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| <b>Catalogue Description</b> | Developing a 3D animation from modeling to rendering: basics of surfacing, lighting, animation, and modeling techniques. Advanced topics: compositing, particle systems, and character animation. |
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| <b>Objective</b> | Fundamentals of 3D modeling, animation, surfacing, and special effects: Understanding the processes involved in the creation of 3D animation and the interaction of vision, budget, and time constraints. Developing an understanding of diverse methods for achieving similar results and decision-making processes involved at various stages of project development. Gaining insight into the differences among the various animation tools. Understanding the opportunities and tracks in the field of 3D animation. |
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| <b>Prerequisites</b> | Knowledge of any 2D paint, drawing, or CAD program |
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| <b>Instructor</b> | Lance S. Winkel<br>E-mail: <a href="mailto:winkel@usc.edu">winkel@usc.edu</a><br>Tel: 213/740.9959<br>Office: OHE 530 H<br>Office Hours:<br>Tue/Thur 8am-10am<br><br>Lab Assistants:<br>Qingzhou Tang: <a href="mailto:qingzhot@usc.edu">qingzhot@usc.edu</a> |
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| <b>Hours</b> | 4 hours |
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| <b>Course Structure</b> | <ul style="list-style-type: none"><li>• The Final Exam will be conducted at the time dictated in the Schedule of Classes.</li><li>• Details and instructions for all projects will be available on Blackboard.</li><li>• For grading criteria of each assignment, project, and exam, see the Grading section below.</li></ul> |
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| <b>Textbook(s)</b> | Blackboard<br>Autodesk Maya Documentation<br>Resources online and at Lynda.com and <a href="http://knowledge.autodesk.com">knowledge.autodesk.com</a><br>Adobe online resources where necessary for Photoshop and After Effects |
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**Grading** Planets = 10 points  
Cityscape 1 of 7 = 10 points  
Cityscape 2 of 7 = 10 points  
Cityscape 3 of 7 = 10 points  
Cityscape 4 of 7 = 10 points  
Cityscape 5 of 7 = 10 points  
Cityscape 6 of 7 = 10 points  
Cityscape 7 of 7 – Finished Rendered = 20 points  
Chess Animation 1 of 3 = 10 points  
Chess Animation 2 of 3 = 10 points  
Chess Animation 3 of 3 – Finished Rendered = 20 points  
Final project = 60 points  
Final Exam = 30 points  
Attendance and Participation = 30 points  
Total = 250 points

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**Grading Scale** Letter grades will be assigned according to the following scale:

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|--------------|----|
| 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+.

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**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>

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**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/>.

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## 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/departments/departments-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](http://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](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.

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### 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.

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# Course Outline

## Week 1 Tuesday – Syllabus and Course Introduction

- Survey of student and 3D animation experience
- Overview of course plan and objectives
- Autodesk Student Software and Licensing
- Lab Policies and Procedures
- Online resources: Highend3d.com, Learning-Maya.com, knowledge.autodesk.com, Lynda.com
- Supplemental learning resources and recommended reading

### Reading

Introduction to Maya – Chapter 1

### Project

Make an Autodesk account. Download and install Maya 2014 from Autodesk

## Week 1 Thursday – Syllabus and Course Introduction

- Introduction to the Maya GUI
- Configuring the user interface including hotkeys, interface color, marking menus, display modes, etc.
- Adjusting cameras, displays, and viewports
- Basic object creation
- Core 3D Concepts (XYZ, RGB)
- Cartesian Coordinates
- Right handed rule
- Basic 3D transforms (translation, rotation, scaling) and animation
- Maya's Online Help

### Project

Using the provided planets scene file, animate the orbit and revolution of each of the planets, moons around the solar system. Learn familiarity with the Maya interfaces, including object selection, navigation, setting animation keys, and basic transforms. Save the scene and submit it to blackboard.

## Week 2 Tuesday – Creating a 3D scene from primitives

- Further introduction to the Maya GUI
- Optimizing the interface for working efficiently
- Polygon components (vertices, edges, faces)
- Creating and editing geometry from primitives
- How modeling primitives relate to modern construction techniques
- Understanding form, function, and structure

### Reading

Introduction to Maya – Chapter 2

### Project

Cityscape (Week 1 of 7) - Create a metropolitan landscape from primitives and simple hierarchies. At least three separate building made with only polygon primitives, duplication, grouping, and parenting. Attempt to faithfully reproduce the most important details. See blackboard for specific details.

