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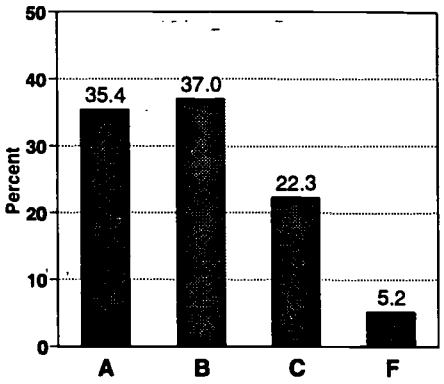
ABSTRACT

The summary information contained in this report provides teachers, school administrators, students, and the general public with an overview of the results from the June 1998 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 are provided to schools and school jurisdiction offices. Findings indicate that 93.3% of the 5,183 students who took the test achieved the acceptable standard, and 30.4% of those 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. (ASK)

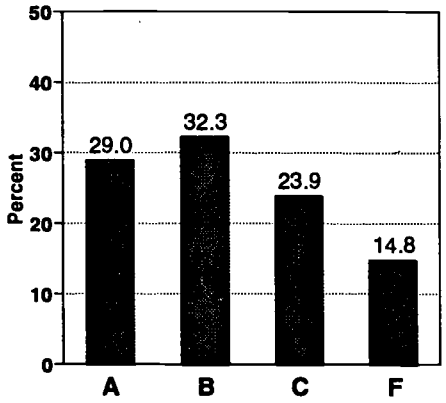
Physics 30

Diploma Examination Results
Examiners' Report for June 1998

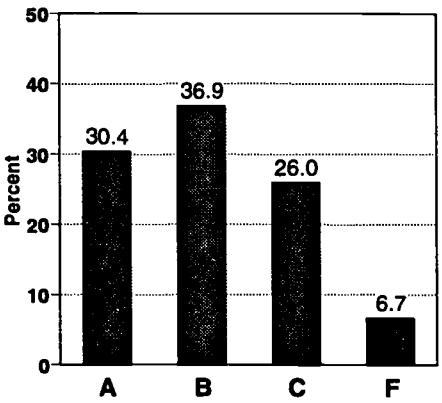
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, and students with an overview of results from the June 1998 administration of the Physics 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, April, June, and August results is made available annually.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 53%, 12 numerical-response questions worth 17%, and 2 written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported is based on the final course marks achieved by 5 183 students in Alberta who wrote the June 1998 examination.

- 93.3% of the 5 183 students achieved the acceptable standard (a final course mark of 50% or higher).
- 30.4% of students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 37.7% of the students who wrote the examination were female. Of these, about 95.1% achieved the acceptable standard for a final course mark compared with 92.2% of the male students. Approximately 29.6% of the female students achieved the standard of excellence, compared with 31.0% of male students.

Students are demonstrating improved skills in dealing with questions related to the Science, Technology, and Society strand of the curriculum. Students are demonstrating improvement by addressing all aspect of written-response questions. However, students continue to have difficulty communicating their understanding of the physics principles used to solve the questions. This may be a result of students relying on algebraically derived formulas that they have memorized rather than basing their solutions on basic physics principles.

Provincial Averages

- The average school-awarded mark was 72.3%.
- The average diploma examination mark was 68.1%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 70.5%.

Approximately 4.2% of the students who wrote the examination in June 1998 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the June 1997 to June 1998 period. This sub-population (217) achieved an examination average of 59.1%, compared with 68.5% for the population (4 966) who first wrote a Physics 30 examination in June 1998. The group of students who rewrote increased their overall average by 10.4%.

