Fields

Curriculum Connections

ALBERTA, NORTHWEST TERRITORIES, NUNAVUT—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.

Physics 30 Curriculum Connections
(2007, updated 2014)

Activity 1: What Is a Field?

Unit B: Forces and Fields

Knowledge

B1.2k explain electrical interactions in terms of the repulsion and attraction of charges

30–B2.1k define vector fields

30–B2.2k compare forces and fields

30–B3.1k describe magnetic interactions in terms of forces and fields

30–B3.2k compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

Skills

Communication and Teamwork

30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Activity 2: Making Electric Fields Real

Unit B: Forces and Fields

Knowledge

30–B1.2k explain electrical interactions in terms of the repulsion and attraction of charges

30–B1.4k explain, qualitatively, the distribution of charge on the surfaces of conductors and insulators

30–B1.6k apply Coulomb's law, quantitatively, to analyze the interaction of two point charges

30–B1.7k determine, quantitatively, the magnitude and direction of the electric force on a point charge due to two or more other point charges in a plane

30–B2.3k compare, qualitatively, gravitational potential energy and electric potential

30–B2.6k explain, quantitatively, electric fields in terms of intensity (strength) and direction, relative to the source of the field and to the effect on an electric charge

30–B2.8k describe, quantitatively, the motion of an electric charge in a uniform electric field

30–B3.2k compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

STS (Nature of Science Emphasis)

30–B1.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

Skills

Initiating and Planning

30–B1.1s and B2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

Performing and Recording

30–B1.2s and B2.2s and B3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- predict, using appropriate hand rules, the relative directions of motion, force and field in electromagnetic interactions **(PR–NS2)**.

Communication and Teamwork

30–B1.4s, B2.4s, and B3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Activity 3: Maxwell's Equations

Unit B: Forces and Fields

Knowledge

30–B3.1k describe magnetic interactions in terms of forces and fields

30–B3.2k compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

30–B3.3k describe how the discoveries of Oersted and Faraday form the foundation of the theory relating electricity to magnetism

30–B3.4k describe, qualitatively, a moving charge as the source of a magnetic field and predict the orientation of the magnetic field from the direction of motion

30–B3.7k describe and explain, qualitatively, the interaction between a magnetic field and a moving charge and between a magnetic field and a current-carrying conductor

30–B3.8k explain, quantitatively, the effect of an external magnetic field on a current-carrying conductor

30–B3.9k describe, qualitatively, the effects of moving a conductor in an external magnetic field, in terms of moving charges in a magnetic field.

STS (Nature of Science Emphasis)

30–B1.1sts and B3.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

Skills

Performing and Recording

30–B1.2s 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–B1.3s and B3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Unit C: Electromagnetic Radiation

Knowledge

30–C1.1k describe, qualitatively, how all accelerating charges produce EMR

30–C1.2k compare and contrast the constituents of the electromagnetic spectrum on the basis of frequency and wavelength

Activity 4: Auroras and Interacting Fields

Unit B: Forces and Fields

Knowledge

30–B1.2k explain electrical interactions in terms of the repulsion and attraction of charges

30–B1.4k explain, qualitatively, the distribution of charge on the surfaces of conductors and insulators

30–B2.8k describe, quantitatively, the motion of an electric charge in a uniform electric field

30–B2.9k explain, quantitatively, electrical interactions using the law of conservation of energy

30–B3.1k describe magnetic interactions in terms of forces and fields

30–B3.2k compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

30–B3.4k describe, qualitatively, a moving charge as the source of a magnetic field and predict the orientation of the magnetic field from the direction of motion

30–B3.5k explain, qualitatively and quantitatively, how a uniform magnetic field affects a moving electric charge, using the relationships among charge, motion, field direction and strength, when motion and field directions are mutually perpendicular

30–B3.6k explain, quantitatively, how uniform magnetic and electric fields affect a moving electric charge, using the relationships among charge, motion, field direction and strength, when motion and field directions are mutually perpendicular

STS (Nature of Science Emphasis)

30–B1.1sts and B3.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

Skills

Performing and Reporting

30–B3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- predict, using appropriate hand rules, the relative directions of motion, force and field in electromagnetic interactions **(PR–NS2)**.

Analyzing and Interpreting

30–B3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Communication and Teamwork

30–B1.4s and B2,4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Unit C: Electromagnetic Radiation

Knowledge

30–C2.1k define the photon as a quantum of EMR and calculate its energy

Unit D: Atomic Physics

Knowledge

30–D2.5k calculate the energy difference between states, using the law of conservation of energy and the observed characteristics of an emitted photon

Activity 5: Explaining Mercury's Orbit

Unit B: Forces and Fields

Knowledge

30–B3.2k compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

STS (Nature of Science Emphasis)

30–B3.3sts explain that scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery **(ST4) [ICT F2–4.4]**

Design Challenge: Using Fields to Go Places

Unit B: Forces and Fields

Knowledge

30–B1.2k explain electrical interactions in terms of the repulsion and attraction of charges

