Operator’s Manual:
Accessible Weight Scale for Seated Users

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Important Safety Instructions

Ensure that weight scale is securely fastened to toilet

The Accessible Weight Scale for Seated Users utilizes two bolts in order to securely fasten the elevated toilet compartment to the toilet. These bolts are located in the rear of the elevated toilet compartment and should be fastened through the holes normally used to fasten the toilet seat to the toilet. These bolts need to be securely fastened before the user attempts to use the device. This will prevent the Accessible Weight Scale for Seated Users from being pulled off the toilet and causing injury to the user.

Do not submerge handheld console in water

The Handheld Console is designed to be water resistant. However, to reduce possible electric shock the user should take care not to submerge the Handheld Console underneath water.

Be aware of position of foot support

The foot support is utilized when taking a measurement in order to take into account the weight of the user’s feet. The user should be aware when getting on and off the device as to the position of the foot support. The foot support does protrude in front of the elevated compartment. The foot support has hinges to help move the foot support plates out of the way when the user wishes to get on the elevated toilet compartment. These should be utilized to ensure safe transfer on and off of the elevated toilet compartment.

Internal electronics should only be accessed by a professional

The internal electronics of the Handheld Console and Elevated Toilet Compartment should only be accessed by a professional. These electronics can cause a mild electric shock if tampered with by anyone other than a professional.

Keep device from extreme heat and/or cold

The Accessible Weight Scale for Seated Users makes use of electronics that will no longer function properly if exposed to extreme heat or extreme cold. To prevent damage to the device these conditions should be avoided when possible.
Users who require assistance should have it

The Accessible Weight Scale for Seated Users is designed to be easy to use for persons having limited mobility. However, for users who require extra assistance and emergency standby, these services should still be made available to them.
Parts and Accessories

Handheld Console

Low Clearance Handles

Adjustable and Removable Foot Support
**Features**

The Accessible Weight Scale for Seated Users makes use of the following features to aid the user in measuring and keeping track of their weight:

- Simple user interface
  - Only three buttons ‘yes’, ‘no’, and ‘setup’
- Displays data visually for users with audio impairments
- Outputs data audibly for users with visual impairments
- Colored buttons used to easily distinguish ‘yes’ and ‘no’ buttons
- Braille labels for buttons for users with visual impairments
- Wireless communication with handheld console
- Low clearance handles
- Adjustable/Removable foot support
- Easily accessible battery compartment
- Access to previously stored weight values
- Measurements automatically taken
- Device powers down automatically after 5 minutes
- Device powers on automatically when weight applied
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1 Introduction

1.1 General Overview

The Accessible Weight Scale for Seated Users is designed to be a comfortable easy to use weight scale for users with difficulty standing for long periods of time. This Model is made for household use on a toilet that does not meet the Americans with Disabilities Act (ADA) requirements. Most household toilets are about 14 inches in height from the floor to the top of the toilet bowl. ADA requires that handicap accessible toilets be between 17 and 19 inches in height. Thus in accordance with industry standards the Accessible Weight Scale for Seated Users elevates the toilet seat 5 inches. The Accessible Weight Scale for Seated Users has three main components, the Elevated Toilet Compartment, the Handheld Console and the Foot Support.

1.1.1 Elevated Toilet Compartment

The Elevated Toilet Compartment is the main component of the Accessible Weight Scale for Seated Users. It houses the load cells and other electronics that operate the scale. The Elevated Toilet Compartment will come with the low clearance handles, the foot support channels and the toilet seat fastened to the compartment.
Figure 1.1.1-1 Top View of Elevated Toilet compartment

The load cells used in the Accessible Weight Scale for Seated Users are the Thames Side-Maywood’s 350a load cells. They each have a capacity of over 600 pounds and can therefore easily support the weight of any user.
The Elevated Toilet Compartment will also come with carriage bolts to be used to fasten the Elevated Toilet Compartment to the toilet. These bolts should be inserted through the holes in the back of the toilet and secured using the washer and nuts. It is important that the Elevated Toilet Compartment be properly installed on the toilet so that it is stable and the bolts are securely fastened prior to use.
The Elevated Toilet Compartment has a battery access panel for easy access to the batteries. Before using the Accessible Weight Scale for Seated Users for the first time the 12V alkaline batteries need to be put into the battery holders located in the battery access panel on the front of the Elevated Toilet Compartment.
1.1.2 Handheld Console

The Handheld Console acts as the user interface. It has three buttons the ‘yes’ button, the ‘no’ button and the ‘setup’ button. All user inputs are given through these three buttons. The buttons are all different colors and shapes to make it easier for the user to distinguish between them. The buttons are also labeled in Braille for users with vision disabilities.
Figure 1.1.2-1 Front view of Handheld Console
The Handheld Console outputs user prompts and weight measurements through the Liquid Crystal Display (LCD) and the text to speech device. The Handheld Console is powered by two 9V batteries located in the rear of the Handheld Console. The Handheld Console can be mounted anywhere in the bathroom using a strip of Velcro. Finally the Handheld Console communicates wirelessly with the Elevated Toilet Compartment. When using the weight scale for the first time batteries need to be added to the back of the Handheld Console. To turn the Handheld Console on simply press the ‘setup’ button.

