NEMETH UNIFORM BRAILLE SYSTEM

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Literary Uses

Compiled by Joyce H. Hull

PREFACE

These words of introduction are addressed to the transcriber or braille reader who has little or no interest in reading or transcribing materials that deal with math or science, but who wants to continue to read and transcribe literary works or non-scientific textbooks. It must be recognized that even in many "non-scientific" texts, one often encounters some phrases or sections that require some basic understanding of the braille notation that governs such text. These "snippets" from a literary work may be a page number, a date, a time-of-day, a model number or a simple equation. This new system will prepare you to handle such material with ease, using a system that is consistent with the techniques being used by a transcriber or reader of a full-fledged scientific work.

This means that the world of the "literary" transcriber and reader, and the world of the "math" transcriber and reader will become one world.

You will find, as you examine this text, which begins to define a new uniform braille system, that there is a great deal of discussion about math and science. The reason for that is simple. Most of the new rules and structures apply to math and science transcriptions. It must be emphasized that this new System requires very few changes from the present code for the literary transcriber or braille reader.

The primary changes for the literary braille user are:

1) Numbers will occupy the lower part of the cell—"dropped numbers."
2) Some changes in punctuation—but many of the most common remain unchanged.
3) Understanding the two modes—narrative, for normal literary material, and notational, for technical material—and learning how to invoke and interpret the indicators for switching from one mode to the other.
4) Minor changes in the technique for defining capitalization and for implementing italics.

That is the essence of the adjustments for literary transcription. Now, what do we **gain** in adopting such a new system?

1) We will be supporting a braille system that will end the need for elementary school children to learn two or three braille codes, with different numeric representation and different formats.
2) We will have a system of defining braille that will offer a great improvement in the ease of converting print to braille by typing or scanning. This feature is the result of the unambiguous braille notation this new System provides. For a given series of braille cells, there will be only one print interpretation and vice versa.
3) Literary transcribers or readers who, upon encountering a math expression that they have questions about, can confer with a transcriber or reader who has gone further into the technical aspects of the new System. That person will now be able to provide the correct technique to transcribe or interpret that expression. None of the rules you use in literary transcriptions have to be discarded as you move into scientific text. There is a **smooth, graceful transition** from the literary to the scientific.
4) There is no need for the literary transcriber, in studying this new System, to go beyond sections that apply to literary works. For those who want to deal with math and scientific transcription, there is a beautiful, new, comprehensive system for that work also. But, we will all be working from the "same score."

So, please keep an open mind and give this new System thoughtful consideration. After a period of adjustment, you will find it a joy to work with.

Joyce H. Hull
Robert E. Stepp, Ph.D

INTRODUCTION

The Nemeth Uniform Braille System (NUBS) is a uniform system of notation, as its name proclaims, with the capability of providing notation regardless of the field in which the notation originates, subject only to the limitations imposed by the braille medium. In this regard, NUBS emulates print in which there is no literary code, no mathematics or technical code, and no code dedicated to a particular field of knowledge.

This presentation begins with Chapter 0. Although it is not an integral part of NUBS, this chapter offers an overview of the braille system and is included for the purpose of generating interest and providing enrichment for the braille user. This is the reason for assigning 0 as the number of this chapter.

The main body of the document is organized into two major sections. The first section provides braille symbols and rules for representing print notation of the kind commonly found in modern documents but for which the current literary code is inadequate. The following is a list of this kind of notation, all of which is discussed in the first section of NUBS:

Accent Marks
Arrows
Comparison Signs
Currency Signs
Diacritics
Greek Letters
Grouping Signs
Legal Signs
Operation Signs
Reference Signs
Simple Fractions
Simple Radicals
Simple Superscripts and Subscripts

A person whose interest lies primarily in the literary area can stop at the end of Literary Section which ends with Chapter 3, at which point all his needs will have been fulfilled.

The second major section of NUBS, the Scientific Section, deals with technical, primarily mathematical notation. Some items in this section are extensions of corresponding items dealt with in the first section; other items are new. Everything in the first section remains valid in the second section.

Some of the more important features of NUBS are the following:

NUBS has been designed based on an explicitly stated set of principles and guidelines.
NUBS has been designed with attention to the possibility of both forward and back translation by a computer.
NUBS makes no changes in the current contraction system of Grade-2 braille.

NUBS identifies which words are narrative and which are notational, thereby removing potential ambiguities.

NUBS includes Teacher Alert sections at appropriate places, calling attention to the kind of information that a student must have so that he may more intelligently deal with the notation presented to him in braille.

NUBS borrows heavily from the Nemeth Code. Therefore, the transition from one to the other should leave any user comfortable. No Nemeth Code textbook collections would become obsolete, and no intensive retraining for certification as a NUBS transcriber would be necessary.

The print version contains simulated braille to present a realistic image of the braille symbols and braille examples presented throughout this work for the benefit of the sighted user. The braille copy contains tactile graphics in the principal reference lists to acquaint the blind user with the shapes of the print symbols which he would otherwise have to deal with in his imagination.

I could not have managed the logistics required to produce this document without help and support from various sources.

Joyce Hull, a transcriber with the Braille Association of Mid-Florida, converted my raw manuscript into neat braille and print bound volumes complete with simulated braille in the print version and tactile graphics in the braille version.

Harry Shafer, a dedicated volunteer, patiently stayed with me, version after version, until all the errors we could find were snuffed out.

The National Braille Association (NBA) has arranged for independent support for the production of successive print and braille versions until one worthy of public display could be produced.

Abraham Nemeth, Ph.D.
2008

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CHAPTER 0
THE BRAILLE SYSTEM: AN OVERVIEW

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0.0 Chapter 0 Reference List

When reading, locate a symbol of interest in the second column; then find its matching description in the first column.

Description	Symbol	
Indicators in this chapter		
begin/end simulated braille		(4,346)
begin-fraction		(1456)
begin italicized phrase		(46,46,56)
begin upper-case phrase		(6,6,56)
end-fraction		(3456)
end italicized phrase		(46,3)
end upper-case phrase		(6,3)
italicized word		(46,56)
notational		(56)
numeric		(3456)
punctuation		(456)
upper case, next letter		(6)
upper case, next word		(6,6)
Miscellaneous Symbols in This Chapter		
bullet (solid dot)		(456,12456)
Punctuation Marks in This Chapter		
comma		
narrative		(2)
notational		(16)
dash		(46,36)
double quotes		
left oriented		(6,236)
right oriented		(6,356)
ellipsis		(6,6,3)
hyphen		(36)
parenthesis		
left		(12356)
right		(23456)
period		
narrative		(256)
notational		(12456)
slash		(456,34)

0.1 A Dilemma

We begin this undertaking by facing and resolving a dilemma. The braille version of this document is written using the braille symbols and rules as we currently envision them to exist when the project is complete. Our decision to do so is based on necessity, not choice. The literary braille code, in its present form, is completely inadequate for this purpose. But how can we use symbols and rules at the very beginning of our undertaking when we have as yet made no formal assignments to any braille symbols and have formulated no rules? Our solution will be to use the notation as currently envisioned, even before it is formally introduced, but we will consider only those aspects of the notation that are relevant and of immediate concern to our current discussion. For example, the title of this document may appear to be a "mystery," about which we shall remain silent at this time, although you are welcome to guess at it. Note that no such dilemma exists in the presentation of the print document.

0.2 To the User

This book is intended to be a teaching text as well as a reference work. Accordingly, we will proceed at a leisurely pace. We will stop to "examine the exhibits," "admire the scenery," and "smell the flowers." The 1972 Nemeth codebook was written strictly as a reference manual. Trying to learn the Nemeth Code from that codebook is like trying to learn to speak English by reading a dictionary. The message that was projected, whether merited or not, was that the Nemeth Code is difficult to learn. We do not want to fall into the same trap with this book.

If you are consulting this book, you are probably already familiar with braille. If you are a transcriber or a proofreader, you have probably been certified in the literary code as well as in some other codes by the Library of Congress. If you are the average braille reader or writer, you are probably able to recognize and use all the contractions of contracted (Grade-2) braille without violating too many of the braille rules. If you write braille that only you will read later, you probably have devised a set of personal contractions and abbreviations which are perfectly clear to you (at least for the first few days after you have devised them) but which are not standard. If you are a teacher, you have probably acquired most of your braille skills on the job rather than in a braille course during your special education preparation. Regardless of the category to which you belong, you are encouraged to review the contents of this chapter so that you can benefit from the enrichment it offers. The additional information contained in each section is intended to enrich and enhance the depth of your knowledge and commitment to the field of braille.

0.3 Braille

The Random House Dictionary defines ***braille*** as follows:

> BRAILLE: a system of writing or printing devised by L. Braille for use by the blind in which combinations of tangible dots or points are used to represent letters, characters, etc., that are read by touch.

"L.," of course, is the initial letter of "Louis," Mr. Braille's first name. The biography of Louis Braille, the history of his system's initial rejection, its long dormancy, and its ultimate acceptance by the international blindness community make fascinating reading and are matters of great interest, but which would take us too far afield. We note, however, that braille was not the only tactile system for reading and writing for the blind that came upon the scene. Among such systems were Boston Line Type, Moon Type, and New York Point. Again, it would take us too far afield to describe these systems or to consider details about them. It is a tribute to the memory of Louis Braille, however, that his original system has outlasted them all by demonstrating its versatility and its overall superior characteristics, so that its basic structure is the current international standard.

Ms. Pamela Lorimer of the United Kingdom has written a paper on the history of braille in partial fulfillment of the requirements for earning her Ph.D. degree from the University of Birmingham. If you are interested, you may download this document from www.braille.org. The document contains 9 chapters and several appendices.

You will notice that we consistently write "braille" with a lower-case *b* except at the beginning of a sentence or when referring to our benefactor himself. Here is an excerpt from a letter on the subject, slightly edited:

> … Notice that I have consistently written "braille" with a lower-case *b*. In my view, "braille" has become an integral part of the English language together with "volt," "watt," "pasteurize," "mesmerize," "platonic," "galvanic," etc. None of the latter are capitalized anymore. Furthermore, "braille" is used as a verb as in "to braille a deck of cards," as an adjective as in "a braille watch," or as a noun as in "it was transcribed into braille." The verbs come in various tenses, such as "brailled" and "brailling." "Braille" also has prefixes and suffixes attached to it as in "brailler," "braillist," "rebraille," "braillo" (vs. "typo,") etc. One of the sincerest ways in which we can honor a great person is to have his or her name become part of the language and write it with a lower-case letter. "Braille," both the man and his gift to us, are with us to help us in almost every daily activity we undertake. He does not need a high-octane jolt or an orthographic fanfare every time he appears; he is inextricably a part of our daily lives like our food, our clothing, and our furniture. …

0.4 The Braille Cell

A traditional ***braille cell*** is a rectangular area in which there are six designated positions arranged like the six spots on the surface of a gaming die or on the surface of a domino tile. Each position, independent of the others, can be either embossed (contain a dot), or it can remain unembossed (contain no dot). For easy reference, a number is assigned to each position. The current numbering scheme assigns the numbers 1, 2, and 3 to the positions on the left side of the cell, from top to bottom, and the numbers 4, 5, and 6 are assigned to the positions on the right side of the cell, again from top to bottom. This was not always the standard numbering scheme. Before 1932, the positions on the top row were numbered 1 and 2 from left to right, the positions in the middle row were numbered 3 and 4 from left to right, and the positions in the bottom row were numbered 5 and 6 from left to right.

0.5 The Dimensions of Braille

The dimensions of braille involve the spacing between the positions within a cell, the spacing between corresponding positions in adjacent cells on the same line, and the spacing between corresponding positions on adjacent lines. These dimensions were determined from the results of numerous studies designed to establish the spacing parameters that yielded the optimal efficiency in reading and writing. Currently, the spacing between adjacent positions within a cell, either horizontally or vertically, is 0.090 inches. The spacing between corresponding positions in adjacent cells on the same line is 0.250 inches (a quarter of an inch). The spacing between corresponding positions on adjacent lines is 0.400 inches. These are only approximate figures. If you are a braille user with worldwide interests, you may have noticed that European hardcopy braille or braille produced on European-made embossing equipment has slightly larger dimensions than the braille produced with U.S. equipment. With these spacing parameters, the standard capacity of a braille page whose dimensions are 11 inches from top to bottom and 11-1/2 inches from left to right is 40 cells per line and 25 lines per page. For a page whose dimensions are 8-1/2 by 11 inches, the standard capacity is 32 cells per line and 25 lines per page. For temporary work, when the preservation of proper margins is irrelevant, these dimensions can sometimes be increased by two cells horizontally and by one line vertically. But the figures cited above are regarded as standard.

Since braille cells are of uniform size, there is no such thing as proportional spacing between characters or kerning in braille. Some sign makers who know nothing about braille but who must comply with ADA requirements sometimes think otherwise and must be corrected accordingly.

There is also *microbraille,* used mostly in Japan and sometimes used on braille labels on audiocassettes. There is also *jumbo braille,* with larger spacing between the dots and lines, mostly used when teaching young children or for use by people with diminished sensitivity in their fingers resulting from various physical conditions.

In recent times, a system known as *8-dot braille* has come upon the scene. In this system, an extra row of dot positions is added to each cell, so that there are now four rows and two columns, for a total of 8 positions in each cell. Numbers are assigned to these additional two positions. The number 7 is assigned to the bottom position in the left column, and the number 8 is assigned to the bottom position in the right column. Most of the refreshable braille displays possess an 8-dot capability. Some braille embossers are also capable of producing 8-dot braille, but it is not possible to work with such embossers interactively—a capability necessary for the manipulation of mathematical expressions and for other purposes. In an 8-dot system, it is possible for both lower-case and upper-case letters to occupy just a single cell. However, if 8-dot braille were standard, the number of lines per braille page would be reduced from 25 to 19 or 20. This 20 percent loss of text capacity per page must be weighed against the advantage of having just one braille cell to represent an upper-case letter or some other symbol that would require two cells for its representation in the 6-dot system. In any case, we are committed to a 6-dot standard, and no further mention will be made of the 8-dot alternative.

0.6 Braille Characters

A *braille character* is any pattern of dots that can be formed within a single cell. The dot pattern which consists of no dots is considered to be one of the possible braille characters.

A braille character is specified by listing the numbers of the positions in the cell in which dots are present to form that character. It is standard practice to list these numbers in ascending order. It is also standard practice to enclose this list within parentheses with no hyphens between the numbers. Thus, (1346) would be regarded as the standard method for specifying the character with dots in the four corners of the cell. However, (1463), although specifying the same character, would not be regarded as standard. When talking about multiple braille characters, the number strings for the characters are set off one from another by a comma. Thus, (456,34) represents two braille characters.

As a dot pattern, a braille character has no intrinsic meaning. Characters acquire meaning only as the result of assignments made to them by someone who is creating a braille system. A baseball umpire was describing his job to an interested baseball fan. "When those pitches hit the catcher's mitt," he explained, "they ain't balls and they ain't strikes; they ain't nothin' till I call 'em."

Most of you would probably identify the dot pattern in the preceding example as representing the letter *x*. If you are an avid musician, however, your first response might be to identify this same dot pattern as meaning "rest an eighth." Each interpretation is correct; it is the background against which the dot pattern is perceived that determines how it is interpreted. Louis Braille himself specified the dot patterns to which the letters of the alphabet should be assigned, and his assignments have stuck to become the international standard ever since.

Consider the braille character

 (2346)

At present, this character is burdened with the following meanings:

- the contraction for "the" in Contracted American English Braille
- the e-grave in French and other languages
- the integral sign in both the Nemeth and the BAUK math codes
- the exclamation mark in the American Computer Braille Code
- the left parenthesis in the BAUK Computer Braille Code
- the whole note a in the International Music Braille Code

As an exercise, you might go through some of the other non-alphabetic braille characters and, for each one, tell what meaning it has in each of the codes listed above.

0.7 The Braille Alphabet

You should be careful not to confuse the ***braille alphabet*** with the English alphabet. The English alphabet has 26 letters which are named and listed in a specific order. There is a

nursery rhyme, to the tune of *Twinkle, Twinkle, Little Star*, by which children learn to recite the letters in their proper order at a very early age. The ***braille alphabet*** contains 64 braille characters; none of them has a name. They are listed in a specific order, and there is no corresponding nursery rhyme or song by which they are enumerated.

In the literature that deals with braille, the 63 palpable braille characters are grouped into 7 "lines" of braille. These lines are then referred to as "Line 1," "Line 2," …, "Line 7." There are 10 braille characters in each of the first five lines. There are 6 characters in Line 6, and 7 characters in Line 7. For the present purpose, the word "group" is more appropriate than the word "line." So in the remainder of this discussion, we will use "group" rather than "line." Notice that the braille character in which there are no dots is excluded from the original listing of the braille characters. We will create a Group 0 and will assign to it the braille character with no dots as its only member. With this as background, then, the 64 braille characters are listed in their standard order:

Group 0 (blank cell)

Group 1 ⠁ ⠃ ⠉ ⠙ ⠑ ⠋ ⠛ ⠓ ⠊ ⠚

Group 2 ⠄ ⠆ ⠒ ⠲ ⠢ ⠖ ⠶ ⠦ ⠔ ⠴

Group 3 ⠥ ⠧ ⠭ ⠽ ⠵ ⠯ ⠿ ⠷ ⠮ ⠾

Group 4 ⠈ ⠘ ⠩ ⠹ ⠱ ⠻ ⠫ ⠺ ⠨ ⠸

Group 5 (lower signs) ⠁ ⠃ ⠉ ⠙ ⠑ ⠋ ⠛ ⠓ ⠊ ⠚

Group 6 ⠅ ⠇ ⠍ ⠝ ⠕ ⠏

Group 7 ⠈ ⠘ ⠩ ⠹ ⠱ ⠻ ⠫

Here is the rationale that Louis Braille used to establish the order of the characters in his braille system. We will return to Group 1 for a more detailed examination, but for now we note only that none of the characters in that group contains a dot in either position 3 or position 6.

If you compare Group 2 with Group 1, you will find that Group 2 duplicates Group 1 except that, for each character in Group 2, there is a dot in position 3 whereas a dot is absent in that position for the characters in Group 1.

Group 3 again duplicates Group 1 except that, for each character in Group 3, there are dots in positions 3 and 6, whereas there are no dots in those positions for the characters in Group 1. The last five characters in Group 3 are sometimes referred to as the "large word signs."

Group 4 again duplicates Group 1, except that, for each character in Group 4, there is a dot in position 6, whereas there is no dot in that position for the characters in Group 1.

Group 5 is yet another duplicate of Group 1, but this time the dot patterns of the characters in Group 1 are displaced so that, for each character, the dots in row 2 are moved to row 3, and the dots in row 1 are moved to row 2. Accordingly, the characters in Group 5 contain no dots in either position 1 or 4. In the literary code, the characters in Group 5 are called *lower signs.* In addition to the ten characters in Group 5, the last two characters in Group 6 are also lower signs.

Group 6 contains the 6 characters which contain a dot in position 3 and which were not included in any of the earlier groups. There is no apparent pattern by which these six characters are ordered, but the order of the characters as listed in that group is standard. However, if you are a musician, you will recognize that the first three characters in Group 6 are the signs for "second interval," "third interval," and "fourth interval," respectively.

Group 7 contains the 7 characters that can be formed by placing dots in positions 4, 5, and 6, that is, using only the right side of the cell. Again, there is no apparent pattern for determining the order of these 7 characters. However, if you are a user of the braille music code, you will recognize that the characters in Group 7, when listed in their standard order, are the signs for "first octave" to "seventh octave," respectively.

