```
% Options for packages loaded elsewhere
\PassOptionsToPackage{unicode}{hyperref}
\PassOptionsToPackage{hyphens}{url}
%
\documentclass[
]{article}
\usepackage{lmodern}
\usepackage{amsmath}
\usepackage{ifxetex,ifluatex}
\ifnum 0\ifxetex 1\fi\ifluatex 1\fi=0 % if pdftex
  \usepackage[T1]{fontenc}
  \usepackage[utf8]{inputenc}
  \usepackage{textcomp} % provide euro and other symbols
  \usepackage{amssymb}
\else % if luatex or xetex
  \usepackage{unicode-math}
  \defaultfontfeatures{Scale=MatchLowercase}
  \defaultfontfeatures[\rmfamily]{Ligatures=TeX,Scale=1}
\fi
% Use upquote if available, for straight quotes in verbatim environments
\IfFileExists{upquote.sty}{\usepackage{upquote}}{}
\IfFileExists{microtype.sty}{% use microtype if available
  \usepackage[]{microtype}
  \UseMicrotypeSet[protrusion]{basicmath} % disable protrusion for tt fonts
}{}
\makeatletter
\@ifundefined{KOMAClassName}{% if non-KOMA class
  \IfFileExists{parskip.sty}{%
    \usepackage{parskip}
```

```
  }{% else
    \setlength{\parindent}{0pt}
    \setlength{\parskip}{6pt plus 2pt minus 1pt}}
}{% if KOMA class
  \KOMAoptions{parskip=half}}
\makeatother
\usepackage{xcolor}
\IfFileExists{xurl.sty}{\usepackage{xurl}}{} % add URL line breaks if available
\IfFileExists{bookmark.sty}{\usepackage{bookmark}}{\usepackage{hyperref}}
\hypersetup{
  pdftitle={Lab 1},
  pdfauthor={Hanlin Wang},
  hidelinks,
  pdfcreator={LaTeX via pandoc}}
\urlstyle{same} % disable monospaced font for URLs
\usepackage[margin=1in]{geometry}
\usepackage{color}
\usepackage{fancyvrb}
\newcommand{\VerbBar}{|}
\newcommand{\VERB}{\Verb[commandchars=\\\{\}]}
\DefineVerbatimEnvironment{Highlighting}{Verbatim}{commandchars=\\\{\}}
% Add ',fontsize=\small' for more characters per line
\usepackage{framed}
\definecolor{shadecolor}{RGB}{248,248,248}
\newenvironment{Shaded}{\begin{snugshade}}{\end{snugshade}}
\newcommand{\AlertTok}[1]{\textcolor[rgb]{0.94,0.16,0.16}{#1}}
\newcommand{\AnnotationTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textbf{\textit{#1}}}}
\newcommand{\AttributeTok}[1]{\textcolor[rgb]{0.77,0.63,0.00}{#1}}
\newcommand{\BaseNTok}[1]{\textcolor[rgb]{0.00,0.00,0.81}{#1}}
```

```
\newcommand{\BuiltInTok}[1]{#1}
\newcommand{\CharTok}[1]{\textcolor[rgb]{0.31,0.60,0.02}{#1}}
\newcommand{\CommentTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textit{#1}}}
\newcommand{\CommentVarTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textbf{\textit{#1}}}}
\newcommand{\ConstantTok}[1]{\textcolor[rgb]{0.00,0.00,0.00}{#1}}
\newcommand{\ControlFlowTok}[1]{\textcolor[rgb]{0.13,0.29,0.53}{\textbf{#1}}}
\newcommand{\DataTypeTok}[1]{\textcolor[rgb]{0.13,0.29,0.53}{#1}}
\newcommand{\DecValTok}[1]{\textcolor[rgb]{0.00,0.00,0.81}{#1}}
\newcommand{\DocumentationTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textbf{\textit{#1}}}}
\newcommand{\ErrorTok}[1]{\textcolor[rgb]{0.64,0.00,0.00}{\textbf{#1}}}
\newcommand{\ExtensionTok}[1]{#1}
\newcommand{\FloatTok}[1]{\textcolor[rgb]{0.00,0.00,0.81}{#1}}
\newcommand{\FunctionTok}[1]{\textcolor[rgb]{0.00,0.00,0.00}{#1}}
\newcommand{\ImportTok}[1]{#1}
\newcommand{\InformationTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textbf{\textit{#1}}}}
\newcommand{\KeywordTok}[1]{\textcolor[rgb]{0.13,0.29,0.53}{\textbf{#1}}}
\newcommand{\NormalTok}[1]{#1}
\newcommand{\OperatorTok}[1]{\textcolor[rgb]{0.81,0.36,0.00}{\textbf{#1}}}
\newcommand{\OtherTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{#1}}
\newcommand{\PreprocessorTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textit{#1}}}
\newcommand{\RegionMarkerTok}[1]{#1}
\newcommand{\SpecialCharTok}[1]{\textcolor[rgb]{0.00,0.00,0.00}{#1}}
\newcommand{\SpecialStringTok}[1]{\textcolor[rgb]{0.31,0.60,0.02}{#1}}
\newcommand{\StringTok}[1]{\textcolor[rgb]{0.31,0.60,0.02}{#1}}
\newcommand{\VariableTok}[1]{\textcolor[rgb]{0.00,0.00,0.00}{#1}}
\newcommand{\VerbatimStringTok}[1]{\textcolor[rgb]{0.31,0.60,0.02}{#1}}
\newcommand{\WarningTok}[1]{\textcolor[rgb]{0.56,0.35,0.01}{\textbf{\textit{#1}}}}
\usepackage{graphicx}
\makeatletter
```

```
\def\maxwidth{\ifdim\Gin@nat@width>\linewidth\linewidth\else\Gin@nat@width\fi}
\def\maxheight{\ifdim\Gin@nat@height>\textheight\textheight\else\Gin@nat@height\fi}
\makeatother
% Scale images if necessary, so that they will not overflow the page
% margins by default, and it is still possible to overwrite the defaults
% using explicit options in \includegraphics[width, height, ...]{}
\setkeys{Gin}{width=\maxwidth,height=\maxheight,keepaspectratio}
% Set default figure placement to htbp
\makeatletter
\def\fps@figure{htbp}
\makeatother
\setlength{\emergencystretch}{3em} % prevent overfull lines
\providecommand{\tightlist}{%
  \setlength{\itemsep}{0pt}\setlength{\parskip}{0pt}}
\setcounter{secnumdepth}{-\maxdimen} % remove section numbering
\ifluatex
  \usepackage{selnolig}  % disable illegal ligatures
\fi

\title{Lab 1}
\author{Hanlin Wang}
\date{11:59PM February 18, 2021}

\begin{document}
\maketitle

You should have RStudio installed to edit this file. You will write code
in places marked ``TO-DO'' to complete the problems. Some of this will
be a pure programming assignment. The tools for the solutions to these
```

problems can be found in the class practice lectures. I want you to use the methods I taught you, not for you to google and come up with whatever works. You won't learn that way.

To ``hand in'' the homework, you should compile or publish this file into a PDF that includes output of your code. Once it's done, push by the deadline to your repository in a directory called ``labs''.

\begin{itemize}
\tightlist
\item
  Print out the numerical constant pi with ten digits after the decimal point using the internal constant \texttt{pi}.
\end{itemize}

\begin{Shaded}
\begin{Highlighting}[]
\FunctionTok{options}\NormalTok{(}\AttributeTok{digits=}\DecValTok{11}\NormalTok{)}
\NormalTok{pi}
\end{Highlighting}
\end{Shaded}

\begin{verbatim}
[1] 3.1415926536
\end{verbatim}

\begin{itemize}
\tightlist
\item

Sum up the first 103 terms of the series 1 + 1/2 + 1/4 + 1/8 +

\ldots{}

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{sum}\NormalTok{(}\DecValTok{1}\SpecialCharTok{/}\NormalTok{(}\DecValTok{2}\SpecialCharTok{\^{}}\NormalTok{(}\DecValTok{0}\SpecialCharTok{:}\DecValTok{102}\NormalTok{)))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 2

\end{verbatim}

\begin{itemize}

\tightlist

\item

Find the product of the first 37 terms in the sequence 1/3, 1/6, 1/9

\ldots{}

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{prod}\NormalTok{(}\DecValTok{1} \SpecialCharTok{/}\NormalTok{(}\DecValTok{3} \SpecialCharTok{*}\NormalTok{(}\DecValTok{1}\SpecialCharTok{:} \DecValTok{37}\NormalTok{)))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 1.613528728e-61

\end{verbatim}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{prod}\NormalTok{(}\DecValTok{1}
\SpecialCharTok{/}\NormalTok{(}\FunctionTok{seq}\NormalTok{(}\AttributeTok{from =}
\DecValTok{3}\NormalTok{, }\AttributeTok{by =} \DecValTok{3}\NormalTok{, }\AttributeTok{length.out
=} \DecValTok{37}\NormalTok{)))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 1.613528728e-61

\end{verbatim}

\begin{itemize}

\tightlist

\item

Find the product of the first 387 terms of

\texttt{1\ *\ 1/2\ *\ 1/4\ *\ 1/8\ *} \ldots{}

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{prod}\NormalTok{(}\DecValTok{1} \SpecialCharTok{/}\NormalTok{(}\DecValTok{2}
\SpecialCharTok{\^{}}\NormalTok{(}\DecValTok{0}\SpecialCharTok{:} \DecValTok{386}\NormalTok{)))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 0

\end{verbatim}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{prod}\NormalTok{(}\DecValTok{1}
\SpecialCharTok{/}\NormalTok{(}\FunctionTok{seq}\NormalTok{(}\AttributeTok{from =}
\DecValTok{2}\NormalTok{, }\AttributeTok{by =} \DecValTok{3}\NormalTok{, }\AttributeTok{length.out
=} \DecValTok{387}\NormalTok{)))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 0

\end{verbatim}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{.Machine}\SpecialCharTok{$}\NormalTok{double.xmin}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 2.2250738585e-308

\end{verbatim}

Is this answer \emph{exactly} correct? It's not correct because the

answer numerically underflow

\#TO-DO

\begin{itemize}

\tightlist

\item

Figure out a means to express the answer more exactly. Not compute

exactly, but express more exactly.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\SpecialCharTok{{-}}\FunctionTok{log}\NormalTok{(}\DecValTok{2}\NormalTok{)}\SpecialCharTok{*}\FunctionTok{sum}\NormalTok{(}\DecValTok{0}\SpecialCharTok{:} \DecValTok{386}\NormalTok{)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] -51771.856063

\end{verbatim}

\begin{itemize}

\tightlist

\item

Create the sequence \texttt{x\ =\ {[}Inf,\ 20,\ 18,\ ...,\ -20{]}}.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{X }\OtherTok{\textless{}{-}}
\FunctionTok{c}\NormalTok{(}\ConstantTok{Inf}\NormalTok{, }\FunctionTok{seq}\NormalTok{(}\AttributeTok{from =} \DecValTok{20}\NormalTok{, }\AttributeTok{to =}
\SpecialCharTok{{-}}\DecValTok{20}\NormalTok{, }\AttributeTok{by =}
\SpecialCharTok{{-}}\DecValTok{2}\NormalTok{))}

\NormalTok{X}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] Inf 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6 -8 -10 -12 -14

[20] -16 -18 -20

\end{verbatim}

Create the sequence

\texttt{x\ =\ {[}log_3(Inf),\ log_3(100),\ log_3(98),\ ...\ log_3(-20){]}}.

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{X }\OtherTok{\textless{}{-}}
\FunctionTok{c}\NormalTok{(}\ConstantTok{Inf}\NormalTok{, }\FunctionTok{seq}\NormalTok{(}\AttributeTok{from =} \DecValTok{100}\NormalTok{, }\AttributeTok{to =}
\SpecialCharTok{{-}}\DecValTok{20}\NormalTok{, }\AttributeTok{by =}
\SpecialCharTok{{-}}\DecValTok{2}\NormalTok{))}

\NormalTok{X }\OtherTok{=} \FunctionTok{log}\NormalTok{(X, }\AttributeTok{base =}
\DecValTok{3}\NormalTok{)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

Warning: NaNs produced

\end{verbatim}

Comment on the appropriateness of the non-numeric values.

\begin{itemize}

\tightlist

\item

Create a vector of booleans where the entry is true if

\texttt{x{[}i{]}} is positive and finite.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{Y }\OtherTok{=} \FunctionTok{is.nan}\NormalTok{(X) }\SpecialCharTok{\&} \FunctionTok{is.finite}\NormalTok{(X) }\SpecialCharTok{\&}\NormalTok{ X }\SpecialCharTok{\textgreater{}} \DecValTok{0}

\end{Highlighting}

\end{Shaded}

\begin{itemize}

\tightlist

\item

Locate the indices of the non-real numbers in this vector. Hint: use

the \texttt{which} function. Don't hesitate to use the documentation

via \texttt{?which}.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{?which}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

starting httpd help server ... done

\end{verbatim}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{which}\NormalTok{(Y }\SpecialCharTok{==} \ConstantTok{FALSE}\NormalTok{)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

