# Assignment 03: On Visualising Vector Fields

PH1050 Computational Physics

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## *Problem Statement*

In the first part of the given problem presents us the expression of Magnetic Field due to an element of a current carrying wire of length 2L in the spherical polar coordinate system.We are asked to integrate the given expression and transform it into Cartesian Coordinate system and then plot the magnetic field lines in X-Y Plane.

In the second part of the given problem i took a charge configuration such that there are 4 point charges situated at (0,0),(0,1),(1,0),(1,1). I found the expression for field and potential and plotted the equipotential surface.

## *Aim*

**Part-1:**
To integrate the given expression for Magnetic Field and transform the cylindrical coordinate system to Cartesian Coordinate system and plot the final expression in the X-Y plane and observe it.

**Part-2:**
1.take a charge configuration,find its field and potential expression
2.plot its equipotential surface and streamline.

## *Code Organization*

Part 1:
1.integrating the function.
2.finding limit l->infinity value of integrated function
3. plotting field lines for l->inifinty
4.plotting field lines for l=1

Part 2:
1. expression for field

2.streamline plotting
3.expression for potential
4.equipotential surface plotting

## Code for computation

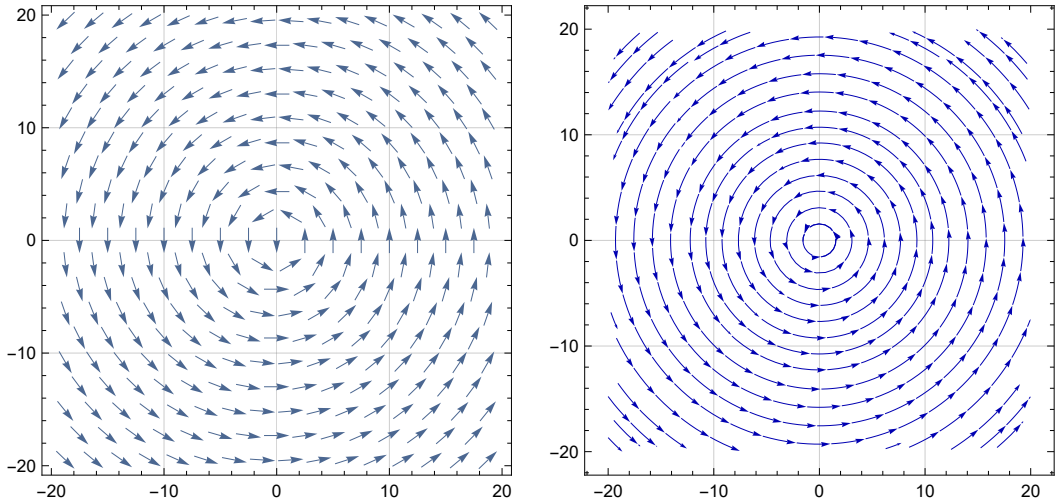
```
b = Integrate[ρ / (ρ^2 + (z - u)^2)^(3/2), {u, -l, l}, Assumptions → {ρ > 0, l > 0, z ∈ Reals}]
a = Limit[((1-z)/Sqrt[l^2+ρ^2-2 l z+z^2] + (l+z)/Sqrt[l^2+ρ^2+2 l z+z^2])/ρ, l → Infinity]
gxy = {-a y / ρ, a x / ρ} /. ρ → (x^2 + y^2) ^ (1 / 2)


Stp = StreamPlot[gxy, {x, -20, 20}, {y, -20, 20},
    VectorColorFunction → "GrayTones", GridLines → Automatic];
vecPlt = VectorPlot[gxy, {x, -20, 20},
    {y, -20, 20}, VectorColorFunction → None, GridLines → Automatic];
GraphicsRow[{vecPlt, Stp}, ImageSize → Large]
hxy = {-b y / ρ, b x / ρ} /. ρ → (x^2 + y^2) ^ (1 / 2)
axy = hxy /. {l → 1, z → 0}
S1tp = StreamPlot[axy, {x, -2, 2}, {y, -2, 2},
    VectorColorFunction → "GrayTones", GridLines → Automatic];
vec1Plt = VectorPlot[axy, {x, -2, 2},
    {y, -2, 2}, VectorColorFunction → None, GridLines → Automatic];
GraphicsRow[{vec1Plt, S1tp}, ImageSize → Large]
(*i take a confurigation of 4 charges of +q at(0,0),(1,0),(0,1)(1,1),*)
forxy = {x / (x ^2 + y^2) ^ (5 / 2) + (x - 1) / ((x - 1) ^2 + y^2) ^ (5 / 2) +
    x / (x ^2 + (y - 1) ^2) ^ (5 / 2) + (x - 1) / ((x - 1) ^2 + (y - 1) ^2) ^ (5 / 2),
  y / (x ^2 + y^2) ^ (5 / 2) + y / ((x - 1) ^2 + y^2) ^ (5 / 2) +
    (y - 1) / (x ^2 + (y - 1) ^2) ^ (5 / 2) + (y - 1) / ((x - 1) ^2 + (y - 1) ^2) ^ (5 / 2)}
S2tp = StreamPlot[forxy, {x, -2, 2}, {y, -2, 2},
    VectorColorFunction → "GrayTones", GridLines → Automatic];
GraphicsRow[{S2tp}, ImageSize → Large]
potxy =
 {1 / (x ^2 + y^2) + 1 / ((x - 1) ^2 + y^2) + 1 / (x ^2 + (y - 1) ^2) + 1 / ((x - 1) ^2 + (y - 1) ^2)}
equipot1 = ContourPlot[potxy, {x, -1, 2}, {y, -1, 2},
    ColorFunction → "TemperatureMap", ImageSize → 300, Contours → 10,
    ContourStyle → Table[{Opacity[1.], Hue[i / 10]}, {i, 15}],
    Axes → True, LabelStyle → {FontSize → 14, Black}, PlotPoints → 50,
    Epilog → Arrow[{{0, -0.3}, {0.0, 0.3}}]] // Quiet
```

