A Deeper Understanding of Energy

Curriculum Connections

ALBERTA, NORTHWEST TERRITORIES, NUNAVUT—Physics 20: Circular Motion, Work and Energy and Physics 30: Atomic Physics

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Physics Curriculum Connections (Physics 20 and Physics 30)
(2007, updated 2014)

Activity 1: The Conservation and Transformation of Energy

Physics 20—Unit C: Circular Motion, Work and Energy

Specific Outcomes for Knowledge

20-C2.1k define mechanical energy as the sum of kinetic and potential energy

20–C2.3k analyze, quantitatively, kinematics and dynamics problems that relate to the conservation of mechanical energy in an isolated system

20–C2.4k recall work as a measure of the mechanical energy transferred and power as the rate of doing work

20–C2.5k describe power qualitatively and quantitatively

20-C2.6k describe, qualitatively, the change in mechanical energy in a system that is not isolated

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

20–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to demonstrate the conservation of energy; *e.g., Is energy conserved in a collision?* **(IP–NS1, IP–NS2)**

Performing and Recording

20–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment to demonstrate the law of conservation of energy **(PR–NS3)**
- research the development of the law of conservation of energy, using library and Internet sources **(PR–NS1) [ICT C1–4.1]**

Analyzing and Interpreting

20–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use free-body diagrams to organize and communicate solutions to work-energy theorem problems **(AI–NS1)**
- solve, quantitatively, kinematics and dynamics problems, using the work-energy theorem **(AI–NS3)** **[ICT C6–4.1]**
- analyze data to determine effective energy conservation strategies; e.g., analyze whether lowering the speed limit or modifying the internal combustion engine saves more energy in vehicles **(AI–ST2, AI–SEC3)** **[ICT C7–4.2]**

Communication and Teamwork

20–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *research the answers to questions they generate*
- *explore and use a variety of methods and resources to increase their knowledge and skills*
- *be critical and constructive when considering new theories and techniques*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *ask questions and conduct research to ensure understanding*
- *expend the effort and time needed to make valid inferences*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*

Safety

show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information*; e.g.,*

- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*

Activity 2: Innovative Technologies

Physics 20—Unit C: Circular Motion, Work and Energy

Specific Outcomes for Knowledge

20–C2.3k analyze, quantitatively, kinematics and dynamics problems that relate to the conservation of mechanical energy in an isolated system

20–C2.4k recall work as a measure of the mechanical energy transferred and power as the rate of doing work

20–C2.5k describe power qualitatively and quantitatively

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Specific Outcomes for Knowledge

20–C2.2sts explain that the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6) [ICT F3–4.1]**

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

20–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to demonstrate the conservation of energy; *e.g., Is energy conserved in a collision?* **(IP–NS1, IP–NS2)**

Performing and Recording

20–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment to demonstrate the law of conservation of energy **(PR–NS3)**
- research the development of the law of conservation of energy, using library and Internet sources **(PR–NS1) [ICT C1–4.1]**

Analyzing and Interpreting

20–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use free-body diagrams to organize and communicate solutions to work-energy theorem problems **(AI–NS1)**
- solve, quantitatively, kinematics and dynamics problems, using the work-energy theorem **(AI–NS3) [ICT C6–4.1]**
- analyze data to determine effective energy conservation strategies*; e.g., analyze whether lowering the speed limit or modifying the internal combustion engine saves more energy in vehicles* **(AI–ST2, AI–SEC3) [ICT C7–4.2]**

20–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *research the answers to questions they generate*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*

Mutual Respect

appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds; *e.g.,*

- *explore personal perspectives, attitudes and beliefs toward scientific and technological advancements*
- *recognize the contribution of science and technology to the progress of civilizations*
- *show support for the development of technologies and science as they relate to human needs*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *insist on evidence before accepting a new idea or a new explanation*
- *assess, critically, their opinion of the value of science and its applications*
- *evaluate inferences and conclusions, being cognizant of the many variables involved in experimentation*
- *ask questions and conduct research to ensure understanding*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*

Stewardship

demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment; *e.g.,*

- *discuss both the positive and negative effects of environmental changes caused by nature and by humans on human beings and society*
- *promote actions that are not injurious to the environment*

Safety

show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information*; e.g.,*

- *read the labels on materials before using them, interpret the WHMIS symbols and consult a reference document if safety symbols are not understood*
- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*

Activity 3: Nuclear Transformations

Physics 30—Unit D: Atomic Physics

Specific Outcomes for Knowledge

30–D3.4k use the law of conservation of charge and mass number to predict the particles emitted by a nucleus

30–D3.5k compare and contrast the characteristics of fission and fusion reactions

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

30–D3.1sts explain that the goal of science is knowledge about the natural world **(NS1)**

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

30–D3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

Analyzing and Interpreting

30–D3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- interpret common nuclear decay chains

Communication and Teamwork

30–D3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical or linguistic modes of representation to communicate findings and conclusions **(CT–NS2)**

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *research the answers to questions they generate*
- *use scientific vocabulary and principles in everyday discussions*
- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that many careers require science- and technology-related knowledge and skills*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *assess, critically, their opinion of the value of science and its applications*
- *ask questions and conduct research to ensure understanding*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*

Safety

show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information*; e.g.,*

- *consider safety a positive limiting factor in scientific and technological endeavours*
- *read the labels on materials before using them, interpret the WHMIS symbols and consult a reference document if safety symbols are not understood*
- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*
- *assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials according to safety guidelines*
- *seek assistance immediately for any first-aid concerns, such as cuts, burns or unusual reactions*

Activity 4: Ionizing Radiation

Physics 30—Unit D: Atomic Physics

Specific Outcomes for Knowledge

30-D3.1k describe the nature and properties, including the biological effects, of alpha, beta and gamma radiation

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

30–D3.1sts explain that the goal of science is knowledge about the natural world (NS1)

30-D3.2sts explain that the products of technology are devices, systems and processes that meet given needs and that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST6, ST7) [ICT F2-4.2, F3-4.1]**

30–D3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- predict the penetrating characteristics of day products

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

30–D3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

Analyzing and Interpreting

30–D3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Communication and Teamwork

30–D3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical or linguistic modes of representation to communicate findings and conclusions **(CT–NS2)**

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *research the answers to questions they generate*
- *explore and use a variety of methods and resources to increase their knowledge and skills*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*
- *be interested in science and technology topics not directly related to their formal studies*
- *recognize the importance of making connections among various science disciplines*
- *maintain interest in pursuing further studies in science*
- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that many careers require science- and technology-related knowledge and skills*

Mutual Respect

appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds; *e.g.,*

- *show support for the development of technologies and science as they relate to human needs*
- *recognize the research contributions of both men and women*
- *recognize the research contributions of Canadians*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *ask questions and conduct research to ensure understanding*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*

Stewardship

demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment; *e.g.,*

- *discuss both the positive and negative effects of environmental changes caused by nature and by humans on human beings and society*
- *promote actions that are not injurious to the environment*

Activity 5: Mass-Energy Equivalence

Physics 30—Unit D: Atomic Physics

Specific Outcomes for Knowledge

30-D3.6k relate, qualitatively and quantitatively, the mass defect of the nucleus to the energy released in nuclear reactions, using Einstein's concept of mass-energy equivalence

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

30–D3.1sts explain that the goal of science is knowledge about the natural world **(NS1)**

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

30–D3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

Performing and Recording

30-D3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

Analyzing and Interpreting

30–D3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Communication and Teamwork

30–D3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical or linguistic modes of representation to communicate findings and conclusions **(CT–NS2)**

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*

- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that many careers require science- and technology-related knowledge and skills*

Mutual Respect

appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds; *e.g.,*

- *use a multiperspective approach, considering scientific, technological, economic, cultural, political and environmental factors when formulating conclusions, solving problems or making decisions on an STS issue*
- *research carefully and discuss openly ethical dilemmas associated with the applications of science and technology*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *ask questions and conduct research to ensure understanding*
- *expend the effort and time needed to make valid inferences*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*

Stewardship

demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment; *e.g.,*

- *consider all perspectives when addressing issues, weighing scientific, technological and ecological factors*
- *discuss both the positive and negative effects of environmental changes caused by nature and by humans on human beings and society*
- *promote actions that are not injurious to the environment*
- *make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations*

Activity 6: Where Do the Elements Come From?

