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Fidget Spinner Generator System for Mi-STAR Unit 7.1

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Fidget Spinner Generator System for Mi-STAR Unit 7.1

Content list (bookmarks - click to jump)

System description and its use in Mi-STAR Unit 7.1

The fidget spinner generator is first used in Lesson 2, and then in several other lessons that follow.

This simple system is an integral and important part of this unit. It allows students to see, feel, and experience how kinetic energy can be transformed to another kind of energy. It is an effective learning tool in the unit because it is reasonably easy to make, has just a few simple and visible components, and reliably transforms enough energy to light an LED (light emitting diode). The LED provides a satisfying light output which is easy to observe.

Students observe how the system components work together and use modeling (diagram models, with labels and text) to understand the mechanisms at work in the system. For example to show their understanding of energy flow through the system, or the unseen mechanism between the spinning magnets and the wire coil.

Later on in the unit, the system is used as a **model** to help students understand more complex systems at work in the real world. Like all models, it has limitations in how closely it replicates more complex systems; such as those which create the electrical energy that we use in our homes each day. (All models are wrong, but some are useful!) Students are encouraged to identify and think about those limitations as they use the system as a model.

How this system fits into the Unit 7.1 Challenge: In the unit challenge a fictional character, Jaime, wants to figure out how to power a video game console while on vacation at an “off the grid” rental home. Jaime, and your students, see a video showing a rowing machine integrated with a small electrical generator which is used to power a video game console for a family. This is the type of system that our fidget spinner system is replicating.

It is important to note that the NGSS DCI content targeted for this unit does NOT include the understanding of electrical circuits, current, voltage, light sources, the electrical grid, and things of this nature. For details on the NGSS content for this unit, please refer to the NGSS connections document provided with the unit materials.

The light makers are first used/observed by students in lesson 2 (where they bring definition to the science word **generator**) and then again several times throughout the unit. Student teams will observe and investigate the system's components, mechanisms, and behavior and also continually apply their learning to the unit challenge.

How to make and use the Fidget Spinner Generator:

A video showing a working system is [HERE.]()

Materials Needed

The following items are needed for each system:

- 1 - Fidget spinner
- 3 - magnets (neodymium or ceramic ferrite … some generators will be made with each type of magnet see text above and lesson plans for details)
- 1 - Coil with 1000 turns of wire (36 AWG is recommended, but other sizes will work)
- 10 inches of copper wire (~24 gage magnet wire or plastic insulated wire is typical) to confine the coil to a donut (toroid) shape. Tape can work here as well, but don't use regular steel-wire twisty ties because the steel is attracted to magnets and will cause problems.
- 1 - LED (light emitting diode)
- Lighter to remove insulation from the wire - used only for construction of the fidget spinner generator system models. (Used only by teachers.)
- For vision-impaired applications, for students who may have problems with flashing light, or just for fun, consider using a small piezoelectric buzzer. The generator can provide enough energy to make the buzzer sound.
- 1 - rectangle of stiff cardboard, plastic, or wood, ~2 inches X ~4 inches, on which to secure the coil, wire, and LED.
- Cellophane tape to hold the coil, wire and LED to the cardboard base.

Fidget spinners (pack of 5)
Magnet Wire (36 AWG, 4OZ, ~3200 ft)
Neodymium Magnets (20 pack with sticky dots)
Ceramic ferrite magnets (see options listed below)

LED (100 pack)
Piezoelectric buzzer
Stiff cardboard, plastic, or wood rectangle ~2" X ~4" (We used samples of Johsonite™ flooring baseboard as shown in the photos. These were obtained from a local flooring store.)

Magnets that are being tested for durability and how well they make the system function:
Ceramic Ferrite Magnets (25mm dia X 4mm thk, 18 pack with sticky dots)
Ceramic Ferrite Magnets (8mm dia X 5mm thk, 20 pack with sticky dots)
Neodymium with epoxy coating (less likely to break, with sticky dots)

A 25 minute instructional video showing the entire process of building the fidget spinner generator system is available HERE.

