ASU

ARIZONA STATE UNIVERSITY

GENERAL STUDIES COURSE PROPOSAL COVER FORM

Course information:

Copy and paste current course information from Class Search/Course Catalog.

Academic Unit: School of Earth and Space Exploration   Department: ____________

Subject: SES   Number: 194   Title: Energy in Everyday Life   Units: 4

Is this a cross-listed course? (Choose one)
If yes, please identify course(s) ____________

Is this a shared course? (choose one) If so, list all academic units offering this course ____________
Course description:

Requested designation: Natural Sciences-SQ
*Note- a **separate** proposal is required for each designation requested*

Eligibility:

Permanent numbered courses must have completed the university's review and approval process.
For the rules governing approval of omnibus courses, contact the General Studies Program Office at (480) 965-0739.

Area(s) proposed course will serve:

A single course may be proposed for more than one core or awareness area. A course may satisfy a core area requirement and more than one awareness area requirements concurrently, but may not satisfy requirements in two core areas simultaneously, even if approved for those areas. With departmental consent, an approved General Studies course may be counted toward both the General Studies requirement and the major program of study.

Checklists for general studies designations:

Complete and attach the appropriate checklist

- Literacy and Critical Inquiry core courses (L)
- Mathematics core courses (MA)
- Computer/statistics/quantitative applications core courses (CS)
- Humanities, Fine Arts and Design core courses (HU)
- Social and Behavioral Sciences core courses (SB)
- Natural Sciences core courses (SQ/SG)
- Global Awareness courses (G)
- Historical Awareness courses (H)
- Cultural Diversity in the United States courses (C)

A complete proposal should include:

- ☐ Signed General Studies Program Course Proposal Cover Form
- ☐ Criteria Checklist for the area
- ☐ Course Syllabus
- ☐ Table of Contents from the textbook, and/or lists of course materials

Contact information:

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Department Chair/Director approval: *(Required)*

Chair/Director name (Typed): James Tyburczy   Date: 28 Oct 2013

Chair/Director (Signature): James A Tyburczy

Course Description – Catalog

Energy is a concept that threads throughout science and engineering and is at the heart of understanding how the world around us works. What is energy? What is matter? How are energy and matter used in biological, chemical, electrical, mechanical, nuclear, and social systems? What would our world be like if there was a nearly infinite supply of inexpensive energy?

Energy in Everyday Life is a survey course designed to serve the needs of undergraduate students and future K-8 teachers by helping them master basic concepts of energy generation, delivery, conversion and efficiency and learn what makes energy universal. In addition, this transdisciplinary course will help students understand concepts and develop skills that crosscut scientific disciplines, such as the ability to observe, think critically, measure, and gather and interpret data.

Course Description – Detailed

Energy in Everyday Life is an introductory (100-level) science course that will be offered for the first time in Spring 2015. It uses as a narrative theme energy's ubiquity in everyday life and is organized around the concept of energy flows, which are crucial to understanding the natural world. Students will explore flows, cycles, and conservation of various forms of energy and matter as they relate to everyday life and the future of this planet. They will conduct inquiries into the efficiencies of both new and established energy generation and conversion methods (e.g., fossil fuels; nuclear, tidal, wind, and hydro-power; passive and active solar systems; geothermal heat transfer) and will also explore biologically-based processes, such as those for cell operation, photosynthesis, biofuel production, energy production and CO_2 capture. Additional areas of exploration include the design, economics, and future perspectives of current and emerging biologically-based processes of bioethanol, bioelectrical systems, methane and hydrogen production, microalgae, and biofuel synthesis.

Because it is focused on a concept central to everyday living, *Energy in Everyday Life* enables students to perceive the relevance of science. Studies suggest that many students, particularly female students, disengage from STEM learning because they fail to see the social relevance of science. Such disengagement is ultimately detrimental to policymaking and global health. *Energy in Everyday Life* highlights how scientists apply seemingly abstract scientific concepts, such as thermodynamics, in ways that have real-world impact on how we live and, ultimately, on the health of the planet.

This theme of energy also demonstrates how scientific disciplines are inextricably linked through principles that weave throughout the natural world and through practices that guide scientific inquiry. *Energy in Everyday Life* students explore key topics across a range of science disciplines – from astronomy to chemistry to life sciences, as well as critical topics in geoscience, environmental science and sustainability science. Students come to understand that exploring scientific questions about energy often requires one to traverse disciplinary boundaries--reflecting the increasingly transdisciplinary character of modern scientific inquiry.

Importantly, *Energy in Everyday Life* also stresses the nature of science as an iterative exploration between theory and experiment. Students deconstruct complex energy-related questions into a series of smaller questions, each of which is uncertain to a greater or lesser degree. Thus, *Energy in Everyday Life* is inherently structured to teach science as a process of answering questions by reducing uncertainties, rather than simply as an expanding body of knowledge.

Energy in Everyday Life endeavors to bring these understandings, along with real content mastery in physics, biology, and earth/space science to the course's target populations: non-science major undergraduates and preservice teachers. These student populations often express high levels of science anxiety. Key to reaching these students is convincing them of the relevance of the topic and helping them move past their fears. This is particularly important with regard to preservice teachers, whose university science experiences often never range beyond general studies courses. People tend to avoid that which they fear and/or don't understand and this dynamic has been especially devastating in K-6 science education, with some studies suggesting that many teachers spend less than an hour a week on science instruction. *Energy in Everyday Life* aims to quell science anxiety by presenting science concepts in fun, accessible, non-traditional ways, and by leveraging societal issues to highlight the relevance and real world applicability of science.

In addition, the content is oriented towards the Next Generation Science Standards (NGSS), new national science standards due to come online in Arizona in the next few years. Such an orientation aims to make the course more relevant and useful to preservice K-8 teachers. By focusing on a cross-cutting concept at the core of emerging science standards (Energy and Matter), the course will help produce K-8 teachers better prepared to teach standards-based content in an integrated manner.

Throughout *Energy in Everyday Life*, students hone their quantitative skills through homework and laboratory activities that challenge them to gather, interpret, and communicate data graphically and mathematically.

ASU--[SQ] CRITERIA

I. - FOR ALL *QUANTITATIVE* [SQ] NATURAL SCIENCES CORE AREA COURSES, THE FOLLOWING ARE CRITICAL CRITERIA AND MUST BE MET:

YES	NO		Identify Documentation Submitted
☒	☐	**A.** Course emphasizes the mastery of basic scientific principles and concepts.	Criteria Justification, Detailed Syllabus
☒	☐	**B.** Addresses knowledge of scientific method.	Criteria Justification, Detailed Syllabus
☒	☐	**C.** Includes coverage of the methods of scientific inquiry that characterize the particular discipline.	Criteria Justification, Detailed Syllabus
☒	☐	**D.** Addresses potential for uncertainty in scientific inquiry.	Criteria Justification, Detailed Syllabus
☒	☐	**E.** Illustrates the usefulness of mathematics in scientific description and reasoning.	Criteria Justification, Detailed Syllabus
☒	☐	**F.** Includes **weekly** laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	Criteria Justification, Detailed Syllabus
☒	☐	**G.** Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	Criteria Justification, Detailed Syllabus
☒	☐	**H.** Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	Criteria Justification, Detailed Syllabus

II. - AT LEAST ONE OF THE FOLLOWING ADDITIONAL CRITERIA MUST BE MET WITHIN THE CONTEXT OF THE COURSE:

YES	NO		Identify Documentation Submitted
☒	☐	**A.** Stresses understanding of the nature of basic scientific issues.	Criteria Justification, Detailed Syllabus
☒	☐	**B.** Develops appreciation of the scope and reality of limitations in scientific capabilities.	Criteria Justification, Detailed Syllabus
☐	☒	**C.** Discusses costs (time, human, financial) and risks of scientific inquiry.	