1.1.3 Foot Support

The foot support is used to support the weight of the user’s feet while a measurement is being taken. To install the foot support slide the upper foot support beam through the foot support channel located underneath the Elevated Toilet Compartment. Line up the holes in the upper foot support beam with the holes in the foot support channel and insert the holding pin. Make sure that the pin goes all the way through in order to hold the foot support securely.
The lower part of the foot support slides onto the bottom beam of the foot support so that the foot support plate is in front of the toilet. Simply slide the foot support bracket up or down to the desired height that is comfortable for the user. The foot support uses a brake on the back of each of the lower foot support bracket. When the desired height of the foot support is achieved the brake should be tightened until the foot support will not move.

The foot support has a hinge so that the user can move the foot support plate out of the way when getting on or getting off the Elevated Toilet Compartment.

1.1.4 Tare the Scale

After setting up the scale according to the information included above and before using the scale for the first time the scale should be tared. Taking a measurement while no one is on the scale allows the scale to determine what the baseline weight is. An
approximated value will be programmed into the scale, but to maximize accuracy the scale should be tared.

In order to Tare the scale press on the elevated toilet compartment and press the ‘setup’ button on the handheld console. This will turn both devices on. Next the user should press the ‘setup’ button to enter the setup menu. Once in the setup menu the user is asked a series of questions. “Would you like to tare the scale now?” will be the question asked pertaining to taring the device. To tare the scale press the ‘yes’ button. This will result in a prompt reminding the user that the scale must be vacant prior to taring the scale and ask the user if they are sure they want to tare the device now. The user presses the ‘yes’ button again and the device will tare itself. After the scale tares it will continue through the rest of the setup menu.

1.1.5 Summary of tasks to set up scale

1. Fasten the elevated toilet compartment securely to toilet using carriage bolts
2. Install foot support
   i. Slide upper foot support beams into foot support chanel
   ii. Secure foot support with holding pins
   iii. Slide foot support bracket onto lower foot support beams
   iv. Adjust height and lock in place using brake
3. Insert batteries in Elevated Toilet Compartment and Handheld Console
4. Tare the weight scale
   i. Turn on elevated toilet compartment and Handheld Console
   ii. Press ‘setup’ button on Handheld Console
   iii. Answer ‘yes’ to “Would you like to tare device?” question

1.2 How to use device

The Accessible Weight Scale for Seated Users will have two main modes of operation. There is the normal mode of operation and the setup mode. The normal mode takes a measurement automatically and outputs it to the user then asks the user if they would like to save the data.

The setup menu allows the user to access some of the extra functions of the Accessible Weight Scale for Seated Users. From the setup menu the user can take a new measurement, view past measurements, export data to a nearby computer and tare the scale for more accurate readings.

1.2.1 Normal Mode

To operate the Accessible weight scale for seated users in normal mode the user should first follow set up instructions included in the previous section. The Elevated Toilet Compartment will turn on automatically when it feels the weight of the user. After a ten second delay the Elevated Toilet Compartment will measure the weight of the user and output it to the Handheld Console wirelessly. The user should turn on the Handheld Console by pressing the ‘setup’ button.

The Handheld Console will output the weight of the user through the LCD and text to speech module. The Handheld Console will then ask the user if they would like to
save this data. If the user presses the ‘yes’ button then the data will be stored. If the user presses ‘no’ or does not press a button the data will not be stored. If the user does not press a button after 5 minutes the program will enter sleep mode. Below is the block diagram of the procedure for operation of the Accessible Weight Scale for Seated Users in normal mode.

Figure 1.2.1-1 Block Diagram of Normal Mode
1.2.2 Setup Mode

The setup mode is used to access some of the special features of the Accessible Weigh Scale for Seated Users. These features include the ability to export data to a nearby computer, view past readings, take a new measurement and tare the scale for greater accuracy.

The scale is powered on the same way as in normal mode by applying weight to the Elevated Toilet Compartment and pressing the Setup button on the Handheld Console. Once the Handheld Console is powered on the user can enter the setup mode by pressing the setup button. The setup menu can be reached at any time during normal mode simply by pressing the ‘setup’ button.

Once in the setup menu the Handheld Console will prompt the user with a series of questions. The user simply has to press the ‘yes’ or ‘no’ button in order to decide whether to take a specific action or not. The last question asked will be whether or not the user would like to return to normal mode. Answering ‘yes’ to this question will return to normal mode. Answering ‘no’ to this question will result in the setup program restarting from the beginning.
Figure 1.2.2-1 Block Diagram of Setup Mode
2 Maintenance

The Accessible Weight Scale for Seated Users was designed to be as easy to use as possible. In light of this fact the Accessible Weight Scale for Seated Users requires very little maintenance in order to continue running. The four main tasks that should be completed on a relatively consistent basis are changing the batteries in the Handheld Console and Elevated Toilet Compartment, Cleaning the Accessible Weight Scale for Seated Users and checking the fastening mechanism and foot support to ensure that none of the components have become loose.

2.1 Changing Batteries in Handheld Console

Changing the batteries in the Handheld Console is a relatively easy process. If the Handheld Console does not turn on then it is likely that the batteries have died and must be changed.

Figure 2.1-1 Handheld Console (Off)

In order to change the batteries on the Handheld Console the user must first find a 9V battery.
The battery holders for the Handheld Console are located on the rear of the Handheld Console at the bottom. The user should open this compartment in order to remove the old batteries.

