Course Description:
This course provides teachers with a deep and useful understanding of energy and the nature of how students use concepts of energy to make sense of phenomena across life, earth, and physical science. This understanding enhances teacher insights into: 1) how matter and energy interact, 2) the relationships of energy to forces and interactions within fields, and 3) pedagogical content knowledge around teaching and learning about energy.

The course provides teachers with knowledge of how energy concepts may be used by students with the Crosscutting Concepts, and Engineering and Science practices.

Course Objectives:
During this course educators will:

● Understand the role of energy in systems in the natural and material world and relate it to STEM instruction in elementary classrooms.
  ➢ Energy in the cycling of water
  ➢ The cycling of matter in organisms require energy
  ➢ Relationships in ecosystems are dependent on energy
  ➢ Energy in everyday life
  ➢ Moving objects contain energy
  ➢ Waves can transmit energy

● Understand and be able to apply the cross-cutting concept of Energy and Matter in the classroom
  ➢ Flows, cycles, and conservation.
  ➢ Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

● Explore and implement innovative, research-based, engaging curriculum, especially around the Utah Core academic standards and college and career readiness, geared towards increasing student achievement.
  ➢ Apply the disciplinary core ideas when planning lessons and teaching.
  ➢ Use cross-cutting concepts when planning lessons and teaching.
  ➢ Implement scientific practices into lesson planning and teaching.

● Develop the skills and dispositions to be a teacher leader in STEM, model instruction, plan with colleagues, complete presentations for local and statewide efforts, etc.
  ➢ Teachers need to have self efficacy and confidence in all areas of STEM.

● Demonstrate proficiency with STEM content, skills, and practices and teach those to students.
  ➢ Communicate using multiple forms of discourse.
  ➢ Develop reasoning and problem solving practices.
➢ Facilitate effective collaboration and communication among the students.
➢ Demonstrate proficiency in STEM content.

Course Construction Recommendations
The goal of this course is to present a variety of non-standard STEM scenarios which will challenge participants to think, explore, communicate, and present solutions. It could be organized many ways, but should establish the teacher more as a mentor than a lecturer. Participants should feel safe following whatever thinking path they launch and allowed to self-correct without intervention. Scenarios should progress in difficulty as the course progresses to ensure participants feel confident in their abilities at the start, grow in tenacity and ability, and feel challenged. It is ideal if scenarios toward the end of the course require multiple strategies and solutions. The course should model quality instructional strategies including multiple opportunities to engage students in science investigations, field experiences, and lab activities.

Course Topics
Please see Addendum A for a more detailed outline of topics for science content that would support the main ideas highlighted below.

Main Idea #1 Energy in Earth Science
The role of energy in moving water through Earth Systems is the focus of this topic. Earth surface processes, weather, and climate serve as a context to develop deep understanding of the nature of energy. Understanding the role of energy in the cycling of matter provides insights into the nature of water, weather and climate on Earth.

Main Idea #2 Energy in Life Science
The flow of energy in organisms is essential to life. Understanding the role of energy in organism and the cycling of matter into, out of, and within organism provides a deeper understanding of the nature of energy.

Information processing is necessary for animals to communicate and respond to the environment. Information is transferred by transferring energy (e.g., sound, light, vibrations).

Relationships in ecosystems and cycles of matter require energy. Understanding the role of energy in ecosystems provides insight into the nature of life on Earth and Earth processes.

Main Idea #3 Energy in Physical Science
Energy is a fundamental and complex idea that is difficult to define. Energy is understood in terms of the effect of energy on matter, energy transfers, transformations, and conservation. Energy in chemical processes provides an opportunity to apply concepts of energy to everyday life.
The relationship between force and energy provides insights into the nature of energy itself. Developing insights into the position of matter within a field provides insights into the relationship between position in a field and energy. Understanding energy is a critical piece to the relationship between energy and force.

Wave properties and electromagnetic radiation are dependent upon energy. Waves can be used to transmit information and energy. Understanding the role of energy in wave properties and electromagnetic radiation provides insight into how information is transferred within different mediums.