Physics 30—Unit D: Atomic Physics

Specific Outcomes for Knowledge

30-D3.2k write nuclear equations, using isotope notation, for alpha, beta-negative and beta-positive decays, including the appropriate neutrino and antineutrino

30-D3.5k compare and contrast the characteristics of fission and fusion reactions

30-D3.6k relate, qualitatively and quantitatively, the mass defect of the nucleus to the energy released in nuclear reactions, using Einstein's concept of mass-energy equivalence

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

30–D3.1sts explain that the goal of science is knowledge about the natural world **(NS1)**

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

30–D3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

Analyzing and Interpreting

30–D3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Communication and Teamwork

30–D3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical or linguistic modes of representation to communicate findings and conclusions **(CT–NS2)**

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *research the answers to questions they generate*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*
- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that many careers require science- and technology-related knowledge and skills*

Mutual Respect

appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds; *e.g.,*

- *use a multiperspective approach, considering scientific, technological, economic, cultural, political and environmental factors when formulating conclusions, solving problems or making decisions on an STS issue*
- *recognize the research contributions of both men and women*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *ask questions and conduct research to ensure understanding*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*

Safety

show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information*; e.g.,*

- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*

- *assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials according to safety guidelines*
- *seek assistance immediately for any first-aid concerns, such as cuts, burns or unusual reactions*
- *keep the work station uncluttered, ensuring that only appropriate laboratory materials are present*

Activity 7: Conservation Laws and Dark Energy

Physics 20—Unit C: Circular Motion, Work and Energy

Specific Outcomes for Knowledge

20–C2.3k analyze, quantitatively, kinematics and dynamics problems that relate to the conservation of mechanical energy in an isolated system

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

20–C2.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

20–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to demonstrate the conservation of energy; *e.g., Is energy conserved in a collision?* **(IP–NS1, IP–NS2)**

Performing and Recording

20–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

Analyzing and Interpreting

20–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Communication and Teamwork

20–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Attitude Outcomes

Interest in Science

show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *research the answers to questions they generate*
- *be critical and constructive when considering new theories and techniques*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*
- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that many careers require science- and technology-related knowledge and skills*

Scientific Inquiry

seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *ask questions and conduct research to ensure understanding*

Collaboration

work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*

Safety

show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information*; e.g.,*

- *read the labels on materials before using them, interpret the WHMIS symbols and consult a reference document if safety symbols are not understood*
- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*
- *assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials according to safety guidelines*
- *seek assistance immediately for any first-aid concerns, such as cuts, burns or unusual reactions*

A Deeper Understanding of Energy

Curriculum Connections

BRITISH COLUMBIA AND YUKON—Science 8, 10, and Physics 11

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* Elaborations are not included in this chart.

Science 8, 10, and Physics 11 Curriculum Connections
(June 2016, March 2018, and June 2018, respectively)

Activity 1: The Conservation and Transformation of Energy

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Making observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - scientific notation

Processing and analyzing data and information

- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled
- Consider the changes in knowledge over time as tools and technologies have developed

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations
- Consider the role of scientists in innovation

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations

Science 10—Content

- law of conservation of energy
- **potential** and **kinetic** energy
- **transformation of energy**
- *local and global* ***impacts of energy transformations*** *from technologies*

Physics 11

- conservation of energy; principle of work and energy

Activity 2: Innovative Technologies

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Making observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world
- Formulate multiple hypotheses and predict multiple outcomes

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - scientific notation

Processing and analyzing data and information

- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled
- Consider the changes in knowledge over time as tools and technologies have developed
- Consider social, ethical, and environmental implications of the findings from their own and others' investigations

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations
- Consider the role of scientists in innovation

Communicating

- Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations

Science 10—Content

- law of conservation of energy
- **transformation of energy**
- local and global **impacts of energy transformations** from technologies

Physics 11—Content

- conservation of energy; principle of work and energy
- **power and efficiency**
- **simple machines** and mechanical advantage

Activity 3: Nuclear Transformations

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Making observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods

Processing and analyzing data and information

- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled
- Consider the changes in knowledge over time as tools and technologies have developed
- Assess risks in the context of personal safety and social responsibility

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations
- Consider the role of scientists in innovation

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon

Science 8—Content

- **atomic theory and models**
- **protons, neutrons, and quarks**

Science 10—Content

- **nuclear energy** and **radiation**
- **transformation of energy**

Activity 4: Ionizing Radiation

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Making observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - scientific notation

Processing and analyzing data and information

- Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies
- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Consider the changes in knowledge over time as tools and technologies have developed
- Connect scientific explorations to careers in science
- Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources
- Consider social, ethical, and environmental implications of the findings from their own and others' investigations
- Assess risks in the context of personal safety and social responsibility

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Contribute to finding solutions to problems at a local and/or global level through inquiry
- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations
- Consider the role of scientists in innovation

Communicating

- Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations

Science 8—Content

- **types and effects of electromagnetic radiation**

Science 10—Content

- **nuclear energy** and **radiation**
- **transformation of energy**
- local and global **impacts of energy transformations** from technologies

Activity 5: Mass-Energy Equivalence

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Planning and conducting

- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - scientific notation

Processing and analyzing data and information

- Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies
- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled
- Consider the changes in knowledge over time as tools and technologies have developed

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations

Science 10—Content

- **nuclear energy** and **radiation**
- **transformation of energy**

Activity 6: Where Do the Elements Come From?

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Planning and conducting

- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - scientific notation

Processing and analyzing data and information

- Experience and interpret the local environment
- Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information
- Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies
- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled
- Consider the changes in knowledge over time as tools and technologies have developed
- Connect scientific explorations to careers in science
- Assess risks in the context of personal safety and social responsibility

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Contribute to finding solutions to problems at a local and/or global level through inquiry

- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations
- Consider the role of scientists in innovation

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations
- Express and reflect on a variety of experiences, perspectives, and worldviews through **place**

Science 8—Content

- **atomic theory and models**
- **protons, neutrons, and quarks**

Science 10—Content

- **nuclear energy** and **radiation**

Activity 7: Conservation Laws and Dark Energy

Curriculum Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - scientific notation

Processing and analyzing data and information

- Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies
- Construct, analyze, and interpret graphs, models, and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled
- Consider the changes in knowledge over time as tools and technologies have developed
- Connect scientific explorations to careers in science
- Assess risks in the context of personal safety and social responsibility

Applying and innovating

- Contribute to care for self, others, community, and world through individual or collaborative approaches
- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations
- Consider the role of scientists in innovation

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations

Science 10—Content

- law of conservation of energy
- **astronomical data and collection methods**

Physics 11—Content

- conservation of energy; principle of work and energy

A Deeper Understanding of Energy

Curriculum Connections

MANITOBA—Senior 4 Physics (40S)

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Senior 4 Physics Curriculum Connections
(2005)

Activity 1: The Conservation and Transformation of Energy

Skills and Attitudes Outcomes

S4P-0-2a Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

S4P-0-2g Develop mathematical models involving linear, power, and/or inverse relationships among variables.

