Strategies for finding magnetic fields with materials

8. Is the magnetization $\vec{M}$ given? If so, calculate the bound currents from M. Now you know all the currents so use step 6.
9. Is μ (or χ_m) for the material given along with the free current and you have symmetry? If so, use Ampere's Law to find H first $\oint \vec{H} \cdot d\vec{l} = I_{f,enc}$. Then use $\vec{B} = \mu\vec{H}$ to get B from H. (You can also get M from H if you need to.)

Strategy for finding E with time changing B

10. Is there symmetry? Use $\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_{enc}}{dt}$ to get E from the time changing magnetic flux. Check the sign with Lenz's Law.

Strategy for finding B from time changing E

11. Is there symmetry? Use $\oint \vec{B} \cdot d\vec{l} = \mu_0 \varepsilon_0 \frac{\partial}{\partial t} \int \vec{E} \cdot d\vec{a}$ to get B from the displacement current enclosed by a loop.

Strategy for finding Capacitance of a configuration of two conductors

12. Put +Q on one conductor and –Q on the other. Calculate E between the conductors and find the potential difference between them using $\Delta V = -\int \vec{E} \cdot d\vec{l}$. The capacitance is given by $C = \frac{Q}{\Delta V}$.

Strategy for finding Resistance of a configuration of two conductors

13. Set a potential difference ΔV between the conductors and find the total current I that flows. Use Ohm's Law to relate E to the current density $\vec{J} = \sigma\vec{E}$ and integrate to find the total current I flowing from one conductor to the other. The resistance is $R = \Delta V/I$. (Sometimes it's easier to start with the current, find E from Ohm's Law, then find ΔV from E.)

Strategy for finding Self Inductance

14. Run a current I through the wire and calculate the flux through the loop. Use $\Phi = LI$ to find the inductance L. Don't forget to include the number of turns linking the flux.
15. If it's hard to define one single loop, first calculate B everywhere and use magnetic energy to get the inductance from $U_m = \int \frac{B^2 d\tau}{2\mu_0} = \frac{1}{2} L I^2$

Strategy for finding Mutual Inductance

16. Run a current I through one loop and calculate the magnetic flux through the other loop. Use $\Phi = MI$ to find the mutual inductance M.