1. Approval of minutes for the meeting of November 22, 2016
2. Dean’s Report (Amr Elnashai)
3. Updates from Undergraduate Studies Committee (Chris Giebink)
4. Updates from Graduate Studies Committee (Esther Gomez)
5. Updates from Engineering Technology Committee (Engr Tech Chair)
6. Updates from Faculty Senate (Engineering Senator)
7. Other Business
1. Approval of minutes for the meeting of October 25, 2016
   Unanimously approved.

2. Dean’s Report (Peter Butler)
   • Impact of volunteering retiring program (VRP) on COE.
     o College submitted a request for emergency rehiring. Requested 6 faculty lines and 2
       staff lines.
     o Provost approved four faculty lines in EE, CSE, ESM and IME, and two staff lines in
       ME and ESM.
     o Working on another proposal for the two missing faculty lines.
     o Submitted a consolidated request to rehire all positions that were vacated in the VRP.
   • Have plans for increasing overall the amount of on-line course offering, particularly at the
     Master level.
   • Work load funds.
     o Requested 4.5 million dollars, relative to 4.3 million last year, got 3 million.
     o 3 million were given to departments to cover two thirds of what departments were
       hoping for, which will help the departments for the Fall. The other 1.5 million will be
       given to us.
   • Enrollment control proposal.
     o Worked on a document that surveyed the numbers of top 20 universities to see what
       they do.
     o The document was circulated with department heads to look at effects on career
       services, advising and departments.
     o Came back with a document that looked at the possibility for entrance to major after
       the first year.
     o Looking at what are the mechanisms that we could control numbers.
     o The document has resonated with the Provost. A meeting will be held on Jan. 17 2017
       to discuss this issue.

3. Updates from Undergraduate Studies Committee (Chris Giebink).
   Five changes, two new course additions.
   • Added
     o AE 405 - Geotechnical Engineering
     o CE 434 – Geotechnical Engineering design
   • Changed
     o CE 340 – Structural Analysis: Prerequisite change
     o CE 410 – Sustainable Residential Land Development: Removal of writing
       component.
     o NUCE 301 – Fundamentals of Reactor Physics: Prerequisite change
     o NUCE 309 – Analytical Techniques for Nuclear Concept: Prerequisite change
     o Service Enterprise Engineering Minor - Expand the minor to include Health and
       Human Development
Unanimously approved except AE 405, which will be sent back to Undergraduate Studies Committee.

4. Updates from Graduate Studies Committees.
   • Graduate Faculty Nominations:
     Category R - Approved
     o Timothy Eden
     o Catherine Berdanier
   • Program Proposals:
     Approved:
     o Removal of Integrated BS-MS degree in ME
   • Course Proposals:
     Returned to Proposer for Changes
     o ACS 525_Add – Nonlinear Acoustics
     o ME 532_Change-Turbulent and Two-Phase Combustion
     Approved
     o ESC 545_Add - Scientific and Engineering Foundations of Additive Manufacturing
     o IE 527_Add - Introduction to Additive Manufacturing
     o IE 573_Add - Manufacturing with Materials
     Unanimously approved.

5. Updates from Engineering Technology Committee
   No items to report.

6. Updates from Faculty Senate (Chris Giebink)
   • Next Senate meeting is Dec 6th
   • Lion path resolution – The faculty senate will be voting on this.
   • Revisions to Senate Policy 48-40 (Deferred grades) and 48-50 (No grade). The policies are being cleaned up to clarify language for grade reporting.
   • There is a report from the special committee on University Governance with regards to the follow-up Report and recommendations for Improving governance and communications and furthering the academic mission at PSU. This is a follow up with regards to the status of how the Board of Trustees has implemented or not implemented the various recommendations from the faculty senate resulting from the November 2011 situation.
   • Informational reports on:
     o Articulation Agree Review
     o Faculty Senate scholarships awarded to Undergraduates ~$254K
     o Submission of Curricular Proposals. Report informs the university community of the undergraduate curricular pathway and discusses resources available and best practices to navigate through the curricula review during the current wide-spread curricular change such as:
       ▪ Gen Ed course recertification
       ▪ Gen Ed course submission
       ▪ Substantial prerequisite updates in anticipation of LionPath enforcement of prerequisites
       ▪ Implementation of the recent US/IL requirement changes
       ▪ routine course and program reviews.
     o Millennium Scholars Program
- Third Party Administrative Services for Penn State’s Medical and Prescription Drug Plan
- Report will be presented on Penn State Health and Wellness Center
- Report on Childcare at PSU. Summary of child care services availability, cost, and university contributions.
- Drug Testing Program for Penn State’s Defense Related Research Units (ARL) and Electro-Optics center. I don’t think this currently applies to any of the research faculty in the college of engineering, but this might be foreshadowing of what might occur in the future for all PSU faculty. The program became effective July 1, 2016 and instituted to ensure the laboratory’s compliance with Federal Regulations for receiving federal funding.

7. Other Business

Update from Faculty Council

- The current P/R faculty designation negatively impacts graduate faculty in some colleges particularly Arts and Architecture, as well as Health and Human Development. This issue will be a topic at the next graduate council meeting, academic standard committee meeting as well as the course approval and joint curriculum committee meeting.
- MA/MS. In order to have all course work from MS, it was proposed to only approve those if there was a notation on the transcript that says ‘thesis completed’ or ‘no thesis required. The council objected to a negative notation on the transcript.
## Undergraduate Studies Curricular Review Committee

### Summary Report for
Engineering Faculty Council Meeting December 13, 2016

<table>
<thead>
<tr>
<th>Type and Description of Change</th>
<th>Description or Rationale for Curricular Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ME 103 – Hybrid Electric Vehicles</strong>&lt;br&gt;Submitted by: Eric Marsh</td>
<td><strong>ADD: New Course</strong>&lt;br&gt;Students in this first-year seminar will be exposed to the design, fabrication, and testing of advanced powertrain vehicles and other cutting-edge automotive technologies. This project-based, group-based course gives students the opportunity to become a member of one of the technical departments within the overall Penn State Advanced Vehicle student team and encourages students to interact with upper-class members of that department. In addition to technical skills, emphasis is placed on soft skills required of today’s professional engineers including: presentation creation, public speaking, and technical writing.&lt;br&gt;&lt;br&gt;This course has been offered as special topics each Spring semester for the last 8 years.</td>
</tr>
<tr>
<td><strong>ME 440 – Mechanical Systems Design Project</strong>&lt;br&gt;Submitted by: Eric Marsh</td>
<td><strong>CHANGE: Prerequisites</strong>&lt;br&gt;Design and analysis of mechanical components and systems. Application of fundamental design and analysis methods to open ended engineering problems. Students develop and practice skills and techniques for managing and executing engineering design projects. These skills are applied to an industry-sponsored project.&lt;br&gt;&lt;br&gt;Project teams perform all facets of product and process design. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students will visit industrial sites to gain an understanding of existing processes and problems and to assess the customer’s needs. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.&lt;br&gt;&lt;br&gt;The course coverage has been adjusted to reduce the number of courses that students must take prior to this course. The requested changes in the course bulletin listing address a bottleneck in our curriculum that was creating problems for students trying to graduate in four years. Some small adjustments were made in the timing of certain topics’ introduction. Due to changes made in the Senior Design Course, ME 370 is no longer needed as a prerequisite. ME 360 should not be listed because it is a prerequisite for ME 340, which remains as a pre-requisite for this course. This allows a substantial simplification in the pre-requisite structure of the capstone design courses. No material was added or removed from the curriculum in making these adjustments.</td>
</tr>
<tr>
<td>ME 442 – Advanced Vehicle Design</td>
<td>CHANGE: Prerequisites</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------</td>
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</tbody>
</table>

Part one of a two course sequence; applications of design and analysis methods to open-ended advanced transportation vehicles. Two semester course; satisfies Senior Design or ME Technical Elective requirements (when combined with ME 443W). Students develop and practice skills and techniques for managing and executing engineering design projects. This is done in the context of an international University-level engineering design competition that is sponsored by government agencies and/or by industry. The competitions are structured to span a full calendar year, with the competition itself taking place in late Spring. For that reason, the course is spread over two semesters. In the Fall semester, there is approximately equal emphasis on classroom lectures and hands-on laboratory activities; in the Spring semester, the emphasis is on hands-on laboratory activities. The focus is advanced powertrain technology for personal transportation vehicles. Broader aspects of energy efficiency, security, and sustainability also will be discussed. The specific technologies that are targeted will evolve with time to remain ahead of what is available in current production vehicles. Project teams perform all facets of product and process design.

This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students also will participate in broader aspects of the design competition. This may include securing sponsorship and funding, participating in outreach and public relations events, developing a business plan, developing a web site, and traveling to competition workshops and to the annual competition. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.

The course coverage has been adjusted to reduce the number of courses that students must take prior to this course. The requested changes in the course bulletin listing address a bottleneck in our curriculum that was creating problems for students trying to graduate in four years. Some small adjustments were made in the timing of certain topics' introduction. Due to changes made in the Senior Design Course ME 370 is no longer needed as a prerequisite. ME 360 should not be listed because it is a prerequisite for ME 340, which remains as a pre-requisite for this course. This allows a substantial simplification in the pre-requisite structure of the capstone design courses. No material was added or removed from the curriculum in making these adjustments.
<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 453 – Powertrain System Modeling, Simulation, and Control</td>
<td>This course introduces students to the control-oriented state-space and transfer function modeling of powertrain components and systems. Relevant application domains include conventional automotive powertrains, hybrid powertrains, locomotive propulsion systems, marine and submarine propulsion systems, and stationary power generation systems. The course introduces students to the use of fundamental principles from thermodynamics, fluid mechanics, and rigid body mechanics for powertrain modeling. Simple, control-oriented models are emphasized. Model integration and simulation topics, including numerical stiffness, solver selection, and integration step size selection are emphasized. Applications of powertrain modeling and control covered in the course include servo-control problems (e.g., air-fuel ratio control) and supervisory power management in hybrid powertrains. This course has been offered twice since its creation: once in the 2014/2015 academic year and once in the 2015/2016 academic year. The course will be offered once per year in the future, with an anticipated enrollment of 20-30 resident students in the fall semester.</td>
</tr>
</tbody>
</table>
Principal Faculty Member(s) Proposing Course

<table>
<thead>
<tr>
<th>Name</th>
<th>User ID</th>
<th>College</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERIC RUSSELL MARSH</td>
<td>erm7</td>
<td>Engineering (EN)</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

College with curricular responsibility: Engineering (EN)

Type of Proposal: [X] Add  [ ] Change  [ ] Drop

Course Designation

(M E ME 103) HYBRID ELECTRIC VEHICLES

Course Information

Special categories for Undergraduate (001-499) courses

Foundations

- Writing/Speaking (GWS)
- Quantification (GQ)

Knowledge Domains

- Health and Wellness (GHW)
- Natural Science (GN)
- Arts (GA)
- Humanities (GH)
- Social and Behavioral Sciences (GS)
- Honors (H)
- Writing Intensive Permanent (WF)
- Writing Intensive One Semester

Additional Designations

- Bachelor of Arts
- International Cultures (WFVIL)
- United States Cultures (US)
- International Cultures (IL)
- Bachelor Of Arts (BA)
- Bachelor Of Arts (BA)
- Honors Course
- Common course number - x94, x95, x96, x97, x99
- Writing Across the Curriculum

First-Year Engagement Program

[ ] First-Year Seminar

Miscellaneous

- Common Course

GE Learning Objectives

- GenEd Learning Objective: Effective Communication
- GenEd Learning Objective: Creative Thinking
- GenEd Learning Objective: Crit & Analytical Think
- GenEd Learning Objective: Global Learning
- GenEd Learning Objective: Integrative Thinking
- GenEd Learning Objective: Key Literacies
Engineering First-Year Seminars are designed to engage students in learning and to facilitate the transition to college life. This course will introduce students to:

- Advancements in cutting-edge automotive technology, with an emphasis on powertrain modeling, design, fabrication, and testing.
- Opportunities for education and research in the automotive sector here at Penn State.
- Facilities available to these students as part of the Penn State community.
- Faculty that share common interests in the automotive sector.
- Benefits of working in an experiential, project-based endeavor.
- Advantages of group-based efforts in a multi-disciplinary setting.
- Soft skills (presentation creation, public speaking, and technical writing) required of modern professionals.
- Technical skills learned and demonstrated by numerous engineering disciplines.

Seminar students will attend the first part of each Advanced Vehicle Team meeting (general business). For the first few weeks of the semester, seminar students then will break out to meet separately with the instructor. By approximately the fourth week of the semester, students will participate directly in the Advanced Vehicle Team by joining one of the project sub-teams and working with upper-class students. Students will be assessed based on their contribution to their sub-team.

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:
Overview of AVT competitions – 1 week (1Lecture)
PSU AVT History – 1 week (1Lecture)
Environmental Health and Safety – 1 week (1Lecture)
Why HEVs? – 1 week (1Lecture)
HEV Architectures – 1 week (1Lecture)
Specific Department and project introduction – 1 week (1Lecture)
Project based learning (varies year-to-year based on current competition needs) – 8 weeks (8Lectures)

Course Description:
Students in this first-year seminar will be exposed to the design, fabrication, and testing of advanced powertrain vehicles and other cutting-edge automotive technologies. This project-based, group-based course gives students the opportunity to become a member of one of the technical departments within the overall Penn State Advanced Vehicle student team and encourages students to interact with upper-class members of that department. In addition to technical skills, emphasis is placed on soft skills required of today’s professional engineers including: presentation creation, public speaking, and technical writing.

The name(s) of the faculty member(s) responsible for the development of the course:
- Name: GARY L NEAL (gl103)
- Title: INSTRUCTOR
Course Justification

Instructional, Educational, and Course Objectives:
This section should define what the student is expected to learn and what skills the student will develop. Engineering First-Year Seminars are designed to engage students in learning and to facilitate the transition to college life. This course will introduce students to:

- advancements in cutting-edge automotive technology, with an emphasis on powertrain modeling, design, fabrication, and testing.
- opportunities for education and research in the automotive sector here at Penn State.
- facilities available to these students as part of the Penn State community.
- faculty that share common interests in the automotive sector.
- benefits of working in an experiential, project-based endeavor.
- advantages of group-based efforts in a multi-disciplinary setting.
- soft skills (presentation creation, public speaking, and technical writing) required of modern professionals.
- technical skills learned and demonstrated by numerous engineering disciplines.

Evaluation Methods:
Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students’ grades should be specifically identified.

Grading

Attendance 20%
Outreach Event 10%
Passport to Success 20%
Peer Evaluations 10%
Presentations 10%
Project Work 20%
Written reports 10%

Students will be evaluated on several metrics with overall grading proportions defined per the Evaluation Methods section. Class attendance and peer evaluations will be used to evaluate students’ proficiency in building relationships with faculty and colleagues and successfully completing their responsibilities. Attendance at various competition-team events will be used to evaluate students’ introduction to the academic community. The Engineering Passport is used to evaluate students’ introduction to university study. Presentations, written reports, and hands-on technical project work will be used to evaluate students’ knowledge of tools and resources available at Penn State.

Relationship/Linkage of Course to Other Courses:
This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course’s role as a prerequisite for other courses. This course is linked to the ME442/443 sequence of Capstone Design courses and to the Penn State Advanced Vehicle Team by directly meeting in the same location and time as these other endeavors. This promotes interaction between freshmen and upper-classmen, allowing freshmen to learn from and interact with their more senior peers. It also allows upperclassmen to gain experience mentoring and guiding their entry-level peers.

Relationship of Course to Major, Option, Minor, or General Education:
This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments. This seminar is appropriate for students who are interested in majoring in numerous engineering fields including: ME, EE, CMPSC, CMPEN, and AERSP. As this seminar directly participates in automotive competitions, students with interest in non-engineering disciplines (Business; Communications; Energy, Business, and Finance, etc.) have also found the seminar interesting due to the “small business” environment, which requires skill sets from many disciplines to be successful.

A description of any special facilities:
A multi-media classroom, under the auspices of the College of Engineering (Continuing & Distance Education), is required for the conduct of this course. All technology needs can be met within the College of Engineering.

Frequency of Offering and Enrollment:
This course has been offered eight times as since 2008. This course will be offered each Spring, with anticipated enrollments of 15-20 students via Resident Instruction.
General Education Designation Requirements

Campuses That Have Offered ( ) Over The Past 4 Years

| semester | AB | AL | BK | BR | BW | CR | DS | ER | FE | GA | GV | HB | HN | HY | LV | MA | NK | PC | SH | SL | UP | WB | WC | WS | XC | XP | XS | YK |
|----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

Curricular Information

Blue Sheet Item #:

Review Date:

SCRID Numbers

(M E ME 103):

Review History (not subject to comparison)

This section represents all consultation history that has occurred on this proposal

Legend

- Approve
- Rejected
- Waiting Review
- User Action Required

- Pending Action(s)
- Moved to Rejected Status
- Approved
- (#) - Review Order Sequence Number

Consultation

Recipient Name: ANDREW ERDMAN

Department: SCHOOL OF ENGINEERING DESIGN, TECHNOLOGY AND PROFESSIONAL PROGRAMS

Position: Consultation

Campus: UNIVERSITY PARK CAMPUS

Title: WALTER ROBB DIRECTOR ELDN

Request sent: 4/25/2016 at 7:30 AM

Concur: Yes

Comments:

Reviewed On: 4/26/2016 at 6:34 PM

Recipient Name: ELENA JOSHI

Department: Industrial And Manufacturing Engineering

Position: Consultation

Campus: UNIVERSITY PARK CAMPUS

Title: INSTR

Request sent: 4/25/2016 at 7:30 AM

Concur: Yes

Comments: (Completed By Default - Exceeded Time Limit)

Reviewed On: 4/29/2016 at 7:15 AM

Recipient Name: RICHARD CIODCI

Department: SCIENCE, ENGINEERING AND TECHNOLOGY

Position: Consultation

Campus: (Not Available)

Title: ASSOC PROF MECH ENG
(1) Request sent: 4/14/2016 at 2:07 PM
Concur: Yes
Comments:
Reviewed On: 4/15/2016 at 10:26 AM

Recipient Name: RUSSELL WARLEY  Department: ENGINEERING
Position: Consultation  Campus: (Not Available)
Title: Interim Director, School of Engineering

(2) Request sent: 4/14/2016 at 2:07 PM
Concur: Yes
Comments:
Reviewed On: 4/18/2016 at 2:41 PM

Recipient Name: SVEN BILEN  Department: SCHOOL OF ENGINEERING DESIGN, TECHNOLOGY AND PROFESSIONAL PROGRAMS
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: DEPT HEAD/SEDTAPP

(3) Request sent: 4/14/2016 at 2:07 PM
Concur: Yes
Comments:
Reviewed On: 4/22/2016 at 1:50 PM

Recipient Name: TIMOTHY WHEELER  Department: (Not Available)
Position: Consultation  Campus: (Not Available)
Title: ASST PROF ELECT ENGR

(6) Request sent: 4/25/2016 at 7:30 AM
Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 4/29/2016 at 7:15 AM

Recipient Name: ANDREW LAU  Department: School of Engr Design, Technology and Prof Prgrms
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: ASSOC PROF ENGR DESIGN

(7) Request sent: 11/3/2016 at 2:58 PM
Concur: Yes
Comments: It would strengthen the proposal to say more about the different items to be graded and how they connect to the course outline and objectives.

Initiator Comments: Students will be evaluated on several metrics with overall grading proportions defined per the Evaluation Methods section. Class attendance and peer evaluations will be used to evaluate students' proficiency in
building relationships with faculty and colleagues and successfully completing their responsibilities. Attendance at various competition-team events will be used to evaluate students’ introduction to the academic community. The Engineering Passport is used to evaluate students’ introduction to university study. Presentations, written reports, and hands-on technical project work will be used to evaluate students’ knowledge of tools and resources available at Penn State.

<table>
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<td>Concur: Yes</td>
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<td>Comments:</td>
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<td>Reviewed On: 11/10/2016 at 10:01 AM</td>
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### Head of Department

<table>
<thead>
<tr>
<th>Recipient Name: KAREN THOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department: (Not Available)</td>
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<tr>
<td>Position: Head of Department</td>
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<tr>
<td>Campus: UNIVERSITY PARK CAMPUS</td>
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<tr>
<td>Title:</td>
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Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

### SCCA Representative

<table>
<thead>
<tr>
<th>Recipient Name: ROBERT MELTON</th>
</tr>
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<tbody>
<tr>
<td>Department: (Not Available)</td>
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<tr>
<td>Position: SCCA Representative</td>
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<tr>
<td>Campus: UNIVERSITY PARK CAMPUS</td>
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Request sent: 9/29/2016 at 10:29 AM
Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

### Dean of the College

<table>
<thead>
<tr>
<th>Recipient Name: PETER BUTLER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department: (Not Available)</td>
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<tr>
<td>Position: Dean of the College</td>
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<tr>
<td>Campus: UNIVERSITY PARK CAMPUS</td>
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<tr>
<td>Title:</td>
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Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

### SCCA Subcommittee Review

<table>
<thead>
<tr>
<th>Recipient Name: CORTNEY SMITH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department: (Not Available)</td>
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</table>
Position: SCCA Subcommittee Review  Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

Recipient Name: KADI CORTER  Department: (Not Available)
Position: SCCA Subcommittee Review  Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

Recipient Name: CYNTHIA ZOOK  Department: (Not Available)
Position: SCCA Subcommittee Review  Campus: UNIVERSITY PARK CAMPUS
Title:

Request sent: 6/21/2016 at 3:05 PM
Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

SCCA Review

Recipient Name: CORTNEY SMITH  Department: (Not Available)
Position: SCCA Review  Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

Recipient Name: KADI CORTER  Department: (Not Available)
Position: SCCA Review  Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]
Recipient Name: **CYNTHIA ZOOK**  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS

Request sent: 6/21/2016 at 3:05 PM  
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

---

**Faculty Senate Review**

Recipient Name: **CORTNEY SMITH**  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

---

Recipient Name: **KADI CORTER**  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]
SENATE COMMITTEE ON CURRICULAR AFFAIRS

COURSE SUBMISSION AND CONSULTATION FORM

Principal Faculty Member(s) Proposing Course

<table>
<thead>
<tr>
<th>Name</th>
<th>User ID</th>
<th>College</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERIC RUSSELL MARSH</td>
<td>erm7</td>
<td>Engineering (EN)</td>
<td>Not Available</td>
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</table>

College with curricular responsibility: Engineering (EN)

Type of Proposal: 
- [] Add
- [X] Change
- [] Drop

I am requesting recertification of this course for the new Gen Ed and/or University Requirements Guidelines?