Let us now return to Group 1 for a more detailed analysis. We begin by noting the rationale that Louis Braille used for constructing a new group using a previous group as a basis. Selecting a pair of adjacent dots, he first added the first dot of the pair to a previously established group to form a new group. He then added both dots of his pair to the same previously established group to form a second new group. Finally, he added the second dot in his pair to the same previously established group to form a third new group. Thus, once Group 1 was established, he chose the pair of adjacent dots composed of dots 3 and 6. He then added dot 3 to the characters of Group 1 to form Group 2; he added dots 3 and 6 to the characters of Group 1 to form Group 3; he added dot 6 to the characters of Group 1 to form Group 4.

Let us regard Group 0, which contains just one character with no dots, as an established group. Emulating Louis Braille's technique, we choose the pair of adjacent dots 1 and 2. By adding first dot 1, then dots 1 and 2, and then dot 2 to the character in Group 0, we obtain Group 1a, namely:

Group 1a ⠁ ⠃ ⠂

Now choose the pair of adjacent dots 4 and 5.

Concentrating on the first character in Group 1a, namely ⠁ (1), we add first dot 4, then dots 4 and 5, and then dot 5 to that first character in Group 1a, obtaining Group 1b, namely:

Group 1b ⠉ ⠋ ⠊

Now concentrating on the second character in Group 1a, namely ⠃ (12), and adding the same dots in the same order as above, we generate Group 1c, namely:

Group 1c ⠛ ⠇ ⠎

Proceeding, we concentrate on the third character of Group 1a, namely ⠠ (2), and add the same dots in the same order as above, we generate Group 1d, namely:

Group 1d ⠡ ⠩ ⠹

Since the third character in Group 1a and the third character in Group 1d belong to Group 5, we discard these characters from their respective groups. We then merge the resulting subgroups into a single group to form Group 1, namely:

Group 1 ⠁ ⠃ ⠉ ⠙ ⠑ ⠋ ⠛ ⠓ ⠊ ⠚

In this way, Mr. Braille established an order among the 64 braille characters that can be formed in a 6-position cell.

According to this ordering, it is now possible to establish a unique rank for each character in the Braille Alphabet. Thus, the rank of the empty cell is 0, the rank of ⠿ (the full cell) is 27, the rank of ⠩ is 40, and the rank of ⠄ is 63.

Conversely, given a number in the range 0-63 interpreted as a rank, a unique braille character is determined by that number. Thus 37 selects the character ⠥ and 53 selects the character ⠵. This ordering becomes important when alphabetizing a list of braille symbols for reference purposes.

0.8 The Assignment of Meaning

So far, we have dealt with braille characters as dot patterns without meaning. The next step that Louis Braille undertook was to assign meanings to the various braille characters. It is intuitively clear that braille character 0 should have the meaning of "space," since it contains no dots.

Thereafter, Mr. Braille determined that characters 1 through 25 in the Braille Alphabet should represent the 25 letters of the French alphabet in their natural order. In his day, there was no *w* in the French alphabet, so that this letter did not fall into its natural position after *v*. You may have heard that the French government is becoming increasingly sensitive to the frequency with which foreign words, particularly English words, are infiltrating the French language. The letter *w* has long since become a part of the French language as the result of such infiltrations. A French government official was particularly irked by the growing popularity of "le weekend" among French speakers and writers. Although the *w* is here to stay in the French alphabet, its displacement from its natural position in the Braille Alphabet is an interesting historical anomaly.

Mr. Braille, being a Frenchman, continued to make assignments to meet the orthographic requirements of the French language. To the characters 26 through 30 he assigned the c-cedilla, the e-acute, the a-grave, the e-grave, and the u-grave, respectively, the latter three in alphabetical order. French does not use the acute accent on any letter except *e*. Furthermore, the grave accent is only used with the letters *a, e,* and *u.* However, each of the five vowels can carry the circumflex accent. Accordingly, Mr. Braille assigned these five accented vowels

to braille characters 31 through 35 in alphabetical order: a-circumflex, e-circumflex, i-circumflex, o-circumflex, and u-circumflex. He continued by assigning diereses and diphthongs used in French to the next four braille characters. He assigned character 40 to *w* of whose existence he was aware only after having attended to the French alphabet and its French modifications. Continuing, he assigned the important punctuation marks to the braille characters in Group 5 and Group 6. Some of his punctuation assignments have since been changed. There are those who would endow Mr. Braille with a "bigger-than-life" esthetic sense that impelled him to choose the signs of Group 5 for most of the punctuation marks. These signs were "dropped" characters and thereby might suggest an auxiliary role for punctuation marks, as some of the punctuation marks do in print. Actually, the assignment of the punctuation marks was just the next item on his agenda, and the characters in Group 5 were the next available characters precisely when he needed them. His "alphabetical" approach to his previous assignments should persuade us that no esthetic motive was involved.

As braille became more popular in other countries, Mr. Braille's assignments were altered to meet the orthographic requirements of other languages, particularly English. On the one hand, French accented letters, French diereses, and French diphthongs were not needed in the English language. On the other hand, the desirability of having a system of contractions was becoming ever stronger. Accordingly, the characters which Mr. Braille used for his accented letters, etc., were reassigned to represent commonly occurring letter groups. The *w* was not restored to its natural position. Characters 26 through 30, called the ***large signs,*** were assigned to the most commonly occurring English words in alphabetical order "and," "for," "of," "the," and "with." This "alphabetical" approach persisted through the next 9 characters, organized into three groups. Each group contains two-letter combinations. Characters 31 through 35 were assigned to combinations ending in *h* in alphabetical order, namely: "ch," "gh," "sh," "th," and "wh." Characters 36 and 37 were assigned to combinations that begin with *e,* again in alphabetical order, namely: "ed" and "er." Finally, characters 38 and 39 were assigned to combinations beginning with *o,* again in alphabetical order, namely: "ou" and "ow." The characters in Group 7 were combined with other characters to form two-cell contractions for commonly-occurring words or word endings in the English language.

Note the conspicuous absence of any reference to numbers in this discussion. We shall deal with numbers in great detail in Chapters 3.

The number of this chapter is 0 because its content is not strictly part of the System we are developing; it is presented primarily for review, for enrichment, and for interest. The next chapter (Chapter 1) will deal with the "NEMETH UNIFORM BRAILLE SYSTEM" as an object in its own right requiring discussion before we can get down to the details. So let's begin.

CHAPTER 1
AIMING AT A UNIFORM BRAILLE SYSTEM

MISSION

We intend to make the world of literature and the treasures of Western Culture in the English language accessible to the blind through the medium of a *Uniform Braille System*.

"Triumphant ideas tend to pass through three stages. In the first stage, they get hooted down as ridiculous beyond belief. In the second, they are widely accepted, but often disparaged as obvious and insignificant. In the third stage, they are acknowledged to be important and some of the hooters are starting to act as if it was their own idea all along."

William James

CHAPTER 1 TOPICS

Mission
1.0 Chapter 1 Reference List
1.1 Proposed Name
1.2 About “Uniform”
1.3 About “Braille”
1.4 A Metaphor
1.5 “Code” vs. “System”
1.6 Scope of NUBS
1.7 Principles and Guidelines

1.0 Chapter 1 Reference List

When writing, locate a description of interest in the first column; then find its matching symbol in the second column.

When reading, locate a symbol of interest in the second column; then find its matching description in the first column.

Description	Symbol	
Indicators in This Chapter		
begin/end simulated braille		(4,346)
begin italicized phrase		(46,46,56)
begin notational phrase that starts with a digit		(56,3456)
begin notational phrase that starts with a non-digit		(56,56)
begin upper-case phrase		(6,6,56)
end italicized phrase		(46,3)
end notational phrase		(56,3)
end upper-case phrase		(6,3)
italics, one word		(46,56)
notational		(56)
numeric		(3456)
punctuation		(456)
upper case, one letter		(6)
upper case, one word		(6,6)

Description	Symbol	
Numeric Symbols		
zero		(356)
one		(2)
two		(23)
three		(25)
four		(256)
five		(26)
six		(235)
seven		(2356)
eight		(236)
nine		(35)
comma		(16)
decimal point		(12456)

Description	Symbol		
Punctuation Marks in This Chapter			
comma			
narrative		(2)	,
notational		(16)	,
double quotes			
left oriented		(6,236)	“
right oriented		(6,356)	”
ellipsis		(6,6,3)	…
hyphen		(36)	-
parentheses			
left		(12356)	(
right		(23456)	)
period			
narrative		(256)	.
notational		(12456)	.
question mark		(236)	?
semicolon		(23)	;
slash		(456,34)	⁄

1.1 Proposed Name

We submit that the name of this proposal shall be the *Nemeth Uniform Braille System.* Its initial letters form the mnemonic *NUBS*, and we will use this mnemonic as appropriate. At other times, it will be convenient to refer to this proposal as the *System*, with an initial upper-case *S*. The bulk of this chapter is devoted to explaining this choice of name. The last section deals with the principles and guidelines upon which the Nemeth Uniform Braille System is based.

1.2 About "Uniform"

Let us, then, address the term "uniform." In what sense will this effort deserve to be called "uniform"?

Print is a uniform system of writing. The dollar sign is always represented by the same graphic regardless of its meaning, regardless of the subject matter being addressed, and regardless of the geographical region in which it is used. And this is also the case for every other symbol in print. The same cannot be said about the current Braille System. The dollar sign has one representation in the literary code, a second representation in the Nemeth Code, and a third representation in the Computer Braille Code. This is also the case for a few other symbols. Over the years, the braille representation for a few symbols has changed. Changes in print representations take centuries to occur. A principal goal of NUBS is to achieve the same kind of uniformity in braille as exists in print. Thus, as you learn braille symbols and then progress, those symbols will remain valid even if they acquire another meaning, even if they deal with a different subject, and even if you use them in a different part of the world.

1.3 About "Braille"

The creation of the Braille System, bequeathed to us by the inventive mind of Louis Braille, ranks among the foremost contributions toward the advancement of modern civilization. It has had a profound and positive effect on the status of blind people. Braille has liberated a whole class of people from a condition of illiteracy and dependence and has given them the means for self-fulfillment and enrichment. The negative feelings of frustration and self-deprecation have been replaced by positive feelings of accomplishment and self-esteem by the thousands of blind people for whom the use of braille has become one of the skills of everyday living.

How braille is implemented is a reliable reflection of the attitudes which the society at large holds concerning the blind people in its midst who use the Braille System. When the needs of the blind who use braille are perceived to be primarily religious and recreational, the need for completeness and accuracy is not as pressing as the need to save space and reduce cost. But blind people no longer live in isolation and in custodial environments to the extent that was once the case. They are, in increasing numbers, taking their rightful places in the society of which they are a part. They need to become aware of and share the same details and nuances of written communication as their sighted peers. Unfortunately, braille, as a communications tool, has not kept pace with the needs of the blind as they become ever more integrated into our society.

Literary braille as currently used has a number of blemishes and defects. None of these is attributable to any limitation which is inherent in the Braille System itself. They all are the result of decisions taken by the rule makers in earlier generations and those of today as well. Many of them persist as the result of benign neglect.

To cite a few examples: The left and the right parentheses are represented by the same symbol in braille. A dash is approximated by two hyphens, and an ellipsis is approximated by three equispaced dots which, according to braille rules, are three apostrophes. There is no provision for the representation of braces, angle brackets, the vertical bar, the backslash, or the underscore as punctuation marks. Only the presence of an accent mark, but not its specific nature, is represented; and only the presence of a letter from a non-English alphabet is represented, but with no clue about the alphabet to which that letter belongs. In some situations, the literary code mandates the substitution of one punctuation in print by a different punctuation in braille; it mandates the substitution of Arabic numbers for Roman numbers; and, in some implementations, it mandates the suppression of capitalization. Biblical and bibliographical citations deviate from their print counterparts, as do references to pages, chapters, and volumes. Mechanisms for representing mathematical, scientific, technical, or linguistic text are not included in the braille literary code. When the need for such representation arose, special codes were devised and retrofitted to the basic code with resulting notational conflicts.

Each of these deviations from print practice may, in itself, be minor, but collectively they establish a kind of subculture which, in the area of written communication, tends to isolate the blind from the mainstream society of which they are a part. When the blind lived de facto segregated and sheltered lives, the fact that braille had "a life of its own" was innocuous; but today blind people, in large part, work shoulder to shoulder with their sighted colleagues; they cannot afford to maintain the arcane communication practices which characterize the way in which braille is used today. It is these practices and the proliferation of these retrofitted codes, and the conflicts they have engendered, that have brought the braille-using community to the realization that a more coherent uniform code is required. Therefore, we will aspire to a more positive approach toward a robust, accurate, open, full-featured system of uniform braille notation with the maximum capabilities that braille will permit, but with a view to preserving as much as possible of the traditional braille system to which large numbers of users have become accustomed.

1.4 A Metaphor

Let us examine the way in which the print system is structured. Upon close reflection and analysis, we find that a good metaphor is a tree with a stout trunk and with many branches. The trunk of the tree can be thought of as the "base" of the print system. It contains the lower-case and upper-case letters of the alphabet, the digits, and the punctuation marks. The basic print system also contains symbols of currency and coinage which may vary from one country to another. Additionally, it contains basic mathematical and scientific symbols that are encountered every day and which are therefore common knowledge. Everyone knows the plus sign, the equals sign, the percent sign, etc., and everyone knows what a fraction looks like. All these symbols are available in various fonts and sizes.

Each branch of the tree corresponds to a specialized field of knowledge and contains the symbols and mechanisms particular to that field. Thus, there is a branch which contains the symbols particular to arithmetic and more advanced mathematics, a branch for the symbols and mechanisms of chemistry and physics, a branch for linguistic symbols, etc. Unless a document is entirely narrative, these specialized symbols are notational "islands" embedded or displayed within the host text which is formed from the basic symbols. When encountering some specialized notation, we simply climb out onto the appropriate branch, grab the required notation, find our way back to the trunk, insert the notation into the text, and then continue with the narrative text. Thus, it is not unusual to find an article in the *New York Times* or in *Fortune Magazine* which contains advanced mathematical notation, an article in the *Wall Street Journal* with chemical formulas, or one or more sections in an arithmetic text devoted to computers or calculators.

In braille, the trunk is not nearly as stout nor as robust as is the trunk in the print system. Some symbols which are part of the trunk in print are not part of the trunk in the literary code. These include the plus sign, the minus sign, the equals sign, the backslash, the vertical bar, and the grouping symbols for braces and angle brackets. Then there are the single quotation marks which are part of the trunk in braille but for which there are no distinct symbols in print. Other symbols, although they belong to the trunk in the literary code, can be used only under restricted conditions. They include the ampersand, the "at" sign, and the crosshatch (also known as the "hash mark"). The dollar sign and the pound sign also belong to this group, but their representation is particularly unfortunate. Their representation was formulated under the simplistic assumptions that they would always be followed by a number, and that this combination of a dollar sign or a pound sign and a number would always occur at the beginning of a word, possibly preceded by some punctuation. As long as these conditions prevail, which is most of the time, the dollar sign and the pound sign present no problem. But there are circumstances, by no means rare, in which these conditions are not met. In the literary code, try to read ⠨⠼⠙⠲⠼⠙ (Mk.4) unambiguously. This is the name of a piece of software that operates so quickly that its speed is comparable to four times the speed of sound. To put any lingering doubts to rest, I will tell you that the character before the number sign is a period; we do not have a dollar sign here.

The blight on the braille trunk is due, as we have pointed out earlier, to the perception by the larger society that blind people are not expected to perform at the same level as the sighted. The needs of the blind, it is perceived, do not extend beyond the facilities made available to them.

Until now, it has been the practice to devise separate braille codes to handle specialized bodies of knowledge or specialized print formats. As we develop NUBS, our aim will be to endow it with a trunk sufficiently robust to emulate print, thereby avoiding problems of the kind we frequently face. Braille has a long and complex history and has attracted many users who have made themselves comfortable with its idiosyncrasies in order to take advantage of the great benefits which braille offers. In the words of Thomas Jefferson in his *Declaration of Independence*:

> … accordingly all experience hath shewn, that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. …

Therefore, we cannot remake the braille system from the beginning; in fact, our self-imposed mandate does not permit it. Accordingly, we shall begin by accepting the braille system as it is and then proceed to make modifications as required to make its trunk more robust. Thereafter, we shall attend to the various branches to devise the special symbols and mechanisms particular to the various fields of knowledge involved.

1.5 "Code" Vs. "System"

Why do we refer to the systems of braille reading and writing as "codes," whereas we do not use that term when referring to the print system of reading and writing? Although Louis Braille devised the basics of the braille system, such as the alphabet, punctuation, and numbers, the contractions and the rules for their use were devised in the early days mostly by superintendents of schools for the blind and other benevolent custodians of blind people. But these men were mostly sighted so that, to them, print was the direct repository of written information, whereas braille could contain this information only in "coded" form. To put information into braille, it had to be "encoded," and the braille had to be "decoded" to extract the information it contained. Accordingly, they referred to their creation as the ***braille code***, and that terminology has persisted as part of our heritage to this day. But to a competent braille user, braille is not a code at all; it is his primary and direct access to reading and writing.

"Code" also carries with it a negative connotation; a subtle suggestion of inefficiency and restricted capability. With "code" are also associated such ideas as "secrecy," "mystery," "privileged access," a challenge to master it or break it, and others. The Morse Code has a restricted character set, and anyone who can copy Morse Code at 30 words per minute is considered by the military to be a high-speed operator.

In view of the foregoing discussion, we will abandon the word "code" and replace it by the word "system." The dictionary defines "system" as: "An organized array of individual elements and parts forming and working as a unit." This is the expectation we have of NUBS.

1.6 Scope of NUBS

A good place to start, when contemplating what functions a braille system should serve, is to consider what functions print serves. Print enables a person with sight to read and write. Braille, then, should provide a blind person with the same ability, albeit through a different sense modality. Such a broad determination as to the scope of braille is, of course, too simplistic to be of help in designing a braille system, so that a deeper and more detailed analysis is needed.

Print is enormously versatile. It has the ability to display Egyptian hieroglyphics, the pictographs of the Chinese and Japanese languages, the alphabetic characters of hundreds of languages, most of which bear little or no relationship to the English alphabet which we use

for reading and writing English, and the hundreds of mathematical, scientific, linguistic, musical, and other miscellaneous “dingbats" used as reference indicators, and a myriad of other purposes. Given the 6-dot cell format that characterizes the Braille System, it would be difficult to make out a credible case to support the claim that all the capabilities of print enumerated above could be implemented in a single uniform braille system. It therefore becomes necessary to restrict our expectations to more reasonable proportions.

There is a broad, central body of knowledge that comprises what may be loosely referred to as “Western Culture." It is this body of knowledge that we envision to be the domain within which a uniform braille system is feasible. Music notation has a valid claim for special treatment, since music notation in print bears no resemblance to the literary notation used for writing English or foreign-language words and sentences. Music, however, is not devoid of words. Words or their abbreviations, either in English or in a foreign language, are used as instructions for controlling the dynamics in the performance of the music. Words, of course, are also used in vocal and choral selections. Nevertheless, NUBS will not be concerned with music notation.

Furthermore, our considerations will be confined to the English language. However, most of the principles and guidelines that underlie the Nemeth Uniform Braille System apply with equal logic in languages other than English, so that anyone wishing to extend this System to other languages may adapt these principles and guidelines to accommodate a particular language. In Section 1.7, we will state explicitly what those principles and guidelines are.

What then remains? What remains is the vast body of literature in the English language that comprises the humanities, the natural sciences, and the social sciences, plus the whole panorama of recreational, religious, self-help, and general-interest books and periodicals accessible to the general public. It is no less than selections from this body of knowledge, from the most elementary to the most advanced levels and across the entire spectrum of human knowledge, that we envision to be the scope of the Nemeth Uniform Braille System.