S3P-0-4b Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solution, and carry out investigations.

S4P-0-4c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S4P-0-4d Develop a sense of personal and shared responsibility for the impact of humans on the environment, and demonstrate concern for social and environmental consequences of proposed actions.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Topic 1.6: Work and Energy

Specific Learning Outcomes

S4P-1-25 Define work as the product of displacement and the component of force parallel to the displacement when the force is constant.

S4P-1-27 Describe work as a transfer of energy.
Include: positive and negative work, kinetic work, conservation of energy

S4P-1-28 Give examples of various forms of energy and describe qualitatively the means by which they can perform work.

S4P-1-33 Solve problems related to the conservation of energy.
Include: gravitational and spring potential, and kinetic energy

Activity 2: Innovative Technologies

Skills and Attitudes Outcomes

S3P-0-1c Relate the historical development of scientific ideas and technology to the form and function of scientific knowledge today.

S4P-0-3a Analyze, from a variety of perspectives, the risks and benefits to society and the environment when applying scientific knowledge or introducing technology.

S4P-0-3c Identify social issues related to science and technology, taking into account human and environmental needs and ethical considerations.

S4P-0-4c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S4P-0-4d Develop a sense of personal and shared responsibility for the impact of humans on the environment, and demonstrate concern for social and environmental consequences of proposed actions.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Topic 1.6: Work and Energy

Specific Learning Outcomes

S4P-1-25 Define work as the product of displacement and the component of force parallel to the displacement when the force is constant.

S4P-1-28 Give examples of various forms of energy and describe qualitatively the means by which they can perform work.

S4P-1-33 Solve problems related to the conservation of energy.
Include: gravitational and spring potential, and kinetic energy

Topic 3.2: Electromagnetic Induction

Specific Learning Outcomes

S4P-3-15 Describe the generation, transmission, and distribution of electricity in Manitoba.
Include: step-up and step-down transformers, power transfer, High Voltage Direct Current

Activity 3: Nuclear Transformations

Skills and Attitudes Outcomes

S4P-0-1c Relate the historical development of scientific ideas and technology to the form and function of scientific knowledge today.

S4P-0-2a Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

S4P-0-2g Develop mathematical models involving linear, power, and/or inverse relationships among variables.

S3P-0-4b Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solution, and carry out investigations.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Topic 1.6: Work and Energy

Specific Learning Outcomes

S4P-1-27 Describe work as a transfer of energy.
Include: positive and negative work, kinetic work, conservation of energy

S4P-1-33 Solve problems related to the conservation of energy.
Include: gravitational and spring potential, and kinetic energy

Topic 4.1: Medical Physics

Specific Learning Outcomes

S4P-4-1 Describe the nuclear model of the atom.
Include: proton, neutron, nucleus, nuclear forces, stability, isotope, mass number, electron, ion

S4P-4-2 Define radioactivity as a nuclear change that releases energy.
Include: Becquerel units, radioactive decay, half life

S4P-4-4 Describe the following types of radiation: alpha, beta, and electromagnetic radiation.
Include: particle radiation, wave radiation, electromagnetic spectrum, linear energy transfer

Activity 4: Ionizing Radiation

Skills and Attitudes Outcomes

S4P-0-2d Estimate and measure accurately using SI units.

S4P-0-2i Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, or other resource people

S4P-0-3a Analyze, from a variety of perspectives, the risks and benefits to society and the environment when applying scientific knowledge or introducing technology.

S4P-0-3c Identify social issues related to science and technology, taking into account human and environmental needs and ethical considerations.

S4P-0-4b Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solution, and carry out investigations.

S4P-0-4c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S4P-0-4d Develop a sense of personal and shared responsibility for the impact of humans on the environment, and demonstrate concern for social and environmental consequences of proposed actions.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Topic 4.1: Medical Physics

Specific Learning Outcomes

S4P-4-2 Define radioactivity as a nuclear change that releases energy.
Include: Becquerel units, radioactive decay, half life

S4P-4-4 Describe the following types of radiation: alpha, beta, and electromagnetic radiation.
Include: particle radiation, wave radiation, electromagnetic spectrum, linear energy transfer

S4P-4-5 Compare and contrast sources and characteristics of ionizing radiation and non-ionizing radiation.
Include: NORM (Naturally Occurring Radioactive Materials), radon, background radiation, incandescent light bulb, hot objects

S4P-4-6 Describe various applications of non-ionizing radiation.

S4P-4-7 Describe various applications of ionizing radiation.

S4P-4-8 Describe the effects of non-ionizing and ionizing radiation on the human body.
Include: equivalency of sievert (Sv) and rem units, solar erythema (sunburn)

S4P-4-9 Research, identify, and examine the application of radiation to diagnostic imaging and treatment techniques.

Activity 5: Mass-Energy Equivalence

Skills and Attitudes Outcomes

S4P-0-4b Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solution, and carry out investigations.

S4P-0-4c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S4P-0-4d Develop a sense of personal and shared responsibility for the impact of humans on the environment, and demonstrate concern for social and environmental consequences of proposed actions.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Topic 1.6: Work and Energy

Specific Learning Outcomes

S4P-1-27 Describe work as a transfer of energy.
Include: positive and negative work, kinetic work, conservation of energy

S4P-1-33 Solve problems related to the conservation of energy.
Include: gravitational and spring potential, and kinetic energy

Topic 4.1: Medical Physics

Specific Learning Outcomes

S4P-4-1 Describe the nuclear model of the atom.
Include: proton, neutron, nucleus, nuclear forces, stability, isotope, mass number, electron, ion–

S4P-4-2 Define radioactivity as a nuclear change that releases energy.
Include: Becquerel units, radioactive decay, half life

Activity 6: Where Do the Elements Come From?

Skills and Attitudes Outcomes

S4P-0-4b Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solution, and carry out investigations.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Topic 1.6: Work and Energy

Specific Learning Outcomes

S4P-1-27 Describe work as a transfer of energy.
Include: positive and negative work, kinetic work, conservation of energy

S4P-1-33 Solve problems related to the conservation of energy.
Include: gravitational and spring potential, and kinetic energy

Topic 4.1: Medical Physics

Specific Learning Outcomes

S4P-4-1 Describe the nuclear model of the atom.
Include: proton, neutron, nucleus, nuclear forces, stability, isotope, mass number, electron, ion–

Activity 7: Conservation Laws and Dark Energy

Skills and Attitudes Outcomes

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

S4P-0-2g Develop mathematical models involving linear, power, and/or inverse relationships among variables.

Topic 1.6: Work and Energy

Specific Learning Outcomes

S4P-1-33 Solve problems related to the conservation of energy.
Include: gravitational and spring potential, and kinetic energy

A Deeper Understanding of Energy

Curriculum Connections

NEW BRUNSWICK—Physics 11: Work and Energy

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Physics 11 Curriculum Connections
(Atlantic Canada Science Curriculum, 2003)

Activity 1: The Conservation and Transformation of Energy

STSE

Nature of Science and Technology

114-9 explain the importance of communicating the results of a scientific or technological endeavour using appropriate language and conventions

Relationships Between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-2 carry out procedures controlling the major variables and adapting or extending procedures where required

213-3 use instruments accurately for collecting data

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

325-9 analyse quantitatively the relationships among force, distance, and work

326-1 analyse quantitatively the relationships among mass, height, speed, and heat energy using the law of conservation of energy

326-5 describe quantitatively mechanical energy as the sum of kinetic and potential energies

326-6 analyse quantitatively problems related to kinematics and dynamics using the mechanical energy concept

326-7 analyse common energy transformation situations using the work-energy theorem

Attitude Outcome Statements

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Interest in Science

439 show a continuing and more informed curiosity and interest in science and science-related issues