[26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

[51] 51 52 53 54 55 56 57 58 59 60 61 62

\end{verbatim}

\begin{itemize}

\tightlist

\item

  Locate the indices of the infinite quantities in this vector.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{which}\NormalTok{(}\FunctionTok{is.infinite}\NormalTok{(X))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}
[1] 1 52
\end{verbatim}

\begin{itemize}
\tightlist
\item
  Locate the indices of the min and max in this vector. Hint: use the
  \texttt{which.min} and \texttt{which.max} functions.
\end{itemize}

\begin{Shaded}
\begin{Highlighting}[]
\FunctionTok{which.min}\NormalTok{(X)}
\end{Highlighting}
\end{Shaded}

\begin{verbatim}
[1] 52
\end{verbatim}

\begin{Shaded}
\begin{Highlighting}[]
\FunctionTok{which.max}\NormalTok{(X)}
\end{Highlighting}
\end{Shaded}

\begin{verbatim}

[1] 1

\end{verbatim}

\begin{itemize}

\tightlist

\item

Count the number of unique values in \texttt{x}.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{length}\NormalTok{(}\FunctionTok{unique}\NormalTok{(X))}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 53

\end{verbatim}

\begin{itemize}

\tightlist

\item

Cast \texttt{x} to a factor. Do the number of levels make sense?

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{as.factor}\NormalTok{(X)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] Inf 4.19180654857877 4.1734172518943 4.15464876785729

[5] 4.13548512895119 4.11590933734319 4.09590327428938 4.07544759935851

[9] 4.05452163806914 4.03310325630434 4.01116871959141 3.98869253500376

[13] 3.96564727304425 3.94200336638929 3.91772888178973 3.89278926071437

[17] 3.86714702345081 3.84076143030548 3.81358809221559 3.78557852142874

[21] 3.75667961082847 3.72683302786084 3.69597450568212 3.66403300987579

[25] 3.63092975357146 3.59657702661571 3.56087679500731 3.52371901428583

[29] 3.48497958377173 3.44451784578705 3.40217350273288 3.3577627814323

[33] 3.31107361281783 3.26185950714291 3.20983167673402 3.15464876785729

[37] 3.09590327428938 3.03310325630434 2.96564727304425 2.89278926071437

[41] 2.8135880922156 2.72683302786084 2.63092975357146 2.52371901428583

[45] 2.40217350273288 2.26185950714291 2.09590327428938 1.89278926071437

[49] 1.63092975357146 1.26185950714291 0.630929753571457 -Inf

[53] NaN NaN NaN NaN

[57] NaN NaN NaN NaN

[61] NaN NaN

53 Levels: -Inf 0.630929753571457 1.26185950714291 ... NaN

\end{verbatim}

\begin{itemize}

\tightlist

\item

Cast \texttt{x} to integers. What do we learn about R's infinity

representation in the integer data type?

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{as.integer}\NormalTok{(X)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

Warning: NAs introduced by coercion to integer range

\end{verbatim}

\begin{verbatim}

[1] NA 4 4 4 4 4 4 4 4 4 4 3 3 3 3 3 3 3 3 3 3 3 3 3

[26] 3 3 3 3 3 3 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 1 1 1

[51] 0 NA NA NA NA NA NA NA NA NA NA NA

\end{verbatim}

\begin{itemize}

\tightlist

\item

  Use \texttt{x} to create a new vector \texttt{y} containing only the

  real numbers in x.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{y }\OtherTok{=}\NormalTok{ X[(}\SpecialCharTok{!}\NormalTok{(}\FunctionTok{is.infinite}\NormalTok{(X) }\SpecialCharTok{\&}
\FunctionTok{is.nan}\NormalTok{(X) }\SpecialCharTok{\&}\NormalTok{ X }\SpecialCharTok{\textless{}}
\DecValTok{0}\NormalTok{))]}

\NormalTok{y}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] Inf 4.19180654858 4.17341725189 4.15464876786 4.13548512895

