Optimal Control

The classical design methods use performance specifications like phase margin, gain margin, bandwidth, overshoot and damping ratio which will lead to systems that will meet the prescribed specifications, but are not optimal in time or in fuel consumption (control energy). there are many control situations where we are concerned with the design of a controller to optimize a given performance index.
Since the early fifties the issues concerning dynamic optimization have received a lot of attention within the framework of control theory. the optimal control problem usually concerns the following three components:

(a) the equations which constitute the model of the controlled system;
(b) the criterion, referred to as the performance index, according to which the system behavior has to be evaluated;
(c) the set of constraints active on the system state, output, control variables, that are yet to be accounted for by the system model.

Preparation of a mathematical model is a general control problem and is not specific to the optimization problem. in many systems, we must incorporate some method of identification of system parameters which may vary as a function of the environment. sometimes the plant is well defined, but the states are not available, which must be estimated in presence of plant disturbance and measurement noise.
The choice of performance index depends on the objective to be realized by the control system. it may be related to (a) the minimization of time (b) regulation of a state or output over extended period of time (c) minimization of fuel consumption (d) minimization of energy (e) maximization of productivity and so on.
The constraints may arise due to the physical nature of the components and operating conditions : the thrust from a booster rocket is finite and limited, the torque of motor is finite, the output of an amplifier is limited by saturation, the speed of a vehicle is finite and so on. A fairly precise idea of the kind of optimal control problems to be discussed here is given by the following simple examples.