UNIVERSITY FACULTY SENATE FORMS

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: Michael Santare phone number x-2246

Department: Mechanical Engineering email address santare@udel.edu

Date: November 10, 2011

Action: Policy change for graduate program
(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc)

Effective term 12 F
(use format 04F, 05W)

Current degree
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: PhD, MSME, MEM
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name:
Proposed new name for revised or new major / minor / concentration / academic unit (if applicable)

Revising or Deleting:

Undergraduate major / Concentration:
(Example: Applied Music – Instrumental degree BMAS)

Undergraduate minor:
(Example: African Studies, Business Administration, English, Leadership, etc.)

Graduate Program Policy statement change: Program Policy Statement Attached
(**Must attach** your Graduate Program Policy Statement)

Graduate Program of Study: Ph.D. in Mechanical Engineering; Master of Science in Mechanical Engineering (MSME); Master of Engineering: Mechanical (MEM)
(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

Graduate minor / concentration:

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")

MEEG 600 Seminar, is a currently listed course that is being changed to a zero credit, Pass/No Credit course requirement.

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

NOT APPLICABLE

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

NONE

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The PhD program in Mechanical Engineering has been growing rapidly in recent years (enrollment has increased 74% since 2007). This growth is consistent with the University, College and Department Strategic plans regarding graduate enrollment. To accommodate and respond to this growth, the department proposes the following graduate policy changes;

First-year Funding
Currently, we admit approximately 13-14 first year students as TAs, and 3-4 as fellows, supported by department funds. The remainder, are funded directly by research projects as RAs. During their first semester, we require the TAs and fellows to identify a mentor, who will agree to support them as an RA beginning in June and for the remainder of their studies. This gives these students the freedom to select a research project and mentor from among the available faculty and projects. This process works well for both the faculty looking to hire RAs and the incoming students looking for PhD projects. Students have the opportunity to meet and discuss research with a variety of faculty. Faculty members can match students to individual research projects based on their interests, strengths and personalities.

However, there are drawbacks; first year students do not always make the best TAs, and funding does not permit us to offer more than a few fellowships. Ideally, we would like to fund all of our first year students as fellows and have them select their mentors and transition to RAs during the first semester. In order to do this we propose the following;

- Admit all first-year PhD students as 1-semester fellows.
- Require fellows to rotate into 2 or 3 one month assignments in research labs in the department.
- Require them to transition to an RA beginning in the second semester.
- Require all PhD students to serve as a TA for one semester during years 2-3.

This will allow us to use the money now used to fund TAs, to fund the first-semester fellowships. The department will still have the same number of TAs (or more) on average, since each incoming student will eventually serve one semester as a TA. (This will require a phase-in period as we transition from first-year TAs to latter-year TAs.)

All TAs will be expected to continue to be actively involved in their research while serving as a TA. Although the exact timing of TA appointments will be flexible, it is desirable for students to complete all TA responsibilities by the end of the 3rd year if possible, to allow students to focus more strongly on their research as they near the end of their graduate studies.

The following specific wording has been added to the Department Graduate policy statement:

V. Teaching Requirement

The ability to communicate effectively is an essential skill for all PhD graduates. Therefore, all PhD students are required to fulfill a teaching requirement, which consists of serving as a Teaching Assistant (TA) for one or two semesters, depending on the assignment. Students are expected to continue to be actively involved in their research while serving as a TA.

International graduate students are required to take International Teaching Assistant (ITA) training through the University's English Language Institute (ELI) prior to their first semester as a graduate student. Training and assessment are part of the University's requirements for the proficiency of international TA's. A final decision on how to resolve any deficiency is made by the Graduate Program Coordinator in consultation with the student's thesis advisor and the Department Chair.

Teaching Assistant positions are assigned by the Graduate Curriculum Chair in advance for the upcoming semester. Students are encouraged to submit their preferences for specific TA positions early to facilitate the process. Although every effort is made to satisfy these requests, students should recognize that this might not be possible in all cases. In addition, the educational needs of the Department may require the Graduate Curriculum Chair to ask students to fill specific TA positions.

NOTE: Students already enrolled in the Ph.D. program can choose to switch to the new guidelines, or continue under the current guidelines.

Advantages to the students and department are;

- Research shows that teaching experience improves students' research skills (Science 19 August 2011: Vol. 333 no. 6045 pp. 1037-1039, see appendix)
- Fellowships are a more attractive recruitment offer than TAs
- Lab rotations will give students a taste of several research projects prior to committing.
- Second and third year students are generally better TAs than first-years

Seminar requirement

Each semester, the department invites a number of accomplished scholars to the department to speak on a wide variety of topics related to mechanical engineering. Attendance at these seminars is a valuable adjunct to a well-rounded research education. Therefore, the department has decided to require its graduate students to attend a portion of department seminars. We are proposing to amend our MSME and PhD requirements accordingly.

MSME students will be required to complete one semester and PhD students will be required to complete three semesters of MEEG 600 Seminar. This course is currently listed as a one-credit course. The proposal includes a change to a 0 credit course, graded Pass/Fail. A Mechanical Engineering faculty member will be assigned to the course and will set policy for taking attendance and grading the course. A copy of the Course-Inventory form is attached.

Updated GRE and TOEFL Scores

As a last minor change, the department is updating the admission requirement listing for GRE and TOEFL minimum scores to reflect the current scoring systems. These are a direct conversion from our old minimum scores using the concordance tables.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

See attached Graduate Program Policy documents

ROUTING AND AUTHORIZATION: (Please do not remove supporting documentation.)

Department Chairperson _____ Date 1/23/12

Dean of College _____ Date 1/24/12.

Chairperson, College Curriculum Committee _____ Date 1/24/12

Chairperson, Senate Com. on UG or GR Studies _____ Date _____

Chairperson, Senate Coordinating Com. _____ Date _____

Secretary, Faculty Senate _____ Date _____

Date of Senate Resolution _____ Date to be Effective _____

Registrar _____ Program Code _____ Date _____

Vice Provost for Academic Affairs & International Programs _____ Date _____

Provost _____ Date _____

Board of Trustee Notification _____ Date _____

Revised 02/09/2009 /khs

COURSE INVENTORY

Course Revision

SEMINAR
EG/Mechanical Engineering
Effective Term: 12F

	Current		Proposed
Course title:	SEMINAR		SEMINAR
Credit type:	Fixed: 1	✱	Fixed: 0
Can this be taken more than once per term:	No		No
Max. repeatable credits:	1	✱	0
Grade type:	Pass/Fail		Pass/Fail
Multicultural:	No		No
First Year Experience:	No		No
Discovery Learning Experience:	No		No
Instructional format:	Lecture: 1	✱	Lecture: 0
Cross-Listed courses:			
Course catalog title:	Seminar		Seminar
Long description:		✱	Lectures by invited scholars on various topics in Mechanical Engineering and related areas.
Prerequisites:			
Corequisites:			
Restrictions:			

Justifications:

Justify the need to revise this course.
The department has had a long tradition of departmental seminars, open to the public Attendance by graduate students is encouraged but not required. By making Seminar a required course, we intend to increase attendance and cultivate a richer intellectual culture for our grad students.

Identify and justify any effect on other courses in your department or in another department. Specifically list other departments chairpersons and/or faculty consulted and summarize results of discussion.
na

Identify the main emphasis of the course and indicate the nature of the change.
The seminar series emphasizes exposure to and intellectual exchange among students and scholars in various areas related to Mechanical Engineering

Instructor reference: Santare,Michael H
santare@udel.edu

Previous step | Save & exit (not submitted) | Finish & submit

Graduate Students' Teaching Experiences Improve Their Methodological Research Skills

David F. Feldon, *et al.*

Science **333**, 1037 (2011);
DOI: 10.1126/science.1204109

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Acknowledgments: This study and its write-up were supported by grants from the William T Grant Foundation and the Institute for Education Science (R305A100367) The authors acknowledge C Hafen for his contribution to the analyses in this study and J Wasserman and S Deal for their contribution to the implementation of the intervention. R C P is part owner of the company that disseminates the pre-K version of the Classroom Assessment Scoring System and co-author of the version used in this investigation. Further information regarding the My Teaching Partner–Secondary program is available at mtpsecondary.net.

