

## **2.752 (UG), 2.753 (G) Development of Mechanical Products - Spring 2014 Syllabus**

**Prerequisite: 2.75, 2.750 or 2.009**

**Units: 3-0-9**

*Updated 31 Jan 2014*

The course focuses on evolving a product from proof-of-concept to beta prototype. Skills includes team building, project planning, budgeting, resource planning; models for scaling, tolerancing, reliability, error budgets, patents, and project planning. Students/teams start with a proof-of-concept product completed in 2.75 or other class (by arrangement) or undertake a class design challenge.

In lieu of taking 12 units of 2.ThU, Undergraduate Course 2 majors taking 2.752 who make a significant, independent, documentable contribution to the product developed in the team project may, by special arrangement, count towards toward a bachelor's thesis requirement. Students taking the graduate version complete additional assignments.

### **Teaching Staff**

<b>Instructor-in-Charge</b>	<b>Instructor &amp; Medical Products Mentor</b>	<b>Drawings, CMM TA</b>	<b>Design Challenge TA</b>
Prof. Alexander Slocum Room 3-445 Phone: 253-0012 <a href="mailto:slocum@mit.edu">slocum@mit.edu</a>	Nevan C. Hanumara Room 3-470 Phone: 258-8541 <a href="mailto:hanumara@mit.edu">hanumara@mit.edu</a>	Anthony Wong Room 3-438 Phone: 253-2052 <a href="mailto:arwong@mit.edu">arwong@mit.edu</a>	Folkers Rojas Room 3-470 Phone: 253-4917 <a href="mailto:folkersr@mit.edu">folkersr@mit.edu</a>
<b>Servos TA</b>	<b>Furniture Design Instructor</b>	<b>Entrepreneurship Mentor</b>	<b>Administrative Guru</b>
Tyler Wortman Room 3-470 Phone: 258-8541 <a href="mailto:wortman@mit.edu">wortman@mit.edu</a>	Brian Chan Hobby Shop Phone: 253-4343 <a href="mailto:chosetec@MIT.EDU">chosetec@MIT.EDU</a>	Christina Chase Martin Trust Center Phone: 324-4048 <a href="mailto:cchase@mit.edu">cchase@mit.edu</a>	Deborah Alibrandi Room 3-438 (9-13:00) Phone: 253-2883 <a href="mailto:deborah@mit.edu">deborah@mit.edu</a>
<b>Team Mentor</b>	<b>Team Mentor</b>	<b>Team Mentor</b>	<b>Team mentor</b>
Julio Guerrero <a href="mailto:jguerrero1000@gmail.com">jguerrero1000@gmail.com</a>	Sandy Campbell Room 3-438 <a href="mailto:sandy_c@mit.edu">sandy_c@mit.edu</a>	Nikolai Begg Room: 3-470 Phone: 258-8541 <a href="mailto:nikolai@mit.edu">nikolai@mit.edu</a>	Dr. Jay Connor <a href="mailto:jcmdhandsurg@comcast.net">jcmdhandsurg@comcast.net</a>

**Website:** <http://web.mit.edu/2.75/>

### **Lectures:**

**Furniture Design Lecture: Tuesday T 3-4:30 Room 3-442**

**Machine Design Lecture: Thursday R 3-4:30 Room 3-442**

All students are allowed/encourage to attend both sets of lectures if possible.

This class seeks to emulate real world product development effort, and in a professional fast paced R&D team there is no room for excuses. Attendance is thus highly recommended at all lectures: Blank looks when issues are raised in design reviews indicate the student was not in lecture/not paying attention and will be reflected accordingly in the student's grade. We will endeavor to run the lectures as workshops, designed to impart practical skills needed for moving the projects along. *Special sessions* can be arranged on an ad-hoc basis and in response to student needs.

Short (5-10 min) in-class quizzes will be given at the beginning of lectures on the material presented in the previous lecture.