Step by step building instructions with photos

1. Assemble all the material needed
2. Obtain or make the coil
    a. The coil, and how to make it ...

To make the coil, this sheet specifies to use ~1000 turns of 36AWG wire. (AWG, American Wire Gage, indicates the diameter of the wire. The larger the number, the thinner the wire. For reference; 40AWG magnet wire is as thin, if not thinner, than most human hair.) Larger wire (with a smaller AWG number) up to size 30AWG, will also work for this system. It's a bit more costly and more bulky but also more robust so it's less likely to break. 36AWG is specified here as a good choice, but other wire may already be on hand or easier to get.

The goal is to make a relatively neat donut shaped coil with an inside diameter of a little less than one inch and with about 1000 turns of magnet wire. This wire then needs to be contained in a neat manner using tape and/or other copper wire as shown here:

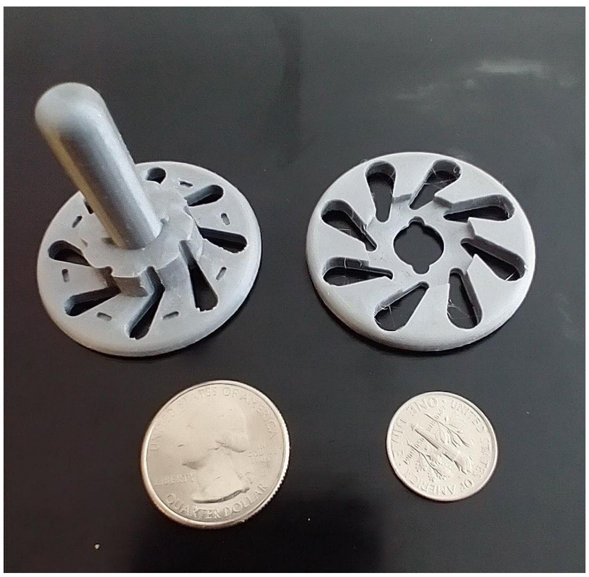
The thicker copper wire is wrapped around to keep the coil's toroid (donut) shape. Any suitable copper wire can be used to bind the magnet wire. The binding wire shown here is not part of the induction coil, but **it must not be steel wire** which is attracted to magnets (e.g. don't use standard twisty ties or other steel wire). Alternatively,one loose end of the coil wire itself can be used to bind the coil, this has the advantage of not needing additional wire of another size, but it makes it more difficult to pull out more wire in case the leads to the LED are broken.

To make the coil, the wire must be unwound from the spool it is shipped with, and re-wound onto something with a diameter of about one inch (about ⅞ inch is ideal). A pill bottle, olive bottle, or similar thing will work, but it is very tedious to do this by hand. A drill motor with abobbin can speed the process greatly. A video showing coil winding with a drill motor is HERE.

If one has access to a 3D printer, a two-piece bobbin can be made to greatly simplify the coil making process. The following two files can be used to print the two pieces, arbor and cap.

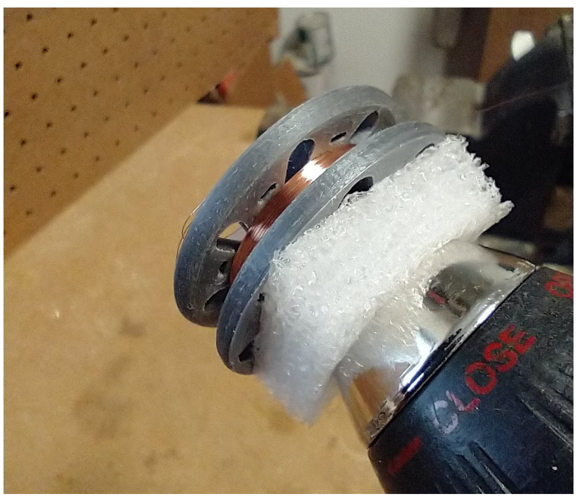
Click on each link below, then click on the blue "Download" button and save each file to your computer. Then share the files with your 3D printer operator and they will handle the rest.

- STL file for Arbor
- STL file for Cap



Left photo: 3D printed parts: *Arbor* on left, *Cap* on right. Note the indentations on the spool and the teardrop shaped slots which allow a separate piece of binding wire to hold the coil in a nice donut (toroid) shape. Also, there are marks (between every slot) on the arbor that indicate how much 36AWG wire is needed to attain about 1000 turns.
Right photo: Two bobbin pieces fitted together, as they will be chucked into a drill motor.