Supporting Online Material
www sciencemag.org/cgi/content/full/333/6045/1034/DC1
Materials and Methods
SOM Text
Figs. S1 and S2
Tables S1 and S2
References

6 May 2011; accepted 11 July 2011
10 1126/science 1207998

Graduate Students' Teaching Experiences Improve Their Methodological Research Skills

David F. Feldon,[1]* James Peugh,[2] Briana E. Timmerman,[3] Michelle A. Maher,[4,5] Melissa Hurst,[4] Denise Strickland,[4] Joanna A. Gilmore,[6] Cindy Stiegelmeyer[7]

Science, technology, engineering, and mathematics (STEM) graduate students are often encouraged to maximize their engagement with supervised research and minimize teaching obligations. However, the process of teaching students engaged in inquiry provides practice in the application of important research skills. Using a performance rubric, we compared the quality of methodological skills demonstrated in written research proposals for two groups of early career graduate students (those with both teaching and research responsibilities and those with only research responsibilities) at the beginning and end of an academic year. After statistically controlling for preexisting differences between groups, students who both taught and conducted research demonstrate significantly greater improvement in their abilities to generate testable hypotheses and design valid experiments. These results indicate that teaching experience can contribute substantially to the improvement of essential research skills.

Academic culture in doctoral research universities' STEM (science, technology, engineering, mathematics) programs typically values research activity over teaching (*1*, *2*). Faculty commonly believe that research activities enhance teaching quality but disbelieve that teaching similarly enhances research skills (*3*, *4*). These beliefs influence not only the professional priorities of STEM faculty, but also the guidance given to and the expectations of their graduate students (*5*, *6*).

Previous research in educational and cognitive psychology suggests that a beneficial relationship between teaching and research skill development can exist to the extent that they entail an overlap of cognitive processes. When teaching in a context that requires students to effectively conceptualize research and solve problems through inquiry (for example, frame testable hypotheses, design valid experiments, or draw appropriate conclusions based on data), instructors must practice these skills themselves as they reason through these problems in order to provide appropriate guidance to their students. When students are trying to solve different problems, the instructor must likewise consider the discrete goals, structure, and methods of each problem, entailing practice in the relevant cognitive skills (*7*). In contrast, a research assistantship in a laboratory probably provides fewer, relatively similar projects that are based on the research agenda of the lab or principal investigator. Further, many high-level research design issues are likely to be resolved without requiring the research assistant to make substantive contributions to, for example, specifying research questions or determining methodology. For graduate students new to a lab, it is likely that the funded grant proposal supporting their work was written and submitted before their arrival.

Additionally, when learners are required to articulate their reasoning processes substantial evidence indicates that they develop more elaborate and effective schemas for problem-solving that facilitate performance on both typical and new problems (*8*, *9*). Therefore, when instructors explain their own research processes to guide their students (*10*) they are further reinforcing their own learning. Research assistantships do not necessarily require extensive self-explanation (*11*).

Several small, qualitative studies report benefits of teaching for graduate student participants' research development. One found that 21 of 27 teaching assistants leading undergraduate labs reported positive benefits to their research skills as a result of their teaching experiences (*12*). Another found that 33% of research advisors supervising participants in a National Science Foundation (NSF) GK-12 program (*13*) directly attributed improvements in participants' research performance to their involvement with the program (*14*). Likewise, a RAND Corporation study found that STEM graduate students participating

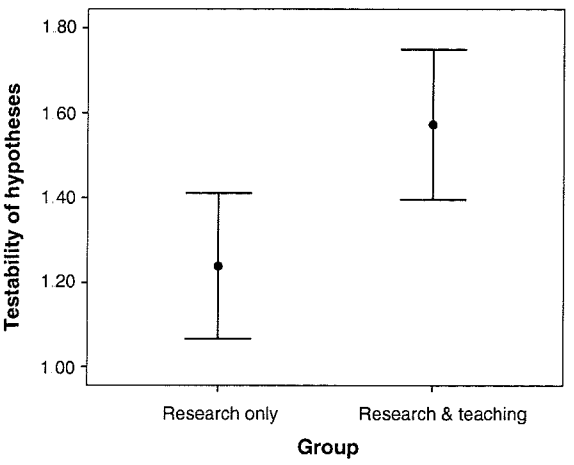

Fig. 1. Effect of both research and teaching experiences compared with research experiences alone for STEM graduate students' improvement in writing testable hypotheses. After statistically controlling for preexisting differences in the quantity of prior research experience, scientific reasoning ability, and earned scores on the written research proposal at the first time point, the quality of the hypotheses proposed were significantly higher in the teaching-and-research condition (Cohen's $d = 0.58$). Error bars represent 95% CIs around the adjusted means.

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in educational outreach frequently reported that teaching helped them to reframe their understandings of their respective science domains to explain it to their own students (*15*). In a larger, quantitative survey of graduate students at one university (n = 524 students), participants who served as both research assistants and teaching assistants self-reported higher subsequent conference presentation and publication rates than that of those who served in only one role (*16*). What each of these studies lacks, however, is a direct measure of participants' research skills on an individual basis with both baseline and post-intervention performance outcomes. Additionally, the problematic nature of self-reported attributions as assessments of learning (*17*, *18*) and the limited inferences about individuals' skills that can be drawn from publication records (*19*) warrant performance-based assessment of individuals' skill improvement to thoroughly evaluate these claims.

We compared the quality of 95 early-career (enrolled in the first three years) graduate students' written research proposals solicited at two time points using a previously validated rubric (*20*) described in the supporting online material (SOM) text. Some participants worked as research assistants with no teaching responsibilities, whereas others held split appointments with both research and teaching responsibilities as either teaching assistants in undergraduate courses or as GK-12 (*21*) participants partnering with middle school teachers of STEM content (*22*). We predicted that those participants who engaged in both teaching and research activities (n = 49 participants) would exhibit substantially greater improvement in certain research skills (setting proposed research in the context of its field, use of primary literature, testability of hypotheses, research and experimental design, establishing reliability and validity of measures, selection of data for analysis, analysis of data, presentation of results, basing conclusions on data, and identifying study limitations) than would those engaged solely in research activities (n = 46 participants).

Participants were enrolled as full-time graduate students in research-oriented master's and doctoral degree programs in empirical STEM disciplines at one of three universities in the eastern United States (*22*). One was a large, doctoral university (undergraduate enrollment ≈ 20,000; graduate enrollment ≈ 6700), and two selectively offered research-intensive masters degrees in STEM fields. Of the two master's institutions, one was large (undergraduate enrollment ≈ 14,000; graduate enrollment ≈ 4000), and one was small (undergraduate enrollment ≈ 8200; graduate enrollment ≈ 500). Data were collected from three annual cohorts between 2007 and 2010.

Participants submitted research proposals related to their academic focal areas in early fall. Before submission, participants were given detailed instructions to include descriptions of the relevant literature and design for their proposed research, as well as anticipated results, other potential outcomes, and the importance of these results. Participants were also given a summary of the evaluation criteria. They then revised these proposals over the course of the academic year and resubmitted them in late spring as part of their participation in the study. The team conducting the study provided no feedback to the participants between the fall and spring submissions, although participants were free to seek independent feedback from other support networks and their programs at their discretion.

