# CS 444 Homework 1
# Due 23:00 Sunday, October 8, 2023

Homework must be typeset and converted to PDF. Handwritten answers will be rejected. Late submission gets zero. We use the Linux servers of the Computer Science Department to collect homework. Take the following steps:

- Apply for an account on the CS subnet within UMB at the CS portal http://portal.cs.umb/registration/registrar/
- Enter a username of your choice
- Enter your UMB email – you will receive a link to activate your CS account
- Enter a password of your choice
- After your CS account is activated, join CS 444
- You can find step-by-step directions at https://www.cs.umb.edu/~ghoffman/linux/apply_process.html
- To submit your homework, prepare one PDF file called **hw1.pdf** – the filename must be exactly **hw1.pdf**, otherwise it will not be collected. Common mistakes for filenames include **Hw1.pdf**, **HW1.pdf**, **hw1.hw1.pdf** and variations thereof.
- Upload the file to the cs444 folder linked to your home directory on the CS Linux server.

There are two questions in this homework.

1. The following table lists the character frequencies in a file.

| char | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| freq | 37 | 31 | 29 | 19 | 17 | 13 | 11 | 7 | 3 | 2 |

(a) Apply Huffman's algorithm to the data, and draw the prefix code tree. The leaves should be annotated with the characters and their frequencies, and internal nodes should be annotated with the total frequencies of their subtrees. When merging two subtrees, put the lower-weight subtree on the right.

(b) Fill out the following table. A left branch is 0, and a right branch is 1.

| char | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

You can draw the Huffman tree by hand, take a picture and include the image in the PDF file of your submission.

2. Consider the following arrivals of processes in an interactive system.

(a) Draw three timelines that illustrate the execution of these processes using

i. Shortest job first, SJF

ii. Nonpreemptive priority NPP – a smaller number has higher priority

iii. Round-robin, RR, with time slice 2

with the following data:

| Process | Arrival time | CPU time | Priority |
|---|---|---|---|
| P1 | 0 | 3 | 2 |
| P2 | 0 | 3 | 1 |
| P3 | 3 | 4 | 2 |
| P4 | 4 | 2 | 3 |
| P5 | 8 | 3 | 1 |
| P6 | 8 | 1 | 2 |

If there is a tie (same CPU time for SJF or same priority for NPP), use first-in-first-out (FIFO) to break the tie. For RR scheduling, if P1 is removed from the CPU and put in the waiting queue just when P3 arrives, P3 will be ahead of P1 in the queue.

(b) What is the average waiting time for RR?