June 1998

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 of 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

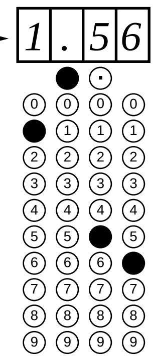
Calculation Question and Solution

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 ⟶



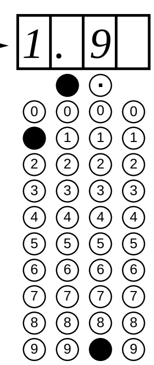
Calculation Question and Solution

A microwave of wavelength 16 cm has a frequency, expressed in scientific notation, of $\boldsymbol{b} \times 10^{w}$ Hz. The value of ***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

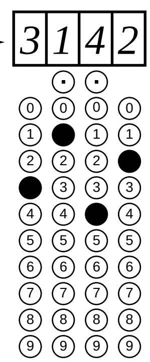
Place the following types of EMR in order of increasing energy:

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

(Record your answer as ☐☐☐☐.)

Answer: 3142

Record 3142 on the answer sheet →



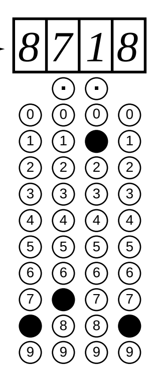
Scientific Notation Question and Solution

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 values 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

Record 8718 on the answer sheet →

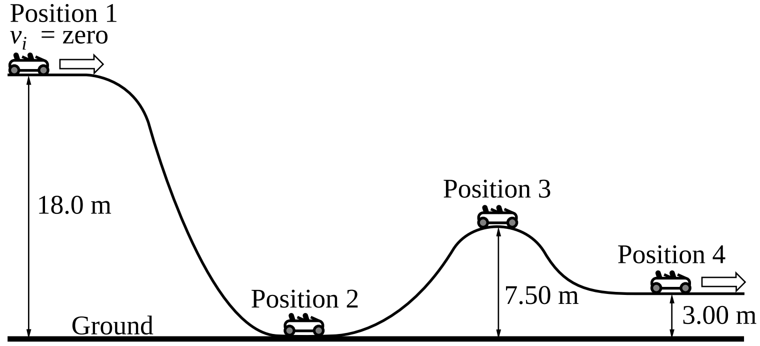


Written Response

- 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.

Use the following information to answer the next three questions.

Roller-Coaster Ride



A 250 kg roller-coaster car starts at position 1 and continues through the entire track. The brakes are applied after the car passes position 4. Assume that the effects of friction on the roller-coaster car are negligible between positions 1 and 4.

Numerical Response

1. When placed in order from **greatest** amount of kinetic energy to **least**, the order of the four different positions of the roller-coaster car labelled on the diagram is __________.

(Record your answer as ☐☐☐☐.)

1. The roller-coaster car's speed at position 4, immediately before the brakes are applied, is

A. 18.8 m/s

B. 17.2 m/s

C. 13.3 m/s

D. 12.1 m/s

Numerical Response

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

2. After the car passes position 4, the brakes stop the car in 3.03 s. The magnitude of the average frictional force applied by the brakes to stop the car, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ N. The values of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, and $\boldsymbol{d}$ are __________.

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

***You can receive marks for this question even if the previous question was answered incorrectly.**

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2. Ruth is diving from a tower 10.0 m above the water. When she is 5.0 m above the surface of the water, her

A. momentum and kinetic energy are about equal

B. velocity is half of the velocity she will have when she touches the water

C. potential energy, with respect to the water, and her momentum are about equal

D. potential energy, with respect to the water, and her kinetic energy are about equal

Use the following information to answer the next question.

I. Energy
II. Displacement
III. Mass
IV. Acceleration
V. Force

3. Which of the above terms represent scalar quantities?

A. I and III only

B. III and V only

C. I, II, and III only

D. II, IV, and V only

Use the following information to answer the next three questions.

In some parts of the world, it is common for people to shoot firearms straight up into the air during celebrations. Falling bullets pose a significant danger to bystanders. Doctors at King/Drew Medical Center in Los Angeles treated 118 people for falling-bullet injuries from 1985 through 1992, and 38 of these people died. All were random victims.

As a bullet falls, its velocity increases until it reaches a maximum, called terminal velocity. The magnitude of a bullet's terminal velocity will depend on its calibre (size), whether it tumbles or not, and whether it falls nose- or blunt-end first.

A 2.00 g bullet fired from a rifle with an initial velocity of 841 m/s travels straight up and reaches an altitude of 2.80×10^3 m. As it falls, it reaches its terminal velocity of 210 m/s.

Numerical Response

3. The rifle has a mass of 3.80 kg. The recoil speed of the rifle, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ m/s. The values of ***a***, ***b***, ***c***, and ***d*** are ___________.

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

4. How much energy is lost as a result of air resistance as the bullet rises to its maximum altitude?

A. 54.9 J

B. 652 J

C. 707 J

D. 762 J

5. What percentage of energy is lost **during the entire flight** of the bullet?

A. 98.4%

B. 93.8%

C. 92.2%

D. 87.0%

Use the following information to answer the next two questions.

A 1 000 kg car travelling east at 29.4 m/s on an icy road hits a parked truck that has a mass of 1 500 kg. Immediately after the collision, the car was moving at 20.0 m/s in the direction 20.0° N of E, and the truck was moving at an unknown speed in the direction 45.0° S of E.

6. What physics principles do police use to determine the speed of the truck?

A. Conservation of kinetic energy but not conservation of momentum

B. Conservation of momentum but not conservation of kinetic energy

C. Both conservation of momentum and conservation of kinetic energy

D. Neither conservation of momentum nor conservation of kinetic energy

Numerical Response

4. The magnitude of the total momentum before the collision, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ kg•m/s. The values of ***a***, ***b***, ***c***, and ***d*** are __________.

