December 2, 2005

TO: The Faculty of the College of Engineering

FROM: The Faculty of the Department of Engineering Education and The First-Year Engineering Curriculum Committee

SUBJECT: Change in Physics Course Requirement for the First-Year Engineering Program.

The Faculty of the Department of Engineering Education and the First-Year Engineering Curriculum Committee have approved adopting a new physics course (PHYS 172) to replace PHYS 152 in the First-Year Engineering Curriculum for the First-Year Engineering program. This action is now submitted to the Engineering Faculty with a recommendation for approval to take effect for beginning students entering the program fall 2006 and thereafter.

A description of proposed course is provided along with reasons for said changes.

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Department of Engineering Education

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE COMMITTEE ON
FACULTY RELATIONS

CFR Minutes 1015

date 2/17

chairman CFR Robert E Montgomery

Current:

PHYS 152 Mechanics
Sem.1 and 2. SS. Class 4, lab.2, cr. 4. Prerequisite or corequisite: MA 162 or equivalent.

Statics, uniform and accelerated motion; Newton's laws; circular motion; energy, momentum, and conservation principles; dynamics of rotation; gravitation and planetary motion; hydrostatics and hydrodynamics; simple harmonic motion; wave motion and sound.

Proposed:

PHYS 172 Modern Mechanics
Sem.1 and 2. SS. Class 3, lab.2, cr. 4. Prerequisite or corequisite: MA 161 or equivalent.

Introductory calculus-based physics course using fundamental interactions between atoms to describe Newtonian mechanics, conservation laws, energy quantization, entropy, the kinetic theory of gases, and related topics and mechanics and thermodynamics. Emphasis is on using only a few fundamental principles to describe physical phenomena extending from nuclei to galaxies. 3-D graphical simulations and numerical problem solving by computer are employed by the student from the very beginning.

Reason:

This physics course will allow the use of research-proven best instructional practices and to closely couple the lecture and laboratory components of the course, thus, making both more effective, in a way that is not possible in PHYS 152. By teaching Newtonian physics in the context of modeling real physical systems students should acquire knowledge that they can transfer to and use effectively in new scientific and engineering contexts. Research has shown that traditional introductory physics curricula typically do not impart such knowledge. The Department of Physics faculty have already approved and adopted this course for their own students.

To understand and to predict the structure and the behavior of real physical systems physicists construct models of the systems from elementary building blocks whose behavior are governed by a small number of fundamental principles. In this course students learn how to model real mechanical and thermal systems as systems of interacting particles governed by the momentum, the energy and the angular momentum principles (Newton's laws of motion) and by the fundamental principle of statistical mechanics. Mechanics and thermal physics are unified by modeling the atomic structure of macroscopic systems.

The course explicitly addresses the approximations and idealizations involved in making usable models of real physical systems. It also develops the vector and calculus concepts needed to build and to use them. This latter content supports and enriches co-requisite mathematics courses. Computer-based modeling skills are developed throughout the course, using 3-D graphical simulations and powerful numerical approaches to problem-solving.

Supporting Documentation:

1. Level: Undergraduate – freshman year
2. Course Instructor: Variable and multiple
3. Course Outline:

Topics in Order	Lectures
The nature of matter, detecting interactions, Newton's 1st law of motion	1
Describing motion (3d vectors), velocity, momentum	2
Rate of change of momentum, force, momentum principle (Newton's 2nd law)	1
Elementary applications of the momentum principle (modeling simple systems)	1
Fundamental forces, gravity, electrostatics, Newton's 3rd law	1
Applying the momentum principle: statics, gravitating systems, circular motion and momentum conservation	2
First mid-term exam	
The atomic structure of matter, elasticity, spring-mass systems	2
Work, rest and kinetic energies of particles, potential energy	1
The energy principle and applications (modeling simple systems)	2
Energy in macroscopic systems, thermal energy and energy dissipation	2
Energy quantization, emission and absorption line spectra	2
Second mid-term exam	
Applications of the momentum and energy principles to model complex systems	2
Collisions, conservation of momentum, elastic and inelastic collisions	2
Angular momentum, the angular momentum principle	1
Applications of the momentum, energy and angular momentum principles to model complex systems	2
Third mid-term exam	
A statistical mechanics model of solids, entropy	2
Temperature and heat capacity	1
The Boltzmann distribution, equipartition	1
Kinetic theory of gases, particle mean free path, pressure and temperature	1
Final examination	

4. Text: Matter & Interactions, Volume 1: Modern Mechanics, Ruth Chabay, Bruce Sherwood, John Wiley & Sons, 2002.
5. Grading: based on homework, laboratories, computational projects, and examinations.

