INSTRUCTIONS FOR PHD QUALIFYING EXAMS
(MATHEMATICAL SCIENCES, SPMS, NTU)

Part I
General Instructions

- Before taking Qualifying Exam (QE, for short), every PhD student is required to pass minimum of 16AUs, and HWG702 with CGPA of at least 3.50.
- All the Ph.D. students in MAS division are required to attend and pass the written Qualifying Exam (QE, for short).
- Each student is allowed to take QE up to two times if he/she fails for the first time.
- Full-Time and/or Part-Time students are required to pass QE within 18 months upon admission.
- PhD QE consists of written QE and oral QE (details can be found below).
- Students are allowed to take oral QE only after they pass written QE. Students have to take oral QE within two months after they pass written QE.

Part II
Instructions for Written QE

- Written QEs are conducted twice a year, one in January and one in July.
- The duration of each written QE is three hours.
- There are 5 topics in the written QE, i.e.
  I. Algebraic Methods,
  II. Continuous methods,
  III. Discrete Methods,
  IV. Mathematical Statistics,
  V. Algorithms and Theory of Computation.
- The duration of written QE is three hours and every student has to choose 2 out of 5 topics from the exam paper.
- The syllabus and textbooks of each topic are shown in Part IV.
- The passing mark is 50%.

Part III
Instructions for Oral QE

- Duration of oral QE is 40 minutes (half an hour for student's presentation and 10 minutes for Q&A).
- There will be three examiners for oral QE.
- The oral QE is mainly to present research progress that students have made since admission.
- The passing mark is 65%.
Part IV
Syllabus and Textbooks for Written QE

1. **MAS 712 Algebraic Methods**

   **Aims and Objectives:** Introduce the basic notions and fundamental theorems of Algebra

   **Syllabus:**
   Group action, the Sylow Theorems, applications of the Sylow Theorems, solvable and nilpotent groups, direct and semidirect products of abelian groups, ring homomorphisms, polynomial rings, unique factorization domains, principal ideal domains, Euclidean domains, irreducibility criteria, splitting fields, normal extensions, separable extensions, algebraic closure, the fundamental theorem of Galois Theory, computing Galois group of polynomials.

   **Textbook and References:**
   - R. Ash, Abstract Algebra: The Basic Graduate Year (Revised 11/02),

2. **MAS 710 Continuous Methods**

   **Aims and Objectives:** This is the first graduate course in analysis and aims to introduce fundamental concepts in real and complex analysis.

   **Syllabus:**
   All chapters and sections mentioned below are from the textbook, Rudin's Real and Complex Analysis.
   - Abstract integration, basic topology, measures and measurability (Chapter 1)
   - Positive Borel measures, Lebesgue measure, Riesz representation theorem (Chapter 2)
   - L^p-spaces, approximation by continuous functions (Chapter 3)
   - Differentiation, the fundamental theorem of calculus (FTC) (Chapter 7, up to and including the section of the FTC)
   - Integration on product spaces, Fubini's theorem (Chapter 8, up to and including the section on Fubini's theorem)
   - Holomorphic functions, Cauchy's theorem, power series, residues (Chapter 10)

   **Textbook:**
   - Reference books:
     - R. Wheeden and A. Zygmund, Measure and Integral: An Introduction to Real Analysis, CRC, 1977
3. **MAS711 Discrete Methods**

   **Aims and Objectives:** Introduce fundamental methods of discrete mathematics

   **Syllabus:**
   - Linear programs, Duality Theorem, The Structure of Polyhedra, Extreme points, Simplex algorithm.
   - Integer programs, Unimodular Matrices.
   - Basics of Matroid Theory, Matroids and the Greedy Algorithm, Intersection of Matroids.

   **Textbooks and References:**
   - Ahuja, Ravindra K.; Magnanti, Thomas L.; Orlin, James B. Network flows. Theory, algorithms, and applications. Prentice Hall.
   - Diestel, Reinhard. Graph theory, Graduate Texts in Mathematics.

4. **MAS 713 Mathematical Statistics**

   **Aims and Objectives:** Provide some basic statistical tools, statistical decision theory and statistical inference, useful for the future research

   **Syllabus:**
   - Review of probability, random variables and their distributions, moments and inequalities; point estimation in parametric setting; point estimation in nonparametric setting; interval estimation and hypothesis testing; asymptotic evaluation and robustness.

   **Textbooks:**

   **References:**
5. MAS 714 Algorithms and Theory of Computation

Aims and Objectives: Provide an introduction to Theory of Computation. Introduce approaches of designing algorithms in different scenarios with analysis.

Syllabus:
Turing machine, Decidability, Time complexity, Space complexity, Algorithm design and analysis (greedy, divide and conquer, dynamic programming), Graph algorithms, Network flow, Approximation algorithms.

Textbooks:

Reference books: