7. SUBJECT DETAILS

7.5 ELECTRO MAGNETIC FIELDS

7.5 ELECTRO MAGNETIC FIELDS

7.5.1 OBJECTIVE AND RELEVANCE

The objective of this course is to introduce the concepts of electric field and magnetic fields and their applications which will be utilized in the development of the theory for power transmission lines and electrical machines. At the completion of this course, the student should able to :

i Understand the fundamental nature of static electric and magnetic fields, potentials, capacitance, inductance, stored energy, materials and boundary conditions.
ii Apply Maxwell's equations and fundamental concepts from dynamic electromagnetic fields including Faraday's Laws of induction, Time harmonic fields and boundary conditions.
iii To understand the impact of engineering solutions in electromagnetics.
iv To make students aware of the need for life-long learning
v The student will analyze magnetic circuits
vi The student will apply Lorentz Force equation to understand charged particle motion.

The topics covering electromagnetic fields will lead to advanced study in

i Electromagnetic compatibility.
ii Principle of bio-electromagnetics
iii Electromagnetic radiation
iv Master's Degree in Environmental Electromagnetic compatibility
v Relevant to industry jobs

7.5.2 SCOPE

The Scope of this subject is to provide the fundamental knowledge to understand the various Electrical Engineering Applications like Electrical machines, Transmission lines and their performance. This leads the scope into the applications of Communication Engineering also.

7.5.3 PREREQUISITES

i Vector calculus
ii Electrostatics and Magnetostatics
iii Physics knowledge
iv Time varying (Electro-magnetic fields) fields

7.5.4.1 JNTU SYLLABUS

UNIT-I

OBJECTIVE

To make the learner to understand how the static field behaves and to clarify the applications of various laws in Electrostatics.

SYLLABUS

Electrostatics: Electrostatic Fields – Coulomb's Law – Electric Field Intensity (EFI) – EFI due to a line and a surface charge – Work done in moving a point charge in an electrostatic field – Electric Potential – Properties of potential function – Potential gradient – Guass's law – Application of Guass's Law – Maxwell's first law, div (D)=ρv Laplace's and Poison's equations – Solution of Laplace's equation in one variable.

If I had only known, I would have been a locksmith.

- Albert Einstein

UNIT-II

OBJECTIVE

This chapter provides the knowledge of Electric dipole and capacitance.
In this chapter the behavior of conductors and dielectrics in Electrostatic fields is provided.

SYLLABUS

Conductors, Dielectrics and Capacitance: Electric dipole – Dipole moment – potential and EFI due to an electric dipole – Torque on an Electric dipole in an electric field – Behavior of conductors in an electric field – Conductors and Insulators. Electric field inside a dielectric material – polarization – Dielectric – Conductor and Dielectric – Dielectric boundary conditions, Capacitance – Capacitance of parallel plate and spherical and co- axial capacitors with composite dielectrics – Energy stored and energy density in a static electric field – Current density – conduction and Convection current densities – Ohm's law in point form – Equation of continuity.

UNIT-III

OBJECTIVE

The basics of Magnetostatics, various fundamental laws and their applications are explained in this chapter. The important and fundamental law in Magnetic, i.e. Ampere's Law and its applications are explained in this chapter.

SYLLABUS

Magneto Statics: Static magnetic fields – Biot-Savart's law –- Magnetic field intensity (MFI) – MFI due to a straight current carrying filament – MFI due to circular, square and solenoid current – Carrying wire – Relation between magnetic flux, magnetic flux density and MFI – Maxwell's second Equation, div(B)=0.

Ampere's circuital law and its applications: viz. MFI due to an infinite sheet of current and a long current carrying filament – Point form of Ampere's circuital law – Maxwell's third equation, Curl (H)=Jc, Field due to a circular loop, rectangular and square loops.

UNIT-IV

OBJECTIVE

The behavior of current carrying conductors in both electric and magnetic fields are explained in this chapter by also including derivation of force and torque equations. The concepts like magnetic potential, inductance, and energy stored in the magnetic field are included in this chapter.

SYLLABUS

FORCE IN MAGNETIC FIELDS AND MAGNETIC POTENTIAL: Magnetic force - Moving charges in a Magnetic field - Lorentz force equation - force on a current element in a magnetic field - Force on a straight and a long current carrying conductor in a magnetic field - Force between two straight long and parallel current carrying conductors - Magnetic dipole and dipole moment - a differential current loop as a magnetic dipole - Torque on a current loop placed in a magnetic field. Scalar Magnetic potential and its limitations, vector magnetic potential and its properties, vector magnetic potential due to simple configurations, vector Poisson's equations.Self and Mutual inductance, Neumann's formulae, determination of self-inductance of a solenoid and toroid and mutual inductance between a straight long wire and a square loop wire in the same plane, energy stored and density in a magnetic field. Introduction to permanent magnets, their characteristics and applications.

UNIT-V

OBJECTIVE

In this chapter, the behavior of the time varying magnetic fields and the summary of Maxwell's equations are provided.

SYLLABUS

Time Varying Fields : Time varying fields – Faraday's laws of electromagnetic induction – Its integral and point forms – Maxwell's fourth equation, Curl (E)=-∂B/∂t – Statically and Dynamically induced EMFs – Simple problems -Modification of Maxwell's equations for time varying fields – Displacement current .

7.5.4.2 GATE SYLLABUS

UNIT-I

Gauss theorem, electric field intensity and potential due to point, line, plane and spherical charge distribution.

UNIT-II

Laplace and Poison's Equations..
Capacitance calculations for simple configurations.

UNIT-III

Biot-Savart's law.
Ampere's law.

UNIT-IV

No topic is under this chapter for GATE.

UNIT-V

Inductance calculations for simple configurations.
No topic is under this chapter for GATE.

Nothing amuses me more than the easy manner with which everybody settles the abundance of those who have a great deal less than themselves. - Jane Austen, Mansfield Park

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7. 5.4.3 IES SYLLABUS

Note: From Unit I to Unit VIII, No topic covered under IES syllabus.

Out of Syllabus:
Concept of wave propagation in Conducting Media
Concept of wave propagation in Dielectric Media
Concept of wave propagation in Transmission Lines

7.5.5 SUGGESTED BOOKS

TEXT BOOKS

T1 Engineering Electromagnetics, William H. Hayt & John. A. Buck, 7th Edn., Mc. Graw-Hill Companies, 2006.
T2 Electro Magnetic Fields, Sadiku, Oxford Publications.

REFERENCE BOOKS

R1 Engineering Electro magnetics, Nathan Ida, 2nd Edn., Springer (India) Pvt. Ltd.,
R2 Introduction to Electro Dynamics, D J Griffiths, 2nd Edn., Prentice-Hall of India Pvt.Ltd.
R3 Electromagnetic fields, by S. Kamakshaiah, Right Publishers, 2007.
R4 Static and Dynamic Electricity, Smyth.
R5 Electromagnetics, J P Tewari.
R6 Electromagnetics, J. D Kraus, 4th Edn., Mc Graw-Hill, Inc. 1992.
R7 Principles of Electromagnetic Theory, A. Srinivasula Reddy, 1st Edn., RBA Publications,Chennai, 2005.
R8 Introduction to Electro Dynamics, D J Griffiths, 2nd Edition, Prentice-Hall of India Pvt.Ltd.

7.5.6 WEBSITES

1. www.electrostatic.com
2. www.emfacts.com
3. www.circuitsage.com
4. www.spine-health.com
5. www.ee.hyu.edu
6. www.feb.se
7. www.engr.wisc.edu
8. www.artechhouse.com
9. www.emfservices.com
10. www.emfsolutions.com
11. www.cst.de
12. www.micro.magnet.fsu.edu
13. www.iitm.ac.in
15. www.iitd.ac.in
16. www.iitk.ac.in
17. www.iitb.ac.in
18. www.iitg.ernet.in
19. www.iisc.ernet-in

7.5.7 EXPERTS' DETAILS

INTERNATIONAL

1. Dr. Y. Baba,
   Dashisha University,
   Kyoto – 610-0321,
   Japan,
   Email: ybaba@mail.doshisa.ac.jp.

2. Dr. M. Ishii,
   University of Tokyo,
   Tokyo – 153 – 8505,
   Japan,
   Email: m.ishii@ieee.org.

NATIONAL

1. Prof. S.V.Kulkarni,
   Assoc. Prof., Dept. of Electrical Engg.,
   IITBombay,
   Powai, Mumbai,
   Email.: svk@iitb.ernet.in.

2. Prof. R. Armugam,
   Prof./ Dept. of Electrical Engg.,
   Anna University, Chennai,
   Email: armugam_r@yahoo.com.

REGIONAL

1. Dr. B.L. Mathur,
   Prof & Head, EEE Dept.,
   SSN College of Engineering,
   Chennai,
   Email: mathu_bl@yahoo.com.

2. Dr. M.Vijaykumar,
   Assoc.Professor,
   Dept. of Electrical Engineering,
   JNTU College of Engineerig,
   Ananthpur, A P,
   Email: mvk_2004@yahoo.com.

7.5.8 JOURNALS

INTERNATIONAL

1. Journal on electromagnetics by Taylor & Francis.
2. IEEE transactions on electromagnetic compatibility
3. IEEE transactions on Magnetics
4. IEEE transactions on power delivery

NATIONAL

1. Journal of electromagnetic waves and applications.
2. Journal on Progress in electromagnetic research
3. International Journal of numerical modeling : electronic networks, devices and fields
4. Journal of Electrical India
5. Journal of IISC
6. Journal of Institution Engineers

7.5.9 FINDINGS AND DEVELOPMENTS

1. Analysis of surface permanent magnet Machinges with fractional slot concentrated windings by A.M . El-Refaie, T.M.Jahns, D.W. Novotny, IEEE transactions on Energy Conversion, Vol 21, March 2006.

2. Comparison of PM Brushless m\Motors, Having either all teeth or alternate teeth wound by D. Ishak, Z.Q. Shu & D. Howe, IEEE transactions on Energy Conversion, Vol 21, March 2006.

3. A Series connected Two motor zix phase drive with Induction and permanent Magnet machines by E.Levi, M.Jone, & S.N. Vukosovic, IEEE transactions on Energy Conversion, Vol 21, March 2006.

4. New trends in parallel electromagnetic fields computation: Parallel Computing in Electrical Engineering, 2002. PARELEC '02. Proceedings. International Conference on Pub. 2002, Butrylo, B. Musy, F. Nicolas, L. Scorretti, R. Vollaire, C., Bialystok Tech. Univ.

5. Numerical Electromagnetic field analysis of unit step response characteristics of Impulse voltage measuring systems by Y. Baba and M.Ishii, IEEE Transaction on Power delivery, Vol 19, January, 2004.

6. A CT saturation Algorthm by Y.C.Kang, S.H.Ok, S.H.Kang, IEEE Transaction on Power delivery, Vol 19, January, 2004.

7.5.10 i. SESSION PLAN

S. No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Books Suggested	Remarks
		UNIT-I			
1.	Electrostatic Fields Coulomb's Law Electric Field Intensity (EFI) EFI due to a line and a surface charge	Review of Vector Analysis	L1 L2	T1-Ch1,T2-Ch1 T2-Ch4,R1-Ch2 R7-Ch1	GATE
		Problems	L3		
		Statement and proof of Coulomb's first and second Law	L4		
		Concept of Electric field intensity (EFI) Expression for EFI in terms of rectangular coordinates	L5	T1-Ch2, T2-Ch4 R1-Ch3,R7-Ch2	
		Study of Electric field intensity due to uniformly charged line	L6	T1-Ch2,T2-Ch4 R1-Ch3,R7-Ch2	
		Study of Electric field intensity due to uniformly charged surface	L7		
2	Work done in moving a point charge in an electrostatic field	Study of concept of Electric Potential	L8	T1-Ch4,T2-Ch4 R1-Ch3,R7-Ch2	
		Derivation of expression for Potential at any point due to point charge	L9		
		Problems solved on Electric Field intensity	L10	T1-Ch2,T2-Ch4 R1-Ch3,R7-Ch2	
		Problems solved on Electric Field intensity and Potential continued	L11	T1-Ch2,T2-Ch4 R1-Ch3,R7-Ch2	
3	Electric Potential Properties of potential function Potential gradient	Study of properties of Potential function in different coordinate systems Expression for Potential Gradient	L12	T1-Ch4,T2-Ch4 R1-Ch3,R7-Ch2	
		Study of relation between Electric Field Intensity and Potential in differential form	L13	T1-Ch4,T2-Ch4 R1-Ch3,R7-Ch2	
		Concept of Electric Flux and Flux Density	L14		
4	Guass's law Application of Guass's Law, Maxwell's first law Div(D)=ρv	Study of Statement and Proof of Guass's Law, Study of Application of Guass's Law for field at point due to an Infinite Line of Charge of uniform Linear Charge Density	L15	T1-Ch3,T2-Ch4 R1-Ch3,R7-Ch2	
		Application of Guass's Law for field at a point due to uniformly charged infinite plate sheet Field at a point due to a Spherical Shell of Charge	L16	T1-Ch3,T2-Ch4 R1-Ch3,R7-Ch2	
		Application of Guass's Law for field due to a Uniformly Charged Solid Sphere	L17	T1-Ch3,T2-Ch4 R1-Ch3,R7-Ch2	
		Concept of a Divergence of a Vector	L18		
		Derivation of Maxwell's first Equation from Divergence Principle Statement of Guass's Divergence Theorem	L19	T1-Ch3,T2-Ch4 R1-Ch3,R7-Ch2	

S. No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Books Suggested	Remarks
		UNIT-II			
5	Laplace's and Poison's equations Solution of Laplace's equation in one variable	Derivation of Laplace & Poisson's Equations.	L20	T1-Ch3,T2-Ch6 R1-Ch3 R7-Ch3	
		Application of Laplace's Equation for One Dimension case to Two uniformly charged parallel planes of infinite extent Solving problems on the above application	L21	T1-Ch3,T2-Ch6 R1-Ch3 R7-Ch3	
		Application of Laplace's Equation for two Cylinder of infinite length Solving problems of same application	L22	T1-Ch3,T2-Ch6 R1-Ch3 R7-Ch3	
6	Electric dipole Dipole moment Potential and EFI due to an electric dipole Torque on an Electric dipole in an electric field	Explanation of Polar dielectrics Non, Polar dielectrics Dipole moment	L23	T1-Ch5,R1-Ch3 R7-Ch3	GATE
		Derivation of Potential & EFI due to Dipole	L24	T1-Ch5,T2-Ch5 R1-Ch3,R7-Ch3	
		Explanation of Torque on an Electric Dipole in an Electric field	L25		
7	Behavior of conductors in an electric field Conductors and Insulators	Explaining Behavior of Conductors in an Electrical Field Study of Conductors and Insulators in detail	L26	T1-Ch5,T2-Ch5 R1-Ch3,R7-Ch3	GATE
8	Electric field inside a dielectric material Polarization Dielectric Conductor and Dielectric Dielectric boundary conditions Energy stored and energy density in a static electric field	Study of Electric Field inside a Dielectric Material, Concept of Polarization, Types of Polarization	L27	T1-Ch5,T2-Ch5 R1-Ch3,R7-Ch3	GATE
		Study of Boundary Conditions for Dielectric, Dielectrics Derivation of both Normal and Tangential Components of the above	L28	T1-Ch5,T2-Ch5 R1-Ch3,R7-Ch3	
		Study of Boundary Conditions for Dielectric, Conductor Derivation of both Normal and Tangential Components of the above	L29	T1-Ch5,T2-Ch5 R1-Ch3,R7-Ch3	
9	Capacitance, Capacitance of parallel plate and spherical and co-axial capacitors with composite dielectrics	Defining capacitance of a capacitor Derivation of a Capacitance of a Parallel Plate Capacitor Derivation of a Capacitance of a Spherical Capacitor	L30	T1-Ch5,R1-Ch3 R7-Ch3	GATE
		Derivation of a Capacitance of a Parallel Plate Capacitor for two media Derivation of a Capacitance of a spherical and co-axial capacitors with composite dielectrics	L31	T1-Ch5,R1-Ch3 R7-Ch3	
		Problems on Capacitance of Parallel Plate and spherical and co-axial capacitors with composite dielectrics	L32	T1-Ch5,R1-Ch3 R7-Ch3	

Do not accustom yourself to use big words for little matters.

- Samuel Johnson

S. No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Books Suggested	Remarks
10	Current density Conduction and Convection current densities Ohm's law in point form, Equation of continuity	Derivation of Energy Stored in an Electric Field and Energy Density in an Electric Field Derivation of Current Density Expression Study of Conduction and Convection Current Densities	L33	T1-Ch4,T2-Ch4 R1-Ch3,R7-Ch3	
		Derivation of Ohm's Law in Point form Problems on Energy Stored and Boundary Conditions Derivation of Continuity Equation or Fifth Maxwell's Equation	L34	T1-Ch10,T2-Ch5 R1-Ch3,R7-Ch3	
		UNIT-IV			
11	Static magnetic fields Biot, Savart's law Magnetic field intensity (MFI),	Study of Magnetic Field, Magnetic Flux Density, MMF, Reluctance Statement and Proof of Biot,Savart's Law and problems on that	L35	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	GATE
12	MFI due to a straight current carrying filament, MFI due to circular, square and solenoid current, Carrying wire	Derivation of Flux intensity at a point due to Straight Current Carrying Filament of Finite and Infinite length	L36	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	
		Derivation of Magnetic Flux intensity at Center of Circular Current Loop and at any point along the axis of Circular Current Loop	L37	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	
		Derivation of Magnetic Field intensity at a point on the axis of Solenoid and Magnetic Flux intensity at the Center of Square Current Loop of Side "a" meters.	L38	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	
13	Relation between magnetic flux, magnetic flux density and MFI, Maxwell's second Equation, div(B)=0	Study of a relation between Magnetic Flux, Flux Density, Magnetic Field Intensity, By explaining Gauss's Law for Magnetic Fields, Problems	L39	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	
14	Ampere's circuital law and its applications viz. MFI due to an infinite sheet of current and a long current carrying filament	Statement and Proof of Ampere's Law in Integral Form and Applications of Ampere's Law MFI due to an infinite sheet of current and a long current carrying filament	L40	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	GATE

S. No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Books Suggested	Remarks
15	Point form of Ampere's circuital law, Maxwell's third equation, Curl (H)=Jc, Field due to a circular loop, rectangular and square loops	Study of Applications of Ampere's Law for Toroidal Coil and Circular Conductor, and Co, axial Cable	L41	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	
		Point form of Ampere's circuital law, Maxwell's third equation, Curl (H)=Jc Field due to a circular loop, rectangular and square loops	L42	T1-Ch8,T2-Ch7 R1-Ch4,R7-Ch4	
16	Magnetic force , Moving charges in a Magnetic field, Lorentz force equation, force on a current element in a magnetic field, Force on a straight and a long current carrying conductor in a magnetic field	Explanation of Magnetic Force and Moving Conductor in a Time, Variant Magnetic Field Derivation of Lorentz Force Equation	L43	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	IES
		Derivation of Force on a Differential Current Element& Force on a straight and a long current carrying conductor in a magnetic field	L44	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	
17	Force between two straight long and parallel current carrying conductors, Magnetic dipole and dipole moment, a differential current loop as a magnetic dipole, Torque on a current loop placed in a magnetic field	Derivation of Force between Two Parallel Current carrying Conductors of Finite length Derivation of Force on a Closed Current Loop and Explanation of Faraday's Disc Generator to relate analysis of Dipole moment and	L45	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	
		Torque on Current Loop in a Magnetic Field And Problems	L46	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	
18	Scalar Magnetic potential and its limitations, vector magnetic potential and its properties, vector magnetic potential due to simple configurations, vector Poisson's equations.	Study of Scalar Magnetic Potential and its limitation Study and Derivation of Vector Magnetic Potential	L47	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	GATE
		Derivation of Vector Magnetic Potential for Current carrying Conductor of finite length and to find Magnetic Flux Density from Vector Potential and Vector Poisson's Equation	L48	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	