Bobbin shown as it is chucked into a drill motor. A piece of foam is used here to help keep the two pieces together, but this isn't needed in all cases.



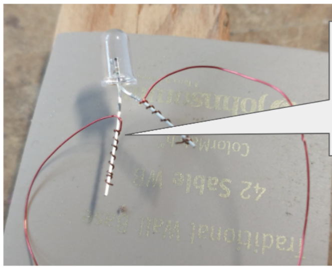
Bobbin shown after the coil wire winding is complete. Note that the wire on the spool goes out to the marks (between the slots) which indicates that the winding is done … this will be about 1000 turns … without having to count turns!

The photo shows a finished coil wound and wrapped (note the thicker wire going around the toroid to hold it together).

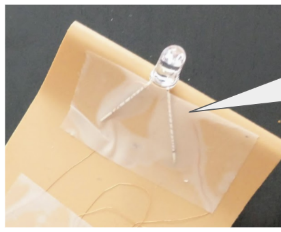
If you have made the old-style generators for Unit 7.1, you can reuse that wire by spooling off of the cardboard box onto a smaller spool or holder. (A 500 turn old style coil makes a perfect coil for this fidget spinner type.) No matter which wire is used, each coil needs between 800 and 1000 turns, so the thinner wire allows more coils for each purchased 4oz spool. A 4 oz. spool of 36AWG wire has about 3200 feet of wire, enough to make about 10 coils.

3. Strip off the varnish wire insulation on the two loose ends of the coil wire. About 1” of insulation needs to be removed, this can be done with a lighter flame (a light touch of the flame, then quickly wipe with a tissue). Sandpaper or an emery board can also work to remove the insulation.

4. Connect the two loose ends (with about 1” of bare, uninsulated wire) of the wire coil to the LED



Detail showing wire/LED connection. About an inch of wire end needs to be stripped of insulation before making connection.

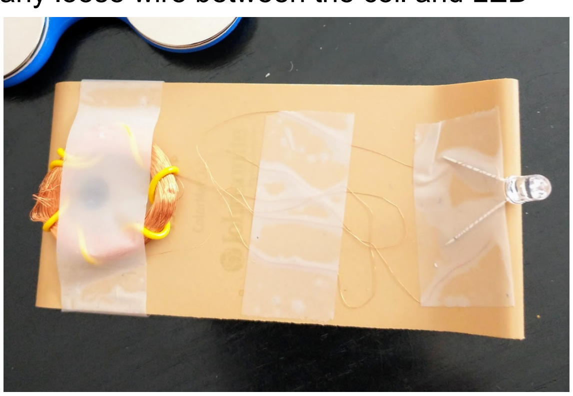


LED and connecting wires should be secured to base with tape. No soldering or other treatment is needed.

