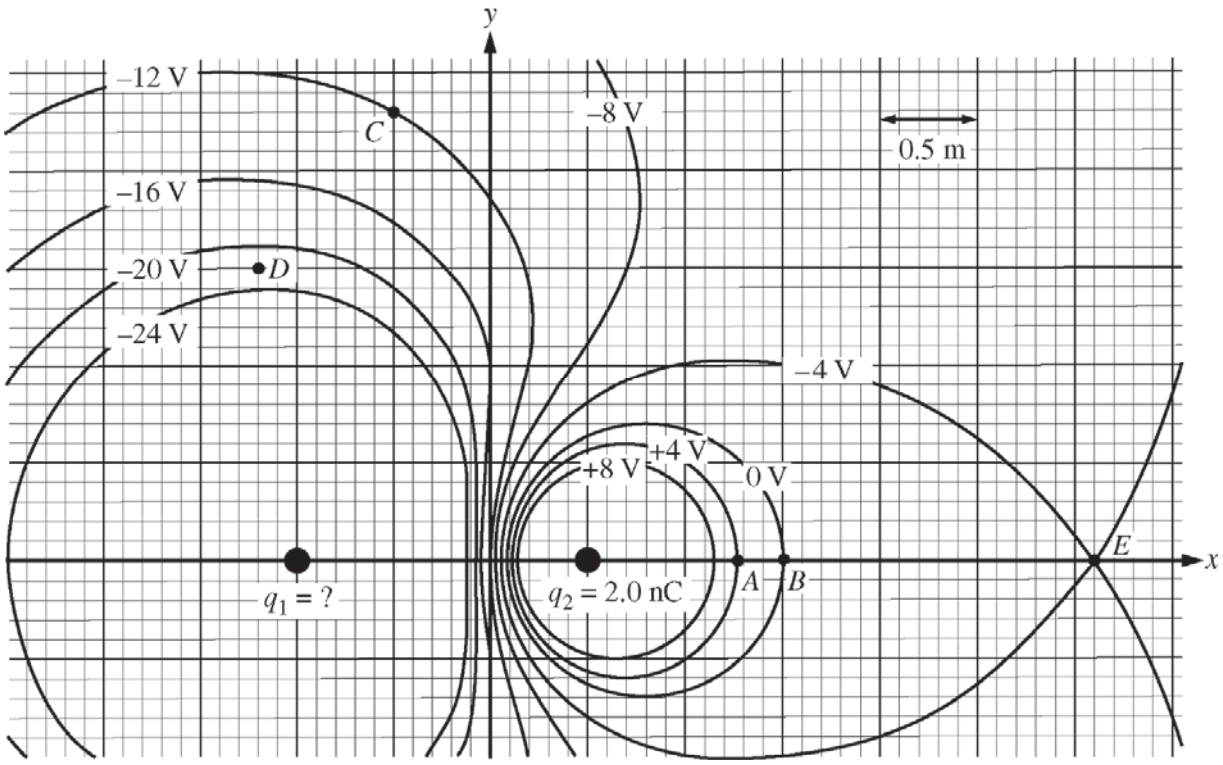
PHYSICS C: ELECTRICITY AND MAGNETISM

SECTION II

Time—45 minutes

3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.



E&M.1.

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) Calculate the value of q_1.

(b) At point C on the diagram, draw a vector representing the direction of the electric field at that point.

(c) Calculate the approximate magnitude of the electric field strength at point D on the diagram.

(d) The equipotential labeled 0 V is the cross section of a nearly spherical surface. Calculate the electric flux for this surface.

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

i. Calculate the work done by the electric field on the proton as it moves from point *A* to point *E*.

ii. Calculate the speed of the proton when it reaches point *E*.

(f) 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?

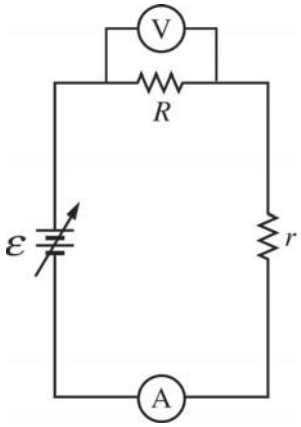
____ Up ____ Down

____ Left ____ Right

____ Into the page ____ Out of the page

____ The direction is undefined since the acceleration is zero.

Justify your answer.



E&M.2.

The circuit shown above consists of a source of variable emf $\mathcal{E}$, an ideal ammeter A, an ideal voltmeter V, a resistor of resistance R, and a sample of wire with resistance r.

(a) How does the current through the wire sample compare with the current through the resistor R ?

_____ It is greater through R. _____ It is greater through the sample.

_____ It is the same through both. _____ It depends on the resistance of the sample.

Justify your answer.

(b) How does the potential difference across the wire sample compare with the potential difference across the resistor R ?

_____ It is greater across R. _____ It is greater across the sample.

_____ It is the same across both. _____ It depends on the resistance of the sample.

Justify your answer.

With the sample of wire in place, the emf of the source is set to a given value. The current through and potential difference across the resistor R are measured. This is repeated for several values of emf, and the data are recorded in the table below.

$\mathcal{E}$ (V)	V_R (V)	I_R (A)		
0.250	0.179	0.162		
0.500	0.335	0.327		
0.750	0.520	0.490		
1.000	0.670	0.687		

(c) Indicate below which quantities should be graphed to yield a straight line that could be used to calculate a numerical value for the resistance of the wire sample.

Horizontal axis: _____

Vertical axis: _____

You may use the remaining columns in the table above, as needed, to record any quantities that you indicated that are not given.

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Question 1

15 points total **Distribution of points**

(a) 3 points

For indicating that the total potential is the sum of the potential from individual point charges — 1 point

Example using point B: $V_B = 0 = V_1 + V_2$

For correctly substituting into the above equation (signs are ignored at this step) — 1 point

$-V_1 = V_2$

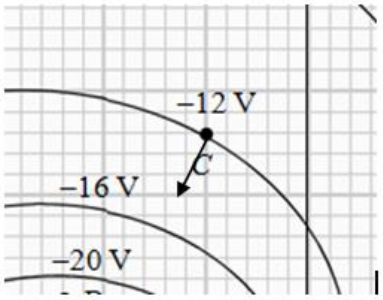
$-\frac{kq_1}{r_1} = \frac{kq_2}{r_2}$

$-\frac{q_1}{(5 \times 0.5m)} = \frac{(2.0\ \text{nC})}{(2 \times 0.5\ \text{m})}$

For a correct answer with correct sign and units — 1 point

$q_1 = -5.0\ \text{nC}$

(b) 2 points



For drawing a vector perpendicular to the equipotential line for *C* — 1 point

For drawing a vector in the direction of the -16 V line — 1 point

(c) 2 points

For using the equation relating the electric field to potential difference — 1 point

$E = -\frac{dV}{dx}$

$|E| \simeq \frac{\Delta V}{\Delta x}$

For substituting values from the figure — 1 point

$E = \frac{(-20\ \text{V} - (-24\ \text{V}))}{(2 \times 0.1\ \text{m})}$

$E = 20\ \text{N/C}$