1. Optimal Design Project
   1.1 Introduction

The objective of this project is to design an Interactive Wheel of Fortune game in which adults at the ATCO sheltered workshop will be able to use. Spending time productively is a large issue at the workshop. When the adults are taking breaks from their jobs it is necessary to have stimulated entertainment. Often times the staff runs out of ideas and ways to spend time with the adults and regularly resort to the television. The Wheel of Fortune game will be a way for the adults to spend their time effectively and interact with others at the same time.

The adults at the sheltered workshop have a wide range of disabilities. The main disabilities include cerebral palsy and mental retardation. These disabilities limit the adults’ range of motion and dexterity. With this in mind the game needs to have specific features that will accommodate the adults.

The sub units of the game will first be examined. The game will consist of many different parts. The first component of the game will be the wheel. Visual enhancement is a large consideration when designing the wheel thus bright colors and light emitting diodes (LEDs) will be incorporated. Following the same format as the second and third alternative designs, this optimal design will use pre-colored plastic instead of plain plastic in which the bright colors need to be painted on. The optimal design will follow the third design by incorporating the use of dowels attached to the pie pieces of the wheel. The next component of the game will include the base of the game. This will be used as the primary support system for the game. The base will also be designed to visually enhance the adults. The larger diameter of the wheel will be used in this optimal design as introduced in the third alternative design. This larger diameter will not allow the wheel to fit inside the box such as the first and second designs used. Now the wheel will sit on top of the box at all times. Figure 1 shows the side view of the complete wheel and base of game. There will be two types of methods in which to spin the wheel. There are two types of spinners due to the large range of disabilities the adults suffer from. As specified in the second and third designs, the optimal design will follow with using a wireless remote with push button and motion sensor. A motor unit will be used to spin the wheel. Generally, a geared, digital converter (DC) motor unit is required. The normally closed switch attached to the motor will also again be used. The second and third alternative designs used pillow block bearings to reduce friction around the dowel and top of wheel when spinning. This optimal design introduces the use of bearing blocks in which the dowel will be able to fit directly inside of the bearing. Another function of the game in which to stimulate the adults will be through the use of audio comments. These comments will be activated by the push of individual buttons. The SP03 text to speech synthesizer will be used to enable these controls. All of these components will be able to fit inside of the base of the game. Figure 2 shows a cross section of the game.
The optimal design will use the new addition to the third design: the use of a tape recorder to audibly speak the questions and answers. This is added to the design so that if the staff member is busy and cannot play the game with the adults the game can still be played.

The questions and answers book will consist of a binder of typed up questions inside of plastic sheets. The questions will be of the elementary level so they are easy enough for the adults to answer correctly. Additional plastic sheets will be provided so that the staff members can add their own questions as time goes on.

Safety is also a large concern. There cannot be any exposed wires due to them being a tripping hazard. Thus, a rechargeable battery will be used to power the game. Also all electronic components of the game need to be completely sealed in case of a spill on the game.
1.2 Subunits
1.2.1 Wheel and Base of Game

The wheel and base of game will be made out of Polyvinyl chloride plastic (PVC). PVC is one of the most valuable products of the chemical industry. Over fifty percent of manufactured PVC is used in the construction industry. PVC is known to be inexpensive and easy to assemble. PVC is produced using a polymerization method of the monomer vinyl chloride.

PVC was the chosen material to be used on the wheel due to having desirable properties. One of these properties includes the elongation at break. PVC will only elongate twenty to forty percent. Thus there will be low wear and deformation on the plastic. Low friction is also a key property of PVC. The specific heat of PVC is 0.9 kJ/(kg·K). PVC is an excellent material to use because it has excellent machining properties and when heated it blends well. PVC is also a smooth plastic. The smooth texture is optimal because the adults have limited motor skills. There cannot be any sharp edges that the adults can scrap themselves on. PVC is also a popular material for tanks and fittings. Additionally, PVC is used for nuts, bolts, ducts, hoods and process tanks. The PVC will be supplied in a wide range of colored sheets (Fig. 3).

![Figure 3: PVC Sheets](image)

The wheel will be of a quarter of an inch (0.635 cm) in thickness and twenty inches (50.8 cm) in diameter. The box will be one half of an inch (1.27 cm) in thickness. The box dimensions will be twenty four inches (60.96 cm) wide and six inches (15.24 cm) deep. The box will have a larger thickness because it has to withstand more weight. Also the box needs to be very stable so that when the wheel spins it does not fall over.

The wheel will consist of eight equal pie pieces. The first design proposed that the wheel would be a single white sheet of PVC plastic. This large white sheet of PVC would then be cut in the dimensions needed for the wheel and base of the game. These two pieces would then be painted in the appropriate manor to be used as the decorations. For example, the wheel would be painted into different sections and then each section would be painted a different color. The second design proposed that each piece of the game be
cut out of individual pre-colored PVC sheet. For example, each pie piece of the wheel will be from a separate sheet of pre-colored PVC. It is more desirable to have the PVC pre-colored so that no paint needs to be used because it (the paint) will eventually chip and flake off over an extended period of time. It is desirable that this game be used for a number of years and for the client to be ultimately happy so therefore it is not advantageous for the game to fall apart. Thus, the same design will be used in this third design.

