Information Bulletin | Physics 30

2015 – 2016 Diploma Examinations Program

Alberta Government

This document was written primarily for:

Students	✓
Teachers	✓ of Physics 30
Administrators	✓
Parents	
General Audience	
Others	

Distribution: This document is posted on the Alberta Education website at education.alberta.ca.

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You can find diploma-examination-related materials on the Alberta Education website at education.alberta.ca.

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*NEW *Diploma Examination Weighting*

As of September 1, 2015, the diploma examination weighting will shift from a 50/50 weighting to a 70/30 weighting, where the school-awarded grades will be worth 70 percent. For further information, please refer to http://education.alberta.ca/admin/testing/diplomaexams/.

*NEW *Time Limits on Diploma Examinations*

The section of the diploma examination instructions pages describing the time students are allowed for writing has been simplified. Previously, this section mentioned the time within which the examination had been designed to be completed, and the additional half hour allowed for students who needed it. Now this section simply states the total allowed writing time, which includes the additional half hour. **No changes have been made to the design of any diploma examination.**

As of the November 2015 session, all science diploma examinations (Biology 30, Chemistry 30, Physics 30, and Science 30) will have a time limit of 3 hours. **The time limits of other diploma examinations have not changed.**

*NEW *Field Testing*

Online Field Testing

All Grade 12 science and mathematics field tests are offered exclusively through an enhanced Quest A+ online delivery system. In addition to digital field tests, hybrid field tests are also available this school year. With a hybrid field test, students receive a paper copy of the test but must respond to the questions online.

Students should use paper data booklets, data pages, or formula sheets for all science and mathematics field tests. These resources will also appear in the online delivery system. Students should also have scrap paper, which may be accessed and downloaded from the "Teacher Resources" section on the home page of the Field Test Request System: http://public.education.alberta.ca/FieldTestScheduler. All paper data sheets or scrap paper with markings must be securely shredded at the end of the field test administration.

Teachers have a 24-hour window to peruse the digital or hybrid field test and are provided with data on how their students performed. These data include the proportion of students who chose each alternative on multiple-choice items and the proportion who left a numerical-response item blank. Test items are blueprinted to program of studies outcomes. This allows teachers to use field test results to learn more about their students' strengths and weaknesses.

Once logged into the digital or hybrid field test, teachers have the same length of time to peruse the test as their students did to write it. Teachers might choose to log into the field test, submit the confidentiality form, and then log out of the test, so that they can finish perusing the test after receiving their students' data.

In addition, teachers have greater flexibility in selecting the time and date when students write, rather than being bound to a pre-determined date.

Finally, online administration enables every school, large or small, to participate. Historically, it was impractical to send field test administrators to remotely located schools, or schools with small classes. Now, all Alberta schools can participate in field tests.

It is important to note that the **security of field test items remains vital** to the administration of diploma examinations. Participating teachers must commit to maintaining the security of field test items. In the case of hybrid field tests, paper copies are mailed to schools and the questions are accessed in the same format as digital-format field tests. Prior to the hybrid field test, the paper copies must be kept secure by the school principal. After the administration of a hybrid-format field test, teachers must mail all paper copies back to Alberta Education.

*NEW *Benefits of Field Tests*

How do field tests help teachers and students?

Teachers receive each student's score promptly, gaining useful, immediate information about their students' levels of expertise and knowledge. Students also benefit from writing a test that duplicates some of the experience of writing a diploma examination. Field tests provide students and teachers with good examples of the style and content of questions that may appear on diploma examinations. Finally, because of field testing, students, teachers, and parents can be reassured that the questions on diploma examinations have undergone a rigorous process of development, improvement, and validation.

Why are field tests necessary?

Field testing is an absolutely essential stage in the development of fair, valid, and reliable provincial examinations. Field testing is basically a process of "testing a test" and "testing questions" before they become part of a diploma examination. Potential diploma examination questions are administered to students in diploma courses throughout the province to determine their difficulty level and appropriateness. Ideally, each field test requires a large student sample to provide the examination developers with reliable information (statistical data and written validation comments from teachers and students).

How are field test data used?

The data received from field tests show the reliability of each question. Sometimes, after one field test round, it is clear that certain questions work very well in terms of fairness, validity, and appropriateness to course content. These questions then move into the diploma examination bank to be used at a future date.

Other questions or sets of questions may not perform as well as we require. These questions are subject to revision and review, then retested in a second or third field test with the aim of generating questions that meet our standards. These changes are influenced by the written comments of students and teachers, who provide valuable advice about the appropriateness of the questions, adequacy of writing time limits, test length, text readability, artwork/graphics clarity and suitability, and question difficulty.

Further Information

Teachers requesting field tests must have a Public Authentication System (PAS) account. All requests are made through the Field Test Request System. Further information, including the closing dates to request a field test, may be obtained by contacting Field.Test@gov.ab.ca, or from the *General Information Bulletin* at http://education.alberta.ca/admin/testing/diplomaexams/diplomabulletin/. Practice items are available at https://questaplus.alberta.ca/.

For more information, contact

Deanna Shostak
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780-422-5160 or Deanna.Shostak@gov.ab.ca

or

Dan Karas
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Special-format Practice Tests

To provide students an opportunity to practise diploma examination-style questions and content in Braille, audio, large print, or coloured print versions, Alberta Education is making special-format practice tests available. Tests are offered in all subjects with a corresponding diploma examination. Alberta schools with registered Alberta K-12 students may place orders for these tests. Braille tests are available in English and, by request, in French. All tests are provided free of charge, but limits may be placed on order volumes to ensure access for everyone.

For more information or to place an order, contact

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Teacher Involvement in the Diploma Examination Process

High-quality diploma examinations are the product of close collaboration between classroom teachers and Alberta Education. Classroom teachers from across Alberta are involved in many aspects of diploma-examination development, including the development of raw items; the building, reviewing, and administering of field tests; and the reviewing of diploma examinations.

Alberta Education values the involvement of the teachers and often asks school jurisdictions for the names of teachers who are interested in participating. Teachers who are interested in developing raw items, building and/or reviewing field tests, or building and/or reviewing diploma examinations are encouraged to ask their principals to submit their names, through proper channels, to the Assessment Sector. The list of teachers interested in these aspects of the development process remains open all year long, and teachers are welcome to have their names submitted at any time.

Periodically we send out information to those Physics 30 teachers who are on our contact list.

For more information, contact

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Course Objectives

Physics 30 is intended to further students' understanding and application of fundamental physics concepts and skills. The focus of the course is on understanding the physics principles behind the natural events that students experience and the technology that they use in their daily lives. The course encourages enthusiasm for the scientific enterprise and develops positive attitudes about physics as an interesting human activity with personal meaning. It develops knowledge, skills, and attitudes to help students become capable of and committed to setting goals, making informed choices, and acting in ways that will improve their own lives as well as life in their communities.

To develop the required knowledge, skills, and attitudes in Physics 30, students must have successfully completed Science 10 and Physics 20.

Although there is no mathematics prerequisite for Physics 20, students who have successfully completed Mathematics 20–1 or Mathematics 20–2 will have better algebra skills to use in the course.

Performance Expectations

Curriculum Standards

Provincial curriculum standards help to communicate how well students need to perform in order to be judged as having achieved the objectives specified in the *Physics 20–30 Program of Studies, 2007* (Revised Edition 2014). The specific statements of standards are written primarily to advise Physics 30 teachers of the extent to which students must know the Physics 30 content and be able to demonstrate the required skills in order to pass the diploma examination.

