Khemis Miliana University
Faculty of Material Science and Computer Science
Department of Physics
L2 Fundamental Physics (2023/2024)

Electromagnetism

Set of Exercises

Chapter 02 Maxwell Equations (Part 01)

Electric and Magnetic Field

Exercise 01:

A ring of charge of radius b is characterized by a uniform line charge density of positive polarity λ. The ring resides in free space and is positioned in the x-y plane, as shown below (Fig.1)

Determine the electric field intensity $\vec{E}$ at a point $P = (0,0,h)$ along the axis of the ring at a distance h from its center.

Hint: *Exploit the available symmetry to find the non-null component of the electric field*

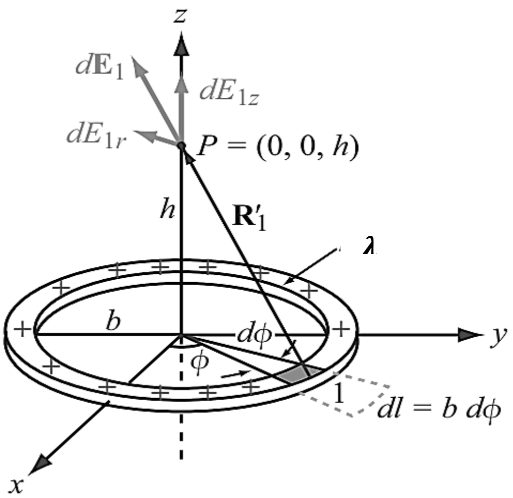

Figure 1. Representation of field created by a charged ring

Exercise 02:

Find the electric field at point P with Cartesian coordinates $(0, 0, h)$ due to a circular disk of radius a and uniform charge density σ residing in the x–y plane (Fig. 2). Also, evaluate E due to an infinite sheet of charge density σ by letting $a \to \infty$.

Exercise 03:

Two infinite lines of charge in free space: one residing in the x–y plane parallel to the x-axis at $y_1 = 2[m]$ and carrying charge density:

$$\lambda_1 = 1[nC.m^{-1}]$$

and a second one residing in the y–z plane parallel to the y-axis at $z_2 = 6[m]$ and carrying a charge density:

$$\lambda_2 = -2[nC.m^{-1}]$$

Determine the electric field at the origin (0,0,0).

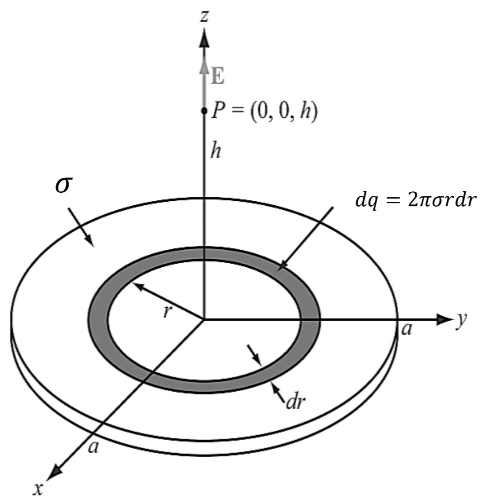

Figure 2. Electric field created by a charged disk

Exercise 04:

Two infinite lines, each carrying a uniform charge density λ, reside in free space parallel to the z-axis at $x = 1$ and $x = -1$. Determine $\vec{E}$ at an arbitrary point along the y axis

Exercise 05:

A circular loop of radius r carries a steady current I. Determine the magnetic field $\vec{B}$ at a point on the axis of the loop.

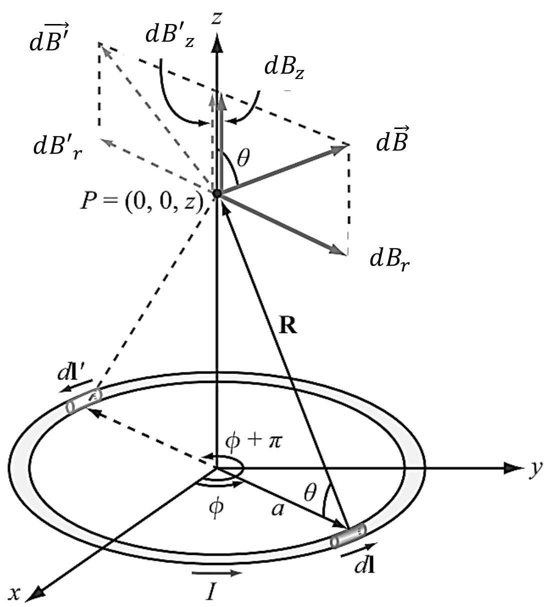

Figure 3. Circular loop carrying a current I

Exercise 06:

A semi-infinite linear conductor extends between $z = 0$ and $z \to +\infty$ along the z-axis. If the current I in the conductor flows along the positive z direction, find $\vec{B}$ at a point in the x-y plane ($z = 0$) at a radial distance r from the conductor.

