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MAKER: Light-Up Star Floor

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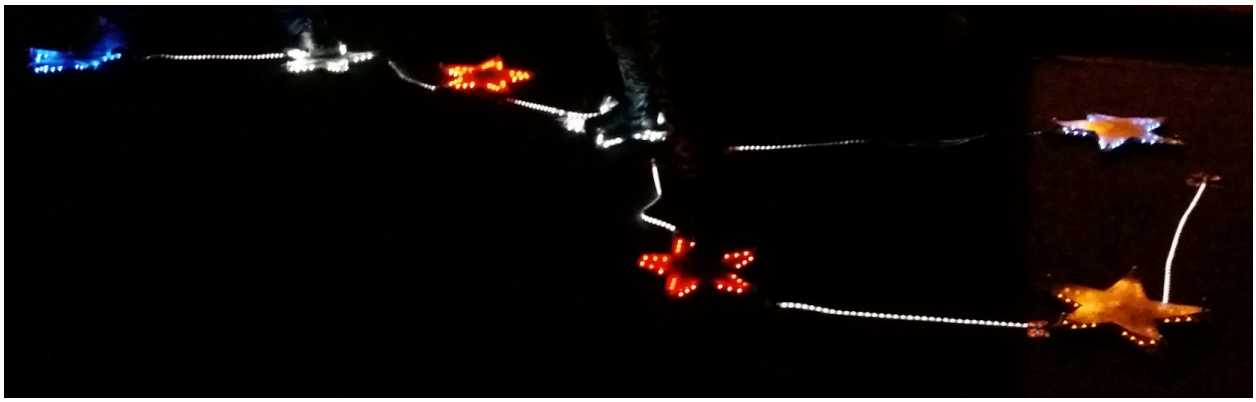
Maker: Light-Up Star Floor

A local engineering and art festival encourages engineers and artists to work together to create beautiful and interactive displays with a science and engineering theme. These displays aim to bring the joys of science and engineering to the general public and inspire others to create their own artwork. One such project was the art car Star Car 2015, which was updated from its 2014 version to include interactive science activities such as a spinning globe, a touch circuit, and a star floor. This star floor was made of seven individual stars which lit up when stepped on, extending the circuit connection concepts from the nearby conductive Star Car installations, which are discussed further in another Maker entry. The stars could be moved around to illustrate different constellations. Overall, the star floor drew the attention of both children and adults for its simple yet eye-catching design and colourful lights.

The star floor also served an educational purpose. It can be used to teach three different science and engineering concepts: astronomy, basic circuits, and the engineering design process.

The star shapes complemented the space theme of the art car. The seven individual stars were not connected by wires and could therefore move independently of each other and be easily

rearranged into different constellations. For example, the stars were placed in the Ursa Major (Big Dipper) constellation that would be recognizable to the festival attendees. Audience members were encouraged to name the constellations, and to arrange their stars in other patterns. The material colours were chosen to reflect the ranges found in star formations as they age, providing the attendees with additional information about astronomy.



The operation of the stars was that of a simple circuit containing the four basic circuit components: a power source, wires, a load, and a switch. The battery was connected by wires to the LED light string through a push-button switch. When enough pressure was placed on the switch it would close the circuit, causing the stars to light up.

Design Process

The design and creation process for these stars outlines and details important design and material choices for the star floor. It is important to mention that while this data is obviously useful to those wishing to build the stars, it can provide an extended lesson on the design process to older students or adults who wish to learn more about the engineering design process. It would be very interesting for children and adults alike to understand that while the stars look quite simple, a detailed design process was used to ensure they would meet all of the desired specifications and operate properly over the course of the festival.

Overall, the design process had several steps: define the problem, determine requirements and constraints, brainstorm alternate solutions, implement the best solution, test, and rework.