1.7 Principles and Guidelines

Long before a single shovel of dirt is turned to excavate the foundation of a building, its architect must carefully specify the functions which the building will serve. He must prepare a detailed set of blueprints showing the structural details of the building and how that structure permits the building to serve its intended functions. Similarly, long before any braille symbol is assigned to represent a print graphic, and long before rules are formulated for the use of those braille symbols, the designer of a braille system must carefully specify the functions that the braille system will perform. He must prepare a detailed set of principles and guidelines which he will use to produce a system that performs its intended functions.

The principles and guidelines within which NUBS will operate are essentially those set forth by BANA in its charge to the Unified Braille Code Project Committee in 1992 and with which we have agreed to comply. They are augmented by others which experience has shown to be useful and effective. Here they are:

a *NUBS will be based on the traditional 6-dot cell.* 8-dot technology is not available for writing nor for the interaction that may be required by other disciplines. The viability of 8-dot braille as a general communication medium has not been sufficiently established and, besides, 8-dot braille would be too great a departure from the system to which most braille users are accustomed See Chapter 0, Section 0.5, for a brief discussion of 8-dot braille.

b *We will expect contracted braille (Grade 2) to be the norm in NUBS.* We regard Contracted English Braille to be the basic braille system which, despite its blemishes and defects, is the "trunk" of the NUBS tree. We will make this "trunk" more robust without tampering with the contraction system. As currently envisioned, no contractions will be dropped and no new ones will be added. Only minor modifications of some rules may be necessary.

c *Under certain conditions, it will be desirable to use uncontracted braille for the narrative portions of the text.* When this is the case, all the other mechanisms of NUBS will still prevail. Thus, only the presence of contractions or their absence is all that is needed to distinguish between a Grade-1 and a Grade-2 document.

d *The NUBS rules will be formulated in such a way as to minimize the amount of intervention that is required by a human operator of a computer to effect correct translation from print to braille or from braille to print.* Complete automation is our goal; but this goal is currently unattainable because of the blemishes and defects that exist in the current Braille System. For example, before the recent change in the representation of the slash, the common expression "and/or" could not be translated properly from braille to print without human intervention.

e *Every notational symbol is either a prefix, a root, or a prefix-root construct.* A *prefix* is any one of the 7 characters in Group 7 of the Braille Alphabet. (See Section 0.7 for a discussion of how the characters of the Braille Alphabet are organized into groups.) A *root* is any braille character that contains any combination of dots 1, 2, and 3. There are 56 roots belonging to Groups 1 through 6. A prefix may be *compound*, that is, it may consist of two or more characters each of which is a prefix.

An indicator has no corresponding print symbol; but it offers important and timely information about the text with which it is associated. A prefix, simple or compound, by itself, can never correspond to a print symbol; it can only be an indicator. However, some indicators are prefixes, roots, or prefix-root combinations.

f *Within reasonable limits, a braille symbol should be identifiable without reference to the context in which it appears.*

g *NUBS will address itself to issues of format as well as to the representation of print graphics.* The format should be so designed that the reader can quickly and easily locate the information that he needs. It should not be assumed that the reader reads sequentially from cell to cell, from line to line, and from page to page. Frequently, he needs to access text randomly both in the forward and the backward direction.

h *Braille symbols in NUBS will be used uniformly within a discipline from the most elementary to the most advanced level, and across all disciplines within the scope of NUBS.* The braille user will learn as much or as little of NUBS as he needs for his current activities. As he broadens his interests, he will learn new symbols without unlearning existing ones with which he is already familiar. This is precisely the same course of development through which a sighted person passes as he broadens his interests. It has often been mistakenly assumed that one must learn the whole System before he can begin to function within it.

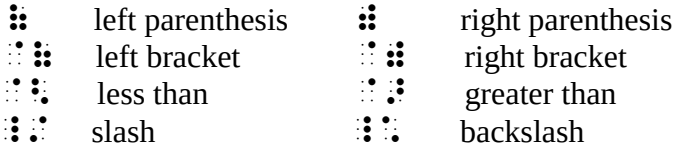
i *Braille symbols will be designed without regard to their meaning.* The dollar sign is frequently encountered in a context that has nothing to do with dollars. The term "dollar sign" simply reflects the most common use of that symbol. Consider the common notation: (x, y). Sometimes this notation means "the ordered pair whose first component is x and whose second component is y." Sometimes it means "the point in the Cartesian plane with abscissa x and ordinate y." Sometimes it means "the open interval on the real line with left endpoint x and right endpoint y." Sometimes it means "the greatest common divisor of x and y." It is not the transcriber's role to distinguish between these meanings. The transcriber's job is to convert this notational word accurately into braille. It is the reader's function to extract whatever meaning his experience and the context of the text permit. In this respect, the braille user is on a level playing field with his sighted peers who must do the same thing. A computer is completely blank about the meaning of any notation.

j *From time to time it will be necessary to insert a transcriber's note into the text. A mechanism must exist by which the reader can distinguish between the words of the transcriber and those of the author*.

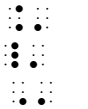
k *NUBS symbols will be so devised that they will be easily identified by the use of mnemonic prompts*. Because a robust NUBS requires a large number of symbols, they would be difficult to recognize or to recall without substantial mnemonic assistance. Several mechanisms are available to provide such assistance. When graphic symbols are symmetric in print, they will also be symmetric in braille. Families of related symbols will share either a common prefix or a common root. (See Section 1.7e.). As appropriate, the geometry of a dot pattern in braille will approximate the geometry of the corresponding symbol in print.

EXAMPLES (of mnemonics)

Mnemonic by Symmetry



Mnemonic by Common Root



Mnemonic by Common Prefix

⠨ prefix for all lower-case Greek letters
⠸ prefix for all upper-case Greek letters
⠈ prefix for all currency symbols

Mnemonic by Geometric Approximation

⠳ left arrow
⠞ right arrow
⠬ up arrow
⠮ down arrow

l *NUBS will be extendable in a systematic manner.* New symbols will not conflict with existing ones, and they will be subject to the same rules as the existing ones in similar situations. The prefix-root mechanism, discussed in Section 1.7e, is the means by which this System can be extended with no theoretical limit. This mechanism will also make it particularly easy to parse a braille text into its component symbols and indicators. This is the first step in performing a back-translation from braille to print.

m *NUBS will preserve commonly accepted print practices with respect to capitalization, punctuation, spelling, grammar, or general orthography in the English language.* We aim to convey an accurate picture of the printed text. We will not substitute non-standard for standard abbreviations or punctuation marks; we will not substitute Arabic numbers for Roman numerals; we will conform to standard practice when brailling biblical or bibliographical citations. A test of the accuracy of the transcription is to perform a reverse transcription and compare the result, aside from format, with the original.

n *The just-in-time principle requires that the user have adequate knowledge of the notation with which he is dealing precisely at the point that he needs such information.* Thus, fraction indicators tell the user precisely when a fraction begins and ends, as well as the order of complexity of the fraction. If radicals are nested, the user is informed just as the radical begins as to the order of its complexity.

o *The minimal enclosure principle requires the avoidance to the greatest extent possible of real or of phantom enclosures in braille when none exist in print.*

p *The preserve-structure principle requires that if two notational expressions in print have the same structure but differ only in content, the same should be true in the braille representation.*

EXAMPLE (of preservation of structure)

Expressions Exhibiting the Same Structure but Differing in Content

⠹⠌⠓ ⠹⠌⠉ $\frac{1}{3}h$ $\frac{1}{c}h$

q *The equal-access principle requires that infrequently occurring structures should not be ignored.* What is an infrequent occurrence to one user is an everyday occurrence to another. A user, on account of his blindness, is not exempt from having to deal with infrequent occurrences. When they occur, they must be dealt with in the same way as sighted people must do.

r *Space saving will not be used as a reason for overriding any of the foregoing principles.*

s *The presence or the absence of a space next to a symbol will not be used as a means of identifying a symbol.* A space may be used to improve readability or to comply with print practice, but not as a factor in determining the meaning of a symbol to which it is adjacent.

t *As NUBS develops, new and useful principles may emerge. If they do, they should be added to the above list and they should become as binding as their predecessors.*

CHAPTER 2
NARRATIVE AND NOTATIONAL TEXT: LIVING TOGETHER

CHAPTER 2 TOPICS

2.0 Chapter 2 Reference List
2.1 The Duality Problem
2.2 Word: The Basic Building Block
2.3 Delimiter
2.4 Words: An Analysis
2.4.1 Teacher Alert
2.5 Phrases and Passages: An Analysis

2.0 Chapter 2 Reference List

When writing, locate a description of interest in the first column; then find its matching symbol in the second column.

When reading, locate a symbol of interest in the second column; then find its matching description in the first column.

Description	Symbol
Comparison Signs in This Chapter	
equals	(123456)
less than	(4,126)
Currency Signs in This Chapter	
dollar sign	(4,234)
Indicators in This Chapter	
base level	(5)
begin/end simulated braille	(4,346)
begin italicized phrase	(46,46,56)
begin notational phrase that starts with a digit	(56,3456)
begin notational phrase that starts with a non-digit	(56,56)
begin upper-case phrase	(6,6,56)
end italicized phrase	(46,3)
end notational phrase	(56,3)
end upper-case phrase	(6,3)
italics, one word	(46,56)
notational	(56)
numeric	(3456)
punctuation	(456)
subscript	(56)
superscript	(45)
toggle between narrative and notational components of a hybrid word	(5)
upper case, one letter	(6)
upper case, one word	(6,6)

Numeric Signs		
zero		(356)
one		(2)
two		(23)
three		(25)
four		(256)
five		(26)
six		(235)
seven		(2356)

eight		(236)
nine		(35)
comma		(16)
decimal point		(12456)

Operation Signs in This Chapter

plus		(346)
slash		(456,34)

Punctuation Marks in This Chapter

apostrophe		(3)
colon		(25)
comma		
narrative		(2)
notational		(16)
dash		(46,36)
double quotes		
left oriented		(6,236)
right oriented		(6,356)
hyphen		(36)
parentheses		
left		(12356)
right		(23456)
period		
narrative		(256)
notational		(12456)
question mark		(236)
semicolon		(23)
slash		(456,34)
underscore		(6,36)

Radicals in This Chapter

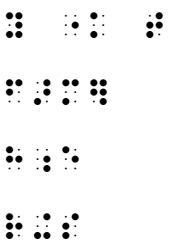
radical sign		(345)
termination sign		(246)

2.1 The Duality Problem

Since we have committed ourselves to respecting BANA mandates with regard to the development of NUBS, we will expect contracted braille to be the norm for users of this System. A special requirement may, from time to time, dictate the use of uncontracted braille. When this occurs, all the mechanisms for distinguishing between narrative and notational text must still be implemented.

If we allow short-form words to count as contractions, we note that every braille character, with the exception of the space and dot 4, is either a braille contraction or part of a contraction. Obviously, it will be necessary to use many braille symbols with a dual interpretation—the standard contracted braille interpretation, and the meaning assigned by this System. We need a mechanism for determining which meaning is intended. We must devise a method for a transcriber or a teacher to indicate which meaning of a braille symbol is intended, and for a reader to determine how to interpret the meaning of any braille symbol. That is, we need a way for two meanings to share the same braille symbol.

We must address this problem now, at the very beginning of our endeavor, so that the examples we present will be realistic and unambiguous. If you have used the 1972 edition of the Nemeth Code, which does not address this problem, you are probably familiar with the anomalies posed by the constructs:



When interpreted as Grade-2 constructs, their meanings are: "you know that," "farmer," "hence," and "rings," respectively. When interpreted as notational constructs, their meanings are: "*y* is less than *t*," "*f* times the square root of *m*," "*h* sub *e*," and "*r* plus *s*," respectively. There are other similar examples of such dual interpretations. It is this kind of ambiguity that prompted many of the rules concerning contractions in the 1972 edition of the Nemeth Code. With the methods to be developed here, most of the contraction rules in Section 55 of that Nemeth Code will be abolished.

We will offer a rigorous definition of a word in Section 2.4. Until then, our intuitive understanding will have to serve.

2.2 Word: The Basic Building Block

Words come in many different guises. Our first impulse is to think of a word as in a novel, delimited at both ends by a space. This simplistic approach turns out, upon deeper analysis, to cause trouble. Is "self-control" one word or two? What about "U-boat," "3-dimensional," "never-to-be-forgotten," or "what-you-see-is-what-you-get"? What about abbreviations, acronyms, mnemonics—are they words? Is a single letter, like *x*, a word? Writers' manuals

are not of one mind on this issue, and you can probably find one that supports your opinion. We need to give firm answers to such questions in order to make this System work without ambiguity.

Here is a preliminary intuitive approach as to what is a word. Words may be thought of as the "bricks" of which a document is built; the delimiters may be thought of as the "mortar" which holds the bricks in place. A word may be an English word in the usual sense—the kind that can be looked up in a dictionary where its expected and usual meaning is found. A word may be an acronym, a mnemonic, or an abbreviation. A word may be a string of symbols that constitutes a notational unit such as the formula for a chemical compound, a mathematical equation, or others that may emerge as we proceed. In particular, a word may be a single letter, a single digit, or a single symbol if these are surrounded by delimiters. A string of digits, with or without commas, decimal points, or both, surrounded by delimiters, is a word.

Now, we need to refine this preliminary, intuitive concept so that it becomes unambiguous and workable. We will attain this goal within the next two sections. This will lead us to the solution of the duality problem that we raised in Section 2.1. Accordingly, we define a ***delimiter*** in Section 2.3, and a ***word*** in Section 2.4. Hopefully, the terms we define and use will evoke the same understanding among those who work with and study this System provided that we present and define them with sufficient care.

2.3 Delimiter

We designate the following as ***delimiters:***

a the space
b the hyphen
c the slash
d the dash

In a hard-copy document, the transition to a new line or to a new page is also a delimiter. In an electronic document, the carriage return, the carriage-return/line-feed combination, and the form-feed are also delimiters. Even if not physically present, there is, by agreement and for technical reasons, a phantom delimiter at the beginning and at the end of every document. The concept of a delimiter applies to a braille, print, or electronic document.

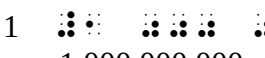
Of the above named delimiters, the space, the hyphen, and the slash are conditional; that is, they cease to be delimiters under specific circumstances, as follows:

The space is not a delimiter when it occurs:

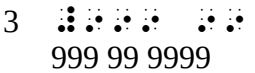
a in a long string of digits to partition that string into shorter substrings of equal length to improve readability, or to preserve the format of a string of numbers.
b on either side of a comparison sign or on either side of an operation sign.
c between a quantity and its associated abbreviation of measure. The quantity may be a number, a letter, or an expression that represents a number. However, even though the number and its abbreviation constitute a single notational word, the notational indicator must nevertheless precede the abbreviation if the abbreviation is a single English letter,

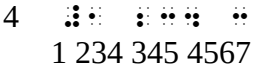
lower or upper-case, or if the abbreviation is a string of letters which constitutes a short-form word.

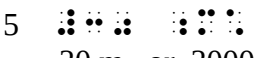
EXAMPLES (regarding the space as a non-delimiter)

1 
1 000 000 000
(A notational word; the spaces within a long number are not delimiters.)

2 
π = 3.14159 26535 89793 …
(One notational word; the ellipsis is in place of another group of digits.)

3 
999 99 9999
(One notational work; preserves the format of a social security number.)

4 
1 234 345 4567
(One notational word; preserves the format of a telephone number.)

5 
30 m, or 3000 cm
(The abbreviation for meters is a single letter; the abbreviation cm is not a short-form word.)

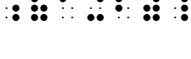
The hyphen and the slash are not delimiters when the components on either side of them are in the same mode.

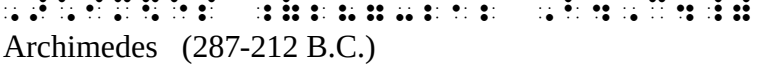
EXAMPLES (Hyphens and slashes are not delimiters.)

6  self-control

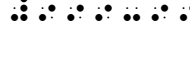
7  what-you-see-is-what-you-get

8 men aged 65-75

9  (a+b)/2 (A slash between two notational components)

10 
Archimedes (287-212 B.C.)
(The space before B.C. is a delimiter since B.C. is not an abbreviation of measure.)

11 10/12/1492

12  999-99-9999 (Format for a social security number)

13 ⠼⠑⠑⠑⠤⠁⠁⠃⠉ 555-1212 (A telephone number)

14 ⠠⠊⠤⠠⠕ I/O (input/output)

In each of Examples 6-14, the components (narrative or notational) on both sides of a hyphen or a slash are of the same mode.

When the component to the left of a hyphen or a slash is narrative and the component to the right of that hyphen or slash is notational, the notational component must be preceded by a notational indicator if it does not begin with a digit, and by a numeric indicator if it does.

EXAMPLES (of constructs containing a hyphen or a slash in which the left component is narrative and the right component is notational)

15 ⠠⠃⠁⠗⠤⠭ Bar-x (Since the second component is notational and is not a digit, a notational indicator is required.)

16 ⠠⠥⠗⠁⠝⠊⠥⠍⠤⠼⠃⠉⠑ uranium-235 (Since the second component in notational and begins with a digit, a numeric indicator is required.)

If the component to the left is notational and the component to the right is narrative, we have a hybrid construct and the hyphen or the slash must be preceded by dot 5. Contractions should be used in the narrative component, if possible.

EXAMPLES (of hybrid constructs containing a hyphen or a slash where the left component is notational and the right component is narrative)

17 ⠼⠉⠐⠤⠙⠊⠍⠑⠝⠎⠊⠕⠝⠁⠇ 3-dimensional

18 ⠠⠭⠐⠤⠔⠞⠻⠉⠑⠏⠞ x-intercept

19 ⠠⠠ ⠼⠁⠐⠤⠔⠉⠓ ⠼⠋⠁⠊⠎⠑ A 6-inch ruler

20 ⠼⠁⠐⠤⠼⠁ 1-to-1

21 ⠠⠝⠐⠤⠋⠕⠇⠙ ⠠⠝⠐⠤⠞⠥⠏⠇⠑ ⠠⠝⠐⠤⠜⠗⠽ n-fold, n-tuple, n-ary

22 ⠠⠭⠤⠠⠕⠝⠌⠭⠤⠠⠕⠋⠋ X-On/X-Off

In each of Examples 17-22, the component to the left of the hyphen or slash is notational and the component the right of the hyphen or slash is narrative. Contractions are used in the narrative components when possible.

The dash is an unconditional delimiter.

With respect to runovers, the dash and the slash behave like hyphens: that is, they may be used between components at the end of a line if they, by chance, fall there. Unlike the hyphen, however, if the dash or the slash cannot be accommodated at the end of a braille line, they may be placed at the beginning of the next line.

2.4 Words: An Analysis

A *word* is a string of symbols between two delimiters but which has no interior delimiters. Accordingly, the delimiters which define a word are not part of that word. The delimiters which define a word need not be alike.

A word may be *narrative, notational,* or *hybrid.*

A word is *narrative* if it is:

a a dictionary word with its usual meaning
b an abbreviation that does not contain any of the notational features listed below
c an acronym
d a plural, possessive, or ordinal ending
e a word ending or part-word ending that converts words into adjectives or nouns like "fold," "tuple," "ary"
f neither notational nor hybrid (See below.)