### **Projects:**

*The primary focus of the class is to evolve a proof-of-concept prototype created prior to the beginning of class into a beta prototype suitable for presentation to potential licensees or investors. This is NOT a class where students start with just an idea... (that class is 2.75).*

There are four options for projects:

1. Projects continuing from 2.75 where the team wishes to refine the design (not redesign) and conduct and report on clinically relevant testing.
2. Projects with working prototypes from other classes (e.g., from 2.009) can be accepted by special arrangements with the instructors. These teams must have a mentor, to meet with them weekly and evaluate their work, and have an appropriate budget and source of funds. The 2.75 teaching staff will be available for technical consultations.

Teams entering with projects will be asked to present a quick introduction to their projects on the first day and be open, as appropriate, to adding team members.

For students not entering with an existing project, or joining an existing team:

3. This year's design challenge comprises the design and analysis of a two degree of freedom tilting head for a waterjet cutter. Teams of 2-3 students will be formed in class.
4. This year we also offer a special project, *Furniture Design*, for the first 12 people (pre-registered get priority, rest lottery). These students will be taught by master craftsman geeks in the MIT Hobby Shop.

Descriptions of both these projects are posted to the website.

*Please understand that given the real-world-problem driven nature of the class and the small teams and aggressive schedule, signing up for a project constitutes an implicit agreement NOT to drop the class.* Because full participation in the project is integral to the class, listeners, unfortunately, cannot be accommodated.

#### *Weekly Team Meetings*

Weekly one-hour team meetings for each team will be arranged with design team mentors to review progress and brainstorm/solve project design problems as well as locate resources. It is critical that for each meeting, each student brings their *design notebook*, which has been peer-reviewed by teammates *before* the meeting! Notebooks may be collected randomly during lecture or during design meetings. *Notebooks are critical for grading, as well as for your personal website, as they are a record of what you actually did to bring your design to reality!*

Given the diversity of projects, at the first team meeting, goals specific to each team are to be identified and agreed upon.

#### *Teamwork*

Teamwork is central to functioning of this class and any modern engineering endeavor, and it is expected that students will work together in a safe, professional, and collegial manner as defined in MIT's policies and procedures, especially 9.0 "Relations and Responsibilities Within the MIT Community," <http://web.mit.edu/policies/9/>. During the first weeks of team work, members are expected to identify challenges with their team's dynamics and bring them to the attention of team members and/or the course staff using the best diplomatic practices available. Prof. Slocum strongly recommends sports (especially long walk & talks or trot & talks) as a means to change the environment, get the blood flowing, and promote new thinking. Team building will be supported by the Gordon-MIT Engineering Leadership Program (<http://web.mit.edu/gordonelp/>) materials.

*At the end of the course team members will have the opportunity to formally review each other and combined ratings can be used to adjust grades by up to a full letter.* A mid semester peer review will be conducted and used to provide team members with anonymous, constructive feedback. (This will not affect grades.)

## Technical Drawings

All parts for projects need to be solid modeled and ANSI standard drawings made for all parts. A Bill of Materials (BOM) must be created. Each team member must be responsible for at least one drawing. Each student will also learn how to operate a CMM and measure one of the produced parts and compare the results to the drawing. Together this will count as an assignment.

## Prototyping

Teams will each have a project specific budget for prototyping and testing their product. In general, this can be used for purchasing components and manufacturing parts. Legitimate expenses include: components, machine shop services (must get an estimate for cost of job), local travel (mileage), etc. *Food is not a legitimate expense.* Deborah Alibrandi will administer team accounts and oversee purchasing procedures and guidelines. Ask the course staff if there are any questions.

Available resources include:

[MIT Hobby Shop](#) - Safety training and membership required

[Edgerton Center Student Shop](#) (44-023) – Safety and shop skills training required

LMP (35-231) – For Mechanical Engineering graduate students only

Pappalardo Shop - Best times are in the morning

Wet lab access is available in 5-026 by special arrangement only.

Limited lab bench space and tools for assembly and testing are available in 5-007 by special arrangement only.

Students often prefer, with the permission of their advisor, to use their own research labs.

