Mathematical Physics - I Aug-November 2008

1. **Lecture 1**
   (a) What is mathematical physics ?
   (b) Scalars and vectors.
   (c) Coordinate systems. Representations of scalars and vectors.
   (d) Addition of vectors. The parallelogram law.
   (e) Scalar multiplication and linear combinations.
2. **Lecture 2**
   (a) Scalar products of vectors. Basis vectors.
   (b) The vector product.
   (c) The scalar triple product
3. **Lecture 3**
   (a) Coordinate transformations. Rotations and scaling.
   (b) Geometric definition of vectors.
4. **Lecture 4**
   (a) Curves: A one parameter family of vectors.
   (b) Differentiation and integration of vectors. Tangents.
   (c) Surfaces: A two parameter family of vectors.
   (d) Tangents and normals.
5. **Lecture 5**
   (a) Scalar and vector fields.
   (b) Differentiation of fields.
   (c) The gradient and directional derivative.
   (d) The divergence of a vector field.
   (e) Lines of Force (integral curves).
6. **Lecture 6**

(a) The curl of a vector field.

(b) Divergenceless fields

(c) Irrotational fields.

7. **Lecture 7**

   (a) Line integrals.

   (b) Surface integrals.

   (c) Volume integrals.

8. **Lecture 8**

   (a) Gauss theorem.

9. **Lecture 9**

   (a) Stokes Theorem.

10. **Lecture 10**

    (a) Curvilinear coordinates. Cylinderical and spherical coordinates.

    (b) Differentiation and integration of scalars. The jacobian.

11. **Lecture 11**

    (a) Vector components in cylinderical and spherical coordinates.

    (b) Gradient, divergence and curl.

12. **Lecture 12**

    (a) General complex linear vector space.

    (b) Linear operations and matrices.

    (c) Matrix multiplication.

    (d) Transposition and conjugation. Non-square matrices, row and column vectors.

    (e) Inner products and the triangle inequality.

13. **Lecture 13**

(a) Linear equations.

(b) Inverse and determinant.

(c) Properties of the determinant.

14. **Lecture 14**

(a) Eigenvalues and eigenvectors.

(b) The secular determinant.

(c) Hermitian, orthogonal and unitary matrices.

15. **Lecture 15**

(a) Diagonalisation of Hermitian matrices.

(b) Left and right eigenvectors of general matrices.

16. **Lecture 16**

(a) Direct products of vector spaces.

(b) Tensors.

17. **Lecture 17**

(a) Vector spaces of functions.

(b) Linear operators, Kernals.

(c) Differential operators.

(d) Eigenvalues and eigenfunctions of differential operators

18. **Lecture 18**

(a) Fourier basis for N dimensional vector spaces.

(b) Discrete Fourier transforms.

(c) Fourier basis for spaces of functions.

(d) Continous Fourier transforms.

Lecture 19

(a) The uncertainty principle.

(b) Convolutions.

(c) Power spectrum.

(d) Multiplying signals.

(e) Filtering signals.

19. **Lecture 20**

(a) First order ordinary differential equations (ODE).

(b) Second order ODE's. Newtons law.

(c) Reduction to first order. Phase space.

20. **Lecture 21**

(a) Forced, damped harmonic oscillator, resonance.

(b) Greens functions.

21. **Lecture 22**

(a) General linear differential equations.

(b) Bessels functions. Legendre polynomials.

22.

23. **Lecture 23**

(a) The Poisson equation.

Lecture 24

(a) The heat equation.

Lecture 25

(a) The wave equation.