

**UNIVERSITY OF NOTRE DAME**  
**DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING**  
**AME40463: Senior Design Project**  
**Spring 2010**

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**Project Coordinators:**

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**A. COURSE OBJECTIVES**

This course is the capstone project in your undergraduate mechanical engineering program. One feature of this course is that not everyone will experience and learn the same things, and your experience will depend upon those aspects of the project upon which you focus. You will be asked to share your experiences with others in the class, so each can benefit from everyone's efforts. The following are the desired learning outcomes for the course.

Learning Outcomes for each student:

1. Contribute to a collaborative group effort resulting in the design and fabrication of a technically sound product.
2. Assume a major role in the design of a key technical feature, component or aspect of the product and be able to effectively communicate your contributions in oral, visual and written form.
3. Demonstrate the effective use of appropriate analytic, numerical or experimental engineering methods in satisfying Outcome 2.

Desired Outcomes for each group:

1. Develop a concept for a product.
2. Develop a virtual model and a robust, functional prototype that effectively demonstrates key technical features of the concept.
3. Develop a product that contains embedded intelligence including sensors, actuators and controllers characteristic of contemporary mechanical engineering systems.
4. Effectively communicate the concept and its development using technical reports and oral presentations.

During the course, considerable emphasis will be placed on innovative concepts and prototyping, but it is expected that key technical decisions related to the design of the product concept will be supported by sound engineering analysis. Balancing innovation with the practical constraints imposed by limited time, experience, resources, facilities and technical support is critical in this project.

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**B. COURSE POLICIES**

**DESIGN TEAMS, PLATFORM AND FUNCTIONAL GROUPS:** The design activities will primarily be conducted by Platform Groups that are responsible for the design, development, and fabrication of devices that are parts of a larger system of multiple, interacting devices. Within Teams, Functional Groups will be used to coordinate technical activities

and decisions. All students are members of a Team and both a Platform and a Functional Group. Each Team will have access to a number of industrial design consultants during the project. The Team will determine the consultant's role.

**GRADING:** Your course grade will be determined based both on your performance and that of your Team/Groups.

- a. Individual deliverables:  
Engineering trade study, engineering notebook, presentations, etc. 40%
- b. Team/Group deliverables:  
Product concept, prototype, documentation and presentation of results 60%

An individual's credit for group deliverables is determined using information from the peer reviews and instructor assessment. Deadlines have been established for each of the deliverable items and must be strictly observed.

**Individual Deliverables:** (40% of total)

Individual platform concept memo	5 %
Engineering trade study (proposal and report)	25 %
PDR and CDR presentations	5 %
Engineering notebook	5 %

**Team Deliverables:** (10% of total)

Team project plan	5%
Composite team compliance with design specifications	5%

**Group Deliverables:** (50% of total)

Functional Group Reports	5 %
Design Documentation	15 %
Prototype compliance with design specifications	25 %
PDR and CDR presentations	5 %

Grading guidelines will be provided for major deliverable items and grades posted on Concourse.

**DESIGN CLASS AND DESIGN STUDIO ATTENDANCE POLICY:** The course is scheduled from 9:30 am – 12:15 pm each Tuesday and Thursday. During this time, discussions, presentations, special equipment training, consulting, and other forms of interaction between students, support staff, TAs, and instructors will take place. This is also the time when all students can attend Team or Group meetings without schedule conflicts. All students are expected to be present from 9:30 am – 12:15 pm each regularly scheduled class. Each Tuesday morning at 9:30am, all students will attend a 15-minute all-student meeting in Rm. 126 DeBartolo. At the conclusion of that meeting, selected individuals/groups may make presentations to the entire class. The other Team/Group presentations and meetings with instructors will be scheduled on Tuesday and Thursday mornings, and you will be provided with a schedule of presenters and times. Approximately every other week, every Functional Group will also be scheduled for an informal, 30-minute discussion session with one of the Instructors. The schedule for those sessions will also be provided. Each student is allowed to miss, without official University excuse, a total of 4 class sessions (this is a 4-credit hour course). Additional unexcused absences will result in being dropped from the course. It is therefore important that you schedule any other professional or personal activities with this policy in mind.