Linking Program Verbs to Cognitive Expectations

Some verbs used in the programs of study carry expectations that require students to recall facts or identify characteristics. For the development of the Physics 30 diploma examination, these verbs are classified as "knowledge" level. Examples of these verbs are listed in the yellow column in the following chart. Some verbs carry expectations that require students to apply their knowledge and skills in conventional situations. For the development of the Physics 30 diploma examination, these verbs are classified as "comprehension and application" verbs. Examples of these verbs are listed in the green column of the chart. Some verbs carry expectations that require students to build new connections, to create relationships between concepts, and to apply models to new and unusual situations. For the development of the Physics 30 diploma examination, these verbs are classified as "higher mental activities." Examples of these verbs are in the blue column of the chart.

The *Physics 20–30 Program of Studies, 2007* (Revised Edition 2014) also contains attitude and skill verbs that are listed in the pink row at the bottom of the chart. The attitudes and skills are foundations of a science education.

Cognitive Expectations		
Knowledge	**Comprehension and Application**	**Higher Mental Activities**
Choose, classify, define, describe, identify, list, label, match, name, outline, predict*, recall, select, state, what, when, who Use memorized or algorithmic methods to solve problems.	Apply, analyze, calculate, change, compare*, contrast, determine, estimate (interpolate or extrapolate), explain*, generalize, interpret*, infer, relate, translate, solve Design a procedure for a known experiment.	Assess, compare*, differentiate, compile, compose, conclude, create, defend, evaluate, explain*, interpret*, judge, justify, organize, plan, summarize Transfer methods from one area to another. Use generalized methods to solve problems. Design a new procedure for an unfamiliar experiment.
Attitudes and Skills Appreciate, collect, conduct, develop, gather, measure, observe, plot, work collaboratively		

*These verbs are ambiguous because they have multiple connotations. The cognitive expectation is communicated by the context. If it is a very familiar context, the expectation is knowledge or comprehension and application; if it is unfamiliar, the expectation is comprehension and application or higher mental activity.

Performance Standards

Acceptable Standard

Students who achieve the acceptable standard in Physics 30 will receive a final course mark of 50% or higher. Students achieving the acceptable standard have gained new skills and knowledge in physics but may encounter difficulties if they choose to enroll in post-secondary physics courses. These students are able to define basic physics terms and are able to state and use formulas as they appear on the equation sheet. They can do this in situations where they need to sort through a limited amount of information. Their laboratory skills are limited to following explicit directions and to using laboratory data to verify known physics information. They are able to identify manipulated and responding variables, but not relevant controlled variables. These students are able to relate graph shape to memorized relationships, but their analysis of graphs is limited to linear data. These students tend to use item-specific methods in their problem solving and rarely apply the major principles of physics in their solutions. When explaining the connections between science, technology, and society, these students tend to use examples provided from textbooks. These students have difficulty connecting physics to real-life scenarios beyond the classroom.

Standard of Excellence

Students who achieve the standard of excellence in Physics 30 receive a final course mark of 80% or higher. They have demonstrated their ability and interest in both mathematics and physics, and feel confident about their scientific abilities. These students should encounter little difficulty in post-secondary physics programs and should be encouraged to pursue careers in which they will utilize their talents in physics. Students who achieve the standard of excellence show flexibility and creativity when solving problems, and changes in problem format do not cause them major difficulties. They seek general methods to solve problems and are not afraid to use physics principles as a framework for their solutions. In the laboratory, students who achieve the standard of excellence can deal with data that are less than perfect or with instructions that are incomplete. These students are able to explicitly relate graph shape to mathematical models and to physics equations. They transfer knowledge from one area of physics to another and can express their answers in clear and concise terms. These students are able to apply cause-and-effect logic in a variety of situations: algebraically, experimentally, etc. In addition, these students can connect their understanding of physics to real-world situations that include technological applications and implications beyond the classroom setting.

Examination Specifications and Design

Each Physics 30 diploma examination is constructed as closely as possible to the following specifications.

Program of Studies Outcomes

The design supports the integration of all Physics 30 general outcomes (GOs) as mandated in the *Physics 20–30 Program of Studies, 2007* (Revised 2014).

Adjustments in the emphasis may be necessary because the examination includes machine-scored scenarios or contexts that cover more than one general outcome. As a result, the examination is not necessarily arranged sequentially by units but is instead built around scenarios or contexts that support STS connections; a set of questions may assess students' ability to integrate several GOs.

		Emphasis (Curricular Fit)
GO A	**Momentum and Impulse:** Students will explain how momentum is conserved when objects interact in an isolated system.	10–20%
GO B	**Forces and Fields:** Students will explain the behaviour of electric charges using the laws that govern electrical interactions. They will describe electrical phenomena using the electric field theory. They will explain how the properties of electric and magnetic fields are applied in numerous devices.	25–35%
GO C	**Electromagnetic Radiation:** Students will explain the nature and behaviour of electromagnetic radiation using the wave model. They will explain the photoelectric effect using the quantum model.	25–35%
GO D	**Atomic Physics:** Students will describe the electrical nature of the atom. They will describe the quantization of energy in atoms and nuclei. They will describe nuclear fission and fusion as powerful energy sources in nature. They will describe the ongoing development of models of the structure of matter.	20–30%

Questions on the diploma examination will require students to demonstrate knowledge of physics concepts and to apply skills in a context that supports making Science, Technology, and Society (STS) connections.

Scientific Process and Communication Skills

Students will

- formulate questions about observed relationships and plan investigations into questions, ideas, problems, and issues
- use a broad range of tools and techniques to record data and information
- analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- apply the skills and conventions of science in communicating information and ideas, and in assessing results

Science, Technology, and Society Connections (STS)

Students will

- explain that technological problems often require multiple solutions that involve different designs, materials, and processes, and that have both intended and unintended consequences
- explain that concepts, models, and theories are often used in interpreting and explaining observations, and in predicting future observations
- explain that scientific knowledge may lead to the development of new technologies and that new technologies may lead to or facilitate scientific discovery
- explain that the goal of technology is to provide solutions to practical problems
- explain that scientific knowledge is subject to change as new evidence becomes apparent, and as laws and theories are tested and subsequently revised, reinforced, or rejected
- explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation, and the ability to provide explanations
- explain that the goal of science is knowledge about the natural world
- 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

The Physics 30 diploma examination consists of 36 multiple-choice and 14 numerical-response items, of equal weight. Fewer than half the items require a calculation.

Machine-Scored Items

Answers for multiple-choice items are recorded in the first section of the machine-scored answer sheet. Answers for numerical-response items are recorded in the second section on the same side of the same machine-scored answer sheet.

Multiple-choice items are of two types: *discrete* and *context-dependent*. A discrete item stands on its own without any additional directions or information. It may take the form of a question or an incomplete statement. A context-dependent item provides information that is separate from the item stem. Many of the multiple-choice items are context dependent. A particular context may be used for more than one multiple-choice item as well as for more than one numerical-response item.

Numerical-response items are of three types: calculation of numerical values; selection of numbered events, structures, or functions from a diagram or list; and determination of a sequence of events.

Assessment of Skills and STS Connections

Physics 30 examination items are designed to measure students' understanding of physics concepts mandated by the *Physics 20–30 Program of Studies, 2007* (updated 2014). Some items also measure students' understanding and use of skills associated with scientific inquiry, and some items have been designed to measure students' understanding of the connections among science, technology, and society. As a result, many items measure how well students can apply the skills and knowledge they have acquired in science to everyday life.

Examination Security

All Physics 30 diploma examinations are secured.

Maintaining Consistent Standards over Time on Diploma Examinations

Student scores on Physics 30 diploma examinations are now equated to the baseline examination. This is done to support fairness to students: each examination score is what the student would have received had he/she written the baseline examination.

