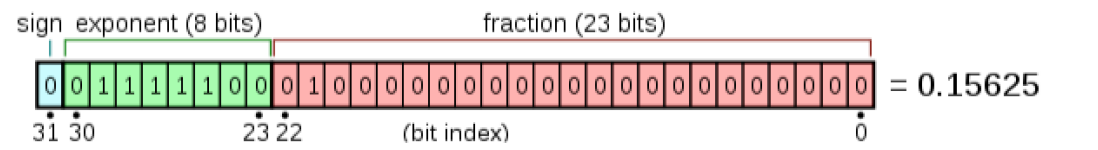
QUESTION 1 *NUMBER SYSTEMS*

(a) Convert the following numbers. You need to show workings to get points!

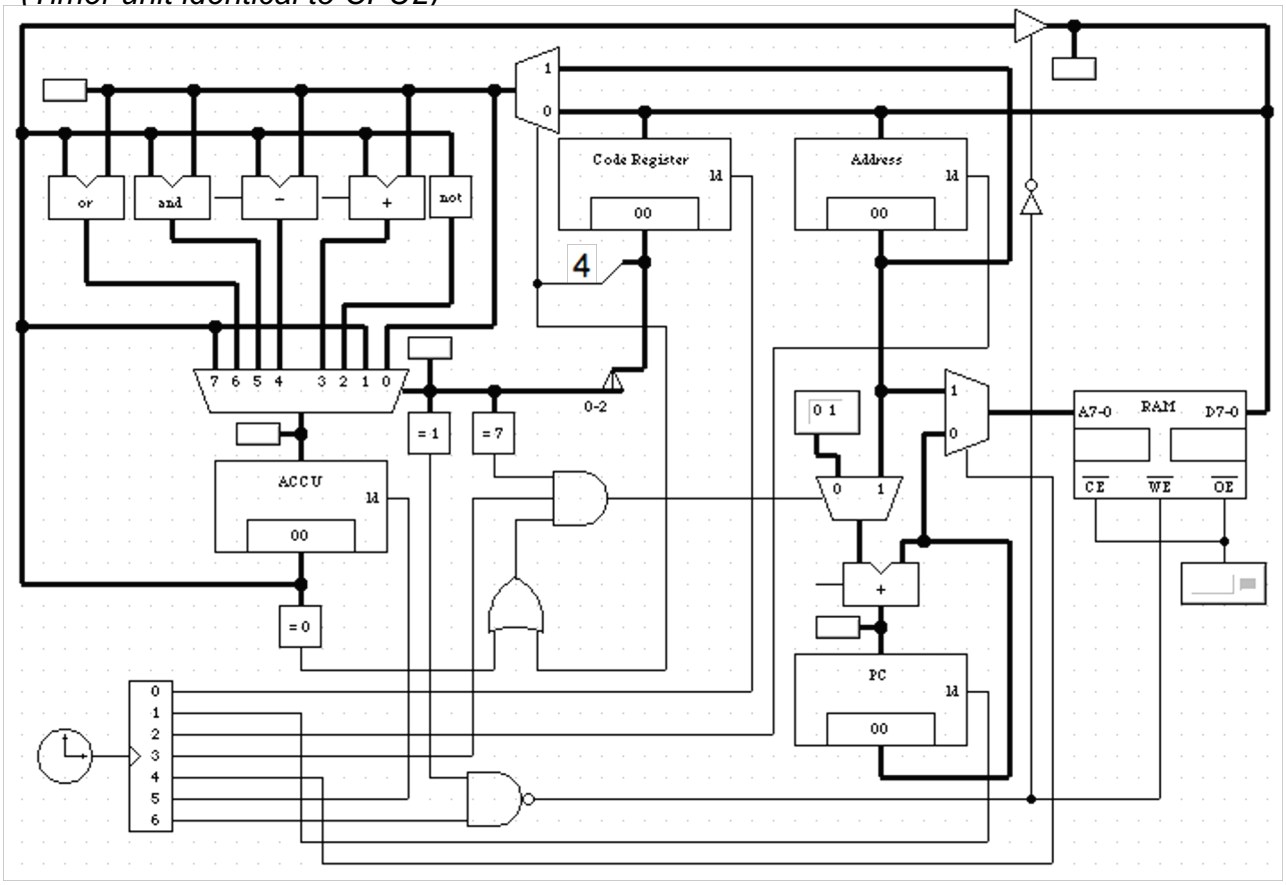
GIVEN	VALUE	CONVERT TO	ANSWERS
Binary **signed**	1010 1010	Decimal	
Binary **signed**	11111 0001	Decimal	
Decimal	88	Radix-8, **unsigned**	
Radix-8, **unsig**.	421	Decimal	
Binary fixed pt.	1101.011	Decimal	
Decimal	42.875	Binary fixed pt.	
IEEE FP	1 1000 0100 1111111 00000000 00000000	Decimal FP	
IEEE FP	0 0000 0000 1000000 00000000 00000000	Decimal FP	
Decimal FP	0.1	IEEE FP (5 decimals)	
Decimal FP	-33.3	IEEE FP (3 decimals)	



Def.: $\text{Number}_{10} = (-1)^{\text{sign}} * 2^{(\text{exponent}-127)} * 1.\text{fraction}_2$

