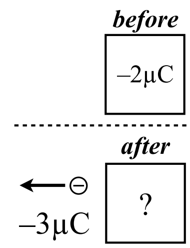
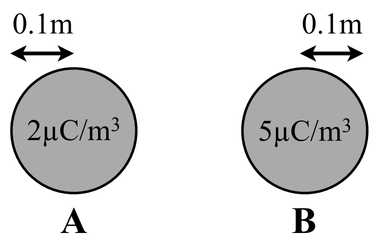
Physics 2140 Sample Exam 1 Solutions

3 1. **C** Consider a box with a net charge of $-2\,\mu$C. If $-3\,\mu$C is removed from the box, the box's net charge becomes
A) $-5\,\mu$C **B)** $-1\,\mu$C **C)** $+1\,\mu$C **D)** $+5\,\mu$C



2. Two positively charged solid spheres, each with 10 cm radius, sit side by side. Sphere A has a charge density of $\rho = 2\,\mu\text{C/m}^3$; sphere B has a charge density of $\rho = 5\,\mu\text{C/m}^3$.



3 (a) **A** What force does sphere A feel, due to sphere B?
A) Force to the left ← **B)** Force to the right →

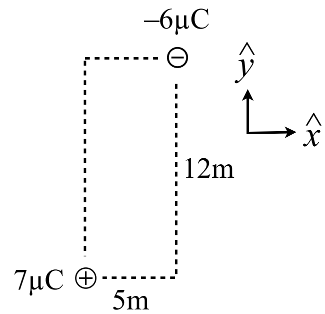
3 (b) **C** Which sphere feels a greater force?
A) Sphere A **B)** Sphere B **C)** Both feel the same force

3 (c) Find the total charge Q on sphere A.
The surface area of a sphere is $4\pi R^2$ and the volume of a sphere is $\frac{4}{3}\pi R^3$.

$$Q = \rho V = (2\,\mu\text{C/m}^3)\left(\frac{4}{3}\pi(0.1\,\text{m})^3\right) = \boxed{8.4\times10^{-3}\,\mu\text{C}} = 8.4\times10^{-9}\,\text{C}$$

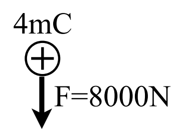
[3] 3. In the figure shown, find the force on the $+7\,\mu$C charge, in component form (i.e. something like $2\hat{x} + 3\hat{y}$). For partial credit, draw $\vec{d}$.

$\vec{d} = -5\hat{x} - 12\hat{y}\,\text{m}$, and $d = \sqrt{5^2 + 12^2} = 13\,\text{m}$.



$$\begin{aligned}\vec{F} &= k\frac{q_s q_t}{d^3}\vec{d} \\ &= (9 \times 10^9)\frac{(-6 \times 10^{-6})(7 \times 10^{-6})}{(13)^3}(-5\hat{x} - 12\hat{y}) \\ &= -1.72 \times 10^{-4}(-5\hat{x} - 12\hat{y}) \\ &= \boxed{(8.6 \times 10^{-4}\hat{x} + 2.1 \times 10^{-3}\hat{y})\,\text{N}}\end{aligned}$$

4. A $+4 \times 10^{-3}$ C charge feels an electric *force* of 8000 N downward.

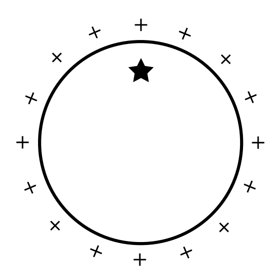


[2] (a) **B** The electric field at the charge's location points
A) upward **B)** downward

[3] (b) Find the magnitude $\left|\vec{E}\right|$ of the electric field at the charge's location.

$$E = \frac{F}{q_T} = \frac{8000\,\text{N}}{4 \times 10^{-3}\,\text{C}} = 2 \times 10^6\,\text{N/C}$$

5. Consider a target inside a spherical shell with a uniform positive surface charge density.



[3] (a) **B** The electric field at the star
A) points up **B)** is zero **C)** points down

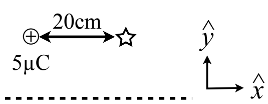
[3] (b) **C** If I place a negative charge at the star, it feels
A) an upward force **B)** a downward force **C)** no force

6. Consider a target 0.2 m to the right of a 5×10^{-6} C charge.

[2] (a) **B** What is the direction of $\vec{E}$ at the star?
A) ← **B)** →

[3] (b) Find the electric field $\vec{E}$ (in component form) at the star.

(a-b)

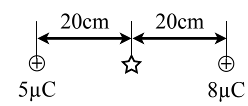


$$\vec{E} = k\frac{q_s}{d^3}\vec{d} = (9 \times 10^9)\frac{5 \times 10^{-6}}{(0.2)^3}(0.2\hat{x})$$

$$= \boxed{1.1 \times 10^6 \hat{x}\,\mathrm{N/C}}$$

[3] (c) Now add an 8×10^{-6} C charge 0.2 m to the right of the star. What is the electric field at the star now?

