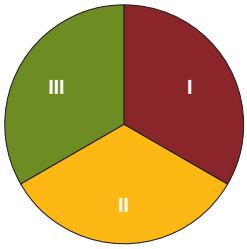
Physics: Content Essays (0262)

Test at a Glance

Test Name	**Physics: Content Essays**
Test Code	**0262**
Time	**1 hour**
Number of Questions	**3 essay questions**
Format	**Exercises pose in-depth questions requiring integrated written responses in English**



Content Categories		Approximate Number of Questions	Approximate Percentage of Examination
I.	Matter and Energy	1	33.3%
II.	Fields and Waves	1	33.3%
III.	Science, Technology, and Society	1	33.3%

About This Test

The Physics: Content Essays test measures the knowledge and competencies necessary for a beginning teacher of physics at a secondary school level. The test assesses examinees' ability to use and analyze critical science concepts in physics and to integrate knowledge from science, technology, and society. Examinees have typically completed or nearly completed a bachelor's degree program in physics, with appropriate coursework in education.

The one-hour test consists of three equally weighted questions. Two questions test both an area of content knowledge and a specific scientific skill; the third question covers the impact of physics on technology and society. Examinees construct their responses to a content question in the context of a specific skill. For instance, one question may ask examinees to discuss fields and waves from the vantage of data analysis and experimental design.

The areas of content knowledge include matter and energy, fields and waves, and the impact of physics on technology and society. (For a description of these content areas, see the Physics: Content Knowledge Test 0265.)

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Scientific skill areas include concepts, models, systems, and patterns, as well as data analysis, experimental design, and investigations:

- Data analysis, experimental design, and investigation questions evaluate examinees' ability to design experiments that test simple hypotheses, analyze and interpret data, suggest demonstrations that illustrate concepts, and propose investigations within a specific content area.
- Concepts, models, and systems questions evaluate examinees' ability to use scientific knowledge to formulate major concepts; to understand model use and limitations and communicate the process by which scientists create and use models; and to understand the interacting components of a system. Patterns content addresses examinees' ability to recognize and relate patterns in the physical world in terms of connections, trends, cycles, and irregular changes over space and time. The emphasis is on the underlying causes and mechanisms of the observed patterns.
- Science, technology, and society questions evaluate examinees' ability to discuss the impact of science and technology on society and to demonstrate an understanding of the scientific concepts and principles involved.

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Sample Test Questions

This section presents sample questions and constructed-response samples along with the standards used in scoring the essays. When you read these sample responses, keep in mind that they will be less polished than if they had been developed at home, edited, and carefully presented. Examinees do not know what questions will be asked and must decide, on the spot, how to respond. Readers take these circumstances into account when scoring the responses.

Readers will assign scores based on the following scoring guide.

SCORING GUIDE

5

- Demonstrates a superior understanding of the science concepts required by the question
  - gives clear, accurate, and well-reasoned explanations
  - uses accurate scientific terminology throughout
  - when required, provides accurate and well-chosen supporting evidence (e.g., physical laws, definitions, examples)
  - any diagrams, tables, and graphs presented are complete, clear, accurate, and well organized

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- Demonstrates a strong understanding of the science concepts required by the question
  - gives clear, accurate, and logical explanations
  - uses accurate scientific terminology
  - when required, provides accurate and relevant supporting evidence (e.g., physical laws, definitions, examples)
  - any diagrams, tables, and graphs presented are generally complete, accurate, and organized

3

- Demonstrates an adequate understanding of the science concepts required by most parts of the question
  - gives generally clear, accurate, and logical explanations
  - uses some accurate scientific terminology
  - when required, provides generally accurate and relevant supporting evidence (e.g., physical laws, definitions, examples)
  - any diagrams, tables, and graphs presented are sufficiently complete and accurate

2

- Demonstrates a limited understanding of the science concepts required by the question, as evidenced by one or more of the following characteristics:
  - may give insufficiently accurate and/or poorly developed explanations
  - may lack accurate scientific terminology
  - when required, may give very limited supporting evidence (e.g., physical laws, definitions, examples)
  - any diagrams, tables, and graphs presented may be incomplete and/or inaccurate

1

- Demonstrates very little understanding of the science concepts required by the question, as evidenced by one or more of the following characteristics:
  - may give inaccurate, illogical, incoherent, or seriously incomplete explanations
  - may fail to use accurate scientific terminology
  - may give little or no supporting evidence (e.g., physical laws, definitions, examples)
  - any diagrams, tables, and graphs presented may be seriously inaccurate, confusing, or incomplete

0

- Completely inaccurate or inappropriate, blank, or off topic

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Sample Essay Question 1

The explanation of the photoelectric effect, for which Albert Einstein received the Nobel Prize in 1921, is one of the triumphs of twentieth-century physics.

A. Describe the photoelectric effect.

B. Discuss the influences of changing the wavelength (or the frequency) of the light, the intensity of the light, and the nature of the material being illuminated.

