# Table of Contents



```
clear;
clc;
```

# Initialization

Basic Parameters

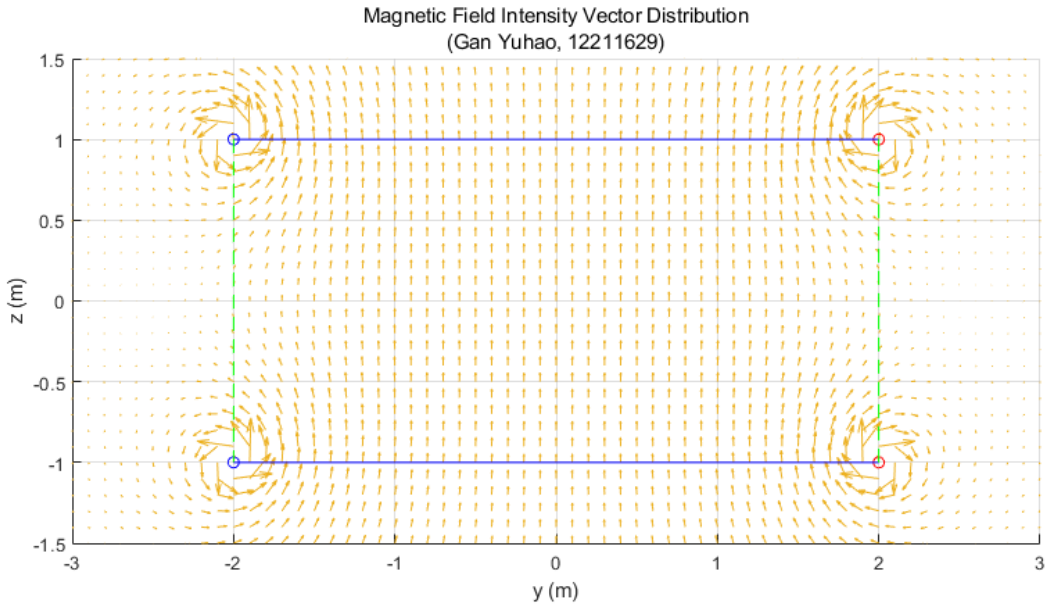
```
a = 2;   % m
I = 500; % As
d = 2;   % m
% Segments Setting
segment_number = 50;
segment_length = 2 * pi * a / segment_number;
angles = linspace(0, 2 * pi , segment_number);
% Range
sampling_density = 10;
length_y = 6;
length_z = 3;
sampling_number_y = sampling_density * length_y + 1;
sampling_number_z = sampling_density * length_z + 1;
range_y = linspace(-length_y / 2, length_y / 2, sampling_number_y);
range_z = linspace(-length_z / 2, length_z / 2, sampling_number_z);
```

# Magnetic Field Intensity Vector Distribution

```
Hy = zeros(sampling_number_y, sampling_number_z);
Hz = zeros(sampling_number_y, sampling_number_z);
% Iterate the mesh points
for it_y = 1 : sampling_number_y
    for it_z = 1 : sampling_number_z
        % Obtain the Vector in yz plane
         P = [0, ...
            (it_y - 1) / sampling_density - length_y / 2, ...
            (it_z - 1) / sampling_density - length_z / 2];
         % Iterate the current Vector
         for S_z = [-d / 2 , d / 2]
             % Iterate the angle segments
             for S_angle = angles(1: segment_number)
                 S = [a * cos(S_angle), a * sin(S_angle), S_z];
                 % Obtain the R vector
                 R = P - S;
```

