COMPUTER SYSTEMS AND ORGANIZATION

Part 1

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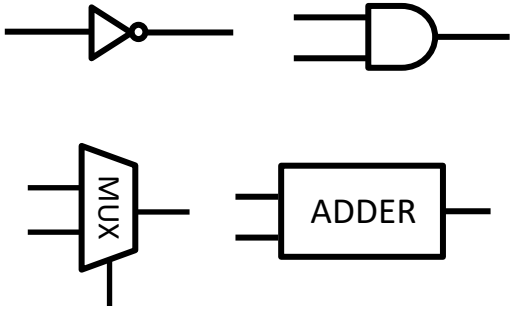
ENGINEERING

REVIEW

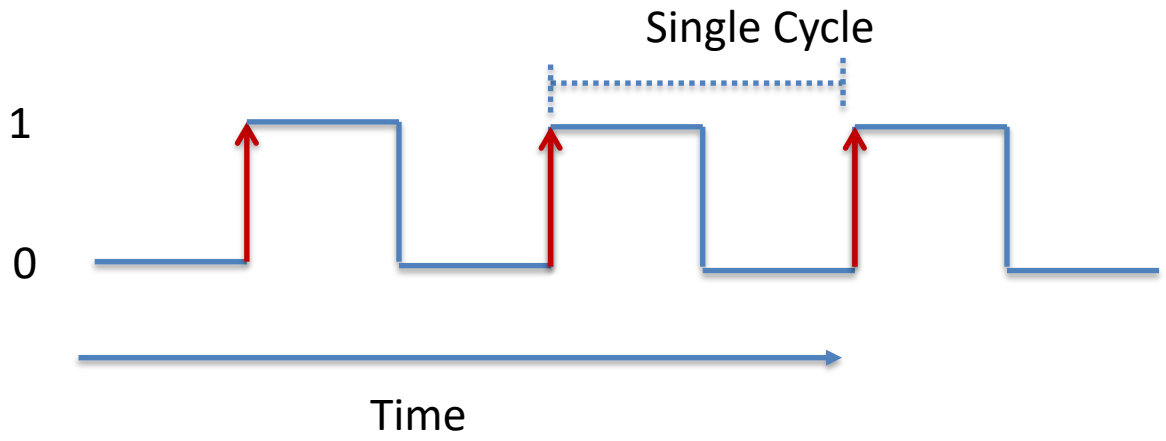
- ✓ What are logic gates?
- ✓ How to make circuits like Multiplexers, Adders?
- ✓ How to represent numbers in different formats?
- ✓ How to store data in registers?



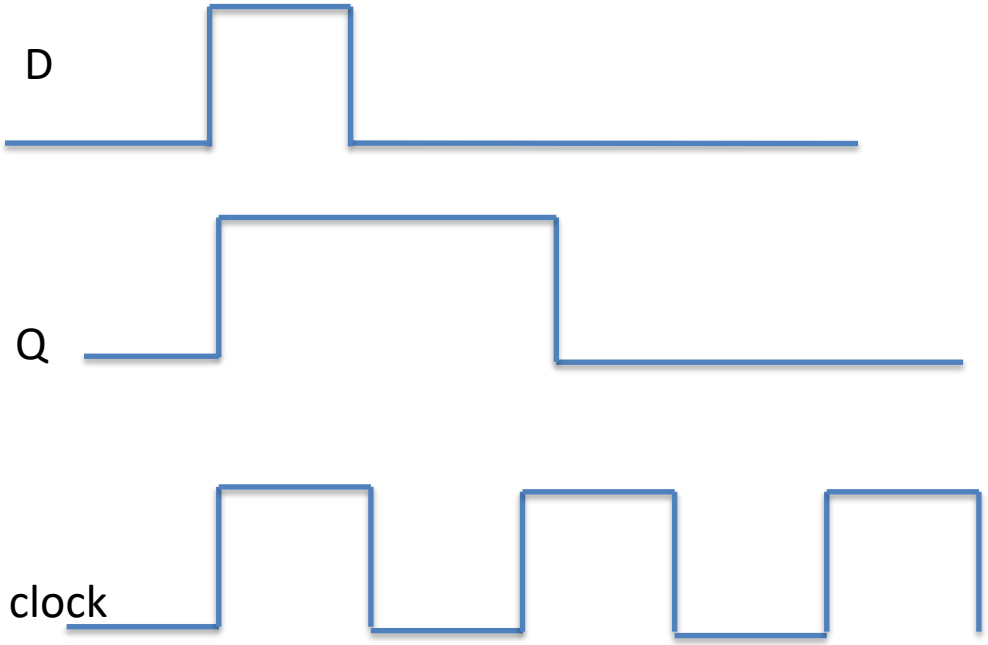
Binary: 0110 Hex:0xAF23

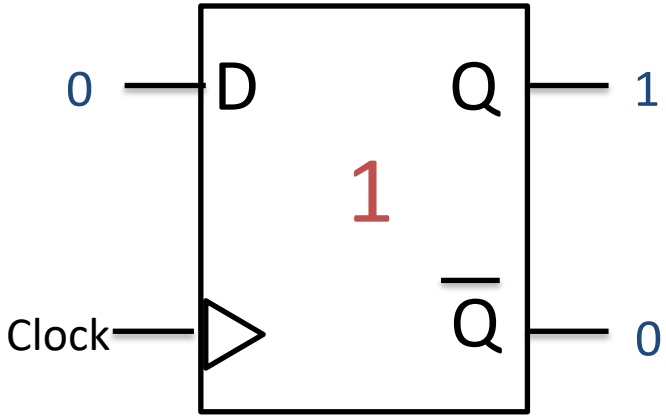
CLOCKS EDGES

Rising Edge (Also called positive edge)

