SIGGRAPH Teaching GEM:

The Corkscrew:
An Intermediate Polygon Modeling Tutorial using Autodesk Maya

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This module is written as a supplement for instructors to learning 3D modeling using Autodesk Maya, however, it could be beneficial for any highly motivated student. If used by an instructor, you can use the first three parts as part of your instruction, then give part 4 (see below) and the tutorial video and files to the students.

Introduction:

3D Design and Animation students are confronted with a daunting array of technical and aesthetic knowledge to assimilate.

One of the first modeling techniques taught is a "revolve". With the revolve students often make wine glasses and wine bottles. This tutorial provides the knowledge to add to the scene by teaching intermediate polygon modeling skills as well as demonstrating how to make a corkscrew.

This project based learning module requires the student to combine and apply critical thinking, research, modeling tools, a good workflow, and aesthetic knowledge. *Part 1* covers research, *Part 2* modeling guidelines, *Part 3* workflow and finally *Part 4* is a tutorial and video which covers polygon modeling processes which focuses on modifying and combining the necessary polygon primitives needed to build a digital cork screw.

This module has the following files:
- Written modeling module
- Four reference images of a corkscrew
- Quicktime video showing the modeling process
- Completed Maya Binary file of the corkscrew

Part 1: Research

In a lab, divide students into groups. Have them research construction tools and techniques involved with the creation of man-made objects. You may wish to compile a list of objects / pictures that the students gather.

Manmade Construction Categories for Research:

- Carpentry techniques:
    - Chamfer vs. bevel
    - Lathing, and extrusions
    - Connecting surfaces
- Plastic: Injection molding
- Glass working
- Ceramics: "Throwing", slip casting
- Stone: Sculpting / cutting, polishing
- Metal working. Moulds, extrusions, lathes, die-casting
- Woven / Cloth

Questions for Discussion:

How does material type affect object construction for physical objects?

What advantages / drawbacks are there to this type of construction?

Not everything is modeled by hand – what are other methods of generating 3D models?

What types of organisms have been modeled with math?

Think of the modeling tools have you tried in Maya. In what ways are they similar to the real world tools, and what ways different?

Part 2: Pre-Production Planning and 3D Modeling Guidelines

Before starting any modeling project, pre-planning your workflow can save large amounts of time. You may want to give the students a copy of Part 2. Ask them to read the ten rules of thumb to help them build their scene.

1. **Analysis:** How is the object constructed in real life?
    a. Extrusions
    b. Subtractive
    c. Modular
        i. Combination of shapes
        ii. Jointed
    d. 100% Symmetrical: Revolved/lathed
    e. Asymmetrical: Sculpted
    f. Organic: Fractals & Chaotic systems
    g. Real Life vs. 3D Modeling for Animation: Though much of the time edge flows in for 3D objects are similar to real life objects – there are exceptions.

2. **Reference:** Do I have enough visual reference? (at least 3 images):
    a. Front
    b. Side
    c. Three-quarter view
    d. Top down

3. **Organization**
    a. Creating project folders and setting your project
    b. Name your objects. Make sure you name the object on the transform node
    c. Organize or Delete Construction Curves / History
    d. Organize your scene into layers

4. **Blocking: (Massing)**
    a. Simplicity: Keep it simple (low poly) as long as you can
    b. Primitive shapes can get you most of the way there

5. **Repetition:** Is there repetition within the object?
    a. If yes, then model only ½ or ¼ of the object and mirror the object

6. **Flow:** Geometry flow follows the object topology
    Most objects are built from materials that have a flow to the material. Understanding how and where this material will bend as well as any underlying structure (example human flesh covers muscle and bones) is critical to developing a model that will animate properly.

7. **Surface Uniformity vs. Surface Complexity**:
    a. Keep it quads (or triangles). You should attempt to have all of the polygons in the model all have four (quad) or three (tri) vertices. This is especially important for when you smooth the geometry or when the mesh needs to deform.

     b. Some areas don't need heavy polygon counts. Look for large areas that have a similar topology, or low detail. While using the edge loop tool maintains quads based geometry, you may be adding additional unnecessary geometry to areas that don't need it. In advanced polygon modeling you will be taught techniques for re-directing edge-flows in order to optimize geometry where you need it as well as to give resolution and definition only to the that need it.

8. **Edges:** Slightly rounded edges (no 100% hard edges)
Real world objects have edges that catch light. In 3D, unless you create geometry along hard edges your 3D model may not light in a realistic manner.

9. **Texture:** What can be done with textures?
Discuss when you would use:
     a. The sculpt geometry tool vs. a bump map
     b. Model holes vs. using a transparency map

10. **Creativity vs. Reinventing the Wheel**
Developing the ability to think like a modeler requires working in the digital medium. However, it is not necessary to "reinvent the wheel" – there are many books and tutorials that will help you learn the tools and correct modeling techniques.

