Lab 02: Variables, Arrays and Scripts

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1 Script File

```
% Math 3341, Fall 2021
% Lab 02: Variables, Arrays and Scripts
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clc             % clear command window
clear           % clear variables workspace
format compact  % show results in compact format

%% 1 1-D Array: Vector
% 1(a)
vec1 = linspace(1, 9, 9)
vec2 = 18:-2:1
vec1Length = length(vec1)
vec2Length = length(vec2)
% 1(b)
vec1Product = prod(vec1)
vecProduct = vec1 .* vec2
dotProduct1 = dot(vec1, vec2)
dotProduct2 = vec1 * vec2'
dotProduct3 = sum(vec1 .* vec2)

%% 2 2-D Array: Matrix
% 2(a)
mat1 = magic(3)
mat1ColSum = sum(mat1, 1)
mat1RowSum = sum(mat1, 2)
mat1DiagSum = sum(diag(mat1))
% 2(b)
mat2 = reshape(vec1, 3, 3)'
matProduct1 = mat1 * mat2
matProduct2 = mat1 .* mat2
% 2(c)
mat3 = [matProduct1;matProduct2]
sumAll = sum(mat3, 'all')
mat3ColMin = min(mat3, [], 1)
mat3RowMax = max(mat3, [], 2)
[rowIndex, colIndex] = find(mat3 <= 20)
% 2(d)
mat3(:, 4) = mat3(:, 2)
```

```
mat3(:, end + 1) = int8(rand(6, 1) * 255)
mat3 = [mat3,colon(0,36,200)']
mat3Size = size(mat3)

%% 3 Array: Char Array vs. String Array
% 3(a)
helloChar = 'hello '
worldChar = 'world'
helloString = "hello "
worldString = "world"
helloWorldChar1 = [helloChar,worldChar]
helloWorldString1 = [helloString,worldString]
helloWorldChar2 = strcat(helloChar, worldChar)
helloWorldString2 = strcat(helloString, worldString)
% 3(b)
helloWorldChar1Class = class(helloWorldChar1)
helloWorldChar2Class = class(helloWorldChar2)
helloWorldString1Class = class(helloWorldString1)
helloWorldString2Class = class(helloWorldString2)
helloWorldChar1Length = length(helloWorldChar1)
helloWorldChar2Length = length(helloWorldChar2)
helloWorldString1Length = length(helloWorldString1)
helloWorldString2Length = length(helloWorldString2)

%% 4 Application: Image Processing
% 4(a)
uwGray = imread('UW_gray.png');
uwGraySize = size(uwGray)
[V, D] = eig(double(uwGray));
maxEigenvalue = max(D, [], 'all')
% 4(b)
imshow(uwGray)
steamboatLeft = uwGray(1:650, 171:650);
steamboatRight = fliplr(steamboatLeft);
steamboat = [steamboatLeft,steamboatRight];
% 4(c)
uwName = uwGray(651:960, :);
uwGrayNew = [steamboat;uwName];
imshow(uwGrayNew)
imwrite(uwGrayNew, 'UW_gray_new.png')
uwGrayNewSize = size(uwGrayNew)
whos
```