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

____

7. When a charged particle accelerates in an electric field, there is a **decrease** in its

A. mass

B. charge

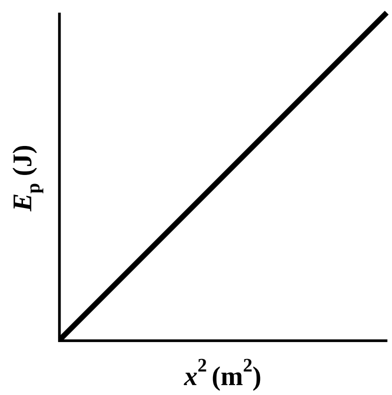
C. kinetic energy

D. potential energy

Use the following information to answer the next question.

A student has learned that the elastic potential energy stored in a spring is determined by the equation $E_p = \frac{1}{2}kx^2$, where x is the displacement of the spring from its resting (equilibrium) position and k is the spring constant for the spring. She conducts an experiment in which she stretches a spring to different lengths and determines the spring's elastic potential energy at each length. Using her data, she plots the following graph.

Potential Energy as a Function of the Square of the Extension



8. The student calculates the slope of the best-fit line. What calculation would she have to make to use this slope value to determine the value of the spring constant?

A. Divide the slope by 2.

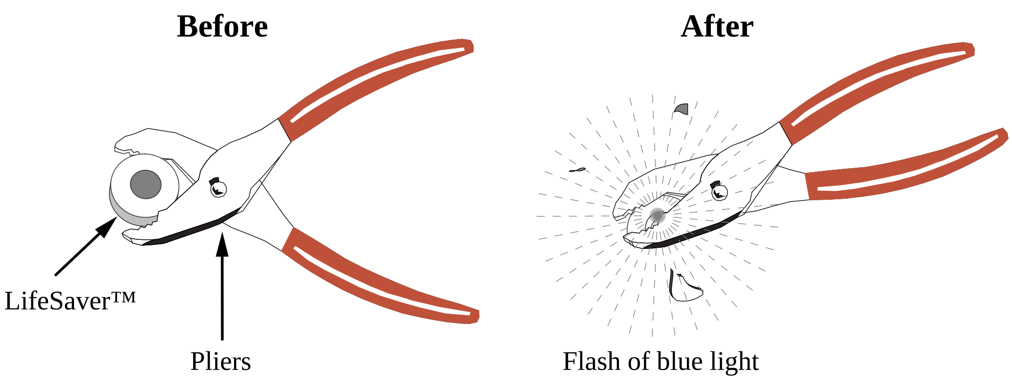
B. Divide the slope by x^2.

C. Multiply the slope by 2.

D. Multiply the slope by x^2.

Use the following information to answer the next four questions.

When a "LifeSavers™ WintOgreen" candy is crushed with pliers in a totally darkened room, a flash of blue light will be observed.



—Hershey Canada Inc.

9. If an average force of 100 N is applied on the handles of the pliers, moving them together through a distance of 4.50 mm, and if the pliers are 35% efficient, then how much energy is transferred to the actual "crushing" of the LifeSavers™ candy?

A. 4.5×10^{2} J

B. 1.6×10^{2} J

C. 4.5×10^{-1} J

D. 1.6×10^{-1} J

Numerical Response

5. If the jaws of the pliers exert an average force on the LifeSavers™ candy of 8.50×10^{2} N for 1.25×10^{-1} s, then the impulse imparted to the LifeSavers™ candy, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ N•s. The values of ***a***, ***b***, ***c***, and ***d*** are __________.

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

Use the following additional information to answer the next question.

As the LifeSavers™ candy is crushed, electrons are released and collide with nitrogen molecules in the air. These collisions cause the nitrogen molecules to emit ultraviolet radiation.

10. The emission of an ultraviolet photon from a nitrogen molecule is a result of

A. electron transitions from a lower energy level to a higher energy level

B. electron transitions from a higher energy level to a lower energy level

C. nuclear fusion of the absorbed electron

D. radioactive decay in the nucleus

Use the following additional information to answer the next question.

The ultraviolet radiation emitted by the nitrogen molecules is absorbed by atoms in the oil of wintergreen found in the LifeSavers™ candy. The atoms in the oil of wintergreen immediately re-emit some of this energy as a flash of blue light.

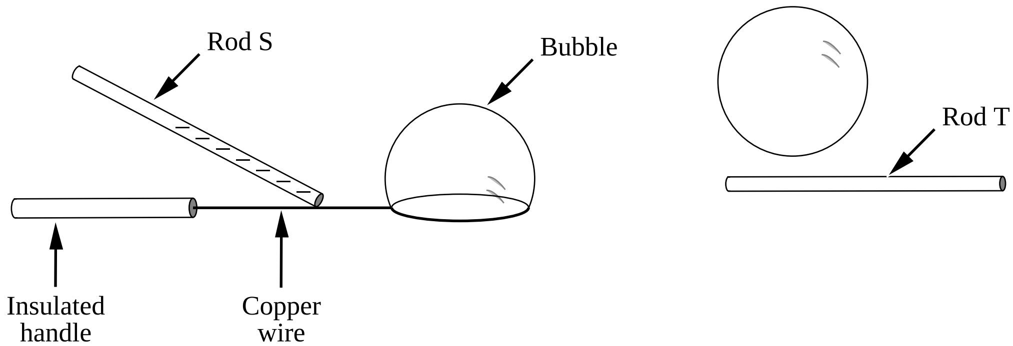
Numerical Response

6. The atoms in the oil of wintergreen absorb ultraviolet radiation with a frequency of 8.50×10^{14} Hz and re-emit blue light with a frequency of 7.50×10^{14} Hz. The energy difference in the conversion, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ J. The value of $\boldsymbol{b}$ is __________.

(Round and record your answer to three digits.)

Use the following information to answer the next question.

Electrostatic Forces



A soap bubble rests on a loop of copper wire. After the wire is touched with negatively charged rod S, the bubble is freed and suspended electrostatically above rod T.

