MA856 Mathematical Foundations of Blood Flow and Drug Delivery 4 0 0 4

Commented [L1]: Already exists in Ph.D Syllabus.

Objective

To enable the students to get an overview of the mathematical description of blood flow and drug delivery in the human circulatory system. To identify the underlying hemodynamic mechanisms and drug delivery strategies in the normal and in various pathological conditions.

Unit 1

Review of preliminary concepts in fluid dynamics, governing equations – conservation of mass, conservation of momentum, Fourier series, Bessel Equations and Mathieu functions. Cardiovascular system, coronary, systemic and pulmonary circulations, modeling of pressure gradient using Burton's model and McDonald's model, other existing models in literature-advantages and disadvantages, root mean square error, steady state oscillation.

Unit 2

Hemodynamic wall parameters and their significance, wall shear stress, oscillatory shear index, relative residence time, Lumen wall interface conditions – no slip and various slip conditions. viscoelastic property of blood, hematocrit, drag force - Schiller-Naumann model, magnetophoretic force, fluidic force, magnetic force, particle-particle interaction, inertia force, Saffman lift force, permeability of the microvessel and carrier particle.

Unit 3

Single phase model, two-phase model and particle fluid suspension model- mathematical formulation, uniform cross section, circular tube, elliptic tube; constant, oscillatory and pulsatile pressure gradient; constant blood viscosity, radially varying blood viscosity; rigid wall, rigid and permeable wall, wall elasticity.

Unit 4

Fundamentals of targeted drug delivery, History of targeted drug delivery, Levels of targeting, Types of drug delivery system- controlled and targeted drug delivery, Different kinds of targeted drug delivery: active and passive targeting, organ specific targeting, Disease, organ and cell based targeting, Physiochemical approaches for targeting, multifunctional approach in targeted drug delivery, Transdermal, Gastroretentive, Nasopulmonary drug delivery system – Introduction, advantages and disadvantages.

Unit 5

Principle of magnetic drug targeting, Advantages of localization of drugs, Classification of magnetic drug delivery systems, Magnetic bioprobes – loading/release of specific drug, Approaches to magnetic drug targeting, Magnetic fields and forces acting upon a particle, magnetic particles, magnetic force dominated behavior, Fluid particle dynamic model, ferrofluid

dynamics – basic idea, magnetization, magnetic susceptibility of the particle, magnetic flux density, advection-diffusion equation, comparison of hemodynamic forces with magnetic forces.

Review of mathematical methods, recent developments, future prospect and identifying the open problem addressed in the literature in the field of blood flow and targeted drug delivery.

Text Books / Reference Books

1. Clement Kleinstreuer and Zelin Xu, Computational microfluidics applied to drug delivery in pulmonary and arterial systems, Microfluidics: Fundamentals, Devices and Applications, First Edition, Wiley-VCH Verlag GmbH & Co., 2018.
2. Sachin Shaw, Mathematical model on magnetic drug targeting in the micro vessel, Magnetism and Magnetic Materials, 2018. DOI: 10.5772/intechopen.68579.
3. Sid M Becker and Andrey V Kuznetsov, Heat transfer and fluid flow in biological processes, Academic Press, Elsevier, USA, 2015.
4. Wilmer W Nichols, Michael O'Rourke, McDonald's Blood Flow in Arteries, Theoretical, Experimental and Clinical Principles, Oxford University Press, New York, 2005.
5. Aleksandar Nelson Nacev, Magnetic Drug Targeting: Developing the basics, Thesis, Department of Bioengineering, University of Maryland, College Park, 2013.
6. Mohammad K D, Manashadi, Mahsa Saadat, Mehdi Mohammadi, Milad Shamsi, Morteza Dejam, Reza kamali and Amir Sanati-Nezhad, Delivery of magnetic micro/nanoparticles and magnetic-based drug/cargo into arterial flow for targeted therapy, Drug Delivery, Vol.25, No.1, 1963-1973, 2018.