2 Output File

```
lab_02_script
vec1 =
     1     2     3     4     5     6     7     8     9
vec2 =
    18    16    14    12    10     8     6     4     2
vec1Length =
     9
vec2Length =
     9
vec1Product =
      362880
vecProduct =
    18    32    42    48    50    48    42    32    18
dotProduct1 =
   330
dotProduct2 =
   330
dotProduct3 =
   330
mat1 =
     8     1     6
     3     5     7
     4     9     2
mat1ColSum =
    15    15    15
mat1RowSum =
    15
    15
    15
mat1DiagSum =
    15
mat2 =
     1     2     3
     4     5     6
     7     8     9
matProduct1 =
    54    69    84
    72    87   102
    54    69    84
matProduct2 =
     8     2    18
    12    25    42
    28    72    18
mat3 =
    54    69    84
```

```
    72    87   102
    54    69    84
     8     2    18
    12    25    42
    28    72    18
sumAll =
   900
mat3ColMin =
     8     2    18
mat3RowMax =
    84
   102
    84
    18
    42
    72
rowIndex =
     4
     5
     4
     4
     6
colIndex =
     1
     1
     2
     3
     3
mat3 =
    54    69    84    69
    72    87   102    87
    54    69    84    69
     8     2    18     2
    12    25    42    25
    28    72    18    72
mat3 =
    54    69    84    69   127
    72    87   102    87   127
    54    69    84    69   124
     8     2    18     2   127
    12    25    42    25    36
    28    72    18    72   108
mat3 =
    54    69    84    69   127     0
    72    87   102    87   127    36
    54    69    84    69   124    72
     8     2    18     2   127   108
    12    25    42    25    36   144
```

```
    28    72    18    72   108   180
mat3Size =
     6     6
helloChar =
    'hello '
worldChar =
    'world'
helloString =
    "hello "
worldString =
    "world"
helloWorldChar1 =
    'hello world'
helloWorldString1 =
  1×2 <a href="matlab:helpPopup string" style="font-weight:bold">string</a> array
    "hello "    "world"
helloWorldChar2 =
    'helloworld'
helloWorldString2 =
    "hello world"
helloWorldChar1Class =
    'char'
helloWorldChar2Class =
    'char'
helloWorldString1Class =
    'string'
helloWorldString2Class =
    'string'
helloWorldChar1Length =
    11
helloWorldChar2Length =
    10
helloWorldString1Length =
     2
helloWorldString2Length =
     1
uwGraySize =
   960   960
maxEigenvalue =
   2.2850e+05
uwGrayNewSize =
   960   960
  Name                          Size                Bytes  Class     Attributes

  D                           960x960            14745600  double    complex
  V                           960x960            14745600  double    complex
  colIndex                      5x1                   40  double
  dotProduct1                   1x1                    8  double
```

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  dotProduct2                1x1                     8  double
  dotProduct3                1x1                     8  double
  helloChar                  1x6                    12  char
  helloString                1x1                   150  string
  helloWorldChar1            1x11                   22  char
  helloWorldChar1Class       1x4                     8  char
  helloWorldChar1Length      1x1                     8  double
  helloWorldChar2            1x10                   20  char
  helloWorldChar2Class       1x4                     8  char
  helloWorldChar2Length      1x1                     8  double
  helloWorldString1          1x2                   204  string
  helloWorldString1Class     1x6                    12  char
  helloWorldString1Length    1x1                     8  double
  helloWorldString2          1x1                   166  string
  helloWorldString2Class     1x6                    12  char
  helloWorldString2Length    1x1                     8  double
  mat1                       3x3                    72  double
  mat1ColSum                 1x3                    24  double
  mat1DiagSum                1x1                     8  double
  mat1RowSum                 3x1                    24  double
  mat2                       3x3                    72  double
  mat3                       6x6                   288  double
  mat3ColMin                 1x3                    24  double
  mat3RowMax                 6x1                    48  double
  mat3Size                   1x2                    16  double
  matProduct1                3x3                    72  double
  matProduct2                3x3                    72  double
  maxEigenvalue              1x1                     8  double
  rowIndex                   5x1                    40  double
  steamboat                650x960                624000  uint8
  steamboatLeft            650x480                312000  uint8
  steamboatRight           650x480                312000  uint8
  sumAll                     1x1                     8  double
  uwGray                   960x960                921600  uint8
  uwGrayNew                960x960                921600  uint8
  uwGrayNewSize              1x2                    16  double
  uwGraySize                 1x2                    16  double
  uwName                   310x960                297600  uint8
  vec1                       1x9                    72  double
  vec1Length                 1x1                     8  double
  vec1Product                1x1                     8  double
  vec2                       1x9                    72  double
  vec2Length                 1x1                     8  double
  vecProduct                 1x9                    72  double
  worldChar                  1x5                    10  char
  worldString                1x1                   150  string

diary off
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3 Figure File

Figure 1: UWyo Logo

4 Basics of LaTeX

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\subsection{Sine functions}
For given $x \in [0, 2\pi]$ with step size $\pi/12$, we can obtain the evaluations
of \eqref{eq:sine} at $x$ (see Table \ref{tab:sine}), and the corresponding plot
(see Figure \ref{fig:sine}).