11. The bubble is suspended because

A. rod T is negatively charged and repels the negative charges on the bubble

B. rod T is positively charged and repels the positive charges on the bubble

C. the bubble induces a negative charge on rod T and is held up by repulsion

D. the bubble induces a positive charge on rod T and is held up by repulsion

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12. The relationship between the electrical force, F, on two small, charged objects and their distance of separation, r, is represented by

A. $F \propto r$

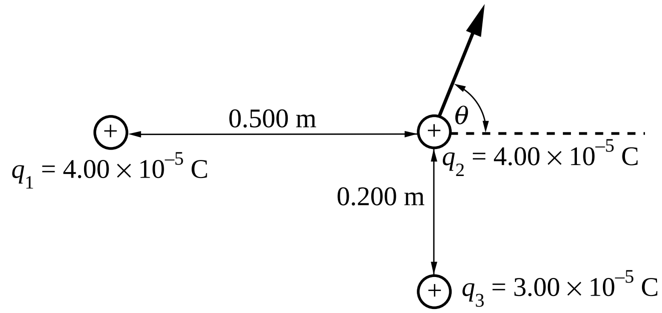
B. $F \propto 1/r$

C. $F \propto r^2$

D. $F \propto 1/r^2$

Use the following information to answer the next two questions.

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



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

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

Numerical Response

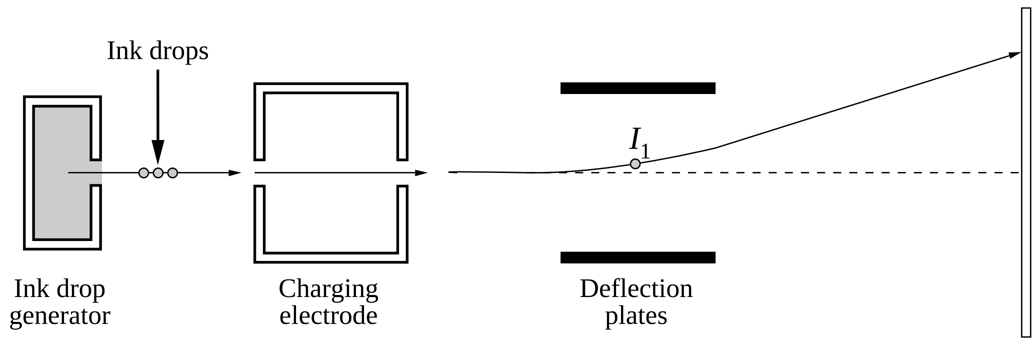
7. The angle labelled θ indicates the direction of the net electrostatic force on q_2. The value of θ is __________°.

(Round and record your answer to three digits.)

Use the following information to answer the next four questions.

Side View of the Components of an Ink-Jet Printer

The essential components of one type of ink-jet printer are shown below.



Ink drops from the generator pass through a charging electrode. By means of a signal from a computer, the charging electrode controls the charge given to the ink drops. Ink drops are deflected between the deflection plates. The amount each drop is deflected determines where it strikes the paper. A typical ink drop has a mass of 1.32×10^{-10} kg. Approximately 100 ink drops are needed to form a single letter on paper.

Ink drop I_1 has a charge of -1.51×10^{-13} C.

Numerical Response

8. The number of excess electrons given to ink drop I_1 expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ electrons. The values of ***a***, ***b***, ***c***, and ***d*** are __________.

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

14. The deflection plates are 0.100 mm apart, and there is a potential difference of 120 V across them. The magnitude of the electric field between the plates is

A. 1.20×10^{6} N/C
B. 1.20×10^{3} N/C
C. 1.20×10^{1} N/C
D. 1.20×10^{-2} N/C

Use your recorded answer for ***Multiple Choice 14*** *to solve* ***Multiple Choice 15.****

15. As the charged ink drop, I_1, moves through the deflection plates, it experiences a force with a magnitude of

A. 1.81×10^{-15} N
B. 1.81×10^{-12} N
C. 1.81×10^{-10} N
D. 1.81×10^{-7} N

***You can receive marks for this question even if the previous question was answered incorrectly.**

16. To cause ink drop I_1 to follow the path shown, the direction of the **electric field** between the charged deflection plates must be toward the

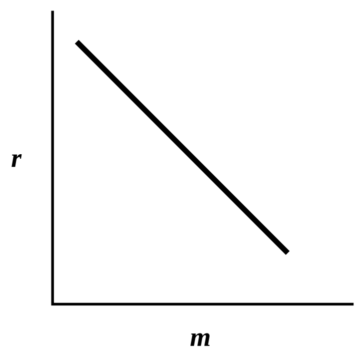
A. bottom of the page
B. top of the page
C. right of the page
D. left of the page

17. In all circuits that have a constant resistance, the power varies

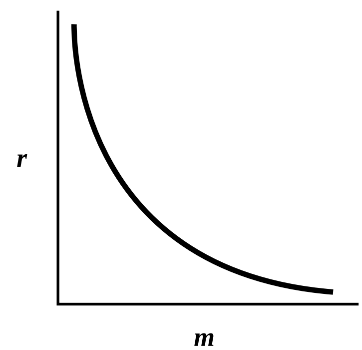
A. directly as the square of the current
B. inversely as the square of the current
C. directly as the square root of the current
D. inversely as the square root of the current

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

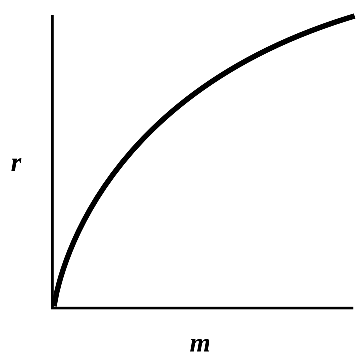
A.



