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Analogy and Historical Approaches to Undergraduate Electromagnetic Education

Kok Yeow You
Communication Engineering Department, Faculty of Electrical Engineering,
Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
kyyou@fke.utm.my

Abstract: Electromagnetic is a challenging course for those who are taking an undergraduate program in electrical and electronics engineering. The content of the electromagnetic is mostly focuses on theoretical physics and mathematics. Moreover, the scope of the electromagnetic is broad and need time to familiarize themselves with these mathematical symbols and expressions. Thus, teaching contents should be summarized. Recently, numerous teaching approaches have been proposed to overcome the above-mentioned issues. Albeit that those proposed approaches are convincing, it is rather difficult for them to practice due to the limitation of learning time and large amount of students. In this paper, the analysis of learning difficulties and suggestions are presented in order to enhance the teaching and learning process within a short period of time. Different types of analogies teaching methods have been suggested; it enables students to imagine the operational phenomena of the electromagnetic. Brief historical and biographical background of electromagnetic are suggested to be introduced to the students during the teaching and learning process. The foundation of electromagnetic theory serves as an essential path which lead to many practical and fascinating areas of the electrical engineering, thus, a stable grasp of the foundation is necessary, as it will lessen the learning difficulties.

Kok Yeow You
Communication Engineering Department,
Faculty of Electrical Engineering,
Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
kyyou@fke.utm.my

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1. Introduction

Nowadays, science and technology in our daily life involves the use of electromagnetic concepts, such as sensory devices, communication equipment, computer, and biomedical instruments. Undeniably, these applications have contributed to the significance of electromagnetic; in which it has become an important subject that needs to be covered in electrical and electronics engineering (EE engineering). The electromagnetic subjects of the undergraduate level are broad as compared to other EE engineering subjects. The content of the electromagnetic is mostly focuses on theoretical physics and mathematics. As known that engineering students are more interested in courses which emphasize problem-solving concerning latest technology or application-oriented courses, and most of them encountered difficulties in acquiring electromagnetic course within a short period of time (14 weeks). There are a few difficulties which commonly faced by the undergraduate students in this era, namely:

(1) Unfamiliar with numerous modern mathematical symbols.

(2) Hard to imagine the shape and direction of the field distribution regarding a given electromagnetic problem. Consequently, students are unable to evaluate the solution of the given problem.

(3) Students do not truly understand the concepts of electromagnetic which are mostly similar and interchangeable.

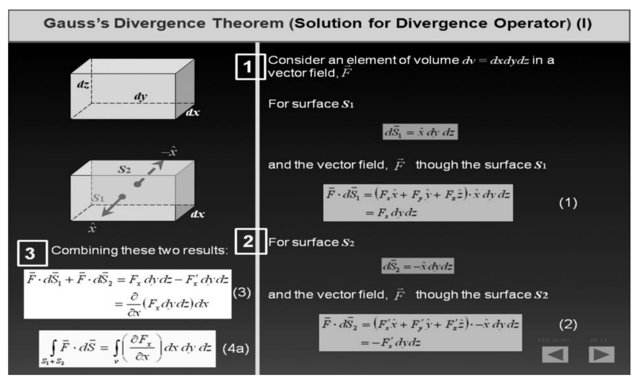
(4) Students are less likely able to interpret their understanding in term of mathematical expression as they failed to correlate theory facts with mathematical expressions.

