

# **Braille notations in mathematics, physics and chemistry in Finnish**

Braille authority of Finland

2022

(auto)translated by Sami Määttä

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## Reader 4

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# For the Reader

This guide introduces the dot markers and markings needed to study mathematics, physics and chemistry in elementary and high school. Together [with the Braille Basics \(in Finnish\)](#) guide, the book forms a fairly comprehensive Finnish Braille manual.

The guide is based on the Score 2000 - *Mathematics, Physics and Chemistry Point Markings guide*, edited by Anneli Salo and published in 2004. The content has been somewhat updated. Some examples have been added and bugs fixed. The order of the texts has been changed. Along with the dot markings made with black text, the position of points in the cell has been added using numbers. Point markings are therefore also accessible to the visually impaired. However, no dots are marked in the example texts.

Nowadays, high school hardly uses braille books for studying mathematics, but mathematics textbooks are made into electronic books (see [Mathematics textbooks](#)). *Entries in mathematics, physics and chemistry in electronic textbooks* [on the Pistekirjoitus.fi](#) site). However, the high school math dot markings have been retained in the guide.

The Braille Advisory Board is grateful for your comments on this book. Feedback can be sent to the Advisory Board's e-mail. Up-to-date contact information can be found [on the Advisory Board's website](#).

Thank you for your help and valuable comments to my colleagues at Celia and the Braille Advisory Board. Thanks also to Anneli Salo, who has served fully in working life, for her previous guide and other work in the world of Braille and point mathematics.

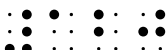
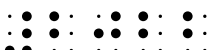
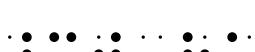
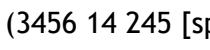
Helsinki 22.11.2022

Essi Aura

–      $\ddot{\cdot}$  (36)     dash, hyphen (also  
hyphen minussign)

## Numbers

Braille numbers are formed by typing letters a–j after the number sign. The scope of the number sign ends with a space.

|    |                                                                                     |              |        |                                                                                      |                             |
|----|-------------------------------------------------------------------------------------|--------------|--------|--------------------------------------------------------------------------------------|-----------------------------|
| 1  |    | (3456 1)     | 11     |    | (3456 1 1)                  |
| 2  |    | (3456 12)    | 20     |    | (3456 12 245)               |
| 3  |    | (3456 14)    | 100    |    | (3456 1 245 245)            |
| 4  |    | (3456 145)   | 120    |    | (3456 1 12 245)             |
| 5  |    | (3456 15)    | 2022   |    | (3456 12 245 12 12)         |
| 6  |   | (3456 124)   | 3081   |   | (3456 14 245 125 1)         |
| 7  |  | (3456 1245)  | 30 ha  |  | (3456 14 245 [space] 125 1) |
| 8  |  | (3456 125)   | 15 h   |  | (3456 1 15 [space] 125)     |
| 9  |  | (3456 24)    | 21,5 a |  | (3456 12 1 2 15 [space] 1)  |
| 0  |  | (3456 245)   |        |                                                                                      |                             |
| 10 |  | (3456 1 245) |        |                                                                                      |                             |

## Grouping numbers

Black print text often uses a space when grouping multi-digit integers, for example, millions. Braille uses the so-called grouping character for numbers, because the space invalidates the number sign's effect. The grouping character is usually **not** used for four-digit numbers.

Punctuation point  $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$  (3) is the primary grouping character for integers in Braille when it comes to this.

Examples:

1000 (four digit number)

$\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$

10 000 or 10.000 (thousands)

$\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$

1 234 000 or 1.234.000 (millions)

$\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$

5,12575 (decimal number and comma)

$\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$

1,234 657 234... (continuing decimal number)

$\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$

Another possible grouping character in braille is the numeric character  $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$  (3456).

A numeric symbol is used as a grouping mark if a number contains a decimal period instead of a decimal comma instead. Decimal point and the grouping point together complicate the interpretation of the number. In this case, the numeric sign will stick to both the character before and after it.

Example:

13 520.78

## Roman numerals

Roman numerals is written in Braille using the same capital letters as in black letters. Roman numerals are preceded by a capital letter sign just like capitalized abbreviations. If a number has more than one character, it must be preceded by two capitalized characters.

$$I = \begin{pmatrix} \cdot & \cdot & \cdot & \bullet \\ \cdot & \cdot & \bullet & \cdot \\ \cdot & \bullet & \cdot & \cdot \end{pmatrix} \quad (6.24)$$

VIII  (6 6 1236 24 24 24)

II  (6 6 24 24)

IX       $\begin{array}{ccc} \cdot & \cdot & \bullet \\ \cdot & \cdot & \bullet \\ \bullet & \bullet & \cdot \end{array}$       (6 6 24 1346)

III  (6 6 24 24 24)

$$X \quad \begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array} \quad \begin{array}{cc} \bullet & \bullet \\ \cdot & \cdot \\ \bullet & \bullet \end{array} \quad (6 \ 1346)$$

IV  $\begin{array}{ccc} \cdot & \cdot & \bullet \\ \cdot & \cdot & \bullet \\ \cdot & \cdot & \bullet \end{array}$  (6 6 24 1236)

$$L \quad \begin{array}{cccc} \cdot & \cdot & \bullet & \cdot \\ \cdot & \cdot & \bullet & \cdot \\ \cdot & \bullet & \bullet & \cdot \end{array} \quad (6 \ 123)$$
$$V \quad \begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array} \quad \begin{array}{cc} \bullet & \cdot \\ \bullet & \cdot \\ \bullet & \cdot \end{array} \quad (6 \ 1236)$$

C  $\begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$   $\begin{array}{cc} \bullet & \bullet \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$  (6 14)

VI  (6 6 1236 24)

D  $\begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array} \begin{array}{cc} \bullet & \bullet \\ \cdot & \bullet \\ \cdot & \cdot \end{array} \quad (6 \ 145)$

VII  (6 6 12 36 24 24)

$$M \quad \begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array} \quad \begin{array}{cc} \bullet & \bullet \\ \cdot & \cdot \\ \bullet & \cdot \end{array} \quad (6 \ 134)$$

Example:

AD MCMXLV (= Anno Domini 1945)

## Dimensions and units

%     ⠠⠼     (1456)     percent

‰     ⠠⠠⠼     (25 1456) per mille

°     ⠠⠨     (356)     degree

§     ⠠⠤     (3456)     section mark (in law)

### Examples:

99 % (space preceeding the percent sign)

⠠⠠⠼ ⠠⠼

115 ‰ (space preceeding the per mille sign)

⠠⠠⠠⠼ ⠠⠠⠼

At 100° (space preceeding the degree sign)

⠠⠠⠠⠨

37 °C (space preceeding the degree sign, cap C with no space)

⠠⠠⠠⠨ ⠠⠠⠠

-43°F (space preceeding the degree sign, cap F with no space)

⠠⠠⠠⠨ ⠠⠠⠠⠠

§5 (Section 5) (space preceeding the section sign, which is the same as the number sign)

⠠⠠⠠⠤ ⠠⠠⠠

## Monetary units

€  (4 15) euro

£     ⋮     (123)     pound

\$  $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$  (2346) or  $\begin{smallmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{smallmatrix}$  (6 145) dollar

Most commonly monetary units is marked in the same way as in the black print, where practices may differ for the marking even for the same currency. The exception is the dollar and pound signs. They are usually used in front of a number and in their basic form without a space. When talking about money, the dollar sign is often replaced by a capital D.

Examples:

6 € 15 snt (snt is for cents in Finnish)

£25

\$35


 or
 

A\$5 (five Australian dollars) (no spaces)

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| • | • | • | • | • | • | • | • |
| • | • | • | • | • | • | • | • |
| • | • | • | • | • | • | • | • |

USD 50 (fifty US dollars) (USD written as is, normal writing rules)

€1 = SEK 9.2 (one euro equals SEK 9.2) (order of signs doesn't have to be done programmatically)

## Areas and volumes

Many units of area and volume use the sign of raising to power sign  $\overset{\cdot}{\underset{\cdot}{\cdot}}$  (346). (See chapter for more details [Powers and roots](#).)

mm<sup>2</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (134 134 346) square millimeter

cm<sup>2</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (14 134 346) square centimeter

dm<sup>2</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (145 134 346) square decimeter

m<sup>2</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (134 346) square metre

a  $\overset{\cdot}{\underset{\cdot}{\cdot}}$  (1) Are (100 square meters)

ha  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (125 1) hectare (10 000 square meters)

km<sup>2</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (13 134 346) square kilometer (1 000 000 square meters)

mm<sup>3</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (134 134 346 3456 14) cubic millimetre

cm<sup>3</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (14 134 346 3456 14) cubic centimetre

dm<sup>3</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (145 134 346 3456 14) cubic decimetre

m<sup>3</sup>  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (134 346 3456 14) cubic metre

ml  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (134 123) millilitre

cl  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (14 123) centiliter

dl  $\overset{\cdot}{\underset{\cdot}{\cdot}} \overset{\cdot}{\underset{\cdot}{\cdot}}$  (145 123) deciliter

l  $\overset{\cdot}{\underset{\cdot}{\cdot}}$  (123) litre

## Dates and times

A number sign on dates comes only in front of the first digit.

If the time entry contains a punctuation mark other than a period, comma or colon, for example, a dash, the number sign must be repeated.

Examples:

30.11.2022

Figure 1 shows a 3x15 grid of dots. The dots are arranged in three rows and fifteen columns. The first row has dots at columns 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, and 15. The second row has dots at columns 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, and 15. The third row has dots at columns 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, and 15. This represents a 3x15 Latin square.

1.-14.3.2023

15. January – 28. February

● ●   ●   ●   ●   ●   ●   ●   ● ●  
 ●   ●   ●   ●   ●   ●   ●   ●   ● ●  
 ●   ●   ●   ●   ●   ●   ●   ●   ● ●

at 14:05 (digital clock display)

klo 8.15-10.35 ("klo" meaning "o'clock")

Time entries for sports results:

24.58,7

## Calculation marks

|        |                                                                                    |            |                                                          |
|--------|------------------------------------------------------------------------------------|------------|----------------------------------------------------------|
| +      |   | (235)      | plus                                                     |
| -      |   | (36)       | minus                                                    |
| ·      |   | (3)        | multiplication sign                                      |
| / or ÷ |   | (34)       | division sign                                            |
| :      |   | (25)       | ratio sign (scale; rarely division sign in Finnish math) |
| =      |   | (2356)     | equals                                                   |
| ≠      |   | (5 2356)   | different from, does not equal                           |
| ≈      |  | (456 2356) | approximation                                            |

Blank six dots  (space) is left before, but not after, all the above characters.

If the multiplication sign is not displayed, a space is between the multiplier and multiplicand.

Examples:

$$3 + 4 = 7$$



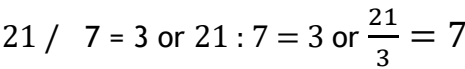
$$5 - 2 \neq 2$$



$$27 \cdot 3 = ?$$



$$(3x + 2y) (2x - 1)$$



1 : 1000 (one-to-thousand ratio)

$$\pi \approx 3,14$$

A blank space is left before and after the next characters.

“Estimates” sign is preceded by a empty six dots, but not after.

## Examples:

$$x < 18$$

The Braille representation of  $x < 18$  consists of the lowercase letter 'x' followed by the less-than sign and the number 18. The less-than sign is formed by a 3-dot cell (dots 1, 2, 3) followed by a 4-dot cell (dots 4, 5, 6).

$$2x > 6$$

The Braille representation of  $2x > 6$  consists of the number 2, the lowercase letter 'x', the greater-than sign, and the number 6. The greater-than sign is formed by a 3-dot cell (dots 1, 2, 3) followed by a 4-dot cell (dots 4, 5, 6).

$$2x \geq 6$$

The Braille representation of  $2x \geq 6$  consists of the number 2, the lowercase letter 'x', the greater-than-or-equal-to sign, and the number 6. The greater-than-or-equal-to sign is formed by a 3-dot cell (dots 1, 2, 3) followed by a 4-dot cell (dots 4, 5, 6) followed by a 5-dot cell (dots 5, 6, 7).

$$x \leq 18$$

The Braille representation of  $x \leq 18$  consists of the lowercase letter 'x', the less-than-or-equal-to sign, and the number 18. The less-than-or-equal-to sign is formed by a 3-dot cell (dots 1, 2, 3) followed by a 4-dot cell (dots 4, 5, 6) followed by a 5-dot cell (dots 5, 6, 7).

