January 1997

Physics 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. You may take an additional 0.5 h to complete the examination.

Total possible marks: 70

This is a **closed-book** examination consisting of

- 37 multiple-choice and 12 numerical-response questions, of equal value, worth 70% of the examination
- 2 written-response questions, worth a total 30% of the examination

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

A tear-out data sheet is included near the back of this booklet. A Periodic Table of the Elements is also provided.

The blank 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.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- If you wish to change an answer, erase **all** traces of your first answer.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Read each question carefully.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response 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. biology
B. physics
C. chemistry
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 and leave any unused boxes blank.**

Examples

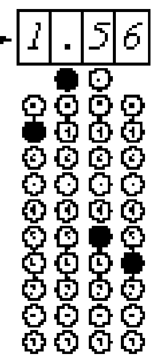
Calculation Question and Solution

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.
(Round and record your answer to three digits.)

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

$$a = \frac{121\ \text{N}}{77.7\ \text{kg}} = 1.5572716$$

Record 1.56 on the answer sheet



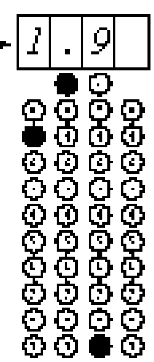
Calculation Question and Solution

A microwave of wavelength 16 cm has a frequency of $\boldsymbol{b} \times 10^{w}$ Hz.
The value of $\boldsymbol{b}$ is _________ .
(Round and record your answer to two digits.)

$$f = \frac{c}{\lambda}$$

$$f = \frac{3.00 \times 10^{8}\ \text{m/s}}{0.16\ \text{m}} = 1.875 \times 10^{9}$$

Record 1.9 on the answer sheet



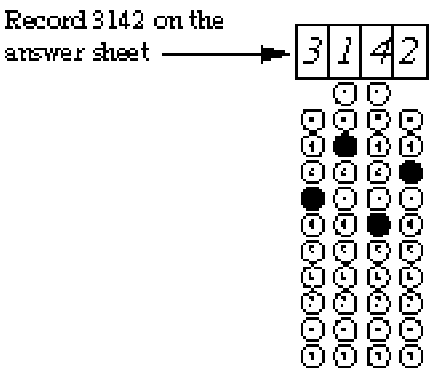
Correct-Order Question and Solution

Place the following types of EMR in order of increasing energy:

1 blue light
2 gamma radiation
3 radio waves
4 ultraviolet radiation

(Record your answer as ☐☐☐☐.)

Answer: 3142

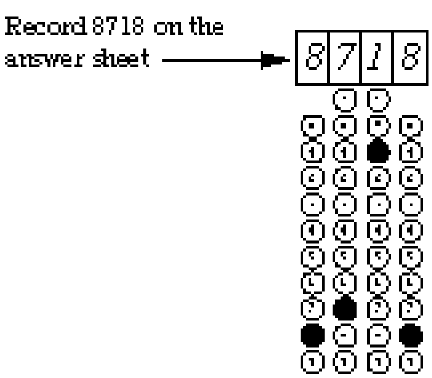


Scientific Notation Question and Solution

A hydrogen-like atom whose 3-2 transition emits light at 164 nm would have an E_1 value of $-\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$ J. The value of ***a***, ***b***, ***c***, and ***d***, are ______.

(Record your answer as $\boxed{a}\,\boxed{b}\,\boxed{c}\,\boxed{d}$.)

Answer: $E_1 = -8.7 \times 10^{-18}$ J



Written Response

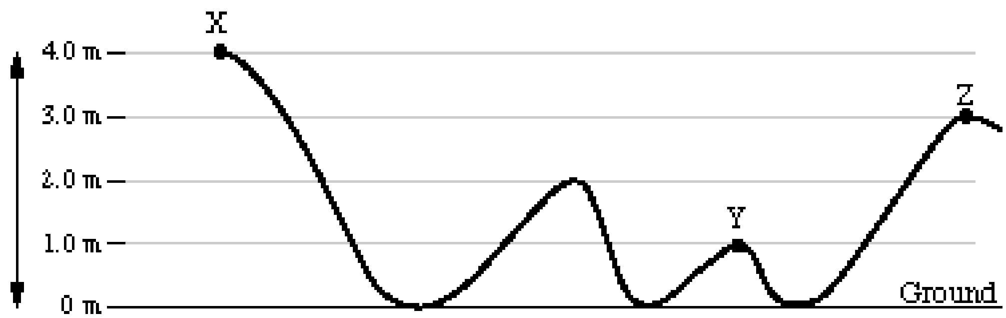
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must be well organized and address **all** the main points of the question.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and explicit.
- Descriptions and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

Numerical Response

1. A horizontal force of 207 N acts on a 7.80 kg bowling ball for 0.520 s.
The change in the ball's speed is __________ m/s.
(Round and record your answer to three digits.)

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

3. A single stationary railway car is bumped by a five-car train moving at 9.3 km/h. The six cars move off together after the collision. Assuming that the masses of all the railway cars are the same, then the speed of the new six-car train immediately after impact is

A. 7.8 km/h

B. 8.5 km/h

C. 9.3 km/h

D. 11 km/h

4. When the electron and the proton in a hydrogen atom are 5.3×10^{-11} m apart, the magnitude of the electrostatic force on the electron is

A. 4.3×10^{-20} N

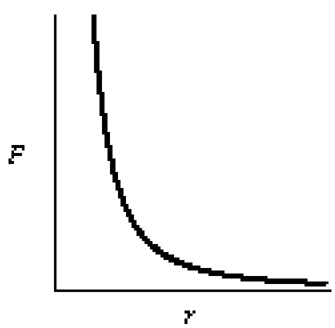
B. 4.3×10^{-18} N

C. 8.2×10^{-12} N

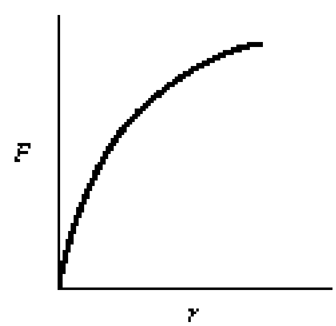
D. 8.2×10^{-8} N

5. Which graph **best** represents the magnitude of the electrostatic force, *F*, as a function of the distance, *r*, between two point charges?

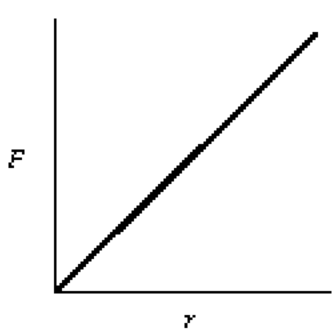
A.



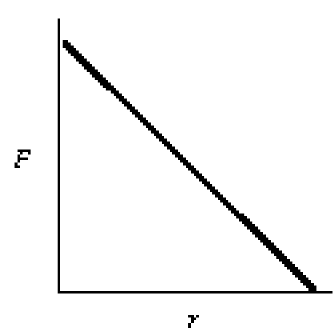
B.



C.

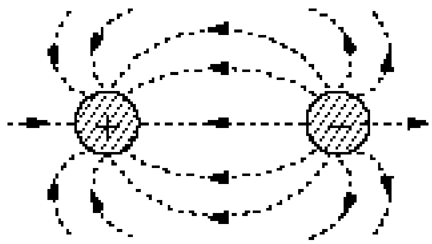


D.

