Engineering Faculty Document No. *79-16*
Date

To: The Faculty of the College of Engineering
From: Eric A. Nauman, Director, Engineering Honors Program
Subject: *New Course:* ENGR 16100 – Honors Creativity and Innovation in Engineering Design I and ENGR 16200 – Honors Creativity and Innovation in Engineering Design II

We are proposing a modification to the 141/142 sequence which currently integrates Engineering Design and Computer Science so that it integrates the material from Physics 172 with Engineering Design concepts. The philosophy of the two course sequences are the same, but the changes to the course content are substantial enough that it requires a new set of course numbers. The proposed course sequence would begin in Fall 2017.

ENGR 16100 – Honors Creativity and Innovation in Engineering Design I
First Year Course, Fall Semester
Sem. 1, Lecture/Studio, Cr. 4
Prerequisite: Honors Standing or Approval from Director of Engineering Honors

Course description: This course introduces students to the engineering profession using physics-based, multidisciplinary, societally relevant content. Students develop engineering approaches to systems, generate and explore creative and innovative ideas, and use of computational methods to support design decisions. In particular, the students will develop the ability to model and investigate physical systems at the microscopic and macroscopic levels with a focus on material interactions. Design challenges and projects will explore a wide range of natural phenomena experimentally and computationally (utilizing Matlab and Python) and engage students in innovative thinking across the engineering disciplines at Purdue. Students experience the process of design and analysis in engineering including how to work effectively in teams. Students also develop skills in project management, engineering fundamentals, oral and graphical communication, logical thinking, and modern engineering tools.

ENGR 16200 – Honors Creativity and Innovation in Engineering Design II
First Year Course, Spring Semester
Sem. 2, Lecture/Studio, Cr. 4
Prerequisite: ENGR 16100

This course continues building on the foundation developed in ENGR 14100. Students take a more in-depth and holistic approach to integrating multiple disciplines perspectives while constructing innovative engineering solutions to open-ended problems. The students continue to explore more complicated models of physical systems, especially gases, fluids, and statistical thermodynamics. The students extend and continue to develop skills in project management, engineering fundamentals, oral and graphical communication, logical thinking, teamwork, and modern engineering tools (e.g. Matlab, and Python).

Reasons: The original version of ENGR 141/142 successfully integrated engineering design and computer science for a total 7 credits over the course of the first year. It provided First Year Engineering credit for engineering design (131/132) and served as the science selective. As mandated by the ELT and ECC, it will no longer count for the science selective as of Fall 2016. This revision will instead integrate engineering design and Physics 172, a course required by all first year engineering students. The modified version of the course will provide credit for engineering design (131/132) and Physics 172. As a result, it will count for 4 credits in the Fall Semester and 4 credits in the Spring Semester (8 credits total). The proposed versions will be re-numbered 161/162 and will replace the content relating to the C and LabView programming languages with Physics content.

These two courses are proposed as a 4.0 credit combining lecture and studio hours. The courses use discussion, activities, demonstrations, and laboratory experiments to introduce students to fundamental engineering concepts. Studio experience is desirable because we will employ design challenges, use of a variety of computer tools, and extended exercises that do not typically fit into traditional lecture or laboratory time patterns to extend the students' knowledge and capabilities. Ultimately the goal is to create an environment that is student/learning-centric rather than teacher/metric-centric.

Students successfully completing the two courses, from a knowledge perspective, have a combined exposure to concepts presented in ENGR 131/132 (4 credit hours) and PHYS 172 (4 credit hours). The emphasis on modeling, experimental validation, and design provides an excellent foundation for students entering their second year. Therefore, the 4 credit hours for each course provides students with the equivalent of 8 credit hours after successfully completing ENGR 162.

Eric A. Nauman, Professor
Director, Engineering Honors Program 3/20/2016
(Requested by)___________________(Date)____
Title

Learning Outcomes for Proposed ENGR 161/162

(Highlighted sections are outcomes that will be introduced, numbers in parentheses indicate emphasis level with a total of 4 credits * 16 weeks = 64 credit-weeks per semester)

