The topic of shaping and controlling transient responses of dynamic systems has important applications. Achieving a desired transient response is an essential design requirement for many control systems. In this research, we discuss the impact on the transient response of linear systems when imposed to a set of integral constraints. The investigation is generalized in a theoretical framework. The formulation of three types of integral constraints is first discussed. Here, the underlying goal is to shape the step response to generate a specific type of transient response admitted by dynamical systems. The problem is then transformed to that of exploring the structures of transfer functions that satisfy these aforementioned constraints. Analytical results are established for a class of second order systems. Subsequently, the results are extended to higher order transfer functions. The characterizations of which a general transfer function should have to meet the three types of the integral constraints are described and evaluated. Next, the implementation requirements to ensure these dynamic characteristics with a given plant transfer function are addressed. In this regard, a control structure, employing combined feedforward and feedback actions, is proposed. Furthermore, the necessary and sufficient conditions to maintain the stability of the overall closed-loop system, produced by the proposed structure, are discussed. Moreover, analysis related to robustness to parametric uncertainty is developed. Structured adaptive estimation strategies are proposed to deal with uncertainty. Implementation examples and simulation results are provided to validate the approaches developed in this work. Further examples to demonstrate the analysis using practical applications are also presented.

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The public is welcome to attend.