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Similarity theory and dimensionless numbers in heat transfer

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Abstract
We present basic concepts underlying the so-called similarity theory that in our opinion should be explained in basic undergraduate general physics courses when dealing with heat transport problems, in particular with those involving natural or free convection. A simple example is described that can be useful in showing a criterion for neglecting convection heat transfer effects in a given experimental situation.

1. Introduction

It is well known that any temperature difference within a physical system causes a transfer of heat from the region of higher temperature to the region of lower temperature. This transport process takes place until the system has attained uniform temperature throughout. The heat flux is a function of the temperatures of both the regions involved and its form depends on the nature of the transport mechanism, which can be conduction, radiation or convection or a coupling of them. Although the first two mechanisms are often discussed in general physics courses, the study of convection is often limited to mentioning the so-called Newton law of cooling. This is perhaps due to the fact that the process of convection is described by a very complex set of differential equations that include a large number of variables and whose analytical solution run into many difficulties. It is well known that the theory of similarity [1] helps to resolve some of them. In that theory, the terms present in the convection equations can be united in dimensionless groups, for which one selects scales of reduction [2]. The so-called dimensionless numbers are used to characterize and classify convection heat transfer problems enabling us to take our knowledge from experimenting with one scale system to learning about another system with different dimensions, i.e. they allow us to experiment with models and predict the behaviour of large bodies under actual conditions. All that one has to establish is to

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