Information Bulletin | Physics 30

2012 – 2013 Diploma Examinations Program

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.

Contents

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

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 or building and/or reviewing field tests 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.

Other opportunities to be involved, such as field testing, have specific closing dates. General dates to be aware of include:

September 2012	Registration for field tests to be administered in December 2012 or January 2013
February 2013	Registration for field tests to be administered in May or June 2013

Periodically we send out information to those Physics 30 teachers who are on our contact list. If you would like to be added to this list, contact Laura Pankratz, the Physics 30 Assessment Standards Team Leader, at Laura.Pankratz@gov.ab.ca.

*NEW *Special-Format Practice Tests*

To provide students an opportunity to practice diploma examination-style questions and content in Braille, audio, large print, or coloured print versions, Alberta Education will make special-format practice tests available through the Learning Resources Centre. All such tests will be available for purchase on a cost-recovery basis with the exception of Braille tests, which will be available for borrowing upon receipt of a refundable deposit. Braille tests will be available in English, and by request in French. For more information, contact the Assessment Sector at 780-427-0010

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.

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*. The specific statements of standards are written primarily to apprise 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 examination.

Linking Program Verbs to Cognitive Expectations

Some verbs carry expectations that require students to recall facts or identify characteristics. The Assessment Sector classifies these as "knowledge" level verbs. Examples of these verbs are listed in the yellow column below. Some verbs carry expectations that require students to apply their knowledge and skills in conventional situations. The Assessment Sector classifies these as "comprehension and application" verbs. Examples of these verbs are listed in the green column below. Some verbs carry expectations that require students to build new connections, to create relationships between concepts, to apply models to new and unusual situations. The Assessment Sector classifies these as "higher mental activities." Examples of these verbs are in the blue column below.

The *Physics 20–30 Program of Studies, 2007* 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: for example, scalar, vector, momentum, force, field, charging by conduction or by induction, refraction, diffraction, interference, the photoelectric effect, the Compton effect, matter-energy equivalence, nucleons, nucleus, decay, half-life, and stable energy states. These students are able to state and use formulas as they appear on the equation sheet: for example, momentum of a single object, linear momentum analysis, electric force, electric field, magnetic deflecting force, motor force, angle of refraction, index of refraction, focal length, magnification, photon energy, work function, mass (activity or percentage) remaining of a radioactive nuclide, photon energy, and energy change associated with photon emission or absorption. 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: for example, conservation laws, balanced or unbalanced forces, and type of motion. 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

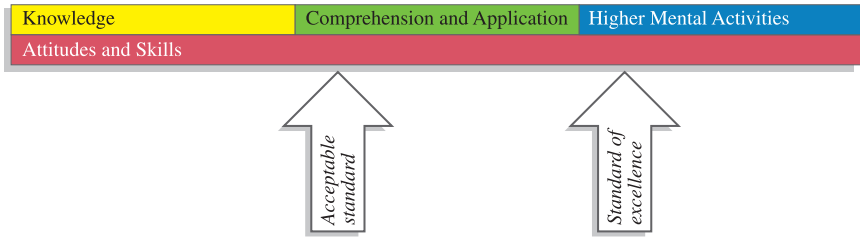
Students who achieve the standard of excellence in Physics 30 receive a final course mark of 80% or higher. They have demonstrated their ability and interest in both mathematics and physics, and feel confident about their scientific abilities. These students should encounter little difficulty in post-secondary 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 minor changes in problem format do not cause them major difficulties. These students are capable of analyzing situations that involve two-dimensional vectors, charge motion initially perpendicular to an external electric field, charge motion perpendicular to an external magnetic field, and energy-level values above or below given values based on photon characteristics, etc. 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.

Performance Standards

Approximately 45% of the items are designed to assess at the *Acceptable Standard* and approximately 25% of the items are designed to assess at the *Standard of Excellence.*



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.*

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 Questions

The examination contains both multiple-choice and numerical-response questions.

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

Multiple-choice questions are of two types: *discrete* and *context-dependent*. A discrete question 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 question provides information that is separate from the question stem. Many of the multiple-choice questions are context dependent. A particular context may be used for more than one multiple-choice question as well as for more than one numerical-response question.

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

Assessment of Skills and STS Connections

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

Examination Security

- The January 2012 and June 2012 Physics 30 Diploma Examinations are secured at the time of writing.

