Heat and Mass Transfer

The field of Heat and Mass Transfer, as it relates to preparation for the Ph.D. degree in Mechanical Engineering or Aerospace Engineering, concerns all aspects of heat and mass transfer relevant to mechanical, nuclear, and aerospace engineering.

Summary of Major Field Body of Knowledge:
Students should master the major field body of knowledge covered in the following courses:
MAE 131A, C132A/232A, 231A, 231B
as well as 3 additional courses pertinent to the field. Possible courses include:
MAE 231C, 231G, 285, 286, 296B, 252C, 250F (at least one of 231C or 231G must be taken)

The written qualifying (preliminary) examination covers the following subset of the major field body of knowledge:
MAE 131A, C132A/232A, 231A, 231B
and a selection of 1 course from:
MAE 231C, 231G.

More details concerning the body of knowledge can be found in the Syllabus for the Major Field, on the next page.

Minimum Requirements for Ph.D. Major Field Students:
The student must pass a written examination in the major field and satisfy other program requirements for the Ph.D. in the MAE Department besides completing all other formal University requirements.

Format of Written Qualifying Examination:
The exam consists of a 4-hour closed book part, emphasizing fundamentals, and a 4-hour open book part, where students will be required to display proficiency in selected advanced topics.

Timing of Written Qualifying Examination:
Offered when three or more students are ready to take it or at a minimum once a year.

Link to old exams:
http://stdntsvcs.mae.ucla.edu/exam/index.htm

Ph.D. Minor Field Requirements:
The minor field requirement can be satisfied by completing MAE 131A (or equivalent) and three other courses selected from MAE 231A, 231B, 231C, 231G, and C132A/232A. The average grade for these courses must be 3.33 or better, and no grade shall be less than B-.
Syllabus for the Major Field in Heat and Mass Transfer

A. Required Fundamentals
   1. Transport Properties [MAE 131A, 132A]
      Properties of Gases
      Properties of Liquids
      Properties of Metals and Nonmetals
      Properties of Porous Solids
   2. Heat Conduction in Stationary Media [MAE 131A]
      One-dimensional steady conduction
      Extended surfaces
      Multidimensional steady conduction
      Transient conduction
   3. The Conservation Equations [MAE 231A, C232A]
      Mass
      Momentum
      Energy
      Chemical species
   4. Heat Convection [MAE 131A, 231A]
      Similitude
      Fully developed laminar flow in ducts
      Laminar boundary layer on a flat plate
      Natural convection
   5. Radiative Heat Transfer [MAE 131A, 231B]
      Physics of Radiation
      Diffuse wall enclosures
      Radiation shields
      Solar radiation
   6. Boiling and Condensation [MAE 131A and/or 231C]
      The pool boiling curve
      Nucleate and film boiling
      The peak and minimum heat fluxes
      Laminar film condensation
   7. Mass Transfer [MAE C132A]
      Definitions of concentrations and fluxes
      Interfacial conditions
      Steady diffusion across a plane wall
      Transient diffusion
      Heterogeneous catalysis
      The analogy between convective heat and mass transfer
      Simultaneous convective heat and mass transfer
      Adiabatic vaporization, wet-bulb temperature
   8. Exchanger Design [MAE 131A, C132A]
      Exchanger balances
Overall heat transfer coefficients
LMTD and ε-NTU methods
Single and two stream heat exchangers
Single stream mass exchangers - catalytic converters and evaporative coolers

B. Advanced topics
Students should prepare themselves for Topics 1-3, and at least one of Topics 4 and 5.

1. Heat Convection [MAE 231A]
   Duct entrance regions
   Laminar boundary layers with pressure gradients
   Turbulent flow in ducts
   Turbulent boundary layers
   Laminar and turbulent natural convection boundary layers
   Variable wall temperature and heat flux
   High speed flow and recovery factors

2. Radiative Heat Transfer [MAE 231B]
   Directional and spectral variation of surface properties
   The equation of radiative transfer
   Radiative heat transfer in participating media
   Engineering calculation of radiation heat transfer in combustion gases
   Coupling radiative transfer with fluid flow and heat conduction

   Diffusion in porous media
   Transport in multicomponent gas mixtures
   Laminar and turbulent boundary layers with mass transfer
   Condensation from vapor-gas mixtures
   Transpiration and sweat cooling

4. Boiling and Two Phase Flow [MAE 231C]
   Nucleate boiling and bubble dynamics
   Maximum and minimum pool boiling heat fluxes
   Pool film boiling
   Forced flow evaporation and boiling
   Film condensation
   Two phase flow regimes
   Two phase flow models

5. Microscopic Energy Transport [MAE 231G]
   Statistical thermodynamics fundamentals
   Energy carriers
   Kinetic and transport theory
   Surface and Interface Effects
   Applications to semiconductor and MEMS devices

C. Course Preparation
As preparation for the written examinations, the student should have taken MAE 131A (or an equivalent course), MAE C132A/232A, 231A, 231B, and 231C or 231G. The student is expected
to have an adequate mathematics preparation for graduate work in the field. Recommended courses include MAE 182A, 182B, and 182C.

In addition to passing the written examination, it is recommended that the student take two advanced specialized courses pertinent to the field. Possible courses include MAE 231C or 231G (whichever one the student was not examined on), 285, 286, 296B, 252C, 250F.

**References:**

The following books are used as texts or reference works in the courses of the major field.
