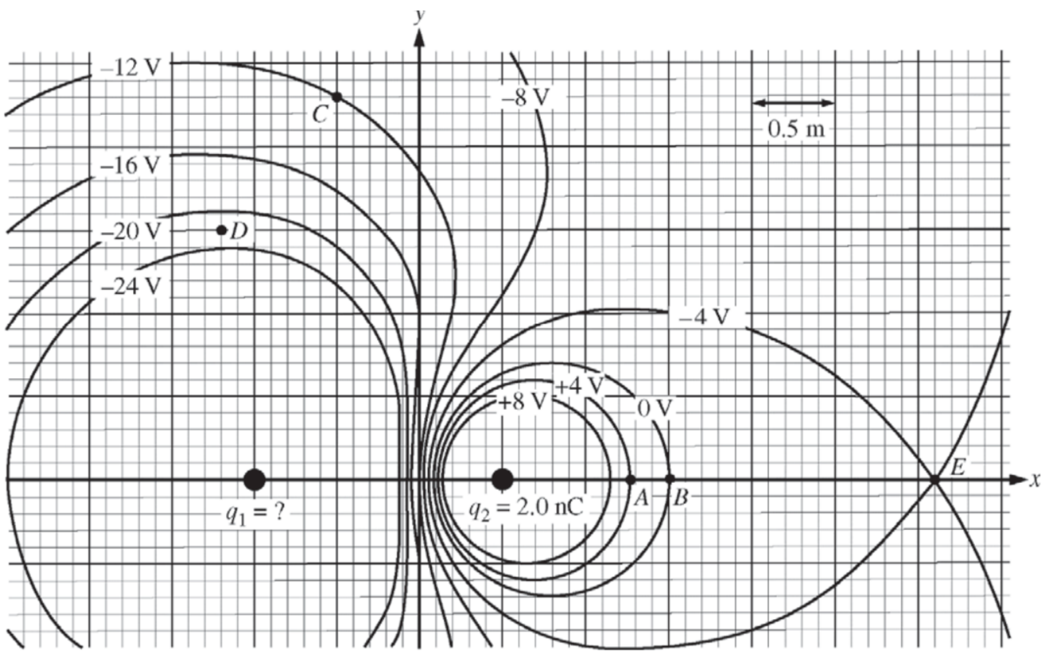
AP Exam Practice
EM 2, 2016



Two point charges, q_1 and q_2, are fixed in place on the x-axis at positions $x_1 = -1.00$ m and $x_2 = +0.50$ m, respectively. Charge q_2 has a value of +2.0 nC. Values of electric potential are illustrated by the given equipotentials in the diagram shown above, which is drawn to scale.

a) Describe in words how you would calculate the value of q_1.

--pick a point on the "x" axis where the electric potential is easily read (Point B would do with a voltage of zero);
--the equipotential lines are generated by the superposition of the electric potential fields generated by both charges, so the voltage at Point B will be due to q1 and q2's voltage fields combined;
--the electric potential function for a point charge is kq/r;
--the sum of the electric potential functions of both charges evaluated at Point B have to sum to the electric potential at that point (which happens to be zero), so writing out that equation will yield q1 as all the other parameters are known.

b) Describe the direction of the electric at point C on the diagram. Explain your response.

--the electric field is down and to the left and perpendicular to the -12 volt equipotential line;
--why? electric fields are perpendicular to equipotential lines;
--and electric fields proceed from higher to lower electric potential;
--looking at Point C, -12 volts is larger than -16 volts so the field must point from the -12 volt equipotential line toward the -16 volt equipotential line, or downward and to the left.

c)

d) Describe how you would calculate the magnitude of the electric field at point D on the diagram.

--an electric field is equal to *minus the voltage change per unit length* in a region;
--Point D is right between -20 and -24 volt equipotential lines, and the distance between those lines is (according to the scale) .2 m.
--knowing the voltage difference and the distance over which that the difference occurs should allow one to determine the magnitude of the electric field at Point D.

e) The equipotential labeled 0 V is the cross section of a nearly spherical surface. Which charge (s) contribute to the electric flux for this surface? Explain your response.

--according to Gauss's Law, electric flux through a surface is proportional to the charge enclosed inside the surface;
--the only charge inside the surface described is q2, so q2 is the only charge contributing to the electric flux through that defined surface.

f) A proton is placed at point A and then released from rest.

a. Is the work done on the proton by the electric field positive, negative, or zero as the proton moves from A to point E? Justify

--in going from A to E, the proton is moving from higher voltage to lower voltage;
--electric fields point from higher voltage to lower voltage;
--a proton that is accelerated along an electric field line will pick up speed (that's what protons do in electric fields);
--kinetic energy is a function of speed, so the proton is picking up kinetic energy;
--according to the work/energy theorem, an increase of kinetic energy means positive work has been done.

b. How would you determine the speed of the proton when it reaches point E?

--a proton's potential energy when at a point whose electric potential is V is qV;
--kinetic energy equals .5mv^2;
--knowing the proton's potential energy at the initial and final point, given that it starts from rest and given that there is no extraneous work being done during the interval, we can use *conservation of energy* to determine the velocity at Point E.

g) An electron is released from rest at point B. Which of the following indicates the direction of the initial acceleration, if any, of the electron?

____ Up ____Down
__x__Left ____Right
____Into the page ____Out of the page
____The direction is undefined since the acceleration is zero.

Justify your answer:

--electric fields are perpendicular to equipotential lines, so the electric field at Point B is along the x-axis;
--electric fields proceed from higher to lower electric potential, so the electric field is to the right.
--negative charges like electrons accelerate opposite the direction of electric fields (defined as the direction a positive charge will accelerate if put in the field), so the electron will accelerate to the left

A less appealing response would be:

--negative charges like electrons in an electric field accelerate in the opposite direction as positive charges like protons.
--Part f-b has already established that a proton would accelerate to the right in the region discussed;
--therefore, an electron would accelerate in the opposite direction or to the left.