UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie

School of Engineering
Department of Mechanical and Aeronautical Engineering

Advanced Heat and Mass Transfer MHM 420/780

Lecturer: Dr Mehdi Mehrabi

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Contents

1. INTRODUCTION

Advanced Heat and Mass Transfer course (MH420/780) follows on the undergraduate heat transfer courses of MTV310 or/and MTV410. It is expected that after the undergraduate courses the student gained enough confidence and experience with the basic principles of heat transfer. This post-graduate course aims to give the student detailed knowledge and experience with the analysis of heat transfer systems and prepare him/her for understanding more complex heat transfer problems.

This study guide is a crucial part of the general study guide of the Department. In the study guide of the Department, information is given on the mission and vision of the department, general administration and regulations (professionalism and integrity, course related information and formal communication, workshop use and safety, plagiarism, class representative duties, sick test and sick exam guidelines, vacation work, appeal process and adjustment of marks, university regulations, frequently asked questions), ECSA outcomes and ECSA exit level outcomes, ECSA knowledge area, CDIO, new curriculum and assessment of cognitive levels. It is expected that you are familiar with the content of the Departmental Study Guide. ***It is available in English and Afrikaans on the Department's website*** *www.me.up.ac.za or:*

English:
http://www.up.ac.za/media/shared/120/Noticeboard/2017/departmental-studyguide-eng-2017_version27may2017.zp119960.pdf

Take note of the specific instructions in the above study guide on:

a. **Safety**
b. **Plagiarism**
c. **What to do if you were sick (very important)?**
d. **Appeal process on the adjustment of marks**

2. GENERAL PREMISE AND EDUCATIONAL APPROACH

A hybrid problem-driven approach to learning will be followed in this course. To develop a deep understanding of the heat transfer and create a problem-solving mind-set, combination of student or lecturer centred methods will be applied.

Heat transfer is one of the main subjects of not only mechanical engineering but also of various other fields of engineering. During this module, student's skills to apply basic concepts of heat transfer learnt from previous modules into more complicated heat transfer applications will develop.

3. MODULES STRUCTURE

This course consists of four study themes:

- **Fundamentals of thermal radiation and radiation heat transfer**
- **Boiling and Condensation**
- **Heat Exchangers**
- **Mass transfer**

3.1. Fundamentals of thermal radiation and radiation heat transfer

When you finish studying this study theme, you should be able to:

- Classify electromagnetic radiation, and identify thermal radiation
- Understand the idealized blackbody, and calculate the total and spectral blackbody emissive power
- Calculate the fraction of radiation emitted in a specified wavelength band using the blackbody radiation functions
- Understand the concept of radiation intensity, and define spectral directional quantities using intensity
- Develop a clear understanding of the properties emissivity, absorptivity, relflectivity, and transmissivity on spectral, directional, and total basis
- Apply Kirchhoff's law to determine the absorptivity of a surface when its emissivity is known
- Model the atmospheric radiation by the use of an effective sky temperature, and appreciate the importance of greenhouse effect
- Define view factor, and understand its importance in radiation heat transfer calculations
- Develop view factor relations, and calculate the unknown view factors in an enclosure by using these relations
- Calculate radiation heat transfer between black surfaces
- Determine radiation heat transfer between diffuse and gray surfaces in an enclosure using the concept of radiosity
- Obtain relations for net rate of radiation heat transfer between the surfaces of a two-zone enclosure, including two large parallel plates, two long concentric cylinders, and two concentric spheres
- Quantify the effect of radiation shields on the reduction of radiation heat transfer between two surfaces, and become aware of the importance of radiation effect in temperature measurements

3.2. Boiling and Condensation

When you finish studying this study theme, you should be able to:

- Differentiate between evaporation and boiling, and gain familiarity with different types of boiling
- Develop a good understanding of the boiling curve, and the different boiling regimes corresponding to different regions of the boiling curve
- Calculate the heat flux and its critical value associated with nucleate boiling, and examine the methods of boiling heat transfer enhancement
- Derive a relation for the heat transfer coefficient in laminar fi lm condensation over a vertical plate
- Calculate the heat flux associated with condensation on inclined and horizontal plates, vertical and horizontal cylinders or spheres, and tube bundles
- Examine dropwise condensation and understand the uncertainties associated with them

3.3. Heat Exchangers

When you finish studying this study theme, you should be able to:

- Recognize numerous types of heat exchangers, and classify them

- Develop an awareness of fouling on surfaces, and determine the overall heat transfer coefficient for a heat exchanger
- Perform a general energy analysis on heat exchangers
- Obtain a relation for the logarithmic mean temperature difference for use in the LMTD method, and modify it for different types of heat exchangers using the correction factor
- Develop relations for effectiveness, and analyze heat exchangers when outlet temperatures are not known using the effectiveness-NTU method
- Know the primary considerations in the selection of heat exchangers

3.4. Mass transfer

When you finish studying this this study theme, you should be able to:

- Understand the concentration gradient and the physical mechanism of mass transfer,
- Recognize the analogy between heat and mass transfer
- Describe the concentration at a location on mass or mole basis, and relate the rate of diffusion to the concentration gradient by Fick's law
- Calculate the rate of mass diffusion through a plane layer under steady conditions
- Predict the migration of water vapor in buildings
- Perform a transient mass diffusion analysis in large mediums,
- Calculate mass transfer by convection
- Analyze simultaneous heat and mass transfer

4. LECTURER AND TEACHING ASSISTANTS

	Name	**Room Number**	**Tel.**	**Email address**
Lecturers	**Dr M Mehrabi**	Eng 3, 6-82	012 (420) 4743	mehdi.mehrabi@up.ac.za
Teaching Assistants	*To be announced			

5. STUDY MATERIALS

Prescribed book:

Heat and Mass Transfer, Fundamentals and Applications*: Fifth Edition,* Yunus Çengel and Afshin Ghajar, McGraw-Hill, ISBN-13: 978-981-4595-27-8, 2015.

A heat transfer textbook**:** *Fourth Edition***,** John H. Lienhard IV and John H. Lienhard V, Dover Publication, Inc, ISBN-13: 978-0-486-47931-6, 2011.
eBook is available at https://univofpretoria.on.worldcat.org/oclc/853622802

Handbook of heat transfer: *Third Edition***,** W.M. Rohsenow, J. P. Hartnett, Y. I. Cho, McGraw-Hill, ISBN 0-07-053555-8, 1998.
eBook is available at https://univofpretoria.on.worldcat.org/oclc/173298049

6. LEARNING ACTIVITIES

6.1. Contact time and learning hours

Number of lectures per semester: 36

This module carries a weighting of 16 credits, indicating that on average a student should spend at least 160 hours to master the required skills (including time for preparation for tests and examinations). This means that on average you should devote some 10 hours of study time per week to this module. The scheduled contact time is approximately three hours per week, which means that another seven hours per week of own study time should be devoted to the module.

6.2. Lectures

Lectures are concentrated on this module four study themes and do not necessarily cover the whole textbooks material. In order to help students with understanding the concepts, parts of the class discussion and examples are based on alternative sources. However, students can base their studies on the textbooks and the class notes. Students are expected to read the textbooks in advance to be able to ask questions during the other lectures. The examples in the textbooks and solved problem during the lectures are most important and must be carefully studied.

6.3. Assignments

Homework assignments will be given for every study theme. Assignments will be uploaded on ClickUP and depending on the complexity of the assignments one or two weeks will be given for the due date. There will be five homework assignments for this course and the assignments should be submitted on the due date and late submission will be penalized by deductions in the semester mark. Assessment schedule will be available on ClickUP.

6.4. Class tests

There will be five unannounced class tests for this course. These class tests will help the lecturer to continuous evaluate of the students throughout the module.

7. RULES OF ASSESSMENT

To be admitted to write exam: In order to be able to write the final exam, obtaining a semester mark of 40% and higher is required.

Pass requirements: In order to pass this module a student must obtain a final mark of at least 50%.

Calculation of the final mark: The final mark is calculated as follows:

Semester mark	50%
Examination mark (final exam)	50%

Calculation of the semester mark: The semester mark is compiled as follows:

Semester tests (Test 1 and Test 2)	70% (35% each)
Unannounced class tests (5 tests)	20%
Homework assignments	10%

Semester tests: Two tests of 90 minutes each will be written during the scheduled test weeks of the School of Engineering. Dates, times and venues will be announced as soon as the timetables become available.

Examination: One exam of three hours will be written during the scheduled UP examination period. Date, time and venue will be announced as soon as the timetables become available.

8. GENERAL

This study guide is a part of the official study guide of the Department of Mechanical and Aeronautical Engineering.