Microscale Transport Processes - Video course

COURSE OUTLINE

The course on micro-scale transport process introduces the fundamental concepts, principles and application of momentum.

Energy and diffusion processes in micro-scale to undergraduate and graduate students of relevant engineering disciplines, e.g., mechanical, chemical, instrumentation, electronics and biomedical engineering.

The course opens with an elaborate discussion on micro-fabrication techniques, and gives the students a good exposure to the practical aspects of micro-scale transport devices.

Next, the classical laws of fluid flow, and how they get affected by the free molecular flow are reviewed.

The electro-kinetic flow is introduced with discussion on electric double layer and Debye length.

Use of interfacial forces in capillaryfilling with passive control of flow is presented.

The array of electrodes that are instrumental in moving / merging / splitting droplets by electro-wetting is described.

The main issues of successful microstructures are presented.

The concepts and examples of micro heat pipes for microscale cooling are introduced.

Consequences of size reduction for different processes and the relevance of material properties and processes, in miniaturized devices are explored.

Beginning with simple atomic encounters from statistical mechanics, macroscopic balance equations and transport properties are derived and the relevance of continuum assumption and the Limits of linear transport properties are analyzed.

The momentum and heat transfer equations in microscale are developed incorporating viscous heating and entropy generation in channel flow.

Finally microfluidic network for heat and mass transfer and relevant relations are introduced.

Micro-reactor comprising of multi-channel stack is described and the associated heat- transfer is addressed using theoretical models.

Taylor dispersion as it applies to micro-channel of non-circular cross-section is derived.

Micro-mixing based on chaotic advection in slanted groove and staggered herringbone is discussed using Poincare map.

Lagrangian particle tracking techniques in CFD for calculation of mixing effectiveness are explained.

Fractionation of aggregates in a stream, based on size, charge, polarity etc. is discussed. Architecture, based on optimal routing of fluid is elaborated.

COURSE DETAIL

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Chemical Engineering

Pre-requisites:

Any fluid mechanics course at the undergraduate level.

Coordinators:

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S.No	Topics	No. of Hours
1	Introduction and applications.	3
2	Micro-fabrication - photolithography, wet and dry etching, molding, casting, assembly, device level packaging.	6
3	Continuum flow (with slip), free molecular flow.	2
4	Electro-osmotic flow, electric double layer.	2
5	Capillary filling, passive valves, electro-wetting.	2
6	Concepts and examples of micro heat pipes, droplet based microfluidics.	3
7	Statistical mechanics, macroscopic balance equations and transport properties.	3
8	Continuum assumption and limits of linear transport properties.	2
9	Momentum and heat transfer equations in microscale.	4
10	Viscous heating and entropy generation in channel flow.	1
11	Microfluidic network for heat and mass transfer.	2
12	Heat transfer / reaction in multi-channel stack.	1
13	Dispersion in micro-canal.	3
14	Chaotic micro-mixing and its characterization.	4
15	Field flow fractionation, electrophoresis, isoelectric focusing, dielectrophoresis.	3
16	Hierarchical architecture.	1
	Total	42