AP® CollegeBoard

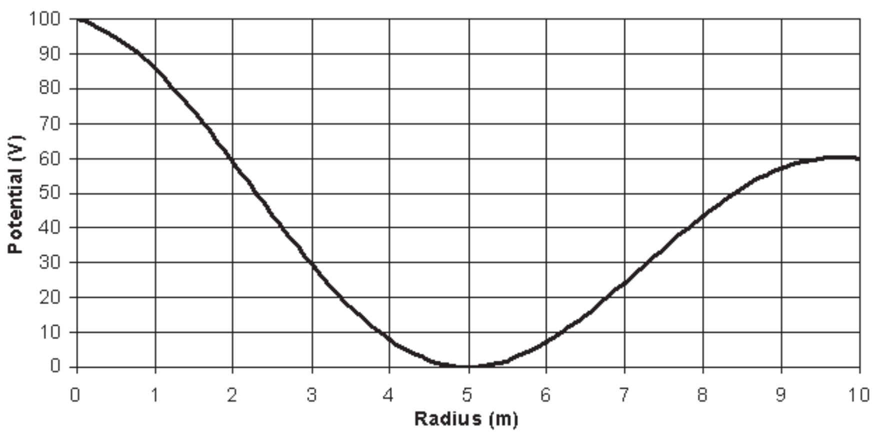
2020 Exam Sample Questions

AP® PHYSICS C: ELECTRICITY AND MAGNETISM

2020 Exam Sample Question 1

Allotted time: 25 minutes (+ 5 minutes to submit)

This question should take approximately 25 minutes. Read each of the parts carefully. Support your answers with relevant physics principles. The parts within the question may not have equal weight. Write your answers in the parts provided after each part. If you find you are in need of symbolic notation that is too difficult to type, you may identify a non-standard symbol and use that throughout your answer. For example, you may identify "Q" as the measurement for an angle.



A large, nonconducting sphere of radius $R = 10\text{ m}$ is fixed in space and carries a spherically symmetrical charge distribution. The sign and density of the charge distribution changes as a function of radius r from the center of the sphere, represented by $\rho(r)$. A hole extends from one side of the sphere, through the sphere's center, and to the opposite side of the sphere. A small nonconducting ball carries a positive net charge and is placed within the hole. The location of the ball is x. The friction between the nonconducting ball and the sphere is negligible, and the ball does not exchange charge with the larger sphere. Gravitational effects are negligible. The graph shows the electric potential $V(r)$ at points in the hole between the center of the sphere at $r = 0\text{ m}$ and at the right end of the sphere at $r = 10\text{ m}$ as a function of r.

(a) What is the farthest position from the center of the sphere from which the ball may be released from rest and exit the sphere? Justify your answer.

(b) The ball is released from the position indicated in part (a) and exits the sphere. Describe the magnitude and direction of the ball's acceleration between $r = 5\text{ m}$ and $r = 10\text{ m}$. Justify your answer.

A student wishing to model the electric field within the hole for $0 < r < 10\text{ m}$ suggests the equation $E(r) = A(B - r)$ where $A = 4\text{ V/m}^2$ and $B = 5\text{ m}$. Consider positive values of $E(r)$ to be directed rightward.

(c) State one feature of this equation that correctly models the electric field within the hole. Justify your answer.

(d) State one feature of this equation that does NOT correctly model the electric field within the hole. Justify your answer.

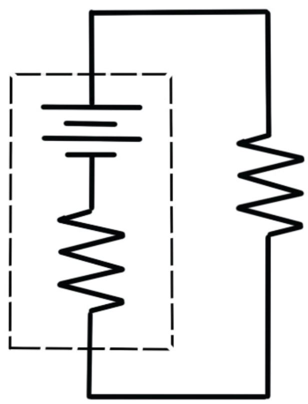
The student checks their work, corrects their mistakes, and derives the correct expression of the function $E(r)$. The student then wishes to derive an expression for $\rho(r)$, the charge density of the sphere as a function of r.

(e) Explain the steps that the student must follow in order to derive $\rho(r)$ from $E(r)$.

2020 Exam Sample Question 2

Allotted time: 15 minutes (+ 5 minutes to submit)

This question should take approximately 15 minutes. Read each of the parts carefully. Support your answers with relevant physics principles. The parts within the question may not have equal weight. Write your answers in the parts provided after each part. If you find you are in need of symbolic notation that is too difficult to type, you may identify a non-standard symbol and use that throughout your answer. For example, you may identify "Q" as the measurement for an angle.



A group of students are to experimentally determine the internal resistance r of a battery using the circuit created as shown. The battery is assumed to have an internal resistance r and constant emf $\mathcal{E}$. The students are expected to find the internal resistance by plotting their data in a graph. The students have access to equipment including, but not limited to, a variety of resistors, multimeters, and other equipment commonly found in a high school physics laboratory.

(a) Clearly identify each quantity to be measured, the symbol used to represent that quantity, and the equipment that would be used to measure the quantity.

(b) Describe the procedure to be used to determine the internal resistance of the battery. Provide enough detail so that another student could replicate the experiment, including any steps necessary to reduce experimental uncertainty. As needed, use the symbols defined in part (a).

(c) Which quantities (raw data or calculated from the data) would be graphed on the x and y axes to produce a graph that could be used to determine the internal resistance of the battery?

(d) Describe which information from the graph described in part (c) would be used and how it would be used to determine the internal resistance of the battery.

(e) After completing their calculations, the students begin to consider the factors that might have produced uncertainties in their results. The students realized that they did not take into account the resistance of the wires used to connect the circuit. Briefly describe how this would affect their calculated value of the internal resistance of the battery. Explain your reasoning.