NOTE: CRITERIA FOR [SG] COURSES BEGIN ON PAGE 4.

III. - [SQ] COURSES MUST ALSO MEET THESE ADDITIONAL CRITERIA:			
YES	**NO**		**Identify Documentation Submitted**
☒	☐	**A.** Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.	Criteria Justification, Detailed Syllabus
		B. Includes a college-level treatment of some of the following topics **(check all that apply below):**	
☒	☐	**a.** Atomic and molecular structure	Criteria Justification, Detailed Syllabus
☒	☐	**b.** Electrical processes	Criteria Justification, Detailed Syllabus
☒	☐	**c.** Chemical processes	Criteria Justification, Detailed Syllabus
☒	☐	**d.** Elementary thermodynamics	Criteria Justification, Detailed Syllabus
☒	☐	**e.** Electromagnetics	Criteria Justification, Detailed Syllabus
☒	☐	**f.** Dynamics and mechanics	Criteria Justification, Detailed Syllabus

[SQ] REQUIREMENTS CANNOT BE MET BY COURSES:
• **Presenting a qualitative survey of a discipline.**
• **Focusing on the impact of science on social, economic, or environmental issues.**
• **Focusing on a specific or limiting but in-depth theme suitable for upper-division majors.**

Course Prefix	Number	Title	Designation
SES	194	Energy in Everyday Life	SQ

Explain in detail which student activities correspond to the specific designation criteria.
Please use the following organizer to explain how the criteria are met.

Criteria (from checksheet)	**How course meets spirit (contextualize specific examples in next column)**	**Please provide detailed evidence of how course meets criteria (i.e., where in syllabus)**
		Designations in this column refer to the Detailed Syllabus (M=module)
I. A. Course emphasizes the mastery of basic scientific principles and concepts.	This course requires that students learn a number of fundamental scientific principles from a number of different fields/disciplines.	For example: PHYSICS: M1 lecture topics: Kinectic, potential, and radiation energy; Formal definition of energy; Formal definition of matter; M1 lab: Interaction of light and matter M3 lecture topics: Physics of collisions; Fission and fusion; M3 labs: Escape velocity M7 lecture topics: Wormholes, black holes, and tesseracts; M7 lab: Warp drive BIOLOGY: M2 lecture topic: Photosynthesis and energy cycles M6 lecture topic: Biomass energy CHEMISTRY: M2 lecture topic: Energy of chemical reactions; M2 labs: What does it take to make water? How much energy is in a gallon of gasoline? EARTH/SPACE SCIENCE: M4 lecture topics: Waves; Energy and matter in weather phenomena; M4 labs: Measuring

		the mass of the Earth; Measuring the strength of an earthquake M6 lecture topics: Wind energy;M6 lab: Tapping geothermal energy BASIC SKILLS: M1 lecture topics: Energy units and scales; What is temperature? Units of matter M2 lecture topics: The atom and its electron cloud M3 lecture topics: Energy conversion; M3 lab: Your electricity meter M4 labs: Average household bill for electrical energy
B. Addresses knowledge of scientific method.	Use of the scientific method as a rigorous means of addressing scientific questions is a unifying theme in the course. Labs routinely require students to use scientific methods to arrive at conclusions.	For example: M1 lecture topic: The scientific method in practice M2 lab: How much energy is in a gallon of gasoline?
C. Includes coverage of the methods of scientific inquiry that characterize the particular discipline.	The course transcends a focus on narrow disciplinary methods to showcase how methods are used across disciplines. On the way to understanding, however, students encounter content and pathways of discovery considered central to a number of disciplines.	For example: M2 lecture topics: Energy from food, Energy efficiency of your car M6 lab: Solar insolance
D. Address potential for uncertainty in scientific inquiry.	A number of labs in the course focus students' attention on how the availability of information and its uncertainty impacts the conclusions we draw about our physical world. In addition, the course asks students to examine competing hypotheses, whose existence reflect uncertainty in the data or model.	M1 lecture topics: Formal definitions of energy; M2 lecture topics: Energy of chemical reactions – endothermic and exothermic M4 lecture topics: What is the energy and mass budget of Earth's interior?
E. Illustrates the usefulness of	The course directly addresses	For example:

mathematics in scientific description and reasoning.	the importance of quantitative measurement in scientific description and reasoning.	M1 lab: Total energy used by the civilizations vs. total energy output from the Sun (order of magnitude) M3 lecture topics: Creating matter from pure energy (Quantification of energy and matter) M4 lecture topics: What is the energy and mass budget of Earth's interior? (Quantification of energy and matter); Earthquakes and the Richter Scale (graphical representation of data); M4 lab: Measuring the strength of an earthquake M6 lecture topics: Energy conversion; Energy on demand (processes of measurement and estimation); M6 lab: Average household bill for electrical energy (standard deviation)
F. Includes weekly laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	The course includes weekly research explorations that include digital labs and manipulatives, as well as "do at home" laboratory activities.	All labs.
G. Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	Students will be required to submit weekly lab reports that include statements of hypotheses, discussion of methods, analysis of data, and discussion of results.	All labs.
H. Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	The course is a transdisciplinary survey that explores the varied disciplinary content and practices	See answer for I.A.
II.A. Stresses the understanding of the nature of basic scientific issues.	As the course is organized around an ongoing transdisciplinary endeavor, students in Energy in Everyday	For example: Nature of science--All modules

	Life really engage the nature of science and the interconnections between scientific disciplines. All modules stress science as an iterative process rooted in observation, experimentation, and communication of results. Students come away with an understanding of basic scientific content and process issues such as how to reduce bias, effectively communicate results, and the role of uncertainty in science.	Interconnectedness of science--M2 lecture topics: What is the total energy required by the human body?, X-rays and gamma rays in medicine, Energy efficiency of the average car M3 lecture topics: How does a microwave work?, Dream of the alchemist: How to make gold M4 lecture topics: How does acoustical energy get translated from a wave to an impulse in your brain?, Does it Matter? M6 lecture topics: Using the moon to make your toast
B. Develops appreciation of the scope and reality of limitations in scientific capabilities.	Students explore the factors behind limitations in scientific capabilities, including the role of technology and the boundaries of current scientific understanding.	For example: M5 lecture topics: Batteries and why none of them are all that great; M5 lab: Transmission line losses
C. Discusses costs (time, human, financial) and risks of scientific inquiry.	Not a significant component of the course, but tangentially addressed in the course's exploration of the financial costs and societal risks of alternative fuel sources.	For example: M6 lecture topics: Fracking, Photovoltaics, Nuclear power, Wind energy, Biomass energy; M6 readings; M6 lab: Tapping geothermal energy
III.A. Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.	The primary focus of Energy in Everyday Life is the centrality of energy and matter ot the natural world, scientific inquiry, and everyday life.	All modules.
B. Includes college-level treatment of some of the following topics:		
a. Atomic and molecular structure	In its treatment of electromagnetic radiation, Energy in Everyday Life engages student in an exploration of the way that matter interacts with radiation. Students learn that many physical properties, such as	For example: M1 lecture topics: What is temperature?; M1 lab: Interaction of light and matter M2 lecture topics: Photosynthesis and energy