S. No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Books Suggested	Remarks
18	Scalar Magnetic potential and its limitations, vector magnetic potential and its properties, vector magnetic potential due to simple configurations, vector Poisson's equations.	Study of Scalar Magnetic Potential and its limitation Study and Derivation of Vector Magnetic Potential	L47	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	GATE
		Derivation of Vector Magnetic Potential for Current carrying Conductor of finite length and to find Magnetic Flux Density from Vector Potential and Vector Poisson's Equation	L48	T1-Ch8,T2-Ch8 R1-Ch4,R7-Ch4	
19	Self and Mutual inductance, Neumans's formulae, determination of self,inductance of a solenoid and toroid and mutual inductance between a straight long wire and a square loop wire in the same plane	Concept of Self and Mutual Inductance Derivation of Self Inductance of Infinite Solenoid Derivation of Inductance of Toroidal Solenoid Coil and Energy Stored and Energy Density in a Magnetic Field	L49	T1-Ch9,T2-Ch8 R1-Ch4,R7-Ch5	
		Mutual induction between straight long wire and a square loop wire in same plane, Problems on Self Inductance and Solenoid, Toroid	L50	T1-Ch9,T2-Ch8 R1-Ch4,R7-Ch5	
20	energy stored and density in a magnetic field. Introduction to permanent magnets, their characteristics and applications.	Energy Stored and Energy Density in a Magnetic Field	L51	T1-Ch9,T2-Ch8 R1-Ch4,R7-Ch5	
		UNIT-V			
21	Time varying fields, Faraday's laws of electromagnetic induction, Its integral and point forms, Maxwell's fourth equation, Curl (E)=,∂B/∂t, Statically and Dynamically induced EMFs, Simple problems	Explanation of Time Varying Fields , Faraday's Laws of Electromagnetic Induction in Integral and Differential Form	L52	T1-Ch10,T2-Ch9 R1-Ch5,R7-Ch6	GATE
		Explanation of Statically and Dynamically Induced EMFs, Problems on Statically and Dynamically Induced EMFs	L53	T1-Ch10,T2-Ch9 R1-Ch5,R7-Ch6	
		Explaining Static Field Maxwell's Equations Expression for Conduction and Displacement Current	L54	T1-Ch10,T2-Ch9 R1-Ch5,R7-Ch6	
22	Modification of Maxwell's equations for time varying fields, Displacement current Poynting Theorem and Poynting vector	Modification of Ampere's Law Modification of Static Field Equations under Time Varying Field	L55	T1-Ch10,R1-Ch5 R7-Ch6	
		Explanation of Maxwell's Equation in integral and Differential Form for Time Varying Field Word Statements of Maxwell's Equations	L56	T1-Ch10,T2-Ch9 R1-Ch5,R7-Ch6	
		Problems on Time Varying Fields, Faraday's Laws of Electromagnetic Induction, Displacement and Conduction Current Densities Poynting Theorem and Poynting vector	L57	T1-Ch10,R1-Ch5 R7-Ch6	

i TUTORIAL PLAN

S. No	Topics scheduled	Salient topics to be discussed
1.	Electrostatic Fields, Coulomb's Law, Electric Field Intensity (EFI), EFI due to a line and a surface charge	Discussion on Electrostatic fields and electric field intensity
2.	Work done in moving a point charge in an electrostatic field, Electric Potential, Properties of potential function, Potential gradient	Problems on Electric Potential
3	Guass's law, Application of Guass's Law, Maxwell's first law, div (D)=ρv, Laplace's and Poison's equations, Solution of Laplace's equation in one variable	Problems on Guass's Law
4	Electric dipole, Dipole moment, potential and EFI due to an electric dipole- Torque on an Electric dipole in an electric field,	Problems on Electric dipole
5	Capacitance, Capacitance of parallel plate and spherical capacitors	Discussion and Problems on capacitance
6	Behavior of conductors in an electric field, Conductors and Insulators, Electric field inside a dielectric material, polarization-	Discussion on dielectric material and its effect on different materials
7	Dielectric, Conductor &Dielectric, Dielectric boundary conditions, Energy stored and energy density in a static electric field	Problems on dielectric
8	Current density conduction and Convection current densities, Ohm's law in point form, Equation of continuity	Problems on current density
9	Static magnetic fields, Biot-Savart's law, Magnetic field intensity (MFI), MFI due to a straight current carrying filament, MFI due to circular, square and solenoid current, Carrying wire- Relation between magnetic flux, magnetic flux density and MFI, Maxwell's second Equation, div(B)=0	Problems on MFI
10	Ampere's circuital law and its applications viz. MFI due to an infinite sheet of current and a long current carrying filament, Point form of Ampere's circuital law, Maxwell's third equation, Curl (H)=Jc	Problems on Ampere's circuital law
11	Magnetic force - Moving charges in a Magnetic field, Lorentz force equation, force on a current element in a magnetic field, Force on a straight and a long current carrying conductor in a magnetic field,	Discussion on charges in a Magnetic field
12	Force between two straight long and parallel current carrying conductors, Magnetic dipole and dipole moment, a differential current loop as a magnetic dipole, Torque on a current loop placed in a magnetic field	Problems on Magnetic dipoles
13	Scalar Magnetic potential and its limitations, vector magnetic potential and its properties, vector magnetic potential due to simple configurations, vector Poisson's equations.	Problems on Magnetic potential
14	Self and Mutual inductance, Neumans's formulae, determination of self-inductance of a solenoid and toroid and mutual inductance between a straight long wire and a square loop wire in the same plane, energy stored and density in a magnetic field. Introduction to permanent magnets, their characteristics and applications.	Problems on self and mutual inductance
15	Time varying fields, Faraday's laws of electromagnetic induction, Its integral and point forms, Maxwell's fourth equation, Curl (E)=-∂B/∂t, Statically and Dynamically induced EMFs, Simple problems - Modification of Maxwell's equations for time varying fields, Displacement current , Poynting Theorem and Poynting vector	Problems on Maxwell's equations

7.5.11 STUDENT SEMINAR TOPICS

1. The finite element method (FEM) in electromagnetic fields.
2. Vector analysis and co-coordinating systems of analysis
3. Fundamentals of electromagnetics with MATLab/ Simulink
4. New trends in parallel electromagnetic fields computation: Parallel Computing in Electrical Engineering, 2002. PARELEC '02. Proceedings. International Conference on Pub. 2002, Butrylo, B. Musy, F. Nicolas, L. Scorretti, R. Vollaire, C., Bialystok Tech. Univ.
5. Vector control of induction motor.
6. Analysis of surface permanent magnet Machinges with fractional slot concentrated windings by A.M . El-Refaie, T.M.Jahns, D.W. Novotny, IEEE transactions on Energy Conversion, Vo l 21, March 2006.
7. Comparison of PM Brushless m\Motors, Having either all teeth or alternate teeth wound by D. Ishak, Z.Q. Shu & D. Howe, IEEE transactions on Energy Conversion, Vol 21, March 2006.
8. Numerical Electromagnetic field analysis of unit step response characteristics of Impulse voltage measuring systems by Y. Baba and M.Ishii, IEEE Transaction on Power delivery, Vol 19, January, 2004.
9. Significance of Maxwell equations for time varying fields
10. Surge is a travelling wave with a light velocity

7.5.12 QUESTION BANK

UNIT-I

1. i. Derive the relation between electric field and potential in differential form. **(Dec-2012)**
   ii. Two point charges q_1 = 250μc and q_2 = 300μc are located at (5,0,0)m and (0,0,-5)m respectively. Find the force on q_1? **(Dec 11)**

2. i. State and express Coulomb's law in vector form.
   ii. Three equal point charges of 2μC are in free space at (0, 0, 0), (2, 0, 0) and (0, 2, 0) respectively. Find net force on Q_4 = 5μc at (2, 2, 0)? **(Dec 11)**

3. i. What is the capacitance of a capacitor of two parallel plates 30 cm by 30 cm, separated by 5mm in air? What is the energy stored by the capacitor if it is charged to a potential difference of 500 volts?
   ii. State and prove conditions at a boundary between two dielectrics. **(Dec 11)**

4. Determine $\overline{E}$ at the origin due to a uniform line charge distribution with linear charge density L = 3.3 ρ_L 10^{-9}C/m located at (3, 4, 0) m. **(Dec 11)**

5. i. What are the criteria for selection of Gaussian surface?
   ii. Given $\overline{D} = 2xy\partial_x + z\overline{\partial}_y + yz^2\overline{\partial}_z$, $find\ \nabla.\overline{D}\ at\ p(2,-1,3)$. **(Dec 11)**

If you would persuade, you must appeal to interest rather than intellect

- Benjamin Franklin

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6. i. State and explain Gauss's law. . **(Nov-2013, May11)**
ii. Derive an expression for potential difference between two concentric spheres of radii `a' and `b' (b>a), if the outer sphere of the inner sphere is charged with Q_c. Apply Gauss's law

7. i. Define electric field intensity.
ii. Figure shows two charges at points A and B in free space. Find the electric field at point P due to there charges?

8. i. Show that the electric field intensity is negative gradient of potential.
ii. The absolute potential (electric) for some region is assumed to be $\phi = \frac{3000}{x} + \frac{2000}{x^2} + \frac{1000}{x^3}$ for all values of x, y, z where ϕ is in volts and x is in meters. What is the electric field intensity at x = 1m? **(May 11)**

9. Two parallel conducting plates 3 cm apart and situated in air are connected to a source of constant potential difference of 72 KV. Find the electric field intensity between the plates. Is it with in permissible value ? If a mica sheet of $\varepsilon_r = 4$ of thickness 1 cm is introduced between the plates, determine the field intensities in air and mica. Given the dielectric strenghts of air and mica as 30 and 1000 kv/cm respectively. **(May 11)**

10. Given $\bar{D} - 2xy\,\bar{a}_x + z\,\bar{a}_y + yz^2\bar{a}_z$, find $\nabla.\bar{D}$ at p(2, -1, 3). **(May 11)**

11. i. Explain the concept of electric field intensity.
ii. A point charges of 500μc each are placed at the corners of a square of $3\sqrt{2}$ m side. The square is located in the Z = 0 plane between x = $\pm\frac{3}{\sqrt{2}}$ m and y = $\pm\frac{3}{\sqrt{2}}$ m in free space. Find the force on a point charges of 30 μc at (0,0,4) m. **(Nov 10, Feb 08)**

12. i. Explain Gauss`s law with example.
ii. Using gauss law Find E at any point due to long infinite charge wire. **(Nov 09, 05, Mar 06)**

13. Two uniform line charges of density 8nC/m are located in a plane with y = 0 at x = $\pm$8m. find the E- field at a point P(0m, 8m, 20m). **(Nov 09)**

14. Find the electric field intensity produced by a point charge distribution at P(1,1,1)caused by four identical 3 nc point charges located at P_1(1,1,0), P_2(-1,1,0), P_3(-1,-1,0) and P_4(1,-1,0). **(Nov 09, 05)**

15. If a point charge of 4 coulombs moves with a velocity of $5u_x + 6u_y - 7u_z$ m/s, find the force exerted
i. if the electric field intensity is $15u_x + 8u_y - 5u_z$ V/m
ii. if the flux density is $5u_x + 7u_y + 9u_z$ wb/m². **(Nov 09)**

16. An infinitely large cylinder has a radius and a uniform charge of one micro coulomb per meter. Calculate the potential at a point 10m away from the cylinder if zero potential point is taken to be at a radial distance of 1m. **(Nov 09, 05)**

17. i. Derive ∇. D=ρ_v from fundamentals.
ii. Four point charges of Q,-2Q,3Q and 4Q are located at the corners of a square of side `d' . Find E at the center of the square. **(Nov 09, Mar 06)**

18. i. Show that the intensity of electric field at any point inside a hollow charged spherical conductor is zero.

ii. A sphere of radius `a' has the charge distribution $\rho(r)$ C/m^3 which produces an electric field intensity given by,
$E_r = Ar^4$, for r <
$= Ar^{-2}$; for r >
Where A is a constant. Find the corresponding charge distribution $\rho(r)$. **(Nov 09)**

19. i. State and explain Coulomb's law for the vector force between two point charges in free space.

ii. A straight line of length l m in free space has a uniform charge density of λ C/m. P is a point on the perpendicular bisector of the line charge, at a distance y m from the line. Find the electric field at P.

iii. Find the electric field at P if the line charge length l extends to infinity **(Nov 09, 07, Feb 08)**

20. i State and prove Gauss's law in integral form, considering static charges in free space.

ii Given that N/C (in $\overline{E}(r,\phi,z) = \frac{1}{\varepsilon 0}\left(2r\cos\phi a_\varphi - \frac{1}{3r}\sin\phi a_z\right)$ cylindrical coordinates), find the flux of E crossing the portion of the z = 0 plane defined by $r \leq a$, $0 \leq f \leq \Pi/2$ in the + ve z -direction.

iii $\nabla V = xa_x + ya_y + za_z$ .If (1,1,1)m is at zero volts, find the potential V(x,y,z). **(Nov 09, 06)**

21. i. State and explain Coulomb's law of electrostatic field in vector form.

ii. It is required to hold four equal point charges to each in equilibrium at the corners of a square. Find the point charge, which will do this if placed at the center of the square. **(May 09, Nov 08)**

22. i. Explain coulomb's law.

ii. Two small identical conducting spheres have charge of 2nC and - 0.5nC respectively. when they are placed 4 cm apart what is the force between them. If they are brought into contact and then separated by 4 cms what is the force between them. **(May 09, Nov 08)**

23. State and explain Coulomb's law for the vector force between two point charges in free space. **(May 09, Feb 08, Nov 07)**

24. i. E is the electric field due to a point charge Q C at the origin in free space. Find $\int_s \overline{E}.\overline{da}$ where S is a spherical surface of radius R m and center at origin.

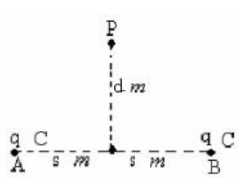
ii. Using Gauss's law, show that the electric field due to an infinite straight line of uniform charge density λ C/m along the z-axis in free space is $(\lambda/2\pi\varepsilon_0 r)\, a_r$ N/C.

iii. An infinitely long cylinder of radius 1m in free space is filled with a uniform charge density of 1nC/m^3. If the potential on the axis of the cylinder is 100V, find the potential variation inside the cylinder. **(May 09, Feb 08)**

25. i. Derive an expression for Potential Gradient.

ii. Determine electric field E at at the origin due to a point charge of 54.9 nC located at (-4,5,3)m in Cartesian coordinates. **(May 09)**

26. i. Figure shows two charges at points figure 1 A and B in free space. Find the electric field at point P. Is the result consistent with what may be expected if d>>s?



ii Find the flux of the electric field through a spherical surface of radius 5m and center origin, in free space, If there is a charge of 10µc at the point (0, 0,3m). What are its units? **(May 09, Nov 07, 06)**

Men occasionally stumble over the truth, but most of them pick themselves up and hurry off as if nothing ever happened.
- Sir Winston Churchill

27. i. State and explain Maxwell's first law.
    ii. Two point charges Q_1 = 5 nC and Q_2 = -4 nC are kept at (3,0,0) and (5,0,0).Determine the electric field at (5,-2,1). **(May 09)**

28. i. State and explain Gauss's law.
    ii. Explain
    a. Electric field intensity due to a line charge.
    b. Electric field due to a charged disc. **(May 09)**

29. i. State and explain Gauss's law.
    ii. Four concentrated charges Q_1 = 0.3 μ c, Q_2 = 0.2 μc, Q_3 = -0.3 μc, Q_4 = 0.2 μc are located at the vertices of a plane rectangle. The length of rectangle is 5 cm and breadth of the rectangle is 2 cm. Find the magnitude and direction of resultant force on Q_1. **(Nov 08)**

30. i. Derive the concept of electric field intensity from Columb's law.
    ii. Derive an expression for electric field intensity at any point 'P' at a radial height 'h' from a finite line charge of λ c/m. extending along the z-axis from 32 to 33 distance 'P' in the x-y plane. **(Nov 08)**

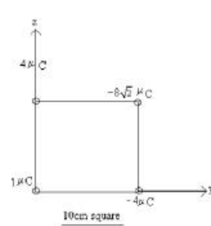
31. i. Discuss the term "electric field due to a static charge configuration".
    ii. Find the electric field at a point outside a sphere of radius R m in free space which carries a uniform charge density ρ C/m3. Use Gauss's law. **(Feb 08)**

32. i. Define the term: "potential difference V(A) - V(B) between points A and B in a static electric field". Give an energy interpretation to potential difference.
    ii. What are the equipotential surfaces for an infinite straight line of uniform charge density? Explain.
    iii. Potential for a certain region is given by V (x, y, z) = 300/x volts; where x is in meters. Find the electric field at the point P:(x= 1m) **(Feb 08, Nov 07)**

33. i. Define the term: Potential difference V(A) - V(B), between points A and B In a static electric field. Explain the concept of reference point and comment on its location.
    ii. What are the equipotentials for an infinite straight line of uniform charge density? Explain.
    iii. A uniformly charged spherical surface of radius 0.5m is in free space. If the potential at the surface is 100V (reference at infinity) what is the surface charge density? **(Nov, Feb 07)**

34. i. Show that the work done in moving a charge from one point to another in an electrostatic field is independent of the path between the points.
    ii. a. Find the potential at a point external to a spherical surface of uniform surface charge density and radius Rm in free space. Use the principle of superposition potentials.
    b. Repeat if the point is internal to the spherical surface.
    c. Comment on the results. **(Feb 07)**

35. i Explain the superposition principle governing the forces between charges at rest.
    ii What are the equipotential surfaces for an infinite plane of uniform surface charge density? Explain.
    iii Charges are located in free space as shown in figure. Find the force experienced by the 1 μc. charge.



(Feb 07)

If you wouldst live long, live well, for folly and wickedness shorten life.
- Benjamin Franklin

36. i Define the term: potential difference V(A) - V(B) between points A and B in a static electric field. Give an energy interpretation to the potential difference.
 ii What are the equipotential surfaces for an infinite straight line of uniform linear charge density? Explain.
 iii Potential for a certain region is given by V (x, y, z) = 300 /x + sin 0.1y + logexy volts; where x and y are in meters. Find the electric field at the point P: (x = 1 m, y = 0.6 m, z = 0). **(Nov 06)**

37. i. Find the potential and field between two large parallel plates which are closely spaced when there is no charge in between the plates.
 ii. A sphere of radius R is having a volume charge density given by ρ= k r
 Where r < R and k is constant .
 Find E at all points and sketch its variation with respect to r **(Mar 06)**

38. i. Determine the potential along the axis of a uniformly charged disc of radius 'a'. The centre of the disc coincides with the origin and the disc is in x-y plane. Also find electric field on the axis
 ii. A charge of 8nC is distributed uniformly along a line of length 8m. Find the field intensity at a radial distance of 2m from the center of the line, assuming air medium **(Mar 06)**

39. i. Find the point charge placed at the center of square which will hold four equal charge +Q each in equilibrium at the corners of the square
 ii. Find the value of electric potential at the point at which E = 0 when point charge of 3µC and 5µC are located at (0,0,0) and (0.6,0)m in XY plane **(Mar 06)**

40. Four positive point charges 10"9 coulomb each are situated in x-y plane at points (0,0),(0,1),(1,1) and (1,0)m. Find the electric field and potential at (1/2 ,1/2) and (1,1). . **(Nov 05)**

41. A circular disc of radius "a" m is charged uniformly with a charge density of c/m^2 Find the electric field intensity at a point "h" m from the disc along its axis. **(Nov 05)**

42. i. Two long metal plates of width 1 m each held at an angle of 100 by an insulated hinge(plates are electrically separated) using laplace's equation determine potential function.
 ii. Potential distributions are given by $V=4/(x^2+y+z^2)$ Find the expression for E. **(Nov 05)**

43. i. A charge of Q is distributed uniformly throughout the volume of a sphere of radius R mts. Find electric field at any point using gauss law.
 ii. Find electric field at any point due to infinite charge surface using Gauss law. **(Nov 05)**

44. Find the E at any point due to a line charge of density l C/m and length L meter. **(May 04)**

45. A total charge of 0.1mC is distributed uniformly along a ring of radius of 5m. calculate the potential on the axis of the ring at a point 5m from the center of the ring. **(May 04)**

46. Find the electric field at any point between two concentric spherical Shells, innerspherical shell has Q1 charge and outer spherical shell has Q2 charge. **(May 04)**

47. Show that the force on a point charge any where with in a circular ring of uniform charge density is zero provided the point charge remains in the plane of the ring. **(May 04)**

48. A circular disc of 10 cm radius is charged uniformly with a total charge of 100mC. Find E at a point 20 cm on its axis. **(May 04)**

49. Two point charge -q and q /2 are situated at the origin and at the point (a,0,0) respectively. At what point does the electric field vanish? **(May 04)**

The worst men often give the best advice.

- Philip James Bailey

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50. The concentrated charge of 0.25mC are located at the vertices of an equilateral triangle 10m of side. Find the magnitude and direction of force on one charge due to the other two charges. **(May 04)**

51. Show that the electric field intensity due to an infinite sheet of charge is independent of the distance of the point from sheet. **(May 04)**

52. A uniform line charge lL = 25nC/m lies on the line x = -3 and z =4 m in free space. Find the electric field intensity at a point (2,5,3)m. **(May 04)**

53. Two long metal plates of width 1m each held at an angle of 10° by an insulated hinge (plates are electrically separated) using laplace's equation determine potential function.