Course Designation

(ME 440) Mechanical Systems Design Project

Course Information

Special categories for Undergraduate (001-499) courses

Foundations

- [] Writing/Speaking (GWS)
- [] Quantification (GQ)

Knowledge Domains

- [] Health & Wellness (GHW)
- [] Natural Sciences (GN)
- [] Arts (GA)
- [] Humanities (GH)
- [] Social and Behavioral Sciences (GS)

Additional Requirements Designations

- [] Bachelor of Arts
- [] International Cultures (IL)
- [] United States Cultures (US)
- [] Honors Course
- [X] One-Semester Course
- [] Common course number - x94, x95, x96, x97, x99
- [X] Writing Across the Curriculum

First-Year Engagement Program

- [] First-Year Seminar

Miscellaneous

- [] Common Course

GE Learning Objectives

- [X] GenEd Learning Objective: Effective Communication
- [X] GenEd Learning Objective: Creative Thinking
- [X] GenEd Learning Objective: Crit & Analytical Think
- [X] GenEd Learning Objective: Global Learning
- [X] GenEd Learning Objective: Integrative Thinking
GenEd Learning Objective: Key Literacies

GenEd Learning Objective: Soc Resp & Ethic Reason

Cross-Listed Courses:

Prerequisites:
ME 340

Corequisites:

Concurrents:
IE 312, ENGL 202C

Recommended Preparations:

Abbreviated Title: Mech Sys Design

Bulletin Listing
Minimum Credits: 3
Maximum Credits: 3
Repeatable: NO

Department with Curricular Responsibility: Mechanical Engineering (UPEN_ME)

Effective Semester: 201617FA / Upon Approval

Travel Component: NO

Course Outline

A brief outline or overview of the course content:

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

Course Description:
Design and analysis of mechanical components and systems. Application of fundamental design and analysis methods to open ended engineering problems. M E 440W Mechanical Systems Design Project (3): Students develop and practice skills and techniques for managing and executing engineering design projects. These skills are applied to an industry-sponsored project. Project teams perform all facets of product and process design. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students will visit industrial sites to gain an understanding of existing processes and problems and to assess the customer's needs. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.

The name(s) of the faculty member(s) responsible for the development of the course:

Name: ERIC MARSH (ERM7)
Title: PROFESSOR OF MECH ENGR
Phone: +1 814 865 5242
Address: 0331 REBER BUILDING
Campus:
City: University Park
Fax:

Course Justification

Instructional, Educational, and Course Objectives:
This section should define what the student is expected to learn and what skills the student will develop.

Evaluation Methods:
Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students’ grades should be specifically identified.

Relationship/Linkage of Course to Other Courses:
This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course's role as a prerequisite for other courses.

Relationship of Course to Major, Option, Minor, or General Education: This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments.

This course is one of three capstone design options that we offer to satisfy the ABET design requirement.

A description of any special facilities:

Frequency of Offering and Enrollment:

Justification for Changing The Proposal:
Include a justification for each change to the course. Particular attention should be paid to the effects of the course change within the discipline and in other disciplines where the course may be required within a major or used as a service course. When a unit submits several course changes, with or without new course proposals, a general statement covering the programmatic effects of the changes should be submitted.

The course coverage has been adjusted to reduce the number of courses that students must take prior to this course. The requested changes in the course bulletin listing address a bottleneck in our curriculum that was creating problems for students trying to graduate in four years. Some small adjustments were made in the timing of certain topics' introduction. Due to changes made in the Senior Design Course ME 370 is no longer needed as a prerequisite. ME 360 should not be listed because it is a prerequisite for ME 340, which remains as a prerequisite for this course. This allows a substantial simplification in the prerequisite structure of the capstone design courses. No material was added or removed from the curriculum in making these adjustments.

General Education Designation Requirements

Writing Across the Curriculum (W,M,X,Y course suffixes)

A copy of the course syllabus:

2. A concise explanation of how the proposed course will fulfill each of the following criteria:
(a) Both informal and formal writing assignments should relate clearly to the course objectives and should serve as effective instruments for learning the subject matter of the course. Instructors should communicate to students the requirements of formal, graded writing assignments in writing, not just orally. In writing-intensive courses, writing assignments are characteristically designed to help students investigate the course subject matter, gain experience in interpreting data or the results of research, shape writing to a particular audience, or practice the type of writing associated with a given profession or discipline. Much of the writing may be informal and ungraded, yet meaningful, so students are encouraged to think and discover through a process in which mistakes are a natural part of learning. Examples of such writing include one-minute papers at the beginning, middle, or end of class; reactions to lectures, labs, and readings; journals, logs, and notebooks of observations, readings, and other experimental activities; letters to classmates; weekly digests; e-mail dialogues; records of peer group discussions; and stories of one's thinking on a problem.

(b) Students will be afforded opportunities to practice writing throughout the semester, with emphasis given to writing as a process that develops through several iterations. Typically, writing-intensive courses require multiple writing assignments, a sequence of preparatory writings (outline, formulation of thesis, first draft) leading to a final product, or informational writing assignments (e.g., regular journal entries, field notes, short in-class papers, revision of first draft) that aid students in developing other written documents. Experimentation with assignments is encouraged.

(c) Opportunities for students to receive written feedback from the instructor and to apply the instructor's feedback to their future writing will be built into the course. The instructor will clearly identify and explain the type of writing required in the course and will provide guidance as needed. A writing-intensive course may also include peer review of written work, tutorial assistance, instructor conferences, group writing projects, the use of writing or learning centers, teaching assistant feedback, and classroom discussions of assigned readings about writing. The use of diverse feedback mechanisms is encouraged, but none of these mechanisms should substitute for the instructor as the principal source of written feedback to the student.

(d) Writing will be evaluated by the instructor, and writing quality will be a factor in determining each student's final grade. Before students begin writing, instructors will communicate to students the criteria by which their writing will be evaluated. Sound criteria for assessing writing quality include, but are not limited to, the writer's ability to direct the material to an intended audience, the employment of organizational strategies, the development of both content and reasoning, adherence to conventions of a particular discipline, accuracy of the information presented, citation and integration of sources, grammar, diction and syntax, and spelling. Writing assignments should be worth at least 25 percent of each student's final grade.

One or two examples of the actual writing assignment sheets the instructor plans to use in the course.
Campuses That Have Offered (ME 440) Over The Past 4 Years

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Curricular Information

Blue Sheet Item #:
Review Date:

SCRID Numbers

(Me 440):

Review History (not subject to comparison)

This section represents all consultation history that has occurred on this proposal.

Legend

- Approve
- Rejected
- Waiting Review
- User Action Required
- Pending Action(s)
- Moved to Rejected Status
- Approved
- (#) - Review Order Sequence Number

Consultation

Recipient Name: AMIT BANERJEE
Department: Science, Engineering And Technology
Position: Consultation
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE
Title: ASSOC PROF OF MECH ENG

Request sent: 11/7/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 11/7/2016 at 9:25 AM

Recipient Name: ANDREW ERDMAN
Department: School of Engr Design, Technology and Prof Pgrms
Position: Consultation
Campus: UNIVERSITY PARK CAMPUS
Title: WALTER ROBB DIRECTOR ELDM

Request sent: 10/31/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 10/31/2016 at 9:34 AM

Recipient Name: ELENA JOSHI
Department: Industrial And Manufacturing Engineering
Position: Consultation
Campus: UNIVERSITY PARK CAMPUS
Title: INSTR
Recipient Name: ISSAM ABU-MAHFOUZ  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PRF ENGINEERING

Recipient Name: JUDE LIU  
Department: Agricultural And Biological Engineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: ASSOCIATE PROFESSOR OF AGROCULTURAL ENG

Recipient Name: MICHAEL IMMEL  
Department: (Not Available)  
Position: Consultation  
Campus: (Not Available)  
Title: INSTRUCTOR OF IE

Recipient Name: RICHARD CIOCCHI  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PROF MECH ENG

Recipient Name: ISSAM ABU-MAHFOUZ  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PRF ENGINEERING

Recipient Name: JUDE LIU  
Department: Agricultural And Biological Engineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: ASSOCIATE PROFESSOR OF AGROCULTURAL ENG

Recipient Name: MICHAEL IMMEL  
Department: (Not Available)  
Position: Consultation  
Campus: (Not Available)  
Title: INSTRUCTOR OF IE

Recipient Name: RICHARD CIOCCHI  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PROF MECH ENG
Title: PROF AEROSPACE ENGR  
Recipient Name: ROBERT MELTON  
Department: Aerospace Engineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: PROF AEROSPACE ENGR

(7) Request sent: 10/31/2016 at 7:30 AM
Concur: Yes  
Comments: The justification section refers to capstone design courses, but that needs to be explained in the section Relation to Major, etc.  
Reviewed On: 11/1/2016 at 9:54 PM
Initiator Comments: A statement was added to the relation to major section.

(15) Request sent: 11/8/2016 at 2:49 PM
Concur: Yes  
Comments:  
Reviewed On: 11/9/2016 at 11:00 AM

Title: ASSOC PROF ENGINEERING  
Recipient Name: RUNGUN NATHAN  
Department: Engineering, Business and Human Development  
Position: Consultation  
Campus: BERKS CAMPUS  
Title: ASSOC PROF ENGINEERING

(13) Request sent: 11/7/2016 at 7:30 AM
Concur: Yes  
Comments: (Completed By Default - Exceeded Time Limit)  
Reviewed On: 11/8/2016 at 7:15 AM

Title: Interim Director, School of Engineering  
Recipient Name: RUSSELL WARLEY  
Department: Engineering  
Position: Consultation  
Campus: PENN STATE ERIE, THE BEHREND COLLEGE  
Title: Interim Director, School of Engineering

(6) Request sent: 10/31/2016 at 7:30 AM
Concur: Yes  
Comments:  
Reviewed On: 11/1/2016 at 8:32 AM

Title: DEPT HEAD/SEDTAPP  
Recipient Name: SVEN BILEN  
Department: School of Engr Design, Technology and Prof Prgrms  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: DEPT HEAD/SEDTAPP

(3) Request sent: 10/24/2016 at 4:51 PM
Concur: Yes  
Comments:  
Reviewed On: 10/29/2016 at 1:05 PM
Recipient Name: TIMOTHY WHEELER  Department: (Not Available)
Position: Consultation  Campus: (Not Available)
Title: ASST PROF ELECT ENGR

Request sent: 11/7/2016 at 7:30 AM
Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 11/8/2016 at 7:15 AM

Recipient Name: WILLIAM LASHER  Department: Engineering
Position: Consultation  Campus: PENN STATE ERIE, THE BEHREND COLLEGE
Title: PROFESSOR MECH ENG

Request sent: 10/31/2016 at 7:30 AM
Concur: Yes
Comments: 
Reviewed On: 10/31/2016 at 11:20 AM

Recipient Name: PHILIP MORRIS  Department: Aerospace Engineering
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: BOEING PROFESSOR OF AERSP

Request sent: 10/25/2016 at 8:46 AM
Concur: Yes
Comments: 
Reviewed On: 11/4/2016 at 7:20 AM

Head of Department

Recipient Name: KAREN THOLE  Department: (Not Available)
Position: Head of Department  Campus: UNIVERSITY PARK CAMPUS
Title: 
Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

SCCA Representative

Recipient Name: ROBERT MELTON  Department: (Not Available)
Position: SCCA Representative  Campus: UNIVERSITY PARK CAMPUS
Title: 
Concur: [Not Yet Reviewed]
Dean of the College

Recipient Name: PETER BUTLER
Position: Dean of the College

SCCA Subcommittee Review

Recipient Name: CORTNEY SMITH
Position: SCCA Subcommittee Review

Recipient Name: CYNTHIA ZOOK
Position: SCCA Subcommittee Review

Recipient Name: KADI CORTER
Position: SCCA Subcommittee Review

SCCA Review

Recipient Name: CORTNEY SMITH
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]  

Recipient Name: CYNTHIA ZOOK  
Department: (Not Available)  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS  
Title:

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]  

Recipient Name: KADI CORTER  
Department: (Not Available)  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS  
Title:

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]  

Faculty Senate Review

Recipient Name: CORTNEY SMITH  
Department: (Not Available)  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS  
Title:

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]  

Recipient Name: KADI CORTER  
Department: (Not Available)  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS  
Title:

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]
## SENATE COMMITTEE ON CURRICULAR AFFAIRS
### COURSE SUBMISSION AND CONSULTATION FORM

**Principal Faculty Member(s) Proposing Course**

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>ERIC RUSSELL MARSH</td>
<td>erm7</td>
<td>Engineering (EN)</td>
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</table>

**College with curricular responsibility:** Engineering (EN)

**Type of Proposal:**
- [ ] Add  
- [X] Change  
- [ ] Drop

- I am requesting recertification of this course for the new Gen Ed and/or University Requirements Guidelines?

### Course Designation

(ME 442) Advanced Vehicle Design I

### Course Information

**Special categories for Undergraduate (001-499) courses**

**Foundations**
- [ ] Writing/Speaking (GWS)
- [ ] Quantification (GQ)

**Knowledge Domains**
- [ ] Health & Wellness (GHW)
- [ ] Natural Sciences (GN)
- [ ] Arts (GA)
- [ ] Humanities (GH)
- [ ] Social and Behavioral Sciences (GS)

**Additional Requirements Designations**
- [ ] Bachelor of Arts
- [ ] International Cultures (IL)
- [ ] United States Cultures (US)
- [ ] Honors Course
- [ ] One-Semester Course
- [ ] Common course number - x94, x95, x96, x97, x99
- [X] Writing Across the Curriculum

### First-Year Engagement Program

- [ ] First-Year Seminar

### Miscellaneous

- [ ] Common Course

**GE Learning Objectives**

- [ ] GenEd Learning Objective: Effective Communication
- [ ] GenEd Learning Objective: Creative Thinking
- [ ] GenEd Learning Objective: Crit & Analytical Think
- [ ] GenEd Learning Objective: Global Learning
- [ ] GenEd Learning Objective: Integrative Thinking
GenEd Learning Objective: Key Literacies

GenEd Learning Objective: Soc Resp & Ethic Reason

Cross-Listed Courses:

Prerequisites:
ME 340

Corequisites:

Concurrents:
IE 312, ENGL 202C

Recommended Preparations:

Abbreviated Title: Avd Lab I

Bulletin Listing

Minimum Credits: 2
Maximum Credits: 2
Repeatable: NO

Department with Curricular Responsibility: ()

Effective Semester: 2016FA Upon Approval

Travel Component: NO

Course Outline

A brief outline or overview of the course content:

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

Course Description:
Part one of a two course sequence; applications of design and analysis methods to open-ended advanced transportation vehicles. Two semester course; satisfies Senior Design or ME Technical Elective requirements (when combined with M E 443W). M E 442W Advanced Vehicle Design I (2) Students develop and practice skills and techniques for managing and executing engineering design projects. This is done in the context of an international University-level design competition that is sponsored by government agencies and/or by industry. The competitions are structured to span a full calendar year, with the competition itself taking place in late Spring. For that reason, the course is spread over two semesters. In the Fall semester, there is approximately equal emphasis on classroom lectures and hands-on laboratory activities; in the Spring semester, the emphasis is on hands-on laboratory activities. The focus is advanced powertrain technology for personal transportation vehicles. Broader aspects of energy efficiency, security, and sustainability also will be discussed. The specific technologies that are targeted will evolve with time to remain ahead of what is available in current production vehicles. Project teams perform all facets of product and process design. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students also will participate in broader aspects of the design competition. This may include securing sponsorship and funding, participating in outreach and public relations events, developing a business plan, developing a web site, and traveling to competition workshops and to the annual competition. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.

The name(s) of the faculty member(s) responsible for the development of the course:

Name: ERIC RUSSELL MARSH (erm7)
Title: PROFESSOR OF MECH ENGR
Phone: +1 814 865 5242
Address: 0331 REBER BUILDING UNIVERSITY PARK UNIVERSITY PARK, PA 16802
Campus:
City: University Park
Fax:

Course Justification

Instructional, Educational, and Course Objectives:
This section should define what the student is expected to learn and what skills the student will develop.

Evaluation Methods:
Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students' grades should be specifically identified.

Relationship/Linkage of Course to Other Courses:
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Relationship of Course to Major, Option, Minor, or General Education:
This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments.

A description of any special facilities:

Frequency of Offering and Enrollment:

Justification for Changing The Proposal:
Include a justification for each change to the course. Particular attention should be paid to the effects of the course change within the discipline and in other disciplines where the course may be required within a major or used as a service course. When a unit submits several course changes, with or without new course proposals, a general statement covering the programmatic effects of the changes should be submitted.

The course coverage has been adjusted to reduce the number of courses that students must take prior to this course. The requested changes in the course bulletin listing address a bottleneck in our curriculum that was creating problems for students trying to graduate in four years. Some small adjustments were made in the timing of certain topics' introduction. Due to changes made in the Senior Design Course ME 370 is no longer needed as a prerequisite. ME 360 should not be listed because it is a pre-requisite for ME 340, which remains as a pre-requisite for this course. This allows a substantial simplification in the pre-requisite structure of the capstone design courses. No material was added or removed from the curriculum in making these adjustments.

General Education Designation Requirements

Writing Across the Curriculum (W,M,X,Y course suffixes)

A copy of the course syllabus:

2. A concise explanation of how the proposed course will fulfill each of the following criteria:

   (a) Both informal and formal writing assignments should relate clearly to the course objectives and should serve as effective instruments for learning the subject matter of the course. Instructors should communicate to students the requirements of formal, graded writing assignments in writing, not just orally. In writing-intensive courses, writing assignments are characteristically designed to help students investigate the course subject matter, gain experience in interpreting data or the results of research, shape writing to a particular audience, or practice the type of writing associated with a given profession or discipline. Much of the writing may be informal and ungraded, yet meaningful, so students are encouraged to think and discover through a process in which mistakes are a natural part of learning. Examples of such writing include one-minute papers at the beginning, middle, or end of class; reactions to lectures, labs, and readings; journals, logs, and notebooks of observations, readings, and other experimental activities; letters to classmates; weekly digests; e-mail dialogues; records of peer group discussions; and stories of one's thinking on a problem.

   (b) Students will be afforded opportunities to practice writing throughout the semester, with emphasis given to writing as a process that develops through several iterations. Typically, writing-intensive courses require multiple writing assignments, a sequence of preparatory writings (outlines, formulation of thesis, first draft) leading to a final product, or informational writing assignments (e.g., regular journal entries, field notes, short in-class papers, revision of first draft) that aid students in developing other written documents. Experimentation with assignments is encouraged.

   (c) Opportunities for students to receive written feedback from the instructor and to apply the instructor's feedback to their future writing will be built into the course. The instructor will clearly identify and explain the type of writing required in the course and will provide guidance as needed. A writing-intensive course may also include peer review of written work, tutorial assistance, instructor conferences, group writing projects, the use of writing or learning centers, teaching assistant feedback, and classroom discussions of assigned readings about writing. The use of diverse feedback mechanisms is encouraged, but none of these mechanisms should substitute for the instructor as the principal source of written feedback to the student.

   (d) Writing will be evaluated by the instructor, and writing quality will be a factor in determining each student's final grade. Before students begin writing, instructors will communicate to students the criteria by which their writing will be
Campuses That Have Offered (ME 442) Over The Past 4 Years

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Curricular Information

Blue Sheet Item #:
Review Date:

**SCRID Numbers**

(ME 442):

**Review History (not subject to comparison)**

This section represents all consultation history that has occurred on this proposal

**Legend**

- Approve
- Rejected
- Waiting Review
- User Action Required
- Pending Action(s)
- Moved to Rejected Status
- Approved
- (#) - Review Order Sequence Number

Consultation

**Recipient Name:** AMIT BANERJEE

**Department:** Science, Engineering And Technology

**Position:** Consultation

**Campus:** PENN STATE HARRISBURG, THE CAPITAL COLLEGE

**Title:** ASSOC PROF OF MECH ENG

Request sent: 11/7/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 11/7/2016 at 9:24 AM

**Recipient Name:** ANDREW ERDMAN

**Department:** School of Engr Design, Technology and Prof Prgrms

**Position:** Consultation

**Campus:** UNIVERSITY PARK CAMPUS

**Title:** WALTER ROBB DIRECTOR ELDM

Request sent: 10/31/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 10/31/2016 at 9:36 AM
Recipient Name: ELENA JOSHI  
Department: Industrial And Manufacturing Engineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: INSTR

Request sent: 11/7/2016 at 7:30 AM  
Concur: Yes  
Comments: (Completed By Default - Exceeded Time Limit)  
Reviewed On: 11/8/2016 at 7:15 AM

Recipient Name: ISSAM ABU-MAHFOUZ  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PRF ENGINEERING

Request sent: 10/31/2016 at 7:30 AM  
Concur: Yes  
Comments:  
Reviewed On: 11/6/2016 at 2:53 PM

Recipient Name: JUDE LIU  
Department: Agricultural And Biological Engineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: ASSOCIATE PROFESSOR OF AGROCULTURAL ENG

Request sent: 10/24/2016 at 4:48 PM  
Concur: Yes  
Comments:  
Reviewed On: 10/25/2016 at 9:11 AM

Recipient Name: MICHAEL IMMEL  
Department: (Not Available)  
Position: Consultation  
Campus: (Not Available)  
Title: INSTRUCTOR OF IE

Request sent: 11/7/2016 at 7:30 AM  
Concur: Yes  
Comments: (Completed By Default - Exceeded Time Limit)  
Reviewed On: 11/8/2016 at 7:15 AM

Recipient Name: RICHARD CIOCCI  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PROF MECH ENG

Request sent: 10/24/2016 at 4:48 PM
Recipient Name: ROBERT MELTON  Department: Aerospace Engineering
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: PROF AEROSPACE ENGR

Request sent: 10/31/2016 at 7:30 AM
Concur: Yes
Comments: The Justification section refers to capstone design courses, but that needs to be explained in the Relationship to Major, etc. section
Reviewed On: 11/1/2016 at 9:57 PM
Initiator Comments: A statement will be added to the relationship to major section.

