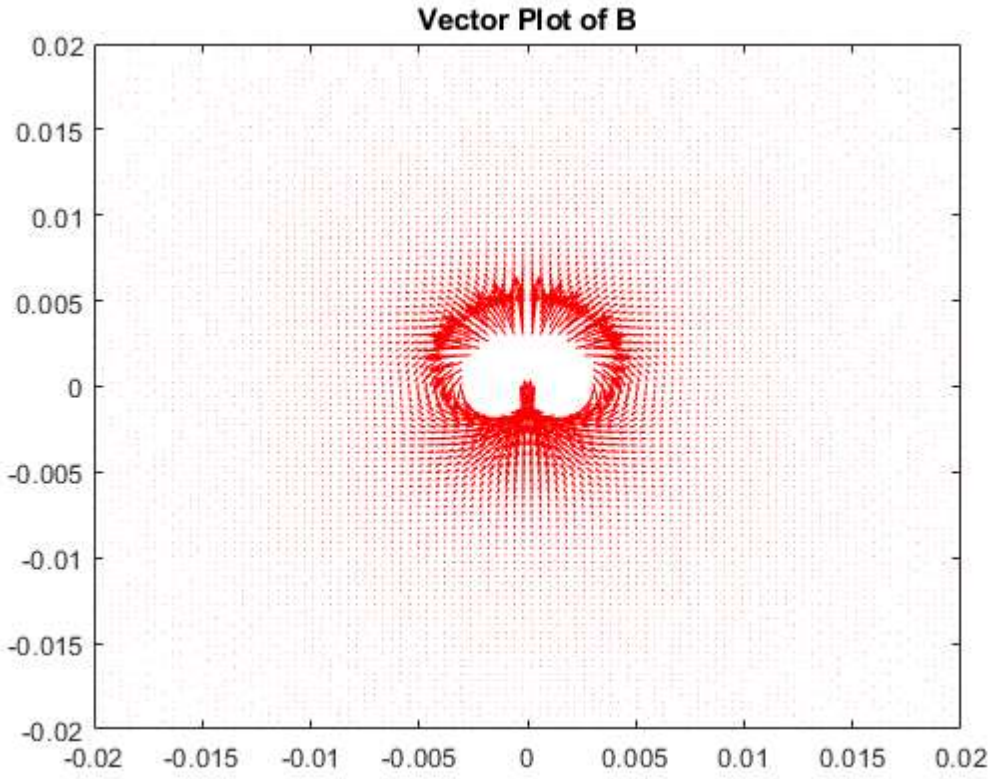
Contents

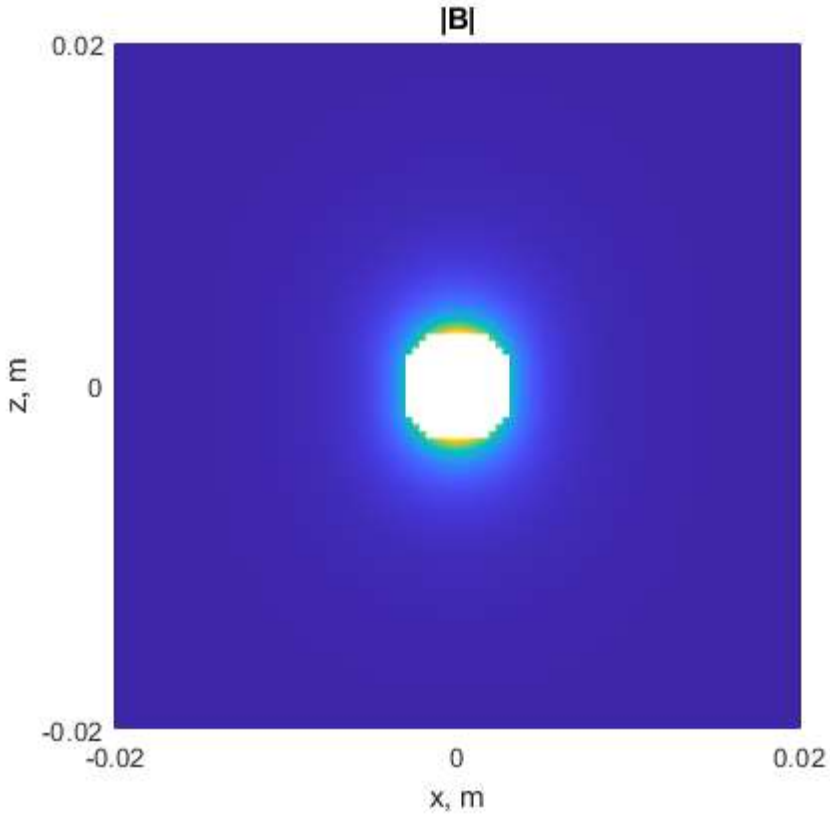

```
clc;
clear all;
close all;
```

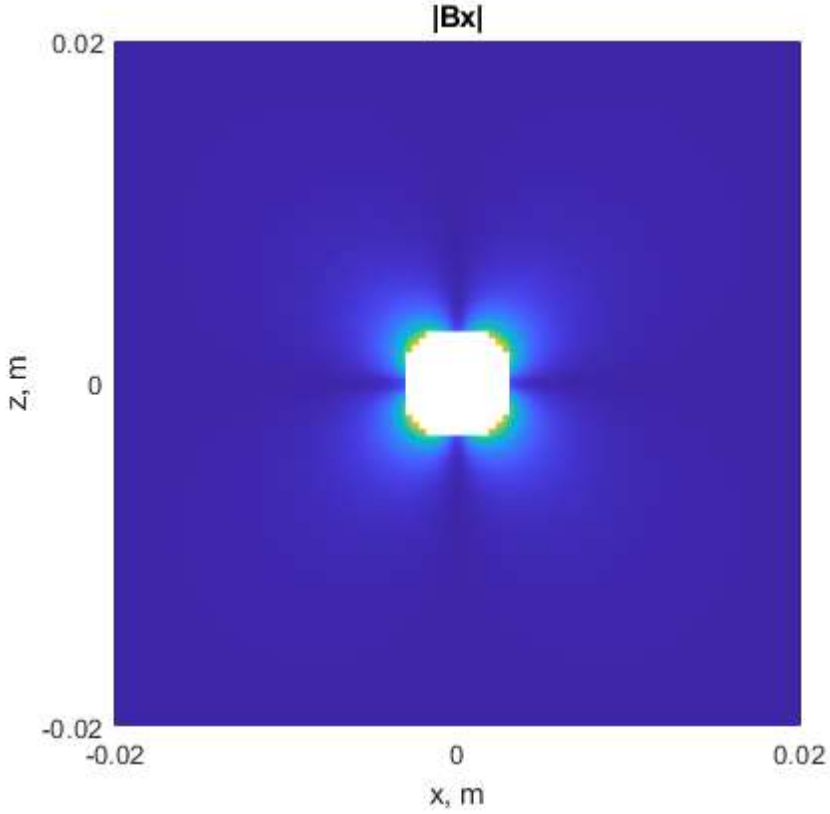
Modeling a simple permanent magnet

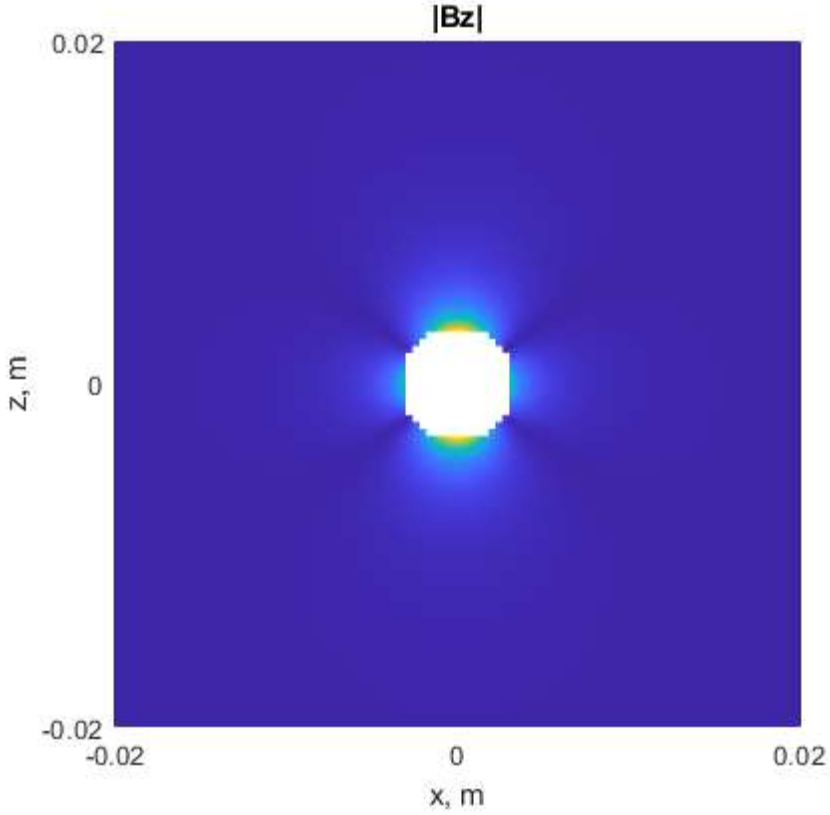
```
x = linspace(-0.02,0.02);
z = linspace(-0.02,0.02);
C = 350/(5.8*10^(6));
[X, Z] = meshgrid(x, z);

th = atan2(X,Z);
phi= atan2(Z,X);
r  = sqrt(X.^2 + Z.^2);
r(r <=0.003) = NaN; %excludes number smaller than

Br  = (C*2.*cos(th))./(r.^3);
Bth = (C  .*sin(th) ./ r.^3);
Bx  = cos(th).*Bth + sin(th).* Br ;
Bz  = cos(th).*Br  - sin(th).* Bth;

figure(1)