54. Potential distributions are given by V=4/(x2+y+z2). Find the expression for E **(May 04)**

55. A sheet of charge s = 2nc/m2 is present at the plane x = 3 in free space and a line charge l = 20nc/m is located at x = 1, z = 4.
    i. Find the magnitude of electric field intensity at the origin.
    ii. Find the direction of E at P(4.56) **(May 04)**

56. A line charge is '2a' meter long and has a uniform charge ldm. Find the potential at a point 'r' meters from line and located on the plane which bisects the line **(May 03)**

57. Define the terms
    i. Electric field intensity
    ii. Electric potential **(May 03)**

58. Derive the relation between electric field and electric potential in rectangular co-ordinators. **(May 03)**

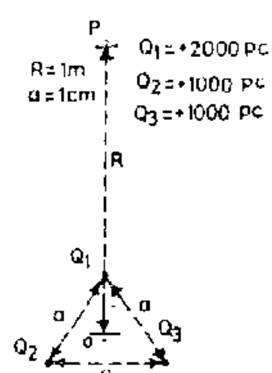
59. Find the electric field strength at the point (1, -2, 1) m given the potential V = 3x2y + 2yz2 + 2 xyz **(May 03)**

60. Find potential function at any point between spherical shell in terms of applied potential using laplace equation. **(May 03)**

61. What is the electric field intensity? Derive the field intensity at any point due to a line charge. **(May 03)**

62. An infinite number of charges, each equal to 'q' are placed along the x = 1, x = 2, x = 4, x = 8, x = 16 and so on. Find the potential and electron field at point x = 0, due to these system of charges. **(GATE 98)**

63. Determine the electric field intensity at the point P for the arrangement shown in figure. **(GATE 97)**



Most of us ask for advice when we know the answer but we want a different one.

\- Ivern Ball

64. A charge +Q is uniformly distributed throughout the volume of a dielectric sphere of radius R and the dielectric constant ?R.Based on Gauss Law, determine the expressions for the electric Field E as a function of distance `r' from the center of sphere, within the ranges 0<r<R and R= r. Indicate expressions for the critical point on the sketch. **(GATE 97)**

65. A charge Q is uniformly distributed along a circular filament of radius a. Deduce the electric field intensity at the center. **(GATE 94)**

66. A charge `Q' is uniformly distributed along a circular filament of radius `a'. Deduce electric field intensity at center. **(GATE 94)**

67. State and explain Gauss's Law A Spherical volume charge distribution r is given by

$$\rho = \rho_0\left[1-\frac{r^2}{100}\right] \quad \text{for r £ 10 mm}$$

$$= 0 \quad \text{for r > 10 mm}$$ **(IES 01)**

68. Show that maximum value of electric field intensity E occurs at r = 7.45 mm. Obtain the value of E at r = 7.45 mm. **(IES 01)**

69. State Guass's Law and develop its mathematical form. Give two examples of its applications. **(IES 00)**

70. Obtain by means of Laplace's equation, the potential distribution between two coaxial conducting cylinders of radii a and c with dielectric of constant e1 filling the region between a and b and a second dielectric of constant e2 filling the region between b and c. Given: c>b>a **(IES 00)**

71. For $\overline{F} = xy^2\overline{a}_x + yz^2\overline{a}_y + 2xz\overline{a}_z$, calculate the line integral $\int_C \overline{F}\cdot\overline{dl}$ where C is the straight line between points (0, 0, 0) and (1, 2, 3) **(IES 00)**

72. Determine the force exerted per meter by a 2 mm dia conductor of infinite length, on a similar parallel conductor 1 m away, when a potential of 1000V is existing between them. Make suitable assumptions about other details you need and state them. **(IES 99)**

73. What do you understand by irrotational fields? State the properties of a static electric field. Find whether the following fields are realizable as static fields:

i. $\overline{F}_1 = \frac{1}{y^z}(y\bar{i}_x - x\bar{i}_y)$

ii. $\overline{F}_2 = K(\cos\phi\bar{i}_r + \sin\phi\bar{i}_\phi)$ - cylindrical coordinates. **(IES 98)**

74. Deduce laplace equation in spherical coordinates and find whether the potential field V = a/r3 sin q volts in a region of free space satisfies it. **(IES 98)**

75. A slab of relative permittivity 6 and thickness 10 mm partially fills the space between two plates of length 1.0m and width 0.5m separated by 10 mm. If the voltage across the plates of the capacitor so formed is 15 kV, find force on the slab to push it inside the plates. **(IES 98)**

76. A sheet charge of uniform density xs extends in the entire X-Y plane. Show that Gauss's law in different form for the entire sheet charge is given by $\nabla\overline{F} = \frac{1}{\varepsilon_0}\rho_0\delta(Z);\delta(Z)$ is Dirac delta function. **(IES 97)**

77. State Maxwell's equation in differential form corresponding to gauss law for electric fields starting from the maxwell's equation in differential form, obtain the poisson's equation for the general situation in which the permitivity of the medium is not constant and is a function of position. **(IES 95)**

78. An infinite cylinder of radius r1(or r1) has a charge distribution of the form, rv = r0 e-r/r1. Derive expressions for electric field and electrostatic potential produced by this charge distribution. The potential Ø is zero at the radius r1 (or r1). **(IES 95)**

79. The gradient of a scalar electric potential function V is given be

$$\Delta V = 3[(x - yz)\bar{a} + (y^2 - zx)\bar{a} + (z - xy)\bar{a}]$$

If the point (1.1.1) is at zero potential, determine the potential function V. **(IES 94)**

80. A small, isolated conducting sphere of radius 'a' is charged with + Q coulombs surrounding this sphere and concentric with it is a conducting shell which possesses no net charge. The inner radius of the shell's is 'b' and outer radius is 'c' all non conducting space is air. Using Gauss Law find the plot E(bar) and potential 'V' every where for o£r£¥, where r is the radial distance from the center of sphere **(IES 93)**

81. Derive the expression for the electric field intensity at any point inside and outside of a sphere of radius 'a' due to a uniform spherical distribution of charge of density r by applying Poissou's equation or its equivalent. Div. D = r both inside the outside the sphere. One constant is evaluated by matching solution at the boundary of the sphere and the other is evaluated by noting that D is zero at the center of the sphere. **(IES 92)**

82. Derive the expression for the electric field intensity at any point inside and outside of a sphere of radius 'a' due to a uniform spherical distribution of charge of density P by applying poisson's equation or its equivalent Div. D = P both inside and outside the sphere. One constant is evaluated by matching solutions at the boundary of the sphere and the other is evaluated by noting that D is zero at the center of the sphere **(IES 92)**

UNIT-II

1. i) **Derive Laplace and Poisson equation.**
   ii) **What is an electric dipole? Obtain expression for torque experienced by an electric dipole in a uniform electric field.**
   iii) Use Laplace's Equation to find the capacitance per unit length of a co-axial cable of inner radius 'a' and outer radius `b' m. Assume $V = V_0$ at r = a and v = 0 at r = b. **(Nov/Dec 2013, Dec-11)**

2. i. What is a dipole? Derive expression for Torque experienced by a dipole.
   ii. A dipole having moment $P = 3\bar{a}_x - 5\bar{a}_y + 10\bar{a}_z$ ncm is located at Q(1, 2, -4) in free space. Find potential v at p(2, 3, 4)? **(Dec 11)**

3. i. Derive Poisson's Equation for homogeneous medium with constant ε.
   ii. Determine whether the following potential fields satisfy Laplace's equation.
   a. $V = x^2 - y^2 + z^2$ **(Dec 12,**
   b. V = r cos ϕ + z. **Nov 11)**

4. i. Show that the torque acting on a dipole of moment p due to an electric field $\bar{E}$ is $\bar{p} \times \bar{E}$.
   ii. Compute the torque for a dipole consisting of 1μc charges in an electric field $\bar{E} = 10^3(z\bar{a}_x - \bar{a}_y - \bar{a}_z)$ separated by 1 mm and located on the z-axis at the origin. **(May 11, Nov 08)**

5. i. What is a dipole? Derive expression for Torque experienced by a dipole in uniform electric field.
   ii. Verify that the potential field given below satisfies the Laplace's equation.
   $V = 4x^2 - 6y^2 + 2z^2$. **(May 11, Nov 10)**

6. Solve Laplace's equation for the potential field in the homogeneous region between two concentric conducting spheres with radii a and b, b > a, if V = 0 at r = b, and V = V_0 at r = a. Find the capacitance between them. **(May 11)**

7. i. Derive expression for torque on an electric dipole in an electric field.
   ii. Point charges of +3μc and -3μc are located at (0, 0, 1)mm and (0,0,-1)mm respectively in free space.
   a. Find dipole moment p?
   b. Find $\bar{E}$ in Spherical components at P(r = 2, θ = 40^0, ϕ = 50^0)? **(May 11)**

8. Using laplace`s equation, for a parallel plate capacitor with the plate surfaces normal to X-axis, find the potential at any point between the plates. $V=V_1$ at $x=x_1$ and $V=V_2$ at $x=x_2$. **(Nov 09)**

9. i. Device an expression for magnetization from dipole moment
   ii. Two long parallel wires separated 7m apart carry curry currents of 55A and 105A respectively in the same direction. Determine the magnitude and direction of the force between them per unit length. **(Nov 09)**

10. What is a dipole, and what is dipole moment? Find an expression for
   i. Potential due to a dipole at a point `0', not in the line connecting the two poles of the dipole.
   ii. The torque experienced by a dipole moment `P1` in a uniform field E, which makes an angle `θ' with the dipole axis. **(Nov 09)**

11. What is a magnetic dipole ? How does a magnetic dipole differ from an electric dipole. **(Nov 09)**

12. i. Derive laplace and poisson's equation.
   ii. A spherical volume charge density distribution is given by v = o (1 r^2/a^2) for r<a = 0 for r>a Find E
   a. inside the charge distribution
   b. outside the charge distribution. **(Nov 13, Nov 09, Mar 06, Nov 05)**

13. For a conducting body in a static electric field of static charges, explain what will be the net electric field inside the conductor, and
   i.. Potential difference between different points inside the conductor.
   ii. Two thin concentric spherical conducting shells of radii 2 cm and 3.5 cm are located in free space with their center at origin. If the potentials of the inner and outer shells are -25v and 150v respectively, find the surface charge densities on the shells. **(May 09, Feb 07)**

14. i. Explain behavior of conductors in an electric field.
   ii. A dipole at the origin in free space has $\overline{P} = 95\Pi\varepsilon_a U_z$ C-m. Find
   a. V at P(x.y,z) in Cartesian coordinate.
   b. E at P(x,y,z) in Cartesian coordinate. **(May 09)**

15. i. What is electric dipole? Explain.
   ii. Derive the expression for torque on an electric dipole in an electric field. **(Dec12, May 09)**

16. i. Find the electric potential due to electric dipole.
   ii. Write Laplace's equation in spherical coordinates .In spherical coordinates V=0 for r = 0.1 m and V = 100V and r = 2 m. Find potential function. **(May 09)**

17. i. Show that the potential due to an electric dipole satisfies Laplace's equation.
   ii. Find the potential due to an electric dipole consisting of +Q at (a/2 ,0,0) and -Q at (-a/2,0,0) at a distance point (r,θ,Φ) in spherical coordinates. **(May 09)**

18. i. Derive an expression for the electric field intensity due to an infinite length line charge along the z-axis at an arbitrary point Q (x, y, z).
ii. A charge of -0.3μC is located at A (25, -30, 15) Cm and a second charge of 0.5μC is located at B (-10, 8, 12) Cm. Find the electric field strength, E at:
a. The origin and
b. Point P (15, 20, 50) cm. **(Nov 08)**

19. Establish Gauss Law in point form and integral form hence deduce the Laplace's and Poissions's equations. **(Nov 08)**

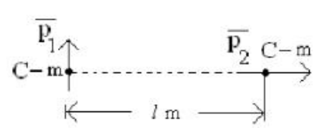
20. For a pure dipole paz C- m at the origin in free space, find the potential at a point A (r, θ, $\phi = \pi/2$) **(Nov 08, 06, Feb 07)**

21. What is the electric field at (x=0, y=0, z=5m) due to a pure dipole 1az ìc-m at the origin? **(Nov 08)**

22. i. A conducting body is in the electric field of static charges. Explain why the net electric field at any point inside the conducting body will be zero.
ii. Use the result of (a) to show that
a. the net volume charge density at any point inside the conductor is zero, and
b. the conductor is an equipotential body. **(Feb 08, Nov 07)**

23. i. In electrostatics, what is meant by a physical dipole?
ii. For a physical dipole in the z-direction, located at the origin in free space, find the potential at a point (r,θ, $\phi = \pi/2$) (in spherical co ordinates).
iii. Point charges of 1 μC and -1 μC are located at (0,0,1) m and (0,0,-1) m respectively in free space.
a. Find the potential at (0,3,4) m.
b. Recalculate the same potential, treating the dipole as a pure dipole. **(Feb 08)**

24. i. Show that the torque on a physical dipole $\bar{p}$ in a uniform electric filed $\bar{E}$ is given by p $\bar{p} \times \bar{E}$. Extend this result to a pure dipole.
ii. Two pure dipoles $\bar{p}_1$ and $\bar{p}_2$ are located in free space as shown in the figure. Find the torque on $\bar{p}_2$ due to the field of $\bar{p}_1$. [It is given that the electric field $\bar{E}$ (r, θ, ϕ) due to a pure dipole paz at the origin is $\frac{P}{4\pi\varepsilon_0 r^3}$ (2 cos θa_r + sin θa_θ) in spherical coordinates]. In which direction will $\bar{p}_2$ tend to rotate due to this torque? **(Feb 08, 07)**



25. i. For a conducting body in the electric field of static charges, explain what will be the
a. net electric field inside the conductor, and
b. volume charge density at any point inside the conductor.
ii. Obtain, from fundamentals, an expression for the capacitance per unit area of a parallel plate capacitor. If the plates are separated by 1 mm in air, and have a potential difference of 1000 V, what is the energy stored per unit area? **(Nov 07)**

26. Use the result of
ii. to find the electric field at the point A. (∇V in spherical co ordinates $\frac{\partial v}{\partial r} a_r + \frac{1}{r}\frac{\partial v}{\partial \theta} a_\theta + \frac{1}{r\sin\theta}\frac{\partial v}{\partial \phi} a_\phi$)
ii. What is the electric field at (x=0, y=0, z=5m) due to a pure dipole 1az μc-m at the origin? **(Feb 07, Nov 06)**

"The formula for my happiness: a Yes, a No, a straight line, a goal."
- Friedrich Wilhelm Nietzsche

27. i What is meant by a pure electric dipole?
ii For a pure dipoles pa_z C-m at the origin in free space, find the potential at a point (r m, θ, φ = π/2) in spherical co ordinates).
iii A dipole of moment 10ax nC m is located at (3,0,0) m in free-space. Find the potential at (5,0,0,)m.
(Feb 07)

28. Find the electric field at any point between two concentric spherical Shells, inner spherical shell has Q_1 charge and outer spherical shell has Q_2 charge. **(Mar 06)**

29. Derive the expression for potential and field between two co-axial cylinders. **(Mar 06)**

30. Derive and expression for the potential difference at any point between spherical shells in terms of applied potential using Laplace equation. **(Nov 05)**

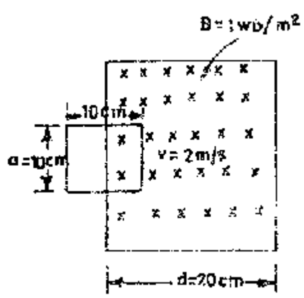
31. Find potential function at any point in a spherical shell in terms of applied potential using laplace equation. **(Nov 05)**

32. A line charge is '2a' meter long and has a uniform charge ldm. Find the potential at a point 'r' meters from line and located on the plane which bisects the line **(May 03)**

33. Show via the construction of a suitable Gaussion surface that the capacitance of a spherical capacitor consisting of two concentric shells of radii `a' and `b' is given by $c=4\pi\varepsilon_0$ ab/b-aWhere ?o is the free space permitivity. **(GATE 99)**

34. An electron moves in the X - Y plane with a speed of 106 m/s. Its velocity vector makes an angle of 60° with X axis. A magnetic field of magnitude 10-2 T exists along the Y axis. Computer the magnetic force exerted on the electron and its direction **(GATE 98)**

35. A square coil of turns and 100 cm side is moved through a steady magnetic field of 1 Wb/m^2 at a constant velocity of 2 m/sec with its plane perpendicular to the field as shown in Figure plot the variation of induced e.m.f. as the coil moves along the field.



(GATE 97)

36. Conducting cylinders at r1 = 1.6 cm and r2 = 5 cm in free space are held at potentials of 80 V and -40 V respectively. Find
i. V and $\bar{E}$ at r = 2 cm
ii. The surface at which V = 0
iii. Capacitance per meter length between the conducting cylinders. **(IES 02)**

37. A sheet of charge, rS =2 nc/m^2 is present at the plane x=3 in free space, and a line charge, rL=20 nc/m is located at x = 1, z = 4. Find
i. The magnitude of the electric field intensity $\bar{E}$ at the origin.
ii. The direction of $\bar{E}$ at (4, 5, 6)
iii. The force per meter length on the line charge. **(IES 02)**

38. If V in the free space is given by $V = \frac{60 \sin\theta}{r^2}$, and a point P is located at r = 3 m, q = 60°, ϕ = 25°, find at P

i. VP ii. P iii. dV/dN iv. $\bar{a}_N$ v. ρ_r **(IES 02)**

39. Obtain by means of Laplace's equation, the potential distribution between two coaxial conducting cylinder of radii `a' and `c' with dielectric of constant ?1 filling the region between `a' and `b' and a second dielectric of constant ? 2 filling the region between `b' and `c'. Give c>b>a **(IES 00)**

40. Derive laplace's equation pertaining to electrostatic potential distribution in a charge free space. Show how this is useful in computing the potential distribution in a two dimensional electrostatic problem using a digital computer. **(IES 99)**

41. Derive the torque produced in vector from when a dipole is situated in a uniform electric field making an angle θ with dipole axis. **(IES 94)**

1. In spherical co-ordinated V = 0 at r = 0.1m and V = 100v at r = 2m. Assuming free space between these concentric spherical shells, find E and D. **(Dec 11)**

2. i. Explain the concept of polarization

 ii. The polarization with a region having ε_r = 2.7 has the uniform values of

 $P = -0.2\,\bar{a}_x + 0.7\,\bar{a}_y + 0.3\,\bar{a}_z\ \mu c / m^2$

 a. E

 b. D

 c. Magnitude of voltage gradient **(Dec 11)**

3. i. State and explain Ohm's law in point form.

 ii. Obtain the expression for equation of continuity for steady currents. **(Dec 11)**

4. Derive the expression for capacitance of a parallel plate capacitor with single dielectric. Also derive the expression for the capacitance of a parallel plate capacitor with two dielectric. **(Dec 11)**

5. i. Derive the conditions at a boundary between two perfect dielectrics.

 ii. Given $\bar{J} = 10^3 \sin \theta \bar{a}_r$ A/m^2 spherical co-ordinates, find the current crossing the spherical shell of r = 0.02m, where r = radius of shell. **(May 11)**

6. Distinguish between conductors and dielectrics.

 ii. A 2μF capacitor is charged by connecting across a 100 V d.c supply. It is now disconnected and then it is connected across another 2μF capacitor. Assuming no leakage, determine the potential difference between the plates of each capacitor and energy stored. **(May 11)**

7. i. Obtain the conditions at a boundary between two dielectrics.

 ii. At boundary between glass (ε_r = 4) and air, the lines of electric field make an angle of 40^0 with normal to the boundary. If electric flux density in the air is 0.25μc/m^3, determine the orientation and magnitude of electric flux density in the glass. **(May 11)**

8. Derive the expression for capacitance of a parallel plate capacitor with single dielectric. Also derive the expression for the capacitance of a parallel plate capacitor with two dielectric. **(May 11)**

9. i. Derive the conditions at a boundary between two dielectrics.
   ii. State Ohm`s law in point form. **(Nov 09)**

10. A parallel plate capacitor has a plate area of 1.5 sq.m. and a plate separation of 5mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3mm with a relative permittivity of 6 and the second has a thickness of 2mm with relative permittivity 4. Find the capacitance? **(Nov 10, 08, 05, Mar 06)**

11. A parallel plate capacitor has a plate area of 2 Sq.m. and a plate separation of 4 mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 4 mm with a relative permittivity of 10 and the second has a thickness of 3 mm with relative permittivity 5. Find the capacitance. Derive the formula uses. **(Nov 09)**

12. A parallel plate capacitor with plates of radius R and separation `d' has a voltage applied at the centre as given by $V = V_0 \sin \omega t$, As a function of radius r (for r<R), find:
   i. The displacement current density $J_d(r)$
   ii. Magnetic field H (r). Take d<<R. **(Nov 09)**

13. i. Show that, in a capacitor, the conduction current and displacement current are equal.
   ii. Find the frequency at which conduction current density and displacement current density are equal in
   a. distilled water, for which $\varepsilon_r = 60$ and $\sigma = 5 \times 10^{-4}$ mho/m
   b. Sea water, for which $\varepsilon_r = 1$ and = 3mho/m. **(Nov 09)**

14. Determine the capacitance of a capacitor consisting of two parallel metal plates 30cm × 30cm surface area and separated by 5mm in air. What is the total energy stored by the capacitor if the capacitor is charged to a potential difference of 1500V. What is the energy density. **(Nov 09)**