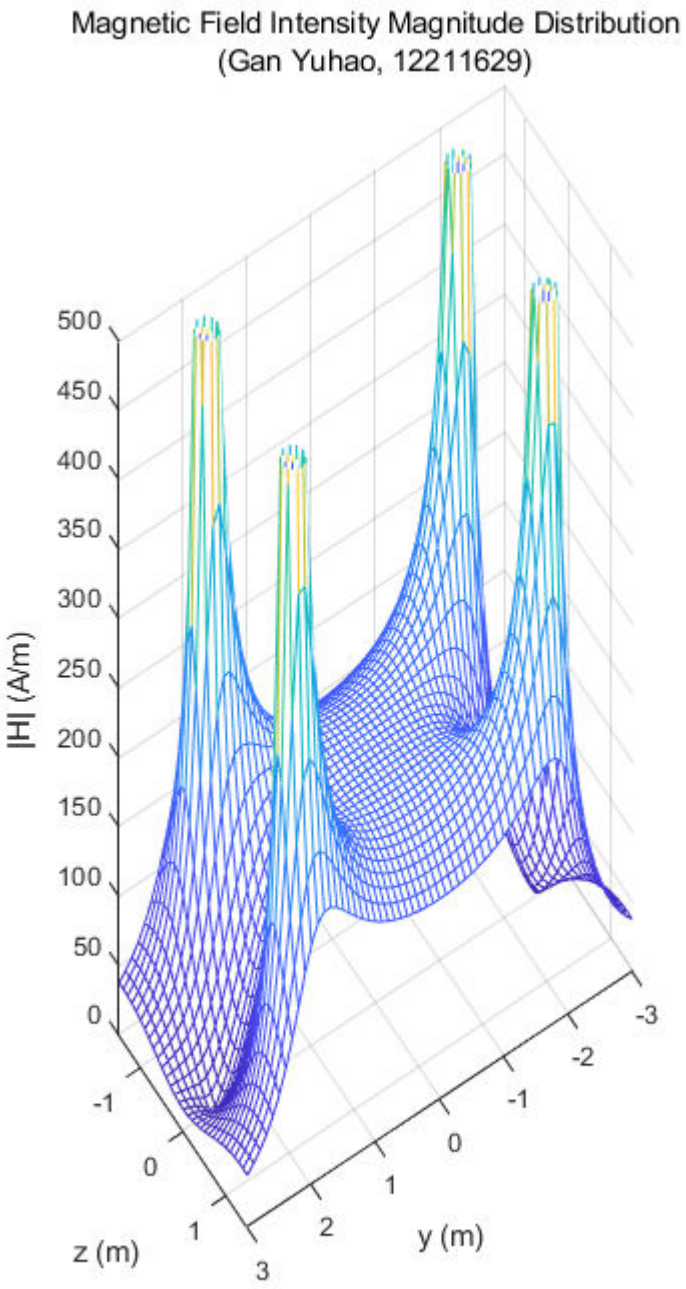
```
                % Obtain the dL
                dL = [-segment_length * sin(S_angle), segment_length *
cos(S_angle),0];
                % Apply Biot-Savart Law
                dH = cross(I .* dL, R) ./ (4 .* pi .* norm(R) .^ 3);
                % Accumulate
                Hy(it_y, it_z) = Hy(it_y, it_z) + dH(2);
                Hz(it_y, it_z) = Hz(it_y, it_z) + dH(3);
            end
        end
    end
end

% Plot the figure
figure(1);
grid on, axis equal, hold on;
[mesh_y, mesh_z] = meshgrid(range_y, range_z);
quiver(mesh_y, mesh_z, Hy', Hz',2);
plot(a, d / 2, 'ro', -a, d / 2, 'bo', a, -d / 2, 'ro', -a, -d / 2, 'bo');
plot([a, -a], [d / 2, d / 2], 'b-', [-a, -a], [d / 2, -d / 2], 'g--', [-a,
a], [-d / 2, -d / 2], 'b-', [a, a], [-d / 2, d / 2], 'g--')
axis([-length_y / 2, length_y / 2, -length_z / 2, length_z / 2]);
set(gcf, 'Position', [50, 50, 900, 600]);
title(["Magnetic Field Intensity Vector Distribution", "(Gan Yuhao,
12211629)"]);
xlabel("y (m)"), ylabel("z (m)");
saveas(1, "Magnetic Field Intensity Vector Distribution","png");
```