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 numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. 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 (out of 1) 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:

- SPC 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	SPC	STS
NR1	2431	0.867		✔				✔
MC1	B	0.756		✔				✔
NR2	1423*	0.708		✔				✔
MC2	D	0.844		✔				
MC3	A	0.601		✔				
NR3	4431	0.533		✔				✔
MC4	B	0.638		✔				✔
MC5	B	0.462		✔				✔
MC6	B	0.656		✔				✔
NR4	2944	0.895		✔				✔
MC7	D	0.752		✔				
MC8	C	0.708		✔			✔	
MC9	D	0.859		✔				✔
NR5	1062	0.827		✔				✔
MC10	B	0.689				✔		✔
NR6	6.63	0.790				✔		✔
MC11	A	0.714	✔					

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
MC12	D	0.838	✔				✔	
MC13	C	0.608		✔				
NR7	78.0	0.484	✔					
NR8	9445	0.715		✔				✔
MC14	A	0.908		✔				✔
MC15	D**	0.923		✔				✔
MC16	A	0.525	✔				✔	✔
MC17	A	0.775			✔		✔	
MC18	D	0.519		✔			✔	
MC19	A	0.601	✔					
NR9	6412	0.548	✔					
MC20	B	0.518	✔				✔	
MC21	C	0.693			✔			✔
MC22	C	0.830	✔					
MC23	D	0.827			✔			✔
MC24	C	0.648		✔			✔	
MC25	A	0.642			✔		✔	
MC26	A	0.729				✔		
MC27	D	0.775				✔		✔
NR10	6.59	0.827				✔		✔
MC28	C	0.674				✔		
NR11	1.71	0.667		✔				
MC29	D	0.844				✔		✔
MC30	C	0.651				✔		
MC31	A	0.483		✔				
MC32	D	0.754				✔		
MC33	C	0.561				✔	✔	
NR12	1.83	0.846				✔		✔
MC34	C	0.888				✔		
MC35	B	0.853				✔		✔
MC36	A	0.882				✔		
MC37	C	0.823				✔	✔	
WR1	—	0.489	✔	✔			✔	✔
WR2	—	0.684			✔		✔	✔

*NR2: 1553 if A was selected from MC1; 1423 if B was selected; 1103 if C was selected. and 9982 if D was selected
**MC15: D if A was selected from MC14; C if B was selected; B if C was selected, and A if D was selected

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared.

Average Percentage Scores of Machine Scored and Written Response

Machine Scored	71.8%
Multiple choice	71.5%
Numerical response	72.6%
Written Response	59.3%*
Question 1	48.9%
Communication	63.0%
Content	43.5%
Question 2	68.4%

* Individual student scores for Question 1 and Question 2 are each weighted 15% of the total exam.

Average Percentage Scores and Total Test Weighting in Percentage by General Learner Expectation

		Average	*Weighting*
GLE 1	Explain gravitational, electrical, and magnetic effects on systems	58.2%	18.9%
GLE 2	Analyze and predict the behaviour and physical interactions of objects	66.9%	38.9%
GLE 3	Describe and analyze resistive circuits and the function of EM devices	69.8%	20.7%
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	77.3%	21.4%
SPC	Scientific Process Skills and Communication Skills	61.9%	34.3%
STS	Connections Among Science, Technology, and Society	72.0%	49.3%

Numerical Response

3. Evaluate each of the following four trigonometric expressions. Identify the order of the values from smallest to largest. Record this order by listing the number of each expression, starting in the extreme left column of numerical response 3.

1 $\tan^2\theta - \sec^2\theta$

2 $\tan\theta - \frac{\sin\theta}{\cos\theta}$

3 $5\sin^2\theta + 5\cos^2\theta$

4. $\frac{1}{7}\sin\theta \csc\theta$

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

Answer: 1243

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9. The amplitude of a given sine function, $f(\theta) = a \sin \theta + d$, is 6. If the maximum value of f is 8, then the minimum value of f is

A. –8
B. –6
***C.** –4
D. 2

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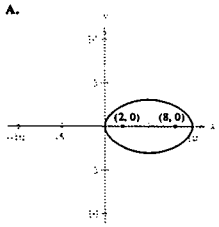
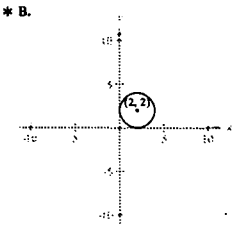
23. A quadratic relation is given by the equation $Ax^2 + Cy^2 + Dx + Ey + F = 0$, where $A \times C \times D \times E = 0$. The foci of the ellipse and hyperbola, the centre of the circle, and the vertex of the parabola are shown. Which of the following graphs could **not** be the graph of this quadratic relation?