quiver(x , z , Bx , Bz , 6 , 'r');
xlim([-0.02 , 0.02])
ylim([-0.02 , 0.02])
title('Vector Plot of B')

%a) |B|
figure(2)
magB = sqrt((Bx).^2 + (Bz).^2);
pcolor (x , z , magB)
axis equal
shading interp
xlim([-0.02 , 0.02])
xticks([-0.02 , 0 , 0.02])
xlabel('x, m')
yticks([-0.02 , 0 , 0.02])
ylim([-0.02 , 0.02])
ylabel('z, m')
title('|B|')
hold on

%b) Magnitude of Bx
figure(3)
magBx = abs(Bx);
pcolor(x , z , magBx)
axis equal
shading interp
xlim([-0.02 , 0.02])
xticks([-0.02, 0, 0.02])
xlabel('x, m')
```

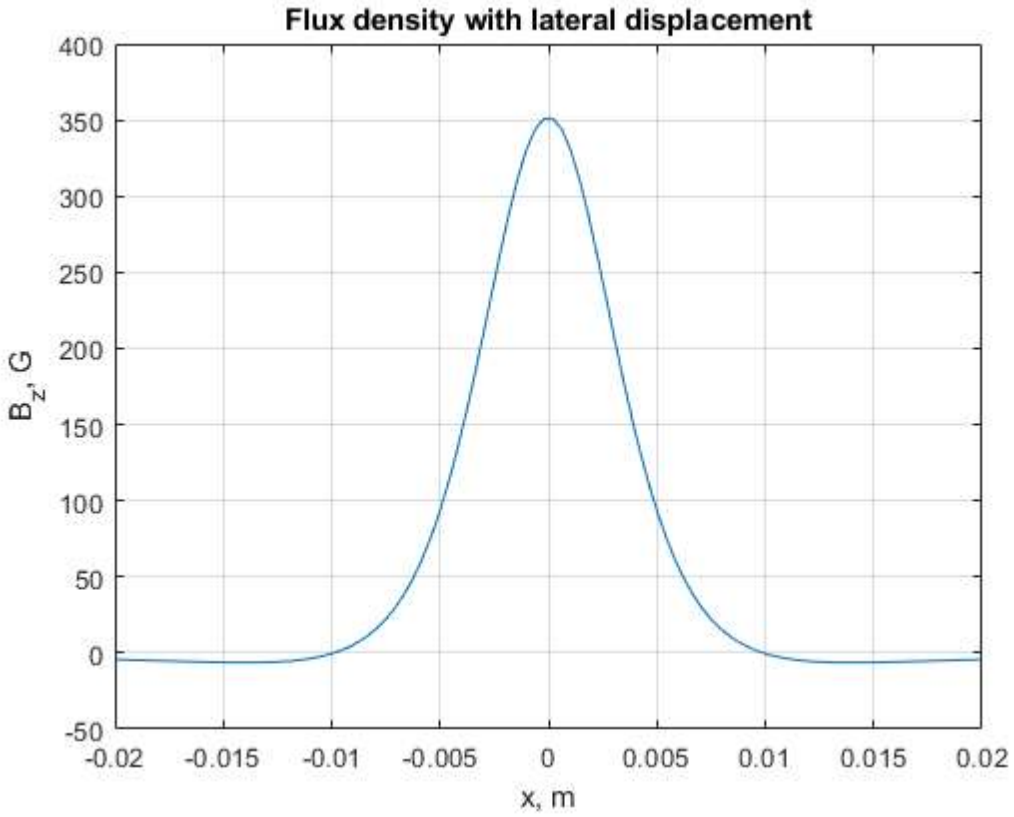
```
ylim([-0.02 , 0.02])
yticks([-0.02 , 0 , 0.02])
ylabel('z, m')
title('|Bx|')
hold on

%c) Magnitude of Bz
figure(4)
magBz = abs(Bz);
pcolor(x , z , magBz)
axis equal
shading interp
xlim([-0.02 , 0.02])
xlabel('x, m')
xticks([-0.02 , 0 , 0.02])
ylim([-0.02,0.02])
yticks([-0.02 , 0 , 0.02])
ylabel('z, m')
title('|Bz|')
hold on

z    = 7*10^(-3);
r    = sqrt(x.^2+z^2);
th   = atan2(x, z);

Bth  = sin(th) .* (C./(r.^3))  ;
Br   = cos(th) .* (C./(r.^3))*2 ;

Brz  = Br .* cos(th);
Bthz = -1 .* Bth .*sin(th);
Bz   =  Bthz + Brz;

figure(5)
plot(x , Bz);
title('Flux density with lateral displacement')
xlabel("x, m");
xlim([-0.02 , 0.02])
ylabel("B_z, G");
ylim([-50 , 400])
grid on
```


