SEF 530 Fundamentals Principles of Physical Science
Stevens Institute of Technology

School: **Engineering and Science**

Course Title: **Fundamental Principles of Physical Science**

Program(s): **Science & Engineering Foundations for Education (SEFE)**
Interdisciplinary

Proposed Course # or Level: **SEF530**

Catalog Description:

This course is the first in a series of five graduate courses for the Science & Engineering Foundations for Education Graduate Certificate Program, designed to engage students in understanding scientific explanations, generating scientific evidence, reflecting on scientific knowledge and participating productively in science through contemporary issues in which science and engineering play a paramount role. A key component of this course is to connect the introduced concepts to the student's real world experience by using simple experiments or analogies to well-known systems.

The course introduces students to the fundamental principles of physical science and provides the foundation for further and deeper understanding of the key issues in global energy production and consumption, global climate change and the engineering of solutions to the problems arising from these phenomena. As the concepts of energy and energy transformations are at the core of this course. To underline the generality of these concepts, mechanic and electrical forces will be first introduced and then parallel the idea of Energy for both simultaneous introduced. Hence the transformation concept is directly generalized to discuss phenomena from the atomic scale to the global scale.

Course Objectives: (This section should provide a description of what students will get out of the course beyond the course itself – i.e., how it will prepare them for their profession, or how the course fits in with the overall curriculum of the program(s) that the course belongs to.)

After completing the course the students, who are in-service elementary and middle school teachers, will be able to apply their content knowledge as well as the fundamental tools of scientific reasoning and practice to the concepts and analysis of real world issues, including the extent to which anthropogenic activities are impacting global change.

This course and the successive courses in the series will prepare the students, from both the perspective of content knowledge as well as pedagogical content knowledge, to bring a rich science and engineering perspective to their curriculum and classroom activities for the benefit of their students.

List of Course Outcomes: The following Course Outcomes are based on the *Understanding By Design* framework that was utilized in the development of this course. Upon completion of SEF 530, participants will have the following:

Enduring Understandings: After SEFE 530 participants will understand that:

- Motion can be categorized in few simple categories (no force / constant force / varying force) and can be described qualitatively and quantitatively using simple models.
- One object can undergo several independent motions at the same time, which can be separated from each other (Mechanical Superposition).
- Models allow us to predict the future and analyze reasons for motion
- Analogy can be applied between gravity and electric force.
- Flow of electricity is governed by resistance and electrical forces.
- Electricity and magnetism are connected through the motion of charges.
- There are three general types of energy (potential, kinetic, and dissipative).
- Energy transfer can be characterized by source, transfer and result.
- Energy transformations follow "similar" rules, but not identical.
- Energy does not get lost.

Essential Questions: After SEFE 530 participants will keep considering:

- Is there a motion that could not be categorized or mathematical described?
- How many (overlapping) motions can an object undergo at the same time?
- Is there a limit to predicting future motion? Are we all "mechanical clockworks"?
- Can you build a mechanical analogy to a PC (or other modern electrical equipment) and how would you do it?
- Where does the analogy between electricity and gravity stop and why is this important?
- How and how much can you charge an object and can you charge all objects?
- How can the total resistance of a circuit be controlled?
- How can you classify an energy form and how would you prove it?
- Is there an unclassifiable (unpredictable) energy and how would it look like?
- Where does energy come from and where does in go in "daily" activities?

Acquisition of Knowledge: After SEFE 530 participants will know:

- All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion.
- An unbalanced force acting on an object changes its speed or direction of motion, or both.
- Motion can be categorized in few simple categories (no force / constant force / varying force)
- The change in motion (direction or speed) of an object is proportional to the applied force and inversely proportional to the mass.
- A charged object can be charged in two ways, which we call either positively or negatively charged. Two objects, depending on their charges, will attract or repel each other.
- Electrical circuits require a complete loop through which an electrical current can pass.
- The flow of current in an electric circuit depends upon the components of the circuit and their arrangement, such as in series or parallel. Electricity flowing through an electric circuit produces magnetic effects in the wires.

- Magnetic forces are very closely related to electric forces and are thought of as different aspects of a single electromagnetic force. Moving electrically charged objects produces magnetic forces and moving magnets produces electric forces.
- Motion appears in different forms and can be transformed within a system. Motion energy is associated with speed of an object, gravitational potential energy with distance compared to the reference point, elastic energy with stretching and compressing of an elastic object, and electrical energy with electric current and circuit.
- Many forms of energy can be considered to be either kinetic energy, which is the energy of motion, or potential energy, which depends on the separation between mutually attracting or repelling objects.
- Energy can be transferred from one system to another in different ways: thermally, mechanically, electrically, and by electromagnetic waves.