Recipient Name: RUNGUN NATHAN  Department: Engineering, Business and Human Development
Position: Consultation  Campus: BERKS CAMPUS
Title: ASSOC PROF ENGINEERING

Request sent: 11/7/2016 at 7:30 AM
Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 11/8/2016 at 7:15 AM

Recipient Name: RUSSELL WARLEY  Department: Engineering
Position: Consultation  Campus: PENN STATE ERIE, THE BEHREND COLLEGE
Title: Interim Director, School of Engineering

Request sent: 10/31/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 11/1/2016 at 8:32 AM

Recipient Name: SVEN BILEN  Department: School of Engr Design, Technology and Prof Prgrms
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: DEPT HEAD/SEDTAPP

Request sent: 10/24/2016 at 4:48 PM
Concur: Yes
<table>
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<tr>
<th>Recipient Name</th>
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<tbody>
<tr>
<td>TIMOTHY WHEELER</td>
<td>(Not Available)</td>
<td>ASST PROF ELECT ENGR</td>
</tr>
<tr>
<td>WILLIAM LASHER</td>
<td>Engineering</td>
<td>PROFESSOR MECH ENG</td>
</tr>
<tr>
<td>PHILIP MORRIS</td>
<td>Aerospace Engineering</td>
<td>BOEING PROFESSOR OF AERSP</td>
</tr>
<tr>
<td>KAREN THOLE</td>
<td>(Not Available)</td>
<td>Head of Department</td>
</tr>
<tr>
<td>ROBERT MELTON</td>
<td>(Not Available)</td>
<td>SCCA Representative</td>
</tr>
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</table>
### Dean of the College

**Recipient Name:** PETER BUTLER  
**Department:** (Not Available)  
**Position:** Dean of the College  
**Campus:** UNIVERSITY PARK CAMPUS

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### SCCA Subcommittee Review

**Recipient Name:** CORTNEY SMITH  
**Department:** (Not Available)  
**Position:** SCCA Subcommittee Review  
**Campus:** UNIVERSITY PARK CAMPUS

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**Recipient Name:** CYNTHIA ZOOK  
**Department:** (Not Available)  
**Position:** SCCA Subcommittee Review  
**Campus:** UNIVERSITY PARK CAMPUS

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**Recipient Name:** KADI CORTER  
**Department:** (Not Available)  
**Position:** SCCA Subcommittee Review  
**Campus:** UNIVERSITY PARK CAMPUS

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Recipient Name: CORTNEY SMITH  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS  
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

Recipient Name: CYNTHIA ZOOK  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS  
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

Recipient Name: KADI CORTER  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS  
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

Faculty Senate Review

Recipient Name: CORTNEY SMITH  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS  
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

Recipient Name: KADI CORTER  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS  
Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]
SENATE COMMITTEE ON CURRICULAR AFFAIRS
COURSE SUBMISSION AND CONSULTATION FORM

Principal Faculty Member(s) Proposing Course

<table>
<thead>
<tr>
<th>Name</th>
<th>User ID</th>
<th>College</th>
<th>Department</th>
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<tbody>
<tr>
<td>HOSAM KADRY FATHY</td>
<td>hkf2</td>
<td>Engineering (EN)</td>
<td>Not Available</td>
</tr>
<tr>
<td>SEAN N BRENNAN</td>
<td>snb10</td>
<td>Engineering (EN)</td>
<td>Not Available</td>
</tr>
<tr>
<td>STEPHANIE STOCKAR</td>
<td>sus772</td>
<td>Engineering (EN)</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

College with curricular responsibility: Engineering (EN)

Type of Proposal: [X] Add  [ ] Change  [ ] Drop

Course Designation

(ME 453) Powertrain System Modeling, Simulation, and Control

Course Information

Special categories for Undergraduate (001-499) courses

Foundations

- Writing/Speaking (GWS)
- Quantification (GQ)

Knowledge Domains

- Health & Wellness (GHW)
- Natural Sciences (GN)
- Arts (GA)
- Humanities (GH)
- Social and Behavioral Sciences (GS)

Additional Requirements Designations

- Bachelor of Arts
- International Cultures (IL)
- United States Cultures (US)
- Honors Course
  - One-Semester Course
    - Common course number - x94, x95, x96, x97, x99
- Writing Across the Curriculum

First-Year Engagement Program

- First-Year Seminar

Miscellaneous

- Common Course

GE Learning Objectives

- GenEd Learning Objective: Effective Communication
- GenEd Learning Objective: Creative Thinking
- GenEd Learning Objective: Crit & Analytical Think
- GenEd Learning Objective: Global Learning
- GenEd Learning Objective: Integrative Thinking
GenEd Learning Objective: Key Literacies

GenEd Learning Objective: Soc Resp & Ethic Reason

Cross-Listed Courses:

Prerequisites:
ME 370

Corequisites:

Concurrents:
ME 450; ME 357

Recommended Preparations:

Abbreviated Title: PWRTRN SYS

Bulletin Listing

Minimum Credits: 3
Maximum Credits: 3
Repeatable: NO

Department with Curricular Responsibility: Mechanical Engineering (UPEN_ME)
Effective Semester: Upon Approval
Travel Component: NO

Course Outline

A brief outline or overview of the course content:
A. State space, all-integrator, and transfer function modeling of simple powertrain systems including:
1. Spark and compression ignition engines
2. Air and fuel systems, injectors, injection timing
3. Piston-cylinder assemblies including compression kinematics, exhaust/intake timing, and advanced combustion engine systems (e.g., Sterling engines)
4. Battery and fuel cell power systems
5. Torque converters
6. Gear trains: dual-shaft, epicyclic, dual-clutch, etc.
7. Dry and wet clutch systems
8. Emissions reduction systems including EGR, catalytic converters, particulate management, etc.
9. Vehicle road load: rolling resistance, aerodynamic drag, tire-road interactions, longitudinal vehicle dynamics

B. Fundamental analogies in multi-domain modeling; a brief introduction to the bond graph modeling language; causality assignment; differential algebraic equation (DAE) models

C. Model integration and simulation:
1. Solution methods: forward and backward Euler, Runge-Kutta, solution of DAE models
2. Integration step size selection; numerical accuracy and stability
3. Numerical stiffness; selection of model accuracy and complexity to avoid stiffness
4. Model integration tools: Matlab/Simulink; Modelica/Dymola

D. Powertrain simulation:
1. Forward vs. backward simulation
2. Simulation duty cycles; standard and naturalistic cycles
3. Role of driver models; introduction to driver modeling
4. Simulation-based powertrain analysis: performance, fuel economy, emissions

E. Hybrid discrete/continuous powertrain models:
1. Discrete event systems in powertrain simulation: control logic and switching dynamics (e.g., stick-slip friction)
2. State transition diagrams
3. State transition modeling environments: Stateflow; Modelica

F. Modeling and control of hybrid electric vehicles:
1. Control-oriented models of electric driveline components
2. Optimal power management problem formulation
3. Solution of optimal powertrain management problems using model predictive control (MPC)

F. Select topics in powertrain control:
1. Air-fuel ratio control
2. Catalytic converter-related control challenges
3. Supervisory power management: series, parallel, and power split configuration examples
A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

Week 1: Vehicle road loads
Week 2: Analysis of vehicle chassis dynamics
Week 3: Model reference chassis control
Week 4: Human driver modeling
Week 5: Internal combustion engines – overview
Week 6: Control-oriented modeling of IC engines
Week 7: Torque converter modeling
Week 8: Clutch and gearbox modeling
Week 9: Driveline/powertrain model integration
Week 10: Conventional powertrain optimization and control
Week 11: Vehicle electrification/hybridization
Week 12: Modeling of electric machines
Week 13: Modeling of electrochemical batteries
Week 14: Optimal hybrid power management
Week 15: Vehicle thermal management

Course Description:
This course introduces students to the control-oriented state-space and transfer function modeling of powertrain components and systems. Relevant application domains include conventional automotive powertrains, hybrid powertrains, locomotive propulsion systems, marine and submarine propulsion systems, and stationary power generation systems. The course introduces students to the use of fundamental principles from thermodynamics, fluid mechanics, and rigid body mechanics for powertrain modeling. Simple, control-oriented models are emphasized. Model integration and simulation topics, including numerical stiffness, solver selection, and integration step size selection are emphasized. Applications of powertrain modeling and control covered in the course include servo-control problems (e.g., air-fuel ratio control) and supervisory power management in hybrid powertrains.

The name(s) of the faculty member(s) responsible for the development of the course:

- Name: HOSAM KADRY FATHY (hk2)
  Title: ASSOC PROF MECHANICAL ENG
  Phone: +1 814 867 4442
  Address: 0157D HAMMOND BLDG UNIVERSITY PARK
  Campus:
  City:
  Fax:

- Name: SEAN BRENNAN (SNB10)
  Title: ASSOC PROF MECHANICAL ENG
  Phone: +1 814 863 2430
  Address: 0157E HAMMOND BLDG
  Campus:
  City:
  Fax:

- Name: STEPHANIE STOCKAR (sus772)
  Title: ASST PROF MECHANICAL ENG.
  Phone: +1 814 863 6276
  Address: 0137 RESEARCH BL EAST UNIVERSITY PARK UNIVERSITY PARK, PA 16802
  Campus:
  City:
  Fax:

Course Justification

Instructional, Educational, and Course Objectives:
This section should define what the student is expected to learn and what skills the student will develop.

After completing this powertrain system modeling, simulation, and control course, students are expected to be able to:

1. Describe the main criteria for the design/evaluation of powertrains, including performance, safety, reliability, durability, fuel economy, emissions, and cost
2. Classify powertrain topologies (e.g., conventional vs. hybrid topologies, series vs. parallel hybrids, etc.)
3. Explain the fundamental tradeoffs between different powertrain topologies with respect to different design/evaluation criteria
4. Build control-oriented models of different conventional and hybrid powertrain components, such as internal combustion engines, torque converters, electric machines, electrochemical batteries, clutches, gearboxes, etc.
5. Formulate powertrain optimization problems, including both powertrain design and control optimization problems
6. Simulate powertrain system models for different drive cycles, assuming either human or automated (i.e., robotic) drivers, to analyze their performance, fuel consumption, emissions, etc.
7. Design optimal powertrain controllers using schemes such as model predictive control
10. Contextualize the process of powertrain modeling, optimization, and control within the broader theoretical framework of state-space dynamic system modeling, analysis, and control.

**Evaluation Methods:**
Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students' grades should be specifically identified.
Exams/quizizzes (30%)
Homework/case studies (30%)
Team projects/presentations (40%)

**Relationship/Linkage of Course to Other Courses:**
This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course’s role as a prerequisite for other courses.
ME 370 is a prerequisite class because it provides students with necessary background knowledge in the modeling of mechanical system dynamics. ME 450 is a Concurrent-requisite because it expands on the above background knowledge and covers the dynamic modeling of multi-domain systems. ME 357 is a Concurrent-requisite and can be used in place of ME 450 (ME 450 or ME 357) because this course also expands on the above background knowledge and explores the modeling of linear systems via transfer functions and state-space models.

**Relationship of Course to Major, Option, Minor, or General Education:**
This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments.
This course will serve as a technical elective for students in Mechanical Engineering (and other Engineering majors).

**A description of any special facilities:**
Special Facilities are not required

**Frequency of Offering and Enrollment:**
This course has been offered twice since its creation: once in the 2014/2015 academic year and once in the 2015/2016 academic year. The course will be offered once per year in the future, with an anticipated enrollment of 20-30 resident students in the fall semester.

**General Education Designation Requirements**

**Campuses That Have Offered ( ) Over The Past 4 Years**

| semester | AB | AL | BK | BR | BW | CR | DS | ER | FE | GA | GV | HB | HN | HY | LV | MA | NK | PC | SH | SL | UP | WB | WC | WS | XC | XP | XS | YK |
|----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

**Curricular Information**
Blue Sheet Item #:
Review Sheet:

**SCRID Numbers**

(ME 453):

**Review History (not subject to comparison)**
This section represents all consultation history that has occurred on this proposal

**Legend**

- ✓ Approve
- ✗ Rejected
- 🤔 Waiting Review
- 🔄 User Action Required
- 🚨 Pending Action(s)
- 🔄 Moved to Rejected Status
- 👍 Approved
- ( #) - Review Order Sequence Number

**Consultation**

- ✓ Recipient Name: JEFFREY CATCHMARK
  Department: Agricultural And Biological Engineering
  Position: Consultation
  Campus: UNIVERSITY PARK CAMPUS
  Title: PROF AG & BIO ENG
Concur: Yes

Comments: A few comments: 1. The proposal does not include a justification for the course in the justification section, i.e., why is the course being continued (has been offered twice before). 2. The course should be reviewed by Dr. Jude Liu in the Agricultural and Biological Engineering Department who also teaches courses in this area. 3. I would suggest the topic of safety engineering be integrated into the course if possible as it is an important but often neglected topic.

Reviewed On: 9/26/2016 at 2:51 PM

Initiator Comments: 1. The course is important for a number of reasons. First, we do not teach a powertrain course in Mechanical Engineering, and the course therefore fills a clear gap in our curriculum. Second, we already have a very strong curriculum in other areas related to automotive engineering, such as vehicle dynamics, combustion, and hardware-in-the-loop simulation. With this course, our curriculum in the automotive area becomes much stronger, and much more comprehensive. Third, many of our students find jobs in the automotive and/or marine propulsion industry, and compete with students from other universities who are better-trained in the powertrain area. This new course will close this gap, and prepare our students to be much more competitive in the powertrain area immediately after graduation. Finally, we have multiple excellent undergraduate project teams that need experience in powertrain systems (e.g., Formula SAE, EcoCar, etc.). Prior to launching this course, these students often came to the course instructors asking for informal mentorship in the topics covered by this course. Teaching the course experimentally twice has helped these student competition teams significantly, and will continue to be valuable as these teams compete in future events over the years.
2. We look forward to the review of the course by Dr. Jude Liu.
3. The reviewer makes an excellent point regarding the need for discussing safety as part of the course. The topic of safety is discussed extensively throughout the course already, and so is the topic of engineering ethics. We use specific examples from the history of the automotive industry to discuss these two topics (e.g., the Ford Pinto, the fatal acceleration events of Toyota vehicles, emissions certifications for VW diesel vehicles, etc.). Because of the nature of safety and ethics as overarching topics that are important in every aspect of automotive engineering, the discussion of these two topics is spread throughout the course, as opposed to having a specific module of the course dedicated to safety. We believe that this is appropriate, but we are also happy to designate specific lectures to safety and ethics if the reviewers feel strongly that this is needed.
Recipient Name: Richard Ciocci  
Department: Science, Engineering And Technology  
Position: Consultation  
Campus: PENN STATE HARRISBURG, THE CAPITAL COLLEGE  
Title: ASSOC PROF MECH ENG

Recipient Name: RUSSELL WARLEY  
Department: Engineering  
Position: Consultation  
Campus: PENN STATE ERIE, THE BEHREND COLLEGE  
Title: Interim Director, School of Engineering

Recipient Name: Timothy Wheeler  
Department: (Not Available)  
Position: Consultation  
Campus: (Not Available)  
Title: ASST PROF ELECT ENGR

Recipient Name: Jude Liu  
Department: (Not Available)  
Position: Consultation  
Campus: (Not Available)  
Title: ASST PROF AG & BIO ENG
Recipient Name: RUNGUN NATHAN  
Department: Engineering, Business and Human Development

Position: Consultation  
Campus: BERKS CAMPUS

Title: ASSOC PROF ENGINEERING

Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 10/21/2016 at 7:15 AM

Request sent: 10/6/2016 at 11:03 AM
Concur: Yes
Comments: We request that M E 357 be allowed in place of ME 450. Otherwise we concur.
Reviewed On: 10/13/2016 at 8:10 PM

Initiator Comments: We have no problem with changing the list of course co-requisites to be "either ME 450 or ME 357", we are glad that Prof. De Vries is interested in this course, and we look forward to working with her on teaching it in the future.

Request sent: 10/21/2016 at 12:46 PM
Concur: Yes
Comments: Could you please make current concurrent from "ME 450; ME 357" to "ME 450 OR ME357"? I have already given my approval, but request this change be made.
Reviewed On: 10/21/2016 at 9:46 PM

Initiator Comments: Thank you for your comments. It has been adjusted to OR as requested. In this system a semi-colon (;) represents an OR and a comma represents (,) AND.

Request sent: 11/7/2016 at 7:30 AM
Concur: Yes
Comments: Thanks for making all the changes and also responding to the comments.
Reviewed On: 11/8/2016 at 4:23 PM

Head of Department

Recipient Name: KAREN ANN THOLE  
Department: (Not Available)

Position: Head of Department  
Campus: UNIVERSITY PARK CAMPUS

Title: 
Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

SCCA Representative

Recipient Name: ROBERT MELTON  
Department: (Not Available)

Position: SCCA Representative  
Campus: UNIVERSITY PARK CAMPUS

Title: 
Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Dean of the College

Recipient Name: PETER BUTLER  
Position: Dean of the College  
Department: (Not Available)  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

SCCA Subcommittee Review

Recipient Name: CORTNEY SMITH  
Position: SCCA Subcommittee Review  
Department: (Not Available)  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

Recipient Name: CYNTHIA ZOOK  
Position: SCCA Subcommittee Review  
Department: (Not Available)  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

Recipient Name: KADI CORTER  
Position: SCCA Subcommittee Review  
Department: (Not Available)  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]

SCCA Review

Recipient Name: CORTNEY SMITH  
Position: SCCA Review  
Department: (Not Available)  
Campus: UNIVERSITY PARK CAMPUS

Concur: [Not Yet Reviewed]  
Comments: [Not Yet Reviewed]  
Reviewed On: [Not Yet Reviewed]
Recipient Name: CYNTHIA ZOOK  
Department: (Not Available)  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS

Recipient Name: KADI CORTER  
Department: (Not Available)  
Position: SCCA Review  
Campus: UNIVERSITY PARK CAMPUS

Recipient Name: CORTNEY SMITH  
Department: (Not Available)  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS

Recipient Name: KADI CORTER  
Department: (Not Available)  
Position: Faculty Senate Review  
Campus: UNIVERSITY PARK CAMPUS
Program Proposals:

Approved (pending revisions):
- New graduate program in Additive Manufacturing and Design offering Resident Master’s of Science and Online Master’s of Engineering Degrees

Course Proposals:

Approved
- (EDSGN 562) Design for Additive Manufacturing
- (EMCH 544) Multiscale Modeling of Materials
- (ME 552) Optimal Control of Energy Systems
### Proposals Submitted to EFC

