Manonmaniam Sundaranar University, Tirunelveli – 12
Department of Physics
University Department
M.Phil. (Physics) - (CBCS)
(From the academic year 2015-2016 onwards)

Eligibility for Admission :

A candidate who has passed M.Sc. Degree Examination with Physics or Applied Physics is eligible for this course. However, candidates with any other Post-graduate degree course in science such as Electronics, Nanoscience, Nuclear Physics, Biophysics etc. may also be considered if the course is equivalent in terms of the syllabus by at least 80 % with regard to the core subjects of the Post-graduate course in Physics of this University. Admission to the M. Phil. course will be offered to those candidates who qualify for a common entrance test conducted in this University.

Course Structure

S.No.	Semester	Subject	Credits	Hours /week	Maximum Marks			Passing Minimum	
					Int.	Ext.	Tot.	Ext.	Tot.
1	I	**Core -I (Theory):** ResearchMethodology	8	8	25	75	100	38	50
2	I	**Core – I (Theory) :** Advanced Physics	8	8	25	75	100	38	50
3	I	**Elective –I (Theory):** a) Materials Science of Thin Films b) Magnetism in Solids c) Energy Storage Materials d) Physical Properties of Materials e) Crystal Growth and Characterization f) Nano Physics g) Advanced NuclearPhysics	8	8	25	75	100	38	50
4	II	**Project and Viva-voce**	16	-	25	75	100	38	50
Total			40	-	-	-	400	-	-

MSU/2016-17/Uni-Dept/M.Phil (Physics)/Semester -I /Ppr.-1/Core-I

RESEARCH METHODOLOGY

UNIT I: Research Methodology-I

Methods of research and methodology of research – Types of research – Selection of research topic and problem – Literature survey – Reference collection – Accessing the current status – Hypothesis - Mode of approach – Actual investigation – Results and conclusion.

UNIT II: Research Methodology-II

Interpretation of the results – Technique of Interpretation – Precautions in Interpretation - Presenting a paper in a scientific seminar – Power point presentation - Art of writing a research paper and thesis – Significance of report writing - Layout of research report / M.Phil. Dissertation – Computers and Researcher - Internet and its applications – Inflibnet.

UNIT III: Numerical Methods-I

Curve fitting - Least squares method. Solution of equations: Newton-Raphson method for solving simultaneous equations – multiple roots. Matrix Inversion: Gauss and Gauss–Jordan – iteration methods. Eigenvalue: Power method

UNIT IV: Numerical Methods-II

Numerical Integration – Trapezoidal and Simpson's rule – Gauss quadrature formula – Lobatto's method - Differential equation: Taylor series method - Runge Kutta method - first order differential equations - simultaneous first order differential equation - simultaneous second order differential equations.

UNIT V: Mathematical Methods

Special functions: Generating function, orthogonality, Recurrence relations for Legendre, Hermite, Bessel functions. Laplace transforms - Important formulae, properties, finding direct and inverse Laplace transform. Greens function – Vibrations of a string, Vibrations of circular and rectangular membranes and deflection of cantilever beam (Theory only)

Books for study and references:

1. S. Rajasekar, P. Philominathan and V. Chinnathambi, arXiv : physics / 0601009v2 [physics.ed-ph] 25 Jan 2006.
2. Research Methodology: Methods and Techniques – C. R. Kothari (New Age International Publishers, New Delhi, 2004)
3. Thesis and assignment writing – J. Anderson, B.H. Durstan and M.Poole, (Wiley Eastern, New Delhi,1977)
4. Numerical Mathematical Analysis – J.B. Scarborough, (Oxford and IBH,1971)
5. Introduction to Numerical methods – P.A. Stark, (Macmillan, 1970)
6. Mathematical Physics for Engineers and Physicists – Louis A. Pipes and Lawrence R. Harvill,(McGraw Hill International, Singapore, 1971)
7. Mathematical Physics – H.K. Dass (S. Chand and company, New Delhi,1997)
8. Mathematical methods for Physicists - George Arfken (Academic Press inc., Newyork, 1994).