## Separator sign

The separator character must be used before the punctuation mark or, for example, the parenthesis if it is possible to misread the dot mark in the character group. Separator mark indicates that the next character is not a number. Point 6 is used as the separator character. (See also [Fractions](#).)

Example (here it's used after the number seven [which is lowered in fraction braille]):

$$\left(1\frac{3}{5} - \frac{5}{7}\right) - \left(\frac{2}{5} + \frac{1}{3}\right)$$

The Braille representation of the example equation uses the separator sign (a 6-dot cell, dots 1, 2, 3, 4, 5, 6) to separate the two groups of fractions. The first group is  $1\frac{3}{5} - \frac{5}{7}$  and the second group is  $\frac{2}{5} + \frac{1}{3}$ . The separator sign is placed between the two groups.

## Parenthesis

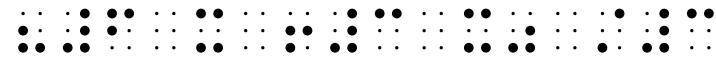
|   |                                                                                   |                             |   |                                                                                   |       |                     |
|---|-----------------------------------------------------------------------------------|-----------------------------|---|-----------------------------------------------------------------------------------|-------|---------------------|
| ( |  | (236) parenthesis open      | < |  | (126) | Start angle bracket |
| ) |  | (356) parenthesis close     | > |  | (156) | End angle closure   |
| [ |  | (12356) Start bracket       |   |  | (456) | absolute value sign |
| ] |  | (23456) Close bracket       |   |                                                                                   |       |                     |
| { |  | (1246) start curly bracket  |   |                                                                                   |       |                     |
| } |  | (12456) close curly bracket |   |                                                                                   |       |                     |

Examples:

$$2 - (-5) = 7$$

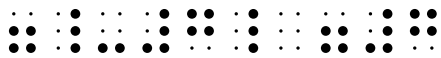


$$(6x + 3x) : 3 \text{ or } \frac{6x + 3x}{3}$$



$$|-(2 + 5)| = |-7| = 7$$

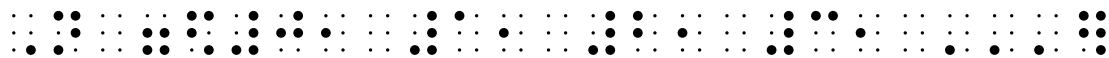




$$92 + [-2 \cdot (18 + 5)]$$



$$N = \{0, 1, 2, 3, \dots\}$$



## Long expressions

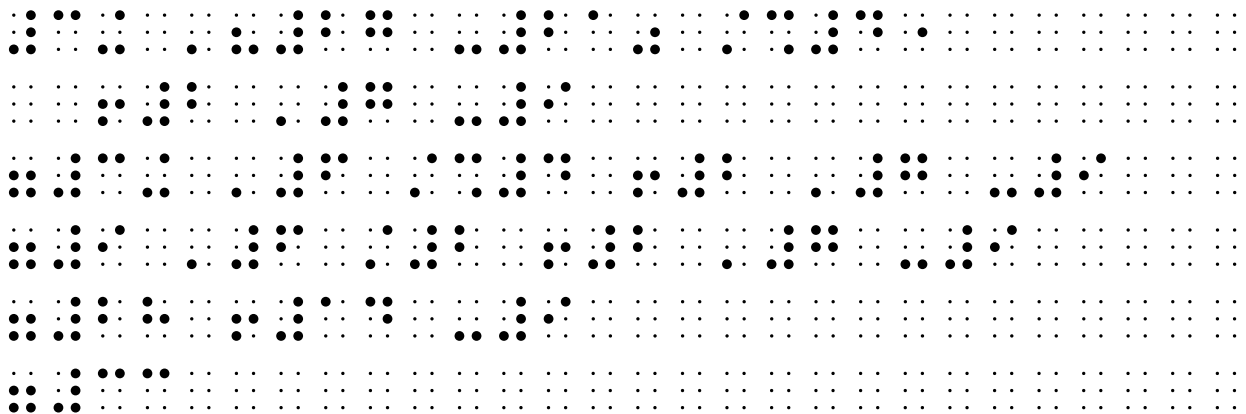
Order of calculation:

1. Expressions inside parentheses are counted,
2. Then the powers and roots in the order of writing.
3. Next, calculate multiplication and division in order,
4. and last count addition and subtraction.

When calculations are written in Braille, the task is divided into rows with equal signs point by point. A new line is always started with an equal sign, if possible. If the expression needs to be split into rows from elsewhere, use as a mathematical hyphen the characters formed by the 5 dot. The beginning of the continuation line is then indented by two spaces. The calculation sign appears at the beginning of the continuation line.

Examples:

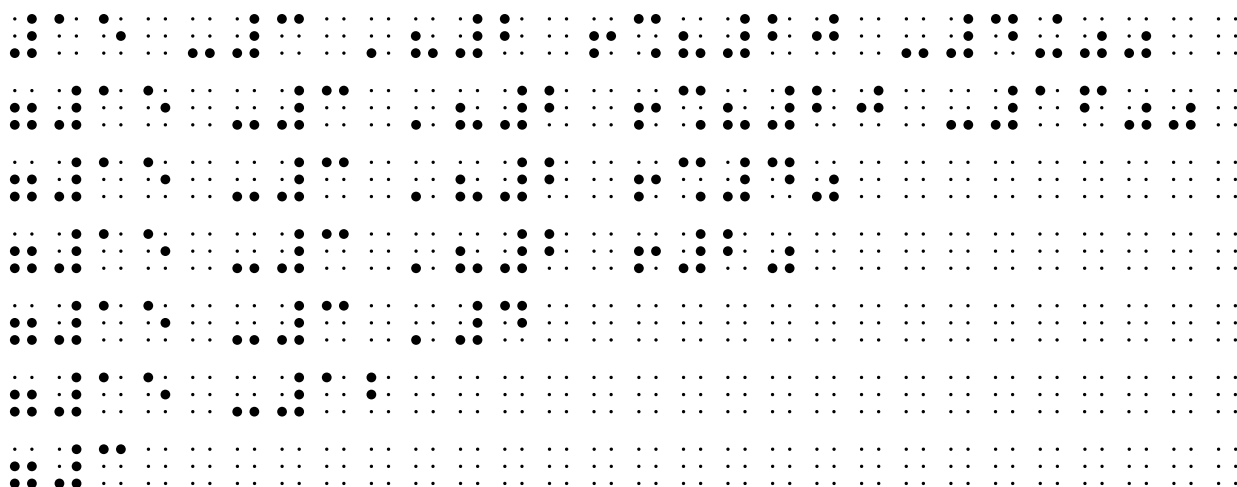
$$\begin{aligned} &3^2 \cdot (27 - 21) : \sqrt{4} + 2 \cdot 7 - 9 \\ &= 3^2 \cdot 6 : \sqrt{4} + 2 \cdot 7 - 9 \\ &= 9 \cdot 6 : 2 + 2 \cdot 7 - 9 \\ &= 28 + 14 - 9 \\ &= 33 \end{aligned}$$

A Braille representation of the calculation steps shown in the previous block. It consists of six lines of Braille, each corresponding to one line of the mathematical derivation. The Braille is correctly formatted, including the use of the 5-dot hyphen for continuation and proper indentation.

$$\begin{aligned} &15 - 3 \cdot (2 + \sqrt{20 - 4^2}) \\ &= 15 - 3 \cdot (2 + \sqrt{20 - 16}) \\ &= 15 - 3 \cdot (2 + \sqrt{4}) \\ &= 15 - 3 \cdot (2 + 2) \\ &= 15 - 3 \cdot 4 \end{aligned}$$

$$= 15 - 12$$

$$= 3$$



## Fractions

In simple fractions (i.e. when neither the numerator nor the denominator of a fraction has multiple terms or letters), the numerator is written like regular numbers. Denominator is written directly after the numerator with so called “lowered numbers” using only points 2, 3, 5 and 6.

|               |  |               |                                       |
|---------------|--|---------------|---------------------------------------|
| $\frac{1}{2}$ |  | (3456 1 23)   | one twelfth (lowered two)             |
| $\frac{1}{3}$ |  | (3456 1 25)   | one-third (lowered three)             |
| $\frac{1}{4}$ |  | (3456 1 256)  | one quarter (lowered four, and so on) |
| $\frac{1}{5}$ |  | (3456 1 26)   | one fifth                             |
| $\frac{1}{6}$ |  | (3456 1 235)  | one-sixth                             |
| $\frac{1}{7}$ |  | (3456 1 2356) | one seventh                           |
| $\frac{1}{8}$ |  | (3456 1 236)  | one eighth                            |
| $\frac{1}{9}$ |  | (3456 1 35)   | one ninth                             |

one tenth

Example:

If a fraction is followed by a parenthesis, the 6 dot shall be used as the separator between them. Otherwise, the parenthesis is interpreted as part of the fraction.

Fractions whose denominator is a long number can be denoted not only as a fraction but also as division.

(division sign)

In mixed fractions, write first the whole part and immediately after that a fraction with the number character.







## Fractional equations

A fractional equation is denoted as a division.

$$\frac{3y}{4} = \frac{3}{4}y$$

$$\text{⠠⠨⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽}$$

If numerator and denominator contain several terms, remember to enclose them in parentheses, even if there are no parentheses in the printed text. Multiplication in numerator can be written without parentheses, because of the order of operations, but in the denominator or the dividend the parentheses are always required, if a space appears in the braille text, as in the following example.

$$\frac{5 + 7}{2 \cdot 3}$$

$$= \frac{12}{6} = 2$$

$$\text{⠠⠨⠠⠼⠠⠔⠠⠒⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽}$$

$$\text{⠠⠨⠠⠼⠠⠔⠠⠒⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽}$$

If divisor's parentheses are forgotten, according to the order of operations, the result will be incorrect:

$$\text{⠠⠨⠠⠼⠠⠔⠠⠒⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽}$$

$$\text{⠠⠨⠠⠼⠠⠔⠠⠒⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽}$$

$$\text{⠠⠨⠠⠼⠠⠔⠠⠒⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽⠠⠼⠠⠔⠠⠨⠠⠼⠠⠔⠠⠽}$$

If the multiplication sign is not displayed, there will be a space between the multiplicative and multiplicand.

Examples:

$$\frac{4x}{6(1-x)}$$

$$\frac{5+x}{5x}$$

$$\frac{x^2 - 7x + 12}{4x - 20} : \frac{x^2 - 8x + 15}{4x - 16}$$

If the fractional equation contains fractions, a separator character  $\frac{\cdot}{\cdot}$  (6) must be placed between the fraction and the closing bracket. Otherwise, the parenthesis will be interpreted as a lowered number zero. (See chapter [Separator mark](#).)

$$\frac{\frac{1}{2} + \frac{1}{3}}{\frac{1}{4} - \frac{1}{5}}$$

$$2^3 \cdot 2^5 = 2^{(3+5)} = 2^8$$

$$2^3 + 2^4 = 8 + 16 = 24$$

$$2^{20} = 1\,048\,576$$

$$4^{\frac{1}{2}} = \sqrt{4} = 2$$

$$4^{-\frac{1}{2}} = \frac{1}{4^{\frac{1}{2}}} = \frac{1}{2}$$

$$2^{\frac{1}{2} + \frac{1}{3}}$$

$$10^{-3}$$

$$2^{\frac{1}{2} + \frac{1}{3}}$$

$$4^{\frac{1}{2}} = \sqrt{4} = 2$$

$$4^{-\frac{1}{2}} = \frac{1}{4^{\frac{1}{2}}} = \frac{1}{2}$$

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$$4^{\frac{1}{2}} = \sqrt{4} = 2$$

$$4^{-\frac{1}{2}} = \frac{1}{4^{\frac{1}{2}}} = \frac{1}{2}$$

$$2^{\frac{1}{2} + \frac{1}{3}}$$

$$10^{-3}$$

$$2^{\frac{1}{2} + \frac{1}{3}}$$

$$2^{\frac{1}{2} + \frac{1}{3}}$$

$$2^{\frac{1}{2} + \frac{1}{3}}$$

## Roots

In square roots the radicand follows immediately the radical sign.

