

Bar Magnet Benchmarks

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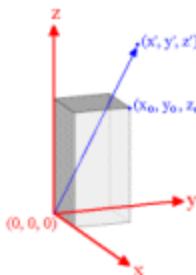
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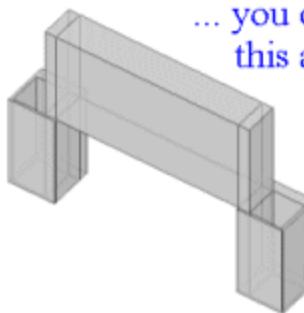
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When evaluating magnetic simulation software you will need some benchmarks for making comparison. Among the benchmarks there should be some of your own measured data on your own products. However, this can be misleading if it is the only benchmark used. Questions come up such as "how much error is there in that measurement?", "how close is the permeability of the actual material to what was used in the simulation?", "did the cutting process locally change the permeability in this material?", "did the magnetizing process truly generate a uniform magnetization in one direction through the magnet's volume?"... So long as such questions remain it is possible to choose the wrong software based on the fact that it gave the "right" answer for the measurement.

If, in fact, the model does not properly represent the real measured device then the program which gave the closest answer this time is probably the worst program to use in general. So, part of the evaluation needs to be some ideal problems for which the exact answer is known. The trick is to come up with ideal problems which are sufficiently challenging to show up differences between various software that might be evaluated.



If you can solve
this magnet...



... you can solve
this assembly

This page discusses one such case, the constant magnetization ($dB/dH=1$) bar magnet. By itself this is not challenging, however, it is possible to make up arbitrarily complex assemblies and still know what the answer should be. The reason is that for constant magnetization the various components don't affect each other. Hence you can find the exact \mathbf{B} field anywhere by superposition of the individual parts. To find the \mathbf{B} fields from the individual parts, use our [Bar Magnet Calculator](#).

1) Simple Case

The [Bar Magnet Calculator](#) already discusses a $1 \times 1 \times 2$ (units are irrelevant) bar magnet, magnetized in the z direction with $Br=1$, $dB/dH=1$. Using our program [AMPERES](#) on a 2.4 GHz PC, and using the default settings, the problem is solved in about 2 seconds. The field at the point $(0.5, 0.5, 4)$ is then calculated as 0.055490202 T. At this position the answer should be $B=0.055490199$ T. The difference is less than 3 in the 8th decimal place.

2) More Challenging Case

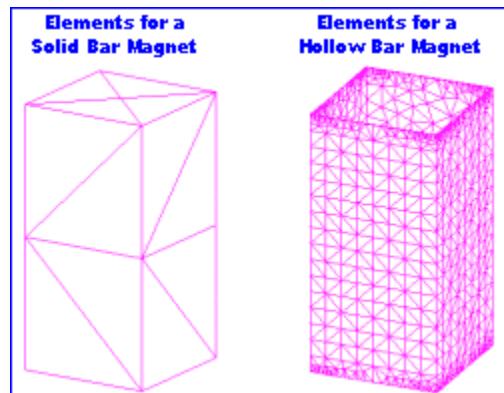
For a more challenging test case the bar magnet from case #1 was made hollow, with a wall thickness of 0.01. This forces a much finer element mesh for any numeric solution. To use the [Bar Magnet Calculator](#) and the principle of superposition, the problem is considered as a solid bar magnet with the hole being a slightly smaller bar magnet with opposite orientation. So for example, for a $1 \times 1 \times 2$ magnet at the position $(1.5, 0.25, 1.1)$ the calculator gives:

$$B_x = 0.007349536$$

$$B_y = -0.0017715728$$

$$B_z = -0.054933985$$

(note, the procedure outlined on the calculator page of



increasing the number of elements to estimate the error is required)

For the hollow part we model a 0.98x0.98x2 bar magnet at the position (1.49, 0.24, 1.1) - a 0.01 adjustment on x and y since the calculator moves the magnet in by this much to be at the origin. The results now are:

$$\begin{aligned}B_x &= 0.007082734 \\B_y &= -0.0017114623 \\B_z &= -0.054933985\end{aligned}$$

Subtracting the middle gives

$$\begin{aligned}B_x &= 0.007349536 - 0.007082734 = 0.000266802 \\B_y &= -0.0017715728 - -0.0017114623 = 0.0000601105 \\B_z &= -0.054933985 - -0.052725620 = -0.002208365\end{aligned}$$

AMPERES Result:

As with the [calculator](#), magnetic simulation programs will be able to provide a variety of accuracy criteria. The more accurate the simulation, the longer it will take. Here are the results from a 14 minute solution (on a 2.4 GHz PC) using [AMPERES](#):

$$\begin{aligned}B_x &= 0.00026680298 \\B_y &= 0.00006010611 \\B_z &= -0.002208356\end{aligned}$$

With this accuracy setting and at this position, [AMPERES](#) is able to provide agreement to 6 or 7 decimal places. For another comparison using the same solution, a position far from the magnet is also calculated (50, 17, 23). In this case we get:

Calculator Result:

$$\begin{aligned}B_x &= 3.53569E-8 \\B_y &= -1.17856E-8 \\B_z &= 1.89949E-8\end{aligned}$$

AMPERES Result (using the same 14 minutes solution as above):

$$\begin{aligned}B_x &= 3.5356886E-8 \\B_y &= 1.1785628E-8 \\B_z &= -1.8994816E-8\end{aligned}$$

Again, even this far away, we see 6 or 7 decimal place agreement between the two solutions. In fact, one of the benefits of using integral techniques is that the solutions are not confined by artificial boundaries to a particular region.

Summary

If you are modeling problems involving permanent magnets, and especially if they operate with dB/dH near 1, you can use the [Bar Magnet Calculator](#) to create some ideal benchmarks for problems similar to the ones of interest. If you have some program besides [AMPERES](#) please run the simple to setup cases described above and see if it is able to provide anywhere near the same accuracy in the same solution time. In the likely event that it does not, you should give us a call to try our full-version 30 day evaluation.