General Physics: Class Exam I

15 February 2019

Name: Solution **Total:** /70

Instructions

- There are 8 questions on 5 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$$e = 1.61 \times 10^{-19}\,\mathrm{C} \qquad q_{\text{electron}} = -e \qquad q_{\text{proton}} = +e$$

$$m_{\text{electron}} = 9.11 \times 10^{-31}\,\mathrm{kg} \qquad m_{\text{proton}} = 1.67 \times 10^{-27}\,\mathrm{kg}$$

$$k = 9.0 \times 10^{9}\,\mathrm{Nm^2/C^2}$$

Question 1

A miniscule sphere contains 2000 excess electrons (the remaining charges cancel out).

a) Determine the total charge of this sphere.

Q = number electrons × charge single electron

$= 2000 \times (-1.6 \times 10^{-19}\mathrm{C}) = \underbrace{-}_{+1}3.2 \times 10^{-16}$

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b) Determine the magnitude of the force that the sphere exerts on a single electron at a distance of 1.0×10^{-10} m from the sphere.

$$F = k\frac{|q_1 q_2|}{r^2} \quad +1$$

$$= 8.99 \times 10^{9}\,\mathrm{Nm^2/C^2}\;\frac{\overset{+1}{3.2\times10^{-16}} \times \overset{+1}{1.6\times10^{-19}}}{(1.0\times10^{-10}\mathrm{m})^2}$$

$= 4.6 \times 10^{-5}\,\mathrm{N}$ +1

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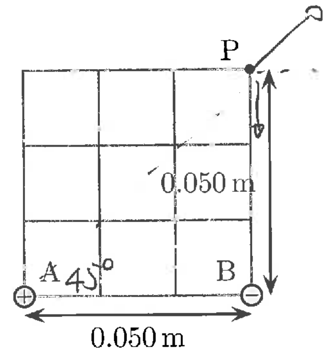
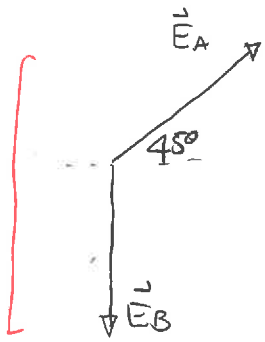
Question 2

Two fixed point charged particles are located as illustrated. The charge of particle A is $+4.0 \times 10^{-9}$ C and the charge of particle B is -1.0×10^{-9} C. Determine the net electric field at the location labeled P.



+1 $\vec{E} = \vec{E}_A + \vec{E}_B$

+2



$r_A = \sqrt{(0.050\,m)^2 + (0.050\,m)^2}$

$= 0.071\,m$ +1

+1

$E_A = k\dfrac{|q_A|}{r_A^2} = 8.99\times10^9 \dfrac{Nm^2}{C^2} \dfrac{|4.0\times10^{-9}C|}{(0.071m)^2}$ +1

$= 7200\,N/C$

$E_B = k\dfrac{|q_B|}{r_B^2} = 8.99\times10^9 Nm^2/C^2 \dfrac{1.0\times10^{-9}C}{(0.050m)^2} = 3600\,N/C$ +2

+2

$E_{Ax} = E_A \cos 45^\circ$

$= 7200\,N/C \cos 45^\circ$

$= 5090\,N/C$

	x	y
$\vec{E}_A$	5090 N/C	5090 N/C
$\vec{E}_B$	0	-3600 N/C
	+1	+1

+2

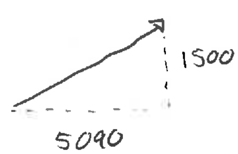
$E_{Ay} = E_A \sin 45^\circ$

$= 7200\,N/C \sin 45^\circ = 5090\,N/C$

+2

$E_x = 5090\,N/C$

$E_y = 1500\,N/C$



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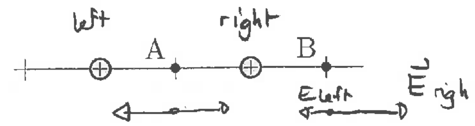
Question 3

Two identical positively charged particles are held fixed as illustrated. Let E_A be the magnitude of the net electric field at A and E_B be the magnitude of the net electric field at B. Which of the following (choose one) is true?



i) $E_A = E_B$

ii) $E_A > E_B$

iii) $E_A < E_B$

$\vec{E}_{right}$ $\vec{E}_{left}$ E_{left} $\vec{E}_{right}$ $\vec{E}_{net}$

$\vec{E} = 0$

$E_A = 0$ $\quad E_B > 0$

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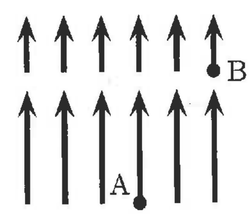
Question 4

Hidden sources produce the illustrated electric field. In separate experiments various charged particles are released from rest, either from point A or else point B.



+4 a) A negatively charged particle is released from rest at point B. In which direction will it move immediately after it has been released? Explain your answer.

