California State University, Chico
Department of Mechanical and Mechatronic Engineering and Advanced Manufacturing

SMFG 468W – CAPSTONE: MANUFACTURING TOOLING (4 Units)
COURSE SYLLABUS – Spring 2021

Lecture:	Tuesday 2-4:50pm (Online)
Lab:	Thursday 2-4:50pm (Online / PLMS 121)

Instructor:	Scott Brogden
Office:	OCNL 415 (Office hours M 4-5pm, T & Th 10-11am, F 1-2pm or by appointment)
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Prerequisites:	SMFG 218, SMFG 360; SMFG 458 or MGMT 444

Course Objective
Students design, fabricate, test, and evaluate production tooling used in the manufacture or assembly of metal or plastic parts in their capstone projects.

Course Usage of Blackboard Learn
Copies of the course syllabus and major assignments may be found on Blackboard Learn. You are responsible for regularly checking the online resources, which are accessed through the Chico State Portal at http://portal.csuchico.edu. Support materials for the course may be provided via the portal and it is expected that you will either have hardcopies or electronic access to the materials during in-class activities.

Student Learning Objectives
Provide students an overview of the tool and die industry by investigating materials, manufacturing techniques, design, and business practices. Provide students an environment to gain practical experience in equipment operation for tool manufacturing, material selection, and cost justification.

Course Content Learning Outcomes
Upon successful completion of this course, students will be able to:

A. Understand and design various types of production tools designed to increase productivity in a manufacturing environment.
B. Apply and understand material selection and cost justification skills to produce tangible production tooling.
C. Functionally communicate technical information through the use of CAD/CAM.

Required Texts and Materials

Textbook (required)

Fundamentals of Tool Design sixth edition, 2010, Society of Manufacturing Engineers, Dearborn, Michigan

We will be following the text closely for the entirety of the course so it is imperative that you get a copy as soon as possible. Readings can be found on the Course Schedule in Blackboard Learn. Quiz/exam questions can and will be pulled from the text; it is in your best interest to keep pace with readings.

Highly Recommended:
Machinery's Handbook 25th edition or newer

Previous course texts for reference

Materials (required)

Calipers (6" or larger)
Safety glasses
Flash drive (back up your data)
Calculator
Laptop Computer with Solidworks Student edition installed

Highly Recommended:
0-1" micrometer

Classroom Protocol

It is expected that students are in-class on time, as the class will start promptly at the scheduled time. Any homework class assignments are due for submission on Blackboard at the assigned time.

The use of technology is encouraged for in-class coursework and activities, however extra-curricular activities (phone calls, email, web surfing, etc.) are not allowed during class. Students violating this policy will be asked to leave, as they are potentially distracting to their colleagues who are engaged in learning.

Safety

A brief training session on lab safety in the Material Removal Laboratory (PLMS 121) will be conducted during the first in-person lab meeting. Students are required to read the Department's *Lab Safety Policies and Procedures* document and sign an acknowledgment form before conducting laboratory experiments. **Safety glasses and closed toed shoes are required and to be worn at all times in the lab**. Failure to do so will result in the student being removed from the lab and being dropped from the class. The student must read, understand, and follow all safety procedures. If there are any

questions about safe operation, the student must talk to the instructor before operating any of the equipment.

Communication

If you need to meet or contact me outside of class hours, please attend my online Zoom office hours, text, or email me.

In the event that I need to contact the class members for matters between class meetings (schedule, assignment, or class changes, etc.,) it will be done via Blackboard Learn, or in some cases your University email or a text message. University policy requires students to monitor campus email accounts and it is suggested that you set up email forwarding if you have another preferred email account.

Dropping and Adding

You are responsible for understanding the policies and procedures about add/drops, academic renewal, etc. found http://www.csuchico.edu/catalog/. You should be aware of the deadlines and penalties for adding and dropping classes.

Assignments and Grading Policy

Assignments are due according to the class schedule and are subject to change, depending on course progress through the semester. Changes to the schedule will be announced during class or via the communication protocol described above.

Any homework class assignments are due at the start of the class and must be submitted in person. Late work will not be accepted.

Students will be assigned groups for in-class or lab activities. It is critical that all group members attend class and work on the group or lab work together.

