June 1997

Physics 30

Grade 12 Diploma Examination

Alberta EDUCATION

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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

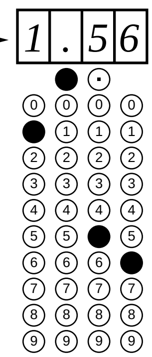
Calculation Question and Solution

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 ⟶



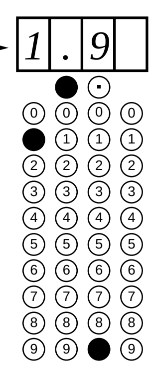
Calculation Question and Solution

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

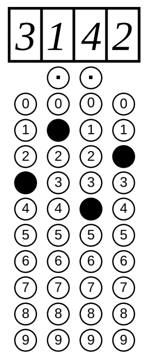
Place the following types of EMR in order of increasing energy:

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

(Record your answer as ☐☐☐☐.)

Answer: 3142

Record 3142 on the answer sheet ⟶



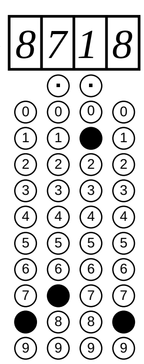
Scientific Notation Question and Solution

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 ***a*** ***b*** ***c*** ***d***.)

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

Record 8718 on the answer sheet ⟶



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.

1. The physical quantity that can have the same unit as impulse is

A. force
B. work
C. power
D. momentum

Use the following information to answer the next two questions.

A 5.00 kg object is dropped from a height above the ground. When the object is 4.00 m from the ground, it has a speed of 9.00 m/s. The potential energy of the object is chosen to be zero at ground level and the effects of air resistance are ignored.

2. What is the total mechanical energy of the falling object?

A. 6.30 J
B. 196 J
C. 202 J
D. 399 J

Numerical Response

*Use your recorded answer for **Multiple Choice 2** to solve **Numerical Response 1**.*

1. The object was dropped from an initial height of __________ m above the ground.
(Round and record your answer to three digits.)

3. A space shuttle astronaut has a mass of 110 kg with her space suit on. She is on a space walk and picks up a full can of spray with a mass of 20 kg. Relative to the space shuttle, she is at rest. She then holds the can directly in front of her centre of mass to avoid rotation and releases 3.0 kg of spray at a speed of 15 m/s. Her speed, relative to the space shuttle, when she has stopped spraying is approximately

A. 0.35 m/s
B. 0.41 m/s
C. 2.3 m/s
D. 2.5 m/s

Use the following information to answer the next question.

A popular game of young children is to shuffle across a carpet with stocking feet and then touch a friend. The spark that can be generated is caused by a charge buildup from the friction of the socks on the carpet.

4. Two friends, Sam and Jeff, shuffled on a carpet and obtained approximately the same negative charge. They then stood shoulder to shoulder without touching. A third friend, Cale, who was not charged, touched Jeff on the shoulder farthest from Sam. What is the nature of the final charges on the three boys?

A. Sam, Jeff, and Cale are all negatively charged.
B. Jeff and Cale are uncharged, and Sam is negatively charged.
C. Sam and Cale are negatively charged, and Jeff is positively charged.
D. Sam is negatively charged, and Jeff and Cale are positively charged.

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5. Three pithballs hang in an isolated container. Ball **X** has a charge of 1.0×10^{-9} C, and balls **Y** and **Z** are neutral. Ball **X** is brought momentarily into contact with ball **Y**, then separated. Ball **Y** is then brought momentarily into contact with ball **Z**, then separated. When placed 1.0 m apart, balls **X** and **Z** will now exert a force on each other of magnitude

A. 1.0×10^{-9} N
B. 1.1×10^{-9} N
C. 2.2×10^{-9} N
D. 9.0×10^{-9} N

Numerical Response

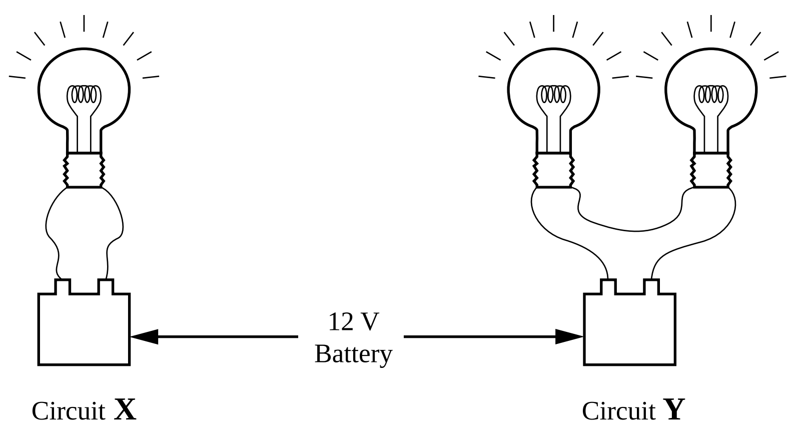
2. Two charged bodies exert electrostatic forces on each other of magnitude 1.11×10^{-4} N. If the magnitude of each charge is doubled and the distance separating them is doubled, then the magnitude of the electrostatic force, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ N. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

Numerical Response

3. In moving an electric charge of 4.00 C from point X to point Y, 15.0 J of work is done. The potential difference between X and Y, in volts, is __________ V.
(Round and record your answer to three digits.)

Use the following information to answer the next question.

Light Bulbs



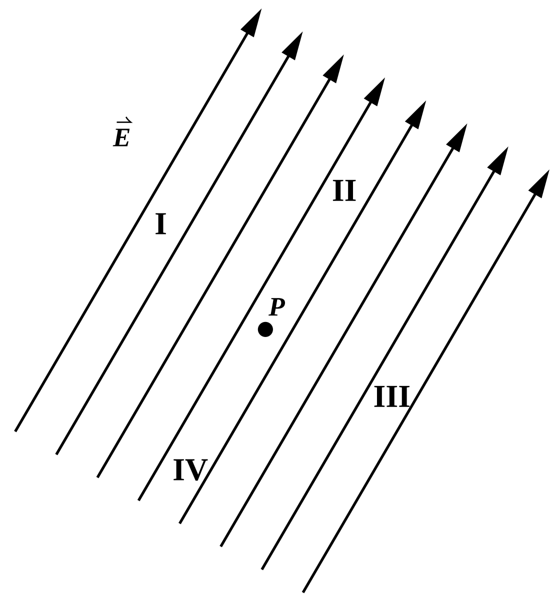
The bulbs have identical resistances, and the batteries are identical.

6. Which of the following statements best describes the diagram above?

A. Circuit Y dissipates more power than does circuit X.
B. The current in circuit Y is larger than the current in circuit X.
C. The current in circuit Y is the same as the current in circuit X.
D. The current in circuit Y is smaller than the current in circuit X.

Use the following information to answer the next question.

Electric Field



The parallel arrows represent the direction of an electric field.

7. An electron is placed at point *P*. It will accelerate toward region

A. I
B. II
C. III
D. IV

---

8. The volt is the SI unit of potential difference. An equivalent SI unit may be written as

A. J/A
B. J/C
C. N/C
D. A/Ω

9. Which of the following is a definition of **conventional** direct current?

A. A movement of negative charge in one direction only
B. A movement of positive charge in one direction only
C. A shift of negative charge that reaches a peak in the forward direction before reversing and reaching a peak in the reverse direction
D. A shift of positive charge that reaches a peak in the forward direction before reversing and reaching a peak in the reverse direction

Use the following information to answer the next two questions.