## Results

integrated value :

$$\frac{z\left(-\frac{1}{\sqrt{(1-z)^2+\rho^2}}+\frac{1}{\sqrt{(1+z)^2+\rho^2}}\right)+1\left(\frac{1}{\sqrt{(1-z)^2+\rho^2}}+\frac{1}{\sqrt{(1+z)^2+\rho^2}}\right)}{\rho}$$

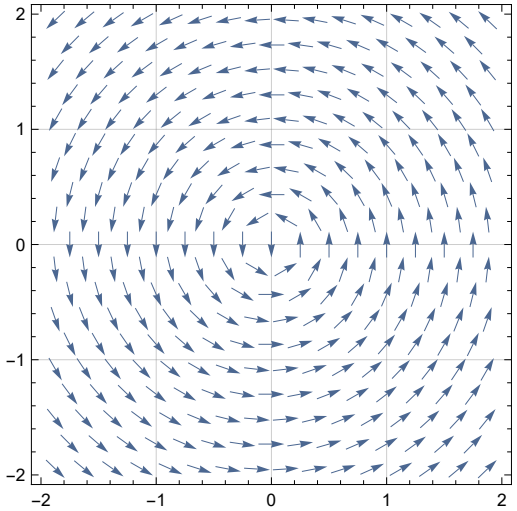
magnetic field lines graph

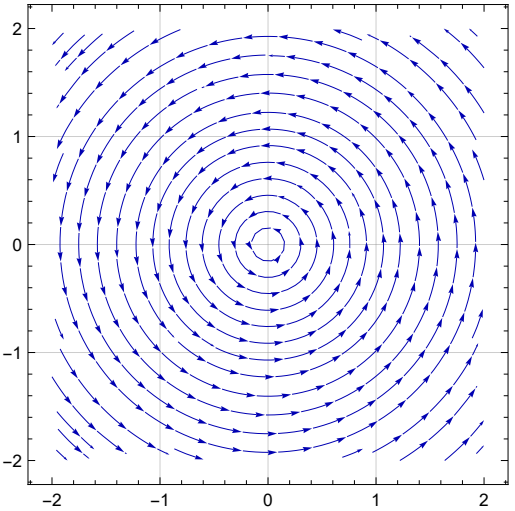




