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Insect Behavior

Flight Mill Video

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The Flight Mill

The flight mill described here was first designed and developed by Dr. Steven Naranjo at the USDA-ARS Arid-Land Agricultural Research Center in Maricopa, Arizona. His laboratory has successfully employed its use in various dispersal studies. A link to his biography and research program is provided amongst this page's navigation links. The flight mills shown here are a prominent component for the work being performed by Dr. Jones' graduate student Teah Smith. Teah provided the underlying descriptions and schematics used here.
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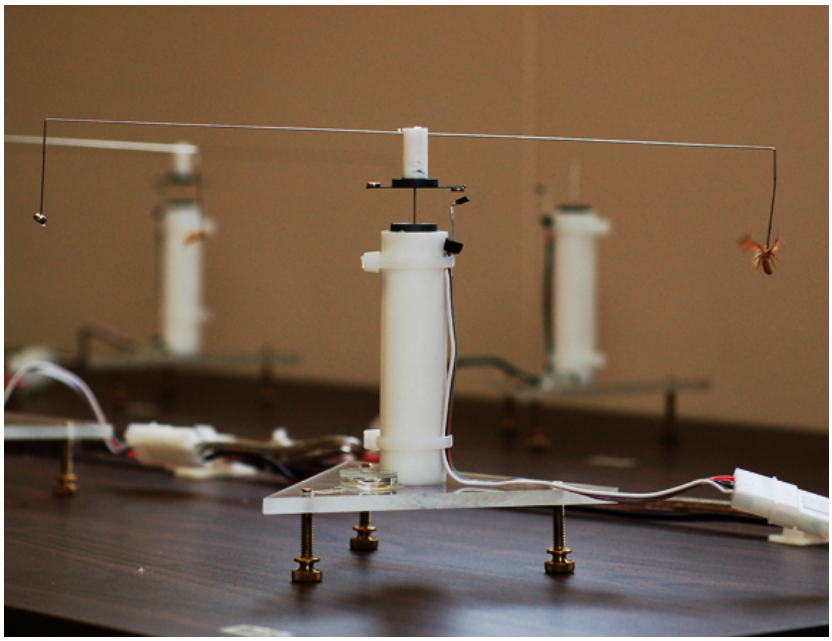
What's a flight mill?	How a flight mill works	Flight mill schematics	Wiring & software	Attaching a codling moth

What is a flight mill?

A flight mill is a device that allows you to measure the speed, distance and periodicity of flight of an insect such as a codling moth or leafroller adult. The flight mill works by utilizing a magnetic levitation mechanism with Teflon bearings minimizing friction as the flight spins. A sensor at the top of the Delrin rod detects the passage of a small magnet near the base of the Teflon bearing when the mill is in motion.

The flight mill is a tool used in our laboratory to evaluate dispersal capabilities of codling moth and leafroller. Although this is obviously an artificial situation bound to yield some artifact findings not associated with the natural moth behavior, it can provide valuable data about the physiology of these moths and their potential dispersal capabilities. The flight mill can be used to measure the impact of various influences on the moth dispersal when used in paired comparisons such as the effects of age, diet, temperature, wind speed or pesticide exposure. Thisis a valuable technique for evaluating the sublethal effects of various pesticides. Conversely, we can also study the effect of flight on various life parameters such as fecundity.



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How the flight mill works

The flight mill works by using magnetic levitation and Teflon bearings to minimize friction (see picture below). Two opposing magnets generate the levitation effect while a hypodermic tube acts as an axil between the Teflon bearing and the Delrin rod (B). A 1-foot long hypodermic tube is used as the flight arm (F) and passes through the top center of the upper Teflon bearing (A). The moth is attachment to one end of the flight arm (see image above). The moth flies in circles, and a small magnet suspended below the upper Teflon bearing (E) is detected by a hall effect sensor (C) attached at the top of the Delrin rod (G). *(Note: Care must be taken when positioning the magnets to ensure that the correct polarities are maintained.)*