Part 3: Workflow and Speed

Being able to create efficient, quality 3D models quickly is critical. Studios can no longer afford to hire people only "familiar with the tools" they must hire people who are specialists in one or several areas.

While a key to mastery of any subject remains practice, learning to use the tools, efficiency is a key to achieving the work speed needed to succeed in this field.

All things being equal between two students who are good 3D modelers, the one who knows hot keys and marking menus will finish projects much more quickly then someone who uses the standard graphical user interface (GUI).

A few areas for a student to focus on:

1. **Spend time going through all of the modeling tools and the sub-options**

2. **Context Sensitive Marking Menus and Hotkeys**

Maya has been designed to have context sensitive menus that give easy access to the specific tools when modeling, thus dramatically speeding up workflow.

Platform Usage Note: Maya on *Mac vs. PC platforms*. In most cases the Ctrl key on the PC will be substituted for the "apple" key on the Macintosh platform. For further clarification please review the *Window/ Settings/Preferences /Hotkey* editor in Maya.

Test out the following two keystroke combinations when doing various Maya operation and review what tools show-up in the marking menus.

- Ctrl (PC)+ RMB (**R**ight **M**ouse **B**utton)
- Command (Mac) + RMB (**R**ight **M**ouse **B**utton)
- Shift+RMB

Maya also has a huge number of presets. Learn as many of the hotkeys and context sensitive menus as possible to speed up workflow.

Press F1 to access help and do a search for "hotkeys" for a useful list!

Pressing: Ctrl+Shift (PC) / Command +Shift (Mac) on a menu item will create an icon in the shelf.

Some basic hotkeys:

Q / W / E / R / T / Y Select / Translate / Rotate / Scale / Repeat
D   Toggle pivot point

X / C / V	Snapping to grid / curve / point
F / A	Focus in on an area / View all
S	Set a key-frame

In addition to all of the hotkeys, and marking menus Maya's interface is completely customizable. You can map any function to a key or a combination of keys to create a personalized workflow. As mentioned previously, do this using the hotkey editor: *Window/ Settings/Preferences /Hotkey*

A further benefit of learning hotkeys is reduced mouse use. Make sure to take frequent breaks, as well as using an ergonomic set-up. This can reducing the risk of carpal tunnel problems.

3. Timing and Self Monitoring

Time yourself while modeling. This will help you better understand and benchmark your modeling speed. Much of a student's future work depends on the ability to make accurate estimates for how long it will take to create models.

Watch yourself when you model. Do you constantly mouse around the Maya interface to select the next tool? Train yourself to avoid doing this. Learn or create a hotkey or marking menu to avoid excessive mousing to menus.

Part 4: Model a corkscrew

Tutorials can help you learn rules of thumb for modeling objects while also helping you learn specific techniques with the modeling tools in Maya.

The following tutorial builds a low-polygon (non-smoothed) corkscrew. It uses multiple modeling techniques and focuses on an efficient workflow to complete the project.

Before starting the tutorial, review the list of rules in Part 2.

- What tools do you think you will use in Maya to build the corkscrew?
  (see the next page for a list of the tools and techniques you will use)
- Can you identify which guidelines go into the modeling for each of the parts of building the corkscrew?

Before starting any polygon model:

Turn on your Poly Count and Border Edges. These tools help identify modeling issues such as un-merged vertices before they become serious:

- Display / Heads Up Display / Poly Count
- Display / Polygons / Border Edges

Tools and techniques covered in this tutorial:

Extrude, combine, mirror polygon, bridge, append to polygon, insert edge loop, edge loop selection, Ring Loop selection, convert selection (vertices to faces and edges to faces), snapping vertices

One key technique to look for in this tutorial is to notice how several primitive objects can be combined to help you build your object.

Create a new project:
- File / Project / New
- Use the default folders and save your file
- Save often and in versions (example Corkscrew01, Corkscrew02, etc). This way, if something goes wrong, with the file you can go to a previous version

Insert your reference Images:
- In each view panel:
  - View / Image Plane / Import Image

Tip: For your future projects it is useful to have the same resolution for each reference image. This makes the reference images easier to line-up in your viewports.

Start Modeling:

Watch the video then refer to the notes below as reference of the procedures used.

