NORTHERN ARIZONA UNIVERSITY

Wonder Factory

Preliminary Report

Team E6

Khaled Alhusainan

Yousef Almutairi

Barjas Albarazi

Faisal Alanezi

Saad Albarazi

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Project Sponsor: The Alstons-Wonder Factory

Instructor: Dr. David Trevas

DISCLAIMER

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1 BACKGROUND

1.1 Introduction

This paper is about a project to build for wonder factory to display it over there. As in the wonder factory only those items are available which are based on science, technology and entertainment as well. Objective of wonder factory is to provide such products to the children that they feel wonder while playing with them. Therefore, in this project we will build such a model product that will be creative, tactile, auditory and safe to operate as well, simple to operate and must be portable. With all these things different ideas will generate in this report and then a final idea will select which will based on all the objectives mentioned earlier.

1.2 Project Description

As our sponsor is basically the wonder factory and they want such a project which is safe to operate and should be exhibit in the wonder factory and have the capability of bring wow from the viewers. It should be a tactile, auditory and visual as possible. And it must be portable with a weight and size as well. With all these requirement, the project description is to make any product for display in wonder factory based on STEM.

1.3 Original System

The original system of the ASMR Spirograph project involved geometric drawings using meticulously engineered drawing toys to whirl about while drawing on a clean sheet of paper. The resulting types of mathematical impressions and roulette curves are called epitrochoids and hypotrochoids. The Spirograph technology was first designed and sold as toy by Denys Fisher who was a British Engineer. Initially, the Spirograph first acted as a drafting tool and later sold as a game. The technology was displayed at the Nuremburg Toy Fair in 1965 and flooded the markets and available in stores as toys.

1.3.1 Original System Structure

The original system structure used a simple mechanism of operation of the Spirograph. The Spirograph is used to make geometric impressions on paper when the small gear is spun inside the main big circle. While the small circle is spinning, the colored pen follows the various movements of the inner and small gear.

The movement of the inner gears enables the colored pen to draw lines within the confines of the big circle as guided by the small circle. The variations of the lines in accordance with the different radius of the two circles create a lovely pattern guided by the gear sizes.

1.3.2 Original System Operation

The original system operation worked with one large circle and a smaller circular gear that was rotated inside the main big gear. A colored pen is guided by a hole that is placed inside the hole of a small gear. Once the smaller circular gear is rotated inside the big circle, impressions are drawn on paper making nice illustrations.

1.3.3 Original System Performance

The original system performance could be able to realize different types of spiral mathematical designs and illustrations using Spirograph tool kit. In addition, the system would carefully design and produce geometric drawing using differently colored pencils. However, the patterns were limited in design and thus the impressions created lacked creativity and flexibility.

1.3.4 Original System Deficiencies

The original design of the Spirograph had some deficiencies that we seek to improve on to make the product a better one.

The patterns created using the original system were limited in design and thus the impressions created lacked creativity and flexibility.

2 REQUIREMENTS

In this section, we will present the requirements of our project provided by our client. These requirements will use in future for doing the project from selecting the design to implementing the design product. In this section customer requirements, engineering requirements with their target values and tolerance, testing procedures and HoQ will present. Here are the customer requirements.

2.1 Customer Requirements

Customer requirements for this project is showing in the following bullets:

- Safe to operate
- Child-like wonder
- Tactile
- Auditory
- Visual
- Simple to operate
- Portable
- Multiple visitors

2.2 Engineering Requirements

Engineering requirements are showing below in table 1.1.

Table 1.1. Engineering Requirements

Engineering Requirements	Target Value	Error
Size	4x4 ft-square	25%
Gear Size	15 inch	5%
Weight	Less than 100 lb	10%
Number of gears	16	0%
Cost	Not determined	N/A

- Size: The system must be able to fit within a 4x4ft square area.
- Gear size: the gear size should range from 15 to 60 cm.
- Weight: Weight of product must be within 100 lb so it can easily carry out for portability purpose.
- Number of gears: total of 16 gears of different shapes and sizes.
- Cost: should be no more than $2000.

2.3 Testing Procedures

In this section, we will discuss how each engineering requirement can be tested. See the following for testing procedures.

Size

Size of the product can measure through the scale by check the length and width of a product, size can calculate.

Great Size

Gear size can calculate also through the scale by measuring the diameter of gear.

Weight

Weight can measure through the weighing scale by simply placing the complete product on the scale and it will tell the weight of it.

