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|-------------------------|-------------------------|-------------------|---------------------------|---------------------|---|
| <b>Semester:</b>        | 7                       |                   |                           |                     |   |
| <b>Course Code:</b>     | ME5110                  |                   |                           |                     |   |
| <b>Course Name:</b>     | Heat Transfer           |                   |                           |                     |   |
| <b>Credits Value:</b>   | 3 (Notional hours: 150) |                   |                           |                     |   |
| <b>Pre-requisites:</b>  | ME3040 and ME5070       |                   |                           |                     |   |
| <b>Core/ Optional:</b>  | Optional                |                   |                           |                     |   |
| <b>Hourly Breakdown</b> | Lectures (hours)        | Tutorials (hours) | Practical classes (hours) | Assignments (hours) | Independent Learning & Assessment (hours) |
|                         | 24                      | 04                |                           | 34                  | 88  |

**Course Aim:** This course aims to deepen the understanding of fundamentals of heat and mass transfer processes, and their relevance to common engineering applications in industrial environments. A particular focus is placed on developing the skills of applying thermodynamics and fluid mechanics in manufacturing, food, agriculture, process, and biological engineering sectors.

**Intended Learning Outcomes:**

At the end of this course, students should be able to:

- **analyze** and solve steady-state & transient conduction heat transfer problems,
- **analyze** and solve radiation heat transfer problems,
- **analyze** problems involving phase change processes,
- **analyze** thermo-fluid mechanical systems in manufacturing, food, agriculture, process, and biological food and agricultural engineering sectors,
- critically **evaluate** applied engineering systems and synthesize components based on knowledge in thermo-fluids to obtain a holistic perspective of performance and operation.

**Course Content:**

- **Two-Dimensional, Steady-State Conduction:** Alternative approaches, the method of separation of variables, the conduction shape factor and the dimensionless conduction heat rate, finite-difference equations, solving the finite-difference equations
- **Transient Conduction:** The lumped capacitance method, validity of the lumped capacitance method, general lumped capacitance analysis, spatial effects, the plane wall with convection, radial systems with convection, the semi-infinite solid, objects with constant surface temperatures or surface, heat fluxes, periodic heating, finite-difference methods
- **Radiation: Processes and Properties:** Fundamental concepts, radiation heat fluxes, radiation intensity, blackbody radiation, emission from real surfaces, absorption, reflection, and

transmission by real surfaces, Kirchhoff's law, the gray surface, environmental radiation

- **Radiation Exchange Between Surfaces:** The view factor, blackbody radiation exchange, radiation exchange between opaque, diffuse, gray surfaces in an enclosure, multimode heat transfer, implications of the simplifying assumptions, radiation exchange with participating media
- **Convection Processes with a Phase Change: Boiling and Condensation:** Boiling modes, pool boiling, forced convection boiling, two-phase flow, two-phase flow in microchannels. Condensation and physical mechanisms, laminar film condensation on a vertical plate, film condensation on radial systems, condensation in horizontal tubes
- **Special study in thermal-fluid applications:** Topic to be selected in consultation with teaching panel (*See notes below*)

**Teaching/ Learning Methods:**

Classroom lectures, tutorials and in-class exercises and assignments

**Assessment Strategy:**

| Continuous Assessment<br>30%  | Final Assessment<br>70% |                  |   |
|---|-------------------------|------------------|---|
| Details:  | Theory<br>(%)           | Practical<br>(%) | Other (%)   |
| Tutorials/Assignments/Quizzes 20%                                       | 50%                     |                  | Special study in<br>thermal-fluid<br>applications/fin<br>al evaluation<br>20% |
| Special study in thermal-fluid applications /progress<br>evaluation 10% |                         |                  |   |

**Recommended Reading:**

- Bergman, T. L., Lavine, A. S., & Incropera, F. P. (2011). *Fundamentals of Heat and Mass Transfer* (7<sup>th</sup> Edition), Wiley.
- J P Holman (2009), *Heat transfer* (10<sup>th</sup> Edition), McGraw Hill.,

**Notes:**

- 1) The **Special study** intends to cover an independent study of which the depth is equivalent to one credit.
- 2) The study shall strictly focus on the topic of application of heat transfer, applied thermodynamics and fluid mechanics selected from industrial applications or from industrial process related to manufacturing, pharmaceutical, food processing, food and agricultural engineering, industrial processing, biological or biomedical engineering etc.

- 3) For the Special study, if required, relevant subject experts could be considered & added by the teacher concern, from within the university, with the endorsement of the course coordinator, to help & guide a particular study/topic/student.