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٧ـ النظرية الكهرومغناطيسة ، تأليف د. عبدالرزاق الراشد و د. ناظم حسون العطار ١٩٨٦

Syllabus for 1st and 2nd Semester

1- **Chapter One:** Vector Analysis and Coordinate Systems

2- **Chapter Two:** Vector Calculus and Transformation between Coordinate Systems

3- **Chapter Three:** Electrostatic Fields

4- **Chapter Four:** Electrostatic Field in Material Space and Boundary Conditions

5- **Chapter Five:** Solution of Laplace's and Poisson's Equations

6- **Chapter Six:** Magnetostatic Field

7- **Chapter Seven:** Magnetic Forces, Materials and Boundary Conditions

8- **Chapter Eight:** Dynamic Electromagnetic Fields

Branches of electromagnetic spectrum in terms of their frequencies, wavelengths and energies

No.	Branches	Frequency (Hz)	Wavelength (m)	Energy (ev)	Sources	Applications
1.	Cosmic Ray	$> 10^{24}$	$< 10^{-12}$	$> 10^6$	Cosmic	Astronomy
2.	Gamma Ray	$10^{19} - 10^{23}$	$10^{-10} - 10^{-12}$	$10^4 - 10^6$	Radioactive elements	Cancer therapy
3.	X-Ray	$10^{16} - 10^{19}$	$10^{-10} - 10^{-8}$	$10^2 - 10^4$	X-Ray machine	Medical diagnosis
4.	Ultra Violet	$10^{15} - 10^{17}$	$10^{-9} - 10^{-7}$	$10^1 - 10^3$	Arc Welding	Sterilization
5.	Visible light	$10^{14} - 10^{15}$	$10^{-7} - 10^{-6}$	$5 - 7$	The Sun	Vision
6.	Infrared	$10^{11} - 10^{15}$	$10^{-6} - 10^{-3}$	$10^{-3} - 5$	Radiant Heater	Photography
7.	Microwave	$10^8 - 10^{11}$	$10^{-3} - 1$	$10^{-6} - 10^{-3}$	1.Microwave oven 2. Mobile phone towers	Tv, radar & Satellite communication
8.	Radio Wave	$10^1 - 10^8$	$1 - 10^8$	$< 10^{-6}$	Tv, FM radio & AM Radio towers with Power lines	Telephone, Navigation & Radio Broadcasting

Branches of Radio Wave Frequencies with Their Applications

No.	Branches	Frequency (Hz)	Applications
1.	ELF	(3-30)Hz	Detection of buried metal or objects
2.	SLF	(30-300)Hz	Sensing or earth's ionosphere
3.	ULF	(300-3000)Hz	Sensing or earth's ionosphere
4.	VLF	(3-30)kHz	Submarine communication
5.	LF	(30-300)kHz	Short distance communication and radio broadcasting
6.	MF	(300-3000)kHz	AM- Radio Broadcasting
7.	HF	(3-30)MHz	Long distance communication and radio broadcasting
8.	VHF	(30-300)MHz	FM-Radio broadcast and TV
9.	UHF	(300-3000)MHz	Radar , Colure TV and Mobile communication
10.	SHF	(3-30)GHz	Aircraft radar, Satellites communication
11.	EHF	(30-300)GHz	Not used due to the high attenuation by atmospheric region

Multiple and submultiples prefixes

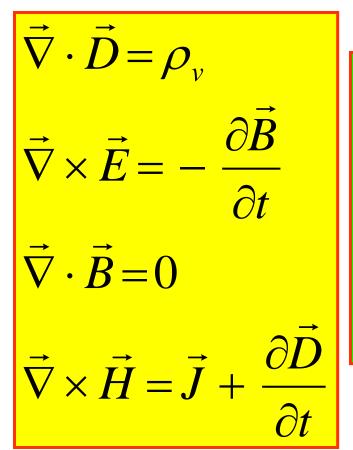| Prefix	Symbol	Magnitude
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Definitions

- **Electromagnetic Theory: Is a branch of physics or electrical engineering which studies the electric and magnetic phenomenon.**

- **Electromagnetic Theory: Is a science which studies the electric and magnetic phenomenon with their engineering applications.**

- **Wave: Generally the wave is defined as a form of energy in move.**

- **Field: Is defined as the action at a distance between two objects without direct contact, such as Electric, Magnetic and Gravitational fields.**

The source of the production of electric, magnetic and electromagnetic field

- **ELECTROSTATICS Field:** Stationary Charges produce E-field. This field and their phenomenon's have been studied by many scientists: Coulomb, Ohm, Gauss, Kirschofe and Volta.