Once the user has removed the old batteries, the new batteries can be put in place and the battery compartment should be closed. If the Handheld Console still does not turn on first check to make sure that the batteries that have just been installed are not dead and are properly installed. If the Handheld Console still does not turn on then there may be a more serious problem and the user should send the Handheld Console back to the manufacturer.
Do not attempt to open any other part of the Handheld Console in order to access the circuits. The Printed Circuit Board (PCB) and other circuits should only be accessed by a licensed professional.

After changing the batteries special care should be taken to properly dispose of the old batteries. Disposing of batteries in the trash can result in significant damage to the environment. It is recommended that all batteries be properly disposed of.

2.2 Changing Batteries in Elevated Toilet Compartment

If the Handheld Console turns on, but does not output a weight it is likely that the batteries in the Elevated Toilet Compartment are dead. Similar to the Handheld Console changing the batteries in the Elevated Toilet Compartment is relatively easy.

Prior to changing the batteries the user should locate a 9V alkaline batteries. A picture of the batteries used in the Elevated Toilet Compartment is shown below.

![9V Alkaline Battery](image)

Figure 2.2-1 9V Alkaline Battery

The battery access panel is located on the front of the Elevated Toilet Compartment.
Once the battery access panel is opened the old batteries can be replaced by the new batteries. It is important to make sure that the new batteries are installed correctly the device will not be powered and more importantly it could cause damage to the weight scale.
Once the batteries are replaced the battery access panel should be closed again. If the Elevated Toilet Compartment still does not operate as it should check again to make sure that the batteries are properly installed. If the problem persists seek the aid of a licensed professional.

Do not attempt to open the Elevated Toilet Compartment in order to access the PCB and other Electronics. Any attempt to fix the Accessible Weight Scale for Seated Users by anyone other than a licensed professional could result possibly result in injury and/or damage to the Accessible Weight Scale.

After changing the batteries special care should be taken to properly dispose of the old batteries. Disposing of batteries in the trash can result in significant damage to the environment. It is recommended that all batteries be properly disposed of.

2.3 Cleaning Accessible Weight Scale for Seated Users

Similar to all other bathroom appliances it is important to clean the Accessible Weight Scale for Seated Users on a regular basis. All surfaces should be cleaned with a disinfectant so as to prevent the proliferation of bacteria.
In a clinical setting this is especially important as diseases could potentially be passed from one user to the next. Similar to a regular toilet above and below the toilet seat should be cleaned.

Periodically it may also be beneficial to clear dust from the screen on the Handheld Console. This will ensure that the LCD is easy to read at all times.

Figure 2.3-1 Front View Handheld Console (being wiped with cloth)

2.4 Tighten Loose Fasteners

As with many mechanical devices fasteners can become loose with time. It is important that when a bolt or screw is noticed as being particularly loose that the user tightens these fasteners again.

Particularly important is making sure that the carriage bolts used to hold the Elevated Toilet Compartment on the Toilet are fastened properly. If these become loose they should be tightened immediately using an adjustable wrench. The carriage bolts should be bolted through the holes normally used for securing the toilet seat to the toilet bowl. If the Elevated Toilet Compartment is not fastened to the toilet properly the user could potentially be injured.
Similarly if screws on the foot support fasteners begin to come loose they may need to be tightened as well using an Alan wrench. This will prevent mechanical failure of the foot support.
3 Technical Description

3.1 Elevated Toilet Compartment

The Elevated Toilet Compartment needed to be 24 inches wide in order to easily accommodate the load cells inside, the foot support underneath and the handles on top. The Elevated Toilet Compartment is comprised of a top panel, a bottom panel, the side panels, and eight support columns.

The Elevated Toilet Compartment uses 8 Aluminum Columns to support the weight of the user. The side panels do support some of the user’s weight, but the principle support system consists of the 8 Aluminum columns.

Figure 2.4-2 Fastening Plate (being tightened)
The eight columns were made of 3/4" diameter Aluminum rods. Each of the rods was cut to a height of 3 3/4". The columns are threaded on both the top and bottom. The columns take 1/4-20x3/4 screws. Flat head screws were used so that the screws did not extend beyond the surface of the top and bottom panels. Below is a top view of one of the aluminum columns.
Figure 3.1-2 Close-up of Column

The side panels of the prototype Accessible Weight Scale for Seated Users are made of the same Aluminum as the top and bottom panels. They were tack welded to the bottom panel to hold them in place. The front panel was cut into two small panels to leave space for the battery access panel. All of the vertical panels are 3 ¾” in height. The side panels are approximately 15” long and the two front panels are each 7” long. The back panel is 20” long.

The side panels of the Elevated Toilet Compartment were too thick to bend for the rounded corners. Instead a 4” diameter PVC pipe was cut into four pieces to fit in all of the four corners. These were spray painted black to match the handles.
The inner hole of the Elevated Toilet Compartment was made of thin aluminum sheet metal. This sheet of Aluminum was bent into a roughly circular shape and spot welded. Its shape final shape was then determined by small tacks that were spot welded to the sheet metal and screwed into the bottom panel.

The toilet seat was simply attached to the top panel the same way as it would be to a toilet bow. The toilet seat hinge screws into the top panel of the Elevated toilet compartment through two plastic screws.

The handles used for this prototype were smaller than originally intended. It was intended to make them low clearance so that the user could slide over them if necessary in transferring from the toilet to their wheel chair. The handles were provided to help users who do not have other transfer bars in their bath room and need extra support in getting on the toilet or maintaining their posture while on the toilet. If the Accessible
weight scale were to be manufactured the handles would be made longer and be a round bar similar to the picture below.