15. Charges are moving with a speed of v m/sec along a line which has a charge density of λ C/m. Both v and λ are constants. Find the current through the line,and show that it is a steady current. **(Nov 09, 07, May 09)**

16. Derive an expression for the energy stored in an electric field. **(Nov 09, IES 96)**

17. i. Establish the electrostatic boundary conditions for the tangential components of electric field and electric displacement at the boundary of two linear dielectrics. **(Dec-2012)**
   ii. z<0 is a region of a linear dielectric of relative permittivity 6.5; and z>0 is free space. Electric field in the free space region is $(-3a_x + 4a_y - 2a_z)$ V/m. Find
   a. $\overline{D}$ for z > 0;
   b. tangential components of $\overline{D}$ & $\overline{E}$ for z < 0, on the boundary. **(May 09, Feb 08)**

18. i. Charges are moving with a speed of v m/sec along a line which has a charge density of λ C/m. Both v and λ are constants. Find the current through the line,and show that it is a steady current.
   ii. Copper has 2 mobile electrons per atom, 0.09375 x 10^{26} atoms per kg, and a density of 9000 kg/m^3. The magnitude of the charge of an electron is 1.6 x 10^{-19} C.
   a. Find the mobile charge per unit length of a copper wire of radius 1 mm.
   b. If there is a steady current of 1A through the wire, find the velocity of the mobile charges. **(May 09, Nov 07)**

19. Derive the expression for the energy stored in a capacitor. **(May 09, Nov 06)**

20. i Define polarization. Explain how a dielectric acquires polarization.
 ii A long straight line of uniform charge density λc/m is surrounded by an insulating medium out to a radius Rm. Find: $\overline{D}$ Also find the electric field in the region outside the insulation. Explain why the electric field cannot be found in the insulation region. **(May 09, Nov, Feb 07, Nov 06)**

21. Derive ohms law in point form from first principles **(May 09, 03)**

22. i. Derive an expression for Ohm's Law in Point form.
 ii. Find the relative permittivity of dielectric material used in parallel capacitor if
 a. C =45nF, d = 0.4mm and S =0.35 m^2 .
 b. d = 0.6 mm, E =700 kv/m and ρ_s =35 $\mu C/m^2$
 c. D =75 $\mu C/m^2$ and energy density is 35 J/m^3. **(May 09)**

23. i. What are boundary conditions? Explain.
 ii. Derive an integral form of Continuity equation and also write it's meaning. **(May 09)**

24. i. Derive an expression for polarization of dielectric.
 ii. Derive an expression for current density. **(May 09)**

25. i. What is Energy density in an Electrostatic field and explain?
 ii. A parallel plate capacitor of 30cm × 30cm and d =3cm is charged to a potential of 2 kv with air as dielectric
 a. Find the energy stored.
 b. The capacitor is now disconnected from source and a dielectric slab is inserted into capacitor (ε_r = 5), calculate the energy stored. **(May 09)**

26. i. Explain duality between $\overline{D}$ and $\overline{J}$ **(Dec-2012)**
 ii. Find the total current in a circular conductor of radius 4 mm if the current density varies according to $J = \frac{10^4}{r} A/m^2$ **(Nov 08)**

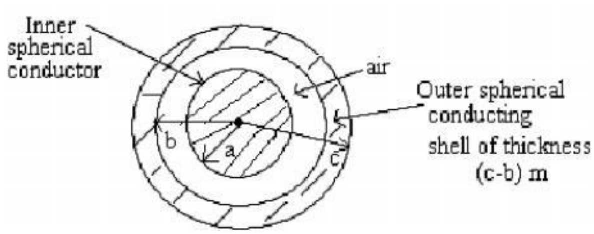
27. i. State and prove the conditions at the boundary between two dielectrics.
 ii. Determine the resistance of insulation in length 'L' of co-axial cable as inner and outer radii are 'a' and 'b' respectively. **(Nov 08)**

28. i. Calculate the capacitance of a parallel plate capacitor with following details. **(Nov 08)**
 Plate area = 150 sq.cm.
 Dielectric εr_1 = 3, d12 = 4mm
 Dielectric εr_2 = 5, d12 = 6 mm
 If 200 V is applied across the plates what will be the voltage gradient across each dielectric.
 ii. The permittivity of the dielectric of parallel plate capacitor increases uniformly from one plate to the other. If A is the surface areas of the plate and d is the thickness of dielectric, derive an expression for capacitance.

29. i. A certain volume of dielectric has a polarization $\overline{P}$ C/m^2. Write the integral expression for the potential at any point due to this dielectric. Explain the different terms in this expression through a figure,
 ii. A spherical dielectric shell has its center at origin, and its internal and external radii are 49 cm and 50 cm respectively. The shell has a polarization of $3a_r$ nC/m^2 (spherical coordinates). Considering only the bound surface density on the outer surface, find the potential of the dielecltric shell. **(Feb 08)**

30. Obtain, from fundamentals, an expression for the capacitance per unit area of a parallel plate capacitor. If the plates are separated by 1 mm in air, and have a potential difference of 1000 V, what is the energy stored per unit area? **(Nov 07)**

31. A concentric spherical conductor arrangement is shown in figure. If the capacitance of the arrangement is 0.1 nF, and a is 10 cm, find b.



(Nov 07)

32. i For a conducting body in a static electric field of static charges, explain what will be the
a. net electric field inside the conductor, and
b. Volume charge density at any point inside the conductor.
ii A parallel plate capacitor with a large plate area is situated in air. With a potential difference of 100 V between the plates, the stored energy 44.21 μ Joule. Per unit area. Find the distance of separation between the plates. **(Nov 06)**

33. i a. Define capacitance. Express its units in 2 different ways.
b. As per the usual definition, show that a capacitance is always positive.
c. Sometimes, capacitance of a single conductor is referred to what does this mean?
ii a. Two large parallel conducting plates are separated by a distance dm in air. Find the capacitance per unit area.
b. A conducting sheet of thickness sm($s<d$) is now introduced between the plates, parallel to them but not touching them. Find the new capacitance per unit area between the outer plates. **(May 09, Nov 06)**

34. i For a conducting body in a static electric field of static charges, explain what will be the
a. net electric field inside the conductor, and
b. the net volume charge density at any point inside the conductor.
ii Define capacitance and explain why it is always a positive quantity.
iii Obtain the capacitance of an isolated conducting sphere of rad 1 cm. **(Nov 06)**

35. i. Derive the expression for capacitance of the spherical condensor.
ii. The radii of two spheres differ by 4 cm and the capacitance of the spherical condensers is 53.33 pf. If the outer sphere is earthed, calculate the radii assuming air as dielectric. **(Mar 06)**

36. i. A parallel plate capacitor consists of 3 dielectric layer If $\varepsilon_{r1}=1$ $d_1 = 0.4$ mm, $\varepsilon_{r2}=1$, $d_2 = 0.6$ mm, $\varepsilon_{r3}=1$, $d_3 = 0.8$ mm and area of cross section 20 sq cm. Find capacitance.
ii. Find the capacitance of parallel plate capacitor when A = 1sq mt distance between the plate 1 mm voltage gradient is 105 V/m and charge density on the plate is 2 $\mu C/m^2$. **(Mar 06)**

37. i. Calculate the capacitance of a parallel plate capacitor with following details.
Plate area = 100 sq.cm.
Dielectric $\varepsilon_{r1} = 4$, d12 = 2mm
Dielectric $\varepsilon_{r2} = 3$, d12 = 3 mm
If 200 V is applied caross the plates what will be the voltage gradient across each dielectric.
ii. The permitivity of the dielectric of parallel plate capacitor increases uniformly from ε_1 at one plate to ε_2 at the other. If A is the surface areas of the plate and d is the thickness of dielectric, derive an expression for capacitance. **(Mar 06, Nov 05)**

When one must, one can.
- Yiddish Proverb

38. i. Two parallel conducting plates 3 cm apart and situated in air are connected to a source of constant potential difference of 72 kv. Find the electric field intensity between the plates. Is it within permissible value? If a mica sheet ($\varepsilon_r = 4$) of thickness 1 cm is introduced between the plates determine the field intensities in air and mica. Given the dielectric strength of air and mica as 30kv/cm and 1000 kv/cm respectively. **(Nov 05)**

ii. A parallel plate capacitor consists of two square metal plates with 500 mm side and separated by 10 mm. A slab of sulphur ($\varepsilon_r = 4$) 6 mm thick is placed on the lower plate and air gap of 4 mm Find capacitance of capacitor. **(Nov 05, May 03)**

39. A parallel plate capacitor consists of 3 dielectric layer If $\varepsilon_r 1 = 1$ $d_1 = 0.4$mm, $\varepsilon_r 2 = 1$,$d_2 = 0.6$mm, $\varepsilon_r 3 = 1$, $d_3 = 0.8$mm and area of cross section 20 sq cm. Find capacitance. **(May 04)**

40. A parallel plate capacitor has a plate area of 1.5 Sq.m and a plate sepration of 5 mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3 mm with a relative permittivity 4. Find the capacitance. **(May 04)**

41. A parallel plate capacitor has a plate area of 2.5 Sqm and a plate separation of 10 mm. There are two dielectric in between the plates. The first dielectric has a thickness of 5 mm with a relative permittivity 5. Find capacitance. **(R7-Ch3)**

42. i The potential at a point in free space due to a volume of dielectric with a polarization P (x, y, z) c/m2 is given by (A) = . $\int_{volume\ of\ dielectric} \frac{\overline{P} dT.a_n}{4\pi E_0}$ Where the terms in the integral are shown in figure 3. (Reference point for the potential is assumed to be at infinity) Obtain the expressions for bound surface charge density and bound volume charge density from the integral given.

ii A dielectric spherical shell, with center origin, negligible thickness, and radius 50 cm has a permanent polarization of 3ar n C/m2 on its surface (spherical co ordinates used). Find the potential at the surface, with reference of infinity. **(Feb 07)**

43. i Define the electric displacement vector $\overline{D}$ in the presence of dielectric .Obtain the expression for its divergence. $\frac{1}{r^2 \sin\theta}\left[\frac{\partial}{\partial r}(r^2 \sin\theta A_r) + \frac{\partial}{\partial\theta}(r \sin\theta A_\theta) + \frac{\partial}{\partial\phi}(rA\phi)\right]$

ii A conducting sphere of radius 20 cm is surrounded up to a radius of 1m by a linear dielectric of dielectric constant 2. An external charge of 1nC is placed on the conductor. Find all the bound charge densities. [∇.A in spherical co ordinates. **(Feb 07)**

44. i Explain the terms
a. linear dielectrics and
b. dielectric constant.

ii A condenser is composed of 2 parallel conducting plates separated by a street of insulation 2mm thick, and with relative permittivity of 4. If external charges of 1n C/m^2 and -1nC/m^2 are placed on the two conducting plates respectively, find all the relevant bound charge densities, and the net charge densities on the conductor surface. **(Feb 07)**

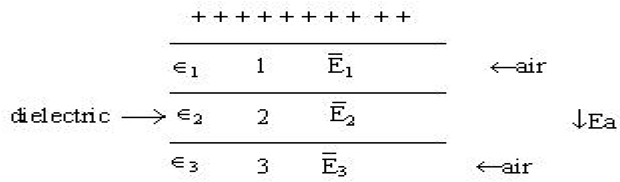
45. For linear dielectric, show that $\overline{D}$Etotal = Eext/ªr, where ªr is the relative permittivity of the dielectric. E total is the toral electric field, and E_{ext} is the electric field due to charges other than bound charges. **(Nov 06)**

46. i. State and explain the term current density.

ii. Find the current in the circular wire, if the current density is J = (1 " e"1000r) $\bar{a}$ z A/m^2 The radius of the wire is 2 mm. **(Nov 12, Mar 06)**

If you count all your assets you always show a profit.
- Robert Quillen

47. T he parallel plate capacitor with a flat slab of dielectric material between the plates shown in below figure 1. Assuming top plate as the charged, calculate and $\bar{P}$ **(Mar 06)**



48. i. Derive the integral form of continuity equation and also write its meaning.
    ii. What is the Capacitance of a Capacitor consisting of two parallel plates 30 cm by 30 cm, Separated by 5 mm in air. What is the energy stored by the capacitor if it is charged to a potential difference of 500 volts.

(Mar 06)

49. Two Cubes of dielectric materials have a common face in the xy plane of rectangular coordinates. An electric field $E2 = 3\bar{a}_x + 4\bar{a}_y - 12\bar{a}_z$ V/m exists in cube 2(z e" 0), the material of which has relative permitivity 3. Obtain the energy density in cube 2. **(Mar 06)**

50. i. Derive the integral form of continuity equation and also write its meaning.
    ii. What is the Capacitance of a Capacitor consisting of two parallel plates 30 cm by 30 cm, Separated by 5 mm in air. What is the energy stored by the capacitor if it is charged to a potential difference of 500 volts. **(Nov 05)**

51. One medium is a dielectric with permitivity ε1 and the other is a conductor Find the angle θ1 between the normal and a field line in medium1 incident on the conductor(medium 2). **(Nov 05)**

52. i. Three point charges 1nC, 3nC and 4nC are located (0,0,0),(0,0,1) and (1,0,0) respectively. Find the energy in the system.
    ii. Find the expression for the energy per unit volume of the dielectric due to electric field in a charged capacitor. **(Nov 05)**

53. An electric field in medium whose relative permitivity is 7 passes in to a medium of relative permitivity 2.If `E makes an angle of 60° with the boundary normal, what angle does the field makes with normal in the second dielectric. **(May 04)**

54. Express the potential outside a polarized dielectric in terms of the internal P - field and its derivatives.

(May 04)

55. An air capacitor consisting of a parallel square plates of 50cm side is charged to a potential difference of 250 volts, when the plates are 1mm apart. Find the work done in separating the plates from 1to 3 mm. Assume perfect insulation. **(May 04)**

56. State and explain the electrical polarization and show that
    P = Lt, P/V, v→0
    Where P = dipole moment, V = Volume. **(May 04)**

57. A 2mF Capacitor is charged by connecting it across a 100v.d.c.supply. It is now disconnected and the capacitor connected across another 2mF capacitor Assuming no leakage, determine the P.d. between the plates of each capacitor and energy stored. Comment on the amount of energy stored in the two cases. **(May 04)**

58. Discuss the phenomenon of refraction of d.c. electric field that occur at the boundary of two conducting media of different conductivities. **(May 04)**

59. Obtain the dielectric boundary conditions at the boundary between two composite dielectrics. **(May 04)**

60. The electric field strength in a mass of proceline (?r=6) in air is 1000 v/cm. At the inner surface of the proceline the field makes angle of 45° to the normal and emerges in to the air .Find the angle of emergence of the external field, and its magnitude. **(May 04)**

61. Find the stored energy in a system of fixed identical point charges q = 4nc at the corners of a square 1m in a side. **(May 04)**

62. Derive the boundary conditions at the interface of two different magnetic media. **(May 03)**

63. Derive the boundary conditions for conductor and a dielectric. **(May 04)**

64. Explain what is meant by the term displacement current. Deduce equation of continuity of current div(J+dD/dt) = 0 **(May 03)**

65. Derive the dielectric boundary conditions at the boundary between two composite dielectrics **(Dec 2013, May 03)**

66. Three point charge 1, 2 and 3 coulombs are situated in free space at the corners of a equilateral triangle of side one meter. Find the energy stored in the system. **(May 03)**

67. Consider a plane boundary between two media of constants m1, E1 and s1, m2, E2 and s2. Establish the relationship between magnetic field intensity on the two sides of the boundary. What happens if the boundary is between air and a perfect conductor? **(May 96)**

68. What is ohm's law at a point? Using the equation V = RI with usual notations, derive ohm is law at a point. **(May 96)**

69. A steadymagnetic field of 100 Amp/m is incident on an iron-air boundary as shown in Fig Relative permeability of iron is 8000.
 i. Write the boundary conditions for the magnetic field in terms of indicated variables and parameters, assuming surface currents to be absent.
 ii Plot α Vs θ for the range of $0< \theta < \pi/2$ **(GATE 92)**

70. The permittivity of the dielectric material between the plates of a parallel plate capacitor varies uniformly from ε_1 at one plate to ε_2 at other plate. Show that the capacitance is given by

$$C = \frac{A}{D} \frac{\varepsilon_2 - \varepsilon_1}{\log_e\left(\frac{\varepsilon_2}{\varepsilon_1}\right)}$$

Where A and d are the area of each plate and separation between the plates respectively. **(IES 00)**

71. The plane x = 0 separates two isotropic linear homogenous magnetic materials. If relative permittivity is 5 for x > 0 and 2 for x < 0,(β/μ) = -2 Ix + 3I4 - Iz. Find $\bar{H}$ and $\bar{m}$ for x > 0. What will be these values if this is a surface current density $\bar{J}$ = 2iy A/m on the plane x =0? **(IES 97)**

You must sacrifice, train, do everything possible to put yourself in a position to win. But if you consider second or third a failure, I feel sorry for you. - Joe Falcon

72. Show that the electromagnetic energy due to charged conductor in space is given by $\frac{1}{2}\int_V \overline{D}\cdot\overline{E}dv$ where fields $\bar{D}$ and $\bar{E}$ occupy whole of the space. **(IES 97)**

73. A square metal plate of 0.2 m side is suspended from one of the arms of a balance such that it is parallel to another fixed horizontal plate of same dimension 1.0 mm below it. What should be the mass placed in the other arm of the balance to maintain the separation on applying 100V across plates? **(IES 97)**

74. Obtain Green's integral identities and state their significance. Apply first identity to show that the specifications of both divergence and curl of a vector with boundary conditions are sufficient to make the function unique. **(IES 97)**

75. Explain what do you understand by perpendicular polarization and parallel polarization. Given two dielectric mediums; medium 1 is space and medium 2 has $\varepsilon_2 = 4\varepsilon_0$ and $\mu = \mu_0$. Determine reflection coefficient for oblique incidence $\theta_1 = 30°$ for i) perpendicular polarization, ii) parallel polarization. **(IES 96)**

76. Starting from the equation of continuity, show for a conducting medium obeying ohms law $\overline{J} = Y\overline{E}$ and using Gauss's law that, $\frac{\partial p}{\partial t} + \frac{Y}{t_0}\ p = 0$ where p is charge density. **(IES 95)**

77. A spherical charge density distribution is given by

$$\rho = \rho_0\left[1 - \frac{r^2}{a^2}\right]; \quad r>a$$

$$= 0; \quad r>a$$

Using Poisson's and Laplace equations as applicable, find $\bar{E}$ everywhere for $0 \le r \le a$, show that maximum value of $\bar{E}$ occurs at r = 0.745a. **(IES 94)**

78. A uniform plane electromagnetic wave is incident at an angle θ_1 at the surface of discontinuity between two homogeneous isotropic dielectrics with permittivity $\in_1$ and $\in_2$, $\in_3$ being the permittivity of the dielectric into which the wave gets refracted at angle q2 If Ei, Er and Et are the electric intensities respectively of the incident, reflected and transmitted wave, show that reflection coefficient for parallel polarization is given by $\frac{E_r}{E_i} = \frac{\tan(\theta_1 - \theta_2)}{\tan(\theta_1 + \theta_2)}$ **(IES 94)**

79. Derive the equation of continuity for current $\Delta \cdot J + \frac{\partial p}{\partial t} = o$, where p is the vector. **(IES 93)**

80. Two isotropic dielectric media 1 and 2 with relative permitivites Er1 and Er2 are separated by a charge force boundary. The conductivities of the two media are zero. The field lines in the two media make angles q1 and q2 with normal to the charge free boundary prove that $\frac{\tan\theta_1}{\tan\theta_2} = \frac{tr_1}{tr_2}$ show that a static electric field line at a dielectric conductor boundary is always perpendicular to the conductor surface when no current is present. **(IES 92)**

You get out in front-you stay out in front.