Diploma Examinations: Multiple Forms

As part of Alberta Education's commitment to fairness to students, and to expand flexibility in the writing of diploma examinations, the number of distinct examination forms (versions) has increased. There are now two forms of diploma examinations in some subjects during major administrations (January and June). The two forms are equated to baseline examinations to ensure that the same standard applies to both forms. Both forms adhere to the established blueprint specifications and are thoroughly reviewed by a technical review committee.

To facilitate the analysis of school-level results, each school receives only one examination form per subject. In subjects offering a translated French-language examination, both forms are administered in English and in French.

For more information, contact

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780-415-0666 or Dan.Karas@gov.ab.ca

*NEW *Science 30 Available in French*

In the 2015–2016 school year, the Science 20-30 Program of Studies (French) will be available for implementation in Alberta Schools. The Science 30 Diploma examination will be offered for the first time in French in June 2016. This French version of the examination will be available in a digital format only.

Publications and Supporting Documents

In addition to this bulletin, the following documents are published by Alberta Education.

- *Physics 20-30 Program of Studies, 2007* (Revised 2014) available on education.alberta.ca
- *Physics 20 and 30 Student-Based Performance Standards* available on education.alberta.ca
- *Written Response Archive* available on education.alberta.ca,
- *Physics 30 Data Booklet* available on education.alberta.ca
- *Archived* Physics 30 Information Bulletins available on education.alberta.ca
- *Calculator Policy* available on education.alberta.ca
- *Diploma Examination Detailed Reports*, available on the Alberta Education Extranet

The Assessment Sector supports online assessment with the testing platform QuestA+ at http://questaplus.alberta.ca.

*NEW

Teacher Comments on Diploma Examinations and Online Field Tests

On the online perusal copies of the diploma examinations administered in January 2015 and June 2015, and on the online field tests, teachers had the opportunity to digitally submit comments and concerns. The comments were greatly appreciated and, in some cases, resulted in action. The following points are in response to some of these comments.

Annihilation

The term *annihilation* caused many students difficulty. In the section titled Reminders and Explanations there is a summary of what students are expected to do for this program outcome.

Refraction

In the optical phenomenon of refraction, the change in direction is caused by a change in speed. The frequency of the EMR is unchanged because the frequency is a property established by the source.

Multiple Answers

Numerical-response items with multiple valid answers allow for student-generated responses that allow students to demonstrate cause-and-effect reasoning. The **potential for multiple** valid answers can be challenging to students who have been reinforced in thinking there is "**only one** right answer."

Program of Study Outcome C1.10k

Program outcome 30-C1.10k has both a computational (numerical value) and a conceptual (why is one model better than another model) aspect. Students who use only one equation, either one, are missing the expectation of the outcome.

Program of Study Outcome C1.8k

Program outcome 30-C1.8k expects that students can describe optical phenomena. Many students used the terms interchangeably. This suggests that their understanding of the the difference between interference, diffraction, and polarization is weak. There are many situations in which interference occurs while diffraction does not.

Conservation of Energy

Students were successful at applying conservation-of-energy principles in situations where a particle accelerated from rest. They were generally successful if a particle was brought to rest. They were generally unsuccessful if the particle started or ended with some speed. This suggests an algorithmic approach rather than a big-picture conservation-of-energy approach was being used by the students.

Physics Principles

The linking of two of the 10 physics principles given on the data sheet to the solution to a problem continued to be a challenge for many students. This was most directly assessed on the two-item scenario that appeared at the end of the diploma examination: numerical-response item 13 asked the students to calculate something and numerical-response item 14 asked the students to identify the physics principles they used. This trend was more significant for students writing the examination in French. In general, for this type of item, there are some situations in which one principle is subsumed by another (e.g., circular motion and accelerated motion). There are some situations in which two principles are equivalent (e.g., work-energy theorem and conservation of energy), but this is not always true. This type of item is not likely to reward a memorized approach. For more examples of the assessment of physics principles using items like numerical-response item 13 and numerical-response item 14, see the Physics 30 Archive or the practice questions on Quest A+. Links to these resources are given on the previous page.

Reminders and Explanations

Definitions of Systems

An isolated system is a system on which no external forces act (this is equivalent to: no external forces do work on the system; or external forces are balanced; or no external forces exist); an open system allows matter and energy to cross the boundary; a closed system allows energy but not matter to cross the boundary. Since the definition of a closed system is inconsistent with matter-energy equivalence, the diploma examination will use "closed" as an adjective for the quantity that doesn't cross the system's boundary. For example, a charged particle accelerating in a uniform electric field is a system that is closed to energy.

Interference Pattern Equations

The program of studies mandates that students apply two equations for interference: $\lambda = \frac{xd}{nl}$ and $\lambda = \frac{d \sin\theta}{n}$. Many students use $\lambda = \frac{xd}{nl}$ exclusively and do not realize that it is a special-case equation that can be applied validly only when $x \ll l$ or $\theta < 10°$.

Lenses

The Physics 30 Diploma Examination will use the terms *diverging* and *converging* when describing or classifying a lens.

Mirrors

The Physics 30 Diploma Examination will use the terms *plane*, *convex*, and *concave* when describing or classifying a mirror.

Directions

Students should be able to use and interpret conventions for directions perpendicular to the page:

- • indicates out of the page
- × indicates into the page

Nuclear Equations

The program of studies specifies that students should be able to write nuclear equations for alpha and beta decay. This includes both beta positive and beta negative decay with the appropriate neutrino and antineutrino.

***NEW** The program of studies also specifies that students will balance equations using conservation principles. On a Physics 30 Diploma Examination, students may be required to translate a verbal description into a nuclear reaction equation. They may also be asked to identify the conservation principle they used to determine the isotope or the element.

To return to your original location after using an internal link, simultaneously press and hold Alt ←.
(This feature may not be supported by all browsers.)

Wave-particle Duality	Students will be expected to know and apply $p = \frac{h}{\lambda}$ and $E = pc$ to determine the particle-like characteristics of photons. Students are expected to know the wave-like characteristics of matter but **not** to derive $\lambda = \frac{h}{mv}$.
Positrons	Students are expected to know and use the term *positron* to describe the antimatter particle corresponding to the electron.
Annihilation	Students should be able to apply mass-energy equivalence to situations in which EMR (photon) energy is converted into matter and to situations in which matter and antimatter annihilate to produce EMR.
Use of Rulers or Straightedges	Students should be encouraged to use a ruler or straightedge when drawing the line of best fit.
Use of Protractors	Students may use protractors to measure angles on the diploma examination.
Default Angle Units and Graphing Calculators	Students who use graphing calculators on Physics 30 field tests and diploma examinations often fail to realize that the units for angle measure may default to radians when the calculator memory is reset. As a result, these students will provide incorrect answers to questions that involve trigonometric functions.
Constants	Students should use constants provided on the data sheet and recorded to three significant digits rather than constants stored in calculators. This is important in order to obtain correct numerical-response answers.
Numerical-response Questions	Students should be familiar with the different formats of numerical-response items and the procedure for completely filling in the bubbles on the answer sheet.