EXAMPLES (of narrative words)

1 dissolve (a dictionary word)

2 Mr. (an abbreviation)

3 e.g. (an abbreviation)

4 wysiwyg (an acronym)

5 brl_zylx (neither notational nor hybrid)

A word is *notational* if it:

a is or contains an operation sign or a comparison sign.
(These are listed in the Basic Literary Symbol Set and in the Mathematics Symbol Set.)
b is or contains a fraction or a radical.
(Fractions and radicals are discussed in Chapters 3 and 5.)
c contains subscripts, superscripts, modifiers, overscripts or underscripts.
(These are discussed in Chapters 3 and 5.)
d contains digits.
(Digits are listed in Section 3.0.13 under Numeric Signs in the Basic Literary Symbol Set.)
e is or contains single letters that are not English words.

f is or contains a letter from a non-English alphabet, an accented letter or a diacritic or a special letter. (Other Alphabets are discussed in Section 3.9. Accent marks and diacritics are discussed in Sections 3.4.1 and 3.4.2)

g contains symbols that are not part of the Basic Literary Symbol Set. (All the symbols of this symbol set are listed in the Basic Literary Symbol Set.)

h is any of the above with attached punctuation that is not a delimiter.

EXAMPLES (of notational words)

6 $2.98 (Contains digits)

7 H_2O (Contains a subscript)

8 $E = mc^2$ (Contains a comparison sign, a single letter that is not a word, and a superscript)

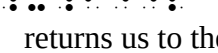
9 x/y (Contains letters that are not words)

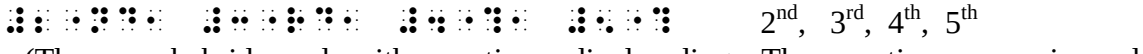
A word is *hybrid* if it contains at least one narrative component and at least one notational component. The components may be in any order. In hybrid words, when proceeding from one component to the next, either notational to narrative or narrative to notational, use dot 5 as a toggle between the components. Contractions should be used in narrative components when possible.

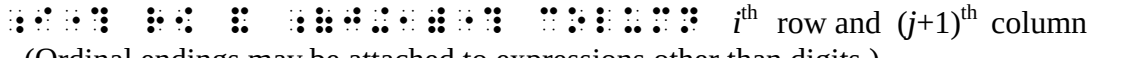
EXAMPLES (of hybrid words)

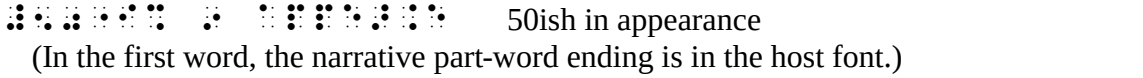
10  3^{rd} (The 3 is notational; the "rd" is its narrative ordinal ending.)

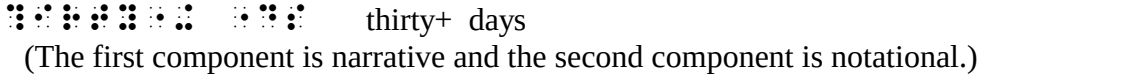
11  1^{st} (The 1 is notational; "st," which may be contracted, is its narrative ordinal ending.)

12  x_is (The plural of x_i . The s is in the host font. The first dot 5 returns us to the base level; the second dot 5 asserts that the s is a narrative plural ending in the host font, and not a variable multiplier of *x* sub *i*.)

13  2^{nd}, 3^{rd}, 4^{th}, 5^{th}
(These are hybrid words with narrative ordinal endings. The narrative comma is used after the narrative ordinal ending.)

14  i^{th} row and $(j+1)^{th}$ column
(Ordinal endings may be attached to expressions other than digits.)

15  50ish in appearance
(In the first word, the narrative part-word ending is in the host font.)

16  thirty+ days
(The first component is narrative and the second component is notational.)

RULES (concerning words)

a *The rules below apply only to words that are not part of a phrase or passage.* (to be discussed below).

b *A narrative word requires no special treatment; it is simply brailled or read as contracted braille text.*

c *If a notational word begins with a digit (a symbol which represents 0 through 9,) that word must begin with the numeric indicator* ⠼ *(3456).* The numeric indicator does not initiate a numeric mode as it does in the current literary code. Its name is more related to its history than to its function. All the symbols in such a word are written and read as notational.

d *If a notational word begins with a non-digit, its first character in braille must be in the notational indicator* ⠨ *(56).* The notational indicator is a direct descendant of the letter sign of the literary code. Just as the letter sign of the literary code does not permit the letter to be interpreted as an alphabetic whole-word contraction, so the notational indicator of NUBS does not permit the characters in a notational word to be interpreted as Grade-2 contractions.

e *If a word is hybrid, its components must be separated by inserting dot 5 between them.* If the first component is narrative, Rule b applies to it. If the first component is notational, Rule c or d applies to it. The status of subsequent components alternates between narrative and notational, the first component setting the rhythm. The beginning of each component except the first is delimited by dot 5, and its status (narrative or notational) is known because of this alternation. Therefore, no further status indication is necessary.

2.4.1 Teacher Alert

You should find an appropriate occasion to explain to your blind students that, in printed books, there is a special font for the printing of mathematical variables. Some of the confusion that may be experienced by a blind student is attributable to the lack of awareness on his part of standard print practice. From time to time, you may remind him of this practice when you perceive that you need to do so. In future chapters, we will encounter other print practices of which the student should be made aware, and attention will be drawn to such practices as appropriate.

To illustrate the importance of distinguishing between fonts, consider the following examples in which all are words:

EXAMPLES (in which the font is important)

1 ⠭ the word "it"

2 ⠨⠭ the letter "x" (*x* is in the notational font.)

3 ⠨⠭ the word "its"

4 ⠨⠭⠄ it's - the abbreviation for "it is"

5 ⠰⠭⠎ *xs* - the product of *x* by *s* (Both letters are in the notational font.)

6 ⠰⠭⠰⠎ *x*s - the plural of *x* (*x* is in the notational font; s is in the host font.)

7 ⠰⠭⠄⠎ *x's* - the product of *x* prime by *s* (Both letters are in the notational font.)

8 ⠨⠭⠄⠰⠎ *x*'s - the plural of *x* prime (*x* is in the notational font; s is in the host font.)

2.5 Phrases and Passages: An Analysis

A phrase and a passage are so closely related that we will discuss them together.

A phrase or a passage consists of a string of three or more consecutive related words. Adjacent words in a phrase or passage may share the delimiter between them. The interior delimiters in a phrase or passage are part of that phrase or passage, although they are not part of the component words.

We think of a *phrase* as a short string of words embedded within the host text, with no change in format as we enter and then leave the phrase.

We think of a *passage* as a longer string of words which is displayed rather than embedded. The display may be either spatial or non-spatial. Thus, a passage is generally recognized by:

- a change in the host format
- the host text is interrupted
- in print, the passage may be separated from the preceding and following host text by blank lines
- the passage itself may be indented relative to the host margin
- it may be centered

The passage may be labeled by a number, a letter, or a combination of these, or even by an arbitrary symbol by which it may be referenced from another part of the text.

A phrase or passage is *narrative* when it is displayed and contains only narrative words; otherwise, we just have a string of narrative words.

A phrase or passage is *notational* if at least one word therein is notational.

EXAMPLES (of notational phrases)

1 x = 1, y = 2, z = 3 ⠰⠭⠀⠨⠅ ⠰⠽⠀⠨⠆ ⠰⠵⠀⠨⠒

(How many words are there in this passage? Why are the digits not preceded by the numeric indicator?)

2 (x = 1, y = 2, z = 3) ⠨⠭⠀⠼⠁⠐⠀⠽⠀⠼⠃⠐⠀⠵⠀⠼⠉⠨⠜

(Why is there just one notational indicator at the beginning? Which rule permits this?)

3 This is a 1-to-1 mapping. ⠠⠨⠼ ⠼⠨⠼ ⠼ ⠨⠼⠐⠼⠨⠼⠐⠼⠨⠼ ⠨⠼⠐⠼⠨⠼⠨⠼

(1-to-1 is a hybrid phrase.)

A phrase or passage is a hybrid construct if its components are joined by either hyphens or slashes, and if some components are narrative and some are notational.

RULES (concerning phrases and passages)

a *A phrase or passage that is narrative needs no indication.*

b *A passage that is displayed needs no indication.* If any part of the display is notational, the whole passage is notational, but narrative components, if any, must be rendered in uncontracted braille. If the displayed passage contains no notational components, then the passage is narrative and should be rendered in contracted braille.

c *A phrase that is notational and is enclosed within grouping signs of any kind, is treated as a single notational word.* Only the notational indicator ⠨ (56) is required before the beginning enclosure symbol.

d *A notational phrase that is not enclosed, and whose first word begins with a digit, requires the digital notational indicator* ⠨⠼ (56,3456) *as its first symbol.*

e *A notational phrase that is not enclosed, and whose first word begins with a non-digit, requires the double notational indicator* ⠨⠨ (56,56) *as its first symbol.*

f *Every word in a notational phrase that begins with a digit, except the first word, must be preceded by the numeric indicator.*

g *A notational phrase that is not enclosed must be terminated by the terminal notational indicator* ⠨⠄ (56,3). If a notational phrase ends in the middle of a word, the same terminal notational indicator must be used.

h *If a notational phrase is enclosed, no terminal notational indicator is needed; the closing enclosure symbol is sufficient.*

One of the goals of this chapter is to make the numeric indicator and the various notational indicators as unobtrusive as possible without compromising the requirement for unambiguous transcribing and reading.

CHAPTER 3
THE TRUNK OF THE TREE

CHAPTER 3 TOPICS

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- 3.0.2 Arrows
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3.9 Other Alphabets, Special Letters
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3.9.3 Special Letters

The purpose of this chapter is to make the literary code more robust. If you look at the subsections in the Basic Literary Symbol Set or at the list of topics which introduces this chapter, you will realize that there are many areas in which the current literary code is incomplete.

3.0 Basic Literary Symbol Set

This symbol set contains signs likely to be found in everyday printed materials, and constitutes the Basic Literary Symbol Set. Signs that are less common have been deferred to Chapter 5, which deals with material that is more technical. The signs in this symbol set have been sorted into categories and the categories have been alphabetized.

When writing, locate a description of interest in the first column: then find its matching symbol in the second column.

When reading, locate a symbol of interest in the second column: then find its matching description in the first column.

Tactile graphic signs are included in the last column. The absence of a tactile graphic signifies an indicator.

Description	Symbol		Graphic
3.0.1 ACCENT MARKS AND DIACRITICS			
acute		(4,35)	é
bar		(156)	ā
breve		(456,5,1)	č
cedilla		(4,36)	ç
circumflex		(6,26)	û
diaeresis		(46,25)	ä
grave		(4,26)	è
hat		(6,26)	ô
hooked n		(456,1246)	ŋ
ligature		(4,25)	
macron		(156)	ē
primary stress mark		(45,34)	/
ring		(46,346)	Å
schwa		(456,26)	ə
secondary stress mark		(56,16)	\
tilde		(46,35)	ñ
umlaut		(46,25)	ö
3.0.2 ARROWS			
east		(4,135)	→
north		(6,16)	↑
north-south		(4,1346)	↕
south		(4,34)	↓
west		(4,246)	←
west-east		(4,123456)	↔

3.0.3 COMPARISON SIGNS

equals	(123456)	=
greater than	(4,345)	>
less than	(4,126)	<

3.0.4 CURRENCY SIGNS

cent	(4,14)	¢
dollar	(4,234)	$
euro	(4,15)	€
franc	(4,124)	₣
pound sterling	(4,123)	£
yen	(4,13456)	¥

3.0.5 ENGLISH ALPHABET, LOWER CASE

a	(1)
b	(12)
c	(14)
d	(145)
e	(15)
f	(124)
g	(1245)
h	(125)
i	(24)
j	(245)
k	(13)
l	(123)
m	(134)
n	(1345)
o	(135)
p	(1234)
q	(12345)
r	(1235)
s	(234)
t	(2345)
u	(136)
v	(1236)
w	(2456)
x	(1346)
y	(13456)
z	(1356)

3.0.6 ENGLISH ALPHABET, UPPER CASE

A	(6,1)
B	(6,12)
C	(6,14)

D		(6,145)
E		(6,15)
F		(6,124)
G		(6,1245)
H		(6,125)
I		(6,24)
J		(6,245)
K		(6,13)
L		(6,123)
M		(6,134)
N		(6,1345)
O		(6,135)
P		(6,1234)
Q		(6,12345)
R		(6,1235)
S		(6,234)
T		(6,2345)
U		(6,136)
V		(6,1236)
W		(6,2456)
X		(6,1346)
Y		(6,13456)
Z		(6,1356)

3.0.7 GREEK ALPHABET, LOWER CASE

alpha		(46,1)	α
beta		(46,12)	β
gamma		(46,1245)	γ
delta		(46,145)	δ
epsilon		(46,15)	ε
eta		(46,156)	η
zeta		(46,1356)	ζ
theta		(46,1456)	θ
iota		(46,24)	ι
kappa		(46,13)	κ
lambda		(46,123)	λ
mu		(46,134)	μ
nu		(46,1345)	ν
xi		(46,1346)	ξ
omicron		(46,135)	ο
pi		(46,1234)	π
rho		(46,1235)	ρ
sigma		(46,234)	σ
tau		(46,2345)	τ
upsilon		(46,136)	υ
phi		(46,124)	φ

chi		(46,12346)	χ
psi		(46,13456)	ψ
omega		(46,2456)	ω

3.0.8 GREEK ALPHABET, UPPER CASE

alpha		(456,1)	A
beta		(456,12)	B
gamma		(456,1245)	Γ
delta		(456,145)	Δ
epsilon		(456,15)	E
eta		(456,156)	H
zeta		(456,1356)	Z
theta		(456,1456)	Θ
iota		(456,24)	I
kappa		(456,13)	K
lambda		(456,123)	Λ
mu		(456,134)	M
nu		(456,1345)	N
xi		(456,1346)	Ξ
omicron		(456,135)	O
pi		(456,1234)	Π
rho		(456,1235)	P
sigma		(456,234)	Σ
tau		(456,2345)	T
upsilon		(456,136)	Y
phi		(456,124)	Φ
chi		(456,12346)	X
psi		(456,13456)	Ψ
omega		(456,2456)	ω

3.0.9 GROUPING SIGNS

angle brackets			
left		(4,126)	<
right		(4,345)	>
braces			
left		(46,12356)	{
right		(46,23456)	}
brackets			
left		(4,12356)	[
right		(4,23456)	]
double quotes			
left oriented		(6,236)	“
right oriented		(6,356)	”
unoriented		(6,2356)	"

parentheses		
left	⠐⠣	(12356) (
right	⠐⠜	(23456))
single quotes		
left oriented	⠠⠦	(4,2) ‘
right oriented	⠄⠴	(6,2) ’
unoriented	⠄	(3) '
transcriber's enclosure		
left	⠠⠶	(46,235)
right	⠠⠷	(46,256)

3.0.10 INDICATORS

base level	⠠	(5)
begin/end simbraille	⠠⠶	(4,346)
begin-fraction	⠼	(1456)
boldface		
begin phrase	⠘⠘⠸	(456,456,56)
end phrase	⠘⠲	(456,3)
one character	⠘⠆	(456,45)
one word	⠘⠸	(456,56)
end fraction	⠰	(3456)
end notation	⠸⠲	(56,3)
foreign language		
begin phrase	⠨⠨⠸	(45,45,56)
end phrase	⠨⠲	(45,3)
one character	⠨⠆	(45,45)
one word	⠨⠸	(45,56)
italics		
begin phrase	⠠⠠⠸	(46,46,56)
end phrase	⠠⠲	(46,3)
one character	⠠⠆	(46,45)
one word	⠠⠸	(46,56)
ligature	⠠⠶	(4,25)
notational		
for a phrase that begins with a digit	⠸⠼	(56,1346)
for a phrase that begins with a non-digit	⠸⠸	(56,56)
enclosed phrase	⠸	(56)
end phrase	⠸⠲	(56,3)
word	⠸	(56)
numeric	⠰	(3456)
punctuation	⠘	(456)
reference	⠠⠱	(4,156)
runover	⠘	(456)
subscript	⠸	(56)

superscript		(45)
termination		(246)
transcriber's enclosure		
left		(46,235)
right		(46,256)
underlined		
begin phrase		(4,4,56)
end phrase		(4,3)
one character		(4,45)
one word		(4,56)
upper case		
begin phrase		(6,6,56)
end phrase		(6,3)
one letter		(6)
one word		(6,6)

3.0.11 LEGAL SIGNS

copyright		(4,46,14)	©
credit		(46,14)	CR
prescription		(46,46,1235)	℞
registered		(4,46,1235)	®
trademark		(4,46,2345)	™

3.0.12 MISCELLANEOUS SIGNS

ampersand		(4,12346)	&
at		(4,1)	@
bullet		(456,12456)	•
caret		(6,26)	^
crosshatch		(46,3456)	#
degrees		(4,12456)	°
infinity		(4,236)	∞
percent		(46,356)	%
per mil		(46, 46, 356)	‰
vertical bar		(4,1256)	|

3.0.13 NUMERIC SIGNS

zero		(356)	0
one		(2)	1
two		(23)	2
three		(25)	3
four		(256)	4
five		(26)	5
six		(235)	6

seven		(2356)	7
eight		(236)	8
nine		(35)	9
comma		(16)	,
decimal point		(12456)	.

3.0.14 OPERATION SIGNS

asterisk		(456,246)	*
divided by		(46,34)	÷
minus		(36)	-
plus		(346)	+
slash		(456,34)	/
times cross		(46,246)	×
times dot		(6,12456)	·

3.0.15 PUNCTUATION

angle brackets			
left		(4,126)	<
right		(4,345)	>
apostrophe		(3)	’
asterisk		(456,246)	*
backslash		(456,16)	\
braces			
left		(46,12356)	{
right		(46,23456)	}
brackets			
left		(4,12356)	[
right		(4,23456)	]
colon		(25)	:
comma			
narrative		(2)	,
notational		(16)	,
dash			
long		(46,46,36)	—
short		(46,36)	–
ditto marks		(6,2356)	"
double quotes			
left oriented		(6,236)	“
right oriented		(6,356)	”
unoriented		(6,2356)	"
ellipsis		(6,6,3)	…
exclamation mark		(235)	!
feet, minutes		(3)	'
hyphen		(36)	-

inches, seconds		(6,2356)	"
inches, seconds		(3,3)	"
parentheses			
left		(12356)	(
right		(23456)	)
period			
narrative		(256)	.
notational		(12456)	.
question mark		(236)	?
semicolon		(23)	;
single quotes			
left-oriented		(4,2)	‘
right-oriented		(6,2)	’
unoriented		(3)	'
slash		(456,34)	/
underscore		(6,36)	_

3.0.16 REFERENCE SIGNS

asterisk		(456,246)	*
dagger		(4,6,1456)	†
double dagger		(4,6,12456)	‡
paragraph sign		(4,6,12346)	¶
pointing finger		(4,6,1246)	**F**
reference indicator		(4,156)	
section sign		(4,6,2346)	§

3.0.17 SIMPLE FRACTIONS

begin-fraction indicator		(1456)	
end-fraction indicator		(3456)	
linear fraction bar		(34)	—
one-fourth as a single graphic		(4,256)	$\frac{1}{4}$
one-half as a single graphic		(4,23)	$\frac{1}{2}$

3.0.18 SIMPLE RADICALS

radical sign			
with vinculum		(345)	$\sqrt{}$
without vinculum		(46,46,345)	$\sqrt{}$
termination indicator		(246)	

3.0.19 SIMPLE SUBSCRIPTS AND SUPERSCRIPTS

baseline level indicator	⁝•	(5)
subscript indicator	⁝••	(56)
superscript indicator	⁝••	(45)

3.1 The English Alphabet

We can put it off no longer! The time has come to attend to the "trunk of the tree," as in the metaphor in Chapter 1, Section 1.4.

