

**Homework 2**

You're only allowed to use the standard built-in Python 3 libraries with the exception of Numpy and Matplotlib.

**Question 1.** Plot the following trigonometric functions for  $-5\pi \leq x \leq 5\pi$ .

$$f(x) = x \sin^2(x), \quad g(x) = -x \sin^2(x)$$

- The title of the plot should read “Trigonometric Functions.”
- The  $x$ -axis label of the plot should read “ $x$ -axis.”
- The  $y$ -axis label of the plot should read “ $y$ -axis.”
- The legends should appropriately denote the different functions by their definition.
- The graphs should have smooth continuos curves.

**Question 2.** Download and save the novel “[The Cosmic Computer](#)” by Piper. Read the saved text file into Python and plot a bar graph of the character frequency (case insensitive).

- The title of the plot should read ‘Character Frequency in “The Cosmic Computer” by Piper.’
- The  $x$ -axis label of the plot should read “Alphabet.”
- The  $y$ -axis label of the plot should read “Frequency.”
- The bars should be sorted in ascending order.

**Question 3.** Using `matplotlib.pyplot.imshow` and an eight by eight binary Numpy array, plot the chess board pattern.

- The  $x$ -ticks should be letters from A to H, A being at the left.
- The  $y$ -ticks should be numbers from 1 to 8, one being at the bottom.
- The title should be “Chess Board Pattern.”

**Question 4.** Following are the two matrices from the last homework,

$$\mathbf{A} = \begin{bmatrix} 1 & 0 & 1 \\ 2 & 1 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 2 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 3 & 1 \\ 4 & 2 & 2 \end{bmatrix}$$

Use Numpy to multiply them and print the product  $\mathbf{AB}$ . Does it match with the one you carried out by hand?

Yes.

**Question 5.** The Gregory series is given as,

$$f(n) = \sum_{i=1}^{i=n} \frac{4(-1)^{i+1}}{2i-1} = \frac{4}{1} - \frac{4}{3} + \frac{4}{5} - \dots + \frac{4(-1)^{n+1}}{2n-1}$$

- 1 Without using any loops, i. e., using vectorised operations over Numpy arrays, plot the following values,

$$\{(n, f(n)) : 1 \leq n \leq 100\}$$

- 2 Plot the following error curve,

$$\{(n, (\pi - f(n))^2) : 1 \leq n \leq 100\}$$

Label the axis and title each plot appropriately. What is  $\lim_{n \rightarrow \infty} f(n)$ ?

**Question 6.** Consider the following study results in table 1,

Point	Real	Predicted
1	—	+
2	—	—
3	—	—
4	—	+
5	+	—
6	+	+
7	+	+
8	+	+

TABLE 1. Real and Predicted Labels

State all the points that are,

- 1 True Negatives 2, 3
- 2 True Positives 6, 7, 8
- 3 False Positives 1, 4
- 4 False Negatives 5

**Question 7.** Give the confusion matrix for table 1.

	Predicted —	Predicted +
Real —	TN	FP
Real +	FN	TP

TABLE 2. Binary Confusion Matrix

	Predicted —	Predicted +
Real —	2	2
Real +	1	3

Table 3. Binary Confusion Matrix

**Question 8.** Again, for table 1, give the following in exact fractions.

- 1 Baseline Accuracy
- 2 Accuracy

$$\frac{\text{Total Correctly Classified}}{\text{Total Examples}}$$

- 3 Precision

$$\frac{\text{True Positives}}{\text{Total Examples Classified as Positive}}$$

- 4 Recall

$$\frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

- 5 F1 Score

$$\frac{2\text{TP}}{2\text{TP} + \text{FP} + \text{FN}}$$

**Question 9.** Often (but not always) how are precision and recall related?

**Question 10.** Between precision and recall, which is a better metric for,

- 1 Predicting good restaurants.
- 2 Predicting cancer.

Precision is better of predicting good restaurants and recall is better for predicting cancer.

**Question 11.** Between precision and recall, which metric is used in the Receiver Operator's Curve (ROC). What does the area under this curve tell us about a prospective classifier?

#### SUBMISSION INSTRUCTIONS

- 1 Submit a PDF that answers all the questions and includes any plots that the assignment asks for.  
Circle and/emphasize your final answer wherever possible.
- 2 Submit a Python file, e. g., `plot.py` that generates all the plots one by one.

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