30–B2.8k describe, quantitatively, the motion of an electric charge in a uniform electric field

30–B3.1k describe magnetic interactions in terms of forces and fields

30–B3.2k compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

30–B3.5k explain, qualitatively and quantitatively, how a uniform magnetic field affects a moving electric charge, using the relationships among charge, motion, field direction and strength, when motion and field directions are mutually perpendicular

30–B3.6k explain, quantitatively, how uniform magnetic and electric fields affect a moving electric charge, using the relationships among charge, motion, field direction and strength, when motion and field directions are mutually perpendicular

STS (Nature of Science Emphasis)

30–B1.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

Skills

Performing and Recording

30–B1.2s and B2.2s 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–B3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

Communication and Teamwork

30–B1.4s, B2.4s, and B3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

Fields

Curriculum Connections

BRITISH COLUMBIA AND YUKON—Physics 12

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*Elaborations are not included in this chart.

Physics 12 Curriculum Connections
(2018)

Activity 1: What Is a Field?

Curricular Competencies

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled

Content

- **electric field** and Coulomb's law
- **magnetic field** and **magnetic force**
- **impulse** and momentum

Activity 2: Making Electric Fields Real

Curricular Competencies

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)

Processing and analyzing data and information

- Construct, analyze, and interpret graphs, models, and/or diagrams

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled

Applying and innovating

- Implement multiple strategies to solve problems in real-life, applied, and conceptual situations

Content

- **electric field** and Coulomb's law
- electric potential energy, electric potential, and electric potential difference
- **electrostatic dynamics and energy relationships**

Activity 3: Maxwell's Equations

Curricular Competencies

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

Evaluating

- Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon

Content

- **electric field** and Coulomb's law
- **magnetic field** and **magnetic force**

Activity 4: Auroras and Interacting Fields

Curricular Competencies

Questioning and predicting

- Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world

Processing and analyzing data and information

- Construct, analyze, and interpret graphs, models, and/or diagrams

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

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon

Content

- **electric field** and Coulomb's law
- electric potential energy, electric potential, and electric potential difference
- **electrostatic dynamics and energy relationships**
- **magnetic field** and **magnetic force**
- **impulse** and momentum

Activity 5: Explaining Mercury's Orbit

n/a

Design Challenge: Using Fields to Go Places

Curricular Competencies

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- 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)

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 their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions

Applying and innovating

- Co-operatively design projects with local and/or global connections and applications
- 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

Content

- **electric field** and Coulomb's law
- electric potential energy, electric potential, and electric potential difference
- **magnetic field** and **magnetic force**
- **impulse** and momentum

Fields

Curriculum Connections

Manitoba—Senior 3 Physics and Senior 4 Physics (40S)

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Physics Curriculum Connections (Senior 3 Physics and Senior 4 Physics)
(2003 and 2005)

Activity 1: What Is a Field?

SENIOR 3 PHYSICS

Skills and Attitudes Outcomes

Nature of Science

S3P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

S3P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

Attitudes

S3P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 4.3: Magnetic Fields

S3P-4-20 Define the magnetic field as the region of space around a magnet where another magnet will experience a force.

S3P-4-22 Describe the concept of magnetic poles and demonstrate that like poles repel and unlike poles attract.

Activity 2: Making Electric Fields Real

SENIOR 3 PHYSICS

Skills and Attitudes Outcomes

Nature of Science

S3P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

Inquiry Skills

S3P-0-2a Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

S3P-0-2h Analyze problems, using vectors. Include: adding and subtracting vectors in straight lines and at right angles, vector components.

Attitudes

S3P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 4.2: Electric Fields

S3P-4-14 Define the electric field qualitatively as the region of space around a charge where a positive test charge experiences a force.

S3P-4-15 Diagram electric fields using lines of force with respect to a positive test charge. Include: single point charges (positive and negative), near two like charges, near two unlike charges, between a single charge and a charged plate, between two oppositely charged parallel plates.

SENIOR 4 PHYSICS (40S)

Skills and Attitudes Outcomes

Nature of Science

S4P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

Inquiry Skills

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

S4P-0-2f Record, organize, and display data, using an appropriate format. Include: labelled diagrams, tables, graphs.

S4P-0-2h Analyze problems, using vectors. Include: adding and subtracting vectors in straight lines and at right angles, vector components.

Attitudes

S4P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 2.3: Electric and Magnetic Fields

S4P-2-14 Illustrate, using diagrams, how the charge distribution on two oppositely charged parallel plates results in a uniform field.

S4P-2-19 Define electric potential difference (voltage) and express the electric field between two oppositely charged parallel plates in terms of voltage and the separation between the plates $\left(\varepsilon = \frac{\Delta V}{d}\right)$.

S4P-2-20 Solve problems for charges moving between or through parallel plates.

Activity 3: Maxwell's Equations

SENIOR 3 PHYSICS

Skills and Attitudes Outcomes

Nature of Science

S3P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

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

Inquiry Skills

S3P-0-2a Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

Attitudes

S3P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 4.3: Magnetic Fields

S3P-4-20 Define the magnetic field as the region of space around a magnet where another magnet will experience a force.