	composition, temperature, density, color, speed, and rotation, can be determined from spectra.	cycles (spectrum of solar radiation M3 lecture topics: How does a microwave oven work? M4 lecture topics: Energy and matter in weather phenomena (greenhouse effect)
b. Electrical processes	Students explore electrical processes in the context of energy transport, storage, and conversion.	For example: M5 lecture topics: Capacitors and inductors; M5 labs: Your electricity meter, Transmission line losses M6 lecture topics: Photovoltaics, Wind energy
c. Chemical processes	The driving force for chemical processes is the release or absorption of energy during chemical reactions. Students examine this concept in a number of different biological and physical contexts, including photosynthesis, fermentation, cooking, and battery storage.	For example: M2 lecture topics: What is the total energy required by the human body?, How much energy does your brain use?, Energy from food, Follow matter from your plate to your bicep, Photosynthesis and energy cycles, Fermentation, Energy efficiency of the average car; M2 lab: What does it take to make water? M3 lecture topics: Why do egg whites go from clear to white when you cook them and when you whip them into meringue? M5 lecture topics: Batteries and why none of them are all that great
d. Elementary thermodynamics	Conservation of energy is a recurring theme throughout the course. Upon leaving the course, students will have had repeated exposure to the 1st Law of Thermodynamics in applied pragmatic contexts.	For example: M1 lecture topics: Kinetic, potential, and radiation energy; Energy conservation and flows M2 lecture topics: Energy from food; Energy of chemical reactions--endothermic and

		exothermic; Balance your formula with stoichiometry M6 lecture topics: Wind energy M7 lecture topics: I want to go to the stars
e. Electromagnetics	The emission and absorption of radiation is a major topic in the course because it is fundamental to the transport of energy.	For example: M2 lecture topics: X-rays and gamma rays in medicine M5 lecture topics: Wireless power transmission stumped even Tesla; Energy conversion M7 lecture topics: Light sails
f. Dynamics and mechanics	Throughout the course, students engage concepts central to Newtonian dynamics and gravity, as well as the limitations of Newtonian physics .	For example: M1 lecture topics: Formal definition of energy M3 lecture topics: Physics of collisions (classical mechanics), gravity wells (Newton's laws of motion); M3 labs: Rockets and Orbits--I want my GPS!, Escape Velocity M4 lab: Measuring the mass of the Earth M6 lecture topics: Using the moon to make your toast (tidal energy) M7 lecture topics: I want to go to the stars (constraints); Faster than light travel (special relativity); Wormholes, black holes, and tesseracts (general relativity)

Criteria Justification: *Energy in Everyday Life*
ASU [SQ] Criteria

I. Critical Criteria

A. Course emphasizes the mastery of basic scientific principles and concepts.

The topic of energy and matter is inherently transdisciplinary and addresses concepts and principles basic to science across a number of disciplines. Students explore topics ranging from astronomy to chemistry to life sciences through physics, geoscience, economics, environmental science and sustainability science. Some specific examples of basic principles and concepts the students will engage include: the definitions of energy and matter; the emission and absorption of radiation by matter; photosynthesis and energy cycles; fermentation; chemistry of reactions; nucleosynthesis; chemistry of reactions; and frontiers of energy production such as fracking, photovoltaics and ocean tides. *Energy in Everyday Life* teaches students the ways in which many of these principles and concepts interact with each other in everyday life - this approach will help to solidify the principles and concepts encountered.

B. Addresses knowledge of scientific method.

Energy in Everyday Life is organized around an ongoing human endeavor: harnessing the world of energy and matter around us. The course does not teach a static body of unrelated facts to be memorized, but introduces science as a dynamic process, guided by a methodology that uses scientific principles and concepts to develop and test hypotheses in a quantitative manner, with an end goal of elucidating fact from perception. This is the essence of the modern scientific method, and so the course is inherently designed to expose students to science as an iterative process of investigation.

The lectures and labs associated with each module of *Energy in Everyday Life* reinforce this design. For example, *Energy in Everyday Life* students will learn about the scientific method by applying it in laboratory exercises and during lecture discussions. The motivating principle behind these exercises is that students will learn general and specific scientific ideas by interacting with realistic simulations and examining realistic (sometimes real) data. The scientific method is taught in these exercises by having students examine a phenomena at the outset of each lab exercise and then formulating hypotheses. They are then given the tools necessary to test their hypotheses and are required to explain how their explorations validate or disprove their hypotheses. As students encounter new data in the lab, they engage in the process of refining their model. In this way, students will gain direct experience with the scientific method. In addition, *Energy in Everyday Life* offers historical examples of how scientists have modified their hypotheses and conclusions over time, based on new or changing data.

C. Includes coverage of the methods of scientific inquiry that characterize the particular discipline.

As an inherently transdisciplinary course, *Energy in Everyday Life* does not focus students' attention on the methods of a particular scientific discipline, but instead seeks to introduce students to a range of scientific disciplines and to highlight the methodological similarities between disciplines--i.e., the universal qualities of scientific inquiry. On the way to this understanding students will encounter content considered central to a number of scientific disciplines.

For example, in Module 6 students explore content and concepts in the realm of sustainability, earth/space science, and physics through a digital manipulative that explores the challenges involved in efficient energy collection. Students consider the impact of angles, cloud cover, seasonal conditions while trying to determine the maximum efficiency of solar devices. Using the digital manipulative, students will find the insolation onto a surface is largest when the surface directly faces the Sun and as the angle increases between the direction at a right angle to the surface and the direction of the rays of sunlight, the insolation is reduced in proportion to the cosine of the angle. Students will quantitatively assess the impact of the local conditions on the measured insolation. Ultimately, they come to understand that these local factors help explain how and why solar energy energy generation on the surface of the Earth depends strongly on local conditions. In addition, students learn that engineers, sustainability scientists, astronomers, and mathematicians can learn more about their own fields by viewing a problem from the viewpoint of another discipline.

D. Addresses potential for uncertainty in scientific inquiry.

Energy in Everyday Life intrinsically familiarizes students with the existence of uncertainty in scientific knowledge. Students encounter the role of uncertainty in science directly in Modules 1, 2, and 4, particularly in terms of the limitations involved in measurement. In addition, transformations of energy is a backbone concept of *Energy in Everyday Life,* and lays the framework for breaking down the topic of energy conservation so as to isolate key areas and assess their uncertainties.

This message is reinforced in a number of modules and laboratory exercises, many of which how students how the availability of information and its uncertainty impacts the conclusions we draw about our physical world on a daily basis. For example, students' exploration of insolation and its dependence on local conditions in Module 6 encourages students to break down the complex problem of estimating how much energy can be generated from a rooftop photovoltaic or thermal solar collector into a sequence of smaller problems (e.g., latitude, altitude, time of day, season, etc) each of which has different degrees of uncertainty. Students will be learn how to formally combine those sources of uncertainty into the final values of their insolation. That is, students will engage the scientific and mathematical process of error propagation

Finally, the *Energy in Everyday Life* addresses uncertainty in the form of competing hypotheses about a natural phenomenon. At their core, competing hypotheses reflect uncertainty in the data or model - an acknowledgement that there are not enough verifiable acts to come to consensus model. This aspect of uncertainty contributes to the student's deeper appreciation of the dynamism of the scientific process.

E. Illustrates the usefulness of mathematics in scientific description and reasoning.

In *Energy in Everyday Life* students are immediately exposed to the notion that mathematics is an essential component for scientific inquiry. This is one of the motivations in designing this "SQ" course in this manner. In Module 1, for example, students learn how to use mathematical reasoning and the graphical representation of data to understand the properties of energy. In Module 2, students will be introduced or reintroduced to the cosine of an angle for determining the insolation of a solar energy collector (see answers C and D above). In subsequent modules, students quantify the energy in a number of different contexts. For example, in Module 2 students determine the amount of energy in a gallon of gasoline and its equivalent in familiar forms (e.g., how many strips of bacon) ; in Module 4 the energy in an earthquake and the Richter scale (this introducing logarithms); in Module 5 for estimating energy usage in home environments; and in Module 6 for estimating cost/benefit analysis of various energy extraction procedures.