- A. J. Foyt

UNIT-III

1. i. State and explain Biot-Savart's law.
   ii. Calculate the magnetic flux density due to a coil of 100 amperes and area $50cm^2$ on the axis of the coil at a distanc 10 m from the centre. **(Dec-2012, Dec 11)**

2. i. Derive maxwells second equation for magneto statics.
   ii. A wire carrying a current of 100 A is bent into a square of 10 cms sides. Calculate the field at the center of the coil. **(Dec 11)**

3. Derive an expression for magnetic field intensity at a radial distance `l' m due to a current carrying wire of finite length. **(Dec 11)**

4. A stationay 10-turns square coil of 1m side is situated with its lower left corner coincident with the origin and with sides x and y, along x-axis and y-axis. Its field B is normal to the plane of the coil and has its amplititude given by $B_0 = \sin\frac{\pi x}{x_1}\sin\frac{\pi y}{y}$ tesla
   Determine the rms value of emf induced in the coil if B harmonically at a frequency of 1 khz. **(Dec 11)**

5. Obtain an expression for magnetic field intensity on the axis of a circular loop of radius `R' carrying a current of I amps. Also get the value at centre of the current loop. **(Dec 2013, May 11)**

6. Derive an expression for $\bar{H}$ due to infinite sheet of current. **(May 11)**

7. A conductor 15m long lies along Z-direction with a current of 6A in az direction. Find the force experience by the condenctor if B= 0.09 $\bar{a}_x$. **(May 11)**

8. An area of $0.65m^2$ in the z=0 plane is enclosed by a filamentry conductor. Find the induced voltage given that $\bar{B} = 0.05 \cos 10^3 t \frac{a_x - a_y}{\sqrt{2}}$ (T). **(May 11)**

9. i. Derive an expression for magnetic field intensity due to a current carryiing wire of infinite lenght, at a radial distance `R' m.
   ii. Calculate the magnetic field intensity $\bar{H}$
   a. At the centre of coil of 4 turns and 10 cm in diameter.
   b. In the interior of the solenoid of length 50 cm uniformly wound with 500 turns. The current in each turn is 2.5 A. **(May 11)**

10. A circular loop located on $x^2 + y^2 = 9$ carries a current of 12A. Determine H at (0,0,6) and (0, 0, -6). Take the direction of current in anti-clockwise direction. **(May 11)**

11. A toroid has the dimensions 15×10^{-3} m mean radius and 2×10^{-2} m radius of cross section and 3×10^{-2} m radius of circular cross- section and is wound with 100 turns of wire. The toroid material is iron with an effective relative permeability of 1400 when the current is 0.7 amp. Calculate the total flux
    i. With no air-gap
    ii. With an air-gap of 10^{-3}m. **(May 11)**

12. i. Find an expression for the flux density at any point `P' on the axis of a finite solenoid when carrying a steady current of I amps.
    ii. What is the flux density at the centre of square loop of 10 turns carrying a current of 10 amperes. The loop is in air and as 2 meter on each side. **(May 11)**

The ability to learn faster than your competitors may be only sustainable competitive advantage.

- Arie de Geus

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13. A circular loop located on $x^2 + y^2 - 9; z=0$ carries a current of 10A. Determine H at (0,0,5) and (0,0,-5). Taken the direction of current in anti-clockwise direction. **(May 11)**

14. If the magnetic field intensity $\bar{H} = (x^2\bar{a}\bar{x} + 2yz\bar{a}\bar{y} - x^2\bar{a}\bar{z})$ A/M. Find the current density at (2,3, 4). **(May 11)**

15. A current element 2m in length lies along the y-axis direction centered at the origin. The current is 5 amps in the $\bar{a}_y$ direction. If it experiences a force 1.5 $\left(\frac{\bar{a}_x + \bar{a}_z}{\sqrt{2}}\right)$ N due to a uniform field $\bar{B}$, determine B. **(May 11)**

16. Find the expression for the magnetic flux density $\bar{B}$ at a distance `h' above the centre of a rectangular loop of wire 'b' m on one side and 'a' m on the other side. The loop carries a current of I amps. **(May 11)**

17. Derive an expression for magnetic field intensity at a radial distance `l' m due to a current carrying wire of finite length. **(Nov 10)**

18. A filamentary conductor is formed into an equilateral triangle with sides of length *l* Carrying a current *l*. Find the magnetic field intensity at the center of the triangle. **(Nov 09)**

19. Obtain the expression for H in all regions if a cylindrical conductor carries a direct current I and its radius is `R' m. Plot the variation of H against the distance `r' from the center of the conductor. **(Nov 09)**

20. Find $\bar{B}$ due to a straight length of L m of steady current I A at a distance of y m from the center of the line current. **(Nov 09)**

21. For the magnetic filed intensity given below, find the current distribution which produces the field using ampere's circuital law in di”erential from in cylindrical coordinates. **(Nov 09)**

$$H \quad \begin{aligned} &= J_0 r^2 a_\phi, 0 < r < a \\ &= J_0 \frac{a^3}{r} a_\phi, a < r < b \\ &= 0, b < r < \propto \end{aligned}$$

22. Starting from Biot Savart's law, obtain the expression for the magnetic field $\bar{B}$ due to a steady surface current in free space. **(Nov, May 09, Feb 08, 07, Nov 07, 06)**

23. i A steady current element $10^{-3}a_z$ A-m is located at the origin in free space. What is the magnetic field due to this element at the point (1,0,0) (in rectangular coordinates)?
    ii. What is the magnetic field at the point (0,0,1)? **(Nov 09, Feb 08, 07)**

24. Find $\bar{B}$ due to a straight length of lm of steady current I A at a distance of y m from the center of the line current. **(May 09, Feb 08, 07, Nov 07, 06)**

25. i State Biot - Savart's law for the magnetic field due to a steady line current in free space
    ii Find due to a straight conductor length l m of and steady current IA at a distance of y m from the center of the line current **(May 09, Feb 07)**

26. Define magentic flux and flux density. **(May 09)**

27. i. Explain the relationship between magnetic flux and magnetic flux density.
    ii. State and prove Maxwell's Divergence equation for static magnetic field. **(May 09)**

28. i. State and explain Biot-Savert's Law.
    ii. A uniform line charge λ_L = 25 nC/m lies on the line x = -3 and z = 4m in free space. Find the electric field intensity at a point (2,5,3). **(May 09)**

The most important part of teaching is to teach what it is to know.

- Simone Weil

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29. i. Explain magnetic field intensity H due to finite conductor.
    ii. a. Find the maximum charge that can be held on the isolated sphere 2m in diameter, the sphere being in air with dielectric strength 40KV/cm.
    b. What would be the maximum charge if this sphere were in oil of $\varepsilon_r = 3.5$ and dielectric strength of 75 KV/cm. **(May 09)**

30. i. Derive an expression for magnetic field intensity due to a circular wire.
    ii. Derive an expression for magnetic field intensity 'H' on the axis of an infinite solenoid **(May 09)**

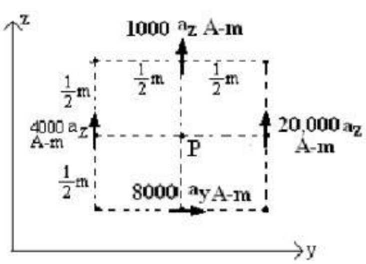
31. A steady current of 10 A is established in a long straight hollow aluminum conductor having inner and outer radius of 1.5 cm and 3 cm respectively. Find the value of B as function of radius. Also define the law used. **(Nov 08)**

32. A single-phase circuit comprises two parallel conductors A and B, each 1 cm diameter and spaced 1 m apart. The conductors carry current of +100 and -100 Amps. respectively. Determine the filed intensity at the surface of each conductor and also in space exactly midway between A and B. **(Nov 08)**

33. A conductor is in the form of a Regular polygon of n sides inscribed in a circle of radius R. Show that the expression for B at the center for a current is given by $|B| = \left(n\mu_0 I/2\pi R\right) Tan\, \pi/n$. **(Nov 08)**

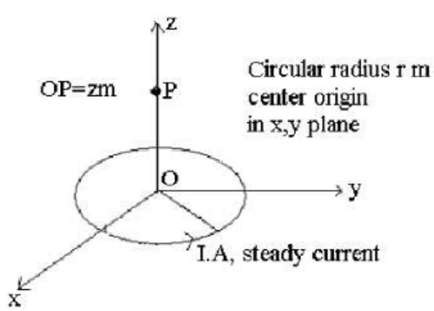
34. Two narrow circular coils A and B have a common axis and are placed 10 cms apart. Coil A has 10 turns of radius 5cm with a current of 1A passing through it. Coil B has a single turn radius 7.5 cms. If the magnetic field at the centre of coil A is to be zero, what current should be passed through coil B. **(Nov 08)**

35. i. State Biot - Savart's law for the magnetic field B due to a steady line current element in free space. Hence obtain the magnetic field due to a steady volume current configuration.
    ii. For the current elements located in free space as shown in figure, find the magnetic field $\overline{B}$ at the point P.



(Nov 07)

36. i State Biot-Savarat's law for the magnetic field B due to a steady line current element in free space.
    ii A solenoid of radius Rm, and N closely wound turns per meter, is in free space with its axis along the Z-axis from the origin to Z =1m. The solenoid is carrying a steady current IA. Find the magnetic field B at the origin (Hint: In figure, magnetic field B and P = $\frac{\mu_0 I r^2}{2(r^2+z^2)^{3/2}} a_z T$)



(Feb 08, Nov 06)

There is that indescribable freshness and unconsciousness about an illiterate person that humbles and mocks the power of the noblest expressive genius. - Walt Whitman

37. i. A steady current of I A extends along the z-axis from $-l/2$m to $l/2$m in free space. Find the magnetic field $\bar{B}$ at a point on the y-axis y m from the origin, using Biot-Savart's law.
ii. Extend the result of (a) to an infinite straight line of steady current. Express the result in cylindrical co ordinates. **(Feb 08)**

38. i a. A steady current element 10-3 azA-m is located at the origin in free space. What is the magnetic field B due to this element at the point (0,1m,0) (in rectangular coordinates)
b. Where should a point be located for the magnetic field due to this element to be 0?
ii A straight length of steady current I A extends from the origin to Z = l m along the Z-axis. Find the magnetic field B at a distance of y m from the origin along the y-axis. **(Nov 06)**

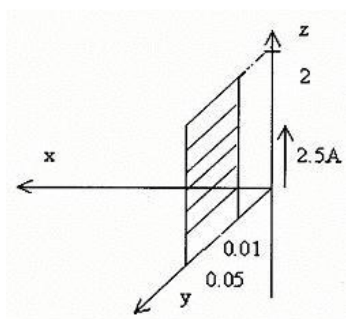
39. A conductor is in the form of a Regular polygon of n sides inscribed in a circle of radius R. Show that the expression for B at the center for a current is given by

$|B| = (n\mu_0 I / 2_\pi R)\text{Tan}\pi / n$ **(Mar 06, Nov 05)**

40. Derive an expression for magnetic field intensity at a point along the axis, due to a circular current carrying loop. **(Nov 2013, Mar 06)**

41. Write down Maxwell's Second and Third equation in point and Integral form. Also state the basic laws from which these two Equations were derived. **(May 04)**

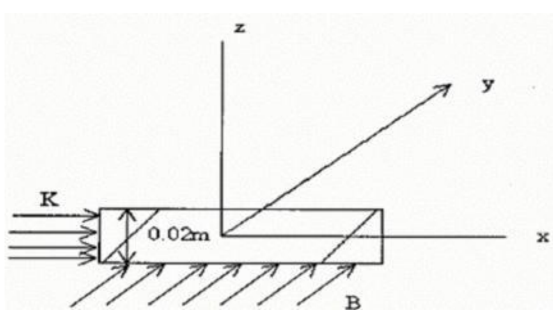
42. Find the flux crossing the portion of the plane ϕ $\pi/4$ defined by 0.01< r < 0.05m and c< Z <2m as shown in figure. A current filament of 2.5A along the z-axis is in the az direction.



(May 04)

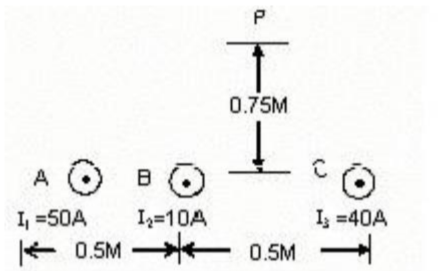
43. Derive an expression for the magnetic field intensity on the axis at a height 'h' due to a current carrying rectangular loop of sides 'a' and 'b'. **(May 04)**

44. A current strip 2cm wide a carries a current of 15 amps in the $\bar{a}_x$ direction, as shown in figure. Find the force on the strip of unit length if the uniform field is $\bar{B} = 0.20\,\bar{a}_y$ Tesla. **(May 04)**



Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught.
- Oscar Wilde

45. Find the magnetic flux density at point P due to current I1, I2 and I3 as shown in figure.



(May 04)

46. A steady current of 1000A is established in a long straight, hollow aluminium conductor of inner radius 1cm and outer radius 2cm. Assume uniform resistivity and calculate B as a function of radius r from the axis of the conductor. **(May 04)**

47. A wire of length L is formed into i a circle, ii an equivalent triangle and iii a square. For the same current I, find the magnetic field H at the centre of each. **(May 04)**

48. A current filament carrying 5A in the general af direction is located along the rectangular path x = +0.2m, y = +0.3m. If a uniform magnetic field B causes a torque on the loop of magnitude of 0.5Nm, find B when By = 0. **(May 04)**

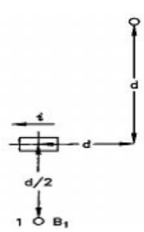
49. A single phase circuit composites two parallel conductors A & B even 1 cm diameter and speed 1m apart. The conductors carry current of +100 and -100 amps. Determine the field intensity at the surface of each conductor and also in space exactly midway between A & B **(May 04)**

50. Two long straight parallel conductors are situated in space and speed D meters a part. Determine the force between them if the two conductors carry currents in i. same direction, ii. Opposite direction. **(May 03)**

51. Explain the Faraday's dise generator and derive an expression for finding the unknown magnetic field. **(May 03)**

52. Find the magnetic field intensity on the axis of a solenoid using Biot - Savart's law. Using the result find out the inductance of a solenoid. **(Nov 02)**

53. A current 1 in the short conducting element shown in figure below produces a flux density B1 at point i. Determine the magnitude and the direction of the flux density vector at point 2



(GATE 2000)

54. A infinitely long straight wire carries 1000A of current and in the vicinity there is a circular conducting loop of 100mm diameter with the center of the loop 1m away from the straight conductor. Both the wire and the loop are coplanar Determine the magnitude and direction of current in the loop that produces a zero flux density at its center. **(GATE 97)**

A friend hears the song in my heart and sings it to me when my memory fails.

- Readers Digest

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55. A long straight cylindrical wire of radius 2 mm is placed parallel to a horizontal plane conducting sheet. The axis of the wire is at a height of 100 mm above the sheet. Calculate the stress in the medium at the upper surface of the sheet jast vertically below the wire. The potential difference between the wire and sheet is 3.3 kV. Derive any formula used and state assumptions made. **(IES 01)**

56. "A handy ' curl meter' in the form of a pin wheel is used to indicate curl of a vector field." Justify the statement. **(IES 01)**

57. The plane x = 0 separates two isotropic linear homogeneous magnetic materials. If relative permittivity is 5 for x > 0 and 2 for x < 0, $B/\mu_0 = -2Tx + 3Ty - Tz$

Find $\overline{H}$ and $\overline{m}$ for x > 0 What will be these values if this is a surface current density $\overline{J} = 2\bar{i}_y A/m$ on the plane x = 0? **(IES 97)**

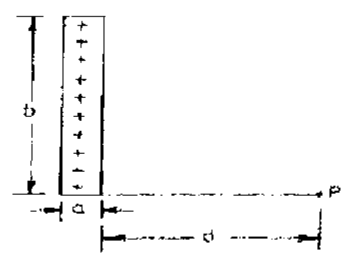
58. A straight wire of length L is charged with electricity of amount q per unit length. This is placed near an earthed conducting sphere of radius of r. The center of the sphere is at a perpendicular distance 's' from the wire. The ends of the wire are equidistant from the center of the sphere. Find the charge on the sphere. Assume that the distribution of charge on the wire is unaffected by induction. **(IES 96)**

59. Show, with usual notations, that $\overline{\nabla} \times H = \bar{j}_c \frac{\partial \overline{D}}{\partial t}$. Find $\overline{\nabla} \times \overline{H}$ if the field is varying harmonically **(IES 96)**

60. State Biot savart law in integral form. Find the magnetic induction at any point on the line through the center and perpendicular to the plane's circular current loop. **(IES 95)**

61. Figure shows a rectangular bus bar for distributing large currents. It is required to find magnetic field at the point 'P' located on x - axis, adjacent to the bus bar and directly opposite one edge of it. Show that the X and Y components of the resulting vector

are given by $B_x = \frac{\mu_0 I}{4\pi b} I_n \frac{d^2 + b^2}{d^2}$ and $B_y = \frac{\mu_0 I}{2\pi b} \tan^{-1}$ **(IES 94)**



62. The electric field intensity of an electromagnetic wave in free space is given by Ey = 0 Ez = 0 Ex = E0 Cos w [t-(Z/v)] Determine expression for the components of magnetic intensity h. **(IES 94)**

63. Two long parallel zinc plated iron pipes have a spacing of 6 m between centers. The pipes are half buried in the ground as show in figure. The diameter of the pipes is 60 cms. The conductivity of the ground is 10-4 mho/meter. Find the resistance between the two pipes per meter length. **(IES 94)**

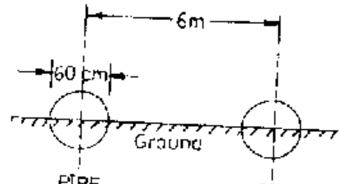


Fig.4(b)

To find a friend one must close one eye-to keep him, two.

- Norman Douglas, Charles Alexander Eastman

64. A infinitely long straight wire carries 1000 A of current and in the vicinity there is a circular conducting loop of 100 diameter with the center of the loop 1 m away from the straight conductor. Both the wire and the loop are coplanar. Determine the magnitude and direction of current in the loop that produces a zero flux density at its center. **(IES 93)**

65. Derive an expression for torque experienced by a current carrying loop placed in a uniform magnetic field. **(Dec 11)**

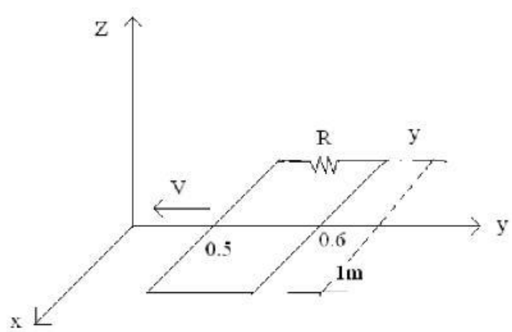
66. Two narrow circular coils A and B have a common axis and are placed 15 cm apart. Coil A has 15 turns of radius 5cm with a current of 1A passing through it. Coil B has a single turn of radius 10cm. If the magnetic field at the centre of coil A is to be zero, what current should be passed coil B. **(Dec 11)**

67. Derive an expression for Maxwell's third equation for static magnetic fields. **(Dec 11)**

68. State and explain Ampere's circuital law. **(Nov 2013, May 11)**

69. A circular loop conductor shown in the figure lies in the z=0 plane, has a radius of 0.1m and a resistance of 5Ω. Give $B = 0.2 \sin 10^3 t\ \bar{a}z(T)$. Determine the current. **(May 11)**

70. A rectangular loop shown in the figure moves towards the origin at a velocity V = -250ay m/s in a 7field $B = 0.8e^{-0.5y}\bar{a}_z$ Telsa. Find the current at the intent the coil sides are at y =0.5m and 0.6m if R=2.5Ω.



(May 11)

71. i. Calculate the inductance of a solenoid 8cm in length, 2cm in radius having r = 100 and carrying 800 turns of wire.
    ii. Calculate the inductance of a toroid formed by surface ρ=3cm and ρ=5cm, z = 0 and z = 1.5cm wrapped with 5000 turns of wire and filled with a magnetic material with $\mu_r = 6$. **(May 11)**

72. A conductor of lenght 4m, carrying a current of 10A in the $\bar{a}_y$ direction lies along the y - axis between y = $\pm$2 . If the field is $\bar{B} = 0.05\ \bar{a}_x$ T, find the work done moving the conductor parallel to itself at constant speed, to x = y = 2m. Derive the formula used. **(May 11)**

73. Using ampere's circuital law, find $\bar{H}$ and $\bar{B}$ inside a long straight non mangentic conductor of `y' radius 8mm carrying a current density of 50 KA/m^2. **(May 11)**

74. i. Using Ampere's Circuital law, find the magnetic field intensity in the case of a closely wound torroidal coil.
    ii. A single-phase circuit comprises two parallel conductors A and B, each 1 cm diameter and spaced 1 m apart. The conductors carry currents of +100 and -100 amps respectively. Determine field intensity at the surface of each conductor and also in space exactly midway between A and B. **(Nov 10)**

75. Two long parallel wires, standing in air 2 m apart carry currents I_1 and I_2 in same direction. The magnetic field intensity at a point midway between the wires is 7.25 AT/m². If the force on each wire per unit length is 2.4 $\times 10^{-4}$, evaluate currents I_1 and I_2. Also derive its necessary required equation. **(Nov 09)**

76. i. Using Amperes work law, find the magnetic field intensity in the case of a close wound toroidal coil.
    ii. Find the magnetic field due to a current I in a coaxial cable whose inner conductor has radius `a' and the outer conductor has the radii `b', c (b < c). (Express the magnetic field as a vector in terms of the current density.) **(Nov 09)**

77. In the cylindrical region $0<\rho<0.5$ m the current density is $J = 4.5\ e^{-2\rho}$ az A/m² and J= 0 elsewhere. Use Ampere's law to find H **(May 09, Feb 07)**

78. i. Determine H for a solid cylinder conductor of radius ρ, where the current I is uniformly distributed over the cross section.
    ii. Two infinitely long and parallel wires carry currents $I_1 - I_2 = I$ Amps in opposite direction. They are separated by a distance of 17.32 cm. If the magnetic field intensity at a point, 10 cm from one wire and 20 cm from other is 13.783 A/m, determine the value of I. **(May 09, Nov 07)**

79. i. State and prove Maxwell's third equation
    ii. A wire carrying a current of 100Amp is bent into a square from 10 cm side. Calculate the field at the centre of the wire. **(May 09)**

80. i. State and prove Ampere's circuital law.
    ii. Currents I1 = I 2 = 10 Amp flow in opposite directions through two long parallel wires, separated by a distance of 20 cm. Find the magnitude and the direction of magnetic flux density at a point 20 cm away from each conductor. **(May 09)**

81. i. List and explain applications of Ampere's circuital law.
    ii. A conductor of length 0.25m lies along the Y-axis and carries a current of 25Amp in the a_y direction. Find the power needed for parallel translation of the conductor to x = 5m at constant speed in 3.0 sec if the uniform field is $\overline{B}=0.06\,\overline{Z}$ T. **(May 09)**

82. i. Prove that curl H = J.
    ii. Calculate the force on a straight conductor of length 30 cm carrying a current of 5Amp in the magnetic field is B = 3.5 × 10 -3 $(\bar{a}_x - \bar{a}_y)$ Tesla, where a x and a y are unit vectors. **(May 09)**

83. i. Show that the field strength at the end of a long solenoid is one - half of that at the centre.
    ii. Find an expression for field intensity at the centre of a circular wire carrying a current I in the anticlockwise direction. The radius of circle is 'r' and the wire in the x - y plane. **(Nov 08)**

84. i. Using Amperes circuital law, obtain an expression for the magnetic field intensity at any point due to a concentric cylindrical conductors, the inner and outer conductors carrying equal and opposite currents.
    ii. Using amperes circuital law, find H and B inside a long straight non magnetic conductor of radius 8 mm carrying a current density of 50 kA/m² **(Nov 08)**

Friendships begin with liking or gratitude roots that can be pulled up.