### **Week 2 Thursday – Creating a 3D scene from primitives**

- Arrayed Duplication
- Groups and Hierarchies
- Parent nodes
- Offset transforms
- Duplication vs. Instancing

#### **Project**

Cityscape (Week 1 of 7) – Continued

### **Week 3 Tuesday – Polygon mesh editing tools**

- Additive vs. subtractive modeling
- Manually manipulating component
- Selection strategies for selecting and isolating component transform
- Splitting polygons vs. deleting edges

#### **Reading**

Introduction to Maya – Chapter 3

#### **Project**

Cityscape (Week 2 of 7) - Populate the scene with at least three new sculpted polygon objects. These should complement the primitive models from the previous turn-in. For this phase of production we are focusing on sculpting through mesh editing techniques as detailed in class. One object should be a vehicle of some form. See blackboard for specific details.

### **Week 3 Thursday – Polygon mesh editing extrusion**

- Polygon extrusion
- Understanding the differences between tools and commands
- Using the show manipulator tool to influence and control extrusion
- Other hybrid tools (bevel, wedge, cut faces, etc)
- Building sample model from blueprint or technical reference

#### **Project**

Cityscape (Week 2 of 7) – Continued

### **Week 4 Tuesday – Materials and Texturing**

- Overview of the rendering pipeline
- Fundamental formulas and math functions (normal, tangents, cosines)
- Defining nodes and attributes
- Introduction to materials and shading groups
- Basic rendering nodes and attributes
- Lambert shader
- Building off of lambert with phong and blinn shaders

#### **Reading**

Introduction to Maya – Chapter 4

#### **Project**

Cityscape (Week 3 of 7) - Assign materials to the objects with the scene. Use the material properties to convey the appropriate type of physical look for the various

surfaces in your scene. Stone, metal, glass, wood, earth, sky, plastic, marble, etc. Make sure to include at least three materials that have 'specular' shading properties, at least one surface shader, and at least one material that uses incandescence. See blackboard for specific details.

#### **Week 4 Thursday – Basic Texturing**

- Introduction to textures
- Defining textures vs. materials
- Assigning textures to material attributes
- Texture nodes and utility nodes
- Sourced vs. procedural texture nodes and concepts for mathematically generated texturing.
- Understanding the four categories of shading nodes and how they work together to shape the rendered scene.

##### **Project**

Cityscape (Week 3 of 7) – Continued

#### **Week 5 Tuesday – Texturing and UV Coordinate Space**

- Understanding UV texture space
- Simple UV projection
- Similarities between manipulating UV coordinates and polygon components
- General workflow for UV unwrapping and export to image manipulation software.
- Best practices for solving texture wrapping problems on complex objects.

##### **Reading**

Introduction to Maya – Chapter 5

##### **Project**

Cityscape (Week 4 of 7) - Assign textures to the objects with the scene. A fully UV unwrapped vehicle or objects to support accurate texturing. Use the mesh projection tools and UV texture editor menus to manually align and sort out any problem UV areas for clean texturing. Use image editing programs to make sourced textures for color, bump, specular, and incandescence attributes. See blackboard for specific details.

#### **Week 5 Thursday – Texturing Pipeline and Texture Painting**

- Types of textures (color, specular, bump, and incandescence)
- Exporting UV template
- Creating textures using image manipulation software
- Techniques for layer based image manipulation
- Assigning textures to material attributes
- Reference libraries and resources for textures and materials

##### **Project**

Cityscape (Week 4 of 7) - Continued

#### **Week 6 Tuesday – Overview of cameras and optics**

- Overview of cameras, terms and techniques
- The mathematics of perspective in optics
- Industry standards

- Maya's virtual camera and settings
- Camera setup
- Film gate, aperture, aspect ratio, lens focal length, angle of view, zoom vs. prime lenses, frame rate, and other standards
- Overview of camera history, manufacturers, and providers

#### **Reading**

Introduction to Maya – Chapter 6

#### **Project**

Cityscape (Week 5 of 7) – Setup a custom camera in Maya. Set it up with appropriate film gate, lens, and working settings. Use the camera's viewport as a director's viewfinder to layout and arrange the various assets of your city into the scene as a complex environment. See blackboard for specific details.