**PROJECT SCHEDULING, DELIVERABLES and TIME EXTENSIONS:** You will be provided with a number of deadline dates for both individual, Team, and Group deliverables. Please note that in almost every case, you and your group can complete and submit these deliverables before the deadline date. The performance evaluation tests (4/15), the **Blue/Gold game (4/23)[NOTE CHANGE]**, and the Critical Design Review (4/22) are the only fixed dates. Any other deliverable can be submitted early. No required submission will be accepted late without an official University excuse.

**COMMUNICATIONS AND COMPUTER POLICY:** You are responsible for archiving and maintaining your Team/Group's information and data. Each Team and Platform group will be provided a special netid. Concourse will

serve as a bulletin board for this course and it should be checked with some regularity. Students should regularly check their email for updates or changes related to the course.

**DESIGN STUDIO POLICY:** The AME Undergraduate Design Studio, B-19 Fitzpatrick Hall, will be available for your use whenever Fitzpatrick Hall is open. Each Platform group will be allocated a workspace that includes storage, meeting, and fabrication spaces. It is the responsibility of every member of this class to make sure that the equipment in this facility is used in a safe and responsible fashion. The room is equipped with a combination lock. Please don't provide the combination for this lock to students who are not in this course and do not prop the door open. Additional guidelines for the use of the Studio and schedules for availability of the prototype fabrication equipment will be provided during the course.

**SPENDING, COST ACCOUNTING and EQUIPMENT ACCOUNTABILITY:** Each Team will be allocated up to \$6500 for development of their team of robots. Each Platform group will have available for their use a number of pieces of issued equipment and tools. Guidelines and procedures for spending and record keeping will be provided. It is expected that all of the issued equipment will be repackaged in the same manner as it was provided and returned in the same condition as issued.

**PROTOTYPE CONSTRUCTION AND SAFETY:** Selected machine tools in B-19 are available for your use at any time. The lathe, band saw, vertical mill, and grinder will be available at limited times and may only be used under the direct supervision of appropriate personnel. 2-D CAD/CAM work-cells will be available, but class members must be certified in their operation prior to use. Safety glasses **MUST** be worn whenever operating any of the equipment in B19. You must also wear hard-soled, closed shoes and appropriate clothing when using the machine shop portion of the Design Studio. You must clean up the work area after using any of this equipment. **Unauthorized use of any of the equipment or facilities or violation of posted safety regulations will result in dismissal from this course.** Your safety is the primary consideration. The prototype as well as all other equipment or supplies purchased from the resources provided by the University remain the property of the University of Notre Dame.

**INTELLIGENT SYSTEMS AND AUTOMATION LEARNING LAB POLICY:** ISALL is located in room 358C of Fitzpatrick Hall and is open Monday-Friday from 8:00 to 4:30. You may work in ISALL any time during these hours, but be advised that technical support staff is available only during regularly scheduled class hours on Tuesday and Thursday and at certain other specific times, which will be posted on the lab door. ISALL is managed by Mr. Brownell who will provide additional information on equipment and services.

**AME MACHINE SHOP POLICY:** The AME machine shop will be available to provide limited support. Mr. Hluchota, the AME Tool and Die maker, will be available for approximately ½ hour for consultation during the weekly design studio sessions. Mr. Hluchota will post his available times. Students are not allowed to use equipment in the AME Cushing shop at any time, though Mr. Hluchota may assist you by performing special tasks if time and resources are available.

**CODE OF HONOR POLICY:** All work submitted in this course must be the work of the student or students submitting the work. Students should be careful to properly cite the sources of ideas and other information that they submit if they are not their own. Collaboration and group effort are keys to success in the course, but there are various items (e.g. engineering notebook, individual trade study, etc.) that must be the work of the individual engineer and submitted information must be the student's own or carry citations to the source. If you have any questions about the appropriateness of a collaboration or citation for an information source, ask prior to submitting the work.

