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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

(I Semester 2022-23)

Assignment-01

Computational Physics (PHY F313) **Date: 26-10-2022**

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Important:

1. It is expected that each group will work on the assignment independently. *Learning is more important than copying!*
2. Submit your assignment by 15-11-22 at the latest. Submission after this date will be treated as late submission. In any case after 19-11-22, the codes will not be executed.
3. Upload the assignments on link shared with you. Do not send through email.
4. Compress all the files in one directory as *grpxx_asgtyy.zip*, where, xx is the group number, yy is the assignment number.

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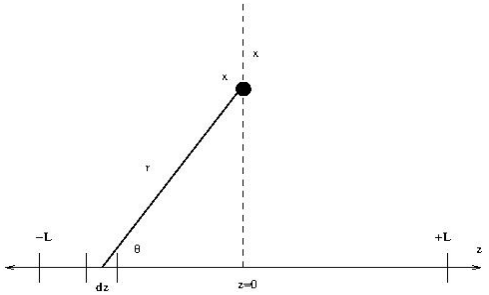
1. The magnetic field produced by a straight wire can be evaluated by Biot-Savart law (fig.1) as,

$$d\boldsymbol{B} = \frac{\mu_0 I}{4\pi}\frac{d\boldsymbol{z}\times\boldsymbol{r}}{r^3}$$

The total field can be written as (for this case),

$$B \approx \int \frac{\mu_0 I}{4\pi}\frac{xdz}{(z^2+x^2)^{3/2}}$$

Calculate the magnetic field from a straight wire by Trapeziodal and Gaussain methods. (a) Compare your results for the same grid size. (b) Plot a graph for magnetic field, $B_y(x)$ as a function of $x = 0 - 1.0$. Consider two wires of lengths, 1 and 100.



The wire is of length $2L$ and consider the field at a point on x-axis. This axis is perpendicular to the wire and intersects the wire at its center. The current is assumed to flow from left to right.

2. What happens if we use the Newton-Raphson Method to obtain the roots of the equation, $f(x) = x^3 - x - 3$ with initial guess, $x_0 = 0$.

3. Write a program to understand the process of nuclear decay through Monte Carlo simulation. Consider $N_0 = 100,500$ (the initial number of unstable nuclei), the probability to decay, $p = 0.01$, the maximum time for the simulation, $t_{max} = 100$. Show the process through a plot.

4. Choose the importance function $p(x) = Ae^{-x}$ and evaluate the integrals:

$$\text{(a)} \int_0^3 x^{3/2}e^{-x}dx \qquad \text{(b)} \int_0^\pi \frac{dx}{x^2+\cos^2 x}$$

5. The Lorenz model is used to study the climate change and is given by

$$\frac{dx}{dt} = a(y-x) \qquad \frac{dy}{dt} = -xz + bx - y \qquad \frac{dz}{dt} = xy - cz$$

where $a = 10,\ c = 8/3$ are some constants. b denotes the temperature difference between the top and bottom surfaces of the fluid. Solve the equations with RK-4 method with $a = 10,\ c = 8/3$ and $b = 5,\ 10,\ 25$. Plot the following:

   (a) z as a function of time for $b = 5, 10, 25$ for $x = 1,\ y = z = 0$. You can move from $t = 0$s to $t = 50$s. Is there any stricking difference at $b = 25$?

   (b) The trajectory of Lorenz model (for $b = 25$) in $x - z$ plane with initial condition as $x = 1,\ y = z = 0$.

   (c) The trajectory in yz plane when $x = 0$ with $b = 25$.

   (d) The trajectory in xz plane when $y = 0$ with $b = 25$.