Accessible Physics Concepts for Blind Students

By:
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C O N N E X I O N S

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Chapter 1

Introduction to Accessible Physics Concepts[1]

1.1 Table of Contents

1.2 Preface

1.2.1 General

This is the first module in a collection of modules designed to make physics accessible to blind students.

See http://cnx.org/content/col11294/latest/ [2] for the main page of the collection. See http://cnx.org/content/col11294/latest/#cnx_sidebar_column [3] for the table of contents for the collection.

The collection is intended to supplement but not to replace the textbook in an introductory high school or college physics course.

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[1]This content is available online at <http://cnx.org/content/m37432/1.2/>.
[2]http://cnx.org/content/col11294/latest/
[3]http://cnx.org/content/col11294/latest/#cnx_sidebar_column

1.2.2 Impetus for this collection of modules

I am a professor of Computer Information Technology at Austin Community College in Austin, TX. For the past couple of years, I have had the privilege of teaching object-oriented Java programming to a blind student. That has gone very well.

Assist a student in physics

During a recent semester, I volunteered to assist this student in her efforts to successfully complete a physics course that she was taking in another department of the college. I quickly learned that she faced significant barriers in this endeavor, not the least of which was the general lack of accessibility provided by the electronic versions of the textbook. (The student had access to both pdf and Word formats of the textbook.)

Not compatible with accessibility tools

I am not visually impaired, so for me the textbook was adequate. However, it contains numerous elements that don't work well when viewed by a blind student using accessibility tools such as an audible screen reader and an electronic line-by-line Braille display.

Pictures and diagrams

For example, each chapter contains numerous pictures and diagrams that are an integral part of the teaching material. In some cases, there is a reasonable verbal explanation for a picture or diagram and in some cases there is little or no explanation. Therefore, a blind student using this particular textbook is deprived of a significant portion of the teaching material.

Physics can be difficult under the best of conditions

Learning physics is difficult for many students even when they have full access to all of the available teaching resources. Learning physics is even more difficult when the student is deprived of some of the available teaching resources.

Greek characters

While it is not surprising that the textbook is full of Greek characters and other fancy typesetting elements such as subscripts, superscripts, vector symbols, etc., this also leads to difficulties relative to the use of a screen reader and Braille display.

Mathematics and equations

The language of physics is mathematics. Many blind students are fully capable of understanding mathematics and equations when they are presented in a format that is accessible to the student.

Hundreds of equations

Each chapter in the textbook contains dozens and in some cases hundreds of equations. The equations in the pdf version of the textbook look OK to a sighted person like myself. However, they mostly look like garbage when viewed by a blind student using an audible screen reader and a Braille display.

The Word version is worse

The equations are garbage when viewed by a sighted person using the Word version of the textbook. I don't know what process was used to convert the pdf version to a Word version, but I do know that the equations weren't properly converted from pdf format to Word format.

Overcoming the barriers

The situations described above are just a few of the barriers that I will attempt to overcome in the modules in this collection. I will have more to say about this later.

1.2.3 Prerequisite requirements

Accessibility tools

In addition to an Internet connection and a browser, you will need the following tools (as a minimum) to work through the exercises in these modules:

- A graph board for plotting graphs and vector diagrams (http://www.youtube.com/watch?v=c8plj9UsJbg [4]).

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[4] http://www.youtube.com/watch?v=c8plj9UsJbg

- A protractor for measuring angles (http://www.youtube.com/watch?v=v-F06HgiUpw [5]).
- An audio screen reader that is compatible with your operating system, such as the NonVisual Desktop Access program (NVDA) that is freely available at http://www.nvda-project.org/ [6] .
- A refreshable Braille display capable of providing a line by line tactile output of information displayed on the computer screen (http://www.userite.com/ecampus/lesson1/tools.php [7]). While I understand that these devices are fairly expensive, you may not be able to work through the exercises without one.

- The ability to create tactile graphics as described at http://cnx.org/content/m38546/latest/ [8] .

I will have more to say about the need for and the use of these tools later.

Prerequisite knowledge

The minimum prerequisites for understanding the material in these modules include the following.