SENIOR 4 PHYSICS (40S)

Skills and Attitudes Outcomes

Nature of Science

S4P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

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

Inquiry Skills

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

Attitudes

S4P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 2.3: Electric and Magnetic Fields

S4P-2-21 Use hand rules to describe the directional relationships between electric and magnetic fields and moving charges.

Topic 3.2: Electromagnetic Induction

S4P-3-8 Demonstrate how a change in magnetic flux induces voltage.

S4P-3-10 Outline Lenz's Law and apply to related problems.

Activity 4: Auroras and Interacting Fields

SENIOR 3 PHYSICS

Skills and Attitudes Outcomes

Nature of Science

S3P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

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

S3P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

Inquiry Skills

S3P-0-2h Analyze problems, using vectors. Include: adding and subtracting vectors in straight lines and at right angles, vector components.

Science, Technology, Society, and the Environment (STSE)

S3P-0-3b Describe examples of how technology has evolved in response to scientific advances, and how scientific knowledge has evolved as a result of new innovations in technology.

Attitudes

S3P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 4.2: Electric Fields

S3P-4-15 Diagram electric fields using lines of force with respect to a positive test charge. Include: single point charges (positive and negative), near two like charges, near two unlike charges, between a single charge and a charged plate, between two oppositely charged parallel plates.

Topic 4.3: Magnetic Fields

S3P-4-20 Define the magnetic field as the region of space around a magnet where another magnet will experience a force.

S3P-4-24 Investigate the influence and effects of the magnetic field of the Earth. Include: auroras, magnetic declination and inclination.

SENIOR 4 PHYSICS (40S)

Skills and Attitudes Outcomes

Nature of Science

S4P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

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

S4P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

Attitudes

S4P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

Specific Learning Outcomes

Topic 2.3: Electric and Magnetic Fields

S4P-2-21 Use hand rules to describe the directional relationships between electric and magnetic fields and moving charges.

Activity 5: Explaining Mercury's Orbit

SENIOR 3 PHYSICS

Skills and Attitudes Outcomes

Nature of Science

S3P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

S3P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

Specific Learning Outcomes

Topic 4.1: Gravitational Fields

S3P-4-01 Define the gravitational field qualitatively as the region of space around a mass where another point mass experiences a force.

Topic 4.4: Electromagnetism

S3P-4-25 Describe and demonstrate the phenomenon of electromagnetism.

S3P-4-26 Diagram and describe qualitatively the magnetic field around a current-carrying wire. Include: direction and intensity of the field.

S3P-4-27 Diagram and describe qualitatively the magnetic field of a solenoid. Include: direction and intensity of the field.

S3P-4-28 Describe and demonstrate the function of an electromagnet. Include: common applications of electromagnets.

Design Challenge: Using Fields to Go Places

SENIOR 3 PHYSICS

Skills and Attitudes Outcomes

Inquiry Skills

S3P-0-2h Analyze problems, using vectors. Include: adding and subtracting vectors in straight lines and at right angles, vector components.

Science, Technology, Society, and the Environment (STSE)

S3P-0-3e Identify a problem, initiate research, and design a technological or other solution to address the problem.

Attitudes

S3P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

S3P-0-4c Demonstrate confidence in carrying out scientific investigations and in addressing STSE issues.

S3P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

Specific Learning Outcomes

Topic 4.3: Magnetic Fields

S3P-4-20 Define the magnetic field as the region of space around a magnet where another magnet will experience a force.

S3P-4-22 Describe the concept of magnetic poles and demonstrate that like poles repel and unlike poles attract.

SENIOR 4 PHYSICS (40S)

Skills and Attitudes Outcomes

Inquiry Skills

S3P-0-2h Analyze problems, using vectors. Include: adding and subtracting vectors in straight lines and at right angles, vector components.

Science, Technology, Society, and the Environment (STSE)

S3P-0-3e Identify a problem, initiate research, and design a technological or other solution to address the problem.

Attitudes

S4P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

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

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

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

Specific Learning Outcomes

Topic 2.3: Electric and Magnetic Fields

S4P-2-20 Solve problems for charges moving between or through parallel plates.

S4P-2-21 Use hand rules to describe the directional relationships between electric and magnetic fields and moving charges.

S4P-2-22 Describe qualitatively various technologies that use electric and magnetic fields.

Fields

Curriculum Connections

NEW BRUNSWICK—Physics 12

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Physics 12 Curriculum Connections
(2003)

Activity 1: What Is a Field?