Recently, numerous teaching approaches have been proposed to overcome the above-mentioned issues such as visualization-based learning approach using computer simulation (Dori and Belcher, 2005; Aciu et al., 2015; Haldar, 2006), project-based method and application-enhanced approach (Beker et al., 1998; Schroder et al., 2009). Albeit that those proposed approaches are convincing, it is rather difficult for them to practice due to the limitation of learning time and large amount of students. Students who enrolled for B. Eng. Degree in Electrical Engineering, Electrical-Electronic Engineering and Electrical-Mechatronic Engineering in Faculty of Electrical Engineering, Universiti Teknologi Malaysia (UTM), electromagnetic theory course is a compulsory subject in the first semester of the second year (14 weeks: 3 hours lecture and 1 hour tutorial per week). The total number of students per semester is ranging from 300 to 400 and they are distributed to several class sections and each class is taught by different lecturers. In fact, most of the second year (first semester) undergraduate students are less prepared and immature in terms of knowledge in order to expose themselves to the latest technology problems. Electromagnetic applications related to the latest technology will be explored in other EE courses by students in the fourth year or those who would later pursue his postgraduate study in theoretical research. Hence, UTM lecturers, who are teaching this course, can only look for better methods to facilitate undergraduate students in order to consolidate their foundation concerning the electromagnetic theories. In this report, some analogies and suggestions of the teaching and learning process are presented to diminish the problems that students might encounter. During the teaching and learning process, a brief introduction of historical and biographical are recommended; this will help to lead the students in understanding the background and philosophy of the created electromagnetic theory. Subsequently, students will not blindly accept the knowledge that has given to them and simultaneously without forgetting what they have been learning. The foundation of electromagnetic theory serves as an essential path which lead to many practical and fascinating areas of the electrical engineering (Donnell, 2015), thus, a stable grasp of the foundation is necessary, as it will lessen the learning difficulties.

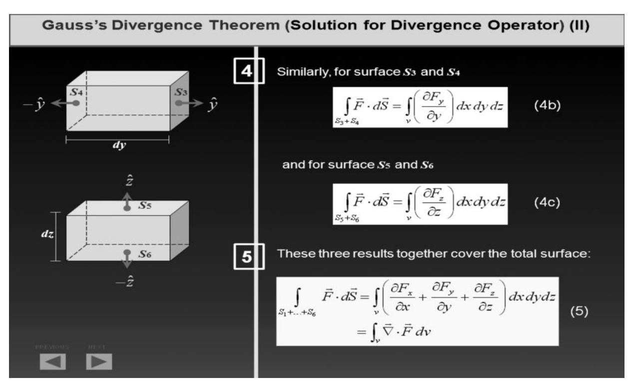
2. Mathematics of Electromagnetic

In the electromagnetic course, a lot of mathematical symbols and expressions are new to the EE engineering students, likewise the students in physics. Hence, they need time to familiarize themselves with these mathematical symbols and expressions. The author suggested that a period of time should be allocated for mathematical topics that are related to electromagnetic concepts before the acquisition of theory. During the lessons of mathematics, lecturers play an important role to clarify the implicit physical meaning of mathematical calculations and symbols thoroughly (Cloete and Holtzhausen, 1991). This is due to most of the engineering students are lack of motivation to spend time on mathematic topics that are rarely used in other EE courses. Furthermore, students will most likely feel less confident to accept the symbols that have abstract meaning as they might be puzzled during the process of self-study. During the undergraduate level, lecturers should convince students that there are only four mathematical topics which are often implemented in the solution to resolve the electromagnetic problems. The mathematical topics can be scheduled as Table 1 so that students have a clear learning target. However, lecturers are encouraged to introduce advanced physical and mathematical concepts gradually, as the occasion demands (Schelkunoff, 1972).

Normally, in order to solve the practical problem, the combination of all mathematical knowledge which above-mentioned is required. Mathematical routines from the topics are not only used to describe the electromagnetic phenomena, but also for other physical phenomena, such as fluid mechanics, gravity mechanics and heat transfer. For instance, at the end of mathematical learning, lecturers can



(a)



(b)

Figure 1: Representation of Gauss's divergence theorem using PowerPoint. (a) First and (b) second slides

review the previous learning concerning the mathematical tools and its physical meaning, as in Table 2. The well-prepared teaching materials are required for students to acquire the mathematic effectively. With the aid of electronic devices (projector) and software (PowerPoint software) (Mukhopadhyay, 2006), the lecturer can easily prepare outstanding teaching materials with animation effect as shown in Fig. 1.

In fact, the basic electromagnetic theory or 'Law' has been taught in physics textbooks during secondary school. At the undergraduate level, most of the learning issues are due to mathematical difficulties. Hence, the time spent in the mathematics lessons must not be less than 1/3 of the time spent in learning the theory within one semester.