[6] 4.11590933734 4.09590327429 4.07544759936 4.05452163807 4.03310325630

[11] 4.01116871959 3.98869253500 3.96564727304 3.94200336639 3.91772888179

[16] 3.89278926071 3.86714702345 3.84076143031 3.81358809222 3.78557852143

[21] 3.75667961083 3.72683302786 3.69597450568 3.66403300988 3.63092975357

[26] 3.59657702662 3.56087679501 3.52371901429 3.48497958377 3.44451784579

[31] 3.40217350273 3.35776278143 3.31107361282 3.26185950714 3.20983167673

[36] 3.15464876786 3.09590327429 3.03310325630 2.96564727304 2.89278926071

[41] 2.81358809222 2.72683302786 2.63092975357 2.52371901429 2.40217350273

[46] 2.26185950714 2.09590327429 1.89278926071 1.63092975357 1.26185950714

[51] 0.63092975357 -Inf NaN NaN NaN

[56] NaN NaN NaN NaN NaN

[61] NaN NaN

\end{verbatim}

\begin{itemize}

\tightlist

\item

Use the left rectangle method to numerically integrate x\^{}2 from 0

to 1 with rectangle width size 1e-6.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{sum}\NormalTok{(}\FunctionTok{seq}\NormalTok{(}\AttributeTok{from =}
\DecValTok{0}\NormalTok{, }\AttributeTok{to =} \DecValTok{1}\SpecialCharTok{{-}}
\FloatTok{1e{-}6}\NormalTok{, }\AttributeTok{by =}
\FloatTok{1e{-}6}\NormalTok{) }\SpecialCharTok{\^{}} \DecValTok{2} \SpecialCharTok{*}
\FloatTok{1e{-}6}\NormalTok{)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 0.33333283333

\end{verbatim}

\begin{itemize}

\tightlist

\item

Calculate the average of 100 realizations of standard Bernoullis in

one line using the \texttt{sample} function.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\FunctionTok{sample}\NormalTok{(}\FunctionTok{c}\NormalTok{(}\DecValTok{0}\NormalTok{,}\DecValTok{1}\NormalTok{), }\AttributeTok{size =} \DecValTok{500}\NormalTok{, }\AttributeTok{replace =}
\ConstantTok{TRUE}\NormalTok{)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 1 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 1 1 1 1 0 0 1 0 1 1 0 1 0 0 0 1 1 1 1 0 0

[38] 0 0 0 1 1 0 1 1 0 0 0 1 0 1 1 1 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 0 1 1 1 0

[75] 1 0 1 1 1 1 1 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 1 1 0 0 1 1 1 0 0 0 0 1 0 0

```
## [112] 1 0 0 0 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 1 1 0 0 1 1 0 0 0 0 0 1 1 0 0
## [149] 0 0 1 0 1 0 1 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 1
## [186] 1 0 0 0 0 1 1 0 1 1 1 0 1 0 0 1 0 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 0 0 1 0 1
## [223] 0 1 1 1 1 1 0 0 1 0 1 1 1 1 0 0 1 1 1 1 1 0 1 1 1 1 0 1 1 1 0 0 1 0 0 0 0 0
## [260] 0 1 0 0 1 0 0 1 0 0 0 0 0 1 1 0 1 1 1 0 0 0 0 1 0 1 1 1 0 0 1 1 1 0 1 1 1
## [297] 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 1 1 0 1 0 1 1
## [334] 0 0 1 1 0 1 0 0 0 1 1 1 1 0 1 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 0 1 1 0 1 0 1
## [371] 0 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 1 1 0 0 1 1 0 1 1 1 0 1 1 1 1 0 1 0 0 1 1
## [408] 1 1 0 0 1 0 1 1 0 0 1 0 0 0 0 1 1 0 0 0 1 1 0 0 1 0 1 0 1 0 1 1 0 0 1 1 1
## [445] 0 1 0 0 0 0 0 1 1 1 0 1 1 0 1 0 1 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 1 1 0 0 1
## [482] 1 1 0 0 1 0 1 1 1 1 1 1 1 0 1 0 1 0 0
```

- Calculate the average of 500 realizations of Bernoullis with p = 0.9 in one line using the `sample` and `mean` functions.

```
mean(sample( c(0,1), 100, replace =
TRUE, prob =
c(0.9, 0.1)))
```

\begin{verbatim}

[1] 0.06

\end{verbatim}

\begin{itemize}

\tightlist

\item

Calculate the average of 1000 realizations of Bernoullis with p = 0.9

in one line using \texttt{rbinom}.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{?rbinom}

\FunctionTok{mean}\NormalTok{(}\FunctionTok{rbinom}\NormalTok{(}\AttributeTok{n =} \DecValTok{1000}\NormalTok{, }\AttributeTok{size =} \DecValTok{1}\NormalTok{, }\AttributeTok{prob =} \FloatTok{0.9}\NormalTok{))

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] 0.912

\end{verbatim}

\begin{itemize}

\tightlist

\item

In class we considered a variable \texttt{x_3} which measured

``criminality''. We imagined L = 4 levels ``none'', ``infraction'',

``misdimeanor'' and ``felony''. Create a variable \texttt{x_3} here

with 100 random elements (equally probable). Create it as a nominal

(i.e.~unordered) factor.

\end{itemize}

\begin{Shaded}

\begin{Highlighting}[]

\NormalTok{X_3 }\OtherTok{=}
\FunctionTok{as.factor}\NormalTok{(}\FunctionTok{sample}\NormalTok{(}\FunctionTok{c}\NormalTok{(}
\StringTok{"none"}\NormalTok{, }\StringTok{"infraction"}\NormalTok{, }\StringTok{"misdimeanor"}\Nor
malTok{ , }\StringTok{"felony"}\NormalTok{), }\AttributeTok{size =}
\DecValTok{100}\NormalTok{, }\AttributeTok{replace =} \ConstantTok{TRUE}\NormalTok{))}

\NormalTok{X_3}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] misdimeanor felony   infraction none   misdimeanor felony

[7] misdimeanor infraction misdimeanor felony   misdimeanor felony

[13] none   misdimeanor infraction infraction felony   felony

[19] infraction infraction felony   felony   none   none

[25] felony   misdimeanor infraction none   none   felony

[31] felony   misdimeanor felony   infraction none   felony

[37] infraction felony   infraction felony   felony   infraction

[43] misdimeanor misdimeanor infraction infraction felony   misdimeanor

[49] felony   felony   infraction misdimeanor none   felony

[55] misdimeanor infraction felony   none   misdimeanor felony

[61] misdimeanor misdimeanor infraction felony   felony   felony

[67] none   felony   misdimeanor none   none   none

[73] misdimeanor felony   none   misdimeanor infraction none

```
##  [79] felony      misdimeanor none        misdimeanor misdimeanor none
##  [85] none        none        misdimeanor felony      none        felony
##  [91] none        misdimeanor infraction  none        infraction  felony
##  [97] felony      misdimeanor none        none
## Levels: felony infraction misdimeanor none
```

\end{verbatim}

\begin{itemize}
\tightlist
\item
  Use \texttt{x_3} to create \texttt{x_3_bin}, a binary feature where
  0 is no crime and 1 is any crime.
\end{itemize}

\begin{Shaded}
\begin{Highlighting}[]
\NormalTok{X_3_bin }\OtherTok{=}\NormalTok{ X_3 }\SpecialCharTok{!=} \StringTok{"none"}
\end{Highlighting}
\end{Shaded}

\begin{itemize}
\tightlist
\item
  Use \texttt{x_3} to create \texttt{x_3_ord}, an ordered factor
  variable. Ensure the proper ordinal ordering.
\end{itemize}

\begin{Shaded}
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\FunctionTok{factor}\NormalTok{(X_3, }\AttributeTok{levels =}
\FunctionTok{c}\NormalTok{(}\StringTok{"none"}\NormalTok{, }\StringTok{"infraction"}\NormalTok{, }\S
tringTok{"misdimeanor"}\NormalTok{ , }\StringTok{"felony"}\NormalTok{), }\AttributeTok{order =}
\ConstantTok{TRUE}\NormalTok{)}

\end{Highlighting}

\end{Shaded}

\begin{verbatim}

[1] misdimeanor felony infraction none misdimeanor felony

[7] misdimeanor infraction misdimeanor felony misdimeanor felony

[13] none misdimeanor infraction infraction felony felony

[19] infraction infraction felony felony none none

[25] felony misdimeanor infraction none none felony

[31] felony misdimeanor felony infraction none felony

[37] infraction felony infraction felony felony infraction

[43] misdimeanor misdimeanor infraction infraction felony misdimeanor

[49] felony felony infraction misdimeanor none felony

[55] misdimeanor infraction felony none misdimeanor felony

[61] misdimeanor misdimeanor infraction felony felony felony

[67] none felony misdimeanor none none none

[73] misdimeanor felony none misdimeanor infraction none

[79] felony misdimeanor none misdimeanor misdimeanor none

[85] none none misdimeanor felony none felony

[91] none misdimeanor infraction none infraction felony

[97] felony misdimeanor none none

Levels: none < infraction < misdimeanor < felony

\end{verbatim}

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\NormalTok{?factor}

\end{Highlighting}

\end{Shaded}

\begin{itemize}

\tightlist

\item

Convert this variable into three binary variables without any

information loss and put them into a data matrix.

\end{itemize}

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\begin{itemize}

\tightlist

\item

What should the sum of each row be (in English)?

\end{itemize}

\#TO-DO

Verify that.

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\end{Highlighting}

\end{Shaded}

\begin{itemize}

\tightlist

\item

How should the column sum look (in English)?

\end{itemize}

\#TO-DO

Verify that.

