(a) Block diagram

15 14 13	12 11 10	9 8 7	6	5 4 3 2	1	0
DA	AA	BA	M B	FS	M D	R W

1) Given the following 16 bit control words for the data-path above determine the micro-operation that is executed.

a) 101 100 101 0 1000 0 1
b) 000 101 111 1 1101 0 1

2) Given the sequence of 16 bit control words below for the data-path above, and initial ASCII character codes in 8bit registers, simulate the data-path to determine the alphanumeric characters in the registers after the execution of the sequence.

011 011 001 0 0010 0 1	R0	01100101
100 100 001 0 1001 0 1	R1	01110010
101 101 001 0 1010 0 1	R2	01110010
001 001 000 0 1011 0 1	R3	01101111
001 001 000 0 0001 0 1	R4	01110010
110 110 001 0 0101 0 1	R5	01101001
111 111 001 0 0101 0 1	R6	01101110
001 111 000 0 0000 0 1	R7	01100111

DA, AA, BA		MB		FS		MD		RW	
Function	Code	Function	Code	Function	Code	Function	Code	Function	Code
R0	000	Register	0	$F = A$	0000	Function	0	No Write	0
R1	001	Constant	1	$F = A + 1$	0001	Data in	1	Write	1
R2	010			$F = A + B$	0010				
R3	011			$F = A + B + 1$	0011				
R4	100			$F = A + \overline{B}$	0100				
R5	101			$F = A + \overline{B} + 1$	0101				
R6	110			$F = A - 1$	0110				
R7	111			$F = A$	0111				
				$F = A \wedge B$	1000				
				$F = A \vee B$	1001				
				$F = A \oplus B$	1010				
				$F = \overline{A}$	1011				
				$F = B$	1100				
				$F = \text{sr } B$	1101				
				$F = \text{sl } B$	1110				

3) Specify the control word that must be applied to the data-path above to implement the following micro-operations. NOTE: some operations may take more than one cycle to complete.

   a) R1 ← SL R1

   b) R3 ← MOVB R1

   c) R1 ← MOVA R2

   d) R1 ← INC R1 1

   E) R3 ← R1 XOR Constant

4) Add the following two instructions to the design done in class. Specify the control words required that must be added to the control unit / data-path showcased in class. The op-code field of the instruction format must increase by 1, which is ok since the register fields decreased by 1.

   jmp label:

   AddMul R1 R2 const, which performs R1+R2 * const