Once the individual pie pieces are cut out, they will be put together to form the entire wheel. The second design proposed the use of IPS Weld-On 2007 to be used as the cement to hold all of the pieces together (Fig. 4). In the third design, IPS Weld-On 2007 was proposed to be used again. IPS Weld-On 2007 is a clear, water thin, fast-drying solvent. This can be applied to the plastic using a brush, syringe, or spray. The cement bonds the two surfaces together in minutes. The wheel needs to be completely flat; thus, a short drying time is optimal. This will allow the group to adjust the pie pieces once the cement has been applied. A Hypo-type Solvent Cement Applicator will be used to apply extra cement into the crevices between pie pieces. This optimal design will use a plastic mold that was introduced in the third design as opposed to the binding that was introduced in the second design. The mold will be more optimal because it provides better insurance that the pie pieces will be held together more tightly (Fig. 5).

![IPS Weld-on 2007](image)

**Figure 4:** IPS Weld-on 2007

![Plastic Mold Well](image)

**Figure 5:** Plastic Mold Well

Seven of the pie pieces will contain one of three different point values. Two pie pieces will contain point value one, two pie pieces will contain point value three, two pie pieces
will contain point value five and the last pie piece will contain point value ten. The eighth pie piece will display “Lose a Turn”. There will be an option to remove this piece from the board and attach a different piece that contains a point value. This will be an option because some of the adults may have hurt feelings or not understand when they land on “Lose a Turn”. It will be at the discretion of the staff members on which pie piece to use. This “Lose a Turn” pie piece will be able to be removed and put back in by the use of Velcro. The Velcro will be as thin as possible so that the pie pieces will still be flush with each other. Extra glue might also be advantageous to use under the unmovable pieces to help with keeping the wheel flat. Figures 6-7 display the colored wheel and additional snap on pie piece. The letters and numbers of the wheel will be stickers that can easily be attached. A dowel will be attached to the top of each pie piece. This dowel is meant to provide the same clicking noise that is sounded when the wheel is spun on the “Wheel of Fortune” television game show. The clicking noise will be produced every time the dowel hits the marker. This clicking noise will provide more enhancements for the adults.

![Diagram of the decorated wheel](image)

**Figure 6: The Decorated Wheel**

![Diagram of a replacement wheel piece](image)

**Figure 7: Replacement Wheel Piece**

The base of the game will be used as the support system. The base will consist of a hollow box (Fig. 8). Again, rather than painting this box, it will be constructed in a
similar manor to the wheel. Different colors of PVC sheet will be used to assemble the sides of the box. Each one of the sides will be held together using the IPS Weld-on 2007. The front of the box will display “Wheel of Fortune” on the outside. This text will be large enough for the players to easily see it. Each side of the box will be a different color. The questions and answers book and all game components, including all electrical components, will be able to fit inside of the box. The electrical components will be contained in a spill proof box. This is imperative in the case that one of the players spills their drink or other liquid onto the game it will produce no electric shock. Therefore, the base of the game will be used as a storage container for the Wheel of Fortune game. The only thing that will not be stored in the base of the game will be the actual wheel. This is because the wheel is much bigger than the base of the game. The wheel will be part of the top of the base and will be attached by the use of hinges. The hinges will be placed on the bottom of the wheel and will attach to a section on the top of the base of the game. Thus only a portion of the wheel will actually be attached to the base of the game. Please refer to Fig. 2 for the cross section of the base of the game.

**Figure 8: External view of Base of Game**

It is important to test the bonding strength of the IPS Weld-on 2007 and PVC plastic before the game is constructed. This will be done using the Tinius Olsen testing device. The percent elongation and force at fracture can both be found which will tell us whether the bonding strength is at an adequate level.

1.2.2 Bearing Blocks

The second and third alternative designs used pillow block bearings in between the dowel to decrease the friction in between the dowel and wheel. This optimal design introduces the use of the bearing block in between the wheel and the dowel (Fig. 9). The dowel of the game will be able to go right through this bearing block. This is needed to minimize the friction between the two surfaces. Plastic spinning on plastic will eventually gall and/or become irritated. Having a bearing block between the two plastics will eliminate this problem. Luckily, the housing material of the bearing block will be self-lubricating so no extra lubrication will be needed.
The bearing block that will be used is a two-bolt flange unit. This two-bolt flange unit is used to provide load support for a rotating shaft axis. The bearing housing is designed to support shafts that are positioned at a ninety degree angle to the mounting surface. Thus the flange unit will be attached to the bottom of the wheel and the dowel will go right through the hole of the flange unit. The selection of the appropriate bearings can be accomplished based on the shaft size and the radial and thrust load requirements. They are designed to support a shaft size. The two-bolt flange unit is designed in an elliptical shape. The two bolt holes are located on opposite sides of the housing. The center line of each hole is aligned with the center line of the shaft (Fig. 10).

When selecting the correct dimensions and measurements of the two-bolt flange unit certain things are very critical. The shaft diameter must be matched with the appropriate corresponding bore dimensions of the bearing unit. If a properly sized unit-matching shaft is selected, the bearing will easily slide onto the shaft, and into the position, ready to be secured by the locking device. The measurement of the distance between the bolt holes centers differs according to the configuration of the housing. The measurement technique used for the two-bolt flange is taken from the center of one bolt hole to the center of the other. This distance is indicated in Fig. 11 by the variable J.