Attitudes

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

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

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

Fields

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and directions of the lines of force

Activity 2: Making Electric Fields Real

Attitudes

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

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

Fields

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and directions of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

Activity 3: Maxwell's Equations

Attitudes

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

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

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

Fields

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and directions of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

328-7 analyse, qualitatively and quantitatively, electromagnetic induction by both a changing magnetic flux and a moving conductor

328-5 analyse, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

328-6 describe the magnetic field produced by current in both a solenoid and a long, straight conductor

Activity 4: Auroras and Interacting Fields

Attitudes

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

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

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

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

Fields

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and directions of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

328-5 analyse, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

Activity 5: Explaining Mercury's Orbit

Attitudes

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

Fields

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and directions of the lines of force

Design Challenge: Using Fields to Go Places

Attitudes

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

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

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

Fields

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and directions of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

328-5 analyse, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

Fields

Curriculum Connections

NEWFOUNDLAND AND LABRADOR—Physics 3204

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Physics 3204 Curriculum Connections
(2019)

Activity 1: What Is a Field?

Fields

Knowledge

32.0 describe gravitational fields as regions of space that affect mass

41.0 describe magnetic fields as regions of space that affect mass and charge

Attitudes

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

Activity 2: Making Electric Fields Real

Fields

Skills

6.0 develop appropriate sampling procedures

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

Knowledge

37.0 describe electric fields as regions of space that affect charge

Activity 3: Maxwell's Equations

Fields

STSE

34.0 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge

Knowledge

37.0 describe electric fields as regions of space that affect charge

41.0 describe magnetic fields as regions of space that affect mass and charge

42.0 describe the magnetic field produced by current in both a solenoid and a long, straight conductor

43.0 analyze, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

46.0 analyze, qualitatively and quantitatively, electromagnetic induction by both a changing magnetic flux and a moving conductor

Activity 4: Auroras and Interacting Fields

Fields

STSE

38.0 analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology

Knowledge

37.0 describe electric fields as regions of space that affect charge

41.0 describe magnetic fields as regions of space that affect mass and charge

43.0 analyze, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

Attitudes

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

Introduction to Quantum Physics

Knowledge

57.0 explain the relationship between the energy levels in Bohr's model, the energy difference between the levels, and the energy of the emitted photons

Activity 5: Explaining Mercury's Orbit

Fields

STSE

36.0 explain how a major scientific milestone revolutionized thinking in the scientific communities

38.0 analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology

Knowledge

32.0 describe gravitational fields as regions of space that affect mass

Design Challenge: Using Fields to Go Places

Fields

STSE

47.0 analyze technological systems to interpret and explain their structure and dynamics

49.0 identify various constraints that result in tradeoffs during the development and improvement of technologies

Skills

16.0 identify and correct practical problems in the way a technological device or system functions

18.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others

Knowledge

37.0 describe electric fields as regions of space that affect charge

41.0 describe magnetic fields as regions of space that affect mass and charge

43.0 analyze, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

Attitudes

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

Fields

Curriculum Connections

NOVA SCOTIA—Physics 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 12 Curriculum Connections
(2002)

Activity 1: What Is a Field?

Fields

- explain the roles of evidence, theories and paradigms, and peer review in the development of the scientific knowledge associated with a major scientific milestone (114-2, 114-5, 115-3)
- describe magnetic, electric, and gravitational fields as regions of space that affect mass and charge (328-1)
- describe magnetic, electric, and gravitational fields by illustrating the source and direction of the lines of force (328-2)
- describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles (328-3)

Attitudes

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

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

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: Making Electric Fields Real

Fields

- describe magnetic, electric, and gravitational fields as regions of space that affect mass and charge (328-1)
- describe magnetic, electric, and gravitational fields by illustrating the source and direction of the lines of force (328-2)

Attitudes

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

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: Maxwell's Equations

Fields

- explain the roles of evidence, theories and paradigms, and peer review in the development of the scientific knowledge associated with a major scientific milestone (114-2, 114-5, 115-3)
- describe magnetic, electric, and gravitational fields as regions of space that affect mass and charge (328-1)
- describe magnetic, electric, and gravitational fields by illustrating the source and direction of the lines of force (328-2)
- describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles (328-3)
- describe the magnetic field produced by a current in a long, straight conductor, and in a solenoid (328-6)
- analyse qualitatively the forces acting on a moving charge in a uniform magnetic field (328-5)
- analyse qualitatively electromagnetic induction by both a changing magnetic flux and a moving conductor (328-7)

Attitudes

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

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

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: Auroras and Interacting Fields

Fields

- explain the roles of evidence, theories and paradigms, and peer review in the development of the scientific knowledge associated with a major scientific milestone (114-2, 114-5, 115-3)
- describe magnetic, electric, and gravitational fields as regions of space that affect mass and charge (328-1)
- describe magnetic, electric, and gravitational fields by illustrating the source and direction of the lines of force (328-2)
- describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles (328-3)
- analyse qualitatively the forces acting on a moving charge in a uniform magnetic field (328-5)

Waves and Modern Physics

- explain the relationship among the energy levels in Bohr's model, the energy difference between levels, and the energy of the emitted photons (329-3)

Attitudes

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

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

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

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 5: Explaining Mercury's Orbit

Fields

- describe magnetic, electric, and gravitational fields as regions of space that affect mass and charge (328-1)
- describe magnetic, electric, and gravitational fields by illustrating the source and direction of the lines of force (328-2)