Torpedo occidentalis is a large electric fish that uses electricity in attack and defense. A typical individual fish is capable of producing potential differences of up to 220 V and of generating pulses of 15.0 A current through its seawater environment. Pulses are typically 2.00×10^{-3} s in duration.

10. The total charge transferred by the fish in one of these pulses is

A. 3.00×10^{-2} C
B. 4.40×10^{-1} C
C. 3.00×10^{3} C
D. 3.30×10^{3} C

Numerical Response

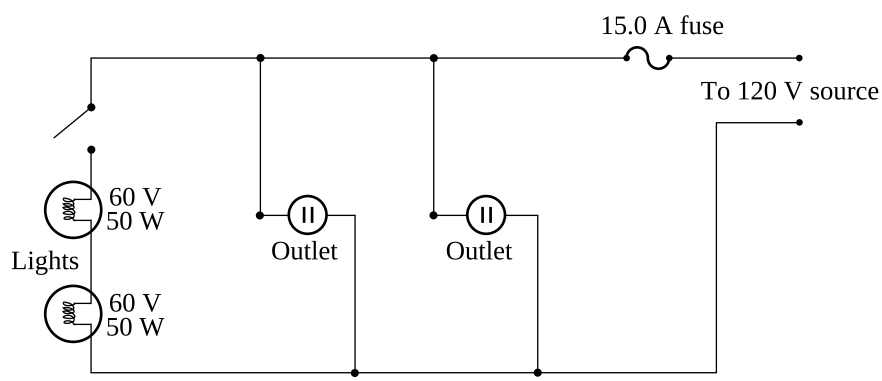
4. The maximum electrical work done during one pulse is __________ J.
(Round and record your answer to three digits.)

11. If the resistance of a circuit is halved and the voltage applied to the circuit is doubled, then the current in the circuit is

A. the same
B. quartered
C. doubled
D. quadrupled

Use the following information to answer the next four questions.

Electric Circuit



The above diagram represents a possible electric circuit in a home. (Assume the wires are of negligible resistance.)

12. When the switch is closed, the above circuit can be correctly described as

A. two series lights, in series with the two outlets
B. two parallel lights, in series with the two outlets
C. two series lights, in parallel with the two outlets
D. two parallel lights, in parallel with the two outlets

13. A 1.00×10^3 W toaster is plugged into one outlet of the circuit and switched on. Both lights are on. The **maximum** power rating for a kettle that could be plugged into the other outlet and switched on without burning out the fuse is

A. 7.00×10^2 W
B. 8.00×10^2 W
C. 1.00×10^3 W
D. 1.50×10^3 W

Numerical Response

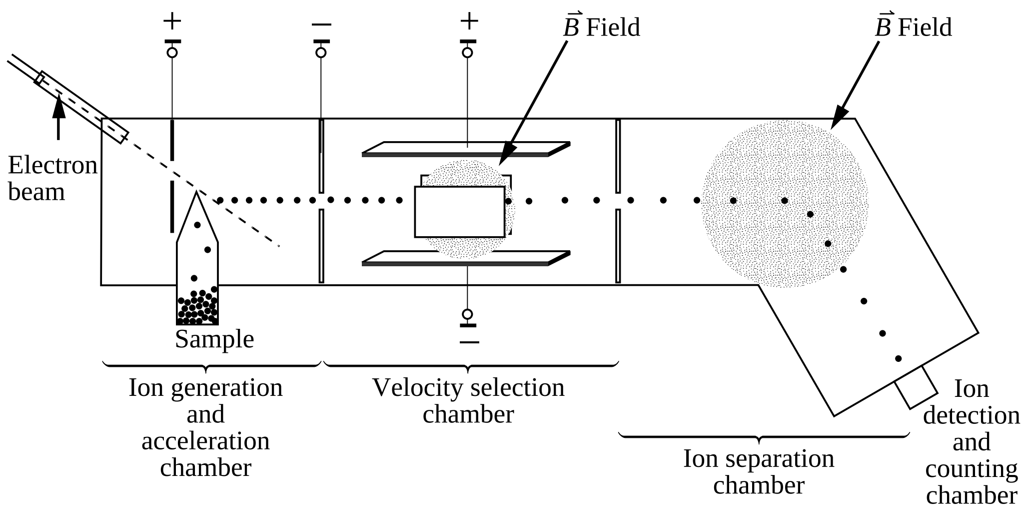
5. When a 1.00×10^3 W toaster is plugged into one of the outlets, the current in the toaster is __________ A.
(Round and record your answer to three digits.)

Numerical Response

6. At a rate of 6.71¢/(kW•h), the cost of operating the 1.00×10^3 W toaster for 1.10 minutes a day for 30 days is __________¢.
(Round and record your answer to three digits.)

Use the following information to answer the next three questions.

Mass Spectrometer



A biochemist uses a mass spectrometer to identify pollutants in a water sample. A mass spectrometer typically consists of four chambers, as shown above.

14. Why do ions of only a certain speed pass through the velocity selection chamber undeflected?

A. Only these ions possess the charge needed to be undeflected by the fields.

B. The electric field strength is the same as the magnetic field strength.

C. Ions travelling at other speeds have insufficient E_k to pass through the chamber.

D. The net deflecting force, from the electric and magnetic fields, is zero for only these ions.

Use the following additional information to answer the next two questions.

The biochemist has the spectrometer set as follows:

- Velocity selection chamber: $\left|\vec{E}\right| = 2.17 \times 10^{4}$ V/m
  $B_{\perp} = 9.00 \times 10^{-3}$ T
- Ion separation chamber: $B_{\perp} = 1.40$ T
  deflecting radius = 1.00 m

At these settings, an ion is detected. The biochemist expects the ion to be one of the ions listed below. The mass corresponding to each ion is given.

Cr^{2+}	8.64×10^{-26} kg
Cd^{2+}	1.86×10^{-25} kg
Hg^{2+}	3.33×10^{-25} kg
Pb^{2+}	3.44×10^{-25} kg

