The goal of this assignment is to get familiar with MATLAB and how to plot functions and direction fields. Note that these instructions are specific to MATLAB, but you are welcome to use any programming language you prefer.

1. Create a MATLAB script, and at the top of the script write down the assignment name, date, and group member names. \% will comment out a line. \%{ ⋯ }\% will comment out a block.

2. Create a grid of 101 points on \([0, 1]\) using the \texttt{linspace} function\(^1\).

3. Create an anonymous function\(^2\) that computes
   \begin{enumerate}
   \item \(f(x) = \sin(2\pi x)\)
   \item \(g(x) = \cos(2\pi x)\)
   \item \(h(x) = e^x\)
   \end{enumerate}

4. Create a vector for each of \(f\), \(g\), and \(h\) where the function is evaluated at the grid points created by \texttt{linspace}.

5. Plot \(f(x)\), \(g(x)\), and \(h(x)\) using the \texttt{plot} function in a single figure. Be sure to label your axes, title your plot, and label which graph corresponds to which function. Use MATLAB functions to add labels to your plots\(^3\).

6. Now, create a grid of 101\(^2\) points on \([0, 1] \times [0, 1]\) using the \texttt{meshgrid} function\(^4\).

7. Create an anonymous function that computes
   \begin{enumerate}
   \item \(q(x, y) = (x - 1)^2 + (y - 1)^2 + 1\)
   \item \(r(x, t) = e^{-t} + x\)
   \item \(s(x, y) = \sin(2\pi x) \sin(2\pi y)\)
   \end{enumerate}

8. Create a matrix that evaluates \(q\), \(r\), and \(s\) at each point of the 101\(^2\) points of the grid on \([0, 1] \times [0, 1]\). Note that you may need to use \texttt{.\^2} and \texttt{.*} instead of the usual \texttt{\^2} and \texttt{*}.

9. Plot \(q\), \(r\), and \(s\) over \([0, 1] \times [0, 1]\) using the \texttt{surf} function\(^5\) in three separate figures. Be sure to label your axes, title your plot, and label which graph corresponds to which function. Use MATLAB functions to add labels to your plots.

10. Create a \(21 \times 21\) grid of \((t, x) \in [0, 10] \times [-1, 1]\). Evaluate \(r(x, t)\) at each point of this grid. Use \texttt{quiver}\(^6\) to plot the direction field for \(\frac{dx}{dt} = r(x, t) = e^{-t} + x\).

Note that we want the horizontal axis to be the \(t\) axis and the vertical axis to by the \(x\) axis. Finally, use \texttt{streamline}\(^7\) to plot some solution trajectories. Use \texttt{startx} = -1:0.1:1 and \texttt{startt} = \texttt{zeros(size(startx))}. Be sure to label your plots.

Note: using the \texttt{hold on} command will allow you to use multiple commands in a single figure. Hint:

\(^{1}\)https://www.mathworks.com/help/matlab/ref/linspace.html
\(^{2}\)https://www.mathworks.com/help/matlab/matlab_prog/anonymous-functions.html
\(^{3}\)https://www.mathworks.com/help/matlab/ref/plot.html
\(^{4}\)https://www.mathworks.com/help/matlab/ref/meshgrid.html
\(^{5}\)https://www.mathworks.com/help/matlab/ref/surf.html
\(^{6}\)https://www.mathworks.com/help/matlab/ref/quiver.html
\(^{7}\)https://www.mathworks.com/help/matlab/ref/streamline.html
%Example for MAT 22B Group Work 1
%Created by Ben Godkin on 6/21/2021

figure(1)
hold on
quiver(t_grid, x_grid, ones(size(x_grid)), r(x_grid, t_grid))

%This creates a vector of initial conditions of the form $\begin{pmatrix} t \\ x \end{pmatrix} = \begin{pmatrix} 0 \\ x \end{pmatrix}$
startx = -1:0.1:1;
startt = zeros(size(startx));
streamline(t_grid, x_grid, ones(size(x_grid)), r(x_grid, t_grid), startt, startx)
hold off