Most participants reported during exit interviews that they used their proposals for an additional purpose beyond the research study, such as to meet requirements for a class, research lab, or conference proposal. This information was interpreted as a positive indicator of both ecological validity and legitimate effort invested in the task.

The research skills addressed specifically in this study were setting context for a study, framing testable hypotheses, attention to validity and reliability of methods, experimental design, appropriate selection of data for analysis, presentation of data, data analysis, basing conclusions on data, identifying limitations, and effective use of primary literature. These criteria were selected through a review of relevant literature and iterative development of criteria with STEM research faculty (*20*, *22*). At least two raters scored each proposal, and any discrepant scores were resolved by discussion until consensus was reached (*23*). Raters possessed graduate degrees in relevant STEM disciplines and attained inter-rater reliability intraclass correlations of 0.6 to 0.9 when scoring participants' research proposals before discussion.

Rubric scores were grouped into three content areas: introduction (encompassing rubric element scores for setting the work in context, use of primary literature, and testability of hypotheses), results (encompassing rubric element scores for research and experimental design, establishing reliability and validity of measures, selection of data for analysis, analysis of the data, and the presentation of the results), and discussion (encompassing rubric element scores for conclusions based on data and identifying the limitations of the study). Multivariate analyses of covariance (MANCOVAs) were conducted in Mplus Version 6.1 (Muthén and Muthén, Los Angeles, CA) to appropriately model the statistically significant correlations among the rubric scores within each of the three content areas (introduction criteria correlations, 0.44 to 0.64; results criteria correlations, 0.26 to 0.69; discussion criteria correlation, 0.29). Further, all response variable rubric scores had 1.1 to 2.0% missing data at the first time point and 14.7% missing data at the second time point. A missing values analysis [$\chi^2(17)$ = 23.20, P = 0.14] showed that the missing data met the assumption for missing completely at random (MCAR) (*24*). However, to preserve the sample size for analysis the missing data were handled more conservatively under missing at random (MAR) (*25*) assumptions by using a maximum likelihood estimation algorithm robust to nonnormally distributed data (MLR) (*26*). Because participants were not randomly selected or assigned to conditions, several covariates were used to statistically control for pre-existing differences between the groups assessed at the first time point: quantity of participants' prior research experience, scores on two tests of scientific reasoning, and the rubric scores from their first research proposal submission (*22*).

We performed testing for significant mean differences between the two independent variable groups in three steps. First, MANCOVA analyses enabled the direct statistical test of the null hypothesis that a given rubric score element mean difference (teaching and research group mean minus the mean for the research-only group) was zero. Second, the analysis of 5000 bootstrap samples of size n = 95 participants enabled the computation of 95% confidence intervals (CIs) for each rubric score mean difference. Third, Cohen's d effect sizes were computed for all mean differences, and Monte Carlo analyses of 5000 generated data sets of size n = 95 participants enabled the determination of the number of times in 5000 samples the null hypothesis (H_0:) of a zero

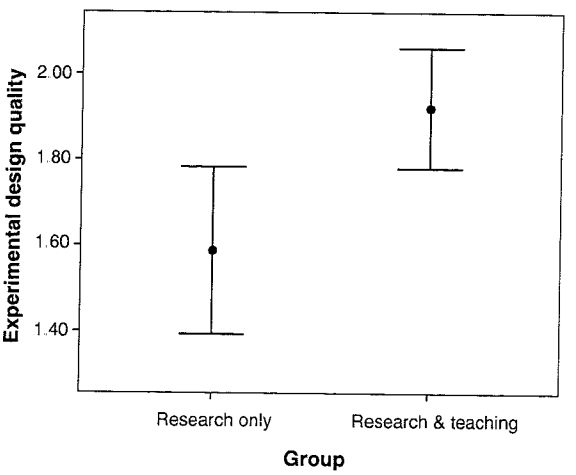

Fig. 2. Effect of both research and teaching experiences compared with research experiences alone for STEM graduate students' improvement in experimental design. After statistically controlling for pre-existing differences in the quantity of prior research experience, scientific reasoning ability, and earned scores on the written research proposal at the first time point, the quality of the experimental designs proposed were significantly higher in the teaching-and-research condition (Cohen's d = 0.63). Error bars represent 95% CIs around the adjusted means.

mean difference for all rubric score elements was rejected. Univariate statistical tests of the observed mean differences between the teaching-and-research and research-only conditions indicated significant results for the rubric score elements "testability of hypotheses" [mean difference = 0.272, $P = 0.006$; CI = (.106, 0.526)] with the null hypothesis rejected in 99.3% of generated data samples (Fig. 1) and "research/experimental design" [mean difference = 0.317, $P = 0.002$; CI = (.106, 0.522)] with the null hypothesis rejected in 100% of generated data samples (Fig. 2).

These findings indicate a medium effect size for teaching and research experiences' impact on participants' abilities to generate testable hypotheses (Cohen's $d = 0.40$) and valid research designs (Cohen's $d = 0.478$) in the context of written research proposals (27.4 and 32.9% nonoverlap between teaching-and-research and research-only distributions for hypotheses and experimental design, respectively) (*27*). Differences in overall writing quality cannot account for the observed effects because only specific skills showed differential outcomes as a function of experience type.

These data provide direct, performance-based evidence of improvement on specific research skills associated with teaching experiences that complement traditional graduate research training. As such, they hold substantial implications for both the programmatic graduate training in STEM and the challenges that universities face as they strive to meet increased demand for instruction with fewer resources. The reframing of teaching experience as a value-added component of graduate research training suggests several substantial changes for the culture and practice of graduate education in STEM disciplines. Further, if teaching becomes a more commonly supported facet of STEM graduate education then students' instructional training and experiences would alleviate persistent concerns that current programs underprepare future STEM faculty to perform their teaching responsibilities (*28*, *29*).

References and Notes

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21. No outcome differences were detected as a function of the type of teaching experience (TA or GK-12) within the sample population participating in both research and teaching.
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Acknowledgments: This work is supported by a grant from the National Science Foundation to D.F., M.M., B.E.T., J. Lyons, and S. Thompson (NSF-0723686). The views expressed do not necessarily represent the views of the supporting funding agency. Data used to conduct the reported analyses can be found in (*22*).

Supporting Online Material

www.sciencemag.org/cgi/content/full/333/6045/1037/DC1
Materials and Methods
SOM Text
Figs. S1 to S4
Tables S1 to S5
Database S1

10 February 2011; accepted 21 June 2011
10.1126/science.1204109

Mutational Inactivation of *STAG2* Causes Aneuploidy in Human Cancer

David A. Solomon,[1] Taeyeon Kim,[1] Laura A. Diaz-Martinez,[2] Joshlean Fair,[1] Abdel G. Elkahloun,[3] Brent T. Harris,[4] Jeffrey A. Toretsky,[1] Steven A. Rosenberg,[5] Neerav Shukla,[6] Marc Ladanyi,[6] Yardena Samuels,[3] C. David James,[7] Hongtao Yu,[2] Jung-Sik Kim,[1] Todd Waldman[1]*

Most cancer cells are characterized by aneuploidy, an abnormal number of chromosomes. We have identified a clue to the mechanistic origins of aneuploidy through integrative genomic analyses of human tumors. A diverse range of tumor types were found to harbor deletions or inactivating mutations of *STAG2*, a gene encoding a subunit of the cohesin complex, which regulates the separation of sister chromatids during cell division. Because *STAG2* is on the X chromosome, its inactivation requires only a single mutational event. Studying a near-diploid human cell line with a stable karyotype, we found that targeted inactivation of *STAG2* led to chromatid cohesion defects and aneuploidy, whereas in two aneuploid human glioblastoma cell lines, targeted correction of the endogenous mutant alleles of *STAG2* led to enhanced chromosomal stability. Thus, genetic disruption of cohesin is a cause of aneuploidy in human cancer.