Table 1: Scope of mathematics for the electromanetic course (5 weeks)

1. Vector Algebra	2. Analytic Geometry	3. Vector Differential Operators	4. Vector Integral Theorems
✓ Magnitude and unit vector .	✓ Cartesian coordinates.	✓ Gradient.	✓ Gauss's flux theorem.
✓ Vector addition .	✓ Cylindrical coordinates.	✓ Divergence.	✓ Stoke's theorem.
✓ Dot product .	✓ Spherical coordinates.	✓ Curl.	✓ Green's theorem.
✓ Cross product .	✓ Distance and angle.	✓ Laplace's equation & Possion's equation.	
		✓ Vector operator identities .	
Basic Vector	*Solve Space Problem*	*DescribeElectromagneticPhenomena*	*SolveElectromagnetic PhenomenainSpace*

Table 2: Quantitative and qualitative information on vector differential operators

Operation	Gravity	Electrostatic	General Physical Meaning
Grad, $\vec{\nabla}$	$-\vec{\nabla}\phi_g = \vec{G}$	$-\vec{\nabla}\phi_e = \vec{E}$	• Field direction and potential are perpendicular each of other. The potential is proportional to the field.
Div, $\vec{\nabla}\cdot$	$\vec{\nabla}\cdot\vec{G} = -g\rho_g$	$\vec{\nabla}\cdot\vec{E} = \rho_e/\varepsilon$	• Field direction is toward the far away from its source (ρ_g or ρ_e). The amount of field 'flow' away is equivalent to the source.
Curl, $\vec{\nabla}\times$	$\vec{\nabla}\times\vec{G} = 0$	$\vec{\nabla}\times\vec{E} = 0$	• No field exists in the rotational direction.
Laplace, $\vec{\nabla}^2$	$\vec{\nabla}^2\phi_g = g\rho_g$	$\vec{\nabla}^2\phi_e = -\rho_e/\varepsilon$	• Field is continuous across a certain boundary (Boundary between two mediums).

$\vec{G}$ and $\vec{E}$ are the vector gravitational field and vector electrostatic field, respectively. ϕ_g and ϕ_e are the scalar potential due to gravitational field and vector electrostatic field, respectively. ρ_g and ρ_e are the massive object density and charge density. g and ε are the constant values.

3. Concept Theory of Electromagnetic

As for the lecture of electromagnetic theory, the main contents of the subject should be simple and clear at the beginning of the class. The close relationship between subtopics is introduced as shown in Fig. 2. Students are encouraged to compare the similarities and differences between different subjects. This enables students to relate the knowledge with various areas of daily life. Nonetheless, engineering students are usually reluctant to make such comparisons than science students, in other words, they pay more attention to technology than academic. For instance, the Coulomb's Law analogous to the Newton's Law of Universal Gravitation is shown in Table 3.

The electromagnetic has numerous concepts which are similar and interchangeable. This will oftentimes mislead the students during their learning process. For instance, many students are confused over the 'Coulomb's Law' and 'Gauss's Law', because both 'Law' share the similar concepts. Thus, the historical and developmental background of the electromagnetic are required to be introduced to the students during an appropriate period. Throughout the introduction, students will have better understanding concerning the theory that had been proposed by the scientists in the past, which developed from the experimental work and some dependent on mathematical derivation. Typically, experimental work will exist first, which later followed by the development of a mathematical derivation. Similarities and differences between the two 'Law' are described in Table 4. The author did experience that most of the students are unable to distinguish the meaning between 'Law' and 'Theorem' (Wikipedia). They might ask: Why there are some electromagnetic theory rules which are called 'Law', while another is denominated as 'Theorem'? What is the distinction between Gauss's Divergence Theorem and Gauss's Law? Normally, author will try to answer the students as tabulated in Table 5.