Teams are responsible for keeping all workspaces clear and returning equipment to the proper storage otherwise access will be revoked. Since each project is different, staff will work individually with teams to ensure that they obtain the necessary resources. *Note: At no time can animal tissue be used in non-bio workspaces.*

*If there are any questions / doubts regarding fabrication or safety - please ask the course staff.*

## Documentation

Students are expected to maintain signed and dated lab notebooks with sketches, calculations, pasted in pictures, etc, which are informally reviewed during meetings and later factor into grading; however their primary function is to document the design process, especially with regards to building a design history file and establishing inventorship. The instructors also keep notebooks, which they update during meetings and presentations and use them to manage the teams and document their own contributions.

Other documentation, in addition to the design notebook, should be posted to the class (secure) Wiki, which will document the development and progress of each project. This Wiki will be viewable by other teams and the staff and will be consulted during class.

The team is responsible for submitting a final report in the form of a journal article suitable for the [ASME Journal of Medical Devices](#) or [ASME Journal of Mechanical Design](#). An “A” grade project is one that is presented in form and content that is actually ready to be submitted to a peer-reviewed journal. *Many of the final reports are either published in a journal or at a conference and a patent application may be filed is appropriate.* In addition to the paper, teams will be expected to turn in their PowerPoint presentations, a 1-page project description, and a video demonstrating their device.

Write early and write often: It is critical to document (write) as-you-go and in order to prevent teams from waiting until the last minute. Ideally by the end of the semester only editing will remain.

## Intellectual Property

For most projects continuing from 2.75 the question of intellectual property is already settled. For any new (potential) IP generated, in general, MIT's standard policies apply. Given the diversity of projects, IP decisions will be made on a case-by-case basis in consultation with the [MIT TLO](#).

Patents are legal documents and not all people involved in a project are necessarily inventors; "inventorship" is determined specifically by linking claims with individuals. Good documentation is thus essential and notebooks are likely to be reviewed by a patent attorney to determine inventorship. Whether or not you are an inventor has no effect on your grade, because you can be a person who reduces an idea to practice and thus be a critical team member and journal paper author even though you might not in the legal sense be an inventor.

### Communication:

2.752/3 is an undergraduate/graduate course that requires students to communicate as professionals (weekly design reviews and final written reports and functioning devices of high quality). The communication requirements for both graduates and undergraduates are the same, because they are all in the context of the team's project, and include:

- Weekly mentor meeting, before which teams are expected to have conducted peer reviews by examining other members' design notebooks.
- Max 20 minute project-plan presentation by the team to the class.
- Max 20 minute mid-term progress presentation by the team to the class.
- Max 20 minute final presentation demonstrating the prototype and presenting business case.
- The team is responsible for submitting a final technical report documenting the prototype, a one page executive summary (brochure), a final PowerPoint deck and a video demonstration of their product.

### Grading:

Term Project – Team Grade Project Management – Setting and following milestones Technical thoroughness – Prototype evaluation and engineering Quality of design (design & execution)	50%
Formal Communications Team Presentations Final Paper Demonstration Video	10%
Individual Performance Contributions to meetings and teamwork Use of lab notebook Peer evaluation results	20%
Preparation: In-Class Short Quizzes	10%
Technical Drawing Assignment	10%
	Total: 100%

An "A" grade is awarded to students who can identify challenges and solutions, perform appropriate detail engineering functions, and realize a design based on a deterministic design process. "A" students do not have to be significantly prodded or reminded to get things done.

### Course e-mail lists:

*Students agree that these e-mail lists will be strictly limited to course use only.*

[2.753-2014@mit.edu](mailto:2.753-2014@mit.edu) Contacts the entire course students and staff

[2.75-staff@mit.edu](mailto:2.75-staff@mit.edu) Contacts the course teaching staff

Teams are welcome to create their own lists, but please let the staff know what they are so that we can contact you more efficiently.

### **Suggested Text Books:**

1. Slocum, A. H., *Precision Machine Design*, © 1995, Society of Manufacturing Engineers, Dearborn, MI  
We have ordered these books directly from SME at a substantial discount.
2. Free Online Text: FUNdaMENTALS of Design by Prof. Slocum posted to the course website. (Students are expected to be familiar with the principles described)

### **Incredibly useful handbooks every practicing design engineer should own:**

1. Machinery's Handbook, Industrial Press, NY, NY
2. R. J. Roark, W. C. Young, Formulas for Stress and Strain, McGraw-Hill Book Company

### **Solid Works:**

Students are expected to be familiar with the software and have it loaded on their laptops. Download from the MechE department [here](#). Some of the lectures will require in-class SolidWorks exercises; you will be warned in advance.