When the root index is 2, it is usually left unwritten. When the index is written, it is separated from the radicand by a zone change sign formed by the 5 dot. The zone of the radical sign ends in a space, so roots with multiple terms must be enclosed in parentheses.

Examples:

$\sqrt{25}$  (square root 25)

$$\sqrt{9} + \sqrt{16} = 3 + 4 = 7$$

$\sqrt[3]{8}$  (third root, cubic root out of eight) (radical sign, number character, number [root], zone end, number character, number)

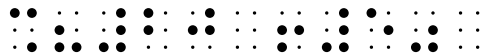
$$\sqrt[5]{32} + \sqrt[6]{1} = 2 + 1 = 3$$

$$27^{\frac{1}{3}} = \sqrt[3]{27} = 3$$

$$2\frac{1}{4} \cdot \sqrt[3]{8} = 2\frac{1}{4} \cdot 2 = 4\frac{1}{2}$$



$$\sqrt{20+5} = \sqrt{25} = 5$$



## Geometry

The following signs (in addition to the above) are used in geometry.

These signs are preceded by an empty space, but not after them:

~    ⠠⠠⠠⠠⠠⠠⠠⠠    (46 2356)    similar (comparable)

≅ or ≡    ⠠⠠⠠⠠⠠⠠⠠⠠    (56 2356)    congruent

On each side of these signs there is an empty space:

⊥    ⠠⠠⠠⠠⠠⠠⠠⠠    (3456 3)    orthogonal

∥    ⠠⠠⠠⠠⠠⠠⠠⠠    (456 456)    parallel

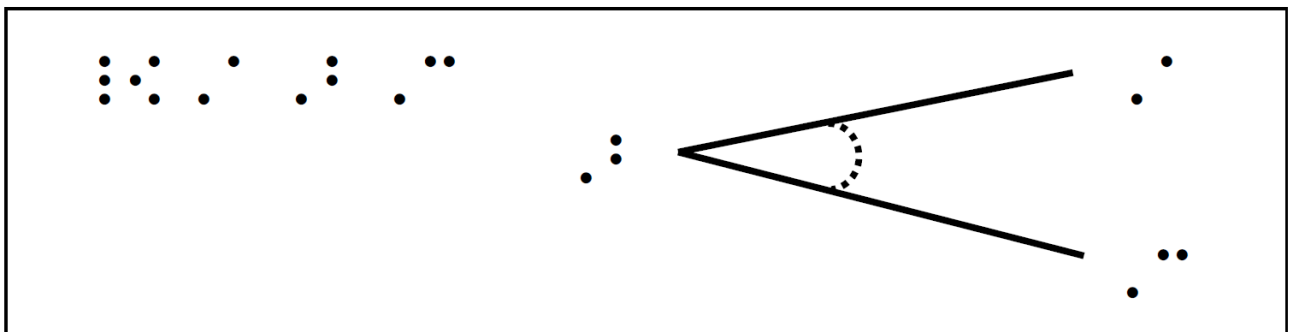
⋈    ⠠⠠⠠⠠⠠⠠⠠⠠    (5 456 456)    not parallel

The following characters are sometimes used instead of words. The angle sign is the most common of them. However, you shouldn't use them in braille text if the symbol appears only a few times in printed text. Then it is better to write the symbol in printed text as a word in braille.

|   |  |                |                |
|---|--|----------------|----------------|
| ∠ |  | (456 246)      | angle          |
| ⊟ |  | (1235 456 246) | straight angle |
| ◻ |  | (1246 12345)   | square         |
| ▭ |  | (1246 1235)    | rectangle      |
| ▭ |  | (1246 1234)    | parallelogram  |
| ⌒ |  | (1246 1)       | arc            |
| △ |  | (1246 145)     | triangle       |

Example:

∠ABC



# Trigonometry

Trigonometric functions:

|       |  |                             |           |
|-------|--|-----------------------------|-----------|
| sin   |  | (234 24 1345)               | sine      |
| cos   |  | (14 135 234)                | cosine    |
| tan   |  | (2345 1 1345)               | tangent   |
| cot   |  | (14 135 2345)               | cotangent |
| sec   |  | (234 15 14)                 | secant    |
| cosec |  | (14 135 234 15 14) cosecant |           |

Example:

$$\tan 90^\circ = \infty \text{ (tangent } 90^\circ \text{ equals infinity)}$$


Other signs necessary for trigonometry:

|     |                                                                                     |              |        |
|-----|-------------------------------------------------------------------------------------|--------------|--------|
| °   |  | (356)        | degree |
| '   |  | (46)         | minute |
| ''  |  | (456)        | second |
| rad |  | (1235 1 145) | radian |

These signs are used like units in general. There will be a space between them and the number before them. Instead of characters, the abbreviations min and s can also be used.

Example:

30° 45' 20" (30 degrees 45 minutes 20 seconds)#30>)



## High school math

## Mathematical hyphen, zone change sign

- (5) Mathematical hyphen, zone change sign (apostrophe ')

A mathematical hyphen is used when a mathematical expression needs to be split into lines somewhere other than the equal sign. (For examples, see [Long expressions](#).)

The zone change sign is needed, for example, to distinguish the root index from the radicand or a definite integral from the integrand or limit from the function. (For more examples, see [Roots](#) and [More characters and annotations](#).)

$$E(X) = \mu = \sum_i p_i x_i \text{ (in statistics, expected value definition) (zone sign used after the sigma subscripts)}$$

## Special language character

Foreign language letter rarely found in the text may be marked with a prefix (points 4 and 5) in the same way as in the rest of the text. However, in mathematical texts, each time it must be indicated in the editor's square brackets, which character is meant, e.g. [i hat] or [u hat].

$$\begin{array}{ccc} \cdot & \bullet & \cdot \\ \cdot & \bullet & \cdot \\ \cdot & \cdot & \bullet \end{array} \quad (45 \ 136) \quad \hat{u} \text{ (u hat)}$$

•  
•  
• (156) Š (In printed text, often sh or s.)

# Vectors

Vectors are marked with  $\vec{\cdot}$  (156). The character is written directly after the vector letter symbol. The same character is used at other times when printed text has a dash over the text, such as the average sign.

Examples:

$$\overline{a}$$

$$\overline{AB} = 3\bar{i} - 4\bar{j}$$

$$\vec{a} \parallel \vec{b} \text{ (parallel vectors } \vec{a} \text{ and } \vec{b}\text{)}$$

## Point product and cross product

•  (3) scalar product

×  (56 3) cross product (vector input)

As with other calculation marks, these are preceded by an empty space, but not after them.

Examples:

$$\overline{v} \cdot \overline{u}$$

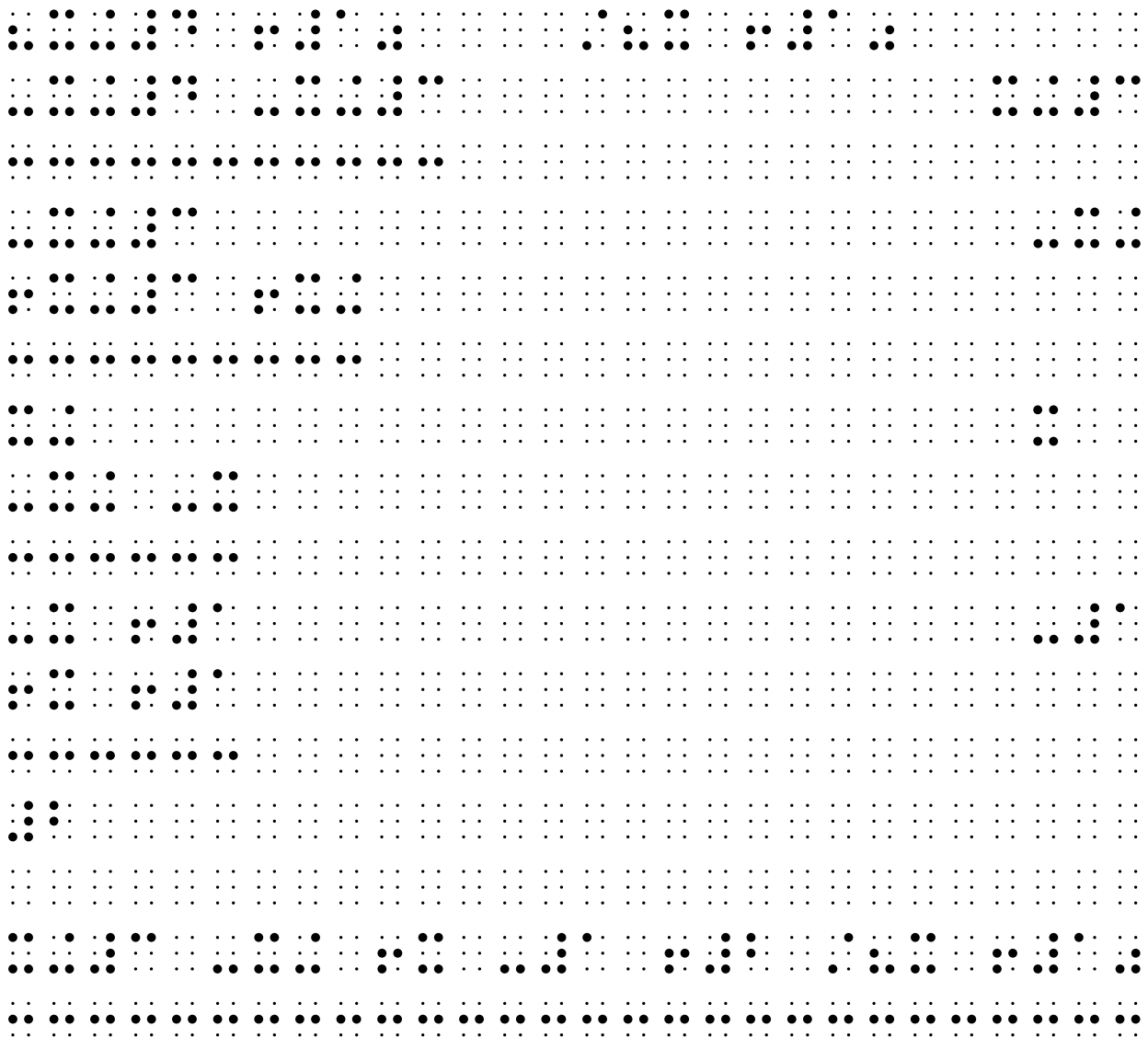
$$\overline{a} \times \overline{b}$$

$$\bar{a} \cdot \bar{b} = |\bar{a}| |\bar{b}| \cos(\bar{a}, \bar{b}), \text{ where } \bar{a}, \bar{b} \neq \bar{0}$$

$$\bar{a}_b = \frac{\bar{a} \cdot \bar{b}}{\bar{b} \cdot \bar{b}} \bar{b} \quad (\text{vector's } \bar{a} \text{ projection of vector on the vector } \bar{b})$$



$$(x^4 + 1) : (x + 1)$$



The division ended with a remainder.

# Systems of equations in printed braille

With systems of equations a blank line is left above and below in braille. The group of equations is indicated in curly brackets (see [Parenthesis](#)). Each equation is written on its own line. The first line of the system of equations is started from the left edge, the other lines are indented by two spaces.

$$\begin{cases} 2x + y = 0 \\ x - y = 5 \end{cases}$$

$$\begin{cases} 2x - 3y - 6 = 0 \quad | \cdot 2 \\ 6x + 12y - 12 = 0 \quad | : 2 \end{cases}$$

$$\begin{array}{rclcl} 4x & - & 6y & - & 12 & = & 0 \\ 3x & + & 6y & - & 6 & = & 0 \end{array}$$

$$\hline 7x \qquad \qquad - 18 = 0$$

$$x = = 18/7 = 2 \frac{4}{7}$$

## Set theory and logic

## Set theory

|       |  |
|-------|--|
| $\in$ |  |
|-------|--|

With the exception of the empty set sign and set curly brackets, a blank space is left in front of all of the above characters, but not after them.

