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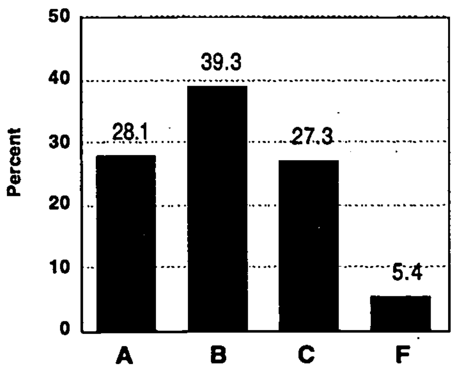
ABSTRACT

The summary information contained in this report provides teachers, school administrators, students, and the general public with an overview of results from the January 1997 administration of the Physics 30 Diploma Examination by the Alberta Department of Education in Canada. This information is most helpful when used with the detailed school and jurisdiction reports that have been provided to schools and school jurisdiction offices. Findings indicate that 92.7% of the 3,099 students who took the test achieved the acceptable standard and 25.6% of these students achieved the standard of excellence. Topics discussed include a description of the examination, achievement of standards, results and examiners' comments, multiple-choice and numerical-response questions, and written-response questions. (JRH)

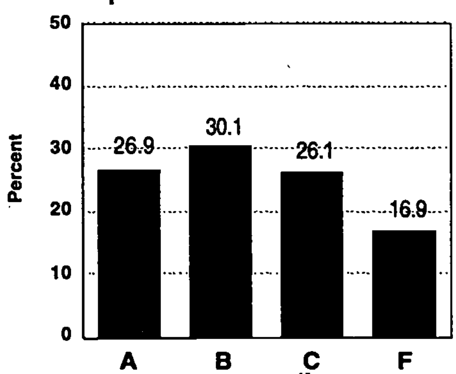
Physics 30

Diploma Examination Results
Examiners' Report for January 1997

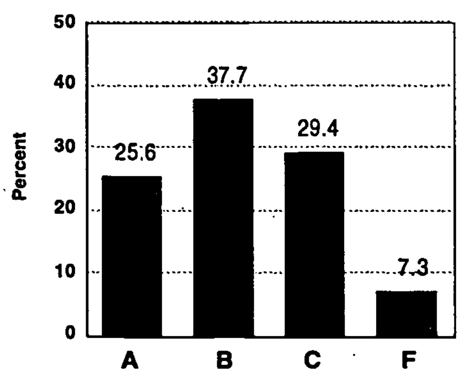
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the January 1997 administration of the Physics 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been provided to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, June, and August results is made available annually.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 52.9%, 12 numerical-response questions worth 17.1%, and 2 written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 3 099 students in Alberta who wrote the January 1997 examination.

- 92.7% of the 3 099 students achieved the acceptable standard (a final course mark of 50% or higher).
- 25.6% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 37.2% of the students who wrote the January 1997 examination were females.

- 94.1% of the female population achieved the acceptable standard (a final course mark of 50% or higher).
- 25.7% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 62.8% of the students who wrote the January 1997 examination were males.

- 91.9% of the male population achieved the acceptable standard (a final course mark of 50% or higher).
- 25.6% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Students are demonstrating a noticeable improvement in their ability to communicate their solutions to the open-ended written-response problem. Students are still experiencing difficulty with two-dimensional momentum problems, problems involving vector additon, and calculations involving algebraic manipulation of variables.

Students First!
Student Evaluation

Alberta
EDUCATION

Provincial Averages

- The average school-awarded mark was 70.4%.
- The average diploma examination mark was 66.9%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 69.0%.