MSU/2016-17/Uni-Dept/M.Phil (Physics)/Semester -I /Ppr.-2/Core-2

Advanced Physics

UNIT I: Quantum Field Theory

Lagrangian field theory – Canonical quantization – Classical field equations – Hamiltonian formulation quantization of field – Non-relativistic field – System of Bosons – System of Fermions – Relativistic fields – Klein Gordon fields – Dirac fields.

UNIT II: Nuclear Physics

Nuclear Models – Nilsson Model – Collective Model – Vibrational and Rotational Contributions – Large hadron Collider –Introduction – Standard Model – Prospects for Higgs Boson.

UNIT III: Bottom up approach

Vacuum deposition of thin films by thermal evaporation – Sputtering of thin films – Electrodeposition of thin films – Sol-Gel process of nano powders – Plasma Enhanced Vapour Decomposition of nano materials – Electro-Deposition of nano composites – Gas Phase Condensation of nano particles.

UNIT IV: High Temperature Superconductivity

High temperature superconductors : Y -123 compounds and substitution at Y sites - Different Methods of synthesis - Solid state reaction method - Characterisation - Crystal structure - Effect of oxygen vacancy ordering - Physical properties- Applications; Bi-based superconductors – different types - Synthesis methods- Characterisation - Comparison of physical properties – Effect of substitution at various sites – Applications.

UNIT V: Characterisation Techniques

Structural: Powder XRD & particle size determination - Fourier Transform Infrared spectroscopy (FTIR) - Impedance analysis - Scanning Electron Microscopy (SEM) with EDX, - Thermogravimetry (TG), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC).

Books for Study and reference:

1. V. K. Thankappan, Quantum Physics, (New Age International (P) Limited Publishers, 2nd Edition New Delhi, 2006) (For unit I)
2. Leonard I. Schiff, Quantum Mechanics, 3rd Edition, MC Graw Hill Book Companies, Singapore, 1968. (For unit I)
3. Bohr and Mottelson: Nuclear structure, vol. II, (Benjamin Publications, London), 1975. (For unit II)
4. Gordon kane, Aaron Pierce: Perspectives on LHC Physics, World Scientific, 2008. (Pages: 1-10, 55-71, 179 – 202) (For unit II)
5. Milton Ohring – Materials Science of Thin films – Academic Press, Indian Edition 2006. (For unit III)
6. A.K.Bandyopadhyay – Nano Materials, New International Publishers, New Delhi, First edition 2007. (For unit III)
7. S. V. Subramanyam and E. S. R. Gopal (Eds.): High temperature superconductors (Wiley – Eastern Ltd.), 1989. (For unit IV)
8. T.V. Ramakrishnan and C. N. R. Rao: Superconductivity Today (Wiley – Eastern Ltd.), 1992. (For unit IV)
9. B.D. Cullity: Elements of X-ray diffraction, (Addison – Wesley, London), second edition,1977. (For unit V)
10. J A Belk: Electron microscopy and microanalysis of crystalline materials (Applied Science Publishers), 1979. (For unit V)
11. Evgenij Barsoukov and J. Ross Macdonald: Impedance Spectroscopy: Theory, Experiment and Applications, (John Wiley & Sons, Inc., Hoboken, New Jersey, second edition), 2005. (For unit V)

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(a): Materials Science of Thin Films

UNIT I: Substrates

Substrate materials – Criteria for substrate selection – Substrate cleaning – Atomic view of substrate surfaces – Electronic nature of surfaces – Surface structures – Reconstructed silicon surfaces – Adsorption reactions on solid surfaces – Statistical theory of surface roughening

UNIT II: Thermodynamics of Nucleation

Surface energies – Capillary theory of heterogeneous nucleation – Film growth modes – Morphological stability of strained layers – Nucleation dependences on substrate temperature and deposition rate – Kinetic processes in nucleation and growth – Atomistic models of the nucleation rate – Cluster coalescence – Ostwald ripening – Cluster migration

UNIT III: Thickness measurement

Optical method for measuring film thickness – Interferometry – Opaque films, transparent films – Spectral reflectometry – Ellipsometry – Profilometry – Quartz crystal Microbalances – Ultrasonic Multilayer Film Meterology – Gravimetric method of thickness measurement.