Figure 9: Wheel and dowel with pillow block bearings

Figure 10: Two-bolt Flange Unit
Figure 11: Two-bolt Flange Unit Measurement

This will be tested quite easily. A small piece of PVC plastic will be attached to the top of the bearing and it will then be spun around for some time to see if any galling does happen. If none happens then it can be concluded that the pillow block bearing has done its job.

1.2.3 Switch

A Single Pole Single Throw (SPST) switch will be used in the Wheel of Fortune game. The switch will be normally closed; this is sometimes referred to as an (off) – on switch. A normally closed switch is one that normally allows current to flow and also prevents current flow when it is agitated. Figure 12 shows a picture of a single pole single throw switch.

Figure 12: SPST switch

Typically the signal(s) are connected to the pole(s) and the throw is the switched connection. In our game that is how the switch will also be connected. The switch will be connected to the motor, which will be acting as the signals. The actual spinner of the game will be acting as the switched connection. It will stay in the off position until a voltage is applied to the motor. When the voltage is applied the switch will move to the on position which will in turn activate the spinner of the game causing it to spin. Once the voltage is no longer running through the motor and into the switch it (the switch) will return to its normally closed position. The spinner will in turn be stopped by the force of gravity. This will help to reduce friction between the plastics and the bearings because the spinner will slow down slowly and eventually stop rather than spinning at full force the entire time.

This was an addition to our first alternative design but has stayed the same throughout our previous other two design. Our client wants the wheel to be stopped by gravity and
this switch is the perfect solution. It can be tested in other programs and experiments prior to adding it into our game. Based on our past knowledge of how switches work (coming from previous labs) this switch, the single pole single throw, should be the most effective

1.2.4 Spinner
In order to spin the wheel a motor will be used. Generally, there are two types of motors out in the market, AC and DC. Through research it was found that an AC motor can lead to potential danger to the user and the designer due to its high voltage supply. Also, the client required that the interactive game should be battery powered rather than direct electricity. This also limits the use of an AC motor due to the fact that DC batteries will be used. The options left for this project are a DC motor or Stepper motor. Due to the complication of programming the stepper motor to stop at a certain position, it is better to use a DC motor (Fig. 13).

Generally, a simple DC motor consists of armature (rotor), commutator, brushes, axle, field magnet, and DC power supply. The rotation of the rotor is due to the magnetic field produced by the field magnets.

When choosing a DC motor for a particular project, it is essential to look at the torque produced by the rotation, the speed of rotation, the duty cycle of the motor and the temperature conditions under which the motor works best. For this design, a DC motor with a maximum angular speed of 90 RPM will be used. The speed will be adjusted using the voltage supply (24 V maximum). As the voltage supply to motor increases the rotation of the motor increases. Also, a microchip will be used to control the random termination of the rotation of the motor. The DC motor will have a high torque to low speed ratio due to the fact that the wheel is going to be constructed out of the plastic and a lot of momentum will be required to move the wheel. Also, as a safety concern, a temperature sensor will be placed near the motor, which will shut off the game off if the temperature of the motor exceeds threshold, preventing the motor from destruction.

The overall process by which this motor will work in this design as follows:
Primarily, the motion sensor or a push button will be activated causing a voltage drop across its electrical components and generating some sort of signal. This signal will become the input of one of the input pins of the microcontroller. The purpose of the microcontroller is to control the time that the motor runs. Due to the fact that the motion sensor will already contain an amplifier that will amplify the signal to 5V, there is no need for an additional amplifying circuit between the output of the motion sensor and the input of the microcontroller. However, to be safe a 5 volts voltage regulator will be placed between the two to prevent any damages. Differently, an amplifier circuit is required between the output of the push button and the input for the microcontroller to amplify the signal to 5 volts. After the signal has been received by the microcontroller, an output pin of the microcontroller will generate a five volts signal for a random time between 3 seconds to 4 seconds. This 5 volts signal will become the input of an amplifier circuit will that amplify the 5 volts into a 12 volts signal. However, due to the fact that the power generated to rotate a load by a motor is closely related to the current, a transistor will be included in the design to amplify the current. So, when this signal reaches the motor, the voltage of the signal will cause the motor to run at the maximum speed with enough power to rotate the load for a random time between 3 to 4 seconds. This process is depicted in Figure 14. The actual schematic for the circuit is shown in Figure 24.

![Diagram of the circuit](image)

**Figure 14: The process by which the motor is triggered.**

Calculation of Torque:

When one is selecting a motor for a specific purpose, he needs to look at the specification sheets and determine if the torque supplied by the motor will be able to overcome that needed for the design. For our design, we are using a simple DC motor whose torque supplied can be related to the speed of the motor using equation 1.

\[
Torque = \left( \frac{-T_o \cdot speed}{W_f} \right) + T_o \tag{Equation 1}
\]

Equation 1 was determined using the Fig. 15, which depicts the general behavior of most motors. In equation 1 $T_o$ stands for the stall Torque, which represents the highest amount
of torque a motor can generate when it is fully loaded. $W_f$ is the free speed of the motor when it is not loaded. These two parameters can be found in the datasheets of the motor. However, the challenge for determining the right motor is to determine the torque needed.

