EE455   Electrical/Mechanical Design   Spring 2019

Catalog Description   Engineering in practice often employs a hybrid of electrical and mechanical design skills. This laboratory-intensive course takes students already proficient in analog design and microcontroller programming, and in the first module ties these skills together with microcontroller analog interfacing methods. The second module consists of a brief treatment of statics and continuum mechanics, and then introduces three-dimensional solid modeling, additive rapid prototyping, and stress analysis techniques. Students then demonstrate mastery of electrical and mechanical design skills in the third module design project. Laboratory experiments involving microcontroller interfacing and computer-aided design complement the lectures. Elective course.

Prerequisites   EE223 – Electrical Circuit Analysis II, EE339 Microcontrollers, PY161 Physics II

Textbook   *Electrical/Mechanical Design*, custom print, McGraw Hill, ISBN: 13-1-121-08169-7

Instructor COL James Squire, NEH 628
Email: squirejc@vmi.edu
Office tel: x7548   Home tel: 264-0122 (call before 1900)
Office hours: stop-ins welcome, or by appointment, or on Mon, Fri from 1400 – 1450.

Course schedule   NEH 428   Lecture: Tue, Thu 1050 – 1140 and Wed 1400 – 1550.

Course Objectives[1]
1.   Develop the ability to effectively work in a small team of engineers to design a product for a client [A,B,C]
2.   Develop the skills necessary to program and interface microcontrollers to solve real-world problems [A,B,C,E]
3.   Develop the skills necessary to model and analyze three dimensional computer-aided design models [A,B,C]

[1] Letters in brackets correspond to Electrical Engineering program objectives

Performance Criteria
for Objective 1:
a.   Students will be able to conduct an interview with a client to ascertain his/her needs and write them as marketing requirements.
b.   Students will be able to write an engineering requirements specification
c.   Students will be able to modify the marketing requirements and engineering requirements to the client's satisfaction as unforeseen difficulties are encountered or opportunities are discovered during development.

for Objective 2:
a.   Students will be able to program a microcontroller using C and interface its digital ports
b.   Students will be able to use a microcontroller's analog input ports and simulate analog output with its PWM ports
c.   Students will be able to program a microcontroller to communicate with a personal computer
d.   Students will be able to interface a variety of sensors to a microcontroller, including force and temperature
e.   Students will be able to interface a variety of effectors to a microcontroller, including motors and relays

for Objective 3:
a.   Students will be able to create a three dimensional solid models involving extruding 2D shapes, lofting, and filleting
b.   Students will be able to conduct advanced solid modeling, including photorealistic scene generation
c.   Students will be able to explain how to obtain rapid prototyped parts given their solid models from online vendors

Topics
- Project Management
    - Needs identification
    - Requirements specification
    - Concept generation and evaluation
    - Functional decomposition
- Microcontroller programming and interfacing
    - C programming review
    - Digital I/O, debouncing, lighting LEDs, interfacing with relays and thyristors for heavy loads
    - Analog input, PWM output, H-bridges
    - Serial communication, interfacing with a PC
- Solid modeling and analysis
    - Basic part modeling techniques including extrusions from 2D sketches and fillets
    - Linear and circular patterning, and photorealistic scene generation
    - Special topics to include a subset of these topics depending on the topic
        - Lofts, shells, 3D sketches
        - Assemblies and mechanisms
        - Computer aided manufacturing, including rapid prototyping
        - Stress and deformation analysis

Work for Grade Policy   Your course grade will be a simple average as shown to in the table to the right. No curves are applied. I will drop your lowest homework grade. As primarily a lab/project course, there is no final examination.

Homework	30%
Graded reviews (6 equally weighted)	60%
Peer reviews	5%
Participation	5%
Total	100%

Homework   When you acknowledge help received, estimate how much is your own work (e.g. "CDT Jones showed me how to set up the node equation matrix when a diode is present. 90% is my own work"). Homework must be completed individually but you may receive help from the other person in your lab group. If you receive help from any person outside your lab group, both you and they will not receive credit for that problem.   This is to encourage brainstorming with others, but to discourage wholesale copying from one person. Regardless of whether or not you decide to break the previous rule, you must acknowledge help from all sources (excluding myself and your textbook) including all classmates, other professors, other current or past cadets' notes, old homework solutions, and books.

Late policy   I do not accept late homework. Homework is due at the start of class. The only authorized exceptions are by direction of the superintendent, hospitalization, or in the case of extenuating circumstances, by *prior* arrangement with me. **Attending a scheduled guard duty does not exempt a cadet from turning in the assignment on time; you can do so either directly to me (under my door in advance of the class) or to a classmate.**

Tests   None.

Professional Component   3 credits of Engineering Topics (specifically, Engineering Science and Design)

Relationship Of Course To Program Outcomes   primarily department program outcomes 1, 5, 11, and 14.