One of the hallmarks of cancer is chromosomal instability, which leads to aneuploidy, translocations, loss of heterozygosity, and other chromosomal aberrations (*1*, *2*). Chromosomal instability is an early event in cancer pathogenesis and is thought to generate the large number of genetic lesions required for a cell to undergo malignant transformation (*3*). It has been hypothesized that this instability is due to inactivating mutations in genes that control the mitotic checkpoint and chromosome segregation (*4*, *5*). However, in the vast majority of human tumors the molecular basis of chromosomal instability and the aneuploidy it produces remains unknown.

To explore this question, we followed up on previous studies in which we used Affymetrix 250K single-nucleotide polymorphism (SNP) arrays to identify novel regions of amplification and deletion in human glioblastoma cell lines (*6*–*8*). In U138MG cells, we identified a region

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Current Policy

GRADUATE PROGRAM

Mechanical Engineering
2011-2012

Mission Statement

The Department of Mechanical Engineering at the University of Delaware offers masters and doctoral degree programs geared toward preparing students for leadership positions in industry, government, and academia. The curriculum for the master's degree is rooted in the fundamentals of mechanical engineering but allows for some flexibility through elective courses. The department offers a research-oriented master's degree with thesis (MSME) and a coursework-only degree (MEM). Recognizing that technology and research is rapidly becoming more cross-disciplinary, the doctoral program (Ph.D.) in the department provides significant flexibility and the ability to tailor one's program to meet the challenges of a broad array of research environments. In addition, the department offers a direct Ph.D. program without the requirements of a master's degree and the ability to accommodate students with backgrounds in mathematics, physics and other engineering disciplines into the program.

Admission to Program

Students are admitted into the graduate program for either a Master's or a doctoral, Ph.D., degree. For students with a bachelor's degree in engineering the following minimum criteria will normally be applied:

1. A baccalaureate degree in mechanical engineering or in a closely related field of science or mathematics.
2. An undergraduate grade point average in engineering, science and mathematics courses of at least 3.0 on a 4.0 scale.
3. A minimum of at least three letters of strong support from former teachers or supervisors.
4. A minimum combined Quantitative and Verbal score of 1200 in the Graduate Record Examination Aptitude Test.
5. A minimum score of 600 (or IBT equivalent) in the Test of English as a Foreign Language for students whose first language is not English. This test is not required of students whose first language is English and who have received an undergraduate or post-graduate degree from a College or University in which English is the sole language of instruction.

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

For applicants with no prior training in engineering, the same minimum criteria will apply. In addition, their records will be reviewed in relation to the intended program of study. Provisional status with specific remedial work may be a basis for acceptance of such applicants.

The acceptance of applicants who have already received a Master's degree in engineering will be based on the above minimum criteria and the results of their graduate work.

Advisement

A temporary academic advisor is assigned to new students when they are admitted to the Department. Students select their permanent advisor once they become familiar with the department, and clear about their research interests. The permanent advisor will be someone whose interest matches the interest of the student insofar as possible. For students on Research Assistantships, the advisor directs their research and advises them on course selection.

MASTER of SCIENCE in MECHANICAL ENGINEERING (MSME)

The Master of Science in Mechanical Engineering (MSME) program consists of 24 credit hours of graduate level coursework, plus 6 credits of Master's Thesis. Coursework must be completed with a grade point average of 3.0 or higher. The requirements are designed both to provide a balanced program in Mechanical Engineering and to allow for a degree of specialization. Students should be able to complete all degree requirements, including the thesis, in 18 to 24 months of full-time study.

I. Course Requirements

A. The following four courses are required (12 credits):

- MEEG 690 Intermediate Engineering Mathematics
- Three from the following list:
    - MEEG 610 Intermediate Solid Mechanics
    - MEEG 620 Intermediate Dynamics
    - MEEG 630 Intermediate Fluid Mechanics
    - MEEG 640 Intermediate Heat Transfer
    - MEEG 683 Orthopedic Biomechanics

Students may petition the Graduate Committee to substitute a more advanced (e.g., 800-level) course on the same topic for one of these required courses.

B. One additional graduate level course (3 credits) in mathematics or numerical methods. The student makes this selection with the documented approval of the Department's Graduate Committee, which has the authority to decide on acceptable courses.

C. Three additional elective graduate level courses (9 credits) in engineering or mathematical, physical or biological sciences. The student makes these selections with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

D. 6 credits of MEEG 869 Master's Thesis.

II. Thesis Requirements

A thesis is required which demonstrates the student's ability to conduct scholarly research. Entering graduate students are expected to choose a thesis advisor and research topic during their first semester in the Department so that they can initiate research and choose appropriate elective courses.

At the completion of the thesis research, candidates for the MSME degree must defend their thesis orally to a committee of at least three faculty members. The committee will be chaired by the thesis advisor who, along with at least one other committee member, must be regular full-time faculty in the Department of Mechanical Engineering. The thesis is to be submitted to committee members at least two weeks in advance of the defense and shall meet the academic and professional standards set forth by the University. Upon acceptance of the thesis, the Committee recommends approval to the Department Chairperson.

III. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's course grades in: MEEG 610 Intermediate Solid Mechanics; MEEG 620 Intermediate Dynamics; MEEG 630 Intermediate Fluid Mechanics; MEEG 640 Intermediate Heat Transfer; and MEEG 690 Intermediate Engineering Mathematics.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

B. The student will demonstrate the ability to conduct, present and defend graduate-level research including literature review, motivation, methodology utilized, results, unique contributions, and conclusions generated.

> Direct assessment: Student learning relative to this outcome is assessed by the quality of the written master's thesis and performance in the thesis defense.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

MASTER OF ENGINEERING: MECHANICAL (MEM)

The Master of Engineering: Mechanical (MEM) program consists of 30 credit hours of graduate level coursework. Coursework must be completed with a grade point average of 3.0 or higher. The requirements are designed to provide a general program and to allow for some concentration of study within Mechanical Engineering. It will be possible to complete this program taking courses in the late afternoon, early evening, and/or in a distance format.

Engineering Outreach can help facilitate part-time graduate education. This degree is not available to students who have been enrolled in the MSME degree program.

I. Course Requirements

A. The following five courses are required (15 credits):

- MEEG 690 Intermediate Engineering Mathematics
- Four from the following list:
    - MEEG 610 Intermediate Solid Mechanics
    - MEEG 620 Intermediate Dynamics
    - MEEG 630 Intermediate Fluid Mechanics
    - MEEG 640 Intermediate Heat Transfer
    - MEEG 683 Orthopedic Biomechanics

Students may petition the Graduate Committee to substitute a more advanced (e.g., 800-level) course on the same topic for one of these required courses.

B. One additional graduate level course (3 credits) in mathematics or numerical methods. The student makes this selection with the documented approval of the Department's Graduate Committee, which has the authority to decide on acceptable courses.

C. One additional graduate level course (3 credits) in Mechanical Engineering. Three credits of MEEG 868 Research can be used toward this requirement. The student makes this selection with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

D. Three additional graduate level courses (9 credits) in engineering, mathematical, physical or biological sciences or business and economics. The student makes these selections with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

II. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's course grades in: MEEG 610 Intermediate Solid Mechanics; MEEG 620 Intermediate Dynamics; MEEG 630 Intermediate Fluid Mechanics; MEEG 640 Intermediate Heat Transfer; and MEEG 690 Intermediate Engineering Mathematics.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

PH.D. in MECHANICAL ENGINEERING

The Ph.D. program in Mechanical Engineering consists of the Ph.D. Qualifier Examination as specified in Section III below, 33 credits of graduate level course work plus 9 credits of Doctoral Dissertation. The Ph.D. program is designed to allow for considerable flexibility in course selection and specialization of study. Course work must be completed with a cumulative grade point average of 3.0 or higher (see Graduate Catalog for relevant details). In addition, the student must pass a Candidacy Examination prior to completing the dissertation requirements. The Ph.D. should be obtainable in four years of full-time study after entering the program. There is no foreign language or teaching requirement for the Ph.D.

