Degree Program:

**□** ECE-Electrical & Computer Engineering,

**▀ ME - Mechanical Engineering**

**□** General Courses for Both ECE & ME Degree Programs

Course Name: **Design and Manufacturing II**

Course Code: VM350

Course Credits: 4

Course Category: **▀** Required **□** Elective

Terms Offered:

**□** Fall \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**□** Spring \_\_\_\_\_\_\_\_\_\_\_\_\_\_

**▀** Summer\_\_\_\_\_2021\_\_\_\_\_

Course Pre-requisite: VM250

***Note*: Anyone who is taking VM350 had to pass VM250 in the previous semester.**

**Textbooks:**

* R.L. Norton, **Design of Machinery** – An Introduction of the Synthesis and Analysis of Mechanisms and Machines, 5th Edition, McGraw-Hill, 2012, ISBN: 978-0-07-352935-6
* J.J. Uicker, G.R. Pennock, J.E. Shigley, **Theory of Machines and Mechanisms**, 4th Edition, Oxford University Press, 2011, ISBN: 978-19-537123-9
* R. G. Budynas, J. K. Nisbett, **Shigley’s Mechanical Engineering Design**, 10th Edition, McGraw-Hill, 2014, ISBN: 978-0-070-339820-4
* D.G. Alciatore, M.B. Histand, **Introduction to Mechatronics and Measurement Systems**, 4th Edition, McGraw-Hill, 2012, ISBN: 978-0-07-338023-0
* J. Donnell, S. Jeter, C. MacDougall, J. Snedeker, **Writing Style, and Standards in Undergraduate Reports**, 3rd Edition, College Publishing, 2016, ISBN:978-1-932780-09-3

Other supplementary course materials may be available during the lecture and posted on CANVAS.

**Instructor:**

Prof. Jaehyung “Joshua” Ju

Teaching Philology: Learning by Doing - Active Classroom Practice & Design Thinking

Email: use an inbox tool on CANVAS

Office: JI Bldg. 500

Office Hour: **Monday 4:30-5:30 pm** / **Friday 5:30 - 6:30 pm** (or Wednesday 6:30-7:30 pm with a prior appointment)

If you communicate with the inbox tool of CANVAS, I will respond within 24 hours. If you communicate via email, I do not guarantee a response.

**Teaching Assistants (TAs):**

|  |  |
| --- | --- |
| **Yuhao Wang**  [wangyuhao@sjtu.edu.cn](mailto:wangyuhao@sjtu.edu.cn)  Office hour: Monday 6:00–8:00 pm | * **The leading** communicator on CANVAS and Feishu * Organizer for Grouping * **Leader** of fabrication lab (F-Lab) activities with grading |
| **Mengxuan Chen**  [mx-chen@sjtu.edu.cn](mailto:mx-chen@sjtu.edu.cn)  Office hour: Tuesday 6:00 - 8:00 pm | * **Leader** of mechatronics lab (M-Lab) activities with grading * Leading grader of the term project & design review |
| **Mengyuan Shen**  [shenmengyuan@sjtu.edu.cn](mailto:shenmengyuan@sjtu.edu.cn)  Office hour: Tuesday 6:00–8:00 pm | * **The leading** grader of homework, exams, class activities. * Assistant of computational lab (C-Lab) activities |
| **Junxiang Zhang (Lab consultant)**  [adajio517@sjtu.edu.cn](mailto:adajio517@sjtu.edu.cn)  Office hour: Monday 6:00–8:00 pm | * **Leader** of the C-lab activities * Supervisor of the term project * Supervisor of the lab facilities |

**Grading Policy:**

|  |  |
| --- | --- |
| Exam I | 20% |
| Exam II (final exam) | 20% |
| Homework assignments on the lectures | 10% |
| Class activities | 5% |
| Lab activities and assignments | 20% |
| Design review - oral presentation of the term project | 5% |
| Final report with a prototype – Novel design, Manufacturing and Assembly of Parts, Critical analysis, Demonstration, and Performance   * Final report (90%) * Gameday performance (10%) | 20% |

*Note*: If a student miss Exam I due to an “excused absence,” we may grade on the missed exam by deducting 15% of the grade of Exam II.

(Note: an excused absence is the one that follows the University guidelines and is approved by the Instructor.)

