PHYS 2140 Exam 1B Solutions

September 24, 2025

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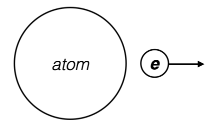
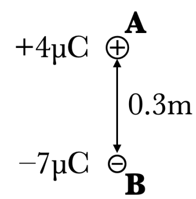
2 1. **B** If a neutral atom loses an electron, it becomes

A) negatively charged **B)** positively charged



2. Consider a charge $q_A = +4\times10^{-6}$ C which is 0.3 m above a charge $q_B = -7\times10^{-6}$ C.



2 (a) **C** Which charge feels the greater force?

A) charge A **B)** charge B

C) both feel the same force

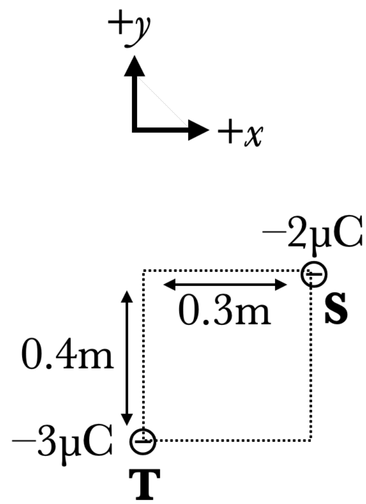
2 (b) **A** In what direction does charge B feel a force?

A) upward **B)** downward

4 (c) What is the magnitude $|\vec{F}|$ of the force that charge B feels?

$$
\begin{aligned}
|\vec{F}| &= k\frac{|q_A q_B|}{d^2} \\
&= (9\times10^9)\frac{(4\times10^{-6})(7\times10^{-6})}{(0.3)^2} \\
&= \boxed{2.8\,\mathrm{N}}
\end{aligned}
$$

3. Consider a charge $q_S = -2 \times 10^{-6}$ C on the upper-right corner of a 0.3 m by 0.4 m rectangle. A $q_T = -3 \times 10^{-6}$ C charge is on the lower-left corner of the rectangle, as shown. We want to find the force on the charge q_T.



4 (a) **D** Which of these is $\vec{d}$, the vector from the source to the target?

A) $0.3\hat{x} + 0.4\hat{y}$ **B)** $-0.3\hat{x} + 0.4\hat{y}$
C) $0.3\hat{x} - 0.4\hat{y}$ **D)** $-0.3\hat{x} - 0.4\hat{y}$

4 (b) **B** What's the magnitude $|\vec{F}|$ of the force on T?

A) 0.11 N **B)** 0.22 N **C)** 0.43 N **D)** 0.64 N

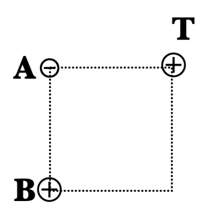
Now $d = |\vec{d}| = \sqrt{(0.3)^2 + (0.4)^2} = 0.5\,\text{m}$.

$$|\vec{F}| = k\frac{|q_S q_T|}{d^2}$$

$$= (9 \times 10^9)\frac{(2 \times 10^{-6})(3 \times 10^{-6})}{(0.5)^2} = \boxed{0.22\,\text{N}}$$

4 4. **C** Consider three charges on a rectangle as shown. If the force on charge T from charge A is $\vec{F}_A = -5\hat{x}$, and the force on T from B is $\vec{F}_B = 3\hat{x} + 4\hat{y}$, what is the magnitude of the net force on T: $|F_T|$. (Hint: don't overthink this!)

A) 0 N **B)** 2 N **C)** 4.5 N **D)** 8.9 N **E)** 10 N



$$\vec{F}_T = \vec{F}_A + \vec{F}_B$$

$$= -5\hat{x} + (3\hat{x} + 4\hat{y})$$

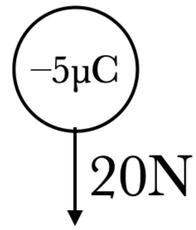
$$= -2\hat{x} + 4\hat{y}$$

$$|\vec{F}_T| = \sqrt{2^2 + 4^2} = \sqrt{20} = 4.5\,\text{N}$$

4

5. $\underline{\textbf{C}}$ A $-5\,\mu$C charge feels a force of 20 N downward in an electric field. What is the electric field it experiences?