Approximately 8.3% of the students who wrote the examination in January 1997 and received a school-awarded mark had written at least one other Physics 30 Diploma Examination during the January 1996 to January 1997 period. This sub-population (257) achieved an examination average of 64.6%, compared with 66.9% for the population (3 099) who first wrote a Physics 30 examination in January 1997.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the acceptable standard will obtain a mark of 50% or higher, and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For some numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer as indicated. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

- GLE 1 Explain gravitational, electrical, and magnetic effects on systems
- GLE 2 Analyze and predict the behaviour and physical interactions of objects
- GLE 3 Describe and analyze resistive circuits and the function of EM devices
- GLE 4 Solve problems related to EM wave behaviour and the atomic theory

Skills:

- SPSC Scientific Process Skills and Communication Skills

Science, Technology, Society:

- STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
NR1	13.8	0.900		√				
MC1	A	0.728		√				
MC2	D	0.298		√				
MC3	A	0.731		√				
MC4	D	0.817		√			√	
MC5	A	0.775		√				
MC6	B	0.816	√					
MC7	A	0.731	√					
MC8	D	0.959	√				√	
MC9	C	0.349		√				
MC10	B	0.648		√				
NR2	12.0	0.971			√			√
NR3	2321	0.580			√			√
NR4	2.70, 2.7	0.684			√			√
NR5	30.0	0.773			√			
NR6	1.53*	0.895			√			
MC11	B	0.526			√			
MC12	C	0.861			√			√

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
NR7	2411**	0.869		√				√
MC13	A	0.625	√					√
MC14	C	0.888			√			
MC15	D	0.796			√		√	
MC16	A	0.585				√		√
MC17	D	0.585	√				√	
MC18	C	0.866		√				
MC19	B	0.765			√			√
MC20	A	0.521		√				√
MC21	D	0.772			√			
MC22	C	0.799			√			√
MC23	C	0.764	√					
NR8	3.00	0.772				√		
MC24	A	0.812				√		
NR9	1.62	0.669				√		
NR10	1.08	0.409				√	√	
MC25	C	0.687				√		√
MC26	D	0.764	√					
MC27	C	0.442				√	√	
MC28	A	0.657				√	√	√
MC29	A	0.580				√	√	
MC30	B	0.809				√	√	√
NR11	5.6, 5.7	0.390				√		√
NR12	4810	0.720				√		√
MC31	A	0.613				√	√	√
MC32	B	0.682				√	√	√
MC33	A	0.528				√		
MC34	D	0.879				√		√
MC35	A	0.684		√			√	√
MC36	D	0.632		√			√	√
MC37	B	0.636				√		
WR1		0.590	√	√			√	√
WR2		0.590		√			√	√

* The algorithm for NR6 is $NR6 = \frac{46}{NR5}$

** The algorithm for NR7 is $NR7 = \frac{MC12}{0.010} = a.b \times 10^{cd}$

Subtests

When analyzing detailed results, bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine Scored

General Learner Expectations:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems	8.8	out of	13
GLE 2	Analyze and predict the behaviour and physical interactions of objects	17.7	out of	28
GLE 3	Describe and analyze resistive circuits and the function of EM devices	9.2	out of	12
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	10.9	out of	17
Skills	Scientific process skills and communication skills	16.9	out of	26
STS	Connections among science, technology, and society	26.5	out of	41

Multiple choice and numerical response: 34.2 out of 49
Multiple choice: 25.6 out of 37
Numerical response: 8.6 out of 12

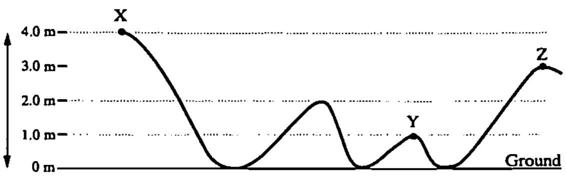
Written Response

Written Response: 12.6 out of 21
Question 1: 6.5 out of 11***
  Communication: 2.2 out of 3
  Content: 4.3 out of 8
Question 2: 5.9 out of 10

*** Individual student scores for Question 1 are equal to the Scale 1 score added to the Scale 2 score, then rounded to a whole number. The written-response total score reflects rounded scores.

Use the following information to answer the next two questions.