Number of Gears

Numbers of gears can count simply.

Cost

Cost will need to calculate by counting the number of parts and estimate the price of each part and then sum up the prices of all parts will give the total cost of this project.

2.4 House of Quality (HoQ)

From the chart in Figure 1 it shows that most important factor is the weight which is effecting most, and then the size of this product. Remaining requirements are also important but size and weight are the most important requirements to follow for this project.

Engineering Requirements / Customer Requirements	Importance	Gear size	Size	Weight	Number of Gears	Cost
Safe to operate	9	3			1	
Child Like wonder	3	1	3	3	9	3
Tactile	3	3			3	
Auditory	9		1	3		1
Visual	9	1	1	1	1	3
Simple to Operate	1		1	3	3	1
Portable	9		9	9	3	3
Multiple Visitors	9	3	3	3	3	3
Technical Importance: Raw Score		75	136	156	111	100
Technical Importance: Relative Weight		13.0%	23.5%	27.0%	19.2%	17.3%
Techanical Target Value		900	15	10	7	100
Upper Target Limit						
Lower Target Limit						
Units		in^2	In	Kg	-	$

Figure 1: House of Quality

3 EXISTING DESIGNS

In this part of report, we will present details about the product and the system level designs. As mentioned in chapter 3 that there are different sort of system levels to explain for any product. A system level design is important to explain because it tells the basic inputs, outputs of any product and this can explain through the black box model. In the same way, there is a functional model which explains about the process of getting the required output through the input. In this section system level will explain some of the existing design that will help in building this project and then subsystem level design with their existing design will present.

3.2 System Level

This is a design project and we will design a unique idea based on STEM for wonder factory display and as the product we are building is the Spirograph system but still there are some existing designs which can help us in building the project.

3.2.1 Existing Design # 1: Funky Bricks Gear Building

This a design for children playing in which around 81 pieces of funky bricks gear building a toy set. All the gears are interconnected with each other so by the rotation of only one side all the gears starts moving this is a concept of interlocking the gear modules [1]. It is showing in Figure 2.

Figure 2: Gear Building

This design can help us building an interlocking gear based system which is safe to use to and entertaining as well. That is why this idea will help us in our design project.

3.2.2 Existing Design # 2: Learning Resources Gears Lights

This is a toy based on the interlocking of gears and this design has multiple modules which operates by the gears. When the initial gear starts rotating it produces the lights from different spots and rotate all the gears together because they are interlocking, as shown below in Figure 3.

Figure 3: Gearing Lights [2]

This is a good idea and it will help us in the project when we will design it. We can build such concept which has these capabilities and operations of interlocking gear systems.

3.2.3 Existing Design # 3: Gears Ocean Wonder

A toy made up of blue color ocean base and few gears overs the base interlocked with each other gives a wow concept. All the gears rotate together and it looks great. Each gear has icons of different ocean creatures which feels like things are moving inside the ocean [3].

Figure 4 shows a sample.

Figure 4: Gear Ocean

This design will help us in building our project as we can go with the gear modules and create a new concept using the gears.

3.3 Functional Decomposition

In this part of the report we will present our different functional models like black box model, hierarchical task analysis and the subsystem levels for this project. First of all is the black box model.

3.3.1 Black Box Model

In this model shown in Figure 5 we have three inputs, one is hand, second is mechanical energy and the third one is turning on and off the system. In the same way, we have three outputs one is Graph, second is Music and third one is On/Off.

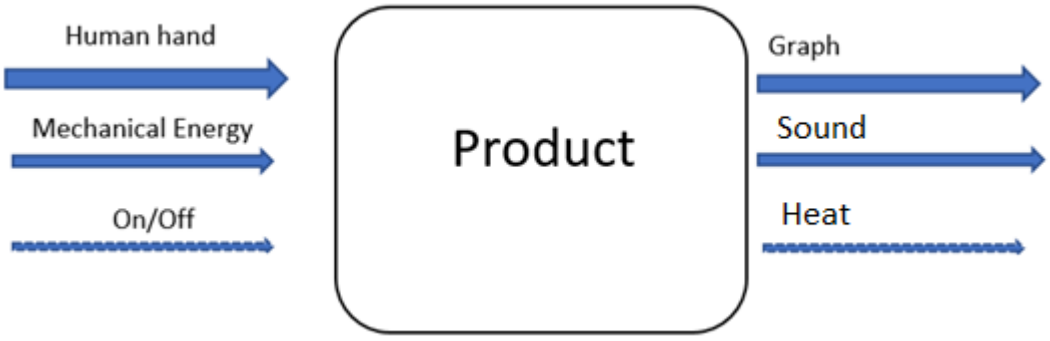

Figure 5: Black Box Model

3.3.2 Functional Model

In this model shown in Figure 6 it has defined that mechanical energy through hand will provide to first gear and then it will rotate and produce sound and also move the pencil which will then rotate in different directions to produce the graph and sound at the end.