During the teaching and learning process of electrodynamics, students will usually ask: What is the difference between Gauss's Law and Maxwell's equations? Why the textbook often uses the term 'Maxwell's equations' and not 'Maxwell's Law' or 'Maxwell's Theorem'? By then, the author will try to answer the doubts as in Table 6. Teaching materials involving analogous elements are able to help students in understanding the phenomenon of electromagnetic, especially for large enrolment class (Mukhopadhyay, 2006). The proposed framing of analogies is shown in Table 7. Generally, most of the initial development of electromagnetic theory is based on the mechanical and hydrodynamics analogies. For instance, Sir Isaac Newton studied the phenomenon of light by considering the light as small particles. Gauss's Law for electrostatic was mathematically equivalent to the behaviour of incompressible fluids. James Clerk Maxwell explained his published equations using the analogy mechanical vortex model (Rautio, 2014; Turnbull, 2013). Theoretical concepts need to be discussed and described with mathematical knowledge that has been learned. In this case, a book authored by Daniel, (2008) which has given the explanation of the meaning for each mathematical symbol can be recommended to the students as an additional reference. At the end of the theoretical study, learning outcome can be reviewed by using the summary notes as shown in Table 8.

4. Concept Theory of Electromagnetic

Schedule a form of general static problems which commonly encountered in electromagnetics in order to help students to narrow the scope of problem-solving learning as illustrated in Table 9. The solved examples should be delivered as many as possible (Turnbull, 2013), this is to ensure that the students are able to relate the mathematical calculations and electromagnetic phenomena. There are a lot of paradigm questions which can be found in the Schaum's outline of electromagnetics (Edminister, 2013).

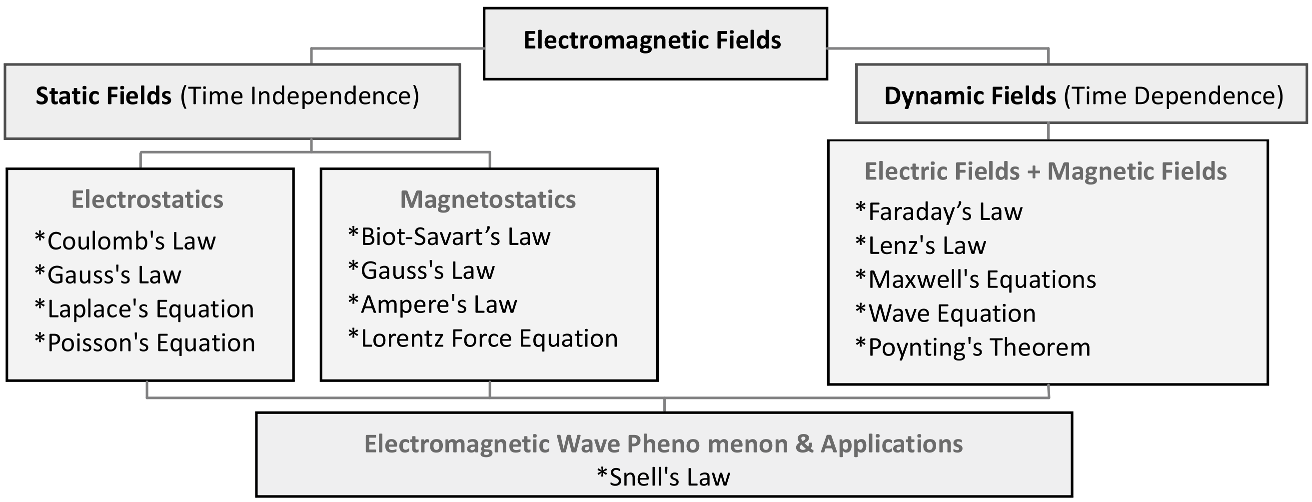


Figure 2: Flow chart for undergraduate electromagnetic study (9 Weeks)

Table 3: Analogous Coulomb's Law and Newton's Law of universal gravitation

Newton's Law of Universal Gravitation (Macroscopic Perspective)	**Coulomb's Law** (Microscopic Perspective)
The magnitude of the gravity force, F of interaction between two point masses (m_1 and m_2) is given as: $$F = G\frac{m_1 m_2}{r^2}$$ where G is the gravitational constant ($\approx 6.674 \times 10^{-11}$ N m^2 kg^{-2}). m_1 and m_2 are the first mass and second mass, respectively. r is the distance between the centers of the masses.	The magnitude of the electrostatic force, F of interaction between two point charges (q_1 and q_2) is given as: $$F = k\frac{q_1 q_2}{r^2}$$ where k is the Coulomb's constant ($\approx 8.988 \times 10^9$ N m^2 C^{-2}). q_1 and q_2 are the first charge and second charge, respectively. r is the distance between the charges.
Both "Law" was proposed based on empirical observations by Sir Isaac Newton (English physicist) in 1687 and Charles-Augustin de Coulomb (French physicist) in 1784, respectively.	

