Slugbotics Mechanical Onboarding:
Introduction to 3D Design and Printing
CRSN-151C

      The Introduction to 3D Design and Printing module of CRSN-151C will introduce you to the basics of Computer Aided Design (CAD) using the 3D modeling software SolidWorks. Solidworks is a powerful, industry standard tool used to draft mechanical drawings and 3D representations of a part or device. Students will learn the Solidworks tools and skills necessary to draft their own parts either from a mechanical drawing or of their own creation. Additionally, students will learn the skills necessary to realize their design through 3D printing and CNC manufacturing. This also includes learning the basic operating principles of 3D printers and CNC routers.

      Students will become familiar with the entire design process of brainstorming, formulating, iterating, and manufacturing through a series of projects given by the student instructors that emphasize different skills. Towards the end of the quarter, participants will have the time to propose and complete a final project of their own choosing. This project will display competency in the learning goals of the course.

Learning Objectives

- CAD version control using grabCAD
- Basic principles of CAD design
- Read and create mechanical drawings
- Understand appropriate usage of SolidWorks 2D sketch tools and dimensioning
- Understand appropriate usage of SolidWorks 3D features and reference geometry
- Basic SolidWorks assemblies
- Basic principles of 3D printing and additive manufacturing
- Operate 3D printers
- Create Gcode for 3D printers using Cura
- Basic principles of deductive manufacturing and CNC milling
- CAM for CNC routers using HSM Express
- Finishing parts after fabrication through post-processing

Check-off: After you've completed this course, you will be cleared to use S-Lab's FDM printers.

Student-Instructor Communication & Office Hours

       In addition to the regularly-scheduled Class lectures/labs, each student-instructor will also have regular office hours that are schedulable through canvas appointments. The specific times are outlined below along with the student-instructors' email contact information.

Informal discussions will take place on slack, this includes: questions about assignments, project discussion, team formation, etc.

Slack Channel: 151c-3dcad

Spencer Jaseph
Email: sjaseph@ucsc.edu
Office Hours:

Matthew Bennett
Email: mabennet@ucsc.edu
Office Hours:

Wren Sakai
Email: wsakai@ucsc.edu
Office hours:

Sri Ram Neravati
Email: sneravat@ucsc.edu
Office hours:

If you need to speak with a TA outside of normal office hours, feel free to email or DM them in Slack to set up a meeting

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Course Requirements

Students will need one composition notebook with grid paper for drawings/sketches and logging course progress. All other materials will be provided by the instructor. This includes a lab space for the machines (3D printers and x-carve), as well as a computer lab for solidworks use. If you choose to install Soldiworks on your computer please bring it to class, to follow along with the student instructor, and to do practice parts.

Course Software

The 3D Design and Printing of CRSN-151C will use the following software. All of the software will be provided by Slugbotics.

Installing this software on your personal machine is recommended but not required. If you choose to install the class software on your personal machine, the student-instructors will alert you when the various pieces of software will be needed.

- **SolidWorks 2021-2022 (5GB):** Our main CAD software, which will be used throughout the class
    - Information on downloading SolidWorks can be found here: https://sites.google.com/ucsc.edu/slugbotics-resources/onboarding/solidworks
    - We will go over installation during class
- **HSMxpress 2020 (2GB)**: A CAM software add on for solidworks used to teach students how to create Gcode for CNC manufacturing
    - Download at: https://www.autodesk.com/campaigns/hsmxpress-download
- **Cura (550MB)**: A "slicer" software used to create Gcode for 3D printers from a CAD model
    - Download at: https://ultimaker.com/software/ultimaker-cura
- **GrabCAD (500MB):** Version control software designed specifically for CAD files
    - Download at: https://grabcad.com/workbench
- **Canvas (Access Online):** Academic organization app used by the entire UC system
- **Slack (Online):** Communication and collaboration application used by Slugbotics
    - Download the desktop app here: https://slack.com/
    - The desktop app is not mandatory but highly recommended
- **Windows 10(32GB to run bootcamp + 16GB USB to install windows):** A large majority of our software runs only on windows 10, so even if you have a Mac you will NEED to install windows 10 to run Solidworks. The instructions for how to do this will be provided.