F. Includes weekly laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.

Students in *Energy in Everyday Life* are assigned laboratory exercises each week that require them to investigate key science concepts in an iterative, inquiry-driven manner (e.g., see answers to C and D above). In a typical weekly exercise, students will develop a hypothesis at the outset of the exercise. They will then obtain (realistic) data or make observations to test their hypothesis and possibly modify their hypothesis. Cumulatively, the modules compel students to revisit conclusions in light of new information/data, highlighting the iterative nature of scientific inquiry. A critical aspect of most of these exercises is that they are computer-based and collaborative. Our philosophy is that appropriately designed collaborative exercises offer a more effective learning experience, and that digital manipulatives give a more effective and engaging hands-on exposure to many scientific/engineering phenomena than do many physical laboratory exercises. One of the goals in delivering this course is to evaluate these two hypothesis.

G. Students submit written reports of laboratory experiments for constructive evaluation by the instructor.

Students in *Energy in Everyday Life are* required to submit weekly digital lab reports that include answering questions about the labs, giving statements of their hypotheses, a description of their methods, presentation of data obtained or generated, an analysis of the data, and summarizing their results. A correct invalidation of a flawed hypothesis will be considered as meritorious as validation of a correct one. These digital reports will be assessed by the TAs and the instructor.

H. Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.

Energy in Everyday Life is a transdisciplinary scientific survey of the many ways that energy weaves throughout both scientific inquiry and the natural world. As such it gives students an introduction to a variety of scientific fields and content knowledge, with an emphasis on the dynamics of the scientific process. Beyond examining practices common to many scientific disciplines, the course also emphasizes the interconnectedness of the natural world--a much broader focus than most introductory science courses, which focus inquiry through a disciplinary lens.

II. At least one of the following additional criteria must be met

A. Stresses the understanding of the nature of basic scientific issues.

Energy in Everyday Life provides students with insights into several basic scientific issues because it is organized around an ongoing transdisciplinary endeavor. As such, students will leave the course with a better mastery of the nature of science and the goals of scientific research than is typical of introductory science courses. This course also emphasizes the interconnections between astronomy, chemistry, life sciences, physics, geoscience, economics, environmental science and sustainability science, and highlights how these disciplines work together to attack the global issues of energy and the local issues of energy in daily life. Hence, *Energy in Everyday Life* stresses the transdisciplinary nature of modern day science.

As a result of working through the modules in *Energy in Everyday Life*, students arrive at an mastery of basic scientific content and process issues such as how to reduce bias, effectively communicate results, and the reality of uncertainty in science and, in some cases, controversy.

B. Develops appreciation of the scope and reality of limitations in scientific capabilities.

From the beginning, students in *Energy in Everyday Life*, develop an appreciation for the scope and limitations in scientific capabilities. As the course progresses, they will learn the reasons for these limitations, both in terms of the challenges posed by each subtopic and the limitations imposed by technology and current scientific understanding. They will also learn about the techniques that scientists are currently using to tackle these challenges, and the limitations in these cutting-edge capabilities.

For example, in learning about how we generate and store energy for everyday life, students learn about the difficulties in storing the massive amounts of energy needed by modern civilization and hence the need for alternative methods of transmission and improvements in storage devices. Students are taught the basic methods by which we store energy - capacitors, inductors, and batteries - and the basic physics and electrical engineering underlying these technologies. Through this knowledge they will gain an appreciation of the limitations of these devices. They will learn about ongoing efforts to significantly alter these devices - or do away with them altogether - that overcome the limitations of existing technologies.

C. Discusses costs (time, human, financial) and risks of scientific inquiry.

The *Energy in Everyday Life* course does not specifically address this topic. However, the course will touch upon the financial costs of alternative fuel sources and the infrastructure to support those sources (e.g., electrical charging stations for cars instead of gas stations); the possible societal risks associated with alternative fuel sources (e.g., fracking and peak oil); and the time it may take before we generate useable amounts of energy from some alternative fuel sources (e.g., fusion reactors).

III. Additional Criteria

A. Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.

The primary focus of *Energy in Everyday Life* is the centrality of energy and matter to the natural world, scientific inquiry, and everyday life. Students engage the topic quantitatively in Module 1 (e.g., basic laws of thermodynamics), Module 2 (e.g., quantifying metabolic energy), Module 3 (e.g., mechanics, particle accelerators), Module 4 (e.g., Richter scale measurements), Module 5 (e.g., energy involved in wireless energy transfer), Module 6 (e.e.g, energy needs in geothermal extraction procedures), and Module 7 (e.g., energy constraints on interstellar travel).

B. Includes a college-level treatment of some of the following topics:

a. Atomic and molecular structure

Related to *Energy in Everyday Life*'s treatment of electromagnetic radiation is the important idea that matter interacts with radiation. In Module 1 and 2 students learn that the exact nature of this interaction is determined by atomic and molecular structure up to energies characteristic of x-rays. As a result, students learn that many physical properties - composition, temperature, density, color, speed, and rotation - can be determined from spectra. As a practical example of the interaction between matter and energy, in Module 3 students will learn how a microwave oven operates. In Module 4, within the context of energy in weather phenomena students also learn that the molecular structures of atmospheric gases determine why some gases absorb infrared radiation, leading to planetary warming (the greenhouse effect), while other gases do not.

b. Electrical processes

Students in *Energy in Everyday Life* encounter electrical processes in Module 5 within the context of energy transport, storage and conversion. For example, students will master elementary aspects of inductors, capacitors, resistors, LRC circuits. Also in Module 5, students will learn about conductance, losses and efficiencies as part of the discussion on energy transport and the electrical grid. Students will master reading electrical meters in Lab 9 of Module 5, and explore aspects of the wireless transmission of energy in Lab 10 of Module 5. Finally in Module 6 students will learn additional components of electrical processes (potential differences, electrons, holes, transformers, etc) during the discussion on photovoltaics and wind energy turbines.

c. Chemical processes

The driving force for chemical processes is the release or absorption of energy during chemical reactions. In Module 2 of *Energy in Everyday Life* students will learn this fundamental concept in the context of mastering how different types of organisms obtain energy from their environment to build the complex macromolecules necessary for life; how such energetic considerations affect the ability of organisms to perform photosynthesis and fermentation; and how much energy it takes to create water from hydrogen and oxygen. In Module 3 students will explore the interchange between chemical energy and mechanical energy in cooking. In Module 5, students will learn chemical energy release and absorption within the context of the storage of energy within batteries.

d. Elementary thermodynamics

In *Energy in Everyday Life* the conservation of energy is a recurring theme. Students are introduced to the 1st Law of Thermodynamics (and the other thermodynamic laws) in Module 1, and conservation of energy appears repeatedly in several Modules. For example, In Module 2 students learn about the energy flow from food ingested into the human body, and the energy release from chemical and nuclear reactions. Elementary thermodynamics also plays a large role in Module 6 when students master the basic issues of using alternative fuels to power modern society, and in Module 7 when students explore potential fuels for space travel. Upon leaving this course, students will have had repeated exposure to the 1st Law of Thermodynamics in applied pragmatic contexts.

e. Electromagnetics

The emission and absorption of radiation is a major topic in *Energy in Everyday Life* because it is fundamental to the transport of energy. In Module 2 students become qualitatively and quantitatively familiar with thermal radiators (e.g., Planck function, Wien's Law, etc) and spectra (wavelength, frequency, speed of light, etc). As another example, in Module 5 students will learn the limitations of transporting energy by photons for the purposes of powering modern civilizations. Finally, in Module 7 students will learn about the absorption of energy from photons to power spaceships by light sails.

f. Dynamics and mechanics

In *Energy in Everyday Life* students will encounter Newtonian mechanics in Module 1 when work, energy, and power are given their physics definitions. In Module 3 students master the energetic aspects of Newtonian dynamics in exploring rockets, and learn the fundamentals of Newtonian gravity when exploring the energy requirements for lifting a rocket out of Earth's gravitational well. In Module 4 and Lab 7 students revisit Newtonian dynamics and gravity in the context of how we measure the mass of the Earth. In Module 6 students will be exposed to tidal forces in the context of tapping tidal energy from the Earth's ocean as an alternative fuel supply. Finally, in Module 7 students are introduced to the limitations of Newtonian physics and their being part of the larger framework of special relativity when learning about the energy requirements for space travel.