Table 4: Similarities and differences between Coulomb's Law and Gauss's Law

Coulomb's Law (Experimental Result)	**Gauss's Law** (Mathematical Derivation)
✓ Charles-Augustin de Coulomb was the first to give definition to the phenomenon of **force** between static charges in 1784.	✓ Johann Carl Friedrich Gauss was the first to give definition to the phenomenon of the **electric field** in a static state in 1813.
✓ The experimental result conducted by C. A. de Coulomb, to describe the phenomenon of electrostatic force is called the **Coulomb's Law**.	✓ The **Gauss's divergence theorem** derived by J. C. F. Gauss was applied into electrostatic fields is called the **Gauss's Law for the electric field.**
The Coulomb's Law can be mathematically proof by Gauss's divergence theorem vice versa. Thus, both 'Law' that apparently seems to be the same.	

Table 5: Distinction between 'Law' and 'Theorem'

Law	Theorem
'Law' is the fact normally proved by practice or experimental work for particularly physical phenomena under certain condition. It may fail or inaccurate for other physical phenomena.	'Theorem' is the fact proved by logic derivation or mathematical routine, which normally also supported by practice, since typically, experimental work exist first, then have a mathematical derivation.
'Law' is usually only focusing on specific areas, such as **Gauss's Law for electrostatic** and **Gauss's Law for magnetostatic.**	'Theorem', such as **Gauss's divergence theorem**, is not only used to describe the electromagnetic phenomena typical, but it may also for other physical phenomena, such as fluid mechanics, gravity mechanics and heat transfer.
The **Gauss's divergence theorem** particularly applied into electrostatic and magnetostatic fields by Johann Carl Friedrich Gauss are called **Gauss's Law for electrostatic** and **Gauss's Law for magnetostatic,** respectively. The term of '**Gauss's divergence theorem**' is normally used in Chapter 1 Electromagnetic textbook for general mathematical learning. Upon entry into the study of electromagnetic theory, known as '**Gauss's law**' is common.	

Table 6: Evolution of electromagnetic theory

Gauss's Law (1813)	Maxwell's Equations (1861 and 1862)
Gauss's Law is only suitable for static fields.	✓ Before James Clerk Maxwell published his equations, Gauss's Law, Ampere's Law and Faraday's Law were well known.
Ampere's Law (1826)	✓ Maxwell has only derived equations in order to link all the 'Laws' together (Schelkunoff 1972). Thus, the equations are normally not called as 'Law'.
Ampere's Law is only valid for steady-state current and 'closed paths' cases (Cloete and Holtzhausen, 1991).	✓ Maxwell corrected the Ampere's Law by adding the term of displacement current. However, at that time, no any physical model or experimental work to justify Maxwell's equations (vector equations including the displacement current term), thus the proposed theory seems incomplete at Maxwell contemporaries. Thus, the equations did not call as 'Theorem'.
Faraday's Law (1831)	
Faraday's Law is only based on experimental observations (Cloete and Holtzhausen, 1991).	✓ Recently, Maxwell's equations have become famous because of the equations provide a complete description of electromagnetic phenomena in four mathematical expressions.