<table>
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<tr>
<th>Proposal Type</th>
<th>Title</th>
<th>Mnemonic</th>
<th>Number or Degree</th>
<th>Action Requested (Add/Change/Drop)</th>
<th>Vote GS&amp;R*</th>
<th>Justification (Why/What for)</th>
<th>Summary of Discussion Points</th>
</tr>
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</table>
| Course       | Design for Additive Manufacturing | EDSGN 562 | Add | Approve | Upon successful completion of the course, students will be able to:  
• Describe the role that design for additive manufacturing plays in the greater field of additive manufacturing.  
• Apply existing design for additive manufacturing approaches and frameworks to design problems.  
• Utilize opportunistic design for additive manufacturing concepts to improve the quality and novelty of a product.  
• Identify and quantify restrictive design for additive manufacturing considerations via experimental methods.  
• Identify and discuss key areas of future research in order to advance the field of design for additive manufacturing. | All agree proposal looks good. |
| Course       | Optimal Control of Energy Systems | ME 552 | Add | Approve | Students taking this course should become familiar with the fundamental methods and tools of optimal control theory and their application to a variety of supervisory energy management problems.  
This course introduces the fundamental principles and methods of optimal control, dynamic programming, and extremum-seeking control, with a focus on the application of these tools to a variety of problems from the energy generation, storage, and management domain. Fundamental topics covered include bond graph modeling of energetic systems, constrained and unconstrained static optimization, the Karush-Kuhn-Tucker conditions, extremum-seeking control, the Bellman principle of optimality, deterministic dynamic programming, Markov chains, stochastic dynamic programming, the Bolza optimal control problem, the Pontryagin maximum principle, the Hamilton-Jacobi-Bellman equation, linear quadratic regulation, bang-bang control, and pseudo-spectral optimal control. Applications examined include impedance matching in photovoltaics and wind power plants, fuel-minimizing optimal vehicle path planning, optimal Lithium-ion battery charging/discharging, optimal power management in hybrid electric and hybrid hydraulic vehicles, and optimal building energy management. The course serves as a broad introduction to fundamental topics covered in more depth in other classes on dynamic programming, adaptive control, and optimal control.  
Equal emphasis is placed on the tools and methods of optimal control theory and their practical application to optimal energy management problems. The course is intended for graduate students in engineering interested in energy management research, and already possessing a basic familiarity with energy systems and dynamic system modeling. Grading is based on a combination of quizzes/exams, in-class presentations, and open-ended projects, with heavy emphasis on project work. | All agree proposal looks good. |
| Course       | Multiscale Modeling of Materials | E MCH 544 | Add | Approve | The instructional objectives include effectively employing usual vehicles of lectures and assignments.  
Recruitment of students into this course will be done by sending course flyers to different departments, including Aerospace Engineering, Mechanical and Nuclear Engineering, Physics, Materials Science and Engineering, and Chemical Engineering. We will assess the attractive points of the course to the registered students, and the relevance of the course materials to their thesis research topics. The educational objectives include conveying the breadth and depth of multiscale computational modeling and its impact on research and society. The course objective is to present a systematic discussion on the fundamental issues in multiscale modeling and its application in modeling materials responses. Students taking this course will acquire in-depth understanding of different multiscale strategies and hands-on experiences in multiscale computational simulations of engineering problems. They will also recognize the potential of multiscale modeling in materials engineering and characterization. | All agree proposal looks good. |
<table>
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<tr>
<th>Proposal Type</th>
<th>Title</th>
<th>Action Requested (Add/Change/Drop)</th>
<th>Vote GS&amp;R*</th>
<th>Justification (Why/What For)</th>
<th>Summary of Discussion Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program</td>
<td>A new graduate program in Additive Manufacturing and Design offering</td>
<td>Add (Approve - with revisions)</td>
<td></td>
<td>The program goals are to educate a new cadre of graduate students and train engineers and manufacturers in the existing workforce to apply a multidisciplinary approach to utilize additive manufacturing and associated design methods and tools effectively. This educational approach will allow those completing the MSAMD and MEngAMD degrees to develop new design methods and paradigms that will shorten product development cycles and manufacturing lead times; exploit the uses of the “digital thread” during product development; be educated on all the technical and ethical issues associated with 3D printing; and to perform detailed analyses of the additive manufacturing processes.</td>
<td>The revision should focus on better differentiating the MS vs MEng tracks, as I think this may be a concern of the Graduate Council.</td>
</tr>
<tr>
<td></td>
<td>Resident’s of Science and Online Master’s of Engineering Degrees</td>
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<td>I am supportive of the proposed program.</td>
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<td>I agree. The requirements for the MS should be much higher and comparable to what students have to do for other MS courses on campus.</td>
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<td>Looks good overall. I agree in wondering whether the final paper subject is enough to distinguish the 2 programs (especially because there is presumably significant room for overlap between the practical and theoretical here).</td>
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<td>This looks like an interesting new program. Overall, I am supportive. However, I do wonder if just the difference in final project/paper focus (theoretical vs practical) is sufficient to differentiate the MS and MEng degrees. It seems that the students will take the same core courses for these two degrees - all of which are listed at the 500-level. Should some of the MEng coursework be 800-level? How will the core courses adequately provide depth in both theory and practical application for the two different groups (MS and MEng students) taking the same course?</td>
<td></td>
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</tbody>
</table>
Graduate Council Subcommittee On New And Revised Programs and Courses

COURSE SUBMISSION AND CONSULTATION FORM

Principal Faculty Member(s) Proposing Course

<table>
<thead>
<tr>
<th>Name</th>
<th>User ID</th>
<th>College</th>
<th>Department</th>
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<tr>
<td>NICHOLAS MEISEL</td>
<td>nam20</td>
<td>Engineering (EN)</td>
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College with curricular responsibility: Engineering (EN)
Type of Proposal: [X] Add  [ ] Change  [ ] Drop

Course Designation
(EDSGN 562) Design for Additive Manufacturing

Course Information

Cross-Listed Courses:

Prerequisites:
IE 587

Corequisites:

Concurrents:
IE 587

Recommended Preparations:

Abbreviated Title: DESIGN FOR ADD MFG

This course will be delivered:

- [X] in residence
- [X] off-site
- [X] online

Bulletin Listing

Minimum Credits: 4
Maximum Credits: 4
Repeatable: NO
Department with Curricular Responsibility: School of Engr Design, Technology and Prof Prgrms (UPEN_SEDTP)
Effective Semester: Upon Approval
Travel Component: NO

Course Outline

A brief outline or overview of the course content:
EDSGN 562 focuses on the evolving role of design in the face of modern additive manufacturing (AM, colloquially 3D printing) systems. The principles discussed in the course span the realms of both product design and manufacturing science. Students from a variety of engineering backgrounds will work in a project-driven environment that leverages research advances in the field of design for AM. In doing so, they will identify key differences between design for additive vs. subtractive manufacturing. Specific topics to be covered are grouped into opportunistic design considerations (e.g., lattice structures, mass customization, topology optimization, multi-material and multi-functional design) and restrictive manufacturability limitations (e.g., impacts of part scale, support material usage). Students who complete the course will be better prepared to recognize the role that additive manufacturing’s design opportunities and limits play in the design of products.

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

- Review of AM part creation chain/digital thread
- Review of the key AM process types
- Review of the generalized design process

**Topic 2:** Introduction to Design for Additive Manufacturing (DiAM, 1 week)
- Relationship of AM design research to material and process research
- Overview of Design for X
- Design for AM (DiAM) vs. Design for Manufacturing
- Introduction to Semester Project

**Topic 3:** Existing DiAM Frameworks (1 week)
- Process-structure-behavior relationships
- Opportunistic vs. restrictive DiAM
- Creation of “designer’s guides”

**Topic 4:** CAD and File Types in DiAM (1 week)
- CAD challenges encountered within AM design
- Additive manufacturing file types

**Topic 5:** Free Complexity and Lattice Structures (2 weeks)
- Shape, hierarchical, material, and functional complexity
- Design of lattice structures (unit cells, nodes, and trusses)

**Topic 6:** Topology Optimization (2 weeks)
- Formulation of optimization problems
- Mesh representations
- Optimization algorithms
- AM constraints in topology optimization

**Topic 7:** Mass Customization (1 week)
- Types of mass customization
- Economic justification for mass customization
- Role of 3D scanning

**Topic 8:** Multi-Material and Multi-Functional DiAM (1 week)
- In-situ embedding
- Design with electronic traces
- Multi-material design approaches and concerns

**Topic 9:** Experimental Techniques to Assess Restrictive DiAM (2 weeks)
- Design of experiments
- Statistical data analysis
- Existing experimental DiAM case studies

**Topic 10:** Role of Size Scale in DiAM (2 weeks)
- Build time impacts
- Minimum feature size and thin wall design
- Impacts of curling and warping
- Consideration of build volume

**Topic 11:** Impact of Support Material in DiAM (1 week)
- Support removal challenges
- Self-supporting angles
- Bridging limits

**Course Description:**

Additive manufacturing (AM, colloquially 3D printing) is rapidly changing the face of modern manufacturing. This layer-by-layer manufacturing approach allows for parts to be created with significant levels of complexity and in cost-effective small batches, with reduced raw material waste when compared with traditional manufacturing processes. This technology has given rise to the need for Design for Additive Manufacturing (DiAM) techniques capable of accounting for both the possibilities and restrictions offered by AM in product design. In this class, students will be exposed to existing DiAM frameworks and will learn to account for both opportunistic possibilities (e.g., lattice structures, topology optimization, and mass customization) and restrictive limitations (e.g., minimum feature size and support material removal) when designing products for creation with additive manufacturing. The material will be presented through a variety of design exercises viewed through the lens of research in the DiAM field. This will include a semester-long project, during which students will combine opportunistic and restrictive considerations toward the creation of a
The objectives of the course include describing the role that DfAM plays in the greater field of additive manufacturing, applying existing DfAM approaches and frameworks to design problems, utilizing opportunistic DfAM to improve product quality and novelty, identifying and quantifying restrictive DfAM considerations through experimentation, and identifying and discussing key areas of future research to advance the field of DfAM. Students will be evaluated on their knowledge through the review and critique of research papers in DfAM, quizzes on topic knowledge, short-form design exercises, and through a semester-long design project that includes both written and oral components.

The course will be taught once a year as a lecture-based course. The course acts as an elective within the existing Engineering Design master’s program and as a core component of the Additive Manufacturing master’s program.

The name(s) of the faculty member(s) responsible for the development of the course:

- Name: NICHOLAS MEISEL (nam20)
  Title: ASST PROF ENGR DESIGN
  Phone: +1 814 865 3163
  Address: 213J HAMMOND BLDG
  Campus:
  City:
  Fax:

- Name: MATTHEW PARKINSON (mbp11)
  Title: ASSOC PROF ENGR DESIGN
  Phone: +1 814 863 9079
  Address: 0213 HAMMOND BLDG
  Campus:
  City:
  Fax:

Course Justification

Instructional, Educational, and Course Objectives:
This section should define what the student is expected to learn and what skills the student will develop. Upon successful completion of the course, students will be able to:

- Describe the role that design for additive manufacturing plays in the greater field of additive manufacturing.
- Apply existing design for additive manufacturing approaches and frameworks to design problems.
- Utilize opportunistic design for additive manufacturing concepts to improve the quality and novelty of a product.
- Identify and quantify restrictive design for additive manufacturing considerations via experimental methods.
- Identify and discuss key areas of future research in order to advance the field of design for additive manufacturing.

Evaluation Methods:
Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students’ grades should be specifically identified.
A student’s ability to meet the stated course objectives will be evaluated through a series of literature critiques, short-form design exercises, and topic quizzes, along with participation in a semester-long, team-based design project. Student course grades will be calculated based on the following:

- Assignment Weight
  Literature Reviews/Critiques (Individual)...15%
  Design Exercises (Individual)....................15%
  Quizzes (Individual)..............................25%
  Semester Project: Proposal (Team)...........5%
  Semester Project: Final Report (Team).....20%
  Semester Project: Final Presentation (Team)...10%
  Semester Project: Final Design File (Team).....10%

Relationship/Linkage of Course to Other Courses:
This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course’s role as a prerequisite for other courses.
This course is a graduate-level course in design for additive manufacturing that builds on the knowledge of existing design and manufacturing courses. Specifically, the course builds on the additive manufacturing process knowledge gained in IE 587 by applying the principles in this class to a design-focused context.

**Relationship of Course to Major, Option, Minor, or General Education:**
This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments. EDSGN 562 will serve as an elective class for graduate students in the existing Engineering Design graduate program and as a core component of the Additive Manufacturing graduate program currently under development.

**A description of any special facilities:**
There are no special facilities required for the proposed course.

Library resources needed for the course include student access to appropriate research journal articles through the Penn State library website.

**Frequency of Offering and Enrollment:**
This course will be offered once per year with an anticipated enrollment of 15-20 students.

---

**Review History**
This section represents all consultation history that has occurred on this proposal

**Legend**
- Approve
- Rejected
- Waiting Review
- User Action Required
- Pending Action(s)
- Moved to Rejected Status
- Approved
- (#) - Review Order Sequence Number

---

**Consultation**

**Recipient Name:** CHENG DONG  
**Department:** Biomedical Engineering  
**Position:** Consultation  
**Campus:** UNIVERSITY PARK CAMPUS  
**Title:** DEPT HEAD/DIST. PROF BIO

(17) **Request sent:** 10/3/2016 at 7:30 AM  
**Concur:** Yes  
**Comments:** (Completed By Default - Exceeded Time Limit)  
**Reviewed On:** 10/6/2016 at 7:15 AM

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**Recipient Name:** JANIS TERPENNY  
**Department:** Industrial And Manufacturing Engineering  
**Position:** Consultation  
**Campus:** UNIVERSITY PARK CAMPUS  
**Title:** DEPT HEAD & PROF INDUSTL
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Request sent: 9/21/2016 at 3:30 PM
Concur: No, this proposal needs significant changes
Comments: If I understand correctly, the course is to be 4 credits. What is the justification for this? Also, the prerequisite IE 587 doesn't appear on the IE department's (http://www.ie.psu.edu/students/graduate/courses.aspx) or the Graduate School's (http://bulletins.psu.edu/graduate/courses/I/I%20E/) web sites. Why?
Reviewed On: 9/25/2016 at 12:38 PM

Initiator Comments: Thank you for your feedback. This proposed course is part of a larger proposal for a Master's Degree in Additive Manufacturing. The decision was made to propose the four core courses for the program (of which the proposed EDSGN 562 is one) at 4 credits instead of the usual 3. This is to allow for more depth in each of the core courses and to better accommodate students taking the course through the World Campus. In this way, online students only taking 1 course per semester may more easily spend an extra 15 hours on a class (the difference between 4 credits and 3 credits) compared to finding time to take a 2nd course. The hope is that this will expedite degree completion for participating students. This approach is commensurate with the Master of Professional Studies in Supply Chain Management degree offered through the World Campus, which has several similarly scoped courses already developed. The IE 587 course listed as a pre-requisite is also part of the larger Additive Manufacturing program proposal and is currently working through the proposal process as well, which is why it does not show up in the course catalog at the moment. The target goal is for both the EDSGN 562 course and IE 587 course to be ready for implementation at the same time, hence its inclusion as a pre-requisite.

Request sent: 10/25/2016 at 10:59 AM
Concur: Yes
Comments:
Reviewed On: 10/26/2016 at 10:57 AM

Recipient Name: M PARFITT
Department: Architectural Engineering
Position: Consultation
Campus: UNIVERSITY PARK CAMPUS
Title: PROFESSOR ARCH ENGR

Request sent: 10/3/2016 at 7:30 AM
Concur: Yes
Comments: Based on my review of the material provided, I feel this is an excellent new program that pulls together knowledge from a number of sources at Penn State into a timely and comprehensive degree program. Given the topic, I feel the required internship is especially appropriate and will benefit those students who do not have much (or any) industry experience and will make the program attractive to students because of the industry interaction. There are no overlaps or duplication of effort in the program relative to Architectural Engineering. As such, you have my support for the new degree program in Additive Manufacturing and Design.
Reviewed On: 10/3/2016 at 9:15 AM
Recipient Name: PATRICK FOX  
Department: Civil And Environmental Engineering  
Position: Consultation  
Title: PROF AND DEPT HEAD  
Campus: UNIVERSITY PARK CAMPUS  
Request sent: 10/3/2016 at 7:30 AM  
Concur: Yes  
Comments:  
Reviewed On: 10/3/2016 at 8:28 AM

Recipient Name: PAUL HEINEMANN  
Department: Agricultural And Biological Engineering  
Position: Consultation  
Title: DEPT HD/PROF AG & BIO ENG  
Campus: UNIVERSITY PARK CAMPUS  
Request sent: 9/21/2016 at 3:30 PM  
Concur: Yes  
Comments: from Virendra Puri, also consulted on this: I have now completed my review of the proposed course, EDSGN 562 – Design for Additive Manufacturing. This course does not impact any of our current graduate course offerings and could be of interest to some of our ABENG graduate students in the machinery systems. I am fully supportive of and approve the course as submitted.  
Reviewed On: 9/26/2016 at 7:31 AM

Recipient Name: PHILIP MORRIS  
Department: Aerospace Engineering  
Position: Consultation  
Title: BOEING PROFESSOR OF AERSP  
Campus: UNIVERSITY PARK CAMPUS  
Request sent: 10/3/2016 at 7:30 AM  
Concur: Yes  
Comments:  
Reviewed On: 10/3/2016 at 8:01 AM

Recipient Name: PHILLIP SAVAGE  
Department: Chemical Engineering  
Position: Consultation  
Title: PROF/DEPT HEAD CHEM ENGR  
Campus: UNIVERSITY PARK CAMPUS  
Request sent: 10/3/2016 at 7:30 AM  
Concur: Yes  
Comments: (Completed By Default - Exceeded Time Limit)  
Reviewed On: 10/7/2016 at 7:15 AM
Recipient Name: SVEN BILEN  
Department: School of Engr Design, Technology and Prof Prgrms  
Position: Consultation  
Title: DEPT HEAD/SED TAPP  
Campus: UNIVERSITY PARK CAMPUS

Request sent: 9/21/2016 at 3:30 PM  
Concur: Yes  
Comments:  
Reviewed On: 9/21/2016 at 7:03 PM

Recipient Name: THOMAS F LAPORTA  
Department: Computer Science And Engineering  
Position: Consultation  
Title: LNHRDCHAIRPROF & DIR EECS  
Campus: UNIVERSITY PARK CAMPUS

Request sent: 9/21/2016 at 3:30 PM  
Concur: Yes  
Comments:  
Reviewed On: 9/23/2016 at 2:17 PM

Recipient Name: MAH MUT TAYLAN KANDEMIR  
Department: (Not Available)  
Position: Consultation  
Title: PROFESSOR COMP SCI & ENG  
Campus: (Not Available)

Request sent: 10/3/2016 at 7:30 AM  
Concur: Yes  
Comments: (Completed By Default - Exceeded Time Limit)  
Reviewed On: 10/7/2016 at 7:15 AM

Recipient Name: MARY FRECKER  
Department: Mechanical Engineering  
Position: Consultation  
Title: Prof of Mechanical Engineering  
Campus: UNIVERSITY PARK CAMPUS

Request sent: 9/21/2016 at 3:30 PM  
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**Request sent:** 10/3/2016 at 7:30 AM
Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 10/7/2016 at 7:15 AM
Recipient Name: RICHARD MISTRICK  Department: Architectural Engineering
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: ASSOC PROF ARCH ENGR

Request sent: 10/3/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 10/3/2016 at 1:26 PM

Recipient Name: ROBERT VOIGT  Department: Industrial And Manufacturing Engineering
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: Professor IE

Request sent: 10/3/2016 at 7:30 AM
Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 10/7/2016 at 7:15 AM

Recipient Name: VICTOR SPARROW  Department: (Not Available)
Position: Consultation  Campus: (Not Available)
Title: DIR GRAD PROG ACOUSTICS

Request sent: 10/3/2016 at 7:30 AM
Concur: Yes
Comments: (Completed By Default - Exceeded Time Limit)
Reviewed On: 10/7/2016 at 7:15 AM

Recipient Name: VIRENDRA PURI  Department: Agricultural And Biological Engineering
Position: Consultation  Campus: UNIVERSITY PARK CAMPUS
Title: DIST PROF AG ENGINEERING

Request sent: 10/3/2016 at 7:30 AM
Concur: Yes
Comments:
Reviewed On: 10/4/2016 at 10:13 AM

Recipient Name: WILLIAM BURGOS  
Department: Civil And Environmental Engineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: PROFESSOR CIVIL & ENV EN

Request sent: 9/21/2016 at 3:31 PM  
Concur: Yes  
Comments: Looks like an excellent and timely new course  
Reviewed On: 9/21/2016 at 3:58 PM

Recipient Name: WILLIAM HANCOCK  
Department: Bioengineering  
Position: Consultation  
Campus: UNIVERSITY PARK CAMPUS  
Title: PROFESSOR BIOENGINEERING

Request sent: 10/3/2016 at 7:30 AM  
Concur: Yes  
Comments: (Completed By Default - Exceeded Time Limit)  
Reviewed On: 10/7/2016 at 7:15 AM

Recipient Name: JAMES NEMES  
Department: Data Analytics  
Position: Consultation  
Campus: PENN STATE GREAT VALLEY  
Title: PROFESSOR & DAA

Request sent: 9/26/2016 at 9:35 AM  
Concur: Yes  
Comments: No specific objection but it isn't clear why this is four credits. Is there a lab component that isn't identified?  
Reviewed On: 9/29/2016 at 1:25 PM

Head of Department

Recipient Name: SVEN BILEN  
Department: (Not Available)  
Position: Head of Department  
Campus: UNIVERSITY PARK CAMPUS  
Title: 
College/School Representative to the Graduate Council Subcommittee on New and Revised Programs and Courses

Recipient Name: MATTHEW PARKINSON
Department: (Not Available)
Position: College/School Representative to the Graduate Council Subcommittee on New and Revised Programs and Courses
Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

Dean of the College

Recipient Name: PETER BUTLER
Department: (Not Available)
Position: Dean of the College
Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]

Review on Behalf of the Dean of the Graduate School

Recipient Name: VICKI HEWITT
Department: (Not Available)
Position: Review on Behalf of the Dean of the Graduate School
Campus: UNIVERSITY PARK CAMPUS
Title:

Concur: [Not Yet Reviewed]
Comments: [Not Yet Reviewed]
Reviewed On: [Not Yet Reviewed]
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Curricular Information

Blue Sheet Item #:  
Review Date:  

SCRID Numbers

(EDSGN 562)
Graduate Council Subcommittee On New And Revised Programs and Courses

COURSE SUBMISSION AND CONSULTATION FORM

Principal Faculty Member(s) Proposing Course

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<td>MARY FRECKER</td>
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College with curricular responsibility: Engineering (EN)

Type of Proposal: [X] Add  [ ] Change  [ ] Drop

Course Designation

(ME 552) Optimal Control of Energy Systems

Course Information

Cross-Listed Courses:

Prerequisites:

ME 450

Corequisites:

Concurrents:

Recommended Preparations:

Abbreviated Title: CTRL ENERGY SYSTS

This course will be delivered:

[X] in residence

[X] off-site

[X] online

Bulletin Listing

Minimum Credits: 3

Maximum Credits: 3

Repeatable: NO

Department with Curricular Responsibility: Mechanical Engineering (UPEN_ME)

Effective Semester: Upon Approval

Travel Component: NO

Course Outline

A brief outline or overview of the course content:

This course introduces the fundamental principles and methods of optimal control, dynamic programming, and extremum-seeking
control, with a focus on the application of these tools for a variety of problems from the energy generation, storage, and management domain. Fundamental topics covered include bond graph modeling of energetic systems, constrained and unconstrained static optimization, the Karush-Kuhn-Tucker conditions, extremum-seeking control, the Bellman principle of optimality, deterministic dynamic programming, Markov chains, stochastic dynamic programming, the Bolza optimal control problem, the Pontryagin maximum principle, the Hamilton-Jacobi-Bellman equation, linear quadratic regulation, bang-bang control, pseudo-spectral optimal control, the optimal control of differentially flat systems, periodic optimal control, and model predictive control. Applications examined include impedance matching in photovoltaics and wind power plants, fuel-minimizing optimal vehicle path planning, optimal Lithium-ion battery charging/discharging, optimal power management in hybrid vehicles, and optimal building energy management.