Prepared by James C. Squire, Professor, 01/10/19

Course Administration

On the Thursday lab of each week I will publish a weekly class assignment, describing the readings, homework, and laboratory goals for the following week. The lab is due at the next graded review; the homework is due the following Tuesday.

Lectures – Tues and Wed

Tuesday and Wed are lecture classes. There will be one homework per week based upon the lecture material. The lectures are arranged in four quarters as shown in the class schedule on the following page. The first three will cover project management, microcontrollers, and solid modeling. These will feel similar to a traditional lecture course, like digital signal processing. At the start of the Thursday lab I collect the HW for the week and distribute the weekly guide for the following week.

Most assignments will be done individually, but some will require one homework partner. If there are an odd number of students in the class, there will be one group of three. Homework partners will change four times during the semester.

Collaboration (other than with your homework partner, for classes of more than three) is not authorized; if done so anyway both the people that gave and received help outside the homework group will not receive credit for the problems on which they collaborated.

Any extra time on Wednesday classes will be allocated to the lab project.

Laboratories - Thu

Thursdays are lab classes. The majority of your work, and course grade (60%), will be here. This is very open-ended, like senior design. Grades here are assigned based on 8 equally-weighted status reports, which are usually due every other week (exact schedule posted below). If there is a graded review, it is also held on a Thursday. You will also present at the URS, and, if selected to present, will earn up to a full letter grade bonus on your lowest graded review based on your presentation.

The laboratory experience is synonymous with the main course project. This year, the project is competition in the Battle of the Rockets (http://www.rocketbattle.org/). This is a national-level contest that has both high school and university tracks; you will compete in the inter-university Mars Rover tournament held on March 30-31 nearby in Culpepper, VA.

Unlike most classes, this is severely front-loaded; the Comprehensive Design Review (CDR) is due to me on 30 January. You may enlist the help of mechanical engineering friends – you may well need their expertise since this is very much a cross-disciplinary project typical in difficulty of what you will encounter when you graduate.

Speaking of difficult: in the approximately decade that the competition has been held, no university has every completed it. Instead, winners have been selected on the basis of completeness of their Preliminary Design Review (PDR), CDR, and how far their rocket/rover systems manage to complete, so start working on the CDR, due in two weeks, now to be competitive with the other teams.

Read the contest rules at the above URL for details. In summary, it involves sending a rocket up to at least 1,000' as measured by an onboard altimeter, where it must disgorge an autonomous rover. Both rover and rocket must fall to the ground by parachute. The rover must disengage from its parachute and move three feet, where it will wait for a command from the students' wireless controller. On that command it will collect from 5 to 25 grams of soil (more soil = more points) within 5 minutes. A second command causes the rover to take a picture of the area from which the soil was collected. The controller must have just two buttons, one initiate soil collection and one to take a picture, and it must be operable with heavy gloves. Historically, most failures involve the rover breaking on landing.

You have a $500 budget beyond the considerable amount of parts already purchased. The rocket is already constructed.

It can happen that a graded review day becomes inconvenient for reasons not apparent at the start of the semester (example: two tests earlier that day). In that case, it may be moved to a Thursday afternoon or Friday morning if 1) all students are in agreement, 2) I am available then, and 3) you request it be moved 7 or more days in advance.

Since this project is also serving as CDT Penny's honor thesis, he will be the Project Manager (PM) for the semester. There will also be a Secretary, whose duties are below; this will rotate at the start of each month in the semester.

PM duties: liason between the team and the instructor. Publish the graded review to me by midnight the day before it is due. If it is late (e.g. published after midnight) it will be reduced 10% (one letter grade) for every 24 hour delay.

Secretary duties: records the goals decided at the graded review for the following graded review and publishes them within 24 hours to the team and to the instructor. Uses a parts order form for order requests, and checks to make sure they are in stock before requesting the order.