Examples:

$x \in A$  ( $x$  is an element of the set  $A$ )

$3 \notin B$  (3 is not an element of B)



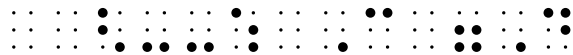
$B \subset A$  (B is a subset of A)



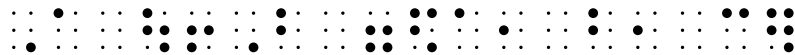
$F \not\subset E$  (F is not a subset of E)



$C \subseteq D$  and  $D \subseteq C \Leftrightarrow C = D$



$A \cup B = \{a, b, c\}$  (union of sets contains elements a, b and c)



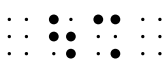
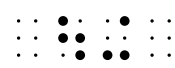
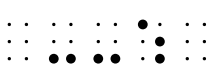
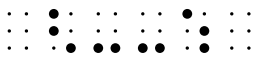
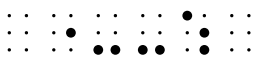
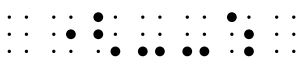
$G \cap H = \emptyset$  (intersection of sets G and H is an empty set i.e. they do not have any common elements)



$A \times B = \{(1, 3), (1, 4), (2, 3), (2, 4)\}$  (the cartesian product of sets A and B is a set whose elements are arranged pairs (1, 3), (1, 4), (2, 3) and (2, 4))

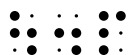


## Logic

|                   |                                                                                   |                   |                                          |
|-------------------|-----------------------------------------------------------------------------------|-------------------|------------------------------------------|
| $\neg$ or $\sim$  |  | (1256 256)        | negation, "no"                           |
| $\wedge$          |  | (1256 146)        | conjunction, "and"                       |
| $\vee$            |  | (1256 346)        | disjunction, "or"                        |
| $\Rightarrow$     |  | (36 36 156)       | implication, "if..., then..."            |
| $\Leftrightarrow$ |  | (126 36 36 156)   | equivalence, "if and only if..., then.." |
| $\nRightarrow$    |  | (5 36 36 156)     |                                          |
| $\Leftrightarrow$ |  | (5 126 36 36 156) |                                          |

The negation is preceded by a space, but not after. There will be a space on both sides of the conjunction, disjunction, implication and equivalence arrows.

$\neg p$  or  $\sim p$  (negation of p, not p)



$p \wedge q$  (p and q)



$p \vee q$  (p or q)

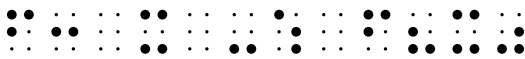


# Functions and descriptions

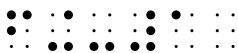
$f(x)$  is written together without spaces.

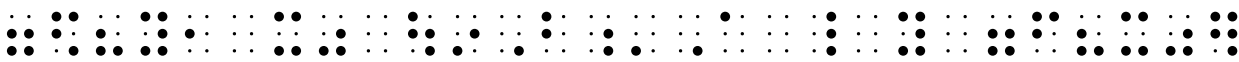
Examples:

$$f: x \rightarrow f(x)$$

A Braille representation of the function notation f: x -> f(x). The function symbol 'f' is in the first cell, followed by a colon, the variable 'x', a right arrow, and another 'f' followed by the variable 'x'.

$$f^{-1} = \{(y, x) \in B \times A | y = f(x)\}$$

A Braille representation of the inverse function symbol f^{-1}.

A Braille representation of the set definition part of the equation: {(y, x) in B x A | y = f(x)}.

$$f: x \rightarrow \begin{cases} -1, & x \leq -1 \\ x^2 + 2x, & -1 < x \leq 1 \\ -x + 3, & x > 1 \end{cases}$$

A Braille representation of the first case of the piecewise function: -1, x <= -1.

A Braille representation of the second case of the piecewise function: x^2 + 2x, -1 < x <= 1.

A Braille representation of the third case of the piecewise function: -x + 3, x > 1.

A Braille representation of the closing brace of the piecewise function.

# Matrices and determinants

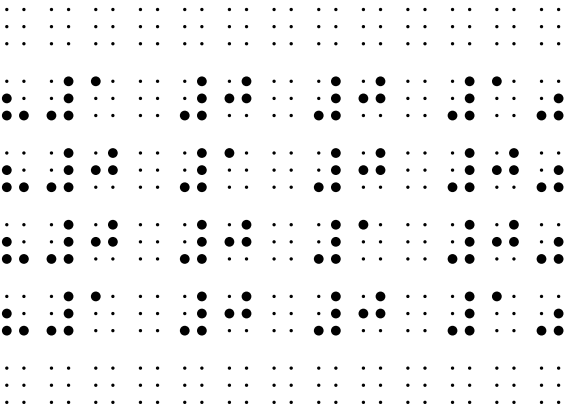
When writing matrices and determinants writing, their format is preserved, if at all possible. If the format needs to be changed due to lack of space, the changes will be explained.

**Matrices**

Parentheses indicating the edges of the matrix are placed at the beginning and end of each array row. Use regular parentheses. An empty row is left above and below the matrix.

Example:

$$\begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \end{pmatrix}$$

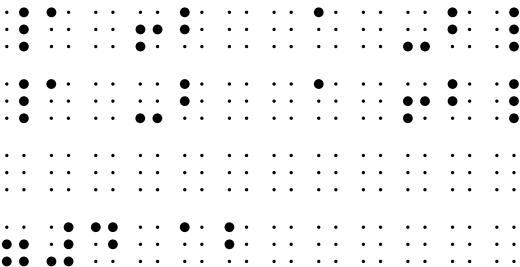


**Determinants**

The vertical lines indicating the edges of the determinant are marked at the beginning and end of each line. Above and below it, an empty line is left.

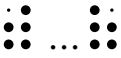
Example:

$$\begin{vmatrix} a + b & a - b \\ a - b & a + b \end{vmatrix} = 4ab$$



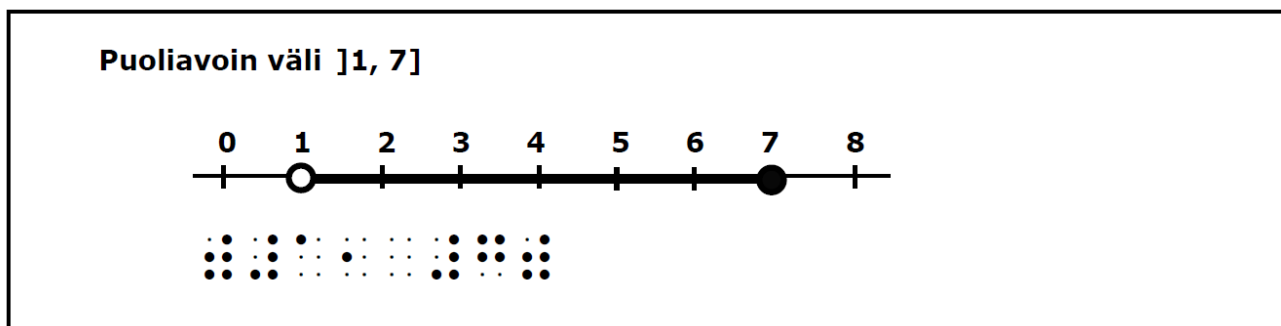
## Other characters used in mathematics

|              |  |               |                                     |
|--------------|--|---------------|-------------------------------------|
| $\equiv$     |  | (2356 2356)   | identical                           |
| $\triangleq$ |  | (25 25)       | estimates                           |
| $><$         |  | (156 126)     | larger or smaller than              |
| $>>$         |  | (156 156)     | a lot larger than                   |
| $<<$         |  | (126 126)     | a lot smaller than                  |
| $\nlessgtr$  |  | (5 156)       | not larger than                     |
| $\nlessgtr$  |  | (5 126)       | not less than                       |
| $\geq$       |  | (156 2356)    | greater or equal to                 |
| $\leq$       |  | (126 2356)    | less or equal to                    |
| $ \dots $    |  | (456 ... 456) | absolute value                      |
| ' and *      |  | (35)          | "comma" and "asterisk"              |
|              |  | (16)          | suffix the sign of the footnote     |
|              |  | (5)           | mathematic hyphen, zone change sign |
| $\infty$     |  | (123456)      | infinity                            |

|        |                                                                                   |                   |                                         |
|--------|-----------------------------------------------------------------------------------|-------------------|-----------------------------------------|
| [...]  |  | (12356 ... 23456) | closed interval                         |
| ]...[  |  | (23456 ... 12356) | open interval                           |
| [... [ |  | (12356 ... 12356) | semi-open interval (from the right), or |
| ]...]  |  | (23456 ... 23456) | semi-open interval (from the left)      |

Example:

Semi-open interval represented by a reading line and Braille



## Arrows

If the arrow's shaft is simple, it is denoted by a single hyphen (points 3 and 6). If the shafts are double, it is denoted by two consecutive hyphens. The tip or tips are marked in the same direction as in the print text.

|   |                                                                                     |              |                            |
|---|-------------------------------------------------------------------------------------|--------------|----------------------------|
| → |  | (36 156)     | Right arrow                |
| ← |  | (126 36)     | Left arrow                 |
| ↔ |  | (126 36 156) | double arrow               |
| ↗ |  | (35 156)     | Ascending arrow            |
| ↘ |  | (26 156)     | Descending arrow           |
| ⇒ |  | (36 36 156)  | double-shafted right arrow |

## Mathematical abbreviations

If different abbreviations are used as characters in the print edition (e.g. max, min, sup and inf), the corresponding abbreviations are used in braille.

|                                                               |                                                                                                                                                                                                        |                |                                        |
|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------------------------|
| log                                                           | $\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$                                                                                                 | (123 135 1245) | logarithm                              |
| lg                                                            | $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$                                                                                                                                 | (123 1245)     |                                        |
| ln                                                            | $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$                                                                                                                                 | (123 1345)     | natural logarithm, logarithm in base e |
| lim                                                           | $\begin{smallmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{smallmatrix}$                                                                                                                 | (123 24 134)   | limes i.e. limit                       |
| sinh $x$                                                      | $\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$                                                                 |                | (hyperbolic sine $x$ )                 |
| arc cos $x$                                                   | $\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$ |                | (arccosine $x$ )                       |
| $\overline{\text{arcSin}}\ x$                                 | $\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$ |                | (main branch of Arcus Sin $X$ )        |
| (The horizontal line above the text is followed by dots 156.) |                                                                                                                                                                                                        |                |                                        |
| ar sinh $x$                                                   | $\begin{smallmatrix} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{smallmatrix}$ |                | (area function)                        |

## More characters and annotations

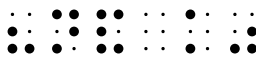
|          |                                                                                        |            |                                                                |
|----------|----------------------------------------------------------------------------------------|------------|----------------------------------------------------------------|
| $\int$   | $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$                 | (2346)     | integral                                                       |
| /        | $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$                 | (456)      | integral after the integrand function, but before substituting |
| $\Sigma$ | $\begin{smallmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{smallmatrix}$ | (456 234)  | sum, sigma                                                     |
| $\Pi$    | $\begin{smallmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{smallmatrix}$ | (456 1234) | product                                                        |
|          | $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$                 | (26)       | lower limit (used in integral, sum, product)                   |
|          | $\begin{smallmatrix} \cdot & \cdot \\ \cdot & \cdot \end{smallmatrix}$                 | (35)       | upper limit (used in integral, sum, product)                   |

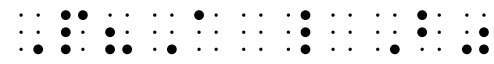
$\forall$         (1256 2)    "for every"

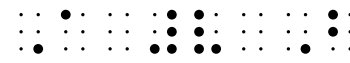
$\exists$         (1256 26)    "exists"

$\nexists$         (1256 5 26)    "does not exist"