**Attendance Policy:**

* **Students in Shanghai must attend lectures and lab sessions**. **Students out of the country must attend lectures and lab sessions online.** If you have to miss a class or lab, you should inform the Instructor ahead of time.
  + A student staying in a country whose time zone difference is more than **10 hours** may not attend the lecture and lab sessions with approval from the instructor.
  + The instructors may provide the lecture slides and recorded videos after class.
  + According to the new SJTU’s education policy, **three times** of absence without prior notification to the instructors results in “**automatic failure** (F)” in the course.
* Students must behave professionally during lectures and lab sessions; the use of mobile devices is not allowed.
* We will check the attendance on a random basis. Maximum 5 points will be given to the final exam as a bonus if a student keeps a good record of presence with **active participation** in the class and lab activities.
* If a student does not show up in the exam, he/she does not get any points on the exam.

**Policy on Assignments**

Students must submit the homework and lab assignments to the Instructor or TAs by the due date. Failure to submit homework on time will get a 25% deduction per day.

* ***Note***: Students in Shanghai must submit assignments on paper before class. The students out of the country can submit assignments online.

Review of the grading: If a student does not consent to the grading, he (or she) can appeal to TAs or the Instructor for review. We will provide course materials and assignments on CANVAS. Students can communicate with TAs and the Instructor via the communication tool of CANVAS. ***Students' responsibility is to check the posted information on Canvas and check the course-related announcements to their registered email addresses.***

**Policy on class-activities**

* All students must submit the screenshot of the activities online within six hours after class.

**Academic Integrity:**

Homework and lab assignments are to be completed on your own unless specified as group assignments. This means:

* Students are not allowed to sit together and work out the details of the problems with anyone.
* Students are not authorized to discuss the problem set with previous class members, nor anyone else who has significant knowledge of the details of the problem set.
* Nor should you compare your written solutions, whether in scrap paper form or your final work product, with other students (and vice versa).
* You are also not allowed to possess, look at, use, or in any way derive advantage from the existence of solutions prepared in previous years.

**Violation of this policy is considered a violation of the honor code. It is grounds for the Instructor (s) to initiate an action that may lead to grade reduction, course withdrawal, University suspension, or expulsion.**

For your information, the UM-STJU JI has a nationally recognized Honor Code of Academic Integrity. This Code sets standards for academic integrity for all students. As a student, you are responsible for upholding these standards. For more information on the Honor Code at UM-SJTU Joint Institute, please visit <http://umji.sjtu.edu.cn/academics/academic-integrity/honor-code/>. After each examination, students must sign their names on the Honor Pledge on the test paper to further exhibit their commitment to academic integrity. The Honor Pledge is as follows: "I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code." Instructors are not required to grade tests in which the signed Honor Pledge does not appear. The Honor Code remains enforced whether or not the student signs the Pledge.

**Lecture @ East Middle Hall (E3) - 406**

**Tuesday 4:00 – 5:40PM**

**Thursday 4:00 – 5:40PM**

**Lab:**

**The schedule of lab sections will be posted on Canvas.**

* **Advanced computational engineering graphics (C-Lab)**
  + **3D CAD drawing using SolidWorks.**
  + **Place: JI computer room (3rd floor of the JI building)**
  + **Time: (Week 1, 2, 3, 5, 6, 7)**
    - **Friday 2:00 – 3:30 PM**
* **Mechatronics (M-Lab):** **(Weeks 1, 3, 5, and 7)** 
  + **Arduino microcontroller programming with sensors and actuators**
  + **Place: Design and Manufacturing Lab (3rd floor of the JI building)**
  + **Time:** 
    - **Friday 3:40 – 5:40 PM**
* **Fabrication (F-Lab):** **(Weeks 2, 4, 6, and 8)** 
  + **Design project with fabrication**
  + **Place: Design and Manufacturing Lab (3rd floor of the JI building)**
  + **Time:** 
    - **Friday 3:40 – 5:40 PM**

**Students are required to attend the lab sessions. TA will collect the lab assignments with an attendance sheet during the lab sessions.**