![Figure 3.1-6 Picture of Handles](image)

As stated previously this prototype was made of Aluminum rather than plastic because of limitations of the facilities here at the University of Connecticut. If this product were to be mass produced it would be made of injection molded plastic. Therefore, the columns would simply be attached to the bottom panel and the top panel could be screwed to the columns. The inner hole, side panels, corners and battery access panel would all be made of the same plastic material and would be one piece.

### 3.1.1 Battery Access Compartment

The battery access compartment houses the batteries for the Elevated Toilet Compartment. The compartment can be easily opened by opening the hatch. The batteries are easily accessible inside and the rest of the electronics are isolated so that they cannot be interfered with by the user.
3.1.2 Fastening Mechanism

The previous fastening mechanism called for four clamps positioned around the bottom of the Elevated Toilet Compartment. This design was changed because its stability came under question. With four clamps it could be possible that one would become loose by someone accidentally knocking into one of the clamps.

Another reason for redesigning the fastening mechanism is that the foot support in the prototype design is attached underneath the elevated toilet compartment. The foot support could inhibit the ability of the user to secure the device if the four clamp system was used.

The fastening mechanism used in the prototype model simply uses two carriage bolts that bolt the bottom panel to the toilet. The carriage bolts pass through the bottom panel and through the holes in the toilet bowl that are normally designated for the toilet seat screws. The fastening mechanism uses two washers and nuts to tighten the carriage bolts and secure the weight scale. Once these bolts are properly tightened they will not come loose and they will hold the Elevated Toilet Compartment in place.
3.2 Foot Support

The mechanical component of the optimal design that had the most number of changes was the foot support. The prototype foot support is made from 80/20’s T slotted Aluminum. The T slotted Aluminum is rectangular in shape and therefore can provide more strength for the foot support. Also since the frame is not solid metal this design allows for foot support with a lower weight than the previously proposed design.

The upper foot support bar is 1ft in length. The lower foot support bar is 8 inches in length. This gives the scale about two inches of adjustable height. It would be
possible to make the lower foot support bar another half inch longer for a slightly greater range of adjustable heights for the foot support.

Figure 3.2-3 Foot Support Fully Extended
The T slots in the 80/20 allow for easier attachment to other pieces of 80/20. In this design we developed our own fastening plate to provide a $105^\circ$ angle between the upper and lower part of the foot support. We used the fastening plates showcased in the 80/20 catalog as a reference changing only the angle at which the fastening holes were drilled.

Figure 3.2-5 Aluminum Fastening Plate
Figure 3.2 -6 Aluminum Fastening Plate Dimensions

80/20 also has a breaking system which uses a lever arm and a plastic break to lock a clamp in place on an 80/20 beam. This added feature allowed for a much simpler design for adjusting the height of the foot support. The previous design called for notches at varying heights. This design would not have allowed for many different settings and also would have been much more difficult to build.
Figure 3.2-7  Foot Support Bracket Dimensions

Figure 3.2-8 Foot Support Bracket
Figure 3.2-9 Plastic Brake

The previous design also did not allow for hinges in order to move the foot support panels out of the users weight when not in use. The hinges ensure that the foot support will not get in the users way when they are getting on or off of the Accessible Weight Scale for Seated Users.
There are two foot support plates that provide a large flat surface for the user to comfortably rest their feet. Below are the dimensions of these panels.

Finally the previous design of the foot support called for the foot support to be inserted through holes in the front panel. This idea was rejected based on internal space constraints, manufacturability, and water proofing. It would have been difficult to make the channels internal rather than external and ensure that the channels were sealed. Also
it was determined that with the load cells being fairly large there would not be enough space inside to allow for a foot support beam. The foot support was not added to the sided of the Elevated Toilet compartment because it would put too much strain on the side panels.

The foot support channels are attached by flathead screws and nuts. The head of the screw is inside the Elevated Toilet Compartment. This gives the bottom panel a flat appearance on the inside. In the actual Accessible Weight Scale for Seated users the channels would be one piece with the rest of the Elevated Toilet Compartment and screws and nuts would not be necessary to attach the foot support channels.

Four channels were used to limit the amount of strain that would be put placed on each channel by the foot support. The dimensions of the channels are shown below.
The single consistency between the previous foot support design and the current foot support design is that a holding pin is used to ensure that the foot support does not slide out of the foot support channel unintentionally.

### 3.3 Microcontrollers

In order to perform most of the functions of the Accessible Weight Scale, including A/D conversion, display, wireless communication and others, two microcontrollers were utilized. The Microchip PIC16F877 microcontrollers were used for the project.