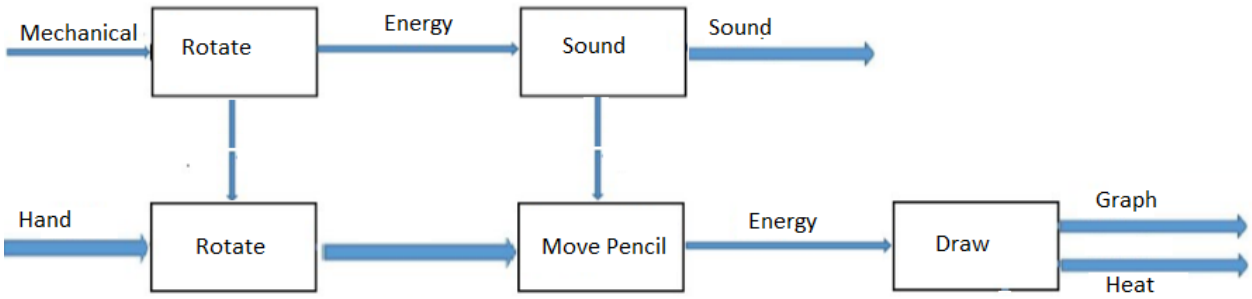

Figure 6: Functional Model

3.4 Subsystem Level

For the above system there are subsystem levels as well which are:

- Gears
- Base
- Spacers for rotation of gears

3.4.1 Subsystem # 1: Gears

3.4.1.1 Existing Design # 1: Plastic Gears

This type of gears are available as shown before in the figure 2, 3 and 4 where different type of gears are made up of plastic. So, we can use this type of gears in our project because it will not rust and neither need any greasing.

3.4.1.2 Existing Design # 2: Steel Gears

This type of gears are also available and these gears are strong and has the capability to drive any sort of load. That is why depends on the need we can use this type of gears in our design project.

3.4.1.3 Existing Design # 3: Iron Gears

Iron gears is another existing design but iron gears are not long lasting and need greasing after sometime furthermore these type of gears got rust.

3.4.2 Subsystem # 2: Base

3.4.2.1 Existing Design # 1: Wooden Base

Bases of different types are available and wooden base is an already existing design. Wooden base provides a smooth base over which pencil can move smoothly and draw things without any hurdles so the wooden base is a good option for our project.

3.4.2.2 Existing Design # 2: Iron Base

Iron base is also an existing design but the problem is that iron bases cannot be smooth like thee wooden bases therefore this existing design is not a good option to go with for our project.

3.4.2.3 Existing Design # 3: Plastic Base

Plastic base is already available and this is a smooth surface without any hurdles and up downs. So this design can use for our project as well.

3.4.3 Subsystem # 3: Spacers

3.4.3.1 Existing Design # 1: Steel Spacers

Steel spacers are available in the market and these types of spacer will be used to rotate the gears at the origin. Steel spacers does not rust that is why these are good to use for our project.

3.4.3.2 Existing Design # 2: Iron Spacers

Iron spacers are available but as they get rust and need greasing that is why these are not good option to use furthermore iron spacers are not good circular movement because they are not slippery even after greasing. In addition, we can use this option if we will not find any other type of spacers.

3.4.3.3 Existing Design # 3: Plastic Spacers

Plastic spacers are available now but these are not strong enough to hold heavy gears and rotate around. So plastic spacers is not a good way to use for rotating heavy gears for our project.

4 DESINGS CONSIDERED

For this project, we have considered two of the design ideas. These are the new concepts designs and will select only from these two concepts. These concepts are presenting below.

4.1 Design # 1: Spiro-Graph

In this design, few gears interlock with each other and holder a pencil through a stand. The pencil stand is attached with the moving gears in such a way that when the handle will push the first gear to rotate, it will rotate all the other gears at the same time and the moving gears will move the pencil over the paper in specific directions to make Spiro graph. This is the major concept of this design idea and it is showing below in the following figure 7.