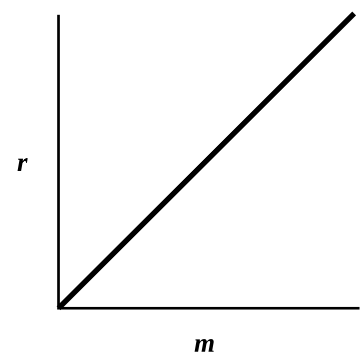
B.



C.



D.



19. Magnets can be produced when small magnetic regions in a metal line up their poles. These magnetic regions are called magnetic

A. domains

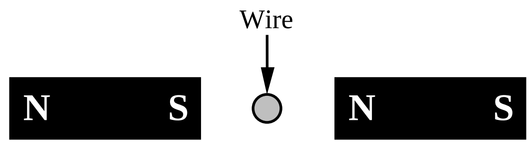
B. fields

C. atoms

D. areas

Use the following information to answer the next question.

Cross-Section of a Wire Suspended in a Magnetic Field



A wire is placed between two permanent magnets. As shown in the diagram, it is positioned so that it is perpendicular to the magnetic field and to the page. The mass of the wire is 0.850 g. The length of the wire perpendicular in the magnetic field is 1.30 cm. The resistance of the wire is 1.20 Ω.

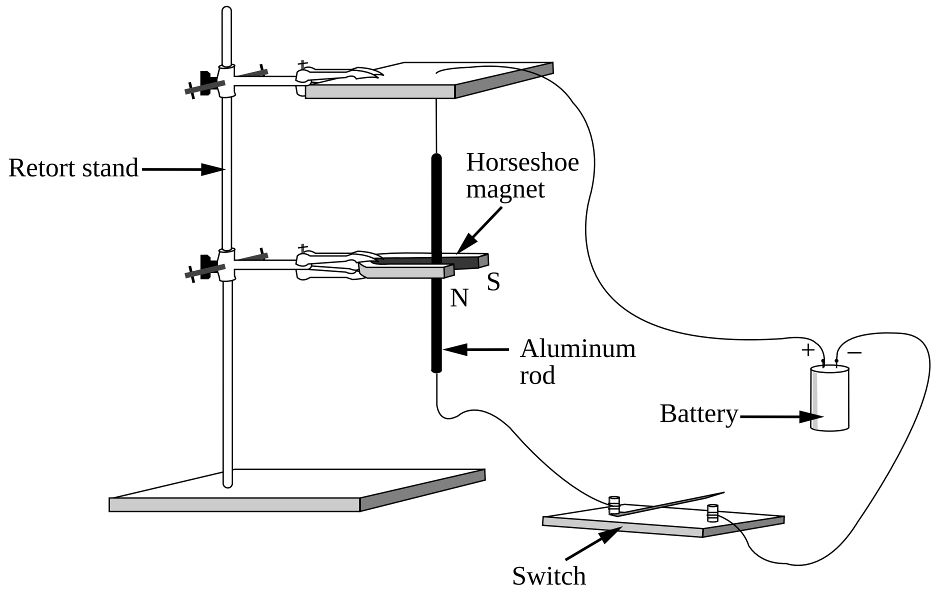
Numerical Response

9. When a potential difference of 12.0 V is applied to the wire, there is sufficient magnetic force to keep the wire supported against gravity. The magnitude of the magnetic field, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ T. The values of ***a***, ***b***, ***c***, and ***d*** are __________.

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

Use the following information to answer the next question.

The diagram below shows an experimental design used to investigate the effect of a magnetic field on a vertical current-carrying conductor. The aluminum rod is able to swing freely.



20. When the switch is closed, a current in the circuit causes the bottom end of the aluminum rod to swing

A. toward the retort stand

B. away from the retort stand

C. toward the south pole of the magnet

D. toward the north pole of the magnet

21. The power line that supplies power to a school has a voltage of 7.20×10^3 V. The transformer between the school and the line reduces this voltage to 2.40×10^2 V. If an ideal transformer delivers 3.84×10^3 J of energy every second to the school, then the current in the primary coil of the transformer is

A. 16.0 A

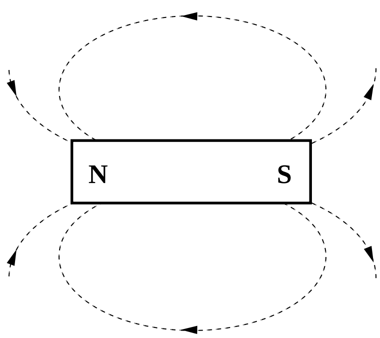
B. 1.88 A

C. 0.533 A

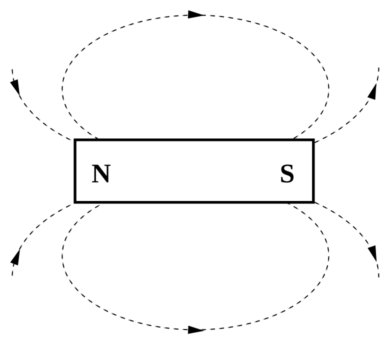
D. 0.0625 A

22. Which of the following diagrams illustrates the magnetic field surrounding a bar magnet?

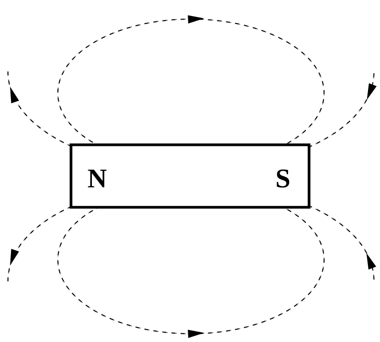
A.



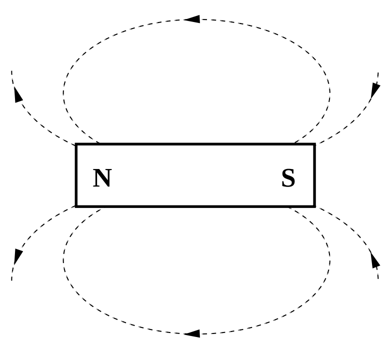
B.