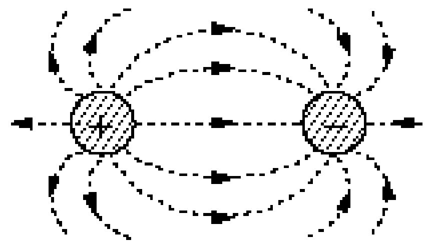


6. The field resulting from a positive point charge and a negative point charge is **best** represented by

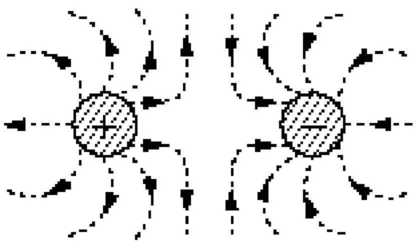
A.



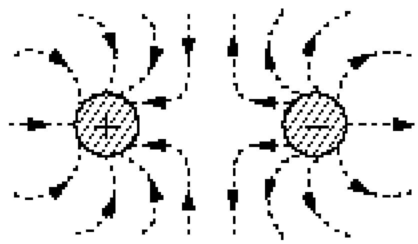
B.



C.



D.



Use the following information to answer the next question.

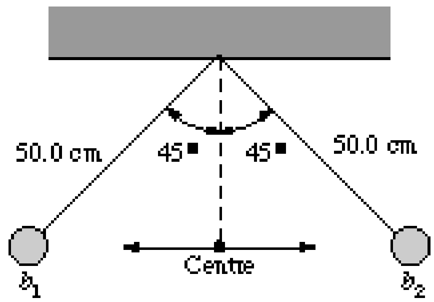
Two parallel metal plates are 1.5 cm apart and are maintained at a potential difference of 2.5×10^{2} V.

7. The magnitude of the electrical force on an alpha particle when the alpha particle is between the plates is

A. 5.3×10^{-15} N
B. 2.7×10^{-15} N
C. 5.3×10^{-17} N
D. 2.7×10^{-17} N

Use the following information to answer the next three questions.

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.

8. The electrostatic force between the charged balls can **best** be described as

A. an attraction due to dissimilar charges
B. a repulsion due to dissimilar charges
C. an attraction due to similar charges
D. a repulsion due to similar charges

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

10. If the charge on b_1 is tripled and the charge on b_2 is reduced to one-third of its original amount, the angles of deviation from centre would

A. increase for b_1 and decrease for b_2
B. remain the same for both b_1 and b_2
C. increase for both b_1 and b_2
D. decrease for both b_1 and b_2

Use the following information to answer the next three questions.

The headlight of a car operates with an input power of 75.0 W and draws a current of 6.25 A.

Numerical Response

2. The voltage supplied to the headlight is __________ V.
(Round and record your answer to three digits.)

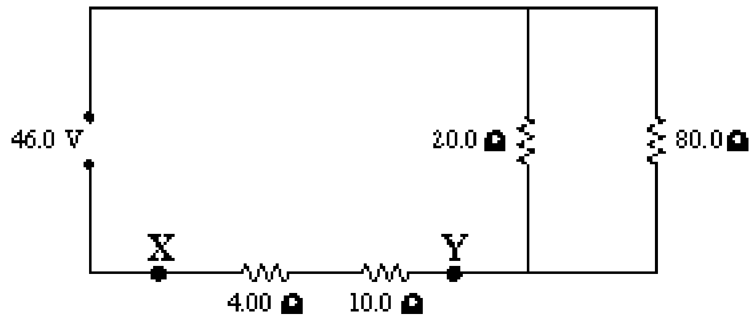
Numerical Response

3. The number of electrons passing through the headlight every minute, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{\boldsymbol{cd}}$ electrons. The values of ***a***, ***b***, ***c***, and ***d*** are ______.
(Record your answer as $\boxed{a}\boxed{b}\boxed{c}\boxed{d}$.)

Numerical Response

4. The energy used by the headlight during 1.00 h of operation, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ J. The value of ***b*** is __________ .
(Round and record your answer to three digits.)

Use the following information to answer the next three questions.



The potential difference between points X and Y is 21.5 V.

Numerical Response

5. The equivalent resistance for the circuit is __________ Ω.
(Round and record your answer to three digits.)

Numerical Response

Use your ***recorded*** *answer for* ***Numerical Response 5*** *to solve* ***Numerical Response 6****.*

6. The total current supplied by the 46.0 V power supply to the circuit is __________ A.
(Round and record your answer to three digits.)

11. The voltage drop across the 20.0 Ω resistor in the circuit is

- **A.** 30.6 V
- **B.** 24.5 V
- **C.** 16.0 V
- **D.** 1.53 V

Use the following information to answer the next three questions.

> Lightning storms are one of the most spectacular phenomena in nature and play a key role in maintaining the electrical balance of Earth. One lightning strike occurred over a potential difference of 200 MV and transferred 12 C of charge to the ground in 0.010 s.

12. The energy released by the lightning strike in this time interval was

A. 3.2×10^{-11} J
B. 2.4×10^{3} J
C. 2.4×10^{9} J
D. 2.4×10^{11} J

Numerical Response

Use your ***recorded*** *answer for* ***Multiple Choice 12*** *to solve* ***Numerical Response 7****.*

7. The power released in this lightning strike, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{\boldsymbol{cd}}$ W. The values of ***a***, ***b***, ***c***, and ***d*** are __________.
(Record your answer as $\boxed{a}\boxed{b}\boxed{c}\boxed{d}$.)

13. People inside a car are protected from the electric fields associated with lightning. Many parts of stereo components are contained in metal boxes. These two examples demonstrate that the electric field inside a closed metal container is

A. zero
B. opposite to the field outside
C. equal to the field outside
D. half the field outside

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14. Which of the following unit combinations is **not** equivalent to an ampere?

A. Watt/volt
B. Volt/ohm
C. Watt/ohm
D. Coulomb/second

15. Energy is used to move a charge of 3.00 C through a circuit with a resistance of $1.00 \times 10^2\ \Omega$ in 1.00 s. If the same amount of energy is used to throw a 1.00 kg ball vertically upward, the maximum height of the ball would be

A. 1.09×10^{-2} m
B. 3.27×10^{-2} m
C. 3.06×10^{1} m
D. 9.17×10^{1} m

16. To boil three cups of water each day for one year using an old model of microwave oven costs \$1.10. A new 750 W microwave oven boils one cup of water in 100 s. If the cost of energy is \$0.0100/MJ, how much money will a consumer **save** by using the new microwave oven to boil three cups of water each day for one year? Assume in each case that the water is at the same starting temperature.

A. \$0.28
B. \$0.82
C. \$1.38
D. \$2.80

Use the following information to answer the next question.