### **Student Support:**

*Because this is a team based class, make-up assignments are usually not practical and if substantial work is missed, the student may be best advised to drop the class. Hence it is imperative that students seek appropriate help at the first sign of difficulty and work with the course staff to make sure issues are rapidly rectified. Resources are available:*

Undergraduates: If you are dealing with a personal or medical issue that is impacting your ability to attend class, complete work, or take an exam, please discuss this with Student Support Services (S3). The deans in S3 will verify your situation, and then discuss with you how to address the missed work. Students will not be excused from coursework without verification from Student Support Services. You may consult with Student Support Services in 5-104 or at 617-253-4861. Also, S3 has walk-in hours Monday-Friday 9:00-10:00am.

Graduate Students: Staff in the Office of the Dean for Graduate Education provide advice and counsel on a variety of issues including faculty/student relationships, conflict negotiation, funding, academic progress, interpersonal concerns, and a student's rights and responsibilities. Please contact them <http://odg.mit.edu/development/advising/> for an appointment. Other resources include your department's graduate officer, [MIT Medical](#) and the [MIT Work Life Center](#).

### **Student Disability Services:**

MIT is committed to the principle of equal access. Students who need disability accommodations are encouraged to speak with Kathleen Monagle ([monaglek@mit.edu](mailto:monaglek@mit.edu)), Associate Dean, prior to or early in the semester so that accommodation requests can be evaluated and addressed in a timely fashion. Even if you are not planning to use accommodations, it is recommended that you meet with SDS staff to familiarize yourself with the services and resources of the office. You may also consult with Student Disability Services in 5-104 or at 617-253-1674. If you have already been approved for accommodations, please contact the course staff early in the semester so that we can work together to get your accommodation logistics in place.

2.752/2.753 2014 Course Schedule

Week #	Start Date	Tuesday Lecture 3:00 - 4:30 pm, Room 3-442	Thursday Lecture 3:00 – 4:30 pm, Room 3-442	Tasks & Project Milestones Teams must post on wiki before Monday class of following week
1	2/3	<b>Kick-off &amp; Course Overview</b> Introduction to projects. Teams with existing projects present to class. <b>Servos:</b> Arduino and controls <i>T. Wortman</i>	<b>Fundamentals of Error Budgeting and Tolerancing</b> <i>A. Slocum</i>	<u>Milestone 1</u> <ul style="list-style-type: none"> <li>• Team Formation</li> <li>• Statement of Intent / Mission Statement (update if needed)</li> <li>• Preliminary task list, GANTT chart and budget</li> <li>• Setup/update team wiki and collect project documentation</li> </ul>
2	2/10	<b>Furniture design lecture</b>	<b>Project structure: Research and Development approaches, scheduling</b> <i>J. Guerrero</i>	<u>Milestone 2</u> <ul style="list-style-type: none"> <li>• Critique of current prototype – define immediate action items</li> <li>• Define deliverable for final prototype</li> <li>• Document literature and prior art findings</li> <li>• Update GANTT chart</li> </ul>
3	2/17	<b>MONDAY CLASS ON TUESDAY</b>	<b>Team Presentations:</b> Current status & Project plan	<u>Milestone 3</u> <ul style="list-style-type: none"> <li>• Preliminary analytical model complete</li> <li>• Preliminary CAD model complete</li> <li>• Create budget.</li> <li>• Update GANTT chart</li> </ul>
4	2/24	<b>Furniture design lecture</b>	<b>Solid Models and part drawings</b> <i>A. Wong</i>	<u>Milestone 4</u> <ul style="list-style-type: none"> <li>• Analytical model complete</li> <li>• Manufacturing plan complete</li> <li>• Update GANTT chart and budget</li> </ul>
5	3/3	<b>Furniture design lecture</b>	<b>Detailed design:</b> Structures, actuators, & bearings as a system <i>A. Slocum</i>	<u>Milestone 5</u> <ul style="list-style-type: none"> <li>• Analytical model used to identify components, tolerances, risks, countermeasures and testing plan</li> <li>• CAD design for manufacturing: at least 1 detailed part drawing</li> <li>• Update GANTT chart and budget</li> </ul>
	3/10	<b>Furniture design lecture</b>	<b>Customer Driven Design</b> <i>C. Chase</i>	<u>Milestone 6</u> <ul style="list-style-type: none"> <li>• Preliminary, properly toleranced drawings complete</li> <li>• Update GANTT chart and budget</li> </ul>
7	3/17	<b>Furniture design lecture</b>	<b>Detailed design:</b> Structures, actuators, & bearings as a system <i>A. Slocum</i>	<u>Milestone 7</u> <ul style="list-style-type: none"> <li>• “Deck” summarizing (1) need, (2) market size, (3) prior art, (4) competitive analysis table</li> <li>• Manufacturing and assembly plan, including materials</li> </ul>