Illustrative Numerical-response Items Assessing Mandated Skills

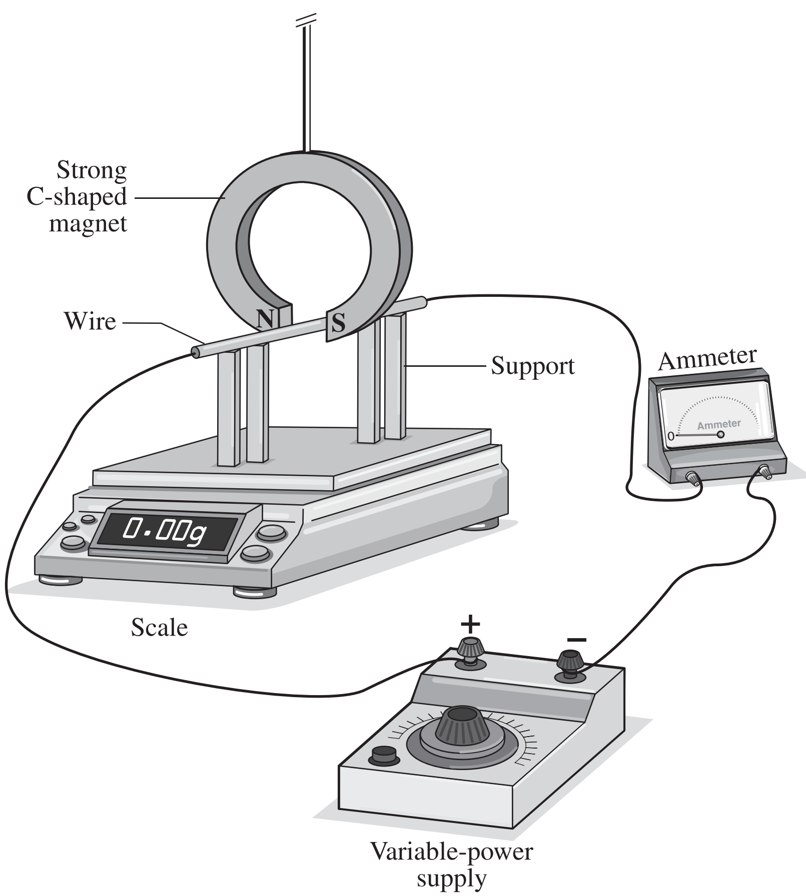
This item illustrates the design-an-experiment skill mandated in the program of studies outcome B3.1s.

B3.1s, *Students will* formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues • design an experiment to demonstrate the effect of a uniform magnetic field on a current-carrying conductor

Use the following information to answer numerical-response question 1.

A group of students sets up the apparatus shown below.

Apparatus



Research Questions

1 Does the length of the wire in the magnetic field affect the magnetic force?

2 Does the magnitude of the current in the wire affect the magnetic force?

3 Does the strength of the magnetic field produced by the C-shaped magnet affect the magnetic force?

4 Does the direction of the electron flow affect the magnetic force?

5 Does the orientation of the wire relative to the external magnetic field affect the magnetic force?

Variables

6 Force on wire

7 Length of wire

8 Strength of the C-shaped magnet

9 Current in wire

Numerical Response

1. Using the numbers above, choose **one research question** that could be investigated using the apparatus and match three of the variables to their respective roles in the investigation of that research question as given below. (There is more than one correct answer.)

Number:	__________	__________	__________	__________
	Research question	**Manipulated variable**	**Responding variable**	**One of the variables that must be controlled**

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: 1768, 1769, 2967, 2968, 4967, or 4968

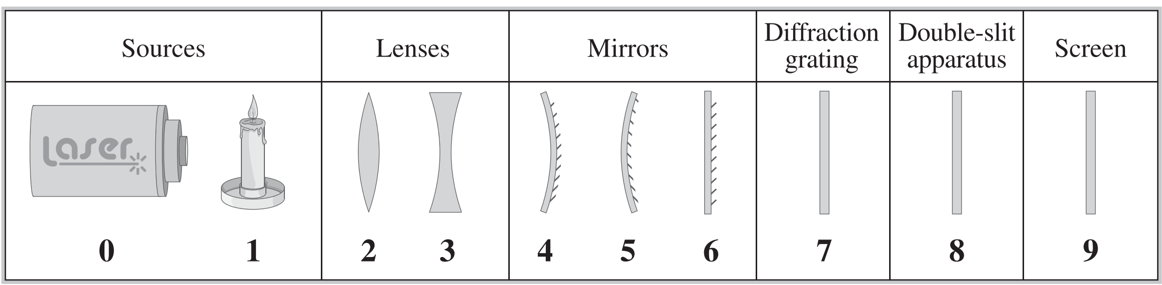
This item illustrates how students can design an investigation by selecting apparatus and then analyze the results from their design. This is mandated in the program of studies outcomes C1.1s, C1.2s, C1.3s.

> C1.1s, *Students will* formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues; C1.2s, *Students will* conduct an investigation to determine the focal length of a … curved mirror; and C1.3s, *Students will* use ray diagrams to describe an image formed by … curved mirrors.

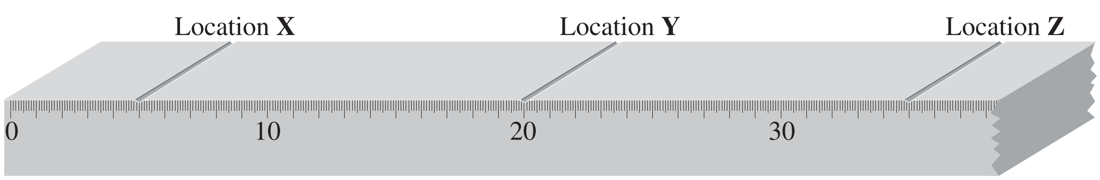
Use the following information to answer numerical-response question 2.

Students use three of the optical apparatus illustrated below to produce a **focused, real** image in a darkened room. One of the apparatus has a focal length of 10.0 cm.

Optical Apparatus



The students place one apparatus at each labelled location on an optics bench, as shown below. The optics bench is scaled in millimetres and labelled in centimetres.



Note: The diagrams are **not** drawn to scale.

Numerical Response

2. The apparatus placed at location

X is numbered ___________ (Record in the **first** column)

Y is numbered ___________ (Record in the **second** column)

Z is numbered ___________ (Record in the **third** column)

(Record your answer in the numerical-response section on the answer sheet.)

Answer: 194, 094, 491, or 490

Commentary

This section of the Program of Studies, C1, is intended to be very hands on. In a standardized assessment context, we need to illustrate the optics experiences that students should have had. To that end, we chose the simple device of a meter stick on its side. Apparatus can be positioned on the meter stick, beside the meter stick, and at one edge of the meter stick. Based on where the apparatus are positioned, students can make predictions or actual measurements. The list of apparatus matches some of the mandated optics experiences.

This question is not at recall level because, since the object is more than a focal length away from the mirror, the screen (where the image is observed) is between the mirror and the object. When the students are faced with this conundrum in the lab, they have to explore how putting the object and the image just a bit off the axis allows the geometry to work and a real image to form.

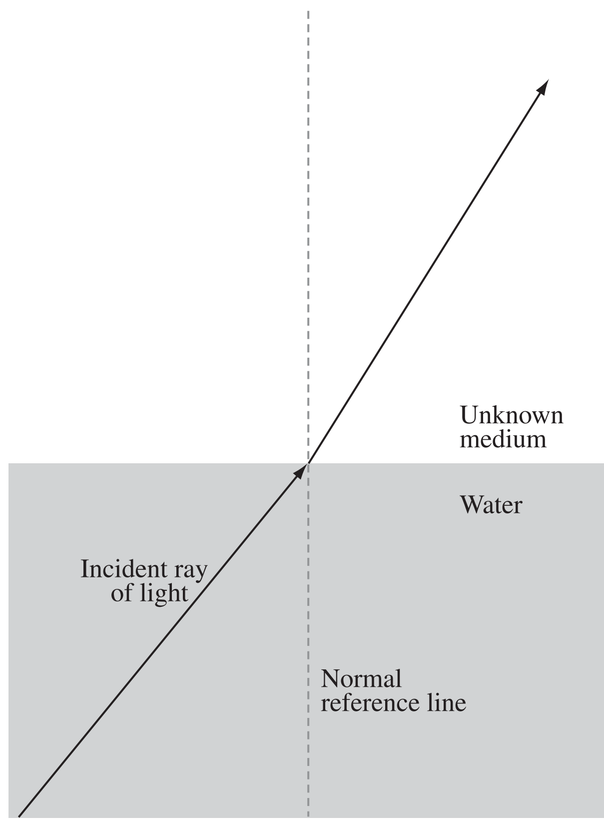
This type of question has many possible applications for assessing experimental design and measurement skills.

