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EVALUATING A WHEELCHAIR MAINTENANCE RESOURCE

An Interactive Qualifying Project Report

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by

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Abstract

The goal of this project was to create a wheelchair maintenance resource for the Massachusetts Department of Mental Retardation that consists of a website, a checklist and a manual. The manual gives step-by-step instructions on how to perform maintenance, while the checklist gives a basic overview of the manual for more experienced and repeat users. The website includes variously formatted copies of the checklist and manual as well as information to contact manufacturers, sales and service centers in Massachusetts, and a Frequently Asked Question section. The website, manual and checklist were each carefully evaluated by surveying technical and non-technical users, as well as wheelchair users and caregivers in order to create revised final products.

Table of Contents

List of Figures

1.0 Introduction

1.1 Types of Wheelchair Users

There are many types of people who need to use a wheelchair throughout their daily life. These categories begin with the simple groupings of children, adults and elderly persons. The users are then categorized by their individual physical and mental abilities. Two subgroups are formed; active users are people who need a wheelchair but are able to function normally in most situations while inactive users are those who cannot perform most physical activities. Alongside these two categories are several categories classifying the various cognitive abilities of wheelchair users. Many wheelchair users have varying degrees of mental impairment, therefore forming a variety of groups, being the cognitively able, mildly impaired, moderately impaired, severely impaired and profoundly impaired. Although many groups and categories exist, only certain groupings will be using the information provided on the website, manual and checklist that have been developed.

1.2 Target Audience

Although there are many different classifications of wheelchair users not all of these will effectively use the materials being provided. Both children and the elderly will most likely not use the website; including the manual and checklist. People in the adult category, meaning anyone physically able to perform the tasks and understand the steps needed to be taken, will perform wheelchair maintenance. Viewing the cognitive categories, only the cognitively able and mildly impaired will have the ability to perform wheelchair maintenance. Caregivers will likely perform wheelchair maintenance for

others who cannot ably perform the maintenance routine. Through this analysis, the target audience for this project should be adult wheelchair owners who are either cognitively able or mildly impaired, and caregivers. This information was used to focus the materials presented to a select audience to use.

2.0 Background

2.1 Previous work

Previous work by Ethan Holmes and Andrew Young at WPI on developing a wheelchair maintenance resource was reported in "Development of an Educational Resource for Preventative Wheelchair Maintenance (2001)." In this project, they created a website and instructional video to assist people in performing preventative wheelchair maintenance. Their website included a maintenance section, which explained why maintenance should be performed. The maintenance section also identified weekly, monthly and yearly maintenance tasks and how they should be performed. The website includes a section describing the toolkit to be used, a bulletin board, a list of manufacturers and how they can be contacted as well as a list of sales and repair facilities in Massachusetts. Another page lists books and videos dealing with wheelchair maintenance. A forty-five minute video was created, mostly describing basic wheelchair maintenance tasks such as cleaning a wheelchair.

Work done by Ethan Holmes and Andrew Young was a good start but left much to be desired. Their website and video were both thoroughly critiqued and not reused for several reasons described in the following section.

2.1.1 Critique of Holmes and Young Website

The Holmes and Young website lacked a great deal of necessary information. Their Interdisciplinary Qualifying Project indicated that there was a survey given to Bruce Klockars of Adaptive Equipment Services, Massachusetts Department of Mental Retardation, where he evaluated the website. Mr. Klockars describes the quality of their website as lacking information. Using the Internet as a medium to distribute information,

Holmes and Young could have provided much more information to the users. Wheelchair owners and caregivers searching for product information or tips on caring for a wheelchair may not have the knowledge that this website seems to assume. Not everyone is knowledgeable about specific terms of wheelchair parts and occasionally terms were used which are not defined anywhere on the website.

The weekly, monthly and yearly maintenance steps are very broad, describing in limited detail how to perform each step. A better method could have been to place small amounts of detail on the first layer, linking them to a larger section of information about a certain feature in case the user needed more assistance. The pictures located on the wheelchair maintenance page and in different areas of the website are very general and do not illustrate the particular area being discussed. The website has a picture of the entire wheel to show the spokes. There could have been many other methods used here; highlighting or outlining the spokes, having an arrow pointing to the spokes or having a larger image of only the spokes, rather than the whole wheel. These are all possibilities that would have led to much more effective images.

There are lists of manufacturers, sales and repair companies available on the website. These lists are very large, detailed and in depth. However, they are so large that finding useful information quickly is difficult. The lists would have been much more effective if they were broken down into multiple groups, depending on certain attributes such as manual wheelchair specialists as opposed to power wheelchair specialists. Structuring this information would cause less frustration to users that may not know what they are looking for thereby avoiding confusion in the large list of companies and businesses.

Holmes and Young's introduction page was very plain and simple. It lacked any useful information. There could have been much more information displayed on the home page, which directed users to different areas, rather than just having the left navigation bar. When viewing the navigation bar, it is very simple but does not always describe the contents linked to it. An example of a high quality navigation bar can be found on the WPI website. The WPI homepage is very descriptive of the content which will be delivered, there is also a more thorough description given when a user places their mouse over one of the links. Homes and Young could have added more detail to each link on the navigation bar, allowing users with slow connections to find information quickly rather than clicking on unnecessary links and waiting for all of them to load.

The home page was tested with a colorblind utility (Colorfilter Wickline, Apr. 2004), which found that their choice of color scheme on the page was very good. Throughout each of the colorblind views, their page was completely readable. This shows that the color contrasts selected between backgrounds and text were good choices.

2.1.2 Critique of Holmes and Young Video

The wheelchair maintenance video created within the Holmes and Young Interdisciplinary Qualifying Project had several shortcomings. Although most of the material presented within the video was acceptable only very basic tasks were performed, the list of tasks could have been much more extensive, and the display of the material could have been improved upon as well. Scenes within the video were too long, which created a very time consuming video. On the positive side, because of its length, the tasks performed within the video could most likely be performed while the viewer was

playing the video. During the video, the wheels were removed several times, to perform various maintenance tasks. These maintenance tasks could have all been performed the first time the wheel was removed. A shorter video would most likely entice more people to watch it and continue to watch it in order to perform maintenance in the future. The video also could have been edited, such as when a wrench fell to the floor, creating a more professional display.

Several of the tasks performed in the video could have been performed in an easier manner than displayed, such as wheel removal. Handgrip installation, as performed in the video with WD-40 in order to ease installation, should have been amended, as this increases the likeliness of the handgrips sliding off the frame, creating a runaway wheelchair.

The clarity of the video itself was mediocre. The lack of quality made it difficult to view the tools displayed in the beginning of the video, which is important, as many people are not very familiar with technical names of various tools. A display of each tool and where it could have been obtained may have been more appropriate. This mediocre quality also made it difficult to view what the instructor was doing in several scenes, such as wrench placement during wheel removal. Overall, the video could have been vastly improved upon.

2.2 Benefits of Wheelchair Maintenance

Wheelchair maintenance is important for several reasons, long-term cost benefit, longevity of equipment, safety, appearance of the wheelchair and for a sense of self. Wheelchair maintenance cuts down costly repairs in the future. Simple tasks such as

cleaning a seat can help to reduce the need for expensive replacement covers, cushions and keep the wheelchair looking great. Preventative maintenance goes a long way in keeping a wheelchair in peak performance and extending the life of the equipment. As noted in the previous Interdisciplinary Qualifying Project by Holmes and Young (2001), the first thing people tend to notice when meeting a wheelchair user is the wheelchair. By properly maintaining and cleaning a wheelchair, it presents a more positive image.

Safety is an important matter with wheelchairs. Simple things such as a loose bolt can cause a wheel to fall off and loose grips can easily create a runaway wheelchair, possibly causing injury to the rider. Incorrect inflation of tires and not replacing them can result in improperly functioning brakes. To maintain safe operation, the operator of the wheelchair must be in control of the wheelchair and know how it functions in order to recognize that there is a problem with the chair. Maintenance can also help to create a sense of self, as it educates and creates knowledge and a feeling of importance in the owner. It can bring about a sense of safety, as the operator will learn how the wheelchair operates.

2.3 Wheelchair Research

Prior to developing the material reported here, considerable research was conducted in the topic of wheelchair maintenance. Research in the library and on the Internet, as well as emails and conversations with Bruce Klockars of Adaptive Equipment Services and Michelle Harris of the Massachusetts Department of Mental Retardation, led us to various sources of information including books, videos and websites.

The Internet was found to be an indispensable resource, as various sites were found to contain information on the topic. The sources were found throughout the Internet, needed to be sorted through since many were not reputable. References to wheelchair maintenance videos were found on the Internet; one video entitled "Making Tracks" ("Making Tracks") was obtained and reviewed.

"Making Tracks" ("Making Tracks") is a very basic video including a portion on wheelchair maintenance. It was useful as a learning tool, in seeing how a wheelchair user performs maintenance so that we could produce a checklist and manual accordingly. This video would help produce a new maintenance video, although the time restrictions in the present project did not allow for a new video.

The book "Choosing a Wheelchair" (Karp), by Gary Karp was found through the Internet and ordered. It proved to be a great resource, as it provided us with an example of using pictures of manual wheelchairs with parts labeled as a base for the checklist. The actual pictures could not be used as they were copyrighted; in addition, the pictures missed several important part labels. "Choosing a Wheelchair" (Karp) became a great source for learning about the different parts of a wheelchair as well as how they operate. The chapter on wheelchair maintenance proved to be indispensable in this project, as it familiarized us with what to look for in maintaining a wheelchair. Signs of what to look for are listed for various wheelchair parts as well as how often to check them, in bulleted form much like a checklist. The maintenance chapter served as a basis for the checklist and the manual.

Various checklists for wheelchair maintenance were found on the Internet as well, many proved to be helpful in creating our own checklist and manual, helping us to

understand the basic essential overview of wheelchair maintenance. Notable websites used for checklist and manual information were Able Data's website (ABLEDATA, July 1994), Elite Medical's website (Elitemedical, Apr. 2004), Ohio State University's website (Ohio State University, July 2003) and a site titled "Information for Wheelchair Users" (Yogi, Dec. 2000)

Able Data's website included a fact sheet, labeled as "ABLEDATA Fact Sheet #23 July 1994." This fact sheet provided information on wheelchair components and how they differ, such as different types of tires and footrests. This information helped produce a checklist and manual that covers a broad range of wheelchair components.

Elite Medical's website on wheelchair maintenance, titled "Keep 'em Rollin': Wheelchair Maintenance." Reasons to why wheel locks may not work were provided, as well as a list and descriptions of maintenance to common wheelchair components. This list was beneficial as it most importantly gave descriptions of what to look for in each component group.

The most important set of information found and used in producing the checklist and manual was Ohio State University's "Wheelchair Maintenance Checklist." This checklist was very comprehensive and included a simple picture with very basic parts labeled. The checklist was divided into different component groups and well organized. It was noted that the picture used in the beginning of the checklist was too outdated, being basic line art, with too few labels. The lack of labels made it hard to follow the checklist, as many components listed in the tasks could not be found within the picture. This checklist provided a good basis with which to build a more comprehensive and well though out checklist.

The website entitled "Information for Wheelchair Users," was found to be a valuable resource as it included a maintenance section. The wheelchair maintenance section provided maintenance tasks that were not found within several other maintenance lists, such as information on maintenance checks on footrests, front casters, forks rear wheels. Many of these were added to the maintenance checklist and manual produced in this project.

Lists of manufacturers found on the Internet were very helpful as well, as they aided in creating a comprehensive list of manufacturers and their websites. Notable lists of manufacturers were found on CIGNA HealthCare Medicare Administration's Website (Cigna HealthCare Medicare Administration, Apr. 2004) as well as on Wheelchairnet's website (Wheelchairnet, Apr. 2004). CIGNA's website provided us with the most complete list of manufacturers and websites and provided a good basis from which to start a list. Wheelchairnet's list provided many manufacturers that CIGNA did not provide. Many manufacturers were found through searching Google for wheelchair manufacturer's websites, other sites were found from the work of Holmes and Young. Holmes and Young's list of service and repair facilities in Massachusetts was found to be quite complete and were reviewed and edited. Some service centers no longer exist and a few more were added.

2.4 Website

The website was developed and created using HTML (Hypertext Markup Language), CSS (Cascading Style Sheets) and JavaScript. Each of these topics will be defined as to the functionality they provide to the creation and usability of the website.

The different languages used are also able to provide the designer with functionality that allows each of the web pages to be quickly updated; eliminating repetition in the code. Following the information on the three web languages that have been used is the research obtained while investigating methods of implementing the website. The website was designed to allow full usability and accessibility to as many users as possible; not to exclude users with handicaps.

2.4.1 Hyper-Text Markup Language

Used as the base to create each of the web pages on the website that will convey to users the necessary information regarding wheelchair maintenance. HTML is defined as "the coding language used to create Hyper-text documents for use on the World Wide Web. HTML looks a lot like old-fashioned typesetting code, where you surround a block of text with codes that indicate how it should appear. Additionally, in HTML you can specify that a block of text or a word is linked to another file on the Internet" (Media Services International Inc., Apr. 2004). Each page is contained as its own file which when accessed by a web browser such as Internet Explorer or Netscape is downloaded to the users computer then translated to be viewed by the user.

2.4.2 Cascading Style Sheets

A cascading style sheet file is defined as having "the purpose to provide more control over the fonts, colors, layout, and other features that go into the web page than could be provided by raw HTML. Also, since the cascading style sheet file is separate from the HTML files, it can be shared (or even inherited) by multiple web pages to help

provide a consistent look-and-feel across a website" (Saugus, Apr. 2004). The features of CSS are not fully supported by all browsers, however all recent versions of popular browsers have it included.

2.4.3 JavaScript

JavaScript is defined as "a scripting language developed to enable web authors to design interactive sites. JavaScript can interact with HTML source code, enabling Web authors to spice up their sites with dynamic content. JavaScript is endorsed by a number of software companies and is an open language that anyone can use without purchasing a license" (Montana State University, Apr. 2004). The language is supported by recent browsers from Netscape and Microsoft among others; although Internet Explorer supports only a subset, which Microsoft calls Jscript.

2.4.4 Research on Website Design

Many areas of website design were investigated prior to the development of the wheelchair maintenance website. The information that was investigated included the storage of information, files and formats and video. During the development stage of the deliverables, it was determined that the video was not necessary. This allowed further investigation of streaming media or download time of video to be eliminated. Decisions needed to be made on the formats that files would be available for download from the website. There are many options ranging from a rich-text format to Adobe's PDF format and Microsoft's Word document; which are the three most commonly used. Before coding of the website began, a language or languages needed to be chosen; a variety were

looked such as Hyper-text markup language (HTML), cascading style sheets (CSS), JavaScript, and PHP (PHP: Hypertext Preprocessor) along with other scripting languages. Once the website was completed, different attributes would need to be tested and assessed. The website would need to be accessible to colorblind users and to any persons with disabilities.

One area, which remains unclear, is hosting of the information. There are numerous choices for hosting of the wheelchair maintenance website, including the WPI servers, a Mechanical Engineering Department server or on the Massachusetts DMR website server. Since video was decided not to be included in, the project the space required would only be about 30MB. If videos were to be included in the future, the space required would be much greater. Either the WPI or DMR web servers would be adequate to support the contents of the web pages that have been developed. If the site was hosted at WPI then DMR could be contacted with the necessary link, which they could then distribute and display on their website. However if DMR was to take control of the website then the files would be delivered to their webmaster. There would not need to be any editing of the files if transferred except the changing of contact information.

The manual and checklist will need to be stored in a document format. This will allow users to download and save these files to their computer for access at a later time. Storing as a document will also allow the information to be easily printed without excess color being used. There are a variety of formats that documents can be stored in. Text documents in any format are extremely small. However, with pictures included in each of the documents the choices become narrower. A format which will stay relatively

small in size while keeping any images that are included at good clarity needs to be used. The two most commonly used by businesses and companies which exhibit these features are Microsoft Word document and Adobe's PDF format. People commonly have Microsoft Word on their computer and therefore allowing download in Word format will provide users to easily save and open the information. For users that lack Microsoft Word, Adobe Reader can be used which is able to open PDF documents and is free to download and use. This may involve an extra step for users to take which is downloading and installing Adobe Reader. However, this can be facilitated by providing a link to Adobe's website, which allows the users to quickly download this program. Multiple options are given since one format may not always be accessible to everyone. Using Adobe Reader for the PDF file format will prevent screen readers from accessing the contents of the documents therefore a second option is given. In addition, users may have other platforms besides Windows that may prevent access to a Microsoft Word Document. Providing multiple formats for the files will cover any issues users may have with one format therefore allowing the user to download and use another.

Accessibility is a major part of website development. It is necessary for any good website to allow access to the maximum number of users rather than prohibiting certain users with disabilities or inadequate software. A website should be viewable by all users including blind users that have screen readers. The World Wide Web consortium website (W3C, Apr. 2004) has formed guidelines that provide a structure allowing web developers to construct web pages that allow access to all groups of people. W3C's goal is "to enhance the functionality and universality of the Web" (W3C, Apr. 2004). Related to the goals put forth by W3C, there have been programs developed that test a web page

to verify it meets certain guidelines. Watchfire (Bobby, Apr 2004) developed online software that allows for testing of web pages against the W3C guidelines.

The W3C website provides a checklist for people to follow, ranking different points in one of three priorities. The first priority being a step that must be followed, otherwise making it impossible for one or more groups to access information. These are the basic requirements of building a website. An example of first priority being, "Ensure that all information conveyed with color is also available without color, for example from context or markup" (W3C Checkpoints, Apr. 2004). The second priority is one that should be satisfied, otherwise one or more groups will find it difficult to access certain information; satisfying these points will remove significant barriers to accessing web documents. A second priority example is to "use style sheets to control layout and presentation" (W3C Checklist, Apr. 2004). The third priority may be completed by web developers and will improve access to web documents. An example of priority three is "Specify the expansion of each abbreviation or acronym in a document where it first occurs" (W3C Checklist, Apr. 2004).