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Stewardship

446 have a sense of personal and shared responsibility for maintaining a sustainable environment

448 want to take action for maintaining a sustainable environment

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 2: Innovative Technologies

STSE

Nature of Science and Technology

114-9 explain the importance of communicating the results of a scientific or technological endeavour using appropriate language and conventions

115-5 analyse why and how a particular technology was developed and improved over time

Relationships Between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-6 describe and evaluate the design of technological solutions and the way they function using principles of energy and momentum

Skills

Performing and Recording

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

Analysing and Interpreting

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

325-9 analyse quantitatively the relationships among force, distance, and work

325-10 analyse quantitatively the relationships among work, time and power

326-1 analyse quantitatively the relationships among mass, height, speed, and heat energy using the law of conservation of energy

326-7 analyse common energy transformation situations using the work-energy theorem

326-8 determine the percentage efficiency of energy transformations

Attitude Outcome Statements

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Stewardship

446 have a sense of personal and shared responsibility for maintaining a sustainable environment

447 project the personal, social, and environmental consequences of proposed action

448 want to take action for maintaining a sustainable environment

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 3: Nuclear Transformations

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

326-7 analyse common energy transformation situations using the work-energy theorem

Attitude Outcome Statements

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

437 appreciate that the applications of science and technology can raise ethical dilemmas

Interest in Science

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 4: Ionizing Radiation

STSE

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Relationships Between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-3 use instruments accurately for collecting data

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

326-7 analyse common energy transformation situations using the work-energy theorem

Attitude Outcome Statements

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

437 appreciate that the applications of science and technology can raise ethical dilemmas

438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds

Interest in Science

439 show a continuing and more informed curiosity and interest in science and science-related issues

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Activity 5: Mass-Energy Equivalence

STSE

Nature of Science and Technology

114-9 explain the importance of communicating the results of a scientific or technological endeavour using appropriate language and conventions

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

326-7 analyse common energy transformation situations using the work-energy theorem

Attitude Outcome Statements

Appreciation of Science

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Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Activity 6: Where Do the Elements Come From?

STSE

Relationships Between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

326-7 analyse common energy transformation situations using the work-energy theorem

Attitude Outcome Statements

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

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Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 7: Conservation Laws and Dark Energy

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-2 carry out procedures controlling the major variables and adapting or extending procedures where required

213-3 use instruments accurately for collecting data

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

Knowledge

326-7 analyse common energy transformation situations using the work-energy theorem

Attitude Outcome Statements

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

A Deeper Understanding of Energy

Curriculum Connections

NEWFOUNDLAND AND LABRADOR—Physics 2204

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Physics 2204 Curriculum Connections
(2018)

Activity 1: The Conservation and Transformation of Energy

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

4.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Performing and Recording

7.0 use instruments effectively and accurately for collecting data [GCO 2]

8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

Analyzing and Interpreting

10.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

12.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

15.0 evaluate the relevance, reliability, and adequacy of data and data collection methods [GCO 2]

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

21.0 identify new questions or problems that arise from what was learned [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

Work

39.0 analyze quantitatively the relationships among force, distance, and work [GCO 3]

40.0 analyze quantitatively the relationships among mass, height, and speed using energy [GCO 3]

Work-Energy Theorem

41.0 analyze common energy transformation situations using the work-energy theorem [GCO 3]

42.0 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions [GCO 1]

Efficiency

45.0 analyze quantitatively the relationships among gravitational potential energy, kinetic energy and heat energy using the law of conservation of energy [GCO 3]

48.0 analyze quantitatively the relationships among work, time, and power [GCO 3]

Simple Harmonic Motion

51.0 explain quantitatively the relationship between potential and kinetic energies of a mass in simple harmonic motion [GCO 3]

Activity 2: Innovative Technologies

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

Performing and Recording

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

Analyzing and Interpreting

10.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

12.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

23.0 identify multiple perspectives that influence a science-related decision or issue [GCO 2]

24.0 develop, present, and defend a position or course of action, based on findings [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

Work-Energy Theorem

41.0 analyze common energy transformation situations using the work-energy theorem [GCO 3]

42.0 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions [GCO 1]

Efficiency

46.0 determine the percent efficiency of energy transformations [GCO 3]

47.0 distinguish between scientific questions and technological problems [GCO 1]

48.0 analyze quantitatively the relationships among work, time, and power [GCO 3]

STSE - Electrical Energy Generation

53.0 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot [GCO 1]

54.0 analyze natural and technological systems to interpret and explain their structure and dynamics [GCO 1]

55.0 identify various constraints that result in tradeoffs during the development and improvement of technologies [GCO 1]

Activity 3: Nuclear Transformations

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

4.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Performing and Recording

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

7.0 use instruments effectively and accurately for collecting data [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

Analyzing and Interpreting

12.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

Work-Energy Theorem

41.0 analyze common energy transformation situations using the work-energy theorem [GCO 3]

42.0 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions [GCO 1]

Elastic and Inelastic Collisions

52.0 determine which laws of conservation of energy or momentum are best used to solve particular real life situations involving elastic and inelastic collisions [GCO 3]

Radioactivity

56.0 describe the products of radioactive decay and the characteristics of alpha, beta, and gamma radiation [GCO 3]

57.0 describe sources of radioactivity in the natural and constructed environments [GCO 3]

58.0 provide examples of how science and technology are an integral part of their lives and their community [GCO 1]

Activity 4: Ionizing Radiation

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

Performing and Recording

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

Analyzing and Interpreting

12.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

Radioactivity

56.0 describe the products of radioactive decay and the characteristics of alpha, beta, and gamma radiation [GCO 3]

57.0 describe sources of radioactivity in the natural and constructed environments [GCO 3]

58.0 provide examples of how science and technology are an integral part of their lives and their community [GCO 1]

Activity 5: Mass-Energy Equivalence

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

4.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Performing and Recording

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

7.0 use instruments effectively and accurately for collecting data [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

Analyzing and Interpreting

12.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

Work

39.0 analyze quantitatively the relationships among force, distance, and work [GCO 3]

Mass-Energy Equivalence

59.0 apply quantitatively the law of conservation of mass and energy, using Einstein's mass-energy equivalence [GCO 3]

Fission and Fusion

60.0 compare and contrast qualitatively and quantitatively nuclear fission and fusion [GCO 3]

Activity 6: Where Do the Elements Come From?

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

Performing and Recording

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

7.0 use instruments effectively and accurately for collecting data [GCO 2]

8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

Analyzing and Interpreting

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

Radioactivity

56.0 describe the products of radioactive decay and the characteristics of alpha, beta, and gamma radiation [GCO 3]

Fission and Fusion

60.0 compare and contrast qualitatively and quantitatively nuclear fission and fusion [GCO 3]

Activity 7: Conservation Laws and Dark Energy

Integrated Skills

Initiating and Planning

1.0 identify questions to investigate that arise from practical problems and issues [GCO 2]

4.0 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making [GCO 2]

Performing and Recording

7.0 use instruments effectively and accurately for collecting data [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

Analyzing and Interpreting

15.0 evaluate the relevance, reliability, and adequacy of data and data collection methods [GCO 2]

17.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

21.0 identify new questions or problems that arise from what was learned [GCO 2]

Communication and Teamwork

22.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]

25.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

Work and Energy

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

42.0 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions

47.0 distinguish between scientific questions and technological problems

53.0 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot

A Deeper Understanding of Energy

Curriculum Connections

NOVA SCOTIA—Physics 11 and 12

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Physics 11 and 12 Curriculum Connections
(2002)

Activity 1: The Conservation and Transformation of Energy

PHYSICS 11: MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

114-9 explain the importance of communicating the results of a scientific or technological endeavour using appropriate language and conventions