ENGR 161

1. Discuss the engineering education process, courses, and options, explain and compare engineering job functions and roles, and use this information to prepare a moderately well-informed course of study for academic and career success (3).
2. Employ academic and career success strategies including managing your personal learning approach, using time management techniques, and demonstrating a personal growth mindset to thoughtfully pursue course activities and the course as a whole (2).
3. Plan and implement systematic design processes using formal engineering management and design tools such as work breakdown structures and House of Quality to design innovative products and systems (6).
4. Investigate and decompose systems in order to design and construct mathematical or computer models that can be employed to better understand or control the systems (6).
5. Describe a wide range of physical phenomena using a few fundamental physical laws (12).
6. Learn how to implement a unified approach that relates microscopic behavior to macroscopic behavior. These include mechanical theories based on particle, spring, and material models (10).
7. Model natural phenomena using computer simulations (5).
8. Demonstrate professional communication skills in the areas of technical writing to produce engineering reports, in presentations to convey engineering evidence and findings verbally and graphically to audiences, and in interpersonal communication to work with other members of the class (2).
9. Work alongside individuals with diverse backgrounds, utilizing the team environment to learn interdependently, give and demand accountability, and accomplish engineering tasks, while recognizing teaming as an open-ended problem that needs to be actively managed and reflected upon (3).
10. Evaluate engineering problems to reach evidence-based conclusions, drawing upon one or more sources of information and data interpretation skills including interpolation, regression, curve fitting, statistics, and data cleaning (5).
11. Incorporate the consideration of engineering ethics, including social, safety, and sustainability issues into instances of engineering thinking and engineering problem

solving so that the broader impacts of engineering work are evaluated and accounted for (3).

12. Apply fundamental engineering skills and knowledge relating to units, dimensions, estimation, visualization, significant digits, and the problem presentation method to engineering applications (2).
13. Display proficiency in the applications of engineering content knowledge including basic statistics (5).

ENGR 162

1. Utilize knowledge of the engineering education process, courses, and options, and engineering job functions and roles to prepare a final course of study for academic and career success (3).
2. Develop a unified approach to microscopic and macroscopic behavior of gases and fluids, especially the use of statistics and quantized atomic levels to motivate basic thermodynamic theories (10).
3. Apply the unified approach to material interactions to a broad array of applications including asteroids, black holes, nuclear fission and fusion, quantization in atoms and molecules, and heat capacity (7).
4. Model natural phenomena using computer simulations (7).
5. Integrate engineering ethics, including social, safety, and sustainability issues into engineering thinking and engineering problem solving to ensure that the broader impacts of engineering work are consistently evaluated and accounted for (3).
6. Display proficiency in the applications of engineering content knowledge including statistics, statics, mechanics of materials, the universal accounting equation, electrical theory, and design of experiments (8).
7. Employ academic and career success strategies including managing your personal learning approach, using time management techniques, and seeking opportunities for self-improvement to thoughtfully pursue course activities and the course as a whole (2).
8. Plan and implement systematic design processes using formal project management and design tools such as work breakdown structures and House of Quality to design innovative products and systems (2).
9. Investigate and decompose systems in order to design and construct mathematical or computer models that can be employed to better understand or control the systems (6).

10. Analyze and translate problems into algorithms composed of logical constructs and be able to create programming-language-independent system charts and flow diagrams embodying those algorithms (5).
11. Demonstrate professional communications skills in the areas of technical writing, presentations, and interpersonal communication to produce engineering reports, convey engineering findings and evidence in writing, verbally, and graphically to readers or audiences, and to work with other members of the class (3).
12. Work alongside individuals with diverse backgrounds in teams, learn interdependently in the team environment, give and demand accountability, and accomplish engineering tasks, while recognizing teaming as an open-ended problem that needs to be actively managed and reflected upon (3).
13. Investigate engineering problems to reach evidence-based conclusions, drawing upon one or more sources of information and data interpretation skills including interpolation, regression, curve fitting, statistics, and data cleaning (3).
14. Apply fundamental engineering skills and knowledge relating to units, dimensions, estimation, spatial reasoning, graphical representation, significant digits, and the problem presentation method to engineering challenges (2).

Supplemental Documentation

Approval from the Head of the Physics Department to count the ENGR 161/162 sequence as completion of PHYS 172.

PURDUE
UNIVERSITY

DEPARTMENT OF PHYSICS AND ASTRONOMY

JOHN P. FINLEY
HEAD

March 8, 2016

Dear Dean Jamieson and Associate Dean Harris,

I would like to offer my support for the proposed modification to ENGR 141/142. Per our discussions with Dr. Nauman, it is our understanding that the course will integrate the content from Physics 172 with Engineering Design concepts over a two semester sequence (4 credits per semester) as described in the attached document.