This item illustrates how students can demonstrate the performing and recording skills mandated by program of studies outcome C1.2s.

C1.2s, *Students will* 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 determine the index of refraction of several different substances

Use the following information to answer numerical-response question 3.

A ray of light travelling from water into an unknown medium is shown below.



Note: You will need to make measurements using a ruler or a protractor.

Numerical Response

3. If the index of refraction of the water is 1.33, then the index of refraction of the second medium is __________.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

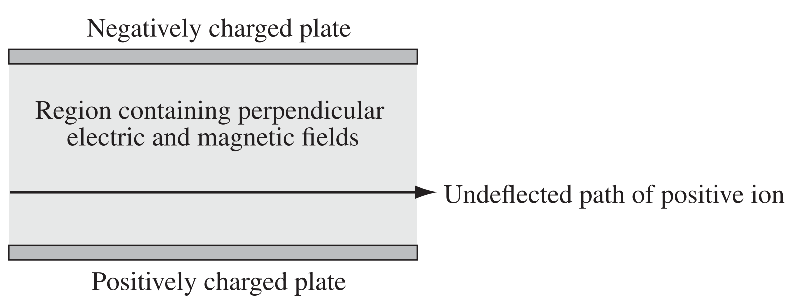
Answer: Any value between 1.54 and 1.69

***NEW** This item allows students to explore the technology of a velocity selector tuned so that the path of positively charged ions is undeflected. In order to be able to do the quantitative analysis correctly, the ability to build a free-body diagram is a prerequisite.

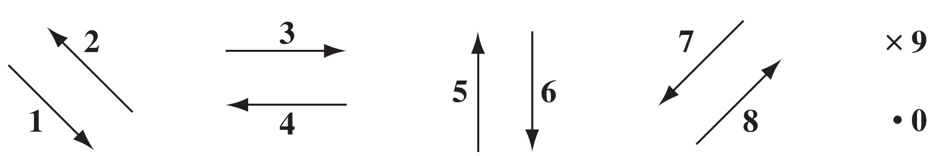
> P30-B3.6k, *Students will* explain, quantitatively, how uniform magnetic and electric fields affect a moving electric charge, using the relationships among charge, motion, field direction and strength, when motion and field directions are mutually perpendicular;
> P30-B2.6k, *Students will* explain, 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;
> P30-B3.3s, *Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions • analyze, quantitatively, the motion of an electric charge following a straight path in uniform and mutually perpendicular electric and magnetic fields, using Newton's second law and vector addition;
> P30-B2.3s, *Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions • use free-body diagrams to describe the forces acting on a charge in an electric field.

***NEW** *Use the following information to answer numerical-response question 4.*

A positively charged ion travels through a region that contains perpendicular electric and magnetic fields. The ion passes through the region undeflected at a constant speed.



Directions



Numerical Response

4. Match the numbers on the directions given above with the descriptions given below.

Direction:	__________	__________	__________	__________
Description:	**Direction of the electric force on the ion**	**Direction of the electric field in the region**	**Direction of the magnetic force on the ion**	**Direction of the magnetic field in the region**

(Record all **four digits** of your answer in the response boxes at the bottom of the screen.)

Answer: 5560

Commentary

In order for students to determine the correct answer they need to be able to follow process.

The direction of the electric force is toward the negatively charged plate (opposites attract). The arrow that is in that direction is numbered 5.

The direction of the electric field is defined as the direction of the force on a positive test charge, so in this situation the students should choose the same direction, numbered 5.

The next blank requires the students to apply several ideas: undeflected motion means net force is zero and there are exactly two significant forces acting on the positively charged particle. So the magnetic force must be in the opposite direction to that of the electric force, and this direction is number 6.

Finally, the students use a hand rule to determine the relative orientation of the velocity, force, and magnetic field. As a result, students should see that the magnetic field is perpendicular to the velocity and force and directed out of the plane of the diagram. The direction that shows this is the point of the arrow, numbered 0.

Analysis of field-test data

Just over 37% of the students who answered this question were able to get the directions of the electric force and electric field correct. Another 1% got the direction wrong and indicated that both directions were the same. Just over 37% of the students who answered this question provided directions for the first and third blanks that were opposite to each other. Finally, just over 58% of the students who answer this question provided a direction of the magnetic field that was perpendicular to the plane of the diagram.

Illustrative Items from Field Testing or Diploma Examinations Showing Word Usage and Exploring Misconceptions

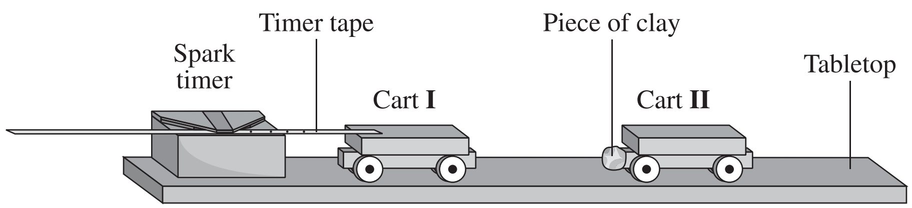
These items have been chosen to illustrate students' strongly held misconceptions, and word usage on the diploma examination.

This first item explores the misconceptions that students hold regarding Newton's third law.

Use the following information to answer question 1.

Two carts, travelling at the same initial speed, move toward each other on a table, as shown below. Cart I has a total mass of 500 g and Cart II has a total mass of 250 g.

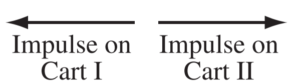
Side View of Colliding Carts



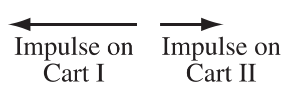
The carts collide. After contact, the carts remain separate from each other and move independently.

1. Which of the following vector diagrams, drawn to scale, shows the magnitude and direction of the impulse experienced by each cart during contact?

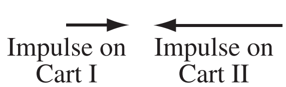
***A.**



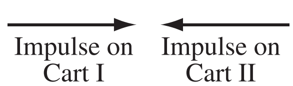
B.



C.



D.



Commentary

This question explores the application of Newton's third law in the student-familiar context of a collision. The majority of the students who answered this question were divided between choices B and C. This reflects a strongly held misconception of the relationship between force and acceleration.

***NEW** This item is included because student performance on the field test item suggests that this program outcome is one that they struggle with.

P30-B1.3k and B1.4k, *Students will* compare the methods of transferring charge (conduction and induction) and explain, qualitatively, the distribution of charge on the surfaces of conductors and insulators.

Use the following information to answer question 2.

A negatively charged rod is brought into contact with an initially neutral sphere supported by an insulated stand. The rod is removed and the resulting net charge distribution on the sphere is illustrated below.