- A good understanding of algebra.
- An understanding of the use of a graph board for plotting graphs and vector diagrams (http://www.youtube.com/watch?v=c8plj9UsJbg [9]). I will have more to say about this later.
- An understanding of the use of a protractor for measuring angles (http://www.youtube.com/watch?v=v-F06HgiUpw [10]). I will have more to say about this later as well.
- A basic understanding of the use of sine, cosine, and tangent from trigonometry (http://www.clarku.edu/~djoyce/trig/ [11]). Once again, I will have more to say about this later.

- An introductory understanding of JavaScript programming (http://www.dickbaldwin.com/tocjscript1.htm [12] and http://www.w3schools.com/js/default.asp [13]). Ditto on more to say about this later.
- An understanding of the creation and use of tactile graphics as described at http://cnx.org/content/m38546/latest/ [14] .

1.2.4 Supplemental material

I recommend that you also study the other lessons in my extensive collection of online programming tutorials. You will find a consolidated index at www.DickBaldwin.com [15] .

1.3 Discussion

The following sections expand on the discussion from above.

1.3.1 Algebra

As I mentioned earlier, the language of physics is mathematics. In order to understand the material in this collection, you will need a good foundation in algebra. If you have such a foundation, you will probably know that to be the case. If not, you might want to work on that before embarking on a course in physics.

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[5] http://www.youtube.com/watch?v=v-F06HgiUpw
[6] http://www.nvda-project.org/
[7] http://www.userite.com/ecampus/lesson1/tools.php
[8] http://cnx.org/content/m38546/latest/
[9] http://www.youtube.com/watch?v=c8plj9UsJbg
[10] http://www.youtube.com/watch?v=v-F06HgiUpw
[11] http://www.clarku.edu/~djoyce/trig/
[12] http://www.dickbaldwin.com/tocjscript1.htm
[13] http://www.w3schools.com/js/default.asp
[14] http://cnx.org/content/m38546/latest/
[15] http://www.dickbaldwin.com/toc.htm

1.3.2 Using a graph board

There is a good chance that you already know how to use a graph board based on your earlier coursework in algebra. If not, there is a series of videos beginning at http://www.youtube.com/watch?v=c8plj9UsJbg [16] that will teach you what a graph board is and how to use it.

Why would I direct a blind student to a video?

Of course, you may be wondering why I would direct a blind student to an instructional video. My hope is that if you need this information on graph boards, you can find a sighted friend who will help you to work through the series of graph-board tutorials on the website referred to above.

You will need a graph board

You will need a graph board to complete many of the exercises in this collection. If you don't have access to one, it shouldn't be too difficult for you and a sighted friend to make one using a sheet of Styrofoam, corkboard, bulletin-board material or any flat surface into which you can push pins and expect them to stay until you pull them out.

Tactile grid lines

To create the tactile grid lines on your homemade graph board, ask your sighted friend to draw the grid lines on a sheet of heavy paper and then perforate them using a serrated tracing wheel (http://en.wikipedia.org/wiki/Tracing_wheel [17]). Then turn the paper over and pin it to the backing material so that you can feel the perforated grid lines.

Perforating with a tracing wheel

I find that it works well to place the paper on a sheet of Styrofoam to perforate the lines with the tracing wheel. Also, some tracing wheels work better than others for this purpose. The serrations are very sharp on some wheels and less sharp on others. The sharp ones work best.

1.3.3 Using a protractor

There is also a good chance that you already know how to use a protractor to measure angles based on your earlier coursework in algebra. If not, there is a series of videos beginning at http://www.youtube.com/watch?v=v-F06HgiUpw [18] that will teach you how to measure angles with a protractor.

Once again, you may be wondering why I would direct a blind student to an instructional video. As before, my hope is that if you need this information, you can find a sighted friend who will help you to work through the series of protractor video tutorials.

You will need a protractor

You will need a protractor to complete many of the exercises in this collection. While it may be possible to adapt a protractor normally used by sighted students for this purpose, this will probably be more difficult than making a graph board.

A protractor that looks like the one in the video can be purchased at http://shop.aph.org/webapp/wcs/stores/servlet/Product_Braille-Large%20Print%20Protractor_1-04115-00P_10001_11051 [19] . However, this is not a recommendation that you purchase this particular brand of protractor. You should do your own shopping and make your own decision.

