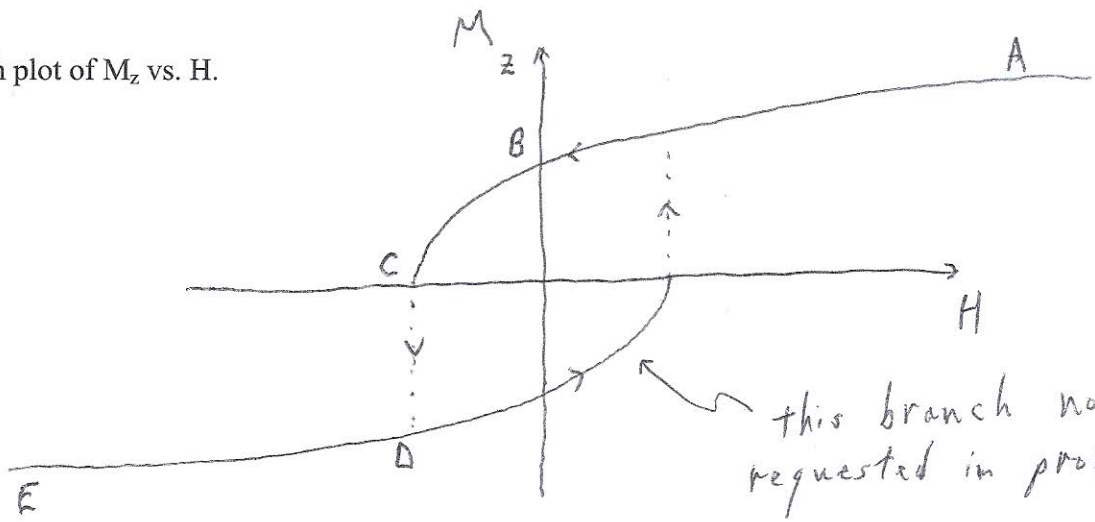
SOLUTIONS

Physics 842 – Fall 2012
Classical Electrodynamics II

Quiz #9 – Thursday, November 29, 2012

A single-domain magnetic particle has the shape of a prolate ellipsoid, with a = b < c. It is oriented with its c-axis at an angle $\theta = \pi/4$ with respect to the z-axis. A large external magnetic field $\vec{H} = H\hat{z}$ is initially applied along the +z direction. The field is gradually reduced to zero, then increased to a large value in the –z direction.

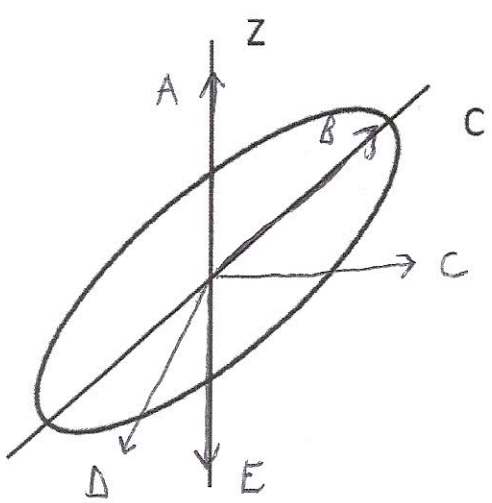
a) Make a rough plot of M_z vs. H.



b) Choose the following five special values of H, and label them on your plot of M_z vs. H:

A: large positive H
B: H = 0
C: H < 0, just before M_z switches
D: H < 0, just after M_z switches
E: large negative H

For each of these values of H, draw the direction of M on the drawing to the right, and label them!



(over)

c) Define ϕ as the angle between M and the +z axis. Write down an expression for the total magnetostatic energy of the system as a function of θ, ϕ, M, H, and the demagnetizing factors n_a and n_c.

(per unit volume)

$$U = 2\pi M^2 \left[n_a \sin^2(\phi - \theta) + n_c \cos^2(\phi - \theta) \right] - MH\cos\phi$$

$$= 2\pi M^2 (n_a - n_c) \sin^2(\phi - \theta) - MH\cos\phi + \text{constant}$$

d) For each of the five values of H you chose in part b), make a rough plot of the total energy vs. ϕ. Do NOT do any calculations – you don't have time. Just guess what the energy must look like to give you the correct plot of M_z vs. H. Note: You should be able to do this even if you could not do part (c).