QUESTION 2a *CPU DESIGN*

Consider the CPU design shown below:
(Timer unit identical to CPU2)



Assume the RAM memory contents starts with the following Bytes (hex):
`10 10  13 FF  03 01  13 01  17 FD  02 00  ...`

Run this program step by step and write down contents of Accu and PC after each step:

Step	**PC**	**Command**	**Accu** (after)
0	0x00	10 10 LOAD-I	
1	0x02	13 FF ADD-I	
2	0x04	03 01 ADD-M	
3			
4			
5			
6			

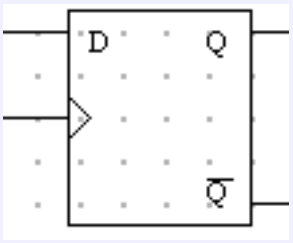
QUESTION 2b *DIGITAL CIRCUIT DESIGN*

Which button was pressed first?

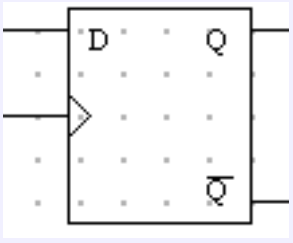
Design a system with 2 digital inputs (a, b) and 2 digital outputs (x, y).
Initially both outputs are 0.
If input a goes from 0 to 1 first, then x is set to 1 (and stays there forever), y stays at 0.
If input b goes from 0 to 1 first, then y is set to 1 (and stays there forever), x stays at 0.

(a) Design a circuit with this functionality using only flip-flops and logic gates.

a



b



QUESTION 3 *ASSEMBLY PROGRAMMING*

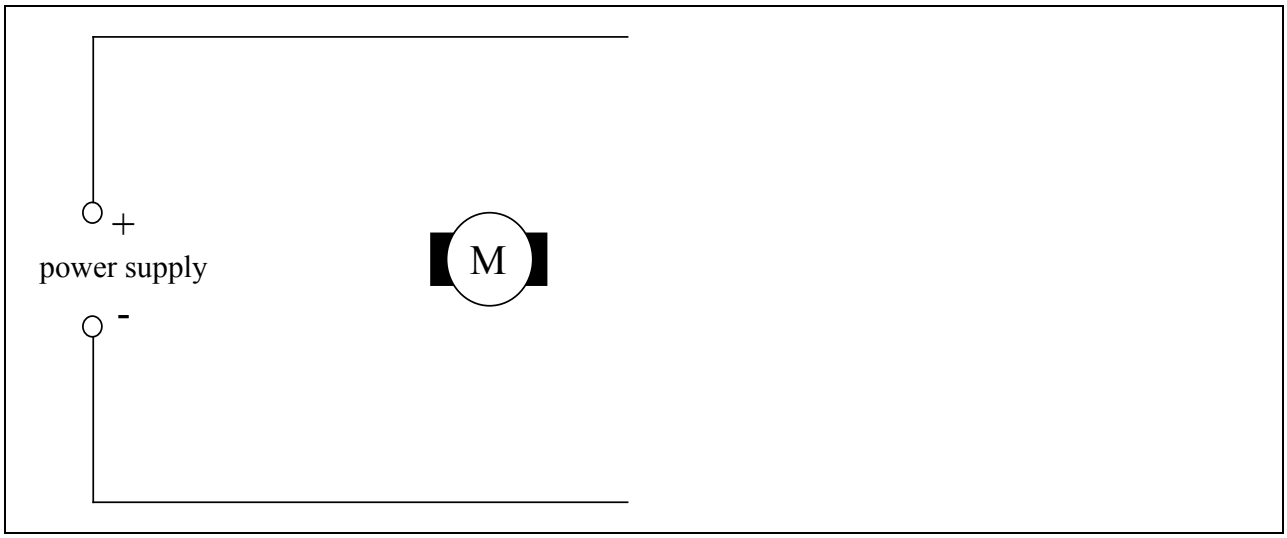
Assume the black box from Q2b is implemented using an Atmel microcontroller.
Write an Atmel assembly program to implement the desired functionality.

Initialize I/O: *not required* (assume already done)
Read input ports a, b: CALL read_a *or* CALL read_b (result in R0)
Write output ports x, y: CALL write_x *or* CALL write_y (value in R0)

```
main:
```

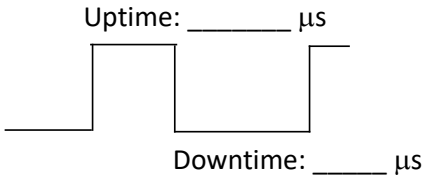
QUESTION 4 *Actuators*

(a) Connect the motor in the diagram below to the power supply, creating a H-bridge with 4 switches.



(b) A motor should run at 20% max speed by using PWM at 100 Hz.

- Enter the timing values in the diagram below.



(c) Complete this program to generated a specified motor speed by using PWM.

- Assume the motor enable line is connected to output **D0** and you can set all bits of port D for simplicity.
- Assume ports have already been initialized.
- There is no encoder feedback.
- Run the while-loop at roughly 100 Hz.
- Use *usleep(microsec)* to sleep for the given number of microseconds.

```
void setPWM(int ratio)  // ratio is between 0 and 100
{
  while(1)
  {









  }
}
```