# Magnetic Field Intensity Magnitude Distribution

```
H_norm = sqrt(Hy .^ 2 + Hz .^ 2);
% Plot the figure
figure(2);
grid on, axis equal, hold on;
[mesh_y, mesh_z] = meshgrid(range_y, range_z);
mesh(mesh_y, mesh_z, H_norm');
axis([-length_y / 2, length_y / 2, -length_z / 2, length_z / 2, 0, 500]);
set(gcf, 'Position', [50, 50, 400, 700]);
title(["Magnetic Field Intensity Magnitude Distribution", "(Gan Yuhao,
12211629)"]);
view([2, 3, 200]);
xlabel("y (m)"), ylabel("z (m)"), zlabel("|H| (A/m)");
saveas(2, " Magnetic Field Intensity Magnitude Distribution" , "png");
```




# Magnetic Line Distribution

Sample the magnitude of H

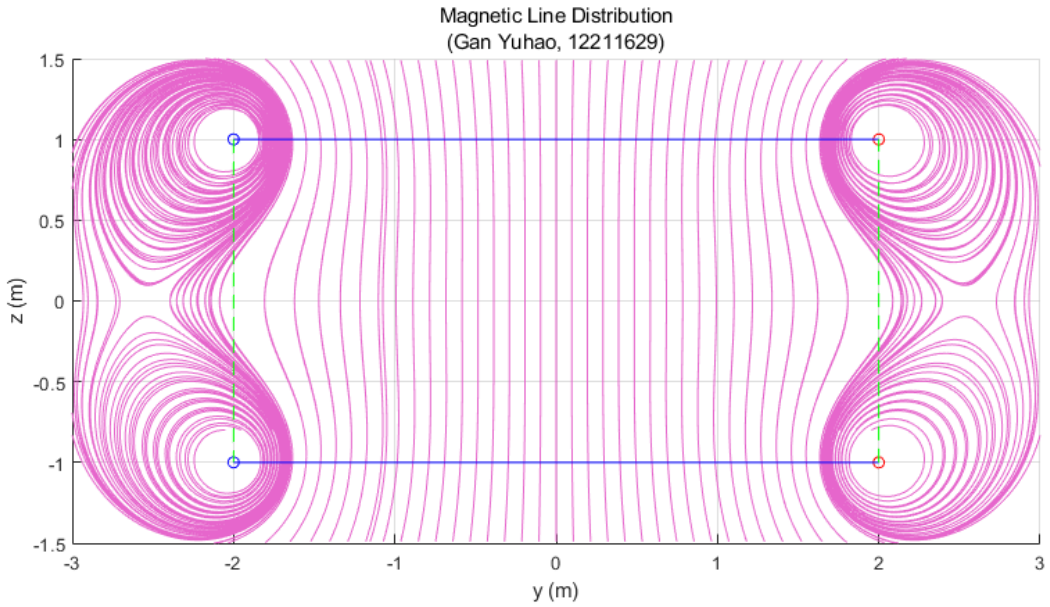
```
H_samples_range_y = [-a - 0.1, a + 0.1];
H_samples_z = d / 2.5;
H_samples_index_y = floor((H_samples_range_y(1) + length_y / 2) *
sampling_density) : floor((H_samples_range_y(2) + length_y / 2) *
```

```
sampling_density);
H_samples_index_z = floor((length_z / 2 + H_samples_z) * sampling_density);
H_samples = H_norm(H_samples_index_y, H_samples_index_z);

% Calculate PDF & CDF
H_pdf = H_samples ./ sum(H_samples);
H_cdf = zeros(1, length(H_pdf));
H_cdf(1) = H_pdf(1);
for it = 2 : length(H_pdf)
    H_cdf(it) = H_cdf(it - 1) + H_pdf(it);
end

% Sample basing on PDF & CDF
line_number = 64;
line_start_y = zeros(1, line_number);
line_start_z = zeros(1, line_number);
uniform_samples = linspace(0.01, 0.978, line_number);
for it_u = 1 : line_number
    u = uniform_samples(it_u);
    if u < H_cdf(1)
        left = 0;
        right = H_samples_range_y(1);
    else
        for it_s = 1 : (length(H_cdf) - 1)
            if u >= H_cdf(it_s) && u < H_cdf(it_s + 1)
                delta = (H_samples_range_y(2) - H_samples_range_y(1)) /
length(H_cdf);
                left = H_samples_range_y(1) + delta * (it_s - 1);
                right = H_samples_range_y(1) + delta * it_s;
            end
        end
    end
    line_start_y(it_u) = (left + right) / 2;
    line_start_z(it_u) = H_samples_z;
end

% Plot the figure
figure(3);
grid on, axis equal, hold on;
[mesh_y, mesh_z] = meshgrid(range_y, range_z);
fig_sl = streamline(mesh_y, mesh_z, -Hy', -Hz', line_start_y, line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
fig_sl = streamline(mesh_y, mesh_z, Hy', Hz', line_start_y, line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
fig_sl = streamline(mesh_y, mesh_z, Hy', Hz', line_start_y, -line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
plot(a, d / 2, 'ro', -a, d / 2, 'bo', a, -d / 2, 'ro', -a, -d / 2, 'bo');
plot([a, -a], [d / 2, d / 2], 'b-', [-a, -a], [d / 2, -d / 2], 'g--', [-a,
a], [-d / 2, -d / 2], 'b-', [a, a], [-d / 2, d / 2], 'g--')
axis([-length_y / 2, length_y / 2, -length_z / 2, length_z / 2]);
set(gcf, 'Position', [50, 50, 900, 600]);
title(["Magnetic Line Distribution", "(Gan Yuhao, 12211629)"]);
xlabel("y (m)"), ylabel("z (m)");
saveas(3, "Magnetic Line Distribution " , "png");
```