2. *The sphere has been charged by the process of* ___***i***___ *, and the material that the sphere is made of is classified as* ___***ii***___ *.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	induction	a conductor
B.	induction	an insulator
C.	conduction	a conductor
***D.**	conduction	an insulator

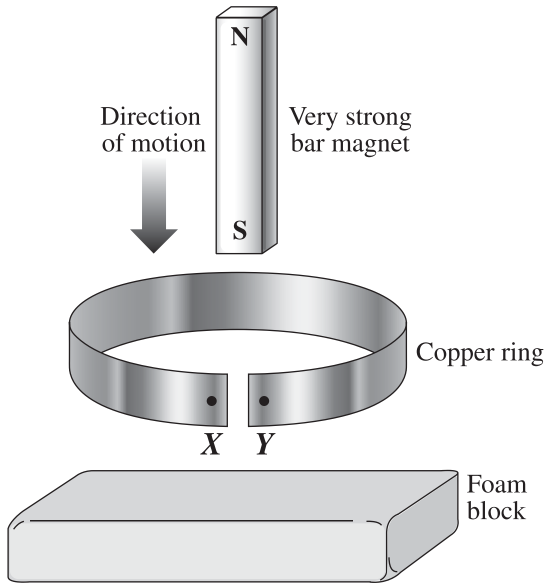
Commentary

In general students were unsuccessful in answering this question. The diagram illustrates that the nature of the excess charge is the same as that of the charging rod, which should allow the students to recognize that the method of charging is conduction. Since the excess charge remains localized on the surface of the sphere, students should recognize this as a characteristic of an electrical insulator.

This group of two items illustrates how the outcome B3.9k can be assessed.

Use the following information to answer question 3.

A very strong bar magnet is dropped onto a foam block through a copper ring that has a slit cut into it, as shown below.



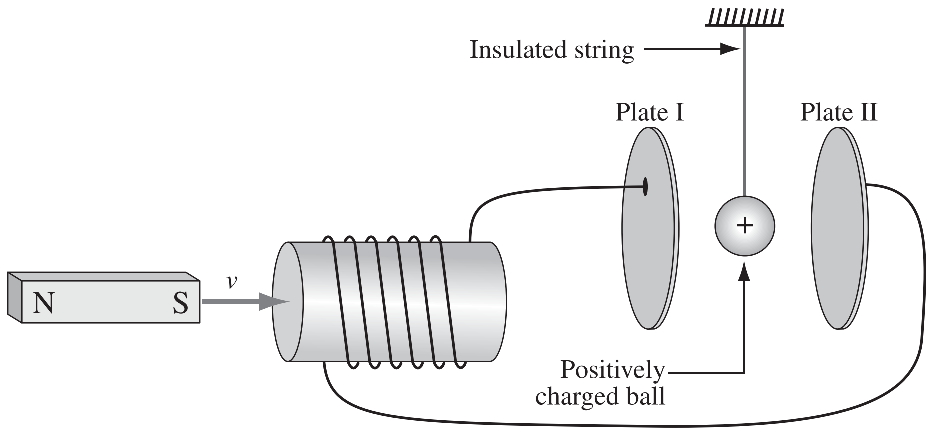
3. *When the south pole of the magnet moves into the ring from above, the direction the electrons inside the copper ring will move is from* ___***i***___ . *Compared to X, the nature of the charge on Y will be relatively* ___***ii***___ .

The statements above are completed by the information in row

Row	***i***	***ii***
A.	*X* to *Y*	negative
B.	*X* to *Y*	positive
C.	*Y* to *X*	negative
***D.**	*Y* to *X*	positive

Use the following information to answer question 4.

A positively charged sphere is suspended on the end of an insulated string in the region between two vertical, metal, parallel plates that are connected to a coil of wire. A magnet is suddenly thrust into the coil of wire, as illustrated below.



4. When the magnet is moved as illustrated above, then the direction of the motion of the positively charged sphere is

A. into the page
B. toward Plate I
***C.** toward Plate II
D. out of the page

This group of two items illustrates the use of *convex* and/or *concave* for a mirror and *diverging* and/or *converging* for a lens.

These words are chosen to make the items completely unambiguous. A convex mirror can only reflect the light off one face and the ray diagram is clear. However, a convex-convex lens can be either diverging or converging depending on the relative positions of the surfaces. So that students know exactly what is happening, we describe the effect of the lens on the light.

Use the following information to answer question 5.

> When a girl who is 122 cm tall stands 40 cm in front of a particular mirror, her virtual image in the mirror is upright and 54 cm tall.

5. *The mirror is ____**i**____ , and the girl's image is located ____**ii**____ away from the mirror.*

The statement above is completed by the information in row

Row	***i***	***ii***
***A.**	convex	18 cm
B.	convex	90 cm
C.	concave	18 cm
D.	concave	90 cm

Use the following information to answer question 6.

> In an investigation, a group of students measures an object to be 10.0 cm tall. They place the object 3.2 cm in front of a thin lens. They observe that a virtual image is formed and measure the distance from the image to the lens to be 4.3 cm.

6. The type of lens and its calculated focal length are, respectively,

A. diverging, and 1.8 cm
B. diverging, and 13 cm
C. converging, and 1.8 cm
***D.** converging, and 13 cm

This two-item set illustrates the assessment of unit D outcomes: D3.5k, D3.3s, and D3.6k.

D3.5k, *Students will* compare and contrast the characteristics of fission and fusion reactions. D3.3s, *Students will* compare the energy released in a nuclear reaction to the energy released in a chemical reaction, on the basis of energy per unit mass of reactants, D3.6k, *Students will* 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.

Use the following information to answer question 7 and numerical-response question 5.

Nuclear Reactions

Reaction I: $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$

Reaction II: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$

Reaction II is currently used in nuclear reactors in Canada. When 1.00 kg of uranium fuel is burned, 6.11×10^{13} J of energy is released.

7. Which of the following rows identifies the fission reaction and compares the energy released in the two reactions per kilogram of fuel?

Row	Fission	Energy per Kilogram
A.	Reaction I	Reaction I releases more than Reaction II
B.	Reaction I	Reaction I releases less than Reaction II
***C.**	Reaction II	Reaction I releases more than Reaction II
D.	Reaction II	Reaction I releases less than Reaction II

Numerical Response

5. The mass equivalent of the energy released by the burning of uranium fuel in a Canadian nuclear reactor, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ kg.
The values of ***a***, ***b***, ***c***, and ***d*** are _____, _____, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: 6794

This item illustrates the difference between *use* and *derive* in the context of the de Broglie equation. By providing the equation and naming the variables students use $p = mv$ from A1.1k to solve the problem. Without the equation in the context box, this question is beyond the expectations of the program of studies.

Use the following information to answer question 8.

Solar wind is hot plasma ejected from the surface of the Sun. The plasma consists, in part, of electrons. de Broglie hypothesized that a moving particle has a wavelength that relates to its momentum, given by the formula below.

$$\lambda = \frac{h}{p}$$

8. The wavelength of one solar-wind electron that has a measured speed of 4.0×10^5 m/s is

A. 9.9×10^{-13} m

***B.** 1.8×10^{-9} m

C. 6.2×10^{6} m

D. 1.1×10^{10} m

Questions Showing Assessment at Various Cognitive Levels

This group of three items shows how outcome C2.5k can be tested at a knowledge-recall level (K), a comprehension/application level (C/A), and a higher mental activity level (HMA).

Students achieving the standard of excellence need to be given the opportunity to show their true ability on HMA-level tasks.

The following is a K-level item.

Use the following information to answer numerical-response question 6.

Classical wave theory and quantum physics make different predictions about the effect of incident electromagnetic radiation on a photoelectric surface.