Sample Response That Received a Score of 5:

A. The photoelectric effect refers to the ejection of electrons from a metal illuminated by radiation. The theoretical explanation of the photoelectric effect by A. Einstein is one of the triumphs of twentieth century physics. According to Einstein, the incident light consists of quanta of energy, or photons, that are absorbed by the electrons in the metal. The energy E of the ejected electrons is equal to $h\nu - E_o$, where ν is the frequency of the incident light, h is Planck's constant, and E_o is the work function of the metal. The photon energy, $h\nu$, must exceed E_o or no electrons will be emitted from the metal. Einstein's explanation of the photoelectric effect was confirmed experimentally by Millikan.

B. Increasing the frequency of the incident light increases the energy of the ejected photoelectrons, while decreasing the frequency eventually results in no photoelectrons being ejected. Increasing the intensity of the incident light increases the number of photoelectrons emitted, but has no effect on their energy. Different materials have different work functions and this can affect the energy of the photoelectrons.

Sample Response That Received a Score of 3:

A. The photoelectric effect, for which Albert Einstein received the Nobel Prize, is concerned with the particle-like nature of light. It describes light as photons, or packets of energy, that can interact with electrons.

The theory seeks to explain that light displays wave features as well as displaying particle characteristics. The energy of the photon is expressed as $E = h / \lambda$ or $E = h\nu$, where E is energy, h is Planck's constant, λ is the wavelength of the light, and ν is the frequency of the light.

B. As the wavelength of a photon decreases, its energy increases. That means more electrons will be emitted from the material being illuminated. Since light intensity is a measure of the number of photons incident upon a given area, increasing the intensity means more electrons will be emitted. The material being illuminated has a work function that limits the number of electrons that can escape.

Sample Response That Received a Score of 1:

A. The photoelectric effect describes the wavelike nature of light.

B. Changing the intensity of the light changes its wavelength and frequency.

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Sample Essay Question 2

Explain what a nuclear reactor is and how it functions to produce electrical energy. Include in your discussion an explanation of the following terms:

Control rod
Moderator
Chain reaction
Shielding
Critical mass

Discuss two problems associated with the development and use of nuclear power plants.

Sample Response That Received a Score of 5:

A nuclear reactor is a device in which nuclear fission is carried out at a controlled rate.

The fuel in a nuclear reactor is a core of fissionable material, e.g., uranium oxide of critical mass, or the minimum mass required for a chain reaction to occur.

A chain reaction is a self-sustaining reaction, a series of reactions in which the products of the reaction initiate other similar reactions. In a nuclear reaction, a number of neutrons are produced per fission reaction, thereby making neutrons available for subsequent reactions.

The chain reaction releases heat which is used to heat water to steam. Turbines are then used to transform the steam into electricity.

The moderator (e.g., water, graphite) is a material that slows down neutrons ejected in the nuclear reaction to the speed necessary to sustain a chain reaction. Neutrons are not absorbed by, nor do they react with, the moderator.

Control rods are raised and lowered as necessary to absorb excess neutrons in order to prevent the production of excess heat and the possibility of a meltdown.

The shielding is the protection surrounding the reaction vessel, the entire reactor, and the personnel operating the system.

Some of the problems associated with the development and use of nuclear power plants are: meltdown, environmental contamination, the high cost in terms of dollars and energy of isotope separation, the reprocessing of spent fuel, waste storage, and a limited supply of the fuel resource.

The fears associated with some of these problems (e.g., leaks, waste disposal, and runaway reactions) are primarily based on the known ability of radioactivity to cause harm to the environment and living organisms.

Studies have shown a higher than average incidence of cancer cases and birth defects around a number of nuclear power plants. This raises questions about the integrity of day-to-day plant operations. Leaks, for example, have occurred at a number of nuclear plants around the world. Some of the leaks have been attributed to poor design, some to uncontrollable circumstances, and still others to negligence. More safeguards are required.

The relatively long half-lifes of the by-products of nuclear reactions make the storage and/or disposal of waste a major issue. The present level of waste disposal technology is still unable to solve many of the problems that exist in this area.

Sample Response That Received a Score of 3:

A nuclear reactor generates electricity using radioactive materials such as uranium. The control rod and the moderator affect the rate of the reaction. A chain reaction results in a large enough number of reactions to produce sufficient energy. The critical mass is the smallest amount of radioactive material required for a chain reaction to occur. The shielding protects the facility and personnel from harmful radiation. Two problems are radioactive waste disposal and contamination.

Sample Response That Received a Score of 1:

A nuclear reactor is a device intended for the nuclear reactions required to produce electricity for humans to use in their everyday lives. Basically, it consists of uranium or other nuclear material that is radioactive. When placed under proper conditions (under protective shielding for safety reasons), the nuclear reactions produced in a chain release heat, which in turn is transformed by means of turbines into electric power.

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