Bobby is a utility developed by Watchfire that provides online validation of a web page to the guidelines given by the World Wide Web Consortium. Watchfire states "Bobby Approved has been devised to measure guidelines set by different organizations. Bobby takes a given webpage and evaluates it against the guidelines provided by W3C. Bobby will measure against both the 'Web Content Accessibility Guidelines 1.0' and the 'U.S. Section 508 Guidelines'" (About Bobby, Apr. 2004). On completion of the Priority 1, 2 and 3 levels in the guidelines, Watchfire allows the website to display a logo showing users that the site has passed the Bobby validation.

Bobby is necessary for the wheelchair maintenance site since it may be relatively common for users to have disabilities in addition to mobility. Therefore, seeing the Bobby logo on the homepage will reassure the person that it will be able to easily navigate. However, there were other tools and validators of web pages that were also looked into. The W3C website contained two validators for analyzing code for any deficiencies. The Markup Validator and the CSS Validator would be used to analyze the different files looking for any types of syntax errors that may occur. The Markup Validator analyzes the HTML portion of the code, while the CSS Validator analyzes the different cascading style sheets that are used to provide color and formatting to the web pages. These programs will not look at the content or accessibility of a web page but rather that the code provided is correct and there doesn't exist anything that was overseen in the syntax. Incorrect syntax would consist of methods or functions that have become outdated or deprecated and now have newer functions to accomplish the same tasks. Other errors may come from tags missing from areas in the code and the incorrect ordering of different tags and statements.

One other tool, which can be used in testing accessibility, is a Colorblindness tool. This is necessary since we do not want to limit the users only to people without colorblindness. This utility allows websites to be displayed lacking certain colors, meaning it is viewable as if a colorblind person was looking at it. We have found multiple organizations, each providing similar utilities that enhance the page to be seen from each of the different types of colorblindness. One particular website allows not only the transformation of web pages to the colors of a person with colorblindness, but also has a "color lab," which allows a user to view these color transformations before

constructing a webpage. This would be useful for picking a color scheme beforehand, rather than altering the colors on a page after creation to maintain readability for all users. The most efficient and effective of the online filters was found at Wickline (Colorfilter Wickline, Apr 2004). This filter allows pages to be displayed at a variety of different levels of colorblindness. The different levels range from normal to protanopia (red and green color blindness), deutanopia (red and green color blindness) and tritanopia (blue and yellow color blindness) along with mono, monochrome and black/white/gray. Each test only takes a short amount of time to return the results in an altered form which can be viewed and judged as to if different objects on the screen can be viewed with the given color scheme. If objects and images are too hard to view using any of the filters, then a user with that form of colorblindness will also have issues viewing the page. Therefore, the colors should be adjusted to allow full viewing at any form of colorblindness.

3.0 Goals and Objectives

The purpose of this project is to create a maintenance resource to assist wheelchair users and people who care for others in wheelchairs. There are three critical aspects of the resource. A maintenance manual is the heart of the resource containing detailed general information about manual wheelchairs and common maintenance issues. In conjunction with the manual, there is a maintenance checklist. The checklist is another tool for the user that aids in the maintenance of a wheelchair. It is designed such that guidelines prevent the user from missing any important processes in wheelchair maintenance. Lastly, this resource has to be readily available to the public; therefore, distribution is the third goal of this project. In today's society, distribution of such information has become incredibly simple with the "world wide web" technology. The Internet is essential in presenting this useful resource to the general public where both the manual and the checklist are present and readily downloadable. The capabilities of this system are endless with simplicity in posting new versions of manuals, checklists, and any other useful medium of information that will arise in the future.

The manual is a compilation all the detailed information regarding wheelchair maintenance in general. It is intended for the users that have not had a great deal of mechanical experience with tools and maintenance. The user needs to think of the chair as a system of parts that work together. The manual is divided into sections, each of which details a subsystem of the chair. This process leads the user into a personal relationship with the chair, thus getting the user to identify the conditions associated with a wheelchair malfunctioning. The major goal of the manual is to instill observation into

the user such that maintenance conditions will be noticed before they become more severe.

The checklist is a series of steps regarding wheelchair maintenance to guide the users through checking the critical aspects of the wheelchair. It is based on a step-by-step thought process that the user can check off when the task has been performed. It can also serve as a maintenance history report if the user records all the information of the chair and files it chronologically to be accessed later. The checklist also instills observation and the system of parts though process. The checklist is broken down into sections identical to the manual to aid in the thought process. The major goal of the checklist is to aid the user in the necessary maintenance routines.

The media are readily available on the wheelchair maintenance website. The goal of the website is to provide the user with information about wheelchair maintenance in a simplistic fashion for both the user and the distributor. The user can download or print out the manual and the checklist instantly from any computer. The website is also a base for the media to be distributed and provides the user with information about service and dealers. Lastly, an evaluation is needed to address issues in the resource that could render the resource ineffective to some users. Therefore, the last goal is to evaluate the effectiveness of the resource by using surveys.

4.0 Manual:

The manual is the heart of this resource. It contains all the information needed for the user to maintain a wheelchair. The manual intended to provide both general maintenance procedures and detailed guidance for wheelchair maintenance. This was done to help people who have not had any experience in maintaining or fixing anything before and also to provide the mechanically inclined with some detailed information about wheelchair maintenance. It was intended to group general information into one document to create a resource that the majority of the users can incorporate. In creating the manual, there were some resources used to create the content but our experiences in physically disassembling and reassembling of the chair compromise the majority of the procedures. Some of the resources were written references; however, the most important resource for creating the manual came from personal communication with Bruce Klockars who is very experienced in wheelchair maintenance.

4.1 Development

An outline of the manual was created to gain an understanding of what needed to be incorporated and to get a perspective of the overall format and layout of the document. The document was based on the format of a car maintenance manual and is broken up into an introduction, general information, regular maintenance and troubleshooting, and subsequent detailed information. The table of contents of the manual is displayed in Figure 4.1. As the development progressed, the format was evaluated and changes were made to create a more fluid and informative document.

TABLE OF CONTENTS

Figure 4.1 Table of contents in the "Guide to wheelchair Maintenance."

Pictures were added to increase the usability and understanding for the user. Pictures added more information and effectiveness to the manual than what could be said by just text. There was no color scheme for the manual. It was determined that the pictures should be grayscale to make the document easier to print off the website and for contrast for those users that are colorblind. The grayscale photos create better contrast between parts of the wheelchair and the background.

4.2 Content

The manual starts out with an introduction to the purpose of the manual and an introduction to manual wheelchairs. It is important for the basic user to understand the different types of wheelchairs, and if their wheelchair is a specialty wheelchair to make clear what is covered in the manual. Another aspect of wheelchairs that the user may not know is the wheelchair identification number located on the chair. This number is important if the user needs any future maintenance or repairs on their chair.

Considering that this was a manual for beginners and veterans, it was decided that basic principles in maintenance and techniques were needed to pervert further frustration and poor technique. In addition, a tool section was needed because not everyone has a chest of tools at their disposal. The tools to maintain a wheelchair were identified and pictures of each were obtained to aid the user in their tool purchasing experience. As with any maintenance manual, safety is discussed and harmful chemicals are addressed. It is an obligation to address these issues in the manual. Any unintended uses of the chemicals can have serious health consequences to the user. Concluding the introduction section of the manual is a section for troubleshooting. It was decided that a better place

for the troubleshooting section is in the front of the manual to provide guidance for the user instead of the user to have to refer all the way to the back of the manual.

Routine maintenance is added for some guidance on preventative maintenance. Suggestions about daily, weekly, and monthly maintenance are made including directions to properly wash the wheelchair. Being observant is a highly desired process in maintaining the wheelchair. If problems are ignored, the wheelchair can become dangerous for the user and very costly to fix when something does go wrong. However, if problems are noticed and fixed early, little overall damage to the chair is a result and the chair will last a lot longer for the user. Being observant is a theme that is continued on through the rest of the routine maintenance section with respect to individual areas of the wheelchair, such as; arms, back, seat, frame, tires, casters, and footrests.

The rest of the sections are devoted to each area of the chair and contain considerable detail. These sections are for reference if a user has a problem with a particular area of the chair. These sections work in conjunction with the troubleshooting section and the routine maintenance sections to fix any problems that arise.

4.3 Use

The manual will be used in residences and group homes to provide the user with a reference for wheelchair maintenance. The manual will be used in residences to provide the user with a handy guide and a reference. This will enable the user to maintain the wheelchair independently of an outside resource, thereby saving time and money. Use in the group homes will enable a caregiver to maintain wheelchairs efficiently and also saving money in the process.

5.0 Checklist

5.1 Development

Development of a checklist began as a basic overview of the detailed maintenance that would be discussed in the manual seemed necessary for repeated users and users that are more knowledgeable. The checklist also served as a basis for writing the manual. Research into past wheelchair maintenance checklists was made on the Internet, as it was the most broad source of information readily available to us in this subject. Various checklists were found on the Internet; these checklists helped us understand the basics of wheelchair maintenance and helped us to create our own checklist. There are several notable websites used for checklist information can be found in the Background section.

After examining the checklists found, many were found to be too short, skipping over key maintenance tasks and several others seemed to contain maintenance tasks that were possibly too difficult for the target audience. Many checklists were not organized in an efficient manner and did not include a detailed photo with major parts labeled. Overall, the most detailed and useful checklist was found to be the Ohio State University checklist (Ohio State University, July 2003). After evaluating the checklists found, it was decided to develop a new checklist based on the information already researched.

Development of the actual checklist began with finding a basic, suitable figure of a wheelchair and labeling all of the common parts whose names would be used throughout the checklist. Later evaluation led to obtaining an actual photo of a common wheelchair and labeling that with all of the general parts, in order to give the user a clearer and more updated image of a wheelchair. Pouring through information on wheelchairs and other maintenance checklists brought up many common tasks that

should be performed; these common tasks were all incorporated into the checklist, as well as several tasks found to be necessary in maintaining safety. Safety was a major factor, as items such as sharp edges on screw heads may cause cuts in both the material of the wheelchair and on the user.

Content of the checklist was decided based on abilities of the target audience, leaving out difficult tasks such as changing bearings. Bruce Klockars and Michelle Harris were questioned on tasks that may be too difficult for the target audience. Other tasks that were decided to be left out of the checklist were adjusting the spokes and changing the tires.

5.2 Use

The checklist is designed to be used by repeat users of the manual and experienced people in order to perform the maintenance tasks described without going through detailed steps in the manual. It will be used as a set of guidelines, listing each maintenance task that should be performed. The checklist will also be used as a quick reference of where to find specific tasks within the manual, as each component group within the checklist provides a reference to the manual. It will allow the user to go through each maintenance task in any order they choose, checking them off, so that no tasks are skipped.

5.3 Content

The checklist contains a photo of a wheelchair with labels of basic parts used throughout the checklist and manual. Under the picture, the checklist is broken up into

various groups: 'Arms', 'Back', 'Seat, Cross Braces, and Frame', 'Wheel Locks', 'Large Wheels', 'Casters' and 'Footrest and Leg Rest (Front Rigging)'. Under each of these various sections is a list of maintenance tasks to be performed for each section. Each of these maintenance tasks is accompanied by a reference to the manual, in order to aid the user in recollecting the necessary information for each step. No detail is included with each of these tasks, as the checklist is meant to be only a basic overview of the tasks performed in the manual.

6.0 Website

The website design was developed to be simple, informative and easy to navigate through to find pages relating to the user's needs. The website was built using hyper-text markup language (HTML), cascading style sheets (CSS) and JavaScript. Using these programming languages, web pages were designed and implemented to display important information. Each area of information was broken down and grouped together. All of maintenance information (i.e. the manual, checklist and tools list) was placed in the Maintenance page while people, companies and businesses that service wheelchairs formed listings under the Services page. The layout chosen is common to websites and therefore easily recognized and familiar for users to navigate. The layout can be viewed in Appendix C along with the content accessible on each of the web pages. The color scheme was chosen to appeal to users however not to be flashy or hard to view. The colors used also needed enough contrast between one another that the website would still be easily viewable to colorblind users. Colorblind users along with others that may have disabilities who will still be accessing the website need to feel comfortable and able to access everything that a normal user would have access too. With this in mind, the site needs to be accessible to anyone that wishes to view the contents, including users with disabilities and people who may not have much computer knowledge. Images were used where appropriate to easily display information to the users. This allows users who are unfamiliar with the terminology of a wheelchair to find the corresponding parts being discussed.

Site Map:

- Wheelchair Maintenance Website
  - Home
  - Maintenance
    - Full Manual
    - Checklist
    - Manual Chapters
      - Selection for each chapter
    - Tools
  - Services
    - Manufacturers Listings
    - Sales and Repair facilities Listings in MA
  - Frequently Asked Questions
    - Answers to any commonly asked questions
  - Contacts
    - Persons maintaining the site
  - Links
    - Links to useful websites

Figure 6.1 Site Map of the Website

In designing the website there seemed to be six necessary areas of content; home, maintenance, services, frequently asked questions, contacts and links (Figure 6.1). Each area was given a button on the navigation bar and links to the corresponding page. These pages then may link to other pages building a hierarchy. One goal during the creation of the website was to allow information to be easily found. With this in mind, the hierarchy of pages cannot be too deep or too wide. If there are too many choices as to which page to visit then users may start guessing and become very frustrated in their search. This can also happen if items of information are buried under several layers of pages. This website was designed having six main pages and only goes a maximum of four layers deep to find any type of information needed.

The website was also created to allow changes to be easily made by any future web maintenance people. The navigation bar can be updated by adding buttons. If this is done the blue bar will also expand to cover the button and look the same as each other button. Cascading style sheets are used to display all additional formatting on the website. Colors, font texts and spacing are mainly done within the rules of the style sheets. This will allow any future changes to the website to resemble all the other pages by using the same font colors and font sizes.

The layout chosen is common to websites and easy to use and navigate. The ease of use and simplicity in design were two reasons for this choice of layout. The title of the website is found at the top left side of the page. The navigation bar resides on the left side of the window stretching downward. The reason for this layout is that English is read left-to-right and top-to-bottom. Having the page follow that scheme would feel most natural for users; especially since people accessing this website may not have much computer knowledge. The navigation buttons when clicked provide additional links to quickly find important information presented on the website. At the bottom of the page is a footer section with an email address allowing users to quickly send any questions they may have about the website or content. Images are also displayed in this area which link to the checklist, manual and manual chapters. The links allow users to directly navigate to these areas since each of these three pieces of information are major focuses of the website.

The color scheme was chosen as something to appeal to users however not to be flashy or hard to view. The colors chosen also needed enough contrast to allow colorblind users the ability to view the website. The main outline of the site is done in a

royal blue tone, while the buttons are turquoise with white lettering. The headers are done in different shades of yellow and gray. The main content on the page is done in normal black text on a white background. Each color provides enough contrast from the others, such as the turquoise buttons on the blue background, to allow any person with or without colorblindness to view the pages. Each page was tested on a colorblind web page filter (Colorfilter Wickline, Apr 2004). This website allowed testing of a variety of colorblindness views each of which resulted in clarity of the different web pages.

Images were used on the website in certain cases to relay messages to the users with more description than might be possible in words. Images were used in the manual and checklist along with the homepage and tools page. Images were mainly used to display the location of certain features of a wheelchair for users unfamiliar with a wheelchair and to show users the correct tools necessary to perform the tasks discussed in the manual and checklist. However, images were not overly used as this would result in slow loading of web pages by users with slow connections. Along with not excessively using images for accessibility reasons, in the HTML code the alt attribute was used on all images to give descriptions of the pictures. Likewise, with any tables on the website, the summary attribute was used to relay what the table contained. Both attributes were required as steps to pass Bobby.

Knowing that many people accessing the content of the website may be using dialup connections; each page was designed to be simple but informative and only used pictures when necessary. This strategy relieved any unnecessary frustration that may be caused if pages take too long to load. Similarly, the goal when creating the manual was that it should remain under 10MB, which would take approximately twenty minutes for a

dialup connection to download the file. The web pages were each tested on a dialup connection at a speed of 56 K per second; pages were viewable within seconds, the checklist could be seen within 10 seconds and the full manual in less than 15 minutes.

The last piece of information taken into account was the amount of the page that would be viewable on smaller screens or screens with smaller resolutions. The goal was to have the main information on a page displayed completely at a resolution of 800 by 600 pixels. This will eliminate unnecessary scrolling back and forth to read a webpage. This task was also tested on a monitor of normal size (i.e. 17-inch monitor), setting the resolution to 800 by 600 pixels and viewing the web pages. All web pages when viewed in this manner were displayed without any unnecessary scrolling back and forth to read text.

7.0 Evaluation

7.1 Survey Methods

The evaluation of the resource consisted of two phases. The first phase implements a survey focusing on the overall layout and flow of the resource. It mainly consists of open-ended questions designed to express the opinions of the user on the design and content of the website along with the information provided in the checklist and manual. The audience for this survey was intended to be family and friends for the purpose of receiving quick results. The second phase of the evaluation implements a survey focusing on the target audience of the resource. The questions were designed to provide much more detail about their opinions for evaluation. More of a focus was on the user's background to aid in the understanding of the person's answers.

7.1.1 Alpha Group

The survey we distributed to the first testing group (i.e. mainly parents and friends or technical and non-technical people) was put together to rapidly obtain a large amount of useful information while not having the user spend large amounts of time completing the survey. The focus of this survey was on the design, content and format of the website. Each question had a different objective concentrating on what users thought was useful and what was not useful along with possibly pointing out areas that were overlooked. The survey is displayed in Figure 7.1.

Technical and Non-Technical User Survey:

Wheelchair Maintenance Website Survey

1. What did you find useful about the website?

2. What did you not find useful about the website?

3. Did each navigation button bring up what you expected to find?

4. How could navigation be improved?

5. Would you include any more buttons or submenus for navigation through the site?

6. Were the tables including the list of manufacturers and their websites and the Sales and Repair Facilities in Massachusetts easy to navigate and read through? How could they be improved?

7. Would you include more pictures on the website? If so, in what areas?

8. Was the checklist descriptive enough to follow if you were performing the wheelchair maintenance?

9. Was the picture on the checklist helpful in performing the maintenance?

10. In chapter 3 of the manual, titled "Arms," read through section 1, "Replacing the Armrest Padding." Would you be able to perform the task with the procedure and pictures present?