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# Table of Contents



# Initialization

```
clear;
clc;
```

# Declarations

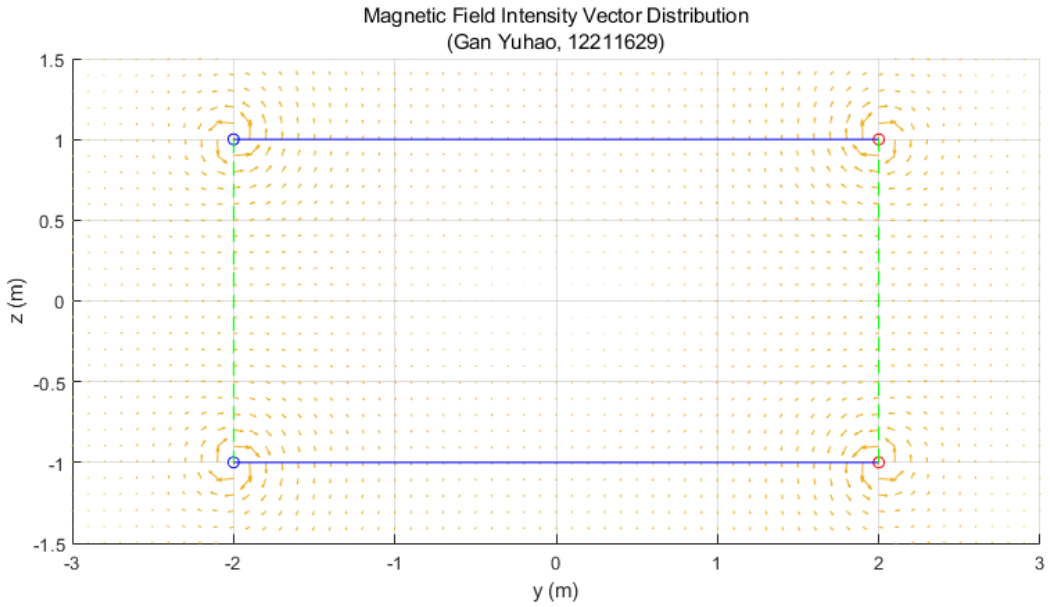
Basic Parameters

```
a = 2;   % m
I = 500; % A
d = 2;   % m
% Scene
segment_number = 50;
segment_length = 2 * pi * a / segment_number;
angles = linspace(0, 2 * pi, segment_number);
% Viewport
sampling_density = 10;
length_y = 6;
length_z = 3;
sampling_number_y = sampling_density * length_y + 1;
sampling_number_z = sampling_density * length_z + 1;
range_y = linspace(-length_y / 2, length_y / 2, sampling_number_y);
range_z = linspace(-length_z / 2, length_z / 2, sampling_number_z);
```