\begin{equation}
  \label{eq:sine}
  \begin{cases}
    y_1 = \sin(x/2) \\
    y_2 = \sin(x)   \\
    y_3 = \sin(2x)
  \end{cases}
\end{equation}
\begin{table}[!hbtp]
\centering
\caption{Sine functions}
\label{tab:sine}
\begin{tabular}{ccrr}
\toprule
        $x$ & $\sin(x/2)$ &   $\sin(x)$ &  $\sin(2x)$ \\
\midrule
$0$      & $0$          & $0$  & $0$ \\
$\pi/2$  & $\sqrt{2}/2$ & $1$  & $0$ \\
$\pi$    & $1$          & $0$  & $0$ \\
$3\pi/2$ & $\sqrt{2}/2$ & $-1$ & $0$ \\
$2\pi$   & $0$          & $0$  & $0$ \\
\bottomrule
\end{tabular}
\end{table}
\begin{figure}[!hbtp]
  \centering
  \includegraphics[width=0.3\textheight]{./fig/sine.pdf}
  \caption{Sine functions}
  \label{fig:sine}
\end{figure}

\subsection{Goldbach's Conjecture}
Pursuing this type of analysis more carefully, Hardy and Littlewood in 1923 conjectured
(as part of their famous \textsl{Hardy–Littlewood prime tuple conjecture}) that for any
fixed $c \geq 2$, the number of representations of a large integer $n$ as the sum of $c$
primes $n = p_1 + \cdots + p_{c}$ with $p_1 \leq \cdots \leq p_c$ should be asymptotically
equal to
\begin{equation}
    \label{eq:hardy}
    \left( \prod_{p} \frac{p \gamma_{c,p} (n)}{(p - 1)^c}\right)
    \int_{2 \leq x_1 \leq \cdots \leq x_c: x_1 + \cdots + x_c = n}
```

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    \frac{d x_1 \cdots d x_{c - 1}}{\ln{x_1} \cdots \ln{x_c}},
\end{equation}
where the product is over all primes $p$, and $\gamma_{c, p}(n)$ is the number of
solutions to the equation $n = q_1 + \cdots + q_c \mod p$ in modular arithmetic,
subject to the constraints $q_1, \ldots, q_c \ne 0 \mod p$. This formula
\eqref{eq:hardy} has been rigorously proven to be asymptotically valid for
$c \geq 3$ from the work of Vinogradov, but is till only a conjecture when $c = 2$.
In the latter case, the above formula simplifies to $0$ when $n$ is odd, and to
$$
2 \Pi_2 \left( \prod_{p|n; p \geq 3} \frac{p - 1}{p - 2} \right)
\int_{2}^{n} \frac{dx}{(\ln{x})^2} \approx 2 \Pi_2
\left( \prod_{p|n; p \geq 3} \frac{p - 1}{p - 2} \right) \frac{n}{(\ln{n})^2},
$$
when $n$ is even, where $\Pi_2$ is Hardy-Littlewood's twin prime constant
$$
\Pi_2 := \prod_{p \geq 3} \left( 1 - \frac{1}{(p - 1)^2} \right) = 0.6601618158\ldots
$$
This sometimes known as the \textsf{extended Goldbach conjecture}.

\emph{Reference}: \href{https://en.wikipedia.org/wiki/Goldbach's_conjecture}{Goldbach's conjecture}.
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