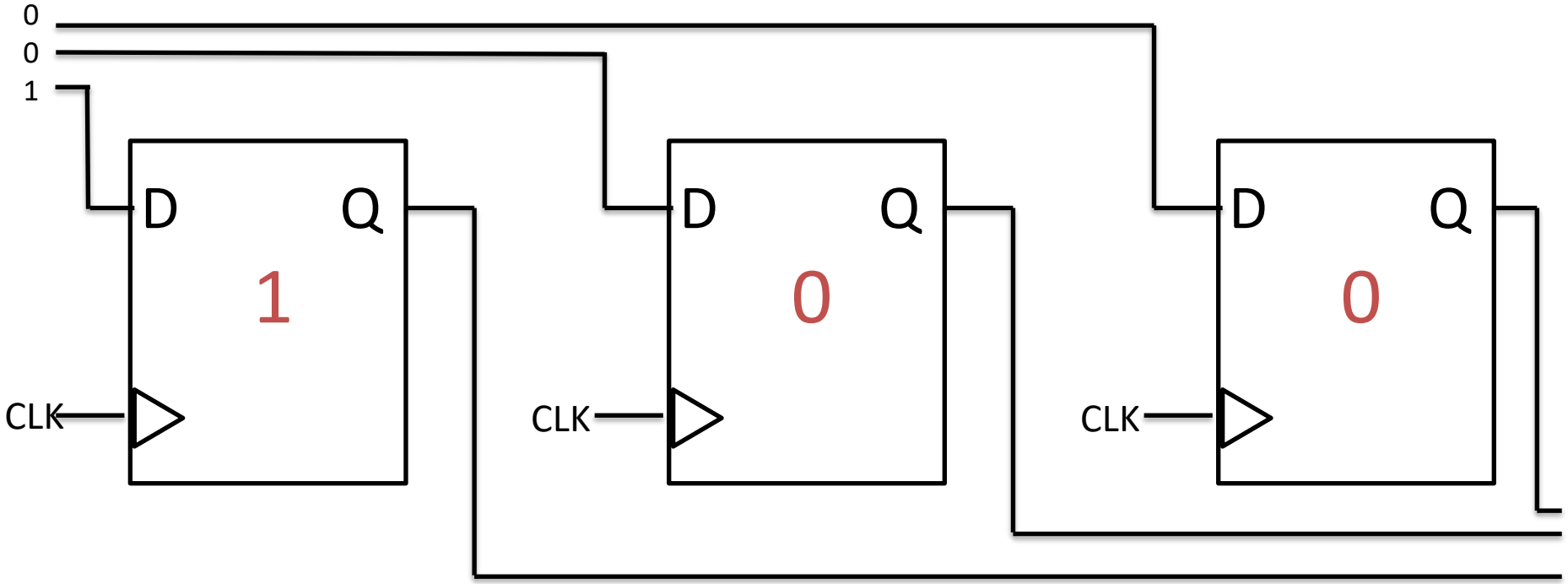


THE FLIP FLOP HOLD HOLDS THE VALUE FOR A CLOCK CYCLE





BUILDING A REGISTER FROM FLIP FLOPS



Removed Q (bar) for reability

3-BIT COUNTER

Let's put it all together and build a 3-bit counter

Circuit that counts from

000,

001,

010,

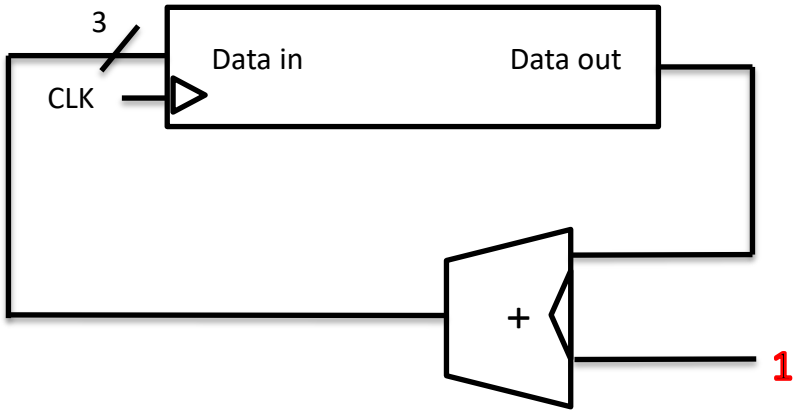
011,

100,

101,

110,

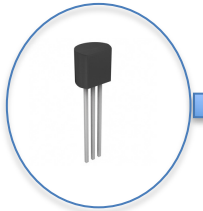
111

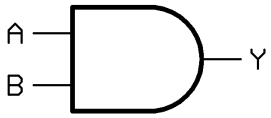


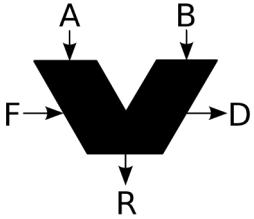
