USC Viterbi School of Engineering

3D Design and Prototyping

ITP 415 (3 Units)
Spring 2016

Catalogue Description	Explore the range of 3D printing and Prototyping technologies, and their application in modern industrial, design, and creative fields.
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. 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	ITP 215
Instructor	Lance S. Winkel E-mail: winkel@usc.edu Tel: 213.740.9959 Office Hours: Mondays / Wednesdays 9am-11:40am OHE 530 H Mondays / Thursdays 1-1:15pm OHE 540 following ITP 102 Tuesdays / Thursdays 9am-9:40am OHE 530 H
Hours	4 hours
Course Structure	• Details for projects, labs, and due dates are detailed in the syllabus below and also on Blackboard. • The Midterm Exam will be Week 6. • The Final Exam will be conducted at the time dictated in the Schedule of Classes. • There will be a capstone Final Project due for viewing during the first half of the Final Exam Session. • Details and instructions for all projects will be available on Blackboard. • For grading criteria of each assignment, project, and exam, see the Grading section below.
Textbook(s)	Recommended: Manufacturing Processes for Design Professionals by Rob Thompson Hardcover: 528 pages (ISBN: 978-0500513750)

Grading	Project 1a – Reference Measurement (10 points) Project 1b – Modeling from Reference (10 points) Project 2a – NURBS Parametric Modeling (10 points) Project 2b – Model cleanup and assembly (10 points) Project 3a – Print Model Brainstorming and Concept (10 points) Project 3b – Print Model Previsualization (10 points) Project 3c – Print Model Design Specification (10 points) Project 4a – Production A (10 points) Project 4b – Production B (10 points) Project 4c – Production C (10 points) Project 4d – Critique (10 points) Project 4e – Conversion and Printing (10 points) Project 5 – Presentation Reel (10 points) Finished Product Model (prior to 3D printing) = 20 points Final Project / Presentation / Physical Model = 40 points Midterm Exam: 20 points Final Exam: 40 points Total = 250 points
Grading Scale	Letter grades will be assigned according to the following scale: 93%+ A 90-92% A- 87-89% B+ 83-86% B 80-82% B- 77-79% C+ 73-76% C 70-72% C- 69 D+ 67-68 D 66 D- 65 and below F Half percentage points will be rounded up to the next whole percentage. So for instance, 89.5% is an A-, but 89.4% is a B+.
Homework	All homework will be submitted on Blackboard. Detailed instructions and resources for each assignment will be posted on Blackboard along. http://blackboard.usc.edu
Policies	*Make-up policy for exams:* To make up for a missed exam, the student must provide a satisfactory reason (as determined by the instructor) along with proper documentation. Make-up exams are generally only offered in emergency situations. Before logging off a computer, students must ensure that they have saved any work to either a USB drive or a service such as Dropbox. 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. Hours are listed at: http://itp.usc.edu/labs/.

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct/.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu/ or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* *http://emergency.usc.edu/* will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.

A Further Note on Plagiarism

NOTE: This is a custom blurb that I use in my classes. You can remove this if you don't want it.

In this class, all homework submissions will be compared with current, previous, and future students' submissions using MOSS, which is a code plagiarism identification program. If your code significantly matches another student's submission, you will be reported to SJACS with the recommended penalty of an F in the course.

It is okay to discuss solutions to specific problems with other students, but it is not okay to look through another student's code. It does not matter if this code is online or from a student you know, it is cheating. Do not share your code with anyone else in this or a future section of the course, as allowing someone else to copy your code carries the same penalty as you copying the code yourself.

Course Outline

Week 1 – Weekly Topic

Day 1

Survey of students and 3D animation experience
Overview of course plan and objectives
Sample work

Day 2

Review fundamentals of 3D modeling (polygons and NURBS)
Parametric modeling and Computer Aided Design

Reading

Manufacturing Processes for Design Professionals, Chapter 1
See Blackboard for slides and assigned reading.

Assignment/Project

Project 1a - Reference Measurement: 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

Day 1

Understanding 3D geometry
Modeling workflows for Polygons
Additive vs. Subtractive Tools

Day 2

Best Practices for constructing printable polygon meshes
Fundamental Structure vs. Ornamentation

Reading

Manufacturing Processes for Design Professionals, Chapter 2
See Blackboard for slides and assigned reading.

Assignment/Project

Project 1b - Modeling from Reference: 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

Day 1

Understanding NURBS
NURBS Surfaces advantages
Similarities and differences between NURBS and CAD drawings
Curve and surface construction
Clean and uniform topology

Day 2

Best Practices for NURBS
Illustrator, IGES, and other import/export pipelines

Reading

Manufacturing Processes for Design Professionals, Chapter 3
See Blackboard for slides and assigned reading.

