Please read the instructions and questions carefully. You will be graded for clarity and correctness. You have 50 minutes to complete this exam, so focus on those questions whose subject matter you know well. This is a closed note and book exam. Write legibly and check your answers before handing it in.

**Short Answer - some will be one or two words – no more than 1 sentence. (40/100 points)**

1. (5pts) What does the tar utility do?

2. (5pts) What is the difference between a multi-user vs. multi-tasking operating system?

3. (5pts) What is a system call?

4. (5pts) What is the purpose of a device driver?

5. (5pts) What are the two ways to define a comment in C?

6. (5pts) What is a function prototype and what is it used for?

7. (5pts) What is the purpose of the **PATH** environment variable?
8. (5pts) What is a word size?

Long Answer - no more than 4 sentences (20/100 points)

15. (10pts) Explain the difference between user space and kernel space.

16. (10pts) Identify and define the three main abstractions upon which UNIX is based.
Programming/Word Problems - take your time and answer clearly and completely. (40/100 points)

15. (10pts) Draw the layout of the process virtual address space by labeling each of the regions of memory and defining (use arrows from regions to written definitions). Be sure to label the virtual addresses at the top and bottom of the process space.
// PROGRAM NESTED
#include <stdio.h>
#define mult(x,y) x=x*y
#define FOO
#define BAR
int main(void) {
#if 0
  printf( "Test A\n");
#elif 1
  printf( "Test B\n");
#elif 1
  ifndef BAR
      printf( "Test C\n");
  #elif 98
      ifdef FOO
          printf( "Test D\n");
      #endif
      ifdef FOO
          printf( "Test E\n");
      #endif
      printf( "Test F\n");
  #endif
  printf( "Test G\n");
  return(0);
}

16. (10pts)

Consider the code for the PROGRAM NESTED above. Write out the output of this program.
17. (10pts) Write the code for the function `count_vowels` that counts the number of vowels (aeiou, ignore y) in a C string. The function should return 0 if it has a non-zero length and return the number of vowels in a 16-bit unsigned integer parameter `vwls`. 
// PROGRAM DIMENSION

#include <stdio.h>
#include <stdint.h>

int main(void) {
    int32_t one_d[10], two_d[5][7], three_d[4][6][8];
    printf("One one_d=%p, one_d[4]=%p\n", one_d, &one_d[4]);
    printf("Two two_d=%p, two_d[3][2]=%p\n", two_d, &two_d[3][2]);
    printf("Three three_d=%p, three_d[2][4][1]=%p\n", three_d, &three_d[2][4][1]);
    return(0);
}

18. (10pts) Consider the PROGRAM DIMENSION program above. Complete the following output (and show your work calculating each of the ??? values below):

One one_d=0x7fff5e8bd7e0, one_d[4]=
Two two_d=0x7fff5e8bd750, two_d[3][2]=
Three three_d=0x7fff5e8bd450, three_d[2][4][1]=

- one_d[4] =

- two_d[3][2] =

- three_d[2][4][1] =

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