- George Eliot

85. i. Describe the application of Amperes circuital law to an unsymmetrical field.
    ii. In the cylindrical region $0 < r < 0.8m$, $J = 3e^{-5r} a_z$ A/m^2. Determine $H = H_\phi a_\phi$ every where. **(Nov 08)**

86. i. Define and establish Amperes circuital law for electromagnetic field.
    ii. An H due to current source is given by $H = (y \cos ax)\, a_x + (y.e^x)\, a_z$. Describe the current density over the yz- plane. **(Nov 08)**

87. i Explain the rotational vector operator? Give a physical example.
    ii Three infinite conductors are carrying a current of 1, 2, 3 Amp respectively in same direction. The conductors are arranged in a straight line at a distance of 1 m. The conductor carrying current 1 A is left most and that 3 Amp is right most. Find the H at a point 1 meter exactly above the conductor carrying 1 Amp current. **(Feb 07)**

88. If the magnetic field intensity is $H = x^2 a_x + 2yz\, a_y + (-x^2)\, a_z$, A/m. Find the current density at point
    i 2, 3, 4
    ii $\rho = 6$, $\varphi = 45^o$, $z = 3$
    iii $r = 3.6$, $\theta = 60^o$, $\varphi = 90^o$. **(Feb 08, 07)**

89. Evaluate both sides of Stoke's theorem for the field $H = \frac{y^2 z}{x} a_x + \frac{0.5 y^2 z^2}{x^2} a_z$ and find the current in a_y direction crossing the square surface in the plane y = 2 bounded by x = z = 1 and x = z = 2. **(Feb 08)**

90. Obtain the expression for the magnetic field intensity and sketch the same for a co-axial cable. **(Feb 08)**

91. A solid non-magnetic conductor of cross section ρ=2 cm, carries a total current of 60 A, in the a_z direction. The conductor is inhomogeneous having a conductivity that varies with ρ as $\sigma = 10^5 (1 + 2.5 * 105\rho^2)$ Siemens/m. Find the total flux crossing through the radial plane defined by $\varphi = 0$, $0 < z < 1$m and $0 < \rho < 1$ cm. **(Nov 07)**

92. The magnetic field intensity H is given by $H = -y(x^2 + y^2)\, a_x + x(x^2 + y^2)\, a_y$ A/m in z = 0 plane for the region $-5 < x, y < 5$. Calculate the current passing through the z = 0 plane and through the region $-1 < x < 1$ and $-2 < y < 2$. **(Nov 07)**

93. A wire of length L, carrying current I Amp, is formed into
    i. a circle
    ii. a equilateral triangle
    iii. a square. Find the MFI at the centre of each. Using Ampere's law. **(Nov 2013, Nov 07)**

94. A circular conductor of 1 cm radius has an internal magnetic field of $H = \frac{1}{\rho}\left(\frac{1}{a^2} \sin a\rho - \frac{\rho}{a} \cos a\rho\right) a_\varphi$ A/m, where $a = \pi / 2\rho o$ and ρo is the radius of the conductor. Calculate total current in the conductor. **(Feb 07)**

95. i How Amperes current law differs from Biot - Savart Law.
    ii Evaluate the closed line integral of H from (5,4,1) to (5,6,1) to (0,6,1) to (0,4,1) to (5,4,1) using straight line segments, if $H = 0.1y^3 a_x + 0.4_x a_z$ A/m. **(Nov 06)**

96. A steady current of 10 A is established in a long straight hollow aluminum conductor having inner and outer radius of 1.5 cm and 3 cm respectively. Find the value of B as function of radius. Also define the law used. **(Nov 06)**

97. i What are the limitations of Amperes current law? How this law can be modified to time varying field.
    ii A circular loop located on $x^2 + y^2 = 9$, $z = 0$ carries a direct current of 10 A.along a_φ direction. Determine H at (0, 0, 5) and (0, 0, -5). **(Feb 08, Nov 06)**

Friendship should be more than biting time can sever.

- T. S. Eliot

98. i State and explain Amperes circuital current law.
ii Given $J = 10^3 \sin\theta \, a_r \, A/m^2$, find the current passing through spherical shell of r = 0.2 m. **(Dec-2012,Nov 06)**

99. A single-phase circuit comprises two parallel conductors A and B, each 1 cm diameter and spaced 1 m apart. The conductors carry current of +100 and -100 Amps. respectively. Determine the filed intensity at the surface of each conductor and also in space exactly midway between A and B. **(Mar 06)**

100. State and prove Ampere's circuital law. Discuss few applications for the same. **(Mar 06, Nov 05)**

101. A conductor of length 4 m, with current held at 10 A in the $\bar{a}_y$ direction, lied along the y-axis between y = ±2m. If the field is $\bar{B} = 0.05 \, \bar{a}_x$ T, find the work done in moving the conductor parallel to itself at constant speed to x=Z=2m. **(Mar 06)**

102. Describe any two applications of Ampere's law. **(May 03)**

103. Find an expression for force and torque on closed circuits carrying current in the magnetic field. **(May 03)**

104. Derive the Maxwell's third equation curl H = J. **(May 03)**

105. State Ampere's law using it find the magnetic field is a coaxial cable **(May 02)**

106. State and explain Ampere's Law for current element. **(Dec-12, May 02)**

107. A infinitely long straight wire carries 1000A of current and in the vicinity there is a circular conducting loop of 100mm diameter with the center of the loop 1m away from the straight conductor. Both the wire and the loop are coplanar Determine the magnitude and direction of current in the loop that produces a zero flux density at its center. **(GATE 97)**

108. A coaxial cable carries uniformly distributed current 1 in the inner conductor and -I in the outer conductor. Determine magnetic field intensity distributions within and outside the coaxial cable by using Ampere's circuital law. **(IES 02)**

109. Show that Ampere's law for steady currents is not applicable for time varying currents. Hence explain the concept & displacement current and its intensity **(IES 99)**

UNIT-IV

1. i. Derive an expression for force on a straight long current carrying conductor placed in a magnetic field.
   ii. A conductor 6m long lies along z-direction with a current of 2A in $\bar{a}_z$ direction. Find the force experienced by the conductor if $\bar{B} = 0.08 \, \bar{a}_x$ tesla. **(Dec 11)**

2. A conductor of length 4m, with current held at 10A in the $\bar{a}_y$ direction laid along the y - axis between y = $\pm$2. If the field is B = 0.05 $\bar{a}_x$ T, find the work done in moving the conductor parallel to itself at constant speed to x = y = 2m. Derive the formula used. **(Dec 11)**

3. Show that the magnetising force at the centre of a concentrated circular coil is 1.047 times as great as the force at the same ampere turns, in which the distance between opposite sides is equal to the diameter of the coil. **(Dec 11)**

4. i. A current element 2m length lies along the y-axis centred at the origin. the current is 6 amps in the $\bar{a}$ y direction. If it experiences a force 2.5 $\left(\frac{\bar{a}_x+\bar{a}_z}{\sqrt{2}}\right)$ N due to a uniform field $\bar{B}$, determine $\bar{B}$.
   ii. A conductor of 5m long lies along Z direction with a current of 2 A in $\bar{a}_x$ direction. Find the force experienced by the conductor if $\bar{B} = 0.06\,\bar{a}_x$ tesla. **(Dec2012, Nov2011)**

5. Derive an expression for torque experienced by a current carrying loop placed in a uniform magnetic field. **(Dec 11)**

6. A single-phase circuit comprises two parallel conductors A and B, each 1 cm diamter and spaced 2m apart. The conductor carry current of +50 and - 50 amps. respectively. Determine the field intensity at the surface of each conductor and also in space exactly midway between A and B. **(May 11)**

7. Given $\overline{D} = 5x^2\bar{\partial}_x + 10z\bar{\partial}_z (c/m^2)$, find the net outward flux crossing the surface of a cube 2m on an edge centred at the origin and the edges of the cube are paralled to the axes. **(May 11)**

8. Derive lorentz force equation. **(Nov 2013, May 11)**

9. Derive an expression for force between two straight long parallel conductors carrying currents in the same direction. **(May 11)**

10. i. Derive an expression for the force between parallel wires carrying currents in the same direction.
    ii. A galvanometer has a rectangular coil suspended in a radial magnetic field which acts across the plane of the coil. The coil 0.01 m by 0.01m has 1000 turns and the flux density is 3 wb/m^2. Find the torque on the coil for a current of 10mA. **(Nov 09)**

11. Two coils A and B with 800 and 1200 turns respectively have a common magnetic circuit. A current of 5A in coil A produces flux of 325×10^{-5} wb and 80% of which links with coil B. If both coils are connected in series and carries a current of 5A. Find the
    i. Self inductance of each coil,
    ii. Mutual inductance,
    iii. Total inductance,
    iv. If the Series connection are changed to make current flow in them in opposite direction which of the above inductance will be effected. Find the percentage change from series aiding case.
    v. Calculate the energy stored by the magnetically coupled circuit when the current in both the coils flows in the same direction and when in opposite direction. **(Nov 09)**

12. Two narrow circular coils A and B have a common axis and are placed 10 cms apart. Coil A has 10 turns of radius 5cm with a current of 1A passing through it. Coil B has a single turn radius 7.5 cms. If the magnetic field at the centre of coil A is to be zero, what current should be passed through coil B. **(Nov 09)**

13. i. Derive expression for the torque acting on a circular current ring placed in a uniform magnetic field.
    ii. Calculate the force on a straight conductor of length 0.30 m carrying a current of 5.0 A in the z-direction where the magnetic field is $B = 3.50\times10^{-3}(u_x - u_y)$ Tesla. (u_x and u_y are unit vectors).
    iii. Find the maximum torque on an 85 turn, rectangular coil 0.2 m by 0.3 m, carrying a current of 20 A and field B = 6.5 Wb/m^2. **(Nov 09)**

14. i. Explain the phenomena why a current carrying conductor kept in magnetic field experience force.
    ii. A rectangular loop of wire in free space joins point A (1, 0, 1) to B (3, 0, 1) to C (3, 0, 4) to A. the wire carries a current of 6 mA flowing in the a_z direction from B to C. A filamentary current of 15 A flows along the entire z axis in the a_z direction. Find force on the loop. **(Nov 09, 07)**

Laughter is the most healthful exertion.

\- Christoph Wilhelm Hufeland

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15. Determine the force per meter length between two long parallel wires A and b seperated by 5 mm in air and carring a curent of 40A
    i. in the same diretion and
    ii. In the opposite direction **(Dec-2012, Nov 09)**

16. i. The magnetic field intensity is H=1200 A/m in a material when B = 2 T. When H is reduced to 400 A/m, B = 1.4 T. Calculate the change in Magnetization.
    ii. Classify the different types of magnetic material? On what basis they are classified? **(May 09, Nov 07)**

17. i Prove that the force on a closed filamentary circuit in a uniform magnetic field is zero
    ii If the magnetic field is $H = (0.01/\mu 0)\, a_x$ A/m, what is a force on a charge of 1 pC moving with a velocity of $10^6\, a_y$ m/s. **(May 09, Feb 07)**

18. i. Explain force between two parallel current carrying conductors.
    ii. A uniform plane wave at 1MHz travels in air in a direction that makes 30^0 with X-axis, 60^0 with Y-axis and 90^0 with Z-axis. It has a Z-directed electric field of magnitude 5 V/m. Express the electric and magnetic fields in vector form. **(May 09)**

19. i. Explain force between two current elements.
    ii. Show that $E = - \Delta V$. **(May 09)**

20. i. Derive an expression for force on a current element.
    ii. Explain the relationship between magnetic torque and moment. **(May 09)**

21. i. State and explain Lorentz force equation.
    ii. What is magnetic dipole? Explain. **(May 09)**

22. i. Derive an expression for force on a current element in a magnetic field.
    ii. If a point charge of 4 coulombs moves with a velocity of 5ux +6uy -7uz m/s, find the force exerted, if the flux density is $5u_x + 7u_y + 9u_z$ wb/m^2. **(Nov 08)**

23. i. Show that T = m B also holds for the torque on a solenoid situate in a uniform magnetic field.
    ii. a. What is the maximum torque on a square loop of 1000 turns in a field of uniform flux density B Tesla? The loop has 10cm side and carries a current of 3A.
    b. What is the magnetic moment of the loop? **(Nov 08)**

24. Find the torque which will be produced on a rectangular current loop if placed to a magnetic field B show that $T = m \times B$ also holds for the system. **(Nov 08)**

25. Justify the equation $T = m \times B$ for a circular coil carrying a steady current I is placed such that its plane lie in the x-y plane and also parallel to the direction of a uniform magnetic field B. **(Nov 08)**

26. i. With the help of basic definitions, prove that T = m x B
    ii. Filamentary currents of $-25a_z$ and $25\, a_z$ Amp are located in the x = 0 plane in free space at y = -1 and y = 1 m respectively. A third filamentary current of $10 - 3a_z$ Amp is located at x = k, y = 0. Find the vector force on a 1 m length of 1 mA filament. **(Feb 08)**

27. In region 1, where r. $(2a_x - 3a_y + a_z) > 5$, let $\mu_{r1} = 10$ and in region 2 where r $(2a_x - 3a_y + a_z) < 5$, let $\mu_{r2} = 2$. $B_1 = 10a_x + 20a_y + 30a_z$ mT everywhere in region 1.
    i. Find the angle θ_1 that B_1 makes with the unit normal a_{N21}.
    ii. Find the angle θ_2 that B_2 makes with the unit normal a_{N21}. **(Feb 08)**

He deserves Paradise who makes his companions laugh.

- The Koran

28. i Obtain the expression for the force experienced by a conductor kept in magnetic field.

ii A point charge for which $Q = 2 * 10^{-16}$ C and $m = 5 * 10^{-26}$ kg is moving in the combined fields $E = 100a_x - 200a_y + 300a_z$ V/m and $B = -3a_x + 2a_y - a_z$ mT. If the charge velocity at t= 0 is $v(o) = (2a_x - 3a_y - 4a_z) * 10^5$ m/s. Give the unit vector showing the direction in which the charge is accelerating at t= 0 and the kinetic energy of the charge at t =0. **(Feb 07)**

29. i Justify the statement 'Most of the electrical machines are working on electromagnetic principles rather than the electrostatic principles'

ii A galvanometer has a rectangular coil side of 10 mm * 30 mm pivoted about the center of shorter side. It is mounted in a radial magnetic field so that a constant magnetic field of 0.4 T always acts across the plane of the coil. If the coil has 1000 turns and carries current 2 mA, find the torque exerted on it. **(Feb 08, Nov 06)**

30. i What is Ampere's force law? Derive the expression.

ii Two long parallel wires separated 2 meters apart carry currents of 50 A and 100 A respectively in the same direction. Determine the magnitude and direction of the force between them per unit length.**(Nov 07, 06)**

31. Explain the nature and behavior of magnetic material. Define and explain the term magnetization.**(Nov 07)**

32. Obtain the expression for the force experienced by two current carrying conductors. What is the direction of force when they are carrying current in similar direction and opposite direction? **(Nov 06)**

33. i Prove that the force on a closed filamentary circuit in a uniform magnetic field is zero

ii If the magnetic field is $H = (0.01/\mu 0)\, a_x$ A/m, what is a force on a charge of 1 pC moving with a velocity of $10^6\, a_y$ m/s **(Nov 06)**

34. Two coils A and B are connected in series. Derive an expression for effective inductance of this system. The two coils are magnetically coupled. **(Mar 06)**

35. A single-phase circuit comprises two parallel conductors A and B, each 1 cm diameter and spaced 1 m apart. The conductors carry current of +100 and -100 Amps. respectively. Determine the filed intensity at the surface of each conductor and also in space exactly midway between A and B. **(Mar 06, Nov 05)**

36. Derive an expression for force between two straight long parallel current carrying conductors. What will be the nature of force if the current are in the same and opposite direction? **(Mar 06, Nov 05)**

37. i. Derive an expression for the force between two current carrying conductors in the same direction.

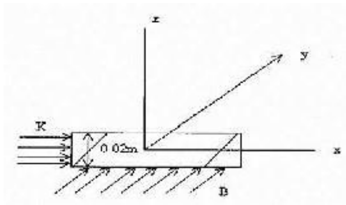
ii. Derive the boundary conditions at the magnetic interfaces and show that $\tan \theta_1 / \theta_2 = \mu_{r1}/\mu_{r2}$ **(Mar 06, Nov 05)**

38. i. What is the torque experienced by a closed circuit carrying a current of I amps and placed in a uniform magnetic field B Tesla.

ii. A galvanometer has a rectangular coil suspended in a radial magnetic field so that the magnetic field always acts across the plane of the coil. If the coil is 10mm by 10mm side and has the 1000 turns and if the magnet provides a constant flux density of 0.3 Tesla, find the torque entered on the coil for a current of 10mA. **(Mar 06, Nov 05)**

39. A wire is bent in to the form of a circle of radius 10 cm. A d.c current of 10 Amps flows in the coil. Find vector magnetic potential at the centre of the coil Medium is air. **(Nov 05)**

40. A current strip 2cm wide a carries a current of 15 amps in the $\bar{a}_x$ direction, as shown in figure . Find the force on the strip of unit length if the uniform field is $\bar{B} = 0.2\,\bar{a}_y$ Tesla **(Nov 05)**



41. Calculate the force on a straight conductor of length 30 cm carrying a current of 5 Amperes in the Z - direction where the magnetic field as B = 3.5 x 10-3 ($\bar{a}$ - $\bar{a}$) Tesla. Where $\bar{a}$ and $\bar{a}$ are unit vectors. **(May 03)**

42. A steady current I flows through a long cylindrical wire of radius R. Find the magnetic vector potential at any point outside the conductor at radius r. Vector potential on the surface of the conductor may be taken to be equal to zero. **(GATE 95)**

43. Give Lorchtz force equation complete form. **(GATE 95)**

44. Determine the force excreted per meter by a 2 mm dia conductor of infinite length, on a similar parallel conductor 1m away. When a potential of 1000 V is existing between them make suitable assumptions about other details you need and state them. **(IES 99)**

1. A solenoid of 500 turns has a length of 50 cm and radius of 10cm. A steel rod of circular cross section is fitted in the solenoid co-axially and tightly. Relative permeability of steel is 3000. A DC current of 10 Amps is passed through this solenoid. Compute inductance of the system, energy stored in the system and mean flux density inside the solenoid. **(Dec 11)**

2. i. Distinguish between self and mutual inductance.
   ii. Derive the expression for coefficient of coupling between two circuits. **(Dec 11)**

3. i. Distinguish between self and mutual inductance.
   ii. A solenoid with N_1 = 1000, R_1 = 10m, L_1 = 50 cm is constructed with in a second coil of N_2 = 2000, R_2 = 2 cm and L_2 = 50 cm. Find the mutual inductance assumiing free space conditions. **(Dec 11)**

4. If a coil of 800H is magnetically coupled to another coil of 200μH. The coefficient of coupling between the coils is 0.05. Calculate inductance if two coils are connected in
   i. series aiding
   ii. series opposing
   iii. parallel aiding
   iv. parallel opposing. **(Dec 11)**

5. i. Explain scalar magnetic potential and give its limitations.
   ii. Explain the importance of vector magnetic potential. **(May 11)**

One horse-laugh is worth ten thousand syllogisms. It is not only more effective; it is also vastly more intelligent.