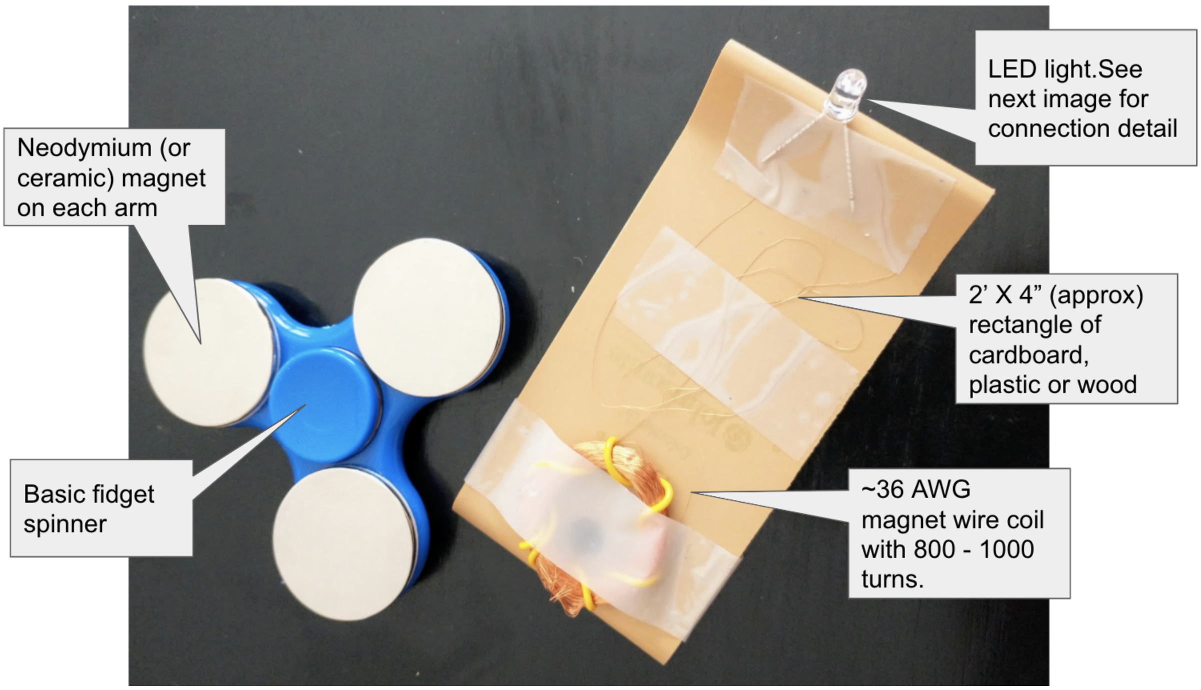
5. Attach coil to baseboard

This coil is ready to be taped to the baseboard. Cellophane tape is fine and allows learners to see the components more clearly.

6. Use tape (transparent cellophane) to fasten the LED to baseboard and also to secure any loose wire between the coil and LED



7. The final step is to attach a magnet to each of the three arms on the fidget spinner. Use the sticky dots that came with magnets (if they exist) or use tape. Note that the strong neodymium magnets will be difficult to secure with tape, the forces between the magnets will overcome regular cellophane tape. If you decide to use tape to secure the strong neodymium magnets, it needs to be a heavy duty type. For ceramic ferrite magnets, cellophane tape is adequate.



Once you've made a few working systems you can decide if you want students to complete any of the above steps. For example, you may want to have them attach the magnets with cellophane tape, and then change between strong and weak magnets for comparison. (Teams could also use two separate spinners for comparison, one with strong and one with weaker magnets.) Students may also be able to connect the LEDs and tape the coil/wire/LED to the baseboard. The more students can do themselves, the better will be their overall understanding of the system, but of course having students do these things may also cause undue pain and heartache for the students and/or their teacher.

Ideally, half the teams in each class will make (or just use) systems with ceramic ferrite magnets (with a relatively weaker magnetic field strength), while others will use neodymium magnets (with a stronger field strength). Among other observations, teams will compare how well each type of system works in order to better understand the magnet's function within the system. After this initial activity, all teams should use the neodymium magnets; they provide a much more satisfying experience because they make the light brighter and light the LED for a longer time with each spin of the fidget spinner.

To use the system:

1. Spin the spinner as fast as reasonably possible, then hold the spinner so the magnets move near the coil of wire WITHOUT TOUCHING.
2. Move the spinner/spinning magnets (up, down, left, right, near, far) to find out which position(s) result in the best lighting of the LED
3. A well made generator should give 10 to 15 seconds of lighting effect (diminishing with time) for one vigorous spin of the magnets as shown in the video HERE.

Troubleshooting a non-functioning generator system. Like any system, this one is made up of individual components which, ideally, interact to make the whole system function properly. If the system isn't functioning (and why else would you be reading this?) then one needs to investigate each system component to see if the problem can be isolated and solved. Let's take a look at the system components one-by-one and how to test each one. We will work through the system from input toward output.

