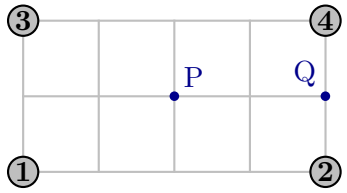
# Electromagnetic Theory: Homework 8

Due: 15 September 2020

## 1 Charges and forces

An arrangement of unknown source charges is arranged in a rectangular pattern as illustrated. A positively charged test particle is placed at location P and it is observed that the net force on this charge is zero.

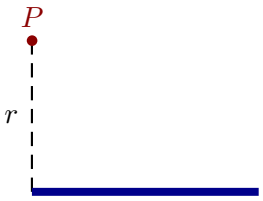



a) The test particle is replaced by another with 1000 times the charge. Will the force on this particle be zero or not? Explain your answer.

b) A different collection of unknown sources is arranged as illustrated and none of these have zero charge. Is it possible that the electric field (produced by the unknown sources) at point Q could be zero? If so, how are the magnitudes of the charges of the source charges at locations 1 and 3 related to each other? Would it be possible for the electric field at both P and Q be zero? Explain your answers.

## 2 Field above a uniformly charged wire

A wire with length $L$ carries uniform charge density $\lambda$.

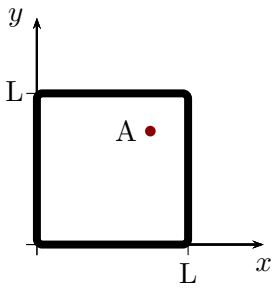



a) Determine an expression for the electric field at any point $P$ perpendicularly above the end of the wire.

b) Determine an expression for the field in the limit as $r \gg L$. What would you expect the field to be?

## 3 Force on a charge in a square loop

Consider a square loop with sides of length $L$ in the $xy$-plane. Suppose that it is positively charged with uniform charge density $\lambda$. A positive test charge, labeled A and with charge $Q$, is placed at $(3L/4, 3L/4)$ toward one corner as illustrated.




a) Describe *how you would use the result for the field above the end of a wire* to determine the force exerted on the test charge. You do not necessarily need to get an expression for the force; just a procedure.

b) Suppose that an additional test particle, with charge $Q'$ were placed at the center of the loop and the original test particle is still at the illustrated location. Would the magnitude of the charge density on the loop have any effect on the net force exerted by the loop and charge A on $Q'$?. Explain your answer, without doing any detailed calculations.

## 4 Electric field produced by a ring of charge

Consider a ring of charge with radius $R$ that lies in the $xy$-plane (see Fig 2.9).

a) Suppose that the charge density along the ring is uniform, i.e. $\lambda(\mathbf{r}') = \lambda$, which is constant. Determine the electric field at a distance $z$ above the center of the ring.

b) For the above case determine the limit for $z \gg R$. What would you have expected in this limit? Does this agree?

c) Suppose that the charge density along the ring is $\lambda(\mathbf{r}') = \lambda \sin\phi'$, where $\lambda$ is constant and $\phi'$ refers to locations along the ring in cylindrical coordinates. Determine the electric field at a distance $z$ above the center of the ring.

d) For the above case determine the limit for $z \gg R$. What would you have expected in this limit? Does this agree?

*Hint: Use cylindrical coordinates. This will result in the appearance of* $\hat{\mathbf{s}}$ *within the integrals. This unit vector varies with* $\phi'$ *and to integrate correctly it must be expressed in terms of* $\hat{\mathbf{x}}$ *and* $\hat{\mathbf{y}}$ *within the integral. Once this is done, you could integrate.*