				<ul style="list-style-type: none"> <li>Update GANTT chart and budget</li> </ul>
8	3/24	<b>SPRING BREAK</b>	<b>SPRING BREAK</b>	<u>Milestone 8</u> <ul style="list-style-type: none"> <li>Take a break, climb a mountain or jump in a lake!</li> <li>But if you are behind, get your schedule aligned</li> </ul>
9	3/31	<b>Furniture design lecture</b>	<b>Adhesives, fastening, joining</b> James Santoianni Loctite Henkel Representative	<u>Milestone 9</u> <ul style="list-style-type: none"> <li>Detail drawings complete, all components ordered and part orders placed with machine shops.</li> <li>Update GANTT chart and budget.</li> </ul>
10	4/7	<b>Team Progress Presentations:</b> Technical presentations demonstrating nearly functional prototypes, current problems and completion plan.	<b>Team Progress Presentations:</b> Technical presentations demonstrating nearly functional prototypes, current problems and completion plan.	<u>Milestone 10</u> <ul style="list-style-type: none"> <li>Begin assembly of device and testing of sub-assemblies</li> <li>Relate performance back to analytical model (close loop and self-reflection, what worked and didn't and how to do better next time)</li> <li>Update GANTT chart and budget</li> </ul>
11	4/14	<b>PATRIOTS DAY HOLIDAY</b>	<b>Plastics Engineering</b> <i>Edward M. Flaherty</i> <i>Nexeo Distribution</i>	<u>Milestone 11</u> <ul style="list-style-type: none"> <li>Update GANTT chart and budget</li> </ul>
12	4/21	No class, teams work on final deliverables	<b>Case study design:</b> Hydraulic hose coupler for Deepwater Horizon A. Slocum	<u>Milestone 12</u> <ul style="list-style-type: none"> <li>Finalize assembly and test performance of final product</li> <li>Update GANTT chart and budget</li> </ul>
13	4/28	No class, teams work on final deliverables	No class, teams work on final deliverables	<u>Milestone 13</u> <ul style="list-style-type: none"> <li>Final paper with detailed analysis of engineering design, manufacturability and future work; one page brochure and PowerPoint deck.</li> <li>Update GANTT chart and budget</li> </ul>
14	5/5	No class, teams work on final deliverables	No class, teams work on final deliverables	<u>Milestone 14</u> <ul style="list-style-type: none"> <li>Draft technical documentation for review in meeting</li> <li>Outline of future work</li> </ul>
15	5/12	<b>No Class</b> Final Presentation: <b>Thursday May 13<sup>th</sup></b> Dinner 6 – 7 pm; Presentations 7 – 10 pm Documentation due last scheduled day of classes (May 15)	<b>No Class</b>	<u>Milestone 15</u> <ul style="list-style-type: none"> <li>Final PowerPoint “deck” complete for “pitch”</li> <li>Technical documentation and one pager complete</li> <li>Video demonstrating product</li> </ul>