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
   b. R7 ← Data in
   c. R1 ← R3 – Constant in
   d. R4 ← R3 + R5

a.

DA	AA	BA	MB	FS	MO	RW
100	xxx	101	0	1110	0	1

b.

DA	AA	BA	MB	FS	MO	RW
111	xxx	xxx	x	xxxx	1	1

c.

DA	AA	BA	MB	FS	MO	RW
001	011	xxx	1	0101	0	1

d.

DA	AA	BA	MB	FS	MO	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
b. 101 110 000 0 1100 0 1
c. 100 100 000 1 1101 0 1

	DA	AA	BA	MB	FS	MD	RW
a.	101	100	101	0	1000	0	1
	R5	R4	R5	B	∧		

R5 ← R4 ∧ R5

1) 101 ← 100 ∧ 101 2) R5 = 101

b.	101	110	000	0	1100	0	1
	R5	R6	R0	B	F=B		

R5 ← R0

1) 101 ← 000 2) R5 = 000

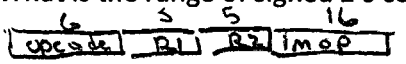
c.	100	100	000	1	1101	0	1
	R4	R4	R0	Constant	SR(B)		

R4 ← SR(constant)

1) 100 ← SR(110) 2) R4 = 011

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?
   b. How many registers can be addressed by either of the register fields?
   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?
   d. What is the range of signed 2's complement immediate operands that can be provided?



a) $m=6$, $2^m = 2^6 = 64$ operations

b) $2^5 = 32$ different Registers

c) $2^{16} = 65536$

d) from $+32767$ to -32767

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?
   b. How many bits are needed for the register field?
   c. How many bits are left for the immediate operand?
   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?
   e. What is the range of signed 2's complement immediate operands that can be provided?

a) 8 bits ; $2^8 = 256 > 130$

b) 6 bits because $2^6 = 64$ registers.

c) 18 bits

d. $2^{18} = 262144$

e. from $+131071$ to -131071

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.

R4 ← 8'b0

DA	AA	BA	MB	FS	MD	RW
100	xxx	xxx	1	1100	0	1

Constant = 000

N will be updated to 0 after the operation (reset) completes and the output exits.

V and C will also be 0.

Z will be updated to 1 after the operation