I. Course Requirements

A. At least four courses (12 credits) at the 600 or higher level in Mechanical Engineering (MEEG)

B. At least three courses (9 credits) at the 800 level.

C. At least one course (3 credits) in mathematics (other than MEEG690).

D. 9 credits of MEEG 969 Doctoral Dissertation.

An individual course can be used to meet more than one of the requirements A, B or C provided the total number of credits is at least 33. MEEG 868 cannot be used toward these requirements.

Students will submit a proposed course plan to the Dissertation Committee at the time of their candidacy exam. Upon approval, it will enter into the candidate's file. Deviations from the proposed plan must be approved by the Dissertation Committee. A copy of the course plan must be sent to the University Office of Graduate Studies.

II. Dissertation Requirements

A dissertation is required which demonstrates the student's ability to conduct independent research. A Dissertation Committee is selected by the advisor and approved by the Department Chairperson. This committee will also serve as the student's Candidacy Examination Committee. At least three Mechanical Engineering Department faculty members and at least one faculty member from another department will serve on the Dissertation Committee. The Committee will be chaired by the research advisor, who must be a regular full-time member of the Department of Mechanical Engineering Faculty. During the course of the research, the student will periodically review progress with the Committee.

The student must orally present the dissertation before the Dissertation Committee at an open defense. The student shall supply final draft copies of the dissertation to members of the Committee at least two weeks before the oral defense. The dissertation must meet the academic and professional standards set forth by the University.

III. Qualifying Examination

The purpose of the qualifying examination is to assess the aptitude of a doctoral student in the early stages of the program. A student must be enrolled in the Ph.D. program, have a minimum GPA of 3.2 and a minimum of 12 graduate coursework credits to complete the qualifying exam.

The qualifying exam will consist of three parts

a) a research aptitude exam based on the student's research interest area
b) one math exam (based on the content in MEEG 690)
c) one mechanical engineering topic exam (based on undergraduate-level mechanical engineering and the content in one of the core courses, MEEG 610, MEEG 620, MEEG 630, MEEG 640)

Part a) will be offered between the end of the first semester and the end of the second semester of study and will:

i) Include a 2-3 page report reviewing and summarizing typically 3 or 4 published peer reviewed journal articles from the literature, in the student's research interest area. The journal articles will be selected by the student's advisor and no more than one of them shall have been authored by the advisor.
ii) Include a 20 minute oral presentation of the above described report, followed by a period of questioning related to the selected papers.
iii) Be graded by a committee of at least three faculty members, including the student's research advisor and two other faculty members, not advising the student, appointed by the department chair. The criteria for grading will be established by the faculty and provided to the student ahead of the exam.

Parts b) and c) will be written exams, offered in early June and must be taken at the first opportunity after the completion of 12 graduate coursework credits toward the Ph.D.

In judging student performance on this examination, the faculty has three options: (i) outright passing, (ii) giving a second chance, and (iii) outright failing. If the student is given a second chance, the faculty will specify the parameters for taking and passing the second chance exam. These decisions will be made in a faculty meeting held as soon as possible following the grading of the exams. There will be no third chance given. A student who ultimately fails the Qualifying Examination is not eligible to continue in the Ph.D. program, but may apply to change his/her matriculation to the MSME program.

IV. Candidacy Examination

The Ph.D. Candidacy Examination must be taken within one and a half years of successful completion of the Qualifying Examination and at least one year prior to the dissertation defense. The student will prepare a comprehensive, written research proposal and defend it orally before the Candidacy Examination Committee (the composition of which is specified in II). The Candidacy Examination is intended to test the student's ability to synthesize knowledge in the formulation of an independent research proposal. Performance is judged by the Candidacy Examination Committee, and any additional requirements they wish to impose must be satisfied before the student is admitted to candidacy. Additional requirements could include, but are not limited to: taking additional course work, modifying the written research proposal, and defending the revised proposal before the Candidacy Examination Committee. Satisfactory completion of any additional requirements must be approved by the student's Candidacy Examination Committee.

NOTE: Students already enrolled in the Ph.D. program can choose to switch to the new guidelines, or continue under the current guidelines.

V. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's performance on the written Ph.D. Qualifying exam.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

B. The student will demonstrate the ability to conduct, present and defend graduate-level research including literature review, motivation, methodology utilized, results, unique contributions, and conclusions generated.

> Direct assessment: Student learning relative to this outcome is assessed by the quality of the written dissertation and performance in the dissertation defense.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

C. The student will demonstrate the ability to propose and present relevant graduate-level research including the description of importance of a problem, a literature review of potential topics where unique contributions can be made and anticipated methodology.

> Direct assessment: Student learning related to this outcome is assessed by performance on the Candidacy Examination.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

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GRADUATE PROGRAM

Mechanical Engineering
~~2011-2012~~2012-2013

Mission Statement

The Department of Mechanical Engineering at the University of Delaware offers masters and doctoral degree programs geared toward preparing students for leadership positions in industry, government, and academia. The curriculum for the master's degree is rooted in the fundamentals of mechanical engineering but allows for some flexibility through elective courses. The department offers a research-oriented master's degree with thesis (MSME) and a coursework-only degree (MEM). Recognizing that technology and research is rapidly becoming more cross-disciplinary, the doctoral program (Ph.D.) in the department provides significant flexibility and the ability to tailor one's program to meet the challenges of a broad array of research environments. In addition, the department offers a direct Ph.D. program without the requirements of a master's degree and the ability to accommodate students with backgrounds in mathematics, physics and other engineering disciplines into the program.

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3. A minimum of at least three letters of strong support from former teachers or supervisors.
4. A minimum combined Quantitative and Verbal score of 308 (1200) ~~in~~ on the Graduate Record Examination Aptitude Test.
5. A minimum score of 600 ~~(or IBT equivalent) in~~on the Test of English as a Foreign Language, at least 250 on the computer-based TOEFL, or at least 100 on the IBT with a speaking score of 20~~for students whose first language is not English~~. This test is not required of students whose first language is English and who have received an undergraduate or post-graduate degree from a College or University in which English is the sole language of instruction.

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

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Advisement

A temporary academic advisor is assigned to new students when they are admitted to the Department. Students select their permanent advisor once they become familiar with the department, and clear about their research interests. The permanent advisor will be someone whose interest matches the interest of the student insofar as possible. For students on Research Assistantships, the advisor directs their research and advises them on course selection.

MASTER of SCIENCE in MECHANICAL ENGINEERING (MSME)

The Master of Science in Mechanical Engineering (MSME) program consists of 24 credit hours of graduate level coursework, plus 6 credits of Master's Thesis. Coursework must be completed with a grade point average of 3.0 or higher (see Graduate Catalog for relevant details). The requirements are designed both to provide a balanced program in Mechanical Engineering and to allow for a degree of specialization. Students should be able to complete all degree requirements, including the thesis, in 18 to 24 months of full-time study.

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A. The following four courses are required (12 credits):

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- Three from the following list:
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    - MEEG 640 Intermediate Heat Transfer
    - MEEG 683 Orthopedic Biomechanics

Students may petition the Graduate Committee to substitute a more advanced (e.g., 800-level) course on the same topic for one of these required courses.

