CS 145: Scientific Programming
Review problems for Exam 1

1. The distance from a point \((x_0, y_0)\) to a line \(ax + by + c = 0\) is given by:

\[
d = \frac{|ax_0 + by_0 + c|}{\sqrt{a^2 + b^2}}
\]

Write Matlab code to compute the distance of the point \((3, -4)\) from the line \(2x - 7y - 10 = 0\). (Hint: First define the variables you know, and then use the abs and sqrt commands to calculate \(d\).)

2. Sound level \(L_p\) in units of decibels is determined by:

\[
L_p = 20 \log_{10} \left( \frac{p}{p_0} \right)
\]

where \(p\) is the sound pressure of the sound, and \(p_0 = 20 \times 10^{-6}\) is a reference sound pressure.

(a) Determine the sound pressure of 90 decibels of noise (the amount generated by a passing truck).

(b) How many times larger (louder) is the sound pressure of the truck versus the sound pressure during a normal conversation, where the loudness is 65 decibels?

3. Give the output of the following Matlab commands:

(a) \([3:3:15]\)

(b) \([7:-2:-3]\)

(c) \(\text{zeros}(3)\)

4. The position as a function of time \((x(t), y(t))\) of a projectile fired with a speed of \(v_0\) at an angle \(\theta\) is given by: \(x(t) = tv_0 \cos(\theta)\) and \(y(t) = tv_0 \sin(\theta) - \frac{gt^2}{2}\), where \(g = 9.81 \text{m/s}^2\). The distance \(r\) to a projectile at time \(t\) is then given by \(r(t) = \sqrt{x(t)^2 + y(t)^2}\).

Consider an example where \(v_0 = 100 \text{m/s}\) and \(\theta = 90^\circ\). Give Matlab code to generate an array that holds the distance to the projectile every second from 0 seconds up to 10 seconds and graphs the result.

5. Fisheries commonly estimate the growth of a fish using the von Bertalanffy growth law:

\[
L = L_{\text{max}} (1 - e^{-K(t+\tau)})
\]

where \(L_{\text{max}}\) is the maximum length, \(K\) is a rate constant, and \(\tau\) is a time constant. These constants vary greatly depending on the species of fish. Assume \(L_{\text{max}} = 50\text{cm}\), and \(\tau = 0.5\) years, calculate the length of a fish at 2 years of age for \(K = 0.25, 0.5,\) and \(0.75\) years.
6. Give Matlab code to solve the following system of linear equations:

\[
\begin{align*}
1.5a - 2b + c + 3d &= 7.5 \\
3a + b - c + 4d &= 16 \\
2a + 6b - 3c - d &= 78 \\
5a + 2b + 4c - 2d &= 71
\end{align*}
\]

7. Suppose you have two arrays \(x\) and \(y\) of length \(n\). Use array operations to calculate

\[
\sum_{i=1}^{n} \sqrt{\frac{|x_i - y_i|}{x_i^2 + y_i^2}}
\]

8. The factorial \(n!\) of a positive integer is defined by \(n! = n \cdot (n-1) \cdot (n-2) \cdots 3 \cdot 2 \cdot 1\). Write a script that (assuming \(n\) has been predefined as a positive integer) will compute the value of \(n!\) and save it as a variable named \(nfac\).

9. Write a Matlab program that (assuming \(m\) and \(n\) have already been predefined) creates a matrix of size \(n \times m\), where the entry in row \(i\) and column \(j\) contains the value \(\sin(i + j)\) (where \(i + j\) is in radians).

10. Write a program that creates an array \(sums\) of length 100 where the entry at index \(n\) is equal to

\[
\sum_{i=1}^{n} \frac{\sin(i)}{2^i}
\]