TODAY'S LECTURE

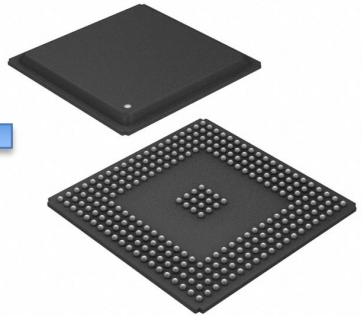
1. How do we use registers as building block to design a computer?
2. What is a register file and how to implement it?
3. Other memory components

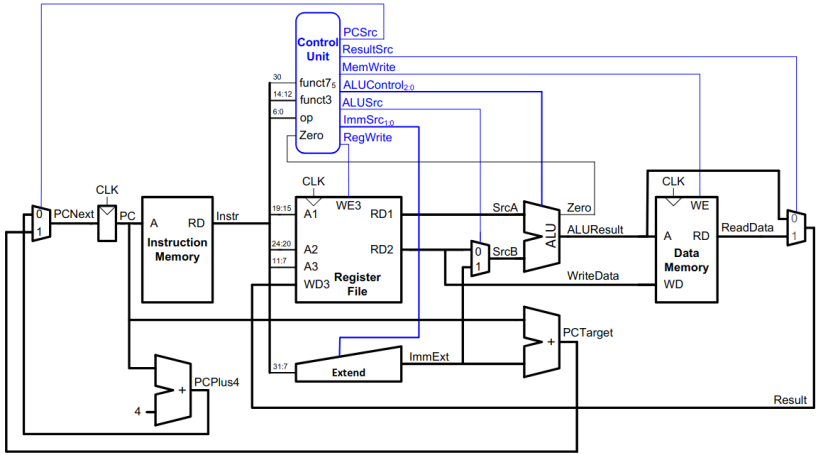
THE MAP (THE MACHINE)





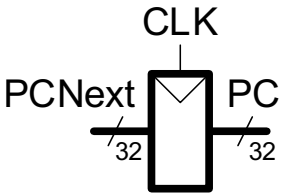


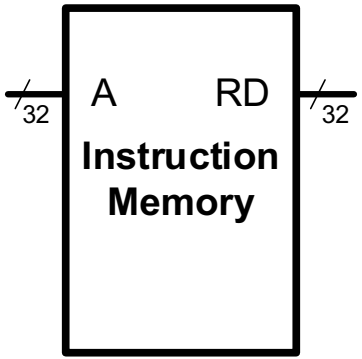


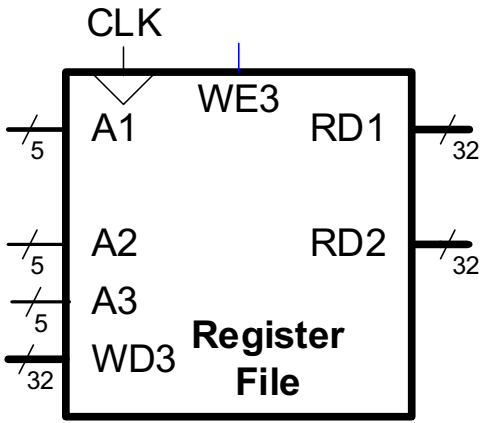


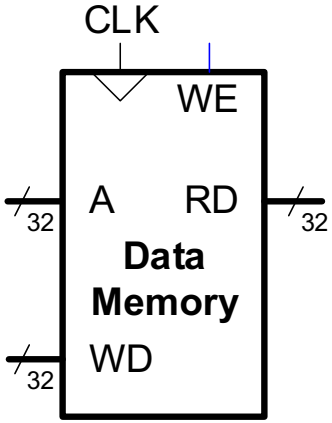
https://github.com/MKrekker/SINGLE-CYCLE-RISC-V