Acquisition of Skills: After SEFE 530 participants will be able to:

- Model and explain how the description of an object's motion from one observer's view may be different from another observer's view.
- Categorize motion in few simple groups (no force / constant force / varying force)
- Describe, measure and predict motion and forces qualitatively (diagrams, pictures, words) and/or quantitatively (graphs, mathematical equations).
- Use computer software to compare motions of different objects acted on by balanced or unbalanced forces.
- Use simple circuits involving batteries and motors to compare and predict the current flow with different circuit arrangements.
- Predict and confirm the brightness of a light when given the number or size of batteries, circuit arrangements.
- Predict and calculate the current /voltage distribution in a simple circuit
- Use qualitative (e.g. energy-bar charts) and quantitative (mathematical equations) techniques to describe and account for the energy transformations.
- Use online simulations to compare the various forms of energy.

Prerequisites:[1] Students must be part of CIESE's NSF funded PISA[2] program cohort for the initial offering of this course. Alternative prerequisites will be developed at the end of the PISA[2] program so that the courses may be offered for general use.

Cross-listing: N/A — show cross-listed course number(s)

Grading Percentages: HW ☒ (25%) Class work ☒ (25%) Mid-term ☐

Final ☒ (25%) Projects ☒ (25%)

Other ☐ (specify both percent and kind of work)

Credits: ☒ 3 credits ☐ Other

For Graduate Credit toward Degree or Certificate

☒ Yes ☐ No ☐ Not for Dept. Majors ☒ Other

Textbook(s) or References

Physics Matters: An Introduction to Conceptual Physics by James Trefil and Robert Hazen with WileyPlus online homework content, John Wiley, 2004. We will also make extensive use of online resources such as ActivPhysics and PhET.

Mode of Delivery ☒Class ☒Online ☐Modules ☐Other

Program/Department Ownership: Science and Engineering Foundations

When first offered: Summer 2012

Department Point of Contact and Title: Rainer Martini, Department of Physics and Engineering Physics

Date approved by individual school and/or department curriculum committee: 5/21/2010 (Graduate Curriculum Committee) Course Revised: 3/2012

Sample Syllabus:

General: The course consists of an intensive summer session with ten days of 5-7 hours face to face class sessions and 5 days of online coursework. Textbook exercises and directed reading taken from the popular press will be utilized. In addition, students will be expected to collaborate on a course project. The face to face course sessions will be an opportunity for students to connect with the science concepts through hands-on investigation, discussion and sharing of ideas and research findings, and showcasing pedagogical approaches for teaching the content.

Shown below is a 10 day schedule of classes with one week of online learning.

	Topic(s)	Reading(s)	Class exercises	HW
Face-to-face Session 1	Force and Motion: 1D motion and its classification		Recording video and analysis of different 1dimensional motions	Additional *Excel* examples will be assigned
Face-to-face Session 2	Force and Motion: 2D motion and idea of force		Video analysis of motion in 2 dimension; modeling of projectile motion	Elementary quantitative exercises
Face-to-face Session 3	Force and Motion: multiple motions, multiple forces, Hook's law	There will be some in class time devoted to readings	Comparison of "Rocket" or spring propelled objects	

Face-to-face Session 4	Electrostatic - Charge, electric force, comparison to gravitational forces		Qualitative and quantitative examination of electrical forces	
Face-to-face Session 5	Electricity and Magnetism - current, Ohm's law, Resistance, serial and parallel circuits		Simple circuits, serial and parallel circuits	
Online Session	Following the intensive summer session the break will consist of reading and problem assignments: 1. student are charged to record multiple motions in the real world, characterize their motion and identify which one are good examples to showcase the relationships mentioned in the NJCCS. Furthermore the students develop an optimal recording situation and have to design a class using the selected motion. (CTS) 2. Identify examples out of the real life experience which demonstrate the analogy between mechanical and electrical force and motion and design again a class which showcases this analogy for one specific electrical equipment.			
Face to Face Session 6	Energy and its Transformation: Potential and kinetic energy		Modified coaster design, target: the object will travel the furthest distance through after leaving rollercoaster	
Face to Face Session 7	Energy and its Transformation: Friction, dissipation		Rubber band car: positive and negative effect of friction, Simple friction measurements	
Face to Face Session 8	Energy and its Transformation: Electric and magnetic Energy		Building and testing simple motor / generator	
Face to Face Session 9	Energy and its Transformation: Concept Potential Energy - Kinetic Energy - Friction and Forces		Comparison of different energies – similarities and differences	
Final Face to Face Session 10	Final Exam			