October 15, 2024

Proposal to establish the B.S. in Engineering Physics

We propose to take the current Applied Physics B.S. program, reduce the overall credit hours and rename it to Engineering Physics. The principles behind this revised degree program is to provide a fundamental physics education with an applied focus that provides students the background to step into an industrial R&D career where a knowledge of engineering principles is of value. The Physics core consists of 41 credits including one semester each of upper division classical mechanics, electrodynamics, statistical physics, and quantum mechanics along with laboratory courses in electronics and instrumentation, advanced physics, and computational physics. In addition the program requires an engineering core of 15 credits which is designed to provide an engineering base of solid and fluid mechanics, control systems, signal processing, and design.

MMAE	202 – Mechanics of Solids	Fall, Spring, Summer
MMAE	232 – Design for Innovation	Fall, Spring
MMAE	313 – Fluid Mechanics	Fall, Spring, Summer
ECE	308 – Signals and Systems	Fall, Spring, Summer
ECE	438 – Control Systems	Fall, Spring, Summer

The program is completed with 9 credits of Engineering Electives and 6 credits of Technical Electives for a total of 125 credit hours.

Engineering Electives

BME	309 – Biomedical Imaging	Fall
BME	422 – Mathematical Methods for Biomedical Engineers	Fall
BME	433 – Biomedical Engineering Applications of Statistics	Fall
BME	438 – Neuroimaging	Spring
ECE	403 – Digital Data and Communications Systems	Fall
ECE	408 – Introduction to Computer Networks	Fall, Spring
ECE	437 – Digital Signal Processing I	Fall
ECE	447 - Artificial Intelligence and Edge Computing[1]	
MMAE	302 – Advanced Mechanics of Solids	Fall
MMAE	320 – Thermodynamics[2]	Fall, Spring, Summer
MMAE	323 – Heat and Mass Transfer[3]	Spring
MMAE	485 – Manufacturing Processes	Fall
CAE	286 – Theory and Concept of Structural Mechanics[4]	Fall, Summer
CAE	287 – Mechanics of Structural Materials	Spring, Summer
CAE	312 – Engineering Systems Analysis	Spring
CAE	419 – Introduction to Transport Engineering	Fall
CAE	470 – Construction Methods and Cost Estimating	Fall, Spring

Technical Electives – can be chosen from Engineering courses above, 400 level Physics courses, or other courses which provide prerequisites for Engineering courses not listed above.

[1] Has not been offered in AY23 or AY24

[2] May be needed as prerequisite

[3] Consent of instructor or MMAE 320

[4] Prerequisite for other CAE courses

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B.S. in Engineering Physics – Sample Curriculum

Semester 1			Semester 2		
PHYS 100	Introduction to the Profession	2	PHYS 221	General Physics II	4
PHYS 123	General Physics I	4	MS 201	Materials Science	3
CHEM 124	Principles of Chemistry I	4	MATH 152	Calculus II	5
MATH 151	Calculus I	5	HUM 10x	Introductory Humanities	3
		15			**15**
Semester 3			**Semester 4**		
PHYS 223	General Physics III for Physics	4	PHYS 304	Statistical Physics & Thermo.	3
CS 105	Intro. to Computer Programming	2	MATH 252	Differential Equations	4
MATH 251	Multivariate & Vector Calculus	4	MMAE 232	Design for Innovation	3
MMAE 202	Mechanics of Solids	3	HUM/SS	Elective	3
HUM/SS	Elective	3	HUM/SS	Elective	3
		16			**16**
Semester 5			**Semester 6**		
PHYS 308	Classical Mechanics I	3	PHYS 240	Computational Science	3
PHYS 300	Instrumentation Laboratory	4	ECE 308	Signals & Systems	3
PHYS 301	Mathematical Methods	3		Engineering Elective	3
MMAE 313	Fluid Mechanics	3	IPRO	Interprofessional Project	3
Engineering Elective		3	HUM/SS	Elective	3
		16			**15**
Semester 7			**Semester 8**		
PHYS 405	Quantum Theory I	3		Engineering Elective	3
PHYS 413	Electricity & Magnetism I	3		Technical Elective	3
PHYS 427	Advanced Physics Lab. I	3	PHYS 485	Physics Colloquium	1
ECE 438	Control Systems	3	IPRO	Interprofessional Project	3
Technical Elective		3	HUM/SS	Elective	3
PHYS 485	Physics Colloquium	3	HUM/SS	Elective	3
		16			**16**
Total B.S. In Engineering Physics					**125**

This sample program distributes the Engineering Core over 5 semesters and equally among Fall and Spring. All the Engineering Core courses can be taken in both Fall and Spring and most also in the Summer terms.

