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EE214000 Electromagnetics, Fall 2020

Your name: ________________ ID: _________________ Jan. 3rd, 2021

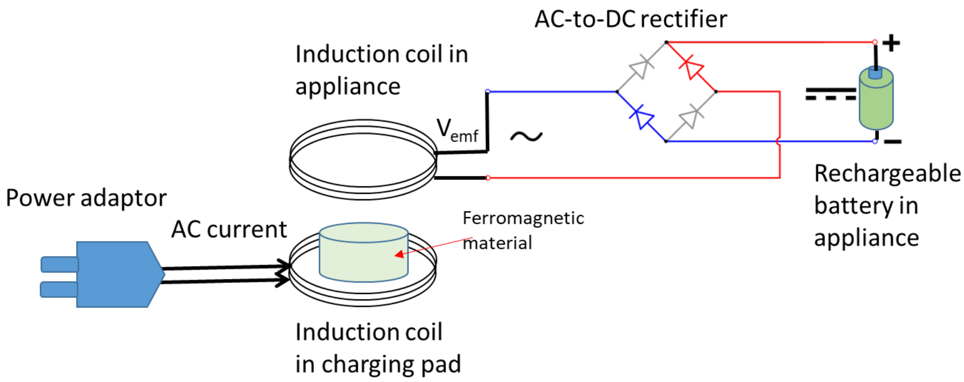
EE214000 Electromagnetics, Fall, 2020
Quiz #17-1, Open books, notes (20 points), due 11 pm, Wednesday, Jan. 6th, 2021
(submission through iLMS)

Late submission won't be accepted!

1. Describe how a cordless(無線) charger charges a cell phone, Apple watch, toothbrush etc.? To explain, draw a circuit including two parts, the charger and the appliance. (3+3 points)

*Images extracted from MOMO and Amazon websites.

→無線充電(cordless charger)利用「電磁感應」以傳遞電力，藉由電流通過傳輸線圈(transmission)而產生變化的磁場，接收線圈(receiver)感應到此變化的磁場後便可將其轉換為交流電訊號(AC)，以達成能量傳遞的目的。 The generated AC signal has to be rectified into a DC signal to charge the rechargeable battery in the appliance.



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2. Write down the 4 Maxwell's Equations, in both differential and integral forms. Also, list the Lorentz Equation and Equation of continuity. Define all the symbols in the expressions. (6 points)

→

	differential	integral
Gauss's law	$\nabla \cdot \vec{D} = \rho_V$	$\oint_S \vec{D} \cdot \overrightarrow{dS} = Q_{in}$
Faraday's law	$\nabla \times \vec{E} = \frac{-\partial \vec{B}}{\partial t}$	$\oint_C \vec{E} \cdot \overrightarrow{dl} = \int_S \frac{-\partial \vec{B}}{\partial t} \cdot \overrightarrow{dS}$
無磁單極	$\nabla \cdot \vec{B} = 0$	$\int_S \vec{B} \cdot \overrightarrow{dS} = 0$
Ampere's law	$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$	$\oint_C \vec{H} \cdot \overrightarrow{dl} = \int_S \vec{J} \cdot \overrightarrow{dS} + \int_S \frac{\partial \vec{D}}{\partial t} \cdot \overrightarrow{dS}$

Lorentz equation: $\vec{F} = q\vec{E} + q\vec{u} \times \vec{B}$,

Equation of continuity: $\nabla \cdot \vec{J} = \frac{-\partial \rho}{\partial t}$,

where E is the electric field intensity, D is the electric flux density, B is the magnetic flux density, H is the magnetic field intensity, J is the volume current density, ρ is the volume charge density, q is the charge, and u is the speed of the charge.

3. Explain why a time-varying magnetic field can't exist in a perfect conductor? (3 points)

→Because $\vec{J} = \sigma \vec{E}$, and for perfect conductor($\sigma \approx \infty$),then the E field in the perfect conductor is nearly 0。

And we substitute into $\nabla \times \vec{E} = \frac{-\partial \vec{B}}{\partial t}$，can derive that the time-varying magnetic field can't exist the perfect conductor。

4. Explain why $\vec{A}(R,t) = \frac{\mu}{4\pi} \int_{V'} \frac{\vec{J}(t - \sqrt{\mu\varepsilon}R)}{R} dv'$, and $V(R,t) = \frac{1}{4\pi\varepsilon} \int_{V'} \frac{\rho(t - \sqrt{\mu\varepsilon}R)}{R} dv'$ describe the ***retarded*** electromagnetic potentials. In other words, if at time t' your power supply induces time-varying charge $\rho(t')$ and

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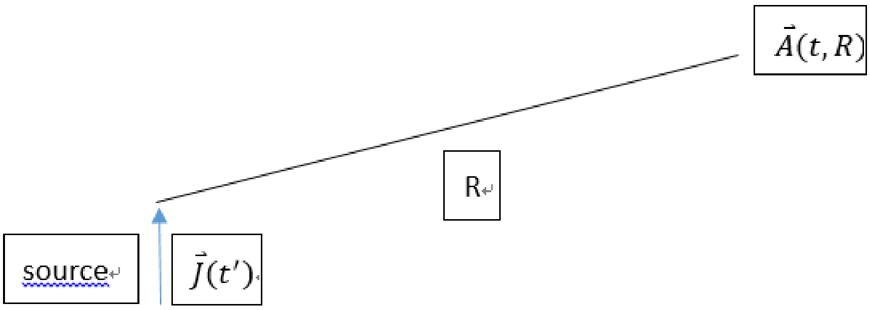
$\vec{J}(t')$ in an antenna, when do you expect that someone would measure $\vec{A}$ and V at a distance R from the antenna? (5 points)



→First, from the expression, we know that t' (the time at the source)is equal to $t - \sqrt{\mu\varepsilon}R$, where t is the time at the field point.

When we set t'=0, then t will equal to $\sqrt{\mu\varepsilon}R$, which means, there's a retarded time for the signal at the source to be detected at the field point. In other words, the velocity of the time-varying electromagnetic signal; isn't ∞ but $c = \dfrac{1}{\sqrt{\mu\varepsilon}}$ 。