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

Review of energetic system modeling: Definition of dynamic systems and the concept of memory; review of state-space modeling; fundamental analogies between mechanical, electrical, thermal, and hydraulic systems; bond graph modeling of lumped-parameter energetic systems.
1 week

Review of nonlinear programming: Unconstrained and constrained nonlinear programming problems; necessary and sufficient conditions for interior optima; the Karush-Kuhn-Tucker optimality conditions; the significance of Lagrange multipliers in the KKT conditions; application of KKT conditions to power-constrained brake-specific fuel consumption minimization in internal combustion engines.
2 weeks

Extremum-seeking control: The impedance matchig principle; the extremum-seeking control algorithm; the relationship between extremum-seeking and impedance matching; stability of extremum-seeking controllers; application to photovoltaic maximum power point tracking and impedance matching in wind power generation
2 weeks

Deterministic dynamic programming: The Bellman principle of optimality; deterministic dynamic programming; Bellman’s curse of dimensionality; coding, vectorization, parallelization, and implementation techniques; application to fuel-minimizing vehicle path planning problems
2 weeks

Review of random processes and Markov chains: Definition of a random process; ensemble and temporal statistics; stationarity and ergodicity; the auto-correlation and power spectral density functions; white noise; the Markov property; Markov chains; fitting a Markov chain to time series data; elementary properties of Markov chains; Markov chain Monte Carlo simulation; application to data-driven modeling of renewable energy availability
2 weeks

Stochastic dynamic programming: Classification of stochastic dynamic programming problems; the shortest-path, infinite-horizon stochastic dynamic programming problem; the Bellman equation; solution of stochastic dynamic programming problems via modified policy iteration; application to optimal hybrid vehicle power management
2 weeks

Continuous-time optimal control: The Bolza optimal control problem; the Pontryagin maximum principle; the Hamilton-Jacobi-Bellman equation; the significance of co-state variables two-point boundary value problems; solution via shooting methods; linear quadratic regulation; bang-bang problems; singular arcs; application to optimal Lithium-ion battery charging and discharging, optimal vibration attenuation problems, and building energy management problems
2 weeks

Advanced topics: Pseudo-spectral optimal control; combined plant/controller optimization; optimal control of differentially flat systems; periodic optimal control; brief introduction to model predictive control; invited lectures on topics including energy-efficient computing and data center energy management
2 weeks

Course Description:
This course introduces the fundamental principles and methods of optimal control, dynamic programming, and extremum-seeking control, with a focus on the application of these tools to a variety of problems from the energy generation, storage, and management domain. Fundamental topics covered include bond graph modeling of energetic systems, constrained and unconstrained static optimization, the Karush-Kuhn-Tucker conditions, extremum-seeking control, the Bellman principle of optimality, deterministic dynamic programming, Markov chains, stochastic dynamic programming, the Bolza optimal control problem, the Pontryagin maximum principle, the Hamilton-Jacobi-Bellman equation, linear quadratic regulation, bang-bang control, and pseudo-spectral optimal control. Applications examined include impedance matching in photovoltaics and wind power plants, fuel-minimizing optimal vehicle path planning, optimal Lithium-ion battery charging/discharging, optimal power management in hybrid electric and hybrid hydraulic vehicles, and optimal building energy management. The course serves as a broad introduction to fundamental topics covered in more depth in other classes on dynamic programming, adaptive control, and optimal control.
Equal emphasis is placed on the tools and methods of optimal control theory and their practical application to optimal energy management problems. The course is intended for graduate students in engineering interested in energy management research, and already possessing a basic familiarity with energy systems and dynamic system modeling. Grading is based on a combination of quizzes/exams, in-class presentations, and open-ended projects, with heavy emphasis on project work.

The name(s) of the faculty member(s) responsible for the development of the course:

- Name: HOSAM FATHY (hkf2)
- Title: ASSOC PROF MECHANICAL ENG
- Phone: +1 814 867 4442
- Address: 0157D HAMMOND BLDG
- Campus:
- City:
- Fax:

Course Justification

Instructional, Educational, and Course Objectives:
This section should define what the student is expected to learn and what skills the student will develop. Students taking this course should become familiar with the fundamental methods and tools of optimal control theory and their application to a variety of supervisory energy management problems.

Evaluation Methods:
Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students’ grades should be specifically identified. Students will be evaluated based on multiple open-ended projects and homework assignments spread throughout the semester (30%), an open-ended final project (30%), in-class instructional experiences (20%), and both traditional and web-based quizzes and exams (20%).

Relationship/Linkage of Course to Other Courses:
This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course’s role as a prerequisite for other courses. This course will serve as a bridge connecting five major strengths at Penn State. First, Penn State already has a number of courses on the fundamentals of control theory. These courses cover a broad range of topics including dynamic system modeling, classical frequency-domain control design, linear system theory, state-space control design, robust control, adaptive control, estimation, nonlinear control, discrete-time control, etc. Second, Penn State already has a number of courses covering the fundamentals of thermodynamics and the modeling/design of different energy systems, including combustion systems, fuel cells, batteries, grid power systems, etc. Third, Penn State GATE (Graduate Automotive Energy Storage) curriculum offers a number of courses focusing on high-power energy storage devices, including flywheels, ultracapacitors, and batteries. Fourth, Penn State has several courses in the static optimization domain, covering topics such as linear programming, nonlinear programming, and stochastic optimization. Finally, Penn State has several advanced and focused courses in the field of dynamic programming, optimal control, and game theory. The proposed course is unique relative to all of these courses, and also complements them well. It provides a broad introduction to the tools and fundamentals of extremum-seeking control, dynamic programming, and optimal control. In doing so, it serves as an introduction to more advanced courses that cover each of these topics individually, with greater depth. It is also the only course at Penn State that bridges the gap between the energy systems domain on the one hand and the system dynamics and control domain on the other hand for a broad spectrum of applications. Penn State’s battery systems course also bridges this gap, but only for electrochemical energy storage applications. Finally, it is the only course at Penn State focusing explicitly on optimal energy management problems: a class of problems that is sufficiently rich and important to deserve its own course.

Relationship of Course to Major, Option, Minor, or General Education:
This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments. This will be a graduate-level course for students pursuing M.S. and Ph.D. degrees in Mechanical Engineering at Penn State. The course has attracted students from other College of Engineering majors – including Chemical Engineering, Electrical Engineering, and Nuclear Engineering – over the past 4 times that it has been offered. Several Computer Science students have audited the class.

A description of any special facilities:
No special facilities are required for the teaching of this course.

**Frequency of Offering and Enrollment:**
This course will be offered in the Fall semester, annually. Based on previous offerings, the course is expected to attract 10-20 students every time it is offered.

**Review History**
This section represents all consultation history that has occurred on this proposal.

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<td>✔️ Approve</td>
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<td>🚨 Pending Action(s)</td>
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**Consultation**

1. **Recipient Name:** PHILLIP SAVAGE  
   **Department:** Chemical Engineering  
   **Position:** Consultation  
   **Campus:** UNIVERSITY PARK CAMPUS  
   **Title:** PROF/DEPT HEAD CHEM ENGR  
   **Request sent:** 11/7/2016 at 7:30 AM  
   **Concur:** Yes  
   **Comments:** (Completed By Default - Exceeded Time Limit)  
   **Reviewed On:** 11/11/2016 at 7:15 AM

2. **Recipient Name:** RICHARD MISTRICK  
   **Department:** Architectural Engineering  
   **Position:** Consultation  
   **Campus:** UNIVERSITY PARK CAMPUS  
   **Title:** ASSOC PROF ARCH ENGR  
   **Request sent:** 10/27/2016 at 11:05 AM  
   **Concur:** Yes  
   **Comments:**  
   **Reviewed On:** 10/27/2016 at 5:02 PM

3. **Recipient Name:** ROBERT VOIGT  
   **Department:** Industrial And Manufacturing Engineering  
   **Position:** Consultation  
   **Campus:** UNIVERSITY PARK CAMPUS  
   **Title:** Professor IE
(3) Request sent: 11/7/2016 at 7:30 AM
   Concur: Yes
   Comments: (Completed By Default - Exceeded Time Limit)
   Reviewed On: 11/11/2016 at 7:15 AM

Recipient Name: VICTOR P PASKO
   Department: (Not Available)
   Position: Consultation
   Campus: (Not Available)
   Title: PROFESSOR ELECT. ENGR.

(4) Request sent: 11/7/2016 at 7:30 AM
   Concur: Yes
   Comments: (Completed By Default - Exceeded Time Limit)
   Reviewed On: 11/11/2016 at 7:15 AM

Head of Department

Recipient Name: KAREN THOLE
   Department: (Not Available)
   Position: Head of Department
   Campus: UNIVERSITY PARK CAMPUS
   Title:

   Concur: [Not Yet Reviewed]
   Comments: [Not Yet Reviewed]
   Reviewed On: [Not Yet Reviewed]

College/School Representative to the Graduate Council Subcommittee on New and Revised Programs and Courses

Recipient Name: MATTHEW PARKINSON
   Department: (Not Available)
   Position: College/School Representative to the Graduate Council Subcommittee on New and Revised Programs and Courses
   Campus: UNIVERSITY PARK CAMPUS
   Title:

   Concur: [Not Yet Reviewed]
   Comments: [Not Yet Reviewed]
   Reviewed On: [Not Yet Reviewed]
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<tr>
<th>Recipient Name</th>
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<tr>
<td>PETER BUTLER</td>
<td>(Not Available)</td>
<td>Review on Behalf of the Dean of the Graduate School</td>
</tr>
<tr>
<td>VICKI HEWITT</td>
<td>(Not Available)</td>
<td>Review on Behalf of the Dean of the Graduate School</td>
</tr>
<tr>
<td>ROBERT BANNON</td>
<td>(Not Available)</td>
<td>Feedback from the Graduate Council Joint Curricular Committee</td>
</tr>
<tr>
<td>CORTNEY SMITH</td>
<td>(Not Available)</td>
<td>Final Confirmation</td>
</tr>
</tbody>
</table>
Recipient Name: KADI CORTER  Department: (Not Available)
Position: Final Confirmation  Campus: UNIVERSITY PARK CAMPUS
Title:


Curricular Information
Blue Sheet Item #:  
Review Date:

SCRID Numbers
(ME 552):
Graduate Council Subcommittee On New And Revised Programs And Courses

COURSE SUBMISSION AND CONSULTATION FORM

Principal Faculty Member Proposing Course: Sulin Zhang
College: ENGINEERING
Department or Instructional Area: ENGINEERING SCIENCE AND MECHANICS
College/Academic Unit With Curriculum Responsibility: ENGINEERING
Type of Proposal: ☑ Add ☐ Change ☐ Drop
Type of Review: ☑ Full ☐ Expedited
(See Guide to Curricular Procedure for definitions of a full or expedited review.)
Course Designation: (E MCH 544) Multiscale Modeling of Materials

Proposed Bulletin Listing
Abbreviation : E MCH
Number : 544
Title : Multiscale Modeling of Materials
Abbreviated Title : Multiscale Mod
Credits : Min: 3 Max: 3
Repeatable : No
Description : Multiscale algorithms coupling different lengths and time scales to solve physical problems with both acceptable accuracy and efficiency.
Prerequisites : E MCH 407 or E MCH 461 or any 400-level course related to computational simulations
Concurrent Courses : None
Cross Listings :
Does this Course have a Travel Component: No

Course Outline
A brief outline or overview of the course content
1. Introduction: Fundamentals
   a. Mechanics of materials
   b. Statistical mechanics
   c. Thermodynamics and kinetics of materials
2. Simulation tools at single length scales
   a. Quantum mechanical calculations
   b. Molecular dynamics with empirical force fields
   c. Finite element methods
3. Multiscale coupling methods
   a. Length scale coupling: hierarchical and concurrent
   b. Time scale coupling

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

Totally 30 lectures

1. Introduction: Fundamentals (subtotal: 5 lectures)
   a. Mechanics of materials (2 lectures)
   b. Statistical mechanics (1 lecture)
   c. Thermodynamics and kinetics of materials (2 lectures)

2. Simulation tools at single length scales (subtotal: 7 lectures)
   a. Electronic structure models (2 lectures)
   b. Molecular dynamics (3 lectures)
   c. Continuum models: finite element and phase field modeling (2 lecture)

3. Multiscale coupling methods (subtotal: 18 lectures)
   a. Length scale coupling
      Hierarchical: Empirical message passing between the scales (1 lecture)
      Hierarchical: Coarse-graining (3 lectures)
      Classical concurrent: multigrid method (1/2 lecture)
      Classical concurrent: adaptive mesh refinement (1/2 lecture)
      Concurrent: Quasi-continuum method (1 lecture)
      Concurrent: Cauchy-Born rule for crystals (1 lecture)
      Concurrent: Extended Cauchy-Born rule of 2D layered crystals (1 lectures)
      Concurrent: Quasi-continuum method (1 lecture)
      Concurrent: MAAD (macroscopic, atomistic, and ab initio) (1/2 lectures)
      Concurrent: Bridging domain method (1/2 lectures)
      Concurrent: Bridging scale method (1/2 lectures)
      Concurrent: Coupling atomistic with dislocation dynamics (1/2 lectures)
   b. Time scale coupling
      Problems with disparate time scales (1 lectures)
      Numerical algorithm for finding transition states (3 lectures)
      Accelerated dynamics and sampling methods (3)

Long Course Description:
A succinct stand-alone course description (up to 400 words) to be made available to students through the on-line Bulletin and Schedule of Courses.

Material response and failure to external loadings features phenomena over different length scales, encompassing chemical reactions at the reaction front and the material separation at a crack tip on the angstrom scale; the motion of materials defects at the nanoscale; the interaction and organization of material defects (such as dislocations) at the mesoscale; and the long-range elastic deformation at the macroscopic scale. It has been a common practice to perform simulations on an individual length scale to obtain the relevant material response and properties: quantum mechanical simulations for lattice constants and binding energies and transition barriers; atomistic simulations for microstructural evolutions, defect nucleation and motion; and continuum models for overall material deformation morphology and failure. Yet, a focus at only one scale often misses physics at other scales that are essential for quantitative prediction of overall material response. Multiscaling strategies coupling different length and time scales are therefore essential for the prediction of material
responses.
This course discusses the key issues of the conventional simulation methods at single length and time scales. The course starts with a revisit of mechanics of materials, statistical mechanics, and thermodynamics and kinetics of materials, which form the fundamental basis for the development of physical-based simulation models. Conventional simulation methods at single length scale will then be followed, including the quantum mechanical simulations, molecular dynamics, finite element simulations, and phase field modeling. Emphasis will be placed on the coupling strategies bridging different length and time scales. The multiscale methods will be delivered in combination with interesting materials phenomena spanning nanostructured and biological materials.

The name(s) of the faculty member(s) responsible for the development of the course
Sulin Zhang

Justification Statement
Instructional, Educational, and Course Objectives
The instructional objectives include effectively employing usual vehicles of lectures and assignments. Recruitment of students into this course will be done by sending course flyers to different departments, including Aerospace Engineering, Mechanical and Nuclear Engineering, Physics, Materials Science and Engineering, and Chemical Engineering. We will assess the attractive points of the course to the registered students, and the relevance of the course materials to their thesis research topics. The educational objectives include conveying the breadth and depth of multiscale computational modeling and its impact on research and society. The course objective is to present a systematic discussion on the fundamental issues in multiscale modeling and its application in modeling materials responses. Students taking this course will acquire in-depth understanding of different multiscale strategies and hands-on experiences in multiscale computational simulations of engineering problems. They will also recognize the potential of multiscale modeling in materials engineering and characterization.

Evaluation Methods
a.   Well-designed analytical problems as homework problems (5 homework sets (40%) ) will be used to evaluate the students’ understanding on background materials and mathematical aspects of multiscale modeling approaches.
b.   Homework problems will also include computational simulations with either commercial software or student’s own developed codes to solve 1D and 2D multiscale problems (3 homework sets, 30%).
c.   Final project (30%)

Relationship/Linkage of Course to Other Courses
This course is complementary to a set of courses in materials Science, Physics, and Mechanics, both in the fundamental and modeling aspects. To name a few, these courses include:

a.   EMCH 560: Finite element analysis
b.   MASTSE 544: Computational materials science of soft materials
c.   MASTSE 580: Computational thermodynamics
d.   MASTSE 581: Computational materials science: continuum, mesoscale simulations
e. CHE 597C: Atomistic-scale simulation methods for engineers
d. PHYS 427: Computational physics and astrophysics

Relationship of Course to Major, Option, Minor, or General Education
The course will be part of ESM graduate curriculum.

A description of any special facilities
Students taking the course will be exposed to parallel computing for which computer clusters in the instructor’s lab and that in COE will be utilized.

Frequency of Offering and Enrollment
It is anticipated that the course will be offered every other year in the fall. This course has been offered 4 times in University Park campus, and the enrollment on average is about 15 students.

Effective Date: Fall 2015

Consultation Summary/Response:

= Concur/Approval
! = Pending Action(s)
# = Review Order
x = Non-Concur/Rejected
? = Awaiting Review

Informal Consultation

Name: Mike Lanagan
Position: Informal Consultant
Title: PROF ESM/MSE
Department: ENGR SCI & MECHANICS
Campus: UNIVERSITY PARK CAMPUS
Concur: Yes
Comments: The course is synergistic with mechanics courses within the Department of Engineering Science and Mechanics, and thermodynamics and kinetics courses within the Materials Science and Engineering Department.
Reviewed On: 6/15/2015 8:42:00 AM

Name: Judith A. Todd
Department: ENGINEERING SCIENCE AND MECHANICS
Position: Informal Consultant
Campus: UNIVERSITY PARK CAMPUS
Title: HEAD/PROF ESM

Concur: Yes
Comments: "Mechanics of Materials is too vague a prerequisite. Suggest using E MCH 524A or equivalent, or a 400-level mechanics course.
Change ESM graduate curriculum to engineering science and mechanics graduate curriculum.
Reviewed On: 6/18/2015 7:48:00 PM

Name: Corina Drapaca
Department: ENGR SCI & MECHANICS
Position: Informal Consultant
Campus: UNIVERSITY PARK CAMPUS
Title: ASSOC PROF ENGR SCI & MCH

Concur: Yes
Comments: Yes
Reviewed On: 6/23/2015 7:29:00 AM

Name: Francesco Costanzo
Department: ENGR SCI & MECHANICS
Position: Informal Consultant
Campus: UNIVERSITY PARK CAMPUS
Title: PROF ESM AND MATHEMATICS

Concur: Yes
Comments: This course deals with how information is transferred across scales, even in cases when the numerical techniques to process the information are different at the different scales. In this sense, the course is very much needed in the current curriculum in mechanics. My only observation is that I would not say that the course is "complementary" to E MCH 560 in that the finite element method is one of the methods that can be used in a multi-scale approach. That is, the proposed course covers material in which the knowledge given in E MCH 560 is applied. The prerequisites are adequate.
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<th>Name</th>
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<tbody>
<tr>
<td>Joseph Cusumano</td>
<td>ENGR SCI &amp; MECHANICS</td>
<td>Informal Consultant</td>
<td>UNIVERSITY PARK CAMPUS</td>
</tr>
<tr>
<td><strong>Title</strong>: PROF ENG SCI &amp; MECH</td>
<td><strong>Concur</strong>: Yes</td>
<td><strong>Comments</strong>: This course will be an excellent addition to the Mechanics curriculum. It addresses an important area of much current research in theoretical and computational mechanics and materials.</td>
<td><strong>Reviewed On</strong>: 8/13/2015 12:50:00 PM</td>
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**Formal Consultation**