1.3.4 JavaScript programming

As I stated earlier, you will need an introductory understanding of JavaScript programming (http://www.dickbaldwin.com/tocjscript1.htm [20] and http://www.w3schools.com/js/default.asp [21]) to work

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[16] http://www.youtube.com/watch?v=c8plj9UsJbg

[17] http://en.wikipedia.org/wiki/Tracing_wheel

[18] http://www.youtube.com/watch?v=v-F06HgiUpw

[19] http://shop.aph.org/webapp/wcs/stores/servlet/Product_Braille-Large%20Print%20Protractor_1-04115-00P_10001_11051

[20] http://www.dickbaldwin.com/tocjscript1.htm

[21] http://www.w3schools.com/js/default.asp

through the exercises in this collection of modules. Why is that?

Incompatible typesetting elements

Typical physics textbooks designed for use by sighted students are full of typesetting elements that are often incompatible with accessibility tools such as screen reading software, a Braille display, or both.

In writing these modules, I will need a way to ensure that all of the text, including the text in equations and other mathematical expressions, is compatible with those tools. One way that I hope to do that is to ensure that all of the text consists only of the characters on a standard QWERTY keyboard (http://en.wikipedia.org/wiki/QWERTY [22]).

Restrict to QWERTY characters

One way to accomplish that goal is to write all equations and other mathematical expressions in a format that is compatible with a standard computer programming language that will only accept a subset of the characters on a QWERTY keyboard. I have selected the programming language named JavaScript for this purpose. While JavaScript is not my favorite programming language, it is adequate for this purpose and is probably the most accessible programming language for blind students.

Prior knowledge of JavaScript is not required

It will not be necessary for you to have prior knowledge of or to develop expertise in JavaScript programming to understand and work through these modules. One of the early modules in the collection will be a module on JavaScript programming. That module will be designed to teach you what you need to know about JavaScript programming to satisfy your needs. There will also be additional information about JavaScript programming scattered throughout the modules on an as-needed basis.

1.3.5 Trigonometry

While it would be advantageous for you to have prior knowledge of trigonometry, that is also not a requirement. One of the early modules in the collection will be an introduction to trigonometry. That module will be designed to teach you what you need to know to understand and work through the material in the modules. There may also be additional information about trigonometry scattered throughout the modules on an as-needed basis.

1.3.6 Pictures and diagrams

I will be very frugal with the use of pictures and diagrams.

In those cases where a picture or a diagram is needed, I will make such pictures and diagrams as simple as possible so that a blind student can print an enlarged version and ask a sighted friend to perforate the lines using a tracing wheel. Then the student can turn the paper over and explore the perforations while reading the text.

In many cases, I will provide detailed instructions for using a graph board to create the picture or diagram.

Finally, I will provide SVG graphics files for all pictures and diagrams so that you can convert them to tactile graphics as described at http://cnx.org/content/m38546/latest/ [23] .

1.3.7 Greek characters

I will not use any Greek characters in the modules. In those cases where the use of a Greek character is unavoidable or highly desirable, I will spell out the name of the character using QWERTY characters.

1.4 Resources

I will publish a module containing consolidated links to resources on my Connexions web page and will update and add to the list as the modules in this collection are published.

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[22]http://en.wikipedia.org/wiki/QWERTY
[23]http://cnx.org/content/m38546/latest/

1.5 Miscellaneous

This section contains a variety of miscellaneous information.

NOTE: **Housekeeping material**

- Module name: Introduction to Accessible Physics Concepts
- File: Phy1000.htm
- Revised: 6/18/2011
- Keywords:
  - · physics
  - · accessible
  - · blind
  - · graph board
  - · protractor
  - · screen reader
  - · Braille display
  - · JavaScript
  - · trigonometry

NOTE: **Disclaimers: Financial** : Although the Connexions site makes it possible for you to download a PDF file for this module at no charge, and also makes it possible for you to purchase a pre-printed version of the PDF file, you should be aware that some of the HTML elements in this module may not translate well into PDF.

I also want you to know that, I receive no financial compensation from the Connexions website even if you purchase the PDF version of the module.