**PROJECT POLICY STATEMENT:** The purpose of AME40463 is to collaboratively design, develop and demonstrate two teams of mechatronic devices for use in evaluating the feasibility of an intercollegiate mechatronic football league. The project is not a competition between students enrolled in the course. Rather, it is an opportunity for everyone involved to work together and gain design experience in achieving this common goal. Individuals will contribute in different ways to this group effort, and those contributions should be supported and recognized by all. Your individual grade will be determined based upon: 1) the success of your collaborative efforts, 2) your individual contributions to those efforts, and

3) individual deliverables. Success for each mechatronic platform will be measured by its ability to satisfy the stated design requirements – NOT in comparison with other platforms. Victory/defeat/score in the Blue/Gold game will not factor into grading. The game is meant to be fun - a time to showcase your excellent design work! Collaboration and design creativity are not only encouraged throughout, they are the only means by which you will achieve success, both collectively and individually.

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### C. TEAM and PLATFORM GROUP PROJECT REQUIREMENTS

The project's goals are to continue to evaluate the feasibility of developing an Intercollegiate Mechatronic Football Competition. The purpose of the proposed competition would be to engage engineering students from participating universities in the design, fabrication, and demonstration of a team of semi-autonomous robots playing the game of Collegiate Mechatronic Football. To be successful, the students would need to develop robust players with effective mechanics and excellent controllability. The overarching educational goal of the project is to involve students in a design effort that requires collaboration and coordination at multiple levels. Teams are composed of multiple platform groups. Platform groups develop devices (players) that must interact at the product level in order to achieve system level (game) objectives. This is representative of many important engineering products and systems being developed today.

#### Project Requirements:

Each Team must:

1. Develop a project management and administration plan, assign students to Platform Groups, and select Team, Platform Group, and Functional Group coordinators.
2. Develop a system of mechatronic devices that meets the guidelines set forth in the 2<sup>nd</sup> Generation Mechatronic Football rules.
3. Each Team of players must contain at least one player in each of the following classifications: 1) QB or QB/P, 2) QB/P or RB/P, 3) Kicker, 4) Center. Details are provided in the Engineering Design Requirements and Performance Evaluation Tests and The Rules of Collegiate Mechatronic Football documents.
4. Demonstrate the results of their design activities through a series of performance tests and demonstrate the effectiveness of the team in a mechatronic football game.

Each Platform Group must:

1. Develop the conceptual design for a machine that satisfies the stated engineering design requirements.
2. Develop effective documentation to communicate the form, function, and performance of the product. The design must be based upon sound engineering modeling, analysis, simulation, and prototyping. The documentation should include engineering justification and address key issues such as performance, fabrication, and assembly. All documentation must be able to be archived and distributed in a digital format.
3. Demonstrate and document the use of appropriate-resolution virtual (CAD) models of the prototype including a complete assembly, subassemblies and in-house fabricated components.
4. Fabricate a fully functional, robust prototype. The prototype will be evaluated against the Engineering Design Specifications provided and any others imposed by the Group.
5. Present the results of this concept development project in a formal Critical Design Review at the conclusion of the project.
6. Follow established procedures for maintaining and returning all issued equipment, follow safety guidelines, and follow cost accounting guidelines.

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### D. PROJECT SCHEDULE OVERVIEW AND PRIMARY MILESTONES

#### Project Schedule - Primary Milestones

12 Jan	Initial project meeting – Begin Team Project Plan development
14 Jan	Platform group assignments <b>due</b>

19 Jan	Team Project Plan <b>due</b>
21 Jan	Individual concept memo and sketches <b>due</b>
26 Jan	Platform Group Preliminary Design Reviews (PDR) begin
9 Feb	Platform group concept selected <b>deadline</b> Individual engineering trade study proposal <b>due</b>
23 Feb	Individual engineering trade study report <b>due</b>
23 Mar	Platform Group Phase I Project Report <b>due</b>
15 Apr	Prototype Performance Testing
22 Apr	Critical Design Review (CDR)
<b>23 Apr</b>	<b>Blue/Gold Game [Friday Evening]</b>
27 Apr	Design studio check-out Engineering notebook <b>due</b> Final design documentation: Platform Group Phase I(revised) and Phase II <b>due</b> Peer reviews <b>due</b>

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## E. DETAILS ON SELECTED DELIVERABLES

Details on the other course/project deliverables will be provided during the semester and posted on the web site.