The first step in the design process was determining the problem to be solved. In this case, it was the design of an interactive astronomy-based floor that would light up when it was stepped on. Further requirements and constraints were then developed, as seen in the list below:

- Stars must be durable enough to withstand heavy use over the festival
- Stars must be portable
- The entire setup must be safe
- They should be modular, so that if one part fails it can be replaced between festival events

Once the requirements and constraints had been defined, the next step in the design process was formulating solutions. A diverse, interdisciplinary team came up with several options for materials for the stars. The first was sheet metal, which would be durable enough for the festival. However, it was quite expensive and heavy, making it difficult to transport the stars. The second idea was a clear plastic, and the first test material was the type of hard plastic used in fluorescent lighting. However, that type of plastic never even made it to a star shape; it cracked under light pressure, so it was not suitable to undertake the necessary load of four festival days. The next material choice was not a conventional plastic for crafts or building. Instead, the tested material was that of the hard plastic mat typically used in home offices so that an office chair can roll smoothly on carpet. This plastic was sturdy but also pliable, and could easily take the pressure of an adult standing (or jumping) on it. As an added bonus, it was fairly cheap and easily bought at a nearby office supply store. Thus, the plastic chair mat was the material of choice.

The second design choice had to do with the wiring and electrical operation of the stars. The original idea was that the stars would be made of a piezoelectric material that would general electricity when it was stepped on. This electricity would then be able to power the LEDs of the stars. This idea was scrapped early on as sourcing a piezoelectric material was costly and would not arrive in time, nor would it generate the necessary electricity to power the LEDs. That left two options for a power supply: AC power that could be converted and distributed to each star, or batteries. A single AC or DC power supply for the entire star floor was not ideal, as it posed wiring and cable management challenges. There would be many wires between the stars to a central location, making it more difficult to rearrange them and providing a tripping hazard to the festival attendees.

This left batteries as the most viable solution for the star floor, which ensured that each star was entirely self-contained and had no wires that could be a hazard. In particular, the A23 battery provided the correct voltage to power the LEDs. However, its lifespan was unknown, as it was not being used for its typical purpose of electronic keychain radio devices such as garage openers or remote car starters. A preliminary test of simply hooking up the battery to the LEDs for 12 hours showed that while the lights dimmed over time, they were still functioning at the end of the time span. This test proved that the batteries would last for the duration of the festival. Batteries also improved the safety of the star floor. Weather in Calgary can be unpredictable in September, and by having the batteries encased in the star it would shelter the electronic components from rain or snow.

Once each alternative was chosen and tested separately, it was time to build an entire star and test its functionality. The steps for building the stars will be provided later in this paper. Of most interest was the interaction between the hard plastic top layer, the foam in the middle, and the switch that would turn on the LEDs. The entire setup was tested by first seeing if the star indeed could be turned on and off using the pressure of a single hand or foot. Once that had been confirmed, the weight on the star progressed from a light step to a jump. The builders jumped heavily on the first star in an attempt to make it fail, but the materials proved to be very strong and held up under the pressure. The importance of testing that ‘extreme’ case became obvious during the festival, where attendees disregarded instructions to step lightly on the stars and turned them into a version of light-up hopscotch.

Once the stars were built they were put into use during the 2015 festival. Of course, the design process did not stop once the product had been built. Observations were made based off of the stars' performance during the festival and several recommendations were made to increase the durability of the star floor.

- A bottom layer of the hard plastic is necessary, as the stars would twist when pressure was not centred, sometimes causing the bolts to rip the foam and compromise the entire structure of the star
- A better material for the bottom of the star would improve its grip on concrete, preventing the star from slipping
- Have a semi-permanent way of fixing the nuts to the bottom of the bolts, so that they do not fall off but could still be removed to fix the internal wiring of the star
- Use a more durable switch. The original operation of the switch that one press-release would close the circuit, and another press-release would open it. Luckily, the fail state of the switch was that it would close the circuit when pressed and open it when released, which was fine for this application. Finding a more durable switch would guarantee our desired operation for the duration of the festival and beyond.

General Materials

- paper, pen
- wire
- hard plastic chair mat
- scissors/tin snips/x-acto knife
- roll of thick foam material
- colourful thin foam
- soldering iron, solder
- heat shrink, electrical tape
- Loctite Threadlocker

Materials (per star)

- 12V LED light string
- push button switch
- battery holder for A23 battery
- A23 battery
- 5 bolts
- 10 nuts
- rubber, grippy materials