MEMORY COMPONENTS OF A PROCESSOR

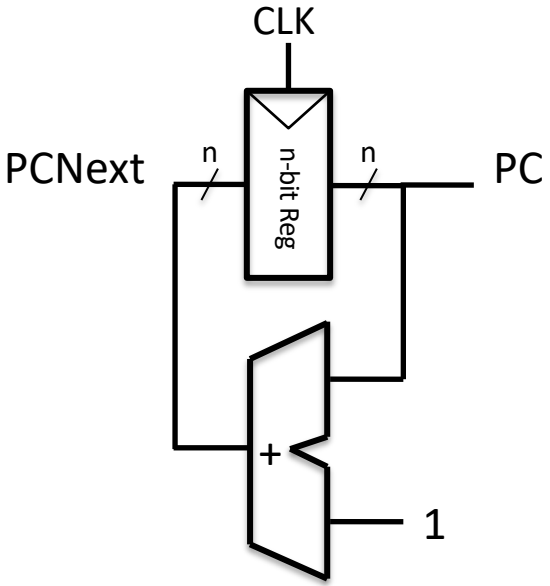






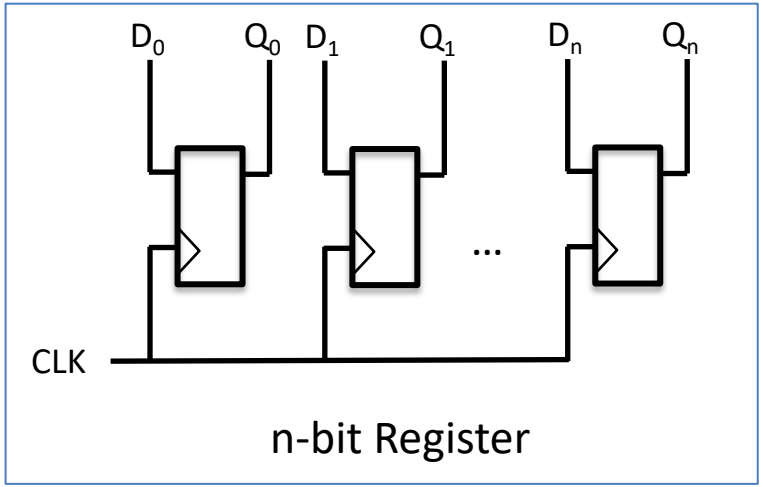


PROGRAM COUNTER



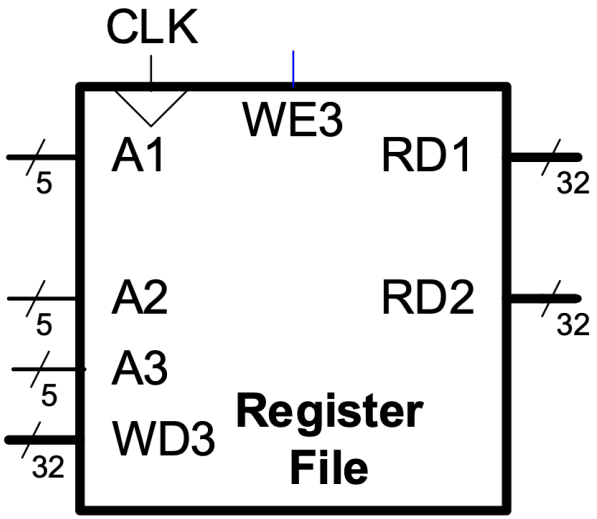
n-bit PC

- To track where we are in a program



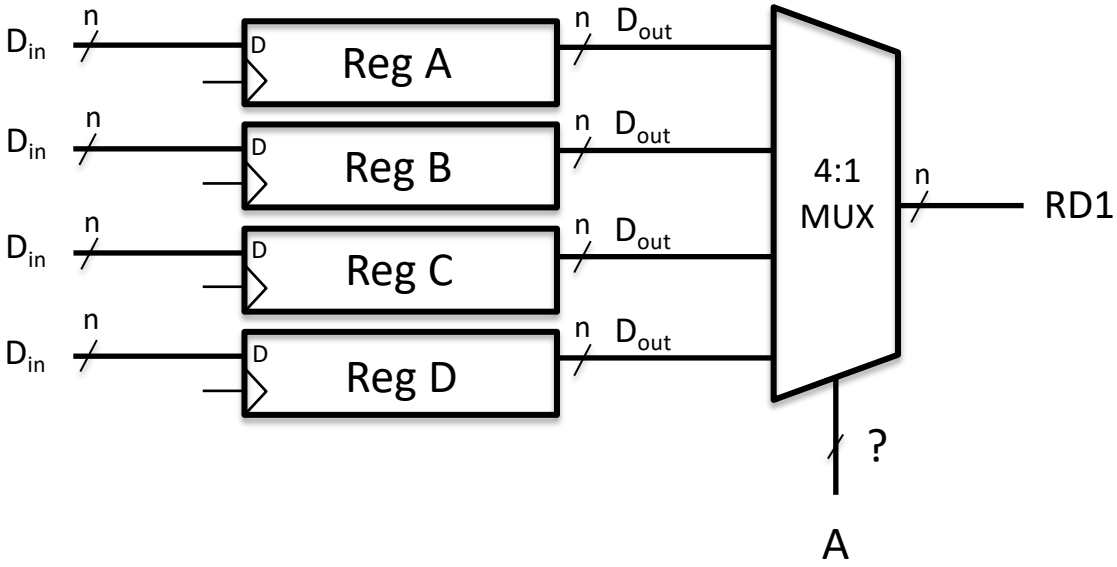
REGISTER FILE

- Temporary storage location
- Stores immediately needed variables