B. One additional graduate level course (3 credits) in mathematics or numerical methods. The student makes this selection with the documented approval of the Department's Graduate Committee, which has the authority to decide on acceptable courses.

C. Three additional elective graduate level courses (9 credits) in engineering or mathematical, physical or biological sciences. The student makes these selections with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

D. At least one semester of MEEG 600 Seminar (0 credits). Special arrangements can be made for part-time students to fulfill this requirement.

~~D~~E. 6 credits of MEEG 869 Master's Thesis.

II. Thesis Requirements

A thesis is required which demonstrates the student's ability to conduct scholarly research. Entering graduate students are expected to choose a thesis advisor and research topic during their first semester in the Department so that they can initiate research and choose appropriate elective courses.

At the completion of the thesis research, candidates for the MSME degree must defend their thesis orally to a committee of at least three faculty members. The committee will be chaired by the thesis advisor who, along with at least one other committee member, must be regular full-time faculty in the Department of Mechanical Engineering. The thesis is to be submitted to committee members at least two weeks in advance of the defense and shall meet the academic

and professional standards set forth by the University. Upon acceptance of the thesis, the Committee recommends approval to the Department Chairperson.

III. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's course grades in: MEEG 610 Intermediate Solid Mechanics; MEEG 620 Intermediate Dynamics; MEEG 630 Intermediate Fluid Mechanics; MEEG 640 Intermediate Heat Transfer; and MEEG 690 Intermediate Engineering Mathematics.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

B. The student will demonstrate the ability to conduct, present and defend graduate-level research including literature review, motivation, methodology utilized, results, unique contributions, and conclusions generated.

> Direct assessment: Student learning relative to this outcome is assessed by the quality of the written master's thesis and performance in the thesis defense.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

MASTER OF ENGINEERING: MECHANICAL (MEM)

The Master of Engineering: Mechanical (MEM) program consists of 30 credit hours of graduate level coursework. Coursework must be completed with a grade point average of 3.0 or higher (see Graduate Catalog for relevant details). The requirements are designed to provide a general program and to allow for some concentration of study within Mechanical Engineering. It will be possible to complete this program taking courses in the late afternoon, early evening, and/or in a distance format.

Engineering Outreach can help facilitate part-time graduate education. This degree is not available to students who have been enrolled in the MSME degree program.

I. Course Requirements

A. The following five courses are required (15 credits):

- MEEG 690 Intermediate Engineering Mathematics
- Four from the following list:
    - MEEG 610 Intermediate Solid Mechanics
    - MEEG 620 Intermediate Dynamics
    - MEEG 630 Intermediate Fluid Mechanics
    - MEEG 640 Intermediate Heat Transfer
    - MEEG 683 Orthopedic Biomechanics

Students may petition the Graduate Committee to substitute a more advanced (e.g., 800-level) course on the same topic for one of these required courses.

B. One additional graduate level course (3 credits) in mathematics or numerical methods. The student makes this selection with the documented approval of the Department's Graduate Committee, which has the authority to decide on acceptable courses.

C. One additional graduate level course (3 credits) in Mechanical Engineering. Three credits of MEEG 868 Research can be used toward this requirement. The student makes this selection with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

D. Three additional graduate level courses (9 credits) in engineering, mathematical, physical or biological sciences or business and economics. The student makes these selections with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

II. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's course grades in: MEEG 610 Intermediate Solid Mechanics; MEEG 620 Intermediate

Dynamics; MEEG 630 Intermediate Fluid Mechanics; MEEG 640 Intermediate Heat Transfer; and MEEG 690 Intermediate Engineering Mathematics.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

PH.D. in MECHANICAL ENGINEERING

The Ph.D. program in Mechanical Engineering consists of ~~the Ph.D. Qualifier Examination as specified in Section III below,~~ 33 credits of graduate level course work plus 9 credits of Doctoral Dissertation. The Ph.D. program is designed to allow for considerable flexibility in course selection and specialization of study. Course work must be completed with a cumulative grade point average of 3.0 or higher (see Graduate Catalog for relevant details). In addition, the student must pass the Qualifying Examination, ~~a~~ Candidacy Examination and fulfill the teaching requirement prior to completing the dissertation requirements. The Ph.D. should be obtainable in four years of full-time study after entering the program. There is no foreign language ~~or teaching~~ requirement for the Ph.D.

I. Course Requirements

A. At least four courses (12 credits) at the 600 or higher level in Mechanical Engineering (MEEG)

B. At least three courses (9 credits) at the 800 level.

C. At least one course (3 credits) in mathematics (other than MEEG690).

D. At least three semesters of MEEG 600 Seminar (0 credits). Special arrangements can be made for part-time students to fulfill this requirement.

~~D~~E. 9 credits of MEEG 969 Doctoral Dissertation.

An individual course can be used to meet more than one of the requirements A, B or C provided the total number of credits is at least 33. MEEG 868 cannot be used toward these requirements.

Students will submit a proposed course plan to the Dissertation Committee at the time of their candidacy exam. Upon approval, it will enter into the candidate's file. Deviations from the proposed plan must be approved by the Dissertation Committee. A copy of the course plan must be sent to the University Office of Graduate Studies.

II. Dissertation Requirements

A dissertation is required which demonstrates the student's ability to conduct independent research. A Dissertation Committee is selected by the advisor and approved by the Department Chairperson. This committee will also serve as the student's Candidacy Examination Committee. At least three Mechanical Engineering Department faculty members and at least one faculty member from another department will serve on the Dissertation Committee. The Committee will be chaired by the research advisor, who must be a regular full-time member of the Department of Mechanical Engineering Faculty. During the course of the research, the student will periodically review progress with the Committee.

The student must orally present the dissertation before the Dissertation Committee at an open defense. The student shall supply final draft copies of the dissertation to members of the Committee at least two weeks before the oral defense. The dissertation must meet the academic

and professional standards set forth by the University.

III. Qualifying Examination

The purpose of the qualifying examination is to assess the aptitude of a doctoral student in the early stages of the program. A student must be enrolled in the Ph.D. program, have a minimum GPA of 3.2 and a minimum of 12 graduate coursework credits to complete the qualifying exam.

The qualifying exam will consist of three parts

a) a research aptitude exam based on the student's research interest area
b) one math exam (based on the content in MEEG 690)
c) one mechanical engineering topic exam (based on undergraduate-level mechanical engineering and the content in one of the core courses, MEEG 610, MEEG 620, MEEG 630, MEEG 640)

Part a) will be offered between the end of the first semester and the end of the second semester of study and will:

i) Include a 2-3 page report reviewing and summarizing typically 3 or 4 published peer reviewed journal articles from the literature, in the student's research interest area. The journal articles will be selected by the student's advisor and no more than one of them shall have been authored by the advisor.
ii) Include a 20 minute oral presentation of the above described report, followed by a period of questioning related to the selected papers.
iii) Be graded by a committee of at least three faculty members, including the student's research advisor and two other faculty members, not advising the student, appointed by the department chair. The criteria for grading will be established by the faculty and provided to the student ahead of the exam.

Parts b) and c) will be written exams, offered in early June and must be taken at the first opportunity after the completion of 12 graduate coursework credits toward the Ph.D.

In judging student performance on this examination, the faculty has three options: (i) outright passing, (ii) giving a second chance, and (iii) outright failing. If the student is given a second chance, the faculty will specify the parameters for taking and passing the second chance exam. These decisions will be made in a faculty meeting held as soon as possible following the grading of the exams. There will be no third chance given. A student who ultimately fails the Qualifying Examination is not eligible to continue in the Ph.D. program, but may apply to change his/her matriculation to the MSME program.

