

Systems and Controls Laboratories on a Shoestring

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This IEEE CSS outreach project designed and developed a low cost apparatus and associated classroom activities for use in introductory systems and control theory undergraduate classes. The apparatus, affectionately known as a “duck car,” is a single degree of freedom vehicle with an infrared distance center that can be used to demonstrate common principles taught in systems and controls classes: system modeling, linearization, steady-state error and system type, disturbance rejection, root locus analysis, single-input, single-output system compensation, effects of nonlinearities, and system sensitivity.

The Outreach project funded six copies of the apparatus along with the development of several activities to be used with the apparatus. The activities use low complexity measurement approaches, such as smartphones, free video tracking software, and voltmeters, to make measurements and assess system properties. Within a 20-minute in-class activity, for example, students can observe and video record the response of the system to a step command in position using a cell phone, extract measurements of the response using video tracking software, and calculate damping and natural frequency from the measured response. By changing a single resistor in circuit, students can trace a root locus as a function of gain.

Initially, the intention was to loan the systems to colleges and universities for use in their classrooms, but the results of the project instead led to a larger three-year NSF funded outreach grant that is currently in progress. This outreach grant supports dissemination of the concept funded by the IEEE grant through the development of 60 additional copies of the duck car for permanent distribution to eight colleges and universities. Faculty participants receiving the copies of the apparatus as part of a workshop held at Dartmouth College will assist in developing and testing additional curricular materials for small group learning. Additional mini-workshops will be held at the American Control Conference, IEEE CDC, and/or ASEE annual conference in 2018 and 2019. Interested faculty can request access to a google doc site with example curricular activities, video, and other workshop materials.

A brief video of the duck-cars in use can be found at <https://www.youtube.com/watch?v=9tfdo0knVOU>.