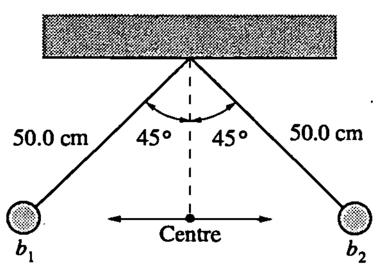
A 0.50 kg steel block starts from rest at point X, which is 4.0 m above the ground, and slides along a steel rail. Assume that the steel is frictionless. The path of the block as it slides along the rail is shown below.



1. The speed of the block at point Z is
   - •A. 4.4 m/s
   - B. 4.9 m/s
   - C. 8.9 m/s
   - D. 14 m/s

2. Assuming that the potential energy of the block is zero at ground level, then the total mechanical energy of the block at point Y is
   - A. 4.9 J
   - B. 9.8 J
   - C. 15 J
   - •D. 20 J

Electrostatics



Two identical conducting balls, b_1 and b_2, each of mass 25.0 g, are hanging on 50.0 cm-long insulating threads. They become equally charged and come to rest with angles of deviation of 45.0° from the vertical.

9. What is the tension in the thread that is supporting one of the balls?
   - A. 0.173 N
   - B. 0.245 N
   - •C. 0.347 N
   - D. 9.81 N

Multiple-Choice and Numerical-Response Questions

The following questions were selected for discussion because they exemplify what is required to achieve the acceptable standard and the standard of excellence.

Multiple-choice question 1: Most students recognized that they needed to find the change in potential energy between points X and Z in order to calculate the kinetic energy at Z and then the speed at Z. Of the students who were unsuccessful in answering the question correctly, the majority chose alternative B. These students most likely made the incorrect assumption that all of the potential energy at X had been converted to kinetic energy by the time the block reached Z.

A total of 72.8% of students answered this question correctly. Of the students who achieved the standard of excellence, 93.1% answered correctly, and of those who achieved the acceptable standard but not the standard of excellence, 72.4% were correct in their response. In addition, 43.4% of students who did not achieve the acceptable standard chose the correct answer.

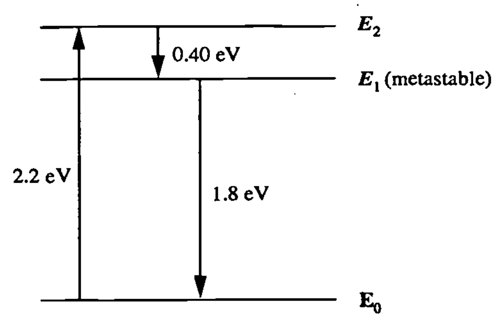
Multiple-choice question 2: The results on this question were considerably lower than expected, with only 29.8% of students answering correctly. In order to solve this problem successfully, students needed to know that the total mechanical energy of the system is the sum of the system's potential energy and kinetic energy at any given time, and that this sum is a constant for an isolated system. More students chose alternative A, the potential energy at Y, than the correct response D. This indicates that students are not familiar with the definition of mechanical energy.

On this question, 58.4% of students who achieved the standard of excellence selected the correct answer, while only 23.8% of those achieving the acceptable standard but not the standard of excellence were able to successfully answer the question. Only 11.4% of students who failed to achieve the acceptable standard answered this question correctly.

Numerical-response question 9: This question required students to find the vector sum of the force due to gravity and the electrostatic force of repulsion. Students continue to experience difficulty with questions that involve vector addition. In this question, a greater percentage of students chose alternative B than the correct alternative, C. It seems that many students used only the force due to gravity in their calculations and ignored the effects of the electrostatic force.

Of the students who achieved the standard of excellence, 53.5% solved this question correctly. Only 30.0% of the students who achieved the acceptable standard but not the standard of excellence were able to complete a correct solution to this problem.