Build instructions

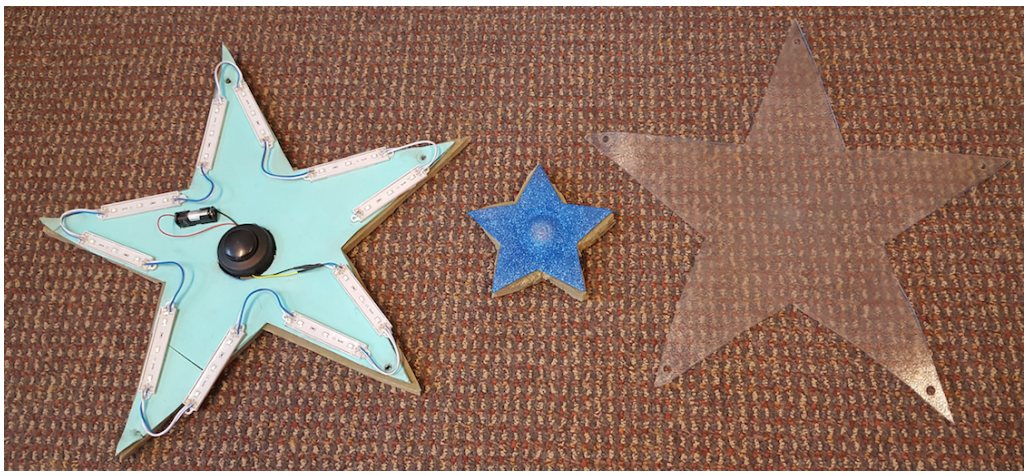
1. Create a template for your five-pointed star. This is easily found on the internet. You want the star to be big enough for a typical adult to press with one foot.
2. Cut out two of these stars from the plastic chair mat

3. Cut out a star from the thick foam. If its colour is not what you want to have showing, cut another star out of some thinner, colourful foam. Hot glue the colourful foam on top of the other foam star.
4. Cut a hole the size and shape of your switch in the centre of the foam star.
5. Create the smaller star that will cover the switch by making a smaller star out of colourful foam. It is possible to already find pre-made colourful, sparkly stars.
6. Trace that smaller star and cut out two layers of the other foam, stacking them on top of each other
7. In the centre of the two stacked pieces of foam, cut another hole to line up with your switch. Do NOT cut this hole in the top, colourful small star.
8. Glue the three small star layers together, with the colourful one on the top. Set this piece aside for now.

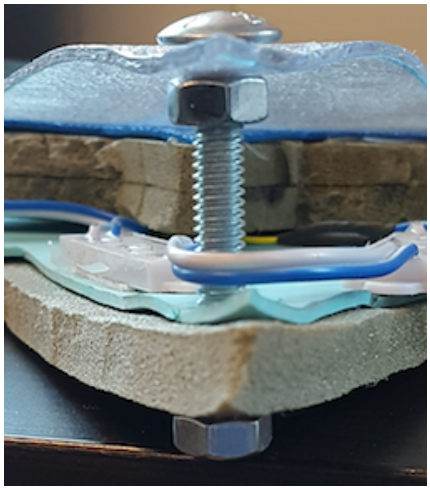

9. Hot glue or otherwise attach the LED strings around the edge of the larger star, making sure to leave about 8” of the string unattached to make it easier to wire up the switch.
10. Attach the positive lead of the battery pack and the positive lead of the LED strings to the switch. Many switches will have screw terminals for this.
11. Solder together the negative lead of the battery pack and the negative lead of the LED string. You may need some extra wire to accomplish this. Use heatshrink (preferred) or electrical tape to insulate any exposed wire.
12. Insert a battery and check to see if your circuit is working! If not, troubleshoot by checking for loose wires and connections, faulty switches, or dead batteries.
13. Slot the switch into the hole you cut in the big star and attach any loose LEDs.

14. Fit the smaller star overtop the switch and then choose a location for the battery pack. To avoid it getting crushed, it is best to place it very close to the edge of the smaller star.

15. Drill holes into the points of the plastic stars and cut these same holes in the larger foam star so that everything is aligned.



16. On each point of the star:
    a. Push a bolt through the top plastic layer and then screw a nut into place on the bottom side of it, applying Loctite to keep the nut from moving. This will keep the points of the stars from collapsing.
    b. Push the bolt through the rest of the layers and screw a second nut on the bottom, sealing it with Loctite.



17. Attach a material to the bottom of the star that will help it grip to the floor.
18. Repeat this process for however many stars you would like to build, varying the colours of the LEDs and foam. Enjoy!