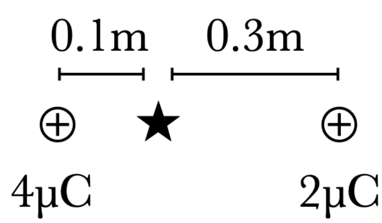
A) $2.5\times10^{-7}\,\text{N/C}\uparrow$ **B)** $1\times10^{-4}\,\text{N/C}\uparrow$ **C)** $4\times10^{6}\,\text{N/C}\uparrow$
D) $2.5\times10^{-7}\,\text{N/C}\downarrow$ **E)** $1\times10^{-4}\,\text{N/C}\downarrow$ **F)** $4\times10^{6}\,\text{N/C}\downarrow$



$$\begin{aligned}\vec{E} &= \frac{\vec{F}}{q}\\ &= \frac{20\,\text{N}\downarrow}{-5\times10^{-6}\,\text{C}}\\ &= -4\times10^{6}\,\text{N/C}\downarrow\\ &= 4\times10^{6}\,\text{N/C}\uparrow\end{aligned}$$

4

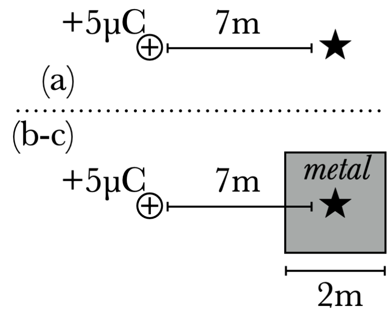
6. What is the electric field at the star between these two charges? Give your answer with at least two significant digits.



$$\begin{aligned}\vec{E} &= \vec{E}_L + \vec{E}_R\\ &= (9\times10^{9})\frac{4\times10^{-6}}{(0.1)^2}(+\hat{x}) + (9\times10^{9})\frac{2\times10^{-6}}{(0.3)^2}(-\hat{x})\\ &= +3.6\times10^{6}\hat{x} - 0.2\times10^{6}\hat{x}\\ &= \boxed{3.4\times10^{5}\,\text{N/C}\rightarrow}\end{aligned}$$

7. Consider a $+5\,\mu$C source charge.

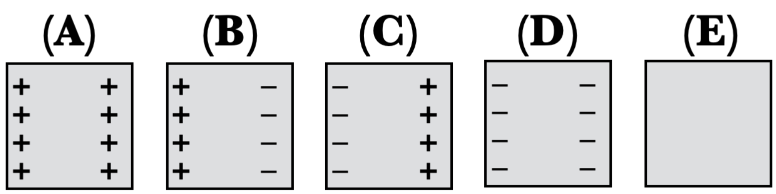
4 (a) What is the electric field at the star, 7 meters away? Include magnitude AND direction (i.e. left, right, etc)



$$\vec{E} = (9 \times 10^9)\frac{+5 \times 10^{-6}}{(7)^2} \rightarrow$$

$$= \boxed{918\,\text{N/C} \rightarrow}$$

2 (b) **C** ______ Now suppose a neutral metal cube with a side of 2 meters is centered on the star. How does charge distribute itself on the surface of the cube?

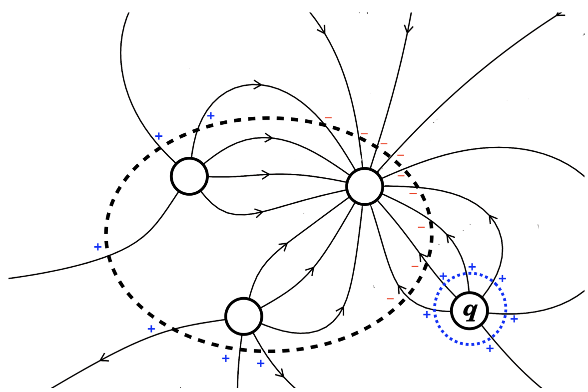


2 (c) **D** ______ Compared to your answer in part (a), the electric field at the star inside the cube

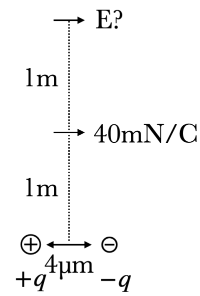
A) is stronger **B)** is the same
C) is weaker but not zero **D)** is zero

4 8. **D** The figure shows some field lines created by the charges shown. A Gaussian (i.e. imaginary) surface is drawn on the figure. If the charge q in the figure is equal to $+6\,\mu$C, then the total charge inside the Gaussian surface is

A) $+3\,\mu$C **B)** $+6\,\mu$C **C)** $+18\,\mu$C
D) $-3\,\mu$C **E)** $-6\,\mu$C **F)** $-18\,\mu$C



9. Consider two charges, $+q$ and $-q$, which are 4 microns apart. The electric field a distance 1 meter above the center of these charges is 40 mN/C. (Yes, a meter is much larger than a micron.)



