

# Material on the MA 532 Final Exam

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1. One-dimensional ODEs: phase portraits, limits, bifurcation diagrams (Supplementary Problems 1, problems 1 - 4).
2.  $\ddot{x} = f(x)$ : phase portraits (Supplementary Problems 1, problems 6 - 7).
3. Existence, uniqueness, flow property (Supplementary Problems 2).
4. Stability, Liapunov functions, Lasalle's Invariance Principle (Exercises 1.35 and 1.36; Supplementary Problems 3, problems 1 - 3).
5. Grönwall's inequality, linear differential equations, Liouville's formula (Exercises 2.2, 2.3, 2.29; Supplementary Problems 4, problems 1–3).
6.  $\dot{x} = Ax$  (Exercise 2.26; Supplementary Problems 5 and 6).
7. Manifolds (Exercise 1.60; Supplementary Problems 7, problem 1)
8. Analyzing equilibria by linearization; analyzing degenerate equilibria in the plane using polar coordinates (Exercise 1.29; Supplementary Problems 7, problems 2–4).
9. Analyzing planar vector fields "at infinity" (Supplementary Problems 7, problem 5; Supplementary Problems 8, problem 1).
10. Periodic solutions of time-periodic differential equations (Supplementary Problems 8, problems 2–8).
11. Using the Poincaré-Bendixson Theorem, the linear variational equation, and Bendixson's Criterion to study closed orbits of differential equations in the plane (Exercises 1.138 [first sentence], 1.144).

*Personal help sheet.* You may bring one sheet of paper with whatever you find helpful written on it. (You may use both sides.)