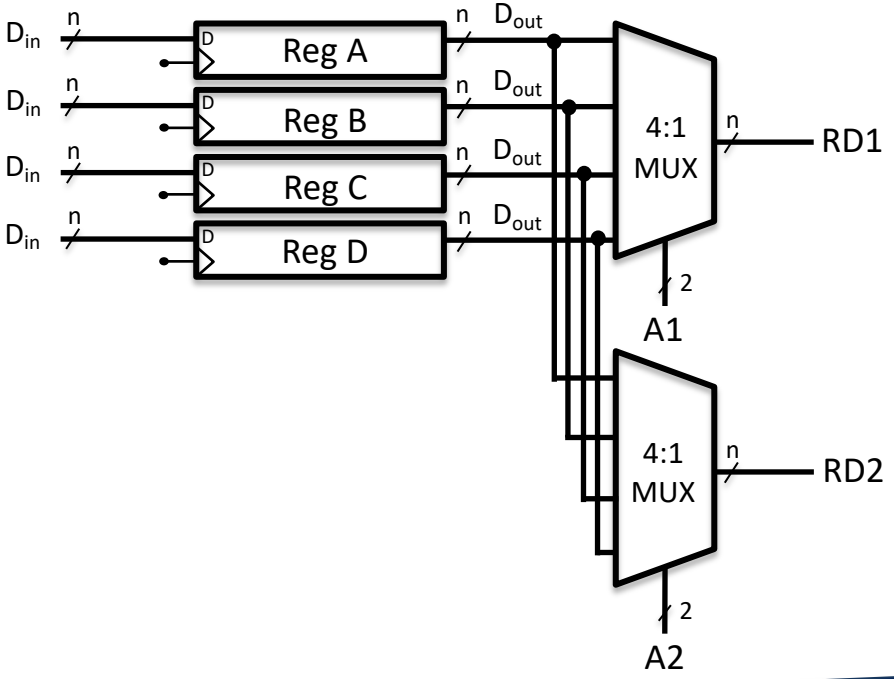


LET'S BUILD A REGISTER FILE OF FOUR REGISTERS

READ FROM A REGISTER FILE



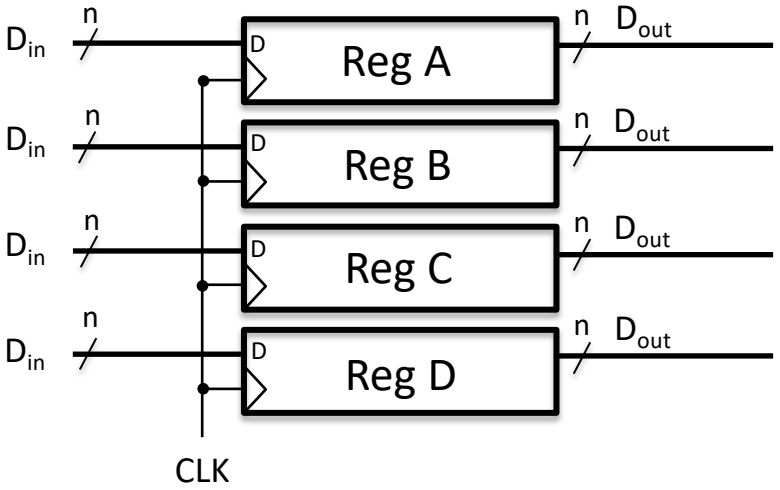
READ FROM A REGISTER FILE



WRITE TO A REGISTER FILE

We want to write to a particular register.

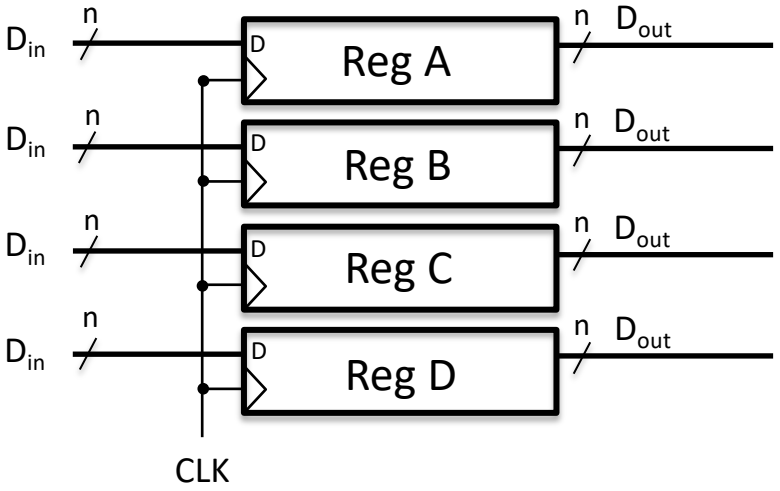
Do you see a problem with this circuit?