15. Which of the above pollutants is detected by the spectrometer?

A. Cr^{2+}
B. Cd^{2+}
C. Hg^{2+}
D. Pb^{2+}

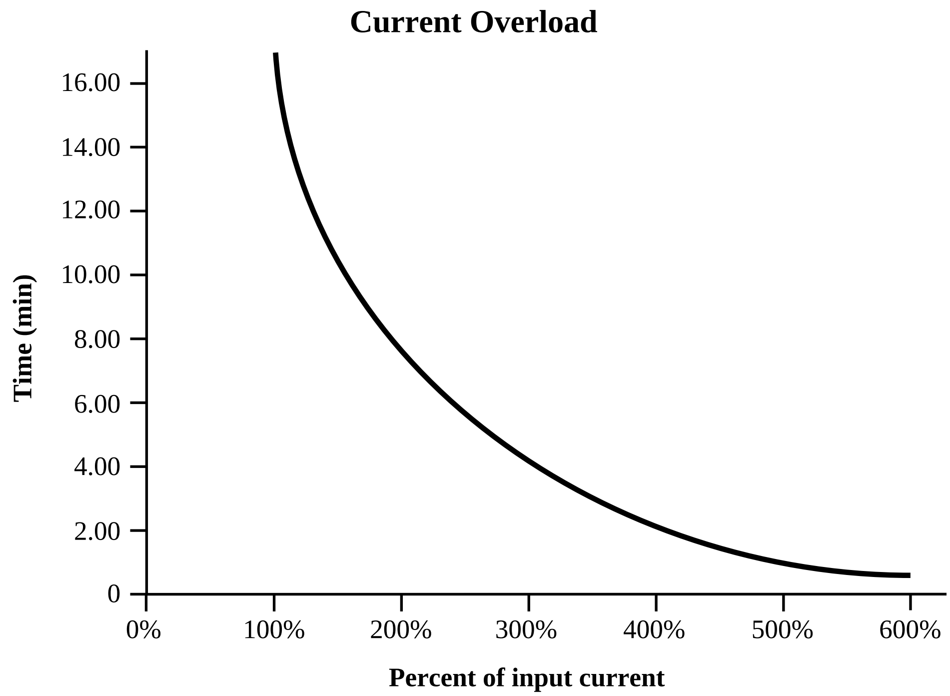
Use the following additional information to answer the next question.

In the ion generation and acceleration chamber, atoms in the sample are ionized by bombarding them with electrons to remove outermost electrons. The biochemist must have the accelerating voltage in the electron gun set high enough to ensure ionization of the particles.

16. Which of the following physical principles must be used to calculate the value of the accelerating voltage in the electron gun?

A. Ohm’s law
B. Coulomb’s law
C. Conservation of energy
D. Conservation of momentum

Use the following information to answer the next two questions.



An electric motor needs to be protected from overheating. The graph shows the time at which motor shutdown will occur due to overloading and overheating for currents greater than 100% of the recommended current.

17. If the maximum recommended input current for the motor is 300 A, the approximate time at which shutdown will occur if the motor is using 150 A is

A. never
B. 4.00 min
C. 12.00 min
D. immediately

18. If the same motor shuts down at 8.00 min, the current before shutdown is approximately

A. 150 A
B. 200 A
C. 600 A
D. 900 A

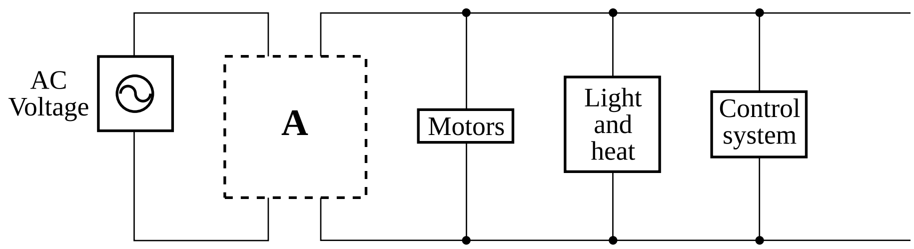
Use the following information to answer the next question.

In many electrically powered passenger trains, the input voltage V_i from the power supply is not the same as the operating voltage V_o of the electrical circuitry of the train.

Examples:

	V_i	V_o
England	750	1 500
English Channel	25 000	1 500
Belgium	3 000	1 500
France	50 000	1 500

The diagram below is a partial schematic of the electrical circuitry of an electric train.



19. The component labelled A in the diagram is **most likely** a

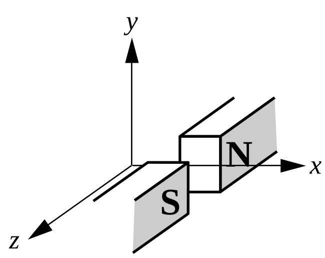
A. battery
B. resistor
C. generator
D. transformer

Numerical Response

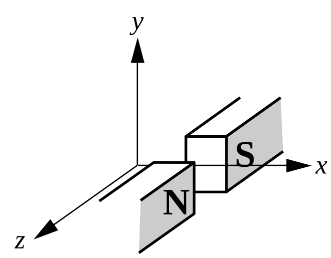
7. A typical television set requires 2.00×10^4 V AC for its operation. Since a television is plugged into a standard 110 V outlet, the voltage must be increased. If the ideal transformer used to increase the voltage has 1.87×10^4 turns of wire on the secondary coil, then the number of turns of wire that must be placed on the primary coil, expressed in scientific notation, is $\boldsymbol{b} \times 10^w$. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

20. The diagrams below show the direction of a magnetic field relative to a set of coordinate axes. A negatively charged particle travels across the page in the positive *x* direction. The magnetic configuration that will cause the particle to bend in the positive *z* direction is

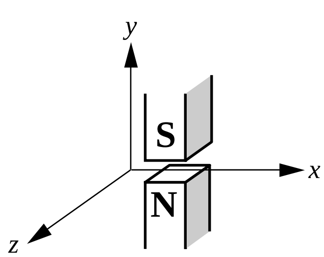
A.



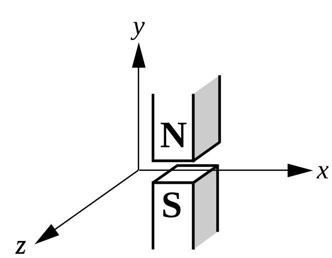
B.



C.



D.



Numerical Response

8. Northern lights are often observed in Alberta skies. The most common colour, green, has a wavelength of 558 nm. When a collision occurs between energetic electrons and oxygen atoms in the upper atmosphere, the oxygen atoms are excited. To cause the most common colour of northern lights, the electrons must be travelling with a minimum speed, expressed in scientific notation, of $\boldsymbol{b} \times 10^{w}$ m/s. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

21. Accelerating charges generate

A. electric waves
B. magnetic waves
C. longitudinal waves
D. electromagnetic waves

Numerical Response

9. If a photon of electromagnetic radiation has a frequency of 1.09×10^{17} Hz, it has a wavelength, expressed in scientific notation, of $\boldsymbol{b} \times 10^{-w}$ m. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

Numerical Response

10. An explosion that produces a flash of light occurs at a distance of 6.06 km from a group of people. The minimum possible time, expressed in scientific notation, that elapses before the people can see the explosion is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ s. The values of ***a***, ***b***, ***c***, and ***d*** are __________.
(Record your answer as $\boxed{a}\ \boxed{b}\ \boxed{c}\ \boxed{d}$.)

22. Which of the following sets of electromagnetic radiations is arranged in order of increasing photon frequency?

A. Gamma rays, ultraviolet radiation, radio waves
B. Radio waves, ultraviolet radiation, gamma rays
C. Gamma rays, radio waves, ultraviolet radiation
D. Radio waves, gamma rays, ultraviolet radiation

Use the following information to answer the next three questions.

A cyclotron is a particle accelerator used to investigate subatomic structure. Magnetic fields are used to control the path of charged particles within a cyclotron.

23. The radius of the path followed by charged particles moving perpendicularly through the magnetic field of a cyclotron could be reduced by

A. increasing the strength of the magnetic field
B. using particles with a smaller charge
C. increasing the speed of the particles
D. using particles with a greater mass

24. The period T for a particle of charge q in a magnetic field of strength B is

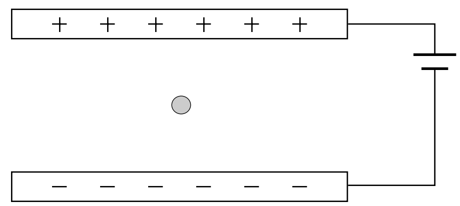
A. $\frac{2\pi m}{qB}$
B. $\frac{\pi m}{qB}$
C. $\frac{qB}{2\pi}$
D. $\frac{qB}{\pi m}$

25. An alpha particle travels in a direction perpendicular to a magnetic field of strength 1.6 T. If the alpha particle experiences a force of magnitude 1.1×10^{-13} N, then its measured speed will be

A. 2.1×10^{-7} m/s
B. 4.3×10^{-7} m/s
C. 2.1×10^{5} m/s
D. 4.3×10^{5} m/s

Use the following information to answer the next question.