Module 1	What is energy? What is matter?
Objectives	Introduce energy and matter and motivate students with some mind-stretching ideas. Develop a sense of relevant physical and temporal scales.

Topics	**Key Concepts**
The scientific method in practice	Inquiry
Formal definition of energy Kinetic, potential, and radiation energy	Process of measurement Physical quantities Thermodynamic Laws Uncertainty in measurement
Energy units and scales Energy extremes – biggest, smallest	Physical quantities Quantum to cosmic scales
What is temperature? Temperature scales, absolute zero	Process of measurement Physical quantities
Formal definition of matter Units of matter Matter extremes – biggest, smallest	Physical quantities Periodic table Quantum to cosmic scales
The world's most famous equation Energy conservation and flows Normal matter vs. Dark matter	Mathematical reasoning Graphical representation of data Frontiers of science

Readings, videos, podcasts, etc.	**Key Concepts**
Armory Lovins, "A 50 year plan for energy" http://www.ted.com/talks/amory_lovins_a_50_year_plan_for_energy.html	Energy in history Energy in the future

Chapter 3 of "Energy: Physical, Environmental and Social Impact"	Force, work, energy, conservation laws
Chapter 5 of "Energy: Physical, Environmental and Social Impact"	Consumption of energy, projection of energy needs

Lab 1	Interaction of light and matter
	Lab description: An interactive exploration of color-temperature relationships.
Lab 2	Total energy used by the civilizations vs. total energy output from the Sun
	Lab description: Students learn to apply order of magnitude estimates.

Module 2	Biology, medicine, chemistry, and your car
Objectives	Learn energy and matter concepts in life sciences and chemistry that affect everyday life and beyond. Develop a sense of the scientific method as a problem-solving process. Equip students with a quantitative toolkit using the concepts of measurement and estimation.

Topics	**Key Concepts**
What is the total energy required by the human body? How much energy does your brain use? Mitochondria Energy from food Follow matter from your plate to your bicep	Interconnectedness of science Biological energy flows Lipids Amino acids Nucleic acids
Photosynthesis and energy cycles	Carbon dioxide - oxygen cycles Spectrum of solar radiation
Fermentation	Quantification of metabolic energy
X-Rays and Gamma rays in medicine What's "He" doing in my MRI?	Interconnectedness of science. Electromagnetic radiation
The atom and its electron cloud	Bohr and quantum viewpoints
Energy of chemical reactions – endothermic and exothermic Balance your formula with stoichiometry	Conservation of energy Thermodynamic Laws Uncertainty in measurement
Energy efficiency of the average car Get it cranking – gasoline vs. diesel Transportation aerodynamics – Prius vs. a semi The journey of palladium to your catalytic converter	Interconnectedness of science Energy of chemical reactions Rare Earth elements

Readings, videos, podcasts, etc.	Key Concepts
Chapter 6 of "Energy: Physical, Environmental and Social Impact"	Atomic structure, chemical energy
Chapter 23 of "Energy: Physical, Environmental and Social Impact"	Photosynthesis, biomass for fuel
http://www.ted.com/talks/jonathan_trent_energy_from_floating_algae_pods.html	Biomass energy

Lab 3	What does it take to make water?
	Lab description: Interactive exercise in which students explore the phases of water and the chemistry of making water.
Lab 4	How much energy is in a gallon of gasoline?
	Lab description: Interactive exploration of energy units and energy equivalents.

Module 3	Cooking, collisions, and rockets
Objectives	Master energy and matter concepts in physics and chemistry that affect everyday life and beyond.

Topics	**Key Concepts**
How does a microwave oven work?	Interconnectedness of science History of science Interaction of photons and matter
Why do egg whites go from clear to white when you cook them *and* when you whip them into meringue?	Chemical reactions Mechanical energy
Does tanning count as cooking?	Interaction of photons and matter
Physics of collisions	Classical mechanics
Fission and fusion	Nuclear physics Process of measurement
Creating matter from pure energy	Quantification of energy and matter Particle accelerators
Dream of the alchemist: How to make gold	Nucleosynthesis Interconnectedness of science
Gravity wells	Newtonian gravity Newton's laws of motion

Readings, videos, podcasts, etc.	**Key Concepts**
http://scitech.web.cern.ch/scitech/toptech/01/MicroWaveOven/microwave_2.shtml	Radiation Energy transport

http://www.livescience.com/32285-how-does-a-microwave-oven-work.html	
Chapter 18 of “Energy: Physical, Environmental and Social Impact”	Nuclear structure, fission, fusion
Chapter 19 of “Energy: Physical, Environmental and Social Impact”	Energy from nuclear reactors
http://www.ted.com/talks/richard_sears_planning_for_the_end_of_oil.html	Oil reserves, oil future

Lab 5	Rockets and Orbits--I want my GPS!
	Lab description: Interactive exercises in orbits, geosynchronous orbits, and how GPS systems work.
Lab 6	Escape Velocity
	Lab description: Interactive exercises in escape velocities and a game based landing on the Moon.

Module 4	Acoustics and the Earth
Objectives	Explore energy and matter concepts from geological and acoustical sciences that affect everyday life and beyond.

Topics	**Key Concepts**
Waves	Physics of oscillations Electromagnetics
How does acoustical energy get translated from a wave to an impulse in your brain?	Interconnectedness of science.
Major and minor keys	Psychology of perception
Shockwaves!	Exceeding the speed of sound
What is the energy and mass budget of Earth's interior?	Quantification of energy and matter Mathematical reasoning Uncertainty in measurement
Earthquakes & the Richter Scale	Plate tectonics Graphical representation of data
Energy and Matter in weather phenomena	Local and global atmospheric phenomena Greenhouse effect
Does it Matter - how many diamonds do you get per ton of ore?	Interconnectedness of science Economics of extraction Process of estimation

Readings, videos, podcasts, etc.	**Key Concepts**
http://www.ted.com/talks/david_mackay_a_reality_check_on_renewables.html	Renewable energy, economics, history of energy usage

http://www.ted.com/talks/steven_cowley_fusion_is_energy_s_future.html	Nuclear energy, fusion

Lab 7	Measuring the mass of the Earth
	Lab description: Exploration of kepler's laws and how mass is measured in binary systems.
Lab 8	Measuring the strength of an earthquake
	Lab description: Quantitative interactive exercises in the Richter scale and energy equivalents.

Module 5	Transport, storage, and conversion
Objectives	Master an understanding of energy and matter flows and cycles that affect everyday life and beyond.

Topics	Key Concepts
The Grid – electricity conductance, losses, and efficiency	Energy transport
Wireless power transmission stumped even Tesla	Directed energy systems Frontiers of science Electromagnetics
Batteries and why none of them are all that great	Energy storage & sustainability Process of measurement
Capacitors and inductors	Energy storage & sustainability Elementary LRC circuits
Energy conversion – photovoltaics and biomass	Energy efficiency Process of measurement
Energy on demand – what happens to energy produced but not used?	Energy conservation Process of estimation
Getting wind and hydroelectric power from the origin to the destination	Energy grid Social impact of energy production

Readings, videos, podcasts, etc.	Key Concepts
Chapter 7 of “Energy: Physical, Environmental and Social Impact”	Thermodynamic laws and efficiency of energy generation
Chapter 8 of “Energy: Physical, Environmental and Social Impact”	Production and distribution of electricity
http://www.ted.com/talks/angela_belcher_using_nature_to_grow_batteries.html	Energy storage, biomass

Lab 9	Your electricity meter, one kilowatt hour at a time
	Lab description: Practical, interactive exploration of measuring energy usage.
Lab 10	Transmission line losses
	Lab description: Exploration of efficiencies in transporting energy over the electrical grid and wireless energy transport.