UNIT IV: Surface Characterization

Scanning Electron Microscopy (SEM) – Transmission Electron Microscopy (TEM) – X-ray diffraction (XRD) – Scanning Tunneling Microscopy (STM) – Atomic Force Microscopy (AFM).

UNIT V: Chemical Characterization of Surfaces and Films

Fingerprinting atoms through electron transitions – X-ray Energy Dispersive Analysis (EDX) – Auger electron Spectroscopy (AES) – X-ray Phtoelectron Spectroscopy (XPS) – Rutherford Backscattering (RBS) – Secondary Ion Mass Spectrometry (SIMS)

Books for study and reference :

1. Milton Ohring – Materials Science of Thin films – Academic Press, Indian Edition 2006.
2. LI.Maissel and R.Gland - Handbook of thin film technology - McGraw Hill book company, New York 1983.

(b): Magnetism in Solids

UNIT I: Magnetism

Diamagnetism - Langevin theory – Susceptibility of atoms, ions and molecules - Paramagnetism - Theories - Rare-earth ions – Iron group ions- Paramagnetic susceptibility of the nucleus – Magnetic properties of an electron gas –Magnetic effects – De Haas – Van Alphen Effect – Galvanomagnetic, Thermomagnetic and Magnetoacoustic effects – Some magnetic properties of superconductors.

UNIT II: Ferromagnetism

Molecular field theory - Exchange interaction - Spin-waves - Band model theory - Ferromagnetic metals and alloys - Crystalline anisotropy - Magnetoelastic effects - Ferromagnetic domains - Single-domain and superparamagnetic particles - permanent magnets and soft magnetic materials – Applications.

UNIT III: Antiferromagnetism

Neutron diffraction studies – Molecular field theory- Indirect exchange interaction – Spin-waves - Crystalline anisotropy – Antiferromagnetic metals and alloys – Applications - Canted spin arrangements – Domains in antiferromagnetic materials.

UNIT IV: Ferrimagnetism

Molecular field theory – Ferrites - Spinels – Garnets – Other ferrimagnetic materials – Soft ferrimagnetic materials – Applications - ferrimagnetism and geophysics.

UNIT V: Experimental Methods in Magnetism

Measurement of magnetic field strength - Fluxmetric method - Galvanomagnetic effect method – Measurement of magnetization- Force and induction methods – Determination of atomic moment and Curie point of ferromagnetics – VSM - Permeability determination – Methods for measuring magnetostriction and magnetic anisotropy - XRD for magnetic materials – FMR, Mössbauer spectroscopy.

Books for study and References:

1. Soshin Chikazumi and Stanley H.Charap: Physics of Magnetism, (John-Wiely & Sons, New York), 1964.
2. A.H. Morrish: Physical Principles of Magnetism (John-Wiely & Sons, New York), 1966.
3. B.D. Cullity: Introduction to Magnetic Materials (Addison – Weslety Publ. Co.), 1972.
4. H. Zijlstra: Experimental Methods in Magnetism (North - Holland Publishing Co.), 1977.
5. John Crangle: Solid State Magnetism, (Edward Arnold - A division of Hodder and Stoughten) 1991.
6. R. M. Bozorth: Ferromagnetism (IEEE Press, Piscataway, NJ), 1993.
7. Charles Kittel: Introduction to Solid State Physics (John-Wiely & Sons, New York), 1996.
8. Soshin Chikazumi: Physics of Ferromagnetism (second edition, Clarendon Press, Oxford), 1997.
9. R. C. O'Handley: Modern Magnetic Materials - Principles and Applications (John Wiley and Sons Inc., NY), 2000.
10. Nicola A. Spaldin: Magnetic Materials - Fundamentals and Device Applications, (University Press, Cambridge), 2003.

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(c): Energy Storage Materials

UNIT I: Fundamentals of Nanomaterials and Thin Films

Nanomaterials: Fundamentals and salient features – Different types of preparation – Sol-Gel Synthesis – Co-Precipitation – Solid State Method; Thin Films: Fundamentals – Spin Coating – Dip Coating – Chemical Bath Deposition – Thermal Evaporation – Electron Beam Evaporation – Applications for Thin Film of Advanced Materials.