Vector Plot of B
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.02
-0.015
-0.01
-0.005
0
0.005
0.01
0.015
0.02


|B|
0.02
0
-0.02
z, m
-0.02
0
0.02
x, m


|Bx|
0.02
0
-0.02
z, m
-0.02
0
0.02
x, m


|Bz|
0.02
0
-0.02
z, m
-0.02
0
0.02
x, m



Field Sensor Responses

Flux Through a Moving Loop for Different Vs & Induced EMF for diff vs

```
 ph = zeros(1, 101);
dph = zeros(1, 100);
a = 10^(-6);
z   = 0.03;
for V = [1, 2, 5, 10]
    t = linspace(-0.04, 0.04, 101);
    for i = 1: length(t)
        x  = t(i) * V;
        th = atan2(x,z);
        r  = sqrt(x.^2 + z.^2);

        Br  = 2*C.*cos(th)./r.^3;
        Bth =   C.*sin(th)./r.^3;

        ph(i) = 1e4*(Br.*cos(th)-(Bth).*sin(th))*a;

        if i ~= 1
           dph(i-1) =(ph(i) - ph(i-1))/(t(i)-t(i-1));
        end
    end
    tnew = t(1:(length(t)-1));

    figure(6)
    plot(t, ph)
    title('Flux Through a Moving Loop for Different Vs')
    legend('V = 1  m/s','V = 2  m/s','V = 5  m/s', 'V = 10 m/s')
    xlabel('t, s')
    ylabel('\psi, T\bulletm^2')
    hold on
```

```
    figure(7)
    plot(tnew, dph)
    title('Induced EMF(t) for Varying Velocities')
    legend('V = 1  m/s','V = 2  m/s','V = 5  m/s', 'V = 10 m/s')
    xlabel('t, s')
    ylabel('V_E_M_F(t),V')
    hold on
end
    hold off

    figure(6)
    xlim([-0.04,0.04])
    xticks(-0.04: 0.01 :0.04)
    ylim([-0.01,0.05])
    yticks(-0.01: 0.01 :0.05)
    grid on

    figure(7)
    xlim([-0.04,0.04])
    xticks(-0.04: 0.01 :0.04)
    ylim([-30,30])
    yticks(-30: 10 :30)
    grid on
```

```
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Warning: Ignoring extra legend entries.
```
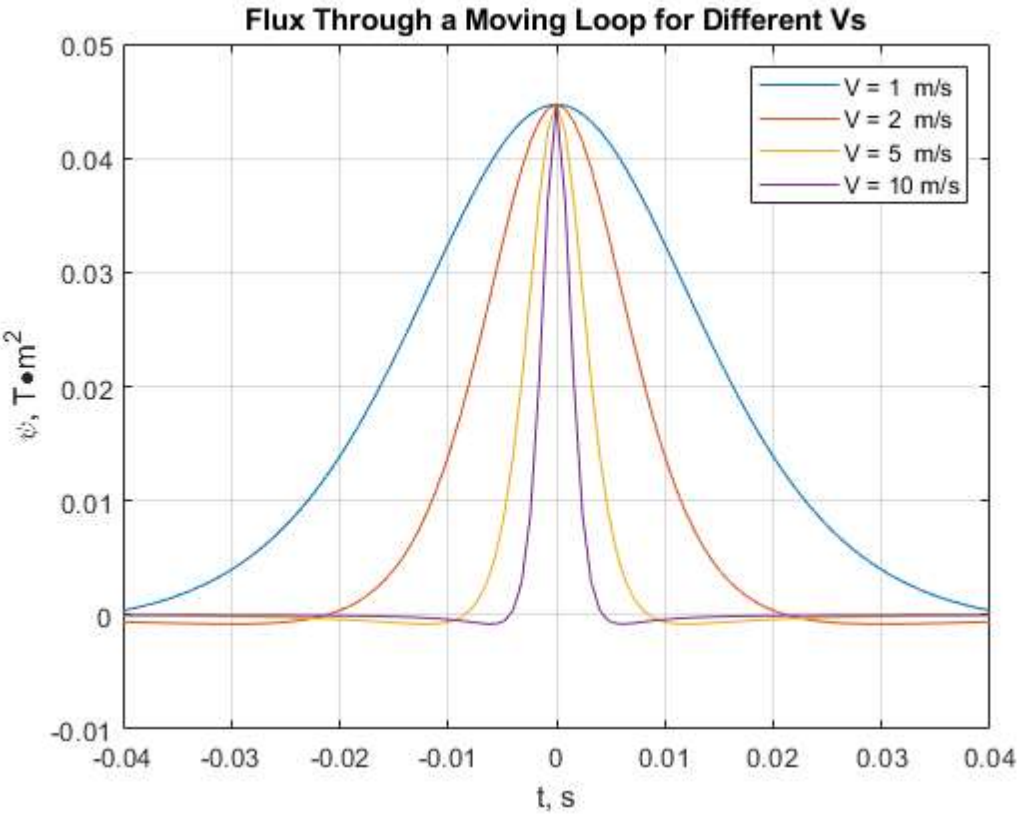
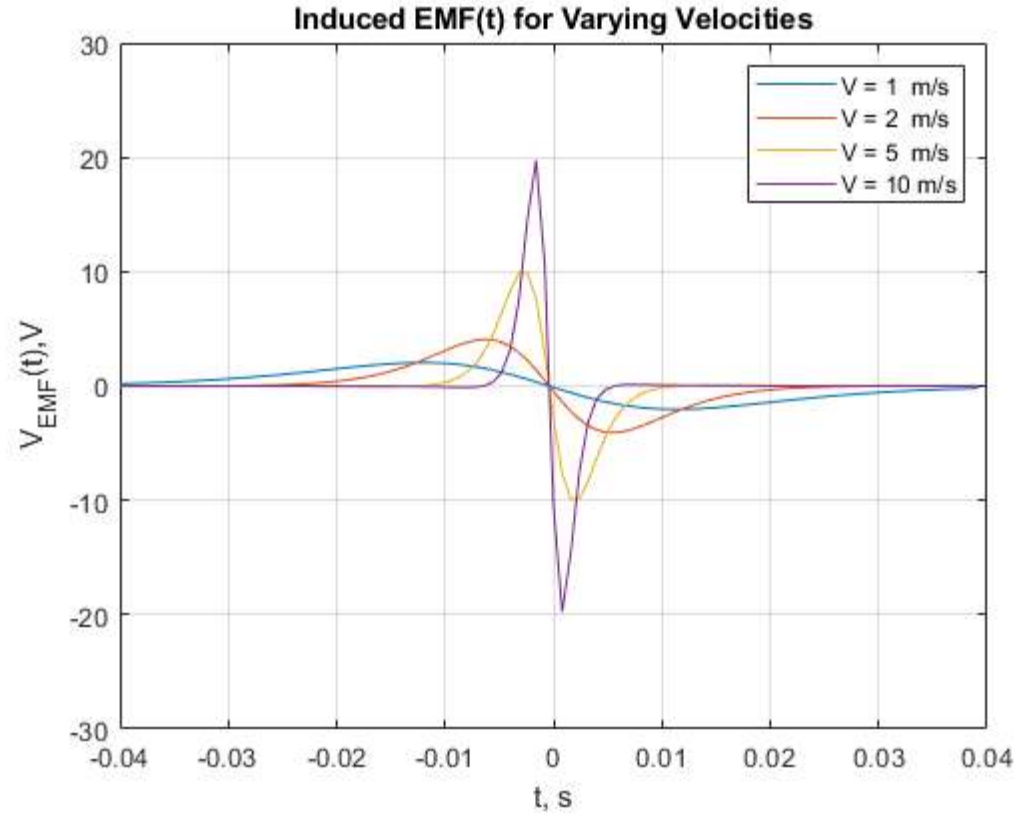