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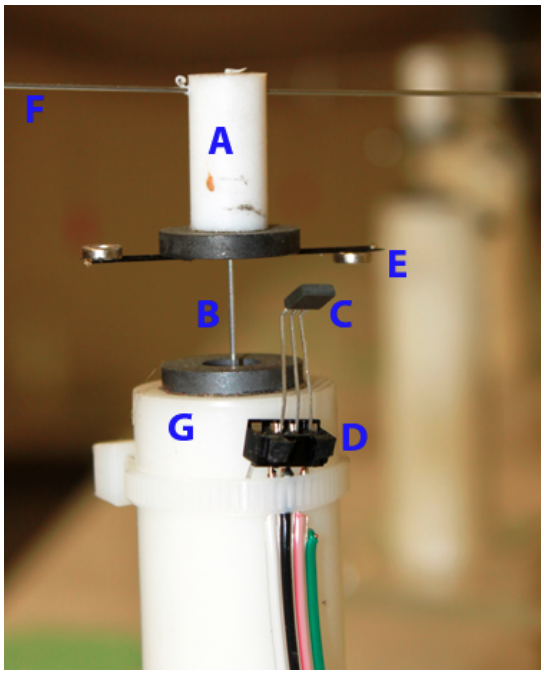
Flight mill schematics

Shown below is the basic schematic diagram for a flight mill. The parenthetical values refer to the drill bit size used to bore the correct hole diameters for the hypodermic tubing (B in above image) running between the upper and lower Teflon bearings and for the flight arm tubing. For a complete schematic showing all part sizes and boring depths please refer to the download link above. You can download the parts ordering information here.



Working portion of the flight mill

A - A magnetic ring is glued to the top teflon bearing; the flight arm (F) passes through the top.

B - A stainless steel hypodermic thin wall tubing separates **A** and **G**; the Teflon surface of the insertion holes allow for friction-less movement while the repelling magnetics keep **A** free-floating.

C - Digital hall effect sensor

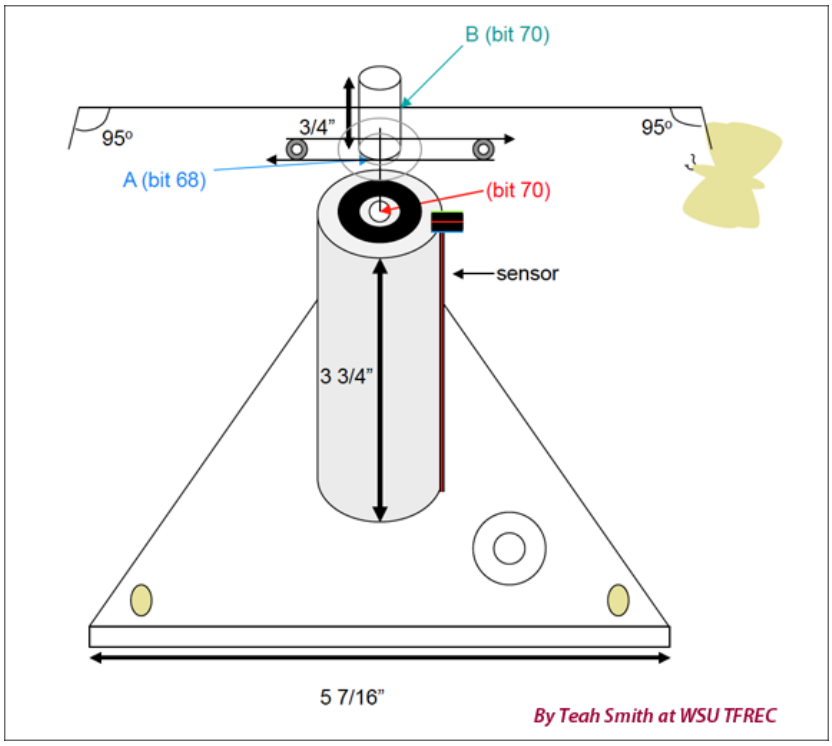
D - Wiring harness; wires run to a multi-connector allowing multiple flight mills to run simultaneously.