11. Reviewing the manual, are there any areas where you would like to see more pictures?

12. Is there anything in particular that you liked or disliked about the checklist, manual and website?

13. Comments and Suggestions?

Figure 7.1 Alpha Group Survey

Q: What did you find useful about the website?

Reason: This question was used to obtain areas of the website that the user would most likely use. The question allowed users to point out the positive aspects of the website. With these areas revealed, we could then focus more attention on other areas that may contain deficiencies found by the other questions.

Q: What did you not find useful about the website?

Reason: The answers we expected from this question would point out flaws or oversights on the web pages that we would need to correct. In addition, information would be obtained regarding areas that were unclear or needed better explanations and problems that people ran into while browsing the website.

Q: Did each navigation button bring up what you expected?

Q: How could navigation be improved?

Reason: These two questions were related to one another. They were part of the survey to determine if the labels on each of the buttons were clear and displayed content equivalent to what people expected. In addition, to determine if there were any sections that should have been included but were left out of the navigation pane. If everything about the navigation was good then the responses would be short saying yes and good. Nevertheless, whether we received long descriptions of issues or short positive feedback, we received necessary information regarding the navigation.

Q: Would you include any more buttons or submenus for navigation through the site?

Reason: This question was meant to find if there needed to be any other submenus when users would click on one of the main buttons. An example would be the maintenance button gives a submenu list of the manual, manual chapters, checklist and tools. However, other buttons have fewer or no options, therefore this question was to provide other possible options for submenu links.

Q: Were the tables including the list of manufacturers and their websites and the sales and repair facilities in Massachusetts easy to navigate and read through? How could it be improved?

Reason: There had not been much feedback on this area up to this point. We were looking to determine if listing them alphabetically was the easiest way to navigate through the different companies or if there were any other ideas of other ways to display the list.

Q: Would you include more pictures on the website? If so, in what areas?

Reason: We wanted to determine if other users thought there were an adequate number of pictures on the website or if pictures should be in areas where we did not use them. One of the goals when designing the website was to make it easily accessible, therefore too many pictures would prevent users from accessing the pages quickly. However if pictures were lacking from any areas that needed them we wanted to know so that users would not become confused.

Q: Was the checklist descriptive enough to follow if you were performing the wheelchair maintenance?

Q: Was the picture on the checklist helpful in performing maintenance?

This was used to find out if the checklist picture was clear and well labeled with all of the useful areas of the wheelchair. The question was also used to find out if the steps in the checklist were clearly described. We were also trying to find out if the terminology was too advanced for people to clearly understand beyond relating the words to the picture.

Q: In chapter 3 of the manual titled "Arms," read through section 1, "Replacing the Armrest padding." Would you be able to perform the task with the procedure and pictures presented?

Reason: We wanted to give the user a specific example from the manual rather than asking them to read the entire manual. This question was used to gather if the structure

and wording in the manual was clear as what procedure to follow and where objects were on the wheelchair. In addition, if something was unknown to the user did the pictures given clarify that issue?

Q: Reviewing the manual, are there any areas where you would like to see more pictures?

Reason: Since the manual is a major part of this project, having enough pictures to clarify any unknown issues is very important. Since users of similar or possibly less knowledge of wheelchairs will be using this information, it needs to be very clear and precise. Therefore, if one person reviewing the manual does not understand an area, there will probably be many others in that same situation.

Q: Is there anything in particular that you liked or disliked about the checklist, manual or website?

Q: Comments and suggestions?

Reason: These last two questions were just trying to obtain any other information or comments that the users found while browsing the website. Since the previous questions could not possibly cover every area of the website this allows for any additional opinions that users may want us to consider.

7.1.2 Beta Group-Users

The second stage of evaluation of the resource was devoted towards the intended audience of the resource. It was decided to focus on content and usability for the beta survey. This segment is more capable of determining the usability of the resource than would an average survey group. The survey can be viewed in Figure 7.1.

Wheelchair Maintenance Website Survey

The wheelchair maintenance website is a resource that is available to the public to help both the wheelchair user and caregiver to understand and maintain a wheelchair for the safety of the person using it. The purpose of this survey is to receive some user feedback regarding the content and layout of the website, the manual, and the checklist. We would greatly appreciate your feedback regarding these media. Thank you.

1. Would you regard yourself as a wheelchair user or a caregiver to a wheelchair user?

   User Caregiver Other_____

2. Do you live/work in a group home or a personal residence?

   Group Home Personal Residence Other_____

3. How long have you been associated with wheelchairs?

   <1 year 1-5 years >5 years

4. How often have you used tools to maintain and fix anything in the past?

   Never A few times All the time

5. How comfortable would you feel working on a wheelchair?

   Not Comfortable Very Comfortable
   (1) (2) (3) (4) (5)

We would like you to access the website at the address above. Navigate around the website to get acquainted with the format and layout.

6. What problems did you have, if any, accessing the website?

Navigate to the "Maintenance" page and download the full manual. This may take a while to download if you have a slow connection.

7. Read through Chapter 1 for basic information about wheelchairs. On the scale below, rate how informative this chapter was relative to the terminology and tools needed to maintain a wheelchair.

   Not Informative Very Informative
   (1) (2) (3) (4) (5)

Briefly explain what you liked about the chapter and what things you feel should be altered or improved.

8. Go to Chapter 4 in the manual and read the section on replacing the seat back. Rate your capability in performing this task with the supplied directions and pictures.

Not Capable				Very Capable
(1)	(2)	(3)	(4)	(5)

Explain what you liked about the chapter and what things you feel should be altered or improved.

9. Now turn to Chapter 6 and read through the section about "Wheel Lock Adjustment." Rate how clear the directions are and if you could follow them.

Unclear				Very Clear
(1)	(2)	(3)	(4)	(5)

Explain what you liked about the chapter and what things you feel should be altered or improved.

10. Rate how clear figures 6.1 and 6.2 are in performing the "Wheel Lock Adjustment" task.

Unclear				Very Clear
(1)	(2)	(3)	(4)	(5)

Explain what you liked about the chapter and what things you feel should be altered or improved.

11. Overall what is your impression of this resource, including the website, the checklist and the manual?

12. Do you feel that this resource could help you maintain a wheelchair to increase its efficiency and safety of the wheelchair?

13. Is there anything you would like to add to the resource or comment on?

Thank you very much for your time and effort completing this survey. We greatly appreciate your input and concerns.

Figure 7.1 Beta Group Survey

With a focus on the user audience, it was determined that there would be some introductory questions on the background of the individual user. The first question is designed to obtain a sense of the present situation of the user of the resource, whether it be a wheelchair user, a caregiver, or another user situation. The question was critical to understanding the user's association with wheelchairs. The second question focused on the environment that user and wheelchair are being used and potentially being maintained, whether it is in a group home, personal residence, or another user environment. These questions set the stage for understanding the person's background.

In order to understand the answers later in the survey, it was imperative that some general questions about wheelchairs and maintenance had to be asked. It was important to get some sort of understanding of the person's familiarity with wheelchairs so the third question "How long have you been associated with wheelchairs?" was created. Then the question of "How often have you used tools to maintain and fix anything in the past?" was created to understand the person's background with tools and their hands on experience. From there it is possible to understand the person's answer to question five, "How comfortable would you feel working on a wheelchair?" based on their previous answers.

Now some specific questions on the content of the manual can be asked such as content in Chapter 1 on the introduction and such. The questions devoted to the user evaluating the specific chapters contained a rating scale on which the user can rate the information or the person's capabilities in performing that task. The rating scale provides a basis for comparison of each user based on their background, wheelchairs, and maintenance answers previously asked. For example, in question seven, the person is

asked to rate the information given about wheelchairs on a scale from one to five and then asked to elaborate on the issues if the user gave the chapter a poor rating. Questions 7 through 10 followed this format with seven being the question on the introduction. Question 8 asks about replacing the back upholstery and the person's capability of performing such task. It was decided to ask this question to gain some information on the person's confidence in this task by just looking at the section. In question 9, the content of the wheel lock adjustment procedure and the capability of the person's ability to perform the task was dealt with. Question 10 dealt with the wheel lock adjustment procedure again but specifically the pictures involved. The basis for asking about the pictures was to address the clarity in the pictures with both the content of the picture and its clarity in black and white.

The last three questions were user opinion questions where the person is able to address any part(s) of the manual. Question 11 asks the user for their overall impression of the manual and resource enabling the user to address any issues with the system. Question 12 addresses the overall goal of the project, which is for users to actually find this resource useful and implement it into their life. Question 13 is a chance for the person to address and comment on anything about the resource.

7.2 Results

7.2.1 Alpha Group Results

Out of the twenty people surveyed in the alpha group, fifteen replies were received. The replies are summarized below. When technical and non-technical people were asked what they found useful about the website, the consensus was that it was easy

to use, informative, well thought out and made so that people with minimal knowledge could find what they are looking for.

When technical and non-technical people were asked what they did not find useful about the website, responses were that some users did not need to see the actual pictures of the necessary tools as they were basic tools, although less mechanically inclined people would find it useful. Another user commented that the home page needs to attract physically challenged people to look further within the website, by providing on the home page what is contained within the site. A suggestion was made to list the titles of each chapter in the manual on the webpage in addition to the chapter number and description.

Technical and non-technical people found that the navigation buttons brought them to the pertinent information, with no unpleasant surprises.

As far as how navigation could be improved, one user responded that the manual might be easier to navigate if you could click directly on tasks in the table of contents to be brought directly to the section you wished to read, rather than scrolling down to the necessary page. One user suggested including a bulleted list of what is included within the website on the home page, using each as a link to the respective page as well. Another user suggested that links be placed on the checklist to the manual to aid navigation. One user commented that it might be a good idea to have a 'back to top' link after each question's answer in the FAQ section, search capability with the web page may be nice as well as the ability to click on something to bookmark the webpage. A comment was made to add a link to 'Links to recent news articles' that goes to a page stating that it is 'under construction.'

Most technical and non-technical users found that the current buttons and submenus properly served their purpose for navigation though the site. One user found that on their laptop, the three buttons on the bottom of the homepage display below the bottom of the page when it loads, the user commented that it may be helpful to have them display within the main page without scrolling or to delete them altogether. Another comment was that it might be nice if you could place the cursor over the buttons on the left and have the sub-links cascade, rather than clicking on maintenance, for example, and having the new links display under that button.

Those surveyed found that the tables including manufacturers and their websites, as well as sales and repair facilities in Massachusetts were easy to navigate and read. They provided quick access and helped to find nearby sales and repair facilities. Several users responded that a few of the links on the manufacturers' web page did not work. One user suggested using different colors so that everything was not black, possibly making it easier to search through. Several users responded that at least one of the manufacturers' websites held onto the browser window, not allowing them to click back to the Wheelchair Maintenance Website.

Most users found that the number of pictures on the website was sufficient. One comment was that the FAQ section might be more interesting if each FAQ included a relevant picture of the wheelchair or problem being addressed.

In general, those surveyed found the checklist descriptive enough to follow if they were performing the wheelchair maintenance.

Technical and non-technical people surveyed commented on the picture displayed on the checklist. The original picture was found to be archaic; therefore, another picture

was used to replace it. The second picture was found to be very helpful although several labels that would be helpful in finding parts of the wheelchair were missing, and some displayed fuzzy on some users' computers. The third and current picture was found to display correctly and be more informative. A suggestion was made by a user to show blow up pictures for each major assembly on the wheelchair.

Non-technical and technical users found that the given maintenance task in the manual, chapter 3, entitled "Arms," was easy to follow and many users commented that most people should have no problem at all performing the task. A suggestion was made to elaborate on the situation where the arm pad is not removable as well as instructions on how to repair cuts and or to replace full covers on armrests and seats.

Most people surveyed found the pictures in the manual to be sufficient for completing the tasks. One user commented that most people are visual, so that more pictures would be more beneficial.

Technical and non-technical users provided additional comments and suggestions. In general the checklist, manual and website were found to be very understandable and in a simple format. Many users stated that the products produced were excellent and ready to be distributed. A suggestion was made to add motorized chairs to the website and the manual, possibly having on a guide on selecting the best wheelchair and a guide to how the physically challenged can compete in racing and meet others. In the manual, a user asked if adjustment to the spokes could be added and also asked how to deal with the two different types of casters in chapter 2, section 7.

Several general comments were made about the website and its content. Several people liked the numerous links to pertinent websites. One user commented that the

pictures of the tools on the website could be made slightly smaller to aid navigation and loading. It was suggested that safety glasses should be included on the tools webpage, and that a safety section could be added to the manual. A user also suggested that clearer pictures of the tools be taken, as well as pictures of the end of each type of screwdriver, how a wrench is used on a nut or bolt, the knives with extended blades, a file, needle nose pliers, a valve stem tool and a close up picture of the adjustable wrench. A list of other useful items, such as rags, a sponge and a bucket was requested as well. It was asked that the type of Phillips head screwdriver be specified as size #1, 2 or 3. A suggestion was made that Sans Serif font or Verdana font may display more clearly and that navy blue text may be softer on people's eyes. A comment was also made that size 12 font may be more appropriate, as many users may be older and not have strong vision. A suggestion was made that some colors, such as the yellowish color on the Maintenance page titles should be changed. A user found that changing the font size to large in Internet Explorer made a link under the maintenance and service buttons overlap the blue bar, rendering the word illegible. A comment stated that it would be expected to find the links to manufacturers under the links page.

7.2.2 Beta Group Results

At the time of writing this report, only one beta survey result had been received. From the result of the survey, the respondent was a caregiver who works in a group home. The respondent has been associated with wheelchairs for greater than five years and has maintained or fixed something in the past. Based on the respondent's experiences, the respondent feels comfortable fixing a wheelchair with a rating of a four

out of five on the comfortable scale level. When asked if there were any problems accessing the website, the respondent noted there were no problems. The respondent was asked to download the manual and read Chapter 1 about basic information about wheelchairs. The respondent was then asked to rate how informative the introductory chapter was relative to terminology and tools needed to maintain a wheelchair. The respondent answered with a five out of five rating scale and commented that the pictures were very thorough and that they were good for novices. When asked about replacing the seat upholstery in Chapter 4, the responded rated the capability level at a four out of five and had no comments. For questions 9 and 10, the respondent answered that the directions and pictures were very clear with a rating of five out of five for both and commented that the pictures were good and simplistic. The respondent was asked for an opinion on the overall impression for the resource and was impressed with the resource and felt that it should be very useful to most of his colleagues. When asked about whether this resource could help in maintaining a wheelchair for safety the respondent said yes. The respondent had a last question about whether WPI has a hyperlink to the website on the home page. Overall the respondent was very pleased with the resource and felt that it is very helpful in maintaining a wheelchair.

7.3 Discussion

7.3.1 Revisions to the website

Discussion: Website

Users agreed that the website was exceptional and not many changes were made after evaluation of the surveys received from users. A couple areas had not been completed at the time of the users evaluation. The following are a list of suggestions made by the users and the reasons for accepting the suggestion or rejecting it.

The navigation pane was agreed by all users as being very well labeled and did not lack any additional buttons or menus at the time. However, there were comments on if the links at the bottom of pages, to the manual, checklist and chapters, were necessary. Each of the rollover links was rather large and could be accomplished by clicking on the maintenance section. Since the manual and checklists are the two major areas of the project we thought that it was a good idea to have direct links to these areas of the website. Also since users will most likely be viewing the page for these two features, it is helpful that the links always appear there. This will avoid unnecessary navigating through other pages.

One other aspect of the navigation bar which was overlooked is if the text size in Internet Explorer is viewed at "Largest" the words will exceed the blue boundary therefore overlapping the white content pane. When this occurs, the white text on white background makes the sub-links hard to read. This was fixed by shortening words that are used and adjusting the coloring of submenus choosing a gray color rather than the white, which would overlap the content if this was to occur again.

All users agreed that the number of pictures on the website was adequate. No comments were made on pictures that should be in a location to better define that area of content. There are not many pictures on the website but ones that are provide excellent information on parts of a wheelchair or relay positive messages to the user regarding wheelchair maintenance.

There were a few areas on the website that lacked information. There was a section on the home page for Latest News articles. This section was deleted since the home page had a better look without this section. In addition, the news articles would need to be updated often with new research being presented in this area. This may become hard to do unless someone is assigned to constantly update the website. Therefore, the content available on the website should not need much updating, only necessary when new wheelchair maintenance techniques are developed or when new products are released that people will need to care for.

The other area that had not been completed at the time was the chapters section on the website. The section lacked titles of the different chapters and any type of description as to what was located in that particular chapter. These were both added to this section making the contents much more informative. The chapter title was added along with a brief summery of contents that would be found in that particular chapter.

Discussion: Tools Page

Many suggestions were made regarding the tool page of the website. As a result, the pictures on the tool page were completely redone, as well as the descriptions and formatting. All user comments were taken into consideration and used on this page, as they were all very helpful in creating a more comprehensive and easy to use tool page.

In the technical and non-technical user surveys, a comment was made to make the images of tools on the tools pages smaller to aid navigation and loading. In response to this comment, the images were compressed and saved at a lower resolution in Adobe Photoshop, decreasing the file size and aiding load time. This allowed the images to be the same viewing size on the webpage while the actual size of the file was much smaller.

Several users suggested that safety glasses be added to the tools page. In response to this comment, safety glasses were quickly added as users safety is a concern within this project and safety glasses had been previously overlooked.

The suggestion was made that clearer pictures be taken of the tools, as well as pictures of the end of each type of screwdriver, how a wrench is used on a nut or bolt, the knives with extended blades, a file, needle nose pliers, a valve stem tool and a close-up picture of an adjustable wrench. All of these considerations were used and each picture was changed. Clearer pictures were taken, using a more precise focusing scheme on the digital camera, as well as pictures of the end of each type of screwdriver. Pictures of each screwdriver, as well as its tip and the type of screw that it is used for were made into one informative image. The picture of how a wrench is used on a nut, as well as a close-up of each end of the wrench and a distant picture were made into one informative image as well. A close up image of a hex key wrench was added to the distant image as well as a close up image of the adjustable wrench to the distant image. A new picture was taken of the utility knives with blades extended, to better show how they work as well as a picture of two types of files and a close up of what one looks like. Pictures of needle nose pliers, two types of tire pressure gauges and the valve stem tool were all taken and

added to the tools page. While editing and adding new pictures, commercial references were removed from all pictures.

