**ECSE 543**

**Assignment 3**

**Numerical Methods in Electrical Engineering**

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## Question 1

### (a)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 | Point 6 |
| B (T) | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 |
| H (A/m) | 0.0 | 14.7 | 36.5 | 71.7 | 121.4 | 197.4 |

Table : The first 6 points to be interpolated

Using Wolfram Alpha to expand this expression gives:

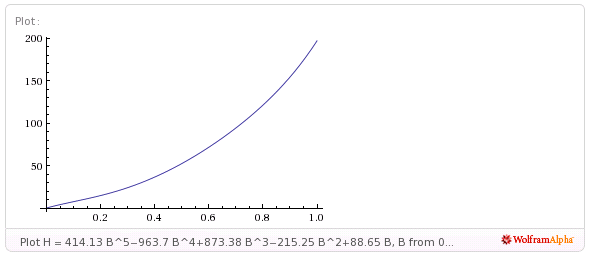


Figure : Plot of H (A/m) versus B (T) Interpolation (first 6 points)

Yes, this interpolation and its associated plot lie close to the true B versus H over this range as the chosen 6 adjacent points are closely spaced. Moreover, the plot resembles a theoretical H versus B plot in a hysteresis loop.

### (b)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Point 1 | Point 2 | Point 3 | Point 4 | Point 5 | Point 6 |
| B (T) | 0.0 | 1.3 | 1.4 | 1.7 | 1.8 | 1.9 |
| H (A/m) | 0.0 | 540.6 | 1062.8 | 8687.4 | 13924.3 | 22650.2 |

Table 2: The given 6 points to be interpolated

The Lagrange polynomial for the points above is given by:

Using Wolfram Alpha to expand this expression gives:

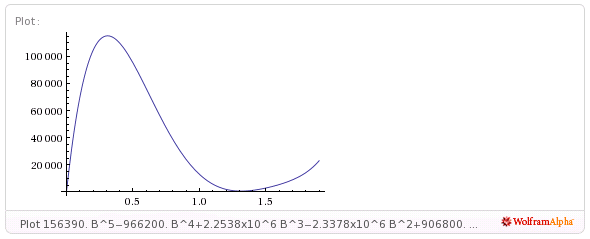


Figure 2: Plot of H (A/m) versus B (T) Interpolation (given 6 points)

No, this interpolation and its associated graph are not plausible H versus B relations as the chosen points to generate the Lagrange polynomial were widely spaced (leading to a divergent polynomial).

### (c)

EXPLAIN HERMITE POLYNOMIALS?

## Question 2

### (a)

The magnetic circuit suggests the following relation:

The reluctance of a magnetically uniform magnetic circuit element can be calculated as:

Thus, substituting the reluctance expressions into our original relation, we obtain:

Then, substituting the given values in the problem statement yields:

### (b)

We are to use the relation between B and H from Table 1 in the assignment instructions. To link to H, we know that , hence, we need only divide to get to B. In other words, we can use our table with:

For the Newton-Raphson method, we solve for in the following relation:

Where:

Since , , then:

The relation between H and B in the steel core is described with a piecewise interpolation of the following points:



is given by:

Our initial guess for the flux is . Linear interpolation (and extrapolation) is used for the B-H relation. The code to solve for the flux was written in C and is included in the appendix ().

The table below shows the results after each iteration of the Newton-Raphson algorithm until the residue drops below .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| k | flux (Wb) | f | f' | |residue| |
| 0 | 0 | -8000 | 40009240 | 1.0056E-304 |
| 1 | 0.000199954 | 9356.654 | 301565700 | 1 |
| 2 | 0.000168927 | 1201.881 | 156953700 | 1.169582 |
| 3 | 0.000161269 | 1.42153E-12 | 156953700 | 0.1502351 |

Table : Results of the NR method after each iteration

The number of iterations are and the final flux value is (Wb).

### (c)

Successive substitution was implemented to solve our problem, but the method does not converge. The divergence is shown in the partial results below:

|  |  |  |
| --- | --- | --- |
| itr | flux (Wb) | f |
| 0 | 0 | -8000 |
| 1 | 8000 | 2.41253E+12 |
| 2 | -2.41253E+12 | -9.65233E+19 |
| 3 | 9.65233E+19 | 2.91081E+28 |
| 4 | -2.91081E+28 | -1.16459E+36 |
| 5 | 1.16459E+36 | 3.51202E+44 |
| … | … | … |
| 35 | 1.9467E+277 | 5.8707E+285 |
| 36 | -5.8707E+285 | -2.3488E+293 |
| 37 | 2.3488E+293 | 7.0832E+301 |
| 38 | -7.0832E+301 | -inf |
| 39 | inf | inf |
| 40 | nan | nan |

Table : Results for non-converging successive substitution

HOW DO I SOLVE SUCCESSIVE SUBSTITUTION DIVERGENCE?

## Question 3

### (a)

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### (b)

FINISH : How to compute dJ/dv & AdJ/dvA\_T (see onenote)

COPY ONENOTE

ISSUE IN CODE: why do I have to define f as –f to get right answer (maybe I’m wrong with the sign in f to begin with?)

The algorithm implemented in question 2 for the Newton-Raphson method was adapted for a vectors in file (see appendix). The error measure was defined as the absolute average of . The algorithm was stopped when this error dropped below

The results of running the program are listed in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| k | Voltage Diode A (V) | Voltage Diode B (V) | f[0] | f[1] | Error |
| 0 | 0 | 0 | -4.40E-04 | 0.00E+00 | 2.20E-04 |
| 1 | 0.145503 | 0.072751 | 1.98E-04 | 1.81E-04 | 1.89E-04 |
| 2 | 0.124114 | 0.081581 | 5.67E-05 | 5.52E-05 | 5.60E-05 |
| 3 | 0.11086 | 0.08925 | 1.02E-05 | 8.56E-06 | 9.38E-06 |
| 4 | 0.107695 | 0.090516 | 3.89E-07 | 3.33E-07 | 3.61E-07 |
| 5 | 0.107564 | 0.090571 | 6.18E-10 | 5.10E-10 | 5.64E-10 |
| 6 | 0.107563 | 0.090571 | 1.51E-15 | 1.28E-15 | 1.39E-15 |

Table : Results of the Newton Raphson method in solving f = 0

The voltage across diode A is found to be equal to 0.107563 (V) and is equal to 0.090671 (V) across diode B.

We observe that the method converges very rapidly. In fact, since:

Then the convergence is indeed quadratic.

## Question 4

### (a)

## Appendix