Energy States of Chromium in a Ruby Crystal Laser



A laser can be made using a ruby crystal containing chromium (Cr) atoms. The lasing action can occur only after electrons in the chromium atoms are "pumped" from the ground state to state E_2 using strong flashes of light. The electron will then undergo a transition from E_2 to the ground state, E_0, or to the intermediate state, E_1.

Photons emitted by the electrons that have undergone transition from E_1 to E_0 may strike other electrons at the E_1 state. This causes a new photon to be emitted along with the original photon. These photons are exactly in phase and moving in the same direction. The cumulative effect of this process creates the laser beam.

Numerical Response

11. Flashes of light pump electrons in the Cr atoms from the ground state, E_0, to state E_2. The wavelength of these flashes of light, expressed in scientific notation, is $b \times 10^{-w}$ m. The value of b is __________.
(Round and record your answer to two digits.)

Answer: 5.6, 5.7

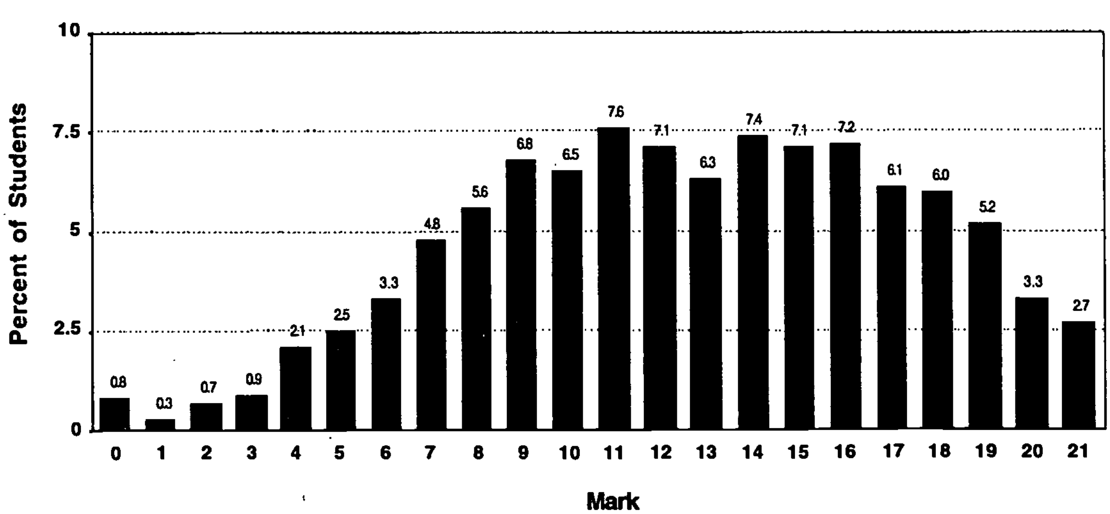
Numerical-response question 11: Students who answered this question correctly were able to calculate the change in energy resulting from the transition between states and to find the corresponding wavelength. The two-step nature of this problem made it a more difficult problem for students who did not achieve the standard of excellence. In addition, many students failed to round and record their answer to two digits, as directed. Numerical-response questions always indicate to students the number of digits the final answer should contain; this is based on the number of significant digits given in the information boxes and the stem of the question. This instruction is designed to assist the students with their solution, but students must take care to follow instructions. A similar concern arises in linked questions where students are instructed to use their recorded response to answer the next question.

On this question, 59.0% of students who achieved the standard of excellence responded correctly, while 38.6% of those achieving the acceptable standard but not the standard of excellence selected the correct response. Of the students who failed to achieve the acceptable standard, 18.2% did not respond to the question and only 9.9% responded with the correct answer.

Written-Response Questions

Of all the students who wrote the exam, 58.2% received a mark of 11 or higher out of 21. The average mark on the written-response questions was 12.6 or 60%.

