**University of California, Berkeley**

**Department of Mechanical Engineering**

**E 29: Manufacturing and Design Communication (4 units)**

**Undergraduate Required Course**

***Syllabus***

**CATALOG DESCRIPTION:**

This course provides an introduction to manufacturing process technologies and the ways in which dimensional requirements for manufactured objects can be precisely communicated, especially through graphical means. Fundamentals of cutting, casting, molding, additive manufacturing, and joining processes are introduced. Geometric dimensioning and tolerancing (GD&T), tolerance analysis for fabrication, concepts of process variability, and metrology techniques are introduced and practiced. Three-dimensional visualization skills for engineering design are developed via sketching and presentation of three-dimensional geometries with two-dimensional engineering drawings. Computer-aided design software is used. Teamwork and effective communication are emphasized through laboratory activities and a design project that integrates the material.

**COURSE PREREQUISITES:**

***Recommended E26*:** Three-dimensional Modeling for Design
or equivalent experience in three-dimensional solid modeling (*e.g.* Solidworks, Fusion 360)

**TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL:**

All required course notes and materials will be provided. *Optional* additional reference materials include:

Lieu, D.K. and Sorby, S.A., Visualization, Modeling, and Graphics for Engineering Design, Cengage Publishers, 2009. ISBN 978-1-4018-4249-9. Library call number: TA174.L54 2009.

Kalpakjian, S. and Schmid, S., Manufacturing Processes for Engineering Materials, 5th Edition, Prentice Hall, 2008. ISBN 978-0132272711. Library call number: TS183.K34 2008.

**COURSE OBJECTIVES:**

Improve three-dimensional visualization skills; enable a student to create and understand engineering drawings; introduce two-dimensional computer-aided geometry modeling as a visualization, design, and analysis tool; enable a student to create and understand tolerances in engineering drawings; enhance critical thinking and design skills; emphasize communication skills, both written and oral; develop teamwork skills; offer experience in hands-on engineering projects; develop early abilities in identifying, formulating, and solving engineering problems; introduce students to the societal context of engineering practice.

**DESIRED COURSE OUTCOMES:**

Upon completion of the course, students will be able to: communicate three-dimensional geometry effectively using sketches; operate two-dimensional CAD software with a high degree of skill and confidence; understand and create engineering drawings; visualize three-dimensional geometry from a series of two-dimensional drawings; fabricate basic parts in the Mechanical Engineering Student Access Machine Shop; understand and communicate tolerance requirements in engineering drawings using industry standard GD&T; use metrology tools to evaluate whether physical parts are within specified tolerances; demonstrate familiarity with manufacturing processes; design simple parts that can be fabricated realistically and economically using these processes.

**TOPICS COVERED:**

Three-dimensional visualization and spatial reasoning, sketching for design communication; fundamentals of orthographic projection with applications; drawing conventions and presentation of three-dimensional geometry on two-dimensional media; **reading and creating engineering drawings; engineering drawing standards; g**eometric dimensioning and tolerancing (GD&T), tolerance analysis for fabrication; fundamentals of manufacturing processes.

**CLASS/LABORATORY SCHEDULE:**

**Three hours of lecture and three hours of laboratory per week.**

**CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT:**

Students learn graphical analysis and design techniques using the hardware and 2-dimensional software tools used by engineers in the field. Students learn to communicate tolerance requirements in engineering drawings using industry standard GD&T used by engineers in the field. Students learn about manufacturing processes with which familiarity is likely to be required as a practicing engineer. Students are introduced effective ways of working in a group through the semester-long design project. As part of this project, students are required to communicate orally and graphically, and make presentations to the class and instructors.

**RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES**

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

**ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES:**

* **Approximately eight homework assignments: 20%**
* **Midterm exam: 15%**
* **Laboratory activities: 25%**
* **Semester project with required participation in final design showcase: 30%**
* **Participation: 10%**

**SAMPLE OF WEEKLY AGENDA:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Week** | **Topics** | **Focal point of laboratory activity** | **Sample optional readings** |
| **Graphical communication**  | **Manufacturing technology** |
| **1** | **Introduction: economic and social importance of manufacturing; classes of manufacturing process; importance of tolerancing; role of graphical communication** | **“Reverse-engineering” exercise: disassemble manufactured objects and form hypotheses about materials and manufacturing processes used. Make observations about interactions between components.** | **Lieu & Sorby Ch. 1Kalpakjian Ch. 1** |
| **2** | **Sketching and visualization** | **Subtractive processes: introduction to milling/routing, drilling, turning, electrical discharge machining, abrasive jet, laser cutting, computer numerical control** | **Japanese (fastener-less) wood joints: rout using Shopbot and attempt to assemble. Include some simple software-driven toolpath planning. Look at and appreciate the role of G-Codes. Learning about what happens when components don’t fit as expected.** | **Lieu & Sorby Ch. 2Kalpakjian Ch. 21** |
| **3** | **Coded plans, rotation exercises** | **Lieu & Sorby Ch. 3Kalpakjian Ch.23** |
| **4** | **Cutting and reflection exercises** | **Tolerancing basics: classes of fit** | **Brainstorming ideas for semester project.** | **Lieu & Sorby Ch. 3** |
| **5** | **Orthogonal projection and standard views** | **Forming and casting processes: Injection molding, compression molding, sand casting, die casting, investment casting** | **Casting and injection molding demos – produce crank handle using a pre-fabricated mold. Use orthogonal projections to describe ribs, draft angles, *etc*.**  | **Lieu & Sorby Ch. 10Kalpakjian Ch .11** |
| **6** | **Pictorial views from orthogonal views** | **Sketching in 3D: exercises set in the context of developing project ideas.** | **Lieu & Sorby Ch. 12Kalpakjian Ch. 19** |
| **7** | **2D CAD drawing** | **Additive manufacturing processes** | **Redesign a component for planar fabrication, produce 2D CAD drawing, and fabricate via abrasive jet or laser cutter.** | **Kalpakjian Ch. 20.3** |
| **8** |  |
| **9** | **Section views**  | **Joining processes: welding; brazing; threads; rivets; adhesives** | **Welding demo: weld the assembly of 2D parts produced in the previous two weeks. Specifying welds on drawings.** | **Lieu & Sorby Ch. 13Kalpakjian Ch. 30** |
| **10** | **Auxiliary views** | **Metrology techniques: surface roughness, manual, contact and non-contact methods** | **Synthesis of project design & manufacturing planning; specification of fits and tolerances.**  | **Lieu & Sorby Ch. 14** |
| **11** | **Engineering drawings** | **GD&T: datum placement**  | **Design reviews for project.** | **Lieu & Sorby Ch. 18** |
| **12** | **Engineering drawings** | **GD&T: datum-related tolerances** | **Dimensional measurements of components, including evaluation of GD&T specifications on drawings.**  | **Lieu & Sorby Ch. 18** |
| **13** | **Emerging visualization methods, e.g. virtual and augmented reality (VR, AR)** | **GD&T: datum-independent and -optional tolerances.** | **Production of GD&T-labeled 2D working drawings for project.** |  |
| **14** | **Emerging visualization methods**  | **Emerging fabrication technologies**  | **Open labs for project fabrication and testing. Optional try-out of a VR/AR CAD tool.** |  |

**Additionally, all E29 students will take the M.E. Student Access Machine Shop orientation at times staggered through the semester, enabling them to use the Shop for fabrication projects in their studies and extracurricular activities.**

**Optional field trips to local manufacturing facilities may also be arranged.**

**PERSON(S) WHO PREPARED THIS DESCRIPTION**

Hayden Taylor, February–March 2020

**ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): [ss completes]
TIE CODE: [ss completes]
GRADING: Letter and/or P/NP
SEMESTER OFFERED: Fall and Spring
COURSES THAT WILL RESTRICT CREDIT: None**

**INSTRUCTORS: Hayden Taylor, Sara McMains, Hannah Stuart
DURATION OF COURSE:** 14 weeks **EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 12
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST:**