(c)



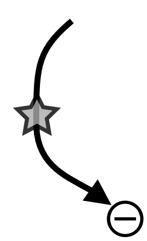
With the $8\,\mu$C charge as the source, $\vec{d} = -0.2\hat{x}$ m, and

$$\vec{E} = k\frac{q_s}{d^3}\vec{d} = (9\times10^9)\frac{8 \times 10^{-6}}{(0.2)^3}(-0.2\hat{x}) = -1.8\times10^6\hat{x}\,\mathrm{N/C}$$

The net electric field is the sum of this and the answer to (b):

$$(1.1 \times 10^6\hat{x} - 1.8 \times 10^6\hat{x})\,\mathrm{N/C} = \boxed{-7 \times 10^5\hat{x}\,\mathrm{N/C}}$$

[3] 7. **C** The figure shows a negative charge, and an electric field line going into that charge. The electric field at the star points in what direction?
A) ↑ **B)** ↘ **C)** ↓ **D)** ↖



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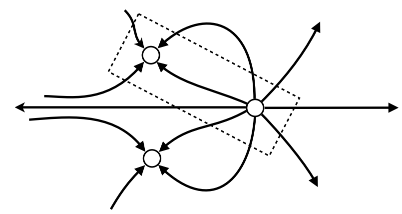
8. The figure shows the electric field lines of three source charges.

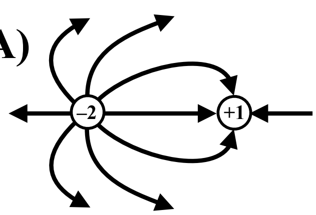


2 (a) **A** The net flux through the dotted rectangle is
A) positive **B)** zero **C)** negative

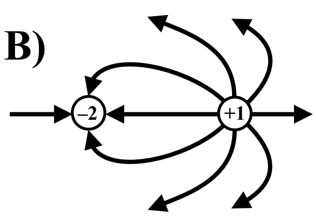
2 (b) **B** The net charge of all three charges is
A) positive **B)** zero **C)** negative

3 9. **D** Consider two charges: a $-2\,\mu$C charge on the left, and $+1\,\mu$C charge on the right. Which of the following shows the correct electric field lines of these two charges?

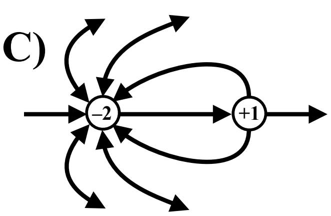
A)



B)

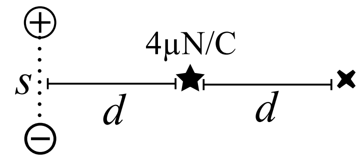


C)



D) None of these.

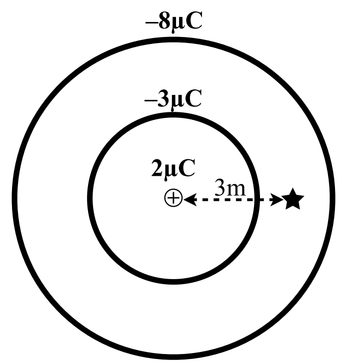
10. The figure shows a dipole, where the two charges are a distance s apart. The electric field d to the right of the dipole is $4\,\mu$N/C. Assume that d is much larger than s.



[3] (a) **C** The direction of the electric field at the star points
A) $\uparrow$ **B)** $\rightarrow$ **C)** $\downarrow$ **D)** $\leftarrow$

[3] (b) **D** What is the magnitude of the electric field $2d$ from the dipole (at the X)?
A) $4\,\mu$N/C **B)** $2\,\mu$N/C **C)** $1\,\mu$N/C **D)** $0.5\,\mu$N/C

11. Consider two concentric spherical shells. The outer shell has a radius of 4 m, and a net charge of $-8\,\mu$C spread evenly on its surface. The inner shell has a radius of 2 m and a net charge of $-3\,\mu$C spread evenly on its surface. At the center of both spheres is a $2\,\mu$C point charge. I'm interested in the electric field at the star.



[2] (a) **A** The field at the star
A) points to the left **B)** is zero **C)** points to the right

[2] (b) **A** The field at the star is the same as that 3 m from a point charge q, where $q =$
A) $-1\,\mu$C **B)** $2\,\mu$C **C)** $-3\,\mu$C **D)** $7\,\mu$C **E)** $-9\,\mu$C

The field is the same as if we collapsed the inner shells to a single point, with a net charge of $2\,\mu\text{C} - 3\,\mu\text{C} = -1\,\mu\text{C}$. Thus

$$\left|\vec{E}\right| = k\frac{|q_s|}{d^2} = (9 \times 10^9)\frac{|-1 \times 10^{-6}|}{(3)^2} = 1000\,\text{N/C}$$