Unit Combinations

I.	J/C
II.	N/(A•m)
III.	T
IV.	(N•s)/(C•m)

17. Which unit combinations could be used correctly for a magnetic field?

A. I, III, and IV
B. II and III only
C. II and IV only
D. II, III, and IV

18. An electric field of strength 1.5×10^4 N/C is perpendicular to a magnetic field of strength 3.0×10^{-3} T. An electron moves perpendicular to both fields and is undeflected as it passes through the fields. The speed of the electron is

A. 2.0×10^{-7} m/s
B. 2.0×10^{-1} m/s
C. 5.0×10^{6} m/s
D. 5.0×10^{7} m/s

19. An ideal transformer steps down 25 000 V to 120 V for use in a house. Several appliances draw a total of 2 000 W from the 120 V side of the transformer. What is the current in the 25 000 V line?

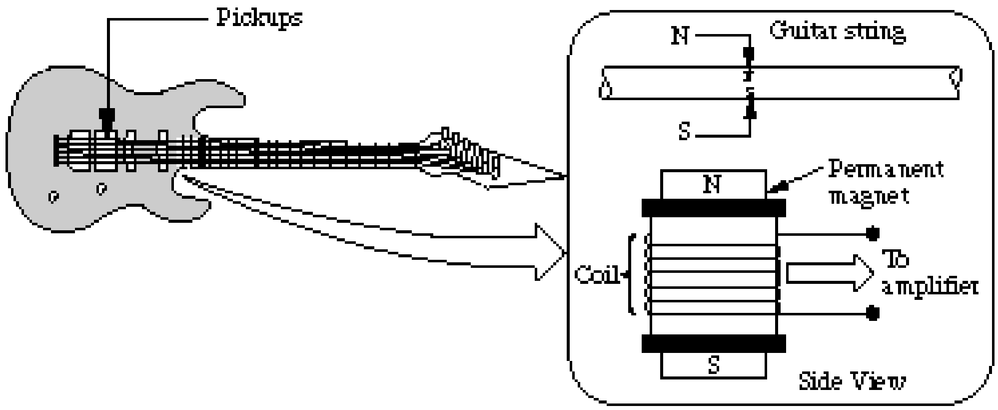
A. 6.00×10^{-2} A
B. 8.00×10^{-2} A
C. 12.5 A
D. 16.7 A

20. When two parallel conducting wires repel each other, the currents in the wires are

A. in opposite directions
B. in the same direction
C. oscillating in phase
D. oppositely charged

Use the following information to answer the next question.

Almost all electric guitars use devices called electromagnetic pickups. A guitar string is composed of metal that becomes magnetized by a permanent magnet found below the string. A coil of wire surrounds the permanent magnet.



21. When the string is plucked, a small current is produced in the coil of wire because

- **A.** a potential difference is produced in the string
- **B.** there is a current in the string that can be amplified
- **C.** there is a charge buildup on the string
- **D.** the string behaves as a magnet moving toward and away from the coil

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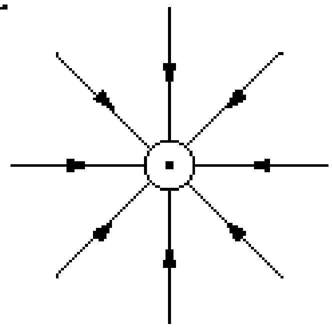
22. French high-speed trains operate using power lines that have an effective voltage of 25.0 kV and a frequency of 50.0 Hz. The maximum or peak voltage of the power lines is

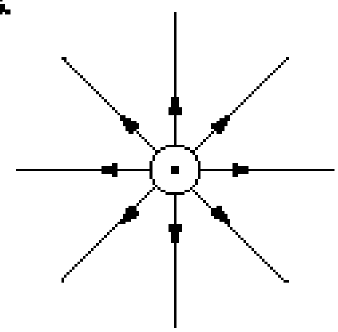
- **A.** 12.5 kV
- **B.** 17.7 kV
- **C.** 35.4 kV
- **D.** 50.0 kV

23. Which of the following diagrams **best** illustrates the magnetic field near a wire that carries an electron current out of the plane of the paper?

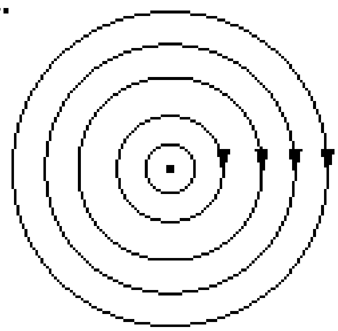
A.



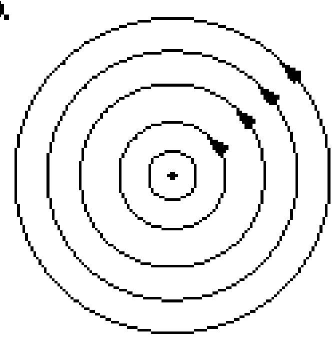
B.



C.



D.



Numerical Response

8. An electromagnetic wave has a frequency of 2.00×10^{24} Hz. The speed of the wave in a vacuum, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ m/s.
The value of ***b*** is __________.
(Round and record your answer to three digits.)

24. In a vacuum, the period of oscillation of a microwave with a wavelength of 2.5 cm is

A. 8.3×10^{-11} s
B. 8.3×10^{-9} s
C. 1.2×10^{8} s
D. 1.2×10^{10} s

Numerical Response

9. The minimum potential difference through which an electron must be accelerated to produce an X-ray of energy 1.62×10^4 eV, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ V. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

Numerical Response

10. A term used in aviation is **radar mile**, which is the time it takes a radar pulse to travel to a target 1.00 mile away and return (1.00 mile = 1.625 km). The radar mile, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ s. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

Use the following information to answer the next question.

> A technological application of quantum theory is the development of "electric eyes," which can be used in automatic door openers or burglar alarms. A light beam shines across a door opening and causes the production of a current in a circuit. When the beam is broken, the current stops and a mechanism is triggered to open a door or sound an alarm.

25. The operation of an electric eye is an application of

A. the Compton effect
B. the wave nature of matter
C. the photoelectric effect
D. Maxwell's electromagnetic wave theory

26. To determine the speed of charged particles in a cathode-ray tube, Thomson balanced the forces produced by

A. an electromagnetic field and a gravitational field

B. a magnetic field and a gravitational field

C. an electric field and a gravitational field

D. an electric field and a magnetic field

27. A student performs a photoelectric experiment in which a photoelectric current is observed for all colours of visible light. The student wants to investigate what effect varying the intensity and colour of the incident light has on the photoelectric current and kinetic energy of the photoelectrons. If the brightness of the light is decreased and the colour is changed from yellow to blue, the photoelectric

A. current and photoelectron energy both decrease

B. current and photoelectron energy both increase

C. current decreases and the photoelectron energy increases

D. current increases and the photoelectron energy decreases

28. When a blue laser beam is incident upon the surface of the metal of a photoelectric cell, there is no photoemission. A second beam of radiation causes photoelectrons to be emitted. The second beam may consist of

A. ultraviolet radiation

B. infrared radiation

C. red laser radiation

D. microwave radiation

29. A photon of energy 1.13 eV is emitted by a hydrogen atom when the electron "jumps" from

A. $n = 6$ to $n = 3$

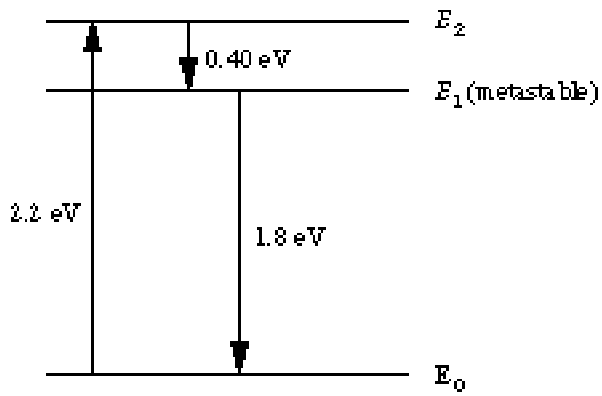
B. $n = 3$ to $n = 6$

C. $n = 5$ to $n = 2$

D. $n = 2$ to $n = 5$

Use the following information to answer the next two questions.