$!$         (6 256)    factorial

$\binom{n}{k}$         (236 1345 12346 [space] 13 356)    (n over k)

$P(A | B)$         (6 1234 236 6 1 [space] 456 [space] 6 12 356)  
(Conditional probability of A when B)

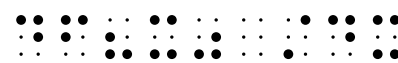
$A \perp B$         (6 1 [space] 3456 1236 [space] 6 12)  
(A and B are independent of each other)

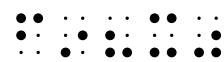
$\bar{x}$         (1346 156)    average

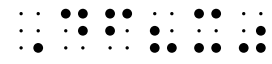
$\underline{s}$         (234 36)    random variable

$E\underline{x}$         (6 15 1346 36)    Expected value of  $\underline{x}$

$C_k^n$         (6 14 16 13 346 1345)

$\frac{df(x)}{dx}$         (145 124 236 1346 356 [space] 34 145 1346)

$f'(x)$         (124 35 236 1346 356)

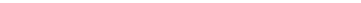
$Df(x)$         (6 145 124 236 1346 356)    (derivative of f(x))

$$f''(x) \quad \begin{array}{cccccc} \bullet & \bullet & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \bullet & \bullet & \bullet & \bullet \end{array} \quad (124 \ 35 \ 35 \ 236 \ 1346 \ 356)$$

$$Df'(x) \quad \begin{array}{ccccccc} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{array} \quad (6 \ 145 \ 124 \ 35 \ 236 \ 1346 \ 356)$$

$$D^{(2)}f(x) \quad \begin{array}{cccccccccccccccc} \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{array}$$

(6 145 346 236 3456 12 356 [space] 124 236 1346 356)

$D^2f(x)$           (6 156 346 [space] 124 236 1346 356)  
 (f(x)'s second derivative)

$$D^{(n)}f(x) \quad \begin{array}{cccccccccccccccc} \cdot & \cdot & & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{array}$$

(6 145 346 236 1345 356 [space] 124 236 1346 356)

$$D^n f(x) \quad \begin{array}{cccccccc} \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \quad (6 \ 145 \ 346 \ 1345 \ [\text{space}] \ 124 \ 236 \ 1346 \ 356)$$

$$\overline{A} \quad \begin{array}{ccc} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{array} \quad (6 \ 1 \ 156) \quad (\text{closure of } A)$$

$$\overline{z} \quad \begin{array}{cc} \bullet & \bullet \\ \bullet & \bullet \\ \bullet & \bullet \end{array} \quad (1356 \ 156) \quad (\text{complex number } z, \text{ complex conjugate})$$

□ or m.o.t.  (134 135 2345) (which was to be proven, QED)

$$\dot{x} = \frac{dx}{dt} \quad \begin{array}{cccccccccccccccc} \bullet & \bullet & \cdot & \cdot & \cdot & \cdot & \bullet & \bullet & \cdot & \cdot & \cdot & \cdot & \bullet & \bullet & \cdot \\ \bullet & \bullet & \cdot & \cdot & \cdot & \cdot & \bullet & \bullet & \cdot & \cdot & \cdot & \cdot & \bullet & \bullet & \cdot \end{array} \quad (1346 \ 3 \text{ [space]} \ 2356 \ 145 \ 1346 \text{ [space]} \ 34 \ 145 \ 2345)$$

$\nabla f$ 

(456 256 124) (gradient)

$$f|_B \quad \begin{array}{ccccc} \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \quad (124 \ 456 \ 16 \ 6 \ 12) \quad (\text{restriction of } f \text{ to } B)$$

Examples:

$\lg 10 a = \lg a + \lg 10$  (space between the logarithm and argument of logarithm)

$\log_e x = \ln x$  (base number is treated a subscript without space next to the logarithm, zone end sign, argument)

$$\lim_{x \rightarrow 0^+} f(x) \text{ (lim with subscript, paren, space before and after arrow sign, paren, zone end, f(x))}$$
$$\lim_{x \rightarrow 1} \frac{x^4 - x}{x^4 - 1} \text{ (brackets used for extra clarity, not necessary)}$$

Figure 1 shows a 2D grid of 10x10 points. The training set is represented by black dots. The dots are arranged in a pattern that is mostly uniform but has some missing points, particularly in the lower right quadrant.

 $\int x^2 dx$  (no space after integral sign, space after superscript)
$$\int (e^x + x) dx$$
[illegible]
$$\int_{\pi}^{2\pi} \tan^2 x \, dx \text{ (zone end after } 2\pi, \text{ no space before tan)}$$

$$\int_0^4 \sqrt{x} dx = \left[ \frac{2}{3} x\sqrt{x} \right]_0^4 \quad (\text{no space after substitution sign})$$



$$\sum_{i=0}^n f_i x_i \quad (\text{sum of } f_i x_i \text{ when } i \text{ goes from zero to } n)$$



$$\prod_{i=0}^r p_i \quad (\text{product of } p_i \text{ when } i \text{ goes from zero to } r)$$



$$\bigcap_{n=1}^{\infty} A_n \quad (\text{intersection of set } A_n, \text{ when } n \text{ goes from one to infinity})$$



$$\bigcup_{i=1}^n A_i \quad (\text{union of sets } A_i \text{ when } i \text{ goes from one to } n)$$



$$(x_n)_{n=1}^{\infty} \quad (\text{sequence } x_n \text{ when } n \text{ goes from } i \text{ to infinity}) \quad (\text{no spaces})$$



$$\forall x \in R, \exists y \in R; y > x$$

(for every real number x there exists a real number y such that y is greater than x)



$$\sqrt[3]{x+5} \text{ (cubic root of the sum } x+5\text{)}$$



$$4!=4*3*2*1=24 \text{ (Factorial of number four)}$$



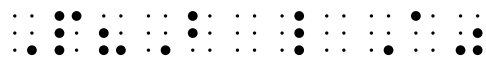
$$n! \text{ (n factorial)}$$



$$\binom{6}{4} = \frac{6!}{4!(6-4)!}$$



$$P(B|A) = \frac{P(AB)}{P(A)}$$



$$\frac{d \ln x}{dx} \text{ or } \frac{d}{dx} \ln x \text{ (derivative of } \ln x\text{)}$$

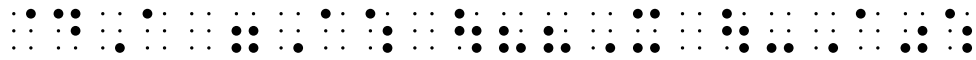


or



$$\partial A = \overline{A} \cap \overline{(X - A)}$$

(Edge of  $X$  subset  $A$  is the inclusions of  $A$  and the complement inclusions of  $A$  intersection)



$p \sim N(58, 2)$  ( $p$  follows normal distribution with parameters 58 and 2)



## “Key symbols”

In front of some signs there is a so called key symbols, which part of mathematics the character belongs to. Such key signs in

set theory     (1256)

in geometry  $\begin{smallmatrix} \bullet & \bullet \\ \vdots & \\ \bullet & \bullet \end{smallmatrix}$  (1246) and  $\begin{smallmatrix} \bullet & \bullet \\ \vdots & \\ \bullet & \bullet \end{smallmatrix}$  (456)

The 5 dot might also be considered a keys symbol of sorts. It negates the next character, eg. "equal to" and "is not equal to" signs.

# Formulas

Volume of a sphere:  $V = \frac{4}{3}\pi r^3$



Area of a sphere:  $A = 4\pi r^2$



The volume of a straight circle-bottom cone:  $V = \frac{1}{3}\pi r^2 h$



Area of the whole circle cone:  $A = \pi r^2 + \pi r \sqrt{r^2 + h^2}$



The formula for solving the equation of the second order:  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$



## Physics notations

Formulas in physics are written according to braille in mathematics. When marking units, printed text is accepted. For example, m/s can be written without a space, even if the operational signs are otherwise always preceded by a blank space. If the zone of the division sign include a space, parentheses must be added to the braille notation. In braille, the division zone ends with a space.

In electrical work, wiring diagrams are written in braille using vertical and horizontal lines, as well as the hallmarks of electrical appliances. Vertical lines are made with points 1, 2 and 3 and horizontal lines with points 1 and 4.

Electrical equipment IDs always included character ⠂ (123456).

Whenever the direction of the current is marked in some way in printed drawings, it is also marked on braille charts, for example, with plus and minus signs.

## Symbols and units of electrical quantities

See also [Greek alphabet](#).

electric current,  $[I] = \text{A}$  (ampere)

(12356 6 24 23456 [space] 2356 6 1)

U voltage,  $[U] = V$  (volt)

E source voltage, electromotive force, electric field strength

V potential,  $[V] = [U] = \text{volt}$

Q electric charge,  $[Q] = C$  (coulomb)

e Elementary charge

C capacitance, [C] = F (farad)

E energy, [E] = J (joule)

R resistance,  $[R] = \Omega$  (ohm)

$\rho$  (roo) resistivity,  $[\rho] = \Omega\text{m}$

E electrical energy, [E] = J (joule)

p electric power, [p] = W (watt)

$\Phi$  magnetic flux, [ $\Phi$ ] = Wb (weber)

B magnetic flux density, [B] = T (tesla)

$\mu_0$  (myu zero) vacuum's permeability

H magnetic field strength, [H] = A/m

L inductance, [L] = H (henry)

F oscillation circuit frequency, [f] = Hz (hertz)

Z impedance, [Z] =  $\Omega$  (ohm)

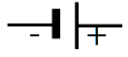
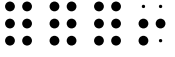
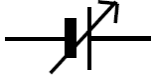
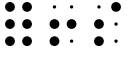
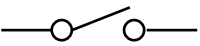
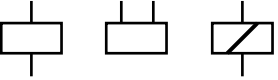
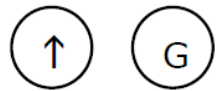
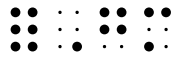
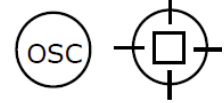
$\varphi$  phase difference

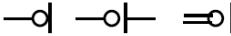
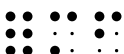
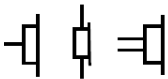
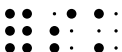
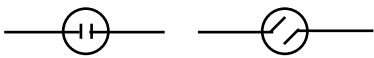
## Common characters

These common characters can be attributed to many other signs:

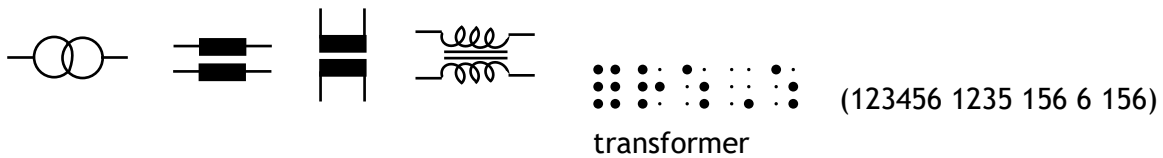
|                                                                                     |                                                                                     |               |                                                           |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------|-----------------------------------------------------------|
|                                                                                     |  | (134)         | at the end of the character (this characters means) meter |
|  |  | (124)         | Foto (light sensitive)                                    |
|  |  | (1346)        | illuminative                                              |
|  |  | (234)         | adjustable (at the end of the mark)                       |
|  |  | (234 15 2345) | "settable"                                                |
|  |  | (123 234)     | slider                                                    |
|  |  | (235)         | to the side of the arrow = p-emitter in the n-region      |
|  |  | (36)          | to the side of the arrow = n-emitter in the p-region      |

