UMass Boston CS 444
Homework 1
Posted Thursday, February 5, 2026
Due Thursday, February 12, 2026 at 11:59 pm

0 General Instructions

Homework must be typeset and converted to PDF format. Drawings must be drawn by hand, photographed and included in your file. Include your full name and your cs username at the top of page 1.

To submit your homework, prepare a PDF file called `hw1.pdf` — the filename must be exactly `hw1.pdf` because a script will collect it. Common mistakes for filenames include Hw1.pdf, HW1.pdf, hw1.hw1.pdf, which loses points. Upload the file to the `cs444` folder in your home directory on the CS Linux server. Practice uploading early and keep intermediate copies using a different names: for example, type: `cp hw1.pdf hw1-v1.pdf`. If you have trouble uploading, email operator@cs.umb.edu for help and copy jane.deblois@umb.edu. Not being able to upload to the server is not a valid excuse for an extension because this is a course in operating systems!

Homework 1 covers:

The textbook chapters: 1 Introduction, 2 Processes and Threads, and slides: ch1.pdf, ch2.pdf, huffman.pdf. The ASCII code chart and classwork on C code: crude_wc.c and endian.c.

For definitions, refer to textbook: 1.6.1 Figure 1-19, p55, 1.8.1 The C Language, 74-75, 1.8.2 Header Files, 75-76, 1.11 Metric Units, 80-81, 2.1.1 The Process Model, 86-88 (has timeline), 2.2.4 Figure 2-14, 108, 2.4.1 Figure 2-22, 122 (has timeline), 2.4.4 Sleep and Wakeup, 127, 2.5 Scheduling: Scheduling algorithm, nonpreemptive, p156, shortest job first, 160-161, round-robin, 162-163, 2.4.10 Priority Inversion 127, 150-151.

For ASCII code chart, C code and slides, refer to instructor website for cs444: https://www.cs.umb.edu/ hdeblois/cs444/f25/. C code is also on the CS server at /home/hdeblois/cs444/.

1 Metric prefixes from Ch1 and ASCII codes

a. How many nanoseconds in one second of time? Please write out all digits of the number.
b. How many bits per second is a 1 gigabit per second channel running at? Please write out all the digits of the number.
c. Kilo as a metric prefix means 1000 or 10^3 exept if it is measuring memory it means 1024 or 2^{10}. Suppose you have one kilobyte of memory drawn as a rectangle that is 8 bytes wide. How high is the rectangle in bytes?
d. Handwriting uses an alphabet and numbers. Computers show letters and numbers on the screen, but of course must use bits to store them. One ASCII code takes one byte of memory for a letter or number or non-printing character. For each of three characters, 'A', '9' and '?', write the codes in decimal, binary and hex.

2 Huffman coding

The following lists the character frequencies in a file:

Char:	1	2	3	4	5	6	7	8	9
Freq:	32	29	19	17	13	11	7	3	2

(a) Apply Huffman's algorithm to the above data and draw the prefix code tree in steps. The leaves should be annotated with the characters and their frequencies, and internal nodes should be annotate with the total frequencies of their subtrees. When merging two subtrees, put the lower-frequency subtree on the LEFT. Please make a series of drawings by hadn that show all your work from forest to complete tree. Please do not use a graphics program.
(b) Fill out the following table with the Huffman codes for each character. On the prefix code tree, a left branch is a 0 and a right branch is a 1. Assemble the code for each leaf node character by reading the branch numbers from top to leaf node. Make a chart of the characters and their codes.

Char:	1	2	3	4	5	6	7	8	9
Code:									

You can draw the Huffman tree by hand, take a picture and include the image in the PDF file of your submission. Be sure to take a picture at each step of your work, starting from individual frequencies for the characters. After you draw all the steps combining the frequencies, sorting as you go, then draw the tree again with the total frequency at the top.

3 Scheduling Processes

Consider the following arrivals of processes in an interactive system.
(a) Draw three timelines that illustrate the execution of processes P1 - P6 described in the table below using these scheduling algorithms:

i. Shortest job first, SJF
ii. Non-preememptive priority, NPP - a smaller number has higher priority
iii. Round-robin, RR - with time slice 2

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

(b) Describe the priority inversion problem discussed in Chapter 2 in two places. Answer these two questions:

i. What are the "unexpected effects" mentioned in 2.4.4 Sleep and Wakeup regarding the defects of busy waiting? Define two processes and explain.

ii. What happened on the Mars 1997 project mentioned in 2.4.10? Use the terms low, mid and high priority to explain.