CRYSTALS, SYMMETRY AND TENSORS

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INTENDED AUDIENCE : Students interested in solid state science and engineering will be benefited. UG and PG students of Physics, Chemistry, Metallurgy, Materials Science, Mechanical Engineering, Chemical Engineering will find the course useful.

COURSE OUTLINE :

Crystallography is fundamental to physics, chemistry, metallurgy, materials science, mechanical engineering, chemical engineering, and any other disciplines dealing with solid state. Despite this importance, due to constraints in design of curriculua a full course is rarely available on this topic. The present course intends to fill this gap. It will begin with basic fundamentals and take the students to advanced concepts of point and space groups symmetry and vector and tensor applications in crystallography.

ABOUT INSTRUCTOR :

Professor Rajesh Prasad (B.Tech., IIT-BHU, Varanasi; M.E., IISc, Bangalore; Ph.D., Cambridge) began teaching Materials Science at University of Cambridge as a graduate teaching assistant for the undergraduate course Crystalline Materials. He now has about three decades of experience in teaching materials science courses at both undergraduate and graduate levels at the Indian Institutes of Technology, at Varanasi, Kanpur and Delhi. He received A.A. Krishnan Gold Medal for his M.E. thesis at the Indian Institute of Science, Bangalore. He has been awarded a Teaching Excellence Award in 2012 by the Indian Institute of Technology Delhi. In 2013, he received the Distinguished Alumnus Award of the Department of Metallurgical Engineering, IIT-BHU, Varanasi.

COURSE PLAN :

Week 1: Geometrical crystallography: crystals, lattice and motif, lattice points and translation vectors, unit cells: primitive and non-primitive. Miller indices of planes and directions.
Week 2: Reciprocal lattice, use of reciprocal lattice in crystallographic calculations, angle between planes, angle between a plane and a direction, d-spacing of planes, volume of a crystal. Structure and metric matrices.
Week 3: Concept of Symmetry, Symmetry operations. Proper and Improper operations. Point and Space operations. Rotation axes: Roto-reflection and Roto-inversion axes. Mirror and glide planes. Inversion centre. Screw axes
Week 4: Definition and properties of mathematical groups. Subgroups. Cosets. Lagrange's theorem
Week 5: Stereographic projection and matrix representation of symmetry operations.
Week 6: Symmetry based Classification of lattices: 7 crystal systems and 14 Bravais lattices. 17 plane groups
Week 7: Symmetry based classification of crystals: 32 Crystal classes and 230 space groups. Possible proper rotation axes for crystals. Possible combination of pure rotation axes: Euler's construction.
Week 8: Development of 32 point groups.
Week 9: Space groups and International Tables
Week 10: Cartesian tensors: definition, rank, representation quadric, magnitude of a property in a given direction.
Week 11: Second-rank tensor properties: electrical and thermal conductivity, thermal expansion coefficient
Week 12: Elasticity and fourth rank tensors. Elastic stiffness and compliance. Calculation of useful elastic properties such as modulus, Poisson ratio etc using tensor methods