Chapter 0 was historical; it presented an overview of the Braille System as we now know it. Chapter 1 was mostly philosophical; it explained why we chose the name *Nemeth Uniform Braille System*, and it laid down some basic principles and guidelines to control the development of our System. Those principles will keep us from going too far astray and will preclude the imposition of someone's preference *du jour* if that preference violates one of these principles. Chapter 1 also introduced us to the metaphor of a tree with a stout trunk and many branches. It is time to begin planting that tree. We will, of course, begin by attending to its trunk. Later, we will graft its branches.

3.1.1 Lower-Case Letters

We begin with the *English Alphabet.* In the braille version of this presentation, the lower-case letters are shown with tactile graphics in Section 3.0.5, in the Basic Literary Symbol Set. It will come as no surprise that the braille characters we choose to represent the letters of the English alphabet are those originally chosen by Louis Braille, and which are standard all over the world in every language that is based on the Roman alphabet. For the sake of completeness, these letters are listed in Section 3.0.5, in the Basic Literary Symbol Set. They are so familiar to all of us, that no further discussion is required about them at this point. These letters become part of our tree trunk.

3.1.2 Upper-Case Letters

Upper-case letters are also part of the English Alphabet. In the braille version of this presentation, the upper-case letters are shown with tactile graphics in Section 3.0.6, in the Basic Literary Symbol Set. In print, there is a set of 26 symbols which represent the upper-case letters, distinct from those which form the lower-case letters. In our 6-dot Braille System, we cannot afford to set aside an additional set of 26 characters for representing the upper-case letters. Therefore, we devise an indicator which asserts that the next letter is upper case. This symbol is called the *upper-case letter indicator.* Its representation is:

upper-case letter indicator  (6)

When this indicator precedes a contraction or a short-form word, only the first letter of that contraction or short-form word is indicated as upper case. This indicator affects only alphabetic characters; it is available as a prefix preceding non-alphabetic characters for other purposes in notational text. It is also part of the final-word contractions "ation" and "ally" in the official literary code.

In many languages, other than English,  (46) is used as the indicator for upper-case letters.

3.1.3 Upper-Case Words

If a word contains letters all of which are upper case, it would be awkward to use this upper-case indicator before each individual letter. Therefore, we need a simpler mechanism to assert that all the letters in a word are upper case. We do this by using the *upper-case word indicator* whose representation is:

upper-case word indicator ⠨⠨ (6,6)

The indicator is placed before the first letter in the sequence of upper-case letters. The delimiter which marks the end of the word then also terminates the effect of the indicator. If capitalization begins in the interior of a word, we simply use the upper-case word indicator at the point at which capitalization begins. If capitalization terminates in the interior of a word, we recognize this with the *terminate upper-case indicator* whose representation is:

terminate upper-case indicator ⠨⠠ (6,3)

Please note that this indicator is the same as the termination sign of the literary code which serves the same purpose.

There are, however, certain situations, to be pointed out at the appropriate time, when the letters of an upper-case word are capitalized individually.

3.1.4 Upper-Case Phrases and Passages

If a phrase or passage is capitalized, as is often the case with centered headings, we indicate this by using the *begin upper-case phrase indicator* whose representation is:

begin upper-case phrase indicator ⠨⠨⠨ (6,6,56)

to introduce the capitalized phrase or passage, and the *end upper-case phrase indicator* whose representation is:

end upper-case phrase indicator ⠨⠠ (6,3)

to terminate it. The indicator for beginning an upper-case phrase behaves like the shift lock on a computer keyboard, and the end upper-case phrase indicator has the effect of releasing the shift lock. Numbers, punctuation marks, and other symbols that are non-alphabetic but which are part of the phrase retain their identity when they are included in such a phrase; only alphabetic symbols or contractions and short-form words which represent alphabetic symbols are interpreted as upper case.

We now add the four indicators to our growing tree trunk.

upper-case letter indicator
upper-case word indicator
begin upper-case phrase indicator
end upper-case phrase indicator

3.1.5 Teacher Alert

You should explain to your students how the print method and the braille method for handling upper-case letters differ. This will probably be your students' first exposure to the concept of an indicator; they will have to deal with many more indicators as they progress. Once, while I was tutoring a blind child, he asked me where the capital sign is on the typewriter. The shift key or the shift lock are not quite the same as the capital sign; they do not generate a character in print as does the capital sign in braille. His question arose from his lack of understanding regarding the print mechanism for representing upper-case letters.

Your students should also become familiar with the shapes of the letters, although they need not acquire the skill of producing them unless this becomes desirable for some other reason. Our everyday vocabulary is full of references to letters and their shapes so that a blind person who is not familiar with their shapes will be at a loss to understand expressions such as: C-clamp, D-connector, I-beam, dining ell, O-ring, S-hook, T-square, U-turn, V-neck and Y-connector. It is also not amiss to call his attention to the word "zigzag" which, in imitation of the letter *z*, means to go first in one direction, and then in another, and then back again.

3.2 Punctuation

The punctuation system in the official literary code is one of its weakest features. Any attempt to create a Uniform Braille System must address the punctuation of the literary code with a view to reforming it. In what follows, punctuation marks will be considered one by one. For each punctuation mark, the relevant background will be provided, and then its representation will be proposed. In the braille version of this draft copy, the punctuation marks are shown with tactile graphics in Section 3.0.15, in the Basic Literary Symbol Set.

3.2.1 Punctuation Indicator

More often than not, before embarking on an announced agenda, there is some underlying issue that must be attended to first. The present situation is no exception. We first introduce the punctuation indicator with only a brief statement; its use will be elaborated as we proceed. The ***punctuation indicator*** asserts that the symbol that follows is a punctuation mark rather than a digit or a contraction. Its representation is:

punctuation indicator  (456)

3.2.2 Parentheses

In English-speaking countries outside of the United States, these are also known as round brackets. In print, there is a distinction between a left and a right parenthesis; in the official literary braille code, there is no such distinction. In many cases, this failure to make the distinction is of little consequence, and this was particularly so for the kind of reading material envisioned by the early creators of the Braille System as being suitable for blind readers. However, in technical environments, especially in mathematics and computer science, the distinction is crucial. For the sake of uniformity, it is necessary to have a left

parenthesis distinct from a right parenthesis at all times, whether the distinction is crucial or not. Therefore, the following symbols for parentheses are proposed:

parenthesis
left ⠣ (12356)
right ⠜ (23456)

In a Grade-2 environment, these symbols are the contractions for "of " and "with." Therefore, they require the punctuation indicator ⠸ (456) to assert that they are punctuation marks. In a notational environment where there are no contractions, these one-cell symbols require no further modification. In a Grade-1 transcription, the punctuation indicator would still be required before a parenthesis that is in contact with a narrative word (see Section 1.7c). When preceded by the punctuation indicator, these symbols lose their meaning as contractions and acquire the meaning as punctuation marks. One usually thinks of the punctuation indicator as being used in a notational context to distinguish punctuation marks from digits; the use of the punctuation indicator in a narrative context vs. its non-use in a notational context in the case of parentheses is therefore somewhat of a switch.

With this proposal, the parentheses of the official literary code, namely, ⠶ (2356) for both the left and the right parenthesis are now abolished and replaced by those proposed here.

3.2.3 Brackets, Braces, Angle Brackets

In English-speaking countries outside of the United States, brackets are sometimes called square brackets. The official literary code provides for brackets. However, the right bracket is an ambiguous construct; it can be interpreted as a parenthesis followed by an apostrophe. In addition, it is not a prefix-root construct, in violation of one of our principles. The following symbols are proposed for brackets:

bracket
left ⠐⠣ (4,12356)
right ⠐⠜ (4,23456)

For the sake of uniformity, these symbols should be used whether they occur in a notational context or a narrative context. They do not conflict with any Grade-2 contractions and thus do not require the punctuation indicator. Accordingly, the brackets of the official literary code are now abolished and replaced by the symbols proposed here.

In English-speaking countries outside of the United States, braces are also called curly brackets or brace brackets. The official literary code makes no provision for braces. The following symbols are proposed for braces:

brace
left ⠐⠸⠣ (46,12356)
right ⠐⠸⠜ (46,23456)

For the sake of uniformity, these symbols should be used whether they occur in a notational context or a narrative context. They do not conflict with any Grade-2 contractions and thus do not require the punctuation indicator.

In print, the most common use for angle brackets is for enclosing e-mail addresses or for enclosing keystrokes. Accordingly, the official literary code makes no provision for angle brackets. The following symbols are proposed for angle brackets:

angle bracket
left  (4,126)
right  (4,345)

In print, the angle brackets and the signs for "less than" and "greater than" are identical. Accordingly, they will also be identical in NUBS. This is in compliance with the principle that requires the transcription of notation regardless of meaning. These symbols do not conflict with any Grade-2 contractions and therefore do not require a punctuation indicator.

In all the grouping symbols proposed so far–parentheses, brackets, braces, and angle brackets–the left and the right components are left-to-right symmetric in NUBS as they also are in print.

3.2.4 Double Quotes

We will now consider the issue of double quotes which is probably the hairiest issue in the punctuation system. First, we will attempt to characterize the problem about double quotes; then we will offer a solution to that problem.

The ASCII number for the double quote is 34 and is simply called "quote." It is used both for the left and the right double quote. There are no ASCII characters for oriented or "smart" quotes, not even in the extended ASCII character set. Typewriters have only one character for the double quote. If the double quote is required in a computer program, it is this unoriented double quote symbol that must be used; it cannot be replaced by any other symbol or set of symbols. Nevertheless, oriented quotes have such strong eye appeal that people have contrived work-arounds to produce them in the ASCII code. Thus, in an ASCII file, unoriented quotes may be ignored altogether and replaced by two grave accent marks to imitate the left-oriented double quote and two apostrophes to imitate the right-oriented double quote, with a little kerning to improve the appearance of these "quotes." Word processors generate their own graphic characters for oriented quotes.

In addition to the primary function of double quotes for enclosing someone's exact words, double quotes serve other functions. Unoriented double quotes are used to represent "inches" of linear measure or "seconds" of degree measure or time measure. Unoriented double quotes are also used as ditto marks.

Now we face the task of finding our way around in this "double-quote jungle" with a view to creating suitable braille symbols and rules for them.

First, we will agree to use oriented quotes in braille when there are oriented quotes in print, and to use unoriented quotes in braille when there are unoriented quotes in print. To do otherwise would deprive the user of knowing how quotes are used in the mainstream world of print. What representation should be used for double quotes? We reject the literary symbols ⠦ (236) and ⠴ (356) on several grounds. The literary left double quote conflicts with the question mark; we cannot accept such conflict in an unambiguous system. Since the literary double-quote symbols will also serve as digits, the punctuation indicator would be required. Finally, the literary double-quote symbols are Grade-2 contractions for "his," "by," and "was" under certain circumstances. Since they carry so much "baggage," they are too "hot" to handle. Weighing all these considerations, we make the following proposal:

double quotes		
left-oriented	⠐⠦	(6,236)
right-oriented	⠐⠴	(6,356)
unoriented	⠐⠶	(6,2356)

Finally, the representation for unoriented quotes can also be used to represent "inches" or "seconds" as well as ditto marks. If it is clear that two apostrophes have been used in print for the representation of "inches" or "seconds" instead of the double quote, two apostrophes may also be used in braille for this purpose. The same is true for the representation of ditto marks.

Acceptance of this proposal implies that the current double quotes of the literary code would now be abolished. It also implies that the current mechanisms for representing "inches" and "seconds" as well as the literary ditto marks would also be abolished.

3.2.5 Single Quotes

Most of the observations concerning double quotes can be converted into analogous remarks concerning single quotes. In print, the apostrophe also serves as the unoriented single quote. It also serves as a representation of "feet" as a measure of length and "minutes" as a measure of angle or of time. In mathematics, the apostrophe serves as the prime sign. In the official literary code, special symbols are devised for the left and right single quote. The transcriber must decide for the reader whether the apostrophe is a single quote or whether it is an apostrophe. Computers have difficulty in making the distinction without human intervention.

Like double quotes, single quotes may be either oriented or unoriented. The same techniques in print are used to achieve this orientation. That is, an accent mark is used for a left-oriented single quote, and an apostrophe is used for a right-oriented single quote. Thus, we make the following proposals:

apostrophe, prime	⠄	(3)
feet, minutes	⠄	(3)
single quote		
left-oriented	⠠⠄	(4,2)
right-oriented	⠄⠠	(6,2)
unoriented	⠄	(3)

Note the geometric similarity between the braille and the print representations of oriented single quotes.

None of these symbols is a Grade-2 contraction and thus does not require the punctuation indicator in any narrative or notational context. This proposal replaces the single quotes of the official literary code which are hereby abolished.

3.2.6 Slash, Backslash, Asterisk

Assigning ⠸⠌ (34) to represent the slash in a Grade-2 environment is, in my view, one of the most ill-conceived assignments that the "experts" could have made; it is the same braille character that is used for the "st" contraction. In many cases, it leads to intolerable ambiguity. Sometimes, only the transcriber, looking at print copy, knows exactly what is intended; the reader is left to guess. Computer back-translators cannot, unaided, cope with the commonly occurring ⠠⠠⠸⠌⠠⠠ construct if the ⠸ (456) were omitted.

The official literary code does not, with justification, provide for the backslash. However, we want the trunk of our tree to be sufficiently robust to contain all the ASCII characters, and so we will make provision for the backslash.

The asterisk is a runner-up to the slash in ill-conception. Other than by context, the reader cannot tell whether the words ⠠⠋⠑⠍⠊⠝⠊⠝⠑ “feminine” or ⠠⠟⠥⠊⠝⠊⠝⠑ “quinine” contain asterisks or consecutive "in" contractions. We propose the following assignments for the three punctuation marks discussed above:

slash	⠸⠌	(456,34)
backslash	⠸⠡	(456,16)
asterisk	⠸⠔	(456,246)

Note the geometric symmetry between the slash and the backslash in braille in imitation of the corresponding symmetry between these same symbols in print. Note also that in each of the above symbols, the ⠸ (456) prefix is part of the symbol and is not the punctuation indicator. They are not Grade-2 contractions and do not require the punctuation indicator in any context. The official literary slash and asterisk are hereby replaced by the symbols proposed above.

3.2.7 Ellipsis

In print, the ellipsis is represented by three equispaced horizontally placed dots. It is commonly thought that these dots are periods. In an ASCII file or on a typewriter, the ellipsis is approximated by three periods. In most word processors, an ellipsis is often represented by three closely equispaced dots so as to occupy the space of one print character.

The official literary code represents a horizontal ellipsis by three consecutive dots 3 which, although intended to represent dots, can only be interpreted by the rules of the literary code as three apostrophes.

We propose the following to represent ellipsis:

horizontal ellipsis ⠐⠐⠐ (6,6,3)

Note this representation conforms to the prefix-root structure required by NUBS for all multicell notational symbols. Note also the geometric correspondence between the braille representation for the ellipsis and the form of the corresponding print symbol.

3.2.8 Semicolon, Colon, Exclamation Mark, Question Mark

These punctuation marks are frequently thought of as "final" punctuation marks, meaning that they occur at the ends of clauses or sentences. In fact, these punctuation marks, with increasing frequency, are found in the middle of words, both in a narrative and a notational context. And, for expository purposes, they sometimes stand alone.

In everyday literature, the colon is, besides its normal function, used to separate the hours from the minutes in telling the time of day. At the end of a letter, the colon is used to separate the initials of the letter's composer from those of the secretary who produced it in print. In mathematics, the colon is used between two numbers or between two expressions to express the ratio between them. The colon is also used in mathematics as an abbreviation for "such that," particularly in set theory.

In mathematics, the exclamation mark is used as the factorial symbol.

The following proposals for the above four punctuation marks agree with how they are represented in the official literary code:

semicolon	⠆	(23)
colon	⠒	(25)
exclamation mark	⠖	(235)
question mark	⠦	(236)

In a narrative Grade-2 context, these punctuation marks will be represented as shown above; but in a notational context they will require the punctuation indicator.

3.2.9 Hyphen, Dash, Underscore

The hyphen poses no problem and will be represented as in the official literary code. For the sake of completeness, it will be listed below even though there is no change.

In general, since the hyphen cannot be confused with a digit, it does not require a punctuation indicator. The only time a punctuation indicator might be required is to distinguish a hyphen from the initial "com" contraction in a Grade-2 environment; but this situation is extremely rare. However, braille users are not exempt from having to deal with rare situations, and so the mechanism exists for making the distinction if necessary.

In print, there is no discernible distinction between a hyphen and a minus sign. This will also be true in NUBS. Thus, the braille reader will be beset by the same hazards and pitfalls which beset a sighted reader; they both will be functioning on a "level playing field." However, a braille user must first decide that he is dealing with a hyphen before he can determine if it is a delimiter.

In print, the dash is represented by a continuous horizontal line. In the official literary code, the dash is approximated by two hyphens. We also use this "approximate" dash in an ASCII file or on a typewriter where there is no true dash. But two hyphens are not a true dash and should not be used to represent a dash. Furthermore, the official literary code distinguishes between a short dash, represented by two hyphens, and a long dash, represented by four hyphens. In print, there are no symbols corresponding to the short dash or the long dash of braille. In print, a popular mark-up and typesetting language, (TeX), provides for an m-dash, the width of the letter *m*, and an n-dash, the width of the letter *n*. In addition, typesetters make the dash have whatever length suits their needs. In print, the various lengths of the dash are used primarily to enhance the appearance of the text and should not be replicated in braille. The dash, unlike the hyphen and the space, is an unconditional delimiter.

The underscore is a punctuation symbol which has no representation in the official literary code. Here we show its representation only when it stands alone, that is, when it underlines a space. Underlining, which is implemented for larger segments of text, will be dealt with in Section 3.6 together with other fonts.

In view of the foregoing discussions, we make the following proposals:

hyphen	⠤	(36)
dash		
long	⠠⠠⠤	(46,46,36)
short	⠠⠤	(46,36)
underscore	⠨⠤	(6,36)

The hyphen, the dash, and the underscore do not require a punctuation indicator in any context, except in the rare case of the hyphen when it could be taken as the "com" contraction.

3.2.10 Period, Comma

Although these are the two most common punctuation marks, we have left them for last because they are probably more controversial than any of the other punctuation marks.

With respect to the period (also called the full stop), it would at first appear that we could use the punctuation indicator with a period in a notational context just as we do for other punctuation marks. In fact, this is what is done in the 1972 revision of the Nemeth Code. However, in a Uniform Braille System, the decimal point should have the same representation as the period. In the 1972 Nemeth Code, the decimal point is represented by dots 46. But this is a violation of the principle that a prefix by itself cannot represent a printable graphic. Besides, this 46 prefix creates ambiguities. For example, when followed by dot 2 it can be interpreted as a decimal point followed by the digit 1 or as the greater-than sign, particularly

when this construct appears in an underscript position. It would no doubt be unreasonable to use a two-cell representation for the decimal point within numbers by using the punctuation indicator and a period. Therefore, another mechanism is needed. Thus, we propose the following for the period:

period
narrative ⠲ (256)
notational ⣲ (12456)

With the implementation of this proposal, we will not have a 100% pure uniform system, because we will then have two representations for the period. However, any proposal will have to make some compromises as long as we are committed to retaining Grade 2 in its present form with minimum change. I believe that this proposal will cause a minimum amount of disruption to the goal of a 100% pure uniform system.