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<th>Name</th>
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<tr>
<td>Xiantao Li</td>
<td>MATHEMATICS</td>
<td>Formal Consultant</td>
<td>UNIVERSITY PARK CAMPUS</td>
</tr>
<tr>
<td><strong>Title</strong>: ASSOC PROF OF MATHEMATICS</td>
<td><strong>Concur</strong>: Yes</td>
<td><strong>Comments</strong>: This would be a nice course for training students across different disciplines. I would imagine that many students from mechanics, chemistry, biology, and applied mathematics will be interested in this opportunity.</td>
<td><strong>Reviewed On</strong>: 5/23/2016 1:03:00 PM</td>
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<tr>
<td>Adr van Duin</td>
<td>MECHANICAL ENGR</td>
<td>Formal Consultant</td>
<td>UNIVERSITY PARK CAMPUS</td>
</tr>
<tr>
<td><strong>Title</strong>: PROF MECHANICAL ENG</td>
<td><strong>Concur</strong>: Yes</td>
<td><strong>Comments</strong>: This course adds a significant new option for students seeking to learn about material simulations. There is a healthy connection with existing courses.</td>
<td><strong>Reviewed On</strong>: 5/30/2016 9:44:00 AM</td>
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<th>Name</th>
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<tbody>
<tr>
<td>William C. Noid</td>
<td>CHEMISTRY</td>
<td>Formal Consultant</td>
<td>UNIVERSITY PARK CAMPUS</td>
</tr>
<tr>
<td><strong>Title</strong>: ASSOC PROF CHEMISTRY</td>
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Concur: Yes
Comments: It appears this course provides a very broad and useful introductory survey of important tools and research problems for modeling material properties. The primary focus appears to be on mechanical properties. Since statistical physics plays a central role in linking scales and since the course covers this topic in one introductory lecture, I wonder if it would be appropriate to either lengthen this review or to require some sort of statistical mechanics course as a prerequisite.
Reviewed On: 5/30/2016 2:22:00 PM

Name: Long-Qing Chen
Department: MATERIALS SCI & ENGR
Campus: UNIVERSITY PARK CAMPUS
Position: Formal Consultant
Title: Hamer PROF MATSE/ESM/MATH

Concur: Yes
Comments: This is a nice course on multiscale modeling. However, the focus of the course is more on mechanics of materials, so a more appropriate title might be Multiscale Modeling of Mechanics of Materials
Reviewed On: 8/29/2016 9:07:00 AM

Required Signatories

Name: Judith A. Todd
Department: (Not Available)
Campus: (Not Available)
Position: Department or Program Head
Title: (Not Available)
Concur: Not Yet Reviewed
Comments: Not Yet Reviewed
Reviewed On: Not Yet Reviewed

Name: Matthew Parkinson
Department: (Not Available)
Campus: (Not Available)
Position: College Representative
Title: (Not Available)
Concur: Not Yet Reviewed
Comments: Not Yet Reviewed
Reviewed On: Not Yet Reviewed

Name: Peter Butler
Department: (Not Available)
Campus: (Not Available)
Position: Dean of the College
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<tr>
<td>Review on behalf of Interim Dean R. Vasilatos-Youken</td>
<td>Campus: (Not Available)</td>
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<tr>
<td>Position: Dean of the Graduate School</td>
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<tr>
<td>Committee feedback/Chairs J. Redwing and C.A. Cole</td>
<td>Campus: (Not Available)</td>
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<td>Position: Graduate Council Subcommittee</td>
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<td>Position: Faculty Senate</td>
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Bluebook Number:
Approval Date:
ProposalID: 20582

Close
Proposal for
A new graduate program in Additive Manufacturing and Design
offering
Resident Master’s of Science and Online Master’s of Engineering Degrees

Units:
College of Engineering: Industrial and Manufacturing Engineering; Engineering Science and Mechanics; Mechanical and Nuclear Engineering; School of Engineering Design, Technology and Professional Programs

College of Earth and Mineral Science: Material Science and Engineering

Submitted by:
Dr. Karen A. Thole
Professor and Department Head
Mechanical and Nuclear Engineering Department
kthole@psu.edu

Dr. Janis Terpenney
Peter and Angela Dal Pezzo Department Head
Harold and Inge Marcus Department of Industrial and Manufacturing Engineering
jpt5311@psu.edu

Dr. Judith Todd
P. B. Breneman Department Head
Engineering Science and Mechanics Department
jtodd@psu.edu

Dr. Susan Sinnott
Professor and Department Head
Department of Materials Science and Engineering
sinnott@matse.psu.edu

Dr. Sven Bilén
Professor and Department Head
School of Engineering Design, Technology, and Professional Programs
sbilen@engr.psu.edu

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Proposal for
Residential Master of Science in Additive Manufacturing and Design
and
Online Master of Engineering in Additive Manufacturing and Design

A. Introductory Narrative

This proposal seeks approval to establish a new graduate program in Additive Manufacturing and Design to be delivered for in-resident students at University Park, who will earn a Master’s of Science degree, and for online students, who will earn a Master’s of Engineering degree delivered through World Campus.

Additive manufacturing (also known as 3D printing) is redefining how components are designed, manufactured, and certified. Building three-dimensional parts layer-by-layer using additive manufacturing gives engineers unprecedented design freedom to create lightweight structures, consolidate assemblies of components into a single 3D printed part, and functionally grade structures to improve performance. This is generating considerable interest in a wide range of industries, including aerospace, consumer goods, energy, medical, oil and gas, and space.

The 3D-printing technology itself enables production of parts that were otherwise too expensive or even impossible to make, while allowing multi-material parts to be designed and created with relative ease. The time required for design–build–test iterations can be significantly decreased for large systems composed of multiple components through the integration of 3D printing into product development strategies. Finally, new methods for qualifying processes and certifying parts for aviation, aerospace, medical, and other regulated industries are being developed since anyone with a 3D printer can now print any part for which they have a 3D computer model. Non-destructive inspection technologies are facilitating this qualification and certification process, but these technologies are also opening up new avenues for reverse engineering products and devices and potentially infringing on patents and intellectual property. The legal and ethical implications of additive manufacturing are not well defined and are confusing as 3D-scanning technology becomes less expensive and easier to use, and the implications on policy and regulatory practices are undergoing scrutiny like never before.

Even though 3D printing is decades old, recent advances in additive manufacturing technology now enable manufacturers to produce end-use parts out of plastic as well as metallic materials. Ceramics, electronics, and organic tissue are also being 3D printed and challenging existing manufacturing paradigms. Designing parts to take full advantage of the freedoms that additive manufacturing allows requires an in-depth understanding beyond that learned in a single “Introduction to 3D Printing” course. Meanwhile, the intricacies of each of the currently seven additive manufacturing processes (e.g., material extrusion, powder-fed fusion, directed energy deposition, etc.) create their own unique challenges when used in a real production environment. Inspecting, qualifying, and certifying parts made using additive manufacturing may be easier thanks to advances in non-destructive inspection technologies, but manufacturers face new challenges ensuring parts meet the requisite design specifications and mechanical properties given the lack of standards and guidelines for tolerancing and design specification. The potential
for additive manufacturing is tremendous, but the process, including both manufacturing as well as design, is not as easy as it looks or is portrayed to the general public.

The College of Engineering and College of Earth and Mineral Science at Penn State are uniquely positioned to educate the next generation of designers, engineers, and manufacturers as well as help retrain the existing workforce in all aspects of additive manufacturing and design. These Colleges already offer an extensive set of courses in additive manufacturing beyond the introductory course and have extensive expertise in all pertinent areas of additive manufacturing: planning, design, engineering, materials science, manufacturing and production, quality control, and inspection.

The proposed Master of Science (MS) and Master of Engineering (MEng) Degree Programs in Additive Manufacturing and Design will leverage these strengths at Penn State to create the first graduate program of its kind in the United States and satisfy a strong demand from numerous industries ramping up their production capabilities—and corresponding workforce—in additive manufacturing. The program will integrate graduate coursework across multiple Departments and Colleges at Penn State and provide unique hands-on experiences for both resident and online students in all aspects of the additive manufacturing process. Courses will be offered online as well as in-residence to target the widest possible audience. All students enrolled in the program, whether resident or online, will be required to spend time on site, working in Penn State’s state-of-the-art additive manufacturing laboratory, CIMP-3D, the Center for Innovative Materials Processing through Direct Digital Deposition (www.cimp-3d.org).

In developing the proposed MS and MEng in Additive Manufacturing and Design, numerous meetings were held with both internal and external constituencies. A series of planning meetings was held with Penn State faculty from each of the departments, colleges, and facilities involved to determine interest levels and potential course offerings. There was strong interest expressed from those faculty teaching the relevant courses. Graduate students who are currently doing research in the additive manufacturing area also expressed strong interest in having such a degree program at Penn State. Finally, members from the Industrial and Professional Advisory Councils (IPAC) of Engineering Science and Mechanics, Industrial and Manufacturing Engineering, Material Science and Engineering, Mechanical and Nuclear Engineering, and the School of Engineering Design, Technology, and Professional Programs met to discuss the proposed MS and MEng programs. All expressed strong support with various suggestions about the program and on site laboratory experience, which we have incorporated into this proposal.

The proposed graduate program is specifically aimed toward industry to create a new cadre of engineers and help retrain the existing engineering workforce to take full advantage of what additive manufacturing has to offer. Students, who are enrolled in the one-year MS program and are coming directly from their undergraduate programs, will be encouraged to participate in internships with industry partners to help them advance the utilization and practice of additive manufacturing. This hands-on experience in industry will culminate in an MS or MEng paper to satisfy a portion the degree requirements. We also envision that these internships will assist students enrolled in the program to find meaningful positions upon completion of the degree. Many industry members have commented on the shortcomings of the current workforce with the requisite skills and knowledge to utilize additive manufacturing to its fullest. To address these
shortcomings, for MS degrees, the culminating experience will be a paper derived from 3
distributed credits under which fundamental theory is applied to develop new knowledge and
processes relevant to advances in additive manufacturing. For M Eng degrees, students will take
a 3-credit course at the end and develop a culminating paper that focuses on practical
applications in the additive manufacturing workplace.

B. Program Statement

1. Degree Requirements

The proposed Master of Science in Additive Manufacturing and Design (MSAMD) and Master
of Engineering in Additive Manufacturing and Design (MEngAMD) degrees are 30-credit
degree programs that are offered resident, in the case of the MSAMD, and online, in the case of
the MEngAMD, to graduate students to provide the analytical and practical skills required to
digitally design, develop, analyze, numerically model, optimize, fabricate, and inspect new
components and subassemblies using appropriate additive manufacturing technologies. This
requires knowledge across multiple domains, including industrial engineering, mechanical
engineering, engineering design, engineering science, and materials science.

All MSAMD and MEngAMD students will be required to enroll in five core, required courses
that cover additive manufacturing processes (4 credits), materials for additive manufacturing (4
credits), the engineering and scientific foundations of additive manufacturing (4 credits), design
for additive manufacturing (4 credits), and a hands-on laboratory experience in additive
manufacturing (3 credits). The 4 credit course options enable students to get more depth in a
single course, which is particularly advantageous to those taking online courses. This gives
instructors the flexibility to develop 3 credit courses with complementary 1 credit lab, which
online students could do in their company, at home, or come to campus. This also provides the
departments with flexibility in instructor assignment and course development as two faculty can
split development and instruction of a 4 credit course and focus on metals (for 2 credits) and
plastics (for 2 credits) within a single course, for example. Finally, the 4 credit course offerings
are commensurate with Supply Chain’s online Masters program offerings, for which we have
already developed 3 courses.

In addition to the core courses, students will be required to enroll in electives (8 credits) that
include design, materials, manufacturing, technical writing, technical presentations, and supply
chain. The students will be required to enroll in a seminar course (1 credit, not counted toward
the degree). To meet the degree requirements, students will be required to complete a
culminating project that leads to a paper, which will be worth three (3) credits. To distinguish the
MSAMD, the students will be required to enroll in research (1 credit) each of three semesters to
account for the three (3) credits. Alternatively, the MEngAMD students will enroll in a single
course (3 credits) in one semester in order to complete their required paper. The resident
students will be encouraged to take part in an internship in industry during the degree program.
Assistance will be provided to the students in finding suitable internships.

Resident and online students will be required to be in-residence at Penn State for two 3-day
periods to take place during the start and the end of the summer semester (for a total of 45 hours,
or 3 credits) for a structured additive manufacturing laboratory course. The laboratory course
will involve the use of the facilities in CIMP-3D as well as the Material Characterization
Laboratory (MCL) in the Millennium Sciences Complex and the Factory for Advanced
Manufacturing Education (FAME) in Industrial and Manufacturing Engineering. CIMP-3D already offers week-long short courses for industry and government employees, thereby demonstrating that this is possible and highly desired by companies without access to state-of-the-art additive manufacturing technology and non-destructive inspection equipment.

All students will be required to complete their program with a culminating project (3 credits) in which the requirement will be a final paper that is reviewed by an academic adviser, who will be on the graduate faculty in one of five departments previously mentioned: (1) Engineering Science and Mechanics, (2) Industrial and Manufacturing Engineering, (3) Material Science and Engineering, (4) Mechanical and Nuclear Engineering, and (5) School of Engineering Design, Technology, and Professional Programs. The final paper requirements, further described in Appendix B, must demonstrate the student’s depth of knowledge in the field of additive manufacturing and design. As an option, the culminating project may be completed either through an industrial internship (for resident students) or at their current place of employment (for online students). The choice of their project topic will be mutually determined by the student and his/her adviser and take into consideration that an M Eng paper focuses on practical applications in the workplace, while the MS paper focuses on integrating various fundamental concepts into new knowledge or processes. The written paper based on the project must contain a project description, literature review, results, analysis, and interpretation of its findings as further described in Appendix B. Students will be encouraged to publish their project work in peer-reviewed journals, trade journals, conference proceedings, or as confidential company reports, depending on the nature of the project and implications of its findings.

All students will be encouraged to complete an internship in industry, in a federal laboratory, or at Penn State (e.g., in CIMP-3D) in which they gain practical experience in additive manufacturing and/or design for additive manufacturing. While this will most likely occur in their place of employment for the online students, the resident students will be assisted in finding an internship. An Industry Advisory Board will be formed to help guide the overall program and assist in the internship program. Members of the advisory board will be expected to offer internship positions to the MSAMD and MEngAMD students. It is expected that most MEngAMD students, however, will be professionals already working in industry. Although the internship will be strongly encouraged, it will not be required to obtain the degree.

The MSAMD and MEngAMD Programs are intentionally structured such that additional course options and electives can be added at a later date through program revision. The core courses have been chosen to be relevant to additive manufacturing regardless of the application domain with future program expansion in mind. In addition, we are proposing to take advantage of several courses that are already offered online in the College of Engineering and College of Earth and Mineral Science.

The requirements for the proposed MSAMD degree are:

1. Minimum of 30 course credits at the 400 level or higher.

2. Completion of five required course credits that total 19 credits with a grade point average of 3.00 or higher. The five required courses are EDSGN 562 (4 credits), E SC 545 (4 credits), IE 527 (4 credits), MatSE 567 (4 credits), and ME 566 (3 credits).

3. A minimum of at least eight (8) credit hours in 400- and/or 500-level courses offered with the following designations: EDSGN, E SC, IE, MATSE, or ME. Note that
EDSGN 596, E SC 596, IE 596, MATSE 596, and ME 596 cannot be used to fulfill this requirement.

4. Completion of three (3) distributed credit hours in one of the following offerings to complete the culminating project: EDSGN 596, E SC 596, IE 596, MATSE 596, or ME 596. MSAMD students will be required to complete one (1) credit in each of three (3) semesters while MEngAMD students can complete a three (3) credit course in one (1) semester.

5. A paper must be completed to meet the specific requirement of the culminating experience. This paper will demonstrate depth of knowledge to his/her adviser, a second reader, and the Director of Graduate Studies in one of the five aforementioned departments.

6. All students must successfully complete one credit of colloquium preferably in their first two semesters in the program. The one-credit colloquium does not count toward the 30 graduate course credits in Requirement 1 above. The following courses are offered to meet this requirement: EDSGN 590, E SC 514, IE 590, MATSE 590, and ME 590.

7. All students will be required to complete SARI (Scholarship and Research Integrity) training.

CULMINATING EXPERIENCE - MSAMD and MEngAMD PAPERS

The candidate registers for 30 course credits of which 19 credits must be the five required courses at the 500 level. A maximum of three credits of EDSGN 596, E SC 596, IE 596, MATSE 596 or ME 596 can be counted in the total of 30 credits for students completing their project and MS paper.

Candidates must write a culminating project paper on a topic mutually agreed upon by the adviser. Students will be encouraged to utilize an industry internship (resident students) or current employer (online students) to identify a relevant or practical problem of importance that additive manufacturing and appropriate design methods could address. The quality of the required paper is such that it must be suitable for publication in a professional journal or proceedings at a national or international conference, which generally requires a peer-review process, as described in the guidelines provided in Appendix B. These guidelines indicate each paper submission must contain sections that fully describe a relevant survey of past literature pertinent to the research; a clear description of the methods used to determine the research results given in the paper; comprehensive analyses of the results in the context of the research topic as well as relative to past studies; and, finally, a synthesis of the results that is concisely summarized. Given all of our graduate faculty are active reviewers of conference proceedings and archival journals, the faculty are well-qualified to rigorously review the research paper presented by the online students.

The colloquium is a one-semester, one-credit requirement for all incoming graduate students, which does not count towards the 30-credit requirement. Resident and online students may enroll in suitable colloquia in EDSGN 590, E SC 514, IE 590, MATSE 590, or ME 590. In the seminars, presenters are experts in the field primarily from outside of Penn State representing...
industry, government, and academia. Included in these lectures are ethics discussions that meet the Scholastic and Research Integrity (SARI) requirements. The colloquia are video captured and made available for the online students. Attendance is monitored through the login to the website for the online students. As discussed later in this proposal, there are a number of advantages in having the online students enroll in one of the colloquia series. In particular, this helps ensure that online students: i) are educated in current research trends, which is important for an MEngAMD degree; ii) identify with Penn State as their institution; iii) are able to participate in the SARI lectures; and iv) have an opportunity to interact with their student colleagues in the program.

The online program will be identical to the resident program. The program will not be cohort based and, as such, permits students to enter or graduate when appropriate. The courses that will be offered are the same as those that we will be offering to our in-resident students, which are all taught by graduate faculty who are either tenure-track or tenured.1

3. Formal Graduate Bulletin Statement

The formal Graduate Bulletin Statement is included in Appendix A.

C. Admission Requirements

To maintain a high quality program, it is important that our students are of a caliber to succeed. As such, the admission requirements for the students enrolling in the MSAMD and MEngAMD degree programs will be based on: academic records, GRE scores, applicable work experience, their personal statement of interests in additive manufacturing design, and three letters of recommendation from a previous professor or supervisor who can attest to the applicant’s academic potential. Applicants will be expected to have a Bachelor of Science or four-year Associate’s degree form an accredited institution in engineering, engineering technology, manufacturing, materials science, or related field. An undergraduate cumulative grade point average of 3.0 or better on a 4.0 scale in the final two years of undergraduate studies is required.

Each application will be closely reviewed by a MSAMD and MEngAMD Admission Committee made up of one faculty member from each of the five participating departments: (1) Engineering Science and Mechanics, (2) Industrial and Manufacturing Engineering, (3) Material Science and Engineering, (4) Mechanical and Nuclear Engineering, and (5) School of Engineering Design, Technology, and Professional Programs. The faculty member who will serve on the MSAMD Admission Committee will be nominated by the respective Department (or School) Head.

The language of instruction at Penn State is English. International applicants must take and submit scores for the TOEFL (Test of English as a Foreign Language) with the exceptions noted below. The minimum acceptable score for the TOEFL is 80 or higher on the internet-based test with a 19 or higher in the speaking section. An acceptable alternative to the TOEFL, which will be accepted, is the International English Language Testing System (IELTS) test, on which a minimum composite score of 6.5 will be required. International applicants are exempt from the TOEFL requirement if they have received a baccalaureate or graduate degree from a

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1 On occasion, the associated Departments hire instructors from the Applied Research Lab to teach courses. The hired instructors all have graduate faculty status, which is overseen by the Department Heads and by the Department’s Promotion and Tenure Committee, in the relevant programs.
college/university/institution in any of the following: Australia, Belize, British Caribbean and British West Indies, Canada (except Quebec), England, Guyana, Republic of Ireland, New Zealand, Northern Ireland, Scotland, the United States and Wales.

D. Justification Statement

1. Program Goals

The program goals are to educate a new cadre of graduate students and train engineers and manufacturers in the existing workforce to apply a multidisciplinary approach to utilize additive manufacturing and associated design methods and tools effectively. This educational approach will allow those completing the MSAMD and MEngAMD degrees to develop new design methods and paradigms that will shorten product development cycles and manufacturing lead times; exploit the uses of the “digital thread” during product development; be educated on all the technical and ethical issues associated with 3D printing; and to perform detailed analyses of the additive manufacturing processes.

2. Needs Assessment

Manufacturers across a broad spectrum of industries, including automotive, aerospace, dental, discrete, high tech, and medical products, are all actively piloting and using 3D printing technologies today, according to a 2015 Forbes.com report. According to a report from Wohlers Associates, a company that provides technical and strategic consulting for manufacturing firms, revenues from additive manufacturing will exceed $21B by 2020, up from just over $3B in 2013. The report goes on to suggest a factor will be the expanded use of technology for producing of parts, especially in metal that go into final products. As a result of advances in additive manufacturing, in particular, industry experts expect an increase in demand for workers with additive manufacturing related skills and education. In a March 2015 article by U.S. News and World Report, dedicated programs are scarce with most schools only offering research opportunities at the graduate level.

In summary, the motivation for adding the MSAMD and MEngAMD degrees to the portfolio of offerings at Penn State are twofold: i) to meet the needs expressed by industry and the current engineering students on the offering of a non-existent degree program that will be offered both in residence and online; and ii) to react to a quickly growing industry that is expected to impact the economy and drive industrial competitiveness in Pennsylvania, the United States, and beyond.