Assignment

Project 2a – NURBS Parametric Modeling: 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

Day 1

Modeling workflows for NURBS and Polygons
Conversion techniques
NURBS to Polygons
Polygons to NURBS
Subdivision surfaces

Day 2

Best practices for geometry conversion
Texturing coordinates
Preserving UV texturing coordinates throughout conversion

Reading

Manufacturing Processes for Design Professionals, Chapter 4
See Blackboard for slides and assigned reading.

Assignment

Project 2b – Model 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

Day 1

Moving Parts and Articulation
Hinges
Ball and cocket
Flexibility and elasticity
Locks and fasteners

Day 2

Form and function
Visualizing the assembly process
Complex interactions and motorizations

Reading

Manufacturing Processes for Design Professionals, Chapter 5
See Blackboard for slides and assigned reading.

Assignment

Project 3a – Print Model 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

Day 1

Broad overview of manufacturing techniques
Molding, sculpting, lathing, lofting, welding, cutting, drilling, gluing, etc.

Day 2

How manufacturing impacts design
Factoring manufacturing back into the printing design process

Reading

Manufacturing Processes for Design Professionals, Chapter 6
See Blackboard for slides and assigned reading.

Assignment

Project 3b – Print Model Previsualization: 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

Day 1

Prominent Designers
Franchises
Success stories
Pop culture

Day 2

Planar Surfaces
Triangulation
Marketability

Reading

Manufacturing Processes for Design Professionals, Chapter 7
See Blackboard for slides and assigned reading.

Assignment

Project 3c – Print Model Design Specification: 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. Instructor will sign off on design specification

Week 8 – Starting a Production

Day 1

Early decision making criteria
Knowing the product
Vision vs. Reality
Scale and cost
Calculating the total cost

Day 2

Midterm Review

Reading

Manufacturing Processes for Design Professionals, Chapter 8
See Blackboard for slides and assigned reading.

Assignment

Project 4a – Production A: Begin manufacturing of the project. Progress checks due each week leading up to the print deadline Week 12.

Week 9 – Measurements and Scale

Day 1

Midterm Exam

Day 2

Tolerances
Initial scene set-up
Roughing in the model

Reading

Manufacturing Processes for Design Professionals, Chapter 9
See Blackboard for slides and assigned reading.

Assignment

Project 4b – Production B: 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

Day 1

Creating a part negative
Bolts, Fasteners
Threading (taps and dies)
Interfacing, support, and reinforcement

Day 2

Structural integrity
Range of motion

Reading

Manufacturing Processes for Design Professionals, Chapter 10
See Blackboard for slides and assigned reading.

Assignment

Project 4c – Production C: Begin manufacturing of the project. Progress checks due each week leading up to the print deadline Week 12.

Week 11 – Prototyping and Printing Technologies

Day 1

History of 3D Printing

Day 2

Overview of 3D 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

Manufacturing Processes for Design Professionals, Chapter 11
See Blackboard for slides and assigned reading.

Assignment

Project 4d – Critique: In class critique of model files. Based off of critique, clean up and refine any last changes to the product. Submissions mush be prepared for print Week 12.

Week 12 – Print Materials

Day 1

Detailing and ornamentation
Printing Resolutions and Tolerances

Day 2

Materials Properties (Temperature, Flexibility, Strength, Brittleness)

Reading

See Blackboard for slides and assigned reading.

Assignment

Project 4e – Conversion and Printing: Convert all parts into triangulated, planar, manifold, airtight meshes. Export to SLA format for final printing. Upload to online print service web site for sample cost confirmation.

Week 13 – Manufacturing and Molding

Day 1

Vacuum forming
Resin casting
Injection Molding
Terms and standards for injection molding systems

Day 2

Planning for injection molding
3D Printing for injection molding

Reading

See Blackboard for slides and assigned reading.

Assignment

Project 5 – Presentation Reel: 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

Day 1

Workflows for printing
Software and Drivers
Formats for Printing (SLA, OBJ, CAD, etc.)

Day 2

Cleanup and airtight modeling
Post and Export

Reading

See Blackboard for slides and assigned reading.

Assignment

Project 5 – Visualization: Cleanup and refine any remaining work. Presentations in class Week 15.

Week 15 – 3D Printing

Day 1

Print Lab setup
Loading models and arranging print stage
Printing

Day 2

Removing support material
Special topics
Remaining time will be Final Exam Study Session

Reading

Study slides on Blackboard

Assignment

Critiques and Presentations in class. Printing and other special topics.
See Blackboard for details and notes for Final Exam

Final Exam – Tuesday, May 10, 2-4pm, OHE 542

Multiple choice
Bring a pencil
Arrive early

Final Product 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 tesseracts!

- 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.
6. Then use an appropriate program such as After Effects to turn that sequence of images into movie file (QuickTime, Sorensen 3).

Due Dates:

Week 7 – Concepts due for approval
Week 12 – Printable models due
Week 15 – Final materials, presentation-ready models, and scene assets due for presentation.
Final Exam Session – TBD, See Schedule of Classes