In the 1972 Nemeth Code, the comma is represented by dot 6. In many situations, this was a poor choice. It is common for coordinates such as (*x, y, z*) to be printed without a space after the commas. In Basic Assembly Language (BAL) for the IBM 370, it is expressly forbidden for a comma to be followed by a space. When the comma is followed by a letter without a space, it renders that letter as upper case and loses its meaning as a comma. In addition, the 1972 Nemeth Code has a special mechanism for showing a comma at the subscript or superscript level. Its purpose was to avoid an otherwise clumsy way to distinguish between a comma at the base level and a comma at some other level. It is therefore necessary to redefine the comma so as to avoid complications of the kind just described.

Pursuant to the above observations, we make the following proposal for the comma:

comma
narrative ⠂ (2)
notational ⠆ (16)

Like the proposal for the period, this proposal for the comma detracts a little more from a 100 percent pure uniform system inasmuch as we have two representations for the comma. If we did not have to operate in a Grade-2 environment, these two punctuation marks as well as others could be represented in one cell, and the punctuation indicator could be dispensed with altogether. Given the Grade-2 constraint, however, this compromise is necessary and reasonable. As NUBS continues to develop, no further compromises of this kind will be necessary. Note, however, that even in the 1972 Nemeth Code, there is already a narrative comma and a notational comma, so that no new "wound" is inflicted by accepting the proposal regarding the comma. Note further, however, that with these proposals in place, the notational period will no longer require a punctuation indicator. Thus, the only punctuation marks that will require a punctuation indicator are:

In notational text
semicolon
colon
exclamation point
question mark

In narrative text
parentheses

Without collecting statistics, I submit that, collectively, these punctuation marks do not constitute a large body of text, so that the punctuation indicator is mostly unobtrusive.

Finally, we add all of the punctuation marks in this section to the trunk of our tree.

3.2.11 Teacher Alert

You should acquaint your students with the way in which punctuation marks appear in print. Without this knowledge, your students will not have a clear notion about why a period is also called a point or a dot. He will not understand why brackets, braces, and angle brackets deserve their names. The terms "slash" and "backslash" will at last make sense to him.

3.3 Numbers

At last we must come to grips with the issue of numbers. This issue has turned out to be the most controversial issue in the development of any uniform system. We will begin by taking a tour of three competing number systems, pointing out the features, both positive and negative, of each. We will, of course, come to the conclusion that the ***dropped number system*** holds out the greatest promise for the development of a uniform braille system, and thereafter we shall proceed along that path.

3.3.1 Upper Numbers

Upper numbers are the same as the letters from ***a*** to ***j***, but are distinguished from those letters by a preceding number sign. We consider upper numbers first because they have a longer history than the other number systems. In order to enhance the credibility of the upper number system, it has been asserted that it was the first choice of Louis Braille himself. However, this assertion is not factual. Ms. Pamela Lorimer of the UK, in partial fulfillment of the doctoral requirement at Birmingham University, submitted a dissertation on the history of braille. This is what she says about numbers:

> It was possible to write the dash used in signs for punctuation and numbers because the board had horizontal grooves, but Braille indicated in his "***Procédé***" (1829, p. 12) that the dash had been found difficult to make with a style, so another method would be found for writing numbers.

Thus, Braille's prototype slate did not implement a true 6-dot system; he tried to create a dash in the "horizontal grooves" of his board to distinguish punctuation from numbers; but the dash was difficult to make (without tearing the paper), and so Braille migrated to the upper number system. His first attempt, however, was to create dropped numbers.

And so, when the literary code came into being, it used upper numbers. In normal narrative text, numbers appear once in a while and upper numbers pose no problem. Most of the time,

they appear as pure numbers; but sometimes they are juxtaposed to letters, and this requires the mechanism of the letter sign to distinguish letters from digits.

The relative rarity of such constructs renders them quite tolerable, and braille readers today live happily with upper numbers together with the occasional required letter signs as long as they deal only with narrative text.

However, when we attempt to use upper numbers in a technical, and in particular a mathematical environment, the results are disastrous. In mathematics, numbers and letters in endless juxtaposition are the essence of mathematical notation. But numbers require a number sign, and letters from *a* to *j* require a letter sign. A simple expression such as 2*a*+3*b* would, if upper numbers were used, require two number signs and two letter signs in addition to the five notational elements which comprise this expression. The number signs and the letter signs have no notational value; they serve only to tell the reader how to interpret the braille. Robust mathematics involves expressions much more complicated than the one above, with a consequent increase in the number signs and letter signs required to represent such expressions, if upper numbers were used. In fact, number signs and letter signs would be so profuse in mathematical expressions, that they would constitute clutter and an infestation of the notation and would interfere with its smooth processing.

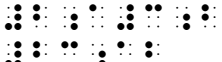
So many additional symbols are required when using upper numbers, that taking notes is next to impossible; there isn't enough time to write even the briefest note. Furthermore, some expressions become so long that they cannot be contained on a 40-cell line, so that line overflow occurs, and this brings in its wake other undesirable consequences.

A further consideration is the alternation of letters and numbers in such constructs as model numbers, serial numbers, account numbers, catalog numbers, foreign addresses and zip codes, section and subsection numbers in legal citations, etc., all of which require excessive processing.

Upper numbers conflict with the letters *a* through *j*. Many observers have remarked that any braille system in which letters and numbers are represented by the same braille characters is fatally flawed.

The number sign used in upper numbers remains effective across digits, the comma, the decimal point, the hyphen and the slash; its effect is terminated by other braille characters. This triggers a whole set of rules which transcribers must implement and which readers must know in order to interpret the braille. In print, there is no equivalent either for the number sign or the letter sign.

Upper numbers create problems when alignment is required. Consider what happens when adding the two hexadecimal numbers, using upper numbers.

2*a*3*b*		(8 cells)
23*ab*		(6 cells)

Digits that should be aligned vertically fall into different braille columns and make the addition a stressful endeavor.

It has been claimed that, esthetically, digits that are principal characters should be "up," while punctuation marks, which are auxiliary characters, should be "down." Note, however, that parentheses, brackets, braces, angle brackets, the slash, the backslash, the exclamation mark, and the question mark are as tall as any upper-case letter. Furthermore, single and double quotes and the apostrophe occupy the superscript position.

Finally, it is a common observation that a prototype, like the airplane invented by the Wright brothers, is hardly state of the art, and, like that airplane, frequently finds a home in a museum.

3.3.2 Dot-6 (French/Antoine) Numbers

This system is much better known in Europe than in North America. The digits 1 through 9 in this system are formed by adding dot 6 to the letters *a* through *i*. If we try adding dot 6 to *j* in order to create 0, we would instead create the letter *w*. Therefore, another symbol is needed for 0. Some European countries use ⠒ (346) for this purpose; some use ⠿ (123456) for this purpose; and some use ⠳ (3456).

The motivation behind this number system is to create numbers which are distinct both from letters and from punctuation marks. This is its principal advantage. There are, however, many offsetting disadvantages.

They are unfamiliar; despite the simple mechanism by which they are formed, it takes considerable mental effort to produce them and to read them. Presumably, one might eventually become accustomed to them so as to recall and recognize them instantaneously; but this takes time and effort. Ask any foreign merchant to verbalize what he is doing when adding a column of figures, and you will discover, with no surprise, that even after many years, he is adding the numbers in his native language.

They commandeer ten of the most valuable one-cell characters, leaving precious few such characters, after the digits are accounted for, for important technical notation.

They are dot-wise dense; each dot-6 digit requires one more dot than do upper numbers or dropped numbers. Digits should be light, quick, and easy to read and write.

In a Grade-2 environment, they still need an indicator to distinguish them from contractions. Without such an indicator, ⠹⠫⠱ (the dot-6 version of 482) could not be distinguished from "though" and ⠹⠱⠿ (the dot-6 version of 397) could not be distinguished from "shower."

For all these reasons, we also reject dot-6 numbers as unsuitable for a uniform braille system.

3.3.3 Dropped Numbers

In the braille version of this proposal, digits are shown with tactile graphics in Section 3.0.13 in the Basic Literary Symbol Set.

Dropped numbers are mirror images of upper numbers. Whereas upper numbers occupy the top four positions in a cell, the corresponding dropped numbers occupy the bottom four positions in a cell.

Dropped numbers are a familiar, de facto, alternative for upper numbers. If you work with a computer, you encounter dropped numbers all the time. All the standard codes used in the English-speaking countries around the world use dropped numbers to some extent. No chemistry code can function effectively without them. No learning is required if you are already a braille user; they are as familiar as upper numbers even when you use them for the first time. They do not cause alignment problems. There is no numeric mode when dropped numbers are used.

One disadvantage of dropped numbers is that they conflict with some punctuation marks. To resolve such conflicts, it is necessary to introduce a punctuation indicator to specify that a dropped character is a punctuation mark rather than a dropped digit. In Section 3.2, which was devoted to the subject of punctuation, we pointed out that in a notational environment, only four punctuation marks require the punctuation indicator. These are: the colon, the semicolon, the exclamation point, and the question mark. These are low-incidence punctuation marks and, even collectively, do not become an obstacle to the smooth processing of notation, particularly since all of them are final punctuation marks and occur when the notation has already been processed. Therefore, we regard the need for an occasional punctuation indicator as a minor disadvantage, greatly outweighed by the many advantages that dropped numbers possess.

Therefore, the Nemeth Uniform Braille System will use dropped numbers uniformly, to the exclusion of the other two number systems. They have been used through all the editions of the Nemeth Code and have been found to be extremely efficient. Many vision teachers teach dropped numbers to their students just learning braille before they teach upper numbers and report this to be very effective.

3.3.4 The Numeric Indicator

You will recall that we have already had a brief encounter with the numeric indicator. In Chapter 2, Section 2.4, Rule c, we are told that the numeric indicator must introduce a notational word that begins with a digit. Elsewhere we stated that the numeric indicator was more historical than functional. At this point, we undertake a further analysis of the numeric indicator. The symbol for the numeric indicator is:

numeric indicator  (3456)

In NUBS, the numeric indicator serves two functions: First, it serves as a dot locator for the braille character that follows it, so that the braille reader can easily ascertain that the next character is in the lower part of the cell. Consider the example:

He made a 1 under par in golf.

Imagine what the result would be if the numeric indicator were omitted! The character for the 1 has no right-hand dots, and the character following the 1 has no left-hand dots. This leaves the 1 relatively isolated. Only the most experienced braille users would locate the single dot representing the 1 easily and correctly. The numeric indicator orients this single dot immediately and precisely. There are other braille characters with dots in every row and every column of the cell that could have been used as a dot locator for the braille character that follows; but the numeric indicator is the number sign in the literary code which has a long association with numbers and was chosen for that reason.

The second function of the numeric indicator is to distinguish a digit from a lower-sign whole-word contraction. Consider the example:

There were 7 birds on the fence. 

The first ⠻ is the contraction for "were;" the next ⠻ is preceded by the numeric indicator which asserts that this is the digit 7 and not the lower-sign whole-word contraction for "were."

These are the only two functions of the numeric indicator. Thus, the numeric indicator does not initiate a numeric mode as does the number sign in the current official literary code. Most digits are not under the influence of any numeric indicator. They are dot-located by neighboring braille characters and, as a member of a notational environment, a digit cannot be taken as a lower-sign contraction.

3.3.5 Comma and Decimal Point in Numbers

A comma in a number is represented just like a comma in any other notational word. Longer numbers may contain several commas to separate the digits into equal-sized groups (usually three digits per group) for improved readability. The comma which is used as a punctuation mark after a number is, as in print, indistinguishable from a comma which occurs in the interior of a number.

The decimal point in a number is represented just like the period in a notational word. When the Dewey Decimal System is used for numbering sections and subsections of a text, a number may contain several "decimal points" as, for example, "Section 2.3.1." As in the above example, a sentence-ending period is indistinguishable from a decimal point, as is also the case in print.

3.3.6 Continental Usage

In many European countries, the decimal point is represented by a comma, and the comma is represented by a period. In NUBS, the same substitutions can be made, thereby preserving the "continental" character of the number.

3.3.7 Roman Numerals

Roman numerals are notational and require the notational indicator. The case (lower or upper) of a Roman numeral should be preserved in braille.

If a letter is attached to a Roman numeral either as a prefix or as a suffix, use dot 5 to separate the prefix or suffix from the Roman numeral to which it is attached.

3.4 Accent Marks, Diacritics, Foreign Languages

Unlike many foreign languages, the English language does not use accent marks. However, many foreign-language words and phrases have found their way into the English language and have become a part thereof; they are said to be anglicized words or anglicized phrases. Such anglicized words and phrases frequently contain accented letters. Different foreign languages feature different sets of accent marks, so that provision must be made for all of the accent marks that can occur in the words or phrases in foreign languages that are likely to infiltrate the English language. In the braille version of this document, accent marks are shown with their tactile graphics in Section 3.0.1, the Basic Literary Symbol Set.

3.4.1 Accent Marks

NUBS is structured to address two different applications of accent marks.

The first of these applies to words and phrases that have come into regular use in the English language and are regarded as "anglicized," according to Rule 1, Section 6a(1), in Braille Formats. If such words or phrases contain accent marks, they are brailled using the rules presented in that section.

The second application of the use of accent marks involves "foreign" words or phrases–text that is not anglicized. The rules for words or phrases in this category are discussed in Section 3.4.3 where the use of "native accent marks" is addressed.

NUBS makes provision for the following accent marks to be used with "anglicized" words or phrases. In the braille version of this document, graphics of the accent marks are shown with letters, as they would appear in print.

acute		(4,35)	é
bar		(156)	ā
cedilla		(4,36)	ç
circumflex		(6,26)	ê
diaeresis		(46,25)	ö
grave		(4,26)	è
hat		(6,26)	ê
macron		(156)	ā
ring		(46,346)	ů
tilde		(46,35)	ñ
umlaut		(46,25)	ö

The above set of accent marks is adequate for most purposes. In braille, they follow the letter which they affect, just as one would place an accent mark after having written the letter in print. The accented letter must be preceded by  (126) if the accent mark is placed above

the letter it affects, and by ⠸ (146) if the accent is placed below the letter it affects. A word with accented letters is notational; it must be preceded by the notational indicator, and no contractions may be used within that word.

The literary code provides a generic accent mark which informs the reader that a letter is accented, but it provides no information as to the nature of the accent mark nor of its position above or below the letter that it affects. This information is readily available to the print reader.

NUBS makes this information available to braille readers who want or need it. However, the mechanism for providing this information is necessarily more cumbersome than is desirable by most people. Therefore, NUBS addresses this problem as follows:

A word which contains accented letters should be brailled according to the current literary code, using dot 4 as the accent mark indicator, at the site where it appears in print. However, the same word, using the NUBS mechanism for showing accented letters, should be presented on a Special Symbols Page at the beginning of the volume in which the word appears. If several words with accented letters appear throughout the volume, they should be collected and presented, alphabetically, using a two-column structure. The first column should show the form of the accented word as it appears in the body of the text. The second column would show the same word, using the NUBS mechanism for showing accented letters as described above. This format gives the braille reader access to all of the information about the accent marks that are used as the sighted reader has.

3.4.2 Diacritics

Diacritics is a system of writing whose purpose is to show the reader how a word is pronounced. It shows how a word is divided into syllables, which syllable has a primary stress and which one as a secondary stress when spoken, and how each symbol within a syllable is associated with the sound it represents.

The mechanisms in print for performing these functions are not standard; there are various devices for showing how a diacritic word is enclosed, how the word is divided into syllables, different devices for showing stress, and different methods for showing how written symbols are converted into phonemes.

Diacritic words are separated from ordinary text by various forms of enclosure. These enclosures are: parentheses, brackets, slash and backslash, vertical bars and angle brackets.

Stress is shown by capitalization, by change of font, or by the use of actual stress marks.

Pronunciation is shown by the use of letters from the English alphabet, by modifiers, and by actually augmenting the English alphabet by a few additional letters.

A word that contains diacritics is notational; it must be preceded by the notational indicator and no contractions may be used in that word. Furthermore, words containing diacritics may not be divided between braille lines.

The various enclosures used for enclosing a diacritic word are already present in NUBS and are not listed again in Section 3.0.1, Accent Marks and Diacritics.

If stress is shown in two different ways in print, such as stress marks and capitalization, or stress marks and font change, use the NUBS stress marks and ignore the additional indication of stress. If stress is shown only by capitalization, use the NUBS capitalization methods. If stress is shown only by a change of font, use italics in NUBS regardless of the actual nature of the font used. Since the font used for stress is not standard and may vary from one text to another, the actual font used is irrelevant and use of italics in NUBS for showing stress is justified.

Various methods are used in print for showing syllable division. The most common are the hyphen, a centered dot between syllables, or a space between syllables. Since the method for showing syllable division in print is not standard, use the hyphen in NUBS to show syllable division regardless of the method for showing syllable division in print.

Various accent marks are used in print for indicating the pronunciation of vowels or vowel combinations. All these accent marks have representation in NUBS and they are all listed in Section 3.0.1, in the Basic Literary Symbol Set.

Print uses various methods for showing that two letters act as one. These are called *ligatures*. To show a ligature, a through-bar or an under-bar is used to tie two letters together. Often, a true ligature is used in which the two participating letters are printed so as to touch each other. A through-bar can be shown using the NUBS overstrike indicator, and an under-bar can be shown using the NUBS method for indicating a modifier beneath a letter. NUBS also offers a ligature indicator whose representation is:

ligature indicator  (4,25)

The ligature indicator has the effect of tying the next two letters together and is placed before the first of these two letters. A modifier or an accent mark may apply to either of these two letters or it may apply to the two-letter combination as a whole. If only one letter is modified, the mechanism for showing the modification is used for that letter only. If both letters are modified together, the indicator for showing modification above or below precedes the ligature indicator.

In diacritic notation, three letters augment the English alphabet. Their NUBS representations are:

breve  (456,5,1)
hooked n  (456,1246)
schwa  (456,26)

At the present time, there is no standard phonetic alphabet in braille. Therefore, it is recommended that you treat the phonetic alphabet like a foreign language; leave NUBS, use whatever phonetic alphabet is current, then return to NUBS.

3.4.3 Foreign Languages

NUBS makes provision for escaping into a foreign language in which the native accent marks of that language can be used.

If the excursion into the foreign language involves only one or two words, the first of the following indicators precedes each word. If the excursion into the foreign language involves three or more words, the second of the following indicators is used before the first word of the foreign-language phrase:

begin foreign word ⠸⠸ (45,56)
begin foreign phrase ⠸⠸⠸ (45,45,56)

The following indicator is used to terminate a foreign-language phrase:

end foreign phrase ⠸⠄ (45,3)

If it is necessary to show a single foreign character, the indicator is:

for a single foreign character ⠸⠸ (45,45)

After the foreign-language word(s) or phrase, return to NUBS is automatic.

When in the foreign-language word or phrase, the accent marks native to that language are used–not the NUBS accent marks.

Note that the symbols ⠸⠸ (45,56) and ⠸⠸⠸ (45,45,56) do not reveal which foreign language has been entered, and therein lies a complication. In braille, in one language, a letter with its accent is represented by a single braille character. In another language, the same letter with the same accent is represented by a different braille character. For example, in French, e acute is represented by ⠿ (123456); in Spanish, e acute is represented by ⠷ (2346). Whereas a print reader is not told what language he has entered, a braille reader must have this information to interpret the native accented letters properly. Thus, we propose that a letter suggestive of the name of the language about to be entered be placed before the foreign-word or foreign-phrase indicator. The following letters are suggested for the most likely languages encountered:

French, f
German, g
Greek, k
Hebrew, h
Italian, i
Latin, l
Spanish, s

3.4.4 Teacher Alert

You should make your students aware that accent marks are written above or below the symbols which they affect. You should also acquaint them with the shapes of the accent marks, since NUBS uses dot patterns for most of the accent marks which suggest the shape of the accent mark in print.