Exercise 07:

Two parallel wires of length $l_1 = l_2 = l$, separated by a distance $d \ll l$ carrying each steady current I_1 and I_2, respectively. Both currents are flowing in the same direction (Fig. 4).

(a) By using Ampere law, determine the corresponding magnetic field induced by each wire at the location of the second wire.

(b) What is the Laplace force applied on each wire by the other one.

(c) Deduce the forces by unit length

(d) Suppose that the conductor carrying the current I_2 is rotated so that it is parallel to the x-axis. What would $\vec{F}_2$ be in this case?

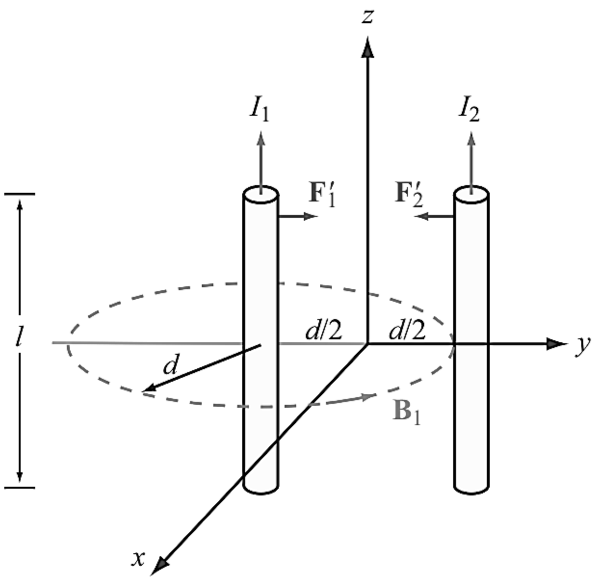

Figure 4. Parallel wires carrying steady currents

Exercise 08:

A vector field is said to be ***conservative*** if its line integral between two points is the same: irrespective of the path taken between them. In a given region of space, the field $\vec{E}$ is given by:

$$\vec{E} = x^2\vec{\imath} + y^2\vec{\jmath} + z^2\vec{k}$$

(a) Confirm that $\vec{E}$ is conservative by demonstrating that $\vec{\nabla} \wedge \vec{E} = 0$.

(b) Compute the potential difference V_{21} between points 1 and 2 as shown in Fig. 5, following the direct path between them.

(c) Compute V_{21} by following the path $ABCD$ between points 1 and 2.

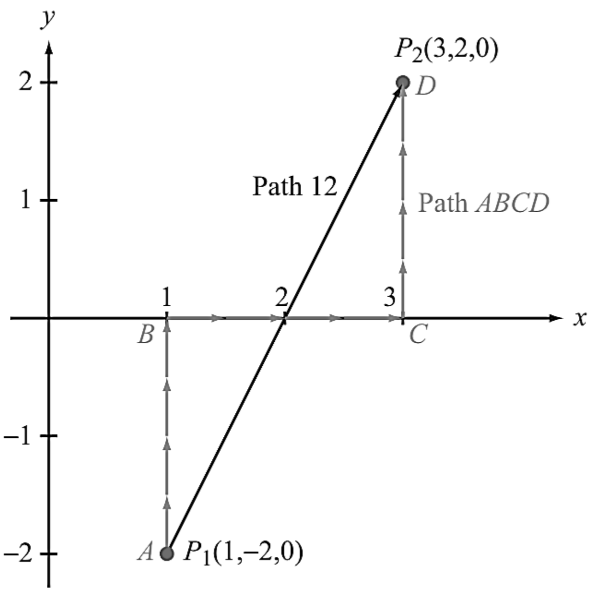

Figure 5. Representation of two-points path

Exercise 09:

An electric dipole consists of two charges of equal magnitude but opposite polarity separated by a distance d. Determine V and $\vec{E}$ at any point P in a free space, given that P is at a distance $R \gg d$ from the dipole center.

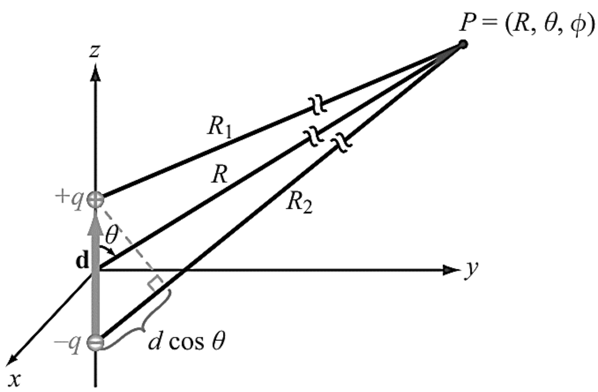

Figure 6. representation of an Electric dipole