Four Photoelectric Effect Predictions

1 Low-intensity electromagnetic radiation incident on a photoelectric surface for long periods of time will cause photoemission.

2 High-intensity electromagnetic radiation will not cause photoemission unless its frequency is greater than the photoelectric surface's threshold frequency.

3 The energy of the emitted photoelectrons will increase if the intensity of the incident electromagnetic radiation is increased.

4 The energy of the emitted photoelectrons is independent of the intensity of the incident electromagnetic radiation.

Numerical Response

6. Match each of the predictions above with the appropriate theory of physics as labelled below. There is more than one correct answer.

Prediction:	________	________	________	________
Appropriate Theory:	**Classical wave theory**		**Quantum physics**	

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: 1324, 3124, 1342, or 3142

The following is a C/A-level item.

Use the following information to answer question 9.

Explanations

I Einstein's explanation of the photoelectric effect requires light to travel in bundles.

II Young's explanation of the observation from double-slit experiments requires light to interfere with itself.

III de Broglie's explanation of stable atomic energy levels requires electrons to exist as standing waves.

9. The explanations above are based on light having

A. only wave properties
B. only particle properties
***C.** both wave and particle properties
D. neither wave nor particle properties

This is an HMA-level item.

Use the following information to answer question 10.

A group of students produces the following observations relating to the photoelectric effect for light that is incident on a surface.

I Light that has a frequency less than the threshold frequency for that surface will not result in the emission of photoelectrons from the surface, regardless of the intensity of the light.

II For light that has a frequency higher than the threshold frequency for that surface, a more intense light produces more photoelectrons than a less intense light.

III The intensity of the light has no effect on the kinetic energy of any photoelectrons that are emitted by the surface.

10. Using classical wave theory (mechanical-wave model), the students can explain

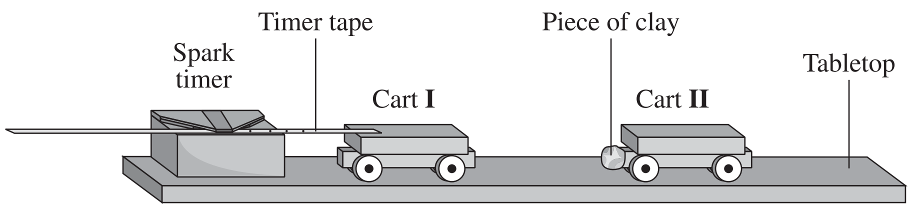
A. observation I only
***B.** observation II only
C. observations I and II
D. observations II and III

Illustrative Graphing Skills

The following set of items illustrates how graphical analysis can be assessed on the the Physics 30 Diploma Examination.

Use the following information to answer question 11 and numerical-response question 7.

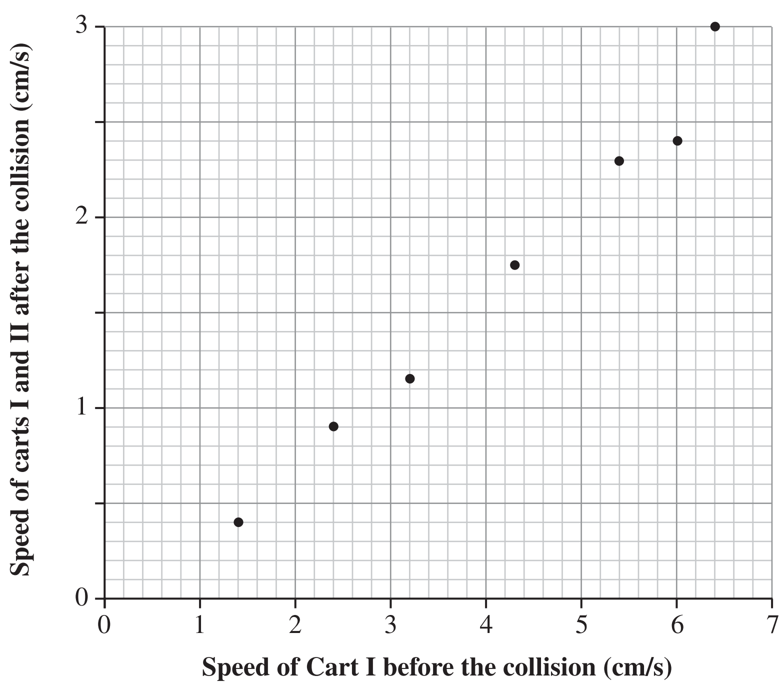
Students perform an experiment using two low-friction laboratory carts. A piece of timer tape is attached to Cart I and fed through a spark timer apparatus. The timer makes a mark on the tape each 0.10 s. Cart I is pushed toward Cart II which is initially at rest. The carts collide, the piece of clay is deformed and holds the carts together as they continue to move. The mass of Cart I is 1.54 kg.



The students repeat the above procedure, manipulating the initial speed of Cart I.

The graph of their observations is given below.

Speed of Carts I and II (After the Collision) as a Function of the Speed of Cart I (Before the Collision)



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(This feature may not be supported by all browsers.)

11. *The collision of the two carts is classified as* ___*i*___ *because* ___*ii*___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	elastic	momentum is conserved
B.	elastic	kinetic energy is conserved
C.	inelastic	momentum is not conserved
***D.**	inelastic	kinetic energy is not conserved

Numerical Response

7. Based on a point on the line of best fit, if Cart I had a speed of 6.0 cm/s before the collision, then the combined speed of the two carts after the collision would be ***a.b*** cm/s. You will need to record the values of ***a*** and ***b***.

Based on the slope of the line of best fit, the **combined** mass of the two carts is ***e.f*** kg. You will need to record the values of ***e*** and ***f***.

The values of ***a***, ***b***, ***e***, and ***f*** are _____, _____, _____, and _____.
a ***b*** ***e*** ***f***

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: Any answer in which the point and calculated value were consistent with a line of best fit for these data was scored as correct. For example, 2633 is acceptable, while 2832 is not.

*NEW *Numeracy on Physics Examinations*

Venn diagrams are a set-theory method that is useful in comparing characteristics or classifying ideas.

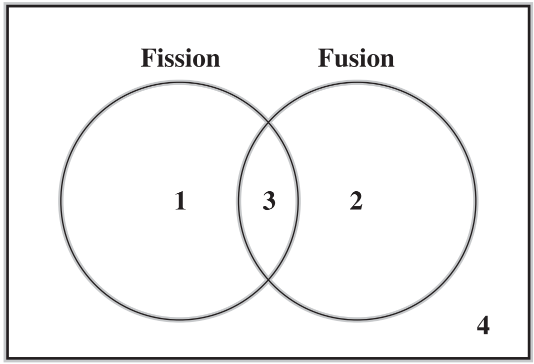
Based on student comments from field tests, students understand that Venn diagrams are used to sort, classify, or compare, but this is a new way of looking at ideas in physics.

The following two items illustrate how mandated program outcomes can be assessed using numeracy and a numerical-response format.

> P30-D3.5k, *Students will* compare and contrast the characteristics of fission and fusion reactions.

***NEW** *Use the following information to answer numerical-response question 8.*

The Venn diagram below can be used to compare fission and fusion.



Numerical Response

8. Match the numbers of the regions in the Venn diagram above with the descriptions given below. (The numbers may be used more than once. There is more than one correct answer.)

The measurable mass of the products is less than the measurable mass of the reactants in a spontaneous reaction.	________	(Record in the **first** box)
The kinetic energy of the system increases in a spontaneous reaction.	________	(Record in the **second** box)
${}^{236}_{92}\text{U} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3\,{}^{1}_{0}\text{n}$	________	(Record in the **third** box)
${}^{236}_{92}\text{U} \rightarrow {}^{232}_{90}\text{Th} + {}^{4}_{2}\alpha$	________	(Record in the **fourth** box)

(Record your answer in the response boxes at the bottom of the screen.)