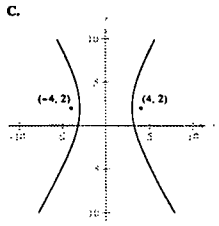
A.



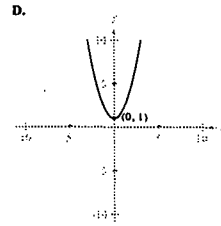
* B.



C.



D.



The multiple-choice and numerical-response sections of the examination comprise questions that represent all content areas in Mathematics 30. A discussion of students' achievement of the curriculum standards in the units Trigonometric and Circular Functions, and Quadratic Relations follows.

Trigonometric and Circular Functions — To achieve the acceptable standard in trigonometric and circular functions, the students must be able to convert angle measurements between degree and radian measure, and given any two of the radian measure of the central angle, the radius, and the length of an arc, determine the unknown measurement. Students must also be able to verify the fundamental trigonometric identities; solve first-degree trigonometric equations on the domain $0 \le \theta < 2\pi$ in radians and $0° \le \theta < 360°$; and simplify and evaluate simple trigonometric expressions involving the fundamental trigonometric identities.

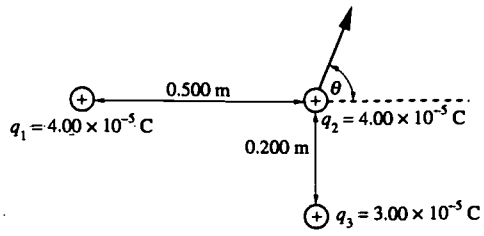
In addition, students must be able to generate the graph of trigonometric functions with the use of graphing calculators or graphing utility packages; explain the effect of each parameter a, b, c, and d on the graph of the $y = a \sin [b(\theta + c)] + d$ and $y = a \cos [b(\theta + c)] + d$ functions; and be able to state the domain and range of $y = \sin \theta$, $y = \cos \theta$, and $y = \tan \theta$. Multiple-choice questions 8, 9, 10, 12, and 13, and numerical-response questions 2 and 3 require students to demonstrate their understanding of this unit.

In addition to the expectations for the acceptable standard, students who achieve the standard of excellence must be able to prove trigonometric identities and solve second-degree trigonometric equations, including double and half angles on the domains $0 \le \theta < 2\pi$ and $0° \le \theta < 360°$. They must be able to explain both orally and in writing the combined effects of the parameters a, b, c, and d on the graphs of $y = a \sin [b(\theta + c)] + d$ and $y = a \cos [b(\theta + c)] + d$ and on the functions domain and range. Multiple-choice question 11 requires this of students.

Quadratic Relations —To achieve the acceptable standard in quadratic relations, students must be able to describe orally, in writing, and by modelling, each of the following: the intersection of a plane and a conical surface that would result in a hyperbola, an ellipse, a parabola, and a circle. They must also be able to identify the position of the plane at which the intersection of a plane and a conical surface defines a degenerate ellipse and hyperbola. Students must be able to describe orally and in writing each of the following: the quadratic relation defined by a combination of numerical coefficients for any quadratic relation in the form $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$, where $B = 0$; the quadratic relation formed when given the value of the eccentricity; the eccentricity when given the quadratic relation; the quadratic

Use the following information to answer the next question.