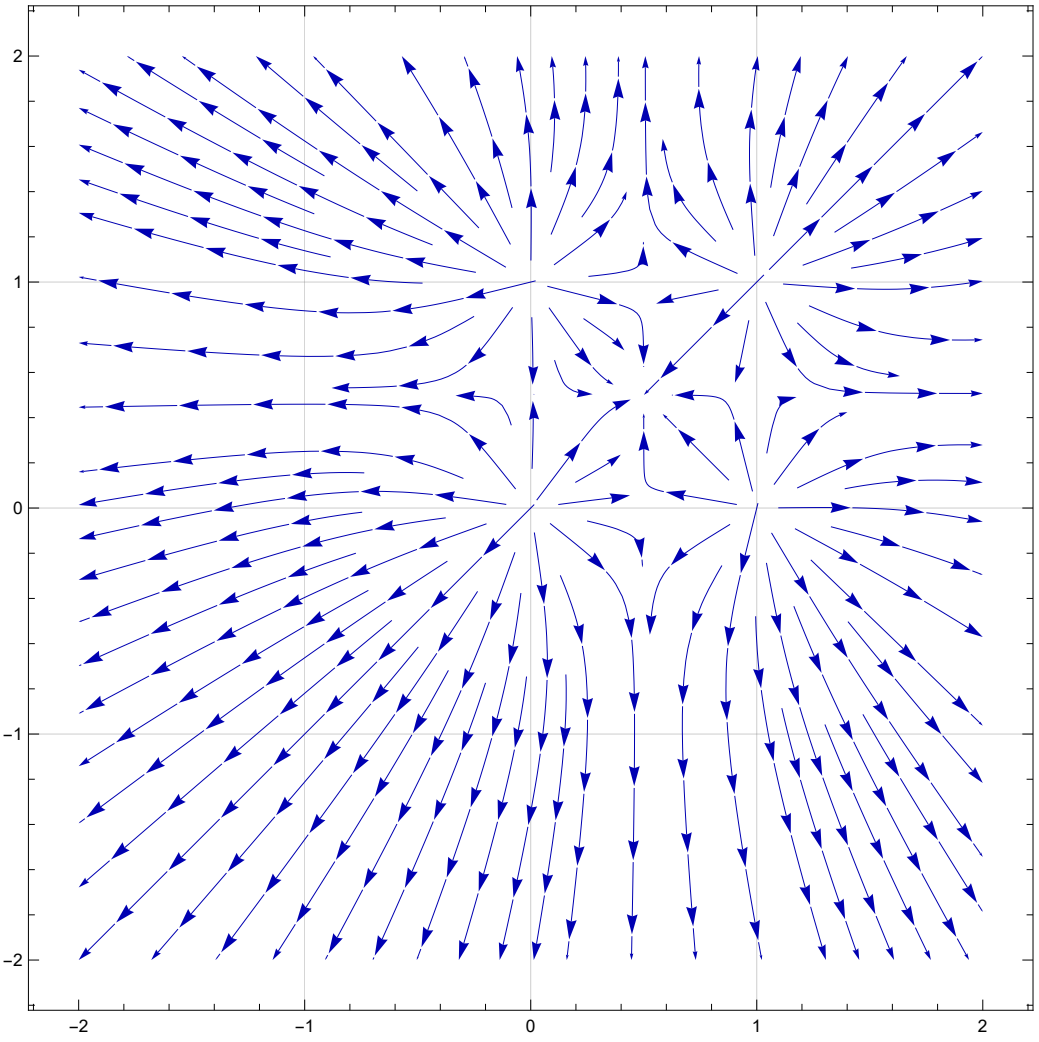


l=1:

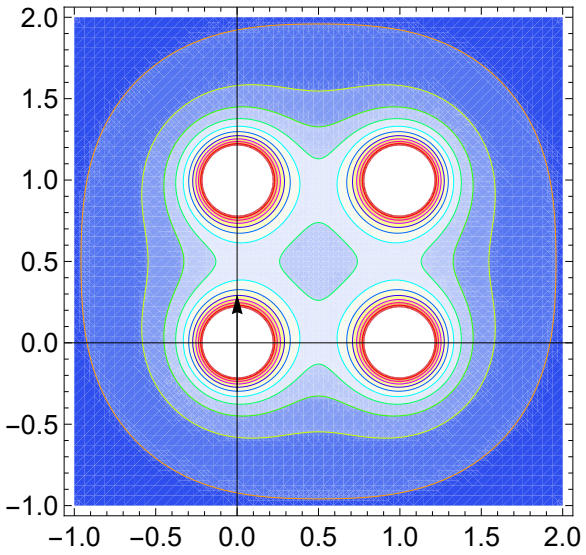



streamline of charge distribution:




equipotential surface:




## Comments

i learnt about how to plot equipotential surface for a charge configuration. i also learnt how to use mathematica for plotting.

## References

1. ChatGPT