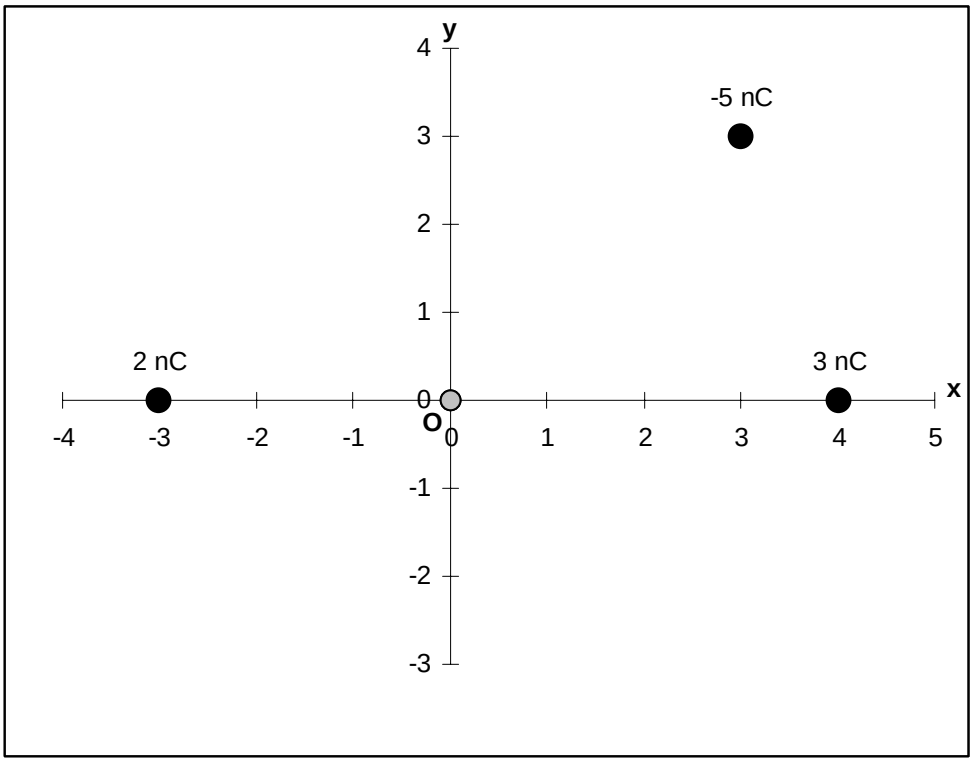
Physics 51 Proficiency Test 1(sample) **(Time: 15 minutes)** **25 points**

By Todd Sauke

Name _____KEY_____ Section # __KEY___

The three charges shown below as black dots are the source of an electric field. The coordinates are measured in meters, and the charges are as indicated in units of nano-Coulombs (nC = 10^{-9} C). Find the magnitude and direction of the electric field vector at the origin, **O**. Pay particular attention to the sign of all quantities.
Use $k = 1/(4 \pi \varepsilon_0) = 9.0 \times 10^9$ N m^2/C^2.



We add the respective x & y components from the three charges, and use the fact that the x component is given by $-kq/r^2$ times the cosine of the angle the charge makes with the +x axis. The y component = $-kq/r^2$ times the sine of the angle.

$E_x = k (2 \cdot 10^{-9} / 3^2 \; - \; 3 \cdot 10^{-9} / 4^2 \; + \; (5 \cdot 10^{-9} / (2 \cdot 3^2)) \cos(45^o))$ (note: cosine is in numerator!)
$= 9 \cdot 10^9 (0.2222 \cdot 10^{-9} \; - 0.1875 \cdot 10^{-9} \; + 0.2778 \cdot 10^{-9} \; \cdot 0.707)$
$= 9 (0.231) = 2.080$

$E_y = k (0.0 \; + \; 0.0 \; + \; (5 \cdot 10^{-9} / (2 \cdot 3^2)) \sin(45^o))$ (note: sine is in numerator!
$= 9 \cdot 10^9 (0.0 \; + 0.0 \; + 0.2778 \cdot 10^{-9} \; \cdot 0.707)$
$= 9 (0.1964) = 1.768$

Magnitude = $\text{sqrt}(Ex^2 + Ey^2) = \text{sqrt}(2.080^2 + 1.768^2) = 2.730$

(you **must check** the quadrant of the angle!)
$\theta = \tan^{-1}(Ey / Ex) = \tan^{-1}(1.768 / 2.080) = 40.4^o$

x-component at **O** = __**2.080**_____N/C y-component at **O** = ____**1.768**_____ N/C

Magnitude of **E** field at **O** __**2.730**___ N/C Direction of **E** field at **O** ___**40.4**___ ^{o}
(relative to +x axis)