Distribution of Marks for Written Response



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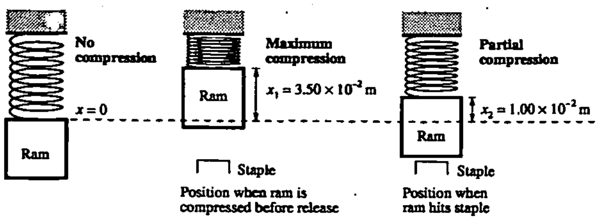
Written Response – 11 marks

A Spring Ram Stapler



Heavy-duty stapling guns use powerful springs in combination with a small metal rod (called a ram) to produce the impact necessary to move staples or nails into materials such as wood, wallboard, or even concrete.

A particular staple gun has a ram with mass 0.200 kg and a spring with a spring constant of 35 000 N/m. When the handle of the gun is squeezed, the spring is compressed to a maximum value of 3.50×10^{-2} m. When the ram makes contact with the staple, the spring is still compressed 1.00×10^{-2} m. Assume that 3.00% of the ram's kinetic energy is transferred to the 2.00 g staple when the ram hits the staple. The potential energy of a spring is $\frac{1}{2}kx^2$.

1. Describe and calculate the energy transformations involved in the operation of the spring ram stapler. Use conservation laws, physics concepts, and related equations to support your answer. Ignore the mass of the spring and the effects of gravitational potential energy on the system.

Note: A maximum of 8 marks will be awarded for the physics used to answer this question. A maximum of 3 marks will be awarded for the effective communication of your response.

Written-response question 1 was well answered. Students were required to describe all three energy transformations explicitly and to provide calculations for the initial spring potential energy, the change in spring potential energy, and the final kinetic energy transferred to the staple. Students demonstrated a good understanding of the concept of conservation of energy. In most cases, responses identified clearly the second and third energy transformations and provided good descriptions as well as the appropriate calculations. Students continue to improve in their ability to organize their work and to communicate their ideas clearly. However, some responses still describe algebraic calculations instead of the physics principles involved in the transformations.

A description of the first transformation, the compression of the spring by someone squeezing the handle of the gun, was missed in many responses. Although students often implied that the handle had been squeezed, they failed to address the transformation explicitly. Another common error was the use of Coulomb's constant for the value of k in $\frac{1}{2}kx^2$.

Two major errors appeared frequently in responses. The first error was that students neglected to square the value of x in $\frac{1}{2}kx^2$. The second error may be mathematical or may indicate a major conceptual misunderstanding: many students calculated $\frac{1}{2}k(x_1 - x_2)^2$ instead of $\frac{1}{2}k(x_1{}^2 - x_2{}^2)$ when finding the change in the spring's potential energy.

Of the students who achieved the standard of excellence on the exam, 76.6% received 9 out of 11 or better on this question.

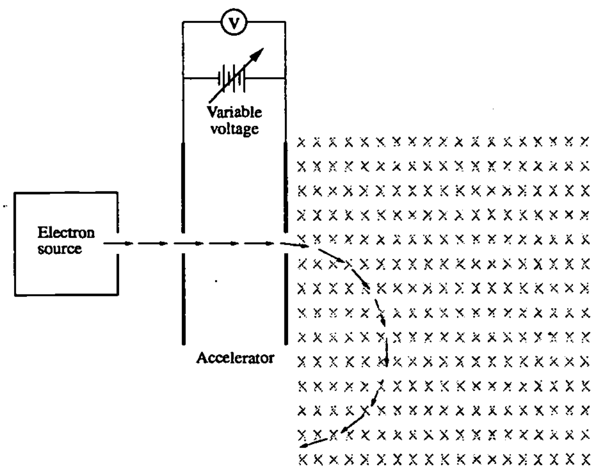
On this question, 61.8% of the students who achieved the acceptable standard but not the standard of excellence received 6 out of 11 or better. Only 1.1% of students did not attempt this question.

On this 11 mark question, the average was 6.5 or 59.0%.

Written Response – 10 marks

A student used the apparatus shown below to measure the radius of curvature of the path of electrons as they pass through a magnetic field that is perpendicular to their path. This experimental design has the voltage as the manipulated variable, the speed calculated from the voltage, and the radius as the responding variable.