Useful items such as rags, a sponge and a bucket were all requested to be added to the tools page and each of these items was added. Another request asked for the specific size Phillips head screwdriver. In response to this request, it was added to the tools page that a #2 screwdriver is needed. This also led to adding better descriptions of several of the tools on the page and why or how they are used. In addition to these changes, each tool picture and description was separated from the next with black line to avoid confusion between different tools. The font size and color of the name of each tool was changed in order to make them stand out and easier to read.

Overall, the redo of the tools section greatly improved usability and was well liked by those who reviewed it. The tools section was subsequently added to the manual, replacing the previous tools section from the old webpage.

Discussion: Tables

The manufacturers' links table and the service and repair facilities in Massachusetts table were found to be easy to navigate and read and did not require much revision. Technical and non-technical users reported that several of the links on the manufacturers' table did not work. The broken links were found and removed. Another user responded that the manufacturers' websites held onto the browser window, not allowing them to click back. In order to fix this problem, changes were made to the HTML code so that each individual link opened in a new window in order to fix this problem. The only other comment made by users about the tables is that they may be

easier to view if different colors, other than black, were used. It was decided that the colors within the table would remain the same, as only dark colors could be used for maximum contrast against the white background to pass colorblind tests. This was only reported by one user, other users liked the tables how they were, so this feature was not changed.

7.3.2 Revisions to the Checklist

After evaluation, several changes were made to the checklist. The photo on the checklist went through several revisions until the third one was found to be clear and informative. Several tasks were also removed and few added to the manual as a result of review of the manual and checklist. A small change was to change the bullets besides each checklist item to boxes, so they could be physically checked off.

Changes were made to the checklist after surveying technical and non-technical users. The original picture on the checklist was found to be archaic by Bruce Klockars. Two new images were used in the manual. The archaic image was also found to be missing several key component labels used in the checklist. These two images came from the book, "Choosing a Wheelchair" (Karp) Both images were of slightly different wheelchairs, but with many descriptive labels.

Technical and non-technical users commented that these two new images displayed fuzzy on their computers and were missing several key labels, although better than the first image. These two images would also require permission from the book's author in order to be permanently placed in the checklist, manual and website. Thus, a third picture was taken at a local nursing home. This third was of excellent quality, so

each important label was added, including those missing from the first two pictures, such as cross braces.

A point was brought up to include blow up pictures for each major assembly on the wheelchair in addition to this third picture. This suggestion was taken into discussion and it was decided that additional blow up pictures would take up too much space on the checklist and that similar pictures could be found in the respective components section in the maintenance manual. The references next to each component group on the checklist leads the user to these respective sections in the manual with more close-up pictures.

Several tasks were removed from the checklist and a few were added to it. On the back section of the checklist, it was added that the nuts and bolts should be checked to make sure they are tight. A reference to hook-on style headrests was deleted, as these are an additional feature to a standard wheelchair and were not included in the checklist or manual. The task to check hill climbers for proper operation was also deleted as they are also an additional feature on wheelchairs that are not included in the checklist or manual.

Overall, the checklist was found to be very comprehensive and did not require many changes. Major changes were only made to the labeled picture placed at the top of the checklist, while minor changes were made within.

7.3.3 Revisions the Manual

Based on the results of the alpha survey, changes in the manual were needed. There were some suggestions made to clarify pictures and content to decrease the confusion and usability of the manual as addressed in the results section 7.2.1. The most

important suggestion made was to redirect the overall attitude of the manual towards an observation standpoint.

An observation standpoint addresses the issue of intimacy with the wheelchair. If the user is being observant then the little minute uncertainties and oddities will be noticed and analyzed. This increases the longevity of the chair if the oddities are fixed promptly and the user will stay safe by reducing the risk that the chair will break when in use.

There were two figures in the introduction that were borrowed from "Choosing a Wheelchair". The first figure displayed a rigid wheelchair with some terminology pointing out some individual parts but not all of them. The second picture was a folding wheelchair with more terminology on specific parts. The decision to change these pictures was based on two reasons. The first reason was that they we not original pictures therefore copyright issues would have to be resolved. The second reason was that there was a discontinuity between the terminology used in the manual and the content used in the pictures. This created considerable confusion for the alpha group during the survey. Therefore, the decision was made to create an original picture that contains all the terminology and meshes properly with the terminology used in the manual.

A suggestion in the content addressed the motivation behind a person implementing this resource into their daily life. The previous motivation was directed toward the person's self-esteem. The main reason behind the original motivation was to get the user to want to maintain their wheelchair by getting some self-gratification in the process. While this motivation is pertinent, it is also very vague. It was suggested to change the "pride in self" to a motivation based on safety, efficiency and ease of

function. This creates a more solid motivation for the user to maintain his or her wheelchair because safety in everyone's mind is important.

The tool page was updated based on the clarity of the pictures and the description in the caption. The new pictures added more information about each tool, such as the screwdriver picture has a picture of a respective screw head and a close up of the screwdriver tip. Such detail was given to all the pictures as previously discussed in "7.3.1 Revisions to the Website." These new pictures better described the tools and their purpose and would aid a user who has not had much or any hand tool experience in choosing the right tool for a specific job.

There were other small changes to the content that increased the flow of the document and resulted in an increase in the usability and functionality. The overall format and layout of the document remained unchanged. The alpha survey presented very good suggestions that make the document more useful.

Based on the limited number of beta surveys received, there were not any changes made to the manual.

8.0 Distribution

Several methods of distribution will take place now that the products are complete. The website, videos and checklists will all be distributed. There are many available methods of distribution and each of them has their advantages and disadvantages. A combination of Internet and manual distributions will be used.

The Internet is a way to reach a vast number of people throughout the world. According to ClickZ Network's website as of March 2004, 297.3 million people are online throughout the world, 144.4 million of them in the USA alone (ClickZ Network, March 2004). One drawback is that the majority of people still use 56k modems, although the trend is moving toward high-speed connections (WebsSiteOptimization, Dec. 2003). Another drawback is that a website needs to be maintained, broken links fixed, and updated with new information. A website domain name must be paid upon a yearly basis and a permanent connection must be available for the server the website is held on to ensure reliability. Altogether, a website can become costly.

The website will be posted on the Department of Mental Retardation's server, as they have offered to host the website on their server, and linked to several popular search engines in order to allow people to easily find it when searching for wheelchair maintenance related topics on the Internet. Michelle Harris of the Department of Mental Retardation and Bruce Klockars of Adaptive Equipment Services will distribute the web address to their clients.

Manuals are a standard type of distribution that have been used for centuries. Manuals are expensive to reproduce and distribute. New versions of a manual must be created in order to make changes and it must be reprinted. Therefore, it was found that

the most efficient method of distribution of the manual would be through the website, as the Internet will reach a broad range of people and cost the user nothing to download and view the manual.

The checklist, while available to view on the website, as well as the manual will be distributed throughout the Department of Mental Retardation by Bruce Klockars and Michelle Harris. The checklist is also available to be either viewed on the website or downloaded. The manual can be viewed in a chapter version on the website, for those who do not wish to download the full manual. Each chapter is given a description and can be clicked on; the user is then brought to the respective place in the manual. The manual can also be downloaded in Adobe PDF format and Microsoft Word document format. These two formats were decided upon, as they are basic and common file formats. Microsoft Word is the most common word processing software and available on most computers, many other programs will open the document type as well. The Adobe Acrobat PDF file format was decided upon because Adobe Acrobat Reader is available free to view PDF files, through the link on the Maintenance page. Adobe Acrobat is a common program installed on most computers as well.

These methods of distribution are based on methods devised to reach the greatest number of people, maximizing the exposure of the products produced by this project. Various file formats maximize the ease of use of the products listed by users with various types of computers with various operating systems. In addition, basic HTML format of the webpage allows for ease of use and a common distribution format for the whole project as a package.

9.0 Conclusion and Recommendations

The goal of this project was to create a wheelchair maintenance resource for the Massachusetts Department of Mental Retardation that consists of a website, a checklist and a manual. A wheelchair maintenance video was proposed during the start of this project; however, creating a video could not be executed within the timeframe of the project. The purpose of the manual is to aid the user in performing wheelchair maintenance and to provide detailed information about wheelchairs and their components. The purpose of the checklist is to provide a list of tasks to be preformed for wheelchair maintenance, produced for experienced and repeat users. The website provides a location for users to easily access the checklist and manual. It also aids the user to find wheelchair sales and repair facilities in Massachusetts and contact information for wheelchair manufacturers. This resource will provide valuable information for wheelchair users and caregivers.

For future revisions of this project, it is recommended that a wheelchair maintenance video be created and distributed with the current website, adding a page to the website with various maintenance video clips. It is also recommended that the checklist and manual be updated as necessary. More frequently asked questions should be added to the website as they arise. The hope is that people at the DMR will recommend this website to people who own or care for wheelchairs. If the website were to become heavily used, the information would need to be occasionally updated so that information did not become outdated and remained informative to the users.

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Appendix A: Manual

Guide to Manual Wheelchair Maintenance;

How to Perform Visual & Manual Maintenance Inspection

By:

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May 4, 2004

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

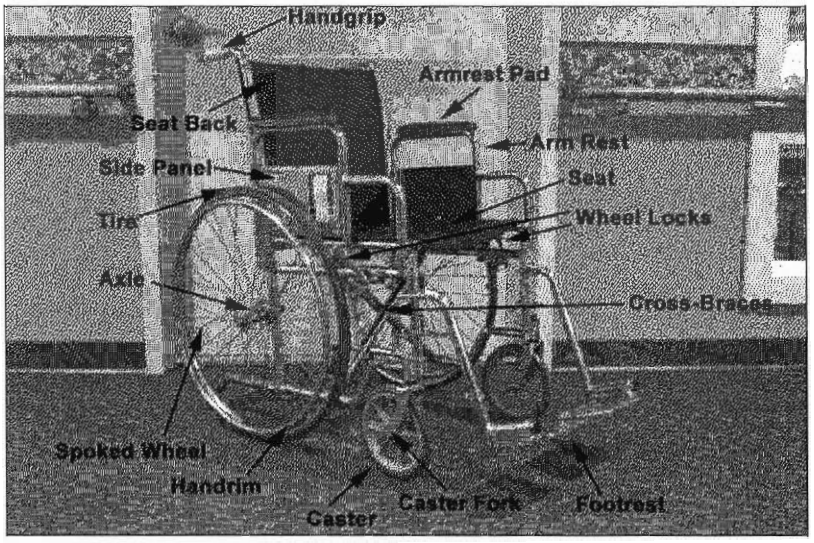
CHAPTER 1: INTRODUCTION

1 About this manual

The purpose of this manual is to help with routine maintenance and addressing problems commonly associated with manual wheelchairs to keep them functional and safe.

Maintenance of a wheelchair will increase the useful life of the chair. It will increase the efficiency, function, and safety of the person using the chair.

If any of these tasks are too daunting to complete yourself, any dealer or repairperson can perform these tasks for you. Talk to your dealer or repairperson to determine which services they can provide, and the details for such a service, such as a loaner chair.



1.1 A typical wheelchair with some terminology.

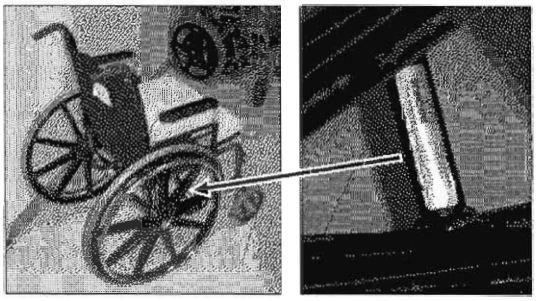
2 Introduction to a manual wheelchair

Figure 1.1 shows a typical wheelchair and some related terminology. There are two basic types of chairs, folding chairs and rigid chairs. The chair in figure 1.1 is a folding chair. Folding chairs conveniently fold to easily fit into most vehicles and offer better stability over rough terrain; however, because of their flexible frames they do not transfer the user's energy into forward motion as efficiently as rigid chairs. Rigid chairs are lighter, stronger, and are more

responsive than folding wheelchairs due to the absence of a folding mechanism; however, rigid chairs are bulky and do not offer the same stability over rough terrain as do the folding chairs. There are many more types of chairs, light, heavy duty, reclining, tilt-in-space, sports and many more specialty chairs. Not all aspects of the specialty chairs are covered in this manual.

3 Wheelchair identification numbers

Every wheelchair contains a sequence of numbers that denotes the manufacturer and model of your chair. The chair identification number is usually located on the rear cross member on the back of the chair *(see figure 1.2)*. This number is needed for any warranty and replacement parts identification and acquisition. This number is also located on your warrantee form from your dealer.



1.2 Location of Identification numbers on this particular wheelchair

4 Maintenance techniques and tools

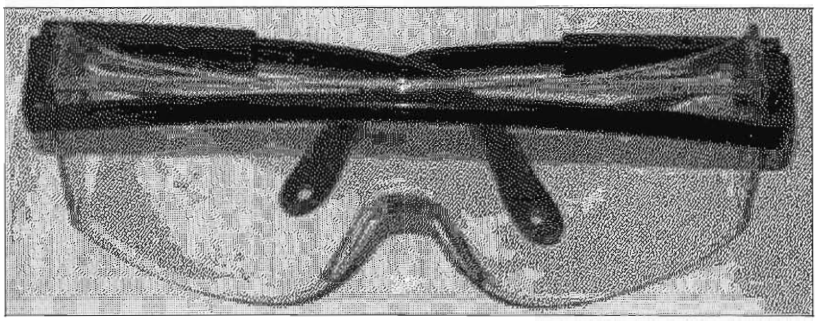
Maintenance techniques

Wheelchairs are usually symmetrical. If a fastener has been removed or lost, there is usually an identical one on the opposite side of the chair. Also, do not try to force a screw or bolt into a hole or thread. If the fastener does not turn smoothly then it is an indication either that the fastener is the wrong size or that the threads have been damaged. In the case that the threads are damaged and are part of the frame, take the wheelchair to a qualified technician to be fixed.

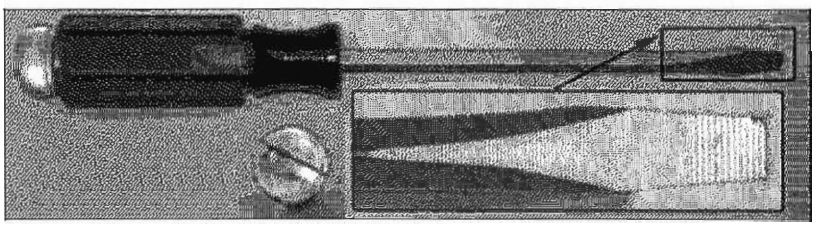
An important practice is to work in a clean environment with a drop cloth in place on the floor to keep your floor clean and assist in finding dropped parts.

Tools

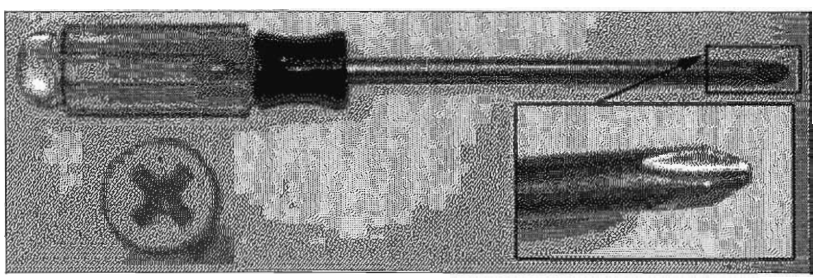
Some general tools needed to fix and maintain your wheelchair:



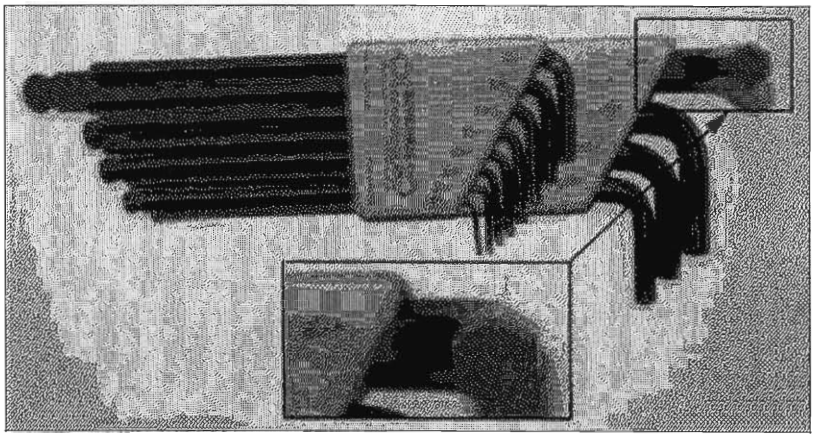
Safety Glasses: These are always recommended when working on your wheelchair.



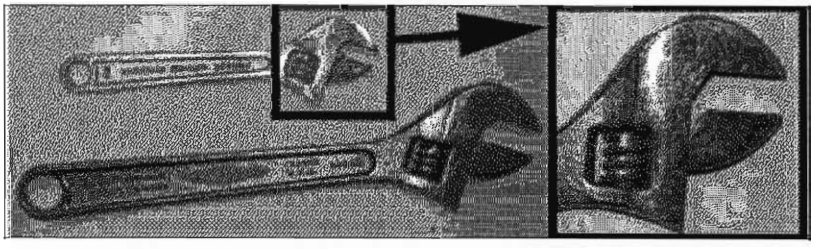
Flathead Screwdriver: The end is flat and thin. The image in the bottom middle of the picture is the type of screw for the screwdriver



A #2 Phillips head Screwdriver: The end is a + shape, usually coming to a point. The image on the bottom left is the type of screw the screwdriver is used for.