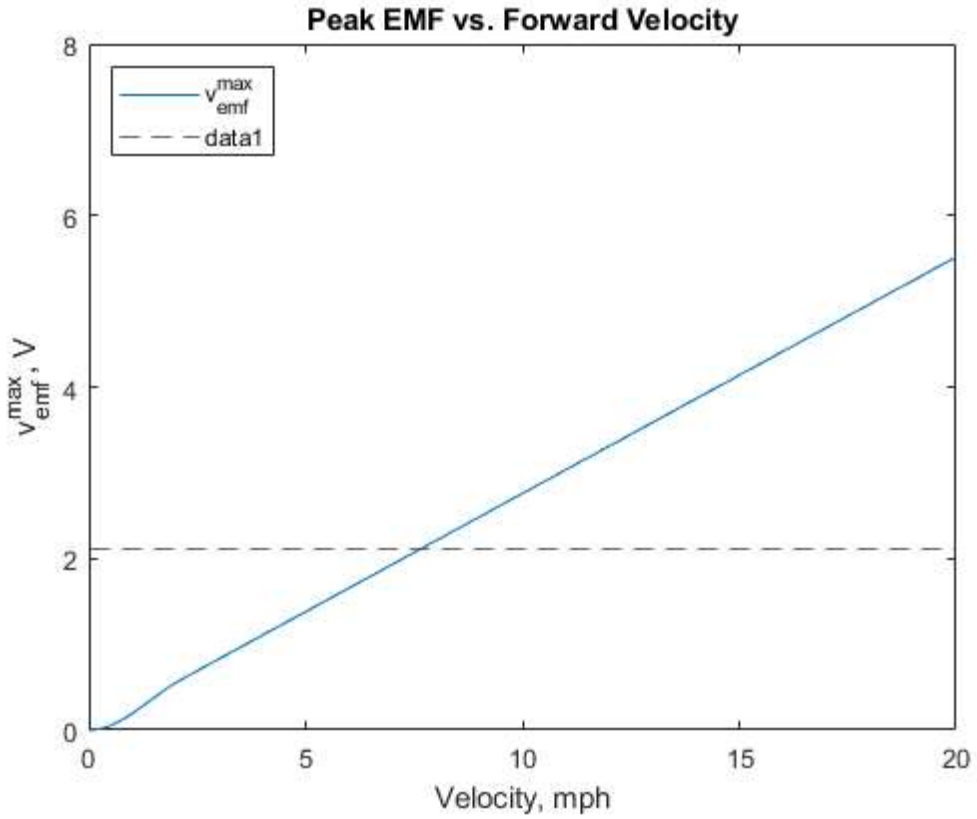


System-level Calculations

```
t    = linspace(-0.04, 0.04, 301);
vmph = linspace(    0,   20, 300);
x    = [];
```

```
psiA = a*10^4;
d    = 662*10^(-3);
z    = 0.03;
vms  = vmph.*0.447;
freq    = vms/pi/d;
vel    = 0.2*pi*freq;

for V = vel
    x = [x ; t*V];
end
th = atan2(x , z);
r  = sqrt(x.^2+z.^2);

Bth =    (C./r.^3).*sin(th);
Br  = 2.*(C./r.^3).*cos(th);
Brx = Br.*cos(th);
Bthz= -1*Bth.*sin(th);
Bz  = Brx + Bthz;
psi = psiA.*Bz;

d = [];
for V = 1:numel(vel) %number of elements in a matrix
    dv = [];
    for i = 1:(numel( psi(1,:))-1)
        dv = [dv, (psi(V, i+1) - psi(V, i))/(t(i+1) - t(i))];
    end
    d = [d, max(dv)];
end

figure
plot(vmph, d);
h = legend('v^{max}_{emf}', '2.1 V','Location','northwest');
yline(2.10, '--');

xlabel('Velocity, mph');
xticks([0, 5, 10, 15, 20])
xlim([0,20])
ylabel('v^{max}_{emf}, V');
yticks([0, 2, 4, 6, 8])
ylim([0,8])
title('Peak EMF vs. Forward Velocity')
```

```
Warning: Ignoring extra legend entries.
```



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