### Individual Deliverables:

1. **Due Thursday, 21 Jan:** Individual Platform Concept Memo - A formal engineering memo that provides each individual's concept for the platform assigned to their platform group. The first page (typed) should include a brief written description of the concept including a description of the key capabilities and design features. There should be at least three additional pages that should include multiple sketches (must be hand-drawn and hand-labeled) of the platform or elements/subsystems of the platform to assist in understanding its basic operation and form. Each student should prepare multiple hard copies of the complete document [two (2) for submission for grading and one for each member of their platform group]. (Hardcopies (2), non-electronic submission and .pdf electronic submission)
2. **Due Tuesday, 27 Apr:** Individual Engineering Design Notebook - Each student will submit his or her engineering notebook for final review and evaluation. Details on the notebook are provided in this handout. These notebooks will be briefly reviewed and ratings provided periodically during design studio sessions. Each student should bring his/her notebook to every class session, and it should be available for evaluation at anytime during those sessions. (Hardcopy, non-electronic submission)
3. **Due Tuesday, 27 Apr:** Individual Peer Review- Instructors will provide a form that each student will complete. A sample of this form is included in this package (some details may change prior to submission). Review of this form at the beginning of the semester may assist you in understanding some of the important issues that will be used by your peers to evaluate your contributions. In order to receive your grade in this course, you must submit this document by the required due date. (Hardcopy, non-electronic submission – form will be provided)

### Team Deliverable:

1. **Due Tuesday, 19 Jan:** Team Project Plan - Each Team will prepare a formal document presenting its project management and administrative policies. The following elements must be included in the document. The formatting for the document is at the team's discretion, but sections/sub-sections should be readily identifiable.
  - Team Goals and Strategies
    - Mechatronic football game playing strategy
    - Mechatronic football team composition strategy
    - Team-level design goals and design strategy

- Management Policies
  - Selection process for Team, Platform, and Functional Group coordinators
  - Coordinator responsibilities
  - Platform group member assignment process
  - Functional group responsibilities
  - Procedures for:
    - Meeting attendance
    - Non-compliance with deadlines
    - Conflicting opinions or ideas
- Administrative Policies
  - Scheduling meetings
  - Communication – Team and Groups
  - Documentation standards, data management and storage
  - Budget allocations
- Preliminary Work Breakdown Schedule
  - Team Milestones
  - Platform Group Milestones
  - Platform Group members who will receive CAM certification

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## F. ENGINEERING DESIGN NOTEBOOK

This important individual deliverable item represents a continuous journal of your activities on this project. It should be a hardbound notebook (permanent or spiral bound but NOT snap-ring binders). Its purpose is to document the development of this product from your perspective and to help you record your activities, contributions, and rationale for the decisions that you or your group make.

You should include on each page of the notebook the date of the entry and sign each page when completed. The book should document thoughts or ideas you and your colleagues develop. The notebook may include items such as written text, sketches, flowcharts, timetables, vendors, part numbers, or any other useful information. Include anything you think will be of value: ideas and thoughts related to the product or the project, preliminary calculations, notes from group meetings, notes from phone conversations (vendors, etc.) along with name and numbers, notes from a test of a prototype, “taped in” emails, letters, “napkins with scribbles”, etc. Notebooks are frequently used to date when inventions were conceived. You may tape information initially written elsewhere onto pages within the book, but the contents of the book must not be able to fall out. You may fill more than one book, and they should be numbered sequentially. You do not need to “tape” into the notebook information that has been recorded or “published” in other forms such as the individual concept study, engineering trade study, etc. This book should represent the notes used to develop those studies. These notebooks will be graded and will be part of your individual evaluation.

Some formatting recommendations:

Sign (bottom of page) and date (top of page) each page as you complete it.

Select a notebook with adequate size to allow you to staple or tape in other information.