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

Knowledge

325-9 analyse quantitatively the relationships among force, distance, and work

325-10 analyse quantitatively the relationships among work, time, and power

326-1 analyse quantitatively the relationships among mass, speed, kinetic energy, and heat using the law of conservation of energy

326-7 analyse common energy transformation situations using the closed system work-energy theorem

PHYSICS 12: FORCE, MOTION, WORK, AND ENERGY

Knowledge

327-4 explain quantitatively the relationship between potential and kinetic energies of a mass in simple harmonic motion

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 2: Innovative Technologies

PHYSICS 11: MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

114-9 explain the importance of communicating the results of a scientific or technological endeavour using appropriate language and conventions

115-5 analyse why and how a particular technology was developed and improved over time

Relationships between Science and Technology

116-6 describe and evaluate the design of technological solution and the way they function using principles of energy and momentum

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

Knowledge

325-10 analyse quantitatively the relationships among work, time, and power

326-1 analyse quantitatively the relationships among mass, speed, kinetic energy, and heat using the law of conservation of energy

326-5 describe quantitatively mechanical energy as the sum of kinetic and potential energies

326-6 analyse quantitatively problems related to kinematics and dynamics using the mechanical energy concept

326-7 analyse common energy transformation situations using the closed system work-energy theorem

326-8 determine the percentage efficiency of energy transformation

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Stewardship

446 have a sense of personal and shared responsibility for maintaining a sustainable environment

447 project the personal, social, and environmental consequences of proposed action

448 want to take action for maintaining a sustainable environment

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 3: Nuclear Transformations

PHYSICS 11: MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

114-9 explain the importance of communicating the results of a scientific or technological endeavour using appropriate language and conventions

115-5 analyse why and how a particular technology was developed and improved over time

Skills

Analysing and Interpreting

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

325-9 analyse quantitatively the relationships among force, distance, and work

326-7 analyse common energy transformation situations using the closed system work-energy theorem

PHYSICS 12: RADIOACTIVITY

STSE

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-6 describe and evaluate the design of technological solutions and the way they function, using scientific principles

Social and Environmental Contexts of Science and Technology

117-5 provide examples of how science and technology are an integral part of their lives and their community

117-7 identify and describe science- and technology-related careers related to the science they are studying

Performing and Recording

213-9 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

Knowledge

329-5 describe sources of radioactivity in the natural and constructed environments

326-9 apply quantitatively the law of conservation of mass and energy using Einstein's mass-energy equivalence

329-4 describe the products of radioactive decay, and the characteristics of alpha, beta, and gamma radiation

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Interest in Science

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 4: Ionizing Radiation

PHYSICS 12: RADIOACTIVITY

STSE

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-6 describe and evaluate the design of technological solutions and the way they function, using scientific principles

Social and Environmental Contexts of Science and Technology

117-5 provide examples of how science and technology are an integral part of their lives and their community

117-7 identify and describe science- and technology-related careers related to the science they are studying

Knowledge

329-5 describe sources of radioactivity in the natural and constructed environments

329-4 describe the products of radioactive decay, and the characteristics of alpha, beta, and gamma radiation

Radioactive Decay

- analyse data on radioactive decay to predict half-life (214-2)

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

437 appreciate that the applications of science and technology can raise ethical dilemmas

438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds

Interest in Science

439 show a continuing and more informed curiosity and interest in science and science-related issues

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Activity 5: Mass-Energy Equivalence

PHYSICS 11: MOMENTUM AND ENERGY

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

Knowledge

326-4 determine which laws of conservation, momentum, and energy are best used to analyse and solve particular real-life problems in elastic and inelastic interactions

325-9 analyse quantitatively the relationships among force, distance, and work

GRADE 12: RADIOACTIVITY

Knowledge

326-9 apply quantitatively the law of conservation of mass and energy using Einstein's mass-energy equivalence

329-6 compare and contrast fission and fusion

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

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441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Activity 6: Where Do the Elements Come From?

PHYSICS 11: MOMENTUM AND ENERGY

STSE

Social and Environmental Contexts of Science and Technology

117-7 identify and describe science- and technology-based careers related to the science they are studying

Skills

Performing and Recording

213-9 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

Communication and Teamwork

215-4 identify multiple perspectives that influence a science-related decision or issue

GRADE 12: RADIOACTIVITY

Knowledge

329-4 describe the products of radioactive decay, and the characteristics of alpha, beta, and gamma radiation

329-6 compare and contrast fission and fusion

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds

Interest in Science

439 show a continuing and more informed curiosity and interest in science and science-related issues

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 7: Conservation Laws and Dark Energy

PHYSICS 11: MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Relationships between Science and Technology

116-4 identify, analyse, and describe examples where technologies were developed based on scientific understanding, their design and function as part of a community's life, and science- and technology-related careers

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-9 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

213-3 use instruments accurately for collecting data

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data and infer or calculate linear and non-linear relationships among variables

Knowledge

326-4 determine which laws of conservation, momentum, and energy are best used to analyse and solve particular real-life problems in elastic and inelastic interactions

325-9 analyse quantitatively the relationships among force, distance, and work

326-7 analyse common energy transformation situations using the closed system work-energy theorem

GRADE 12: RADIOACTIVITY

STSE

Social and Environmental Contexts of Science and Technology

117-5 provide examples of how science and technology are an integral part of their lives and their community

118-2 analyse from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology

Skills

Performing and Recording

213-8 select and use apparatus and materials safely

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Grade 11: A Deeper Understanding of Energy

Curriculum Connections

ONTARIO - Energy and Society

IP = Initiating and Planning, PR = Performing and Recording, AI = Analysing and Interpreting, C = Communicating

Physics Curriculum Connections (SPH3U)

Activity 1: The Conservation and Transformation of Energy

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.2** select appropriate instruments (e.g., probeware, calorimeters, pendulums, solenoids) and materials (e.g., drag sleds, electric bells, balls, ramps), and identify appropriate methods, techniques, and procedures, for each inquiry [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models) [C]
- **A1.13** express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures [C]

Energy and Society

- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D2.3** use the law of conservation of energy to solve problems in simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat) [AI]
- **D2.4** plan and conduct inquiries involving transformations between gravitational potential energy and kinetic energy (e.g., using a pendulum, a falling ball, an object rolling down a ramp) to test the law of conservation of energy [IP, PR]
- **D3.1** describe a variety of energy transfers and transformations, and explain them using the law of conservation of energy
- **D3.2** explain the concepts of and interrelationships between energy, work, and power, and identify and describe their related units
- **D3.3** explain the following concepts, giving examples of each, and identify their related units: *thermal energy*, *kinetic energy*, *gravitational potential energy*, *heat, specific heat capacity*, *specific latent heat*, *power*, and *efficiency*

Physics Curriculum Connections (SPH3U)

Activity 2: Innovative Technologies

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.3** identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.9** analyse the information gathered from research sources for logic, accuracy, reliability, adequacy, and bias [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models) [C]
- **A1.12** use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation for qualitative and quantitative data (e.g., vector diagrams, free-body diagrams, algebraic equations) [C]
- **A1.13** express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures [C]