A Millikan Experiment



A potential difference of 12.0 V is maintained between two parallel metal plates that are 5.00 cm apart.

Numerical Response

11. A mass with a +1.00 elementary charge placed between the plates will experience an electric force, expressed in scientific notation, of magnitude $\boldsymbol{b} \times 10^{-w}$ N. The value of $\boldsymbol{b}$ is __________.
(Round and record your answer to three digits.)

---

26. X-rays may be focused using

A. magnetic fields
B. electric fields
C. either electric or magnetic fields
D. neither electric nor magnetic fields

27. In a photoelectric experiment, the maximum kinetic energy of photoelectrons does **not** depend on the

A. work function of the emitting material
B. wavelength of the incident light
C. intensity of the incident light
D. energy of an incident photon

28. Copper has a work function of 4.46 eV. What is the maximum kinetic energy of the ejected electrons if the metal is illuminated by light with a wavelength of 450 nm?

A. 2.72×10^{-19} J
B. 4.42×10^{-19} J
C. 7.14×10^{-19} J
D. 0 J, because no electrons are ejected

29. Louis de Broglie proposed that

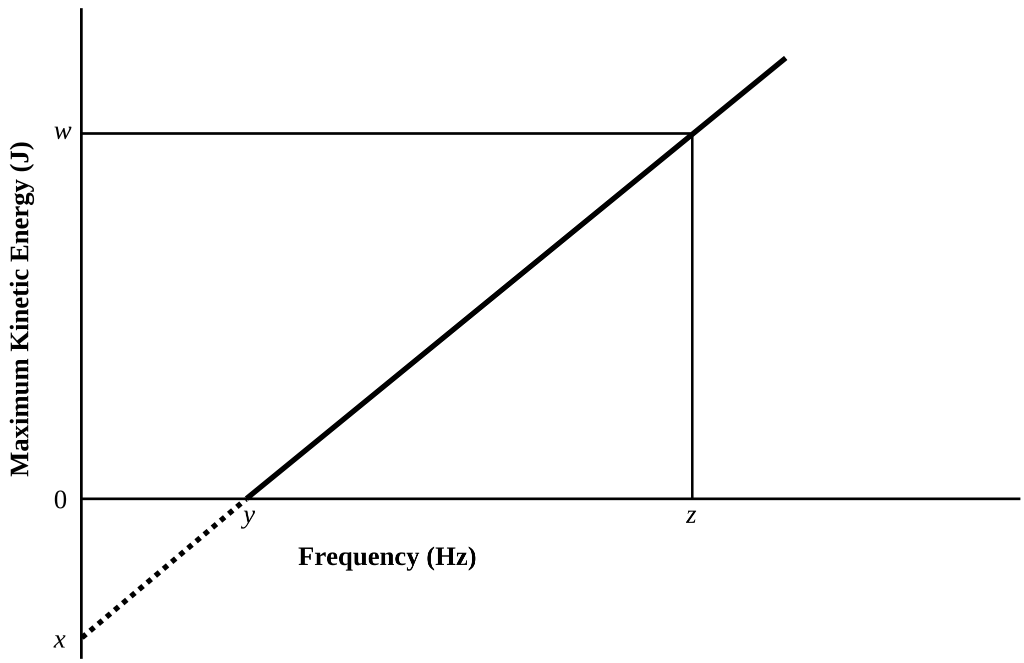
A. the energy absorbed by an atom is the same as the energy released by an atom
B. if light has particle properties, then particles have wave properties
C. the intensity of light controls the current in the photoelectric effect
D. energy and mass are related

30. A burglar knows that an alarm in a certain museum makes use of the photoelectric effect. Ultraviolet light shines on a photocell with a work function of 5.01 eV. Any break in the light will set the alarm off. The burglar realizes that if he shines his own ultraviolet light source at the photocell, he can ensure that there is no break in the light and that the alarm will not be set off. He obtains an ultraviolet light source with a frequency of 1.13×10^{15} Hz. Will he be successful in his burglary attempt and why?

A. No, because the frequency of the burglar’s light is too low for the photocell to function.
B. No, because the frequency of the burglar’s light is too high for the photocell to function.
C. Yes, because the frequency of the burglar’s light is low enough for the photocell to function.
D. Yes, because the frequency of the burglar’s light is high enough for the photocell to function.

Use the following information to answer the next two questions.

Robert Millikan showed experimentally that Einstein's photoelectric equation $E_{k_{max}} = hf - W$ was valid. Using a variety of cathode materials, he measured the maximum kinetic energy of photoelectrons while varying the light frequency. The graph shown is typical for a particular cathode. The dotted line is an extrapolation (extension) of the experimental data.



The letters *w*, *x*, *y*, and *z* represent experimental or extrapolated data.

31. The value for Planck's constant could be determined with the expression

A. $\dfrac{w}{z-y}$

B. $\dfrac{w}{z}$

C. $\dfrac{w\,(z-y)}{2}$

D. $-\dfrac{y}{x}$

32. The work function of the cathode material is equal to the expression

A. $\dfrac{w - x}{z}$

B. $\dfrac{w}{z}$

C. $-x$

D. y

---

33. An atom has energy states E_1 = –4.8 eV, E_2 = –2.4 eV, E_3 = –1.2 eV, E_4 = –0.80 eV, and E_5 = –0.40 eV. The wavelength of emitted light when an electron in the atom makes the transition E_4 to E_1 is

A. 2.6×10^{-7} m
B. 3.1×10^{-7} m
C. 1.6×10^{-6} m
D. 5.0×10^{-6} m

Use the following information to answer the next question.

In December 1994, research physicists in Darmstadt, Germany, announced that they had detected three atoms of a new element. With 111 protons and 161 neutrons, this lab-made element had the highest atomic number known to that date. To create element 111, the physicists bombarded bismuth atoms, which have 83 protons, with a beam of nickel atoms, which contain 28 protons. Signals of the three atoms of element 111 appeared for less than two-thousandths of a second. The atoms then decayed into lighter elements and alpha particles. One of the isotopes produced in the decay was element 107 with a mass number of 264. This isotope had never previously been observed.