Make all entries in pen (not required but encouraged).

Leave no blank pages, and any large blank areas should be crossed-out.

Write legibly. If it can't be read, it is of limited value.

**AME40463: Spring 2010 Senior Design Project**  
Confidential Peer and Project Evaluation

Place the evaluation form in a sealed envelope and return it to either Prof. Schmiedeler or Prof. Batill, by 9:30 a.m., Tuesday, April 27, 2010.

Reviewer: \_\_\_\_\_

This form should be used to provide a confidential, professional evaluation of each member of your Platform group. This evaluation is a key element in the instructor's evaluation of each individual in the group. Please consider each item carefully. Rate each member of the group in each area, on a scale from 0-10, with a 10 being the highest rating. **THE AVERAGE FOR THE ENTIRE GROUP MUST BE "5" FOR EACH CATEGORY** (i.e. in the example below with a 6-person group you would have a total of 30 points to distribute in each category). You will have to select your own relative merit on that scale, and it is important that you are consistent. You will also be asked to provide brief handwritten comments about each team member. Submission of this review form is a course requirement.

CATEGORY	1	2	3	4	5	6	7	8	9	10	TOTAL
ENGINEER'S NAME											
1.											
2.											
3.											
4.											
5.											
6.											
TOTAL (=20)											

CATEGORIES:

1. TECHNICAL ABILITY
2. ORAL COMMUNICATION SKILLS: LISTENING AND SPEAKING
3. WILLINGNESS AND ABILITY TO WORK WITH OTHERS IN THE GROUP
4. WILLINGNESS AND ABILITY TO CONTRIBUTE IDEAS
5. ABILITY TO ADAPT TO NEW IDEAS
6. COMPLIANCE WITH GROUP DEADLINES
7. CONTRIBUTIONS BASED UPON FUNCTIONAL GROUP PARTICIPATION
8. CONTRIBUTIONS TO PROJECT DOCUMENTATION
9. CONTRIBUTIONS TO PROTOTYPE FABRICATION, ASSEMBLY AND TESTING
10. OVERALL LEVEL OF EFFORT

## AME 40463 Senior Design Project: Spring 2010

### Team Project Plan - Grading Criteria

Team: \_\_\_\_\_

Score: \_\_\_\_\_

Possible Total Score - 80 pts

1. Format: (10 pts)
  - a. Organized into readily identifiable sections with titles
  - b. Text elements are concise and consistent using complete sentences, not simply bullet points
2. Team Goals and Strategies: (15 pts)
  - a. Provides details on game playing strategy, and illustrates a sound understanding of the rules
  - b. Provides details on the number, types, and basic capabilities of the platforms the team will develop, and in particular includes strategies for platform interactions
  - c. Presents a team-level design strategy for platform development, and explicitly identifies key team design goals
3. Project Management Policies: (25 pts)
  - a. Coordinator selection process (Team, Platform and Functional Groups)
  - b. Coordinator responsibilities
  - c. Platform group assignment process
  - d. Functional group organizational structure and responsibilities
  - e. Guidelines for dealing with technical or personnel problems
4. Project Administrative Policies (20 pts)
  - a. Process for scheduling meetings
  - b. Process for intra-Team and intra-Group communication
  - c. Documentation standards, common software requirements, data management and archiving
  - d. Team budget allocation and tracking
5. Preliminary Work Breakdown Structure (10 pts)
  - a. Team milestones
  - b. Platform group milestones
  - c. Platform group members who will receive CAM certification

Evaluator's Comments:

**AME 40463 Senior Design Project: Spring 2010**

Individual Concept Memo - Grading Criteria

Engineer: \_\_\_\_\_

Score: \_\_\_\_\_

Possible Total Rating - 25 pts

1. Format: (5 pts)
  - a. Single, typed first page 2 pts
  - b. Hand-drawn sketches 2 pts
  - c. Sketches labeled 1 pt
2. Explicit statement of anticipated key design requirements 3 pts
3. Brief written description of concept and its key features/characteristics 4 pts
4. Explicit statement of how the concept will be moved and controlled and how any mechanism/s will be powered. 3 pts
5. Hand-drawn sketches: (10 pts)
  - a. Quality of sketches 3 pts
  - b. Quantity of sketches 3 pts
  - c. Effectiveness in explaining form 2 pts
  - d. Effectiveness in explaining operation 2 pts

Evaluator's Comments:

## AME40463 Senior Design Project: Spring 2010

### Engineering Design Notebook - Grading Criteria

Engineer: \_\_\_\_\_

Score : \_\_\_\_\_

Possible total score - 40 pts.