Table 7: Analogies between four types of physical system

Mechanical		Electromagnetic	
Mechanical Spring	Potential Energy, $U_{Spring} = (1/2)kx^2$	**Electrical Circuit**	Stored Energy, $U_{Cap} = (1/2)CV^2$
	Kinetic Energy, $U_{Mass} = (1/2)mv^2$		Released Energy, $U_{Ind} = (1/2)LI^2$
Spring displacement, x Object speed, v	Velocity, $v = \partial x/\partial t$	Voltage, V Current, I	Current, $I = \partial q/\partial t$
Spring coefficient, k Object mass, m	Angular frequency, $\omega = \sqrt{k/m}$	Capacitance, C Inductance, L	Angular frequency, $\omega = \sqrt{1/(LC)}$
	Impedance, $Z = (kx)/v$		Impedance, $Z = V/I$
Acoustic Wave	Sound Potential Energy, $U = (1/2k)P^2$	**Electromagnetic Wave**	Electric Energy, $U = (1/2)\varepsilon_o E^2$
Sound pressure, P Particle velocity, v	Sound Kinetic Energy, $U = (1/2)\rho v^2$	Electric field, E Magnetic field, H	Magnetic Energy, $U = (1/2)\mu_o H^2$
	Sound speed, $v = \sqrt{k/\rho}$		Wave speed, $v = \sqrt{1/(\varepsilon_o \mu_o)}$
Elastic bulk modulus, k Medium density, ρ	Sound impedance, $Z = P/v$	Permittivity, ε_o Permeability, μ_o	Wave impedance, $Z = E/H$

5. Application of Electromagnetic

The section of electromagnetic applications in most of the undergraduate textbooks merely focuses on microwave and communication applications, such as waveguides, dipole antennas, and RF transmission line. Moreover, most of the textbooks do not make a scientific analogy between those applications. Hence, most undergraduate students will be less appreciate concerning the use of those microwave device applications and cannot fully aware of the electromagnetic theories, which can be used in different fields of science coherent, especially for those students who are in the first semester of the second year. The author believes that the applications of electromagnetic toward natural phenomena will be more appealing to students, for example, introducing the electromagnetic energy which generated by the human body or the earth as shown in Table 10, Table 11 and Table 12, respectively. Thus, the fundamental knowledge apropos of these areas should be included in classroom teaching. In addition, the electromagnetic theory has been widely applied in the fields of biology, geology, and nanomaterials recently.

6. Conclusion

Author has integrated various analogies teaching methods in delivering the topic of electromagnetic, which is less adopted by the electromagnetic textbook. Indeed,

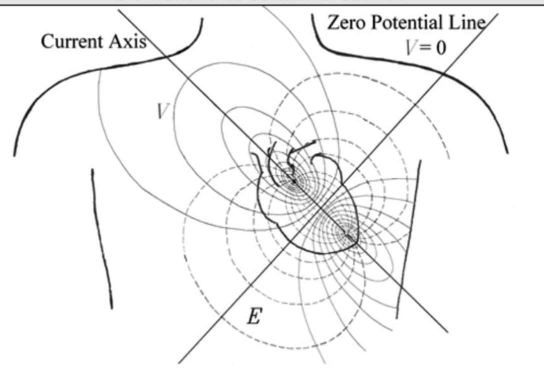
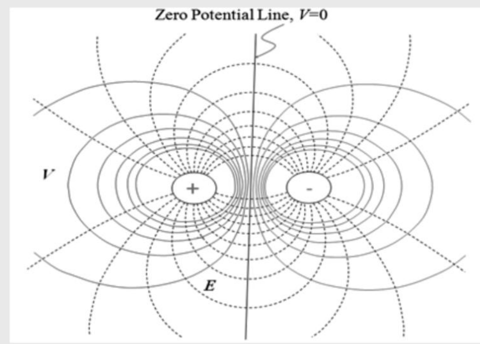
Table 8: Analogous Coulomb's Law and Newton's Law of universal gravitation

