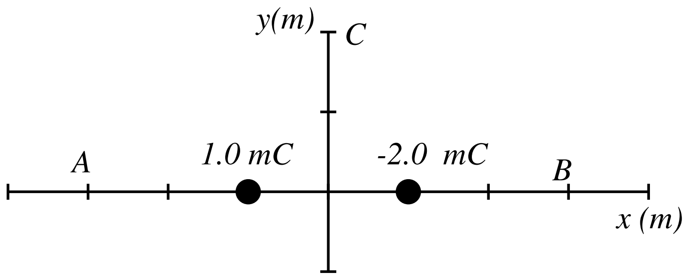
1. Two charges are placed in a line as shown below



(a) Find the electric field strength at points A, B and C

At A the electric field due to the -2 mC charge points right (toward the negative charge) and has magnitude

$$E = (9 \times 10^9)(2 \times 10^{-3})/4^2 = 1.125 \times 10^6 \text{ N/C}$$

and the electric field due to the 1 mC charge points left (away from the positive charge) and has magnitude

$$E = (9 \times 10^9)(1 \times 10^{-3})/2^2 = 2.25 \times 10^6 \text{ N/C}.$$

So the total electric field is to the left with magnitude

$$E = (2.25 - 1.125 \times 10^6 = 1.125 \times 10^6 \text{ N/C}.$$

Similarly at B the electric field due to the -2 mC charge points left (toward the negative charge) and has magnitude

$$E = (9 \times 10^9)(2 \times 10^{-3})/2^2 = 4.5 \times 10^6 \text{ N/C}$$

and the electric field due to the 1 mC charge points right (away from the positive charge) and has magnitude

$$E = (9 \times 10^9)(1 \times 10^{-3})/4^2 = 0.5625 \times 10^6 \text{ N/C}.$$

So the total electric field is to the left with magnitude

$$E = (4.5 - .5625) \times 10^6 = 3.9 \times 10^6 \text{ N/C}.$$

At C the magnitude of the electric field due to the -2 mC is

$$E = (9 \times 10^9)(2 \times 10^{-3})/5 = 3.6 \times 10^6 \text{ N/C},$$

pointing down toward the negative charge. The x component is

$$E_x = E \cos\theta = E(1/\sqrt{5}) = 1.61 \times 10^6 \text{ N/C}$$

and the y component is

$$E_y = -E\sin\theta = -E(2/\sqrt{5}) = -3.22 \times 10^6 \text{ N/C}.$$

Similarly the magnitude of the field due to the 1 mC charge at C is

$$E = (9 \times 10^9)(1 \times 10^{-3})/5 = 1.8 \times 10^6 \text{ N/C},$$

pointing up away from the negative charge. The x component is

$$E_x = E\cos\theta = E(1/\sqrt{5}) = 0.805 \times 10^6 \text{ N/C}$$

and the y component is

$$E_y = E\sin\theta = E(2/\sqrt{5}) = 1.61 \times 10^6 \text{ N/C}.$$

So the combined electric field has x component

$$E_x = (1.61 + 0.805) \times 10^6 = 2.41 \times 10^6 \text{ N/C}$$

and the y component is

$$E_y = (-3.22 + 1.61) \times 10^6 = -1.61 \times 10^6 \text{ N/C}.$$

(b) Find the location where the electric field is zero.
The electric field will be zero on the left of the 1 mC charge. Here the fields due to each charge are opposite in direction and will be equal in magnitude at one point. Let the point where the field is zero be d units to the left of the 1 mC charge. Then the field due to the 1 mC charge has magnitude $E = k(1mC)/d^2$ and the field due to the -2 mC charge has magnitude $E = k(2mC)/(2+d)^2$. Setting these two equal implies that $k/d^2 = 2k/(2+d)^2 \Rightarrow (2+d)^2 = 2d^2 \Rightarrow d+2 = \sqrt{2}d \Rightarrow d = 2/(\sqrt{2}-1) = 4.83$ m left of the 1 mC charge, or at position $x = -5.83$.

(c) Repeat your calculation for the case where both charges are positive.
If both charges where positive then the fields would cancel between the two charges because it is here where the fields point in opposite directions. Let the point where the field is zero be d units to the right of the 1 mC charge. Then the electric field is zero when $k/d^2 = 2k/(2-d)^2 \Rightarrow (2-d)^2 = 2d^2 \Rightarrow 2-d = \sqrt{2}d \Rightarrow d = 2/(\sqrt{2}+1) = 0.83$ m to the right of the 1 mC charge or at position $x = -0.17$.