The torque due to the inertia of the wheel is equal to the inertia of the wheel times the angular velocity of the wheel. The moment of inertia of a wheel is equal to the mass of the wheel times the radius of the wheel squared. Angular velocity of the wheel can be determined from the fact that the maximum speed the wheel will run at is 30 revolutions per minute (.5 revolutions every second). And the design requires that the wheel reaches this speed in 2 seconds. This means that the acceleration of the wheel is equal to the .25 revolutions per second squared. In order to determine the angular acceleration of the wheel, divide the acceleration of the wheel by the radius of the wheel (6 inches). The angular velocity of the wheel with 6 inches of radius is around .0416 revolutions per second squared-inches.

Using the density of PVC to be around 1.50 grams per milliliter and volume of the wheel can be calculated by multiplying the area of the disk times the thickness of the wheel. So, the mass of the wheel is 1.50 g/ml times 459 ml, which is equal to 689 grams. From this we can calculate the moment of inertia for the wheel, which turns out to be 24804 grams-inches squared. Finally, the torque due to the inertia of the wheel is 24804*.0416, which is equal to 1031 grams-inches-revolutions per second squared. The frictional torque can be neglected due to its small value. Altogether, a motor that can provide a torque well above 1031 grams-inches-revolutions per second should be good.
Figure 15: The figures depict the typical behavior of a motor. A) Speed-Torque curve. B) Power-Torque curve. C) Current-Torque Curve.

Testing for the functionality of the motor can be done by placing similar load on the shaft of the motor to and see if the motor is able to rotate the load. Also, a Labview program can written to test the functionality of the circuit by designing the program is the digital output connection can be used to stimulate the circuit and start the rotation of the motor. The program will provide the signal for 3 to 4 seconds randomly, similar to the microprocessor. If the motor rotates as intended then, the troubleshooting for any problems can be made user by concentrating on the microprocessor program or even the validity of the signal outputted by the motion sensor or the push button amplifier circuit.

Overall, this design took into consideration the amplifying of signal received from the push button and the motion sensor to a value of 5V when a signal is detected. Also, different from previous design an amplifier circuit will be used rather than a relay to amplify the voltage required for the maximum rotation speed. Similar, with the previous design is the use of a transistor to amplify the current so that the motor can generate enough power to rotate the load.

1.2.5 Methods of Spinning the Wheel

Due to the fact that the adults playing the game have some disabilities that limit their motor function there will be two different types of spin activators. The first type of activators will be a push button on a remote control that will wirelessly activate the wheel to spin while the second activator will be a motion sensor that will be located on the base of the game.

The remote being used will be the CMD-KEYX-XXX Keyfob Command Unit supplied by Linx Technologies (Fig. 16). This keyfob is commonly used for general purpose remote control and command purposes such as keyless entry, garage/gate openers, lighting control, security/call systems and home/industrial automation. The entire keyfob is of a compact size (5.69 cm long, 3.43 cm wide and 1.14 cm thick). There is an option to have anywhere from one to five buttons. The activator button of the keyfob is large so that it is easy to find and press. The keyfob has selectable addressing which allows for $2^{10}$ distinct transmitter-receiver relationships. The keyfob will be powered by a three volt lithium cell.
The keyfob combines a high-performance surface acoustic wave (SAW) based transmitter with an encoder that is located inside of the keyfob. The status of any one of the optional five buttons can be transmitted with the state of ten address lines for security and unique transmitter/receiver relationships. Once one of the optional five buttons is activated power is sent to the internal circuit and the encoder IC is activated. The encoder will then detect the logic states of the address traces and button data lines. The states are then arranged into a three transmission cycle that will continue on until the button on the keyfob is released. The data from the encoder is used to modulate the transmitter. This will then activate through the antenna and be sent into the airways. This signal will then be received by any Linx KH or LC receiver or function module that is of the same frequency. The received data is then decoded by the decoder IC or custom microcontroller. A match is then looked for between the transmitted address bits and address settings of the receiving device. If there is a match then the decoder output is set to replicate the transmitter’s button status. Please see Fig. 17 for the keyfob schematic diagram.

The receiver to be used is the 4-Position Relay Function Module supplied by Linx Technologies (Fig. 18). This function module has the same general purpose applications as the keyfob. There is also selectable addressing as an option for the function module. When the function module and keyfob act together they become a reliable wireless
switching device for distances up to 304.8 m. Overall the function module is of a small size so that it is able to fit inside of the base of the game. The function module is 14.67 cm across, 4.5 cm high and 8.1 cm thick.

Figure 18: 4-Position Relay Function Module

After there has been a match the decoder’s outputs are set to replicate the state of the encoder’s data lines. The relay outputs of the function module are then latched on or off. Momentary operation is desired when using the remote thus jumper pads J2 through J5 will be bridged. Each one of the jumpers corresponds to a relay. Figure 19 shows the jumper pads inside of the relay function module. Figure 20 displays the schematic of the function module.

