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Topics: Algebraic Topology and Dynamical Systems

Algebraic Topology:

Fundamental Group:
- Van Kampen Theorem
- Covering Spaces

Homology:
- Simplicial, Singular, and Cellular Homology
- Exact Sequences and excision
- Axioms for homology
- Homology and Fundamental Group
- Simplicial Approximation

Cohomology
- Simplicial, Singular, Cellular Cohomology
- Exact sequences and excision
- Cup, Cap products
- Kunneth formula
- Orientation and Duality

De Rham Cohomology
- Mayer Vietoris Sequence
- Poincare Duality
- de Rham Theorem

Hodge Theory [3, 4]
- Hodge Decomposition, Hodge theorem
- Combinatorial Hodge Theorem [4]

Dynamical Systems Theory:

Discrete Dynamics:
- Fixed Points, Periodic Points, Limit Sets
- Stability of fixed points and periodic points

Chaos:
- Lyapunov Exponents
- Topological Entropy

Ordinary Differential Equations:
- Existence, Uniqueness
- Liapunov Functions
- Linear Theory, Hyperbolicity
- Fixed Points, Periodic Orbits
- Stability of fixed points and period orbits
- Poincare-Bendixson Theorem

Bifurcation Theory [2,3]
- Saddle-Node, Transcritical, Pitchfork, Hysteresis,
Hopf Bifurcations

Conley Index Theory [3]
- Chain Recurrence, Conley's Fundamental Theorem
- Morse Decompositions, Index pairs, Conley index
- Fundamental theorem of dynamical systems
- Connecting homomorphism, Connection matrix theory

References:
[1] Hatcher A., *Algebraic Topology*
[2] Bott R., and L. W. Tu, *Differential Forms in Algebraic Topology*
[3] Warner F., *Foundations of Differentiable Manifolds and Lie Groups*
[4] X. Jiang, L.-H. Lim, Y. Yao, and Y. Ye. Statistical ranking and combinatorial Hodge theory. Mathematical Programming, 127:203–244, 2011

[1] Robinson, C., *Dynamical Systems*
[2] Hale, J., and Kocak, H., *Dynamics and Bifurcations*
[3] Mischaikow, K. *Conley index theory*. In Dynamical systems (Montecatini Terme, 1994), vol. 1609 of Lecture Notes in Math. Springer, 119–207.