Robustness as a system property describes the degree to which a system is able to function correctly in the presence of disturbances, i.e., unforeseen or erroneous inputs. In this paper, we introduce a notion of robustness termed input-output dynamical stability for cyber-physical systems (CPS) which merges existing notions of robustness for continuous systems and discrete systems. The notion captures two intuitive aims of robustness: bounded disturbances have bounded effects and the consequences of a sporadic disturbance disappear over time. We present a design methodology for robust CPS which is based on an abstraction and refinement process. We suggest several novel notions of simulation relations to ensure the soundness of the approach. In addition, we show how such simulation relations can be constructed compositionally. The different concepts and results are illustrated throughout the paper with examples.