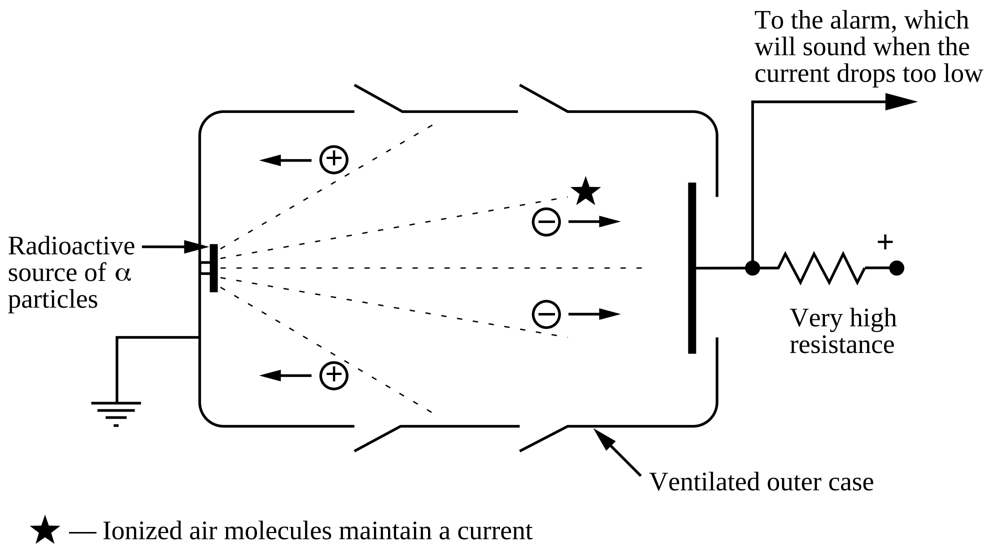
Note: Because neither element 111 nor element 107 had been officially named, element 111 was referred to as *X* and element 107 was referred to as *Y*.

34. The overall nuclear equation for this decay reaction is

A. ${}^{161}_{111}X \rightarrow {}^{264}_{107}Y + 2\,{}^{4}_{2}\text{He}$
B. ${}^{272}_{111}X \rightarrow {}^{264}_{107}Y + 2\,{}^{4}_{2}\text{He}$
C. ${}^{161}_{111}X \rightarrow {}^{153}_{107}Y + 2\,{}^{4}_{2}\text{He}$
D. ${}^{272}_{111}X \rightarrow {}^{264}_{107}Y + {}^{8}_{4}\text{Be}$

Use the following information to answer the next three questions.

Smoke Alarm



Half-Life of Selected Isotopes

Element	Isotope	Half-life	Radiation produced
hydrogen	$^{3}_{1}H$	12.3 a	ß
carbon	$^{14}_{6}C$	5715 a	ß
iodine	$^{131}_{53}I$	8.04 d	ß
lead	$^{212}_{82}Pb$	10.6 h	ß
polonium	$^{194}_{84}Po$	0.7 s	α
polonium	$^{210}_{84}Po$	138 d	α
uranium	$^{227}_{92}U$	1.1 min	α
uranium	$^{235}_{92}U$	7.04×10^{8} a	α
uranium	$^{238}_{92}U$	4.46×10^{9} a	α
plutonium	$^{236}_{94}Pu$	2.87 a	α
plutonium	$^{242}_{94}Pu$	3.76×10^{5} a	α
Legend: a = annum = year			

35. Given the specifications of this smoke alarm, which of the following isotopes could be used as a radioactive source?

A. ${}^{3}_{1}\mathrm{H}$

B. ${}^{14}_{6}\mathrm{C}$

C. ${}^{194}_{84}\mathrm{Po}$

D. ${}^{236}_{94}\mathrm{Pu}$

36. The product of the alpha decay of ${}^{238}_{92}\mathrm{U}$ is

A. ${}^{234}_{90}\mathrm{Th}$

B. ${}^{232}_{90}\mathrm{Th}$

C. ${}^{232}_{92}\mathrm{U}$

D. ${}^{234}_{90}\mathrm{U}$

Numerical Response

12. Tritium (${}^{3}_{1}\mathrm{H}$), an isotope of hydrogen, was once used in some watches to produce a fluorescent glow. Assuming that the brightness of the glow is proportional to the amount of tritium present, the length of time it would take for the watch to reach $\frac{1}{4}$ of its original brightness is __________ years.
(Round and record your answer to three digits.)

---

37. To calculate the amount of energy given off during a fusion reaction, the equation that should be used is

A. $E = hf$

B. $E = \frac{1}{2} mv^2$

C. $E = mc^2$

D. $E = \frac{h}{t}$

Written Response — 11 marks

1. An astronaut has just landed on an unknown, uninhabited planet and has to send some information about the planet back to Earth. Assume the astronaut has all of the equipment needed to perform the necessary experiments.

Using physics concepts as well as any related formulas, describe procedures that could be used in order to:

- **measure** the magnitude and direction of the gravitational field at the astronaut's location on the unknown planet
- determine whether or not there is an electric field at the location and, if there is, to determine its **magnitude** and **direction**
- determine whether or not there is a magnetic field at the location and, if there is, to determine its **direction**

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.

For Department Use Only

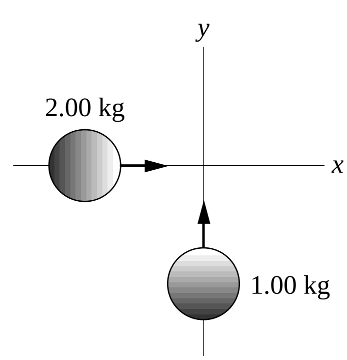
Use the following information to answer written-response question 2.

Computer-Generated Data

time (s)	2.00 kg p_x kg•m/s	2.00 kg p_y kg•m/s	2.00 kg $\vec{p}$ kg•m/s	1.00 kg p_x kg•m/s	1.00 kg p_y kg•m/s	1.00 kg $\vec{p}$ kg•m/s
0.000	18.0	0.00	18.0	0.00	4.00	4.00
0.020	18.0	0.00	18.0	0.00	4.00	4.00
0.040	18.0	0.00	18.0	0.00	4.00	4.00
0.060	18.0	0.00	18.0	0.00	4.00	4.00
0.080	18.0	0.00	18.0	0.00	4.00	4.00
0.100	18.0	0.00	18.0	0.00	4.00	4.00
0.120	18.0	0.00	18.0	0.00	4.00	4.00
0.140	18.0	0.00	18.0	0.00	4.00	4.00
0.160	18.0	0.00	18.0	0.00	4.00	4.00
0.180	12.5	7.31	14.5	5.48	–3.31	6.41
0.200	12.5	7.32	14.5	5.47	–3.32	6.40
0.220	12.5	7.32	14.5	5.47	–3.32	6.40
0.240	12.5	7.32	14.5	5.47	–3.32	6.40
0.260	12.5	7.32	14.5	5.47	–3.32	6.40
0.280	12.5	7.32	14.5	5.47	–3.32	6.40
0.300	12.5	7.32	14.5	5.47	–3.32	6.40
0.320	12.5	7.32	14.5	5.47	–3.32	6.40
0.340	12.5	7.32	14.5	5.47	–3.32	6.40
0.360	12.5	7.32	14.5	5.47	–3.32	6.40
0.380	12.5	7.32	14.5	5.47	–3.32	6.40
0.400	12.5	7.32	14.5	5.47	–3.32	6.40

Note: p_x and p_y are the x and y components of a momentum vector $\vec{p}$.

Two Dimensional Collision



Written Response — 10 marks

2. A 2.00 kg ball and a 1.00 kg ball collide. Their original directions of motion are as indicated in the diagram. A computer program that simulates this collision generated the data on the previous page.

a. Indicate **on the diagram** the approximate direction of motion for each ball after collision.

b. Determine the speed of each ball before **and** after the collision.

c. Determine the angle between the balls **after** the collision.