Course Grade Breakdown:

Midterm Exam	10%
Final Exam	10%
Quizzes, Gear Checks, Lab Activities	20%
Prototype Project	25%
Production Project (including presentation)	35%
Total	100%

Students are allowed to have 1 page (8.5”x11” Front and Back) of notes for use on any quiz or exam. Makeup quizzes or exams are not allowed unless there was a documented emergency and a doctor’s note.

Project Descriptions:

1. **Prototype Tooling project (individual)**

   Each student will complete one prototype project. This project will be an individual activity that demonstrates knowledge of some aspect of tooling. The

goal for this project is to produce a tool (or other device) that would increase productivity and decrease costs when used in a manufacturing environment. This deliverable is simply a prototype, so it should not be overly complex; it is **a proof of concept.** Example: if you want to make a nested milling fixture, instead of making a 4-sided, 16-cavity tombstone, make a single cavity (and all the hardware that goes with it). It should be noted that this is a capstone course and students will think of and execute their own projects.

Choosing a Project:

Remember that this is a prototype exercise. Choose a project that meets all of the requirements below, but take care to make sure that you have not signed up for too great a task. I am in no way suggesting that you suppress your creativity, just keep in mind that you will be responsible for completing your project on time.

Deliverables:

Note: For the items below, please report your findings in paragraph form.

1.) Project description:
A detailed account of the project and all of its features.
What is the problem the project addresses?
What are the project's requirements? (what does it need to accomplish?)

2.) Project Sketches: Visual representation of initial ideas
What is this project going to look like?
What are the rough dimensions?
Designate the key features (Where might datums be? Where are the tight tolerances?)
Either scan your sketches or take a **good picture** of them.

3.) Solidworks CAD Model
A complete 3D model of every part of your project (apply a material).
A complete 3D assembly model of your project with exploded view.
Design for manufacturability must be built into your model (if it is a milled part, did you radius the internal corners?).
Did you use mechanical fasteners? They should appear in the assembly drawing.

4.) Technical Drawings:
Always be as clear as possible.
Use ANSI standards (third-angle projection)
There must be a drawing for every part except toolbox (purchased) items.
Specify a material on every part drawing.
Use GD&T on every drawing and be able to justify it.
An assembly drawing (collapsed and exploded views) with completed bill of materials.

Note: Your individual project may vary. You have license to make your drawings as clear as possible. If you need multiple drawings for the same part in different views to preserve clarity, include them.

5.) Material Selection:
What material or material(s) are you using?
Why? Give some justification.
What were other material choices you considered?
Where are you sourcing your material(s)?
What is the cost of the material(s)? (If it is lab material, find the lowest price online)
Note: It is in your best interest to be thinking of material selection from day one. We do have access to some funds for material acquisition, but it will be easier and quicker if you are using common materials that we already have. Some projects will require material to be ordered, but if there is something we already have that does the job just as well, ask to use that material.

6.) Process Selection:
What manufacturing processes will you use to produce your project?
Justify your choices. (Casting may be a good choice. Pieces of your project may need to be ground.)
Could any other processes be used to make your part? Which ones? Why?

7.) Tool Selection:
What tools are required to make your project? (be specific)
Endmills? Drills? HSS or Carbide? Specifications of tools?
What machines will you use?
How many operations are required?
What manual operations will you do? (Deburring? Sanding?)
If money was no object, what tools would you use?

8.) Purchased Parts Required:
Did you use any?
Which ones?
How many?
What was the cost? (If they were lab-sourced, find an online price)

9.) What you learned:
Did you meet your tolerances?
If not, suggest why.
Conclude your paper with a brief summary.
What did you learn?
What was difficult?
What was easy?

Turning it in:

Along with the answers to all of the questions above (in paragraph form), you will have hand sketches, drawings, and the finished prototype project tool.

i.) Create a folder or 3-ring binder with your name and the name of your project on the outside cover.
ii.) Put all of your written material and drawings in the folder or binder. All drawings should include the department border and title block.
iii.) Include either the scans or photographs of your hand sketches.
iv.) Submit your physical project and the project's documentation at the beginning of class on the due date.

