2. Vector

A vector (or one-dimensional array) v is a collection of values (or elements) of the same type, each identified by an index in the range 1 to length(v). Combine values into a vector with c(...). e.g.

\[ v \leftarrow c(2.71, 5, 3.14) \]
\[ \text{length}(v) \]
\[ v \]

<table>
<thead>
<tr>
<th>index</th>
<th>value</th>
<th>index</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.71</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>2</td>
<td>&quot;ant&quot;</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>3</td>
<td>&quot;chainsaw&quot;</td>
</tr>
</tbody>
</table>

Basic Vector Types, and Specifying Constants of These Types

- **numeric** (real number): digits with optional decimal point, with optional suffix of E or e for exponent digits (scientific notation); e.g. 3.14e2 is ___________

- **character** (which should have been called character string): a string (or word) in double or single quotes, "..." or '...'. (Escape sequences include \" (double quote), \' (single quote), \n (newline), \t (tab), and \ (backslash).)

\[ \text{paste}(..., \text{sep} = \" \"") \text{ makes a string from its arguments, separated by sep. e.g.} \]

\[ \text{oak} \leftarrow 70 \]
\[ \text{text} = \text{paste}(\text{sep}="\", \"Tree names include \"oak.\"\"\n\text{nOak weighs }, \text{oak}, \" \text{lbs/ft}^{-3}.\n") \]
\[ \text{cat}(..., \text{sep} = \" \") \text{ pastes and writes to console, interpreting escape sequences. e.g.} \]
\[ \text{cat(text)} \]
\[ \text{cat(sep = \"\", \"oak=\", \text{oak}, \"\n\") # display variable with helpful label} \]

- **logical**: TRUE and FALSE (which become 1 and 0 when used in arithmetic)
  - any(v) is TRUE if any of the values in v is TRUE; all(v) is TRUE if all are
  - e.g. \[ v > 3, \text{words == "ant"}, \text{sum}(v > 3), \text{sum(words == "ant")} \]

\[ \text{vector(mode="logical", length=0)} \text{ creates a vector of the given mode and length.} \]

To change a vector’s type, use as.numeric(), as.character(), or as.logical(). (There are three other basic types we will not use much: integer, complex, and raw.)

Names attribute

names(x) gets or sets a vector of character (strings) corresponding to values in x. e.g.

\[ \text{names}(v) = c(\"e\", \"five\", \"pi\") \]
\[ v \] # set names
\[ \text{names}(v) = \text{NULL}; v \] # remove names

Names can also be set with c() by specifying “name=value” pairs. e.g. \[ y = c(\text{burger}=2.50, \text{fries}=1.50); y \]
A Few Functions

e.g. x <- c(12, 11, 16, 11)

sum(x), max(x), mean(x), median(x), sd(x)

Operators (which act element-wise on vectors)

- arithmetic: + - * / ^ (and, for integer division, \%\%/ is quotient, \%\% is remainder)
e.g. The sample standard deviation of \(x_1, x_2, \ldots, x_n\) is

\[s_x = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}\]

\[n = \text{length}(x)\]

\[\text{sqrt}(\text{sum}(\{x - \text{mean}(x)\}^2) / (n-1))\]

- relation: > >= < <= == != (last two are equals and is not equal to)

- logic:

<table>
<thead>
<tr>
<th>! (“not”)</th>
<th>T</th>
<th>F</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>T</td>
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<th>&amp; (“and”)</th>
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- assignment: <- (or =, which is not ==)

- sequence: : (colon); e.g. 11:14 is c( , , , )

seq() is a related function:

- seq(from=1, to=1, by), e.g. seq(10, 15, by=2) is c( , , , )
- seq(from=1, to=1, length.out), e.g. seq(10, 15, length.out=3) is c( , , , )

- matching: %in%, e.g. 1:3 %in% c(2, 7) is c( , , , )

Indexing

- For a vector \(v\) of positive integer, \(x[v]\) is those elements of \(x\) with indices in \(v\); e.g. for \(x \leftarrow 11:20\) and \(v \leftarrow c(1, 2, 10)\), \(x[v]\) is c( , , , ); \(x[3]\) is c( ) (or ________)

- For a vector \(v\) of negative integer, \(x[v]\) is those elements of \(x\) excluding those with indices in \(v\); e.g. for \(x \leftarrow 11:20\) and \(v \leftarrow c(-1, -2, -10)\), \(x[v]\) is ________

- For a vector \(v\) of logical,

  - which(v) is a vector of indices for which \(v[i]\) is TRUE; e.g.

    \[\text{indices} = \text{which}(x < 14) \ # c( , , , )\]

    Now use the indices: \(x[\text{indices}]\) is c( , , , )

    - \(x[v]\) is those elements of \(x\) corresponding to TRUE values in \(v\). e.g.

      \[x[x < 14]\] is c( , , , )

      (so “which” could have been omitted in previous example)

      e.g. \(x[ (x \%\% 2) == 0 ]\)

- For a vector \(v\) of character names, \(x[v]\) is those elements of \(x\) whose names are in \(v\); e.g.

  \(x \leftarrow 1:3; \text{names}(x) \leftarrow c("one", "two", "Fred"); v \leftarrow c("Fred", "one"); x[v]\) is ________