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\end{Highlighting}

\end{Shaded}

\begin{itemize}

\tightlist

\item

Generate a matrix with 100 rows where the first column is realization from a normal with mean 17 and variance 38, the second column is uniform between -10 and 10, the third column is poisson with mean 6, the fourth column in exponential with lambda of 9, the fifth column is binomial with n = 20 and p = 0.12 and the sixth column is a binary variable with exactly 24\% 1's dispersed randomly. Name the rows the

entries of the \texttt{fake_first_names} vector.

\end{itemize}

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\NormalTok{fake_first_names }\OtherTok{=} \FunctionTok{c}\NormalTok{(}

\StringTok{"Sophia"}\NormalTok{, }\StringTok{"Emma"}\NormalTok{, }\StringTok{"Olivia"}\NormalTok{, }\StringTok{"Ava"}\NormalTok{, }\StringTok{"Mia"}\NormalTok{, }\StringTok{"Isabella"}\NormalTok{, }\StringTok{"Riley"}\NormalTok{,

\StringTok{"Aria"}\NormalTok{, }\StringTok{"Zoe"}\NormalTok{, }\StringTok{"Charlotte"}\NormalTok{, }\StringTok{"Lily"}\NormalTok{, }\StringTok{"Layla"}\NormalTok{, }\StringTok{"Amelia"}\NormalTok{, }\StringTok{"Emily"}\NormalTok{,

\StringTok{"Madelyn"}\NormalTok{, }\StringTok{"Aubrey"}\NormalTok{, }\StringTok{"Adalyn"}\NormalTok{, }\StringTok{"Madison"}\NormalTok{, }\StringTok{"Chloe"}\NormalTok{, }\StringTok{"Harper"}\NormalTok{,

\StringTok{"Abigail"}\NormalTok{, }\StringTok{"Aaliyah"}\NormalTok{, }\StringTok{"Avery"}\NormalTok{, }\StringTok{"Evelyn"}\NormalTok{, }\StringTok{"Kaylee"}\NormalTok{, }\StringTok{"Ella"}\NormalTok{, }\StringTok{"Ellie"}\NormalTok{,

\StringTok{"Scarlett"}\NormalTok{, }\StringTok{"Arianna"}\NormalTok{, }\StringTok{"Hailey"}\NormalTok{, }\StringTok{"Nora"}\NormalTok{, }\StringTok{"Addison"}\NormalTok{, }\StringTok{"Brooklyn"}\NormalTok{,

\StringTok{"Hannah"}\NormalTok{, }\StringTok{"Mila"}\NormalTok{, }\StringTok{"Leah"}\NormalTok{, }\StringTok{"Elizabeth"}\NormalTok{, }\StringTok{"Sarah"}\NormalTok{, }\StringTok{"Eliana"}\NormalTok{, }\StringTok{"Mackenzie"}\NormalTok{,

\StringTok{"Peyton"}\NormalTok{, }\StringTok{"Maria"}\NormalTok{, }\StringTok{"Grace"}\NormalTok{, }\StringTok{"Adeline"}\NormalTok{, }\StringTok{"Elena"}\NormalTok{, }\StringTok{"Anna"}\NormalTok{, }\StringTok{"Victoria"}\NormalTok{,

\StringTok{"Camilla"}\NormalTok{, }\StringTok{"Lillian"}\NormalTok{, }\StringTok{"Natalie"}\NormalTok{

, }\StringTok{"Jackson"}\NormalTok{, }\StringTok{"Aiden"}\NormalTok{, }\StringTok{"Lucas"}\NormalTok{, }

\StringTok{"Liam"}\NormalTok{, }\StringTok{"Noah"}\NormalTok{, }\StringTok{"Ethan"}\NormalTok{, }\StringTok{"Mason"}\NormalTok{, }\StringTok{"Caden"}\NormalTok{, }\StringTok{"Oliver"}\NormalTok{, }\StringTok{"Elijah"}\NormalTok{, }

\StringTok{"Grayson"}\NormalTok{, }\StringTok{"Jacob"}\NormalTok{, }\StringTok{"Michael"}\NormalTok{, }\StringTok{"Benjamin"}\NormalTok{, }\StringTok{"Carter"}\NormalTok{, }\StringTok{"James"}\NormalTok{, }

\StringTok{"Jayden"}\NormalTok{, }\StringTok{"Logan"}\NormalTok{, }\StringTok{"Alexander"}\NormalTok{, }\StringTok{"Caleb"}\NormalTok{, }\StringTok{"Ryan"}\NormalTok{, }\StringTok{"Luke"}\NormalTok{, }\StringTok{"Daniel"}\NormalTok{, }