Three charges, q_1, q_2, and q_3, are placed at the vertices of a right angle triangle, as shown below.



13. The magnitude of the net electrostatic force acting on q_2 is

A. 212 N
B. 263 N
***C.** 276 N
D. 327 N

Multiple-choice question 13 clearly distinguished between the students who achieved the acceptable standard on the examination and those who did not achieve the acceptable standard on the examination. In order to obtain the correct answer, students had to find the magnitudes of the two electrostatic forces acting on q_2. The students then had to find net force by evaluating the resultant of the two perpendicular electrostatic force vectors. Students who did not answer this question correctly tended to find either the sum or the difference between the magnitudes of the two forces acting on q_2.

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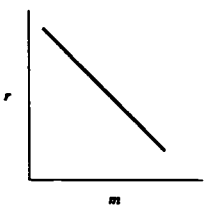
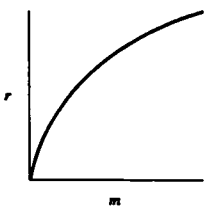
18. Ions, each having a single charge, are accelerated to a given speed. They then enter a magnetic field in a direction perpendicular to the field. The radius of the curved path of each ion is measured. The graph that **best** shows the relationship between the mass of an ion and the radius of its path is

A.

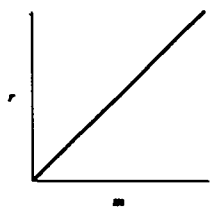


B.

C.

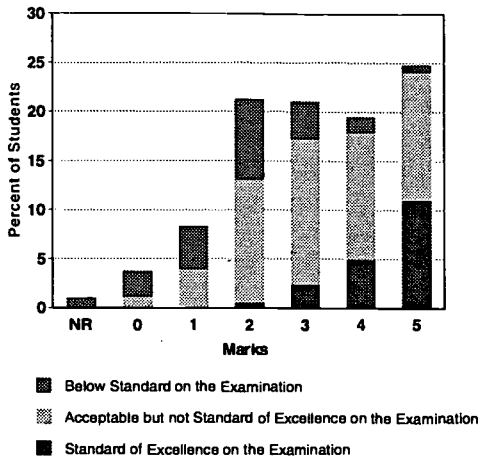


***D.**



For **multiple-choice question 18**, students who achieved the standard of excellence on the examination performed well on this question. They recognized that the magnetic force acting on the ion produced circular motion. By mathematically relating the unbalanced magnetic force to the equation for circular motion, students found that the radius of the curved path varied linearly with the mass of the ion. Students who did not achieve the standard of excellence experienced difficulty with the question because the solution requires the use of an equation that had to be derived from formulas found on the data sheet. In addition, the students experienced difficulty relating a mathematical equation to graphical relationship.

Distribution of Marks for Question 1

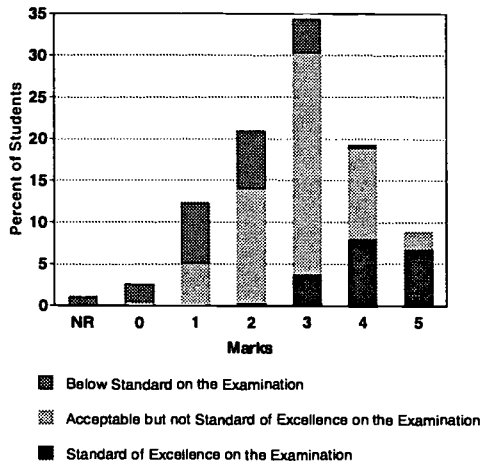


Question 1 required students to identify which of three types of graph paper would be most appropriate on which to draw ellipses for two distinct cases. Case 1 provided the value of the eccentricity of an ellipse as $\frac{2}{3}$ and the distance between the directrix and the focus as 5 units. Case 2 gave the distance between an ellipse's two foci, F_1 and F_2, as 12 units and the sum of the distances from a point, P, on the ellipse to two fixed points, F_1 and F_2, as 14 units. Students were asked to clearly describe the steps they would take to sketch the ellipse for either Case 1 or Case 2. Examples of flaws in students' solutions included not clearly communicating the location of the foci and/or directrix, not describing clearly how to locate more than one point on the ellipse, and not explaining that the points had to be joined to form an ellipse.