Overview of Lab for the Matter and Interaction Mechanics Course (PHYS 172)

The weekly laboratory session is tightly linked to the material presented in lecture and to the student homework for that week. The typical laboratory session consists of a short experiment, a computational modeling of the experiment, and the solving of associated analytical problem on a whiteboard (small group problem solving). The experiments provide hands-on examples of the material being studied. They use both simple and computerized data acquisition techniques. A highly visual computer modeling language is used where the students can easily enter the appropriate physics (e.g., use Newton's laws to predict the momentum) and see the object move in accordance with the physics they inserted. The graphical commands are essentially transparent to the students. Small groups of students solve problems on whiteboards that are associated with the experiment and the homework due that week. Below is a list of the lab activities planned for this course with short descriptions of each activity.

Lab #1. Vectors and VPython

- Vectors and Vector Operations
- Overview of graphical software modeling language VPython

Lab #2 Motion and Modeling

- Measuring the position, velocity and acceleration of an object using computerized data acquisition
- Analyzing and modeling the motion using the Momentum principle (or Newton's laws)

Lab #3 Gravity and Moon Voyage

- Cavendish experiment for measuring the force of gravity on ordinary objects and finding the universal gravitational constant G
- Motion with a nonconstant force: modeling a voyage to the Moon
- Whiteboard problems on the momentum principle

Lab #4: The Ball-Spring Model of Matter

- Measuring the spring constant and period of a mass on a coiled spring
- Measuring Young's Modulus of copper and the spring constant of a straight copper wire and calculating the interatomic spring constant for a Ball-Spring model of Matter (the interatomic spring constant is used for subsequent thermodynamic exercises)

Lab #5: Modeling Spring Oscillations

- Modeling a Block Hanging from a Spring
- Analytical solution of mass on spring

Lab #6: Momentum and Energy of a Bouncing Ball

- Measuring, analyzing, and modeling the momentum and energy of a Bouncing Ball

Lab #7: Energy on a Moon Voyage

- Modeling a system with kinetic and potential energy (nonconstant force)
- Whiteboard problems on the energy principle

Lab #8: Energy, Power, Internal Energy

- Students climb a ladder and the energy principle is used to find the change in the student's internal energy and the power expended. Comparison of choosing two different systems to analyze problem (i.e., student alone, student plus earth). Distinction between work and potential energy.
- Whiteboard problems on the energy principle

Lab #9: Real and Point Particle Systems

- Students jump and the jump is analyzed using the energy principle and momentum principle. Different information can be found via analyzing the real system or the point particle (center of mass) description of the system. Summarizes the use of the energy and momentum principle.
- Quantized energy: measurement and prediction of atomic spectra

Lab #10: Collisions: Rutherford Scattering

- Conservation of energy and momentum in a collision. Model of collision of alpha particle with gold nucleus (gives information about atomic structure).
- Whiteboard problems on collisions

Lab #11: Angular Momentum, Torques, Moment of Inertia

- Measurement of torques, angular momentum and moment of inertia of students and other apparatus on a rotating platform. Conservation of angular momentum is seen in a complex rotating system.
- Modeling of a falling yo-yo and whiteboard problem of the Hovering Yo-Yo

Lab #12: Entropy and Temperature

- Einstein's model of a solid (3D quantized harmonic oscillators): ways of distributing energy between two solid blocks. Finding entropy and, in particular, the arrangement with maximum entropy of this two solid system.
- Use model to calculate the temperature of an aluminum block as a function of its thermal energy.
- Whiteboard problem combining energy, angular momentum, and heat capacity

Lab #13: Specific Heat

- Computer model to calculate specific heat as a function of temperature for Aluminum and Lead.
- Comparison to experimental data for Aluminum and Lead
- Measurement of specific heat of water

Lab #14 Review for Final Exam

- Whiteboard problems on various topics