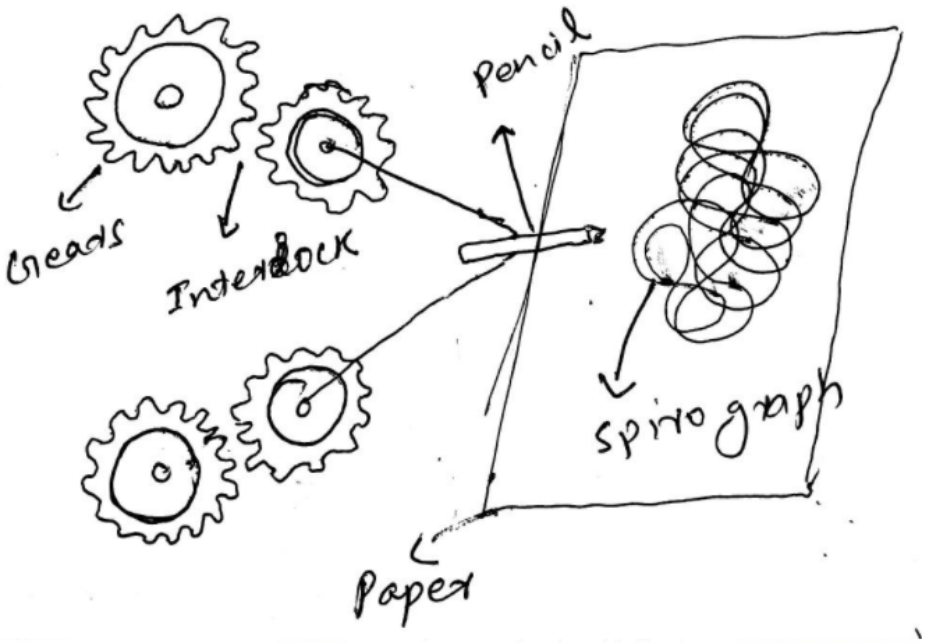

Figure 7: Spiro-Graph

4.2 Design # 2: Parallel Series Circuit Houses

The idea to make two houses one is of parallel circuits and second is of series circuits. The concept is that to show the difference between working of parallel circuits and series circuits. In each house, different lights attach at different points so when the switch turns on, bulbs will glow on but they are on timing and their light effect will be different for parallel connections and for series connections so being a STEM project this idea is also a learning module as showing below in figure 8.

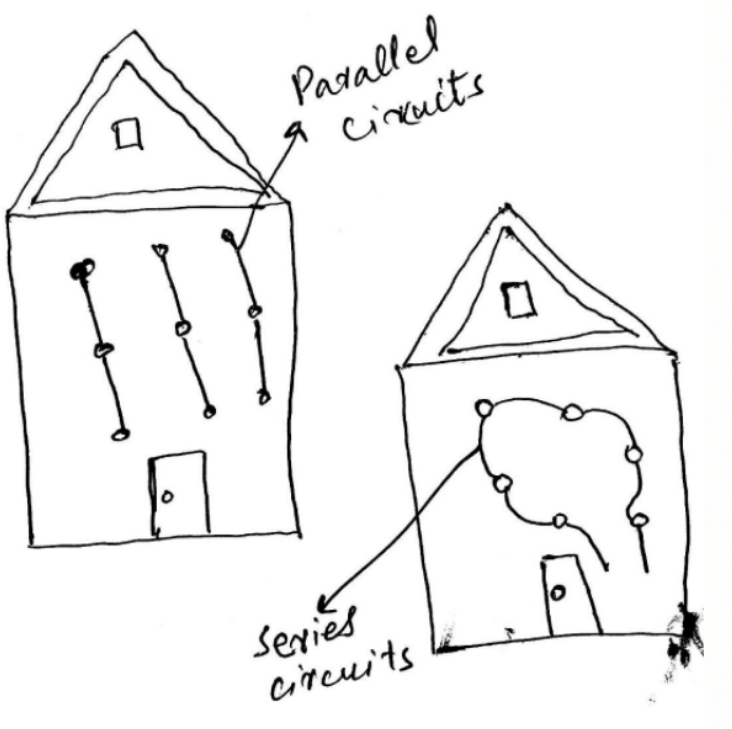

Figure 8: parallel Series Houses

5 DESIGN SELECTED

In chapter 5, it says that when you got the ideas, rationale the design ideas for the final solution and to do so there are different methods but for this project we will go with only two methods one is Pugh Chart and second is Decision matrix. These two methods are using for narrow down the ideas. But here we have generated only two concepts and we have decided to go with the first design idea after discussing it with our clients. But still we will check through the methods that which one is better to go with.