Attitudes

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

Design Challenge: Using Fields to Go Places

Fields

- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others (215-1)
- describe magnetic, electric, and gravitational fields as regions of space that affect mass and charge (328-1)
- describe magnetic, electric, and gravitational fields by illustrating the source and direction of the lines of force (328-2)
- describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles (328-3)
- analyse qualitatively the forces acting on a moving charge in a uniform magnetic field (328-5)

Attitudes

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

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

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 12: Fields

Curriculum Connections

ONTARIO - Physics–University Preparation

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

Physics Curriculum Connections (SPH4U)
Activity 1: What Is a Field?
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]
– **A1.10** 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 (e.g., vector diagrams, free-body diagrams, vector components, and algebraic equations) [C]
Energy and Momentum
– **C2.1** use appropriate terminology related to energy and momentum, including, but not limited to: *work*, *work–energy theorem*, *kinetic energy*, *gravitational potential energy*, *elastic potential energy*, *thermal energy*, *impulse*, *change in momentum–impulse theorem*, *elastic collision*, and *inelastic collision* [C]
– **C2.6** analyse, in qualitative and quantitative terms, elastic and inelastic collisions in one and two dimensions, using the laws of conservation of momentum and conservation of energy, and solve related problems [PR, AI]
Gravitational, Electric, and Magnetic Fields
– **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
– **D3.2** compare and contrast the corresponding properties of gravitational, electric, and magnetic fields (e.g., the strength of each field; the relationship between charge in electric fields and mass in gravitational fields)
– **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

Physics Curriculum Connections (SPH4U)

Activity 2: Making Electric Fields Real

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, flow charts, graphs, and/or diagrams [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and 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]

Gravitational, Electric, and Magnetic Fields

- **D1.1** analyse the operation of a technological system that uses gravitational, electric, or magnetic fields (e.g., a home entertainment system, a computer, magnetic strips on credit cards) [AI, C]
- **D1.2** assess the impact on society and the environment of technologies that use gravitational, electric, or magnetic fields (e.g., satellites used in surveillance or storm tracking, particle accelerators that provide high-energy particles for medical imaging) [AI, C]
- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.3** analyse, and solve problems involving, electric force, field strength, potential energy, and potential as they apply to uniform and non-uniform electric fields (e.g., the fields produced by a parallel plate and by point charges) [AI]
- **D3.2** compare and contrast the corresponding properties of gravitational, electric, and magnetic fields (e.g., the strength of each field; the relationship between charge in electric fields and mass in gravitational fields)
- **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

Physics Curriculum Connections (SPH4U)

Activity 3: Maxwell's Equations

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]
- **A1.10** 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 (e.g., vector diagrams, free-body diagrams, vector components, and algebraic equations) [C]
- **A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., laser optics researcher, geoscientist, photonics researcher, aerospace engineer) and the education and training necessary for these careers
- **A2.2** describe the contributions of scientists, including Canadians (e.g., Elizabeth MacGill, Pierre Coulombe, Allan Carswell, Gerhard Herzberg), to the fields under study

Gravitational, Electric, and Magnetic Fields

- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.3** analyse, and solve problems involving, electric force, field strength, potential energy, and potential as they apply to uniform and non-uniform electric fields (e.g., the fields produced by a parallel plate and by point charges) [AI]
- **D2.4** analyse, and solve problems involving, the force on charges moving in a uniform magnetic field (e.g., the force on a current-carrying conductor or a free electron) [AI]
- **D2.5** conduct a laboratory inquiry or computer simulation to examine the behaviour of a particle in a field (e.g., test Coulomb's law; replicate Millikan's experiment or Rutherford's scattering experiment; use a bubble or cloud chamber) [PR]
- **D3.2** compare and contrast the corresponding properties of gravitational, electric, and magnetic fields (e.g., the strength of each field; the relationship between charge in electric fields and mass in gravitational fields)
- **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

The Wave Nature of Light

- **E3.4** describe, in qualitative terms, the production of electromagnetic radiation by an oscillating electric dipole (e.g., a radio transmitter, a microwave emitter, an X-ray emitter, electron energy transitions in an atom)

Physics Curriculum Connections (SPH4U)

Activity 4: Auroras and Interacting Fields

Scientific Investigation Skills and Career Exploration

- **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 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]

Dynamics

- **B2.6** analyse, in qualitative and quantitative terms, the forces acting on and the acceleration experienced by an object in uniform circular motion in horizontal and vertical planes, and use free-body diagrams and algebraic equations to solve related problems [AI, C]
- **B2.7** conduct inquiries into the uniform circular motion of an object (e.g., using video analysis of an amusement park ride, measuring the forces and period of a tether ball), and analyse, in qualitative and quantitative terms, the relationships between centripetal acceleration, centripetal force, radius of orbit, period, frequency, mass, and speed [PR, AI]