Answer: 3114 and 3314

Commentary

This Venn diagram allows students to compare both concepts and reaction types. The process for answering this question is as follows.

A decrease in measurable mass in a spontaneous reaction occurs in both nuclear fission and nuclear fusion, making the first blank a 3. We allowed two answers for the second blank, 3 and 1, because at a Grade 12 level we expect a 3, but from an advanced-physics perspective there are examples of nuclear fusion that do not increase the kinetic energy of the system. This is one of the great strengths of a numerical-response-style question: all valid answers can be accepted. For the last two blanks, the uranium fission reaction equation would be classified as fission only (1) and alpha decay of uranium is neither fission nor fusion (therefore 4).

The top three incorrect answers provided by students and the frequency of those answers:

Answer	Frequency	Commentary
1314	5%	These students can distinguish between types of nuclear reactions but are missing the conceptual foundation.
2314	5%	These students can distinguish between types of nuclear reactions but are missing the conceptual foundation.
3412	5%	These students have the memorized knowledge foundation but not the understanding to distinguish between types of nuclear reactions.

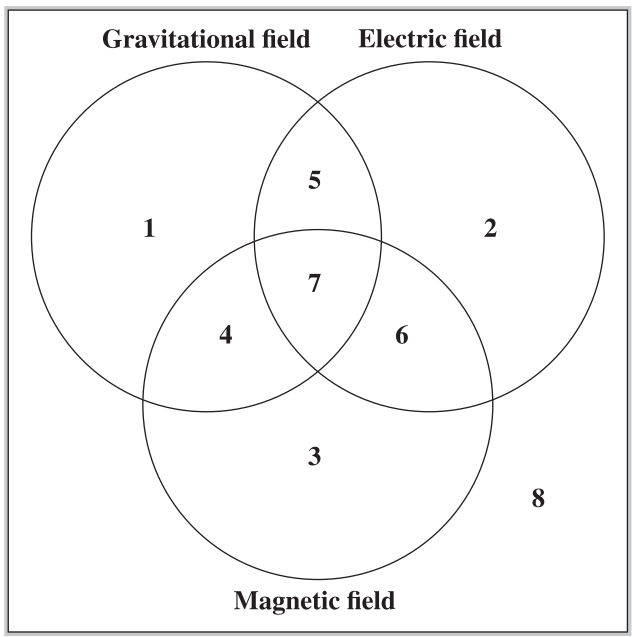
*NEW

P30-B3.2k, *Students will* compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions

Use the following information to answer numerical-response question 9.

The Venn diagram below can be used to compare gravitational fields, electric fields, and magnetic fields.

Venn Diagram* of Fields



*In this Venn diagram, the numbered regions represent aspects of fields that are unique to one field (regions 1, 2, and 3), shared by two of the fields (regions 4, 5, and 6), shared by all three of the fields (region 7), or are not an aspect of any of the fields (region 8).

Numerical Response

9. Match the numbers of the regions in the Venn diagram above with the descriptions given below.

Number:	______	______	______	______
Description:	**Can be directed toward the source**	**Can be directed away from the source**	**Is inversely proportional to the distance squared**	**Is directly proportional to the distance squared**

(Record all **four digits** of your answer in the response boxes at the bottom of the screen.)

Answer: 7658

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Commentary

This Venn diagram is a really powerful way of meeting outcome P30B3.2k in terms of comparing fields. To be successful, students need to have a solid foundation in the characteristics of each of the fields. For example, gravity is always radially inward, electric fields are perpendicular to the surface so that point sources give radial fields and flat plates produce parallel field lines, and magnetic fields are loops.

In the specifics of this question, directed toward the source is true for ALL of them (7). The word "can" is much less strong than "is always," which would have produced a first-blank answer of 1. The second blank is true for electric and magnetic fields but not gravitational fields, so the region is 6. Fields that fall as 1-over-r2 are gravitational and electric but not magnetic, which makes the region 5. The final blank is not an attribute of any of these fields and so would be classified into region 8.

This type of question has many possible applications for assessing outcomes in Physics 30.

Instructions Pages for Physics 30 Diploma Examinations

Physics 30

Grade 12 Diploma Examination

Description

*NEW **Time: 3 hours**. You have a total of 3 hours to complete this closed-book examination.

This examination consists of 36 multiple-choice and 14 numerical-response questions, of equal value.

This examination contains sets of related questions. A set of questions may contain multiple-choice and/or numerical-response questions.

Tear-out data pages are included near the back of this booklet. A Periodic Table of the Elements is also provided.

Instructions

- Turn to the last page of the examination booklet. Carefully fold and tear out the machine-scored answer sheet along the perforation.
- Use **only** an **HB** pencil for the answer sheet.
- Fill in the information on the back cover of the examination booklet and the answer sheet as directed by the presiding examiner.
- You are expected to provide your own calculator. You may use any scientific calculator or a graphing calculator approved by Alberta Education.
- You **must** have cleared your calculator of all information that is stored in the programmable or parametric memory.
- You may use a ruler and a protractor.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or an observation.
- When performing calculations, use the values of the constants provided on the tear-out data pages.
- If you wish to change an answer, erase **all** traces of your first answer.
- Do **not** fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Now read the detailed instructions for answering machine-scored questions.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

A. chemistry
B. biology
C. physics
D. science

Answer Sheet

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box. Any boxes on the right that are not needed are to remain blank.**

Examples

Calculation Question and Solution

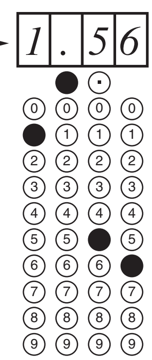
If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass will be _________ m/s^2.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

$$a = \frac{F}{m}$$

$$= \frac{121 \text{ N}}{77.7 \text{ kg}} = 1.557 \text{ m/s}^2$$

Record 1.56 on the answer sheet →



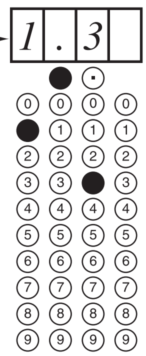
Calculation Question and Solution

A microwave of wavelength 24 cm has a frequency of _________ $\times 10^{w}$ Hz.

(Record your **two-digit answer** in the numerical-response section on the answer sheet.)

$f = c/\lambda$
$= (3.00 \times 10^{8}\text{ m/s})/(0.24\text{ m})$
$f = 1.25 \times 10^{9}$ Hz

Record 1.3 on the answer sheet ⟶



Correct-Order Question and Solution

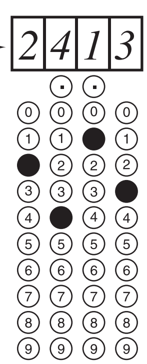
Four Subjects	
1	Physics
2	Biology
3	Science
4	Chemistry

When the subjects above are arranged in alphabetical order, their order is ____, ____, ____, and ____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: 2413

Record 2413 on the answer sheet ⟶



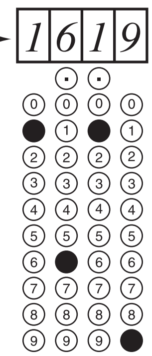
Scientific Notation Question and Solution

The charge on an electron is $-\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$ C. The values of ***a***, ***b***, ***c***, and ***d*** are ___, ___, ___, and ___.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: $q = -1.6 \times 10^{-19}$ C

Record 1619 on the answer sheet ⟶



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