

Pneumatics in 2.007 – Design and Manufacturing I: Advances in 2011

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Overview

This document describes our efforts to further advance uses of fluid power in the MIT course “2.007 – Design and Manufacturing”. Specifically, we developed new lectures, homework, and exam items related to fluid power. We also added an explicitly, air powered design challenge. In an homage to a practical joke MIT students played on the Harvard-Yale football game, any robot that could inflate a balloon would earn one point per liter. As a result, many students chose to work on various pump designs, many with great success. The subject evaluations continue to improve as they have steadily for the past three years.



Figure 1. A famous pneumatic “hack”.

Background

2.007 is a core Mechanical Engineering subject that supports the Department’s educational objectives, especially those related to design and manufacturing. As the catalog description explains, 2.007 places “emphasis on the creative design process bolstered by application of physical laws...” The main project in the course is a robot design. Each student develops their own concept, builds it, and operates it in a contest.

Further Advancing Lecture Content Related to Pneumatics

The focus of our proposal to NFPA this past year was to further advance the formal instruction we provide in 2.007 relevant to pneumatics. There was substantial new material related to fluids, thermodynamics, pneumatics, and related sensing and control in both lecture and lab sessions. For example, since we asked students to ensure their robots conform to

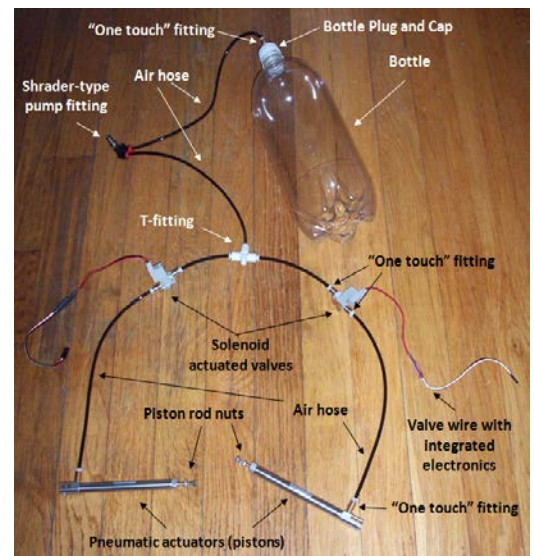
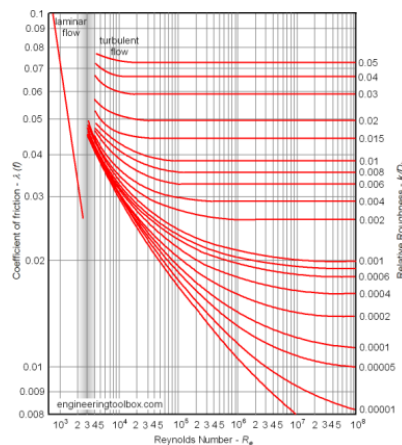
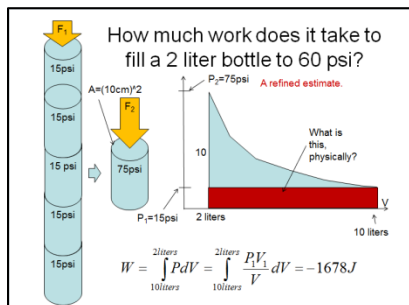


Figure 2. Pneumatics related material presented in lecture during spring 2011.

an “energy budget”, we taught them how to estimate the energy stored in the two liter bottles they were allowed to carry on board their robots. Since there were significant losses in the air lines leading to the balloons, we showed students how to use Moody diagrams to assess the associated pressure drop.

Homework and Exams

To follow up on the new material added to the lectures, we gave students practice via homework and assessed their retention through exams. We worked to link the assignments to the robot designs. For example, one of the homework questions was to design a servo-actuated valve for use as an option in the robots (this would enable greater flow rate than the solenoid actuated valves in the kit).

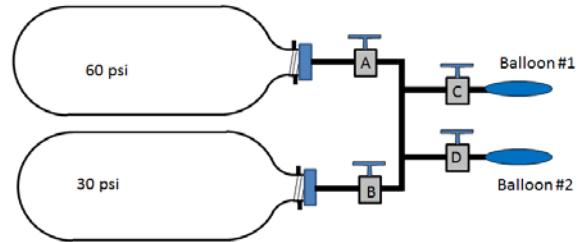


Figure 3. An exam item given in spring 2011

Following up on the instruction and homework, we asked pneumatic related questions on exams for the first time in spring 2011. For example, related to Figure 3, we asked “You open valves A and C only. Estimate the final volume of balloon #1” and “You open valves A and C only and allow the system to reach steady state. You subsequently close valves A and C and then open valves B and D simultaneously. You finally open valves A, B, C, and D simultaneously. Estimate the final volume of balloon #1.” Students did well on these challenging tasks.

The Robots Students Designed and Built

The main pay-off for all this work was the success of the students’ robots. Many more students incorporated pneumatic elements than in previous years. In addition to the usual pneumatic powered prehensors, lifting mechanisms, and such, this year we saw students develop an interesting variety of pumps and impellers. 46 different videos of student work from 2011 are available at: <http://techtv.mit.edu/collections/2007videos:1852/videos>

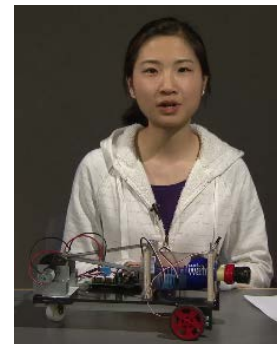


Figure 4. Some examples of student use of pneumatics. Left to right: Lauren Kuntz and her custom valve. Katie Gero’s centrifugal pump. Daisy Yuen’s positive displacement pump.