IV. Candidacy Examination

The Ph.D. Candidacy Examination must be taken within one and a half years of successful completion of the Qualifying Examination and at least one year prior to the dissertation defense. The student will prepare a comprehensive, written research proposal and defend it orally before the Candidacy Examination Committee (the composition of which is specified in II). The Candidacy Examination is intended to test the student's ability to synthesize knowledge in the formulation of an independent research proposal. Performance is judged by the Candidacy Examination Committee, and any additional requirements they wish to impose must be satisfied before the student is admitted to candidacy. Additional requirements could include, but are not

limited to: taking additional course work, modifying the written research proposal, and defending the revised proposal before the Candidacy Examination Committee. Satisfactory completion of any additional requirements must be approved by the student's Candidacy Examination Committee.

V. Teaching Requirement

The ability to communicate effectively is an essential skill for all PhD graduates. Therefore, all PhD students are required to fulfill a teaching requirement, which consists of serving as a Teaching Assistant (TA) for one or two semesters, depending on the assignment. Students are expected to continue to be actively involved in their research while serving as a TA.

International graduate students are required to take International Teaching Assistant (ITA) training through the University's English Language Institute (ELI) prior to their first semester as a graduate student. Training and assessment are part of the University's requirements for the proficiency of international TA's. A final decision on how to resolve any deficiency is made by the Graduate Program Coordinator in consultation with the student's thesis advisor and the Department Chair.

Teaching Assistant positions are assigned by the Graduate Curriculum Chair in advance for the upcoming semester. Students are encouraged to submit their preferences for specific TA positions early to facilitate the process. Although every effort is made to satisfy these requests, students should recognize that this might not be possible in all cases. In addition, the educational needs of the Department may require the Graduate Curriculum Chair to ask students to fill specific TA positions.

NOTE: Students already enrolled in the Ph.D. program can choose to switch to the new guidelines, or continue under the current guidelines.

~~V~~VI. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

Direct assessment: Student learning relative to this outcome is assessed by the student's performance on the written Ph.D. Qualifying exam.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

B. The student will demonstrate the ability to conduct, present and defend graduate-level research including literature review, motivation, methodology utilized, results, unique contributions, and conclusions generated.

Direct assessment: Student learning relative to this outcome is assessed by the quality of the written dissertation and performance in the dissertation defense.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

C. The student will demonstrate the ability to propose and present relevant graduate-level research including the description of importance of a problem, a literature review of potential topics where unique contributions can be made and anticipated methodology.

Direct assessment: Student learning related to this outcome is assessed by performance on the Candidacy Examination.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

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GRADUATE PROGRAM

Mechanical Engineering
2012-2013

Mission Statement

The Department of Mechanical Engineering at the University of Delaware offers masters and doctoral degree programs geared toward preparing students for leadership positions in industry, government, and academia. The curriculum for the master's degree is rooted in the fundamentals of mechanical engineering but allows for some flexibility through elective courses. The department offers a research-oriented master's degree with thesis (MSME) and a coursework-only degree (MEM). Recognizing that technology and research is rapidly becoming more cross-disciplinary, the doctoral program (Ph.D.) in the department provides significant flexibility and the ability to tailor one's program to meet the challenges of a broad array of research environments. In addition, the department offers a direct Ph.D. program without the requirements of a master's degree and the ability to accommodate students with backgrounds in mathematics, physics and other engineering disciplines into the program.

Admission to Program

Students are admitted into the graduate program for either a Master's or a doctoral, Ph.D., degree. For students with a bachelor's degree in engineering the following minimum criteria will normally be applied:

1. A baccalaureate degree in mechanical engineering or in a closely related field of science or mathematics.
2. An undergraduate grade point average in engineering, science and mathematics courses of at least 3.0 on a 4.0 scale.
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Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

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The acceptance of applicants who have already received a Master's degree in engineering will be based on the above minimum criteria and the results of their graduate work.

Advisement

A temporary academic advisor is assigned to new students when they are admitted to the Department. Students select their permanent advisor once they become familiar with the department, and clear about their research interests. The permanent advisor will be someone whose interest matches the interest of the student insofar as possible. For students on Research Assistantships, the advisor directs their research and advises them on course selection.

MASTER of SCIENCE in MECHANICAL ENGINEERING (MSME)

The Master of Science in Mechanical Engineering (MSME) program consists of 24 credit hours of graduate level coursework, plus 6 credits of Master's Thesis. Coursework must be completed with a grade point average of 3.0 or higher (see Graduate Catalog for relevant details). The requirements are designed both to provide a balanced program in Mechanical Engineering and to allow for a degree of specialization. Students should be able to complete all degree requirements, including the thesis, in 18 to 24 months of full-time study.

I. Course Requirements

A. The following four courses are required (12 credits):

- MEEG 690 Intermediate Engineering Mathematics
- Three from the following list:
    - MEEG 610 Intermediate Solid Mechanics
    - MEEG 620 Intermediate Dynamics
    - MEEG 630 Intermediate Fluid Mechanics
    - MEEG 640 Intermediate Heat Transfer
    - MEEG 683 Orthopedic Biomechanics

Students may petition the Graduate Committee to substitute a more advanced (e.g., 800-level) course on the same topic for one of these required courses.

B. One additional graduate level course (3 credits) in mathematics or numerical methods. The student makes this selection with the documented approval of the Department's Graduate Committee, which has the authority to decide on acceptable courses.

C. Three additional elective graduate level courses (9 credits) in engineering or mathematical, physical or biological sciences. The student makes these selections with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

D. At least one semester of MEEG 600 Seminar (0 credits). Special arrangements can be made for part-time students to fulfill this requirement.

E. 6 credits of MEEG 869 Master's Thesis.

II. Thesis Requirements

A thesis is required which demonstrates the student's ability to conduct scholarly research. Entering graduate students are expected to choose a thesis advisor and research topic during their first semester in the Department so that they can initiate research and choose appropriate elective courses.

At the completion of the thesis research, candidates for the MSME degree must defend their thesis orally to a committee of at least three faculty members. The committee will be chaired by the thesis advisor who, along with at least one other committee member, must be regular full-time faculty in the Department of Mechanical Engineering. The thesis is to be submitted to committee members at least two weeks in advance of the defense and shall meet the academic

and professional standards set forth by the University. Upon acceptance of the thesis, the Committee recommends approval to the Department Chairperson.

III. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's course grades in: MEEG 610 Intermediate Solid Mechanics; MEEG 620 Intermediate Dynamics; MEEG 630 Intermediate Fluid Mechanics; MEEG 640 Intermediate Heat Transfer; and MEEG 690 Intermediate Engineering Mathematics.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

B. The student will demonstrate the ability to conduct, present and defend graduate-level research including literature review, motivation, methodology utilized, results, unique contributions, and conclusions generated.

> Direct assessment: Student learning relative to this outcome is assessed by the quality of the written master's thesis and performance in the thesis defense.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

MASTER OF ENGINEERING: MECHANICAL (MEM)

The Master of Engineering: Mechanical (MEM) program consists of 30 credit hours of graduate level coursework. Coursework must be completed with a grade point average of 3.0 or higher (see Graduate Catalog for relevant details). The requirements are designed to provide a general program and to allow for some concentration of study within Mechanical Engineering. It will be possible to complete this program taking courses in the late afternoon, early evening, and/or in a distance format.

Engineering Outreach can help facilitate part-time graduate education. This degree is not available to students who have been enrolled in the MSME degree program.

I. Course Requirements

A. The following five courses are required (15 credits):

- MEEG 690 Intermediate Engineering Mathematics
- Four from the following list:
    - MEEG 610 Intermediate Solid Mechanics
    - MEEG 620 Intermediate Dynamics
    - MEEG 630 Intermediate Fluid Mechanics
    - MEEG 640 Intermediate Heat Transfer
    - MEEG 683 Orthopedic Biomechanics

Students may petition the Graduate Committee to substitute a more advanced (e.g., 800-level) course on the same topic for one of these required courses.