Accelerating Potential Difference (V)	Speed (10^6 m/s)	Radius (10^{-2} m)
20.0	2.65	7.2
40.0	3.75	9.1
60.0	4.59	11.0
80.0	5.30	12.8
100.0	5.93	14.1
120.0	6.49	16.3



× indicates magnetic field into the page

2. **a.** Plot the graph of radius as a function of speed, and construct a best-fit line.

b. Using the slope or other appropriate averaging technique, determine the strength of the magnetic field.

c. Derive the equation that would allow the student to calculate the speed of the electrons from the accelerating potential.

Written-response question 2 had an average of 5.9 out of 10 or 59%. In general, students demonstrated good graphing skills and a good understanding of how to calculate the slope and determine the strength of the magnetic field. Proper graphing techniques and suitable averaging methods were used by many students. However, some common errors emerged. These included:

- drawing the wrong graph (Voltage vs. Radius or Voltage vs. Velocity)
- choosing the axes inappropriately
- forgetting units on axes labels
- drawing an incorrect best-fit line
- using data points to calculate slope
- using inappropriate averaging technique (e.g., calculating v_{avg} and r_{avg} and using these to calculate B_{avg})

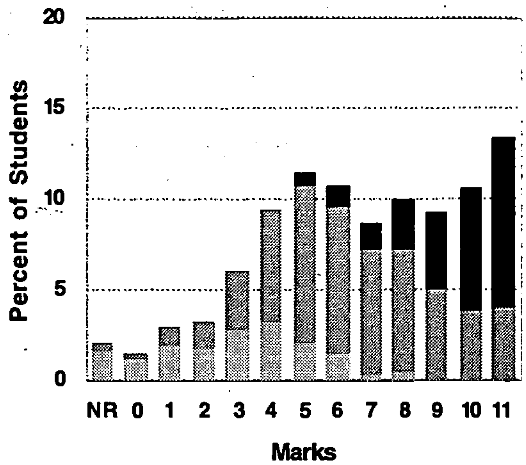
Comments on graphing and averaging techniques can be found in the **1996–97 Physics 30 Information Bulletin.**

In solving part c, although many students failed to explicitly state the energy relationship they were using, they were still able to derive the equation to calculate the speed of the electron from the accelerating potential.

On this question, 72.1% of the students who achieved the standard of excellence on the exam received a mark of 8 out of 10 or better.

Of the students who achieved the acceptable standard but not the standard of excellence, 66.3% scored 5 out of 10 or better on this question. Less than 1% of students did not attempt this question.

Distribution of Marks for Question 1

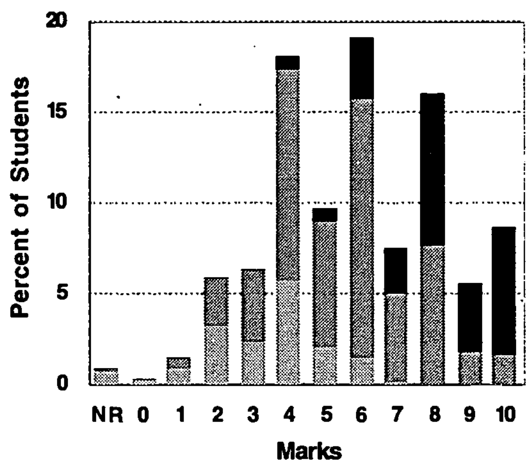


Standard of Excellence on the Examination

Acceptable but not Standard of Excellence on the Examination

Below Standard on the Examination

Distribution of Marks for Question 2



Standard of Excellence on the Examination

Acceptable but not Standard of Excellence on the Examination

Below Standard on the Examination

For further information, contact Corinne McCabe (cmccabe@edc.gov.ab.ca) or Phill Campbell (pcampbell@edc.gov.ab.ca) at the Student Evaluation Branch at 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.