![Figure 3.3-1 – PIC16F877]
The PIC16F877 microcontrollers were chosen due to the abundance of A/D conversion pins, USART capability for the wireless communication, SCL and SDA pins for the Text-to-Speech device, as well as pins for the input of pushbuttons. To further illustrate why the PIC16F877 microcontroller was chosen, the key features for the microcontroller are shown below:

![Figure 3.3-2 – Key Features for PIC16F877](image-url)

In order to configure the analog to digital converter of the microcontroller, the ADCON0 and ADCON1 registers had to be used and configured to match the needs of the A/D conversions. The three load cells used in the device required individual A/D inputs, which were input to RA1, RA2 and RA3. The bit channels were selected and set through the source code, which is shown in Figure ???. The ADCON0 register specifications are shown on the following page:
Figure 3.3-3 – ADCON0 Register

The ADCON1 register, shown on the following page, was used to configure the A/D pins/bits for the input of each of the load cells. It was also used to right justify the returned result of the 10-bit A/D conversion, so that a value between 0 and 1023 could be obtained. Bits 0-3 were set as all zeros in order to allow for all analog inputs, which was required for the analog signals being input from the load cells.
Source code, written in C, for the A/D conversion subroutines is shown below and on the following page to demonstrate the structure of the program for the conversions.

```c
void init_a2d(void)
{
    // ADCON0=0b01000101; // select Fosc/2
    ADCON0=0;
    // ADCON1=0b01000000; // select left justify result. A/D port configuration
    RA0-RA4=analog, RA5-RA7=digital
    ADCON1=0x80;
    ADON=1; // turn on the A2D conversion module
```
The ADC_VALUE and ADC_VALUE+, shown above, are set up to return a 10-bit result, which was needed for greater precision in obtaining the weight, although the comment after the “return” says that an 8 MSB will be returned.

### 3.4 Load Cells

The load cells are another extremely significant part of the device as they are the mechanisms for allowing a weight to ultimately be taken. Thames Side-Maywood’s 350a load cells were chosen for the device, and their specifications are shown on the following page:
Figure 3.3-5 – 350a Load Cell Specifications

The load cells were wired such that the +ve input GREEN received +12V, the –ve output BLACK was grounded, the +ve output RED was input into an op amp, and the –ve output WHITE was wired into an op amp. The two outputs were wired into the op amps in a difference amplifier setup to obtain the difference between the two signals and obtain the millivolt change when a load was applied. The difference amplifier circuit and the TL072CP op amps are shown below:

![Difference Amplifier Schematic](image)

![Op Amp Pinout](image)

The difference amplifier circuit also allowed for the difference between the signals to be amplified by wiring feedback resistors with greater resistance than those of the input resistors, and corresponded to the equation gain=Rf/Ri. Because the rated output
of the load cells was 2mV/V, which was 24mV/V with a +12V excitation voltage, the signals needed to be amplified by a factor of 200 to bring the full scale range to about 0-5V for allowable input to the A/D converters of the microcontroller. The amplified signals from the load cells were then filtered for unwanted noise using a first order low-pass filter as shown in Figure 3.3-7.

![Figure 3.3-7 – First Order Low-Pass Filter](image)

The output signal from the filters was then input to a corresponding A/D pin on the microcontroller (RA1, RA2, and RA3).

### 3.5 Wireless Communication

In order to make the Accessible Weight Scale for Seated Users wireless and more convenient to the user, Bluetooth wireless technology was used. Two embedded Bluetooth modules, eb505-SER, from A7 Engineering were utilized to provide the wireless functionality and communicate between the two microcontrollers. Figure 3.5-1 shows a picture of the module and its pinout.

![Figure 3.5-1 – eb505-SER Bluetooth Technology and Pinout](image)

<table>
<thead>
<tr>
<th>Pinout</th>
<th>CN1</th>
<th>CN2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 NC 2 GND</td>
<td>1 NC 2 NC</td>
</tr>
<tr>
<td></td>
<td>3 NC 4 TX</td>
<td>3 NC 4 NC</td>
</tr>
<tr>
<td></td>
<td>5 NC 6 RX</td>
<td>5 NC 6 NC</td>
</tr>
<tr>
<td></td>
<td>7 NC 8 Status</td>
<td>7 NC 8 NC</td>
</tr>
<tr>
<td></td>
<td>9 NC 10 Mode</td>
<td>9 NC 10 NC</td>
</tr>
<tr>
<td></td>
<td>11 NC 12 RTS</td>
<td>11 NC 12 NC</td>
</tr>
<tr>
<td></td>
<td>13 NC 14 CTS</td>
<td>13 NC 14 NC</td>
</tr>
<tr>
<td></td>
<td>15 NC 16 NC</td>
<td>15 NC 16 NC</td>
</tr>
<tr>
<td></td>
<td>17 NC 18 On/Off</td>
<td>17 NC 18 NC</td>
</tr>
<tr>
<td></td>
<td>19 NC 20 VCC</td>
<td>19 GND 20 NC</td>
</tr>
</tbody>
</table>
The eb505-SER utilizes two 20-pin connectors corresponding to CN1 and CN2. For CN1, pin 2 is grounded, pin 4 is wired to the Tx pin on the microcontroller, pin 6 is wired to the Rx pin on the microcontroller, and pin 20 is wired to +5V. The only pin wired from CN2 is pin 19, which is wired to ground. The two Bluetooth modules communicate through the USART functions of the two microcontrollers using source code written to allow the modules to connect and then transmit/receive necessary information.

USART communicates using characters and character strings. Therefore, it was necessary to convert the number value of the user’s weight into a character string. To do this we used the sprintf() function available in the <stdio.h> C compiler library. Below is sample code for how to implement the sprintf() function.

```c
#include <pic.h>
#include <stdio.h>

char buf [5];
float weight;

void main ( )
{
    weight = 176.8;
    sprintf(buf, "%.1f", weight);
    for(;;);
}
```

The % sign is used to indicate that a conversion will take place. The ‘.1’ means that there will be one decimal place and ‘f’ signifies that the variable being converted is a float. Once the value of weight is stored in the character string ‘buf’ it can be outputted using USART write string functions.