# Magnetic Field Intensity Vector Distribution

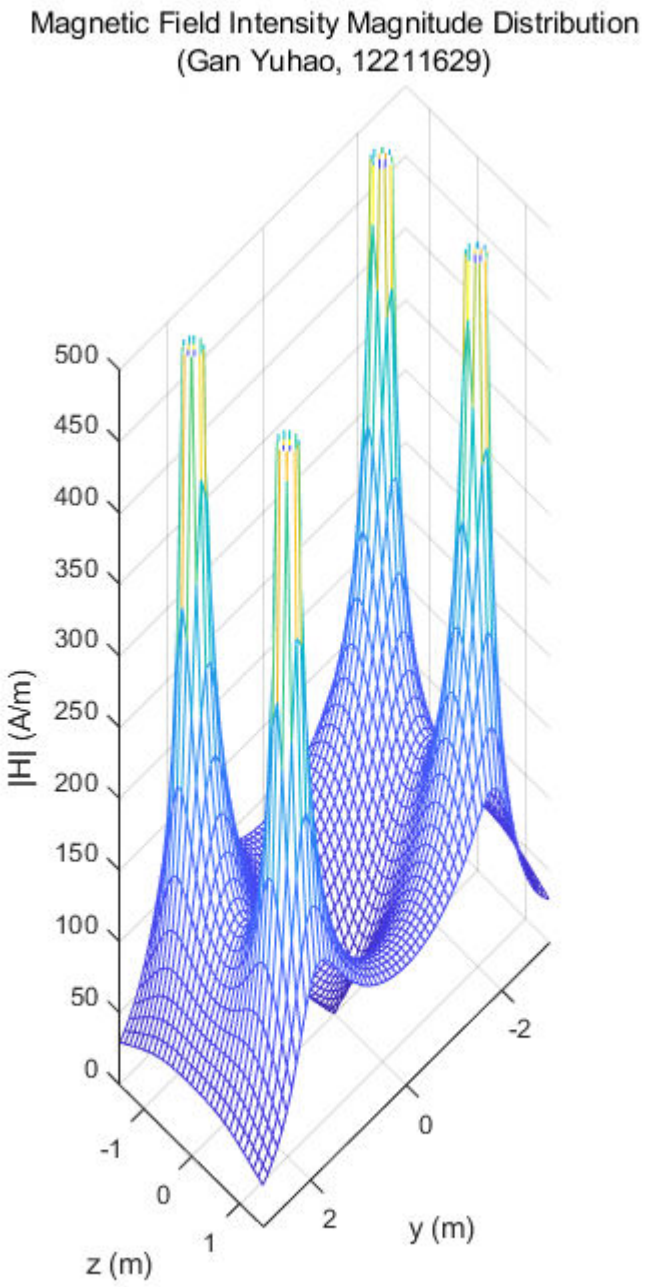
```
Hy = zeros(sampling_number_y, sampling_number_z);
Hz = zeros(sampling_number_y, sampling_number_z);
% Iterate the mesh points
for it_y = 1 : sampling_number_y
    for it_z = 1 : sampling_number_z
        % Obtain real position of the mesh point
        P = [0, ...
            (it_y - 1) / sampling_density - length_y / 2, ...
            (it_z - 1) / sampling_density - length_z / 2];
        % Iterate the loops
        for S_z = [-d / 2, d / 2]
            % Iterate the segments
            for S_angle = angles(1 : segment_number)
                % Obtain the position of current segment
```

```
                S = [a * cos(S_angle), a * sin(S_angle), S_z];
                % Obtain the displacement
                R = P - S;
                % Obtain the differential length
                dL = [-segment_length * sin(S_angle), segment_length *
cos(S_angle), 0] * sign(S_z);
                % Apply Biot-Savart Law
                dH = cross(I .* dL, R) ./ (4 .* pi .* norm(R) .^ 3);
                % Accumulate
                Hy(it_y, it_z) = Hy(it_y, it_z) + dH(2);
                Hz(it_y, it_z) = Hz(it_y, it_z) + dH(3);
            end
        end
    end
end

% Plot the figure
figure(1);
grid on, axis equal, hold on;
[mesh_y, mesh_z] = meshgrid(range_y, range_z);
quiver(mesh_y, mesh_z, Hy', Hz');
plot(a, d / 2, 'ro', -a, d / 2, 'bo', a, -d / 2, 'ro', -a, -d / 2, 'bo');
plot([a, -a], [d / 2, d / 2], 'b-', [-a, -a], [d / 2, -d / 2], 'g--', [-a,
a], [-d / 2, -d / 2], 'b-', [a, a], [-d / 2, d / 2], 'g--')
axis([-length_y / 2, length_y / 2, -length_z / 2, length_z / 2]);
set(gcf, 'Position', [50, 50, 900, 600]);
title(["Magnetic Field Intensity Vector Distribution", "(Gan Yuhao,
12211629)"]);
xlabel("y (m)"), ylabel("z (m)");
saveas(1, "Magnetic Field Intensity Vector Distribution 2","png");
```




