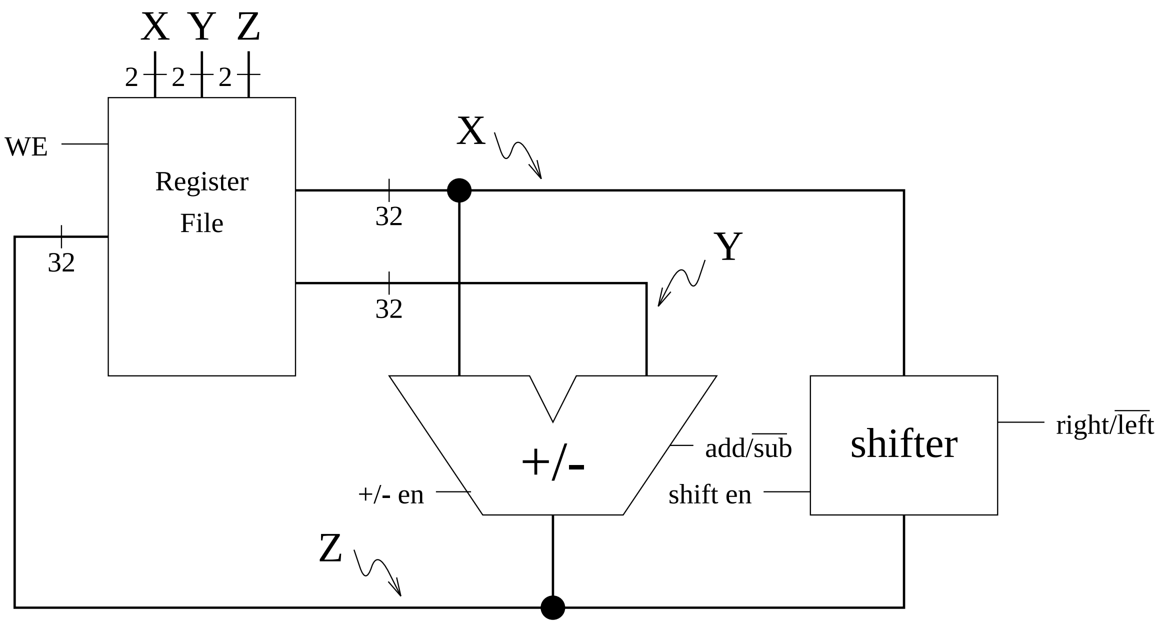
Microcode

The datapath below incorporates an adder/subtractor and a one bit shifter. The arithmetic operation is specified by the $add/\overline{sub}$ control line. The subtraction is X - Y. The shift direction is controlled by the $right/\overline{left}$ control line. The enable signals determine which functional unit drives the Z bus. The datapath also contains a register file with four registers. On each cycle, one add/sub *or* shift operation can occur in the datapath.



Part A Write microcode for this datapath to compute the average of the four initial values in the register file, leaving the result in register zero. You may modify other any register once its value has been summed. Put your answers in decimal (i.e., to select register two on the X bus, put a 2 in the X column).

cycle	X	Y	Z	WE	$add/\overline{sub}$	$+/-$ $enable$	$right/\overline{left}$	$shift\,enable$
1								
2								
3								
4								
5								

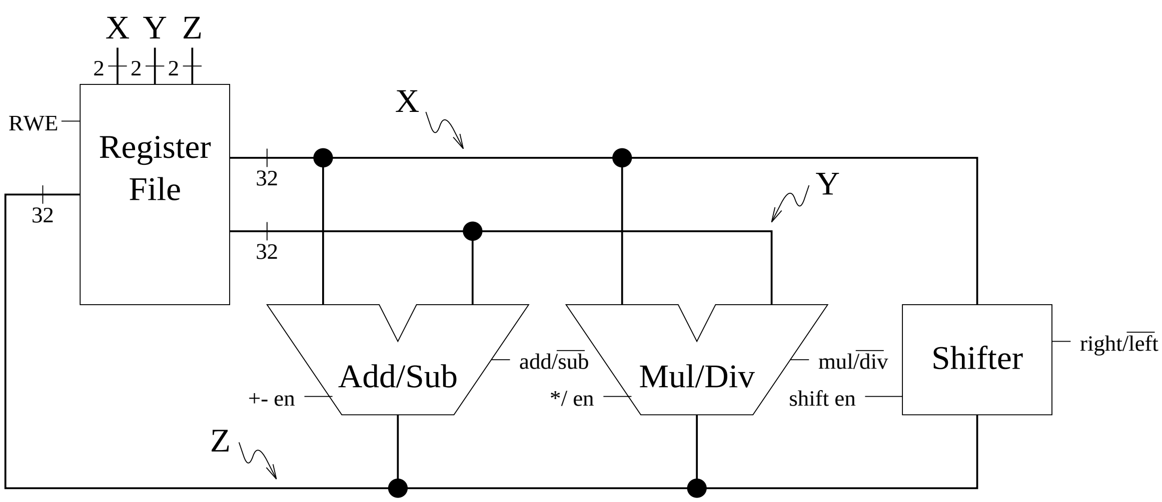
Part B Write microcode for this datapath to compute the function:

$$R_0 = (R_1 + R_3)/2 + 4(R_2 - R_0)$$

You may modify any register once its initial value has been used. Put your answers in decimal.

cycle	X	Y	Z	WE	$add/\overline{sub}$	$+/-$ $enable$	$right/\overline{left}$	$shift\,enable$
1								
2								
3								
4								
5								
6								
7								
8								

Part C The datapath below incorporates an adder/subtractor, multiply/divider, and a one bit shifter. An arithmetic operation is specified by the $add/\overline{sub}$ and $mul/\overline{div}$ control lines. Subtraction is $(X - Y)$; division is (X/Y). The shift direction is controlled by the $right/\overline{left}$ control line. The enable signals determine which functional unit drives the Z bus. The datapath also contains a register file with four registers.



Write microcode for this datapath to compute the function below. The initial values of the registers should be used in the equation. Any register may be modified once its initial value has been used for the last time. Express all signals in octal notation (i.e., to select register two on the X bus, put a "2" in the X column).

$$R_0 = \frac{(R_0 - 2R_1)(\frac{R_2}{4})}{(R_3 + R_0)}$$

cycle	X	Y	Z	RWE	$add/\overline{sub}$	$+-\ en$	$mul/\overline{div}$	*/en	$right/\overline{left}$	$shift\,en$
1										
2										
3										
4										
5										
6										
7										
8										

Part D Using the datapath above, write microcode for this datapath to compute the function below.

$$R_0 = \frac{(R_3 - 3R_1)R_2}{(R_1 + R_0)^2}$$

cycle	X	Y	Z	RWE	$add/\overline{sub}$	$+-\ en$	$mul/\overline{div}$	*/en	$right/\overline{left}$	$shift\,en$
1										
2										
3										
4										
5										
6										
7										
8										

Part E For the datapath above, write microcode for this datapath to compute the function below. The initial values of the registers should be used in the equation. Modify **only** R_0. All other registers should be unchanged by this procedure. Use only registers R_0, R_1, R_2, and R_3.

$$R_0 = \frac{(R_1 - 12R_2)^2}{R_3}$$

cycle	X	Y	Z	RWE	$add/\overline{sub}$	$+-en$	$mul/\overline{div}$	*/en	$right/\overline{left}$	$shift\,en$
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Part F Write microcode for this datapath to compute the value ($5R_3$) leaving the result in R_0.

cycle	X	Y	Z	RWE	$add/\overline{sub}$	$+-en$	$mul/\overline{div}$	*/en	$right/\overline{left}$	$shift\,en$
1										
2										
3										
4										

Part G Write microcode for this datapath to exchange the contents of R_1 and R_2. Use only registers R_1 and R_2. Don't worry about overflows.

cycle	X	Y	Z	RWE	$add/\overline{sub}$	$+-en$	$mul/\overline{div}$	*/en	$right/\overline{left}$	$shift\,en$
1										
2										
3										
4										

Part H Write microcode for this datapath to compute the function below. For this part, use only R_0, R_1, R_2.