3.5 Currency Signs

NUBS provides for the most common currency symbols. In print, currency symbols are characterized by a suggestive letter through which there is a slash. In the braille version of this document, currency symbols are shown with tactile graphics in Section 3.0.4, in the Basic Literary Symbol Set. In NUBS, ⠈ (4) is the prefix uniformly used before the relevant letters to represent symbols of currency. Here is the list of currency symbols which NUBS recognizes:

cent	⠈⠉	(4,14)
dollar	⠈⠎	(4,234)
euro	⠈⠑	(4,15)
franc	⠈⠋	(4,124)
pound sterling	⠈⠇	(4,123)
yen	⠈⠽	(4,13456)

In the case of the dollar sign, *s* is used as the root because this is the letter which is slashed in print. In an attempt to emphasize the commercial side of Christmas, many people write Christmas with a slash through the *s*, thus making a dollar sign. This ploy would be lost on a braille reader if the dollar sign were represented in some other way.

3.6 Fonts

In this section, ***fonts*** is used in a generic sense to include type variations such as capitalization, underlining, and colored printing, in addition to other standard fonts such as italic type, boldface type, and others.

Capitalization in the English alphabet has already been considered in Section 3.1.2 through 3.1.4 of this chapter. Note, however, that the method for beginning and ending a capitalized phrase follows the same pattern that is used for beginning and ending a phrase in any other font.

NUBS makes specific provision for the following fonts:

boldface

begin phrase	⠸⠸⠸	(456,456,56)
end phrase	⠸⠄	(456,3)
one character	⠸⠈	(456,45)
one word	⠸⠸	(456,56)

italics

begin phrase	⠨⠨⠸	(46,46,56)
end phrase	⠨⠲	(46,3)
one character	⠨⠨	(46,45)
one word	⠨⠸	(46,56)

underlined

begin phrase	⠠⠠⠸	(4,4,56)
end phrase	⠠⠲	(4,3)
one character	⠠⠨	(4,45)
one word	⠠⠸	(4,56)

upper case

begin phrase	⠠⠠⠸	(6,6,56)
end phrase	⠠⠲	(6,3)
one letter	⠠	(6)
one word	⠠⠠	(6,6)

Since NUBS is extendable, other font indicators can be created using constructs analogous to those proposed above. Fonts that might be included are:

colored text
sanserif type
script font
transcriber-identified fonts as may be required

A transcriber should not slavishly follow every font change in print by indicating that change in braille. Font changes should be indicated only when the change offers valuable information to the braille reader. A font change may be used:

to indicate emphasis
to delimit an exact title or caption
to comply with a use explicitly indicated by the author

3.6.1 Typographic Conventions

Here is an excerpt from a computer manual (Turbo C) which will hopefully convince you of the need for these fonts:

…

Monospace type – This typeface represents text as it appears on the screen (or in your program) and anything you must type (such as command-line options).

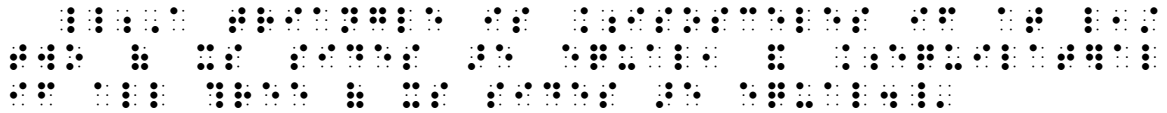
< > – Angle brackets in text or DOS command lines enclose optional input or data that depend on your system, which should not be typed verbatim. Angle brackets in the function reference section enclose the names of include files.

Boldface – Turbo C function names (such as **printf**) are shown in boldface when mentioned within text (but not in program examples).
Italics – Italics indicate variable names (identifiers) within portions of text and emphasize certain words (especially new terms).
Bold monospace – This typeface represents Turbo C keywords (such as ***char***, ***switch***, ***near***, and ***cdecl***).
Keycaps – This special typeface indicates a key on your keyboard. It is often used when describing a particular key you should type, e.g., "Press ESC to exit a menu."
…

Failure to implement the fonts specified in the text would leave the braille reader at a significant disadvantage.

Phrases in varying fonts may be nested to good effect. In some textbooks, definitions are printed in boldface type, with the term being defined printed in italic type without changing the boldface type. For example:

A triangle is *isosceles* if at least two of its sides are equal, and *equilateral* if all three of its sides are equal.



The words "isosceles" and "equilateral" are italicized while remaining bold.

3.7 Further Extensions to the Literary Code

In the general literature, many signs related to technical fields, and signs having global application are encountered, but for which the official literary code either makes no provision or makes an inappropriate one. Here are some of the most common signs that you are likely to encounter from time to time in the general literature, presented in various categories.

3.7.1 Arrows

The most commonly occurring arrows are:

east		(4,135)
north		(6,16)
north-south		(4,1346)
south		(4,34)
west		(4,246)
west-east		(4,123456)

The dot configurations of the one-way horizontal and vertical arrows suggest the direction in which the arrows point.

To form the roots of the two-way arrows, the roots of the corresponding one-way arrows are combined into a single cell. Thus, combining ⠒ (135) and ⠔ (246) which are the roots of the one-way horizontal arrows into a single cell produces ⠿ (123456) which is the root of the two-way horizontal arrow. Similarly, combining ⠐ (16) and ⠠ (34) which are the roots of the one-way vertical arrows into a single cell produces ⠦ (1346) which is the root of the two-way vertical arrow.

Other arrows, which occur less frequently, can be found in Chapter 5.

3.7.2 Comparison Signs

The NUBS symbols for the principal signs of comparison are as follows:

equals	⠿	(123456)
greater than	⠨⠜	(4,345)
less than	⠨⠣	(4,126)

The equals sign is the same as the contraction for "for." When confusion might occur because of this coincidence, the word "for" should be spelled out, as, for example, in

2 for $5, ⠼⠃ ⠿ ⠼⠑⠋

rather than ⠼⠃ ⠿ ⠼⠑⠋

Similarly, the notational indicator must be used when the full cell should be the equals sign rather than the contraction for "for." For example:

5280 feet = 1 mile ⠼⠑⠃⠛⠀⠋⠑⠑⠞⠀⠶⠀⠼⠁⠀⠍⠊⠇⠑

rather than ⠼⠑⠃⠛⠀⠋⠑⠑⠞⠀⠿⠀⠼⠁⠀⠍⠊⠇⠑

Note the left-to-right symmetry of the "less than" and "greater than" constructs in braille as is also the case in print.

Other comparison signs less commonly encountered and of a more technical nature can be found in Chapter 5.

3.7.3 Grouping Signs

The following are the most common grouping signs:

angle brackets		
left	⠨⠣	(4,126)
right	⠨⠜	(4, 345)
braces		
left	⠨⠷	(46,12356)
right	⠨⠾	(46,23456)

brackets		
left		(4,12356)
right		(4,23456)
double quotes		
left oriented		(6,236)
right oriented		(6,356)
unoriented		(6,2356)
parentheses		
left		(12356)
right		(23456)
single quotes		
left oriented		(4,2)
right oriented		(6,2)
unoriented		(3)
transcriber's enclosure		
left		(46,235)
right		(46,256)

Note the left-to-right symmetry in each pair of the braille grouping signs in conformance with the left-to-right symmetry of the corresponding print signs.

The parentheses listed above replace those of the literary code. They require the punctuation indicator when they are in contact with a narrative word.

The brackets listed above replace those of the literary code. They never require the punctuation indicator.

The braces listed above are an extension of the literary code since the literary code makes no provision for them. They never require the punctuation indicator.

In print, the angle brackets listed above are primarily used for enclosing e-mail addresses and for enclosing other keystrokes. They constitute a further extension of the literary code, and they never require the punctuation indicator.

The double and single quotes, both oriented and unoriented, replace those of the literary code. They never require the punctuation indicator.

The transcriber's enclosure signs are indicators since they correspond to nothing in print.

3.7.4 Legal Signs

NUBS provides special symbols for the following legal graphics:

copyright		(4,46,14)
credit		(46,14)
prescription		(46,46,1235)
registered		(4,46,1235)
trademark		(4,46,2345)

The "credit" sign is formed from the letters C and R touching each other so as to form a single graphic symbol that occupies one print position. It is used in bank, broker, and credit card statements to flag the amount to which it is attached as a credit; entries not so flagged are debits.

The literary code represents the "copyright," the "registered," and the "trademark" signs by enclosing the relevant letters within parentheses. But this is only an approximation to the exact symbols. NUBS provides symbols which, when back-translated, will produce the exact symbol required.

The R in the "prescription" sign stands for "recipe." Since "registered" and "prescription" have the same root, they cannot have the same prefix.

3.7.5 Miscellaneous Signs

Nubs provides for the following commonly occurring signs:

ampersand		(4,12346)
at sign		(4,1)
bullet		(456,12456)
caret		(6,26)
crosshatch		(46,3456)
degree sign		(4,12456)
infinity		(4,236)
percent sign		(46,356)
per mil sign		(46,46,356)
vertical bar		(4,1256)

The "at" sign and the ampersand may not be replaced by the words "at" and "and" as they are, most of the time, in the literary code.

The "bullet" may not be replaced by a dash as is done, most of the time, in the literary code.

The crosshatch is sometimes referred to as the hash mark or the octothorpe. It is also called the "number" sign or the "pound" sign.

The "degree" sign is inherently at the superscript position and therefore never requires the superscript indicator to establish that position and does not require the base-level indicator to return to the base level.

The "infinity" sign looks like the digit 8 on its side in print and is sometimes referred to as the "lazy 8."

The percent sign of the literary code is replaced by the symbol listed above.

3.7.6 Operation Signs

The most common signs of operation in arithmetic and algebra are:

asterisk		(456,246)
divided by		(46,34)
minus		(36)
plus		(346)
slash		(456,34)
times cross		(46,246)
times dot		(6,12456)

When the plus sign appears in print, it must be represented by the symbol listed above; it cannot be replaced by "plus" nor by  (4,346) which is the most recent literary code incarnation. For the most part, the minus sign cannot be distinguished from the hyphen except by context. However, this is also true for sighted people, so that the blind and the sighted are subject to the same pitfalls. Since the hyphen is a conditional delimiter whereas the minus sign is not, the braille user encounters a problem in this regard which a sighted user does not face.

When multiplying numbers, the times cross is usually used as the operation sign; the times dot would be too easily confused with the decimal point. On the other hand, when multiplying algebraic expressions, the times dot is usually used as the sign of operation; the times cross would be too easily confused with the letter *x* which is very likely to occur in an algebraic expression. Note how the NUBS times cross mimics the print times cross by producing a dot pattern which can be perceived as an *x*.

The asterisk is used as the multiplication operator in computer programming and related text.

When multiplying two variables or two enclosed expressions, the multiplication operator is usually omitted altogether, as in *xy* or *(a+d)(b+c).*

In expressions which are contained in computer programs, the asterisk is most commonly used as the multiplication operator, and is never assumed to be implicitly present as in algebra.

In computer programs, the slash is most commonly used as the division operator; the dividend and the divisor are enclosed within parentheses as necessary.

Operators are more fully discussed in Chapter 5 and less common additional operators are also introduced there.

3.7.7 Reference Signs

NUBS offers the following reference signs:

asterisk	⠰⠔	(456,246)
dagger	⠠⠄⠰⠖	(4,6,1456)
double dagger	⠠⠄⠰⠶	(4,6,12456)
paragraph sign	⠠⠄⠰⠦	(4,6,12346)
pointing finger	⠠⠄⠰⠲	(4,6,1246)
reference indicator	⠠⠔	(4,156)
section sign	⠠⠄⠰⠎	(4,6,2346)

NUBS does not put reference signs in the superscript position as is almost always the case in print. Instead, the reference sign is always preceded by the reference indicator ⠠⠔ (4,156) to alert the braille user that there is a footnote or a marginal note on the braille page flagged by the same reference sign.

The mnemonic mechanism for forming the roots of the reference signs is as follows: Take the first letter of the sign's name and add dot 6. Thus, *p* is the first letter of "paragraph" and, when dot 6 is added, the root becomes ⠰⠦ (12346). According to this mnemonic, the root for "section" becomes ⠰⠎ (2346), for "dagger" it becomes ⠰⠖ (1456), and for "finger" it becomes ⠰⠲ (1246). Since the first letters of "dagger" and "double dagger" are identical, we use the letter *g* for "double dagger," and the root becomes ⠰⠶ (12456).

"Asterisk" is an exception. Other than being a reference sign, the asterisk serves many other functions, and we wish to use the same sign for the asterisk throughout NUBS.

Print uses many more reference signs than are provided by NUBS, and these are often referred to as "dingbats." Because of the extendability of NUBS, these dingbats can be created if required using the same prefix as is used for the reference signs above.

3.7.8 Simple Fractions

In print, the basic structure of a fraction consists of a ruled line called the ***fraction bar***, above which is the part of the fraction called the ***numerator***, and below which is the part of the fraction called the ***denominator***. The numerator and the denominator are frequently referred to as the ***terms*** of the fraction. Accordingly, the numerator is sometimes called the ***upper term*** and the denominator is sometimes called the ***lower term*** of the fraction. The length of the fraction bar is the same as the length of the longer term. If the length of the other term is shorter, it is generally centered on the fraction bar in print. Simple fractions are, by far, the most common.

In NUBS, fractions can be represented in two ways, linearly and spatially. Here we present the linear method; spatial representation of fractions is presented in Chapter 5, Section 5.7.2.

When represented linearly, the characters which convey the information contained in a fraction occupy consecutive cells along the braille line. The symbol which represents the fraction bar is called the *linear fraction bar.*

When representing a linear fraction, NUBS uses the following symbols:

begin-fraction indicator	⠸⠹	(1456)
end-fraction indicator	⠼⠹	(3456)
linear fraction bar	⠸	(34)

A fraction is notational and, when embedded in surrounding text, must be introduced by the notational indicator ⠸ (56). Every fraction, without exception, must be enclosed within fraction indicators to mark the beginning and the end of the fraction. This requirement implements one of the basic design principles in NUBS, namely, the *just-in-time principle*. In the case of the fractions, the reader must know when a fraction has begun and when it has ended. A sighted person has this information just by looking at the fraction.

The current literary code provides only for fractions that contain numbers. However, as the following examples show, fractions may contain numbers, letters, operation signs, radicals, and any combination of these.

EXAMPLES (of simple fractions)

1 $\frac{1}{3}$ ⠸⠹⠼⠁⠸⠼⠉⠼

2 $\frac{2a}{3b}$ ⠸⠹⠼⠃⠁⠸⠼⠉⠃⠼

3 $\frac{5+4+6+5}{4}$ ⠸⠹⠼⠑⠬⠼⠙⠬⠼⠋⠬⠼⠑⠸⠼⠙⠼

4 $\text{rate} = \frac{\text{distance}}{\text{time}}$ ⠸⠹⠗⠁⠞⠑⠀⠨⠅⠀⠹⠙⠊⠎⠞⠁⠝⠉⠑⠸⠼⠞⠊⠍⠑⠼

5 $\frac{5-\sqrt{3}}{2}$ ⠸⠹⠼⠑⠤⠩⠼⠉⠸⠼⠃⠼

These examples are intended to demonstrate the variety of notation that can be contained in a simple fraction. We think of the first three fractions as being embedded in surrounding text and therefore require the notational indicator. We think of the last two examples as displayed text and thus do not require any notational indicator. Since Example 4 is displayed text, it is notational; none of the characters therein may be interpreted as contractions.

3.7.8.1 Quasi-Vertical Fractions

If a simple fraction is embedded within a print line in which the other characters are otherwise printed one after another in a straight line, the vertical structure of the simple fraction will result in considerable white space above and below the printed line. To minimize this white space, many typesetters will tilt the fraction bar so that it looks like a slash. They then print the numerator of the fraction near the top of this tilted fraction bar, and print the denominator of the fraction near the bottom of this tilted fraction bar. To reduce the amount of while space still further, they will, in addition, print the terms of the fraction in smaller type than is used for the other parts of the line. This reduces the length of the tilted fraction bar. Simple fractions that are printed using one or both of these methods are called *quasi-vertical fractions.*

NUBS does not distinguish between simple fractions with a horizontal fraction bar and a simple fraction that is quasi-vertical because there in no notational difference between the two forms, and white space is not an issue in braille. Fraction indicators must still be used, but the quasi-vertical fraction bar is represented by the linear fraction bar ⠌ (34). Thus, in a back-translation, the tilt of the fraction bar will be lost.

EXAMPLES (of quasi-vertical fractions)

1 $a+b/c+d$ ⠆⠁⠐⠌⠉⠐⠙⠰

2 $3\,x/y$ ⠼⠉⠭⠌⠽⠰

In Example 1, the numerator is printed near the top of the tilted fraction bar, and the denominator is printed near its bottom. In Example 2, the fraction bar is also tilted, but this time the terms of the fraction are printed in smaller type.

3.7.8.2 Teacher Alert

You should, by tactile drawings or by other means, show your students some fractions and their variations, making sure that your students understand the print notation for representing fractions. Without such comprehension, your students will find expressions like “top of the fraction” or “bottom of the fraction” confusing. When learning to divide one fraction by another, the expression “invert the denominator“ will be murky unless your students have a firm grasp of what the underlying print notation is. In fact, it is recommended that when fractions are first introduced, that they be represented spatially in braille to reinforce the students’ concept of how fractions are written in print.

3.7.8.3 The Slash

The symbol for the slash is:

slash ⠸⠌ (456,34)

Sometimes a typesetter may tilt the fraction bar without repositioning the terms of the fraction and without reducing the size of the type. Because the slash has so many other uses, NUBS does not recognize such text as a fraction. Consider the expression:

$a+b/c+d$ ⠰⠁⠬⠃⠸⠌⠉⠬⠙⠰

It may be tempting to regard this text as a fraction whose numerator is $a+b$ and whose denominator is $c+d$. But this interpretation would be mathematically incorrect. The correct mathematical interpretation is:

$$a+\frac{b}{c}+d$$ ⠰⠁⠬⠃⠌⠉⠬⠙⠰

By treating constructs containing the slash in the manner just described, a sighted reader and a braille reader have the same opportunity of avoiding or of falling into the same trap.

RULES (regarding the slash)

a *Even when it appears "clear" that the slash is a substitute fraction bar, NUBS does not recognize such notation as a fraction unless other typesetting mechanisms attest to a quasi-vertical fraction.*

b *When a fraction is known to be quasi-vertical, its fraction bar, which looks like a slash in print, must nevertheless be rendered as a linear fraction bar in braille.*

c *In all other situations, the slash must be treated either as a sign of operation or as a punctuation mark.*

EXCEPTION

See RULES (regarding mixed numbers: Section 3.7.8.4)

The slash has many uses other than as a substitute fraction bar. It is used between the components of a date. It is used between the components of model numbers, serial numbers, catalog numbers, and similar notation. It is used in conjunction with the asterisk to initiate and terminate a comment statement in the C language and in other modern programming languages. It is used as an informal substitute for the word "or" in many contexts such as in I/O, X-on/X-off, and/or, and he/she.

EXAMPLES (showing some uses of the slash)

1 1/3 ⠼⠁⠸⠌⠉

2 I/(*n*) ⠠⠊⠸⠌⠐⠣⠝⠐⠜

3 6/28/95 ⠼⠋⠸⠌⠼⠃⠓⠸⠌⠼⠊⠊

Example 1 shows a configuration in which the slash is a substitute fraction bar. However, no enclosing fraction indicators are used in this case, in accordance with NUBS rules.

