Objective
Explore the range of 3D printing and Prototyping technologies, and their application in modern industrial, design, and creative fields. Overview of 3D design and modeling techniques for modern Rapid Prototyping and Additive Manufacturing applications.

Concepts
Prototyping technologies, base materials, and their applications. 3D modeling and design techniques for manufacturing and product development. Successful modeling methodologies, topologies for exporting to printing, measurement techniques, and manufacturing tolerances. Overview of modeling software and modeling techniques, including procedural modeling.

Prerequisites
Any course prerequisites for the class. If you are unsure, please contact the ITP advisor

Instructor
Lance S. Winkel

Contacting the Instructor
Email Address: winkel@usc.edu
Telephone: 213.740.9956

Office Hours
Office Hours and location. OHE 530 H. Hours TBD

Lab Assistants
TBD

Lecture
1.5 hours per week

Lab
1.5 hours per week

Required Textbooks
Manufacturing Processes for Design Professionals by Rob Thompson

Optional Textbooks
Slides and Resources on USC Blackboard website

Website
Class materials are posted on the USC Blackboard website. https://blackboard.usc.edu/

Grading
15 weekly progress checks, 10 points each = 150 points
Initial Product Design = 20 points
Finished Product Model (prior to 3D printing) = 20 points
Final Project / Presentation / Physical Model = 60 points
Total = 250 points

Grading Scale
A  100-93
A-  92-90
Policies

Attendance: The course content and projects are so closely tied together; excessive absences will severely and negatively affect the learning process. Any student who misses three or more classes will fail the course.

Projects: All projects and weekly assignments are due at the start of class and are considered late 1/2 hour after class begins. Only one project or assignment may be turned in late. All other late projects will NOT be accepted unless pre-approved by the instructor. With the instructor’s approval, on time projects may be redone for additional credit but must be turned in by the following class session. The final project may not be turned in late.

Before logging off a computer, students must ensure that they have emailed or saved projects created during the class or lab session. Any work saved to the computer will be erased after restarting the computer. ITP is not responsible for any work lost.

ITP offers Open Lab use for all students enrolled in ITP classes. These open labs are held beginning the second week of classes through the last week of classes. Please contact your instructor for specific times and days for the current semester.

Incomplete and Missing Grades

Excerpts for this section have been taken from the University Grading Handbook, located at http://www.usc.edu/dept/ARR/grades/gradinghandbook/index.html. Please see the link for more details on this and any other grading concerns.

A grade of Missing Grade (MG) “should only be assigned in unique or unusual situations... for those cases in which a student does not complete work for the course before the semester ends. All missing grades must be resolved by the instructor through the Correction of Grade Process. One calendar year is allowed to resolve a MG. If an MG is not resolved [within] one year the grade is changed to [Unofficial Withdrawal] UW and will be calculated into the grade point average a zero grade points.

A grade of Incomplete (IN) “is assigned when work is no completed because of documented illness or other ‘emergency’ occurring after the twelfth week of the semester (or 12th week equivalency for any course scheduled for less than 15 weeks).”

Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section
11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

**Students with Disabilities**

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your course instructor (or TA) as early in the semester as possible. DSP is located in STU 301 and is open from 8:30am to 5:00pm, Monday through Friday. Website and contact information for DSP http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu
3D Design and Prototyping
ITP 415 (2 Units)

Course Outline
Subject to Change Throughout the Semester

Week 1 – Weekly Topic
- Survey of students and 3D animation experience
- Overview of course plan and objectives
- Sample work
  - Review fundamentals of 3D modeling (polygons and NURBS)

Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment/Project (If Applicable)
Project 1 - Reference: Find a simple object (bolt, mechanical part, gear, piston head, etc.) to serve as a resource in class. Find or shoot proportional reference images of the object (top, front, side, comparative scale if using two objects). Bring the object, a ruler, and digital image files for next class.

Week 2 – Basic Modeling
- Understanding 3D geometry
- Modeling workflows for Polygons
- Additive vs. Subtractive Tools
- Best Practices for Polygons

Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment/Project (If Applicable)
Project 1 - Introduction to Modeling: Using the proportional reference images, model the simple object as accurately as possible. Pay close attention to screw threading, mounting points, articulation points, and other details, etc.

Week 3 – Intermediate Modeling
- Understanding NURBS
- NURBS Surfaces advantages
- Curve and surface construction
- Clean and uniform topology
- Best Practices for NURBS

Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment (If Applicable)
Project 2 – NURBS: Build the exact same object from Project 1 using only NURBS geometry. The parts can be assembled from NURBS curves or from NURBS surface primitives, but should achieve the same level of physical detail.

Week 4 – Advanced Modeling
- Modeling workflows for NURBS and Polygons
- Conversion techniques
- NURBS to Polygons
- Polygons to NURBS
- Subdivision surfaces
- Best practices
- Preserving UV texturing coordinates throughout conversion

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 2 – Final cleanup and assembly: Use the most advantageous geometries from both Project 1 and Project 2, as well as conversion tools, and cleanup techniques. Assemble the master part in its entirety with no overlapping UV texture coordinates as a single uniform mesh object. Texture coordinates should look clean and make sense. Mesh should have uniform polygons and be manifold.

**Week 5 – Modeling for design and production**
- Moving Parts and Articulation
- Form and function
- Visualizing the assembly process

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 3 – Brainstorming and Concept: Design three unique parts or objects. Begin by identifying the purpose and function of the object. There should be something unique about the object’s function or a significant deviation from a conventional approach. Also, the designs should contain moving part, or articulation, or some form of interlocking pieces that will normally require post fabrication assembly.