Energy and Society

- **D1.1** analyse, using the principles of energy transformations, a technology that involves the transfer and transformation of thermal energy (e.g., a power station, an air conditioner, a fuel cell, a laser printer) [AI, C]
- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D2.3** use the law of conservation of energy to solve problems in simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat) [AI]
- **D2.4** plan and conduct inquiries involving transformations between gravitational potential energy and kinetic energy (e.g., using a pendulum, a falling ball, an object rolling down a ramp) to test the law of conservation of energy [IP, PR]
- **D2.5** solve problems involving the relationship between power, energy, and time [AI]
- **D2.7** compare and contrast the input energy, useful output energy, and per cent efficiency of selected energy generation methods (e.g., hydroelectric, thermal, geothermal, nuclear fission, nuclear fusion, wind, solar) [AI, C]
- **D3.1** describe a variety of energy transfers and transformations, and explain them using the law of conservation of energy
- **D3.2** explain the concepts of and interrelationships between energy, work, and power, and identify and describe their related units
- **D3.3** explain the following concepts, giving examples of each, and identify their related units: *thermal energy*, *kinetic energy*, *gravitational potential energy*, *heat, specific heat capacity*, *specific latent heat*, *power*, and *efficiency*
- **D3.4** identify, qualitatively, the relationship between efficiency and thermal energy transfer

Physics Curriculum Connections (SPH3U)

Activity 3: Nuclear Transformations

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.3** identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately [IP]
- **A1.4** apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.12** use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation for qualitative and quantitative data (e.g., vector diagrams, free-body diagrams, algebraic equations) [C]
- **A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., theoretical physicist; communications, networks, and control systems professional; engineer; metallurgist) and the education and training necessary for these careers

Energy and Society

- **D1.2** assess, on the basis of research, how technologies related to nuclear, thermal, or geothermal energy affect society and the environment (e.g., thermal regulating units, radiopharmaceuticals, dry-steam power plants, ground-source heat pumps) [IP, PR, AI, C]
- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D2.3** use the law of conservation of energy to solve problems in simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat) [AI]
- **D2.8** investigate the relationship between the concepts of conservation of mass and conservation of energy, and solve problems using the mass–energy equivalence [PR, AI]
- **D3.5** describe, with reference to force and displacement along the line of force, the conditions that are required for work to be done
- **D3.9** identify and describe the structure of common nuclear isotopes (e.g., hydrogen, deuterium, tritium)
- **D3.10** compare the characteristics of (e.g., mass, charge, speed, penetrating power, ionizing ability) and safety precautions related to alpha particles, beta particles, and gamma rays

Physics Curriculum Connections (SPH3U)

Activity 4: Ionizing Radiation

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.3** identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., theoretical physicist; communications, networks, and control systems professional; engineer; metallurgist) and the education and training necessary for these careers
- **A2.2** describe the contributions of scientists, including Canadians (e.g., Richard E. Taylor, Leonard T. Bruton, Willard S. Boyle, Martha Salcudean, Harriet Brooks, Louis Slotin), to the fields under study

Energy and Society

- **D1.2** assess, on the basis of research, how technologies related to nuclear, thermal, or geothermal energy affect society and the environment (e.g., thermal regulating units, radiopharmaceuticals, dry-steam power plants, ground-source heat pumps) [IP, PR, AI, C]
- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D3.2** explain the concepts of and interrelationships between energy, work, and power, and identify and describe their related units
- **D3.8** distinguish between and provide examples of conduction, convection, and radiation
- **D3.10** compare the characteristics of (e.g., mass, charge, speed, penetrating power, ionizing ability) and safety precautions related to alpha particles, beta particles, and gamma rays

Physics Curriculum Connections (SPH3U)

Activity 5: Mass-Energy Equivalence

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models) [C]
- **A1.12** use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation for qualitative and quantitative data (e.g., vector diagrams, free-body diagrams, algebraic equations) [C]
- **A1.13** express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures [C]
- **A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., theoretical physicist; communications, networks, and control systems professional; engineer; metallurgist) and the education and training necessary for these careers

Energy and Society

- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D2.3** use the law of conservation of energy to solve problems in simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat) [AI]
- **D2.4** plan and conduct inquiries involving transformations between gravitational potential energy and kinetic energy (e.g., using a pendulum, a falling ball, an object rolling down a ramp) to test the law of conservation of energy [IP, PR]
- **D2.8** investigate the relationship between the concepts of conservation of mass and conservation of energy, and solve problems using the mass–energy equivalence [PR, AI]
- **D3.1** describe a variety of energy transfers and transformations, and explain them using the law of conservation of energy
- **D3.2** explain the concepts of and interrelationships between energy, work, and power, and identify and describe their related units
- **D3.3** explain the following concepts, giving examples of each, and identify their related units: *thermal energy*, *kinetic energy*, *gravitational potential energy*, *heat, specific heat capacity*, *specific latent heat*, *power*, and *efficiency*
- **D3.5** describe, with reference to force and displacement along the line of force, the conditions that are required for work to be done
- **D3.6** describe and compare nuclear fission and nuclear fusion

Physics Curriculum Connections (SPH3U)

Activity 6: Where Do the Elements Come From?

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.4** apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., theoretical physicist; communications, networks, and control systems professional; engineer; metallurgist) and the education and training necessary for these careers
- **A2.2** describe the contributions of scientists, including Canadians (e.g., Richard E. Taylor, Leonard T. Bruton, Willard S. Boyle, Martha Salcudean, Harriet Brooks, Louis Slotin), to the fields under study

Energy and Society

- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D2.3** use the law of conservation of energy to solve problems in simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat) [AI]
- **D2.4** plan and conduct inquiries involving transformations between gravitational potential energy and kinetic energy (e.g., using a pendulum, a falling ball, an object rolling down a ramp) to test the law of conservation of energy [IP, PR]
- **D2.8** investigate the relationship between the concepts of conservation of mass and conservation of energy, and solve problems using the mass–energy equivalence [PR, AI]
- **D3.1** describe a variety of energy transfers and transformations, and explain them using the law of conservation of energy
- **D3.2** explain the concepts of and interrelationships between energy, work, and power, and identify and describe their related units
- **D3.3** explain the following concepts, giving examples of each, and identify their related units: *thermal energy*, *kinetic energy*, *gravitational potential energy*, *heat, specific heat capacity*, *specific latent heat*, *power*, and *efficiency*
- **D3.5** describe, with reference to force and displacement along the line of force, the conditions that are required for work to be done
- **D3.6** describe and compare nuclear fission and nuclear fusion

Physics Curriculum Connections (SPH3U)

Activity 7: Conservation Laws and Dark Energy

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.2** select appropriate instruments (e.g., probeware, calorimeters, pendulums, solenoids) and materials (e.g., drag sleds, electric bells, balls, ramps), and identify appropriate methods, techniques, and procedures, for each inquiry [IP]
- **A1.4** apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.12** use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation for qualitative and quantitative data (e.g., vector diagrams, free-body diagrams, algebraic equations) [C]
- **A1.13** express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures [C]
- **A2.2** describe the contributions of scientists, including Canadians (e.g., Richard E. Taylor, Leonard T. Bruton, Willard S. Boyle, Martha Salcudean, Harriet Brooks, Louis Slotin), to the fields under study

Energy and Society

- **D2.1** use appropriate terminology related to energy transformations, including, but not limited to: *mechanical energy*, *gravitational potential energy*, *kinetic energy*, *work*, *power*, *fission*, *fusion*, *heat*, *heat capacity*, *temperature*, and *latent heat* [C]
- **D2.3** use the law of conservation of energy to solve problems in simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat) [AI]
- **D2.8** investigate the relationship between the concepts of conservation of mass and conservation of energy, and solve problems using the mass–energy equivalence [PR, AI]
- **D3.1** describe a variety of energy transfers and transformations, and explain them using the law of conservation of energy
- **D3.3** explain the following concepts, giving examples of each, and identify their related units: *thermal energy*, *kinetic energy*, *gravitational potential energy*, *heat, specific heat capacity*, *specific latent heat*, *power*, and *efficiency*

A Deeper Understanding of Energy

Curriculum Connections

PRINCE EDWARD ISLAND—Physics 521A

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Physics 521A Curriculum Connections
(2009)