**Pedagogy Focus of Course**
The purpose of this course is to ensure that course participants apply the pedagogical content knowledge needed to teach STEM concepts to students in the elementary grades. Course participants must know how to create environments to ensure content knowledge and conceptual understandings inherent in the content. Course participants should integrate the content with a variety of pedagogical concepts and strategies into the course. This integration should be modeled throughout the course to create a student-centered learning environment in which elementary students plan and carry out investigations, engineer solutions to problems, and construct evidence-based explanations of real-world phenomena. The course should model quality instructional strategies including multiple opportunities to engage students in science investigations, field experiences, and lab activities.

**Knowledge of STEM for Course Participants:**
Course Participants learn the skills and dispositions to employ prior content knowledge, skills, beliefs and concepts, to engage student instruction that clarifies misconceptions and confusions around particular topics. Course participants utilize knowledge of cognition, child development, and learning theory to enhance instruction. Course participants develop knowledge of learners culturally and socially to enhance student motivation and interest in STEM.

**Effective STEM teaching practices**
- Ability to Ask Scientific Questions and Define Problems
- Ability to Plan and Carry Out Investigations
- Ability to Analyze, Interpret Data, and Make Predictions
- Ability to Develop and Use Models
- Ability to Construct Explanations and Design Solutions
- Ability to Engage in Argument from Evidence
- Ability to Use Mathematical and Computational Thinking
- Ability to Obtain, Evaluate and Communicate Information

**Knowledge of STEM curriculum and assessment:**
1. Understandings of science content and process knowledge and skills
2. Abilities to think critically and solve simple to complex problems
3. Capabilities of designing scientific experiments, analyzing data, and drawing conclusions
4. Capacities to see and articulate relationships between science topics and real-world issues and concerns
5. Skills using mathematics as a tool for science learning
(Above are from NSTA position statement on assessment)
6. Demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.
7. Apply digital tools to gather, evaluate, and use information
8. Use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
9. Use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
10. Understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.
11. Demonstrate a sound understanding of technology concepts, systems, and operations.
(Above are from ISTE student standards)
12. Select, use, adapt and determine the suitability of STEM curricula and teaching materials (e.g., textbooks, technology, manipulatives) for particular learning goals.
13. Be cognizant of a formative assessment cycle (administering a formative assessment, analyzing student work from the assessment, using that analysis to enhance teacher knowledge, and designing and teaching reengagement lessons) and resources.
14. Provide appropriate interpretations of assessment results, and communicate results (in context) to specific individuals and groups (e.g., students, parents, caregivers, colleagues, administrators, policymakers, community members).
(Above are from AMTE Standards for Elementary Mathematics Specialists)

Possible Assignments:
- Content exams, performance tasks, and homework for determining participants’ knowledge for teaching on the topic of energy in STEM
- Clinical interview: Design an interview to determine student understanding of energy in STEM, including interview questions with extensions to press for student understanding. Videotape and conduct the interview. Analyze the video using a rubric that assesses both student understanding and the interview process.
- Differentiated lesson: Select one of the course objectives. Develop a lesson to meet the objective for the whole group. Then develop differentiation activities for at least three populations (e.g., gifted students, English Language Learners, Students with Disabilities).
- Action research project: Action research is a particular approach to research that aims to improve practice by addressing real-world situations and needs through
focused, reflective practice and the application of interventions or procedures that are designed for improving performance. Develop a classroom research project about teaching concepts of energy in STEM for your own classroom. Consult education literature, citing at least three sources from peer-reviewed journals. Develop a research question which could be a new teaching, assessment, or curriculum strategy for rational numbers in your class. Collect data, and analyze the results.

- Case study: Write a case presenting the STEM thinking of a student or group of students. Be sure to include details in your narrative, such as student dialogue, your questions, and what you were thinking as you listened to the students. Analyze the student thinking and discuss the questions that are raised for you in the students’ STEM thinking.
- Lesson study cycle: Work with a group to develop a task-based lesson including anticipated student responses, questions for classroom discourse, and formative assessment. One person in the group will teach the lesson while other members of the group observe student thinking. Group members refine the lesson in response to the observation data and then teach and analyze the lesson in their own classes.
- Reflections on your own STEM understanding: Keep a reflections log that discusses: a STEM idea from the session that is new or important for you, a question you have, and an application of the STEM idea for your classroom.
- Reading research – choose from possible articles and do an assignment based on the article; discussions, agreement/disagreement, impact in classrooms.
- Lesson study via video tools such as Teaching Channel Teacher Teams
- Use technology to enhance and explore areas of energy in STEM.