Energy and Momentum

- **C2.1** use appropriate terminology related to energy and momentum, including, but not limited to: *work*, *work–energy theorem*, *kinetic energy*, *gravitational potential energy*, *elastic potential energy*, *thermal energy*, *impulse*, *change in momentum–impulse theorem*, *elastic collision*, and *inelastic collision* [C]
- **C2.3** use an inquiry process to analyse, in qualitative and quantitative terms, situations involving work, gravitational potential energy, kinetic energy, thermal energy, and elastic potential energy, in one and two dimensions (e.g., a block sliding along an inclined plane with friction; a cart rising and falling on a roller coaster track; an object, such as a mass attached to a spring pendulum, that undergoes simple harmonic motion), and use the law of conservation of energy to solve related problems [PR, AI]
- **C3.2** describe and explain the simple harmonic motion (SHM) of an object, and explain the relationship between SHM, Hooke's law, and uniform circular motion
- **C3.4** explain the implications of the laws of conservation of energy and conservation of momentum with reference to mechanical systems (e.g., damped harmonic motion in shock absorbers, the impossibility of developing a perpetual motion machine)

Gravitational, Electric, and Magnetic Fields

- **D2.4** analyse, and solve problems involving, the force on charges moving in a uniform magnetic field (e.g., the force on a current-carrying conductor or a free electron) [AI]
- **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

The Wave Nature of Light

- **E3.4** describe, in qualitative terms, the production of electromagnetic radiation by an oscillating electric dipole (e.g., a radio transmitter, a microwave emitter, an X-ray emitter, electron energy transitions in an atom)

Physics Curriculum Connections (SPH4U)

Activity 5: Explaining Mercury's Orbit

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]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and 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]

Dynamics

- **B2.6** analyse, in qualitative and quantitative terms, the forces acting on and the acceleration experienced by an object in uniform circular motion in horizontal and vertical planes, and use free-body diagrams and algebraic equations to solve related problems [AI, C]

Gravitational, Electric, and Magnetic Fields

- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.2** analyse, and solve problems relating to, Newton's law of universal gravitation and circular motion (e.g., with respect to satellite orbits, black holes, dark matter) [AI]
- **D3.1** identify, and compare the properties of, fundamental forces that are associated with different theories and models of physics (e.g., the theory of general relativity and the standard model of particle physics)

Design Challenge: Using Fields to Go Places

Scientific Investigation Skills and Career Exploration

- **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, flow charts, graphs, and/or diagrams [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and 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]

Dynamics

- **B1.1** analyse a technological device that applies the principles of linear or circular motion (e.g., a slingshot, a rocket launcher, a race car, a trebuchet) [AI, C]

Energy and Momentum

- **C1.1** analyse, with reference to the principles of energy and momentum, and propose practical ways to improve, a technology or procedure that applies these principles (e.g., fireworks, rocket propulsion, protective equipment, forensic analysis of vehicle crashes, demolition of buildings) [AI, C]

Gravitational, Electric, and Magnetic Fields

- **D1.1** analyse the operation of a technological system that uses gravitational, electric, or magnetic fields (e.g., a home entertainment system, a computer, magnetic strips on credit cards) [AI, C]
- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.3** analyse, and solve problems involving, electric force, field strength, potential energy, and potential as they apply to uniform and non-uniform electric fields (e.g., the fields produced by a parallel plate and by point charges) [AI]
- **D2.4** analyse, and solve problems involving, the force on charges moving in a uniform magnetic field (e.g., the force on a current-carrying conductor or a free electron) [AI]
- **D2.5** conduct a laboratory inquiry or computer simulation to examine the behaviour of a particle in a field (e.g., test Coulomb's law; replicate Millikan's experiment or Rutherford's scattering experiment; use a bubble or cloud chamber) [PR]

Earth and Space Science

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

Earth and Space Science Curriculum Connections (SES4U)
Activity 4: Auroras and Interacting Fields
Planetary Science (Science of the Solar System) – **C2.3** use an inquiry or research process to investigate the effects of various forms of radiation and high-energy particles on bodies, organisms, and devices within the solar system (e.g., the effects of cosmic rays on atmospheric phenomena, of ultraviolet light on human and animal eyes and skin, of solar wind on radio communications) [IP, PR] – **C2.5** investigate the properties of Earth that protect life from hazards such as radiation and collision with other bodies (e.g., Earth's orbital position helps protect it from asteroids, some of which are deflected by the Jovian planets; Earth's magnetic field protects the planet from solar wind; atmospheric ozone minimizes incoming ultraviolet radiation) [PR] – **C3.9** describe the major external processes and phenomena that affect Earth (e.g., radiation and particles from the "quiet" and "active" sun; cosmic rays; gravity of the sun and moon; asteroidal and cometary debris, including their force, energy, and matter)
Activity 5: Explaining Mercury's Orbit
Astronomy (Science of the Universe) – **B1.1** analyse a major milestone in astronomical knowledge or theory (e.g., the discovery of the red shift in the spectra of galaxies; the knowledge gathered from the particle accelerator experiments at CERN in Switzerland), and explain how it revolutionized thinking in the scientific community [AI, C] ***Planetary Science (Science of the Solar System)*** – **C2.1** use appropriate terminology related to planetary science, including, but not limited to: *solar system*, *geocentric*, *heliocentric*, *geodesy*, *geosynchronous*, *eccentricity*, *apogee*, *aphelion*, *perigee*, and *perihelion* [C] – **C2.6** investigate techniques used to study and understand objects in the solar system (e.g., the measurement of gravitational pull on space probes to determine the mass of an object, the use of spectroscopy to study atmospheric compositions, the use of the global positioning system to track plate movement and tectonic activity from space) [PR] – **C3.1** explain the composition of the solar system (e.g., the sun, terrestrial inner planets, the asteroid belt, gas giant outer planets, the Kuiper belt, the scattered disc, the heliopause, the Oort cloud), and describe the characteristics of each component – **C3.7** identify Kepler's laws, and use them to describe planetary motions (e.g., the shape of their orbits; differences in their orbital velocity) – **C3.8** identify Newton's laws, and use them to explain planetary motion