E - Small magnets glued to 2 #1 insect pins, one on the underside triggers the sensor while the other one acts as a counter balance (must be positioned with the polarity reversed).

F - Flight arm: a foot-long hypodermic tube where a moth is attached to one end with a counter balance on the other.

G - A second magnetic ring is glued to the bottom Delrin rod repelling the magnet on **A** generating the levitation force.

Download Detailed Schematics



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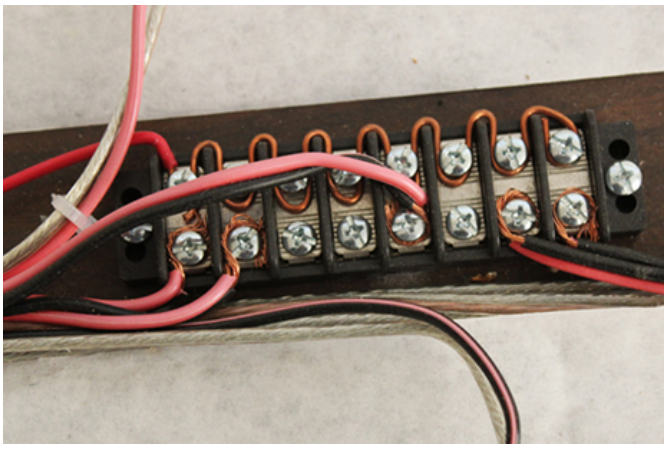
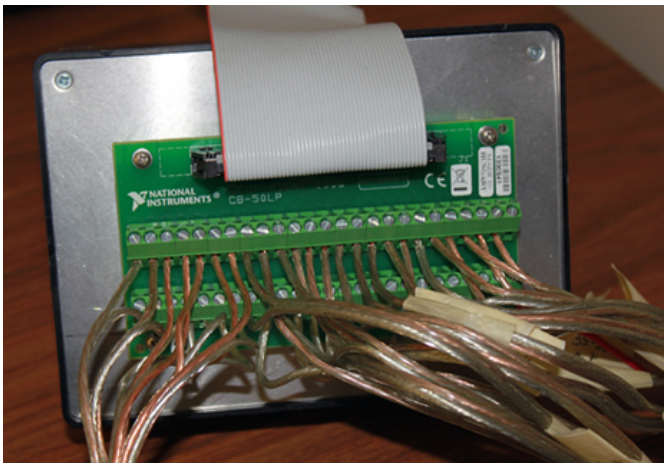
Flight mill wiring and software

As mentioned above, several flight mills can be run simultaneously. In fact, our lab's set up allows for 24 separate flight mills to run and be recorded separately. The wiring for each flight mill runs to a main connector board (below top). Wires from this connector and any additional connector units are run to the main wiring connector block (below bottom; parts # NI 777101-01). From this block runs the 50-pin ribbon cable (parts # NI 180524-10) that plugs into a PC port (part # NI 77690-01). The data is collected and analyzed using Labview Full Development System software (parts #NI 776670-09). All of the major wiring components and software were purchased from National Instruments Corp. You can download the wiring parts ordering information here and download the analysis routine here (zipped file).





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Attaching Codling Moth

The main Insect Behavior web page presents a video going through the procedure we use to attach a codling moth to the flight mill. Click here to view the video in YouTube. The basic steps are listed below.

1. Cool moth on a gel ice block wrapped in paper towels. The towels keeps condensation from wetting the moth and prevents freezer burn.
2. Once the moth is cooled, remove the thoracic scales using a small brush. This allows the glue to adhere to the thorax.
3. Place a small drop of glue from a low temperature glue gun on the head of a #1 insect pin and touch it to the moth's thorax. Low temperature glue is essential to prevent burning and death of the moth.
4. Carefully insert the pointed end of the insect pin into the opening of the hypodermic tube of the flight arm of the flight mill. This should fit snug enough to hold in place without slipping.

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Useful Links

EnhancedBC
WSU TFREC Entomology
Pest Management Transitions Project

Resources

WSU Decision Aid System
Orchard Pest Management

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