C.

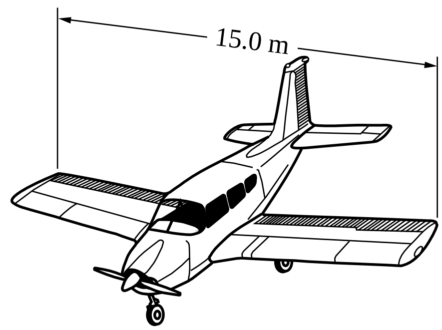


D.



Use the following information to answer the next question.

A plane has a wing span of 15.0 m. While flying directly over the north magnetic pole at 250 km/h, a potential difference is induced between the plane's wing tips. Earth's magnetic field at this position is 6.0×10^{-5} T and is perpendicular to the path of the plane.



23. The potential difference between the wing tips is

A. 2.8×10^{5} V
B. 7.7×10^{4} V
C. 2.3×10^{-1} V
D. 6.3×10^{-2} V

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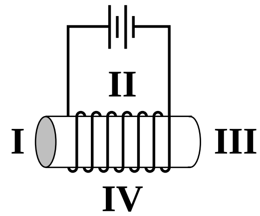
24. A stream of electrons with a given speed, *v*, enters a magnetic field of known intensity, *B*. The direction of the motion of the electrons is perpendicular to the direction of the magnetic field. Changes are made to both *B* and *v*. The radius of the circular path of the electrons will always increase when

A. *B* increases and *v* increases
B. *B* increases and *v* decreases
C. *B* decreases and *v* increases
D. *B* decreases and *v* decreases

25. The north pole of the solenoid shown below is at position



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

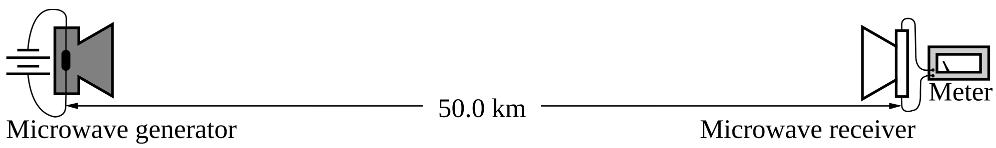
26. The wavelength of ultraviolet light is

A. shorter than that of visible light and longer than that of gamma rays
B. longer than that of visible light and shorter than that of gamma rays
C. shorter than that of visible light and longer than that of infrared rays
D. longer than that of visible light and longer than that of infrared rays

Use the following information to answer the next two questions.

Microwave Communication

A microwave generator emits photons that each have 4.37×10^{-23} J of energy. Some of these photons are detected by a microwave receiver placed 50.0 km away.



27. The time it takes microwave photons to travel from the generator to the receiver is

A. 6.00×10^{-4} s
B. 5.10×10^{-4} s
C. 3.33×10^{-4} s
D. 1.67×10^{-4} s

Numerical Response

10. The frequency of the microwave photons, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ Hz. The value of $\boldsymbol{b}$ is __________.

(Round and record your answer to three digits.)

28. Maxwell proposed the theory that an oscillating electric field generates a

A. parallel electric charge
B. constant magnetic field
C. changing magnetic field
D. perpendicular electric charge

Numerical Response

11. In a magnetic field with a strength of 5.60×10^{-2} T, an alpha particle travels in a circular path with a radius of 6.40×10^{-3} m. The speed of the alpha particle, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ m/s. The value of $\boldsymbol{b}$ is __________.

(Round and record your answer to three digits.)

29. Some cellular phones operate in the 9.0×10^{2} MHz band of the electromagnetic spectrum. The energy associated with each photon of this frequency is approximately

A. 1.4×10^{-15} eV
B. 1.4×10^{-13} eV
C. 3.7×10^{-8} eV
D. 3.7×10^{-6} eV

30. The property of cathode rays that provides the **best** evidence to suggest that they are **not** electromagnetic radiation, is that they

A. are emitted by a variety of cathode materials

B. move between electrodes at high speeds

C. can be deflected by a magnetic field

D. tend to travel in straight lines

31. The charge and the approximate diameter of a nucleus may be estimated from

A. alpha particle scattering experiments

B. X-ray diffraction experiments

C. photoelectron experiments

D. cathode-ray experiments

32. The minimum frequency of incident radiation required to raise an electron in a hydrogen atom from the ground state to the third energy level is approximately

A. 1.0×10^{-7} Hz

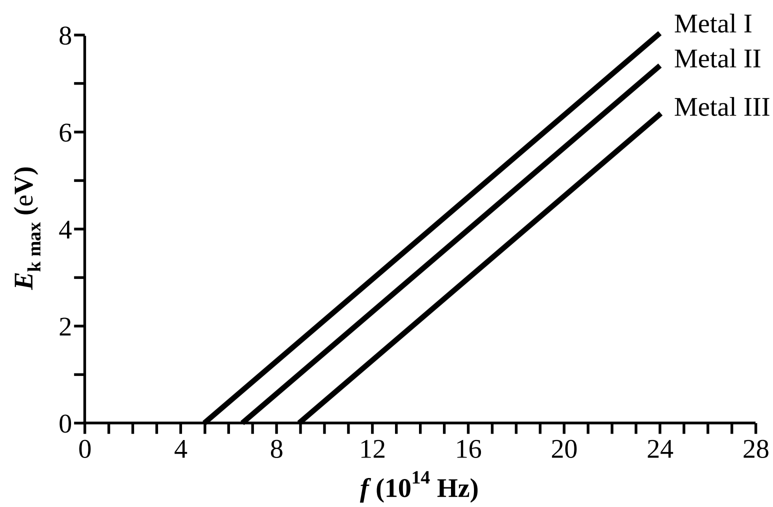
B. 3.3×10^{-2} Hz

C. 3.1×10^{1} Hz

D. 3.0×10^{15} Hz

Use the following information to answer the next question.