Fields

Curriculum Connections

PRINCE EDWARD ISLAND—Physics 621A

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Physics 621A Curriculum Connections
(2010)

Activity 1: What Is a Field?

Electricity and Magnetism

STSE

Nature of Science and Technology

114-2 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge

114-5 describe the importance of peer review in the development of scientific knowledge

115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities

Knowledge

308-14 identify properties of static electric charges

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and direction of the lines of force

Activity 2: Making Electric Fields Real

Electricity and Magnetism

Skills

Initiating and Planning

212-4 state a prediction and a hypothesis based on available evidence and background information

212-6 design an experiment and identify specific variables

Performing and Recording

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

Knowledge

308-14 identify properties of static electric charges

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and direction of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

Activity 3: Maxwell's Equations

Electricity and Magnetism

STSE

Nature of Science and Technology

114-2 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge

114-5 describe the importance of peer review in the development of scientific knowledge

115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities

Knowledge

308-15 compare qualitatively static electricity and electric current

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and direction of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

328-7 analyse, qualitatively and quantitatively, electromagnetic induction by both a changing magnetic flux and a moving conductor

328-6 describe the magnetic field produced by current in both a solenoid and a long, straight conductor

Activity 4: Auroras and Interacting Fields

Electricity and Magnetism

STSE

Nature of Science and Technology

114-2 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge

114-5 describe the importance of peer review in the development of scientific knowledge

115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities

Knowledge

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and direction of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

328-5 analyse, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

Activity 5: Explaining Mercury's Orbit

Electricity and Magnetism

Knowledge

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and direction of the lines of force

Design Challenge: Using Fields to Go Places

Electricity and Magnetism

Skills

Communication and Teamwork

215-1 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others

Knowledge

328-1 describe gravitational, electric, and magnetic fields as regions of space that affect mass and charge

328-2 describe gravitational, electric, and magnetic fields by illustrating the source and direction of the lines of force

328-3 describe electric fields in terms of like and unlike charges, and magnetic fields in terms of poles

328-5 analyse, qualitatively and quantitatively, the forces acting on a moving charge and on an electric current in a uniform magnetic field

Fields

Curriculum Connections

SASKATCHEWAN—Physics 30

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Physics 30 Curriculum Connections
(2016)

Activity 1: What Is a Field?

Fields

PH30-FI1 Investigate gravitational fields and their interactions with matter. [SI, DM]

a. Discuss the value of the concept of fields and field theory and the meaning of field strength in understanding the effects of non-contact forces (i.e., action at a distance). (STSE)

b. Describe the characteristics of the gravitational force and its effect on large-scale phenomena throughout the universe. (K, STSE)

PH30-FI2 Investigate electric and magnetic fields and their interactions with matter. [SI, TPS]

c. Recognize that electric fields act on point charges, including action at a distance and following the inverse-square law to determine strength of field. (S, K)

e. Describe current scientific thinking regarding the electromagnetic force, one of the four fundamental interactions. (K, STSE)

Activity 2: Making Electric Fields Real

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)

b. Provide examples of how Newton's three laws of motion can describe the movement of objects in the real world. (STSE, K)

g. Predict and investigate the effect of balanced or unbalanced forces, including the effect of friction, on an object that is at rest, undergoing uniform motion or undergoing uniformly accelerated motion. (K, S)

Fields

PH30-FI1 Investigate gravitational fields and their interactions with matter. [SI, DM]

a. Discuss the value of the concept of fields and field theory and the meaning of field strength in understanding the effects of non-contact forces (i.e., action at a distance). (STSE)

PH30-FI2 Investigate electric and magnetic fields and their interactions with matter. [SI, TPS]

a. Recognize that electric fields act on point charges, including action at a distance and following the inverse-square law to determine strength of field. (S, K)

b. Draw and describe electric field lines for like and unlike point charges and plates separated by a distance. (K, S)

c. Examine how the electric field strength at a point varies according to the inverse square of the distance between two charges, with reference to the equation $E = \frac{kQ}{d^2}$. (K, S)