- H. L. Mencken

6. Filamentary currents of -25 $\bar{a}_z$ and 25 $\bar{a}_z$ amperes are located in the x=0 plane in free space at y = -1 and y = 1m respectively. a third filamentary current of $10^{-3}\bar{a}_x$ amperes is located at x = k, y = 0. Find the vector force on a 1m length of 1mA filament? **(May 11)**

7. i. Derive expression for inductance of a toroid.
   ii. A toroid 600 turns wound on a core of circular cross-section 6 cm^2, a mean diameter of 38 cm. The core material has permeability 1000. Calculate the inductance of the coil. **(May 11)**

8. Derive Neuman's formula for mutual inductance considering two loops carrying currents I_1 and I_2. **(May 11)**

9. A conductor of length 100 cm moves at right angles to uniform field of strength 10000 lines per cm^2 with a velocity of 50 m/s. Calculate emf induced in it when the conductor moves at an angle 30^0 to the direction of the field. **(Nov 10)**

10. Explain the concept of vector magnetic potential and derive the expression for the same. **(Nov 10)**

11. Show that the magnetic vector potential for two long straight, parallel wires carrying the same direction I, in opposite direction is given by $A = \frac{\eta_0 I}{2\pi} \ln\left(\frac{r_2}{r_1}\right) a_n$. **(Nov 09)**

12. Investigate the vector magnetic potential for the infinite, straight, current element L in free space. **(Nov 09)**

13. Find a the magnetic vector potential with in a cylindrical conductor of radius `a', axis on the z - axis, carrying I in the a_z direction by using $\nabla^2 A = \mu o J$. Take A = 0 at r = a. **(Nov 09)**

14. i Obtain the expression for inductance of a toroid.
    ii A solenoid of 10 cm in length consists of 1000 turns having the cross section radius of 1 cm. Find the inductance of solenoid. What is the value of current required to maintain a flux of 1 mWb in the toroid. Take μr = 1500. **(Nov 09, 07, 06, Feb 08, 07)**

15. If $A = 10\rho^{1.5} a_z$ Wb/m in free space, find H, J. **(May 09, Feb 08)**

16. i Explain the self and mutual inductance. Obtain the expression for same.
    ii A coil of 1 mH is magnetically coupled to another coil of 500 μ H. The coefficient of coupling between two coils is 0.015. Calculate the inductance, if these two coils are connected in series addition and series opposition. **(Dec 2013, May 09, Nov 07, 06)**

17. i. Find the mutual inductance between rectangular wire and the longest conductor lying in the plane.
    ii. A solenoid of 500 turns has a length of 50 cm and radius of 10 cm. A steel rod of circular cross section is fitted in the solenoid co-axially and tightly. Relative permeability of steel is 3000 A, dc current of 10 Amp is passed through the solenoid. Compute inductance of the system, energy stored in the system and mean flux density inside the solenoid. **(May 09)**

18. i. Derive an expression for magnetic vector potential.
    ii. State and explain Neumann's formulae. **(May 09)**

19. i. Distinguish between self inductance and mutual inductance.
    ii. Explain
    a. inductance of a solenoid
    b. inductance of a circular solenoid or toroid. **(May 09)**

20. i. Derive an expression for magnetic scalar potential.
    ii. Derive an expression for energy density and energy stored. **(May 09)**

21. i. Derive an expression for mutual inductance use Newmann's formulae.
    ii. Current in a coil is increased from zero to 15 amps at a uniform rate in 6 seconds. It is found that this coil develops self induced emf of 150 volts whereas an emf of 25 volt is produced in a neighbouring coil. Compute self inductance of the first coil and the mutual inductance between the two coils. **(Nov 08)**

22. i. Derive an expression for energy density in a magnetic field.
    ii. A magnetic circuit comprising a toroid of 500 turns and an area of $6cm^2$ and mean radius of 15cm and carries a current of 4A. Find reluctance and flux assume $\mu r=1$. **(Nov 08)**

23. Find the mutual inductance between two toroidal windings which are closely wound on iron core of relative permeability 900. The mean radius of the core is 5cm and radius of its cross-section is 5cm. Each winding has also 800 turns. **(Nov 08)**

24. i. Explain the difference between magnetic vector potential and magnetic scalar potential
    ii. Current in a coil is increased from 0 to 10 Amps at a uniform rate is 5 sec. It is found that this coil develops self induced emf of 100V where as an emf of 20V is reduced in a neighbouring coil. Compute self inductance of the first coil and mutual inductance between the two coils. **(Nov 08)**

25. i Explain the Lap lace's & Poisson's' equations for steady magnetic field.
    ii A current sheet $K = 2.4\ a_z$ A/m is present at the surface. $\rho = 1.2$ in free space. Find H for . $\rho > 1.2$. Find scalar magnetic potential at $(1.5, 0.6\pi, 1)$, if scalar magnetic potential is zero at $\varphi = 0$ and barrier is at $\varphi=\pi$. **(Feb 08, Nov 06)**

26. i What is vector magnetic potential? What are its properties? How vector magnetic potential and flux density are related?
    ii A current sheet $K = 40a_z$ A/m is located in free space at x = 0.25 m and a second sheet $K = -40a_z$ A/m is at x = -0.25 m, let vector magnetic potential may be zero at P (0.1, 0.2, 0.3), find vector magnetic potential in Cartesian co-ordinates for $-0.25 < x, y, z < 0.25$. **(Nov 07, 06)**

27. i. Prove that inductance of coil is given by $L = \mu_0\mu_r N^2 A/l$ Henry. Where N = number of turns of coil, A = cross sectional area of coil and l = length of magnetic path.
    ii. A spiral straight spring consists of 1000 turns of copper wire. The length of spring is 10 cm. Find the inductance of spring if the current flowing through spring is 5 Amp and radius of spring is 1cm. If this spring is bent in to a circle find the new inductance of spring. (Neglect elongation of spring). **(Nov 07)**

28. A certain magnetic field intensity is given in free space as $H = 20\left(\frac{xa_x+ya_y}{x^2+y^2}\right)$ A/m. Find scalar magnetic potential in Cartesian co-ordinates if it is zero at P (1, 1, 1). Find vector magnetic potential in Cartesian co-ordinates if Ax = Ay = Az = 0 at P (1, 1, 1). **(Feb 07)**

29. i Explain the term mutual inductance. Obtain the expression for mutual inductance of closely coupled coils.
    ii Two coils are wound on a common circular magnetic circuit of 45 cm^2 in section and having mean radius of 50 cm. One coil has 180 turns and other has 750. Calculate the mutual inductance of coils, if the relative permeability of iron path is 2400. If both the coils are connected in series what would be the self inductance of coil. **(Feb 07)**

30. A torroid is made up of closed steel ring of mean diameter equal to 75 cm. The area of cross section of steel ring in 5 sq.cm. and the number of turns of insulated copper wire wound around the ring material is 500. The relative permeability of steel is 2000 and current is the coil in 5 Amps. Find energy density and total stored energy in the ring. **(Mar 06)**

Our patience will achieve more than our force.
- Edmund Burke

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31. A straight long wire is situated parallel to one side of a square coil. Each side of the coil has a length of 10 cm. The distance between straight wire and the centre of the coil is 20 cm. Find mutual inductance of the system. Derive formula used. **(Mar 06)**

32. An iron ring has a mean circumference of 125 cm and cross sectional area of 10 cm2. It is wound with 500 turns of wire. When it carries 1.5 amps, the flux produced is 1 milli Weber. What is the relative permeability of the iron material and what is the inductance of the system?. If a length of 1 mm is removed from the iron ring, what is the new value of inductance of the system? **(Mar 06)**

33. Explain the distinction between self-inductance and mutual inductance with relevant diagrams. State the factors, which influence L and M. Suggest ways of producing a coil of large inductance with minimum dimensions. **(Mar 06)**

34. A circuit has 2000 turns enclosing a magnetic circuit of 30 sq. cm. cross section. A current of 5 Amps in the circuit produces a flux density of 1 Tesla. When the current is doubled, the flux density increases by only 50 per cent. Determine mean value of inductance of the circuit between 5 Amps and 10 Amps. Find e.m.f. induced in the coil when current increases uniformly from 5 Amps to 10 Amps in 0.1 second. **(Nov 05)**

35. Prove that the internal inductance of a non-magnetic cylindrical wire of radius 'a' carrying a uniformly distributed current I is µ0/8pHenries per mt. **(Nov 05)**

36. Define and explain the term scalar magnetic potential inside a magnetic field. What is the usefulness of this parameter? State its limitations. How can we determine this quantity as a function of X, Y and Z co-ordinates in space? **(Nov 05)**

37. A wire is bent in to the form of a square coil. Each side of the coil has a length of 20 cm. The coil carries a current of 10 Amps. The medium is air. Find vector magnetic potential at the centre of the coil. **(Nov 05)**

38. Show that the electric field E induced by a time varying magnetic field B is given by the expression.

$\Delta \text{ x E} \frac{-\partial b}{\partial T}$ **(Nov 05)**

39. Prove that in the case of two mutually coupled coils M = $\sqrt{L_1 L_2}$ K with usual notations. **(May 04)**

40. Two coils A and B are connected in series. Derive an expression for effective inductance of this system. The two coils are magnetically coupled. **(May 04)**

41. A two-conductor transmission line is made up of conductors, which are separated by a distance of 2 mt. The radius of each conductor is 1 cm. The medium is air. Compute the exact value of inductance of each conductor per kmt. length. Derive formula used. **(May 04)**

42. Prove that the internal inductance of a non-magnetic cylindrical wire of radius 'a' carrying a uniformly distributed current I is $\mu_{0-}/8\pi$ Henries per mt. **(May 04)**

43. A solenoid having a mean diameter of 20cm and length of 50 cm has 1000 turns. This coil is placed co axially inside another solenoid having a mean diameter of 60 cm and number of turns equal to 200. Length of the outer solenoid in equal to that of inner solenoid computer L, L2 and M neglect leakage medium is air **(May 04)**

44. A torroid is made if closed iron wound with 300 turns of insulated copper wier. The cross sectional area of the ring in 52 cm. The mean radius of the ring in 10 cm. Relative permeability of iron is 1000. Find self inductance and derive formula used. **(May 03)**

45. A straight long wire is situated parallel to one side of a square coil. Each side of the coil has a length of 10 cm. The distance between straight wire and the center of the coil is 20 cm. Find mutual inductance of the system. Derive formula used. **(May 03)**

46. A coil of negligible dimensions of N turns in the form of a regular polygon of 'n' sides inscribed in a circle of radius R meter. When the coil carries a current of I amperes in air show that the magnitude of the magnetic flux density at the center is given by $B = \frac{U_0 \cdot NI}{2\pi R} \cdot \tan\left[\frac{\pi}{n}\right]$ **(May 03)**

47. Obtain an expression for energy density in a static magnetic field. **(May 03)**

48. A conductor of finite length '2L' carries a current of I amperes. Compute the vector magnetic potential and hence the field intensity B at a point distance R from the axis of the conductor. Take R << L. **(May 03)**

49. Distinguish between scalar and vector magnetic potentials. **(May 97)**

50. Explain statically and dynamically indeed **(May 06)**

51. Derive an expression for the energy stored in a magnetic field. **(May 06)**

52. Find the inductance of a solenoid of 2500 turns wound uniformly over a cylindrical paper tube of length of 0.5 m and 4 cm in diameter, medium is air. **(May 06)**

53. A steady current I amps flows through a long cylindrical wire of radius R find the vector magnetic potential on the surface of the conductor may be taken to be equal to zero. **(GATE 95)**

54. A steady current I flows through a long cylindrical wire of radius R find the magnetic vector potential at any point outside the conductor at radius r vector potential on the sequence of the conductor may between to be equal to zero. **(GATE 95)**

55. A pair of long parallel wires carry a current of I amp in opposite direction in the plane of a closed rectangular loop of wire of dimensions l and b as shown in figure below. Determine an expression for the induced electromotive force in the loop using Faraday's law of induction. **(GATE 93)**

56. Show that the electromagnetic energy due to changed conductor in space is given by $\frac{1}{2}\int_V \overline{D} \cdot \overline{E} \cdot dv$ where fields $\overline{D}$ and $\overline{E}$ occupy whole of the space. **(IES 97)**

57. Define magnetic potential vector, Derive an expression for the mutual inductance between two straight parallel wires of length L using magnetic vector potential **(IES 96)**

58. What do you understand by magnetic vector potential , Find the magnetic vector potential $\overline{A}$, of a long wire of circular cross section of radius b carrying a current of density J. From this value of A deduce the expression for $\overline{B}$ **(IES 96)**

It is important not to ignore forecasts that are uncongenial.

- Jib Fowles

59. Give the properties of a linearly, polarized uniform plane wave. A uniform plane wave is specified by $H = 2e^{-j0.1z} I_y$ A/m.
If the velocity of the wave is z x 108 m/s and the relative permeability is 1.6, find the frequency relative permittivity, wave length and intrinsic impedance. **(IES 92)**

60. A toroidal iron ring has a uniform cross sectional area of 50 mm2, and a mean magnetic path length of 100 mm. The ring has an airgap of 1 mm. The ring is excited with a DC current of 1A through a coil of 100 turns wound uniformly along its length. The iron may be assumed to be perfect magnetic material. The effect of fringing at the gap may be assumed to increase the effective area of magnetic flux at the gap by 10% Evaluate.
   i. the exciting mmf of the coil.
   ii. the effective reductance of magnetic circuit.
   iii. the magnetic flux in the airgap
   iv. the inductance of the coil.
   v. the energy stored in the magnetic field under the above excitation. **(IES 92)**

61. Distinguish the linearly, elliptically and circularly polarized waves. An elliptically polarized wave in air has x and y components:
Ex = 4 sin (ωt – βz) volts/meter
Ey = 8 sin (ωt – βz + 75°) volts/meter
Find the Poynting vector. For air, the intrinsic impedance is 367.7 ohms. **(IES 92)**

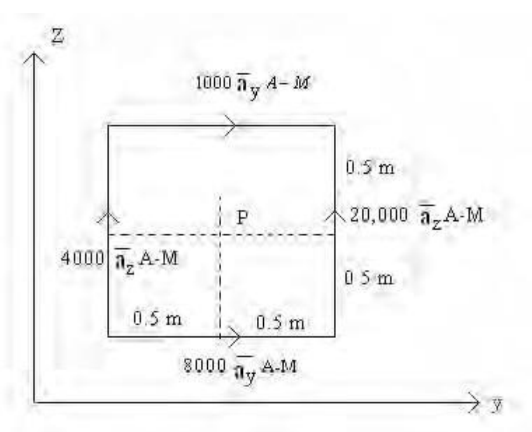
62. A fixed, square 9 turn coil with lower left corner at the origin has sides of lengths x1 and yr If x1 = y1 = 1m and if the magnetic flux densith is normal to the plane of the coil and has a space variation of amplitude

$B_0 = 5\sin\frac{\pi x}{x_1}\sin\frac{\pi y}{y_1} r$, find the r.m.s., e.m.f. induced in the coil if $\overline{B}$ varies harmonically with time at 1000 Cps. **(IES 92)**

UNIT-V

1. State and prove Poynting theorem. **(Nov/Dec 2013, Dec 12, Dec2011)**

2. For the current elements located in free space as shown in figure, find the magnetic field $\overline{B}$ at the point p.



(Dec 11)

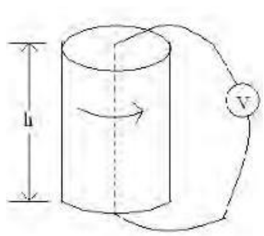
If we can't figure something out in three weeks, we probably shouldn't bother.
- Steven Gilbert

3. i. Write Maxwell's Fourth equation in differential form and word form.

ii. An area of $0.65m^2$ in the z = 0 plane is enclosed by a filamentary conductor. Find the induced voltage, given that $B = 0.05 \cos 10^3 t \left(\frac{\bar{a}_y + \bar{a}_z}{V_z}\right)$test. **(Dec 2012 & 2011)**

4. Write Maxwell's equations in differential and integral form for time varying fields and mention the law it represents. **(Dec 11)**

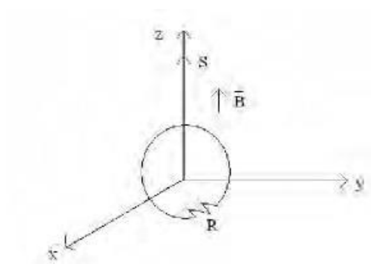
5. i. A conducting cylinder of radius 7cm and height 15 cm rotates at 600 rev/min in a radial field $\bar{B}=0.2\,\bar{a}_r$ Telsla. Sliding contacts at the top and bottom connenc to a voltmeter as shown in figure. Find the induced voltage.



(Dec 2013, May 11)

ii. Distinguish statically induced emf and dynamically induced emf.

6. A conductor is bent in the form of a regular polygon of `n' sides inscribed in a circle of radius `r'. Show that the expression for magnetic flux density $\bar{B}$ at the centre for a current of I amp is $B = \frac{\mu_0 NI}{2\pi r} \tan \frac{\pi}{n}$.



(May 11)

7. Define statically induced emf and dynamically induced emf. **(May 11)**

8. A negative point charge Q = -40 nc is moving with a velocity of 6×10^6m=s in a direction specified by the unit vector $a = -0.48\bar{a}_x - 0.6\bar{a}_y + 0.64\bar{a}_z$. Find the magnetic vector force extarted on the moving particle by the fuild

i. $\bar{B} = 2a_x - 3a_y + 5a_z$ mwb/ m^2

ii. $\bar{E} = 2a_x - 3\bar{a}_y + 5\bar{a}_z$ KV/m. **(May 11)**

9. Derive the integral form of continuity equation and also write its meaning. **(May 11)**

10. i. Moist rod has conductivity 10^{-3}mho/m and $e_r = 2.5$. Find $\bar{J}_C$ and $\bar{J}_D$ where $E = 6 \times 10^{-6} \sin 9 \times 10^9 t$(v=m).

ii. Explain what is meant by displacement current deduce equation of continuity of current div $\left(\bar{J} + \frac{\delta \bar{D}}{\delta t}\right)$=0. **(May 11)**

11. A conductor of length 4m, with current held at 10A in the ay direction laid along the y-axis between $y = \pm 2$. If the field is $\bar{B} = 0.05\ \bar{a}_x$ T, find the work done in moving the conductor parallel to itself at constant speed to x = y = 2m. Derive the formula used. **(Nov 10)**

12. i. Write Maxwell's equations in good conductors for time varying fields and static fields both in differential and integral forms.
    ii. Find the conduction and displacement current densities in a material having conductivity of 10^{-3} S/m and $\varepsilon_r = 3$, if the electric field in material is, $E = 2 \times 10^{-6} \sin(5.0 \times 10^9 t)$ V/m. **(Nov 09)**

13. For a z - direction current of I Amps owing in an infinitely long conductor, verify that the magnetic vector potential can be return as $A = -k\ \frac{\mu_0 I}{4\pi} \log(x^2 + y^2)$. **(Nov 09)**

14. i. Starting with Faradays law, derive Maxwell's equation in integral form based on this law. Also obtain the corresponding differential relation by applying strokes theorem.
    ii. The total flux at the end of a long bar magnet is 360 μ wb. The end of the magnet is withdrawn through a 1000 turn coil in 1/80 sec. What is the emf generated in the coil. **(Nov 09)**

15. i State and explain Faradays law of electromagnetic induction.
    ii If $E = 200\ e^{(4y - kt)} a_x$ V/m in free space, use Maxwell's equation to find H, knowing that all fields varying harmonically for which $\nabla \times E = -j\omega\mu H$. **(Nov 09, 07, Feb 07)**

16. i. Obtain the expression for Displacement current density.
    ii. Find the displacement current density next to your radio, in air, where the local FM station provides a carrier having $H = 0.2 \cos[210(3 * 10^8 t - x)]\ a_z$ A/m. **(May 09, Feb 08)**

17. i. Discuss the physical interpretation of Maxwell's equations.
    ii. A parallel plate capacitor with plate area of 5 cm^2 and plate separation of 3mm has a voltage 50 Sin $10^3 t$ volts applied to its plates. Calculate the displacement current, assuming $\varepsilon = 2\varepsilon 0$. **(May 09, Nov 08)**

18. Deduce Poynting theorem in complex form and discuss its significance. **(May 09, IES 98)**

19. i. Write Maxwell's equations for time varying fields.
    ii. State Poynting's theorem. What is Poynting vector? **(Dec2012, May 09)**

20. i. Write and explain Maxwell's fourth equation.
    ii. Derive the boundary conditions for time varying fields. **(May 09)**

21. i. Derive an expression for displacement current.
    ii. Write and explain Maxwell's fourth equation. **(Dec2012, May 09)**

22. i. State and explain Faraday's laws of electro magnetic induction.
    ii. Differentiate between statically and mutually induced emfs. **(May 09)**

23. i. Explain the Maxwell's equations for harmonically time varying fields.
    ii. A faraday's copper disc 0.3m diameter is rotated at 60 rps on a horizontal axis perpendicular to and through the centre of disc, the axis laying in a horizontal field of 20μTesla. Determine emf measured between the brushes. **(Nov 08)**

24. i. Explain Faraday's law of electromagnetic induction and derive the expression for induced emf.
    ii. Find the conduction and displacement current densities in a material having conductivity of 10^{-3} S/m and $\varepsilon_r = 2.5$, if the electric field in material is, $E = 5.8 \times 10.6 \sin(9 \times 10^9 t)$ V/m. **(Nov 08)**

Try not to become a man of success but rather to become a man of value.