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.

30. What is the frequency of light emitted from the laser when the electron in the chromium atom goes from state E_1 to state E_0?

A. 9.7×10^{13} Hz
B. 4.3×10^{14} Hz
C. 5.3×10^{14} Hz
D. 1.1×10^{15} Hz

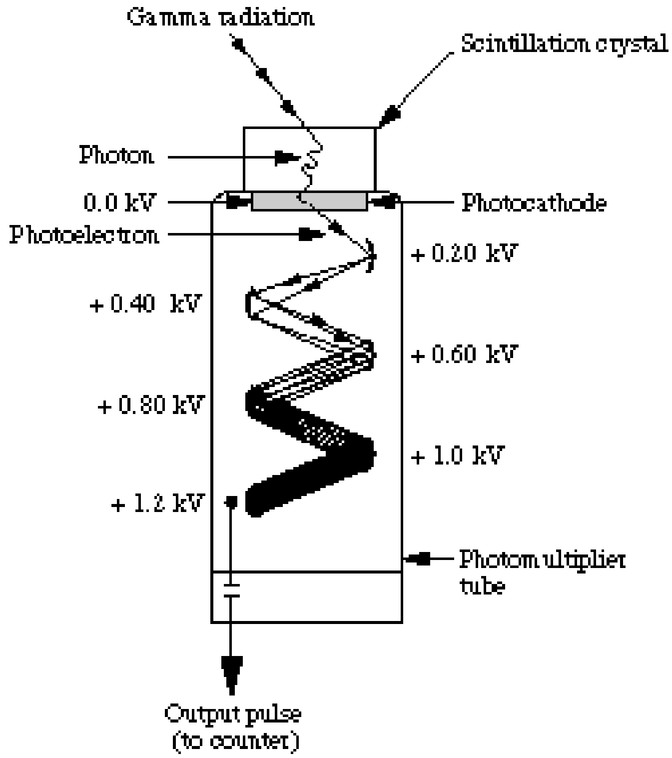
Numerical Response

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 $\boldsymbol{b} \times 10^{-w}$ m. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to two digits.)

Use the following information to answer the next three questions.

Photomultiplier Tube

When the scintillation crystal is struck by gamma radiation, it emits photons with a wavelength of 4.93×10^{-7} m. Some of these photons strike the photocathode. As a result, electrons are ejected from the bottom surface of the photocathode. The work function of the photocathode is 2.10 eV.



31. The maximum kinetic energy of the electrons ejected from the photocathode is

A. 6.7×10^{-20} J
B. 3.4×10^{-19} J
C. 4.0×10^{-19} J
D. 7.4×10^{-19} J

32. The electrons leaving the photocathode are attracted by the 0.20 kV electrode. The maximum speed they attain is

A. 8.6×10^{5} m/s
B. 8.4×10^{6} m/s
C. 7.0×10^{13} m/s
D. 2.1×10^{15} m/s

Use the following additional information to answer the next question.

Inner Workings of the Photomultiplier Tube

An electron striking the 0.20 kV electrode will use its energy to eject multiple secondary electrons from the electrode. The secondary electrons accelerate toward the next electrode, and the process continues along successive increases in voltage. The energy required to release a single electron is 40.0 eV.

33. Assume all of the kinetic energy of an electron striking the 0.20 kV electrode is used to eject secondary electrons. The number of electrons released from the 0.20 kV electrode is

- **A.** 5
- **B.** 10
- **C.** 100
- **D.** 200

Numerical Response

12. In the ground state of a hydrogen atom, the radius of the electron orbit is 5.3×10^{-11} m. According to the Bohr model, the radius of the electron orbit corresponding to the third energy level, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$ m. The values of ***a***, ***b***, ***c***, and ***d*** are ______.
(Round and record your answer as $\boxed{a}\,\boxed{b}\,\boxed{c}\,\boxed{d}$.)

34. The half-life of radium-226 is 1.6×10^{3} years. How long will it take for 20.0 mg of radium-226 to decay to 2.50 mg?

- **A.** 1.3×10^{3} years
- **B.** 1.6×10^{3} years
- **C.** 3.2×10^{3} years
- **D.** 4.8×10^{3} years

Use the following information to answer the next two questions.

> Recently H. J. Rose and G.A. Jones of Oxford University predicted that the decay of radium-223 would emit alpha particles (^{4}He) as well as a few double alphas (^{8}Be) and even triple alphas (^{12}C).
>
> The experiment was run for 600 days. The results of the experiment showed the detection of 2.2×10^{10} alpha particles, but the double and triple alphas were not detected. However, unexpectedly, nineteen carbon-14 nuclei were detected. This experiment has led scientists to continue to look for other examples of radioactive decay in which medium-sized nuclei such as carbon-14 are produced.

35. Which of the following initial products was observed in the greatest abundance?

A. Radon-219
B. Polonium-215
C. Lead-211
D. Lead-209

36. Which of the following products was **not** predicted by Rose and Jones?

A. Radon-219
B. Polonium-215
C. Lead-211
D. Lead-209

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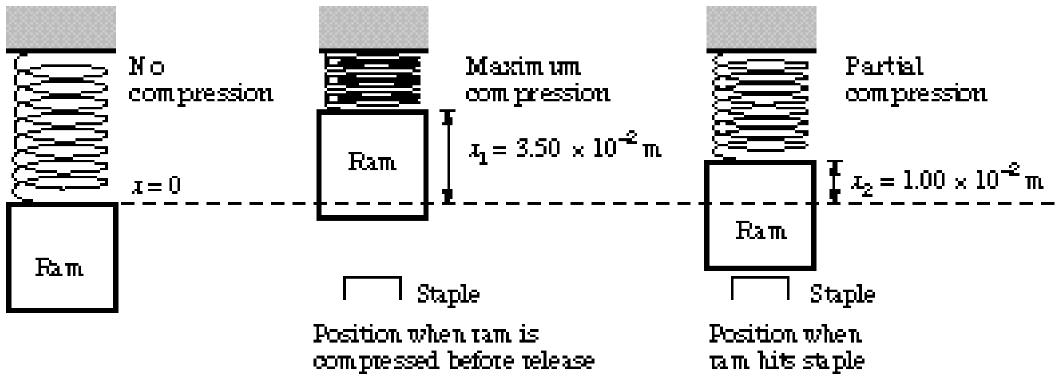
37. In a nuclear reaction, the mass of the products was determined to be considerably less than the mass of the reactants. A correct explanation of this is that

A. the reaction was a beta-decay
B. a large amount of energy was released in the reaction
C. the mass of the alpha and beta particles was not accounted for
D. a large amount of energy was required to cause the reaction to occur

Written Response — 11 marks

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

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.