<table>
<thead>
<tr>
<th>Relay</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumper</td>
<td>J2</td>
<td>J3</td>
<td>J4</td>
<td></td>
</tr>
</tbody>
</table>

Figure 19: Jumper Pads of Relay Function Module
Figure 20: Schematic of the Function Module

The function module will be attached to the switch that activates the motor unit. The switch is to be attached to the heavy-duty quick-connect block terminals of the function module. Wire gages from 16-26 AWG are accepted.

The orientation of the antenna is extremely important in receiving a proper signal. The product is designed to allow the user to be able to rotate and move the antenna around. However, it is found to be most optimal when the antenna is in a vertical position. The placement of the module will also affect the range. The module will be placed inside the base of the game. The base of the game is made out of PVC plastic (non-conductive) thus it will not be necessary to have the antenna sticking out of the side of the base.

The other type of activator will be a motion sensor (Fig. 21). It was indicated by the client that some of the adults that will be playing have difficulty performing simple motor tasks. Thus, it would be optimal to make activating the wheel as simple as having the player wave his or her hand over the side of the box facing them. The motion sensor will have a beam angle of 38° horizontal and 22° vertical. This is optimal because we do not want a large range of sensing. Players could make simple movements that may activate the motion sensor when it is not their turn so therefore the range of motion sensing cannot be too great.
Testing of both types of spin activators is necessary in the game's function. It is extremely important to test the remote in the type of environment that the game will normally be played in. External noise, such as produced by motors or other sources of RF emissions, paging towers and amateur radio activity, are all examples of interference with the wireless signal. It is mentioned that there is a television in the central room. Therefore it is important that the remote for the game functions at a different frequency than the remote for the television. The two activators will also be functioning at different frequencies to prevent double activation.

1.2.6 Audio Comments
There will be four audio comments that can be activated when playing the game. This will be made possible using the SP03 text to speech synthesizer. The SP03 module includes an audio amplifier, a three volt regulator with level conversion to five volts, PIC processor, WTS701 (single text to speech chip) and forty millimeter speaker. An RS232 interface will be used to speak up to thirty predefined phrases. A PC program SP03.EXE is used to load up to thirty predefined phrases into the SP03. The SP03 module has the capability of taking the ASCII text and converting it to audible words. Refer to Fig. 22 below which shows the SP03 and connections and Fig. 23 which displays the connections to the SP03.
The RS232 serial port is used to control the SP03. Three connections to the host and a five volt power supply are needed. Thirty-two serial commands are able to be sent to the SP03. To speak a single phrase one sends a single command byte to the SP03. Table 1
shows the command bytes and how they are acknowledged by the SP03 for a “hello”
example. Command 0x80 is used to speak a line of text. After the 0x80 command is
three control bytes (volume, pitch and speed) and the ASCII text. Following the text is a
0x1a character and a 0x00 character.

<table>
<thead>
<tr>
<th>Table 1: SP03 Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Command byte Transmitted to SP03 Module</strong></td>
</tr>
<tr>
<td>Command 0x80 0x80</td>
</tr>
<tr>
<td>Full Volume 0x00 0x00</td>
</tr>
<tr>
<td>Speech Pitch 0x04 0x04</td>
</tr>
<tr>
<td>Speech Speed 0x02 0x02</td>
</tr>
<tr>
<td>Text 'H' 'H'</td>
</tr>
<tr>
<td>Text 'e' 'e'</td>
</tr>
<tr>
<td>Text 'I' 'I'</td>
</tr>
<tr>
<td>Text 'o' 'o'</td>
</tr>
<tr>
<td>NULL 0x00 0x00</td>
</tr>
<tr>
<td>SP03 will now speak the text</td>
</tr>
</tbody>
</table>

Command 0x81 is used to read back to the WTS701’s status register. After this is read a
response will be sent with first the low byte and then the high byte of the WTS701 status
register. The C code is displayed in Fig. 24.

```c
    do {
        SerOut(0x81);       // send Get Status command
        sts = SerIn();      // get low byte
        sts += SerIn()<<8;  // get high byte
        sts &= 0x8003;      // select bits to test
    } while(sts != 0x8001);   // and loop until finished speaking

Figure 24: C Code
```

Command 0x82 is used by the SP03.EXE program to download the thirty predefined
phrases into the PIC’s flash memory. Operation of the SP03.EXE program is started by
selecting the Com port and setting the Volume, Pitch and Speed sliders as shown below in
Fig. 25. Typing a phrase into the boxes and pressing “Test” will allow the words to be
spoken. Programming the phrases is done by pressing the “Program” button. The
phrases will then be compressed and stored into the flash memory of the PIC16F872
processor. The message bar will show when the program is completely processed. Thus
a computer is not needed at all times. The computer program is simply used to type the
phrases that are desired to be spoken by the SP03. Once the phrases are typed in they are
burnt onto the microprocessor and the use of a computer is not necessary any longer.
1.2.7 Game Power
The game will be powered by three nine volt batteries. The batteries will be rechargeable and long-lasting to make the game last as long as possible. The batteries will be easily accessible on the game base to make taking out and recharging the batteries an easy task. Voltage regulators will be added to ensure that high voltages will not be supplied to certain components of the game.