If you choose not to install the software on your personal machine or if your computer does not satisfy the requirements, please reach out to a student-instructor and we will provide alternative arrangements.

Class Structure

CRSN-151C will start instruction in E2 585, 581, and transfer to Thimann labs room 372 for select classes. Students will be notified beforehand through canvas when thimann 372 will be used.

The course will be held on Tuesdays and Thursdays from 7:10 - 8:45pm

Engineering Notebook

For every project you complete in this section, you will need to record sketches, ideas, designs, etc. in your engineering notebook. This mostly involves drafting your CAD files by hand, or recording any problems you encounter while working. Specific details for notebook content is found in this handout. At the end of each week, you will submit any new content in your engineering notebook to Canvas so that instructors can grade your work and provide feedback. Importantly, your notebook submission will also signify to instructors to review any new CAD files submitted to GrabCAD.

Late Policy: Notebooks can be submitted up until Sunday at midnight of each week. Late notebook submissions will follow the same late penalty as projects, shown in the Project Late Policy Section. Be sure to submit by Sunday for timely project feedback.

Modules

This course is organized into modules (0-8). Each module consists of two parts: a prelab and project. Each module will take place over a week.

Prelabs:

Each week will have a mandatory prelab that is due Tuesday before class at 7:10pm. Prelabs are designed to show students how to use specific Solidworks tools in preparation for upcoming material.

Late Policy: Late submissions will **NOT** be graded.

Projects:

Projects are more open-ended design tasks that will give students applied practice of course content learned during the week.
To submit projects you must
- Save your final work in your local GrabCad folder
- Push your work to GrabCad
- Submit to the appropriate assignment to Canvas

Project Late Policy:

- Projects will be due at 11:59 PM on their due date.

- Projects will be accepted late with a 5% penalty for each day late, up to a maximum of 5 late days for each assignment.
- Projects will be accepted late with no penalty if the student contacts the instructors with prior notice and has an adequate reason.

All materials and instructions for the projects/prelabs can be found on Canvas in the files and modules sections. However, due to file formatting concerns, all CAD files pertaining to the class must be downloaded/submitted via GrabCAD, which we will teach you to use. **Non-CAD files will always be handled through Canvas, but CAD files will always be handled through GrabCAD.**

Grading

There are a possible 1000 points to be earned throughout the class.
- Projects: 40%
- Prelabs 30%
- Notebook: 20%
- Final Project: 10%

At the end of the quarter, your total points will be compiled and a final grade will be assigned based on the below point breakdown. Keep in mind that there will be extra credit opportunities. Grades will not be curved.

Schedule

Week 0: Introduction

- Learning Goals: CAD version control using grabCAD, Basic principles of CAD design
- **Module 0:** Prelab and project 0 due 9/28
- Thursday 9/23
    - The design cycle
    - What will be covered in the course
    - What is CAD
    - What are manufacturing processes

Week 1: CAD Sketching

- Learning Goals: Read mechanical drawings, Understand appropriate usage of SolidWorks 2D sketch tools and dimensioning
- **Module 1:**
    - Prelab 1 due 9/28 7:10pm
    - Project 1 due 10/3 11:59pm
- Tuesday 9/28
    - Syllabus
    - Additive design cycle
    - Creating a solution
    - Engineering notebooks
    - Solidworks UI
    - Sketching tools
- Thursday 9/30
    - Sketch tools review
    - Defined vs. undefined sketches
    - Sketching from a drawing
    - Sketch relations

Week 2: CAD 3D Features

- Learning Goals: Understand appropriate usage of SolidWorks 3D features and reference geometry, Read and create mechanical drawings
- **Module 2**
    - Prelab 2 due 10/5 7:10pm
    - Project 2 due 10/10 11:59pm
- Tuesday 10/5 **Class Topics:**
    - Using extrusions
    - Sketching on different planes
    - Editing features
- Thursday 10/7 **Class Topics:**
    - CAD Drawings
    - Drawing conventions and annotations