UNIT II: Energy Resources – I

Renewable Energy Resources – Solar Cells – Types of Solar Cells – Principles of Solar cells; Solar Spectrum - Solar Time and Angles - Day Length - Angle of Incidence on Tilted Surface – Sun Path Diagram - Shadow Angle Protractor; Solar Cell Physics: p-n junction - Homo and Hetero junctions - Metal and Semiconductor Interface - The Photovoltaic Effect – Design of a Complete Silicon, GaAs, InP Solar Cell – Dye Sensitized Solar Cell - Si-H Based Solar Cells - Quantum Well Solar Cell; Efficiency Measurements - Applications of Solar Cells.

UNIT III: Energy Resources – II

Fuel Cells – Types of Fuel Cells and its Components – Principles of Fuel Cells - Difference Between Batteries and Fuel Cells - Fuel Cell Thermodynamics - Heat, Work Potentials, Prediction of Reversible Voltage, Reduction and Oxidation - Fuel Cell Efficiency - Problems with Fuel Cells - Applications of Fuel Cells; Physics of Hydrogen Storage: Fundamentals - Advanced Materials Based Approaches to Hydrogen Storage - Hydrogen Storage in Bulk and Nanomaterials - Metal Hydrides, Metallic Alloy Hydrides, Carbon Nanotubes.

UNIT IV: Characterization Techniques

Structural: Powder XRD – Determination of grain size/crystallite size using X-ray line broadening studies; Spectroscopic: Fourier Transform Infra Red (FTIR), Ultra Violet (UV) and Photoluminescence (PL); Electron Microscope – Scanning Electron Microscopy (SEM) – Transmission Electron Microscopy (TEM) – Energy Dispersive X-ray Spectroscopy (EDAX).

UNIT V: Electrochemical Investigations

Impedance Spectroscopy: Fundamentals – Characterization of Grain and Grain Boundaries - Bode Plots – Nyquist Plots; Cyclic Voltammetry – REDOX Properties; Chronoamperometry; I-V Characteristics - Fundamentals and Applications.

Books for study and references:

1. Charles Kittel: Introduction to Solid State Physics (John Wiley & Sons, Inc.,) eighth edition, 2005.
2. Charles P. Poole Jr, Frand J.Owens: Introduction to Nanotechnology, (John Wiley &Sons), 2003.
3. G.Cao: Nanostructures & Nanomaterials: Synthesis, Properties & Applications, (Imperial College Press), 2004.
4. A. Goswami: Thin film fundamentals (New Age international (P) Ltd., New Delhi), 2006.
5. H.P. Garg, J. Prakash: Solar Energy Fundamentals and Applications, (Tata McGraw-Hill), 2005.
6. R.P. O'Hayre, S. Cha, W. Colella, F.B. Prinz: Fuel Cell Fundamentals, (Wiley) 2006.
7. B.D. Cullity: Elements of X-ray diffraction, (Addison – Wesley, London), second edition,1977.
8. J.A. Belk: Electron microscopy and microanalysis of crystalline materials (Applied Science Publishers), 1979.
9. A.J. Bard, L. R. Faulkner: Electrochemical Methods, (Wiley) 2004.
10. Evgenij Barsoukov, J. Ross Macdonald: Impedance Spectroscopy: Theory, Experiment and Applications, (John Wiley & Sons, Inc., Hoboken, New Jersey, second edition), 2005.

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(d): Physical Properties of Materials

UNIT I: Symmetry and Tensor

Structure - property relations – transformation – symmetry operation and elements – stereographic projections of point groups – tensor description of physical properties – polar and axial tensor properties.

UNIT II: Pyroelectricity and dielectric constant

Pyroelectric and electrocaloric tensors – pyroelectric measurements – pyroelectric materials – dielectric tensor – experimental methods – polycrystalline dielectrics.

UNIT III: Stress, Strain, piezoelectric and piezomagnetic

Stress transformation – strain tensor – Piezoelectricity – tensor and matrix formulation – experimental techniques – piezoelectric ceramics – magnetic point groups – saturation magnetization and pyromagnetism – magnetic susceptibility – magnetoelectricity – piezomagnetism.