### **Week 6 Thursday – Cameras in 3D**

- Cinematography references
- Good and bad camerawork and composition
- Laying out and populating a 3D scene
- Animating a camera
- Graph editor curves
- The Five C's, Cinematography, Fundamental techniques for good camera work

#### **Project**

Cityscape (Week 5 of 7) – Continued

### **Week 7 Tuesday – Lighting in 3D**

- The application of lighting in 3D
- Types of lights and their uses
- Good lights (directional, spot, point, and area)
- Bad lights (ambient and volume)
- Ray traced and depth mapped shadows
- Soft shadows, penumbra, falloff, and other phenomena
- Using the Render Settings window to prepare a scene for lighting
- Memory efficiency and pipeline specific differences of each renderer

#### **Reading**

Introduction to Maya – Chapter 7

#### **Project**

Cityscape (Week 6 of 7) - Light the scene to establish a specific mood. Lighting reference will help to achieve the best possible emotional context and exposure quality for the scene. Animate the camera so that it makes a well-controlled cinematic camera move. Choreograph the vehicle's animation so that it travels in relation to the camera through a 10 second shot. See blackboard for specific details.

### **Week 7 Thursday – Animating a vehicle**

- Review key framing techniques
- Animating with basic hierarchies
- Using parent – child relationships to further enhance animation capabilities
- Techniques to produce better performance

- Animating props and cameras
- Using the Render Settings window to prepare a scene for render

### **Project**

Cityscape (Week 6 of 7) – Continued

### **Week 8 Tuesday – Rendering**

- Rendering image sequences from Maya
- Proper naming conventions (name.#.ext, etc.)
- Importing image sequences into post production and compositing programs
- Creating QuickTime movies
- Understanding compression codecs, quality, compression, file size
- Industry specific examples of why you only render image sequences (never render movie files!)

### **Reading**

Introduction to Maya – Chapter 8

### **Project**

Cityscape (Week 7 of 7) – Setup the animated scene for rendering. Render the scene out as a sequence of images and then import the sequence into the post compositing program for final QuickTime output. See blackboard for specific details.

### **Week 8 Thursday – History of 3D Computer Graphics**

- Why Tron is the most important movie in the history of mankind... or at least 3D
- How small steps created an industry
- The hurdles and limitations of early 3D
- Trace the major innovations of 3D and technology over the last 30 years, from early experiments through the modern production and business models of today.
- Mergers, acquisitions, trends, and the future

### **Project**

Cityscape (Week 7 of 7) – Continued

### **Week 9 Tuesday – NURBS Overview**

- Non-Uniform Rational B-Splines
- Curve based modeling within the scope of production
- NURBS in contrast to polygons
- Modeling concepts and workflow for NURBS
- Defining NURBS and NURBS components
- Control Vertices, Control Hulls, Curve Degree, Spans/Sections
- Making sense of NURBS mathematics ( $\#CVs = Degree + \#Spans$ )
- Advantages to NURBS in modern production

### **Reading**

Introduction to Maya – Chapter 9

### **Project**

Chess Animation (Week 1 of 3) – Add image planes to your profile orthographic cameras as modeling reference. Use NURBS curves to define the profile and contours for the objects. Use curve editing and surfacing operations to build out the shape of the chess pieces in NURBS. Then convert to polygons for any remaining detailing. Build at least



two different chess pieces using NURBS and/or polygon techniques. See blackboard for specific details.

### **Week 9 Thursday – NURBS and spline-based modeling**

- Working with NURBS Curves
- Curve editing, Attachment, Detachment, and Rebuilding
- Uniform vs. Non-Uniform curves
- Converting curves into surfaces
- Using revolve to form the chess shape from a profile
- Best practices for NURBS to polygon conversion
- Boolean modeling techniques
- Construction history
- Essential steps to prepare a character model for animation

#### **Project**

Chess Animation (Week 1 of 3) – Continued

### **Week 10 Tuesday – Basic character setup**

- Non-linear deformers
- Curve, Bend, Twist, Wave, Sine, Squash
- Understanding deformation order
- Approaches for restructuring the deformation order for proper performance behavior
- Hierarchies for animation

#### **Reading**

Introduction to Maya – Chapter 10

#### **Project**

Chess Animation (Week 2 of 3) – Clean up the models for animation. Use animation deformers to enable the models to perform as necessary for the animation sequence that is to follow. Begin animating at least two of the chess pieces through a 5 - 10 second animation. See blackboard for specific details.

