USC Viterbi School of Engineering

Advanced 3D Modeling, Animation, and Special Effects

ITP305 (3 Units)

Catalogue Description	Advanced modeling, surfacing, and animation techniques for commercial visualization and animation applications. Dynamics, scripting, and advanced automation procedures for articulation and professional effects.
Objective	In this course, students build upon fundamental techniques to create professional quality imagery and motion. Students learn advanced animation construction, incorporation of and integration with external media, and techniques to automate and optimize development processes. Advanced modeling techniques such as NURBS modeling, advanced surfacing techniques such as specularity and sequenced mapping, and advanced animation and special effects including controllers, effectors, dynamics, and multiple emitters. In addition, students will be introduced to productivity and optimization techniques such as scripting and expressions. Students will also be introduced to a variety of compositing methods.
Prerequisites	ITP 215
Instructor	Lance S. Winkel E-mail: winkel@usc.edu Tel: 213/740.9959 Office: OHE 530 H Office Hours: Tue/Thur 8-10am, 2-3pm by appointment
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. Wednesday, May 9, 2-4 p.m. • 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: Digital Lighting & Rendering (3rd Edition) by Jeremy Birn (ISBN-13: 978-0321928986)

Grading	Rigid body collision = 15 points) Particle impact = 15 points) Giant Robot Model progress checks (3) = 10 points each (30 total) Giant Robot Model Complete = 20 points Giant Robot Rigging progress checks (2) = 10 points (20 total) Giant Robot Rigging Complete = 20 points Final project (See detailed instructions below) = 60 points Midterm Exam = 20 points Final Exam = 50 points Attendance and Participation = 30 points Total = 280 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

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 or source material. 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 work yourself.

Course Outline

Week 1 – Introduction to dynamic geometry

Day 1

Rigid Bodies Overview
Fields and dynamic movement
Workflow, baking animation, and processing efficiency

Day 2

Modeling fractured surfaces
Best practices for render quality (Hero) vs. dynamic stand-in (Stunt) geometry
Visual sleight of hand

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 1

Assignment/Project

Rigid Body Collision: Create a Rigid Body simulation of collapsing, destructing, or fracturing geometry. Model and dynamically process the sequence. Use at least 50 rigid solved objects. Bake the sequence out as keyframed animation.

Week 2 – Particle dynamics

Day 1

Understanding particle simulation and workflow
Particle tools and concepts: emitters, unique attributes, lifespan, and shaders
Defining look and behavior for particles

Day 2

Smoke, fire, rain, dust, sorcery, sparks, lasers, swarms, and other applications
Particle disk cache
Per particle attributes

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 2

Assignment/Project

Particle Impact: Use particles to enhance and add impact to an animation scene. Examples will vary based on scene concept. You may use previous models and animation. Fire and smoke for rockets. Smoke or dust trails at an impact or following the pressure wave of a speeding vehicle. Venting from a reactor. Lasers and awesome stuff. Demonstrate lifespan, per particle attributes, particle shaders, and disk cache.

Week 3 – Advanced modeling theory

Day 1

Forms that work well with Polygons
Forms that work well with NURBS
Setting up a scene for modeling
Image planes

Day 2

Mesh topology
Quad's (4-sided) vs. Tri's (3-sided) vs. multi-sided faces

2-manifold vs. non-manifold polygon geometry
Complicated meshes and Boolean modeling operations

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 3

Assignment

Giant Robot (Progress 1 of 4) – Design and prepare a character design for the Giant Robot. Create a project folder, set up the scene and scale, and begin modeling the Giant Robot. Main shapes of entire character should be blocked in. Due week 4.

Week 4 – Modeling with NURBS

Day 1

NURBS (Non-Uniform Rational B-Splines)
NURBS components (Control Vertices, Hulls, Spans/Sections, Curve Degree, Edit Points, U and V coordinates)
Curve-based modeling concepts and techniques

Day 2

Complex extrusions and lofts
Bi-Rails

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 4

Assignment

Giant Robot (Progress 2 of 4) – Add details to the Giant Robot using multiple techniques including NURBS. At least five (5) detail structures should use NURBS geometry. Due week 5.

Week 5 – Modeling cleanup and texture implications

Day 1

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

Day 2

Subdivision surfaces
Best practices
Preserving UV texturing coordinates throughout conversion

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 5

Assignment

Giant Robot (Progress 3 of 4) – Finish and clean up the geometry of the Giant Robot character for group critique in class. Objects should be named cleanly in preparation for the next phases of the project. Due week 6.

Week 6 – UV unwrapping and texturing

Day 1

In class critique of the Giant Robot models
UV Coordinates
UV Projections and unwrapping
NURBS vs. polygon UV coordinate space
Exporting UV snapshots to Photoshop
Materials Fundamentals

Day 2

Midterm Exam

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 6

Assignment

Giant Robot (Complete 4 of 4) – Unwrap the UV's of the Giant Robot, and assigning custom materials to each object. Create UV snapshots of each unwrapped object. Due week 7.

Week 7 – Automation and Movement

Day 1

Skeletons and hierarchies
Rigging for hard surfaces and multi-object models
Binding
Preparing geometry for rigging and animation
Review fundamental animation and performance principles

Day 2

Forward vs. Inverse Kinematics
Hierarchies: Parent -> Child Relationships
Skeletons and Joint Hierarchies
Organizing a complex character (defining what and how things move)
Creating a simple rig
Range of motion and types of motion

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 7

Assignment

Giant Robot Rig (Progress 1 of 3) – Cleanup models for rigging. Build a skeleton hierarchy to support the automation of the model. Bind the geometry. Due week 8.