 Affiliation : I am a professor of Computer Information Technology at Austin Community College in Austin, TX.

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Chapter 2

If You Can Imagine It, You Can Draw It using SVG[1]

2.1 Table of Contents

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[1]This content is available online at <http://cnx.org/content/m39607/1.5/>.

2.2 Preface

2.2.1 General

This module is part of a collection of modules designed to make physics concepts accessible to blind students.

See http://cnx.org/content/col11294/latest/ [2] for the main page of the collection and http://cnx.org/content/col11294/latest/#cnx_sidebar_column [3] for the table of contents for the collection.

The collection is intended to supplement but not to replace the textbook in an introductory course in high school or college physics.

The study of physics is replete with requirements to create and analyze technical drawings. This is obviously more difficult for blind students than for sighted students. However, blind students can draw technical diagrams and the purpose of this module is to show you how. If you can imagine it, you can draw it using SVG.

2.2.2 Prerequisites

In addition to an Internet connection and a browser, you will need the following tools *(as a minimum)* to work through the exercises in these modules:

• A   graph   board   for   plotting   graphs   and   vector   diagrams   (http://www.youtube.com/watch?v=c8plj9UsJbg [4]).
• A protractor for measuring angles (http://www.youtube.com/watch?v=v-F06HgiUpw [5]).
• An audio screen reader that is compatible with your operating system, such as the NonVisual Desktop Access program (NVDA), which is freely available at http://www.nvda-project.org/ [6] .
• A refreshable Braille display capable of providing a line by line tactile output of information displayed on the computer monitor (http://www.userite.com/ecampus/lesson1/tools.php [7]).
• A device to create Braille labels. Will be used to label graphs constructed on the graph board.
• The ability to create tactile graphics as described at http://cnx.org/content/m38546/latest/ [8] .

The minimum prerequisites for understanding the material in these modules include:

• A good understanding of algebra.

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[2]http://cnx.org/content/col11294/latest/
[3]http://cnx.org/content/col11294/latest/#cnx_sidebar_column
[4]http://www.youtube.com/watch?v=c8plj9UsJbg
[5]http://www.youtube.com/watch?v=v-F06HgiUpw
[6]http://www.nvda-project.org/
[7]http://www.userite.com/ecampus/lesson1/tools.php
[8]http://cnx.org/content/m38546/latest/

- An understanding of the use of a graph board for plotting graphs and vector diagrams (http://www.youtube.com/watch?v=c8plj9UsJbg [9]).
- An understanding of the use of a protractor for measuring angles (http://www.youtube.com/watch?v=v-F06HgiUpw [10]).
- A basic understanding of the use of sine, cosine, and tangent from trigonometry (http://www.clarku.edu/~djoyce/trig/ [11]).
- An introductory understanding of JavaScript programming (http://www.dickbaldwin.com/tocjscript1.htm [12] and http://www.w3schools.com/js/default.asp [13]).
- An understanding of all of the material covered in the earlier modules in this collection.
- An understanding of the creation and use of tactile graphics as described at http://cnx.org/content/m38546/latest/ [14] .

2.2.3 Viewing tip

I recommend that you open another copy of this document in a separate browser window and use the following links to easily find and view the figures and listings while you are reading about them.

2.2.3.1 Figures

2.2.3.2 Listings

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[9] http://www.youtube.com/watch?v=c8plj9UsJbg
[10] http://www.youtube.com/watch?v=v-F06HgiUpw
[11] http://www.clarku.edu/~djoyce/trig/
[12] http://www.dickbaldwin.com/tocjscript1.htm
[13] http://www.w3schools.com/js/default.asp
[14] http://cnx.org/content/m38546/latest/

2.2.4 Supplemental material

I recommend that you also study the other lessons in my extensive collection of online programming tutorials. You will find a consolidated index at www.DickBaldwin.com [15] .

2.3 Discussion

2.3.1 Creation of tactile graphics

The module titled   *Manual Creation of Tactile Graphics*   at http://cnx.org/content/m38546/latest/ [16] explains how to create tactile graphics from svg files that I will provide.

If you are going to have an assistant create tactile graphics for this module, **you will need to** download the file named Phy1002.zip [17] , which contains the svg files for this module. Extract the svg files from the zip file and provide them to your assistant.