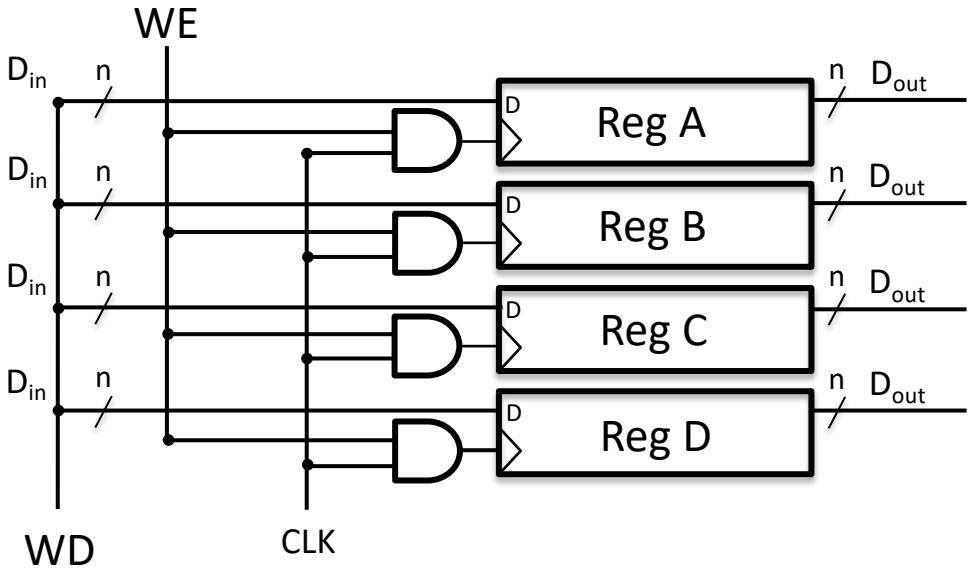
WRITE TO A REGISTER FILE

Additional input signals:

1. Write enable
2. Address of the register to be written (A3)



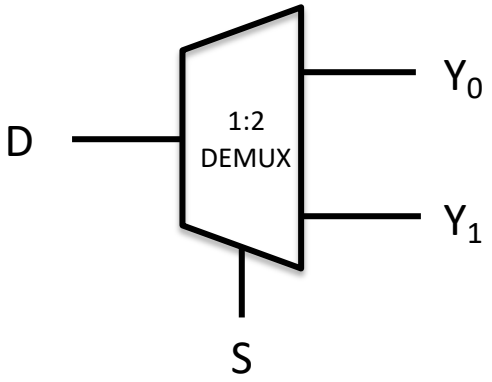
WRITE TO A REGISTER FILE



Are we missing a component?

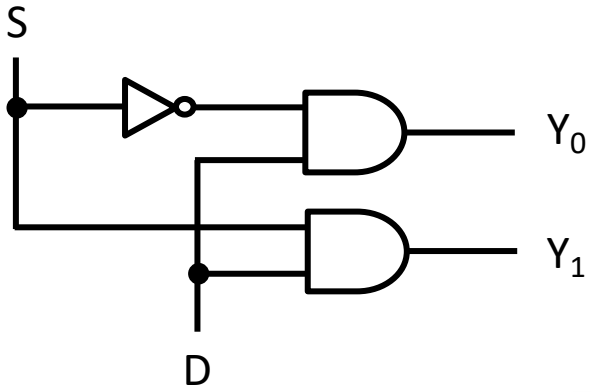
DEMULTIPLEXER (DEMUX)

Example: **1:2 Demux**

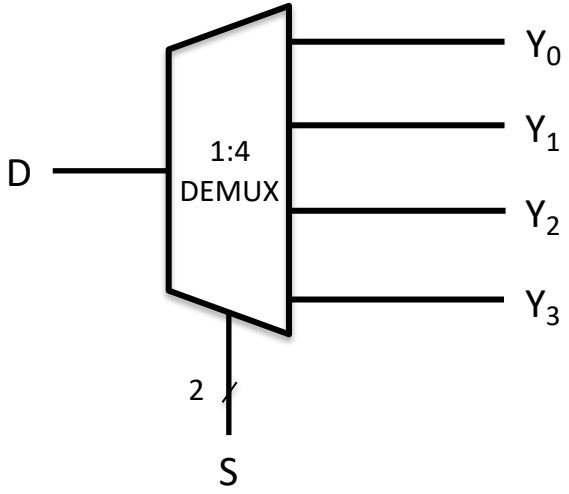


S	Y0	Y1
0	**D**	0
1	0	**D**

- Connects one input to one of the **N** outputs
- **Select** input is **$\log_2 N$ bits** – control input



