Engineering Physics

Objectives:	00UV	**Discipline:**	Physics
Ponderation:	3-2-3	**Course Code:**	203-BZE-05
Prerequisite:	00UR (*Mechanics*)	**Course Credit:**	2 2/3
Corequisite:	00UP (*Calculus II*)	**Semester:**	4

Introduction

Engineering Physics is a Science Option course designed for final semester students intending to pursue their studies in one of the pure or applied physical sciences. The course will both extend the students' knowledge of Mechanics to some of the subtler aspects of rotational motion and also apply their knowledge of basic Mechanics to a variety of different phenomena. These latter will include fluid mechanics, statics as applied to trusses, frames and three-dimensional equilibrium problems. Also considered are strength-related properties of materials and the internal stresses and strains of members subjected to tensile and compressive forces as well as beams for which shear force and bending moment diagrams are covered as are both bending stresses and shear stresses.

An important feature of all modern scientific work is the universal presence of computers used to gather and analyze data as well as in modelling various physical phenomena. To help students to thrive in this new environment, a series of spreadsheet sessions are scheduled in which the students learn to analyze data and to model solutions for several dynamics problems **-** free fall subject to turbulent damping, the construction of elliptic integrals to describe a falling rod and the solution to a truss problem. The students also perform experiments in which the data are gathered by computer. The data are then analyzed using spreadsheets **-** including differentiation, integration and smoothing of numerical data. Finally, some elements of programming are incorporated in the course via the construction of algorithms in spreadsheets as well as in creating procedures in the Maple symbolic mathematics program.

Some of the learning activities in *Engineering Physics* will contribute to the attainment of objective 00UU and are marked **[00UU]**.

In the Science Program, *Engineering Physics* contributes to the following program goals described in the *Exit Profile*:

	Goals of the Science Program	**Performance Criteria**
1.	To master the knowledge and skills of a basic scientific education	00UV, 00UU
2.	To master the knowledge and skills of a basic general education	
3.	To apply the experimental method	3.1 – 3.5
4.	To take a systematic approach to problem solving	4.1 – 4.6
5.	To use the appropriate data-processing technology	5.1, 5.2, 5.4, 5.5
6.	To reason logically	6.1 – 6.4
7.	To communicate effectively	7.1, 7.3 – 7.6
8.	To learn in an autonomous manner	8.1 – 8.3
9.	To work as members of a team	9.1 – 9.3
10.	To recognize the links between science, technology and the evolution of society	10.1 – 10.3
11.	To construct a personal system of values	11.2, 11.3
12.	To identify the context in which scientific ideas originated and evolved	
13.	To display attitudes and behaviour compatible with the scientific spirit and method	13.1 –13.5
14.	To apply acquired knowledge and skills to new situations	14.1

Objectives and Standards for *Engineering Physics*

In the following chart, italicized items marked with (*) are optional enrichment items which will not be evaluated in the final exam (these are not the only possible enrichment items — they are the most commonly used ones).

OBJECTIVE	STANDARD	LEARNING OBJECTIVES
Course Objective	**Achievement Context**	
To analyze different physical situations and phenomena of interest to engineers and scientists using the fundamental laws of Mechanics and to use computers to model various phenomena and to gather data in pertinent experiments.	1. In theoretical situations, working individually to solve problems taken from a standard college-level Physics textbook 2. In experimental settings, in the lab, working individually or in a group, with the aid of a laboratory write-up, or of scientific documentation, to write lab reports	
	General Performance Criteria	
	1. Appropriate use of concepts, laws and principles 2. Adequate diagrams to represent physical situations 3. Use of appropriate terminology and units 4. Use of vector techniques where appropriate 5. Graphical and mathematical representations of motion 6. Justification of the steps taken in analyzing a situation 7. Rigorous application of Newton's Laws and the conservation principles 8. Critical judgment of results 9. Interpretation of the limits of model 10. Submission of laboratory reports written in accordance with established norms	

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
1. To analyze a wide variety of rotational phenomena using the concepts of dynamics and energy	1.1. Analysis of the rotation of a rigid body about a fixed axis	1.1.1. Derive the laws describing rotation of a rigid body about a fixed axis. 1.1.2. Calculate moments of inertia and apply the parallel-axis theorem. 1.1.3. Use the concepts of work and energy in rotational motion. 1.1.4. Determine the moment of inertia of a compound pulley in the laboratory by direct measurement as well as by dynamically by measuring the motion of the system using a smart pulley.
	1.2. Analysis of the vector properties of rotational quantities	1.2.1. Describe the rationale for using vector notions in rotational motion. 1.2.2. Use the concept of angular momentum in the solution of dynamics problems. 1.2.3. Explain and use the law of conservation of angular momentum. 1.2.4. Discuss precession.
	1.3. Analysis of rolling motion	1.3.1. Use Newton's laws to solve problems in rolling motion. 1.3.2. Use energy concepts in solving problems involving skidding and rolling motion.
2. To analyze problems in fluid statics and dynamics	2.1. Precise use of the concepts, laws and terminology basic to the understanding of hydrostatic pressure to solve problems of interest	2.1.1. Derive Pascal's Principle from the variation of pressure with depth within a fluid and apply it to oceans and atmospheres. 2.1.2. Use Pascal's Principle to solve problems. 2.1.3. Describe the functioning of a hydraulic lift in terms of Pascal's Principle. **[00UU]** 2.1.4. Explain buoyancy as a consequence of the variation of pressure with depth. **[00UU]** 2.1.5. Use the concept of buoyancy to derive Archimedes' Principle. 2.1.6. Use Archimedes' Principle to solve problems of interest.
	2.2. Application of the conservation of energy to the derivation of Bernoulli's Principle and use of it and the equation of continuity to describe the motion of fluids	2.2.1. Apply the equation of continuity and Bernoulli's Principle to derive the following results and use them to solve problems: **[00UU]** • Torricelli's law for the velocity of efflux • aerodynamic lift • the Venturi effect and its application in Venturi meters and carburetors • the Pitot tube for the determination of velocities of fluid flow
3. To analyze problems in static equilibrium in two- and three dimensions	3.1. Recognition and classification of the basic kinds of loads and supports	3.1.1. Identify the number of unknown forces associated with various kinds of supports. 3.1.2. Analyze problems involving both concentrated and distributed loads. 3.1.3. Use free-body diagrams systematically in the analysis of equilibrium problems.
	3.2. Rigorous solution of truss problems under a variety of loading conditions	3.2.1. Identify and understand the significance of two- and three-force members. 3.2.2. Use the method of joints to solve for the forces in all the members of a