1.2.8 General Circuit of the Game

![General Circuit Diagram]

Figure 26: General circuit
1.2.9 Voice Recorder

During the playing of the game a complication may come up that prevents a staff member being present to read the questions and answers. This potential problem will be solved by having a voice recorder available with some questions and answers previously taped with pauses included so that the game can still be played. Figure 27 shows a potential voice recorder that can be used. Figure 28 outlines the specifications of the voice recorder.

Figure 27: Microcassette Voice Recorder M-475

<table>
<thead>
<tr>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Audio</strong></td>
</tr>
<tr>
<td><strong>Tape System:</strong> 2-Track 1-Channel monaural</td>
</tr>
<tr>
<td><strong>Frequency Response:</strong> 250-4000Hz</td>
</tr>
<tr>
<td><strong>Inputs and Outputs</strong></td>
</tr>
<tr>
<td><strong>Input(s) --- DC-In, 3V</strong></td>
</tr>
<tr>
<td><strong>Output(s) --- Earphone/Headphones</strong></td>
</tr>
<tr>
<td><strong>Power</strong></td>
</tr>
<tr>
<td><strong>Power Requirements:</strong> DC 3V with &quot;AAA&quot; x 2 batteries (supplied); AC 120V, 60Hz with optional AC adaptor.</td>
</tr>
<tr>
<td><strong>Battery Life</strong>(Approx.): Rec: 14.5 hours</td>
</tr>
<tr>
<td><strong>Speaker</strong></td>
</tr>
<tr>
<td><strong>Speaker Unit:</strong> 1.4&quot; (36mm)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
</tr>
</tbody>
</table>

20
<table>
<thead>
<tr>
<th>Features</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>3.42 oz (97g)</td>
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<tr>
<td>Dimensions</td>
<td>2.1&quot; x 4.3&quot; x .85&quot; (54 x 109 x 22mm)</td>
</tr>
<tr>
<td>Supplied Accessories</td>
<td></td>
</tr>
<tr>
<td>Microcassette</td>
<td>x 1</td>
</tr>
<tr>
<td>&quot;AAA&quot; Batteries</td>
<td>x 2</td>
</tr>
<tr>
<td>Color</td>
<td>Silver</td>
</tr>
</tbody>
</table>

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**Figure 28: Microcassette Voice Recorder Specifications**

This will greatly help in the making of this game to be user-friendly. By having a voice recorder available the game will be able to be played at any time, even when the staff members are not present. However, the voice recorder is not part of the circuit of the game. It will be a feature that can be used only when a staff member cannot be present. It will run on batteries and will not need to be attached to the game’s power supply at all. This is an addition to the previous designs so that the game can be played at any time.

1.2.10 Questions and Answers Book

There will be twenty questions and answers provided with the game. The questions should be constructed so that the adults can answer them with ease. Thus each of the twenty questions will be written at the elementary level. Each question and answer will be typed on a sheet of paper. Each sheet of paper will be inserted into a plastic cover sheet to ensure that the questions and answers can withstand wear and tear over time. Additional plastic cover sheets will be supplied to enable to staff to add their own questions when they see fit. The binder will be small enough to fit inside of the base of the game. This will allow for easier transport.
2. Realistic Constraints

Engineering standards were reviewed and compared to the components of the Interactive Wheel of Fortune Game. Engineering standards were searched within the database created by the International Electrotechnical Commission (IEC).

### Table 2: IEC Standards

<table>
<thead>
<tr>
<th>Code #</th>
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<tr>
<td>19.020</td>
<td>IEC 61124(2006-03): Reliability testing - Compliance tests for constant failure rate and constant failure intensity</td>
</tr>
<tr>
<td>21.240</td>
<td>Rotary-reciprocating mechanisms and their parts</td>
</tr>
<tr>
<td>21.040</td>
<td>Screw Threads</td>
</tr>
<tr>
<td>21.060</td>
<td>Fasteners</td>
</tr>
<tr>
<td>31.240</td>
<td>IEC 62194(2005-08): Method of evaluating the thermal performance of enclosures</td>
</tr>
</tbody>
</table>
The economic consideration has mainly to do with the cost of the overall game. Many games that are currently on the market and are designed specifically for disabled people are extremely expensive. Many disabled people have limited money available for extra things due to high medical bills. These people should have equal opportunity when buying a typical board game. It is important when designing this game to keep this in mind. There will not be a need for the game if it is too expensive.

Environmental impacts have to do with the packaging and electronics of the game. All of the products used in the development of the game must be environmentally safe. The battery used to supply power must be certified and suitable for the use of the game. An alkaline battery will be used because it is much safer than a lead acid battery. Some components may age and need to be replaced. Thus it is important that all components be able to be thrown away and not harm the environment. It is very important to keep the environment in mind when designing any new product. There are many materials that are able to be recycled and designers must keep this in mind and try to use as many of these materials as possible.

Sustainability considerations need to be closely examined. The game will mainly be used in the ATCO sheltered workshop central room; however it will also be transported to the Passion Works Studio. The game must be heavy duty and able to be moved around. It is not desirable to have components of the game falling off or breaking down. It is of advantage to have the game last as long as possible. The game can nearly be re-created by adding new questions such that as adults keep playing the game it will never be boring. Thus the batteries will be rechargeable, the motor unit will be high powered and the plastic will be of optimal thickness and quality so that the game can be played for many years.

