R. A. Kishek **ENEE 686 Outline, Spring 2003** **January 28, 2003**

1. **What is a beam?**
   Historical Introduction, Applications, Sources, Experimental Techniques Applications

2. **Review Newton-Maxwell**, notation

3. **Derive Self-Fields for Uniform Beam**
   - define perveance
   - relativistic effects and dependence on $\beta\gamma$

4. **Define Emittance and Phase Space Concept**
   - *Hamilton's formulation of equations of motion*
   - Liouville's Theorem

5. **Sacherer's Derivation of Envelope Equation**
   - Significance of Envelope Equation, Equivalent Beams
   - concept of space-charge-dominated vs. emittance-dominated beams
   - normalized envelope equation: $r'' + \kappa = K + \varepsilon^2$ [$r \rightarrow r/a$; $\kappa \rightarrow \kappa a$; $\varepsilon \rightarrow \varepsilon/a$]

6. **Computer Codes to solve Envelope Equations**
   (Matrices and matrix formulation on envelope equation)

7. **Smooth Approximation**
   - Free expansion of beams
   - Particle orbits, betatron motion, tune depression by space charge

8. **Particle-in-cell model and codes**

9. **Focusing and Lenses**:
   - Electric vs. Magnetic focusing
   - Types of Magnets
   - Bending and Dispersion

10. **Periodic Lattices, Matrix formulation, Floquet's Theorem**:
    - Solenoids vs. alternating-gradient
    - Betatron motion revisited

11. **Courant-Snyder Theory and concept of beam ellipse**.

12. **Misalignments and Mismatches**

13. **Self-Consistent Theory of Beams: Vlasov-Maxwell formulation**
    - Uniform (K-V) distribution

14. **Emittance growth and brightness issues**

15. **Acceleration**
    - RF, types of accelerators
    - Synchrotron Oscillations
    - *Induction Accelerators*
    - *Beam cooling due to acceleration*

16. **Radiation and Microwave Generation**
    - radiation processes
    - types of microwave devices