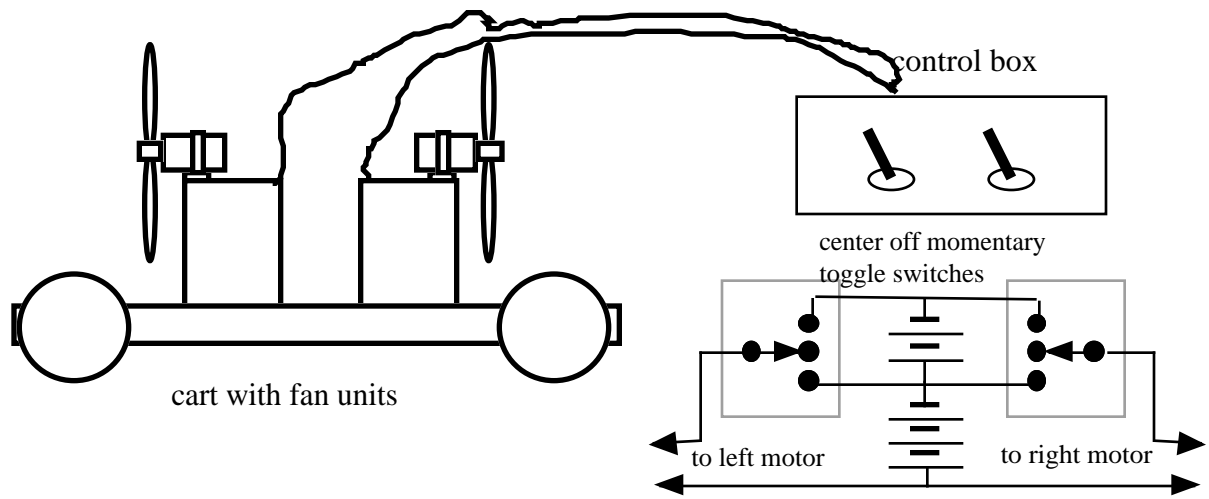


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Apparatus Title: Low-cost cart with "duelling" fan units and controller box

Abstract: A flip switch controller allows teacher or student to apply two force levels to each of two opposing fan units mounted on a low cost low-friction cart. This allows investigation of the effects of canceling or partially canceling forces on the cart to aid in understanding the concepts of net force in Newton's second law and canceling forces in Newton's first law.



Description: Two fan units (modified from R. A. Morse, *The Physics Teacher*, 31, 7, 1993, p436-438) are built by sanding a slight flat on the surface of PVC pipe coupling. Drill holes to mount tubing hanger and mini phone jack, clip motor into mount and solder leads to jack. Drill out propeller hub for T-bushing and press fit prop and bushing onto motor shaft. Duct tape units to cart. Control box flip switches allow 3 or 4 D-cells to power each fan which can be off, on low or high power. Cart can now be controlled in back and forth motion. Acceleration can be compared qualitatively or using motion detectors.

Parts List

Item	Vendor	Part Number	Cost
12 ft. mini to lug cable x 2	Radio Shack	RS420-2454	\$2.99 x 2 = \$5.98
DPDT Auto Flip Switch x 2	Radio Shack	RS275-709	\$4.29 x 2 = \$8.58
Plastic Battery Holder, 2-D x 2	Radio Shack	RS270-386A	\$1.69
Plastic Battery Holder, 1-D	Radio Shack	RS270-403A	\$0.99
Project Box, 7"x5"x3"	Radio Shack	RS270-1807	\$5.99
General Purpose Cart	Cynmar Corp.	095-18531	\$13.95
D-cell battery x 5	Any store	-----	\$1.00 x 5 = \$5.00
PVC pipe coupling 2" x 2	Hardware store	-----	\$0.39 x 2 = \$0.78
High-torque DC motor x 2	Science Source	21418	\$1.40 x 2 = \$2.80
3/4" PVC tubing hanger x 2	Genova	521071	\$0.10 x 2 = \$0.20
1/2" #10 pan head screw x 2	Hardware store	-----	\$0.03 x 2 = \$0.06
Propeller (5" dia 3" pitch) x 2	Cox Hobbies	858	\$1.30 x 2 = \$2.60
T-bushing propeller mount	Science Source	21542	\$0.17 x 2 = \$0.34
1/8" mini Phone jack x 2	Radio Shack	274-251C	\$1.00 x 2 = \$2.00

TOTAL: \$50.96

Note: parts costs are for single or small quantities purchased from local suppliers. Quantity purchase, particularly of electrical parts from another supplier (e.g. Mouser Electronics) would cost significantly less.