Manufacturability is important when looking at the large range of events. It is important to again keep manufacturing inexpensive. This game is able to be used by a large range of clients. It is specifically designed to be used by people with disabilities. However, anyone can play the game and find it stimulating. Thus there is a large client number which proves the game could be manufactured in large amounts.

Ethical issues are a large consideration. It is important to design this game based on the players being disabled. However the design does not want to insult anyone or make any
player feel uncomfortable. This is important when designing the questions of the game. They need to be of ease so that the players can answer them correctly.

There are limited health and safety concerns due to the fact that the game does not go into any human or test anything on or inside of the human. Thus no one will be unhealthy if the game malfunctions. The main health and safety concerns were to not have any tripping hazards by eliminating the power cord and enclosing all electronic components as to prevent shock.

The game is meant to stimulate the players and allow them to interact with one another. This enhances their social skills. The game is intended to bring about joy and excitement. Any political considerations could have to do with any ethical concerns that have to do with the game. It is not foreseen as to have any large political problems when designing the game.
3. Safety Issues

Safety considerations are some of the most important issues when designing and building a project. It is important that nothing on the project does any harm to anyone interacting with the specified project. In this case an interactive Wheel of Fortune game cannot harm the disabled adults that will be playing it at the ATCO sheltered workshop.

All of the wires containing electrical signals throughout the game will be insulated and covered in some sort of plastic coating so that they will not fray or split at inconvenient times. The wires must also not be exposed so therefore they will be entirely enclosed in the base of the game. This will help to prevent any tripping hazards, which could be quite detrimental to the players of the game. This is especially important due to the fact that the players have many disabilities and most of them have limited motor skills in which any small tripping hazard will be amplified.

The batteries used to power the game must not be hazardous to someone’s health. Alkaline batteries are not considered hazardous waste under the US Environmental Protection Agency so therefore they are the optimum battery of choice. Lead acid batteries should not, and will not, be used throughout this project due to the fact that they could be very hazardous to everyone interacting with the game. Lead-acid batteries use a chemical reaction to do work on a charge and produce a voltage between their output terminals. This sounds like a good thing but in reality it produces many hazards. This is the main reason that lead-acid batteries will not be used in the game.

When dealing with motors there are many mechanical safety issues that become prevalent as a device is worked upon. A voltage regulator must be used as an adaptor so that the motor unit will not get too much power which will in turn cause it to burn out and possibly start a fire. The wires from the motor must also be covered for the personal safety. This will also help to prevent wires from touching, which will in turn short-circuit the motor. Proper occupational safety and health administration (OSHA) standards need to be followed in the building of the motor. The motor must be enclosed so that the spinning will not cause any harm. A thirty revolutions per minute (rpm) motor was chosen so that it will not cause the spinner to spin so fast that it would cause bodily harm to the players playing the game. However thirty rpm’s will be fast enough to make the wheel spin which will in turn captivate the adults playing the game. The actual spinner on the game will not pose any risks to the adults playing the game. The wheel will only be spinning at thirty rpm’s for a very small amount of time and then it will slowly come to a complete stop. This feature will minimize any injuries that could come to light.

When the actual building of the game takes place proper protection needs to be available for the builders. A voltage meter should be on hand so that no device gets to much power. When using tools it is imperative that the user knows how to handle the tool itself as well as the operation protocols that go along with it. The proper safety specifications must also be, and will also be, followed so that no harm gets done to the builders themselves.
4. Impact of Engineering Solutions

Today, there are thousands of disabled people that cannot live their lives independently and function as a normal person. Taking care of these disabled brings a lot of value within our society. Due to this fact, organizations have been formed to make the disabled feel like a normal person. One such organization is the ATCO sheltered workshop, situated in Athens. At the workshop, the disabled adults are giving work to do. However, during most of their free time, they spend numerous hours watching television, which provides them with a dreamland and prevents them from getting harmed. However, television doesn’t serve the purpose of a life. The television does not provide social stimulation. In order for the workshop to prove to be beneficial to the disabled adults, the ATCO staff members desire that people that do suffer from disabilities are able to enjoy games and other stimulations that healthy people do.

Our client’s believe that a Wheel of Fortune game will provide the disabled adults at the workshop shelter a way to become more sociable and interactive with their surroundings. Social skills are imperative in functioning in this every changing global society. Furthermore, designing an interactive wheel of fortune game for the disabled can have many impacts that are global, societal, economical, and environmental.