Of the students who met the acceptable standard of achievement on the examination, 76% received at least 3 out of 5 marks, and of students who achieved the standard of excellence on the examination, 83% scored 4 or more marks out of 5.

On this 5-mark question, the average mark was 3.2 or 64%.

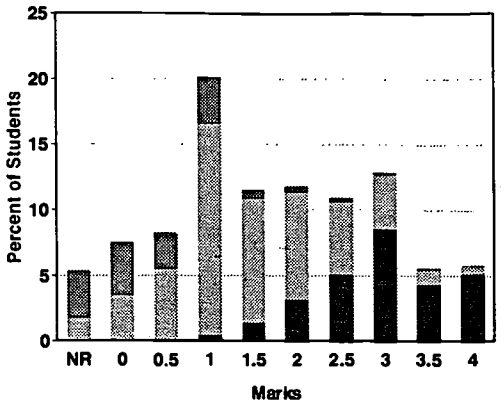
Distribution of Marks for Question 2



Question 2 provided students with a function $f(n) = 2^n$, $n \in N$, which represented the number of ways that you can place n distinguishable balls in two jars of different sizes. A diagram showed ways of placing a black ball and a white ball in two different sized jars. Students were asked to complete a chart so that it showed the relation between any number of distinguishable balls from 1 through 5 inclusive, and the number of ways the balls could be placed in two jars of different sizes. Students were asked to evaluate $\sum_{k=1}^{12} f(k)$ and, given an expression involving combinations that also represented the number of ways four balls of different colours could be put into two different jars, to explain the meaning of one of the terms from the expression $({}_4C_2 \times {}_2C_2)$ in the context of the problem. Finally, students were required to determine a function, g, that would represent the number of ways n distinguishable balls can be placed in two identical jars and justify their answer. Examples of common flaws in students' solutions included not understanding the summation notation, not explaining the meaning of $({}_4C_2 \times {}_2C_2)$ within the context of the problem, not writing the function, g, correctly, and using an explanation of a mathematical process rather than justifying their answer. Students achieving the acceptable standard were expected to score 3 or more marks out of 5, and students achieving the standard of excellence were expected to score 4 or more marks out of 5. Of the students who achieved the acceptable standard on the examination, 75% scored 3 or more marks out of 5, and of the students who achieved the standard of excellence, 77% scored 4 or more marks out of 5.

On this 5-mark question, the average mark was 2.8 or 56%.

Distribution of Marks for Question 1 - Scale 2



Below Standard on the Examination

Acceptable but not Standard of Excellence on the Examination

Standard of Excellence on the Examination

A site contains soil that is radioactive. The soil may be emitting one or more of alpha particles, beta particles, or gamma rays. As the physics expert for the clean-up crew, you have been provided with a sample of the soil for analysis. The sample is placed inside a specially designed container that permits radiation particles and rays to exit only in a straight-line path. Your laboratory contains all other necessary apparatus.

Written Response – 15%

1. Describe a procedure for determining which types of radiation are being emitted by the soil sample. Include:
   - a safety note to the rest of the clean-up crew describing the dangers associated with one of the three forms of radiation
   - a description of the method you would use to identify alpha particles, beta particles, and gamma rays
   - an explanation of how you would use your results to identify the types of radiation emitted by the soil

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

Students often demonstrated a confusion between electric and magnetic fields. For example, a diagram showed charged parallel plates, but the description and equations corresponded to a particle travelling through a magnetic field.