5.1 Rationale for Design Selection

In order to select the design through the methods, first of all move towards the Pugh Chart.

5.1.1 Pugh Chart

From Pugh chart in Table 1.2, we got the Spiro Graph as a final design. Now check it with Decision Matrix.

Table 1.2: Pugh Chart

STEM Designs	Weightage	Spiro-Graph	Parallel Series House
Safe to Operate	8	+	-
Child-like Wonder	7	+	+
Tactile	6	+	-
Auditory	5	+	-
Visual	4	+	+
Simple to Operate	3	+	-
Portable	2	+	-
Multiple Visitors	1	+	+
Number of Plus		8	3
Number of Minus		0	5

5.1.2 Decision Matrix

From the Decision matrix in table 1.3, we have found that the best idea to go with is Spiro Graph and this has decided already with clients. The initial design of the final decision is showing below with the gears and made up in solid works for better visualization.

Table 1.3: Decision Matrix

	Safe to Operate	Child-like Wonder	Tactile	Auditor	Visual	Simple to Operate	Portable	Multiple Visitors	Total
Weightage	8	7	6	5	4	3	2	1	
Spiro Graph	6 x 8 = 48	7 x 7 = 49	5 x 6 = 30	4 x 5 = 20	6 x 4 = 24	7 x 3 = 21	8 x 2 = 16	2 x 1= 1	179
Parallel Series House	2 x 8 = 16	4 x 7 = 28	4 x 6 = 24	1 x 5 = 5	6 x 4 = 24	2 x 3 = 6	3 x 2 = 6	4 x 1= 4	113

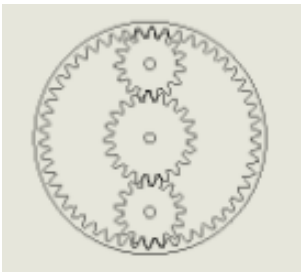

Figure 9: Gear Box

Figure 10: Interlocking of Gears

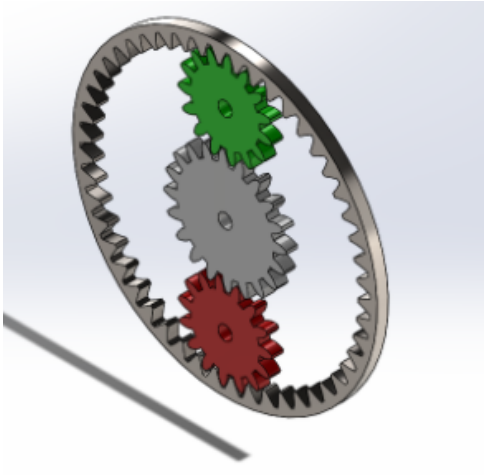

Figure 11: ISO View

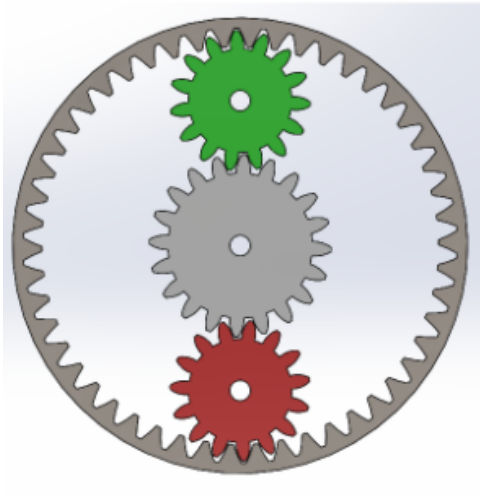

Figure 12: Front View

It can be seen from the Figure 9,10,11 and 12 that 4 gears interlock with each other and with the motion of only one center gear, all the other gears will start moving.

REFERENCES

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[3] B. Minds, “Junior Gears Ocean Wonder” available [online]. http://www.brightminds.co.uk/junior-gears-ocean-wonder/p3858