- **Flicking the spinner** - The spinner needs to be "flicked" with hearty enthusiasm. It's nor a crazy-difficult amount, but don't be shy.
- **The spinner** - is there friction or something keeping the spinner from spinning freely? Sometimes the spinner handles get pushed up (or down) and press on the body of the spinner slowing it down.
- **The magnets on the spinner** - There should be a magnet on EACH of the three arms, securely affixed and placed so the spinner is in balance.
- **The coil** - Are there breaks in the wire? Is the coil wound fairly tight and well-bound?
- **The loose ends of wire (i.e. leads) between coil and LED** - The two wire leads coming off of the coil should be fastened (e.g. taped) to the LED-coil board but shouldn't have tight twists or kinks which might break the wire and cause the LED not to light. Also the two leads can't touch one another where the varnish has been removed (see next step). If the varnish is intact, the wires can touch and/or cross each other.
- **Connection of wire to the bulb** - This can be a common trouble spot. Each lead of wire from the coil needs to be free of the varnish insulation that coats the magnet wire. See the video and instructions for how to do this with a lighter or candle flame. Once the varnish is removed, the wire should be wound onto the leads of the LED as tightly as reasonably possible, then taped to secure everything.
- **The LED light source** - The LED should light up with a 3V source, such as two standard (1.5 volt) AAA batteries. Use tape to connect two batteries in series and then a wire between one end of the two batteries and one of the LED leads. When this is done, touch the other LED lead to the other end of the battery pair and it should light. If not,

then this is likely the problem. Fortunately, LEDs are inexpensive and usually come in packs of 20 to 100 - so it's easy to replace this item in the system

Using the Fidget Spinner system with a falling mass potential energy storage, Lesson 6

- A 20 second video clip showing the system being used as intended is HERE.
- An 11 minute Instructional video for the Lesson 6 activity is HERE.

To help with the activities in Lesson 6, Mi-STAR provides STL files for parts which can be 3D printed. These files will print a holder, a spinner grabber, and a drum (the grabber and drum click together to make a two-piece assembly). The activities can be done without the 3D printed parts, but if at all possible, we recommend printing the parts.

Click on each link below, then click on the blue "Download" button and save each file to your computer. Then share the files with your 3D printer operator and they will handle the rest.

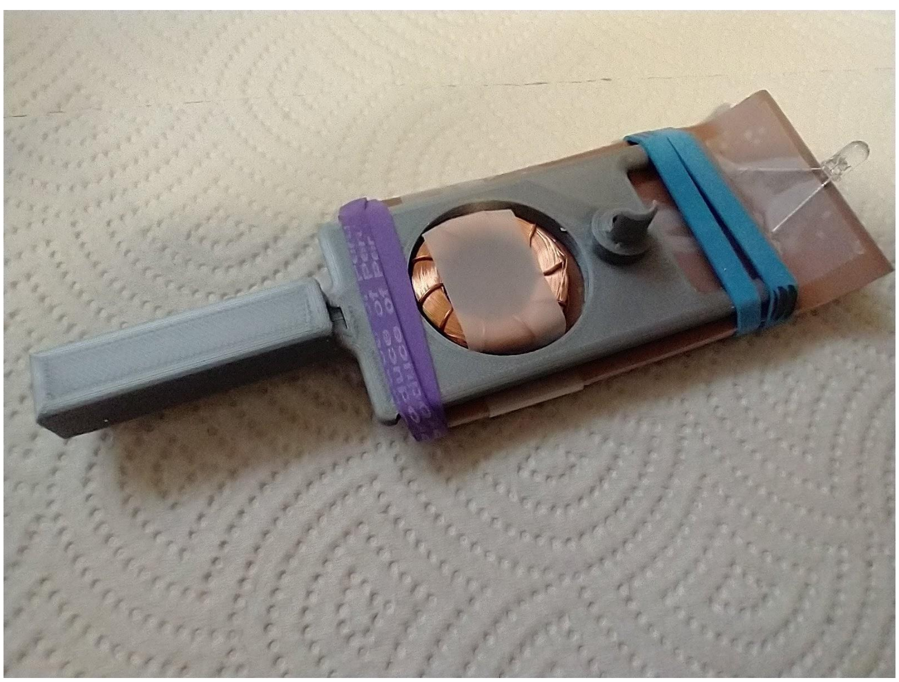
- STL file for Holder
- STL file for Spinner Grabber
- STL file for Drum

Step-by-step instructions for assembling the parts with the fidget spinner.

