Physics 3034 – Spring 2024 – The formula sheet in your head

1. Write down all four Maxwell Equations in vacuum in differential form.
2. Write their names next to them.
3. Use appropriate math to change them all to integral form. Justify your steps.
4. In the differential form above, replace B and E with D and H (where appropriate) assuming a linear medium.
5. Identify the Maxwell displacement current term in problems 1 and 2 (circle it).
6. Write down the equation for the Poynting vector and express in words the meaning of the Poynting vector.
7. $u =$? (where u is the total electromagnetic energy density)
8. What is the equation that defines self-inductance? Mutual inductance?
9. What is the energy in an inductor carrying a current I?
10. What is the energy in a capacitor with a charge Q?
11. Write down Poynting's theorem in differential form assuming no work is being done on free charges.
12. Convert it to integral form.
13. What are the units for Poynting vector? What are the units for light intensity?
14. What is the expression for light intensity that has an E^2 in it?
15. What is the relation be index of refraction and permittivity and susceptibility constants?
16. Write a valid equation relating λ, ω, and c.
17. Write a valid equation relating λ and k.
18. What are the four electromagnetic boundary conditions at a flat dielectric interface?
19. Derive them from Maxwell's equations. (Use sketches and a sentence where needed).
20. What's the speed of a mechanical wave in a stretched string? Can you derive it?
21. How do the reflection/transmission coefficients of a mechanical wave relate to those of an electromagnetic wave?
22. $E_r = E_i \frac{n_2 - n_1}{n_2 + n_1}$. What is the reflection coefficient R?
23. Given the formula for E_r above, what is the formula for E_t in terms of E_i?
24. What is the transmission coefficient T, and how is it defined?
25. Show how to get from Maxwell's equations to the wave equation.

Vector Identities

$$\vec{A} \cdot (\vec{B} \times \vec{C}) = \vec{B} \cdot (\vec{C} \times \vec{A}) = \vec{C} \cdot (\vec{A} \times \vec{B}) \quad (1)$$

$$\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B}) \quad (2)$$

$$\nabla \cdot (\nabla \times \vec{A}) = 0 \quad (3)$$

$$\nabla \times (\nabla f) = 0 \quad (4)$$

$$\nabla \times (\nabla \times \vec{A}) = \nabla(\nabla \cdot \vec{A}) - \nabla^2 \vec{A} \quad (5)$$