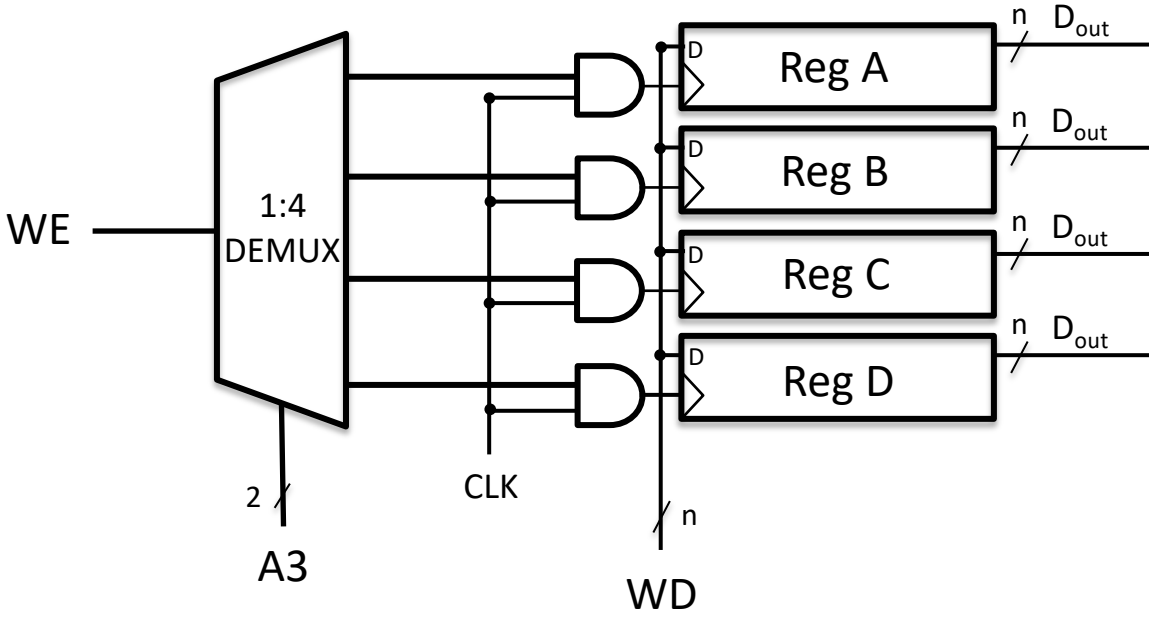
HIGH-ORDER DEMULTIPLEXER



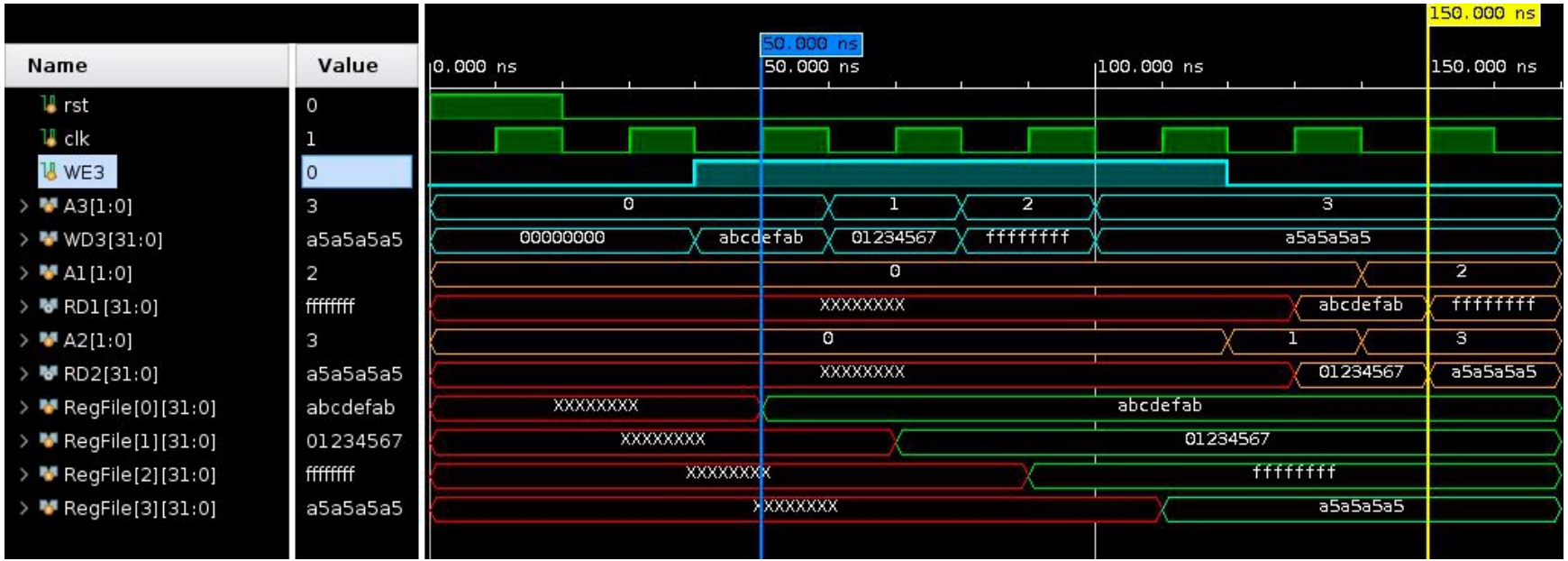
S	Y0	Y1	Y2	Y3
00	**D**	0	0	0
01	0	**D**	0	0
10	0	0	**D**	0
11	0	0	0	**D**

Can you implement higher-order demuxes like 1:8, 1:16, 1:64 using lower-order demuxes?