The communication component of student responses for this question was generally well done, but often lacked detail. A major weakness in responses was that students did not address the need for a detection system. Since the particles are not visible, a direct observation of the particles was not possible. The students had to identify a detector used to measure the particles that passed through the apparatus.

Many techniques for identifying the type of radiation were accepted. When using the spectrometer solution, many students did not demonstrate an understanding that a particle's radius of curvature through the magnetic field is affected by its mass, speed, and charge. Students often did not consider that when alpha, beta, and gamma particles are emitted by a nuclear decay, they move at different speeds, and pass through a magnetic field with different curve shapes.

Many students demonstrated an invalid use of a velocity selector. An invalid response showed both alpha and beta particles passing simultaneously through the selector without deflection. Since these particles differ in charge, mass, and speed, only one type of particle would pass through without deflection.

In **written-response question 2**, the majority of students were able to draw correct schematic diagrams for both the original circuit and the modified circuit. The diagrams were generally clear and correctly labelled. The most common error students made on the schematic diagrams was to add a non-resistive parallel branch that acted to short the circuit.

Most students correctly identified whether a bulb would be on or off in response to the movement of the switch. However, student descriptions of what happened to the 3.0 W and the 15.0 W bulbs when the switch was open and closed in the two-bulb circuit often lacked communication of the physics principles used to solve the problem. Most students did not provide an adequate discussion of the current travelling through the bulbs that is required to light them, nor did they show an adequate understanding of Kirchhoff's Laws to describe bulb brightness.

Question 2

5 The student
- completes the chart correctly **and**
- evaluates $\sum_{k=1}^{12} f(k)$ **and**
- explains the meaning of ${}_4C_2 \times {}_2C_2$ using the context of the problem **and**
- determines and justifies $g(n) = \frac{2^n}{2}$ or $g(n) = 2^{n-1}$

4 The student's solution demonstrates a good understanding of the problem by
- correctly completing 3 of the 4 bullets **or**
- completing bullets 1 and 2; however, there is a weak explanation of ${}_4C_2 \times {}_2C_2$ **and/or** a weak justification in bullet 4

3 The student demonstrates some understanding and finds partial solutions by
- completing the chart **and** one other bullet **or**
- completing the chart **and** making significant progress on at least 2 other bullets **or**
- explaining the meaning of ${}_4C_2 \times {}_2C_2$ within the context of the problem **and** demonstrating some understanding on another bullet **or**
- completing the 4th bullet **and** showing some understanding on another bullet

2 The student explores initial stages and applies some relevant mathematical knowledge by
- completing the chart correctly **and** demonstrating some understanding on another bullet **or**
- correctly completing one of bullets 2, 3, or 4

1 The student explores the initial stages of the problem.

Question 3

5 The student
- determines an expression for t_n and the value of t_{10} **and**
- determines correct values for c and d **and**
- completes a logical argument to show that $\log(a), \log(ar), \ldots \log(ar^{n-1})$ is arithmetic with a common difference of $\log r$

4 The student demonstrates a good understanding of the problem by
- determining t_{10}, t_n, c, and d **and** a start is made on the argument **or**
- completing the argument, using the general case, but only gets 3 of the 4 (t_{10}, t_n, c, and d)

3 The student demonstrates some understanding by
- determining 3 or 4 of t_{10}, t_n, c, and d **or**
- determining a correct value for 2 of the 4 (t_{10}, t_n, c, and d) and beginning the proof (may use specific values for the terms) **or**
- providing a logical argument to show $\log(a), \log(ar), \ldots \log(ar^{n-1})$ is arithmetic, stating $d = \log r$ (must be argued in general terms)

2 The student
- determines the value of t_{10} and an expression for t_n **or**
- determines the value of c and/or d **or**
- provides an incomplete argument for the fourth bullet

1 The student explores the initial stages of the problem

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

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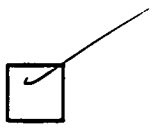

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