UNIT IV: Nonlinear phenomena and ferroic classes

Nonlinear dielectrics – properties – electrostriction – magnetostriction – actuators – Ferroic crystals – free energy formulation – ferroelasticity – ferromagnetism – magnetic anisotropy – ferroelectricity – secondary ferroics – order parameters.

UNIT V: Nonlinear Optical material

Electromagnetic waves – optical indicatrix and refractive index – ray normals – and ray directions – structure-property relationships – birefringence and crystal structure – linear electro-optic effect and coefficients – pockels effect in KDP and ADP crystals – Second Harmonic Generation – optical activity – nonlinear origin – tensor description – Faraday effect.

Books for study and reference:

1. Properties of Materials, Robert .E. Newnham, Oxford University Press, (2005)
2. Physical Properties of Crystals: Their Representation by Tensors and Matrices, J.F. Nye, Oxford University Press, Reprint (2000)

(e) : Crystal Growth and Characterization

UNIT I: Nucleation and Growth

Nucleation – Different kinds of nucleation - Concept of formation of critical nucleus – Classical theory of nucleation - Spherical and cylindrical nucleus - Growth Kinetics of Thin Films – Thin Film Structure – Crystal System and Symmetry.

UNIT II: Low temperature Solution Growth and Crystal Pulling

Solution - Solubility and super solubility – Expression of super saturation – Miers T-C diagram - Constant temperature bath and crystallizer – Seed preparation and mounting - Slow cooling and solvent evaporation methods. Material considerations – Crystal growth – Solid solutions and impurities – Growth control – Special techniques.

UNIT III: Gel Growth Technique

Principle – Various types – Structure of gel – Importance of gel – Experimental procedure – Chemical reaction method – Single and double diffusion method – Chemical reduction method – Complex and decomplexion method – Advantages of gel method.

UNIT IV: Melt Growth Techniques

Bridgman technique - Basic process – Various crucibles design - Thermal consideration – Vertical Bridgman technique-Crystal Pulling technique - Czochralski technique – Experimental arrangement – Growth process –Zone melting technique –Skull melting process –Verneuil Process.

UNIT V: Crystalline perfection and Structural Characterization

Volume, Area, Line and point defects – Threshold concentration of defects in crystals – Methods of detecting imperfections. Different probes for structure analysis – Principles of X-ray diffraction – Fourier transform Infrared analysis (FT-IR)–Scanning Electron Microscopy (SEM) – UV-Vis-NIR Spectrometer – Vickers Micro hardness.

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Books for Study and Reference:

1. J.C. Brice, Crystal Growth Processes, John Wiley and Sons, New York (1986)
2. P. SanthanaRagavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam (2001)
3. Brain R. Pamplin, Crystal Growth (2nd Edn.), Pergamon Press, Oxford (1980)
4. Heinz K. Henisch, Crystal in Gels and Liecegand Rings, Cambridge University Press, Cambridge (1988).
5. Crystal Growth in Gel media by A.R.Patel and A.Venkateswara Rao (Bulletin of Materials Science, 4(5), 1982, 527 – 528).
6. M.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, Instrumental Methods of Analysis (7th Edn.), CBS Publishers and Distributors, New Delhi (1986)

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(f): Nano Physics

UNIT I: Synthesis and Processing of Nanoparticles

Top-down and Bottom-up approaches – Synthesis of metallic and semiconductor Nanoparticles – Physical and chemical techniques – Ball milling – Laser ablation – Physical vapour deposition (PVD) – plasma arching – Chemical Vapour deposition (CVD) – Sonochemical.

UNIT II: Quantum Concepts of Nano- Structures

Infinite well – Finite well – Low dimensional systems – two and three dimensional potential wells – Idea of quantum well structure – Quantum dots – Quantum wires. Kinetically confined synthesis of nanoparticles.

UNIT III: Basic properties of Nanoparticles

Particles size –particles shape – particles density – composite structure – Mechanical property – Electrical properties – Magnetic properties – Optical property of Nanoparticles.

UNIT IV: Characterization of Nanomaterials

X- ray diffraction – UV–VIS spectroscopy, Impedance Spectroscopy, SEM – TEM – AFM – Thermal Analysis.

