Additional instructions:

- start Matlab and open a new script
- clean the Matlab:

```
clc
close all
clear all
```

- set the model variables:

```
global f hmax % define f and hmax as global
variable so that you do not need to feed them into
the function hh, bellow.
ms=1.7e6; m0=4e-7*pi;
a=512; c=0.75; k=570; al=5e-5; ls=10e-6;
f=1.;
hmax=8000;
```

- define the step size and the time

```
steps =1000;
dt=1/(f*steps);
t=[0:dt:3*1/f];
```

- initialize the first step (the function hh() is given later and can be in the same file as the script. insated of using h1 in the expression of ma, we use h1=1 as to avoid divide by 0.

```
[h1 dh1]=hh(t(1));
ma(1)=ms*(coth(1/a)-a/1); % anhysteretic M
mi(1)=ma(1)/(k-al*ma(1)); % irreversible M, with
                          % d=1 and mi=0
h(1)=h1;
```

- loop over time, starting at t(2) as t(1) is already initialized

```
for i=2:length(t)
    [h1 dh1]=hh(t(i));
    d=sign(dh1);
    h(i)=h1;
    if abs(h1)<=1e-10 h1=sign(h1); end % avoid dividing
by 0.
    ma1=ms*(coth(h1/a)-a/h1);
    ma(i)=ma1;
```

```
    mi1=mi(i-1)+(h(i)-h(i-1))*((ma(i-1)-mi(i-1)))/(k*d-al*(ma(i-1)-mi(i-1)));
    mi(i)=mi1;
end
```

- in the above, at each step (i), ma is calculated according to the Langevin equation, and mi integrated with Euler scheme from the previous values of ma and mi (step=i-1), only h is taken from the current step (i).
- After the loop ends, we have arrays of the quantities needed and we can calculate the other quantities using the given equation:

```
mr=c*(ma-mi);
m=mr+mi;
l=ls*(m/ms).^2;
b=m0*(h+m);
he=h+al*m;
```

- Now we have all the quantities and we can plot them:

```
figure(1);
plot(h,b,'b',h,m0*m,'r');
legend('H-B','H-M');
xlabel('H (A/m)');
ylabel('B or M (T)');
grid on;
```

- We can also compute the losses and print them:

```
disp(cat(2,'the losses are: ',num2str(sum(h(end-steps:end).*diff(b(end-steps-1:end)))),' (J/m^3)'));
```

- At the end of the script you still need to have the function hh:

```
function [h dh]=hh(t)
global f hmax;

h=hmax*sin(2*pi*f*t);
dh=2*pi*f*hmax*cos(2*pi*f*t);
end
```