- Albert Einstein

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25. i. Derive the expression for one of the Maxwell's equation $\nabla \times E = -\frac{\partial B}{\partial t}$

ii. Find the frequency at which conduction current density and displacement current density are equal in a medium with $\sigma = 2 \times 10.4$ mho/m and ε_r=81. **(Nov 08)**

26. i. Explain how the displacement current density differs from Conduction current density.

ii. Find the J_D in air within a larger power distribution transformer where B = 1.1 cos [1.257 * 10^{-6}(3*10^8t - y)] a_x Tesla. **(Feb 08)**

27. i. Explain the terms

a. Motional EMF

b. Static EMF

ii. A copper wire carries a conduction current of 1 Amp. Determine the displacement current in the wire at 1 MHz. for copper $\varepsilon = \varepsilon_0$ and $\sigma = 5.8 * 10^7$ Siemens/m. **(Feb 08)**

28. A co-axial capacitor has the parameters a=5 mm, b = 30mm, I = 20 cm, εr = 8, and $\sigma = 10^{-6}$ Siemens/m. If the conduction current density in the capacitor is (2/ρ) sin 10^6t aρ A/m^2, find

i. The total conduction current through the capacitor.

ii. The Maximum value of the displacement current density.

iii. The total displacement current. **(Feb 08)**

29. i Explain why conduction current is absent through the capacitor.

ii Find the displacement current within a parallel plate capacitor where $\varepsilon_0 = 100\,^{a}{}_{\sigma}$, A = 0.1 m^2, d= 0.05mm and the capacitor voltage is 100 sin 2000πt Volts. **(Nov 07, 06)**

30. Given $E = E_o z^2 e^{-t} a_x$ V/m in free space. Determine if there exists a magnetic field such that both Faraday's law and Ampere's current law are satisfied. **(Feb 07)**

31. i Explain how the current flowing through capacitor differs from the normal conduction current.

ii Moist soil has a conductivity of 10^{-3} Siemens/m and εr = 2.5, find JC and JD where E = 6 * 10^{-6} sin (9 * 10^9t) V/m. **(Feb 07)**

32. i In a region defined by $\sigma = 10^6$ Siemens/ m and εr = 4, at certain frequency the ratio of conduction and displacement current density is unity. Find frequency

ii Find the value of K in the following pair of fields in free space, such that they satisfy Maxwell's equation. $D = 5xa_x - 2ya_y + Kz\,a_z$ mC/m^2 and $B = 2\,a_y$ mT. **(Nov 06)**

33. i Explain the nature of current flowing through the capacitor.

ii Find J_D in a typical metallic conductor at 60 Hz where $\sigma = 5*10^7$ Siemens/m, $\varepsilon = \varepsilon_o$ and J = 10^6sin [117.193.22t - z)]a_x A/m^2. **(Nov 06)**

34. i In free space E=Em sin (ωt - âz) a_x V/m, from Maxwell's equation, find H.

ii The circular loop conductor having a radius of 0.15 m is placed in X-Y plane. This loop consists of a resistance of 25 Ohms. If the magnitude of flux density is B = 0.5 sin 10^3t a_z Tesla, find the current flowing through the loop. **(May 09, Nov 06)**

35. Write Maxwell's equations in good conductors for time varying fields and static fields both in differential and integral form? **(Mar 06)**

36. Derive the wave equation in an conducting medium form Maxwell's electromagnetic field equations and hence, show that a plane EMW is attenuated as its propagates though the medium. Find the skin depth. What is skin effect? **(Mar 06)**

37. A conductor of length 100cm moves at right angles to a uniform field of strength 10,000 Lines per cm^2, with a velocity of 50 metres/sec. calculate the EMF induced in it. Find also the value of the induced EMF when the conductor moves at an angle of 30^0 to the direction of the field.

(Mar 06, May 04)

38\. i. Explain what is meant by the term displacement current. Deduce equation of continuity of current div (J+dD/dt)=0.

ii. Find the displacement current density within a parallel plate Capacitor where $\hat{I} = 100\hat{I}_0$, a=0.01m^2, d=0.05 mm and the capacitor Voltage is 100 sin 200 πt volts? **(Mar 06)**

39\. i. Write down Maxwell's equations in their general integral form. Derive the corresponding equations for fields varying harmonically with time.

ii. Show that the ration of the amplitude of the conduction current and displacement current density is

$\frac{\sigma}{\omega\varepsilon}$ for the applied field E = E_{max} Cos wt V/m. **(Mar 06)**

40\. i. Distinguish between conduction and displacement currents?

ii. A Faradays copper disc 0.3 m diameter is rotated at 60 rps on a horizontal axis perpendicular to and though the center of the disc, the axis lying in a horizontal field of 20 micro Tesla. Determine the EMF measured between the brushes. **(Nov 05)**

41\. i. State Maxwell's equations in their general point form and derive their form for harmonically varying fields.

ii. In a material for which σ = 5.0(Wm)-1 and σ_r = 1 the electric field intensity is E = 250 sin 10^{10}t V/m. Find the conduction and displacement current densities and the frequency at which they have equal magnitudes.

(Nov 05, May 04)

42\. i. State and explain the Faraday's laws in Electro magnetic induction?

ii. A stationary 10turns square coil of 1-meter side is situated with its lower left corner coincident with the origin and with side's x1 and y1 along x-axis and y-axis. If the field B is normal to the plane of the coil and has its amplitude given by $B_0 = \sin\frac{\pi x}{x1}\sin\frac{\pi y}{y1}$ Tesla. Determine the r.m.s value of e.m.f. induced in the coil if B varies harmonically at a frequency of 1 KHz. **(Nov 05, May 04)**

43. A square loop of wire 25 cm by 25 cm has a voltmeter (of infinite impedance) connected in series with one side. Determine the voltage induced by the meter when the loop is placed in an alternating field, the maximum intensity of which is 1 AMP per metre. The plane of the loop is perpendicular to the magnetic field varying at a frequency of 10 MHz. **(Nov 05)**

44\. i. Derive the general solution of wave equation.

ii. Prove that the average poynting vector is given by $P_{avg} = \frac{1}{2}(H_m)^2 R_e(\eta)$ Findthe value of P_{avg} for free space, dielectric medium. **(Nov 05)**

45. A coaxial capacitor with inner radius 5mm, outer radius 6mm and length 500mm has a dielectric for which er =6.7 and an applied voltage 250 sin 377 t volts. Determine the displacement current and compare with the conduction current. **(May 04)**

46. Write down Maxwell's equations in their general integral form. Derive the corresponding equations for fields varying harmonically with time. **(May 03)**

47. Show that the ration of the amplitude of the conduction current and displacement current density is s/WE for the applied field E = Emax cos wt V/m **(May 03)**

48. Write down Maxwell's equation is their general form, and give the word statement expression (statement) **(May 03)**

49. A straight conduction of length 40 cm moves perpendicularly to its axis at a velocity of 50 m/Sec in a uniform magnetic field of density 1.0 Wb/m2. Evaluate the emf induced inflected in the conductor if the direction of motion is i) Normal to the field, ii) Parallel to field, iii) At an angle of 60° to the orientation of field. **(May 03)**

50. Explain why expression $\Delta x \bar{H} = Ji$ should be modified for time varying magnetic fields. **(May 03)**

51. A mild steel ring having a cross sectional area of 5 Sq cm and a mean circumference of 50 cm and has a coil of 250 turns wound uniformly around. Calculate the current required to produce a flux of 0.8 x 10-3 in the ring Mr = 1000 for mild stall **(May 03)**

52. In a material for which T = 5.0 $(\Omega m)^{-1}$ and Tr =1 the electric field intensity is E = 250 Sing 1010tV/m. Find the conduction and displacement current density and the frequency at which they have equal magnitudes. **(May 03)**

53. Show that the displacement current in the dielectric of a parallel plate capacitor is equal to the conduction current in the leads. **(May 03)**

54. Explain what is meant by the tism displacement current **(May 03)**

55. i. State faradays law's of induction
ii. A rectangular loop of sides a, b has its plane normal to a magnetic flux density of strength Bo sin Wt. What is the voltage induced in the above loop. **(GATE 94)**

56. Derive Maxwell's equations, the Poynting theorem and explain the physical significance of the terms involved. **(IES 96)**

57. A transmission line operating at 500 M rad/sec hs L = 0.5 μH/m, C = 32 pF/m, G = 100 μOhm/m and R = 25 Ohm/m. Calculateg,γ, α, β, ν, λ and z0. **(IES 02)**

58. Define Poynting's therorem. Show that ratio of Poyting's vector to energy density is $\leq 3 \times 10^8$m/s. **(IES 01)**

59. Explain traveling waves on a transmission line and define Standing Wave Ratio (SWR). A high frequency lossless transmission line has a characteristics impedance of 600 Ohm. Calculate the value of current SWR when the load is (500 + j300) Ohm. **(IES 01)**

60. From Maxwell's curl equations derive the wave equation in E for a plane wave traveling in the positive Y - direction in an isotropic homogeneous lossless medium. The electric field is in Z - direction. **(IES 00)**
Assuming harmonic variation, state a solution of this equation and prove that it is a solution.

61. Define in relation to traveling waves, the following:
i) Reflection coefficient; ii) Transmission coefficient; iii) Standing wave ratio **(IES 00)**

62. i. What is the difference between fundamental and derived units?
ii. Give the salient features of primary and secondary standards. **(IES 00)**

63. Using Maxwell's equations, derive equation to demonstrate the propagation of uniform plane waves in a perfect dielectric medium. **(IES 99)**

64. The magnetic field intensity H of a plane wave in free space is 0.20 A/m and is in the Y direction. If the wave is propagating in the Z direction with a frequency of 3 GHz. Find the wave length, amplitude and direction of the E Vector. μ_0 = 4p0 x 10-7 H/m and ε_0 = 8.85 x 10-12 F/m **(IES 99)**

65. Discuss the wave propagation in i) a lossy dielectric, ii) a aconductor. Derive relevant equation **(IES 99)**

66. In a region where $\varepsilon_R = \mu_R = 1$ and $\sigma = 0$

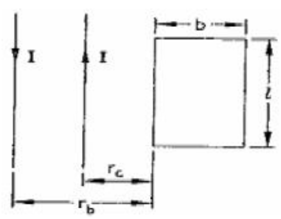
$$\overline{A} = 10^{-3} y \cos 3\times10^{8} t \cos Z \overline{a}_z Wb/m$$

V = 3 x 10^5ysin3 x 10^8 t sin ZV

Find $\overline{E}$ and $\overline{H}$ **(IES 98)**

67. State Maxwell's equation for harmonically varying fields and deduce the wave equation in a conducting medium. Discuss the significance of depth of penetration and skin effect. **(IES 98)**

68. Show that Ampere's law for steady currents is not applicable for time varying currents. Hence explain the concept of displacement current and its intensity. Find the displacement current through a surface at a radius r (a < r < ii in a co-axial cylindrical capacitor of length 1 when a voltage v = Vm sin wt applied; a and b being radii of inner and outer cylinders respectively.



(IES 98)

69. Define and distinguish between Brewster angle and critical angle with reference to an electromagnetic wave incident on a separating surface between two perfect dielectrics. Show that critical angle is normally grater than Brewster angle. A perpendicularly polarized e.m. wave is incident on a s surface ($\mu_r = 1$; $\varepsilon_r = 10$) separating glass from air. Find the critical angle. If the magnitude of the electric field of the incident wave is 1 V/m and the incident angle is 45°, find the magnitude of the field at the separating surface in air. **(IES 98)**

70. The electric field intensity of an e.m. wave at the origin of the spherical co-ordinate system is given by

$$\overline{E} = \frac{E_0}{r} \sin\theta \cos(\omega t - \beta r)\bar{i}_\phi; \beta = \omega\sqrt{\mu_0\varepsilon_0}$$

i. Associated magnetic field
ii. Polynting vector
iii. Power over a spherical surface of radius r around the origin. **(IES 97)**

71. The electric field intensity associated with a plane e.m. wave along any direction in free space is given by $\overline{E}(r) = \frac{1}{2}\left[(-2\sqrt{3} - j)\overline{a}_x + (2 - j\sqrt{3})\overline{a}_y + j2\sqrt{3}\overline{a}_z\right]\varepsilon^{-j\frac{\pi}{5}(\sqrt{3}x+3y+2z)}$ Find

i. direction of wave propagation
ii. frequency and wave length
iii. apparent wave lengths and phase velocities along three axes. **(IES 97)**

Go confidently in the direction of your dreams. Live the life you have imagined.

- Henry David Thoreau

72. Derive the Helmholtz equation for in the form: $\overline{\nabla} + \overline{E} - \mu\sigma \frac{\partial \overline{E}}{\partial t} - \mu\varepsilon \frac{\partial^2 E}{\partial r^2} = 0$

The electric field intensity associated with a plane wave traveling in a perfect dielectric medium is given by. Ex(z,t) = 12 cos (2 π x 10^7t – 0.1 πz V/m
Find i) Velocity of propagation, ii) Intrinsic impedance. **(IES 96)**

73. Show with usual notation that $\Delta x H = Tc \frac{\partial D}{\partial t}$ Find D x H if the field is varying harmonically. **(IES 96)**

74. Obtain Maxwell's equation in integral and differential form as desired from Faraday's Law. **(IES 95)**

75. Define in relation to traveling waves, the following:
   i. Reflection coeffectient
   ii. Transmission coefficient, and
   iii. Standing wave ratio.

An electric wave traveling in air is incident normally on a boundary between air and dielectric having permeability m0 and relative permittivity er = 4. Prove that one ninth of the incident power is reflected and eight ninth of it transmitted into the second medium. **(IES 95)**

76. What do you understand by,
   i. Uniform plane wave
   ii. Linearly polarized wave, and
   ii. Elliptically polarized wave?

The electric field intensity associated with a plane wave traveling in a perfect dielectric medium having

$\mu = \mu_0$ is given by $\overline{E} = 10\cos(6\pi \times 10^7 t - 0.4\pi z)\bar{i}_x \frac{V}{m}$

Find the phase velocity, the permittivity of the medium and associated magnetic field vector $\overline{H}$. Velocity in free space = 3 x 108 m/s. **(IES 95)**

77. State Maxwell's equation for free space and prove that they are satisfied by $\overline{E} = \frac{\theta \overline{A}}{\theta T}; \overline{H} = Curl \overline{A}$

provided that Div $\overline{A} = 0$ **(IES 94)**

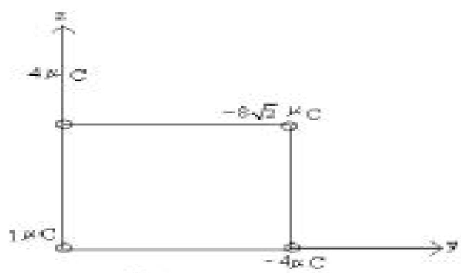
78. Obtain Maxwell's equation is deferential from as derived from Faraday's Law. **(IES 94)**

79. i. Determine if the vector, $\overline{F} = y\bar{i}_x - x\bar{i}_y$ can represent a magnetic field B
   ii. Find the skin depth of penetration in copper at 10000 Mhz. Resistivity of copper is 1.7 x 10-6 ohm cm. **(IES 93)**

Assignment Questions:

Unit I:

1. State and express Coulomb's law in vector form
2. Derive the relation between electric field and potential in differential form.
3. Derive ∇. D=ρ from fundamentals
4. Four positive point charges 10"9 coulomb each are situated in x-y plane at points (0,0),(0,1),(1,1) and (1,0)m. Find the electric field and potential at (1/2 ,1/2) and (1,1).
5. a) Explain the superposition principle governing the forces between charges at rest.
   b) What are the equipotential surfaces for an infinite plane of uniform surface charge density?
   c) Charges are located in free space as shown in figure. Find the force experienced by the 1 μc. charge.



10cm square

Unit II:

1. i) **Derive Laplace and Poisson equation.**
   ii) What is an electric dipole? Obtain expression for torque experienced by an electric dipole in a uniform electric field.
   iii) Use Laplace's Equation to find the capacitance per unit length of a co-axial cable of inner radius 'a' and outer radius `b' m. Assume V_0 at r = a and v = 0 at r = b.

2. i. What is a dipole? Derive expression for Torque experienced by a dipole.
   ii. A dipole having moment $P = 3\bar{a}_x - 5\bar{a}_y + 10\bar{a}_z$ ncm is located at Q(1, 2, -4) in free space. Find potential v at p(2, 3, 4)?

3. Solve Laplace's equation for the potential field in the homogeneous region between two concentric conducting spheres with radii a and b, b > a, if V = 0 at r = b, and V = V_0 at r = a. Find the capacitance between them

4. i. Derive expression for torque on an electric dipole in an electric field.
   ii. Point charges of +3μc and -3μc are located at (0, 0, 1)mm and (0,0,-1)mm respectively in free space.
   a. Find dipole moment p?

5. i. Device an expression for magnetization from dipole moment
   ii. Two long parallel wires separated 7m apart carry curry currents of 55A and 105A respectively in the same direction. Determine the magnitude and direction of the force between them per unit length.

Unit III:

1. i. State and explain Biot-Savart's law.
   ii. Calculate the magnetic flux density due to a coil of 100 amperes and area $50cm^2$ on the axis of the coil at a distance 10 m from the centre.

2. Derive an expression for magnetic field intensity at a radial distance `l' m due to a current carrying wire of finite length.

3. Obtain an expression for magnetic field intensity on the axis of a circular loop of radius `R' carrying a current of I amps. Also get the value at centre of the current loop.

4.. An area of $0.65m^2$ in the z=0 plane is enclosed by a filamentry conductor. Find the induced voltage given that $\bar{B} = 0.05 \cos 10^{3} t$ [illegible] (T).

5. i. Derive an expression for magnetic field intensity due to a current carrying wire of infinite length, at a radial distance `R' m.
   ii. Calculate the magnetic field intensity $\bar{H}$
   a. At the centre of coil of 4 turns and 10 cm in diameter.
   b. In the interior of the solenoid of length 50 cm uniformly wound with 500 turns. The current in each turn is 2.5 A.

6. A toroid has the dimensions 15×10^{-3} m mean radius and 2×10^{-2} m radius of cross section and 3×10^{-2} m radius of circular cross- section and is wound with 100 turns of wire. The toroid material is iron with an effective relative permeability of 1400 when the current is 0.7 amp. Calculate the total flux
   i. With no air-gap
   ii. With an air-gap of 10^{-3}m.

Unit IV:

1. i Prove that the force on a closed filamentary circuit in a uniform magnetic field is zero
   ii If the magnetic field is H = (0.01/μ0) a_x A/m, what is a force on a charge of 1 pC moving with a velocity of 106 a_y m/s.

2 . i. Explain force between two current elements.
   ii. Show that E = - ΔV.

3. i. Derive an expression for force on a current element.
   ii. Explain the relationship between magnetic torque and moment.

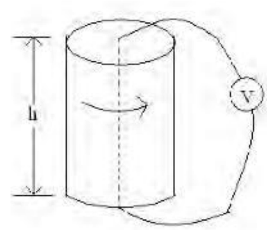
4. i. State and explain Lorentz force equation.
   ii. What is magnetic dipole? Explain.

5 i. Derive an expression for force on a current element in a magnetic field.
   ii. If a point charge of 4 coulombs moves with a velocity of 5ux +6uy -7uz m/s, find the force exerted, if the flux density is $5u_x + 7u_y + 9u_z$ wb/m^2.

6. Find the torque which will be produced on a rectangular current loop if placed to a magnetic field B show that T = m × B also holds for the system.

Unit V:

1. State and prove Poynting theorem
2. Write Maxwell's Fourth equation in differential form and word form
3. Explain Faraday's law of electromagnetic induction and derive the expression for induced emf
4. Show that the ration of the amplitude of the conduction current and displacement current density is $\frac{\sigma}{\omega\varepsilon}$ for the applied field $E = E_{max}$ Cos wt V/m
5. i. a_r A conducting cylinder of radius 7cm and height 15 cm rotates at 600 rev/min in a radial field B =0.2 Telsla. Sliding contacts at the top and bottom connect to a voltmeter as shown in figure. Find the induced voltage.



6.

7.

ii. Distinguish statically induced emf and dynamically induced emf.

6. Explain why expression $\Delta x \bar{H} = Ji$ should be modified for time varying magnetic fields.