UNIT V: Applications of Nanomaterials

Application in molecular and nano devices: Nanodots – Molecular recognition – Quantum dot wells – Antimicrobial activity – Nanooptics – Nano DNA devices – Drug delivery system – Cancer treatment.

Books for study and reference:

1. Koch CC, Nanostructures Materials processing, properties and potential applications, Williams Andrew Publishing, Noyes, 2002.
2. Jackie Y. Ying, Nanostructures Materials, Academic Press, USA, 2001.
3. Charles P. Polle Jr & Frank J. Owens, Introductions to Nanotechnology, John Wiley & Sons(Asia) Pvt. Ltd., New Delhi, 2006.
4. D. Bimerg, M. Grundmann and N.N. Ledentsov, Quantum dot heterostructures, Jon Wiley and sons. 1998.
5. T. Pradeep, Nano: The Essentials, Tata MC Grew – Hill Pvt. Ltd., New Delhi, 2007.
6. Willard, Merritt, Dean and Settle, Instrumental Methods of Analysis. CBS Publishers & Distributors, Delhi, 1986.
7. J. Ross Mcdonald, Impedance Spectroscopy Emphasizing solid materials and systems, John Wiley & sons, New York, 1996.

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(g): Advanced Nuclear Physics

UNIT I

Collective models of nuclei: The unified model of Bohr and Mottelson – Rotational and vibrational states of spherical nuclei – Vibrations of deformed nuclei – Single particle motion in a deformed potential; the Nilsson model – Strutinsky model- Two centre shell model – Cranking model – BCS model for nuclei.

UNIT II

Quarks Gluons and strong interactions – The Standard model – asymmetric freedom and confinement in QCD – Receipts and signature of QGP – Physics of the quark-hadron phase transition – basic thermodynamics – system with non-interacting particles – Hadron string confinement – percolation of hadrons – Bag equation of state – Hadrons limiting temperature – Parameterized equation of state – Lattice equation of state. Relativistic heavy ion collisions.

UNIT III

Bulk properties of nuclei. Nuclear level density and methods of obtaining nuclear level densities. Statistical calculation of level densities.

UNIT IV

High angular momentum phenomena – Generation of angular momentum. Structure of shells in single particle phenomena – Predictions of Superdeformed states at high angular momenta – Phenomenon of neutron emission.

UNIT V

Accelerator based Nuclear Physics Research in India: BARC- TIFR heavy ion accelerator facility - LINAC, Pelletron, Folded Tandem Ion Accelerators and its applications; IUAC (NSC) - HYRA and HIRA; VECC - Variable energy cyclotron and superconducting Cyclotron.

Books for Study and References:

1. V.M. Strutinsky, Nuclear Physics A 122 (1968) 1-33.
2. Nuclear Superfluidity pairing in finite systems - D. M. Brink and R. A. Broglia - Cambridge University press 2010
3. Particles and nuclei. An introduction to the Physical concepts – Bogdan Povh, Klaus Rith, Christoph Scholz, and Frank Zetsche - Springer 2002 (Page No. 97).
4. Quark Gluon Plasma – Kohsuke Yagi, Tetsuo Hatsuda, and YAsuo Miake – Cambridge University press (Page No. 1-14 and 39-55).
5. Nuclear structure, Volume I: Single particle motion – Aage Bohr and Ben R. Mottelson – World Scientific 2008 (Page No. 138-194, 281 -293).
6. The use of Statistical Models in Heavy-Ion Reaction studies – Robert G. Stokstad (Page No. 83-108).
7. High angular momentum phenomena – Ikuko Hamamoto (Page No. 313-338).
8. Ph. D. Thesis - T.R. Rajasekaran, University of Madras, 1989
9. Nuclear structure, Volume II: Nuclear deformations – Aage Bohr and Ben R. Mottelson – World Scientific 2008 (Page No. 579-614).
10. Ph. D. Thesis – G. Kanthimathi, Manonmaniam Sundaranar University, 2009
11. Ph. D. Thesis – S.Selvaraj, Manonmaniam Sundaranar University, 2003
12. www.barc.ernet.in, www.tifr.res.in, www.nsc.ernet.in, www.veccal.ernet.in

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