ECE 2504: Introduction to Computer Engineering
Homework Assignment 9 (50 points)

1. (12 points) Specify the 16-bit control word that must be applied to the datapath of the single-cycle simple computer in Chapter 9 of your textbook (See Fig 9-11) to implement each of the following micro-operations. Use the control word fields shown in Figure 9-16.

   a. R4 ← sl R5
   **DA AA BA MB FS MD RW**
   **100 XXX 101 0 1110 0 1**
   b. R7 ← Data in
   **DA AA BA MB FS MD RW**
   **111 XXX XXX X XXXX 1 1**
   c. R1 ← R3 – Constant in
   **DA AA BA MB FS MD RW**
   **001 011 XXX 1 0101 0 1**
   d. R4 ← R3 + R5
   **DA AA BA MB FS MD RW**
   **100 011 101 0 0010 0 1**

2. (9 points) Given the following 16-bit control words for the same datapath, determine the micro-operation that is executed (in RTL), and the change in register contents. Use the following assumptions.

   - Prior to execution of the given control word, the registers contain the value of their number (e.g. R5 contains 0x05).
   - Constant has value 0x06
   - Data in has value 0x1B

   a. 101 100 101 0 1000 0 1 DA AA BA MB FS MD RW
      **R5 <- R4 ^ R5**
   b. 101 110 000 0 1100 0 1
      **R5 = R0**
   c. 100 100 000 1 1101 0 1
      **R4 = sr Constant In**

3. (12 points) A computer has a 32-bit instruction word broken into fields as follows: a six-bit wide opcode; two five-bit wide register fields; and a 16-bit wide immediate operand/register field.

   a. What is the maximum number of operations that can be specified?
      **2^6 or 64 operations operations maximum**
   b. How many registers can be addressed by either of the register fields?
      **32 or 2^5 registers can be specified**
   c. If the immediate operand is used as an unsigned address to memory, what is the maximum number of words that can be addressed in memory?
      **65536 or 2^15 words can be placed maximum**
   d. What is the range of signed 2's complement immediate operands that can be provided?
      **+- 32768**

4. (12 points) A digital computer has a memory unit with a 32-bit instruction and a register file with 64 registers. The instruction set consists of 130 different operations. There is only one type of instruction format, with an opcode, a register file address, and an immediate operand. Each instruction is stored in one word of memory.

   a. How many bits are needed for the opcode?
      **8 bits since 2^8 is 256 which is the next largest number capable of storing all 130 operations.**
   b. How many bits are needed for the register field?
      **6 bits since 2^6 is 64 which is capable of storing all the registers**
   c. How many bits are left for the immediate operand?
      **18 bits since the opcode takes up 8 and the register takes up 6 bits. And 32-14 = 18 bits**
   d. If the immediate operand is used as an unsigned address to memory, what is the maximum number of words that can be addressed in memory?
      **262144 or 2^18 as that is how many numbers/space capable in 18 bits.**
   e. What is the range of signed 2's complement immediate operands that can be provided?
      **+- 131072 which is half of 262144 since 2s complement can contain both positive and negative numbers split between its total amount of storage capacity which totals 262144 in the end.**

5. (5 points) Give an instruction for the single cycle computer that resets register R4 to 0 and updates the *Z* and *N* status bits based on the value 0 loaded into R4. By examining the ALU logic provided in Chapter 9, determine the values of the V and C status bits.

**Where the micro operations is thus:**

**R4 <- 0**

**DA AA BA MB FS MD RW**
**100 000 000 0 1010 0 1**

**Where we are setting operand A and operand B to be the same register – in this case Register 0 – so that we may use the operation of XOR (FS code 1010). This will produce a final value of 0 since all the values are XOR'ed together. Mux B should thus be set to 0 to allow us use of Operand A and operand B. Mux D should be set to 0 for we are not expecting data in and are just using the general Function Unit. This is also the case because we are required to update the Z and N status bits which are in the function unit, thus making the choice of setting Mux D to a value 0 the obvious one. Lastly, this is a function where we are 'writing' the value of 0 to a register R4 and so RW will be set to 1.**

**The values of N will be 0 and Z will be 1 when the operation completes. This is because the value is indeed 0 (so Z = 1)once it is finished and where the sign is not negative ( so N = 0). V and C are still equal to 0 as overflow and a carry in did not happen.**