Laws	Maxwell's Equations		
	Expressions	**Description**	**Information**
Gauss's Law for electric fields	**Integral form:** $\underbrace{\varepsilon_o \oint\!\!\oint \vec{E} \cdot d\vec{S}}_{Left} = \underbrace{q}_{Right}$	**Left:** The number of electric field, $\vec{E}$ lines – perpendicularly passing through to a closed surface, $\vec{S}$. **Right:** Total amount of charge, q contained within that surface, $\vec{S}$	Electric charge produces an electric field, $\vec{E}$ and the flux of that field passing through any closed surface is proportional to the total charge, q contained within that surface. Charge on an insulated conductor moves outward surface, $\vec{S}$.
	Differential form: $\underbrace{\varepsilon_o \vec{\nabla} \cdot \vec{E}}_{Left} = \underbrace{\rho}_{Right}$	**Left:** Divergence of the electric field, $\vec{E}$ – the tendency of the field to 'flow' away from a specified location. **Right:** Electric charge density, ρ.	The electric field, $\vec{E}$ produced by electric charge diverges from positive charge and converges upon negative charge. The electric field, $\vec{E}$ is tendency to propagate perpendicularly away from a surface charge.
Gauss's Law for magnetic fields	**Integral form:** $\underbrace{\mu_o \oint\!\!\oint \vec{H} \cdot d\vec{S}}_{Left} = \underbrace{0}_{Right}$	**Left:** The number of magnetic field, $\vec{H}$ lines – perpendicularly passing through a closed surface, $\vec{S}$. **Right:** Identically zero.	The total magnetic flux passing through any closed surface is zero. Flux enter the closed surface is same with the flux come out from the surface.
	Differential form: $\underbrace{\mu_o \vec{\nabla} \cdot \vec{H}}_{Left} = \underbrace{0}_{Right}$	**Left:** Divergence of the magnetic field, $\vec{H}$ – the tendency of the field to 'flow' away from a point than toward it. **Right:** Identically zero.	The divergence of the magnetic field at any point is zero. Confirmed that only exist magnetic dipole. (naturedly no magnetic monopole)
Faraday's Law	**Integral form:** $\underbrace{\oint_C \vec{E} \cdot d\vec{l}}_{Left} = \underbrace{-\mu_o \int_S \frac{\partial \vec{H}}{\partial t} \cdot d\vec{S}}_{Right}$	**Left:** The circulation of the vector electric field, $\vec{E}$ around a closed path, C. **Right:** The rate of change with time (d/dt) of magnetic field, $\vec{H}$ through any surface, $\vec{S}$.	Changing magnetic flux through a surface induces an emf in any boundary path, C of that surface, $\vec{S}$ and a changing magnetic field, $\vec{H}$ induces a circulating electric field, $\vec{E}$.
	Differential form: $\underbrace{\vec{\nabla} \times \vec{E}}_{Left} = \underbrace{-\mu_o \frac{\partial \vec{H}}{\partial t}}_{Right}$	**Left:** Curl of the electric field, $\vec{E}$ – the tendency of the field lines to circulate around a point. **Right:** The rate of change of the magnetic field, $\vec{H}$ over time (d/dt)	A circulating electric field, $\vec{E}$ is produced by a magnetic field, $\vec{H}$ that changes with time.
Ampere's Law	**Integral form:** $\underbrace{\oint_C \vec{H} \cdot d\vec{l}}_{Left} = \underbrace{\int_S \left(\vec{J}_c + \varepsilon_o \frac{\partial \vec{E}}{\partial t} \right) \cdot d\vec{S}}_{Right}$	**Left:** The circulation of the magnetic field, $\vec{H}$ around a closed path, C. **Right:** Two sources for the magnetic field, $\vec{H}$; a steady conduction current, $\vec{J}_c$ and a changing electric field, $\vec{E}$ through any surface, $\vec{S}$ bounded by closed path, C.	An electric current or a changing electric flux through a surface produces a circulating magnetic field, $\vec{H}$ around any path, C that bounds that surface, $\vec{S}$.
	Differential form: $\underbrace{\vec{\nabla} \times \vec{H}}_{Left} = \underbrace{\vec{J}_c + \varepsilon_o \frac{\partial \vec{E}}{\partial t}}_{Right}$	**Left:** Curl of the magnetic field, $\vec{H}$ – the tendency of the field lines to circulate around a point. **Right:** Two terms represent the electric current density, $\vec{J}_c$ and the time rate of change of the electric field, $\vec{E}$.	A circulating electric field, $\vec{E}$ is produced by a magnetic field, $\vec{H}$ that changes with time. An electric current, $\vec{J}_c$ or a changing electric field, $\vec{E}$ through a surface produces a circulating magnetic field, $\vec{H}$ around any path that bounds that surface.