4 (a) **E** What is the electric field 2 meters above the center of these charges?

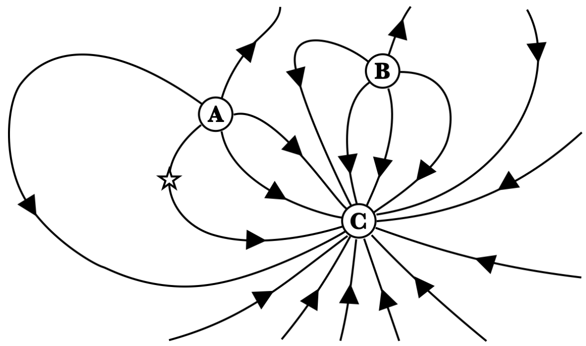
A) 80 mN/C **B)** 40 mN/C **C)** 20 mN/C **D)** 10 mN/C **E)** 5 mN/C

The electric field of a dipole (two equal and opposite charges) dies away as $1/d^3$.

2 (b) What is the name of this charge configuration?

dipole

10. Consider the field lines created by these three charges: A, B, and C.



4 (a) D Which charge or charges are positive?

A) A **B)** B **C)** C
D) A&B **E)** A&C **F)** B&C
G) All of them **H)** None of them

4 (b) C Which charge has the largest magnitude $|q|$?

A) A **B)** B **C)** C

4 (c) E In which direction does the electric field at the star point?

A) $\uparrow$ **B)** $\nearrow$ **C)** $\rightarrow$ **D)** $\searrow$ **E)** $\downarrow$

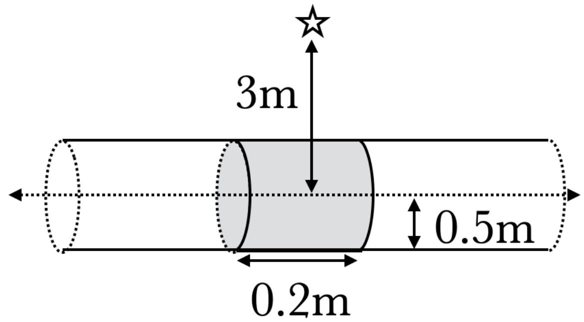
Tangential to the field line

4 (d) A The total charge of these three charges is

A) negative **B)** zero **C)** positive

More field lines are coming from off-screen than going off-screen

11. This figure shows an infinite cylindrical shell with a charge density of $4\,\mu\mathrm{C/m^2}$ and a radius of $R = 0.5\,\mathrm{m}$.



2 (a) **B** What symbol should we use to represent this charge density?

A) λ **B)** σ **C)** ρ

This is a shell, so only the surface matters

4 (b) **C** What is the total charge of a section of the cylinder that is $0.2\,\mathrm{m}$ wide with a surface area of $0.628\,\mathrm{m^2}$?

A) $0.16\,\mu\mathrm{C}$ **B)** $0.64\,\mu\mathrm{C}$ **C)** $2.51\,\mu\mathrm{C}$ **D)** $6.4\,\mu\mathrm{C}$

$$Q = \sigma A = (4\,\mu\mathrm{C/m^3})(0.628\,\mathrm{m^3}) = 2.51\,\mu\mathrm{C}$$

3 XC (c) What is the electric field at the star, a distance of $3\,\mathrm{m}$ from the axis of the cylinder? Include magnitude AND direction.

The linear charge density of the grey cylinder is $\lambda = \frac{Q}{L} = \frac{2.51\,\mu\mathrm{C}}{0.2\,\mathrm{m}} = 12.55\,\mu\mathrm{C/m}$.

$$\begin{aligned} E &= \frac{2k\lambda}{r} \\ &= \frac{2(9\times10^9)(12.55\times10^{-6}}{3)} = \boxed{7.5\times10^4\,\mathrm{N/C}\uparrow} \end{aligned}$$