Module 6	The frontiers and economics of energy production
Objectives	Explore the economics of energy generation and usage, and the frontiers of energy generation and sustainability.

Topics	**Key Concepts**
Revisit total energy budget of civilization	Interconnectedness of science Process of estimation
Dollar cost per unit energy	Local and global markets
Peak oil	Process of estimation
Fracking	Geomorphology of natural gas
Photovoltaics	Interaction of radiation with matter Electrons and holes Insolation
Nuclear power – fission and fusion	Nuclear physics of fission and fusion Radioactive decay
Using the moon to make your toast	Interconnectedness of science Tidal energy
Wind energy	Turbines Conservation of energy
Biomass energy	Relationships in ecosystems

Readings, videos, podcasts, etc.	**Key Concepts**
http://www.engineering.com/Videos/VideoPlayer/tabid/4627/VideoId/3268/Fracking-Explained-Opportunity-Or-Danger.aspx	Earth Structure Energy finance

	Energy sustainability
Chapter 24 of "Energy: Physical, Environmental and Social Impact"	Solar energy, photovoltaics, tidal energy
Chapter 25 of "Energy: Physical, Environmental and Social Impact"	Energy storage, novel energy alternatives
Clean energy future podcast by Steven Chu https://itunes.apple.com/us/podcast/a-clean-energy-future/id78511357?i=93271871&mt=2	Clean energy

Lab 11	Average household bill for electrical energy
	Lab description: Graphical exploration of Big Data to estimate mean energy bills with standard deviations.
Lab 12	Solar insolance
	Lab description: Exploration of efficiency of solar energy collection
Lab 13	Clim'Way
	Lab Description: Interactive focused on community planning needed to reduce greenhouse gas emissions and energy consumption.

Module 7	Science of science fiction
Objectives	Explore the energy science behind concepts popularized in fiction.

Topics	Key Concepts
I want to go to the stars	Distance, time, and energy constraints Scientific Method
Matter-antimatter engines	Existence of antimatter
Light sails	Pressure from photons Electromagnetics
Cloaking	Terahertz materials
Superconductors	Critical temperature Bosonic behavior
Faster than light travel	Special relativity
Wormholes, black holes, and tesseracts	General relativity Schwartzchild & Kerr black holes

Readings, videos, podcasts, etc.	Key Concepts
http://science.howstuffworks.com/rocket.htm	Physics of rockets
http://science.howstuffworks.com/antimatter.htm	Matter -antimatter egins
http://en.wikipedia.org/wiki/Solar_sail	Momentum & energy from light-matter interactions

Lab 14	Warp drive

	Lab description: Game based exploration of faster than light travel.

SES194: Energy in Everyday Life (4 credits)
Syllabus, Spring 2015
Online course

4 credits
No prerequisites
General Studies: Science Quantitative (SQ)

Course Description
Energy is a concept that threads throughout science and engineering and is at the heart of understanding how the world around us works. What is energy? What is matter? How is energy and matter used in dynamical acoustical, biological, chemical, electrical, mechanical, nuclear, and social systems? What would our world be like if there was a nearly infinite supply of inexpensive energy? *Energy in Everyday Life* is an online survey course designed to serve the needs of undergraduate students and future K-8 teachers by helping them master basic concepts of energy generation, delivery, conversion, and efficiency and learn what makes energy universal. In addition, this transdisciplinary course will help students understand concepts and develop skills that crosscut scientific disciplines, such as the ability to observe, think critically, measure, and gather and interpret data.

Students will explore key topics across a range of science disciplines – from astronomy to chemistry to life sciences, as well as critical topics in geoscience, environmental science and sustainability science. The emphasis in teaching these science concepts is for students to attain qualitative and quantitative understanding, including the construction and interpretation of charts and graphs and the use of simple equations to test hypotheses.

In *Energy in Everyday Life,* students deconstruct complex energy-related questions into a series of smaller questions, each of which is uncertain to a greater or lesser degree. Thus, *Energy in Everyday Life* is inherently structured to teach science as a process of iterative exploration between theory and experiment and as a process of answering questions by reducing uncertainties, rather than simply as an expanding body of knowledge.

Instructors:
Frank Timmes, Professor, School of Earth and Space Exploration
Office: ISTB4-597, francis.timmes@asu.edu

Meredith Turnbough, Assistant Research Professor, College of Liberal Arts and Sciences
Office: CPCOM 313, meredith.turnbough@asu.edu

Course Objectives

1. Introduce students to basic concepts in astronomy, physics, life science, and geoscience in an integrative manner around the theme of energy and matter.

2. Educate a broad audience of students with an introduction to the science of energy and matter and topics surrounding the generation, transport, conversion, and use of energy and matter in everyday life, and the energy sustainability of our planet.

3. Excite students about the relevance of the basic sciences and the predictive aspects of quantitative science.

4. Expose students to science as an iterative process of exploration and discovery, experiment and theory, driven by the scientific method but not beholden to it.

Student Learning Objectives
After taking this course students will be able to:

1. Understand the use of the scientific method and how it helps people problem solve.

2. Use concepts in astronomy, physics, life science, and geoscience to qualitatively and quantitatively describe essential features of the world around them.

3. Define the characteristics that are essential to flows of energy and matter.

4. Critically compare and contrast modes of energy and matter generation, transport, conversion, and use.

Curricular Articulation
Energy and Matter is an introductory course that can be chosen by future K-8 teachers and non-science major undergraduates to fulfill their programmatic science course requirements, in particular the General Studies Science Quantitative (SQ) requirement. It will provide students with tools and material that will help prepare them for success in the upper division electives.

Required materials and activities
Students will access course content via a series of weekly course readings, video lectures, powerpoint presentations, scientific simulations, and laboratory activities posted on the course homepage in the course management system (Learning Studio).

Primary course text: Gordon Aubrecht, *Energy: Physical, Environmental, and Social Impact*, 3rd edition (Addison Wesley, 2005). Note: We are working with Pearson Publishers to create an e-version of the portions of the textbook that the course uses.

Assignments and Grading:

Homework (50%)
Homework assignments are designed to develop students' understanding of basic science concepts, to hone their critical thinking skills, and to develop their abilities to express data and results quantitatively. Students will complete 14 homework assignments, two per week, in LearningStudio. Each homework is worth 100 points and will take about 45 minutes. On average, there will be 2-3 quantitative problems per week. Collectively, homework assignments will comprise 50% of the course grade. Each homework assignment will be worth 3.57% of the final grade. Students will be permitted to collaborate on homework assignments in groups up to 6 people.

Exams (50%)
There will be 3 exams, roughly one every 2 weeks, to allow students to demonstrate content mastery. The exams will be completed in MasteringAstronomy and follow the same style and content level as the homework. Collectively, the exams will comprise 50% of the course grade, with each exam worth 16.67% of the student's grade.

Course Grades
Final grades are based on the number of points earned on the homework and exams. Students will be able to see their percentage of the total points to date in Learning Studio. Final grades for the course are generally based on a curve; that is, relative to your colleagues. However, I allow for absolute scores - 90% or better will get an A, 80% or better a B, 70% or better a C, 60% or better a D, below 60% is a failing grade.

