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Department: Mechanical

Course title: Convection Heat Transfer

Module – II. Natural convection, Boiling and Condensation.

-7 Conservation equations – Natural convection.

- Natural convection vs Free convection. Examples of applications.
- Natural convection examples; Free convection phenomena and examples.
- Continuity (mass conservation) - in differential form.
- Conservation of momentum (2nd law of motion) – in differential form.
- Coupling of temperature and velocity fields.
- Conservation of energy (1st law of thermodynamics to an open system) – in differential form.
- Non-dimensional form of conservation equations.
- Grashof number. Rayleigh number – their physical significance.
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-8 Free convection on a flat plate, cylinder, in an enclosure.

- Vertical smooth plate in still unbounded fluid (free convection)
- Development of hydrodynamic and thermal boundary layers.
- Conservation equations. Effect of Prandtl number ($Pr \ll 1$, $Pr \approx 1$, $Pr \gg 1$).
- Correlations for local and average skin friction coefficient, heat transfer coefficient and Nusselt number; their limitations. Selection of property values.
- Examples of applications and problem solving.
- Horizontal and inclined smooth plate in still unbounded fluid (free convection)
- Development of hydrodynamic and thermal boundary layers.
- Correlations for local and average skin friction coefficient, heat transfer coefficient and Nusselt number; their limitations. Selection of property values.
- Natural convection in enclosures
- Large parallel plates, concentric cylinders.
- Nature of flow and circulation. Correlations.

-9 Boiling - Pool.

- Configurations: Pool boiling, droplet impingement boiling, boiling inside tubes with examples (boilers, nuclear reactors, solar energy, refrigeration, component cooling, manufacturing, etc.)
- Pool boiling (natural convection/forced?)

- Pool boiling phenomena and regimes; Nucleation sites. Non-uniform nucleation and "hot spots"; burnout.
- Conservation equations – complex two-phases; randomness.
- Correlations for average Nusselt number for different regimes, and their limitations.
- Examples of applications and problem solving.

-10 Boiling inside tubes.

- Boiling phenomena and regimes.
- Conservation equations – complex two-phases; randomness.
- Correlations for average Nusselt number in different regimes and their limitations.

-11 Condensation - External.

- Configurations: On a flat vertical plate, tube exterior, tube interior, spray condensation, bulk condensation, homogeneous condensation (precipitation). Applications: condensers feedwater heaters power plants, refrigeration, etc.).
- Film condensation on a flat plate
- Conservation equations; Non-dimensional numbers; Correlations; Limitations
- Drop-wise condensation on a flat plate
- Phenomena; Modelling; Correlations; Limitations.

-12 Condensation inside tubes.

- Regimes of condensation.
- Correlations.
- Effect of tube surface characteristics.
- Applications.

Numerical modelling and simulation.

- Importance of geometrical modelling, conservation equations, boundary conditions, initial conditions on model definition. Domain selection.
- Two-phase flow aspects related to boiling and condensation and complexity of equations, randomness of phenomena, and impact on mathematical formulation.