Instrucciones:

- Fecha de publicación: 6 de septiembre de 2021 a las 13:00.
- Fecha de entrega: 13 de septiembre de 2021 hasta las 23:55.
- Único medio de entrega: `https://e-aulas.urosario.edu.co`.
- Formato de entrega: PDF con el informe escrito en LaTeX de máximo dos páginas.
- Solamente un miembro del grupo debe realizar la entrega.
- La actividad debe realizarse en **grupos de dos estudiantes**. Si sobra una persona, habrá **un solo grupo de tres estudiaantes**.

Protocolo para la evaluación:

Los siguientes lineamientos serán seguidos de forma estricta y sin excepción.

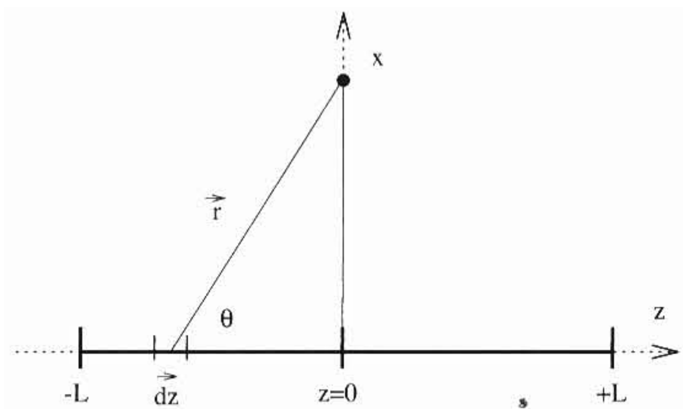
1. Los grupos pueden consultar sus ideas con el profesor para recibir orientación; sin embargo, **la solución y detalles del ejercicio deben realizarlos los integrantes de cada grupo**. Cualquier tipo de fraude o plagio es causa de anulación directa de la evaluación y correspondiente proceso disciplinario.
2. El grupo de trabajo debe indicar en su entrega de la solución a la actividad cualquier asistencia que haya recibido.
3. El grupo no debe consultar ninguna solución a la actividad que no sea la suya.
4. El grupo no debe intentar ocultar ningún código que no sea propio en la solución a la actividad (a excepción del que se encuentra en las plantillas).
5. Todas las entregas están sujetas a herramientas automatizadas de detección de plagio en códigos y textos.
6. `e-aulas` se cerrará a la hora en punto acordada para el final de la evaluación. La solución de la actividad debe ser subida antes de esta hora. El material entregado a través de e-aulas será calificado tal como está. Si ningún tipo de material es entregado por este medio, la nota de la evaluación será 0.0.

No habrán excepciones a estas reglas.

Problem Set

1. Use `Python3` and its libraries: `numpy` and `scipy` to solve the following problem. Specifically the functions in the package `scipy.integrate`.

   The design of electronic devices often include the evaluation of magnetic fields they generate. Indeed, the electrical current of the device produces the magnetic field and its quality depends on the geometry of the device. Let us assume that the device is a simple straight wire made out of a material characterized by μ_0 and carries a current I flowing in a wire segment of length $d\mathbf{z}$. The geometry of the problem is shown in the Figure.



   To calculate the magnetic field $d\mathbf{B}$ we use the Biot-Savart law which states that

$$d\mathbf{B}(\mathbf{r}) = \frac{\mu_0 I}{4\pi}\frac{d\mathbf{z}\times\mathbf{r}}{r^3},$$

   where $\mathbf{r}$ is the vector, $r = ||\mathbf{r}||$ its magnitude, that runs from the segment carrying the current to the point in question. For this particular device the cross product can be written in terms of the angle θ simplifying the above expression to something that depends on $\sin\theta/r^2$. The total magnetic field $B = B(\mathbf{r})$ is the integral of $d\mathbf{B}$ over the length of the wire, which we assume is of length $2L$ and that the wire is centered at the origin an runs along the z axis.

   Evaluate the magnetic field as a function of distance from the wire by numerically integrating Biot-Savart's law. Use units of current such that $\mu_0 I = 1$ and $L = 1$. Generate the following plots and interpret your results.

   a) Calculate the magnitude of the field B as a function of x/L for $y = z = 0$. In the same plot show results of numerical integration using Composite Trapezoidal rule with a step $\Delta z = 0{,}5, 0{,}1, 0{,}05, 0{,}01$. Also include the result of the numerical integration using standard Trapezoidal rule.

   b) Calculate the magnitude of the field B as a function of x/L for $y = z = 0$. In the same plot show results of numerical integration using Composite Simpson's rules with a step $\Delta z = 0{,}5, 0{,}1, 0{,}05, 0{,}01$. Also include the result of the numerical integration using standard Simpson's rule.

c) Compute the magnetic field as a function of x/L for $y = 0$ and $z = L$, using Composite Simpson's rule and $\Delta z = 0{,}01$. Include in this plot your result for the same parameters and $z = 0$ and compare the magnetic fields at those two values of z. Repeat for $L = 10$. Discuss why the magnetic field is different.

d) Compare your numerical results with the analytical, exact, result for an infinitely long wire. Derive a rule of thumb concerning how small the grid size must be in comparison with the distance from the wire, in order for the calculated field to be within $p\,\%$ of the exact result. Apply you criterion for $p = 5$ and check its validity.

The working teams must hand in a two-page paper typeset in LaTeX with the corresponding analysis and interpretation of the items. In order to take advantage of the space available, the use of the environment `revtex-4.1` or similar is strongly encouraged. Be brief and straight to the point. Make sure that every step of your work is justified and properly explained.