Maximum Kinetic Energy versus Frequency



The graph shows how the maximum kinetic energy of photoelectrons depends upon the frequency of the incident radiation for three different metals.

33. Which of the metals will emit photoelectrons when illuminated by visible light?

A. I only

B. III only

C. I and II only

D. II and III only

Use the following information to answer the next three questions.

Photochromic Glasses

Photochromic glasses are eyeglasses that darken automatically when exposed to bright sunlight. The special glass in these eyeglasses contains crystals of silver chloride (AgCl). When the glass is exposed to sunlight, the silver ions (Ag^+) are converted to atoms of metallic silver ($Ag_{(s)}$), which are dark. This process darkens the glass. The amount of energy required to convert one silver ion (Ag^+) to one metallic silver atom ($Ag_{(s)}$) is 1.21×10^{-18} J.

When the eyeglasses are moved out of the bright sunlight, they lighten automatically.

Numerical Response

12. The minimum frequency of light required to darken the glasses, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ Hz. The value of $\boldsymbol{b}$ is __________.

(Round and record your answer to three digits.)

34. When the eyeglasses are worn indoors, they do not darken. This is because the photons from incandescent bulbs have

A. sufficient energy to convert Cl^- ions to Cl atoms

B. insufficient energy to pass through the special glass

C. insufficient energy to continue to convert Ag^+ ions to Ag atoms

D. sufficient energy to cause photoelectric emission of the Ag atoms

35. The type of electromagnetic radiation present in sunlight that is required to darken photochromic glasses is

A. infrared

B. ultraviolet

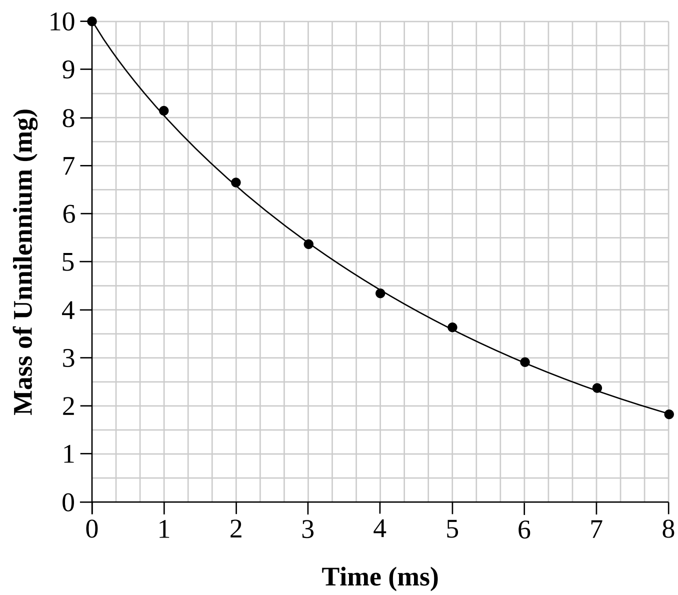
C. microwave

D. visible light

Use the following information to answer the next two questions.

As artificial elements are created, they are added to the periodic table. In 1982, the 109th element, unnilennium, was created. It was found that unnilennium emits alpha particles as it decays.

Radioactive Decay of Unnilennium



36. The nuclear equation describing this decay is

A. ${}^{266}_{109}\text{Une} \rightarrow {}^{262}_{107}\text{Uns} + {}^{4}_{2}\text{He}$

B. ${}^{266}_{109}\text{Une} \rightarrow {}^{266}_{110}\text{Und} + {}^{0}_{-1}\text{e}$

C. ${}^{266}_{109}\text{Une} \rightarrow {}^{266}_{109}\text{Une} + \gamma$

D. ${}^{266}_{109}\text{Une} \rightarrow {}^{265}_{108}\text{Uno} + {}^{1}_{1}\text{H}$

37. As determined from the graph, the half-life of unnilennium is between

A. 1 ms and 2 ms

B. 2 ms and 3 ms

C. 3 ms and 4 ms

D. 4 ms and 5 ms

Use the following information to answer the next question.

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

Written Response – 15%

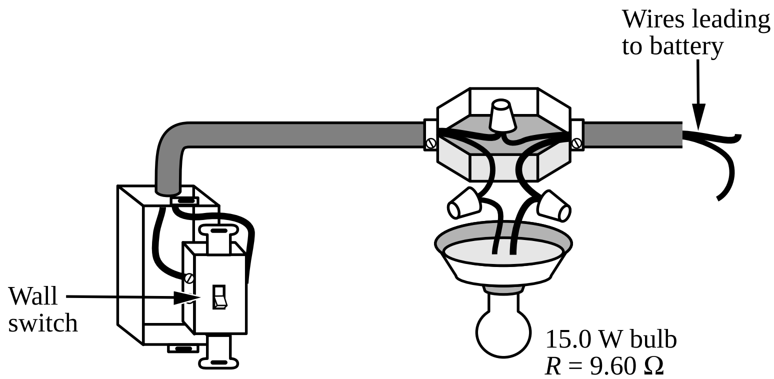
1. Describe a procedure for determining which types of radiation are being emitted by the soil sample. Include:

- a safety note to the rest of the clean-up crew describing the dangers associated with **one** of the three forms of radiation
- a description of the method you would use to identify alpha particles, beta particles, and gamma rays
- an explanation of how you would use your results to identify the types of radiation emitted by the soil

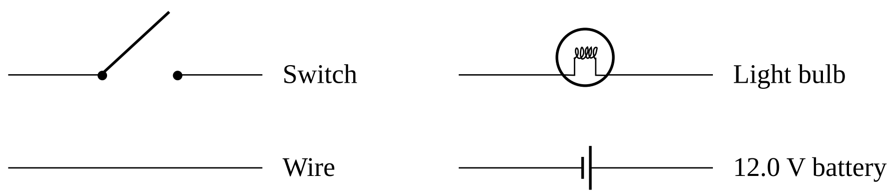
Note: A maximum of 8 marks will be awarded for the physics used to solve this problem. A maximum of 3 marks will be awarded for the effective communication of your response.