## Device IDs and other markings

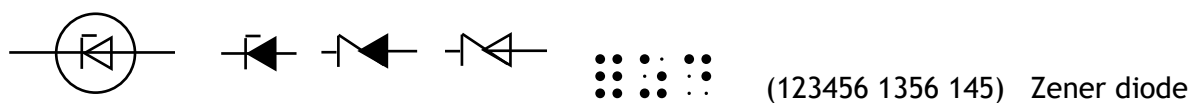
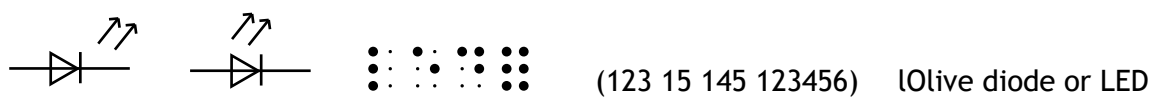
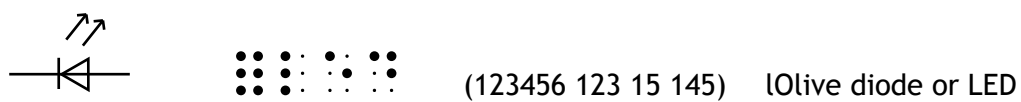
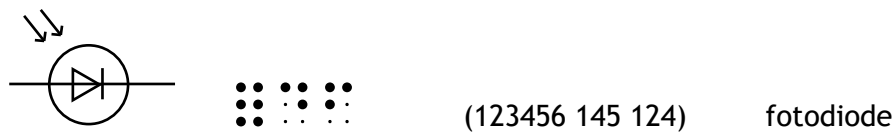
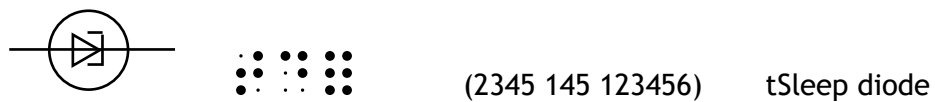
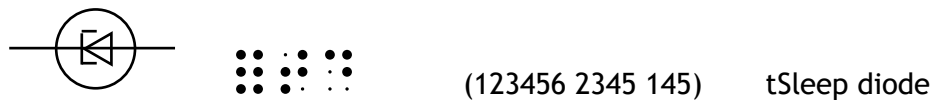
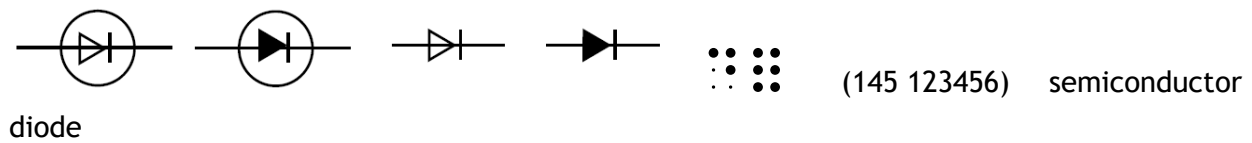
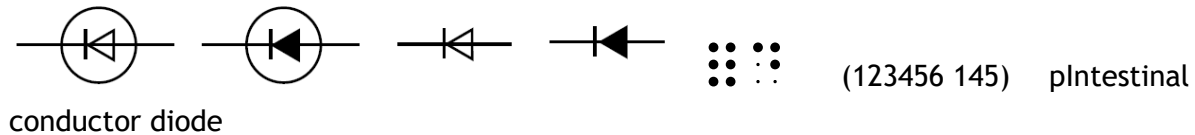
|                                                                                     |                                                                                     |                            |                                          |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------|------------------------------------------|
| — or =                                                                              |    | (123456 2345)              | Direct current (DC)                      |
|    |    | (123456 1236)              | Alternating current (AC)                 |
|    |    | (235 123456)               | Electric pair or battery or power source |
|    |    | (123456 123456 123456 235) | electric battery                         |
|    |    | (123456 235 234)           | battery with adjustable voltage          |
|    |    | (123456 34)                | switch                                   |
|    |    | (123456 134)               | ground (usually)                         |
|   |   | (123456 134 1235)          | attached to frame or rack                |
|  |  | (123456 1235 15 123)       | relay                                    |
|  |  | (123456 6 1236 134)        | voltage meter                            |
|  |  | (123456 6 1 134)           | ampere meters                            |
|  |  | (123456 46 134 6 1236 134) | microvolt meter                          |
|  |  | (123456 134 6 1 134)       | milliamper meter                         |
|  |  | (123456 6 1245 134)        | galvanometer                             |
|  |  | (123456 135 234 14)        | oscilloscope                             |

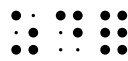
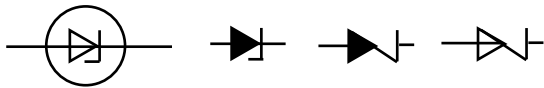
|                                                                                     |                                                                                     |                         |                                  |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------|----------------------------------|
|    |    | (123456 6 1245)         | generator (usually)              |
|    |    | (123456 6 1245 1236)    | alternator                       |
|    |    | (123456 6 1245 3456 14) | three-phase generator            |
|    |    | (123456 1 1345 2345)    | antenna                          |
|    |    | (123456 134 124)        | microphone                       |
|    |    | (123456 13 2345 1345)   | speaker                          |
|   |  | (123456 13 123 13)      | earphone                         |
|  |  | (123456 234 13)         | bell                             |
|  |  | (123456 234 134 1235)   | “door bell”, intercom            |
|  |  | (123456 1346)           | signal lamp                      |
|  |  | (123456 1245)           | Glow indicator lamp, glim        |
|  |  | (123456 13)             | capacitor                        |
|  |  | (123456 15 123 13)      | electrolytic capacitor           |
|  |  | (235 123456 15 123 13)  | polarized electrolytic capacitor |

|  |  |                           |                                                                 |                        |
|--|--|---------------------------|-----------------------------------------------------------------|------------------------|
|  |  | (123456 13 234)           | Auxiliary capacitor                                             |                        |
|  |  | (123456 1234 123 13)      | bottle capacitor                                                |                        |
|  |  |                           |                                                                 | (123456 1235) resistor |
|  |  | (123456 1235 234 15 2345) | mountable resistor                                              |                        |
|  |  | (123456 1235 234)         | variable resistor                                               |                        |
|  |  | (123456 1235 123 234)     | adjustment resistor, slide adjustment                           |                        |
|  |  |                           | (123456 123 145 1235) fotoresistance, light resistance (LDR)    |                        |
|  |  | (123456 1235 1346)        | Light resistance                                                |                        |
|  |  | (123456 1235 25)          | varoke or fuse                                                  |                        |
|  |  | (123456 1235 234 1234)    | voltage divider, or control potentiometer                       |                        |
|  |  | (123456 1235 123)         | Inductive reactance                                             |                        |
|  |  | (123456 1235 14)          | Capacitive reactance                                            |                        |
|  |  | (123456 1235 1356)        | Apparent resistance 'impedance'                                 |                        |
|  |  | (123456 1235 2345 36)     | thermistor (NTC resistor)<br>negat. temperature coefficient -t° |                        |
|  |  | (123456 1235 2345 235)    | thermistor (PTC resistor)<br>Posit. temperature coefficient +t° |                        |
|  |  |                           | (123456 1235 156 156) klive, coil                               |                        |
|  |  | (123456 1235 156 156 25)  | coil with iron core                                             |                        |

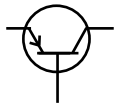


On diodes and triodes, a 6-point mark on the side of the cross line!

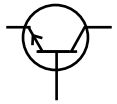




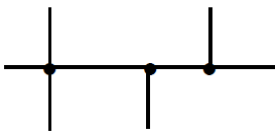
(1356 145 123456) Zener diode



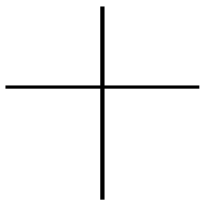
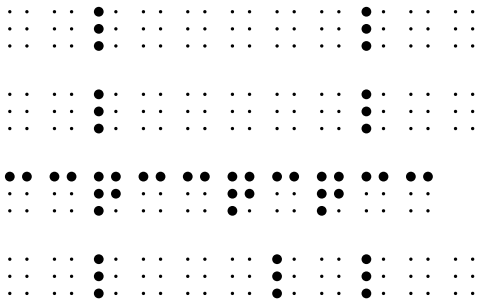
(123456 235 1234 1345 1234) PNP transistor



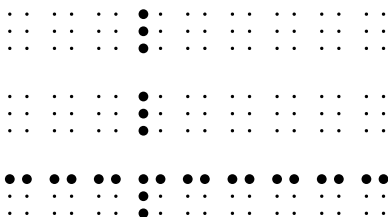
(123456 36 1345 1234 1345) PN transistor



wire branching

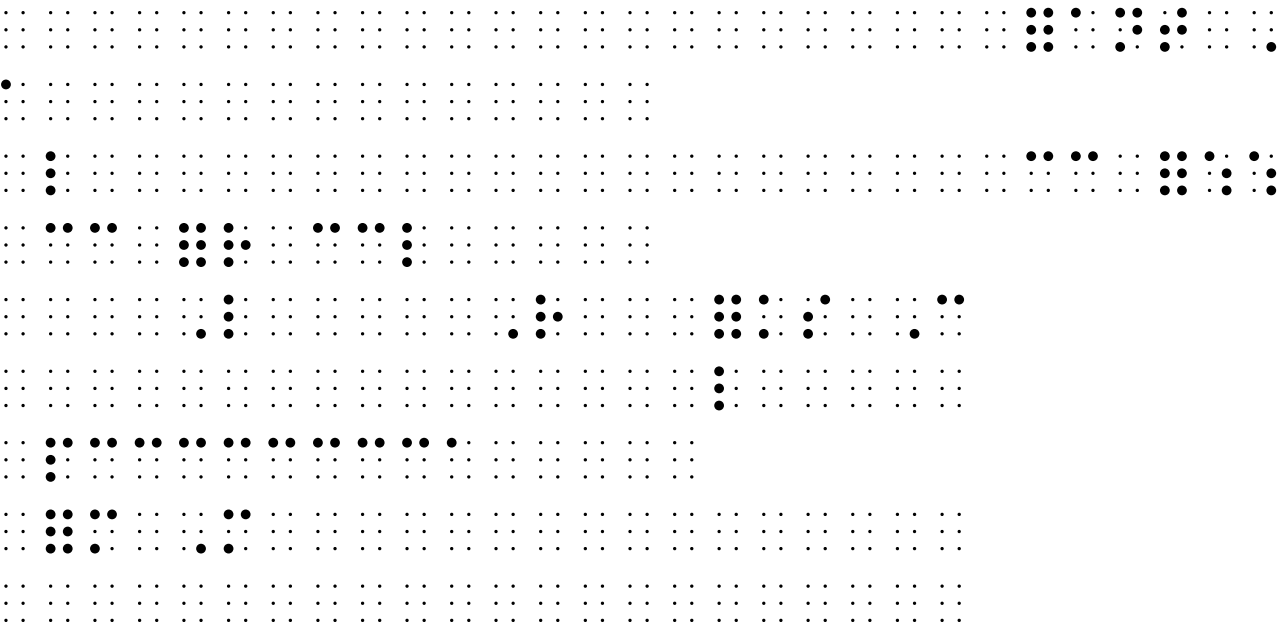
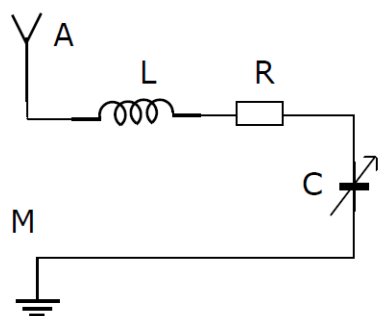