How to Succeed in this Course
1. Check your ASU email regularly.
2. Log in to the course web site daily.
3. Communicate with your TAs and instructor.
4. Create a study schedule so that you don't fall behind on assignments.
5. Honor the homework and exam deadlines.

Communicating With the Instructor
This course uses a "three before me" policy in regards to student to faculty communications. When questions arise during the course of this class, please remember to check these three sources for an answer before asking either instructor to reply to your individual questions:
1. Course syllabus
2. Announcements when you log in
3. The "Hallway Conversations" discussion board

This policy will help you to identify answers before we can get back to you and it also helps your instructor from answering similar questions or concerns multiple times.

If you cannot find an answer to your question, please first post your question to the "Hallway

Conversations" discussion board. Here your question can be answered to the benefit of all students by either your fellow students who know the answer to your question or the instructor. You are encouraged to answer questions from other students in the discussion forum when you know the answer in order to help provide timely assistance. In general, the TAs and the instructor will answer questions between 8am and 5pm, Monday to Friday. If a response is posted outside of those hours, it is a bonus. The TAs and I are not on call 24 hours a day to immediately answer questions. If you do not receive an answer to your question through the discussion board within a reasonable amount of time (allow at least 24 hours), then you should send an email to the TAs for the course.

If you have questions of a personal nature such as relating a personal emergency, questioning a grade on an assignment, or something else that needs to be communicated privately, you are welcome to contact me via email or phone. My preference is that you will try to email me first. I will usually respond to email and phone messages from 8am to 5pm on weekdays, please allow 24 hours for me to respond. Please be sure to email me at the email address listed under "Meet Your Instructor".

If you have a question about the technology being used in the course, please contact the Help Desk for assistance (see contact information under Technical Support information).

Conduct

Students are required to adhere to the behavior standards listed in the

Arizona Board of Regents Policy Manual Chapter V – Campus and Student Affairs: Code of Conduct http://www.azregents.edu/policymanual/default.aspx,ACD 125: Computer, Internet, and Electronic Communications http://www.asu.edu/aad/manuals/acd/acd125.htm, and the ASU Student Academic Integrity Policy http://www.asu.edu/studentaffairs/studentlife/srr/index.htm.

Students are entitled to receive instruction free from interference by other members of the class. If a student is disruptive, an instructor may ask the student to stop the disruptive behavior and warn the student that such disruptive behavior can result in withdrawal from the course. An instructor may withdraw a student from a course when the student's behavior disrupts the educational process under USI 201-10 (http://www.asu.edu/aad/manuals/usi/usi201-10.html).

Appropriate classroom behavior is defined by the instructor. This includes the number and length of individual messages online. Course discussion messages should remain focused on the assigned discussion topics. Students must maintain a cordial atmosphere and use tact in expressing differences of opinion. Inappropriate discussion board messages may be deleted if an instructor feels it is necessary. Students will be notified privately that their posting was inappropriate.

Student access to the course Send Email feature may be limited or removed if an instructor feels students are sending inappropriate messages to other students in the course.

Syllabus Disclaimer
The instructor views the course syllabus as an educational contract between the instructor and students. Every effort will be made to avoid changing the course schedule, but the possibility exists that unforeseen events will make syllabus changes necessary. The instructor reserves the right to make changes to the syllabus. Students will be notified in a timely manner of any syllabus changes via email or in the course site Announcements. Please remember to check your ASU email and the course site Announcements often.

Accessibility Statement
In compliance with the Rehabilitation Act of 1973, Section 504, and the Americans with Disabilities Act of 1990, professional disability specialists and support staff at the Disability Resource Centers (DRC) facilitate a comprehensive range of academic support services and accommodations for qualified students with disabilities. DRC staff coordinate transition from high schools and community colleges, in-service training for faculty and staff, resolution of accessibility issues, community outreach, and collaboration between all ASU campuses regarding disability policies, procedures, and accommodations.

Students who wish to request an accommodation for a disability should contact the Disability Resource Center (DRC) for their campus.

Tempe Campus http://www.asu.edu/studentaffairs/ed/drc/ 480-965-1234 (Voice) 480-965-9000 (TTY)	West Campus http://www.west.asu.edu/drc/ University Center Building (UCB), Room 130 602-543-8145 (Voice)
Polytechnic Campus http://www.asu.edu/studentaffairs/ed/drc/ 480-727-1165 (Voice) 480-727-1009 (TTY)	Downtown Phoenix Campus http://campus.asu.edu/downtown/DRC University Center Building, Suite 160 602-496-4321 (Voice) 602-496-0378 (TTY)

Lectures, Labs, Discussion Questions

Module 1: What are Energy and Matter?
Topics:
The scientific method in practice
Formal definition of energy
Kinetic, potential, and radiation energy
Energy units and scales

Energy extremes – biggest, smallest
What is temperature?
Temperature scales, absolute zero
Formal definition of matter
Units of matter
Matter extremes – biggest, smallest
The world's most famous equation
Energy conservation and flows
Normal matter vs. Dark matter

Readings, videos, podcasts, etc.:
Armory Lovins, "A 50 year plan for energy"
http://www.ted.com/talks/amory_lovins_a_50_year_plan_for_energy.html
Chapter 3 of "Energy: Physical, Environmental and Social Impact"
Chapter 5 of "Energy: Physical, Environmental and Social Impact"

Labs:
1. Interaction of light and matter
2. Total energy used by the civilizations vs. total energy output from the Sun

Discussion question: What would we do with a source of free, unlimited energy?

Module 2: Biology, Medicine, Chemistry, and Your Car
Topics:
What is the total energy required by the human body?
How much energy does your brain use?
Mitochondria
Energy from food
Follow matter from your plate to your bicep
Photosynthesis and energy cycles
Fermentation
X-Rays and Gamma rays in medicine
What's "He" doing in my MRI?
The atom and its electron cloud
Energy of chemical reactions – endothermic and exothermic
Balance your formula with stoichiometry
Energy efficiency of the average car
Get it cranking – gasoline vs. diesel
Transportation aerodynamics – Prius vs. a semi
The journey of palladium to your catalytic converter

Readings, videos, podcasts, etc.:
Chapter 6 of "Energy: Physical, Environmental and Social Impact"
Chapter 23 of "Energy: Physical, Environmental and Social Impact"
http://www.ted.com/talks/jonathan_trent_energy_from_floating_algae_pods.html

Labs:
3. What does it take to make water?
4. How much energy is in a gallon of gasoline?

Discussion: Energy needs for clean drinking water

Module 3: Cooking, Collisions and Rockets
Topics:
How does a microwave oven work?
Why do egg whites go from clear to white when you cook them *and* when you whip them into meringue?
Does tanning count as cooking?
Physics of collisions
Fission and fusion
Creating matter from pure energy
Dream of the alchemist: How to make gold
Gravity wells

Readings, videos, podcasts, etc.:
http://scitech.web.cern.ch/scitech/toptech/01/MicroWaveOven/microwave_2.shtml
http://www.livescience.com/32285-how-does-a-microwave-oven-work.html
Chapter 18 of "Energy: Physical, Environmental and Social Impact"
Chapter 19 of "Energy: Physical, Environmental and Social Impact"
http://www.ted.com/talks/richard_sears_planning_for_the_end_of_oil.html

Labs:
5. Rockets and Orbits--I want my GPS!
6. Escape Velocity

Discussion question: Why does a Pollock painting have different perceived energy than a Rembrandt painting?

Module 4: Acoustics and the Earth
Topics:
Waves
How does acoustical energy get translated from a wave to an impulse in your brain?
Major and minor keys
Shockwaves!
What is the energy and mass budget of Earth's interior?
Earthquakes & the Richter Scale
Energy and Matter in weather phenomena
Does it Matter - how many diamonds do you get per ton of ore?