- **MAGNETOSTATICS Field:** Moving charges or stationary current lead to the production of magnetic field. This field and their phenomenon's have been studied by many scientists: Oerestd, Ampere, Biot-Savart, Henry, Lenz, Lorentz and Faraday.

- **Electromagnetic Field:** Time varying current or when the charge is accelerated (i.e. moving with varying velocity) the field which produced is known as electromagnetic field. This theory has been constructed by Maxwell who unified the theory of electricity and magnetism through a set of four equations known as the Maxwell's equation:

$$\vec{\nabla} \cdot \vec{D} = \rho_v$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

$D = Electric\ flux\ density\ (C/m^2)$

$E = Electric\ field\ Intensity\ (N/C)\ or\ (V/m)$

$B = Magnetic\ flux\ density\ (Web/m^2)$

$H = Magnetic\ field\ \text{int}\ ensity\ (A/m)$

$\rho_v = Ch\arg e\ density\ (C/m^3)$

$J = Current\ density\ (A/m^2)$

History of Electric and Magnetic Phenomenon

1. **ca. 900 Legend has** it that while walking across a field in northern Greece, a shepherd named Magnus experiences a pull on the iron nails in his sandals by the black rock he was standing on. The region was later named Magnesia and the rock became known as magnetite [a form of iron with permanent magnetism].

2. **ca. 600 Greek philosopher Thales** describes how amber, after being rubbed with cat fur, can pick up feathers [static electricity].

3. **ca. 1000 Magnetic** compass used as a navigational device.

4. **1600 William Gilbert (English)** coins the term electric after the Greek word for amber (elektron), and observes that a compass needle points north-south because the Earth acts as a bar magnet.

5. **1671 Isaac Newton (English)** demonstrates that white light is a mixture of all the colors.

6. **1733 Charles-Francois du Fay (French)** discovered that electric charges are of two forms, and that like charges repel and unlike charges attract.

7. **1745 Pieter van Musschenbroek (Dutch)** invents the Leyden jar, the first electrical capacitor.

8. **1752 Benjamin Franklin (American)** invents the lightning rod and demonstrates that lightning is electricity.

9. **1785 Charles-Augustin de Coulomb (French)** demonstrates that the electrical force between charges is proportional to the inverse of the square of the distance between them.

10. **1800 Alessandro Volta (Italian)** develops the first electric battery.

11. **1820 Hans Christian Oersted (Danish)** demonstrates the interconnection between electricity and magnetism through his discovery that an electric current in a wire causes a compass needle to orient itself perpendicular to the wire.

12. **1820 Andre-Marie Ampere (French)** notes that parallel currents in wires attract each other and opposite currents repel.

13. **1820 Jean-Baptiste Biot (French)** and Felix Savart (French) develop the Biot-Savart law relating the magnetic field induced by a wire segment to the current flowing through it.

14. **1827 Georg Simon Ohm (German)** formulates Ohm's law relating electric potential to current and resistance.

15. **1827 Joseph Henry (American) introduces the concept of inductance and built one of the earliest electric motors. He also assisted Samuel Morse in the development of the telegraph.**

16. **1831 Michael Faraday (English) discovers that a changing magnetic flux can induce an electromotive force.**

17. **1835 Carl Friedrich Gauss (German) formulates Gauss's law relating the electric flux flowing through an enclosed surface to the enclosed electric charge.**

18. **1873 James Clerk Maxwell (Scottish) publishes his *Treatise on Electricity and Magnetism* in which he unites the discoveries of Coulomb, Oersted, Ampere, Faraday, and others into four elegantly constructed mathematical equations known today as Maxwell's Equations.**

19. **1887 Heinrich Hertz (German) builds a system that can generate electromagnetic waves (at radio frequencies) and detect them.**

20. **1888 Nikola Tesla (Serbian-American) invents the ac (alternating current) electric motor.**

21. **1895 Wilhelm Roentgen (German) discovers Xrays. One of his first X-ray images was of the bones in his wife's hand. [1901 Nobel Prize in physics.]**

22. **1897 Joseph John Thomson (English) discovers the electron and measures its charge-to-mass ratio. [1906 Nobel Prize in physics.]**

23. **1905 Albert Einstein (German-American) explains the photoelectric effect discovered earlier by Hertz in 1887. [1921 Nobel Prize in physics.]**