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
		truss. 3.2.3. Use the method of sections to solve for the forces in specific members of a truss.
	3.3. Rigorous solution for the forces exerted by the connections in frames under a variety of loading conditions	3.3.1. Identify two-force members to simplify the solution of frame problems 3.3.2. Use the method of members to solve frame problems
	3.4. Rigorous application of the concepts of static equilibrium to three-dimensional problems	3.4.1. Use direction cosines in the analysis of problems involving cables and rods. 3.4.2. Visualize and correctly represent three-dimensional problems diagrammatically. 3.4.3. Set up and solve the equations (up to six) of equilibrium in three-dimensional problems.
4. To analyze the behaviour of materials under tensile and compressive loads	4.1. Detailed description of the elastic properties of materials; and their use in the laboratory	4.1.1. Apply the concepts of axial stress and strain in the solution of two-force member problems. 4.1.2. Describe the concepts of elastic modulus, Poisson ratio, proportional limit, yield point and the difference between ductile and brittle materials. 4.1.3. Relate the bulk modulus to the elastic modulus and the Poisson ratio. 4.1.4. Determine in the laboratory the elastic modulus of various metals.
	4.2. Precise use of the concepts listed above in the solution of problems	4.2.1. Calculate deformations and design members able to satisfy constraints on maximum stress and/or deformation. **[00UU]** 4.2.2. State and use the generalized Hooke Law. 4.2.3. Describe the properties of thin-walled pressure vessels and solve design problems for them. **[00UU]**
5. To analyze and solve problems involving beams under a variety of loading conditions	5.1. Rigorous application of the concepts of shear force and bending moment to the solution of beam problems	5.1.1. Derive the differential relations between shear force and bending moment and between shear force and distributed load. 5.1.2. Solve for the functional dependence of the shear force and bending moment for different loading and support conditions. 5.1.3. Construct shear force and bending moment diagrams. 5.1.4. Find the points of maximum bending moment and of inflection in any given problem.
6. To analyze the internal stresses and strains in beams under a variety of loading conditions	6.1. Detailed analysis of bending (tensile/compressive) stresses and strains in loaded beams	6.1.1. Use the concepts of neutral axis, centroid and area moment of inertia in solving beam problems. 6.1.2. Derive the relation between bending stresses and bending moments and use it to derive the distribution of stress both horizontally and vertically throughout a loaded beam for various loadings. 6.1.3. Solve design problems involving beams subject to maximum bending stresses. **[00UU]** 6.1.4. Study in the laboratory the horizontal and vertical stress distributions

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
		in simply-supported and cantilever beams.
	6.2. Analysis of shear stresses in beams	6.2.1. Appreciate the necessity of horizontal (complementary) shear to satisfy the constraints of static equilibrium. 6.2.2. Analyze the horizontal and vertical distribution of shear in beams under various loading conditions and study the effect of beam cross-sectional shape on the maximum shear stress in beams.
7. To gain enhanced proficiency in the use of computers in a scientific context	7.1. Familiarity with the uses of a spreadsheet program (Excel) in application to a variety of scientific problems	7.1.1. Use spreadsheets to fit curves of experimental data obtained in experiments performed in the course. **[00UU]** 7.1.2. Use spreadsheets to solve ordinary differential equations arising in physical problems. **[00UU]** 7.1.3. Use spreadsheets in the solution of a truss problem allowing variation of the loads and to represent the forces in the various members of the truss by means of bar graphs. **[00UU]** 7.1.4. Use of the Maple symbolic mathematics environment to create programming procedures.. **[00UU]**
	7.2. Facility in the use of the data gathering capabilities of computers	7.2.1. Use the computer in conjunction with a smart pulley in order to study the motion of a mass plus compound pulley system to allow for a dynamic determination of the moment of inertia of the pulley. **[00UU]** 7.2.2. Use the computer to gather data on vibrational motion of two different systems using two different sensors: a potentiometer for the motion of a pendulum and a piezoelectric accelerometer for the vibrations of a bar. **[00UU]** 7.2.3. Use the spreadsheet skills acquired earlier in the course to differentiate the position data obtained for the pendulum above and to integrate the acceleration data obtained for the bar above; smoothing techniques are applied in the first step once the problems arising in differentiating experimental data are recognized. **[00UU]**

Methodology

Engineering Physics is presented in a series of lectures, labs and demonstrations. Emphasis is placed on developing a thorough understanding of the principles introduced in the course and facility in the setting up and solving of problems. Differential and integral calculus, vector techniques and differential equations are used extensively as problem solving tools. Students are required to apply intelligently the basic laws of physics to a wide range of phenomena of significant interest in engineering. Spread sheet sessions, held in the computer lab, require students to model physical phenomena and to analyze experimental data.