**Course Topics:**

1. Review of the design process and relevant design principles.
2. Fundamental kinematic analysis of mechanisms such as four-bar linkages and cams.
3. Application of basic materials and mechanics to mechanical design.
4. Analysis and synthesis focus on the selection methods for essential components, including gears, bearings, springs, power screws, and fasteners.
5. Introduction of standard mechatronic components; selection and application of motors based upon predictive models and motion curves.
6. Design of mechanical or mechatronic systems for given requirements, such as motions, trajectories, power ratings, etc.
7. Analysis of load and power flow through transmission systems such as gears, linkages, cams.
8. Preparation of engineering instructions (tolerance drawing and text) by selecting the appropriate materials and manufacturing processes based upon geometry, loading, and tolerances.
9. Build and assemble mechanical systems using standard machine shop tools (manual/CNC mill, lathe, drill, and laser cutter) and advanced manufacturing tools, e.g., 3D printing.
10. Test and evaluate simple machine systems and components for performance and failure behavior using physical and virtual prototypes.

**Course objective:**

1. To teach students how to formulate the design and manufacturing problems for mechanical and mechatronic systems.
2. To teach students how to apply the general mechanical engineering sciences in analyses specific to the design of mechanical components and mechatronic systems.
3. To teach students in a laboratory setting how to generate concepts, conduct analyses to size components, construct, assemble, and program a prototype and test its function to meet the specifications of a design and manufacturing problems.
4. To reinforce students' team skills through a team project, including problem formulation, problem solutions, and written reporting of results.
5. To reinforce students' visualization and hands-on skills through virtual prototyping and physical construction exercise.

**Course Outcomes:**

1. Design (synthesize) of basic mechanical systems (including components such as linkages, cams, bearings, and gears) and mechatronics systems (which integrate electronic control and mechanical components) to operate under given motion requirements
2. Perform analyses of the underlying kinematics of a mechanical system to predict behavior and evaluate fundamental mechanical quantities (trajectory, velocity, acceleration, force, etc.)
3. Apply appropriate selection criteria to choose standard mechanical components such as gears, bearings, and springs.
4. Virtual prototyping of mechanical systems using one or more commercial CAD programs - e.g., SolidWorks for linkage simulation performance.
5. Test and evaluate the physical prototypes of simple machine systems and components for performance and benchmarks.
6. Critique and redesign mechanical systems and components for enhanced performance and reliability.
7. Compile reference (e.g., catalog, handbook, and textbook) resources to formulate an analysis for specific mechanical and mechatronic components addressed within those resources.
8. Conduct failure analyses, including stiffness, static strength, and fatigue strength, appropriate for sizing standard components.
9. Use primary machines and hand tools to manufacture simple parts from metal and plastic to reasonable tolerance and assemble them into a functional device.
10. Communicate engineering decisions, the justification for those decisions, designs, manufacturing plans, and test results in writing.

**[[1]](#footnote-1)ABET Outcomes:**

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (5)
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (4)
3. An ability to communicate effectively with a range of audiences (5)
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (4)
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (5)
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to conclude (5)
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies (5)

**Assignments:**

There will be about 12homework assignments (and ~15 in-class activities) on lecture and about 14 lab assignments from the lab activities.

**Term Project:**

Coursework also consists of a semester-long group project. Team members will be chosen ***by the Instructor*** based on some criteria. There is a presentation for a design review on **Thursday**, **July 8,** and **Friday**, **July 9.** We expect an 80% of your prototype is ready by the time of the presentation. The design competition is on **Friday**, **July 23**. The deadline for the final project report (~15 pages) is **Friday, July 30.**

**Exams:**

There will be two exams in this course, each of which accounts for 20% in the final grade. The content covered in each exam will be specified during the lecture. Exam I is scheduled on **Friday**, **June 17,** and Exam II takes on **Week 13**.

**Peer evaluation:**

Since the collaborative activity is an essential part of this course, each member will be asked to submit a peer evaluation sheet at the end of the semester to evaluate the participation of each team member (including yourself) to project activities. A peer evaluation form is available on the course Canvas site under “Final Project.”