The sprintf() function requires a significant amount of memory especially when converting a float to a character string. However, the microcontroller in the Elevated Toilet Compartment does not require a significant amount of memory for other functions and thus the sprintf() function fit well with our programming needs.

3.6 Text-to-Speech

The Accessible Weight Scale for Seated Users not only displays a user’s weight via the LCD screen, but speaks prompts, questions, and data using a text-to-speech device enclosed in the handheld console. The SP03 text-to-speech module, manufactured by Devantech, was used to incorporate the speech functionality of the device. It uses a an audio amplifier, embedded PIC chip, WINBOND chip, and speaker to provide the speech output, when used in conjunction with the host microcontroller. The SP03 and its corresponding pinout is shown in Figure ?? below:
3.6 Text-to-Speech Module

Using IIC functionality in the Master Synchronous Serial Port of the PIC16F877, the device is able to read in the text that is written to the module and then audibly output that text as speech for the user to hear. It identifies modes that the user can select, corresponding questions that the user may answer, and speaks the weight of the user when a weight is taken.

3.7 LCD

An LCD (liquid crystal display) was incorporated into the device as part of the user interface to display text and numbers corresponding to selectable modes, questions/commands, and outputs. The Lumex LCM-S01602DSR/D was chosen for incorporation into the device due to its high quality for a low cost. The Lumex LCD utilizes the standard Hitachi 44870 LCD controllers for a 14 hole pinout. The Lumex LCD is shown below in Figure 3.7-1:
Fourteen pins can be seen in the above figure, at the top of the module, which correspond to the following pinout:

- 1 = Vss (Ground)
- 2 = Vdd (+5V)
- 3 = Vo (Ground)
- 4 = RS (Register Select)
- 5 = RW (Read/Write)
- 6 = E (Enable)
- 7 – 14 = DB0-DB7 (Data Bits)

DB0 through DB3 were wired to ground and were not used in the source code for display to the LCD. DB4 through DB7 were wired to pins RD0 through RD3 respectively, and were set as such in the source code, a snippet of which is shown in the following code:

```c
#include <pic.h>
#include "lcd.h"
#include "delay.h"

#define LCD_RS RA3
#define LCD_RW RA2
#define LCD_EN RA1

#define LCD_DATA PORTD

#define LCD_STROBE() ((LCD_EN = 1),(LCD_EN=0))

/* write a byte to the LCD in 4 bit mode */

void lcd_write(unsigned char c)
{
    DelayUs(40);
    LCD_DATA = ( ( c >> 4 ) & 0x0F );
    LCD_STROBE();
}
```


```c

LCD_DATA = ( c & 0x0F );
LCD_STROBE();

/*
 * Clear and home the LCD
 */
void
lcd_clear(void)
{
    LCD_RS = 0;
    lcd_write(0x1);
    DelayMs(2);
}

/* write a string of chars to the LCD */
void
lcd_puts(const char * s)
{
    LCD_RS = 1; // write characters
    while(*s)
        lcd_write(*s++);
}

/* write one character to the LCD */
void
lcd_putch(char c)
{
    LCD_RS = 1; // write characters
    lcd_write( c );
}

/*
 * Go to the specified position
 */
void
lcd_goto(unsigned char pos)
{
    LCD_RS = 1;
    lcd_write(0x80+pos);
}
```

/* initialise the LCD - put into 4 bit mode */
void
lcd_init()
{
    char init_value;

    ADCON1 = 0x06; // Disable analog pins on PORTA

    init_value = 0x3;
    TRISA=0;
    TRISD=0;
    LCD_RS = 0;
    LCD_EN = 0;
    LCD_RW = 0;

    DelayMs(15); // wait 15mSec after power applied,
    LCD_DATA = init_value;
    LCD_STROBE();
    DelayMs(5);
    LCD_STROBE();
    DelayUs(200);
    LCD_STROBE();
    DelayUs(200);
    LCD_DATA = 2; // Four bit mode
    LCD_STROBE();

    lcd_write(0x28); // Set interface length
    lcd_write(0xF); // Display On, Cursor On, Cursor Blink
    lcd_clear(); // Clear screen
    lcd_write(0x6); // Set entry Mode
}

The code initializes the LCD module and the corresponding pins on the microcontroller so that data can be read and written to the module for display to the user.

3.8 Pushbuttons

The three pushbuttons of the device were input to pins RB0, RB1, and RB2 for the mode button, yes button, and no button respectively. Input to PORTB allowed for simple addressing in the code for the pushbuttons/switching subroutines. Three separate pushbuttons were purchased with different colors – red for the no button, green for the yes button, and black for the mode button. The buttons utilized in the device are shown below in Figure 3.8-1:
All three of the pushbuttons are setup so that the NO pin of each pushbutton is input to their corresponding PORTB pins, while the C pin is wired to +5V. This allows for a pulse of +5V to be sent to the microcontroller so that the button press can be recognized and allow for a function or subroutine to be performed in the source code.

