Use Mouse Commands (see Quick Commands sheet). Orbit, Zoom & Pan. Click on the “?” to refresh memory.
      8. Other
   3. Grid Setup (Lower Right-hand are of Workplane).
      1. Units of Measure (millimeters or inches; millimeters are preferred), Workplane width & height, Snap grid (I use 0.1 mm).
   4. Other
   5. Other
3. Adding & Moving Shapes (15 minutes)
   1. The “Primitives” of Shapes Panel.
   2. Moving objects. Using “arrow” keys; “shift” for 10 times the movement value.
   3. Scaling & Changing Dimensions: using “Grips,” will change the size and can modify the shape. Use the “Alt” key to scale relative to the center point, and use the “Shift” key for overall uniform scaling.
   4. Rotating Shapes: “Curved Arrows” for rotating in three planes. Cursor closer to object for standardized increments, further our calls for 10 increments.
   5. Selecting Strategies. Using Command Box to select all objects, Shift + Left Click, Control + Left Click, Command Box to Select All and De-select some to see objects inside one another.
   6. Using the Work Plane Tool.
      1. To center and align objects.
      2. To change the angle through which you want to pull or push objects.
   7. Measuring & Using the Ruler Tool
   8. Grouping & Ungrouping & Locking objects.
   9. Using the Hole Object
   10. Align Tool. Select all objects with a bounding box, Adjust->Align.
   11. Mirror Tool
       1. Alternate Technique: Click & drag grips through the middle axis, not very accurate.
       2. Adjust->Mirror: three mirroring axes available.
   12. Other
   13. Other
4. Creating & Duplicating Patterns (15 minutes)
   1. Copying Objects
      1. First way: Copy (Ctl + C)->Paste (Ctl + V)
      2. Second Way: Edit->Copy, Edit->Paste
      3. By orbiting 900, one can change the direction of the copied objects.
      4. To copy to a new document, Rt Click->Design->New->Project (creates a new tab), Ctl + P->Select New Tab->Ctl + V
      5. Copies in a rotating fashion: Alt + C->click on Rotate Grips->Pull out copies (e.g.making gear teeth in a circle).
      6. Copy & Paste in Place: Alt + C-> Alt + Shift + V to paste in place. You then, need to pull the second copy out as the copied version will exist in the same place as the original source object. Alternate option is Edit->Duplicate->pull copy & source objects apart.
      7. To make a duplicate “complete design.” Design->Duplicate (right click to get “New Tab” option)->Select new tab->Ctl V to place an identical design in another tab.
   2. Creating Linear Patterns
      1. “Smart Duplicate:” Edit->Duplicate->Arrow Keys to move->Edit Duplicate to make repeating patterns.
   3. Creating Circular Patterns
      1. “Smart Duplicate:” Edit->Duplicate->Pull Out->Rotate->Ctl D->Ctl D
      2. Use the Rotate Grips to put a rotation in the copied objects, see https://www.lynda.com/Tinkercad-tutorials/Creating-circular-pattern/371402/422792-4.html
   4. Other
   5. Other
5. Shape Generators (30 minutes)
   1. Introducing Shape Generators
      1. Generally, from code. Some will allow you to “View Code” to see how they are constructed.
      2. Drag sliders to change the size.
   2. Extension Generator
      1. Under “Tinkercad” Shapes->Extrusion
      2. Modify the shape in the “Inspector” window.
      3. Make designs in different axes by rotating the object on the Workplane.
   3. Polygon Generator
      1. Objects are parameterized so they can be altered with sliders in the “Inspector Window,”
   4. Text Generator
      1. Tinkercad->Text
      2. Change fonts, heights and introduce unique text.
   5. Image Generator
      1. Starts out as a flat, square space.
      2. Incorporate any jpeg image file you like.
      3. Toggle between embossing and engraving.
   6. Community Generators
      1. Import 2D SVG files into Tinkercad.
      2. Import->File
      3. If problems arise, modify the file in Adobe Illustrator.
      4. Modify the file.
      5. Save as a .svg file.
      6. Jpeg and PNG files as well.
   7. Grouping objects
      1. Click and drag somewhere on the Workplane to create a “Selection Box.”
      2. Select Adjust->Align to have several ways to align the objects.
      3. When all you want is selected and aligned, click on “Group.”
   8. Using shape combinations and “shape-to-hole-to-shape-to-hole” combinations with “Combine” to create complex geometry see <https://www.lynda.com/Tinkercad-tutorials/Creating-complex-shapes/164026/174885-4.html> as an example.