There is an increased demand for advanced technical degrees by both newly graduated engineering students as well as practicing engineers. It is predicted that, over the next ten years, 3.5 million manufacturing jobs will become available. Moreover, in the last ten years, undergraduate engineering enrollments in the U.S. have increased from 400,000 to 620,000. For example, mechanical engineers (MEs) number as the fourth largest engineering occupation with about 240,000 employed in the United States. About half of those MEs are employed in the

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2 http://www.sme.org/
3 http://www.asee.org/
professional, scientific, and technical services sector. Because many of these MEs are working in highly technical fields, it is of interest to offer a technically strong degree program. The proposed program will present online students with the opportunity to gain technical depth in additive manufacturing and design, which was not available when they completed their undergraduate degrees.

Currently, there are seven federally-funded manufacturing institutes in the United States; the first was the National Additive Manufacturing Innovation Institute, now called America Makes (https://americamakes.us/). Penn State was a founding partner in America Makes, which is focused on additive manufacturing technologies. While America Makes offers numerous educational programs, there currently exist no full degree programs.

3. Program Objectives

The overall goal of the MSAMD and MEngAMD Programs is to educate students and working engineers to become technically outstanding experts in additive manufacturing. Specifically, the objectives include:

1. Apply foundational knowledge, critical thinking, problem solving, and creativity in the uses of additive manufacturing and associated design tools and methods.
2. Grow as leaders in manufacturing while maintaining the highest ethical standards in applying additive manufacturing to industry-relevant problems and design challenges.
3. Strive for the advancement of the state-of-art in additive manufacturing and design technologies.
4. Develop innovative solutions through new design paradigms in their respective industries. It is recognized that Masters-level study leads to the development of in-depth knowledge of an engineering discipline. This knowledge may include advanced fundamental theory, hands-on practice in design and research, or complex problem solving through applications of mathematics, science and engineering. At Penn State, we offer Master’s of Science (MS) and Master’s of Engineering (MEng) degrees. The MS and MEng have equal rigor but distinct educational goals as defined by the Graduate School.

The MS is an academic degree, which is “strongly oriented towards research and the creation of new knowledge” whereas MEng is a professional degree, which “emphasizes practical application of knowledge for solving problems”. Both the MS and MEng degrees require a culminating experience in which students demonstrate the ability to analyze and synthesize information within their field of study.

The culminating experience for an MS degree may be research conducted under the supervision of a faculty mentor, an independent study experience completed under the direction of a faculty member, or a course-based culminating experience. Regardless of the type of culminating experience, the MS degree requires that the writing of a thesis or a scholarly paper.

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4 Penn State’s World Campus, “Environmental Scan: Market for an Online Master’s Degree in Mechanical Engineering,” 2011.
5 Here and in the learning objective the word, advanced, is intended to indicate that this understanding should be beyond that of a BS degree.
For an MEng degree, the culminating experience may include a project, an internship, or other similar experience, or writing of a paper on a topic that has relevance to professional practice. The specific nature of the culminating experience is determined by the faculty responsible for offering the degree program. The proposed program offers two different tracks: MS and MEng with the differentiation being that previously described.

4. Program Size and Duration

The MSAMD Program is expected to accept 10 new students each year and the MEngAMD Program is expected to accept an estimated 20 online students. It is expected that the resident students will complete their degree in one year. For the online students, it is expected that it will require approximately three years to complete their degrees (~3 courses per year). As such, it is expected that a maximum of 100 students will be enrolled in the program during any one year.

5. Proposed Course Offerings and Schedule

An overview of the thirty (30) credit program of study includes:
- nineteen (19) credits of formal course work in five required courses (4 credits each in IE, EDSGN, E SC, MATSE for depth; and 3 credits in ME that involve a practical, hands-on laboratory component);
- eight (8) credits of design, materials, manufacturing, technical writing, technical speaking, and supply chain electives (for breadth and depth); and
- three (3) credits for a paper (for an individual project based on culminating project).

The 19 credits of required courses include:
E SC 545 (J. Todd) Engineering and science of additive manufacturing, including laser-based interactions, modeling and simulation, in situ process monitoring sensing technologies (4 credits);
IE 527 (S. Joshi): Digital workflow for additive manufacturing, reverse engineering, overview of additive manufacturing processes for metals and polymers, applications and case studies (4 credits);
EDSGN 562 (N. Meisel) Design for additive manufacturing, topology optimization, lattice structures, multi-material analysis and design (4 credits);
MatSE 567 (A. Beese) Critical considerations for additive manufacturing of metals, focusing on processing structure-property relationships. (4 credits);
ME 566 (T. Simpson) Hands-on additive manufacturing lab with powder bed fusion, directed energy, non-destructive inspection (3 credits)
In addition, there are eight (8) credits of electives required in design, materials, and manufacturing. There are already numerous electives available both online and in resident from the five aforementioned departments.

For the first three years, the table below describes the schedule for the five required course offerings. Each of the fall and spring semesters the graduate colloquium courses will be offered online and in residence. In each of the fall, spring, and summer semesters the culminating

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6 This estimate is based on interest levels expressed by GE, Lockheed Martin, LORD Corporation, and NAVAIR, among others.
project course will also be offered. It is expected that beyond the first three years, the five
required course offerings will be repeated according to the schedule for the 2019/2020 academic
year. In addition to these five required course offerings, there is a wide variety of online courses
that can meet the electives requirement for both the resident and online students. It is expected
that the number of electives will grow given the new faculty who are being hired at Penn State.

<table>
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<th>Offering Schedule for Five Required Course</th>
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<td>ESC 545</td>
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<td>IE 527</td>
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<td>MatSE 567</td>
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<td>EDSGN 567</td>
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<tr>
<td>ME 566</td>
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6. How the Program Strengthens Penn State

Penn State is well-positioned to lead the first-of-its-kind degree program in additive
manufacturing and design for many reasons. First, Penn State has significant depth of expertise
in additive manufacturing and design in the College of Engineering (Engineering Science and
Mechanics; Industrial and Manufacturing Engineering; School of Engineering Design,
Technology, and Professional Programs; and Mechanical and Nuclear Engineering); the College
of Earth and Mineral Science (Materials Science and Engineering); Smeal College of Business
(Supply Chain and Information Systems); and the Applied Research Laboratory. Many of the
faculty in these departments are strong collaborators through the Center for Innovative Materials
Processing through Direct Digital Deposition (CIMP-3D), which maintains a research portfolio
of approximately $8M per year in additive manufacturing, including design, materials, process
sensing, qualification/certification, etc. Second, there is significant interest and support for 3D
printing across Penn State.

At the University level, 3D printing is becoming increasingly important to driving economic
development and ensuring a sustainable future. The University’s thematic priority of Driving
Digital Innovation states that Penn State will be a leader in making sure our students are prepared
for the digital age to foster economic growth. Entrepreneurial opportunities in 3D printing and
additive manufacturing abound, both in using the technology to foster entrepreneurship as well
as driving innovation within additive manufacturing (e.g., spinning out software related to
additive manufacturing and design, new start-ups related to additive manufacturing technology).
Thus, the proposed program aligns well with President Barron’s Invent Penn State initiatives as
3D printing and additive manufacturing serve as a key innovation asset to the University.

In the College of Engineering and aforementioned departments, one of the research thrusts from
the 2015–2020 Strategic Plan is Advanced Manufacturing for Medical, Electronic, and
Mechanical Sciences, which will advance manufacturing technology, in general, and 3D
printing, in particular. In concert with the College of Engineering, the Mechanical and Nuclear
Engineering, Engineering Science and Mechanics, and Industrial and Manufacturing Engineering
Departments have included additive manufacturing as key areas in their strategic plans, and
multiple new faculty hires have occurred within the College of Engineering in areas related to additive manufacturing.

The proposed MSAMD and MEngAMD degree programs also provide an ideal platform for continued growth in response to the many areas in which 3D printing is quickly evolving: bioprinting, hybrid manufacturing, the internet of things, and many others.

7. Impact on Existing Programs and Faculty Load

As was previously mentioned, the MSAMD will be offered as both a one-year MS degree program for resident students and the MEngAMD degree program for online students, most of whom will be working in industry. Given the degree program will be shared among five units in two Colleges and will involve courses that would apply to existing MS degree programs in their respective disciplines, it is expected that the impact on the faculty workloads in any single department to be minimal. The four departments and one school include: (1) Engineering Science and Mechanics, (2) Industrial and Manufacturing Engineering, (3) Material Science and Engineering, (4) Mechanical and Nuclear Engineering, and (5) School of Engineering Design, Technology, and Professional Programs.

### Faculty Teaching Five Required Courses

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<th>Faculty</th>
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<tbody>
<tr>
<td>Tim Simpson</td>
<td>Professor of Mechanical Engineering and Industrial Engineering</td>
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<tr>
<td>Nick Meisel</td>
<td>Assistant Professor of Engineering Design and Mechanical Engineering</td>
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<tr>
<td>Judith Todd</td>
<td>Professor and Department Head of Engineering Science and Mechanics</td>
</tr>
<tr>
<td>Allison Beese</td>
<td>Assistant Professor of Material Science and Engineering</td>
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<tr>
<td>Sanji Joshi</td>
<td>Professor of Industrial and Manufacturing Engineering</td>
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There is a strong emphasis on developing one-year MS programs at Penn State to serve a wider audience of students. Similar to many of Penn State’s peer institutions, it has been identified that there is a need to serve students who want to further their education in a specialized area.

The online degree will permit us to offer a wider range of courses for MNE’s on-campus MSME students. In-resident students will only be permitted to enroll in the on-campus versions of the online courses. Second, the degree program will allow us to enhance MNE’s current Master of Science in Mechanical Engineering course offerings since students will be permitted to enroll in the online mechanical engineering courses as technical electives. Third, the resources we expect to acquire through the offering of the online program will permit the associated departments to grow in graduate student support and in tenure/tenure-track faculty lines.

Another positive impact that the degree programs will have, albeit harder to quantify, is the added benefit of having the in-residence students enroll with practicing engineers in the same course, which will enrich the discussions for both our faculty and our students. We do expect that bridges will be strengthened between industry, government, and Penn State as the online students will bring their experiences into the classroom. In fact, we plan to leverage the projects performed by the students and papers written by the students in the program to help us identify new research directions, validate our analytical models and design tools, develop new industry partnership, and broaden the impact of Penn State’s research in additive manufacturing.
8. Units’ Ability to Offer a High-Quality Resident and On-Line Program

The MSAMD and MEngAMD degree programs will be administered through one Department, namely Mechanical and Nuclear Engineering.

All of the departments associated with this proposed effort offer strong, nationally ranked resident graduate programs. In addition, the Mechanical and Nuclear Engineering Department has two active online graduate programs: one is the MS in Mechanical Engineering and the other is an MEng in Nuclear Engineering. The enrollments in these two online programs include 45 MSME and 55 MEngNucE students. Note that the MSME online program was introduced in 2014 while the MEngNucE online degree was initiated approximately ten years ago.

In July 2016, the Department of Mechanical and Nuclear Engineering along with the support of Penn State’s World Campus invested in two non-tenure track individuals: Dr. Catherine Berdanier who holds a doctoral degree in Engineering Education from Purdue University and Dr. Robin Tate who holds a doctoral degree in Educational Psychology from Penn State. Both of these individuals are assisting the tenured/tenure-track faculty who are teaching graduate courses online and in resident with effective, state-of-the-art teaching methods as well as effective assessment methods. Their efforts are contributing to the existing Masters of Science in Mechanical Engineering online degree program in which those courses may also be used as technical electives for the proposed Masters of Science in Additive Manufacturing and Design degree program.

All of the Departments and School associated with the proposed MSAMD and MEngAMD programs have agreed to commit resources to hire two individuals: one instructional designer (this is in addition to the one already existing in the Mechanical and Nuclear Engineering Department) and one staff assistant. The instructional designer will assist all of the faculty in developing the five required courses as well as the continued growth of the elective courses. The staff assistant will track the students’ progress, track the associated data for the Program, and assist the online and resident students with any questions they have.

We propose to manage the MSAMD and MEngAMD in the Mechanical and Nuclear Engineering Department, and the online MEngAMD degree program will be executed through World Campus in the SAVE model.

9. Learning Objectives and Expected Student Accomplishments

The MS is an academic degree that is “strongly oriented towards research and the creation of new knowledge”. The degree requires a “significant culminating or capstone experience or other mechanism to demonstrate evidence of analytical ability and synthesis of material.”

Proposed MSAMD Learning Objectives:

A. Graduates will be able to demonstrate understanding of advanced core principles and methods from selected sub-fields of additive manufacturing and design at a depth consistent with their course of study.

B. Graduates will be able to apply their knowledge of and methods from selected sub-fields of additive manufacturing and design to formulate and solve engineering problems.
C. Graduates will be able to analyze and synthesize knowledge within the field of additive manufacturing and design to extend existing knowledge through a research experience or a course-based culminating experience.

D. Graduates will be able to demonstrate proficiency in oral and written communication appropriate to their discipline.

E. Graduates will be able to demonstrate an understanding of, and a commitment to, the standards for scholarship and research integrity within additive manufacturing and design.

The Master’s of Engineering (M Eng) is a professional degree that “emphasizes practical application of knowledge for solving problems”. “All MEng programs require a significant culminating or ‘capstone’ experience. Each program has established the specific manner for meeting the requirement, which may take the form of a paper, project, internship, or other similar experience serving to demonstrate comprehensive and in-depth knowledge of the practice of the field of study. The nature and extent of this work and when it is to be undertaken within the program of study shall be determined by the major program.”

Proposed MEngAMD Learning Objectives:

A. Graduates will be able to demonstrate understanding of advanced core principles and methods from selected sub-fields of additive manufacturing and design at a depth consistent with their course of study.

B. Graduates will be able to apply their knowledge of selected sub-fields of additive manufacturing and design to formulate and solve engineering problems.

C. Graduates will be able to analyze and synthesize knowledge within the field of additive manufacturing and design to address a complex problem with practical relevance.

D. Graduates will be able to demonstrate proficiency in oral and written communication appropriate to their discipline.

E. Graduates will be able to demonstrate an understanding of, and a commitment to, academic integrity and the standards for professional practice within additive manufacturing and design.

Graduates of the MSAMD and MEngAMD programs will be able to design and manufacture components using the latest additive manufacturing techniques for a wide range of applications including aerospace, energy, medical, transportation, chemical, food, health, and others. It is expected that the graduates will be effective in both large companies, many of which are embracing additive manufacturing for reducing product development times, and small companies, many of which are developing new products or processes that are too risky for larger companies to pursue.

10. Non-duplication of Other Degree Programs

As was stated, there are currently no graduate degree programs in additive manufacturing in the United States. And, not graduate degree programs in additive manufacturing are given at Penn State.
E. Essential Elements of Residency

To best meet the needs of working professionals, the MEngAMD program will be offered online through Penn State’s World Campus. The following items address the elements of residency that will be supported in the online environment.

1. Interaction Between Faculty and Students Beyond Direct Instruction

The interaction between faculty and students will take place through the courses and through the completion of their culminating project and paper to fulfill the degree requirements. During course offerings, the distance students will interact with the faculty during specified office hours either by phone or through web-conferencing such as that provided by Skype. In addition, discussion boards will be set up for all students to interact with the instructor as well as each other. All faculty will be provided cameras for their offices to assist with “face-to-face” interactions. In addition, students will interact directly with the faculty through email exchanges.

To complete the paper option, the online students will enroll in three (3) credits in one of the five special projects sections (EDSGN 596, ESC 596, IE 596, MATSE 596 or ME 596) which will count towards the thirty (30) credits. Through enrolling in one of these sections, they will be assisted by the Department of Mechanical and Nuclear Engineering (degree home department) in identifying a graduate faculty member with whom they will complete the culminating project needed for the paper. A website will be developed with project solicitations by the graduate faculty from which the student may elect to choose. Alternatively, the students will have the option of proposing a project to one of our graduate faculty for consideration. Faculty will be appropriately compensated for working with the online students on their particular research topic and associated paper.

2. Interaction Among Students

The MEngAMD online students will need to meet the same requirement maintained by our MSAMD resident students in attending a graduate colloquium. This is an important experience that will accomplish two important objectives: i) ensure the online students are educated in modern research topics; and ii) ensure the online students have opportunities to be engaged with resident students and faculty at Penn State.

Both the MEngAMD online and MSAMD resident students will be required to enroll in ME 566, which is a hands-on lab course that will take place on campus in CIMP-3D. During the lab, the on-line and resident students will work side-by-side in the lab, completing a set of design, fabrication, and testing exercises related to additive manufacturing. ME 566 will involve fabrication of both polymer and metallic components using the 3D printers and additive manufacturing systems in CIMP-3D, characterizing and inspection components in CIMP-3D and Penn State’s Materials Characterization Lab, and machining and post-processing components in the Factory for Advanced Manufacturing Education in Industrial & Manufacturing Engineering. The lab will provide an in-depth hands-on experience that relates the theory and knowledge learned in their courses to practical implementation and application of additive manufacturing in a realistic environment.

The colloquium is a one-semester, one-credit requirement for all incoming graduate students, which does not count towards the thirty (30) credit requirement. The colloquium includes
speakers from around the world who are experts in their research fields. Many are from highly respected institutions, while there are numerous other experts from industry and from government research laboratories. The colloquium will be captured and made available for the online students. Attendance will be monitored through the login to view the seminars.

In addition to the colloquium, course instructors bear primary responsibility for emphasizing a learning environment for the online students that fosters interactions among students. This type of learning environment is created and fostered through the assistance of an instructional designer and expert in engineering education, who were previously discussed.

3. Access to Information and Instructional Resources

Libraries

Penn State’s University Libraries provides a wealth of resources to the Penn State academic community including those students enrolled through World Campus programs. The Penn State’s library system is the 7th largest research library in North America with more than 100,000 e-books. As with the resident students, the online students enrolled in the MEngAMD degree program will have access to the library resources to access e-journals, e-books, course reserves and database searches, which will be helpful for their course work as well as for preparation of their research-based paper to meet the degree requirements.

In addition to the Library’s electronic copies of various materials, University Libraries provides access to interlibrary loan and document delivery materials in both hard copy and electronic format. Online students simply make a request for mail delivery of books and journal articles that are owned by any Penn State library location, as well as materials from other libraries through the Interlibrary Loan service. Articles not found in the Penn State Libraries may also be requested by using a document delivery service that is provided whereby articles are faxed or delivered in electronic format (PDF, for example).

Assistance can be requested from reference librarians via email, phone calls, or chat services. Also available are online library tutorials for student use to become acquainted with the many resources available.

4. Access to Suitable Academic Advising and Support Services

Academic Advising

Just as our in-resident students are advised, our online students will be advised by our respective graduate programs; and they will be advised by their assigned graduate faculty adviser on matters related to their paper. The Associate Department Head of Graduate Programs in the Department of Mechanical and Nuclear Engineering, along with the office staff members, will provide special assistance needed by the online students regarding their degree progression. The Associate Department Head will also closely monitor the course selections made by the online students to ensure the appropriate technical courses are taken. Advising for students in the online program will take place through a mutually agreeable combination of email, web/audio conferencing, telephone calls, and in-person meetings when appropriate.

As with our in-resident students, the online students will need assistance with choosing a graduate faculty adviser to advise them when preparing the required research paper. To assist
the students in choosing an adviser, a website will be maintained whereby research topics will be suggested by faculty who are seeking to advise the online students. The Graduate Faculty in each of the five Departments and School will directly advise the online students in completing the research projects. Alternatively, the online students may also propose a research topic and seek an adviser through the help of the Mechanical and Nuclear Engineering’s Graduate Studies Office. All faculty advisers will be assigned by the Mechanical and Nuclear Engineering’s Associate Department Head for Graduate Studies.

World Campus Admissions and Financial Aid
World Campus will typically be the first point of contact for prospective students for the online program. The Admissions staff will address questions from prospective students, and discuss financial aid options.

5. Students’ Contribution to the Program, College, and University

As was previously mentioned, the work experiences that the online students will bring into the classroom will be of benefit to our faculty and to our on-campus students. These contributions could lead to enhanced discussions as well as potential research collaborations.

6. Identification with Penn State

The students enrolling in the online MEngAMD degree program will identify with Penn State through several avenues:

   i) enrolling in EDSGN/IE/MATSE/ME or 590 ESC 514 colloquium;
   ii) interacting directly with the faculty through courses and office hours;
   iii) being advised by a Penn State graduate adviser; and
   iv) enrolling in the ME 566 laboratory as part of their program.

Discussion boards will be provided for interaction between the students (online and resident) as well as with the faculty. These discussion boards will be used as a vehicle to discuss topics as well as to post relevant material.

D. Program Operation and Maintenance

1. Program Coordination

The coordination for the MSAMD and MEngAMD Programs will reside within the Mechanical and Nuclear Engineering Department at Penn State – University Park with the primary operations occurring within the MNE Graduate Office. Those below will be involved in administering the online program. Note that two positions are listed as open, but it is expected that these will be filled once the degree program has been approved.

Dr. Karen A. Thole, Professor and Department Head, MNE Department
Dr. Mary Frecker, Associate Department Head of Graduate Studies, MNE Department
Dr. Tim Simpson, Professor of Mechanical Engineering and Industrial Engineering
To be named, Staff Assistant in the Graduate Office, MNE Department, who will serve as the primary contact within the Department for the online students.

To be named, Instructional Designer, Mechanical and Nuclear Engineering, who will serve the faculty’s online course development.

Ms. Sonya Leitzell, Director of Academic Affairs, World Campus, who will serve as the person who will coordinate the online MEngAMD degree program with the World Campus.

2. Academic Support to Students

Resident students will be supported through the Mechanical and Nuclear Engineering Department’s Graduate Office given the program will be housed in that department. In addition, project advising will take place in each of the respective departments. Online students will be supported through student scheduling, registration, and billing which are all integrated into the World Campus support system for students. The reporting of grades will occur through Lion Path. The Help Desk will provide the needed technical support through email or by phone.