3.9 Handheld Console

The handheld console is the full user interface of the Accessible Weight Scale for Seated Users, which houses the three pushbuttons, the LCD module, the text-to-speech module, and one PIC16F877 all soldered to a printed circuit board (PCB). The electrical schematic of the components within the handheld console is shown in Figure 3.9-1.
The previous schematic shows J, the LCD 14-pin connector, which has pins 1, 3, and 7-10 wired to ground, while pin 2 is wired to +5V. Pins 4, 5, and 6 are wired to RA1, RA2, and RA3 respectively. Pins 11-14 are wired to RD0-RD3 respectively. The schematic shows the three pushbuttons as SW1, SW2, and SW3 with each C pin wired to +5V, and their NO pins wired to RB0-RB2 respectively. The SP03 text-to-speech module has pins 5 and 7 grounded, pin 1 wired to +5V, pins 2 and 3 wired to 2kΩ and to RC3 and RC4 of the microcontroller respectively. The eb505-SER Bluetooth module is wired as discussed in the *Wireless Communications* section. A 9V battery is wired to a LM7805 voltage regulator to allow for the 9V to be regulated to 5V for the electrical components voltage requirements. Both Vss’s of the PIC16F877 are wired to ground and both Vdd’s of the PIC are wired to +5V. A 4Mhz oscillator crystal is wired to pins 13 and 14, and pin is wired to a 100kΩ resistor to +5V.
The PCB schematic for the handheld console, which fully corresponds to the handheld console schematic, is shown below:

Figure 3.9-2 – Handheld Console PCB

Load Cell/PIC2 Amplification Schematic and PCB

A schematic for the load cell/pic 2 amplification and filtering circuit is shown in the following figure:
The connections for the components of the circuit schematic above are the same as those for the handheld console, except for the IC’s. IC1, IC2, and IC3 correspond to the TL072CP operational amplifiers that amplify and filter the load cell signals. IC4, IC5 and IC6 correspond to three of the same ICL 7660SCPA-ND voltage inverter chips, manufactured by Intersil. These three chips are incorporated to invert the +12V supplied by the 12-volt batteries into a -12V for input to the –Vcc pins of the TL072CP so that they can function as desired. The wiring of the load cells to the operational amplifiers was discussed in the Load Cells section. The corresponding printed circuit board for the Load Cells/PIC 2 Amplification and Filtering circuit is shown on the following page.
4 Trouble Shooting

The following table lists potential problems or difficulties that could arise with the electronics/electrical components of the device, the potential causes, and possible solutions to fixing the problems or difficulties.

Disclaimer: Electrical problems or difficulties that arise should not be addressed by the user. The user should contact the manufacturer when an electrical problem is presented. This is to avoid possible injury to the user, as well as causing more damage to the device electronics.
<table>
<thead>
<tr>
<th>Problem</th>
<th>Potential Cause(s)</th>
<th>Resolution</th>
</tr>
</thead>
</table>
| 1.) Device will not power on | - Dead battery in handheld console  
- Dead batteries in elevated compartment | - Replace battery in handheld console  
- Replace batteries in elevated compartment |
| 2.) No display to LCD | - Power problem  
- Most likely an electrical connection problem on the handheld console PCB | - Wait for handheld console to auto turn off, turn back on  
- Contact manufacturer for corrective action and service |
| 3.) Button pressing is not allowing user to take a weight, switch between modes, etc. | - Most likely an electrical connection problem on the handheld console PCB | - Contact manufacturer for corrective action and service |
| 4.) No sound is heard from speaker when it should be | - Most likely an electrical connection problem on the handheld console PCB | - Wait for handheld console to auto turn off, turn back on  
- Contact manufacturer for corrective action and service |
| 5.) LCD shows only black block | - Problem with the handheld console or load cell microcontroller, memory possibly erased | - Wait for handheld console to auto turn off, turn back on  
- Contact manufacturer for corrective action and service |
<table>
<thead>
<tr>
<th>Issue</th>
<th>Possible Cause</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.) Device allows user to press button for a weight but does not return a weight to the LCD or speak the weight</td>
<td>Possible connection problem with the Bluetooth modules</td>
<td>Wait for handheld console to auto turn off, turn back on, try to take a weight again. If this does not work, contact manufacturer for corrective action and service.</td>
</tr>
<tr>
<td>7.) The smell of burning is noticed when device is turned on</td>
<td>An electrical failure resulting in dead electrical components on either the handheld console PCB or the load cell PCB</td>
<td>Allow device auto turn off, do not attempt to power device back on, contact manufacturer for corrective action and service.</td>
</tr>
<tr>
<td>8.) Large volume of liquid has been spilled on handheld console</td>
<td>N/A</td>
<td>Allow device to auto turn off, wait two hours, attempt to power device on. If this does not work, contact manufacturer for corrective action and service.</td>
</tr>
<tr>
<td>9.) Handheld console has fallen into the toilet</td>
<td>N/A</td>
<td>If the user cannot retrieve the handheld console, then someone capable of retrieving the console must do so. Allow the device to dry for at least two hours. If it does not</td>
</tr>
</tbody>
</table>
Problems associated with the hardware of the device, namely the elevated compartment, the leg/foot supports, fastening mechanism, etc. will be addressed for the remainder of this section. Step-by-step instructions are listed and illustrated with the use of pictures.

**Problem:** Elevated compartment is loose, moves side-to-side, or sways.

**Causes:** Loose fastening mechanism and/or carriage bolts.

*Step 1:* Look at carriage bolts underneath the toilet to see if bolts are loose.