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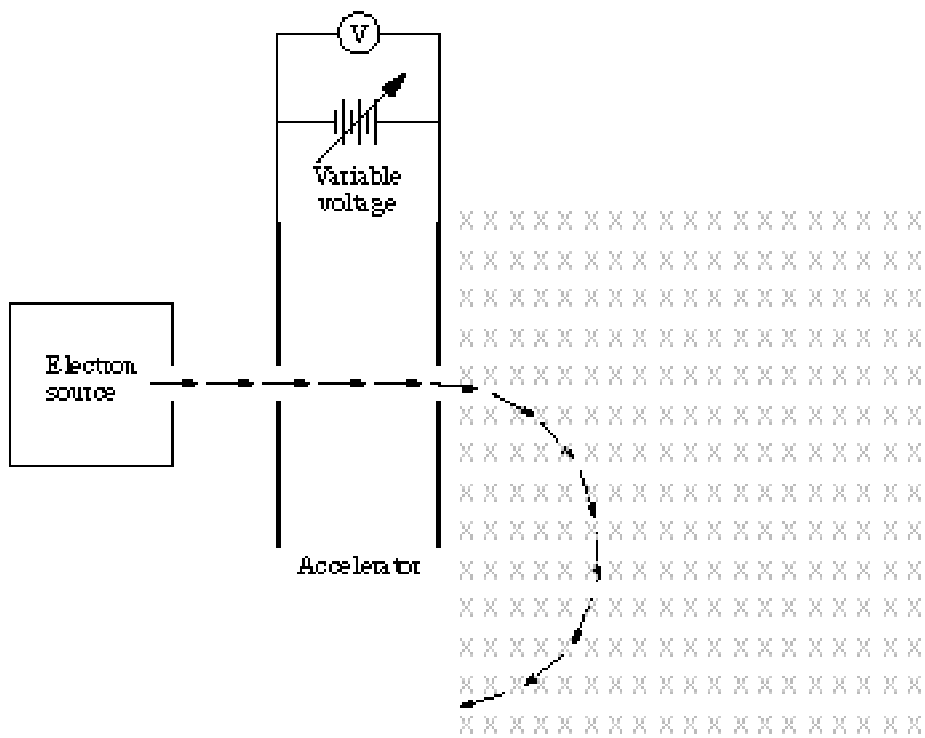
Written Response — 10 marks

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

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

Continued

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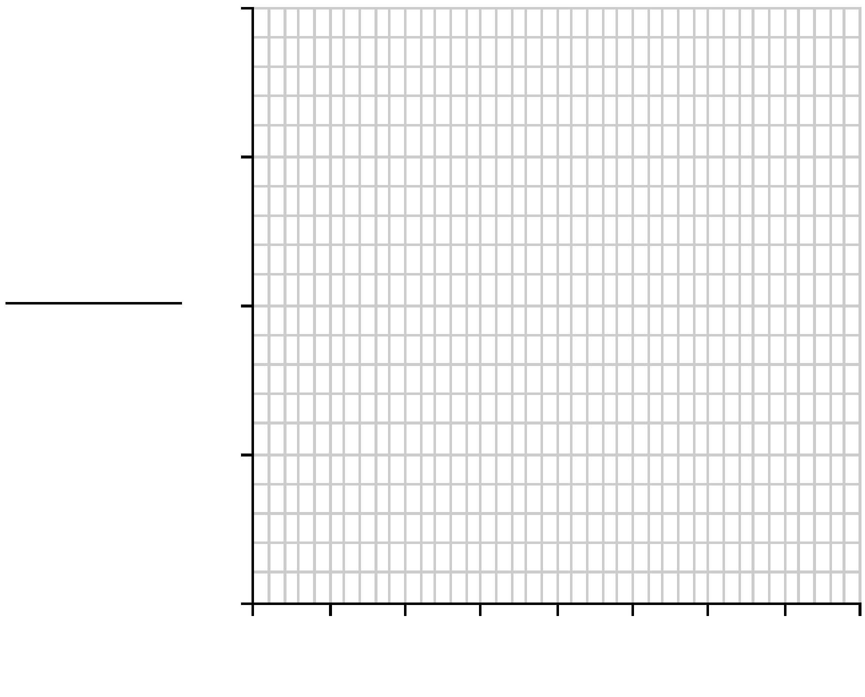
2. **a.** Plot the graph of radius as a function of speed, and construct a best-fit line.

(title)



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

For Department Use Only

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

You have now completed the examination.
If you have time, you may wish to check your answers.

Fold and tear along perforation.

PHYSICS DATA SHEETS

CONSTANTS

Gravity, Electricity, and Magnetism

Acceleration Due to Gravity **or** Gravitational Field Near Earth	a_g <u>or</u> $g = 9.81\ \text{m/s}^2$ <u>or</u> $9.81\ \text{N/kg}$
Gravitational Constant..............................	$G = 6.67 \times 10^{-11}\ \text{N•m}^2/\text{kg}^2$
Mass of Earth...	$M_e = 5.98 \times 10^{24}\ \text{kg}$
Radius of Earth...	$R_e = 6.37 \times 10^{6}\ \text{m}$
Coulomb’s Law Constant.........................	$k = 8.99 \times 10^{9}\ \text{N•m}^2/\text{C}^2$
Electron Volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$
Elementary Charge...................................	$e = 1.60 \times 10^{-19}\ \text{C}$
Index of Refraction of Air	$n = 1.00$
Speed of Light in Vacuum........................	$c = 3.00 \times 10^{8}\ \text{m/s}$

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen	$E_1 = -2.18 \times 10^{-18}\ \text{J}$ <u>or</u> $-13.6\ \text{eV}$
Planck’s Constant....................................	$h = 6.63 \times 10^{-34}\ \text{J•s}$
Radius of 1st Bohr Orbit of Hydrogen......	$r_1 = 5.29 \times 10^{-11}\ \text{m}$
Rydberg’s Constant for Hydrogen............	$R_H = 1.10 \times 10^{7}/\text{m}$

Particles

	Rest Mass	**Charge**
Alpha Particle...............	$m_\alpha = 6.65 \times 10^{-27}\ \text{kg}$	α^{2+}
Electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	e^-
Neutron.........................	$m_n = 1.67 \times 10^{-27}\ \text{kg}$	n^0
Proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	p^+

Trigonometry and Vectors

$$\sin\theta = \frac{\textit{opposite}}{\textit{hypotenuse}}$$

$$\cos\theta = \frac{\textit{adjacent}}{\textit{hypotenuse}}$$

$$\tan\theta = \frac{\textit{opposite}}{\textit{adjacent}}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

For any Vector $\vec{R}$

$$R = \sqrt{R_x{}^2 + R_y{}^2}$$

$$\tan\theta = \frac{R_y}{R_x}$$

$$R_x = R\cos\theta$$

$$R_y = R\sin\theta$$

Prefixes Used With SI Units

Prefix	**Symbol**	**Exponential Value**	**Prefix**	**Symbol**	**Exponential Value**
pico.............	p..................	10^{-12}	tera..............	T.................	10^{12}
nano	n..................	10^{-9}	giga.............	G.................	10^{9}
micro...........	μ	10^{-6}	mega...........	M................	10^{6}
milli	m.................	10^{-3}	kilo.............	k	10^{3}
centi	c..................	10^{-2}	hecto...........	h	10^{2}
deci	d..................	10^{-1}	deka............	da................	10^{1}