Maintaining Consistent Standards over Time on Diploma Examinations

A baseline examination will be established, and equating will be reestablished as a result of the standard setting associated with the change in the program of studies.

Publications and Supporting Documents

The following documents are published by Alberta Education.

- *Physics 20-30 Program of Studies, 2007* available on education.alberta.ca, via this pathway:
  Teachers > Programs of Study > (Programs of Study) Science > Programs of Study > (Senior High) Physics 20-30
- *Physics 20 and 30 Classroom-Based Performance Standards* available on education.alberta.ca, via this pathway:
  Administrators > Provincial Testing > Diploma Examinations > Diploma Examination Information Bulletins
- *Physics 30 Information Bulletin 2011–2012* available on education.alberta.ca, via this pathway:
  Administrators > Provincial Testing > Diploma Examinations > Diploma Examination Information Bulletins
- *Physics 30 Data Booklet* available on education.alberta.ca, via this pathway:
  Administrators > Provincial Testing > Diploma Examinations
- *Archived* Physics 30 Information Bulletins available on education.alberta.ca, via this pathway: Administrators > Provincial Testing > Diploma Examinations > Diploma Examination Information Bulletins
- *Calculator Policy* available on education.alberta.ca, via this pathway:
  Administrators > Provincial Testing > Diploma Examinations > Diploma Examination Information Bulletins
- *Assessment Highlights* available on education.alberta.ca, via this pathway:
  Teachers > (Additional Programs and Services) > Diploma Exams > Assessment Highlights
- *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.

Reminders and Explanations

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 which 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 page
× indicates into the page

Nuclear Equations

The curriculum 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.

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.

Use of Rulers or Straight-Edges

Students should be encouraged to use a ruler or straight-edge when drawing the line of best fit.

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

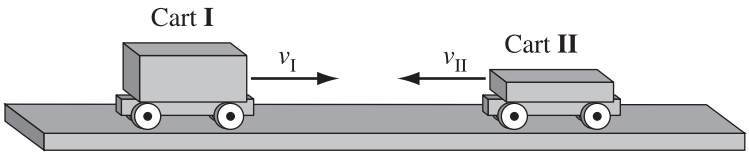
These items have been selected to illustrate students' strongly held misconceptions, word usage on the diploma, and how machine scored items can assess an outcome at different cognitive levels: K, C/A, HMA.

This first group of three items explores the misconceptions that students hold regarding Newton's third law.

Use the following information to answer the first two questions.

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.

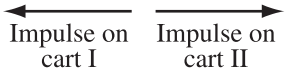
Side View of Colliding Carts



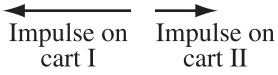
The carts collide. After contact, the carts remain separate from each other and move independently.

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

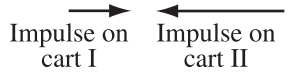
* **A.**



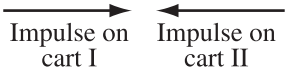
B.



C.



D.



Multiple-choice 1 Statistical Performance:

Group	**A***	**B**	**C**	**D**
Total:	0.298	0.350	0.292	0.060
High:	0.391			
Mid:	0.331			
Low:	0.188			

(The values represent the proportion that made that selection. The high and low groups each contain approximately 25% of the group. In this case 29.8% of the total chose A, which is the correct answer. 39.1% of the high group, 33.1% of the middle group, and 18.8% of the low group chose A.)

2. *During this collision, momentum* ___***i***___ *conserved and kinetic energy* ***most likely*** ___***ii***___ *conserved.*

The statement above is completed by the information in row

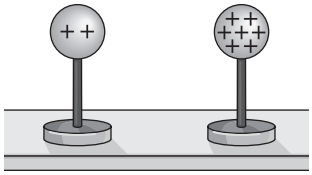
Row	***i***	***ii***
A.	is not	is
B.	is not	is not
C.	is	is
***D.**	is	is not

Multiple-choice 2 Statistical Performance:

Group	**A**	**B**	**C**	**D***
Total:	0.068	0.086	0.239	0.607
High:				0.777
Mid:				0.669
Low:				0.403

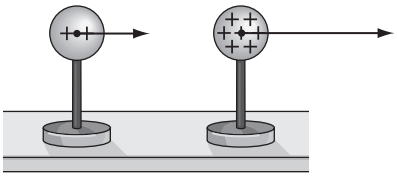
Use the following information to answer the next question.