Activity 1: The Conservation and Transformation of Energy

MOMENTUM AND ENERGY

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence, and appropriate processes for problem solving, inquiring, and decision making

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

Knowledge

325-9 analyse quantitatively the relationships among force, displacement, and work

325-10 analyse quantitatively the relationships among work, time, and power

326-1 analyse quantitatively the relationships among mass, height, speed, and heat energy using the law of conservation of energy

326-5 describe quantitatively mechanical energy as the sum of kinetic and potential energies

326-6 analyse quantitatively problems related to kinematics and dynamics using the mechanical energy concept

326-7 analyse common energy transformation situations using the work-energy theorem

326-4 determine which laws of conservation of energy or momentum are best used to solve particular real-life situations involving elastic and inelastic collisions

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 2: Innovative Technologies

MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Relationships between Science and Technology

116-6 describe and evaluate the design of technological solutions and the way they function using principles of energy and momentum

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

Knowledge

325-9 analyse quantitatively the relationships among force, displacement, and work

325-10 analyse quantitatively the relationships among work, time, and power

326-1 analyse quantitatively the relationships among mass, height, speed, and heat energy using the law of conservation of energy

326-5 describe quantitatively mechanical energy as the sum of kinetic and potential energies

326-6 analyse quantitatively problems related to kinematics and dynamics using the mechanical energy concept

326-7 analyse common energy transformation situations using the work-energy theorem

326-8 determine the percent efficiency of energy transformations

326-4 determine which laws of conservation of energy or momentum are best used to solve particular real-life situations involving elastic and inelastic collisions

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Stewardship

446 have a sense of personal and shared responsibility for maintaining a sustainable environment

447 project the personal, social, and environmental consequences of proposed action

448 want to take action for maintaining a sustainable environment

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 3: Nuclear Transformations

MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Skills

Analysing and Interpreting

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Knowledge

325-9 analyse quantitatively the relationships among force, displacement, and work

325-10 analyse quantitatively the relationships among work, time, and power

326-1 analyse quantitatively the relationships among mass, height, speed, and heat energy using the law of conservation of energy

326-7 analyse common energy transformation situations using the work-energy theorem

326-4 determine which laws of conservation of energy or momentum are best used to solve particular real-life situations involving elastic and inelastic collisions

WAVES

Performing and Recording

213-7 select and integrate information from various print and electronic sources or from several parts of the same source

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

Interest in Science

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 4: Ionizing Radiation

MOMENTUM AND ENERGY

STSE

115-5 analyse why and how a particular technology was developed and improved over time

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence, and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-3 use instruments effectively and accurately for collecting data

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

Appreciation of Science

437 appreciate that the applications of science and technology can raise ethical dilemmas

438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Knowledge

326-1 analyse quantitatively the relationships among mass, height, speed, and heat energy using the law of conservation of energy

326-7 analyse common energy transformation situations using the work-energy theorem

Attitudes

Appreciation of Science

436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not

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438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds

Interest in Science

439 show a continuing and more informed curiosity and interest in science and science-related issues

441 consider further studies and careers in science- and technology-related fields

Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Activity 5: Mass-Energy Equivalence

MOMENTUM AND ENERGY

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

Knowledge

325-9 analyse quantitatively the relationships among force, displacement, and work

326-7 analyse common energy transformation situations using the work-energy theorem

326-4 determine which laws of conservation of energy or momentum are best used to solve particular real-life situations involving elastic and inelastic collisions

Attitudes

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Scientific Inquiry

442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations

443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Activity 6: Where Do the Elements Come From?

MOMENTUM AND ENERGY

Skills

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

Knowledge

325-9 analyse quantitatively the relationships among force, displacement, and work

326-7 analyse common energy transformation situations using the work-energy theorem

326-6 analyse quantitatively problems related to kinematics and dynamics using the mechanical energy concept

Attitudes

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443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

Activity 7: Conservation Laws and Dark Energy

MOMENTUM AND ENERGY

STSE

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

Skills

Initiating and Planning

212-8 evaluate and select appropriate instruments for collecting evidence, and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-3 use instruments accurately for collecting data

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

Knowledge

325-9 analyse quantitatively the relationships among force, displacement, and work

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326-6 analyse quantitatively problems related to kinematics and dynamics using the mechanical energy concept

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Scientific Inquiry

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443 use factual information and rational explanations when analysing and evaluating

444 value the processes for drawing conclusions

Collaboration

445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas

Safety in Science

449 show concern for safety and accept the need for rules and regulations

450 be aware of the direct and indirect consequences of their actions

A Deeper Understanding of Energy

Curriculum Connections

SASKATCHEWAN—Physics 30

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

* Further curriculum connections can be made to Science 9, but that is beyond the scope of this particular chart.

Physics 30 Curriculum Connections
(2016, updated April 2017)

Activity 1: The Conservation and Transformation of Energy

Physics 30—Conservation Laws

PH30-CO1 Investigate the nature of mechanical energy and efficiency in mechanical systems in relation to the law of conservation of energy. [SI]

a. Recognize work as the transfer of energy that takes place when a force acts over a displacement. (K)

c. Discuss how common usage of the terms work, energy and power differ from their operational definitions in physics. (K)

d. Identify the properties (e.g., boundaries, inputs and outputs) of a system with respect to total mechanical energy. (STSE, K)

e. Explain the law of conservation of energy in terms of isolated and non-isolated systems and conservation of mechanical energy. (STSE, K)

h. Discuss the challenges in modeling conservation of energy in real-life situations. (STSE)

Physics 30—Forces and Motion

PH30-FM2 Analyze the effects of forces on objects undergoing uniform motion, uniformly accelerated motion and circular motion. [SI]

a. Pose questions related to practical examples of the effects of forces on objects. (STSE)

e. Solve problems involving force, mass and acceleration, using free-body diagrams and Newton's second law of motion ($\vec{F} = m\vec{a}$). (K, S)

f. Describe the effect of friction and air resistance, including terminal velocity, on objects in motion (e.g., rollercoasters, skydiving, snowboards, meteors entering Earth's atmosphere, inclined plane situations, rolling balls, spacecraft and satellite re-entry, aircraft, race cars and artillery). (K, STSE)

Foundation 4: Attitudes

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Activity 2: Innovative Technologies

Physics 30—Student-Directed Study

PH30-SDS1 Create and carry out a plan to explore one or more topics of personal interest relevant to Physics 30 in depth. [DM, SI, TPS]

a. Design a scientific investigation related to a topic of study in Physics 30 that includes a testable question, a hypothesis, an experimental design that will test the hypothesis and detailed procedures for collecting and analyzing data. (STSE, S)

b. Carry out an experiment following established scientific protocols to investigate a question of interest related to one or more of the topics of Physics 30. (S, A, K, STSE)

d. Design, construct and evaluate the effectiveness of a device, model or technique that demonstrates the scientific principles underlying concept related to a Physics 30 topic. (STSE, S)

e. Debate an issue related to physics, including developing materials to support the arguments for and arguments against a position. (A, K, S)

Physics 30—Conservation Laws

PH30-CO1 Investigate the nature of mechanical energy and efficiency in mechanical systems in relation to the law of conservation of energy. [SI]

a. Recognize work as the transfer of energy that takes place when a force acts over a displacement. (K)

b. Identify the conditions required for positive, negative and zero mechanical work and their relation to the angle between the applied force and displacement. (K)

c. Discuss how common usage of the terms work, energy and power differ from their operational definitions in physics. (K)

d. Identify the properties (e.g., boundaries, inputs and outputs) of a system with respect to total mechanical energy. (STSE, K)

e. Explain the law of conservation of energy in terms of isolated and non-isolated systems and conservation of mechanical energy. (STSE, K)

h. Discuss the challenges in modeling conservation of energy in real-life situations. (STSE)

i. Investigate the efficiency of energy transformations in various technologies with reference to useful work, friction and the production heat, sound and light. (K, STSE)