The Engineering and Technical Electives are distributed in both Fall and Spring terms and there are many choices available which fit this distribution. Given the flexibility of the Engineering Core offerings, the Summer term may be used to obtain more options for the Engineering and Technical Electives.

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Learning Objectives

Desired learning outcomes for the program are enumerated below. Upon completion of the program, a successful student will be able to:

1. Demonstrate understanding of **classical mechanics** by being able to solve problems (at an advanced undergraduate level), including problems involving
    a. Newtonian mechanics
    b. Conservation laws
    c. Lagrangian and Hamiltonian mechanics
    d. Stress, strain & shear
    e. Incompressible and turbulent flow

    Relevant Courses: PHYS-123, PHYS-308, MMAE-202, MMAE-313

2. Demonstrate understanding of **electricity & magnetism** by being able to solve problems (at an advanced undergraduate level) including problems involving
    a. Electrostatics
    b. Magnetostatics
    c. Electrodynamics

    Relevant Courses: PHYS-221, PHYS-413,

3. Demonstrate understanding of **quantum mechanics** by being able to solve problems (at an advanced undergraduate level) including problems involving
    a. Bound states and/or scattering in simple one-dimensional potentials
    b. Atomic physics (e.g. the hydrogen atom)
    c. The quantum theory of angular momentum and spin

    Relevant Courses: PHYS-223, PHYS-405,

4. Demonstrate understanding of **thermal and statistical physics** by being able to solve problems (at an advanced undergraduate level) including problems involving
    a. The laws of thermodynamics
    b. The connection between microscopic physics and thermodynamic properties
    c. Boltzmann, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distributions

    Relevant Courses: PHYS-223, PHYS-304

5. Model physical systems using advanced **mathematics** and apply mathematical techniques correctly. This will involve students becoming proficient in
    a. Algebra, trigonometry, and precalculus
    b. Single and multivariable calculus
    c. Linear algebra
    d. Differential equations
    e. Complex analysis

    Relevant Courses: PHYS-301, perhaps PHYS-308, PHYS-405, PHYS-413

6. Design, write, execute, and troubleshoot **computational** code which may model physical phenomena or perform data analysis. This will involve students being familiar with
    a. Scientific computing languages and tools, including Python, Mathematica, and Octave/MATLAB
    b. Algorithms and tools to solve algebraic or differential equations numerically, and to perform numerical integration
    c. The treatment of numerical errors.
    d. Standards for documentation of computer code in the discipline

    Relevant Courses: PHYS-240, perhaps PHYS-308, PHYS-405, PHYS-413

7. Demonstrate the ability to **design and instantiate mechanical systems and scientific experiments**. To this end, a student will need to be familiar with
    a. Tools for design including isometric sketching, mechanical drawing and CAD
    b. The ability to work in a team to design and build mechanical systems
    c. Modern experimental instrumentation and fabrication methods
    d. Techniques to troubleshoot their apparatus
    e. Analysis methods, including the incorporation and interpretation of experimental errors.
    f. Standards for scientific and engineering communication in the discipline

    Relevant Courses: MMAE-232, PHYS-427, perhaps PHYS-123, PHYS-221, PHYS-223, MMAE-202

8. Demonstrate understanding of **control systems and signals** by being able to solve problems (at an advanced undergraduate level) including problems involving
    a. Time and frequency domain representation and analysis of continuous and discrete time signals
    b. Sampling and sampling theory
    c. Fourier series convolution, transfer functions and Fourier, Laplace and Z-transforms
    d. Signal-flow graphs and block diagrams
    e. Types of feedback control, transient response and time domain design

    Relevant Courses: ECE-308, ECE-438, perhaps PHYS-300, PHYS-301