<table>
<thead>
<tr>
<th>Problem Description</th>
<th>Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke can be seen emanating from the handheld console</td>
<td>- An electrical failure resulting in dead electrical components on the handheld console PCB</td>
<td>- Allow device auto turn off, do not attempt to power device back on, contact manufacturer for corrective action and service.</td>
</tr>
<tr>
<td>9V Battery Connector for handheld console has become loose or disconnected</td>
<td>N/A</td>
<td>- Contact the manufacturer for corrective action and service/replacement.</td>
</tr>
<tr>
<td>12V battery connectors for the elevated compartment have become loose or disconnected</td>
<td>N/A</td>
<td>- Contact the manufacturer for corrective action and service/replacement.</td>
</tr>
</tbody>
</table>
Step 2: If the carriage bolts are loose, obtain an adjustable wrench, and tighten the hexagonal nuts so that the bolts are tightened.
**Problem:** Total leg/foot support(s) are loose, move side-to-side, or sway with legs in position.

**Causes:** Loose nuts and bolts on channels attaching leg/foot supports to elevated toilet compartment.

*Step 1:* Look at channels, underneath the elevated toilet compartment, holding the leg/foot supports to determine whether or not they are loose.

![Figure 4.3 – Leg/Foot Support Channels](image)

*Step 2:* If the channels are loose, they must be tightened by tightening both the screws and nuts holding the channels to the elevated compartment as shown below:
Figure 4.4 – Tightening of Screws & Nuts on Channels
**Problem:** Foot supports are not at the desired height of the user.

**Cause:** Foot support was set at a higher or lower height than desired.

*Step 1:* Find the black lever arm on the back of the foot supports, which is tightened to a plastic brake holding the foot support to the leg support.

![Figure 4.5 – Black Lever Arm of Foot Support](image)
Step 2: While holding the bottom of the foot support as to stop it from sliding off the leg support, loosen the black lever arm.

Figure 4.6 – Loosening of Black Lever Arm
Step 3: While the black lever arm is loosened and the foot support can readily slide, move the foot support up or down on the leg support to desired height of the user.

Figure 4.7 – Moving the Foot Support Up/Down
Step 4: When the foot support is in the desired position, make sure that it is held in that position and tighten the black lever arm.

Figure 4.8 – Tightening of the Black Lever Arm
**Problem:** Foot plate cannot be moved up or down.

**Cause:** Hinges attached to foot plate may be somewhat stuck, not allowing movement.

*Step 1:* Check the hinges attached to the foot plates to inspect their integrity. Try to push on foot plates to see if any movement is allowed.

![Figure 4.9 – Pushing of Foot Plates to Inspect Hinge Integrity](image-url)
Step 2: If the hinges are in fact stuck, lightly apply some oil to the hinges, or a water displacer such as WD-40, to lubricate the hinges.

Figure 4.10 – Application of oil/WD-40 to Hinges
Step 3: After the application of oil/WD-40, again try to move/push the hinges up or down.

Figure 4.11 – Pushing of Foot Plates after WD-40 Applied to Hinges

Step 4: If the previous steps do not work, the same type of hinges should be purchased at a local hardware store and installed on the foot support. Contact the manufacturer for further detail.
**Problem:** Toilet seat is loose on the elevated toilet compartment.

**Cause:** Screws and nuts fastening the toilet seat to the elevated toilet compartment are loose.

Disclaimer: It is highly recommended that the following steps be performed by a licensed mechanical engineer.

**Step 1:** Unscrew the flathead screws, eight in total, on the top plate of the elevated toilet compartment.

![Figure 4.12 – Unscrewing of Flathead Screws on Top Plate](image-url)
Step 2: Remove all of the flathead screws and group them together. Remove the top plate of the elevated toilet compartment.

Figure 4.13 – Removal of Top Plate from Elevated Toilet Compartment
Step 3: Place the top plate so that the toilet seat is on a flat surface.

Figure 4.14– Placement of Top Plate with Toilet Seat on Flat Surface
Step 4: Tighten hexagonal bolts on toilet seat screws so that they are tight and the toilet seat does not move.

Figure 4.15 – Tightening of Screws of the Toilet Seat
**Problem:** Handheld console will not power on.

**Cause:** 9V battery is dead.

*Step 1:* Open battery compartment located on the back of the handheld console as shown below.

![Figure 4.16 – Opening of Battery Compartment on Handheld Console](image-url)
Step 2: Remove 9V battery from the battery connector.

Figure 4.17 – Removal of 9V Battery from Battery Connector
Step 3: Insert a new 9V battery into the battery connector.

Figure 4.18 – Insertion of 9V Battery into Battery Connector
Step 4: Close the handheld console battery compartment.

Figure 4.19 – Closing of Handheld Console Battery Compartment
**Problem:** Handheld console will power on, but no weight can be returned when a weight is taken.

**Cause:** Elevated toilet compartment’s 9V batteries are dead.

*Step 1:* Open the battery compartment, located in the front of the elevated toilet compartment.

![Figure 1: Opening of the Elevated Toilet Compartment Battery Compartment](image)
Step 2: Remove the 9V batteries from the battery holders.

Figure 4.20: Removal of 9V batteries from battery holders
Step 3: Insert new 9V batteries into battery holders.

Figure 4.21 – Insertion of 9V batteries into battery holders
Step 4: Close the elevated toilet compartment battery compartment.

Figure 4.22 – Closing of the Battery Compartment