People all over the world suffer from a number of different disabilities, such as cerebral palsy. Due to these disabilities, they have very limited more skills. Nevertheless, the disabled are very smart, but have limited reading abilities. Currently, there are not many games made for the disabled in the world. Many of the games that are designed for the disabled are extremely expensive and do not provide much entertainment. Many of these market games are simple card games and are not true board games. Although many people with disabilities lack simple motor skills that many people take for granted, there is much technology that can be used to assist the disabled in playing a board game. This design takes into consideration the limited movement of the disabled adults. The game will provide a motion sensor that will require very small movement in order for the game to start. Also, it takes into consideration the reading levels of the players. Thus this game is designed for people of all ages. If a disabled player is able to read they are able to see and read their own question. If a player does not have any reading skills then the staff member or other person can assist them and verbally answer their question. Also, if this game were to go global it would be very easy to produce in different languages. All that would need to be changed is the one pie piece “Lose a Turn” and the questions and answers book. Having a game designed specifically for disabled people to use will help them to realize their importance to this world. It will help build their social skills with other disabled adults and the staff members. Plus, answering the question correctly might help build their self-esteem. Overall, this game will provide the adults a chance to become more sociable.

As mentioned earlier, the market games that are designed specifically for disabled people are expensive. As many people that suffer from disabilities spend much money annually on treatment and long-term care, they often do not have extra money to spend on visual
enhancement and entertainment. That is why many disabled people are resorted to watching the television. If this engineering design were to be placed into the market, it will prove to be a great economical decision due to its low cost and potential profits. Low cost is extremely important to people when purchasing a game. Furthermore, the profits cannot be limited to monetary values, but rather it is important to see the profits gained by the disabled adults. The joy that many of these adults will experience is profound. Not only will they be enhancing their social skills, but also they will be able to be visually enhanced by all of the visual enhancement features in the Wheel of Fortune Game. Overall, economically this design provides an interactive Wheel of Fortune game made for the disabled adults with low cost and large profit.

There are very few environmental issues concerning this design. Unfortunately, the material used for the design eventually will be thrown out or recycled and replaced with new material in order to guarantee operational safety and good results. However, not all material can be recycled and some that can be recycled can prove to be expensive. Eventually, all the material will be thrown out, making the environment more hazardous and dangerous for everybody. In a greater aspect, when one defines environmental concerns, he or she can also take into consideration the safety surrounding the design. As described in the safety section of the report, this interactive game will prove to be safe to the people playing the game and to the surrounding environment. The material that will be used for the design has been used previously by engineers in many different designs and has proven to be environmentally safe. However, it is very hard to determine the effects that the surrounding environment will have on the material used. In other words, it is hard to determine how the material used will react if some sort of chemical was accidentally spilled onto the game. This spillage may cause a bad reaction and make the environment toxic. This environmental safety issue will be taken into consideration when the guide of the game will be written. The names of all the known chemicals that might react unpleasantly with the material used will be given in this guide.

Overall, globally this design will make our society more aware of their surroundings and understand the value that a disabled person provides to us. On the other hand, the disabled adults will see and understand their importance in this world. Economically, the designed game takes into consideration the high cost of living and caring for a disabled and provides a game that will prove to be relatively inexpensive compared to the profits gained from it. Also, this will be the only game of its kind, designed especially for the disabled and prove to be beneficial to its manufacturers. In terms of society, this game will provide the disables adults with the chance to enhance their social skills with others around them. Plus, it will help build their self-esteem levels higher. At the last the environmental issues surrounding this design are small, but need to be taken into consideration. The two environmental issues that prove to most important are the recycling of material and unpleasant chemical reactions with the material used to build the game.
5. Life-Long Learning

In the process of learning how to create an interactive Wheel of Fortune game, new knowledge and techniques were acquired. Researching the different parts to the game revealed that there are many different tools that can be used that are available.

Upon researching how we could get words to be spoken during the playing of the game many new things were found. The SP03 text to speech synthesizer was found to be something that could do everything that was needed and more. New vocabulary had to be learned as well as new processes of researching the information needed. Even though the SP03 can have up to thirty programmed phrases the Wheel of Fortune game will only use four. There will be extra “spaces” but we learned how to deal with that and make the game benefit from it. Computer programming will also be incorporated into the use of the SP03 text to speech synthesizer. The specific programming language will need to be learned so that this will be something that can actually be built. Outside help will be incorporated in this task so that the program will be accurate and will run correctly.

In the process of coming up with the game different motors needed to be researched with the best one chosen for the game. You can either have a DC motor and an AC motor. With a DC motor the signal will have to be converted to an AC signal before it can be used. However, we have chosen a DC motor based on the research we found. Different websites were used so that we could have the best information available. Once the type of motor was chosen the revolutions per minute (rpm) had to be analyzed and chosen as well. This was important because the motor is what will make the wheel spin so therefore the rpm’s could not spin the wheel too fast or too slow.

Different plastics were researched so that the best plastic could be incorporated into this project. It became prevalent that polyvinyl chloride plastic would be the plastic of choice. Acrylonitrile Butadiene Styrene (ABS) plastic was researched due to the fact that it is used to make light, rigid, molded products. However, there was not enough substantial information to make us want to use ABS plastic over PVC plastic.

The game incorporates different types of switches in the different parts of the game. These needed to be researched so that an educated decision as to which one to use could be made. Information gained from previous classes was put to good use as well. Talking to previous teachers about the best switch to use also proved to be a great asset in this area.

Working in a team of three students has helped us to learn about group working. Each person has had their own tasks and without them getting done the project will not be completed. This has been challenging at times but it has also helped in the preparation for the working world. Having a team with each person having a different specialty has been an asset and is something that should always be striven for when working on future projects.
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