(parts **d.** *and* **e.** *are on the next page)*

Department Use Only

d. Show that the total momentum before the collision is equal to the total momentum after the collision.

e. How much kinetic energy is lost as a result of this collision?

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

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen	$E_1 = -2.18 \times 10^{-18}$ J or -13.6 eV
Planck's Constant	$h = 6.63 \times 10^{-34}$ J•s or 4.14×10^{-15} eV•s
Radius of 1st Bohr Orbit of Hydrogen	$r_1 = 5.29 \times 10^{-11}$ m
Rydberg's Constant for Hydrogen	$R_H = 1.10 \times 10^{7}$/m

Particles

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

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

$\vec{d} = \vec{v}_f t - \frac{1}{2}\vec{a}t^2$

$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$

$\vec{d} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right)t$

$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

$v_f^2 = v_i^2 + 2ad$

$v = \frac{2\pi r}{T}$

$a = \frac{v^2}{r}$

Dynamics

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

$F_g = \frac{Gm_1m_2}{r^2}$

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

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

$\vec{F}_g = m\vec{g}$

$F_c = \frac{mv^2}{r}$

$F_f = \mu F_N$

$\vec{F}_s = -k\vec{x}$

$F_c = \frac{4\pi^2 mr}{T^2}$

Momentum and Energy

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

$E_k = \frac{1}{2}mv^2$

$W = Fd$

$E_p = mgh$

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

$E_p = \frac{1}{2}kx^2$

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

Waves and Light

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

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

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

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

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

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

$v = f\lambda$

$m = \frac{h_i}{h_0} = \frac{-d_i}{d_0}$

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

$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i}$

Atomic Physics

$hf = E_{k_{max}} + W$

$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$W = hf_0$

$E_{k_{max}} = qV_{stop}$

$E_n = \frac{1}{n^2}E_1$

$r_n = n^2 r_1$

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

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

Quantum Mechanics and Nuclear Physics

$E = mc^2$

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

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

Electricity and Magnetism

$F_e = \frac{kq_1q_2}{r^2}$

$V = IR$

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

$P = IV$

$\vec{E} = \frac{\vec{F}_e}{q}$

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

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

$F_m = IlB_\perp$

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

$F_m = qvB_\perp$

$V = lvB_\perp$

$R = R_1 + R_2 + R_3$

$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$

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

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

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

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		VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA or O
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 (266.11) 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 (277.03) 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 molar mass → 6.94

Name → lithium

Based on $^{12}_{6}C$

( ) Indicates mass of the most stable isotope

Tear-out Page

No marks will be given for work done on this page.

Fold and tear along perforation.

Pag

No marks will be given for work done on this page.

Fold and tear along perforation.

mm

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190

200

210

Tear Off Page (partially visible at page edge)

No marks will be given for work done on this page.

Fold and tear along perforation.

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No marks will be given for work done on this page.

PHYSICS 30

DIPLOMA EXAMINATION

JUNE 1997

Multiple Choice
and
Numerical Response
Key

Draft
Written Response
Scoring Guide

MULTIPLE-CHOICE KEY – June 1997 (972)

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

NUMERICAL-RESPONSE KEY

1.	8.13*
2.	1.11
3.	3.75
4.	6.60
5.	8.33
6.	3.69
7.	1.03
8.	8.85
9.	2.75
10.	2025
11.	3.84
12.	24.6

*If MC 2 is A, then NR 1 is 0.13
B, then NR 1 is 4.00
C, then NR 1 is 4.12
D, then NR 1 is 8.13

PHYSICS 30 DIPLOMA EXAMINATION 972
WRITTEN-RESPONSE SCORING GUIDE

General Comments

1. Final answers must include appropriate units and should be expressed to the correct number of significant digits.

2. Most questions include a range of values for numerical answers. If no range is included, allow a discrepancy of ± 5% where appropriate.

3. Do not double penalize a student. If the calculations to a part yield a wrong answer and that answer is used correctly in a following part, award full marks for the following part.

4. In all written-response questions involving calculations, an explicit formula statement is required as a first step, with the substituted values explicitly written down in a subsequent step. If a number with no unit is substituted, assume that the omitted unit is the appropriate SI base unit.

5. These are **sample** answers: different approaches may be used.

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

<table>
<tr><td colspan="2">When marking CONTENT, the marker should consider how effectively the response uses physics concepts, knowledge, and skills to provide a solution to the problem.</td></tr>
<tr><th>Score</th><th>Criteria</th></tr>
<tr><td>4</td><td>The response:
• uses a method that reflects a thorough understanding of how to detect and measure the gravitational field (magnitude and direction), the electric field (magnitude and direction), and the magnetic field (direction)
• provides a complete description of the method used to detect and measure each field
• identifies relevant scientific and technological concepts and interrelationships are explicit
• has, if used, formula that are appropriate 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</td></tr>
<tr><td>3</td><td>The response:
• uses a method that reflects a good understanding of how to detect and measure the magnitude and direction of fields
• provides a description of the method used to detect and measure fields
• identifies relevant scientific and technological concepts and interrelationships are explicit
• has, if used, formula that are appropriate, 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 or omission, however, there is little doubt that the understanding of physics content is good</td></tr>
<tr><td>2</td><td>The response:
• uses a method that reflects a basic understanding of how to detect the presence of fields
• provides a description of the method used to detect or measure fields
• identifies relevant scientific and technological concepts and interrelationships are evident
• has, if used, formula that are appropriate, however, errors in substitution and/or calculation hinder the understanding of the physics content
• has, if used, diagrams and/or sketches that may be appropriate, although some aspect is incorrect or incomplete
• has major inconsistencies or major omissions</td></tr>
<tr><td>1</td><td>The response:
• uses a method that reflects a poor understanding of fields
• provides a description of the method used to detect or measure one field although some aspect may be incorrect or 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</td></tr>
<tr><td>0</td><td>The response:
• uses a method that reflects little or no understanding of fields
• may have formula but they do not address any of the major points
• has, if present, diagrams and/or sketches that are incorrect, inappropriate, and incomplete
• has major omissions</td></tr>
<tr><td>NR</td><td>No response is given.</td></tr>
</table>

(11 marks) **1.** An astronaut has just landed on an unknown, uninhabited planet and has to send some information about the planet back to Earth. Assume the astronaut has all of the equipment needed to perform the necessary experiments.

Using physics concepts as well as any related formulas, describe procedures that could be used in order to:

- **measure** the magnitude and direction of the gravitational field at the astronaut's location on the unknown planet
- determine whether or not there is an electric field at the location and, if there is, to determine its **magnitude** and **direction**
- determine whether or not there is a magnetic field at the location and, if there is, to determine its **direction**

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.

The following is a list of possible methods for determining $\vec{g}$, $\vec{E}$ and $\vec{B}$. Students may choose other methods.

Gravitational Field Strength

- Measure time of fall of an object over a known distance.
- Substitute values into the equation:

$$d = v_1 t + \frac{1}{2}at^2 \quad \text{or similar calculation}$$

OR

- Use a spring scale to weigh a known mass.
- Divide weight by mass in equation:

$$g = F_g/m$$

- The direction of the gravitational field is the direction that the mass accelerates.