Tear-out Page

EQUATIONS

Kinematics

$\vec{v}_{\mathrm{ave}} = \frac{\vec{d}}{t}$

$\vec{d} = \vec{v}_{\mathrm{f}} t - \frac{1}{2}\vec{a}t^2$

$\vec{a} = \frac{\vec{v}_{\mathrm{f}} - \vec{v}_{\mathrm{i}}}{t}$

$\vec{d} = \left(\frac{\vec{v}_{\mathrm{f}} + \vec{v}_{\mathrm{i}}}{2}\right)t$

$\vec{d} = \vec{v}_{\mathrm{i}} t + \frac{1}{2}\vec{a}t^2$

$v_{\mathrm{f}}^2 = v_{\mathrm{i}}^2 + 2ad$

Dynamics

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

$F_{\mathrm{g}} = \frac{Gm_1m_2}{r^2}$

$\vec{F}\Delta t = m\Delta\vec{v}$

$g = \frac{Gm_1}{r^2}$

$\vec{F}_{\mathrm{g}} = m\vec{g}$

$F_{\mathrm{c}} = \frac{mv^2}{r}$

$F_{\mathrm{f}} = \mu F_{\mathrm{N}}$

$F_{\mathrm{c}} = \frac{4\pi^2 mr}{T^2}$

$\vec{F}_{\mathrm{s}} = -k\vec{x}$

Momentum and Energy

$\vec{p} = m\vec{v}$

$E_{\mathrm{k}} = \frac{1}{2}mv^2$

$W = Fd$

$W = \Delta E = Fd\cos\theta$

$E_{\mathrm{p}} = mgh$

$P = \frac{W}{t} = \frac{\Delta E}{t}$

$E_{\mathrm{p}} = \frac{1}{2}kx^2$

Waves and Light

$T = 2\pi\sqrt{\frac{m}{k}}$

$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$

$T = 2\pi\sqrt{\frac{l}{g}}$

$\lambda = \frac{xd}{nl}$

$T = \frac{1}{f}$

$\lambda = \frac{d\sin\theta}{n}$

$v = f\lambda$

$m = \frac{h_{\mathrm{i}}}{h_0} = \frac{-d_{\mathrm{i}}}{d_0}$

$\frac{\lambda_1}{2} = l;\quad \frac{\lambda_1}{4} = l$

$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_{\mathrm{i}}}$

Atomic Physics

$hf = E_{\mathrm{k}_{\mathrm{max}}} + W$

$\frac{1}{\lambda} = R_{\mathrm{H}}\left(\frac{1}{n_{\mathrm{f}}^2} - \frac{1}{n_{\mathrm{i}}^2}\right)$

$W = hf_0$

$E_{\mathrm{n}} = \frac{1}{n^2}E_1$

$E_{\mathrm{k}_{\mathrm{max}}} = qV_{\mathrm{stop}}$

$r_{\mathrm{n}} = n^2 r_1$

$E = hf = \frac{hc}{\lambda}$

$N = N_0\left(\frac{1}{2}\right)^n$

Quantum Mechanics and Nuclear Physics

$E = mc^2$

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

$p = \frac{hf}{c};\quad E = pc$

Electricity and Magnetism

$F_{\mathrm{e}} = \frac{kq_1q_2}{r^2}$

$V = IR$

$|\vec{E}| = \frac{kq_1}{r^2}$

$P = IV$

$\vec{E} = \frac{\vec{F}_{\mathrm{e}}}{q}$

$I = \frac{q}{t}$

$|\vec{E}| = \frac{V}{d}$

$F_{\mathrm{m}} = IlB$

$V = \frac{\Delta E}{q}$

$F_{\mathrm{m}} = qvB$

$R = R_1 + R_2 + R_3$

$V = lvB$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{N_{\mathrm{p}}}{N_{\mathrm{s}}} = \frac{V_{\mathrm{p}}}{V_{\mathrm{s}}} = \frac{I_{\mathrm{s}}}{I_{\mathrm{p}}}$

$I_{\mathrm{eff}} = 0.707\, I_{\mathrm{max}}$

$V_{\mathrm{eff}} = 0.707\, V_{\mathrm{max}}$

Fold and tear along perforation.

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IA	IIA	IIIB	IVB	VB	VIB	VIIB		VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA or 0
1 H 1.01 hydrogen																	2 He 4.00 helium
3 Li 6.94 lithium	4 Be 9.01 beryllium											5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen	9 F 19.00 fluorine	10 Ne 20.17 neon
11 Na 22.99 sodium	12 Mg 24.31 magnesium											13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.06 sulphur	17 Cl 35.45 chlorine	18 Ar 39.95 argon
19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.90 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.71 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.72 gallium	32 Ge 72.59 germanium	33 As 74.92 arsenic	34 Se 78.96 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton
37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.94 molybdenum	43 Tc (98.91) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.40 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.69 tin	51 Sb 121.75 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.30 xenon
55 Cs 132.91 cesium	56 Ba 137.33 barium	57-71	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.85 tungsten	75 Re 186.21 rhenium	76 Os 190.20 osmium	77 Ir 192.22 iridium	78 Pt 195.09 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.37 thallium	82 Pb 207.19 lead	83 Bi 208.98 bismuth	84 Po (208.98) polonium	85 At (209.98) astatine	86 Rn (222.02) radon
87 Fr (223.02) francium	88 Ra (226.03) radium	89-103	104 Unq (261.11) unnilquadium	105 Unp (262.11) unnilpentium	106 Unh (263.12) unnilhexium	107 Uns (262.12) unnilseptium	108 Uno (265) unniloctium	109 Une (266) unnilennium									

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (144.91) promethium	62 Sm 150.35 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.04 ytterbium	71 Lu 174.97 lutetium
89 Ac (227.03) actinium	90 Th (232.04) thorium	91 Pa (231.04) protactinium	92 U 238.03 uranium	93 Np (237.05) neptunium	94 Pu (244.06) plutonium	95 Am (243.06) americium	96 Cm (247.07) curium	97 Bk (247.07) berkelium	98 Cf (242.06) californium	99 Es (252.08) einsteinium	100 Fm (257.10) fermium	101 Md (258.10) mendelevium	102 No (259.10) nobelium	103 Lr (260.11) lawrencium

Key

Atomic number →	3 Li	← Symbol
Atomic mass →	6.94	
Name →	lithium	

[illegible]

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PHYSICS 30

DIPLOMA EXAMINATION

JANUARY 1997

Multiple Choice
and
Numerical Response
Key

Draft
Written Response
Scoring Guide

MULTIPLE-CHOICE KEY

1.	A	**20.**	A
2.	D	**21.**	D
3.	A	**22.**	C
4.	D	**23.**	C
5.	A	**24.**	A
6.	B	**25.**	C
7.	A	**26.**	D
8.	D	**27.**	C
9.	C	**28.**	A
10.	B	**29.**	A
11.	B	**30.**	B
12.	C	**31.**	A
13.	A	**32.**	B
14.	C	**33.**	A
15.	D	**34.**	D
16.	A	**35.**	A
17.	D	**36.**	D
18.	C	**37.**	B
19.	B		