### **Week 10 Thursday – Advanced character setup concepts**

- Advanced controller setups
- Adding custom attributes to Maya nodes
- Driving automation by connecting attributes
- Input and Outputs, and the connection editor

#### **Project**

Chess Animation (Week 2 of 3) – Continued

### **Week 11 Tuesday – Animating a simple character**

- Planning a performance
- The importance of acting out a performance
- Key framing tools and techniques
- Using the Graph Editor
- The relationship between motion curves and nuances of movement
- Understanding motion curves, keys, and tangents

#### **Reading**

Introduction to Maya – Chapter 11

**Project**

Chess Animation (Week 3 of 3) - Finish animating the chess pieces and render the scene using the same procedures as we used at the end of the previous project. See blackboard for specific details.

**Week 11 Thursday – Refining the performance**

- Refining and further developing an animation
- Isolating erroneous movement behavior
- Fine tuning the timing and performance
- More Graph Editor

**Project**

Chess Animation (Week 3 of 3) – Continued

**Week 12 Tuesday – The Final Project**

- Solve any animation problems with the Chess Animation
- Adding texture to a deforming character mesh
- Lighting for animation
- Discuss the Final Project
- Overview of the remaining timeline for the class

**Reading**

Introduction to Maya – Chapter 12

**Project**

Final Project: Discuss the final project. Final project listed at bottom of syllabus. Also see blackboard for specific details. Due at the start of our Finals Week class session. In-class screening and critique will follow. Progress checks will be due each week.

**Week 12 Thursday – Posing a character**

- Animating a full human character using a pre-rigged character rig
- Setting motion keys across arrays of joints and skeletons
- The importance of pose in expressing character personality
- Blocking in a performance

**Project**

Continue Final Project.

**Week 13 Tuesday – Animating a character**

- IK – Inverse Kinematics
- FK – Forward Kinematics
- Understanding the fundamental differences between animating IK and FK hierarchies.
- How and where to apply IK and FK to movement and articulation problems
- Working with a rig

**Project**

Final Project Proposals Due & Progress Check

### **Week 13 Thursday – Advanced Rendering topics**

- Batch Rendering
- Command line rendering
- Rendering across multiple machines
- Networked, farmed, and distributed rendering
- Types of renderers

#### **Project**

Continue Final Project.

### **Week 14 Tuesday – Mental Ray and special topics in 3D rendering**

- Differences between the software and Mental Ray renderer
- Benefits of Mental Ray
- Final gathering
- Image based lighting (IBL) and High Dynamic Range Images (HDRI)

#### **Project**

Continue Final Project.

### **Week 14 Thursday – Dynamics and Particles**

- Particle processing and scene setup
- Types of particles
- Fields, physics properties, and methods for achieving effects
- Materials and refining look

#### **Project**

Continue Final Project

### **Week 15 Tuesday – Final Project Viewing**

- Viewing of Final Projects
- In class critique

### **Week 15 Thursday – Final Exam Review Day**

- Review slides

### **Final Exam – Tuesday, May 9, 11am-1pm, OHE 540**

All students must attend Final Exam session!

### **Final Project:**

Due Date: At start of Final Exam Session

**Tuesday, Dec 12, 8am-10am, OHE 540**

Must be submitted onto Blackboard by due date.

Using any and all of the techniques we have covered in the class thus far, create a 20 second animated sequence consisting of at least four consecutive shots. You may do more if you feel ambitious.

A complete Final Project submission will consist of a finished rendered QuickTime movie file as well all Maya scene files, project folders, textures, and supporting materials.

QuickTime file should be Sorensen 3 codec; 640x480 minimum resolution, HD and other aspect ratios are okay.

- At least three new detailed assets must be built and showcased in this project.
  - An asset can be anything from a building, to an environment, to a detailed prop, to a vehicle, or even a full character.
  - In order to optimize your time, you may use any previous assets and models to supplement this project. If you are recycling assets in this way, make sure to significantly improve them so that they compliment this new project (i.e. better texturing, shape language, edge topology, or detailing.)
- Demonstrate your best animation in the project
  - Weight
  - Timing
  - Controlled key-framing
  - Secondary animation.

The Final project is worth 60 points. Progress checks are due each week leading up to the deadline. The Final project will be graded based on:

- Meets base requirements
  - Total 20 seconds
  - Four consecutive shots, rendered (5 points per rendered shot)
- Demonstrated effort (10 points)
- Complexity, range, and effective use of tools (10 points)
- Quality of the finished product
  - Animation performance (10 points)
  - Visual quality (10 points)

Have fun! Make awesome work!