Electric Field

– Determine the mass of an uncharged object.
– Place a known charge, q, on the object.
– Suspend the charged object.
– Determine whether its apparent weight is more than, less than, or equal to its weight as determined by $F_g = mg$. (Or determine if the charged object is pulled aside from the vertical.)
– Any variation in the weight indicates the presence of an electric field.
– The amount of variation is the electric force on the object.
– To determine the strength of the electric field, the electric force must be divided by the charge on the object.
– The direction of the electric field is:
  —the direction of the electric force if the charge is positive
  —opposite to the direction of the electric force if the charge is negative

Magnetic Field

- Use a compass or a dipping needle.
- The direction of the force on the N-pole of the compass is the direction of the magnetic field.

The marks are arrived at in the following manner.
Take the level the response is at from the ***Scoring Guide for the Foundations of Scientific Knowledge: Physics*** and multiply by two (4 × 2 = 8).

Add the score from the **Assessment of Communication Skills** (8 + 3 = 11).

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

Computer-Generated Data

time (s)	2.00 kg p_x kg•m/s	2.00 kg p_y kg•m/s	2.00 kg $\lvert\vec{p}\rvert$ kg•m/s	1.00 kg p_x kg•m/s	1.00 kg p_y kg•m/s	1.00 kg $\lvert\vec{p}\rvert$ kg•m/s
0.000	18.0	0.00	18.0	0.00	4.00	4.00
0.020	18.0	0.00	18.0	0.00	4.00	4.00
0.040	18.0	0.00	18.0	0.00	4.00	4.00
0.060	18.0	0.00	18.0	0.00	4.00	4.00
0.080	18.0	0.00	18.0	0.00	4.00	4.00
0.100	18.0	0.00	18.0	0.00	4.00	4.00
0.120	18.0	0.00	18.0	0.00	4.00	4.00
0.140	18.0	0.00	18.0	0.00	4.00	4.00
0.160	18.0	0.00	18.0	0.00	4.00	4.00
0.180	12.5	7.31	14.5	5.48	–3.31	6.41
0.200	12.5	7.32	14.5	5.47	–3.32	6.40
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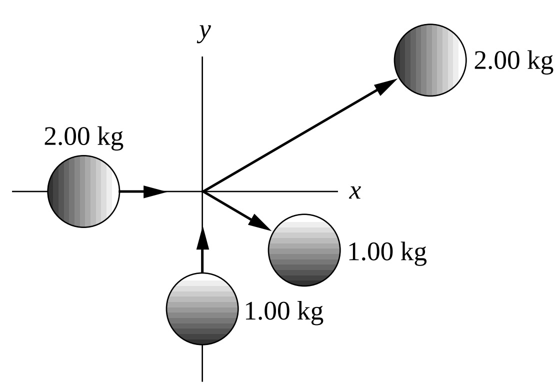
0.340	12.5	7.32	14.5	5.47	–3.32	6.40
0.360	12.5	7.32	14.5	5.47	–3.32	6.40
0.380	12.5	7.32	14.5	5.47	–3.32	6.40
0.400	12.5	7.32	14.5	5.47	–3.32	6.40

Note: p_x and p_y are the x and y components of a momentum vector $\vec{p}$.

Two Dimensional Collision



2. A 2.00 kg ball and a 1.00 kg ball collide. Their original directions of motion are as indicated in the diagram. A computer program that simulates this collision generated the data on the previous page. **(10 marks)**

a. Indicate **on the diagram** the approximate direction of motion for each ball after collision.

There are two checks for this part:

1. 2.00 kg ball in the first quadrant and labelled correctly
2. 1.00 kg ball in the fourth quadrant and labelled correctly

NOTE: no checks are awarded if the collision is physically impossible

b. Determine the speed of each ball before **and** after the collision.

1 kg ball

$p = mv$

$$v_{1\text{ before}} = \frac{p_{\text{before}}}{m} = \frac{4.00\text{ kg•m/s}}{1.00\text{ kg}} = 4.00\text{ m/s}$$

$$v_{1\text{ after}} = \frac{p_{\text{after}}}{m} = \frac{6.40\text{ kg•m/s}}{1.00\text{ kg}} = 6.40\text{ m/s}$$

$$\text{or} \quad = \frac{6.41\text{ kg•m/s}}{1.00\text{ kg}} = 6.41\text{ m/s}$$

2 kg ball

$$v_{2\text{ before}} = \frac{p_{\text{before}}}{m} = \frac{18.0\text{ kg•m/s}}{2.00\text{ kg}} = 9.00\text{ m/s}$$

$$v_{2\text{ after}} = \frac{p_{\text{after}}}{m} = \frac{14.5\text{ kg•m/s}}{2.00\text{ kg}} = 7.25\text{ m/s}$$

There are five checks for this part:

3. stating $p = mv$ or equivalent
4. an answer $v_{1\text{ before}} = 4.00$ m/s
5. an answer $v_{1\text{ after}} = 6.40$ m/s or 6.41 m/s
6. an answer $v_{2\text{ before}} = 9.00$ m/s
7. an answer $v_{2\text{ after}} = 7.25$ m/s

c. Determine the angle between the balls **after** the collision.

1 kg ball

$$\tan^{-1}\frac{p_y}{p_x} = \text{angle};\ \tan^{-1}\frac{-3.32}{5.47} = -31.26° \quad \text{or } \tan^{-1}\frac{-3.31}{5.48} = -31.13°$$

The angle is measured with respect to horizontal *x*-axis

2 kg ball

$$\tan^{-1}\frac{p_y}{p_x} = \text{angle};\ \tan^{-1}\frac{7.32}{12.50} = 30.35° \quad \text{or } \tan^{-1}\frac{-7.31}{12.50} = 30.32°$$

The angle is measured with respect to horizontal *x*-axis

Angle between balls = 30.35° + 31.26° = 61.6°

or

Angle between balls = 30.32° + 31.13° = 61.5°

There are four checks for this part:

8. using a valid method to calculate angles
9. an angle for the 1.00 kg ball consistent with the method used
10. an angle for the 2.00 kg ball consistent with the method used
11. an answer: angle between the balls = 61.4° through 61.7°or consistent with method used and diagram

d. Show that the total momentum before the collision is equal to the total momentum after the collision.

If the *x* components of the momentum before and after collision are equal and the *y* components of the momentum before and after collision are equal, then the total momentum before and after collision is equal.

or

$$\Sigma p_{x\text{ before}} = \Sigma p_{x\text{ after}}$$

$$\Sigma p_{y\text{ before}} = \Sigma p_{y\text{ after}}$$

$$\text{therefore } p_{\text{ total before}} = p_{\text{ total after}}$$

$$p_{x\text{ before}} = 18.0\text{ kg•m/s}$$

$$p_{x\text{ after}} = 12.5\text{ kg•m/s} + 5.48\text{ kg•m/s} = 18.0\text{ kg•m/s}$$

$$p_{y\text{ before}} = 4.00\text{ kg•m/s}$$

$$p_{y\text{ after}} = 7.31\text{ kg•m/s} + –3.31\text{ kg•m/s} = 4.00\text{ kg•m/s}$$

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

<u>Method One</u>

12. explicitly stating that if momentum along each axis is conserved, then total momentum is conserved
13. stating $p_{x\text{ before}}$ = 18.0 kg•m/s and $p_{y\text{ before}}$ = 4.00 kg•m/s
14. showing that $p_{x\text{ after}}$ = 12.5 + 5.48 kg•m/s = 18.0 kg•m/s
15. showing that $p_{y\text{ after}}$ = 7.31 + –3.31 kg•m/s = 4.00 kg•m/s