**Suggested Resources:**

Framework for K-12 Science Education
http://www.nextgenscience.org/framework-k%E2%80%9312-science-education

Energy in the cycling of water
http://serc.carleton.edu/eslabs/weather/2a.html

The cycling of matter in organisms require energy
https://www.youtube.com/watch?v=x37DJLcJ0dI

Relationships in ecosystems are dependent on energy
http://www.learner.org/courses/envsci/unit/text.php?unit=4&secNum=3

Energy in everyday life

Moving objects contain energy

Waves can transmit energy
http://youtu.be/4S-MevRKGzs?list=PLllVwaZQkS2rtZG_L7ho89oEsaYL3kJUWq

ISTE Standards for Technology
http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-S_PDF.pdf

NSTA Statement on Assessment
http://www.nsta.org/about/positions/assessment.aspx
Engineering is Elementary
http://www.eie.org/
Addendum A

Clarifications for Energy in Earth Science
Understanding the role of energy in the cycling of water provides insights into the nature of water, weather and climate on Earth.

● (K-2) Water is found in many types of places and in different forms on Earth.
● (3-5) Most of Earth’s water is in the ocean and much of the Earth’s freshwater is in glaciers or underground.
● (6-8) Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.
● (K-2) Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region and time. People record weather patterns over time.
● (3-5) Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed.
● (6-8) Complex interactions determine local weather patterns and influence climate, including the role of the ocean.

Clarifications for Energy in Life Science
The cycling of matter in organism requires energy. Understanding the role of energy in this process provides insights into the nature of life on Earth.

● (K-2) Animals obtain food they need from plants or other animals. Plants need water and light.
● (3-5) Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival.
● (6-8) Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.

Information processing is necessary for animals to communicate to and respond to the environment. Information is transferred by transferring energy (e.g., sound, light, vibrations).

● (K-2) Animals sense and communicate information and respond to inputs with behaviors that help them grow and survive.
● (3-5) Different sense receptors are specialized for particular kinds of information. Animals use their perceptions and memories to guide their actions. Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behavior or memories.
● (6-8) NA
The relationships seen in ecosystems and in cycles of matter are dependent on energy. Understanding the role of energy in ecosystems provides insight into the nature of life on Earth and Earth processes.

- (K-2) Plants depend on water and light to grow, and also depend on animals for pollination or to move their seeds around.
- (3-5) The food of almost any animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials back to the soil.
- (6-8) Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared.
- (K-2) Animals obtain food they need from plants or other animals. Plants need water and light.
- (K-2) In a region, some kinds of severe weather are more likely than others. Forecasts allow communities to prepare for severe weather.
- (3-5) Matter cycles between the air and soil and among organisms as they live and die.
- (6-8) The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.

**Clarifications for Energy in Physical Science**

Energy is a fundamental and complex idea. Understanding definitions of energy provides insight into the nature of energy on Earth.

- (K-2) NA
- (3-5) Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.
- (6-8) Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.

Energy transfer, conservation of energy, and energy in chemical processes directly relate to energy in everyday life.

- (K-2) Sunlight warms Earth’s surface.
- (3-5) Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.
- (6-8) Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical
or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.

- (K-2) Sunlight warms Earth's surface.
- (3-5) Energy can be “produced,” “used,” or “released” by converting stored energy. Plants capture energy from sunlight, which can later be used as fuel or food.
- (6-8) Sunlight is captured by plants and used in a reaction to produce sugar molecules, which can be reversed by burning those molecules to release energy.

Energy is a critical piece to the relationship between energy and force. Understanding the role of energy in this relationship will help students investigate:

- (K-2) Bigger pushes and pulls cause bigger changes in an object’s motion or shape.
- (3-5) When objects collide, contact forces transfer energy so as to change the objects’ motions.
- (6-8) When two objects interact, each one exerts a force on the other, and these forces can transfer energy between them.

Wave properties and electromagnetic radiation.

- (K-2) Sound can make matter vibrate, and vibrating matter can make sound.
- (3-5) Waves are regular patterns of motion, which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves can make objects move.
- (6-8) A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy.
- (K-2) Objects can be seen only when light is available to illuminate them.
- (3-5) Object can be seen when light reflected from their surface enters our eyes.
- (6-8) The construct of a wave is used to model how light interacts with objects.