**Lecture Schedule: (tentative)[[2]](#footnote-2)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Week** | **Date** | **Class** | **Topic** | **Chapters** | **HW** |
| 1 | Tu 5/11 | 1 | Course Overview, Project, Introduction to Design, | Norton-1 | HW 0 |
| Th 5/13 | 2 | Kinematic fundamentals (I): Kinematic pairs, Mobility | Norton-2 | HW 1 |
| 2 | Tu 5/18 | 3 | Kinematic fundamentals (II): Number synthesis, Isomers, transformation | Norton-2 |  |
| Th 5/20 | 4 | Kinematic fundamentals (III): intermittent motion, inversion, Grashof condition | Norton-2 | HW 2 |
| 3 | Tu 5/25 | 5 | Kinematic fundamentals (IV): linkages of more than four bars, spring as a link, compliant mechanisms, MEMS | Norton-3 |  |
| Th 5/27 | 6 | Graphical linkage synthesis (I) | Norton-3 | HW 3 |
| 4 | Tu 6/1 | 7 | Graphical linkage synthesis (II) – drawing | Norton-4 | HW 4 |
| Th 6/3 | 8 | Position analysis (I) - (Class activity; crank-slider) | Norton-4 |  |
| 5 | Tu 6/8 | 9 | Position analysis (II) - (Class activity; crank-rocker) | Norton-6 |  |
| Th 6/10 | 10 | Velocity analysis (Class activity III) | Norton-7 | HW 5 |
| 6 | Tu 6/15 | 11 | Acceleration analysis (Class activity – Vector loop analysis), Spatial mechanisms | Uicker- 13 | HW 6 |
| Th 6/17 |  | Exam I (Midterm-exam) |  |  |
| 7 | Tu 6/22 | 12 | Introduction to mechatronics | Alciatore – 1,2 |  |
| Sun 6/24 | 13 | Sensors, Actuators | Alciatore - 9.10 |  |
| 8 | Tu 6/29 | 14 | Kineto-statics (Design), Kineto-dynamics (Design) | Uicker-11, 12 | HW 7 |
| Th 7/1 | 15 | Cam design | Cleghorn 7 | HW 8 |
| 9 | Tu 7/6 | 16 | Gear fundamentals, Spur gear | Cleghorn 5 |  |
| Th 7/8 |  | Design review (First groups) |  |  |
| Fr 7/9 |  | Design review (Second groups) |  |  |
| 10 | Tu 7/13 | 17 | Gears - Design and Manufacturing | Cleghorn 5 | HW 9 |
| Th 7/15 | 18 | Gear trains – Ordinary gear trains | Cleghorn 5 |  |
| 11 | Tu 7/20 | 19 | Gear trains - Planetary gear train, Transmission | Cleghorn 6 |  |
| Th 7/22 | 20 | Gear trains – Differentials, Advanced gear trains | Cleghorn 6 | HW 10 |
| Fr 7/23 |  | Design competition – game day |  |  |
| 12 | Tu 7/27 | 21 | Tips for technical writing |  |  |
| Th 7/29 | 22 | Review & Research on Design of Machinery |  |  |
| 13 | Fri 8/6 |  | Exam II (Final exam) 4:00-5:40 pm |  |  |

**[[3]](#footnote-3)Lab Schedule: (tentative)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Week** | **Engineering graphics**  **(C-Lab)** | **Mechatronics:**  **(M-Lab)** | **Fabrication:**  **(F-Lab)** |
| 1 | **C-Lab #1**  4-bar mechanism (crank-rocker linkage) | **M-Lab #1**  Programming with a color sensor |  |
| 2 | **C-Lab #2**  CAM and follower |  | **F-Lab #1**  Insect robot with four-bar linkages |
| 3 | **C-Lab #3**  4-bar mechanism (slider-crank linkage) | **M-Lab #2**  Measuring speed of sound/distance using an ultrasonic sensor |  |
| 4 | No C-Lab |  | **F-Lab #2**  A hydraulic-powered robot arm |
| 5 | **C-Lab #4**  Gearbox | **M-Lab #3**  Control of DC motors |  |
| 6 | **C-Lab #5**  Car engine (collaborative project) |  | **F-Lab #3**  Building a gearbox |
| 7 | **C-Lab #6**  Drone (collaborative project) | **M-Lab #4**  Temperature and humidity sensors |  |
| 8 | Extra work for the project | | |
| 9 | Design review | | |
| 10 | Extra work for the project | | |
| 11 | The design competition – game day | | |
| 12 | Extra work for the project reports | | |

1. Number in ( ) indicates a level of extent; 1-5. [↑](#footnote-ref-1)
2. green – kinematics, blue- machine element design, red – mechatronics, purple- design and manufacturing hands-on activities [↑](#footnote-ref-2)
3. We may give bonus points up to 5 for each lab activity that students posted on social networks – Facebook, YouTube, Bilibili, etc. with 30 likes or more. [↑](#footnote-ref-3)