AP® Physics C: Electricity and Magnetism

Course Overview

About the Advanced Placement Program® (AP®)

The Advanced Placement Program® has enabled millions of students to take college-level courses and earn college credit, advanced placement, or both, while still in high school. AP Exams are given each year in May. Students who earn a qualifying score on an AP Exam are typically eligible, in college, to receive credit, placement into advanced courses, or both. Every aspect of AP course and exam development is the result of collaboration between AP teachers and college faculty. They work together to develop AP courses and exams, set scoring standards, and score the exams. College faculty review every AP teacher's course syllabus. We commit to supporting educators and communities in their efforts to make AP courses widely available, advancing students in their plans for college and careers.

AP Physics Program

The AP Program offers four physics courses:

AP Physics 1: Algebra-Based is a full-year course that is equivalent to a first-semester introductory college course in algebra-based physics.

AP Physics 2: Algebra-Based is a full-year course that is equivalent to a second-semester introductory college course in algebra-based physics.

AP Physics C: Mechanics is a full-year course that is equivalent to a semester-long introductory calculus-based college course.

AP Physics C: Electricity and Magnetism is a full-year course following Physics C: Mechanics and is equivalent to a semester-long introductory calculus-based college course.

AP Physics C: Electricity and Magnetism Course Overview

AP Physics C: Electricity and Magnetism is a calculus-based, college-level physics course, especially appropriate for students planning to specialize or major in physical science or engineering. The course explores topics such as electrostatics; conductors, capacitors, and dielectrics; electric circuits; magnetic fields; and electromagnetism. Introductory differential and integral calculus are used throughout the course.

PREREQUISITES

Students should have taken or be concurrently taking calculus.

LABORATORY REQUIREMENT

This course requires that 25% of instructional time be spent in hands-on laboratory work, with an emphasis on inquiry-based investigations that provide students with opportunities to demonstrate the foundational physics principles and apply the science practices. Colleges may require students to present their laboratory materials from AP science courses before granting college credit for laboratory work, so students are encouraged to retain their notebooks, reports, and other materials.

AP Physics C: Electricity and Magnetism Course Content

The course content is organized into six commonly taught units, which have been arranged in the following suggested, logical sequence.

- **Unit 8:** Electric Charges, Fields, and Gauss's Law
- **Unit 9:** Electric Potential
- **Unit 10:** Conductors and Capacitors
- **Unit 11:** Electric Circuits
- **Unit 12:** Magnetic Fields and Electromagnetism
- **Unit 13:** Electromagnetic Induction

Each unit is broken down into teachable segments called topics.

AP Physics C: Electricity and Magnetism Science Practices

The following science practices describe what skills students should develop during the course:

- **Creating Representations:** Create representations that depict physical phenomena.
- **Mathematical Routines:** Conduct analyses to derive, calculate, estimate, or predict.
- **Scientific Questioning and Argumentation:** Describe experimental procedures, analyze data, and support claims.

AP Physics C: Electricity and Magnetism Exam Structure

AP PHYSICS C: ELECTRICITY AND MAGNETISM EXAM—3 HOURS

Assessment Overview

The AP Physics C: Electricity and Magnetism Exam assesses student application of the science practices and understanding of the learning objectives outlined in the course framework. The exam is 3 hours long and includes 42 multiple-choice questions and 4 free-response questions. The 4 free-response questions appear in the order listed in the table. A four-function, scientific, or graphing calculator is allowed on both sections of the exam.

Format of Assessment

Section I:	Multiple Choice | 42 Questions | 85 Minutes | 50% of Exam Score
Section II:	Free Response | 4 Questions | 95 Minutes | 50% of Exam Score

- **Question 1:** Mathematical Routines (10 points)
- **Question 2:** Translation Between Representations (12 points)
- **Question 3:** Experimental Design and Analysis (10 points)
- **Question 4:** Qualitative/Quantitative Translation (8 points)

Exam Components

Sample Multiple-Choice Question

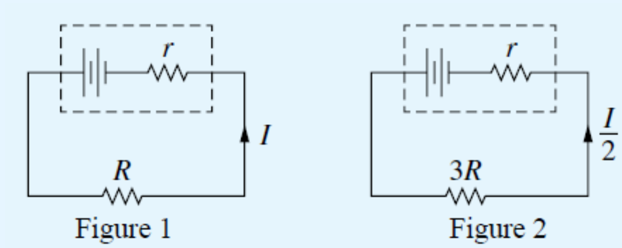
When a nonideal battery is connected to a resistor with resistance R, as shown in Figure 1, the current in the circuit is I. When the same nonideal battery is connected to a resistor with resistance $3R$, as shown in Figure 2, the current in the circuit is $\frac{I}{2}$. What is the internal resistance r of the battery?

(A) $\frac{R}{4}$

(B) $\frac{R}{2}$

(C) R

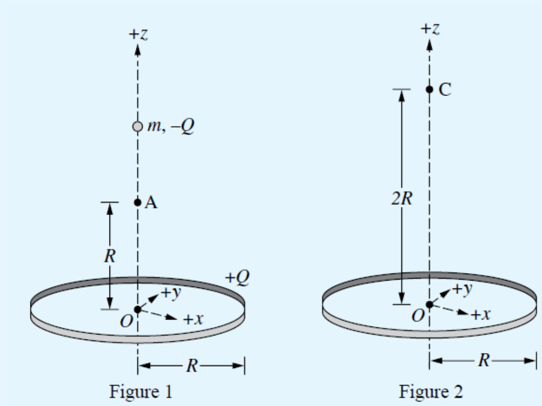
(D) $2R$



Correct Answer: C

Sample Free-Response Question: Mathematical Routines

A thin, nonconducting ring is held fixed in the xy-plane with its center at the origin O. The ring has radius R and a positive charge $+Q$ uniformly distributed around its circumference. A small sphere of mass m and negative charge $-Q$ is on the z-axis, as shown in Figure 1. Point A is located on the z-axis at $z = R$.



A. i. In which of the following regions, if any, can the sphere be placed on the z-axis so that the net electric potential at Point A due to the sphere and the ring is zero? **Indicate** your answer by writing one of the following:

- Above Point A only
- Below Point A only
- Either above or below Point A
- There is no location the sphere can be placed so that the net electric potential is zero.

Briefly **justify** your reasoning.

ii. The sphere is released from the rest on the z-axis some distance above the ring. All forces other than the electric force exerted by the ring are negligible. The sphere passes through the origin O, where it has speed v_0, and continues moving, eventually passing through location $z = -3R$. **Derive** an expression for the speed of the sphere at the instant the sphere passes through the location $z = -3R$. Express your answer in terms of m, Q, R, v_0, and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

The sphere is then removed. Figure 2 shows the ring and Point C, which is located at $z = 2R$ on the z-axis.

B. **Derive** an expression for the magnitude of the electric field due to the ring at Point C. Express your answer in terms of Q, R, and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.