<u>Method Two</u>

12. recognizing that both magnitude and direction of the sum of momentum vectors is conserved
13. showing (diagram or calculation) that the magnitude of the sum of the momentum vectors before collision is 18.4 kg•m/s
14. showing (diagram or calculation) that the magnitude of the sum of the momentum vectors after collision is 18.4 kg•m/s
15. showing (diagram or calculation) that the direction of the total momentum vectors before and after collision is equal to 12.5° with respect to the x-axis

e. How much kinetic energy is lost as a result of this collision?

$$E_{\text{k before}} = \frac{1}{2}\left[m_1 v_1{}^2 + m_2 v_2{}^2\right]$$

$$E_{\text{k before}} = \frac{1}{2}\left[1.00\text{ kg} \times (4.00\text{ m/s})^2 + 2.00\text{ kg} \times (9.00\text{ m/s})^2\right]$$

$$E_{\text{k before}} = 89.0\text{ J}$$

$$E_{\text{k after}} = \frac{1}{2}\left[m_1 v_1{}^2 + m_2 v_2{}^2\right]$$

$$E_{\text{k after}} = \frac{1}{2}\left[1.00\text{ kg} \times (6.40\text{ m/s})^2 + 2\ 00\text{ kg} \times (7.25\text{ m/s})^2\right]$$

$$E_{\text{k after}} = 73.0\text{ J}$$

$$E_{\text{k lost}} = E_{\text{k before}} - E_{\text{k after}}$$

$$E_{\text{k lost}} = 89.0\text{ J} - 73.0\text{ J} = 16.0\text{ J}$$

There are five checks for this part:

16. stating $E_{\text{k}} = \frac{1}{2} mv^2$ or equivalent
17. substitution into a valid formula for $E_{\text{k before}}$ consistent with previous work
18. substitution into a valid formula for $E_{\text{k after}}$ consistent with previous work
19. using $E_{\text{k lost}} = E_{\text{k before}} - E_{\text{k after}}$
20. answer $E_{\text{k lost}} = 16.0$ J or consistent with previous work

Checks	Marks
19 or 20	10
17 or 18	9
15 or 16	8
13 or 14	7
12	6
10 or 11	5
8 or 9	4
6 or 7	3
4 or 5	2
2 or 3	1
0 or 1	0

PHYSICS DE – 972

Multiple Choice & Numerical Response

Item	Key	Diff.	CRPB	Concept	Knowl	Skill	STS	Cog. Lev.	Source	Standard
MC1	D	0.743	0.180	30.1.2				K	4210	
MC2	D	0.536	0.416	30.1.1	3			C/A	9611	
NR1	8.13*	0.592	0.362	30.1.1	5			HMA	9611	
MC3	A	0.707	0.282	30.1.2	4	1		C/A	9625	
MC4	A	0.480	0.257	30.2.1	4	1		C/A	9561	
MC5	B	0.570	0.353	30.2.2	2			HMA	9556	
NR2	1.11	0.750	0.173	30.2.2	1			C/A	4162	
NR3	3.75	0.895	0.302	30.2.3	6			HMA	9625	
MC6	D	0.373	0.234	30.2.4	4	3		C/A	9612	
MC7	D	0.320	0.262	30.2.3	4			C/A	9613	
MC8	B	0.785	0.398	30.2.4	1			C/A	9613	
MC9	B	0.566	0.284	30.2.4	3			K	9624	
MC10	A	0.899	0.277	30.2.4	2			C/A	9613	
NR4	6.60	0.729	0.354	30.2.4	5			C/A	9613	
MC11	D	0.818	0.223	30.2.4				HMA	4225	
MC12	C	0.898	0.150	30.2.4	7			C/A	9625	
MC13	A	0.793	0.352	30.2.4	5			C/A	9625	
NR5	8.33	0.719	0.313	30.2.4	5			C/A	9625	
NR6	3.69	0.516	0.296	30.2.4	5			HMA	9625	
MC14	D	0.467	0.313	30.3.2	3			K	4235	
MC15	B	0.599	0.246	30.3.2	3	3	3	HMA	4235	
MC16	C	0.419	0.191	30.3.3	4	3	3	C/A	4235	
MC17	A	0.717	0.132	30.3.2			2	C/A	9611	
MC18	C	0.675	0.283	30.3.2			2	C/A	9611	
MC19	D	0.845	0.278	30.3.2	8		1	C/A	9624	
NR7	1.03	0.572	0.186	30.3.2	8			C/A	4193	
MC20	D	0.494	0.320	30.3.2	3	2		HMA	4194	
NR8	8.85	0.336	0.462	30.4.4	7			C/A	4140	
MC21	D	0.752	0.176	30.3.2	4			K	9627	
NR9	2.75	0.925	0.285	30.3.3	3			C/A	4235	
NR10	2025	0.588	0.401	30.3.3	3	1		C/A	1105	
MC22	B	0.822	0.196	30.3.3	2			K	9627	
MC23	A	0.667	0.364	30.4.1				C/A	963	
MC24	A	0.667	0.327	30.4.1				HMA	963	
MC25	C	0.818	0.200	30.3.2	3			C/A	9627	
NR11	3.84	0.649	0.336	30.4.1				C/A	9624	
MC26	D	0.417	0.218	30.4.2	10		4	C/A	4194	
MC27	C	0.498	0.251	30.4.2	4			K	9626	
MC28	D	0.501	0.504	30.4.2				C/A	963	
MC29	B	0.839	0.194	30.4.2	11			K	4245	
MC30	A	0.687	0.357	30.4.2	6		1	C/A	4150	
MC31	A	0.522	0.200	30.4.2	6			HMA	9624	
MC32	C	0.454	0.390	30.4.2	6			HMA	9624	
MC33	B	0.650	0.370	30.4.4	6			C/A	1456	
MC34	B	0.544	0.279	30.4.3	3	4	1	C/A	9622	
MC35	D	0.359	0.129	30.4.3	1			C/A	9625	
MC36	A	0.848	0.176	30.4.3	5			C/A	9625	
NR12	24.6	0.559	0.417	30.4.3	4			C/A	9625	
MC37	C	0.856	0.141	30.4.3	8			K	9626	

Written Response

Item	Value	Diff.	Descrip.	Concept	Knowl	Skill	STS	Cog. Lev.	Source	Standard
1	11	0.564	gravity	30.2/30.3					9571	
2	10	0.521	2-D collis	30.1.2	3	1			9536	

Multiple Choice Average	0.638	if MC2 is	A, then NR 1 is 0.13
Numerical Response Average	0.653		B, then NR 1 is 4.00
Written Response Average	0.544		C, then NR 1 is 4.12
Total Test Average	0.612		D, then NR 1 is 8.13

0.743	
0.536	
	0.592
0.707	
0.480	
0.570	
	0.750
	0.895
0.373	
0.320	
0.785	
0.566	
0.899	
	0.729
0.818	
0.898	
0.793	
	0.719
	0.516
0.467	
0.599	
0.419	
0.717	
0.675	
0.845	
	0.572
0.494	
	0.336
0.752	
	0.925
	0.588
0.822	
0.667	
0.667	
0.818	
	0.649
0.417	
0.498	
0.501	
0.839	
0.687	
0.522	
0.454	
0.650	
0.544	
0.359	
0.848	
	0.559
0.856	

23.605
7.830