Top Piece:
- Start with a cube. Extrude a face and follow ½ way around the shape.
- Use a cylinder cap for the flat plane near the top
- Mesh/Combine the two objects
- Connect the cylinder to the extrusion. Snap vertices (hotkey "v") then merge vertices. Or you can use the "merge vertex tool" (new in Maya 2010)
- Duplicate / mirror polygon to duplicate the two sides
- Extrude down from the cylinder caps
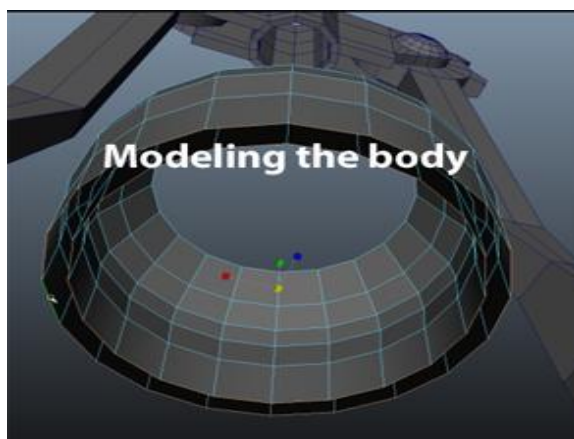
Create the Body:

Center Connection Plate
Create a new cylinder (10 sides), going up and down on the Y axis
Create another cylinder (14 sides) perpendicular to the first, with it's center on the Z axis
Snap 3 of the vertices on cylinder 2 to cylinder 1

Add edge loops so that the number of vertices match and Mesh/Combine the two objects.

Append / Bridge Between:
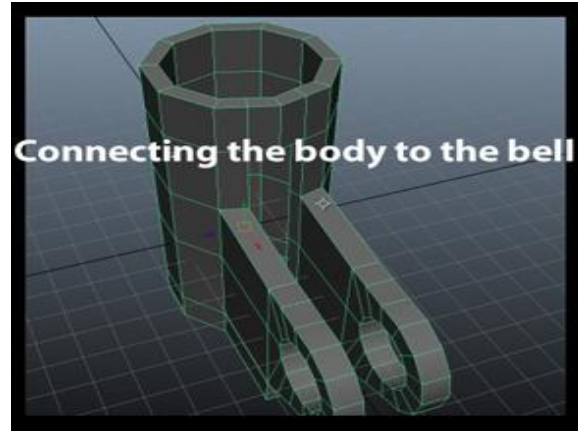- ¼ of a tube
- Box
- Modified Cylinder

Create the Arms:
- Create a cube
- Scale the subdivisions to they are even along the edges
- Extrude along the length of the arm
- Scale out the top
- Smooth

Create the Gear:
- Create a cylinder with 14 sides, and 2 caps
- Temporarily turn off "Keep Faces Together"
- Polygon Menu / Edit Mesh / Keep Faces Together (unchecked)
- Extrude the 6 Faces of the Gear

Combining the Gear to the Arms
- Mesh/Combine the gear and the arm
- Delete the extra faces where the two pieces of geometry connect
- Snap the vertices between the arm and the gear

Create the Joint / Screw
Create a cylinder
Extrude

Create the Bell: (bottom piece)
- Create a cylinder
- *Mesh / Combine* the cylinder to the top *connection plate*

Here are **two ways** to create the center piece which connects to the screw:

Revolve (lathe):
- Create CVs
- CV Curve Settings Linear
- Start on Snap the middle and the end to the center
- Revolve (set to create quad based polygons)

- Convert to a polygon (only necessary if you skipped the previous step ☺)

Cylinder:
- Create a cylinder with 12 subdivisions, and 10 height divisions
- Select every other edge going up the cylinder
- Ring loop select the edges
- Convert the edge selection to faces
- Extrude. Push in slightly (or in the Channel Box: Local Translate Z: -0.2)

Create the Corkscrew:
- Create a helix primitive
- Edge loop select the inner part of the helix
- Translate the selected edge inward toward the center of the helix
- Insert 4 edge loops to create a harder edge

Your Low-polygon corkscrew is complete!

If you want create a high polygon corkscrew that has rounded edges:
- Insert edge loops near edges that you want to be slightly rounded
- Mesh / Smooth

Please see the included example of the corkscrew with protected edges as well as the smoothed corkscrew model.

Now…build several additional objects to create a scene around the corkscrew

This could be a real life scene, or it could be something very fantastic. Imagine what the model would look like if:

- The corkscrew was a spaceship
- If it was opening a building shaped like a bottle?
- If the corkscrew anthropomorphized (could you give it humanoid / or robotic qualities)

Instructions for creating the scene:

- Group all of the pieces of the Corkscrew (Ctrl + G (PC) / (Command + G (MAC)
- Light the scene with a 3 point lighting system
- Apply simple shaders without textures on them
    - (unless you plan on laying out your UVs)
- Delete the history on your objects
- Name all of your objects.
- Create a camera
    - Set three keyframes on the camera of your scene from different views
- Render your scene from 3 views using Production Quality, and reflections