$\vec{F} = m\vec{a}$ $\quad \vec{F} = q\vec{E}$ (+1) $\quad$ so q negative (+1) $\Rightarrow \vec{F}$ is $\downarrow$

$\Rightarrow \vec{a}$ is $\downarrow$

Need this or ~~$\Delta V q$~~ $\Delta K + q\Delta V$ to complete explanation (4)

moves $\downarrow$ (+2)

+6 b) A particle with charge +8.0 C is placed at point A and the force on it is 16 N. This is replaced by a particle with charge +4.0 C. Determine the force on this new particle.

Need field $\quad F = qE$ (+1)

$16\,N = 8.0C\,E \Rightarrow E = 2N/C$ (+2)

Then $\quad F = qE = 4.0C \times 2N/C \Rightarrow F = 8N$ on new particle (+3)

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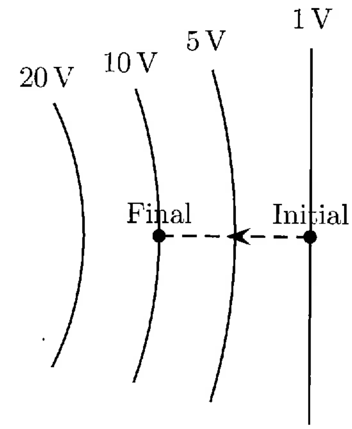
$$\Delta U_{elec} = \underbrace{q}_{\text{negative}}\underbrace{\Delta V}_{\text{positive}} \quad 9V \quad \Rightarrow \quad \Delta U_{elec} < 0$$

Question 5

A distribution of charges produces the illustrated electric potential. An electron moves from the illustrated initial to final points.



a) Which of the following (choose one) is true for change in electric potential energy of the electron?

  i) $\Delta U_{\text{elec}} = 0$.

  ii) $\Delta U_{\text{elec}} > 0$.

  iii) $\Delta U_{\text{elec}} < 0$.

b) Which of the following (choose one) is true for the electron?

  i) Its speed at the final location is the same as at the initial location.

  ii) Its speed at the final location is larger than at the initial location.

  iii) Its speed at the final location is smaller than at the initial location.

$\Delta K + q\Delta V = 0$

$\Delta K = \underbrace{-\underbrace{q\Delta V}_{\text{negative}}}_{\text{positive}} \rightarrow K$ increases

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Question 6

Two charges are held fixed as illustrated. Let V_A be the electric potential at point A and V_B be the potential at B. Which of the following (choose one) is true?

  i) $V_A = V_B$ and both are 0 V.

  ii) $V_A = V_B$ and neither are 0 V.

  iii) $V_A > V_B$.

  iv) $V_A < V_B$.

At A $V_A = 0$

B $V_B > 0$

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Question 7

Two parallel plates are held 0.080 m apart. The electric potential difference from one plate to the other is 2.0×10^3 V. Determine the magnitude of the electric field between the plates.

$$E = \left|\frac{\Delta V}{\Delta s}\right| = \left|\frac{2.0 \times 10^3 \text{ V}}{0.080 \text{ m}}\right| = 25000 \text{ V/m}$$

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Question 8

An atomic nucleus consists of a number of protons, whose total charge is 8.0×10^{-18} C. Another single proton is released from rest at a distance of 2.0×10^{-10} m from the nucleus.

a) Determine the electric potential produced by the nucleus at the location where the proton is released.

+1 $\left[V = k\frac{q}{r} = 8.99\times10^{9}\frac{Nm^2}{C^2}\ \overbrace{\frac{8.0\times10^{-18}C}{2.0\times10^{-10}m}}^{+1} \right.$

$\left. = 360V \right]$ +2

b) Determine the speed of the proton when it is infinitely far from the nucleus.

nucleus

$r_i = 2.0\times10^{-10}m$ $\qquad r_f = \infty$

$v_i = 0 m/s$ $\qquad v_f = ?$

+1 $\left[\Delta K + \overbrace{q\,\Delta V}^{+1} = 0 \right.$

$K_f - K_i + \underbrace{q_i\,\Delta V}_{+1} = 0 \Rightarrow K_f = K_i - q\,\Delta V$

$= \underbrace{\cancel{\tfrac{1}{2}mv_i^2}}_{+1}\ {}^{0} - q(V_f - V_i)$

From a) $\quad V_i = 360V$

Then $\quad V_f = k\frac{q}{r_f} = k\frac{q}{\infty} = 0V \Big]$ +2

So $\quad K_f = -\overset{\text{proton}}{q}(-360)$

$\overbrace{\tfrac{1}{2}mv_f^2}^{+1} = 1.6\times10^{-19}C \times 360 = 5.8\times10^{-17}J$

+4 $\Big[\tfrac{1}{2}(1.67\times10^{-27}kg)\,v_f^2 = 5.8\times10^{-17}J$

$v_f^2 = 6.9\times10^{10} m^2/s^2$

$\Rightarrow v_f = 2.6\times10^{5} m/s$

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