NUMERICAL-RESPONSE KEY

1.	13.8
2.	12.0
3.	2321
4.	2.70, 2.7
5.	30.0
6.	1.53
7.	2411
8.	3.00
9.	1.62
10.	1.08
11.	5.6, 5.7
12.	4810

Holistic Scoring Guide

Reporting Category: Physics COMMUNICATION

When marking **COMMUNICATION**, the marker should consider how effectively the response **describes in detail the method, procedure, or strategy used to provide a solution to the problem.**	
Score	**Criteria**
3	The response: • is complete, well organized and clear • demonstrates in detail a strategy in a logical manner • demonstrates consistency of thought • uses physics vocabulary appropriately and precisely • demonstrates an explicit relationship between the explanation and diagrams (if used) • explicitly states formula(s) • may have a mathematical error present, but it does not hinder the understanding of either the strategy or the solution
2	The response: • is organized, however, errors sometimes affect the clarity • demonstrates a strategy but details are general and/or sometimes lacking • demonstrates consistency of thought most of the time, however, some gaps in logic leave it somewhat open to interpretation • uses physics vocabulary, however, it may not be precise • demonstrates an implicit relationship between explanation and diagrams (if used) • uses formula(s) that are likely inferred by analyzing the calculations • likely has mathematical errors present that may hinder the understanding of either the strategy or the solution
1	The response: • lacks organization and errors affect the clarity • attempts to demonstrate a strategy but provides little or no detail • demonstrates a lack of consistency of thought and it is difficult to interpret • uses physics vocabulary, however, it is often misused • demonstrates a weak relationship between the explanation and diagrams (if used) • may not state formula(s), however, it is possible that they can be deciphered by analyzing the calculations • has mathematical errors that hinder the understanding of the strategy and/or the solution
0	The response: • has very little written and/or contains very little relevant information • is not organized, and is confusing and/or frustrating to the reader • does not demonstrate a strategy to solve the problem • uses little or no physics vocabulary, however, if present, it is misused • demonstrates no relationship between the explanation, if present, and diagrams (if used) • may state formula but it does not contribute towards the solution
NR	No response given.

Holistic Scoring Guide

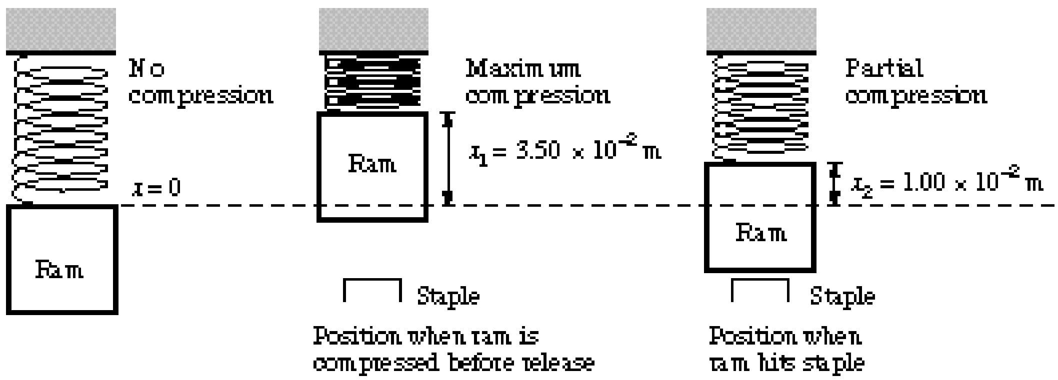
Reporting Category: Physics CONTENT

When marking **CONTENT**, the marker should consider how effectively the response **uses physics concepts, knowledge, and skills to provide a solution to the problem**.	
Score	**Criteria**
4	The response: • uses an appropriate method that reflects a **thorough understanding** of the Conservation of Energy and **describes** the energy transformations involved in the operation of a spring ram stapler • provides a complete description of the method used **and** shows how to solve the problem • correctly uses formula, and although minor errors in substitution and/or calculation may be present they do not hinder the understanding of the physics content • has, if used, diagrams and/or sketches that are appropriate, correct, and complete • has no major omissions or inconsistencies
3	The response: • uses an appropriate method that reflects a **good understanding** of the Conservation of Energy and **describes** energy transformations involved in the operation of a spring ram stapler • provides a description of the method used **and** shows how to solve the problem • correctly uses formula, however, errors in substitution and/or calculation may hinder the understanding of the physics content • has, if used, diagrams and/or sketches that are appropriate, although some aspect may be incorrect or incomplete • may have several minor inconsistencies or perhaps one major inconsistency, however, there is little doubt that the understanding of physics content is good
2	The response: • uses a method that reflects a **basic understanding** of the energy transformations involved in the operation of a spring ram stapler • provides either a description of the method used **or** shows how to solve the problem • uses formula, however, errors and inconsistencies in substitution and/or calculation hinder the understanding of the physics content presented • has, if used, diagrams and/or sketches that may be appropriate, although some aspect is incorrect or incomplete • has inconsistencies or a major omission
1	The response: • uses a method that reflects a **poor understanding** of the energy transformations involved in the operation of a spring ram stapler • provides a description of the method used, or a solution, that is incomplete • may use formula, however, the application is incorrect or inappropriate • has, if present, diagrams and/or sketches that are inappropriate, incorrect, and/or incomplete • has minor and major inconsistencies and/or omissions
0	The response: • uses a method that reflects little or no understanding of the energy transformations involved in the operation of a spring ram stapler • may have formula and substitution but they do not address energy transformations • has, if present, diagrams and/or sketches that are incorrect, inappropriate, and incomplete • has major omissions
NR	No response is given.

Written Response — 11 marks

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

A Spring Ram Stapler



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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 — 10 marks