Readings, videos, podcasts, etc.:
http://www.ted.com/talks/david_mackay_a_reality_check_on_renewables.html
http://www.ted.com/talks/steven_cowley_fusion_is_energy_s_future.html

Labs:
7. Measuring the mass of the Earth
8. Measuring the strength of an earthquake

Discussion question: Can anyone hear you in space?

Module 5: Transport, Storage, and Conversion
Topics:
The Grid – electricity conductance, losses, and efficiency
Wireless power transmission stumped even Tesla
Batteries and why none of them are all that great
Capacitors and inductors
Energy conversion – photovoltaics and biomass
Energy on demand – what happens to energy produced but not used?
Getting wind and hydroelectric power from the origin to the destination

Readings, videos, podcasts, etc.:
Chapter 7 of “Energy: Physical, Environmental and Social Impact”
Chapter 8 of “Energy: Physical, Environmental and Social Impact”
http://www.ted.com/talks/angela_belcher_using_nature_to_grow_batteries.html

Labs:
9. Your electricity meter, one kilowatt hour at a time
10. Transmission line losses

Discussion question: What if batteries were 100% efficient?

Module 6: Frontiers and Economics of Energy Production
Topics:
Revisit total energy budget of civilization
Dollar cost per unit energy
Peak oil
Fracking
Photovoltaics
Nuclear power – fission and fusion
Using the moon to make your toast
Wind energy
Biomass energy

Readings, videos, podcasts, etc.:
http://www.engineering.com/Videos/VideoPlayer/tabid/4627/VideoId/3268/Fracking-Explained-Opportunity-Or-Danger.aspx
Chapter 24 of “Energy: Physical, Environmental and Social Impact”
Chapter 25 of “Energy: Physical, Environmental and Social Impact”
Clean energy future podcast by Steven Chu
https://itunes.apple.com/us/podcast/a-clean-energy-future/id78511357?i=93271871&mt=2

Labs:
11. Average household bill for electrical energy:
12. Solar insolance
13. Clim'Way

Discussion question: Why is gasoline more expensive in Europe than in the US?

Module 7: Science of Science Fiction
Topics:
I want to go to the stars
Matter-antimatter engines
Light sails
Cloaking
Superconductors
Faster than light travel
Wormholes, black holes, and tesseracts

Readings, videos, podcasts, etc.:
http://science.howstuffworks.com/rocket.htm
http://science.howstuffworks.com/antimatter.htm
http://en.wikipedia.org/wiki/Solar_sail

Labs:
14. Warp drive

Discussion question: What would we do with a source of free, unlimited energy?

PRIMARY COURSE TEXT: Gordon Aubrecht, *Energy: Physical, Environmental, and Social Impact*. 3rd Edition. Addison-Wesley, 2005.

TABLE OF CONTENTS

Note: We will be working with Pearson to develop an e-version of the portions of the textbook the courses uses.

SES194: ENERGY IN EVERYDAY LIFE—SAMPLE LAB OUTCOMES AND ACTIVITIES
INSTRUCTOR: F. Timmes, School of Earth and Space Exploration
GENERAL STUDIES: Requesting SQ designation

Module 1: Lab 2: Estimating total annual energy

In Lab 2 students will use digital manipulatives (coded in html5 and php) to learn, in a structured environment, how to make order of magnitudes estimates. The lab begins with a review of scientific notation and units, including opportunities for students to practice multiplication and division of physical quantities numbers in scientific notation.

After defining the term "order of magnitude," Lab 2 uses a digital game to prepare students to make order of magnitude estimates of everyday quantities. Examples of everyday quantities include the hottest and coldest temperatures ever recorded on Earth. Because of their familiarity with temperatures on Earth, students can estimate these quantitates reasonably accurately. Students progress toward demonstrating the practical application of their order of magnitude skills by answering the question: "How much does it cost (monetary cost) to operate a street lamp in Tempe, Arizona over the course of a year?"

Through the game, students learn the “divide-and-conquer” strategy of estimating an answer to such seemly open questions; that the total cost can be estimated by first estimating the energy an average light bulb in their home use, then estimating the number of light bulbs in their house, then estimating the number of such homes and industrial uses in the world. Students can estimate the power reasonably accurately, because they are familiar with light bulbs through their everyday lives. The digital manipulative would guide the students’ thinking along these lines: a typical household light bulb is about 100 W, there are the equivalent of about 100 light bulbs per house, there are perhaps a 1 billion such homes in the world. By multiplying these order of magnitude estimate, students will estimate about 10^{13} W in use at any given time. Multiplying by the number of seconds per year, about 3 x 10^{7}, yields an estimate for the annual energy consumption by all of civilization, about 10^{20} Joules. Students will be invited to compare their order of magnitude estimate with more refined estimates to discover their estimate is "the right answer".

By the end of the module, students will be able to:

1. Define order of magnitude.
2. Translate a number into scientific notation.
3. Manipulate numbers in scientific notation (add, subtract, multiply, etc.).
5. Demonstrate an understanding of scale.
6. Identify units of measurement frequently found in discussions about energy.
7. Articulate why estimation is important in scientific inquiry and how it aids scientists.
8. Apply their understanding of order of magnitude in practical scenario.

Module 2: Lab 3: What does it take to make water?

Lab 3 is a digital interactive, coded in html5 and php, in which students explore the phases of water and the energy needed to produce liquid water from its constituent gases. The lab explores chemical reactions, thermodynamics, conservation or energy, and the financial costs involved in the production of chemical compounds. Students are given a fixed volume of hydrogen that costs X, a fixed volume of oxygen that costs Y, and a fixed amount of energy that costs Z. In the first part of the lab, students iteratively explore the stoichiometry of water to determine how much water can they make if energy or financial cost were not considerations. In the second part of the lab, students iteratively investigate how much water they can make with a given energy reserve, irrespective of financial cost. In the final part of the lab, students attempt to make as much water as they can, while minimizing the cost of the hydrogen, oxygen and energy. The interactive gamifies student participation by tying a student's score to the amount of water they successfully produce under the various energy or cost constraints.

By the end of the module, students will be able to:

1. Define the scientific term “mole”.
2. Balance a chemical equation.
3. Determine the quantities of reactants needed to produce a product.
4. Describe how water is produced.
5. Articulate the physical and financial constraints on creating water.

Module 6: Lab 12: Solar Insolance

In Lab 12 is a digital interactive, coded in html5 and php, through which students explore the efficiency of solar energy collection to produce electricity. Students will be given a choice of common solar energy collectors, each of which has a different cost per unit collector area, and a budget of N dollars. In the first part of the lab, students will determine the best angle at which to position a collector in a given real geographical location, in order to produce the most amount of energy at the cheapest cost throughout a cloudless day during summer solstice. In the second part of the lab, students repeat the exercise, but during the winter solstice. Students learn (a) the trade-off between different collector types and (b) the importance of the angle that the sun makes with the solar collector, both throughout the day and seasonally. In the third part of the lab, students attempt to produce the most amount of energy at the cheapest cost throughout a partially cloudy day during summer solstice. The duration and opacity of the clouds will be fixed quantities. Student engagement is maximized through gamification, which ties the student's score to how much energy the students makes under the various conditions and cost constraints.

By the end of the module, students will be able to:

1. Explain the interaction of radiation with matter
2. Define insolation.
3. Demonstrate an understanding of the ‘projection effect’ and how the angle of the sunbeam impacts the efficiency of solar energy collectors.
4. Explain how electricity can be directly produced from solar collectors.
5. Articulate the physical and financial constraints harvesting the Sun's energy.