Ideas:

Drilling fixture/jig
Milling fixture
Welding fixture
Assembly fixture
Bending fixture
Turning fixture (chuck jaws, etc.)
Soldering fixture
Soft tooling for thermoforming
Soft tooling for injection/blow molding
Soft tooling for polymer casting
Simple matched plate pattern for sand casting
Soft tooling for composite layup

2. Production Tooling Project ~~(collaborative groups of 2-4 members)~~

Each ~~team~~ will produce the tooling required for the mass production of a part or parts. This project differs from that of the prototype in that it is a more in-depth exercise designed for students to apply many different skills. It is expected that projects will be more complex, creative, and have larger assemblies than the prototype project. Students will have the entire semester to complete this project with deliverables due along the way. This is the time to apply the skills that you have learned throughout the major. I do not expect you to know how to do everything yourself on day one. Remember that we are after problem solving skills; if you do not know how to do something, find out where to look for the answer. The nature of our equipment dictates that you will be machining, regardless of the end use of your project. I highly recommend that you go back and study your SMFG 360 and SMFG 260 information; it will help. Also keep in mind that **your lab time is precious, especially during the pandemic.**

Deliverables:

Anytime the project is being worked on, keep track of your hours (MS-Excel recommended).

1.) Project description:
A detailed account of the project and all of its features.
What is the problem the project will address?
What are the project's requirements? (What does it need to accomplish?)
Who would the customer be?
How does the project increase productivity?
What machine (if any) is the project designed for?

2.) Project Sketches: Visual representation of initial ideas
What is the project going to look like?
Show some rough dimensions.
Designate the key features (Where might datums be? Where are the tight tolerances?)
Save all the initial rough sketches to be included in the project's documentation.
How many parts are there going to be?

3.) Solidworks CAD Model:
A complete 3D model of every part of the project, including material(s).
A complete 3D assembly model of the project with exploded view.
Is design for manufacturability built into the project? (For example, if it is a milled part, are internal corners radiused?)
Are mechanical fasteners being used? They should appear in the assembly.
How does the tool function?
How competent does the operator need to be?
What kind of ergonomics were designed into the project?
How many hours were spent on CAD work?

4.) Technical Drawings:
Drawings should always be as clear as possible.
Use ANSI standards (third-angle projection, etc.)
Use the department drawing naming standards.
Include a drawing for every part except toolbox items (purchased parts).
Specify material on all part drawings.
Include fully defined part geometry with proper GD&T on every drawing.
An assembly drawing (collapsed and exploded views) with completed bill of materials should be included.
How many hours were spent on drawings?
<u>Note:</u> Your group has license to make the project drawings as clear as possible. If multiple drawings are needed for the same part in different views to preserve clarity, supply them.

5.) Material Selection:
What material or materials are being used?
Why? Give some justification.
What were other material choices the group considered?
Where are the materials being sourced?

Did the material have to have its properties modified (heat treatment)?
What was the material cost? (If it is shop material, find the lowest price online)
What is the project's estimated weight in Solidworks?
How much does it actually weigh?
How many hours were spent on material selection?
Note: It is in your group's best interest to be thinking of material selection from day one. We do have access to some funds for material acquisition, but it will be easier and quicker if you are using common materials that we already have. Some projects will require material to be ordered, but if there is something we already have that does the job just as well, ask to use that material.

6.) Process Selection:
What manufacturing processes will your team use to produce the project?
Justify process choices. (If casting has too poor a surface finish, state that. If pieces of your project need to be lapped, explain why.)
Could any other manufacturing processes be used to make the project parts?
Why were those processes not used?
How many hours were spent on process selection?

7.) Tool Selection:
What tools were required to make the project? (Be specific)
Drills? Endmills? Chamfer mills? HSS or Carbide? How many flutes?
Tool materials, dimensions?
What machines did your team use?
How many operations were required?
What manual operations were performed? (Deburring? Sanding? Blasting?)
What was cycle time for each CNC part?

8.) Purchased Parts Required:
Did the project require any?
What are they?
How many of each were used?
What was the cost? (If they were found in the lab, find a current price.)

9.) What you learned:
Conclude your paper with a summary.
What did the group learn from the project?
What was difficult?
What was easy?
What would your team do differently if the project was repeated?
How many total hours did the project require?