Two identical conducting spheres are fastened to electrically insulated stands. The charge on one of the spheres is greater than the charge on the other.

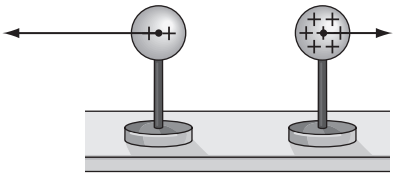


3. Which of the following diagrams, drawn to scale, **best** represents the magnitude and direction of the electrostatic forces on each of the charged spheres?

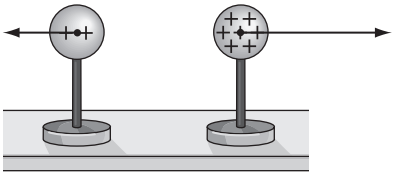
A.



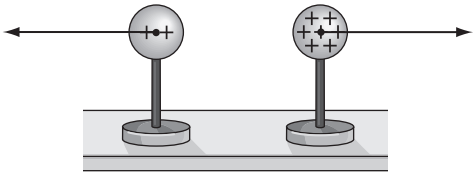
B.



C.



***D.**



Multiple-choice 3 Statistical Performance:

Group	**A**	**B**	**C**	**D***
Total:	0.016	0.471	0.245	0.268
High:				0.573
Mid:				0.195
Low:				0.087

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 the next question.

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.

4. *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

Multiple-choice 4 Statistical Performance:

Group	**A***	**B**	**C**	**D**
Total:	0.556	0.088	0.310	0.046
High:	0.690			
Mid:	0.564			
Low:	0.395			

Use the following information to answer the next question.

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.

5. 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

Multiple-choice 5 Statistical Performance:

Group	**A**	**B**	**C**	**D***
Total:	0.365	0.208	0.250	0.173
High:				0.326
Mid:				0.154
Low:				0.073

This group of three items shows how outcome P30-C2.5k can be tested at a knowledge-recall level (K), a comprehension/application level (C/A), and at a higher mental activity level (HMA).

Students achieving 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 the next question.

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

1. 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 physic**s	

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

Answer: 1324, 3124, 1342 or 3142

Numerical-response 1 Statistical Performance:

Group	**Correct**	**Incorrect**	**No Response**
Total:	0.502	0.495	0.004
High:	0.766		
Mid:	0.476		
Low:	0.279		

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

The following is a C/A-level item.

Use the following information to answer the next question.

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.

6. 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

Multiple-choice 6 Statistical Performance: *This item has not been field tested.*

This is an HMA-level item.

Use the following information to answer the next question.

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.

7. 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

Multiple-choice 7 Statistical Performance:

Group	**A**	**B***	**C**	**D**
Total:	0.201	0.218	0.429	0.150
High:		0.352		
Mid:		0.172		
Low:		0.116		

Instruction Pages for Physics 30 Diploma Examinations

Physics 30

Grade 12 Diploma Examination

Description

Time: 2 hours. This closed-book examination was developed to be completed in 2 h; however, you may take an additional 0.5 h to complete the 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.

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.*

- 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.

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

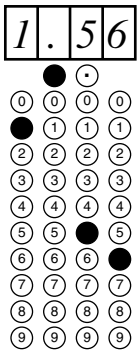
If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass will be _____ m/s^2.

(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 →



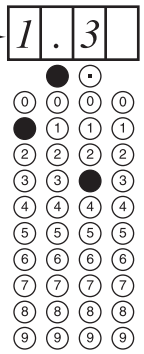
Calculation Question and Solution

A microwave of wavelength 24 cm has a frequency of _____ × 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

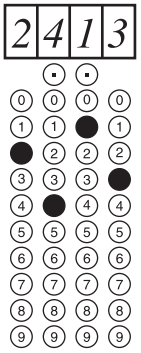
1 Physics
2 Biology
3 Science
4 Chemistry

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 →



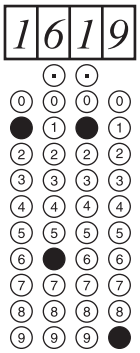
Scientific Notation Question and Solution

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