Programmable Fan Cart

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Fancarts: They turn on, they provide an approximately constant force, and they turn off.

But why stop there? With an easy-to-program Arduino microcontroller, a Hall switch, and a few inexpensive electronic components, it’s possible to modify a fancart to give complete control over where it turns on or off, how long it stays on or off, and how fast it spins in between. You can even control the fan direction!

By putting small magnets on the track to trigger the Hall switch, it’s possible to have a constant force over a certain distance. Measurements of the cart speed before and after the region where the fan is on show that the change in kinetic energy is equal to the force times the distance, verifying the work-energy theorem.

The same microcontroller can turn the fan on at one magnet, then turn the fan off some time later. Measurements of the cart’s speed before and after this impulse show that the change in momentum is equal to the force times the time, verifying the impulse-momentum theorem.

And since the microcontroller can have complete control over everything to do with the fan, it’s possible to vary the fan direction as well as speed. This level of control opens up all sorts of new experimental opportunities such as an “anharmonic oscillator fan cart”.

The hardware for this apparatus (shown on the left) can be built for less than $30 per unit. Here I used EagleCAD and toner-transfer paper to create a 2-sided circuitboard, but point-to-point soldering on proto-board works also.

The firmware to install on the microcontroller (outlined on the right) can be uploaded with free open-source tools using any Macintosh, Linux, or even Windows computer. The language used is just C/c++ with some added libraries, so it’s easy to modify the firmware so that your units do exactly what you want for your teaching purposes.

This cart has the full version of the program on the right loaded into its Arduino, so it can do all three of the ‘modes’ described above. Try them!

- Turn the switch on. The three indicator lights will blink to tell you that the mode is set to 1 (one blink) the speed is set to 2 (two blinks) and the time is 2 seconds (two blinks). Finally all three lights will illuminate, letting you know that it is ready to go.
- Put the cart on the track and roll it past the magnets. In mode 1, the first magnet will turn the fan on and the second will turn it off.
- Try changing the parameters. Pressing the speed button will cause the green light to blink twice, indicating that the speed is currently set at 2. To change the speed, hold the speed button for more than two seconds and then release it. The green light will go out, indicating that the device is in speed adjustment mode. Subsequent presses of the speed button will cycle through the speed options: 3, then 1, then 2. Set it where you want, then press any other button to exit adjustment mode.
- Change the mode and/or time by the same method. Mode 2 causes the fan to run for a set time after detecting a magnet. Mode 3 causes the fan to change direction each time a magnet is detected.
- Pressing any button while the fan is running will cause the fan to turn off.

One more thing this board is designed to fit the PASCO Mi-tek fan cart accessory, but it can work with any small fan motor — or any other DC device that can take a 5V-level Maslowed (5V low) input. It’s safe with supply voltages up to 5 Volts, and can source up to 1.2 Amps. There’s nothing special about fan cart motors — it could just as easily be used to drive a Peltier heater, for example.

There’s nothing special about the Hall effect switch, either. Any component that takes a 5V supply and returns a high-level output would work fine.