10.) Analysis:
i.) Assuming that each team member makes $50 per hour, what was the total labor cost?

ii.) Assuming that manual equipment costs are $75 per hour, what was the total manual machining cost?
iii.) Assuming that CNC equipment costs are $125 per hour, what was the total CNC machining cost?
iv.) What was the total material cost?
v.) What was the total tooling cost? (Assume all tooling had to be purchased, even if lab tooling was borrowed.)
vi.) Calculate the Total Project Cost by adding all of the above.
vii.) What would be a realistic sale price for each item the project tool would hypothetically produce?
viii.) Break even analysis:
Assume a 15% markup would be charged for the tool your team produced. What is the sale price of the tool?
How many parts does the customer need to produce to break even with the sale price of the tool?

Turning it in:

Along with the answers to all of the questions above (in paragraph form), your group will have hand sketches, drawings, and the finished project tool.

i.) Create a folder or 3-ring binder with your name and the name of your project on the outside cover.
ii.) Put all of your written material and drawings in the folder or binder. All drawings should include the department border and title block.
iii.) Include either the originals, scans or photographs of your hand sketches.
iv.) Submit your physical project and the project's documentation at the beginning of class on the due date.

11.) Oral Presentation:
Your team is required to present its findings to the class.
The length of the presentation should not exceed 15 minutes.
Include a Powerpoint slide show with visuals.

Ideas:

Complete polymer injection mold (if funding is approved)
Extrusion blow mold
Match plate for sand casting (meeting complexity standards)
Tombstone for machining
Multi-part fixture plate for milling
Composite compression mold
Composite vacuum mold (meeting complexity standards)
Grinding jigs
Modular fixtures
4th axis-rotary fixtures
Welding fixtures

3. **Lab Policies**

   This is a capstone course and as such, lab time is extremely important. Students are expected to be in lab (online or in-person) on time and with all required materials. **Safety glasses and closed toed shoes must be worn at all times in the lab.** Students will need their own computers with Solidworks and SolidCAM installed to ensure that they have a computer to work on CAD/CAM activities. Also note that lab time is the time for making things. There will be some in-lab activities assigned, but when those are done, spend the rest of the scheduled lab time on the projects. Make sure that you are working on CAD files and other project materials in your spare time; it is part of your homework. **You will not make it if you only work on your projects during lab time.**

University Policies and Campus Resources

Academic integrity
Students are expected to be familiar with the University's Academic Integrity Policy. Your own commitment to learning, as evidenced by your enrollment at California State University, Chico, and the University's Academic Integrity Policy requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the Office of Student Judicial Affairs. The policy on academic integrity and other resources related to student conduct can be found at:
http://www.csuchico.edu/sjd/integrity.shtml.

Campus Policy in Compliance with the American Disabilities Act
If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Students with disabilities requesting accommodations must register with the DSS Office (Disability Support Services) to establish a record of their disability.
Special accommodations for exams require ample notice to the testing office and must be submitted to the instructor well in advance of the exam date.

IT Support Services
Computer labs for student use are located on the first and fourth floor of the Meriam Library, Room 116 and 450, Tehama Hall Room 131, and the Bell Memorial Union (BMU) basement. You can get help using your computer from IT Support Services; contact them through their website, http://www.csuchico.edu/itss. Additional labs may be available to students in your department or college.

Student Services
Student services are designed to assist students in the development of their full academic potential and to motivate them to become self-directed learners. Students can find support for services such as skills assessment, individual or group tutorials, subject advising,

learning assistance, summer academic preparation and basic skills development. Student services information can be found at: http://www.csuchico.edu/current-students.

Americans with Disabilities Act
If you need course adaptations or accommodations because of a disability or chronic illness, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Please also contact Accessibility Resource Center (ARC) as they are the designated department responsible for approving and coordinating reasonable accommodations and services for students with disabilities. ARC will help you understand your rights and responsibilities under the Americans with Disabilities Act and provide you further assistance with requesting and arranging accommodations.

Accessibility Resource Center
http://www.csuchico.edu/arc
530-898-5959
Student Services Center 170
arcdept@csuchico.edu

Student Learning Center
The mission of the Student Learning Center (SLC) is to provide services that will assist CSU, Chico students to become independent learners. The SLC prepares and supports students in their college course work by offering a variety of programs and resources to meet student needs. The SLC facilitates the academic transition and retention of students from high schools and community colleges by providing study strategy information, content subject tutoring, and supplemental instruction. The SLC is online at http://www.csuchico.edu/slc. The University Writing Center has been combined with the Student Learning Center.