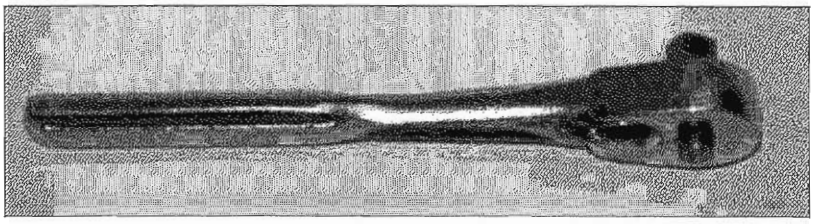


Hex Key Wrenches: Also comes in the form of a jack-knife. Your wheelchair may require Metric or Standard sizes.

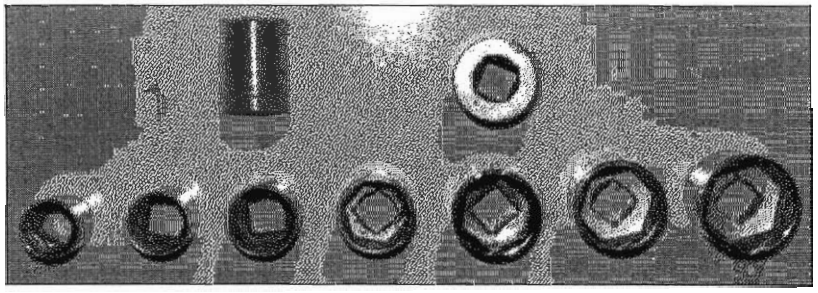


Adjustable Wrench: Allows for size adjustments at the end of the wrench.

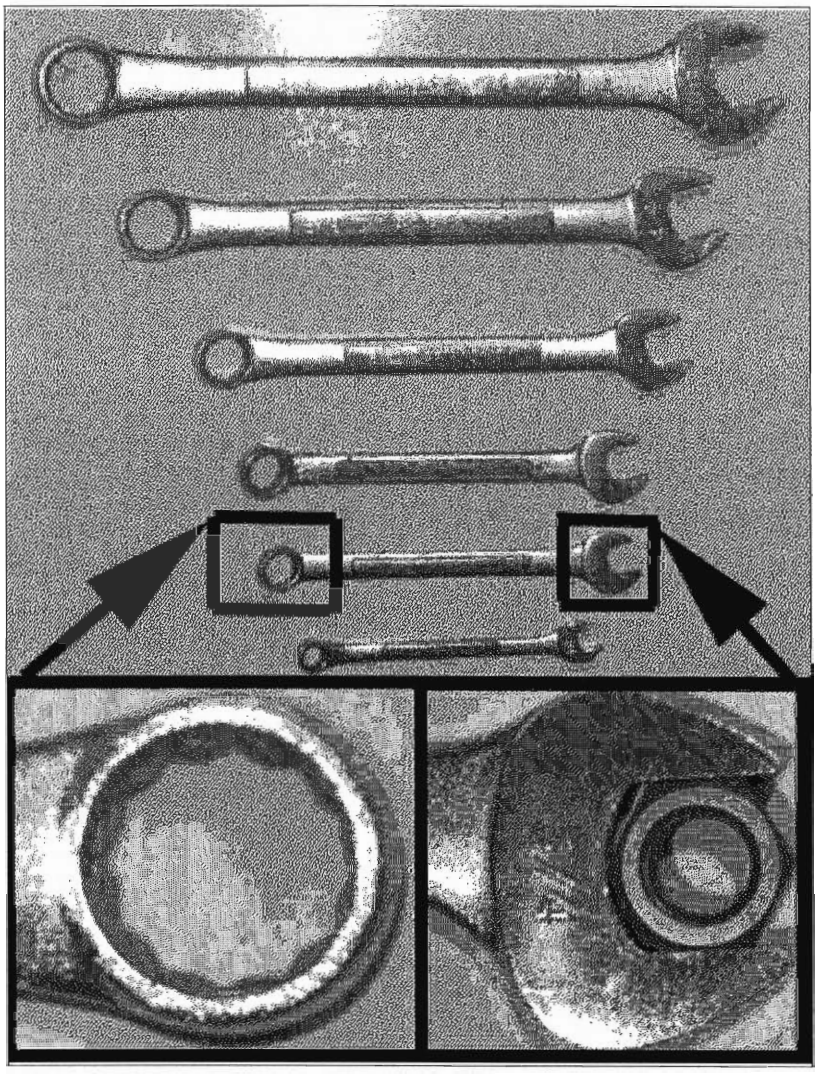
OPTIONAL TOOLS:



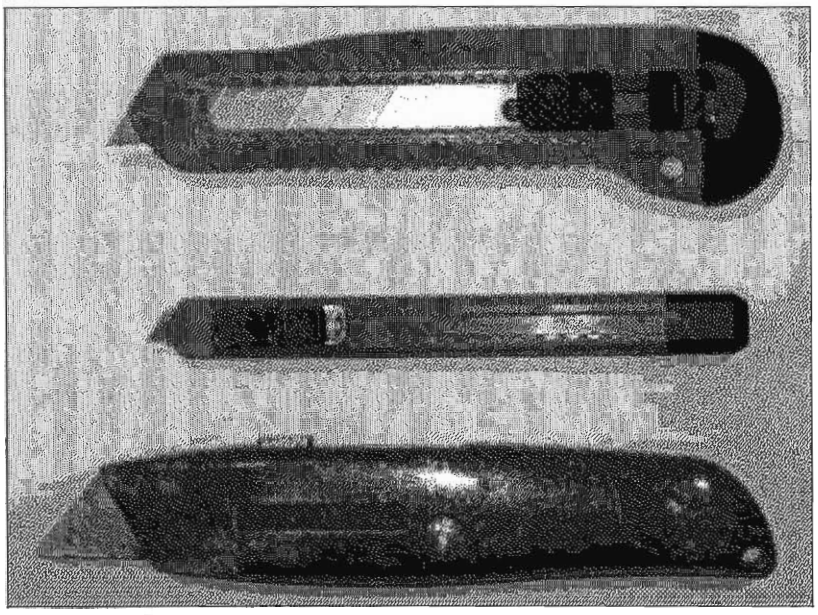
3/8" Ratchet Wrench (attaches to 3/8" sockets): Attaches to 3/8" sockets. Used with the sockets below.



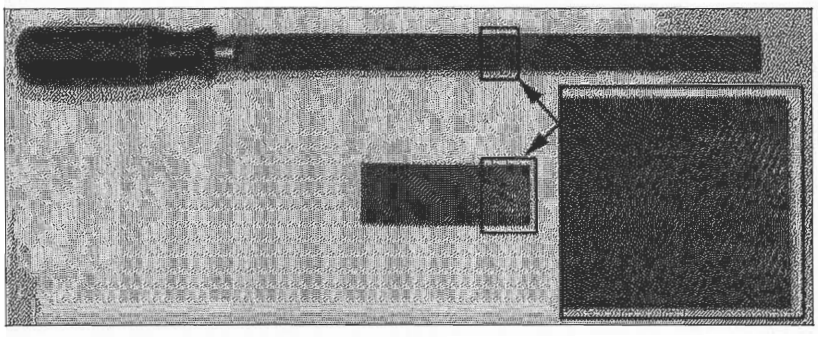
3/8" Sockets (various sizes shown): Your wheelchair may require metric or US sizes. Used with the ratchet wrench above.



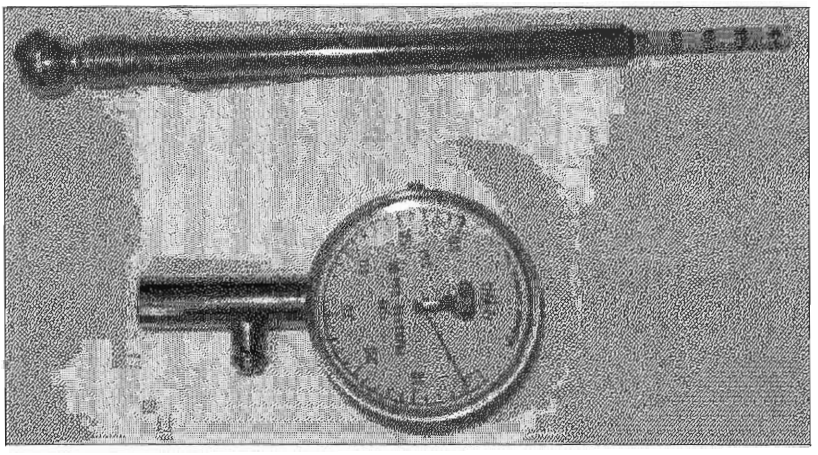
Box Wrenches (various sizes shown): Your wheelchair may require Metric or Standard sizes. The two pictures on the bottom display how the wrench fits on a nut or bolt



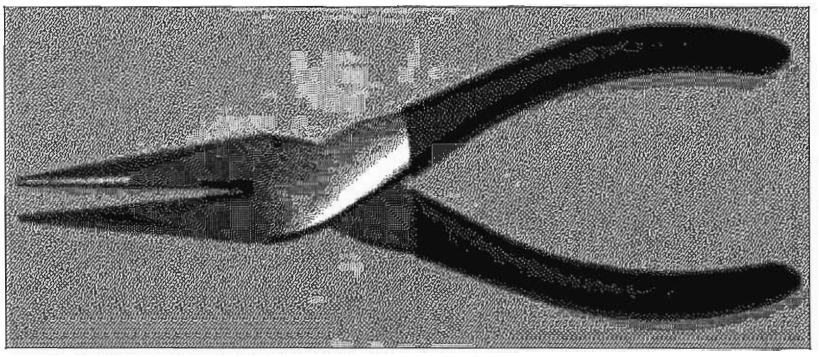
Utility Knifes: Three examples of different utility knives.



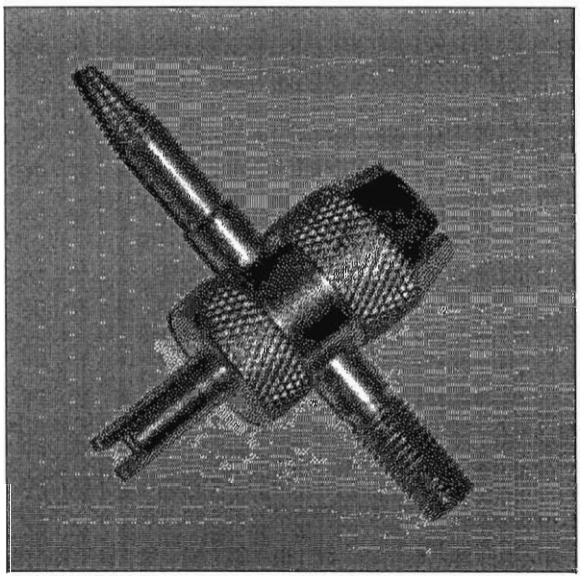
File: Used for filing down sharp metal screw heads, etc.



Tire Pressure Gage: Two different types displayed in the picture.



Needle Nose Pliers:



Valve Core Wrench:

5 Chemicals and lubricants

There are many chemicals and lubricants that can be used in maintaining and cleaning your wheelchair. Be sure to check for irritants and hazards associated with them. We recommend using a non-toxic cleaner diluted with water to clean a wheelchair. Be careful not to get lubricants on your skin as they may irritate the skin and can be harmful in large quantities. Do not ingest any cleaning solvent or lubricant, even if they are non-toxic, they can still be harmful to your health in small quantities. Do not soak the chair when washing it, this can lead to more problems in the future by rusting parts. Wash the chair using water on a damp cloth with mild soap, and rinse using clean water on another damp cloth. Do not use chemicals that can build up over time. Use a plastic mesh abrasive made for cleaning Teflon pan to take off dried material.

6 Troubleshooting

- **Arms**

1	Adjustable arms do not adjust.

1 Check that the arms are not damaged.

2 Check for rust around the mechanism. If corrosion is present, scrape off the corrosion with a small screwdriver and lubricate the mechanism, wait a few minutes and try to adjust the arms. If successful, remove the arms and scrape the rest of the corrosion off the arms.

3 Lubricate the mechanism with penetrating fluid, such as "WD-40", wait a few minutes, and try to adjust the arms.

2 Metal is poking through arm pads.

1 Feel the arm padding, if you feel a metal object in the padding then the screws are too long, replace them with shorter screws.
2 The screws holding on the arm pads are too long. Replace with shorter screws.
3 The arm pad is excessively worn. Replace arm pad.

3 Detachable arms do not detach/reattach.

1 Rust at the quick release mechanism. Use a penetrating fluid wait a few minutes and try to remove the arms.
2 Broken quick release mechanism.
3 Not detachable.
4 Arms or receivers bent.

4 Arm locks do not engage.

1 Arm frame is bent.
2 Lock is broken, obtain a replacement if possible, or contact your dealer or service center.

5 Arm panel(s) have fallen off.

1 Broken or missing hardware.
2 Broken panel. Obtain a replacement panel.

- **Back**

1 Seat back fabric is torn, fraying.

1 Excessive wear and cuts contribute to fabric failure. Purchase a new seat back and replace the old one.

2 Check the back tubes for alignment. If this is the case, check the screws and replace if missing or tighten if present.
3 Check the screws for missing or sharp edges. Replace screws.

2 Handgrips slip, slide off, or rotate.

1 Adhesive has worn away, replace handgrips **Chapter 4.2**.
2 Handgrips are worn and need replacement **Chapter 4.2**.

- **Seat, Cross Braces, and Frame**

1 The seat fabric is torn.

1 Excessive wear, sagging, and cuts can contribute to fabric tearing. Replace seat **Chapter 5.2**.

2 Folding chair does not fold.

1 Cross brace bolt too tight, loosen bolt
2 Missing hardware. Replace hardware.
3 Bent or broken links in mechanism. Bring to dealer or service center.
4 Dirt and grime preventing the mechanism from moving. Clean the folding mechanism **Chapter 5.2**, lubricate moving parts

3 Only three wheels touch the ground, when seated in chair.

1 Bent fame members, broken welds in frame, or missing hardware. Replace missing hardware, for other problems, bring chair to dealer to discuss options in fixing the chair.

- **Large Wheels**

1 Wheels are hard to spin.

1 Grinding noise, dirt in bearings or broken ball bearings. Take the chair to your dealer or service center to have it looked at.
2 Axle is too tight, loosen axle nut until it turns freely but not so loose that it wobbles.

2 Hand rims have fallen off.

1 Missing hardware. Replace hardware. If the threads have stripped, replace hand rims.
2 Hand rims are broken at interfaces. Replace hand rims.

3 Wheelchair moves when wheel locks are engaged.

1 Check proper tire pressure. Inflate if needed.
2 Check for excessive tire wear. Get the tire replaced.
3 Wheel locks are out of adjustment, turn to **Chapter 6.1** for adjustment of the wheel locks. If broken, obtain new locks from dealer.

4 Pneumatic tires are flat, or do not hold air.

1 Leaky valve stem core. Use a valve core wrench to tighten the valve core.
2 Tube is punctured. Recommend air-less inserts to prevent future flat tires. Visit dealer for installation.

5 The wheels wobble when the chair is in motion.

1 Axles are loose. Tighten wheel axle nuts until they do not wobble but can still rotate freely.
2 Axle plate is loose. Tighten bolts and align plates.
3 Bearings are worn. Take to your dealer or service center to replace the bearings.

- **Casters**

1 Casters flutter when chair is in motion.

1 Caster stem is loose. Tighten the stem nut on top of the caster fork until it is tight but can still rotate freely
2 Stem bearings worn or damaged. Replace bearings.
3 If pneumatic caster, check for proper pressure. Inflate if necessary.

2 The caster wheel is hard to spin.

1 Bushings/bearings are worn/damaged. Replace the bearings and bushings.
2 Axle nut is too tight, loosen nut.
3 The fork is bent. Obtain a replacement fork from dealer.
4 Stem bearings worn or damaged, replace bearings.

- **Footrests and Leg Rests**

1 Footrest does not adjust in length.

1 Corrosion. Disassemble the length adjustment rod and clean with steel wool until shiny and smooth.
2 Damaged. Replace with a new length adjustment rod
3 Dirty. Disassemble and clean with a non-abrasive cleaner and reassemble.

CHAPTER 2: ROUTINE MAINTENANCE

1 Maintenance schedule

Daily

- Check for excessive dirt and grime you may have picked up throughout the day and clean accordingly.

Weekly

- Clean your wheelchair and check for signs of wear. *(Section 2)*
- Check the tire pressure. *(Section 3)*
- Check that your wheel locks function properly. *(Section 3.4)*
- For folding wheelchairs, check that the wheelchair folds smoothly. (Section 4)

Monthy

- Check that your casters and forks move freely

2 Cleaning Your Wheelchair and Being Observant

You will want to routinely clean the wheelchair at least every other week, more if you are outside a lot or wheeling on unpaved terrain. Cleaning prevents dirt and grime from working its way into the internals of the wheel axles and casters. Cleaning also sets you up for a good visual inspection of the chair. Dirt and grime will prevent the wheels and casters from turning efficiently and thus will require you to use more effort. A sign that there is dirt and grime in the wheels is a grinding noise when the wheel is turned.

Be observant! The only way you will know if something has gone wrong or something will go wrong is if you pay careful attention to the chair. Become personal with the chair, it is not difficult to determine if there is something wrong or unusual with the chair. One way to become observant with a wheelchair is to just look at its individual parts and how they fit together with the other parts of the chair. The goal is to recognize unusual or abnormal traits of a chair that is broken or in need of repair. Another way to get accustomed to the wheelchair is to give it a good wash with a damp cloth and some warm water. However, do not soak the chair by spraying it with a hose or dumping water on it, this will only cause more problems in the future.

The items required to clean your wheelchair are a bucket of warm water and a clean soft cloth. As you are cleaning your wheelchair, check for damage and loose parts. This task will become easier once you become accustomed to your wheelchair.

1. Check for peeling paint and peeling chrome finish; peeling chrome is very sharp, be careful not to cut yourself. Peeling chrome is a manufacturing defect and must be fixed.
2. Check for damage to the upholstery and frame.