# Magnetic Field Intensity Magnitude Distribution

```
H_norm = sqrt(Hy .^ 2 + Hz .^ 2);

% Plot the figure
figure(2);
grid on, axis equal, hold on;
[mesh_y, mesh_z] = meshgrid(range_y, range_z);
mesh(mesh_y, mesh_z, H_norm');
axis([-length_y / 2, length_y / 2, -length_z / 2, length_z / 2, 0, 500]);
set(gcf, 'Position', [50, 50, 400, 700]);
view([3, 3, 200]);
title(["Magnetic Field Intensity Magnitude Distribution", "(Gan Yuhao,
12211629)"]);
xlabel("y (m)"), ylabel("z (m)"), zlabel("|H| (A/m)");
saveas(2, " Magnetic Field Intensity Magnitude Distribution 2" , "png");
```



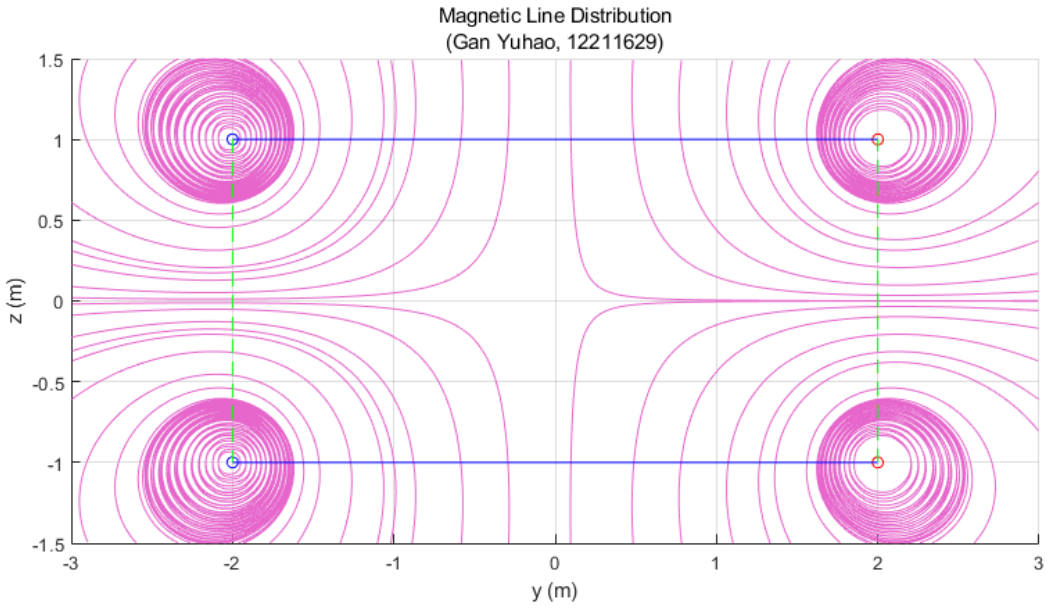

# Magnetic Line Distribution

Sample the magnitude of H

```
H_samples_range_y = [-a, a];
H_samples_z = d / 2;
H_samples_index_y = floor((H_samples_range_y(1) + length_y / 2) *
sampling_density) : floor((H_samples_range_y(2) + length_y / 2) *
```

```
sampling_density);
H_samples_index_z = floor((length_z / 2 + H_samples_z) * sampling_density);
H_samples = H_norm(H_samples_index_y, H_samples_index_z);

% Calculate PDF & CDF
H_pdf = H_samples ./ sum(H_samples);
H_cdf = zeros(1, length(H_pdf));
H_cdf(1) = H_pdf(1);
for it = 2 : length(H_pdf)
    H_cdf(it) = H_cdf(it - 1) + H_pdf(it);
end

% Sample basing on PDF & CDF
line_number = 28;
line_start_y = zeros(1, line_number);
line_start_z = zeros(1, line_number);
uniform_samples = linspace(0.012, 0.99, line_number);
for it_u = 1 : line_number
    u = uniform_samples(it_u);
    if u < H_cdf(1)
        left = 0;
        right = H_samples_range_y(1);
    else