   9. Other
   10. Other
6. Cutting and using Planes (10 minutes)
   1. Normally, begin with a Box shape.
   2. Pull the top of the Box shape into “negative space” to cut at the “Z = 0” workplane.
   3. Then Group them.
7. Importing Files (10 minutes)
   1. Importing SVG Files
      1. Import->File->Browse to file
   2. Importing STL Files
      1. Import->File->Browse to file
      2. It will appear in the middle of the workplane. You may have select everything else and drag them out of the way to view the file.
      3. Other
   3. Cut-Copy-Paste to transfer files between design files.
   4. Other
   5. Other
8. Finishing
   1. Splitting Objects (60 minutes)
      1. <https://www.youtube.com/watch?v=1SwSqROgLpY&t=292s>
      2. Shape->Box->Hole->Half-way through model->Duplicate Hole Box->Drag Outer-most slider past the end of the opposite box and beyond model->Zoom into Hole Box and click on object inside to select it->Ctl D->Shift Click->Group->Shift-Click Other End->Group and you have both sides of the model separated.
   2. Chamfers
      1. <https://www.youtube.com/watch?v=J-6X6in6Las>
      2. Create Hole Box🡪Raise and Angle it->Group->Repeat as Needed
      3. Chamfers and Fillets are more complex in “mesh-based” design packages as compared to “vector-based” design packages.
   3. Fillets
      1. <https://www.youtube.com/watch?v=J-6X6in6Las>
      2. Round Roof Object->Split in Half->Convert to Hole shape->Use it to remove a half circle out of a Box shape->Group->Convert Reformed Box to a Hole->use this form to fashion round edges on your model by Grouping.
   4. Shell Object
      1. <https://www.youtube.com/watch?v=xxtONgRdxDY&t=86s>
      2. Duplicate Model in Place->Make Inner Object Slightly Smaller->Change the Inner Object to Hole->Group the two objects to take out the inside with a uniform offset distance.
   5. Naming & Sharing Files (or Models)
      1. Files will be automatically named in TinkerCad.
      2. Design->Properties->Change the and Visibility as appropriate.
      3. Alternatively, to change the name and save on your computer, download the file and rename it.
   6. Downloading Your Design
      1. Main Menu->Design->Download for 3D Printing
   7. Other
   8. Other
9. Design Concepts (45 minutes)
   1. Drawings and sketches
      1. Think in orthogonal views: Top, side, Back, Cross-section and Mid-section.
      2. Graphing paper
      3. Model sizes consistent with the “build platform” of your printer and the amount of time to print the object.
   2. Measurement
      1. In millimeters
      2. Digital calipers
         1. Calibration
         2. Inside versus outside measurements
         3. Plunger for measuring depth
         4. Shoulder for measuring “distance from normal”
      3. Metric ruler
   3. Design Tips
      1. Design from the center of the workplane, unless you plan to “mirror.”
      2. Walls in widths of extrudant
      3. 90+% of strength comes from <25% filling
   4. Anticipate problems
      1. Overhangs
         1. 450 rule
         2. Supports mean part rework.
      2. Advantages and disadvantages of various 3D printing materials
      3. Part orientation
      4. Sectioning into sub-components to avoid problems
      5. Printing orientation and strength
      6. Avoid supports, rafts and brims when possible
      7. Other
   5. Other
   6. Other
10. Downloading TinkerCad files to your printer (5 minutes)
11. Preparing to print (30 minutes)
    1. Orientation
    2. Supports, Rafts and Brims
    3. Warping
    4. Material selection
    5. Printing speed, heat and precision/resolution
    6. Review slicing
12. Individual design project (180 minutes)
    1. Project proposals.
    2. Review for feasibility and difficulty
    3. Discuss overall “design strategy.”
    4. Design
13. Print design
    1. Setup for printing
    2. Print
14. Re-design as appropriate
15. Re-print
16. Other