3 Check for wobbles in the frame, tighten bolts and screws, but do not over tighten. If the bolts are too tight your folding wheelchair will not fold easily, if this is the case, loosen the bolts or screws so that the chair folds properly.
4 Check the casters for hair and fibrous material in the axles.
5 If equipped with pneumatic tires, check that the bead is set properly around the rim and on each side.
6 Check for excessive grease leaking out of the axles.
7 Check that every component functions properly and in the manner it is supposed to work. If a component does not function properly, search for the section in this manual for disassembly procedure, clean the individual components, and reassemble.

3 Arms

- Check for obvious signs of damage in the arms and replace appropriate parts.
- Check the armrest padding for signs of screws poking through.
- If your chair is equipped with detachable arms, make sure that they are not too tight and can be removed freely.
- If your chair is equipped with adjustable arms, make sure the arms adjust, lock into place, and fit properly.
- Check that the arm locks fully engage. Refer to **Chapter 6.1** for adjustment.
- Check that the panel fasteners are tightened and that there are no sharp edges on the panels.

4 Back

- Check for obvious signs of damage in the back upholstery and replace or repair the appropriate parts.
- Check the material for rips and fraying, the material should have a constant tautness throughout.
- Check for missing and loose hardware.
- Inspect the back brace joints for cracks, bends and other damage.
- Check that the handgrips are secure, they should not move at all on their posts.
- Check the safety belts for fraying and damage.
- Check the reclining back adjustment mechanism to be sure it works properly (if so equipped).

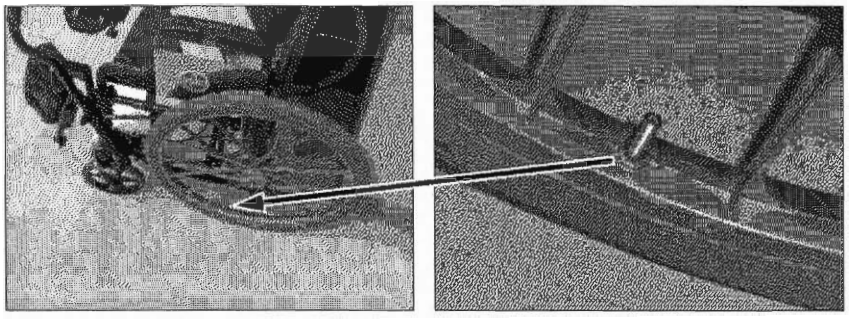
5 Seat, Cross Braces, and Frame

- Check the seat for tears or rips and that the seat is well secured on the frame.
- Check the screws, nuts, and bolts for stripping, sharp edges, or rust.
- Check that carrying straps are secured and not worn or frayed. If they are excessively worn, replace them with new carrying straps, **(Chapter 5)**.
- Inspect the seat rails for bends and cracks.

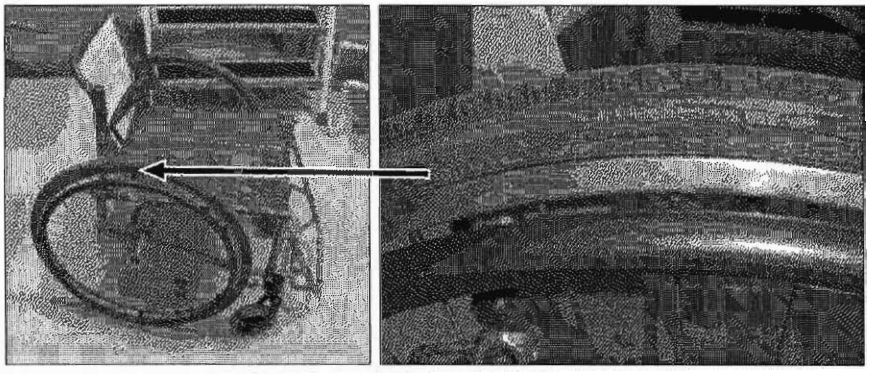
- For folding chairs, check that the center pin nut is secure, the pin must be free floating/loose and that the nut be an anti-reverse type so that the chair can fold and keep traction properly **(Chapter 5)**.
- Check that the seat rail guides are present and slide firmly in to the guides when the chair is open.
- Check that all four wheels touch the ground evenly, if they do not check for binding in one on the joints, check the welded joints for damage, and check for bent frame members.

6 Tire and Tire Pressure Checks

You can only check tire pressure on pneumatic tires. Pneumatic tires have a valve stem used to inflate and deflate the tire ***(see figure 2.0)***. If your tires do not have a valve stem, they are solid rubber tires; this is the case on many caster wheels ***(Section 5)***. If there is a constant problem with the tires of the chair, it is highly recommended to replace the tubes with a foamy insert to prevent flat tires.



2.0 View of a valve stem on a pneumatic tire.



2.1 View of inscription of pressure required in tire.

1 Maintaining optimal tire pressure ensures proper rolling resistance and traction on various surfaces. The operating pressure for a pneumatic tire is written on the side wall *(see figure 2.1).*
2 Periodically inspect the tread for signs of wear and damage. Look closely for cuts, punctures, and imbedded material. If a constant leak is present and there is no obvious sign of damage to the tire, use a valve core wrench to make sure the valve core is tight. If you suspect a small puncture, use a soapy water solution to spray on the tire with a spray bottle. The soapy solution will bubble where there is a leak.
3 Keep an accurate gage handy to check tire pressure. Although the pressure gauges on air hoses at gas stations are handy, they are often inaccurate and may not register to the pressure necessary for a pneumatic tire for a wheelchair.
4 Check your wheel locks by engaging them, if the wheel locks engage properly the wheelchair should not move. If the wheelchair moves with the wheel locks engaged turn to **Chapter 6** for wheel lock adjustment.
5 Check that the wheels spin straight on the axle. To do this tip the wheelchair on its opposite side and spin the wheel. The wheel should not wobble, if the wheel wobbles, the axle is bent and needs to be replaced, go to a wheelchair professional to solve this problem.
6 Check that the rubber tips are on the wheel lock handles and are not damaged or degraded.

7 Casters

Casters are the small wheels on the front of the wheelchair. There are two different types of casters and the difference is in the tire, they can either be pneumatic or solid rubber.

- If casters are pneumatic, check the pressure as you would for the large tires.
- Check the tire for excessive wear, such as cracking, and flat spots. Also check that the tire is on the rim evenly around the whole wheel.
- Check for excessive damage in the stem, fork, and wheel. If any of these are damaged, take your wheelchair to your service shop to order replacement parts.
- Look for signs of excessive grease leaking out of the axle or stem of the caster.
- Check that the caster wheel and fork spin freely and are not wobbly. If the caster wheel is wobbly, use two appropriately sized wrenches to tighten the axle until the wheel doesn't wobble but not so tight that the wheel does not spin. If the fork is wobbly, if it flutters at high speed, firmly hold the wheel, pry off the dust cap, and tighten the nut at the top of the fork until it does not wobble. If either of these nuts are stripped, take the assembly apart **(Chapter 8),** and purchase new hardware from your service shop or from a local hardware store.
- Check for hairs and fibers in the axle of the wheel. To clean the hair and fiber out of the axle, disassemble, clean, and reassemble the axle **(Chapter 8)**.

8 Footrests and Leg Rests

- Check footrests and leg rests for signs of wear and damage.
- Ensure that the lock mechanism locks into place correctly.
- Footplates should not have any sharp edges or cracks.
- Check that the end cap is in place.
- Check for loose or missing hardware.
- The footrest length adjustment mechanism should function properly and should not bind.
- The leg rest panels should not contain any sharp edges.
- The leg rest adjustment rod should not have any scratches or it will not function properly.
- Check that the footrest bumpers are intact and function properly.
- The footplate should rotate and stay up in place.
- The leg rest should elevate and return easily.
- The calf pads' screws should be secure.
- Calf pads should be free to pivot out of the way for transfers.

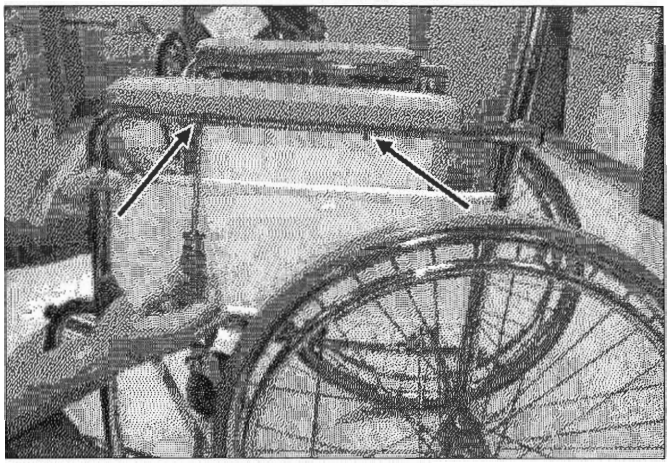
CHAPTER 3: ARMS

1 Replacing the Armrest Padding

To replace the armrest padding, a replacement pad must be obtained.
Once the replacement has been obtained, make sure that the replacement looks similar to the part being replaced.

Removal:

1 Remove the armrest assembly from the chair if possible, some armrests cannot be removed and armrest-padding replacement can be done without removing the armrest assembly.
2 Remove the screws or bolts holding on the armrest padding located underneath the armrests *(see figure 3.0)*.



3.0 This is a non-removable arm rest. Remove screws (in this case, two screws, indicated by arrows) holding the armrest padding.

Replacement:

1 Clean the mating surfaces with a soft cloth and a gentle cleaner.
2 Align the holes on the new padding with the holes in the arm frame.
3 Assemble the new armrest padding using the old screws.
4 Tighten the armrest padding until it does not move.

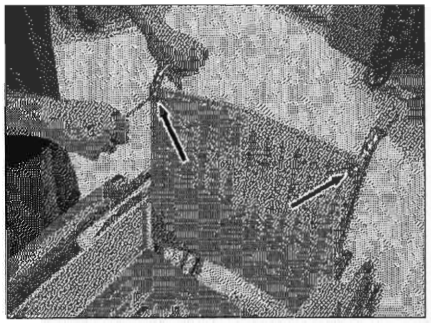
CHAPTER 4: BACK

1 Replacing the Back Upholstry

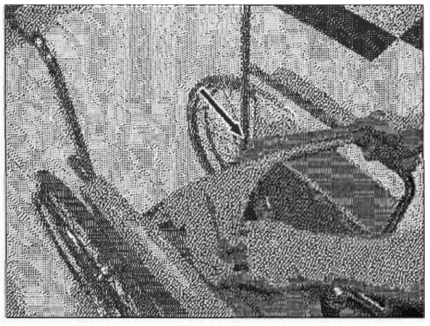
There are two types of seat backs. There are ones that secure only with screws to the frame and there are ones that slide over the frame of the chair where the hand grips are located. If your seat back slides over the frame where the handgrips are located, you may have to remove and replace the handgrips to remove and replace the seat back (**Chapter 4.2**). Obtain a replacement seat back from your dealer or supply store. You will need your Manufacturer and model number to obtain the correct replacement seat back for your wheelchair. Refer to ***Chapter 1, Section 3, Wheelchair Identification Numbers***.

Removal:

1 Remove the old seat back by first unfastening the screws located on the outer edge of the seat back ***(see figure 4.1)***; they can either be located in the front of the chair or on the back of the chair.
2 Remove the seat back by sliding it over the frame rails or removing it from the chair frame ***(see figure 4.2)***.



4.1 Removing the screws from the seat back



4.2 Removing the seat back from the frame

Replacement:

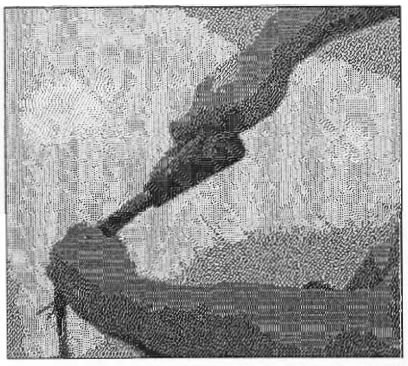
1 Clean the seat back supports with soap and water and dry with a soft cloth.
2 Replace with the new seat back by sliding it over the frame and fastening it using the same screws.

2 Replacing the Handgrips

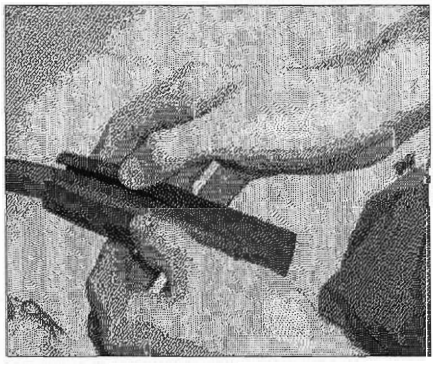
Obtain the new handgrips for your wheelchair.

Removal:

1 Hold the chair with one hand and using a sharp utility knife, cut along the top of the handgrip all the way to the end *(see figure 4.4)*.
2 Peel off the old hand grip starting from the open end of the grip and working your way to the other end while working off the handgrip *(see figure 4.5)*.



4.4 Cutting the old hand grip off.



4.5 Peel off the old hand grip starting from the open end.

Replacement:

1 Clean the bare handles with a soapy water solution and dry with a clean rag. If there is old glue or tape on the bare handles, scrape it off with a utility knife or a plastic mesh abrasive sponge to clean the bars.
2 Use fast drying hair spray, varnish, or paint and apply it to the inside of the rubber grip. These products will act as a lubricant when wet and an adhesive when dry.
3 Slide the grips on the handlebars until they reach the end. When dry, the grips will be securely fastened on the handlebars.

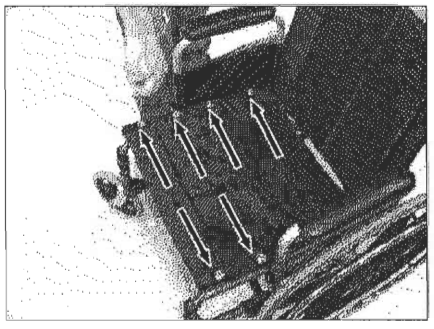
CHAPTER 5: SEAT, CROSS BRACES, AND FRAME

1 Replacing the Sling Seat Upholstery

To replace the seat, you first need to obtain a replacement seat from your dealer or service center.

Removal:

1 Loosen and remove the screws holding on the seat, they are located on the side by the armrests *(see figure 5.1)*.



5.1 Removing the screws from the seat frame.

5.2 Inserting the screws back into the seat frame.

Replacement:

1 Clean the seat rails with soap and water and dry with a clean rag.
2 Line up the holes on the seat rails with the holes in the new seat and reinsert the screws *(see figure 5.2)*.

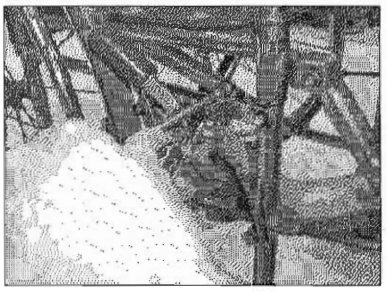
CHAPTER 6: WHEEL LOCKS

1 Wheel lock adjustment

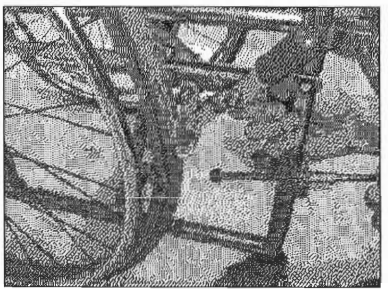
The wheel locks are located on the frame next to the larger wheels.

1 To adjust the wheel locks, loosen the bolts, that securely hold the mechanism to the frame *(see figure 6.1)*.

2 Engage the wheel locks and push them toward the tire until the lock touches the tire *(see figure 6.2)*.



6.1 Loosening the adjustment screws.

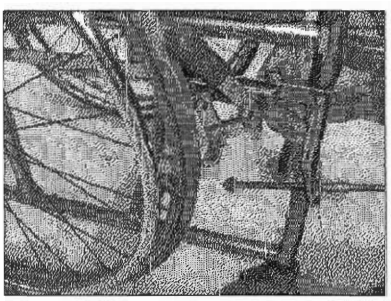


6.2 Engage the wheel lock and push it to the wheel until it touches the wheel.

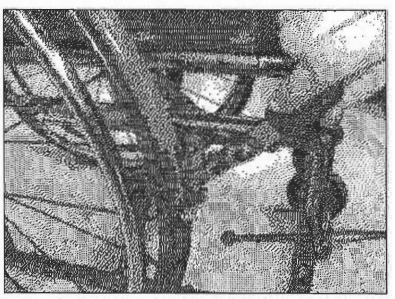
3 Disengage the wheel locks and push them closer to the wheel about a quarter inch more *(see figure 6.3)*.

4 Tighten the bolts holding the mechanism to the frame. Be careful not to move the mechanism location.

5 When the bolts are tight and secure, engage the wheel locks to test and make sure that the tire does not move *(see figure 6.4)*.



6.3 Disengage the wheel lock and push it a little closer to the wheel.



6.4 Tighten and test the wheel lock to be sure it holds the wheel.

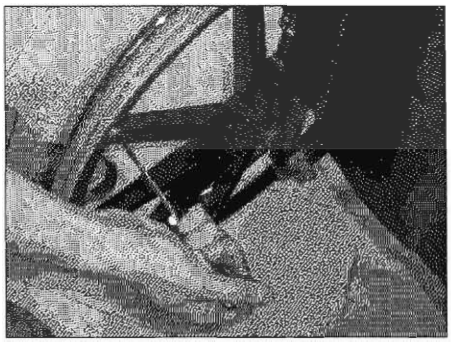
CHAPTER 7: LARGE WHEELS

1 Hand Rim Replacement

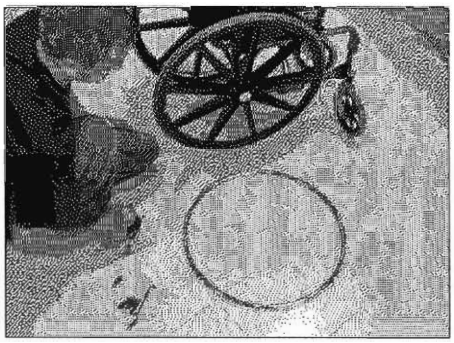
Obtain a new hand rim to replace the old one.