WRITE TO A REGISTER FILE



TIMING DIAGRAM

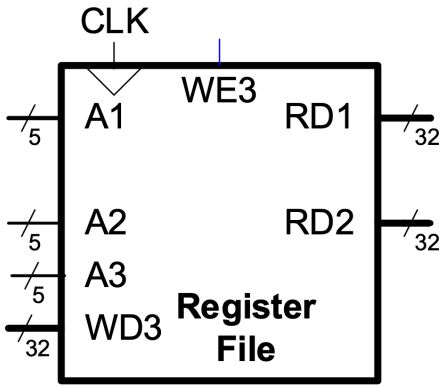


32 32-BIT REGISTER FILE

Simultaneously read from two registers and write into one register

Components:

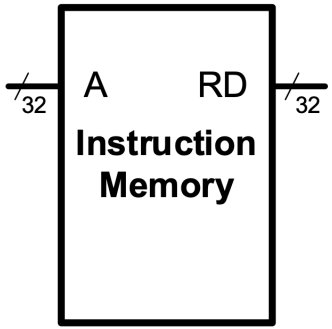
1. Multiplexers
2. Registers
3. Demultiplexers



INSTRUCTION MEMORY

- Stores the program

➢ Read data (RD) for a given address (A)

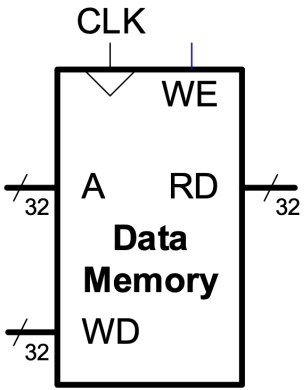


For this class, we will assume we cannot write to Instruction Memory.

DATA MEMORY

- Contains data needed by the program

- Read data (RD) from a given address (A)
- Write data (WD) to a given address (A)



IS THIS IT?

- Are the RAMs in your laptop just made of flipflops?
- Are your hard disks in your computer systems just made of flipflops?
- Do you have other memory components in your computer?

MEMORY HIERARCHY

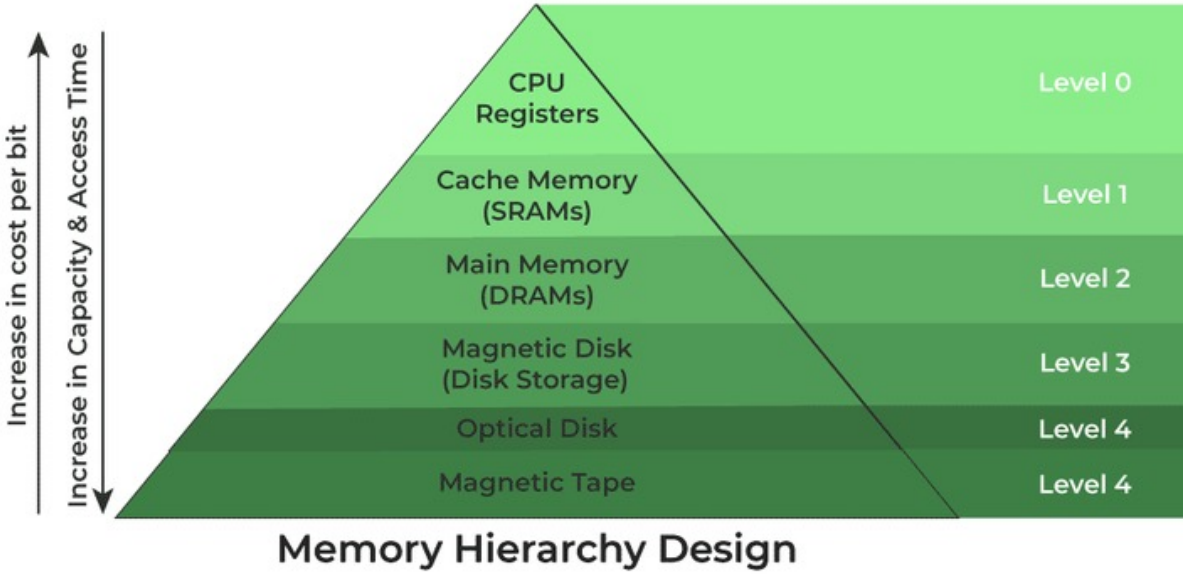


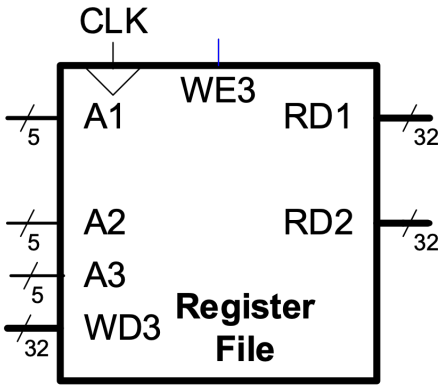
Figure from: https://www.geeksforgeeks.org/memory-hierarchy-design-and-its-characteristics/

EXERCISE

What should be the input signals to

1. write 0xABCD to Register #8?
2. read from Register #31 and Register #16?

Register counting starts from 0



QUESTIONS?