As stated on Penn State’s World Campus website, the following support will be provided by World Campus to our online students:

— walking students through the program application process, including identifying the required supporting documentation; finding financial aid, scholarships, and other types of financial support; and preparing them for learning in an online environment;

— using University systems to access course syllabi and assignments; interact with professors and peers; make tuition payments; order textbooks and software through the online bookstore; and use the University Libraries system;

— providing resources for online students including career counseling, exam proctoring and tech support;

— linking online students with communities and special services for military members and veterans, international students, alumni, corporate education, students with disabilities, and those transferring from other universities and colleges; and

— providing connections for the online students to the Penn State community by keeping students up-to-date with events, important dates, and Penn State news.

3. Instructional Design Support and Available Facilities

Only the laboratory component of the proposed degree program requires specialized facilities for the program. These laboratory facilities include those contained in CIMP-3D, the Materials Research Institute, the Learning Factory, and the FAME Lab.

The online course delivery for the MEngAMD degree will coincide with the resident course delivery for one semester each year while offerings to the online students will be multiple semesters throughout the year. While the online students will be able to view the lecture
synchronously or asynchronously, the resident students will receive the information live at the specified course meeting times. Several resources, however, will be provided to the students and faculty to ensure a successful online and resident course delivery. Each of the Department (and School) Heads has ultimate responsibility to ensure course material is developed to meet the program delivery schedule.

CANVAS will be the primary web-based course management system. Through CANVAS, students will receive the needed course materials (syllabi, readings, etc) and lectures. CANVAS also supports access to course content including asynchronous threaded discussion and real-time chat, automated quizzing with immediate feedback, grade management, and reporting functions.

To assist faculty members in converting existing course material to a fully online environment, we will make use of an Instructional Designer who will be hired and shared by the Departments participating in the MEngAMD Program. The Mechanical and Nuclear Engineering Department will make use of their experiences and lessons already learned in their online MSME and MEngNucE Programs. Videoconferencing will be made possible through the dedicated online recording classrooms in the Mechanical and Nuclear Engineering Department as well as the College of Engineering.

There are also numerous resources at Penn State for faculty teaching online courses through the Penn State Learning Design Community Hub, which is a website devoted to staff and instructors working with instructional technology (http://wcfd.psu.edu/).

4. Technological Resources Needed by Online Students

Students in the online MEngAMD degree program are expected to possess or have access to a personal computer and a broadband internet connection. The minimum system and software specifications are outlined at http://ets.tlt.psu.edu/learningdesign/. No specific hardware or equipment is required to complete the program.

E. Consultation with Other Units Affected by the Proposed Program

Written responses indicating consultation with other units are identified below. Responses are included in the appendix.

<table>
<thead>
<tr>
<th>Units Consulted</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penn State – Great Valley, James Nemes, Chancellor</td>
<td>positive</td>
</tr>
<tr>
<td>World Campus, Renata Engel, Associate Vice Provost of Online Programs</td>
<td>positive</td>
</tr>
<tr>
<td>Libraries, Barbara Dewey, Dean (Bonnie Osif, Librarian)</td>
<td>positive</td>
</tr>
<tr>
<td>Earth and Mineral Sciences, Assoc Dean John Hellmann</td>
<td>positive</td>
</tr>
<tr>
<td>Aerospace Engineering, P. Morris</td>
<td>positive</td>
</tr>
<tr>
<td>Architectural Engineering, K. Parfitt</td>
<td>positive</td>
</tr>
<tr>
<td>Bioengineering, C. Dong</td>
<td>positive</td>
</tr>
<tr>
<td>Chemical Engineering, P. Savage</td>
<td>positive</td>
</tr>
</tbody>
</table>
F. Program Quality

Assessment of the program quality will continuously be done through multiple avenues. The assessment plan will include tracking the following statistics: faculty’s Students’ Rating of Teaching Effectiveness scores (SRTEs); enrollments; entering graduate student quality in terms of experience, grade point averages, and GRE scores; student diversity in terms of professional and academic backgrounds, gender and ethnicity; time to degree; publications of culminating papers; internship experiences; and student placement.

Peer teaching reviews will be conducted each semester for non-tenured faculty members and annually for Associate Professors. Students’ assignments are submitted electronically through their online classroom environment—just like they would turn them in to their professor on campus. Most exams are taken through an approved University proctor. Once a student is enrolled, we will help them secure a proctor nearby.

Exit surveys as well as post-graduate surveys will also be developed and provided to those graduating from the program. These surveys will be constructed through the help of an assessment expert.

It will be the responsibility of the Department Heads, Associate Department Heads of Graduate studies and the Director of the Academic Affairs in World Campus to ensure that the program is maintained at a high quality. Per Graduate Council policy, the Departments and School will report back to the Committee on Programs and Courses three years after the initial enrollment of the first cohort of students with information to assess success and quality of the program. Guidelines for reporting are provided by the Office of the Dean of the Graduate School.

One additional measure of quality to be tracked will be the research papers that are written to meet the degree requirements. It is expected that the research papers, in particular, will be of publishable quality as is stated in the degree requirements. Papers that are produced through the degree program will be graded in terms of quality by the faculty adviser, the second reader, and the Graduate Program Officers in each of the five Departments and School. As mentioned, the papers will be tracked to see whether a published document is produced from the research.
Appendix A: Graduate Bulletin Statement

Masters of Science in Additive Manufacturing and Design (resident)
Masters of Engineering in Additive Manufacturing and Design (online)
KAREN A. THOLE, Head of the Department of Mechanical and Nuclear Engineering
137 Reber Building
814-865-2519

Graduate Faculty:
- Engineering Science and Mechanics
- Industrial and Manufacturing Engineering
- Material Science and Engineering
- Mechanical Engineering
- School of Engineering Design, Technology, and Professional Programs

Degree Conferred:
- M.S. in Additive Manufacturing and Design
- M.Eng. in Additive Manufacturing and Design

The Program
The overall goal of the Masters of Science in Additive Manufacturing and Design and Masters of Engineering in Additive Manufacturing and Design are to educate students and working engineers to become technically outstanding experts in additive manufacturing. Specifically, the objectives include:
1. Apply foundational knowledge, critical thinking, problem solving, and creativity in the uses of additive manufacturing and associated design tools and methods.
2. Grow as leaders in manufacturing while maintaining the highest ethical standards in applying additive manufacturing to industry-relevant problems and design challenges.
3. Strive for the advancement of the state-of-art in additive manufacturing and design.
4. Develop innovative solutions through new design paradigms in their respective industries.

Admission Requirements
To maintain a high quality program, it is important that our students are of a caliber to succeed. As such, the admission requirements for the students enrolling in the MSAMD and MEngAMD degree program will be based on: academic records, GRE scores, applicable work experience, their personal statement of interests in additive manufacturing design, and three letters of recommendation from a previous professor or supervisor who can attest to the applicant’s academic potential. Applicants will be expected to have a Bachelor of Science or four-year Associates degree form an accredited institution in engineering, manufacturing, materials science, or related field. An undergraduate cumulative grade point average of 3.0 or better on a 4.0 scale in the final two years of undergraduate studies is required.

Each application will be closely reviewed by a MSAMD and MEngAMD Admission Committee made up of one faculty member from each of the five participating departments: (1) Engineering Science and Mechanics, (2) Industrial and Manufacturing Engineering, (3) Material Science and Engineering, (4) Mechanical and Nuclear Engineering, and (5) School of Engineering Design, Technology, and Professional Programs. The faculty member, who will serve on the MSAMD
and MEngAMD Admission Committee, will be nominated by the respective Department (or School) Head.

The language of instruction at Penn State is English. International applicants must take and submit scores for the TOEFL (Test of English as a Foreign Language) with the exceptions noted below. The minimum acceptable score for the TOEFL is 80 or higher on the internet-based test with a 19 or higher in the speaking section. An acceptable alternative to the TOEFL, which will be accepted, is the International English Language Testing System (IELTS) test, on which a minimum composite score of 6.5 will be required. International applicants are exempt from the TOEFL requirement who have received a baccalaureate or graduate degree from a college/university/institution in any of the following: Australia, Belize, British Caribbean and British West Indies, Canada (except Quebec), England, Guyana, Republic of Ireland, New Zealand, Northern Ireland, Scotland, the United States and Wales.

**Degree Requirements**

1. Minimum of 30 course credits at the 400 level or higher.

2. Completion of five required course credits that total 19 credits with a grade point average of 3.00 or higher. The five required courses are EDSGN 562 (4 credits), E SC 545 (4 credits), IE 527 (4 credits), MatSE 567 (4 credits), and ME 566 (3 credits).

3. A minimum of at least eight (8) credit hours in 400 and/or 500 level courses offered with the following designations: EDSGN, E SC, IE, MATSE, or ME. Note that EDSGN 596, E SC 596, IE 596, MATSE 596, and ME 596 cannot be used to fulfill this requirement.

4. Completion of three (3) course credits in one of the following offerings to complete the culminating project: EDSGN 596, E SC 596, IE 596, MATSE 596, or ME 596. MSAMD students will be required to complete one (1) credit in each of three (3) semesters while MEngAMD students can complete a three (3) credit course in one (1) semester.

5. A paper must be completed to meet the specific requirement of the culminating experience. This paper will demonstrate depth of knowledge to his/her adviser, a second reader, and the Associate Department Head of Graduate Studies in one of the five aforementioned Departments.

6. All students must successfully complete one credit of colloquium preferably in their first two semesters in the program. The one-credit colloquium does not count toward the 30 graduate course credits in Requirement 1 above. The following courses are offered to meet this requirement: EDSGN 590, ESC 514, IE 590, MATSE 590, and ME 590.

7. All students will be required to complete SARI (Scholarship and Research Integrity) training.

*CULMINATING EXPERIENCE - MS PAPER and MEng PAPER*

The candidate registers for 30 course credits of which 19 credits must be the five required courses at the 500 level. A maximum of three credits of EDSGN 596, E SC 596, IE 596,
MATSE 596 or ME 596 can be counted in the total of 30 credits for students completing their project and MS paper.

Candidates must write a culminating project paper on a topic mutually agreed upon by the adviser. Students will be encouraged to utilize an industry internship (resident students) or current employer (online students) to identify a relevant or practical problem of importance that additive manufacturing and appropriate design methods could address. The quality of the required paper is such that it must be suitable for publication in a professional journal or proceedings at a national or international conference, which generally requires a peer-review process, as described in the guidelines provided in Appendix B. These guidelines indicate each paper submission must contain sections that fully describe a relevant survey of past literature pertinent to the research; a clear description of the methods used to determine the research results given in the paper; comprehensive analyses of the results in the context of the research topic as well as relative to past studies; and finally a synthesis of the results that is concisely summarized. Given all of our graduate faculty are active reviewers of conference proceedings and archival journals, the faculty are well-qualified to rigorously review the research paper presented by the online students.

The colloquium is a one-semester, one-credit requirement for all incoming graduate students, which does not count towards the 30-credit requirement. Resident and online students may enroll in suitable colloquia in EDSGN 590, ESC 514, IE 590, MATSE 590, or ME 590. In the seminars, presenters are experts in the field primarily from outside of Penn State representing industry, government and academia. Included in these lectures are ethics discussions that meet the Scholastic and Research Integrity (SARI) requirements. The colloquia are video captured and made available for the online students.
Appendix B: Expectations for Culminating Paper

To ensure that MS and MEng papers is of the quality of accepted professional quality standards, the following guidelines have been established by the mechanical engineering graduate faculty. Compliance will be monitored and enforced by the paper advisor, the paper reader, and the Associate Head of Graduate Programs.

In content, length and structure, the paper is expected to be one that would be acceptable for publication in a peer-reviewed professional journal, or for presentation at a peer-reviewed national or international conference. Examples of papers that would not meet this standard would be a technical report to a sponsor, a presentation at a local or regional conference, or a presentation at a conference where selection is not based on a full-paper peer-review process.

In the case of a multiple-author paper, the degree candidate must be the first author, and the paper must be primarily the work of the degree candidate. If there are coauthors other than the degree candidate and his/her faculty advisor, then a brief summary of the contributions of each coauthor and an estimate of each coauthor's percentage of effort must be included.

If the paper has already been published and/or presented, or has been accepted for publication and/or presentation, then the actual journal- or conference-formatted paper or manuscript should be submitted. Documentation must be provided to show that the paper has been published and/or presented, or has been accepted for publication and/or presentation. The role of the reader in this case is primarily to confirm that the target journal or conference meets the criteria outlined above, and that the documentation is in order.

If the paper has been submitted for publication or presentation, but has not yet been accepted, then the actual journal- or conference-formatted manuscript should be submitted. Documentation must be provided to show that the manuscript is under consideration for publication and/or presentation. If reviewer comments are available, those should be provided. In addition to confirming that the journal or conference is appropriate, the reader in this case will effectively have the role of a peer reviewer, and will judge whether the manuscript is, in principle, suitable for publication in the target journal or presentation at the target conference.

If the paper has not yet been submitted for publication and/or presentation, but will be in the near future, then the requirements in the previous paragraph still apply, with the exception of the requirement to provide documentation that the paper is under consideration.

Finally, if the paper is not one that has been or will be submitted for publication or presentation, then an appropriate target journal or conference must be selected by the student and paper advisor, and the paper must be prepared as if it were going to be submitted to that journal or conference. An appropriate template to use in this case would be the one that is available for professional technical papers, for example (see http://www.asme.org/kb/proceedings/proceedings/author-templates). In this case, the paper reader must judge whether the paper would be acceptable, in principle, for publication in the target journal or presentation at the target conference. This option will place a greater burden on the reader, as he/she will not have the advantage of knowing that external peer reviewers are also reading and evaluating the paper.
Appendix C: Consultation with Other Units Affected by the Program

From Professor Cheng Dong, Dept Head, Biomedical Engineering

hi Karen,
BME grad curriculum reviewed your proposal along with me. We support the proposal.
BME is expanding bio-manufacturing and tissue engineering areas. So if help is ever needed in
biomedical applications from your Additive Manufacturing and Design, BME will be there to assist and
support you.
For example, Jian Yang leads a Transformative Biomaterials and Biotechnology Lab and investigates a
methodology for functional biomaterial development and uses biomaterials as a tool for bio-
manufacturing tissues.
In 2015-16, we hired Xiaoyun (Lance) Lian, whose research focuses on bio-manufacturing clinical
applicable cells from human stem cells, such as the cardiomyocytes, neurons and/or pancreatic beta
cells.
In our current 2017-18 search, BME will join Chemistry to co-hire a faculty in areas of
biosynthesis, applying nature and biology as guidelines for the development of novel chemical tools,
methods, or biomaterials that address biomedical problems in bio-manufacturing for the (re)generation
of tissue and organs. Areas of particular interest include: the synthesis of biomolecules (e.g. proteins,
peptides and nucleic acids) for applications such as bio-manufacturing, manipulation or probing of
biological processes, as well as biomimetic synthesis of nanoscale materials for macroscopic
manufacturing of tissue or organ mimics.
Good luck with your proposal.
Best,
Cheng

________________________________

From Dr. Phil Savage, Dept Head, Chemical Engineering

Karen

I looked over the document you sent regarding the new MS degree. It looks like a very nice program and that
it will give Penn State a leadership position. I am supportive.

Phil

________________________________

From Dean Andrew Sears, Dean, College of Informational Science and Technology

Karen,

Thanks for sharing this proposal. I shared it with the college’s Associate Deans who address academic
programs and they agreed that we do not see any issues or concerns from an IST perspective. If there’s
interest in exploring the risks that come along with these ideas, I may have some people who would be
interested in talking about this and ensuring appropriate content is integrated into a corresponding IST
course. Just let me know if there is interest.

Thanks,
Andrew
From Professor Nicholas Petruzzi

Dear Nicholas,

Thank you very much for the time and effort you took to review our proposal. I am aware of your program, particularly with IE 527. In principle, what you are suggesting is very much welcomed. We would be pleased to accept your students into courses associated with this MSAMD degree program. It makes sense to share resources as best we can. I suggest that once we have our program approved, we meet to talk about an MOU that outlines an agreement on the courses regarding enrollments, financials, etc.

Thank you again and we appreciate the help. I look forward to working with you.

Karen

From: Nicholas Petruzzi [mailto:ncp12@smeal.psu.edu]
Sent: Saturday, September 24, 2016 1:23 PM
To: Karen Thole <kthole@engr.psu.edu>; ncp12@psu.edu
Cc: Peter J. Butler <pjbbio@engr.psu.edu>; Janis P. Terpenny <jpt5311@engr.psu.edu>; Judith Todd <JTodd@engr.psu.edu>; Sven Bilen <SBilen@engr.psu.edu>; sinnott@matse.psu.edu; Mary Frecker <mxf36@engr.psu.edu>; kthole@psu.edu
Subject: RE: MS in Additive Manufacturing and Design

Dear Karen,

Thank you for consulting me on this proposal. Overall, I lend my support. Indeed, I look forward to any potential synergies it generates with our SCM programs and industry partners. On that note, I offer up a question as food for thought: Would courses in this degree program be available as electives to students enrolled in other graduate degree programs? I ask because we typically have students in our MPS in SCM program who express keen interests in taking advanced manufacturing courses from Engineering. To wit, we currently have a track of students taking a three course sequence in IE, namely IE 573 (Manufacturing Material) + IE 574 (Advanced Manufacturing Processes) + IE 527 (Additive Manufacturing). Given that some or all of these particular courses would satisfy degree requirements for the proposed MS in Additive Manufacturing and Design, I think there are potential strategic-level
synergies and operational efficiencies to be had from some level of concerted coordination across programs.

Sincerely,

Nick

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From Professor James Nemes, Chancellor, Penn State Great Valley

Dear James,

Thank you so much for your comments regarding our proposal. We appreciate your willingness to review and respond in such a timely manner. Below are our responses. Please feel free to let us know whether this satisfies your concerns.

Karen

From: JAMES A NEMES [mailto:jan16@psu.edu]
Sent: Tuesday, September 20, 2016 8:30 AM
To: Karen Thole <kthole@engr.psu.edu>
Cc: Peter J. Butler <pjbbio@engr.psu.edu>; Judith Todd <JTodd@engr.psu.edu>; Janis P. Terpenny <jpt5311@engr.psu.edu>; Sven Bilen <SBilen@engr.psu.edu>; sinnott@matse.psu.edu; Mary Frecker <mxf36@engr.psu.edu>; kthole@psu.edu; DAVID RUSSELL <RZN@PSU.EDU>
Subject: RE: MS in Additive Manufacturing and Design

Karen,

This is obviously a very timely proposal, and Penn State is well-positioned to deliver it, so I am therefore very supportive.
Thank you so much for your comments.

I do have a few comments on the proposal, which are listed below:

1) I recognize this is part of a larger discussion, but it seems that this would more appropriately be considered an M.Eng. rather than an M.S.
We have now changed this degree to an MEng for the online students and an MS for the resident students with the appropriate requirements for each in terms of the culminating paper. MS students will be required to enroll in one credit of research each of three semesters.

2) Unless I’m missing it, I don’t see EDSGN 562, E SC 545, IE 527, or ME 566 in the graduate bulletin. Our experience has been that programs will not be approved unless the required courses for it have been approved. Also makes it difficult to review the program proposal without knowing the content of these courses.
Many of these courses are making their way through the process now. These should appear soon and prior to the program proposal review. Nearly all are in the works or are already completed.
3) It's not clear from the offering schedule in section 5, if those courses are online courses or resident courses or both. These courses will be offered both online and in resident.

4) In several places of the proposal there is a mention of ‘one-year master’s programs’ but it seems this program is directed more toward online students who would take three years. The one year master’s program references seem misleading. We want to offer this degree both online and as a one year M.S. The proposal indicates such.

5) The proposal states that the online students will also take ME 566, which is a ‘hands-on’ lab course. Is this a 15 week course? Would the online students spend a semester at University Park? The proposal didn’t specify how this would work. The expectation for this particular course is that students will be required to be on campus for two three-day, intensive visits to learn the required material in ME 566. Tim Simpson already teaches a very popular industry practicum, which we will build upon for ME 566.

Jim
James A. Nemes, D.Sc.
Chancellor and Chief Academic Officer
Professor of Mechanical Engineering
School of Graduate Professional Studies
Penn State Great Valley
30 East Swedesford Road
Malvern, PA 19355-1443
Phone: 610-648-3335
Fax: 610-648-3377
jan16@psu.edu

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From Professor Phil Morris, Aerospace Engineering

Karen:

All the feedback from those faculty members who replied has been positive.

I will complete the form if I can log in from Spain.

Phil

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From Professor Pat Fox, Civil and Environmental Engineering

Hi Karen -

The CEE Department is supportive of this new degree program, with no concerns. The topic, justification, and outline are well-considered and will be of significant benefit to the college. There is minimal overlap with our CEE programs.

Please let me know if you need any further feedback.
From Professor Kevin Parfitt, Architectural Engineering

Karen,

Based on my review of the material provided, I feel this is an excellent new program that pulls together knowledge from a number of sources at Penn State into a timely and comprehensive degree program. Given the topic, I feel the required internship is especially appropriate and will benefit those students who do not have much (or any) industry experience and will make the program attractive to students because of the industry interaction. There are no overlaps or duplication of effort in the program relative to Architectural Engineering. As such, you have my support for the new degree program in Additive Manufacturing and Design.

Thanks for including me in the review process.

Good luck!

Kevin

From Professor Tom Laporta, School of Electrical Engineering and Computer Science

Karen,

I am positive on your new MS degree. There is minimal overlap with our programs and is very well formulated.

Regards,

Tom