$$R_0 = \frac{(3R_0 - R_1)(R_2 + R_1 - R_0)}{2}$$

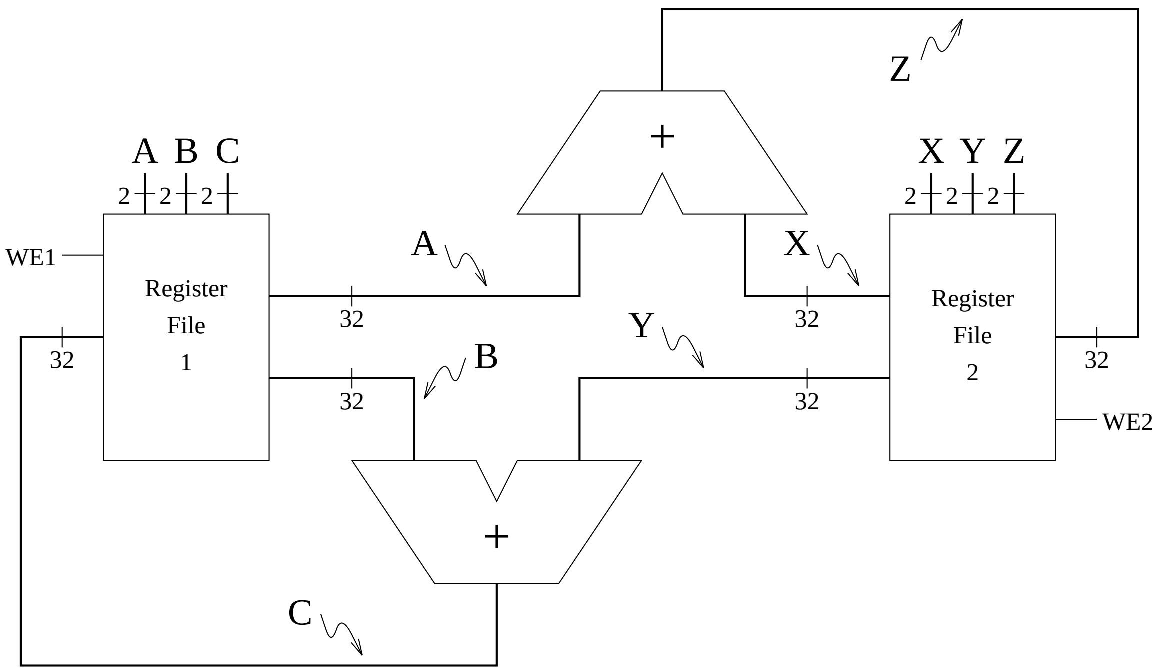
cycle	X	Y	Z	RWE	$add/\overline{sub}$	$+-\ en$	$mul/\overline{div}$	$*/$ en	$right/\overline{left}$	$shift\,en$
1										
2										
3										
4										
5										
6										
7										
8										

Part I For the datapath above, describe each microcode instruction below using register transfer notation (e.g., $R_0 \leftarrow R_1 + R_2$). Then deduce the expression computed by the microsequence.

cycle	X	Y	Z	RWE	$\frac{add}{\overline{sub}}$	$+-$ en	$\frac{mul}{\overline{div}}$	$*/$ en	$\frac{right}{\overline{left}}$	$shift$ en	description
1	3	2	2	1	0	0	0	1	0	0	
2	2	0	2	1	0	0	0	0	0	1	
3	1	0	1	1	0	0	0	0	1	1	
4	1	0	1	1	0	0	0	0	1	1	
5	2	1	1	1	1	1	0	0	0	0	
6	1	0	0	1	0	0	0	1	0	0	

R_0 = ____

Part J The datapath below incorporates **two** adders which can operate in parallel. It also has two register files, each containing four registers, to supply operands to the adders and store the results. On each cycle, up to **two** additions can occur in this datapath. Your task is to write microcode for this datapath to sum all eight initial values in the register files, leaving the result in register zero of register file 1. You may modify other any register once its value has been summed. For register file 1, A and B are the read ports, and C is the write port. For register file 2, X and Y are the read ports and Z is the write port. Be sure you understand the bus connections in the datapath before you begin. Since there are eight registers, seven additions need to be performed. With two additions per cycle, you should require four datapath cycles to complete the operation. Put your answers in decimal (i.e., to select register 2 on the A bus, put a two in the A column).



cycle	A	B	C	WE_1	X	Y	Z	WE_2
1								
2								
3								
4								