○ How to create drawings

Week 3: Advanced 2d and 3D tools

● Learning Goals: SolidWorks 3D features and reference geometry
● **Module 3**
    ○ Prelab 3 due 10/12 7:10pm
    ○ Project 3 due 10/17 11:59pm
● Tuesday 10/12 **Class Topics:**
    ○ Remaining sketch tools
    ○ Linear and rotational sketch patterns
    ○ Reference geometry
    ○ Section view
  Thursday 10/14 **Class Topics:**
    ○ 3D feature tools: revolve, swept, loft, hole wizard, shell, fillet, pattern

Week 4: Assemblies

● Learning Goals: Basic SolidWorks assemblies
● **Module 4**
    ○ Prelab 4 due 10/19 7:10pm
    ○ Project 4 due 10/24 11:59pm
● Tuesday 10/19 **Class Topics:**
    ○ How to open/create an assembly
    ○ How to place parts in assembly
    ○ Basic mates
    ○ Patterning components
  Thursday 10/21 **Class Topics:**
    ○ Assembly drawings
    ○ BOM and auto-ballooning

Week 5: Cura and FDM 3D printing introduction

● Learning Goals: Basic principles of 3D printing, Creating Gcode for 3D printers using Cura
● **Module 5**
    ○ Prelab 5 due 10/26 7:10pm
    ○ Project 5 due 10/31 11:59pm
  Tuesday 10/26 **Class Topics**
    ○ What is 3D printing
    ○ Overview of 3D printer components
    ○ Gcode and 3D printer workflow
    ○ Designing parts for 3D printing
    ○ Complete Cura program setup
  Thursday 10/28 **Class Topics**

- Basic Cura UI and operations
- Cura Settings
- How print settings effect 3D prints
- Understand the different temperature and speed settings of different filaments
  - PLA, PETG

Final project proposal due 10/28 7:10pm

Week 6: Introduction to CAM and CNC machining

- Learning Goals: Basic principles of deductive manufacturing and CNC milling, CAM for CNC routers using HSMxpress
- **Module 6**
  - Prelab 6 due 11/2 7:10pm
  - Project 6 due 11/7 11:59pm

Tuesday 11/2 **Class Topics:**
- What is deductive manufacturing
- What is a CNC router and what is it used for
- How to open HSM CAM in solidworks
- How to create a new CAM job in HSM
- What is the WCS and how to set the WCS for your part

Thursday 11/4 **Class Topics:**
- How to create a new machine operation
  - Drilling
  - 2D contour (interior and exterior)
  - Bore
  - 2D pocket/2D adaptive clearing
- How to navigate the operation settings
- What are feeds and speeds?

Schedule design check in
Final project groups due by 11/2 8:45pm

Week 7: Post Processing

- Learning Goals: Finishing parts after fabrication through post-processing
- **Module 7**
  - Prelab 7 due 11/9 7:10pm
  - Project 7 due 11/16 11:59pm

Tuesday 11/9
- Different types of machines
- CNC vs. manual machines
- X-Carve demo

Thursday 11/11: Holiday, no lecture

Week 8: Project Revision and Presentation

- Learning Goals: Taking designs to finalized products
- **Module 8**

    - Prelab 8 due 11/18 7:10pm
    - Project 8 due 11/21 11:59pm
- Tuesday 11/16
    - The revision process
    - Materials, stress, and strain
    - Final project workday
- Thursday 11/18
    - Prelab video debrief
    - Technical presentations

Week 9: Project Revision and Presentation(cont.)

- Learning Goals: Taking designs to finalized products
- **Module 9**
- Tuesday 11/23
    - What is a trade study
    - Trade study examples
- Thursday 11/25 (holiday)

Week 10: Final Project Work Week

- Learning Goals:
    - Open lab time
    - Prepare for presenting projects to peers

Week 11: Final Project Week

- Final project due Wednesday Dec. 8 at 10:30pm
    - Present work for final projects
    - Submit survey for review of module