

Variational methods for boundary value problems

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Dedicated to Dr. Alex McNabb on the occasion of his 70th birthday in January 2000.

Abstract. The variational formulation of boundary value problems is valuable in providing remarkably easy computational algorithms as well as an alternative framework with which to prove existence results. Boundary conditions impose constraints which can be annoying from a computational point of view. The question is then posed: what is the most general boundary value problem which can be posed in variational form with the boundary conditions appearing naturally? Special cases of two-point problems in one-dimension and some higher dimensional problems are addressed. There is a deep connection with self-adjointness for the linear case. Further cases under which a Lagrangian may or may not exist are explained.

Keywords: natural boundary conditions, self-adjointness, Hamiltonian, Lagrangian.

1. Introduction

1.1. Background

Variational methods provide a conceptual and computational framework for boundary value problems (BVP's). In the paper we derive conditions which guarantee that a given BVP can be reformulated in variational form. This can be a way of proving existence for BVP's (Graham-Eagle and Wake [6]) and it also provides a scheme for determination of a computational algorithm as in Fradkin and Wake [5]. In the case of nonlinear eigenvalue problems, these can be a way of producing outcomes like parameter path-following as has been produced by other means by computer packages like Auto (Doedel [2]).

The question of what precise conditions need to be imposed on boundary value problems so that they can be written in variational form has been discussed sporadically in the literature, see for example Anderson and Thompson [1], Fels [3],

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