        for it_s = 1 : (length(H_cdf) - 1)
            if u >= H_cdf(it_s) && u < H_cdf(it_s + 1)
                delta = (H_samples_range_y(2) - H_samples_range_y(1)) /
length(H_cdf);
                left = H_samples_range_y(1) + delta * (it_s - 1);
                right = H_samples_range_y(1) + delta * it_s;
            end
        end
    end
    line_start_y(it_u) = (left + right) / 2;
    line_start_z(it_u) = H_samples_z;
end

% Plot the figure
figure(3);
grid on, axis equal, hold on;
[mesh_y, mesh_z] = meshgrid(range_y, range_z);
fig_sl = streamline(mesh_y, mesh_z, -Hy', -Hz', line_start_y, line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
fig_sl = streamline(mesh_y, mesh_z, Hy', Hz', line_start_y, line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
fig_sl = streamline(mesh_y, mesh_z, -Hy', -Hz', line_start_y, -line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
fig_sl = streamline(mesh_y, mesh_z, Hy', Hz', line_start_y, -line_start_z);
set(fig_sl, "lineWidth", 0.4, "color", [0.9, 0.4, 0.8]);
plot(a, d / 2, 'ro', -a, d / 2, 'bo', a, -d / 2, 'ro', -a, -d / 2, 'bo');
plot([a, -a], [d / 2, d / 2], 'b-', [-a, -a], [d / 2, -d / 2], 'g--', [-a,
a], [-d / 2, -d / 2], 'b-', [a, a], [-d / 2, d / 2], 'g--')
axis([-length_y / 2, length_y / 2, -length_z / 2, length_z / 2]);
set(gcf, 'Position', [50, 50, 900, 600]);
title(["Magnetic Line Distribution", "(Gan Yuhao, 12211629)"]);
```

```
xlabel("y (m)"), ylabel("z (m)");
saveas(3, "Magnetic Line Distribution 2" , "png");
```

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