Use the following information to answer the next question.

The diagram below illustrates how a single light fixture is connected to a battery and switch, as might be found in a recreational vehicle (RV).



The following schematic symbols represent circuit components.



Written Response – 15%

2. • Using the symbols shown above, draw and label a schematic diagram representing this circuit.

- Draw and label a second schematic diagram containing one switch, the 12.0 V battery, and a 3.0 W nightlight bulb in parallel with the 15.0 W bulb. Design this two-light-bulb circuit so that the switch controls only the 15.0 W bulb.
- Describe what happens to the 3.0 W bulb and the 15.0 W bulb when the switch is open and when it is closed in the two-light-bulb circuit.
- Calculate the total power, total current, and total resistance of the two-light-bulb circuit when the switch is closed.

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

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 $9.81\ \text{N/kg}$
Gravitational Constant	$G = 6.67 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$
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	$k = 8.99 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2$
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	$E_1 = -2.18 \times 10^{-18}\ \text{J}$ or $-13.6\ \text{eV}$
Planck's Constant	$h = 6.63 \times 10^{-34}\ \text{J}\bullet\text{s}$ or $4.14 \times 10^{-15}\ \text{eV}\bullet\text{s}$
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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Dynamics

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

$F_{\text{g}} = \frac{Gm_1 m_2}{r^2}$

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

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

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

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

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

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

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

Momentum and Energy

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

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

$W = Fd$

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

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

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

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

Waves and Light

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

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

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

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

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

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

$v = f\lambda$

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

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

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

Atomic Physics

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

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

$W = hf_0$

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

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

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

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

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

Quantum Mechanics and Nuclear Physics

$E = mc^2$

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

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

Electricity and Magnetism

$F_{\text{e}} = \frac{kq_1 q_2}{r^2}$

$V = IR$

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

$P = IV$

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

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

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

$F_{\text{m}} = IlB_{\perp}$

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

$F_{\text{m}} = qvB_{\perp}$

$V = lvB_{\perp}$

$R = R_1 + R_2 + R_3$

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

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

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

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

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
Symbol ←	Li
Atomic molar mass →	6.94
Name →	lithium

Based on $^{12}_{6}C$
( ) Indicates mass of the most stable isotope

Tear-out Page

Tear-out Page

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

Fold and tear along perforation.

mm

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

Tear-out Page

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

Fold and tear along perforation.

mm

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

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

PHYSICS 30

DIPLOMA EXAMINATION

JUNE 1998

Multiple Choice
and
Numerical Response
Key

Written Response
Scoring Guide

Physics 30 – June 1998
MULTIPLE-CHOICE KEY

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

NUMERICAL-RESPONSE KEY

1.	2431
2.	1423*
3.	4431
4.	2944
5.	1062
6.	6.63
7.	78.0
8.	9445
9.	6412
10.	6.59
11.	1.71, 1.72
12.	1.83

*If MC1 is A, then NR 2 is 1553
B, then NR 2 is 1423
C, then NR 2 is 1103
D, then NR 2 is 9982

**If MC14 is A, then MC 15 is D
B, then MC 15 is C
C, then MC 15 is B
D, then MC 15 is A
If MC 15 is D, then it is always correct

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 how to detect and identify each of the three types of radiation and provides an appropriate safety note relating to the danger associated with one type of radiation • provides a complete description of the method used and explicitly shows how the results are used to identify the radiation type • 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 how to detect and identify the radiation and provides an appropriate safety note relating to the danger associated with one type of radiation • provides a description of the method used and implicitly shows how the results are used to identify the radiation type • 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 radiation • provides a description of the method used and/or explains how to identify the radiation • 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 radiation • provides a correct explanation of one aspect of radiation • 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 radiation • does not provide a description of the method used • may have formula and substitution but they do not address the question • has, if present, diagrams and/or sketches that are incorrect, inappropriate, and incomplete • has major omissions
NR	No response is given.

Use the following information to answer the next question.

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

Written Response – 15%

1. Describe a procedure for determining which types of radiation are being emitted by the soil sample. Include:

- a safety note to the rest of the clean-up crew describing the dangers associated with **one** of the three forms of radiation
- a description of the method you would use to identify alpha particles, beta particles, and gamma rays
- an explanation of how you would use your results to identify the types of radiation emitted by the soil

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

The marks are arrived at in the following manner.
Take the level the response is at from the ***Holistic Scoring Guide Physics CONTENT***
and multiply by two ($4 \times 2 = 8$).

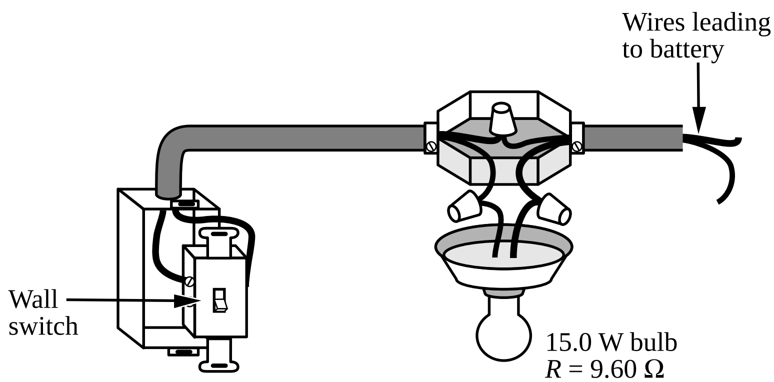
Add the score from the
Holistic Scoring Guide Physics COMMUNICATION ($8 + 3 = 11$).