Table 9: The relationship between the types of coordinate form of static fields problem cases

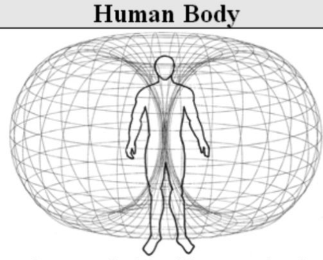
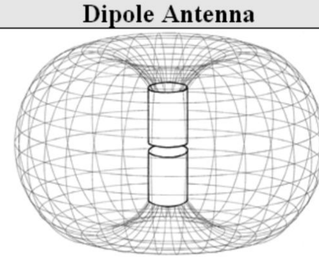
Coordinate	The problems most often encountered	
	Electrostatic Cases	**Magnetostatic Cases**
Cartesian	- Any uniform charge distribution using a scale of Cartesian coordinates.	- The current flowing on the horizontal infinite extent plane.
Cylindrical	- Uniform charge distribution on cylindrical conductor. - Uniform charge distribution on the infinite length of line. - Uniform charge distribution on the infinite extent horizontal plane. - Uniform charge distribution on the horizontal circle plane. - Uniform charge distribution on the circle line.	- The current flowing in circumference. - The current flowing in an infinite straight line. - The current flows in the solenoid and toroid.
Spherical	- Uniform charge distribution on the surface of a sphere. - Uniform charge distribution of the point.	- Problem for the case of spheres less found.

Table 10: Analogy between potential distributions of human heart and dipole charges

Potential of Human Heart	Potential of Dipole Charges
 Electric field of human body	 Electric dipole charges

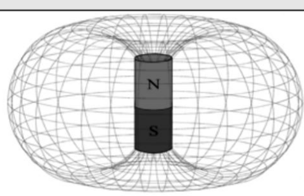
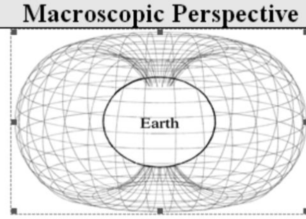
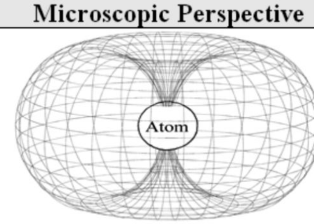
1. Scientist found that the current-dipole concept can be represented the electrical activity of the human heart, which is the analogy with electric dipole charges (Rollin McCraty, 2015).

Table 11: Analogy between electric field distributions of human body and dipole antenna

Human Body	Dipole Antenna
 Electric field of human body	 Electric field of dipole antenna

1. The electric field distribution of body generated by heart is similar to electric field distribution of dipole antenna.
2. Scientist found that the human cardiac field is modulated by different emotional states and the electromagnetic field may transmit information that can be received by others (Like antenna) (Rollin McCraty, 2015).

Table 12: Analogy between magnetic field distributions of earth and atom

	Macroscopic Perspective	Microscopic Perspective
 Magnetic field of bar magnet	 Magnetic field of Earth	 Magnetic field of atom

1. The magnetic field distributions of Earth and atom are similar to a dipole field generated by a bar magnet.
2. Electromagnetic theory is capable of explaining natural phenomena of macro-science and micro-science, such as the magnetic fields of Earth and atomic.
3. The explanation of macro-science phenomena using electromagnetic theories is closer to classical or Newtonian mechanics theory. Whereas, in micro-science, electromagnetic are more likely to explain the tendency to modern quantum theory (Phy.Org).

learning and teaching is a two-way process. The approaches of teaching and learning are closely related; both methods must be corresponding to each other. For instance, Zebly, (1972) reported that students gave good evaluation to his teaching method when he used the textbook which reflects the same point of view. On the other hand, he got bad reviews when he followed a point of view which is different from the textbook. Currently, undergraduate students are required to absorb a variety of information and knowledge in achieving their academic success, and they do not have much time to spend in solely one subject. Hence, the teaching materials are proposed to be summarized in the form of charts and tables, so that students can grasp the knowledge within a short period of time.

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