B. One additional graduate level course (3 credits) in mathematics or numerical methods. The student makes this selection with the documented approval of the Department's Graduate Committee, which has the authority to decide on acceptable courses.

C. One additional graduate level course (3 credits) in Mechanical Engineering. Three credits of MEEG 868 Research can be used toward this requirement. The student makes this selection with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

D. Three additional graduate level courses (9 credits) in engineering, mathematical, physical or biological sciences or business and economics. The student makes these selections with the documented approval of the department's Graduate Committee, which has the authority to decide on acceptable courses.

II. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's course grades in: MEEG 610 Intermediate Solid Mechanics; MEEG 620 Intermediate

Dynamics; MEEG 630 Intermediate Fluid Mechanics; MEEG 640 Intermediate Heat Transfer; and MEEG 690 Intermediate Engineering Mathematics.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

PH.D. in MECHANICAL ENGINEERING

The Ph.D. program in Mechanical Engineering consists of 33 credits of graduate level course work plus 9 credits of Doctoral Dissertation. The Ph.D. program is designed to allow for considerable flexibility in course selection and specialization of study. Course work must be completed with a cumulative grade point average of 3.0 or higher (see Graduate Catalog for relevant details). In addition, the student must pass the Qualifying Examination, Candidacy Examination and fulfill the teaching requirement prior to completing the dissertation requirements. The Ph.D. should be obtainable in four years of full-time study after entering the program. There is no foreign language requirement for the Ph.D.

I. Course Requirements

A. At least four courses (12 credits) at the 600 or higher level in Mechanical Engineering (MEEG)

B. At least three courses (9 credits) at the 800 level.

C. At least one course (3 credits) in mathematics (other than MEEG690).

D. At least three semesters of MEEG 600 Seminar (0 credits). Special arrangements can be made for part-time students to fulfill this requirement.

E. 9 credits of MEEG 969 Doctoral Dissertation.

An individual course can be used to meet more than one of the requirements A, B or C provided the total number of credits is at least 33. MEEG 868 cannot be used toward these requirements.

Students will submit a proposed course plan to the Dissertation Committee at the time of their candidacy exam. Upon approval, it will enter into the candidate's file. Deviations from the proposed plan must be approved by the Dissertation Committee. A copy of the course plan must be sent to the University Office of Graduate Studies.

II. Dissertation Requirements

A dissertation is required which demonstrates the student's ability to conduct independent research. A Dissertation Committee is selected by the advisor and approved by the Department Chairperson. This committee will also serve as the student's Candidacy Examination Committee. At least three Mechanical Engineering Department faculty members and at least one faculty member from another department will serve on the Dissertation Committee. The Committee will be chaired by the research advisor, who must be a regular full-time member of the Department of Mechanical Engineering Faculty. During the course of the research, the student will periodically review progress with the Committee.

The student must orally present the dissertation before the Dissertation Committee at an open defense. The student shall supply final draft copies of the dissertation to members of the Committee at least two weeks before the oral defense. The dissertation must meet the academic and professional standards set forth by the University.

III. Qualifying Examination

The purpose of the qualifying examination is to assess the aptitude of a doctoral student in the early stages of the program. A student must be enrolled in the Ph.D. program, have a minimum GPA of 3.2 and a minimum of 12 graduate coursework credits to complete the qualifying exam.

The qualifying exam will consist of three parts

a) a research aptitude exam based on the student's research interest area
b) one math exam (based on the content in MEEG 690)
c) one mechanical engineering topic exam (based on undergraduate-level mechanical engineering and the content in one of the core courses, MEEG 610, MEEG 620, MEEG 630, MEEG 640)

Part a) will be offered between the end of the first semester and the end of the second semester of study and will:

i) Include a 2-3 page report reviewing and summarizing typically 3 or 4 published peer reviewed journal articles from the literature, in the student's research interest area. The journal articles will be selected by the student's advisor and no more than one of them shall have been authored by the advisor.
ii) Include a 20 minute oral presentation of the above described report, followed by a period of questioning related to the selected papers.
iii) Be graded by a committee of at least three faculty members, including the student's research advisor and two other faculty members, not advising the student, appointed by the department chair. The criteria for grading will be established by the faculty and provided to the student ahead of the exam.

Parts b) and c) will be written exams, offered in early June and must be taken at the first opportunity after the completion of 12 graduate coursework credits toward the Ph.D.

In judging student performance on this examination, the faculty has three options: (i) outright passing, (ii) giving a second chance, and (iii) outright failing. If the student is given a second chance, the faculty will specify the parameters for taking and passing the second chance exam. These decisions will be made in a faculty meeting held as soon as possible following the grading of the exams. There will be no third chance given. A student who ultimately fails the Qualifying Examination is not eligible to continue in the Ph.D. program, but may apply to change his/her matriculation to the MSME program.

IV. Candidacy Examination

The Ph.D. Candidacy Examination must be taken within one and a half years of successful completion of the Qualifying Examination and at least one year prior to the dissertation defense. The student will prepare a comprehensive, written research proposal and defend it orally before the Candidacy Examination Committee (the composition of which is specified in II). The Candidacy Examination is intended to test the student's ability to synthesize knowledge in the formulation of an independent research proposal. Performance is judged by the Candidacy Examination Committee, and any additional requirements they wish to impose must be satisfied before the student is admitted to candidacy. Additional requirements could include, but are not limited to: taking additional course work, modifying the written research proposal, and defending the revised proposal before the Candidacy Examination Committee. Satisfactory completion of

any additional requirements must be approved by the student's Candidacy Examination Committee.

V. Teaching Requirement

The ability to communicate effectively is an essential skill for all PhD graduates. Therefore, all PhD students are required to fulfill a teaching requirement, which consists of serving as a Teaching Assistant (TA) for one or two semesters, depending on the assignment. Students are expected to continue to be actively involved in their research while serving as a TA.

International graduate students are required to take International Teaching Assistant (ITA) training through the University's English Language Institute (ELI) prior to their first semester as a graduate student. Training and assessment are part of the University's requirements for the proficiency of international TA's. A final decision on how to resolve any deficiency is made by the Graduate Program Coordinator in consultation with the student's thesis advisor and the Department Chair.

Teaching Assistant positions are assigned by the Graduate Curriculum Chair in advance for the upcoming semester. Students are encouraged to submit their preferences for specific TA positions early to facilitate the process. Although every effort is made to satisfy these requests, students should recognize that this might not be possible in all cases. In addition, the educational needs of the Department may require the Graduate Curriculum Chair to ask students to fill specific TA positions.

NOTE: Students already enrolled in the Ph.D. program can choose to switch to the new guidelines, or continue under the current guidelines.

VI. Learning Outcomes and Assessment

A. The student will demonstrate the ability to apply graduate-level mathematics to the solution of engineering problems in at least two of the general areas of solid mechanics, fluid mechanics, dynamics and heat transfer.

> Direct assessment: Student learning relative to this outcome is assessed by the student's performance on the written Ph.D. Qualifying exam.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

B. The student will demonstrate the ability to conduct, present and defend graduate-level research including literature review, motivation, methodology utilized, results, unique contributions, and conclusions generated.

> Direct assessment: Student learning relative to this outcome is assessed by the quality of the written dissertation and performance in the dissertation defense.
>
> Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.

C. The student will demonstrate the ability to propose and present relevant graduate-level

research including the description of importance of a problem, a literature review of potential topics where unique contributions can be made and anticipated methodology.

Direct assessment: Student learning related to this outcome is assessed by performance on the Candidacy Examination.

Indirect assessment: A current and updated employment listing will serve as indirect evidence of student attainment of the learning goal.