"Anaholistic" Scoring Guide

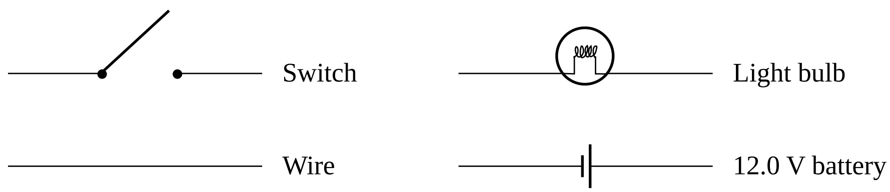
Major Concepts: Drawing schematic diagram; Drawing a parallel circuit; Operation of parallel circuit; Power and Ohm's Law relationships	
Level	**Criteria**
NR	No response is given.
0	The response: • identifies an area of physics that does not apply to the major concepts • uses inappropriate formulas, diagrams, and/or explanations
1	The response: • attempts at least two of the major concepts **or** uses an appropriate method that reflects a good understanding of one of the major concepts • errors in the formulas, diagrams, and/or explanations are present and the answer is not consistent with calculated results
2	The response: • uses an appropriate method that reflects a basic understanding of three of the four major concepts **or** a good understanding of two of the major concepts • has formulas and/or diagrams that are implicitly correct, but the applications of these are not made to the final solution **or** errors in application of equations are present but the answer is consistent with calculated results
3	The response: • uses an appropriate method that reflects a basic understanding of all four of the major concepts **or** a good understanding of three of the major concepts • uses an appropriate method that reflects an excellent understanding of two of the major concepts **and** a basic understanding of one of the two remaining concepts • formulas and/or diagrams may be implicit, but are applied correctly; errors in calculations and/or substitutions are present which hinder the understanding of the physics content • explanations are correct but lack detail • has a major omission or inconsistency
4	The response: • uses an appropriate method that reflects a good understanding of all of the major concepts **or** an excellent understanding of three of the major concepts • explanations are correct and detailed • most formulas are explicit and are applied correctly • has minor errors, omissions, or inconsistencies in calculations and/or substitutions but these do not hinder the understanding of the physics content • most diagrams are appropriate, correct, and complete • may have errors in units, significant digits, rounding or graphing
5	The response: • uses an appropriate method that reflects an excellent understanding of all the major concepts • provides a complete description of the method used and shows a complete solution to the problem • explicitly states formulas • may have a minor error, or omission, or inconsistency, but it does not hinder the understanding of the physics content • diagrams are appropriate, correct and complete • may have an error in significant digits or rounding

Use the following information to answer the next question.

The diagram below illustrates how a single light fixture is connected to a battery and switch, as might be found in a recreational vehicle (RV).

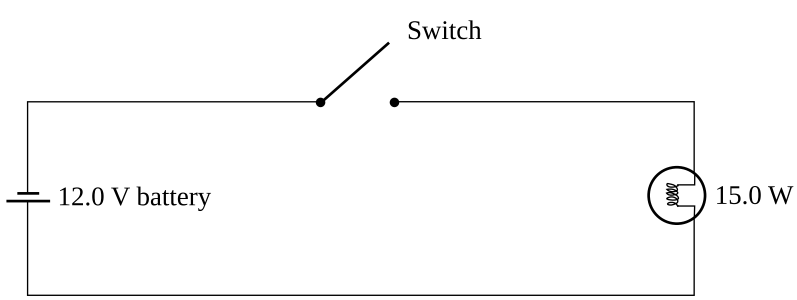


The following schematic symbols represent circuit components.

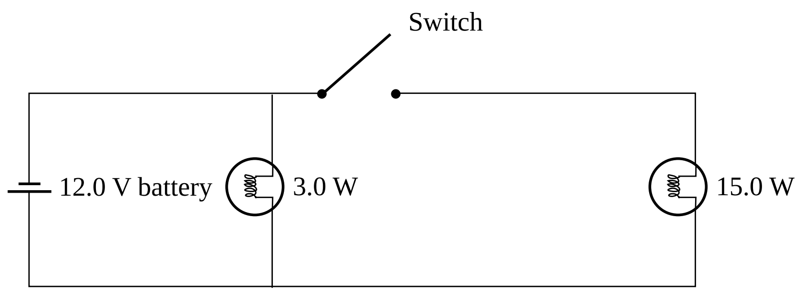


Written Response – 15%

2. • Using the symbols shown above, draw and label a schematic diagram representing this circuit.



- Draw and label a second schematic diagram containing one switch, the 12.0 V battery, and a 3.0 W nightlight bulb in parallel with the 15.0 W bulb. Design this two-light-bulb circuit so that the switch controls only the 15.0 W bulb.



- Describe what happens to the 3.0 W bulb and the 15.0 W bulb when the switch is open and when it is closed in the two-light-bulb circuit.

When the switch is open there is a current through the 3.0 W bulb and the bulb is lit. There is no current through the 15.0 W bulb.

When the switch is closed there is a current through both bulbs and therefore both bulbs are lit.

The brightness of the 3.0 W bulb does not change whether the switch is open or closed.

- Calculate the total power, total current, and total resistance of the two-light-bulb circuit when the switch is closed.

$$\begin{aligned} P_T &= P_{15} + P_3 \\ &= 15.0\text{ W} + 3.0\text{ W} \\ P_T &= 18.0\text{ W} \end{aligned}$$

$$\begin{aligned} P_T &= I_T V_T \\ I_T &= \frac{P_T}{V_T} \\ &= \frac{18.0\text{ W}}{12.0\text{ V}} \\ I_T &= 1.50\text{ A} \end{aligned}$$

$$\begin{aligned} V_T &= I_T R_T \\ R_T &= \frac{V_T}{I_T} \\ &= \frac{12.0\text{ V}}{1.50\text{ A}} \\ R_T &= 8.00\ \Omega \end{aligned}$$