**Week 6 – Modeling for manufacturing**
- Broad overview of manufacturing techniques
- Molding, sculpting, lathing, lofting, welding, cutting, drilling, gluing, etc.
- How manufacturing impacts design

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 3 – Previsualizing the design: Model a rough block-in of each part. These are fast and low detailed models, but should contain enough information and detail to describe form, function, silhouette, and help identify potential manufacturing and fabrication contingencies.

**Week 7 – 3D Design Fundamentals**
- Prominent Designers
- Franchises
- Success stories
- Pop culture
- Planar Surfaces
- Triangulation
Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment (If Applicable)
Project 3 – Final Design: Based on critique of the proposed design and previsualization models, pick one specific design to serve as the basis for the remainder of the course. Make necessary design changes. Add embellishments and style, resolve any lingering design concerns, and render it as series of scaled orthographic (top, front, side) profile images. Additionally, design a packaging, carriage, holster, or other interacting accessory that can fit or be fitted to the chosen designed product.

Week 8 – Starting a Production
- Early decision making criteria
- Knowing the product
- Vision vs. Reality
- Scale and cost

Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment (If Applicable)
Project 4 – Building the product: Begin manufacturing of the project. Progress checks due each week leading up to the print deadline Week 12.

Week 9 – Measurements and Scale
- Tolerances
- Initial scene set-up
- Roughing in the model

Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment (If Applicable)
Project 4 – Building the product: Begin manufacturing of the project. Progress checks due each week leading up to the print deadline Week 12.

Week 10 – Modeling to fit a master part
- Creating a part negative
- Bolts, Fasteners
- Interfacing and support
- Structure
- Range of motion

Reading (If Applicable)
See Blackboard for slides and assigned reading.

Assignment (If Applicable)
Project 4 – Building the product: Begin manufacturing of the project. Progress checks due each week leading up to the print deadline Week 12.

Week 11 – Prototyping and Printing Technologies
- Selective Laser Sintering (SLS)
- Direct Metal Laser Sintering (DMLS)
- Fused Deposition Modeling (FDM)
- Stereolithography (SLA)
- Laminated Object Manufacturing (LOM)
- Electron Beam Melting (EBM)
- 3D Printing (3DP)

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 4 – Critique: In class critique of model files. Based off of critique, clean up and refine any last changes to the product. Submissions must be prepared for print Week 12.

**Week 12 – Print Materials**
- Detailing
- Printing Resolutions and Tolerances
- Materials Properties (Temperature, Flexibility, Strength, Britteness)

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 4 – Conversion and Printing: Convert all parts into triangulated, planar, manifold, airtight meshes. Export to SLA format for final printing. Upload to online print service website for sample cost confirmation.

**Week 13 – Manufacturing and Molding**
- Injection Molding
- Projection Manufacturing
- Terms and standards for injection molding systems

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 5 – Visualization: Using the completed model to build a demonstration reel of either the assembly or operation of the designed device. Due for presentation along with finished printed parts Week 15.

**Week 14 – Processing and Cleanup**
- Workflows for printing
- Software and Drivers
- Formats for Printing (SLA, OBJ, CAD, etc.)
- Cleanup and airtight modeling
- Post and Export

**Reading (If Applicable)**
See Blackboard for slides and assigned reading.

**Assignment (If Applicable)**
Project 5 – Visualization: Cleanup and refine any remaining work. Presentations in class Week 15.

**Week 15 – 3D Printing**
- Print Lab setup
- Loading models and arranging print stage
- Printing
- Removing support material
Final Exam Details:

Product:
Design a product for printing. You can choose the form and function of those objects, but consider that the final product will be something that would be functional and structurally printable if manufactured. No 4th dimensional tesseract!

- The object should contain no less than four component parts.
- These can be parts for assembly and/or they can be parts that articulate:
  - For assembled parts, consider the method of assembly and specific details relating to fastening, screws, bolts, glues, adhesives, or any third party parts required to complete the assembly process.
  - For articulating parts, consider the range of motion, strength of connection, and any other specific details relating to its movement.

Planning:
Begin by brainstorming three (3) potential candidates for consideration. Research similar designs or products that have a similar use or demonstrate a similar set of functions. Consider any specific third party parts such as screws, bolts, or fasteners that may be incorporated into the design and impact its feasibility.

Production:
Based on the brainstorming phase and in-class feedback, determine a final candidate for production and build it using any and all techniques covered so far throughout the course.

Final Presentation:
Plan to present a 5-10 minute design to manufacturing presentation. Following your presentation, you will be leading the class through a discussion about your piece. Areas of discussion that can be included:

Design:
- Include major design considerations – size, use, function, etc.
- Primary influences, designers, or art styles you may have built from.
- Any specific aesthetic you were aiming for.
- Outside of just the limitations of print cost, what were the major production complexities you encountered?
• Make sure to keep any visual development assets and sources.

**Manufacture:**
• What is the hypothetical process for manufacturing?
• Are any outsourced components incorporated into the design?

**Function:**
• Define the process of user interaction and/or assembly
Visualization:

1. Lay out your objects into a scene.
2. Add materials, lights, and a limited set as appropriate to professionally stage your design/product.
3. Animate a quick assembly of the object and/or a nicely arranged product shot for it.
4. Set up a simple camera pass or turnaround.
5. Use the Mental Ray renderer in Maya to process the scene into a sequence of rendered images.
   Then use an appropriate program such as After Effects to turn that sequence of images into movie file (Quicktime, Sorensen 3).

Due Dates:

Week 13 – Concepts due
Week 14 – Printable models due
Week 15 – Presentation-ready models and scene assets due
Final Exam Session – Final materials due for presentation