The notation in Example 2 is not a fraction and is not represented as such. The transcriber is not expected to know what the notation means. The reader will probably rely on an explanation of this notation presented earlier in the text to assign a meaning to it.

In Example 3, the components of a date are separated by slashes.

3.7.8.4 Mixed Numbers

A *mixed number* consists of an integral part followed by a fractional part. The integral part may be a positive or negative integer. The terms of the fractional part are positive integers; they are generally shown in smaller type. The fraction bar in the fractional part may be either a horizontal fraction bar or a slash. Only integers are permitted as components of a mixed number, but one or more of these integers may be replaced by the omission sign.

RULES (regarding mixed numbers)

a *A mixed number consists of an integral part followed by a fractional part. In NUBS, the fractional part must be enclosed within fraction indicators.*

b *In the fractional part of a mixed number, a horizontal fraction bar in print must be represented by a linear fraction bar in braille, and a slash in print must be represented by a slash in braille.*

Note that this is a departure from the method for representing mixed numbers in the 1972 Nemeth Code in which special indicators were provided for the fractional part of a mixed number.

EXAMPLES (regarding mixed numbers)

1 $4\frac{3}{8}$ ⠼⠙⠼⠉⠌⠓

2 4 3/8 ⠼⠙⠼⠉⠸⠌⠓

3 $x\frac{3}{8}$, $3\frac{1}{y}$ ⠭⠼⠉⠌⠓ ⠼⠉⠼⠁⠌⠽

The first two examples represent the same mixed number. In the first example, the fraction bar is horizontal; in the second, it is the slash.

The two expressions in Example 3 are not mixed numbers; both contain letters.

3.7.8.5 Graphic Symbols for One-Half and One-Fourth

The key to the right of the p on a standard typewriter contains two graphics: a graphic for *one-half* (without the shift key) and a graphic for *one-fourth* (with the shift key). These

graphics occupy the space of one print character. Two-cell symbols have been devised for these graphics as follows:

the one-fourth graphic		(4, 256)
the one-half graphic		(4, 23)

These symbols must be used only when displaying, describing, or discussing the layout of a typewriter keyboard.

Additional information about fractions is found in Chapter 5.

3.7.9 Simple Radicals

NUBS offers the following symbols related to radicals:

radical sign		
with vinculum		(345)
without vinculum		(46,46,345)
termination indicator		(246)

The radical sign, without further modification, is by far the most commonly encountered form. The radical sign is frequently referred to as the ***square root sign.*** Even the simplest calculators feature a square root key. Attached to the radical sign, and extending to the right to cover all the notation over which the radical sign is effective, is a horizontal bar called the ***vinculum.*** The notation under the vinculum is called the ***radicand.*** The notation that includes the radical sign and the radicand is called the ***radical expression.*** A radical expression is notational.

The vinculum is not represented in braille. Instead, a ***termination indicator*** is supplied to show exactly where the vinculum ends. It is then implied that all the notation between the radical sign and the termination indicator is covered by the vinculum. Note that the termination indicator is not the same as the one provided in the 1972 Nemeth Code.

A radical sign without a vinculum is rare. In older works, particularly in typescripts, the radicand is enclosed within parentheses or other enclosure symbols to specify the notation over which the radical sign has effect. The braille reader must rely on the notation to determine the effectiveness of the radical sign, in the same way that a print reader must do.

The radical sign without the vinculum is also used as the ***check mark.***

RULES (regarding the representation of a radical expression)

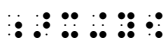
a ***The radical sign must be the first symbol of the radical expression.*** The radical sign is then followed by the radicand.

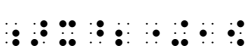
b ***The termination indicator must be used after the last character under the vinculum.***

c ***When there is no vinculum, NUBS provides an alternative radical sign.***

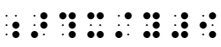
EXAMPLES (regarding simple radical expressions)

1 $\sqrt{2}$ 

2 $\sqrt{x+y}$ 

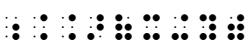
3 $\sqrt{x^2+1}$ 

4 $\sqrt{x^2+y^2}$ 

5 $\sqrt{\frac{x}{y}}$ 

6 $3\sqrt{a}$ 

7 The symbol  means "square root."

8 $\sqrt{(x+y)}$ 

The expressions in Examples 1 through 6 are intended to show that there is no restriction on the notation that forms the radicand.

In Examples 7 and 8, the radical sign has no vinculum.

3.7.10 Simple Subscripts and Superscripts

NUBS offers the following indicators related to simple subscripts and superscripts:

base level		(5)
subscript		(56)
superscript		(45)

Note how suggestive these indicators are for indicating their respective level changes.

The term ***subscript*** means “written lower” and the term ***superscript*** mean “written higher”. These are accurate descriptions of the positions of such notation relative to the base line. Subscripts and superscripts show up frequently in the general literature. H_2O, the chemical formula for water, and CO_2, the chemical formula for carbon dioxide, are good examples.

In print, subscripts and superscripts are written to the right of the notation to which they apply. Not only are subscripts and superscripts displaced from the base line, but they are generally printed in a reduced type size. This reduced type size is not an inherent part of the notation. It is done to reduce the amount of white space above and below the base line which contains them.

A subscript or a superscript may be as simple as a letter, a digit, or some other single symbol, or it may be a more complicated expression, including the possibility of fractions, radicals, or both. Braille is a system in which symbols are written linearly, one after another. It is not practical or feasible to write subscripts or superscripts at levels different from that of the base line, as is done in print. It is therefore necessary to devise symbols which indicate a level change rather than actually changing the level at which the notation is brailled. Such symbols are called *level indicators.* A level indicator does not represent a symbol that can be printed; rather, it offers important and in-time information about the disposition of the print symbols which it affects. This is not our first encounter with indicators. We have already come across the numeric indicator, the various font indicators, the fraction indicators, and the termination indicator for radicals.

Section 3.7.7 dealt with the reference signs. Attention is routinely called to the presence of a footnote, a marginal note, or other kinds of notes by means of a symbol in the superscript position. In NUBS, such reference symbols are not to be treated by the methods for indicating level changes about to be presented below. See Section 3.7.7 for handling references.

RULE (for level indicators)

Once a level has been established by one of the level indicators listed above, that level remains in effect until it is changed either by another level indicator or by a space.

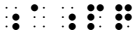
EXAMPLES (illustrating the use of subscripts and superscripts)

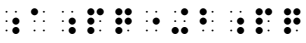
1 x^2 

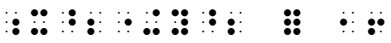
2 x^n 

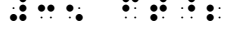
3 $y^{1/2}$ 

4 $c^{\sqrt{2}}$ 

5 a_{pq} 

6 $a_{pq} + b_{pq}$ 

7 $x^2 + y^2 = 16$ 

8 35 ft^2 

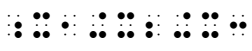
3.7.10.1 Teacher Alert

You should show your students how subscripts and superscripts are handled in print, preferably with tactile graphics, and you should explain to your students how braille gives the same information to the braille reader.

3.7.10.2 Numeric Subscripts

NUBS provides an abbreviated notation for numeric subscripts. This method dispenses with the subscript indicator, and the reader is returned to the base level when the number has ended. To qualify for this abbreviated notation, a number may contain not only digits, but commas and a decimal point as well. This notational abbreviation is available only when a number is a subscript to a letter; it does not apply to numbers which are subscript to other symbols. The letter to which a number is subscript may be in any case, an in any font, or from any alphabet. However, the letter to which the number is a subscript must be at the base level.

EXAMPLES (of numeric subscripts)

1 $x_1+x_2+x_3$ 

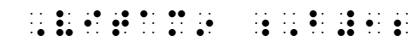
2 $a_{11}x_1+a_{12}x_2+ \ldots +a_{1n}x_n = b_1$

3 $a_{n1}x_1+a_{n2}x_2+ \ldots +a_{nn}x_n = b_n$

(The numbers which follow *x* are subscripts to *x*, but the numbers which follow *n* are at the same level as *n*.)

Numbers which follow a letter are not always subscript to that letter. This is particularly true in the case of model and serial numbers and in the identifiers in most programming languages. Only when the letter and the number are at the base level, the number, in NUBS, must be preceded by the numeric indicator, ⠼ (3456). Note that this indicator differs from the one used in the 1972 Nemeth Code.

EXAMPLE (of numbers which follow letters but which are not subscripts)

4 Vitamin B12 

(The number follows the letter at the base level.)

3.8 Contractions, Sequencing, Hyphenation

3.8.1 Contractions

The official literary code contains many anomalies regarding the use of contractions. NUBS does not attempt to resolve those anomalies. It regards the contraction system of the official literary code as a "black box" whose insides is not the domain of NUBS.

We make the following minor modifications:

a The contractions for "to," "into" and "by" may not be joined to a notational word.

b Do not contract "for" when it might be mistaken for the equals sign; use the notational indicator before the equals sign when it might be mistaken for "for". (See Section 3.7.2.)

In the 1972 edition of the Nemeth Code, there were various rules concerning the use or the non-use of contractions; none of those rules applies in NUBS.

3.8.2 Sequencing

Sequencing is the Grade-2 feature which permits certain words to be written without a space in braille even though there is a space between those words in print. The purpose of sequencing in braille is to save space.

Words that could be sequenced were:

"and," "for," "of," "the" and "with".

Furthermore, any of these words could be followed without a space by the word "a". In addition, the words

"to," "into" and "by"

could be written without a space next to whatever word followed.

However, at one time, Grade-2 braille contained a "natural pause" rule which disallowed sequencing when, if permitted, sequencing would destroy the sense of the sentence. Here is an example of such a situation:

He was passed by while others were noticed.

In this example, connecting "by" to "while" via sequencing would destroy the sense of the sentence, so sequencing was disallowed. However, the "natural pause" rule is difficult to implement on a computer, so that the rule has now been abolished.

I am personally opposed to sequencing because it destroys the orthography of the English language which, in my opinion, no code or system should do. However, NUBS is committed to preserving Grade 2. Therefore, NUBS will permit sequencing so as to leave Grade 2 intact. Nevertheless, here is a suggestion for partially reviving the "natural pause" rule which can easily be implemented by a table lookup. The words that can be sequenced become row headings in the table. The same words in the same order also become column headings in the table. We think of the words in the row headings as the "first word," and the words in the column headings as the "second word". If the first word can be properly sequenced with the second word, the table contains a y for "yes" at the intersection of the row containing the first word and the column containing the second word; if it is inappropriate to sequence the first

word with the second word, an n for "no" is entered in the table where the row and column containing the two words intersect.

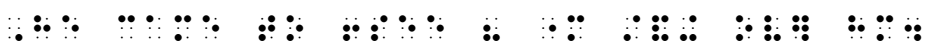
Here is the table:

	and	for	of	the	with	to	into	by	a
and	n	y	y	y	y	n	n	n	y
for	n	n	n	y	n	n	n	n	y
of	n	n	n	y	n	n	n	n	y
the	n	n	n	n	n	n	n	n	n
with	n	n	n	y	n	n	n	n	y
to	n	n	n	y	n	n	n	n	y
into	n	n	n	y	n	n	n	n	y
by	n	n	n	y	n	n	n	n	y
a	n	n	n	n	n	n	n	n	n

This table, as previously asserted, would only partially restore the "natural pause" rule. The example above would not be helped by this table. But phrases like "to and fro" and "by and large" would.

A sentence such as:

> He came to to see his mother standing over him.



definitely would.

3.8.3 Hyphenation

NUBS recommends that, for the most part, hyphenation be avoided. Experience has taught us that space is rarely saved by maximum hyphenation. The space saved by hyphenation on one line is usually insufficient to accommodate another word on the next line. Even when space is gained for another word by hyphenating, this gain is propagated from line to line, and is finally lost at the end of the paragraph; the last line of the paragraph becomes a little shorter. Even if, by rare chance, a line is saved by hyphenating, this saved line will propagate from page to page and will finally be lost at the end of the chapter or other place where the rest of the braille page is left blank; this page will have one less line. It is indeed rare that a page can be saved in a braille volume as a result of hyphenating, and rarer still, in the case of two-sided embossing, that a sheet of paper will be saved by hyphenating in a volume of braille.

A hard hyphen is one that is present in the print text, as opposed to a soft hyphen which refers to a hyphen created by the transcriber when hyphenating a word. It is permissible to hyphenate at a hard hyphen if the braille line breaks at such a place.

3.8.3.1 Prefixes

There are, however, certain situations in which hyphenation is justified because, by not hyphenating, the ends of the braille lines would be too jagged. Below is a list of prefixes, common in the English language, collected over a period of time, after which hyphenation is justified because of the length of the prefix. These prefixes are followed by one or two examples showing why hyphenation is justified after these prefixes.

aero – aerodynamic aeroplane
ante – antebellum antechamber
anthro – anthropology anthropomorphic
anti – antidote antivirus
auto – autoimmune automatic automotive
cardio – cardiogram cardiovascular
circum – circumference circumnavigate
contra – contraband contradict
counter – counterattack counterbalance
electro – electromagnetism electrolyte electromechanical
extra – extracurricular extraordinary
hemo – hemoglobin hemostat
helio – heliocentric heliotrope
hetero – heterodyne heterosexual
hydro – hydroelectric hydrophobia
hyper – hypersensitive hypertension
hypo – hypochondriac hypothalamus hypothetical
infra – infrared infrastructure
intra – intramural intravenous
mega – megabyte megacycle
meta – metabolic metamorphosis
micro – microphone microscope
multi – multilingual multinational
neuro – neurological neuroscientist
ortho – orthodontist orthostatic
photo – photograph photosynthesis
physio – physiological physiotherapy
poly – polygraph polysaturated
proto – protoplasm prototype
pseudo – pseudopod pseudoscience
psycho – psychoanalysis psychotherapy
retro – retrograde retrovirus
semi – semiannual semicircle
super – supermarket superstructure
tele – telephone telescope
thermo – thermodynamic thermoelectric thermostat
tran – transcribe transistor
trans – transcontinental translator
ultra – ultrasound ultraviolet

No doubt, there are other similar prefixes that are not included in the above list and, if recognized, may be added. Note that prefixes like "bio" and "inter" are not included. I believe that prefixes that require three cells or less do not qualify as candidates for hyphenation.

3.8.3.2 Suffixes

There are also a few suffixes that merit consideration as candidates for hyphenation. Some of these are:

bilities – possibilities probabilities
bility – accountability feasibility
cial – financial official
cially – financially officially
cies – efficiencies fallacies
hood – motherhood priesthood
ically – economically ironically radically
liest – earliest homeliest
liness – cleanliness loneliness
manship – penmanship salesmanship
ties – activities amenities
tious – ambitious repetitious
tive – adjective narrative positive
tory – auditory mandatory

As with prefixes, you will recognize other similar suffixes when you meet them. Only those which require four or more braille characters warrant consideration as candidates for hyphenation.

Do not hyphenate if the first character on the next line will be ⠸ (6) or ⠒ (56). If dot 6 is the first character, the reader may take the letter that follows as upper case. If dots 56 form the first character, the reader may interpret the word that follows as notational.

3.8.3.3 Compound Words

Many words in the English language are a combination of words which were once separate or hyphenated but which have evolved into a single word. Typical words of this kind, called "compound words," are:

airplane, beekeeper, cupboard, daredevil, endpoint, farreaching, getaway, headhunter, icebreaker, jackhammer, keystroke, lipstick, masterpiece, nearsighted, overemphasize, payroll, quicksilver, racehorse, seascape, tapemeasure, underdeveloped, viewpoint, waterfront, yellowbird, zipperpull

Such words may be hyphenated between components of the word. Contractions, if available, may not be used to bridge across components, as is also the rule in the official literary code.

In all the above cases–prefixes, suffixes, and compound words–hyphenation is discretionary, not mandatory.

3.9 Other Alphabets, Special Letters

3.9.1 The Greek Alphabet

Not only are Greek letters used for notational purposes in mathematics and the physical sciences, they also occur in everyday literature. The names of fraternities and sororities are composed of Greek letters. The letter π (pi) is used when giving the formula for the circumference or the area of a circle. The letter σ (sigma) is used in the social sciences when giving the standard deviation of a set of data. The letter μ (mu) is used as the prefix meaning "micro" (a millionth) with units of measurement as in μg–microgram.

NUBS makes specific provision for the Greek alphabet, both lower-case and upper-case letters. NUBS uses the prefixes listed below to distinguish between a Greek lower-case letter and a Greek upper-case letter.

prefix for lower-case Greek letters		(46)
prefix for upper-case Greek letters		(456)

The roots for the Greek letters are those of the International Greek Alphabet devised under the auspices of UNESCO**:** I did not make the assignments. The following is a chart of the Standard Greek Alphabet. It shows the name of the letter; the simulated braille representation, both lower case and upper case, of the letter; and the dots which form the root of the letter. In the Basic Literary Symbol Set of this chapter, the Greek letters are also shown; the lower-case letters and the upper-case letters are shown in separate listings. In the braille version of this text, the lists there also show the tactile graphics for both sets of Greek letters.

Name of letter	Lower-case braille	Upper-case braille	Dots: root only
alpha			(1)
beta			(12)
gamma			(1245)
delta			(145)
epsilon			(15)
eta			(156)
zeta			(1356)
theta			(1456)
iota			(24)
kappa			(13)
lambda			(123)
mu			(134)
nu			(1345)
xi			(1346)

omicron			(135)
pi			(1234)
rho			(1235)
sigma			(234)
tau			(2345)
upsilon			(136)
phi			(124)
chi			(12346)
psi			(13456)
omega			(2456)

Greek letters in other fonts use the same indicators as are used for those fonts in the English alphabet.

Greek letters which are used for the names of fraternities and sororities should be regarded as notational, since some of the upper-case letters conflict with Grade-2 contractions.

3.9.2 Other Alphabets

The use of alphabets other than the Greek alphabet for notational purposes is rare. Sometimes, a work is translated from a foreign language and the letters of that language that are used for notational purposes are retained in the translation. Thus, a work translated from the German may retain the Gothic (old German) letters used for notational purposes in the original. The same may be true of a work translated from the Russian which uses Cyrillic letters for notational purposes. The 1972 Nemeth Code made provision for the Gothic, Cyrillic and Hebrew alphabets. Although NUBS does not make specific provision for those alphabets, prefixes can easily be assigned for the letters of such alphabets as the need arises, because of the extendability of NUBS.

3.9.3 Special Letters

Letters from various alphabets are used for notational purposes; they are listed and discussed in Chapter 5.

INDEX FOR THE LITERARY SECTION.

An index is presented at this point because Chapters 0, 1, 2, and 3 constitute the Literary Section of NUBS. Only those aspects of mathematics that are common to general literature, such as those discussed in Section 3.7, are presented in this literary unit. The remaining chapters deal with the more mathematical aspects of the proposed System.

Therefore, Chapters 0 through 3 are being treated as a self-contained entity, so that those who are interested only in the literary aspects of the System can limit their study to these chapters. Those who deal with more technical aspects of the System will want to investigate Chapters 4 and 5. At the end of Chapter 5, there is a global index that covers Chapters 0 through 5.

Each entry in the index includes the section number and the print page number. In the braille version, this is followed by an additional notation to provide the braille volume and braille page number. For example a reference of: ANGLE BRACKETS 3.2.3 49 indicates that angle brackets are addressed in Section 3.2.3 on print page 49. Since the indexed item may not occur at the beginning of the referenced section, the print page listed may not include the start of that section.

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