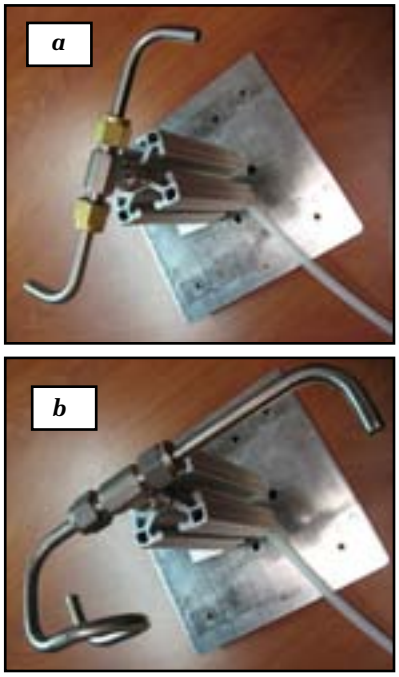
Demonstrating Macroscopic Momentum Balances in a Fluid Mechanics Course

Students learn more effectively if they first predict what should happen then observe physical phenomena before diving into the governing equations and rigorous mathematics. The resulting conceptual understanding allows students to comprehend mathematical solutions, identify errors in their solutions, and understand the significance of the results.

A simple demonstration constructed from tubing and fittings to facilitate students' conceptual understanding of momentum balances is introduced. Students were asked which way the tubing would rotate if air (using lungs) or water (for outdoor demonstrations) is pumped through a sprinkler-type apparatus (Figure 1). They experimented with the configuration by replacing the tubing with loops, plugging an outlet, and reversing the flow direction. An explicit solution for the resulting torque (as a function of flow rate, tube inner diameter, pressure drop, and length of the arms) was then solved from fundamental principles. This calculation allowed students to understand how the system could be modified to obtain more (or less) torque. Applications (water sprinkler, spaceship docking, Flixborough Disaster,[1] etc.) were then discussed to give a sample of real-life applications.

Construction of this system is relatively cheap (Table 1), and can be almost free if parts are salvaged. A tube cutter, tube bender, Allen wrenches, and a drill/clamp (to drill a hole through the aluminum plate for mounting) are required for construction. Follow normal safety procedures during construction.



Figures 1. *(a) Setup with normal bends, (b) Setup with twists and loops, (c) Schematic of Unit.*

REFERENCE

1. The Flixborough Disaster, Report of the Court of Inquiry, 1975, <https://www.icheme.org/communities/special-interest-groups/safety and loss prevention/resources/~/media/Documents/Subject Groups/Safety_Loss_Prevention/HSE Accident Reports/The Flixborough Disaster - Report of the Court of Inquiry.pdf> ❐

TABLE 1
Equipment parts list and cost estimate per demonstration unit. (Prices as of April 2017)

Item (Vendor, Part Number)	Quantity	Price / unit	Total
¼" Polyethylene Tubing (McMaster Carr®, 5181K39)	1	$2.50 / 25 feet	$2.50
1.50" x 1.50" Lite T-slot profile (80/20® Inc., 1515-Lite)	1	$3.75 / 4-inch cut	$3.75
Black Screw with Slide-In T-nut (80/20® Inc., 3320)	2	$0.60 / each	$1.20
3-hole Inside Corner Bracket (80/20® Inc., 4376)	1	$4.15 / each	$4.15
13 x 13 cm aluminum plate (80/20® Inc., 65-2452)	1	$16.63 / each	$16.63
¼" SS Union Tee (Swagelok®, SS-400-3)	1	$22.60 / each	$22.60
¼" SS tubing (Swagelok®)	2 ft	$20.00 / ft	$40.00
Total			$90.83

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