Dr. Nauman has been interacting primarily with Drs. Hirsch and Haugan who will oversee the development and integration of the content. The students who complete both courses will receive credit for Physics 172 through the Physics department. Students who only complete ENGR 141 will be expected to take Physics 172 separately.

It is our understanding that the course will be offered for at least three years in order to properly evaluate its successful features and those that need continued improvement. We are excited to move forward on this collaborative educational effort.

Sincerely,

John P. Finley
Head, Department of Physics and Astronomy

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Draft of ENGR 161/162 Syllabus

ENGR 161 - Topics

Week	Monday	Wednesday	Friday
1	Orientation and Design Challenge 1 (Ratiometer)	AFL Presentation, Reflection on DC 1, Definition of Engineering, Team 1	Team Assignments, Teaming 2, CoC, Peer Mentors
2	Algorithmic Thinking, Flowcharting, Systems Thinking, Functional Block Diagrams	Exploring Matter, Scalars, and Vectors – Active Learning	Introduction to computing for the engineer and Linux ACT. Project 1
3	Approximation, estimation, validation (Modeling and Science). What are gravitational waves and how are they measured?	Python 1 ACT – Introduction, Calculating Dot products, projections, and cross products.	Forces and moments across length scales. Project 1
4	Design Project Management, Gantt charts,	Python 2 ACT	Velocity, Momentum, Forces, Peer Mentors
5	Newton's 3 laws	Systems, Free Body Diagrams, Translating FBD to equations	Python 3 ACT – Fundamental interactions across length scales.
6	Finding Goals, Requirements, Specifications and Metrics	Introduction to Project 2	Brainstorming and Morph Charts
7	FBDs and alternative energy	Python 4 ACT – Contact Interactions	**Exam 1**
8	Evidence-Based Decision Making (House of Quality)	Python 5 ACT – Computational Modeling Design Challenge (Engineering disasters - Kursk)	DC2 – Computational Modeling Sub-problem.
9	Analysis tools: data cleaning, selected points, least squares, nonlinear fits	Famous experiments in Physics	Descriptive statistics Peer Mentors
10	Programming Challenge – Obtaining data from the Mass Spectrometer	Descriptive Statistics, Regression and goodness of fit. Analyzing the results from the mass spectrometer	Introduction to Statistics, reasoning with data challenge (Just in Time Manufacturing), Distributions
11	Normality, Central Tendency, Standard Normal Distribution, Histograms	Standard normal distribution, diagnosing normality, qualitative features	Rate of change of momentum, cylindrical polar coordinates
12	Physics and the planets	**Exam 2**	Energy Principles – 1
13	Energy Principles – 2	Energy Principles – 3	Design Challenge
14	Famous experiments in Physics	Physics of Superheroes	In class experiment – Speed of Sound in fluids and solids
15	Engineering Disasters	Statistics Practice	Project 2 Feedback and Open Project Time
16	Work on Projects	Project 2 Presentations	Class Reflections, Exit Survey

ENGR 162 - Topics

Week	Monday	Wednesday	Friday
1	Introduction, Review of statistics.	Matlab 1	Energy Review, Peer Mentors
2	Sampling Issues and Opportunities, Peer Mentors	Matlab 2 – Computational review of scalars, vectors, Physics of baseball/softball	Design Challenge 1
3	Introduction to hypothesis testing	Matlab 3	Energy – general formula, how it relates to power
4	Confidence Intervals	Matlab 4	Internal energy - 1
5	P-values and examples	Matlab 5	Internal energy - 2 (Laboratory experiment)
6	Difference of Means	Matlab 6	Energy quantization
7	Design considerations – ethics, culture	Design Challenge	**Exam 1**
8	Multiparticle systems – macroscale motions and kinetic energy	Matlab 7	Multiparticle systems – friction and the real world
9	Collisions – elastic and inelastic	Collisions – scattering and statistics – finding the nucleus	Collisions in the laboratory
10	Angular momentum 1	Angular momentum 2	Project 2 – water storage
11	Project 2 – water storage	Project 2 – water storage	Project 2 – water storage
12	Project 2 – water storage	**Exam 2**	Entropy 1 – introduction and laboratory experiment
13	Entropy 2 – quantum computing	Entropy in gases, fluids, solids, and biological systems	Introduction to gases – mean free path
14	Introduction to engines	Design challenge	Efficiency and entropy
15	Famous experiments in Physics	Newton, Einstein, and Turing	Mass Spectrometry
16	Project Work Time	Project 3 presentation	Exit Survey, Reflection, Moving speeches