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

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
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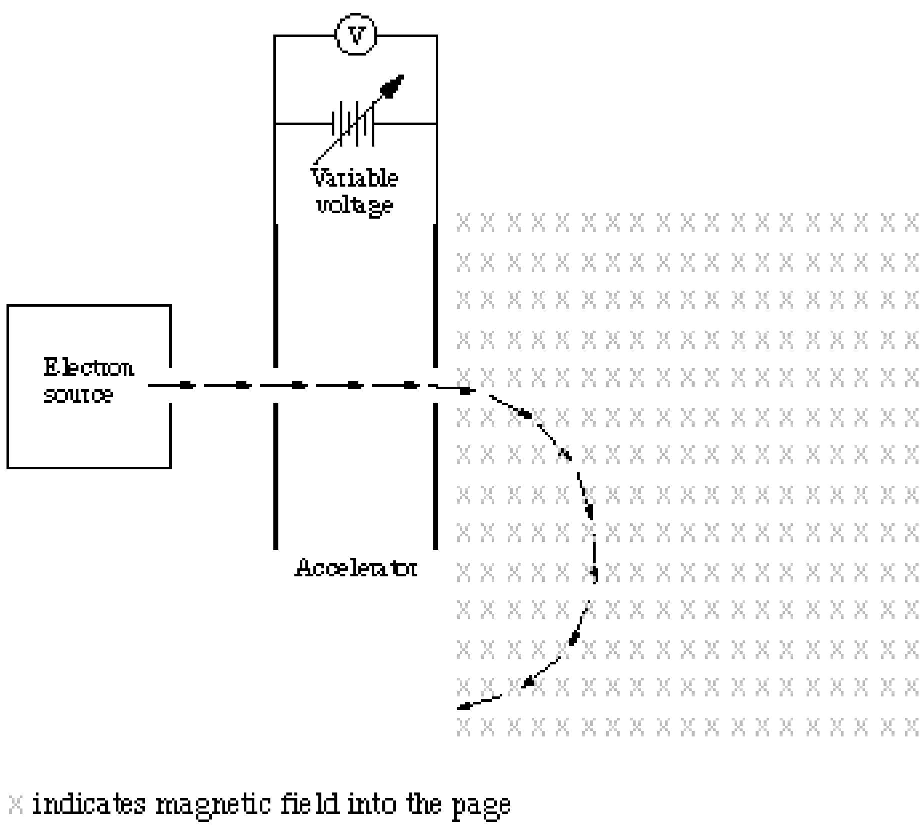
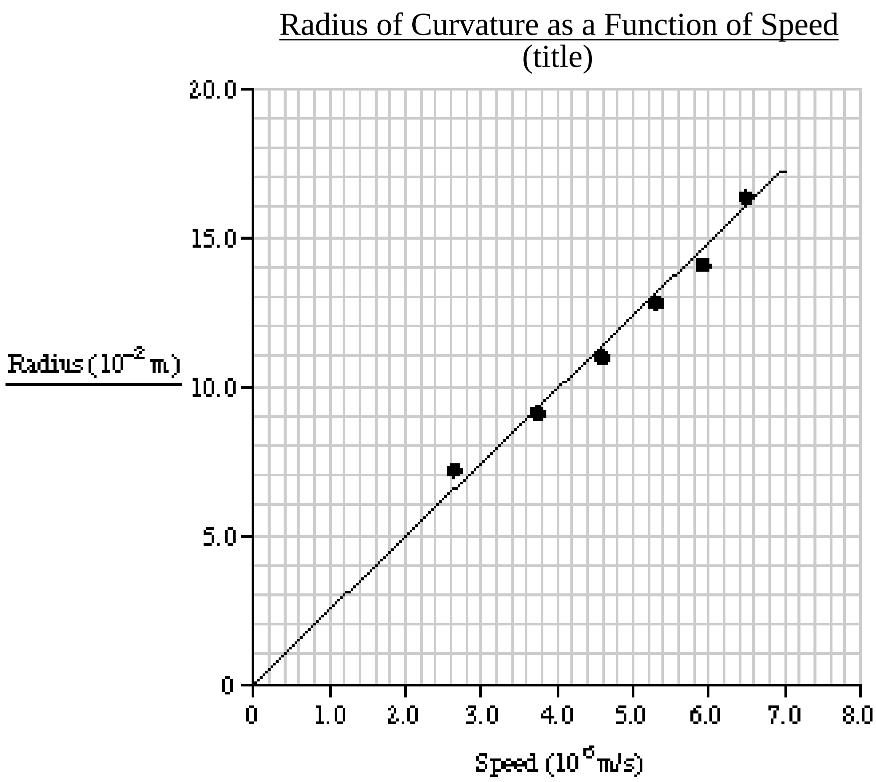


Continued

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



There are six checks for this part:

1. appropriate title consistent with graph (exception special case)
2. x-axis is speed and y-axis is radius
3. labelling axes appropriately
4. scaling axes correctly
5. plotting points accurately
6. drawing the best fit line

Special cases: graphing voltage as a function of speed **or** voltage vs radius, **etc.** award a maximum of three checks, 4 ,5, and 6

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

Method 1:

$$\text{slope} = \frac{\text{rise}}{\text{run}}$$

$$= (17.2 - 5.0)10^{-2}\ \text{m}/(7.0 - 2.0)10^{6}\ \text{m/s})$$

$$\text{slope} = 2.44 \times 10^{-8}\ \text{s}$$

$$F_{\text{c}} = F_{\text{m}}$$

$$\frac{mv^2}{R} = qvB$$

$$v = \frac{qBR}{m}$$

$$\text{slope} = \frac{R}{v} = \frac{m}{qB}$$

$$B = \frac{m}{(q)(\text{slope})}$$

$$= \frac{9.11 \times 10^{-31}\ \text{kg}}{(1.60 \times 10^{-19}\ \text{C})(2.44 \times 10^{-8}\ \text{s})}$$

$$B = 2.32 \times 10^{-4}\ \text{T}$$

$$B = 2.3 \times 10^{-4}\ \text{T}$$

There are <u>six</u> checks for this part:

7. explicitly stating slope = rise/run or equivalent
8. substitution of points on the line into a valid equation
9. calculating slope = 2.4×10^{-8} s or consistent with graph or substitution
10. using $F_{\text{c}} = F_{\text{m}}$ or equivalent
11. using $B = \dfrac{m}{(q)(\text{slope})}$ or consistent with graph
12. an answer $B = 2.3 \times 10^{-4}$ T or consistent with substitution into a valid equation

Method 2:

$$F_m = F_c$$

$$qvB = \frac{mv^2}{R}$$

$$B = \frac{mv}{qR}$$

$$B_1 = \frac{(9.11 \times 10^{-31}\ \text{kg})(2.65 \times 10^{6}\ \text{m/s})}{(1.60 \times 10^{-19}\ \text{C})(7.2 \times 10^{-2}\ \text{m})}$$

$$B_1 = 2.096 \times 10^{-4}\ \text{T}$$

$$B_2 = 2.346 \times 10^{-4}\ \text{T}$$

$$B_3 = 2.376 \times 10^{-4}\ \text{T}$$

$$B_4 = 2.358 \times 10^{-4}\ \text{T}$$

$$B_5 = 2.395 \times 10^{-4}\ \text{T}$$

$$B_6 = 2.267 \times 10^{-4}\ \text{T}$$

$$B_{ave} = 2.306 \times 10^{-4}\ \text{T} = 2.3 \times 10^{-4}\ \text{T}$$

There are six checks for this part:

7. explicitly stating $F_m = F_c$ or equivalent
8. using $B = \frac{mv}{qR}$ or equivalent
9. correct substitution of values into a valid equation
10. calculating the six values of the magnetic field
11. explicitly using an average
12. an answer $B = 2.3 \times 10^{-4}$ T or consistent with substitution into a valid equation

Note: averaging radius and speed results in the loss of checks 9 and 10

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

$$E_{\mathrm{i}} = E_{\mathrm{f}}$$
$$qV = \frac{1}{2}mv^2$$
$$v = \sqrt{2qV/m}$$

There are <u>four</u> checks for this part:

13. stating $E = qV$ **or** $E = \frac{1}{2}mv^2$
14. using $E = \frac{1}{2}mv^2$ **and** $E = qV$
15. equating $qV = \frac{1}{2}mv^2$
16. an answer $v = \sqrt{2qV/m}$ or $v = 2\ V/(B\ r)$ or equivalent

Checks	Marks
15 or 16	10
14	9
12 or 13	8
11	7
9 or 10	6
8	5
6 or 7	4
5	3
3 or 4	2
1 or 2	1
0	0