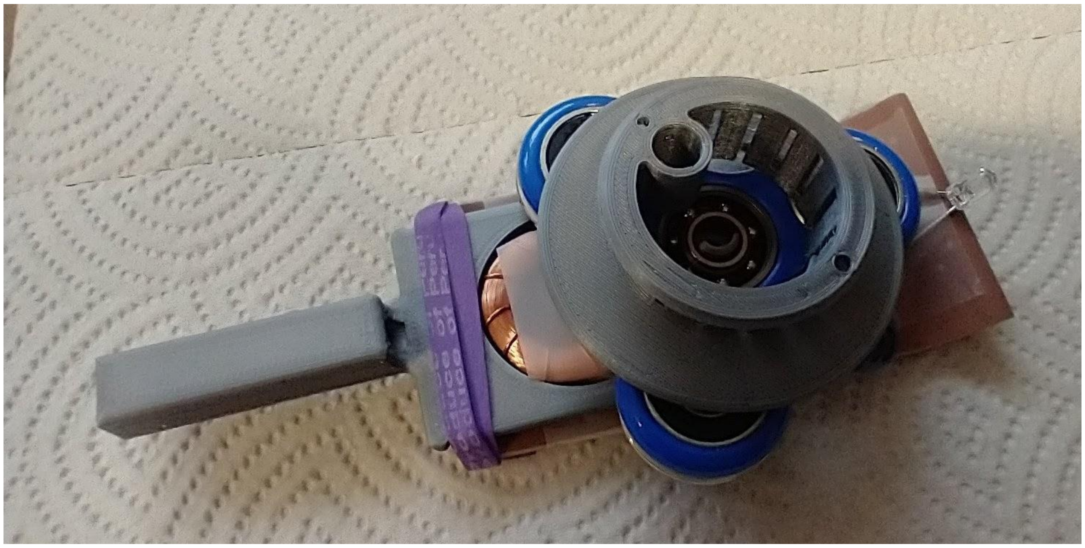
These are the three printed pieces as they would come off the printer. The **holder** is on the bottom-left, the **drum** in the top-middle and the **spinner grabber** on the right.

Here are the **drum** and **spinner grabber** after fitting them together. The three cylinders on the grabber will fit into the bearing holes on the spinner itself as shown below.

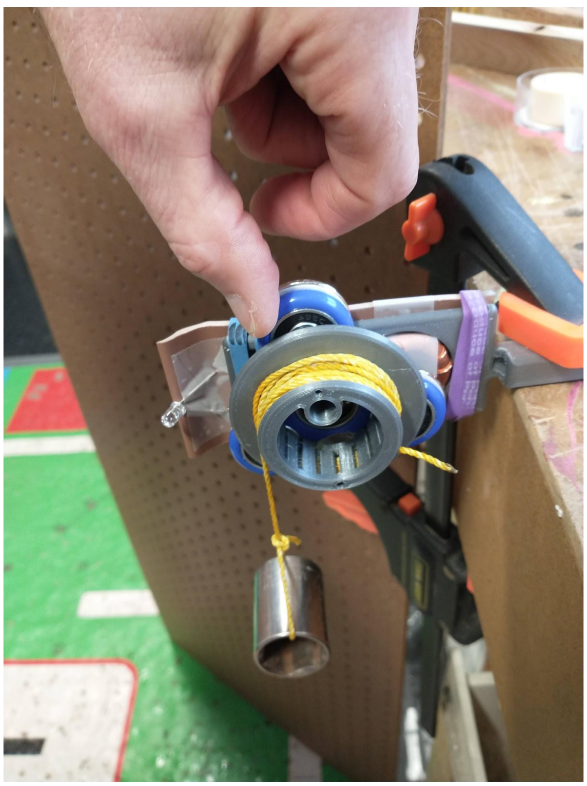
Here are the three parts assembled together with the spinner, but without the coil-LED board.



Here, the coil-LED board is affixed to the holder using rubber bands.



This photo shows everything assembled together to be used in the Lesson 6 activities.



The entire assembly can be held by a student or, as shown here, clamped to a desk or table. The holder and drum are used with a string and a mass to spin the generating system to light the LED. Students can observe and record results comparing how different masses and drop-heights affect the behavior of the system (e.g. how long the LED lights up).

You can also build a similar falling mass system without a 3D printer using pieces of a Bic round stic pen:

Thanks for using Mi-STAR!