In each case where I am providing an svg file for the creation of tactile graphics, I will identify the name of the appropriate svg file and display an image of the contents of the file for the benefit of your assistant. As explained at http://cnx.org/content/m38546/latest/ [18] , those images will be mirror images of the actual images so that your assistant can emboss the image from the back of the paper and you can explore it from the front.

I will also display a non-mirror-image version of the image so that your assistant can easily read the text in the image.

2.3.2 What is SVG *(Scalable Vector Graphics)* ?

The shortest answer that I can come up with is that SVG is a technology that makes it possible for a blind student to create technical drawings. If the student can imagine it, the student can draw it using SVG and drawing tools that I will provide in this module.

According to Wikipedia [19]

"Scalable Vector Graphics (SVG) is a family of specifications of an XML-based file format for describing two-dimensional vector graphics, both static and dynamic (i.e. interactive or animated).

The SVG specification is an open standard that has been under development by the World Wide Web Consortium (W3C) since 1999. SVG images and their behaviors are defined in XML text files. This means that they can be searched, indexed, scripted and, if required, compressed.

Since they are XML files *, SVG images can be created and edited with any text editor, but it is often more convenient to create these types of images with drawing programs such as*   *Inkscape* [20] *.*

All major modern web browsers have at least some degree of support and render SVG markup directly, including Mozilla Firefox, Internet Explorer 9, Google Chrome and Safari. However, no earlier versions of Microsoft Internet Explorer (IE) support SVG natively."

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[15] http://www.dickbaldwin.com/toc.htm
[16] http://cnx.org/content/m38546/latest/
[17] http://cnx.org/content/m39607/latest/Phy1002.zip
[18] http://cnx.org/content/m38546/latest/
[19] http://en.wikipedia.org/wiki/Scalable_Vector_Graphics
[20] http://inkscape.org/

The SVG home page

The SVG home page is located at http://www.w3.org/TR/SVG/ [21]

That is where you will find technical specifications for the many capabilities that SVG has to offer. Those capabilities are vast. In this module, you will learn to create SVG files to draw the following **basic shapes** along with text:

- line
- rectangle
- circle
- ellipse
- polyline
- polygon

You will also learn how to manipulate certain aspects of the following **attributes** on those shapes and on the text that you create:

- stroke
- stroke-width
- stroke-opacity
- fill
- fill-opacity
- font-style
- font-weight

While this barely scratches the surface in terms of overall SVG capability, it does provide a set of tools that will put you in good stead relative to creating drawings for your science, technology, engineering, and mathematics courses.

2.3.3 What does this mean to you?

Let me refer back (p. 10) to the most important statement so far in this document:

" *Since they are XML files, SVG images can be created and edited with any text editor* "

What this means is that if you can imagine a technical drawing in terms of objects created from the basic shapes (p. 11) listed above along with their attributes (p. 11) , and you can mentally organize the sizes and positions of those objects in a drawing, you can use a text editor to create an SVG file, which, in turn can be used to render the drawing on the screen or on paper.

Using the SVG file

Once the drawing exists in the form of an SVG file, it can be printed and submitted as part of an assignment. Also, if you have access to the necessary equipment or assistance, it can be turned into a tactile drawing for you and other blind students to explore by touch.

You can also use the file format converter at http://www.online-utility.org/image_converter.jsp [22] to convert the file to other formats such as **png and jpeg** . This makes it possible for you to use the drawing for other purposes, such as conversion to sound using software that is available at http://www.seeingwithsound.com/winvoice.htm [23] .

And last but not least, if you happen to have access to the IVEO learning system [24] , the SVG files that you create can be used with that system to be explored by touch and sound.

Even though you may be blind or visually impaired and you may never have drawn anything in your life, don't let that stop you. If you can imagine it, you can draw it using SVG. My purpose in publishing this module is to help you develop that skill.

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[21] http://www.w3.org/TR/SVG/
[22] http://www.online-utility.org/image_converter.jsp
[23] http://www.seeingwithsound.com/winvoice.htm
[24] http://www.viewplus.com/solutions/touch-audio-learning/

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