#### **Use and Presentation: (20 pts)**

1. Consistent entries (10 pts)
  - a. Multiple entries every week during the project (10)
  - b. Entries on Tues/Thurs every week during the project (8)
  - c. Multiple entries for most weeks (some weeks missing) (6)
  - d. Entries on Tues/Thurs (some weeks missing) (4)
  - e. Irregular use with significant gaps in entries (2)
2. Professional presentation (5 pts)
  - a. Consistently neat and well organized (5)
  - b. Irregular or marginal quality of presentation (2)
  - c. Consistently poor presentation (0)
3. All entries signed and dated (5 pts)

#### **Content: (20 pts)**

1. Engineering content (5 pts)
  - a. Consistently used to record the technical issues (5)
  - b. Irregular or marginal use to record technical issues (2)
  - c. Not used to record the technical issues (0)
2. Organizational material and meeting or discussion notes content (5 pts)
  - a. Consistently used to record the organizational issues (5)
  - b. Irregular or marginal use to record organizational issues (2)
  - c. Not used to record the organizational issues (0)
3. Useful and effective sketches and schematics with explanations (10 pts)
  - a. Effective, consistent use of drawing/sketches to illustrate ideas (10)
  - b. Consistent use of drawing/sketches – many incomplete or confusing (7)
  - c. Inconsistent use of sketches (4)
  - d. Very limited use of illustrations (2)
  - e. Sketches not used to document design development (0)

University of Notre Dame  
**Spring 2010**

	Mon	Tues	Wed	Thur	Fri	
		12 <sup>First Class Day</sup>	13	14	15	
JAN	18	19	20	21	22	
	25	26	27	28	29	
FEB	1	2	3	4	5	
	8	9	10	11	12	
	15	16	17	18	19	
	22	23	24	25	26	
MAR	1	2	3	4	5	
	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>BREAK</b>
	15	16	17	18	19	
	22	23	24	25	26	
	29	30	31			
APR				1	<b>2</b>	<b>EASTER</b>
	<b>5</b>	6	7	8	9	
	12	13	14	15	16	
	19	20	21	22	<b>23</b>	<b>Blue/Gold</b>
	26	27	28 <sup>last class day</sup>	29 <sup>study</sup>	30 <sup>study</sup>	
MAY	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>EXAMS</b>
	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>Senior Week</b>

Major Task OR Milestone	W1 1/12	W2 1/19	W3 1/26	W4 2/2	W5 2/9	W6 2/16	W7 2/23	W8 3/2	W9 3/9	W10 3/16	W11 3/23	W12 3/30	W13 4/6	W14 4/13	W15 4/20	B/G 4/23	W16 4/27
Platform Groups Assigned	X								B R E A K								
Team Project Plan Due		X															
Individual Concept Memo Due			X														
Platform Concept Selection Study			[Bar]														
Platform Concepts Selected					X												
Indiv. Eng. Study Proposal Prep.			[Bar]														
Indiv. Eng. Study Proposal Due					X												
Indiv. EG Trade Study					[Bar]												
Indiv. Eng. Trade Study Due							X										
Platform Concept Devel.					[Bar]												
Phase I - Design Report Due											X						
Platform Prototype Fabrication					[Bar]												
Prototype Validation Test															X		
Design Review Preparation															[Bar]		
Critical Design Review																X	
Blue/Gold Game																X	
Final Design Documentation Due - Phase I Final and Phase II																	X
PDRs			X	X	X	X	X	X	X	X	X	X	X	X	X	X	