\StringTok{"Jack"}\NormalTok{, }\StringTok{"William"}\NormalTok{, }\StringTok{"Owen"}\NormalTok{, }\StringTok{"Gabriel"}\NormalTok{, }\StringTok{"Matthew"}\NormalTok{, }\StringTok{"Connor"}\NormalTok{, }\StringTok{"Jayce"}\NormalTok{, }

\StringTok{"Isaac"}\NormalTok{, }\StringTok{"Sebastian"}\NormalTok{, }\StringTok{"Henry"}\NormalTok{, }\StringTok{"Muhammad"}\NormalTok{, }\StringTok{"Cameron"}\NormalTok{, }\StringTok{"Wyatt"}\NormalTok{, }

\StringTok{"Dylan"}\NormalTok{, }\StringTok{"Nathan"}\NormalTok{, }\StringTok{"Nicholas"}\NormalTok{, }\StringTok{"Julian"}\NormalTok{, }\StringTok{"Eli"}\NormalTok{, }\StringTok{"Levi"}\NormalTok{, }\StringTok{"Isaiah"}\NormalTok{, }

\StringTok{"Landon"}\NormalTok{, }\StringTok{"David"}\NormalTok{, }\StringTok{"Christian"}\NormalTok{, }\StringTok{"Andrew"}\NormalTok{, }\StringTok{"Brayden"}\NormalTok{, }\StringTok{"John"}\NormalTok{, }

\StringTok{"Lincoln"}

\NormalTok{)}

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\begin{itemize}

\tightlist

\item
Create a data frame of the same data as above except make the binary variable a factor ``DOMESTIC'' vs ``FOREIGN'' for 0 and 1 respectively. Use RStudio's \texttt{View} function to ensure this worked as desired.
\end{itemize}

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\begin{itemize}
\tightlist
\item
Print out a table of the binary variable. Then print out the proportions of ``DOMESTIC'' vs ``FOREIGN''.
\end{itemize}

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Print out a summary of the whole dataframe.

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\begin{itemize}
\tightlist
\item
  Let \texttt{n\ =\ 50}. Create a n x n matrix \texttt{R} of exactly
  50\% entries 0's, 25\% 1's 25\% 2's. These values should be in random
  locations.
\end{itemize}

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\begin{itemize}
\tightlist
\item
  Randomly punch holes (i.e.~\texttt{NA}) values in this matrix so that
  an each entry is missing with probability 30\%.
\end{itemize}

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\begin{itemize}

\tightlist

\item

Sort the rows in matrix \texttt{R} by the largest row sum to lowest.

Be careful about the NA's!

\end{itemize}

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\tightlist

\item

We will now learn the \texttt{apply} function. This is a handy

function that saves writing for loops which should be eschewed in R.

Use the apply function to compute a vector whose entries are the

standard deviation of each row. Use the apply function to compute a

vector whose entries are the standard deviation of each column. Be

careful about the NA's! This should be one line.

\end{itemize}

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\begin{itemize}

\tightlist

\item

Use the \texttt{apply} function to compute a vector whose entries are the count of entries that are 1 or 2 in each column. This should be one line.

\end{itemize}

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\begin{itemize}

\tightlist

\item

Use the \texttt{split} function to create a list whose keys are the column number and values are the vector of the columns. Look at the last example in the documentation \texttt{?split}.

\end{itemize}

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\begin{itemize}
\tightlist
\item
  In one statement, use the \texttt{lapply} function to create a list
  whose keys are the column number and values are themselves a list with
  keys: ``min'' whose value is the minimum of the column, ``max'' whose
  value is the maximum of the column, ``pct_missing'' is the proportion
  of missingness in the column and ``first_NA'' whose value is the row
  number of the first time the NA appears.
\end{itemize}

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\begin{itemize}
\tightlist
\item
  Set a seed and then create a vector \texttt{v} consisting of a sample
  of 1,000 iid normal realizations with mean -10 and variance 100.
\end{itemize}

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\begin{itemize}

\tightlist

\item

Repeat this exercise by resetting the seed to ensure you obtain the

same results.

\end{itemize}

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\begin{itemize}

\tightlist

\item

Find the average of \texttt{v} and the standard error of \texttt{v}.

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\begin{itemize}

\tightlist

\item

Find the 5\%ile of \texttt{v} and use the \texttt{qnorm} function to

compute what it theoretically should be. Is the estimate about what is

expected by theory?

\end{itemize}

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\begin{itemize}

\tightlist

\item

What is the percentile of \texttt{v} that corresponds to the value 0?

What should it be theoretically? Is the estimate about what is

expected by theory?

\end{itemize}

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\end{document}
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