Title: Study of the one dimensional and transient bioheat transfer equation: Multi-layer solution development and applications

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Source: International Journal of Heat and Mass Transfer **Volume:** 62
Pages: 153-162 **DOI:** 10.1016/j.ijheatmasstransfer.2012.11.082 **Published:** Jul 2013

Document Type: Article

Language: English

Abstract: In this work we derive an analytical solution given by Bessel series to the transient and one-dimensional (1D) bioheat transfer equation in a multi-layer region with spatially dependent heat sources. Each region represents an independent biological tissue characterized by temperature-invariant physiological parameters and a linearly temperature dependent metabolic heat generation. Moreover, 1D Cartesian, cylindrical or spherical coordinates are used to define the geometry and temperature boundary conditions of first, second and third kinds are assumed at the inner and outer surfaces. We present two examples of clinical applications for the developed solution. In the first one, we investigate two different heat source terms to simulate the heating in a tumor and its surrounding tissue, induced during a magnetic fluid hyperthermia technique used for cancer treatment. To obtain an accurate analytical solution, we determine the error associated with the truncated Bessel series that defines the transient solution. In the second application, we explore the potential of this model to study the effect of different environmental conditions in a multi-layered human head model (brain, bone and scalp). The convective heat transfer effect of a large blood vessel located inside the brain is also investigated. The results are further compared with a numerical solution obtained by the Finite Element Method and computed with COMSOL Multi-physics v4.1 (c).

Author Keywords: Bioheat transfer equation; Method of separation of variables; Eigenfunctions and eigenvalues; Bessel functions; Finite Element Method; Hyperthermia applications

KeyWords Plus: Magnetic fluid hyperthermia; Heat-transfer; Model; Multiregion; Tissue

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Publisher: Pergamon-Elsevier Science LTD
Publisher Address: The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, England
ISSN: 0017-9310

Citation: RODRIGUES, D. B.; PEREIRA, P. J. S.; LIMAO-VIEIRA, P.; STAUFFER, P. R.; MACCARINI, P. F. - Study of the one dimensional and transient bioheat transfer equation: Multi-layer solution development and applications. International Journal of Heat and Mass Transfer. ISSN 0017-9310. Vol. 62 (2013), p. 153-162.