Activity 3: Maxwell's Equations

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)

g. Predict and investigate the effect of balanced or unbalanced forces, including the effect of friction, on an object that is at rest, undergoing uniform motion or undergoing uniformly accelerated motion. (K, S)

Fields

PH30-FI1 Investigate gravitational fields and their interactions with matter. [SI, DM]

a. Discuss the value of the concept of fields and field theory and the meaning of field strength in understanding the effects of non-contact forces (i.e., action at a distance). (STSE)

PH30-FI2 Investigate electric and magnetic fields and their interactions with matter. [SI, TPS]

a. Recognize that electric fields act on point charges, including action at a distance and following the inverse-square law to determine strength of field. (S, K)

b. Draw and describe electric field lines for like and unlike point charges and plates separated by a distance. (K, S)

g. Represent magnetic fields using magnetic field lines. (K, S)

h. Represent the direction of the magnetic field around current-induced conductors, including linear wires and wire coils, using the right hand and/or left-hand rules. (K, S)

j. Analyze the direction of positive, negative and neutral charges moving in natural (e.g., solar flares and aurorae) and man-made (e.g., particle accelerators and MRI's) magnetic fields. (K, STSE)

Activity 4: Auroras and Interacting Fields

Forces and Motion

PH30-FM1 Analyze motion in one- and two-dimensions, including uniform motion, uniformly accelerated motion, circular motion and projectile motion. [SI]

a. Provide examples of situations in which everyday objects undergo uniform motion, uniformly accelerated motion, circular motion and projectile motion. (STSE)

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)

Fields

PH30-FI1 Investigate gravitational fields and their interactions with matter. [SI, DM]

a. Discuss the value of the concept of fields and field theory and the meaning of field strength in understanding the effects of non-contact forces (i.e., action at a distance). (STSE)

PH30-FI2 Investigate electric and magnetic fields and their interactions with matter. [SI, TPS]

a. Recognize that electric fields act on point charges, including action at a distance and following the inverse-square law to determine strength of field. (S, K)

b. Draw and describe electric field lines for like and unlike point charges and plates separated by a distance. (K, S)

g. Represent magnetic fields using magnetic field lines. (K, S)

i. Research the characteristics of Earth's magnetic field, including the effects of short- and long-term changes to the field. (STSE, K, A)

j. Analyze the direction of positive, negative and neutral charges moving in natural (e.g., solar flares and aurorae) and man-made (e.g., particle accelerators and MRI's) magnetic fields. (K, STSE)

Activity 5: Explaining Mercury's Orbit

Fields

PH30-FI1 Investigate gravitational fields and their interactions with matter. [SI, DM]

a. Discuss the value of the concept of fields and field theory and the meaning of field strength in understanding the effects of non-contact forces (i.e., action at a distance). (STSE)

b. Describe the characteristics of the gravitational force and its effect on large-scale phenomena throughout the universe. (K, STSE)

Design Challenge: Using Fields to Go Places

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)

b. Provide examples of how Newton's three laws of motion can describe the movement of objects in the real world. (STSE, K)

g. Predict and investigate the effect of balanced or unbalanced forces, including the effect of friction, on an object that is at rest, undergoing uniform motion or undergoing uniformly accelerated motion. (K, S)

Fields

PH30-FI1 Investigate gravitational fields and their interactions with matter. [SI, DM]

a. Discuss the value of the concept of fields and field theory and the meaning of field strength in understanding the effects of non-contact forces (i.e., action at a distance). (STSE)

PH30-FI2 Investigate electric and magnetic fields and their interactions with matter. [SI, TPS]

a. Recognize that electric fields act on point charges, including action at a distance and following the inverse-square law to determine strength of field. (S, K)

b. Draw and describe electric field lines for like and unlike point charges and plates separated by a distance. (K, S)

f. Recognize how our understanding of the interrelationships between magnetic and electric fields has led to the development of technologies such as generators and electromagnets (e.g., moving charged particles create a magnetic field, interaction of electric and magnetic fields). (K, STSE)

g. Represent magnetic fields using magnetic field lines. (K, S)

j. Analyze the direction of positive, negative and neutral charges moving in natural (e.g., solar flares and aurorae) and man-made (e.g., particle accelerators and MRI's) magnetic fields. (K, STSE)

k. Design, construct and evaluate a prototype of a technology (e.g., electric motor, generator or electromagnet) to demonstrate principles of electromagnetism. (K, S)

Fields

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: What Is a Field?

Energy

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 t he energies in gravitational, magnetic, or electric fields.]

Activity 2: Making Electric Fields Real

Forces and Interactions

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

Energy

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.]

Activity 3: Maxwell's Equations

Forces and Interactions

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

Energy

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.]

Activity 4: Auroras and Interacting Fields

Forces and Interactions

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

Energy

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.]

Activity 5: Explaining Mercury's Orbit

Forces and Interactions

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

Space Systems

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representation for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

Design Challenge: Using Fields to Go Places

Forces and Interactions

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

Energy

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative

evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

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.]