(25) Question 1. Design an analog amplifier with the following relationship

\[ V_{\text{out}} = 100 \cdot (V_1 - V_2) + 2.5 \]

\( V_1 \) and \( V_2 \) are analog inputs, and \( V_{\text{out}} \) is the analog output. You do not need to worry about input or output impedance. Your circuit will operate on a ±12 V supply using REF02 references and OP07 op amp(s). The REF02 creates a +5.00 reference voltage. Full credit will be given to proper solutions using one REF02 and one OP07 op amp. Show the analog circuit. Label all resistor values. You do not need to show the power supply connections for the OP07 and REF02.
(25) Question 2. Consider a problem of running two foreground threads using a preemptive scheduler with semaphore synchronization (like Lab 17.) There are three shared 8-bit global variables:

```
unsigned char In1, In2, Out;
```

First, the client thread should create two pieces of data and store them in In1 and In2. Once new data is available in In1 and In2, the server thread should calculate the maximum of these two numbers and place the result in Out. Once new calculation is complete and the result is available in Out, the client thread should output the result. The basic shell of this operation is given. Define one or more semaphores, then add calls to the following three functions in order to properly synchronize the interactions between client and server.

```
int OS_InitSemaphore(Sema4Type *semaPt, short value);
void OS_Wait(Sema4Type *semaPt);
void OS_Signal(Sema4Type *semaPt);
```

You will define one or more semaphores and calls to the semaphore functions, otherwise no other changes are allowed. For each semaphore you add, explain what it means to be 0, 1 etc. Assume client is run first.

```c
void client(void){
    DDRA=DDRB=0; // Ports A, B are input
    DDRC=0xFF;   // Port C is an output
    while(1){
        In1=PORTA; // read first input
        In2=PORTB; // read second input
        PORTC=Out; // output the result
    }
}

void server(void){
    while(1){
        if(In1>=In2){
            Out = In1; // In1 is larger
        }
        else{
            Out = In2; // In2 is larger
        }
    }
}
```
(25) **Question 3.** You have a 10-bit 0 to +5V digital to analog converter (DAC) and use it to create an analog output wave. The maximum slope (slew rate) of the desired wave is 100V/s, and the output rate is 1000 samples/sec. This means a periodic interrupt will output a new value to the DAC every 1 ms. What is the expected maximum error (i.e., difference between the desired wave and the actual analog output)?

(25) **Question 4.** A transducer has the following quadratic relationship

\[ T = 0.0083R^2 - 12.465R + 6632 \]

where T is the temperature and R is the resistance. Write a C function using fixed-point math (integer calculations) that takes R as an input and gives T as an output. **DO NOT IMPLEMENT TABLE-LOOKUP WITH LINEAR INTERPOLATION.** Implement the quadratic equation directly. The domain of R is 200 to 640, and the range of T is 2000 to 4500.