Week 8 – Controlling Animation

Day 1

Float, Vector, Integer, and Boolean data types
Controllers
Driven Keys
Direct Connections

Day 2

Expressions, functions, and MEL
MEL format
Python/MEL format
Time, attribute, and mathematic operators

String, and Enum data types
Custom variables

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 8

Assignment

Giant Robot Rig (Progress 2 of 3) – Build all necessary controllers and secondary motion controls. Use expressions, set driven keys, and direct connections to manage these functions. Due week 9.

Week 9 – Constraints and Deformation

Day 1

Understanding animation constraints
Tranformations
Deformations
Blending between multiple constraints

Day 2

Planning advanced multi-nodal mechanical constraints
Turrets, treads, and synchronized mechanical structures
Avoiding breakage

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 9

Assignment

Giant Robot Rig (Complete 3 of 3) – Finish the rig. Refine any remaining control problems. Due week 10.

Week 10 – Visual Effects and Animation

Day 1

In class critique of the Giant Robot rigs
Adding visual effects to animated scenes
Shatters, explosions, and other types of effects

Day 2

Previs for VFX
View previous successful projects

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 10

Assignment

Begin the Final Project. Details on Blackboard. Progress checks due each week. Due during final exam session.

Week 11 – Render Layers and Render Passes

Day 1

Rendering engines (Mental Ray, Renderman, VRay)
Render Layers
Render Passes

Day 2

Overview of file formats and their application
R, G, B, A, Z, and other channels
Bit depth (8, 16, 32), integer vs. floating point, compression, and color

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 11

Assignment

Final Project progress check due week 12.
Break a lit scene down into its constituent render contribution passes. Separate render passes for each major scene element (minimum: environment, subject object, and background). Each pass should also contain diffuse, specular, reflection, lighting, shadow, and GI passes.

Week 12 – Compositing

Day 1

Introducing the Nuke interface
Node based compositing

Day 2

Read, merge, and write nodes
Merge arithmetic operators
Nuke script planning and layout strategies

Reading

Reference Slides
Digital Lighting & Rendering – Chapter 12

Assignment

Final Project progress check due week 13.
Using Nuke and the render passes from the previous assignment; reassemble the sequence to achieve the closest matching composite result. Once this is complete, use color correction and other layers to sweeten the sequence.

Week 13 – Compositing for dynamics

Day 1

Zdepth
Particle render passes and special topics
Black hole matte

Day 2

ID channels
Particle layers for special effects (heat blurs, atmospheric distortions, etc.)
Reasons to break out certain passes into a unique scene

Reading

Reference Slides

Assignment

Final Project progress check due week 14.

Week 14 – Advanced dynamics

Day 1

Fluid dynamics
nDynamics (nParticles, nCloth)

<u>Day 2</u>

Mapping fluids to particles
The overburn technique

<u>Reading</u>

Reference Slides

<u>Assignment</u>

Final Project progress check due week 15.

Week 15 – Final Rendering and Advanced Topics

<u>Day 1</u>

Final class critique
Putting the finishing touches on a completed scene
Rendering and post processing of a finished scene
Review of dynamics tools based on needs of projects

<u>Day 2</u>

Final Exam Review

<u>Reading</u>

Reference Slides

<u>Assignment</u>

Pull out all the stops to finish this Final project! The final should be at least 15 seconds long and be composed of at least three shots. This is a chance for you to use camera, shot selection, character performance, lighting, and effects to create a finished portfolio quality piece. Final output should be QuickTime format, Sorensen 3 or H.264 codec. I would like to collect project folders as well. Final Project due for viewing and in-class critique at start of our arranged Final Exam session.

Final Exam – Wednesday, May 9, 2-4 p.m.

Multiple choice
Bring a pencil
Arrive early

Final Project

<u>Due</u>

Due at start of our Final Exam session according to the Final Exam Schedule

Wednesday, May 9, 2-4 p.m.

<u>Details</u>

The final should be at least 15 seconds long and be composed of at least three shots. This is a chance for you to use camera, shot selection, character performance, lighting, and effects to create a finished portfolio quality piece.

Final output should be QuickTime format, Sorensen 3 or H.264 codec. I would like to collect project folders as well. Final Project due for viewing and in-class critique at start of our arranged Final Exam session.

The scene must include dynamic simulation and include at least two of the following techniques:

- Rigid bodies
- Particles
- Fluids
- Overburn
- nCloth

The scene should be rendered in multiple passes with particles rendered separately from the geometry and composited using After Effects or Nuke.

- Diffuse (normal)
- Reflection (add)
- Specular (add)
- Shadow (subtract)
- Hardware effects (if necessary)
- Software effects (if necessary)

Due at start of our Final Exam session according to the Final Exam Schedule

Assessment:

The Final project is worth 60 points. The Final project will be graded based on:

- Fifteen seconds long, three shots = 10 points
- Demonstrated effort = 10 points
- Complexity, range, and effective use of tools = 10 points
- Quality of the finished product
    - Performance = 20 points
    - Visual quality = 10 points