Foundation 4: Attitudes

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Stewardship

Students will be encouraged to develop responsibility in the application of science and technology in relation to society and the natural environment.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Activity 3: Nuclear Transformations

Physics 30—Conservation Laws

PH30-CO1 Investigate the nature of mechanical energy and efficiency in mechanical systems in relation to the law of conservation of energy. [SI]

a. Recognize work as the transfer of energy that takes place when a force acts over a displacement. (K)

b. Identify the conditions required for positive, negative and zero mechanical work and their relation to the angle between the applied force and displacement. (K)

c. Discuss how common usage of the terms work, energy and power differ from their operational definitions in physics. (K)

d. Identify the properties (e.g., boundaries, inputs and outputs) of a system with respect to total mechanical energy. (STSE, K)

g. Design and perform experiments and/or simulations, including collecting, analyzing and interpreting data, to determine the kinetic energy involved in elastic and inelastic interactions (e.g., curling stones, billiard balls, bouncing ball, seatbelts and automobile collisions). (STSE, S)

Physics 30—Modern Physics

PH30-MP2 Assess the effects of radioactivity and applications of nuclear technology on society and the environment. [CP, DM, SI]

d. Represent nuclear reactions involving alpha, beta and gamma decay using words, diagrams and equations. (S)

e. Explain that some isotopes undergo natural radioactive decay, and that half-life is a measure of the rate of radioactive decay. (K)

l. Explain the characteristics of the strong nuclear force and its role in maintaining atomic stability. (K, STSE)

n. Analyze societal and environmental impacts of applications of nuclear technologies such as medical isotopes, food irradiation, smoke detectors, industrial radiography, pesticide tracers, nuclear weapons, nuclear reactors and nuclear waste disposal. (A, STSE)

Foundation 4: Attitudes

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Activity 4: Ionizing Radiation

Physics 30—Modern Physics

PH30-MP2 Assess the effects of radioactivity and applications of nuclear technology on society and the environment. [CP, DM, SI]

a. Research the contributions of women (e.g., Harriet Brooks, Marie Curie, Lise Meitner, Chien-Shiung Wu, Mileva Maric and Ida Noddack) from various cultures to the development of scientific understanding of radioactivity.

b. Identify natural and artificial sources of radiation on Earth and throughout the universe. (K)

c. Compare the characteristics (e.g., composition, penetrating power, speed and potential danger) of alpha, beta and gamma radiation. (K) (STSE)

d. Represent nuclear reactions involving alpha, beta and gamma decay using words, diagrams and equations. (S)

f. Assess the short- and long-term implications of radiation on living things, including the effects on different types of tissues and cells. (A, K, STSE)

n. Analyze societal and environmental impacts of applications of nuclear technologies such as medical isotopes, food irradiation, smoke detectors, industrial radiography, pesticide tracers, nuclear weapons, nuclear reactors and nuclear waste disposal. (A, STSE)

Foundation 4: Attitudes

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Stewardship

Students will be encouraged to develop responsibility in the application of science and technology in relation to society and the natural environment.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Activity 5: Mass-Energy Equivalence

Physics 30—Modern Physics

PH30-MP2 Assess the effects of radioactivity and applications of nuclear technology on society and the environment. [CP, DM, SI]

d. Represent nuclear reactions involving alpha, beta and gamma decay using words, diagrams and equations. (S)

i. Model the process of nuclear fission, including conditions necessary for a chain reaction. (K, S)

m. Discuss the importance of mass defect and $e = mc^2$ and why this particular equation has gained such prominence in society. (STSE, A)

n. Research the development of quantum mechanics and relativity, including perspectives of key scientists such as Albert Einstein, Maxwell Planck, Edwin Schrödinger, Werner Heisenberg, Thomas Young and Stephen Hawking. (STSE)

Foundation 4: Attitudes

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Stewardship

Students will be encouraged to develop responsibility in the application of science and technology in relation to society and the natural environment.

Activity 6: Where Do the Elements Come From?

Physics 30—Modern Physics

PH30-MP2 Assess the effects of radioactivity and applications of nuclear technology on society and the environment. [CP, DM, SI]

a. Research the contributions of women (e.g., Harriet Brooks, Marie Curie, Lise Meitner, Chien-Shiung Wu, Mileva Maric and Ida Noddack) from various cultures to the development of scientific understanding of radioactivity.

k. Examine the process of nuclear fusion and the difficulties in harnessing nuclear fusion as an energy source. (K, STSE)

n. Analyze societal and environmental impacts of applications of nuclear technologies such as medical isotopes, food irradiation, smoke detectors, industrial radiography, pesticide tracers, nuclear weapons, nuclear reactors and nuclear waste disposal. (A, STSE)

Physics 30—Conservation Laws

PH30-CO1 Investigate the nature of mechanical energy and efficiency in mechanical systems in relation to the law of conservation of energy. [SI]

d. Identify the properties (e.g., boundaries, inputs and outputs) of a system with respect to total mechanical energy. (STSE, K)

g. Design and perform experiments and/or simulations, including collecting, analyzing and interpreting data, to determine the kinetic energy involved in elastic and inelastic interactions (e.g., curling stones, billiard balls, bouncing ball, seatbelts and automobile collisions). (STSE, S)

Foundation 4: Attitudes

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Activity 7: Conservation Laws and Dark Energy

Physics 30—Modern Physics

PH30-MP2 Assess the effects of radioactivity and applications of nuclear technology on society and the environment. [CP, DM, SI]

h. Describe the characteristics of the weak nuclear force and its role in beta decay. (K, STSE)

Physics 30—Conservation Laws

PH30-CO1 Investigate the nature of mechanical energy and efficiency in mechanical systems in relation to the law of conservation of energy. [SI]

a. Recognize work as the transfer of energy that takes place when a force acts over a displacement. (K)

c. Discuss how common usage of the terms work, energy and power differ from their operational definitions in physics. (K)

d. Identify the properties (e.g., boundaries, inputs and outputs) of a system with respect to total mechanical energy. (STSE, K)

e. Explain the law of conservation of energy in terms of isolated and non-isolated systems and conservation of mechanical energy. (STSE, K)

g. Design and perform experiments and/or simulations, including collecting, analyzing and interpreting data, to determine the kinetic energy involved in elastic and inelastic interactions (e.g., curling stones, billiard balls, bouncing ball, seatbelts and automobile collisions). (STSE, S)

h. Discuss the challenges in modeling conservation of energy in real-life situations. (STSE)

Physics 30—Forces and Motion

PH30-FM2 Analyze the effects of forces on objects undergoing uniform motion, uniformly accelerated motion and circular motion. [SI]

i. Explore the limitations of Newton's laws of motion in relativistic and quantum situations (e.g., objects moving at or near the speed of light and subatomic particles). (K, STSE)

Foundation 4: Attitudes

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

A Deeper Understanding of Energy

Curriculum Connections

Next Generation Science Standards (NGSS): Grades 9–12

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Physics Curriculum Connections
(April 2013)

Activity 1: The Conservation and Transformation of Energy

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

Activity 2: Innovative Technologies

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

Activity 3: Nuclear Transformations

Structure and Properties of Matter

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*]

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]

Earth and Space Systems

HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's

core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]

Activity 4: Ionizing Radiation

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

Activity 5: Mass-Energy Equivalence

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

Activity 6: Where Do the Elements Come From?

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]

Earth and Space Systems

HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

Activity 7: Conservation Laws and Dark Energy

Physical Science

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]