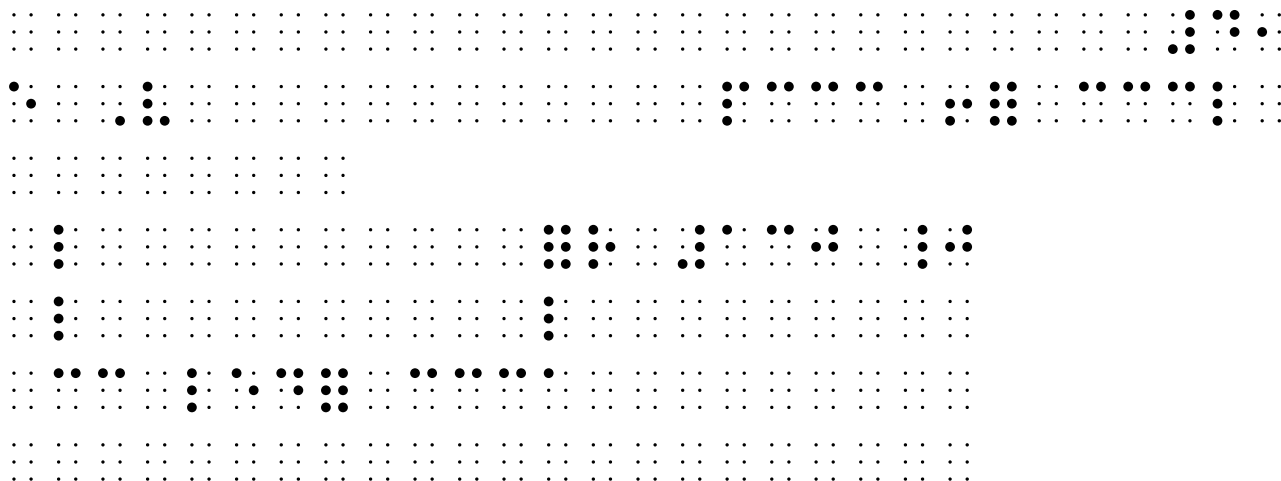
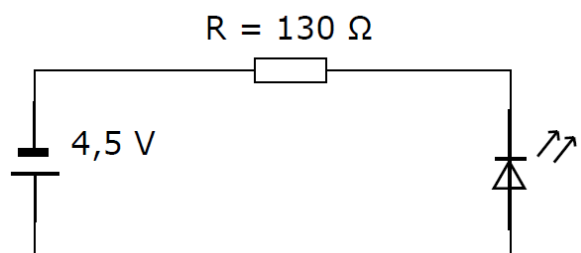
wire cruise, no connection

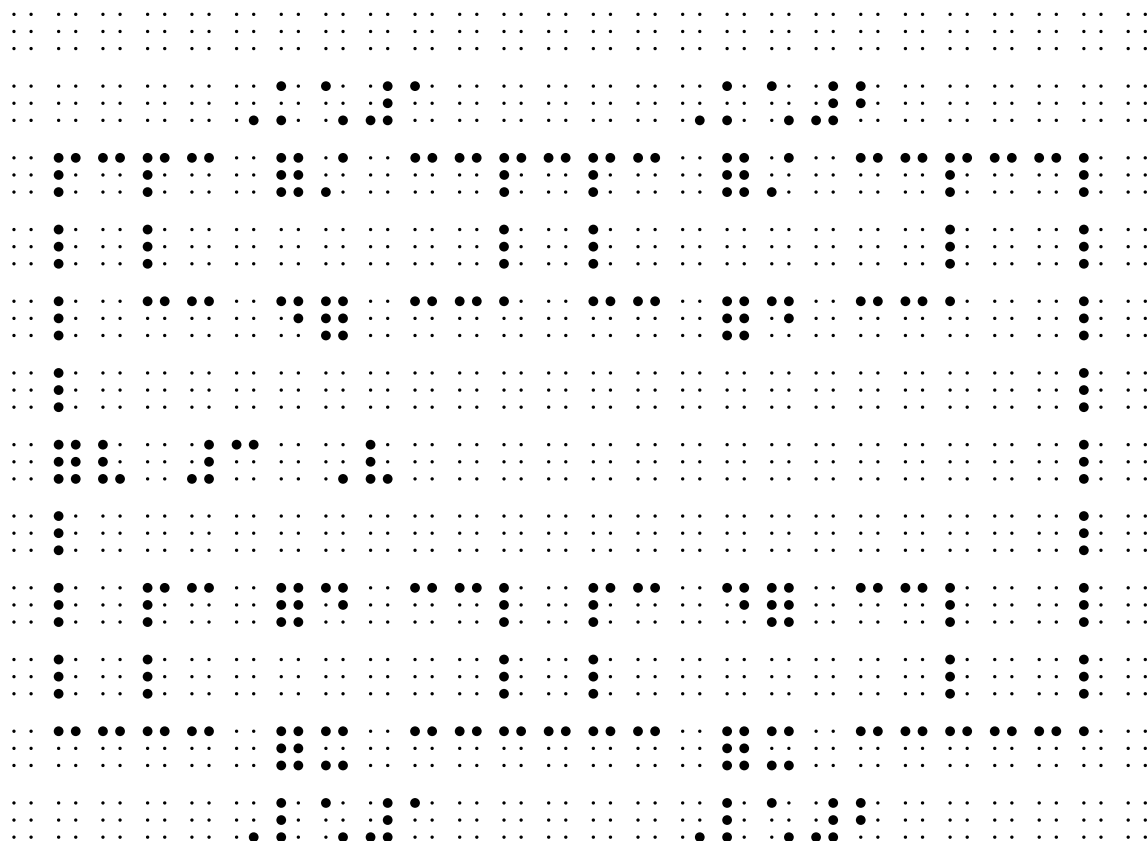
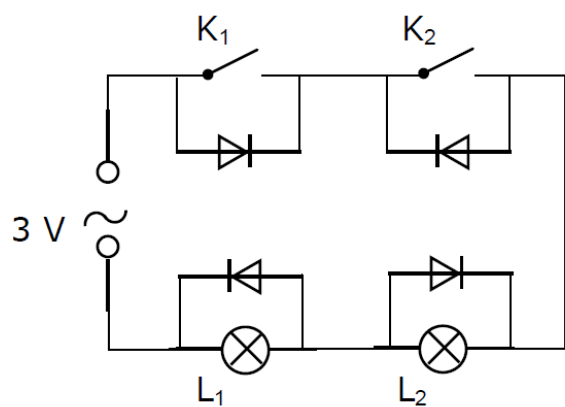




Examples







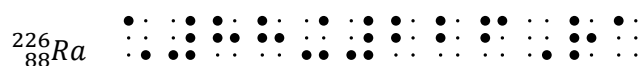
# Chemistry labeling

## Chemical signs and structural formulas of elements

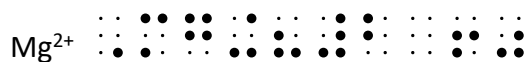
Chemical signs of elements written as in printed text: uppercase letters as uppercase and lowercase as lowercase.



The atomic number is written first as a subscript and the mass number is written as a superscript (raised to power). No spaces.



The charge of an ion is written as a superscript after the element. Parentheses are used when necessary.



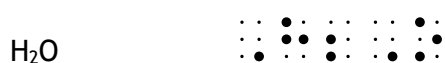
## Abbreviated structural formulas of chemical compounds

In chemical formulas, subscript numbers indicating the number of atoms are denoted with lowered numbers without a numerical character.

In chemical formulas, the characters of elements (letters) are not separated by a space. Also, there will be no space between the coefficient and the character of the element (letter).

Atomic groups are written in parentheses consisting of dots 1, 2 and 6 (opening parentheses) and dots 3, 4 and 5 (closing parenthesis).

Examples:

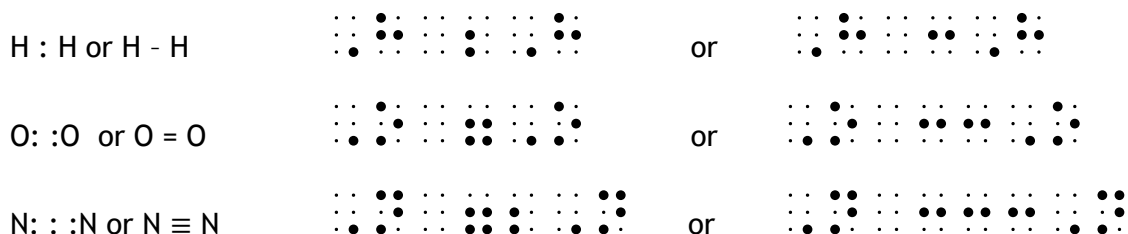


1,2-diethyl-1-propanol





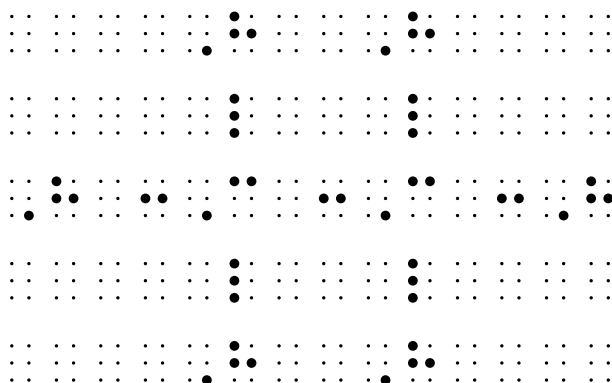
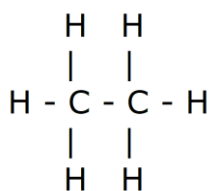
In abbreviated structural formulas bond lines or colons are converted to corresponding Braille. Space preceding the character, but not after the character (compare to operational characters).

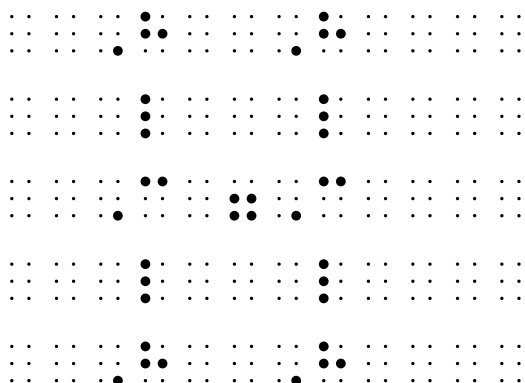


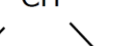
## Complete structural formulas of chemical compounds

Bond lines in complete structural formulas The aim is to mark horizontally or vertically, in which case formulas can be represented in Braille. Design formulas where not all lines can be converted to vertical and horizontal lines shall be embossed.

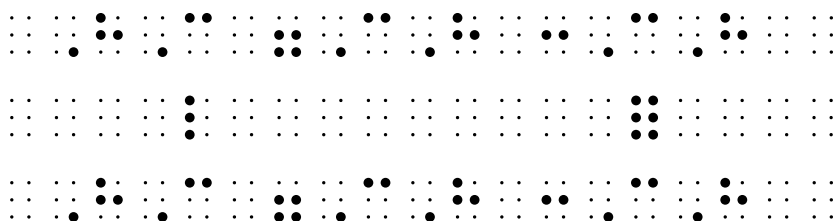
Ethane (saturated hydrocarbon)



$$\begin{array}{c} \text{H} & \text{H} \\ | & | \\ \text{C} = & \text{C} \\ | & | \\ \text{H} & \text{H} \end{array} \quad \text{tai} \quad \begin{array}{c} \text{H} & \text{H} \\ \backslash & / \\ \text{C} = & \text{C} \\ / & \backslash \\ \text{H} & \text{H} \end{array}$$