Class Schedule

	Lecture/Lab	Date	Day	Topic
Project Management	1	16 Jan	W	Course administration
	2 (lab 1)	17	R	
	3	22	T	
	4	23	W	
	5 (lab 2)	24	**R**	**Client Meeting #1** **Graded Review #1: CDR draft 1**
	6	29	T	
	7	30	W	
	8 (lab 3)	31	**R**	**Client Meeting #2** **Graded Review #2: CDR DUE**
Microcontrollers	9	5 Feb	T	
	10	6	W	
	11 (lab 4)	7	R	
	12	12	T	
	13	13	W	
	14 (lab 5)	14	R	**Graded Review #3**
	15	19	T	
	16	20	W	
	17 (lab 6)	21	R	
	18	26	T	
	19	27	W	
	20 (lab 7)	28	R	**Graded Review #4**
Project Management	21	5 Mar	T	
	22	6	W	
	23 (lab 8)	7	R	
	24	12	T	
	25	13	W	
	26 (lab 9)	14	R	**Graded Review #5**
				Spring Break
	27	26	T	
	28	27	W	
	29 (lab 10)	28	R	**Graded Review #6**
Battle of the Rockets: Fri-Sun, 29-31 March				
Solid Modeling / Entrepreneurship	30	2 Apr	T	Comp time for 48 hours at competition
	31	3	W	Clean rocket/flight systems/rover for window display
	32 (lab 11)	4	R	Comp time for 48 hours at competition
	33 (lab 12)	11	R	(FTX on T, W-is-a-M) Comp time for 48 hours at competition
	34	16	T	Solidworks
	35	17	W	Solidworks
	36 (lab 13)	18	R	Solidworks
	37	23	T	Solidworks
	38	24	W	Solidworks
	39 (lab 14)	25	R	Solidworks
	40	30	T	Entrepreneurship
	41	1 May	W	Entrepreneurship
	42 (lab 15)	2	R	Entrepreneurship

<u>**Appendix A: Institute Work For Grade Policy**</u>

"**Work for grade**" is defined as any work presented to an instructor for a formal grade or undertaken in satisfaction of a requirement for successful completion of a course or degree requirement. All work submitted for grade is considered the cadet's own work. "**Cadet's own work**" means that he or she has composed the work from his or her general accumulation of knowledge and skill except as clearly and fully documented and that it has been composed especially for the current assignment. No work previously submitted in any course at VMI or elsewhere will be resubmitted or reformatted for submission in a current course without the specific approval of the instructor.

In all work for grade, failure to distinguish between the cadet's own work and ideas and the work and ideas of others is known as **plagiarism**. Proper documentation clearly and fully identifies the sources of all borrowed ideas, quotations, or other assistance. The cadet is referred to the VMI-authorized handbook for rules concerning quotations, paraphrases, and documentation.

In all written work for grade, the cadet must include the words "**HELP RECEIVED**" conspicuously on the document, and he or she must then do one of two things: (1) state "none," meaning that no help was received except as documented in the work; or (2) explain in detail the nature of the help received. In oral work for grade, the cadet must make the same declaration before beginning the presentation. Admission of help received may result in a lower grade but will not result in prosecution for an honor violation.

Cadets are prohibited from discussing the contents of a quiz/exam until it is returned to them or final course grades are posted. This enjoinder does not imply that any inadvertent expression or behavior that might indicate one's feeling about the test should be considered a breach of honor. The real issue is whether cadets received information, not available to everyone else in the class, which would give them an unfair advantage. If a cadet inadvertently gives or receives information, the incident must be reported to the professor and the Honor Court.

Each cadet bears the responsibility for familiarizing himself or herself thoroughly with the policies stated in this section, with any supplementary statement regarding work for grade expressed by the academic department in which he or she is taking a course, and with any special conditions provided in writing by the professor for a given assignment. If there is any doubt or uncertainty about the correct interpretation of a policy, the cadet should consult the instructor of the course. There should be no confusion, however, on the basic principle that it is never acceptable to submit someone else's work, written or otherwise, formally graded or not, as one's own.

The violation by a cadet of any of these policies will, if he or she is found guilty by the Honor Court, result in his or her being dismissed from VMI. Neither ignorance nor professed confusion about the correct interpretation of these policies is an excuse.

<u>**Appendix B: Department Work For Grade Policy**</u>

Tutoring (e.g. Writing Center, Academic Center, athletic tutors, private tutors): The ECE Department supports and encourages cadet use of learning aids as offered by the VMI Writing Center, VMI Academic Center, and tutors. All assistance from these, and other similar aids, must be explicitly described in the statement regarding help received.

Peer Collaboration: Peer collaboration policies, including policies on critical comments, will be established by the individual faculty of the ECE Department, and may vary from assignment to assignment. Each ECE faculty member will clearly indicate the appropriate collaboration policy for each assignment. Policy regarding laboratory groups, team cooperation, interaction between teams, etc. will be established by the individual faculty. All assistance from such peer collaboration must be explicitly described in the cadet statement regarding help received.

Computer Aids (including calculators, translators, spelling, style, and grammar checkers): The ECE Department supports and encourages cadet use of computer aids, including calculators, translators, spelling, style, and grammar checkers to improve the quality of the cadets' work. The use of such computer aids does not constitute help received.

<u>**Appendix C: Learning Disability Statement**</u>
If you have a documented disability and want accommodations in my class, please register with the Office of Disabilities Services, 2nd Floor, Post Infirmary, 464-7667, and provide me with an Accommodations Letter outlining your accommodations. I will be glad to meet with you privately to discuss your needs. Accommodations must be arranged with me at least 72 hours prior to the graded activity.