Removal:

1 Using a screwdriver, loosen and remove the screws on the backside of the wheel that hold on the hand rim *(see figure 7.1, 7.2)*.



7.1 Unscrewing the hand rim.



7.2 View of the hand rim off of the wheel.

Replacement:

1 Clean the through holes on the wheel that the hand rim fastens to with soapy water and dry with a clean cloth.
2 Using the same screws that you took off, attach the new hand rim. Insert all the screws but do not tighten. Once all the screws are in place, tighten them with a screwdriver. This is to prevent the hand rims from being misaligned with the wheel and to make installation easier.

2 Tire/Tube Replacement

If tire or tube replacement is necessary, we highly recommend substituting pneumatic tubes with air-less inserts. The inserts will prevent any flat tires in the future. You can get information about air-less inserts from your wheelchair dealer.

3 Spoke Wheels

The spokes can often become loose or broken and warp the wheel. You can take the wheel to a bicycle shop to straighten the wheel and replace or tighten the spokes. We do not recommend doing work on your spoke wheels. They require a highly skilled technician. We recommend upgrading to "Mag" wheels. "Mag" wheels are a solid one-piece wheel, are very strong, and require much less maintenance making wheelchair maintenance much easier.

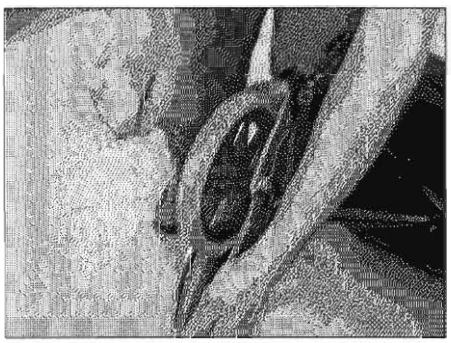
CHAPTER 8: CASTERS

1 Cleaning the Casters

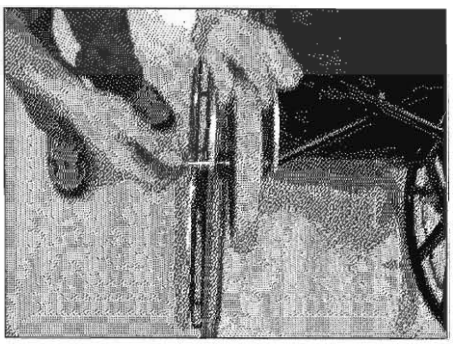
An easy way to clean all the hair out of the caster axle is to take the caster wheel off completely.

Removal:

1 Get two appropriately sized wrenches for both sides of the wheel.
2 Hold the caster wheel steady and using both wrenches turn the one in your right hand toward you to loosen it ***(see figure 8.1)***.
3 Remove the nut, pull the bolt out of the axle and set it aside.
4 Pull the caster wheel off and clean the hairs out of both sides and clean off the caster forks.



8.1 Loosen the axle and nut using two appropriately sized wrenches.



8.2 Insert the axle through both the wheel and the fork.

Replacement:

1 Align the holes in the caster wheels with the holes in the caster fork.
2 Insert the bolt all the way through both the fork and the wheel ***(see figure 8.2)***.
3 Place the nut on the end of the bolt and turn clockwise until hand tight.
4 Use the wrenches again to tighten the axle until snug, do not tighten it too much.
5 Make sure the caster wheel spins freely, if not, loosen the nut by turning it counter clockwise until the wheel turns freely.

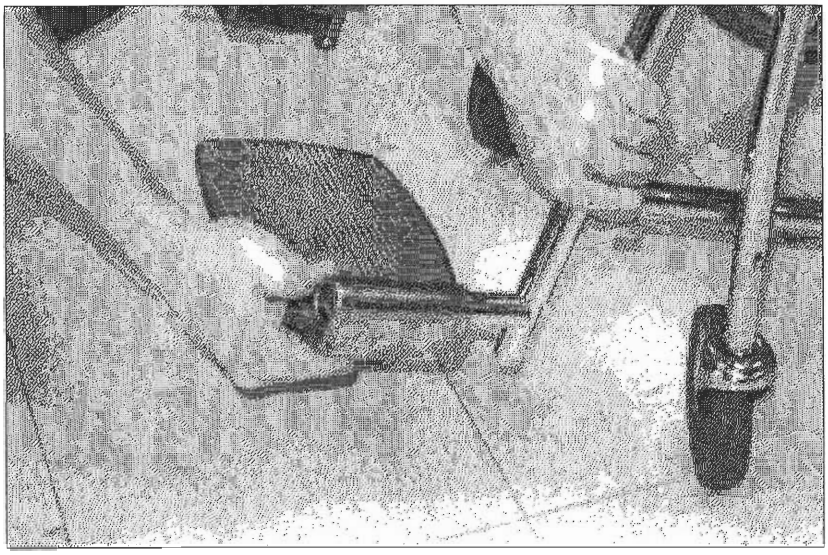
CHAPTER 9: FOOTRESTS AND LEG RESTS

1 Cleaning the Footrests

The footrests can become coated in dirt and grime very easily because they are close to the ground. If the footrests become difficult to fold out of the way, remove the foot rests and clean both the inside of the footrest hole and the tubing that the footrest attaches to.

Removal:

1 Remove the dust cap off the end of the footrest tubing with your hands, or if it is tight, you may use a pair of pliers to gently remove it.
2 Then use your hands to hold the chair and pull off the footrest from the footrest tube *(see figure 9.1)*.

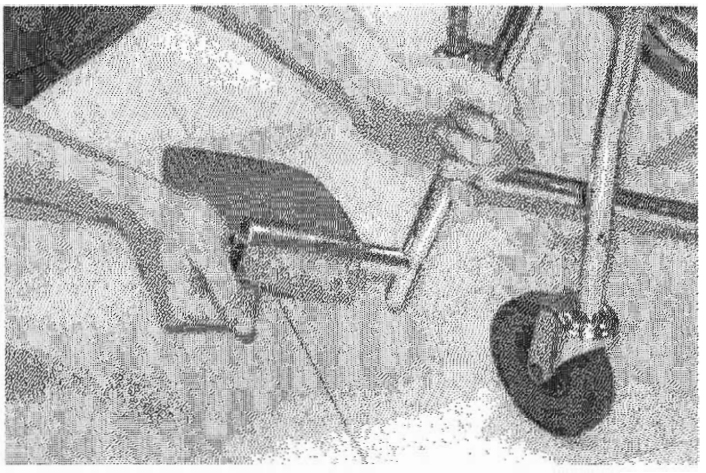


9.1 Removing the footrest.

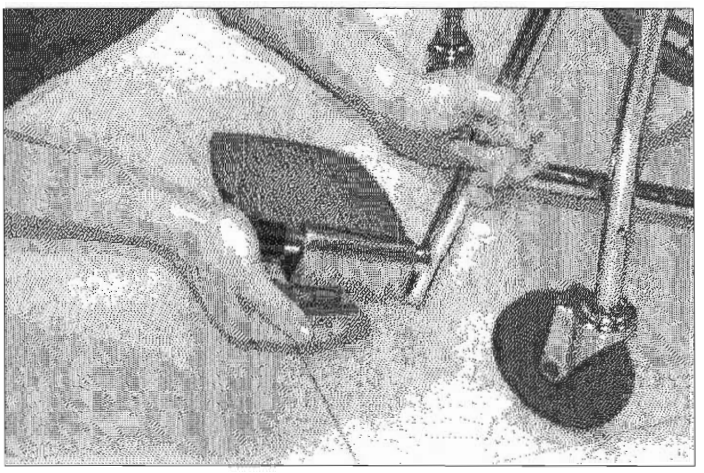
Reinstallation:

1 Align the hole in the footrest with and footrest tube and make sure it looks correct with respect to the other side *(see figure 9.2).*
2 Push the footrest on to the tube all the way.

3 Push the dust cap back on the end of the tube *(see figure 9.3)*.



9.2 Reinstalling the footrest on the footrest tube.



9.3 Reinstalling the dust cap on the footrest.

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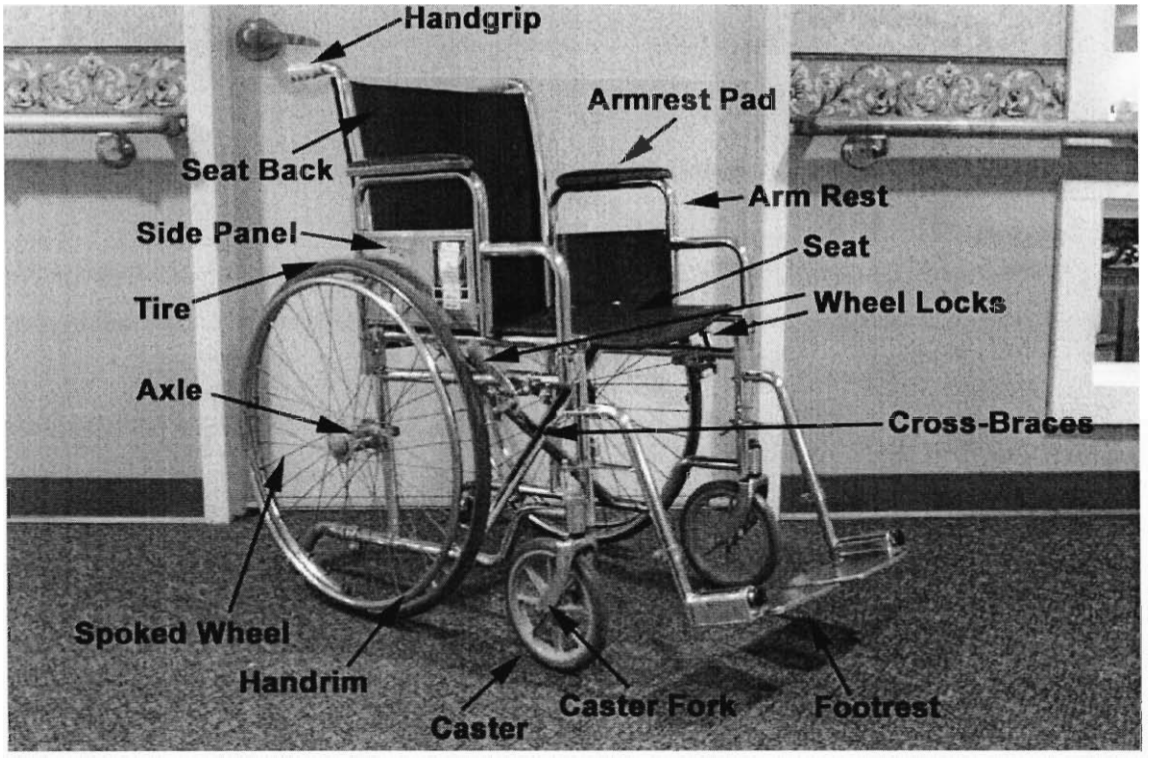
Wheelchair Maintenance Checklist



Arms *(Chapter 2.3)**

- ☐ Armrests – Check to make sure that the screws are not poking through the arm padding. Also, check for dangerous burrs or sharp edges on the heads of the screws.
- ☐ Detachable Arms – Make sure that the arms are not overly tightened, yet still secure.
- ☐ Adjustable-height Arms – Make sure arms adjust, lock into place and fit properly.
- ☐ Arm locks – Check that the locks fully engage.
- ☐ Side Panels – Check that panel fasteners are tightened and that there are no sharp edges on the panels.

Back *(Chapter 2.4)**

- ☐ Check all materials for rips and tears. Materials should all fit with the same tightness; areas should not be loose while others are tight. Check the nuts and bolts to be sure they are tight.
- ☐ Make sure all hardware is present, fully tightened and installed through the correct reinforcing strips.
- ☐ Check the back brace joints for cracks, bends and other damage.
- ☐ Handgrips should be tight and secure; they should not rotate on the posts.

- ☐ Check the Safety Belts for fraying or damage.
- ☐ Headrests should function properly.
- ☐ Check all adjustments to reclining backs, be sure they work correctly.
- ☐ Spreader-bar Assembly - Check for loose hardware. Look for damage to folding linkage.
- ☐ Hinged-back Assembly - Check the slide lock to be sure it works. Check all hardware to be sure it is present and snug.

Seat, Cross Braces, And Frame *(Chapter 2.5)**

- ☐ Check that the seat material is snug on the frame and that there are no rips or tears.
- ☐ Check for stripped screws and sharp edges on screw heads.
- ☐ Check that carrying straps are not worn or frayed.
- ☐ Check for sticking cross braces by folding the chair.
- ☐ Sight down seat rails, checking for cracks and bends.
- ☐ Check that the center pin nut (connects the two cross-braces) is secure.
- ☐ Front Post Slides - Fold the chair and sight down both posts, checking for straightness and roundness. While opening the chair, check that the posts do not rub or hit the caster forks. Fold the chair once again, checking that the posts do not come out of the sockets.
- ☐ Seat Rail-guides - Check that guides are present. Open the chair and make sure the seat rails firmly fit into the guides.
- ☐ Check that all four wheels are touching the ground evenly, if not there may be a failing weld or the frame may be bent.

Wheel Locks *(Chapter 2.6)**

- ☐ Tire Pressure – Check tire pressure before checking the wheel locks.
- ☐ Locks – each should securely engage the tire surface preventing the wheel from moving.
- ☐ Rubber Tips – should be present on wheel locks and not be cracked or split.

Large Wheels *(Chapter 2.6)**

- ☐ Check the wheels for trueness (making sure the wheels spin straight, without wobbling)
- ☐ Pluck the spokes, checking for equal tightness, and making sure there are no spokes missing.
- ☐ Check the wheel for side play. Side play indicates the need for adjustment or new bearings.
- ☐ Check for tire wear.
- ☐ Check that there are no gaps between tires and rims.
- ☐ Pneumatic Tires - Check for wear, cracks and tire pressure.
- ☐ Axles and Axle-lock Nuts – If removing the wheels, make sure axle threads are in good condition, check bushings for wear and make sure nuts are not rounded.
- ☐ Quick release Axles – While pushing the plunger pin in, the ball bearings at the other end should be loose and recessed. After releasing the plunger pin, the ball bearings should appear raised.

- ☐ Check that the hub caps are properly in place.
- ☐ Check that there is not a large amount of grease leaking from around the wheel axles or joints.
- ☐ Spin the wheels and make sure they turn easily and without a grinding sound, indicating damaged bearings.
- ☐ Hand rims and Attaching Hardware - Check hand rims for sharp edges. Check that the rims are securely attached. Check for missing hardware and that there are no cracks on anything.
- ☐ Axle Plates – Check that the plates are secure. If there is camber or toe adjustment, make sure the washer configuration is the same on both sides.
- ☐ Axle Sleeves – Check that the distances on the front and rear axle sleeves are the same.

Casters *(Chapter 2.7)**

- ☐ Forks and Retaining Mechanism - check for bending on the sides and the stem. Be sure stem is firmly attached to fork. Check threads and locking nut or retaining ring.
- ☐ Stem Bearings - check for excessive play in all directions, the casters should not flutter at high speeds.
- ☐ Wheels and Bearings - check for excessive wobble in bearings. Check axle and nut for stripping. Check that felt washers and/or string guards are present.
- ☐ Tires - Check for excessive tire wear and verify that the tire is secured on rim. Check and adjust the pressure on the tires as needed.
- ☐ Caster Housing - Select a level surface and roll-check chair. If chair veers more than a foot in a ten-foot distance, check frame for damage. Check alignment of housing on frame. Check fork and stem for bent condition.
- ☐ Check that there is not a large amount of grease leaking from around the wheel axles or joints.
- ☐ Spin the wheels, making sure they spin easily, without a grinding sound. A grinding noise indicates damaged bearings. Also, make sure the casters spin freely.