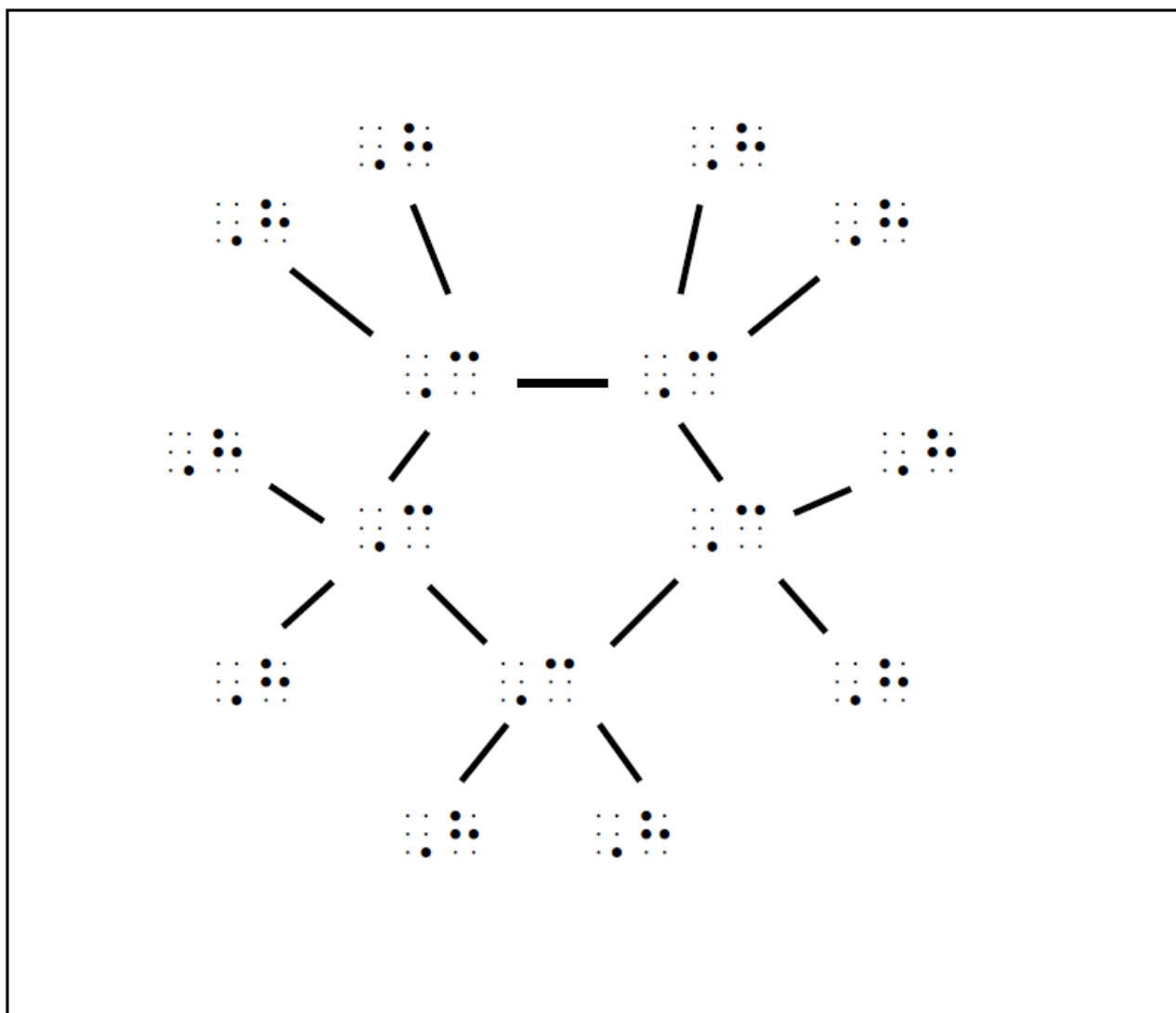
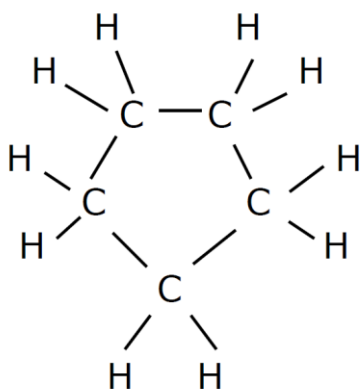






The figure consists of two 10x10 grids of dots. In the top grid, there are 10 black dots located at the following (row, column) coordinates: (1,4), (1,5), (1,6), (1,7), (1,8), (1,9), (1,10), (2,4), (2,5), (2,6), (2,7), (2,8), (2,9), (2,10), (3,4), (3,5), (3,6), (3,7), (3,8), (3,9), (3,10), (4,4), (4,5), (4,6), (4,7), (4,8), (4,9), (4,10), (5,4), (5,5), (5,6), (5,7), (5,8), (5,9), (5,10), (6,4), (6,5), (6,6), (6,7), (6,8), (6,9), (6,10), (7,4), (7,5), (7,6), (7,7), (7,8), (7,9), (7,10), (8,4), (8,5), (8,6), (8,7), (8,8), (8,9), (8,10), (9,4), (9,5), (9,6), (9,7), (9,8), (9,9), (9,10), (10,4), (10,5), (10,6), (10,7), (10,8), (10,9), (10,10). In the bottom grid, there are 10 black dots located at the following (row, column) coordinates: (1,4), (1,5), (1,6), (1,7), (1,8), (1,9), (1,10), (2,4), (2,5), (2,6), (2,7), (2,8), (2,9), (2,10), (3,4), (3,5), (3,6), (3,7), (3,8), (3,9), (3,10), (4,4), (4,5), (4,6), (4,7), (4,8), (4,9), (4,10), (5,4), (5,5), (5,6), (5,7), (5,8), (5,9), (5,10), (6,4), (6,5), (6,6), (6,7), (6,8), (6,9), (6,10), (7,4), (7,5), (7,6), (7,7), (7,8), (7,9), (7,10), (8,4), (8,5), (8,6), (8,7), (8,8), (8,9), (8,10), (9,4), (9,5), (9,6), (9,7), (9,8), (9,9), (9,10), (10,4), (10,5), (10,6), (10,7), (10,8), (10,9), (10,10).

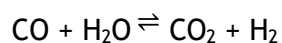
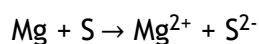
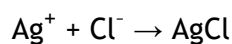
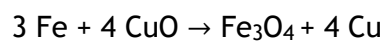
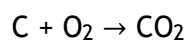
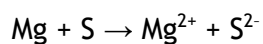
It is necessary to make a relief from cyclopentane.



## Chemical equations

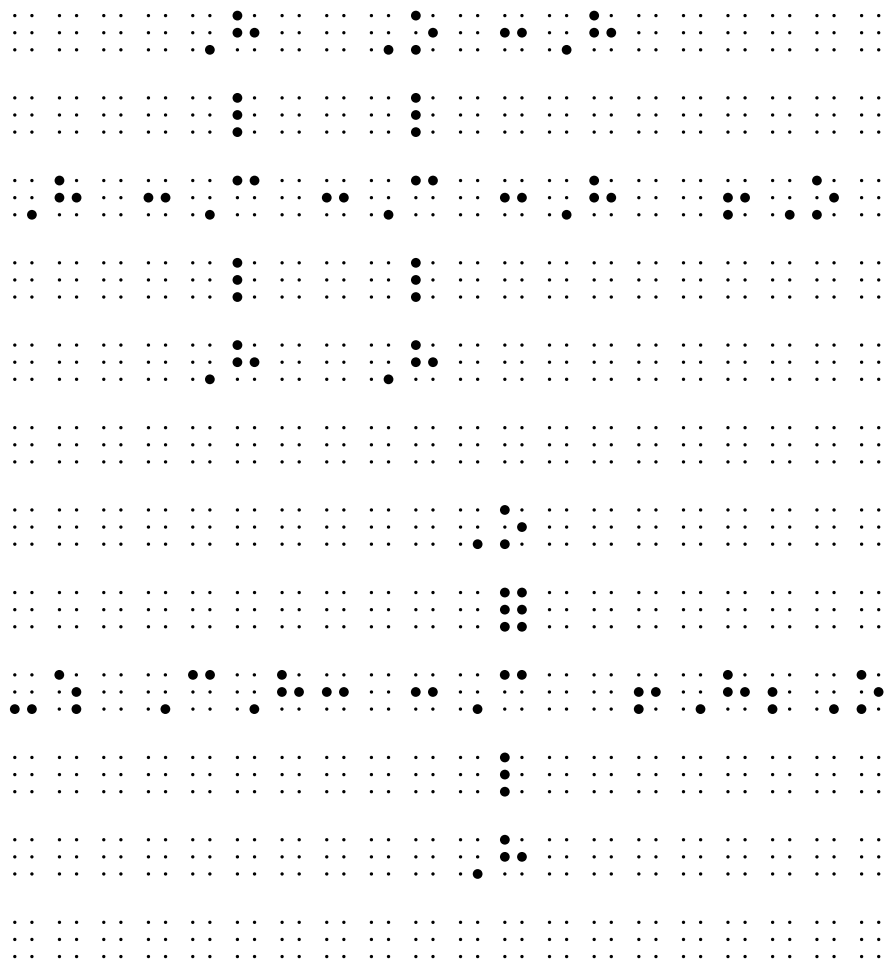
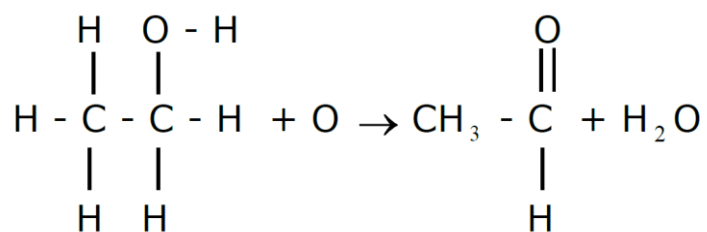
Chemical equations are divided into different rows, preferably at the arrow. Then there is no need to use a mathematical hyphen.

Examples:





ethanol + oxygen → acetaldehyde + water



# Information technology notations

In computer programs and e.g. notation used in web addresses:

|    |                                                                                     |         |                  |
|----|-------------------------------------------------------------------------------------|---------|------------------|
| _  |    | (346)   | underscore       |
| !  |    | (256)   | exclamation mark |
| /  |    | (34)    | slash            |
| \  |    | (146)   | backslash        |
|    |    | (456)   | vertical line    |
| &  |    | (12346) | ampersand        |
| \$ |   | (2346)  | dollar sign      |
| ~  |  | (45)    | tilde            |
| @  |  | (4)     | at sign          |
| .  |  | (3)     | point            |

Six dot numbers used only in computer programs.

|   |                                                                                     |          |   |                                                                                     |         |
|---|-------------------------------------------------------------------------------------|----------|---|-------------------------------------------------------------------------------------|---------|
| 0 |  | (123456) | 5 |  | (156)   |
| 1 |  | (16)     | 6 |  | (1246)  |
| 2 |  | (126)    | 7 |  | (12456) |
| 3 |  | (146)    | 8 |  | (1256)  |
| 4 |  | (1456)   | 9 |  | (246)   |

# Greek alphabet

In the Greek alphabet, the capital letter is denoted by the dots 456, and the lowercase letter by the dots 46.

|   |                                                                                                |   |                                                                                               |         |
|---|------------------------------------------------------------------------------------------------|---|-----------------------------------------------------------------------------------------------|---------|
| Α |  (456 1)      | α |  (46 1)      | alpha   |
| Β |  (456 12)     | β |  (46 12)     | beta    |
| Γ |  (456 1245)   | γ |  (46 1245)   | gamma   |
| Δ |  (456 145)    | δ |  (46 145)    | delta   |
| Ε |  (456 15)     | ε |  (46 15)     | epsilon |
| Ζ |  (456 1356)   | ζ |  (46 1356)   | Dzeeta  |
| Η |  (456 345)  | η |  (46 345)  | eta     |
| Θ |  (456 1456) | θ |  (46 1456) | theta   |
| Ι |  (456 24)   | ι |  (46 24)   | iota    |
| Κ |  (456 13)   | κ |  (46 13)   | kappa   |
| Λ |  (456 123)  | λ |  (46 123)  | lambda  |
| Μ |  (456 134)  | μ |  (46 134)  | mu      |
| Ν |  (456 1345) | ν |  (46 1345) | nu      |
| Ξ |  (456 1346) | ξ |  (46 1346) | xi      |
| Ο |  (456 135)  | ο |  (46 135)  | omicron |
| Π |  (456 1234) | π |  (46 1234) | pi      |

|   |                                                                                   |             |   |                                                                                   |            |         |
|---|-----------------------------------------------------------------------------------|-------------|---|-----------------------------------------------------------------------------------|------------|---------|
| P |  | (456 1235)  | ρ |  | (46 1235)  | Roo     |
| Σ |  | (456 234)   | σ |  | (46 234)   | sigma   |
| T |  | (456 2345)  | τ |  | (46 2345)  | tau     |
| Υ |  | (456 13456) | υ |  | (46 13456) | upsilon |
| Φ |  | (456 124)   | φ |  | (46 124)   | phi     |
| X |  | (456 125)   | χ |  | (46 125)   | chi     |
| Ψ |  | (456 12346) | ψ |  | (46 12346) | psi     |
| Ω |  | (456 245)   | ω |  | (46 245)   | omega   |

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