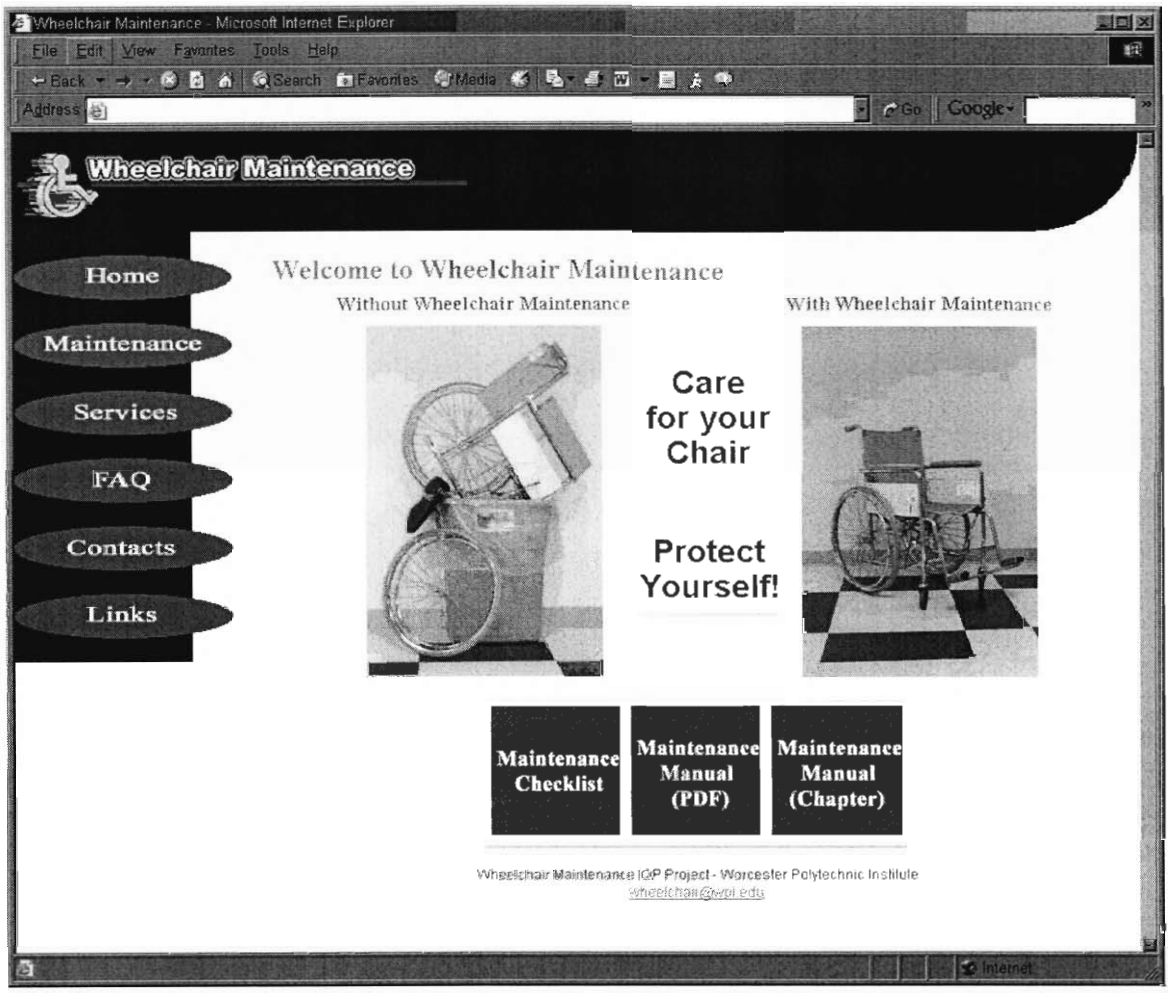
Footrest and Leg Rest (Front Rigging) *(Chapter 2.8)**

- ☐ Engage the Lock Mechanism and make sure it functions properly.
- ☐ Look out for excessive wear anywhere in the mechanism.
- ☐ Footplates should not contain any sharp edges and should hold at any position.
- ☐ Check for damage and proper function of the footrest length adjustment mechanism.
- ☐ The leg rest panels should not contain any sharp edges. Check that all hardware is present and check for wear in the leg rest panels.
- ☐ The leg rest adjustment rod should not have any scratches or it will not function properly. Check for all hardware and make sure it functions properly.
- ☐ Foot rest bumpers should be intact and not excessively worn.

* The chapter number refers to the "Guide to Manual Wheelchair Maintenance." More information about the title and contents can be found on the website.

Appendix C: Webpage

Home Page:



Maintenance page:

Maintenance

Information regarding the care of wheelchairs can be found here. The following checklist, manual and list of tools are aids to perform the maintenance required to ensure the long life of your wheelchair. Each can be viewed from the website or downloaded for a personal copy. If your computer lacks a program to open these files, a free reader can be downloaded by following the link at the right for Adobe Acrobat Reader.

Checklist

This contains a brief overview of all the steps needed to be taken while performing weekly, monthly and yearly checkups of a wheelchair. Each step is an

overview of the particular task to be accomplished. If a more involved description of each step is needed the manual should be used.

- Choose a format to view the checklist:
    - In the browser window (checklist.html)
    - Microsoft Word Document (checklist.doc)
    - PDF Document (.pdf)

Manual

This is a very in-depth and descriptive version of the checklist. Each step is well defined and labeled with the appropriate pictures to guide all skill levels through the process of wheelchair maintenance.

- Download and view specific chapters.
- Choose a format to view the manual:
    - Microsoft Word Document (manual.doc)
    - PDF Document (manual.pdf)

Tools

Here is a list and pictures of recommended wheelchair maintenance tools. These are useful in performing the tasks listed on the checklist, manual and videos.

- Recommended tools

Services page:

Services

A list of manufacturers of manual wheelchairs and links to there websites can be found here:

Manufacturer List

A list of sales and repair facilities found in Massachusetts can be found here:

Sales and Repair Facilities in Massachusetts

FAQ page:

Frequently Asked Questions

FAQ Answers and Solutions:

Why is wheelchair maintenance important?

Wheelchair maintenance helps to ensure long life from the wheelchair. It also helps to protect the wheelchair user from unexpected accidents that can occur from a improperly maintained wheelchair. When maintenance is performed on a regular basis, it can help to ensure long life and safety from the wheelchair.

The wheelchair does not travel in a straight line.

If your wheelchair does not travel in straight line; the frame may be damaged. Do not ignore these kinds of symptoms as they may lead to unsafe conditions of the wheelchair. The best way to correct these issues is to take your wheelchair to a professional.

A folding wheelchair does not open or close easily.

If your folding wheelchair does not open or close easily; the frame may be damaged. Do not ignore these kinds of symptoms as they may lead to unsafe conditions of the wheelchair. The best way to correct these issues is to take your wheelchair to a professional.

Upholstery seems loose on the chair.

Chair backs with adjustable straps need regular attention. It is usually easiest to enlist someone's help to tighten these straps if you are in the wheelchair, as it is awkward to reach behind yourself.

Sling-seat upholstery becomes loose after applying weight.

It is important not to allow your seat to sag; as this allows your cushion to bend, which could damage it. A seat that is sagging compromises your postural support and optimal protection from pressure sores. Some sling seats can be adjusted by removing one side from the frame and then pulling the material tight before replacing it.

Keeping heel loop studs tight.

This is done partially to avoid losing the bolt. The small bolt that goes up through the bottom of the footrest has nothing to hold it in place if it comes out. You might not discover it is gone until your foot slides off the footrest.

Contacts page:

Contacts

This website has been created as part of an IQP project at Worcester Polytechnic Institute.

People to contact during the development and production of this project.

Name	Position
Chris Kopec	Group Member
Adam Trimby	Group Member
Joe Sarcione	Group Member
Professor Allen Hoffman	Advisor
Professor Holly Ault	Advisor

Links page:

Links

Department of Mental Retardation

http://www.dmr.state.ma.us/

Elite Medical's Website (with Wheelchair Maintenance Information):

http://www.elitemedical.com/ehms1/wheelchairs.html

Able Data's Website (federally funded project to provide information on assistive technology):

http://www.abledata.com/text2/project.htm

The Massachusetts Rehabilitation Commission Website:

http://www.state.ma.us/mrc/vr/rehabtech.htm

Assistive Technology Resource Center (WPI):

http://www.me.wpi.edu/Research/ATRC/

Manufacturer's Table:

21st Century Scientific www.wheelchairs.com/	Giraldin www.giraldin.it/default_eng.htm	New Hall's Wheels www.newhalls.com/
Abbey Medical www.abbeymedical.net/	Golden Technologies www.goldentech.com/	Natural Access www.natural-access.com/product.htm
Adorno Rogers Technology, Inc. www.adorno-rogers.com/	Guardian www.1apowerwheelchairs.com/	Optima www.positiondynamics.com/
AgrAbility Project www.agrabilityproject.org/	Gunnell www.gunnell-inc.com/	Optiway Technology, Inc. www.optiway.com/
American Bantex Corporation www.americanbantex.com/	Hoveround www.hoveround.com/	Otto Bock Group www.ottobock.com/
Amigo Mobility www.myamigo.com	Invacare www.invacare.com/	PDG – Product Design Group www.prodgroup.com/
Armor Manufacturing Corporation www.armor.com.tw/	Kuschall www.epc-wheelchairs.co.uk/ www.thewheelchaircentre.co.uk/	RGK Wheelchairs www.rgklife.com/
Bruno Independent Living Aids, Inc. www.bruno.com/	Labac www.planetmobility.com/	Redman www.redmanpowerchair.com/
Convaid www.convaid.com/	Leisure Lift, Inc. www.leisurelift.com/prod01.htm	Roll-Ability www.roll.co.za/
ConvaQuip www.convaquip.com/	Levo USA, Inc. www.levousa.com/	Snug Seat www.snugseat.com/
Dalton Medical www.daltonmedical.com/	Liberator Wheelchairs, Inc. www.liberatorwheelchairs.com/	Summit Durable Medical Equipment

		www.summitdme.com/
DCC Shoprider, Inc. www.dcc.ie/dcc/about_us/	LifeStand www.lifestand.ws/	Sunrise Medical www.sunrisemedical.com/
Dr. K Healthcare Products www.drkmedical.com/	Major Mobility Products www.majormobility.com/	Teftec Corporation www.teftec.com/
Electric Mobility Corporation www.electricmobility.com	MEDBLOC www.medbloc.com/	TiSport www.tisport.net/
ETAC www.etac.com/	Medline www.medline.com/	Theradyne www.theradyne.com/
Everest & Jennings www.everestjennings.com/	Meyra www.meyra.com/	Trac About, Inc. www.tracabout.com/
Evermed www.edmond-wheelchair.com/	Mobility Express www.mobilityexpress.com/	Tuffcare www.tuffcare.com/
Freedom Designs www.freedomdesigns.com/	Mobility Vision www.mobility-vision.com/index.html	Vestil Innovation in Motion www.vestil.com/wc/
Gendron www.gendroninc.com/	Mogo www.mogowheelchairsusa.com/	Wheelchairs of Kansas www.wheelchairsofkansas.com/
		Winmed Products Company www.winmedproducts.com/

Sales and Repair Facilities in Massachusetts Table:

Aable Services 45 Deer Run Circle, Barre, MA 01005 (978) 355-3016	Homedco Springfield, MA 01104 (413) 443-4788
Able Ramp Company 12 Garfield Circle, Burlington, MA 01803	Hospital Pharmacy 825 Washington Street, Norwood, MA 02062

(781) 270-9100	(781) 762-2758
Adaptive Mobilty Equipment 11 Grand Army Highway, Somerset, MA 02726 (508) 676-7575	Hudson Home Health Care Rehabilitation Equipment 630 Silver Street, Agawam, MA 01001 (413) 786-7666
AFCO Equipment Corporation 175 California Street, Newton, MA 02458 (617) 244-7200	Hutchinson Medical 333 Highland Avenue, Salem, MA 01970 (978) 741-1770
Agawam Medical Supply 723 Main Street, Agawam, MA 01001 (413) 789-1100	Infinite Access East Inc 36 Mechanic Street, Foxboro, MA 02035 (508) 543-7919
All Care Home Health Services P.O. Box 4073, Brockton, MA 02303 (781) 297-2002 (781) 341-9627 (fax) (800) 427-1234 (toll-free)	Johnson Drug CO 577 Main Street, Waltham, MA 02452 (781) 893-3870
Alternative Care Providers 51 Middlesex Street, North Chelmsford, MA 01863 (978) 251-7077 (978) 251-7252 (fax) (800) 258-0907 (toll-free)	Letourneaus Pharmacy Inc 351 North Main Street, Andover, MA 01810 (978) 475-7779
American Elevator CO Inc 214 Harvard Avenue, Allston, MA 02134 (617) 730-8200	Lifeplus Inc Revere, MA 02151 (781) 485-0166
American Ramp Systems 202 West First, South Boston, MA 02127 (617) 269-5666 (617) 268-3701 (fax) (800) 649-8215 (toll-free) http://www.americanramp.com	Lomedco (978) 459-6101
American Services for the Handicapped and Elderly In 214 Harvard Avenue, Allston, MA 02134 (617) 730-8200	Louis & Clark Homecare Medical 490 Page Boulevard, Springfield, MA 01104 (413) 737-7456
Automotive Innovations Inc 4 1st Street, Bridgewater, MA 02324 (508) 697-8324	Louis & Clark Medical Supply Springfield, MA 01109 (413) 782-1980
Ayers Handicap Conversion Center 440 East Squantum Street, Quincy, MA 02171 (617) 328-0102	Manchester Home Improvement 209 Rogers Avenue, West Springfield, MA 01089 (413) 733-4689
Baxter Pharmacy 385 Washington Street, Quincy, MA 02169 (617) 773-7733	Marchant Medical Supply 426 Main Street, Hyannis, MA 02601 (508) 790-8912

	(800) 235-0131 (toll-free)
Belmont Medical Supply CO 185 Belmont Street, Belmont, MA 02478 (617) 484-3888	McNabb General Store Main, Pepperell, MA 01463 (978) 433-3323
Bouvier Pharmacy Inc 515 Lincoln Street, Marlborough, MA 01752 (508) 485-0432	Medequip Inc 134 Bliss Street, West Springfield, MA 01089 (413) 737-5466
Burke Medical Equipment 165 Front Street, Chicopee, MA 01013 (413) 592-5464	Medi-Rents Inc 132 Brookline Avenue, Boston, MA 02215 (617) 247-1000 (800) 322-2232 (toll-free)
Burke Medical Equipment Inc 8 Walnut Street, Maynard, MA 01754 (978) 461-0426	Medical Aids Inc 128 Main Street, Hyannis, MA 02601 (508) 771-2010
Butler R D & CO 65 Ryan Drive, Raynham, MA 02767 (508) 823-7799	Motion Automotive Specialty Route 20, Brimfield, MA 01010 (413) 245-9949
Byrne Home Health Center 16 North Main Street, Natick, MA 01760 (508) 655-3656	New England Home Health Care 38 Centre Street, Middleboro, MA 02346 (508) 947-0225
CHL Wheelchair Sales & Service Corporation Southbridge, MA 01550 (508) 765-2614	New England Medical Homecare Inc 7 Saint Mark Street, Auburn, MA 01501 (508) 832-3760
Ciampa Medical Supply 425 Cambridge Street, Cambridge, MA 02141 (617) 547-0325	New England Mobility 10 Windemere Way, Bridgewater, MA 02324 (508) 697-0635
Claflin Continuing Care 949 Main Street, Weymouth, MA 02190 (781) 331-8696	New England Therapeutic 17 Wilson Street, Chelmsford, MA 01824 (978) 250-0808
Collins Surgical 87 Westgate Drive, Brockton, MA 02301 (508) 580-2825	PKP Rehabilitation Inc 1600 Providence Highway, Walpole, MA 02081 (508) 660-2105
Conlin S Pharmacy Lawrence, MA 01840 (978) 552-1725	Prescription Pharmacy Inc 38 Centre Street, Middleboro, MA 02346 (508) 947-1909
Conlin's Pharmacy 30 Lawrence Street, Methuen, MA 01844 (978) 552-1750 (978) 552-1725 (888) 266-5467 (toll-free) info@conlinsnet.com	R-D Butler & CO Inc 320 West Center, West Bridgewater, MA 02379 (508) 586-7819
Davco Industries Inc 42 Walnut Street, Haverhill, MA 01830	Renmar Distribution 100 Ashburton Avenue, Woburn, MA 01801

(978) 373-5693	(781) 938-1158
Denmarks Home Medical Equipment Inc 128 Main Street, Hyannis, MA 02601 (508) 771-2010	Source Equipment Company 38 Fruit Street, Leominster, MA 01453 (978) 537-3498 (fax) (800) 743-5545 (toll-free) support@sourceequipment.com
Denmarks Home Medical Equipment Inc 55 Main Street, Orleans, MA 02653 (508) 255-0132	Southeast Railing & Iron Works CO 901 Turnpike Street, Canton, MA 02021 (781) 828-7088
Denmarks Home Medical Equipment Inc 509 Kempton Street, New Bedford, MA 02740 (508) 999-1239	Sullivans Medical Supply 1 Corinth Street, Roslindale, MA 02131 (617) 325-0013
Denmarks Home Medical Equipment 5 Tremont Street, Taunton, MA 02780 (508) 822-5000	Surgimed Corporation 109 Eagle Street, North Adams, MA 01247 (413) 663-8655
Design Able 65 Ryan Drive, Raynham, MA 02767 (508) 823-3099	Suspension Compression Sys 238 Broadway, Cambridge, MA 02139 (617) 868-9120 (617) 868-9121
Diversified Medical Equipment 143 Mill Street, Leominster, MA 01453 (978) 537-8707	Thyssen Dover Elevator 665 Concord Avenue, Cambridge, MA 02138 (617) 547-9000
Elevator Service & Repair CO Springfield, MA 01103 (413) 739-1885	Tooheys Pharmacy 175 Main Street, Hudson, MA 01749 (978) 562-2424
Elmwood Towing 74 Baldwin Street, West Springfield, MA 01089 (413) 732-0600	Totally Mobile 182 Turnpike Road, Westborough, MA 01581 (800) 366-2994 (toll-free) http://www.totallymobile.baweb.com
Enhancements Unlimited 238 Broadway, Cambridge, MA 02139 (617) 492-1441	TURA S Pharmacy 85 Summer Street, Kingston, MA 02364 (781) 585-2595
F W Access 148 Washburn Street, Northborough, MA 01532 (508) 393-9883	United Cerebral Palsy Association of Berkshire Count Pittsfield, MA 01201 (413) 447-9555
Foley John 28 Whites Path, South Yarmouth, MA 02664 (508) 394-1375	United Cerebral Palsy Association of Berkshire Count 57 Main Street, North Adams, MA 01247 (413) 664-9345
Footit Health Care Store 340 Memorial Avenue, West Springfield, MA 01089 (413) 733-7843	United Surgical Centers 87 Westgate Drive, Brockton, MA 02301 (508) 580-2825

Furnance Brook Apothecary 385 Washington Street, Quincy, MA 02169 (617) 773-7733	Van Go Inc 110 Frank Bennett Highway, Saugus, MA 01906 (781) 231-1000
Handilift stairlifts-wheelchair lifts-elevators since 1975 (518) 393-2274 (518) 393-7683 (fax) (888) 558-5438 (toll-free) lwmiller@handilift.com http://www.handilift.com	West Gate Pharmacy 215 West Main Street, Hyannis, MA 02601 (508) 775-9211
Healthalliance 143 Mill Street, Leominster, MA 01453 (978) 537-8707 (978) 537-8797 (fax)	Wheel Chair Repair Clinic 57 Main Street, North Adams, MA 01247 (413) 664-9345
Healthwise 825 Washington Street, Norwood, MA 02062 (781) 762-2758	Wheelchair Depot 315 Main Street, West Springfield, MA 01089 (413) 736-0376
Home Health Care Supplies Inc 33 Whistlestop Mall, Rockport, MA 01966 (978) 546-3454	Wheelchairs Unlimited Inc 129 Barber Avenue, Worcester, MA 01606 (508) 856-7488