Cpr E 281 Lab13
ELECTRICAL AND COMPUTER ENGINEERING
IOWA STATE UNIVERSITY

Lab13 Answer Sheet

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Submission Instructions:

Prelab:

1. **No prelab**

Lab:

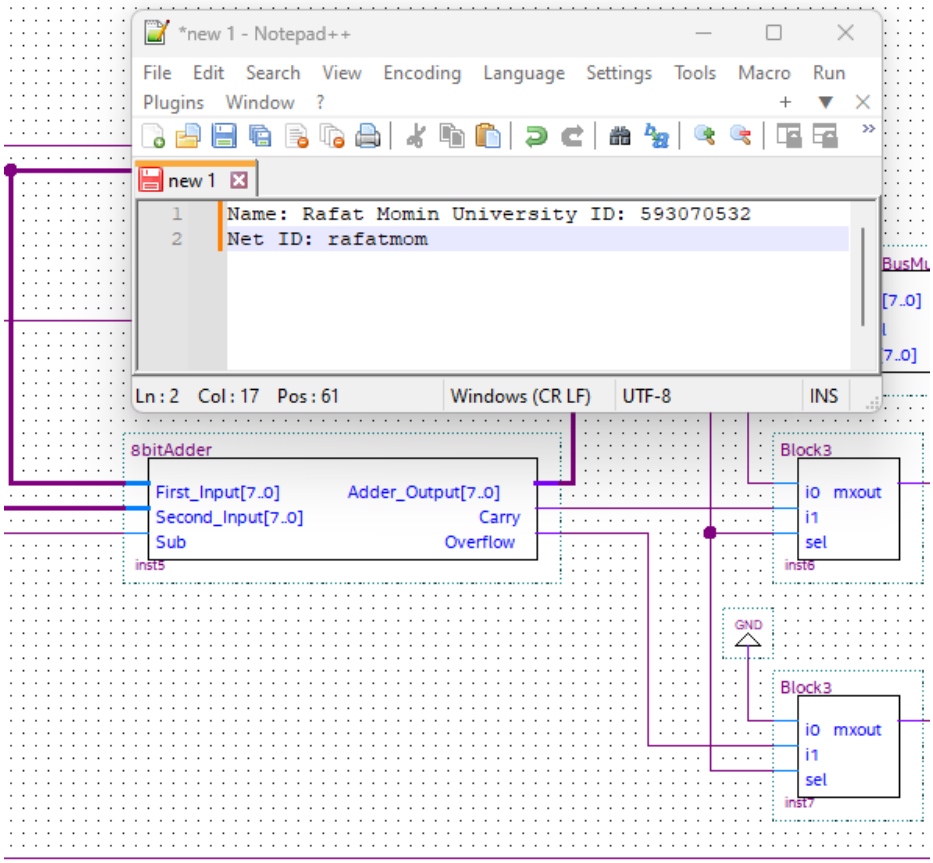
1. **Complete the scavenger hunt according to the instructions**
2. **Take screenshots of each component and include them in the document below (note: to receive points your NetID has to be visible in the screenshot, say in a command window that is in the background).**
3. **Complete this document and upload it to Canvas**

Lab13 Answer Sheet

Part 1: CPU Scavenger Hunt

Q1. Find the **adder** inside the ALU and answer the following:

- What is the name of this component?
- **Answer:** 8-bit adder
- Is it a ripple-carry or carry lookahead adder?
- **Answer:** Ripple-carry
- Can it also do subtraction?
- **Answer:** Yes, it can. (Because of XOR)
- What is the size of its two operands in bits?
- **Answer:** 8 bits
- <<< screenshot of the adder symbol >>>



- **Screenshot for Q1**

Q2. Find a 4-to-16 **decoder** and answer the following:

- What is the name of this component?
- **Answer:** 4to16DecoderWithEnable

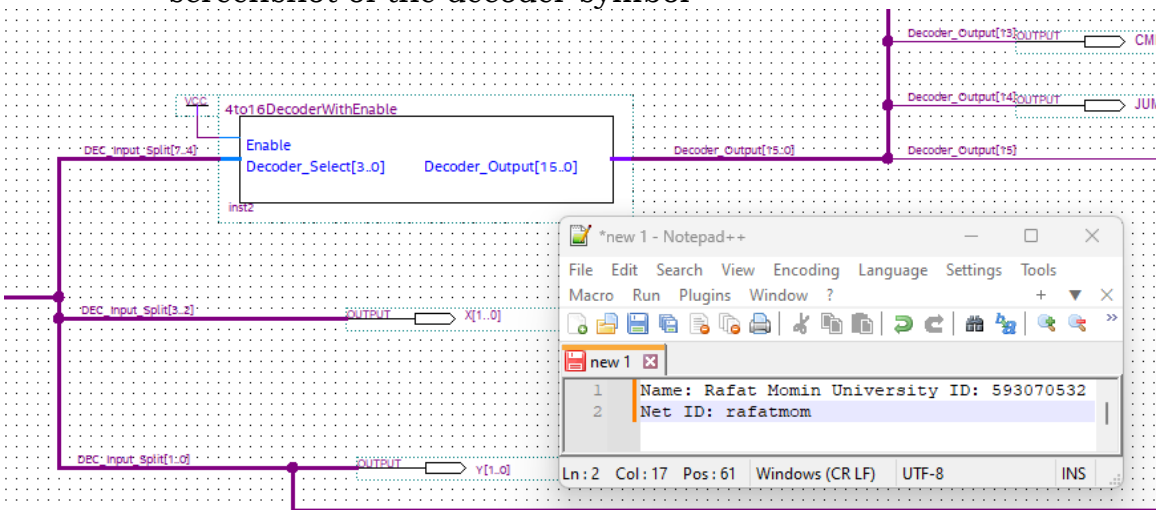
- Does it have an enable input?
  Answer: Yes

- What are the names of its outputs 4 and 6?
- **Answer:** 4 is Add, and 6 is Sub.

- Can you guess what is its function in this CPU?

- **Answer:** It helps to decide whether an addition or a subtraction will happen based on the output of the instruction memory.

- <<< screenshot of the decoder symbol >>>



Screenshot for Q2

Q3. Find a **shifter circuit** and answer the following:

- What is the name of this component?
- **Answer:** ShiftNoDFF

- What is the size of the input in bits?

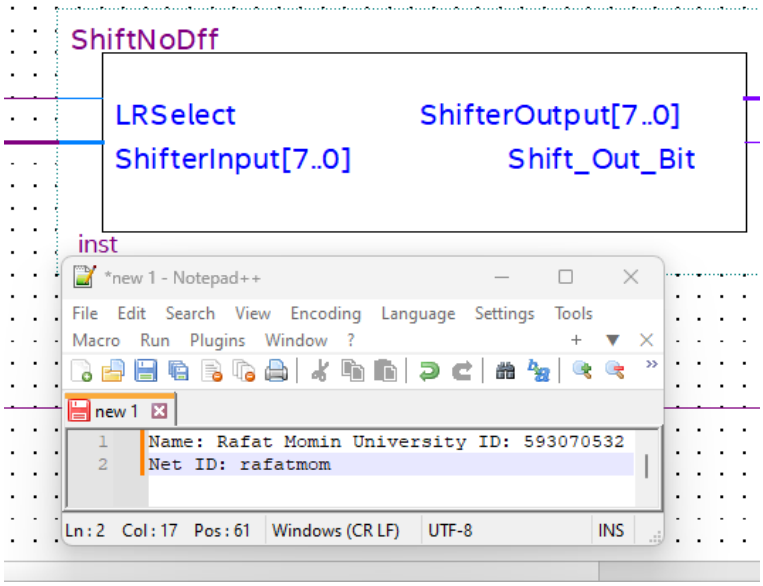
- **Answer:** 8

- What happens to the most significant bit on shift left?
  Answer: It takes the most significant bit out of the circuit to the output.

- What happens to the least significant bit on shift right?

- **Answer:** It takes the least significant bit out the circuit to the output.

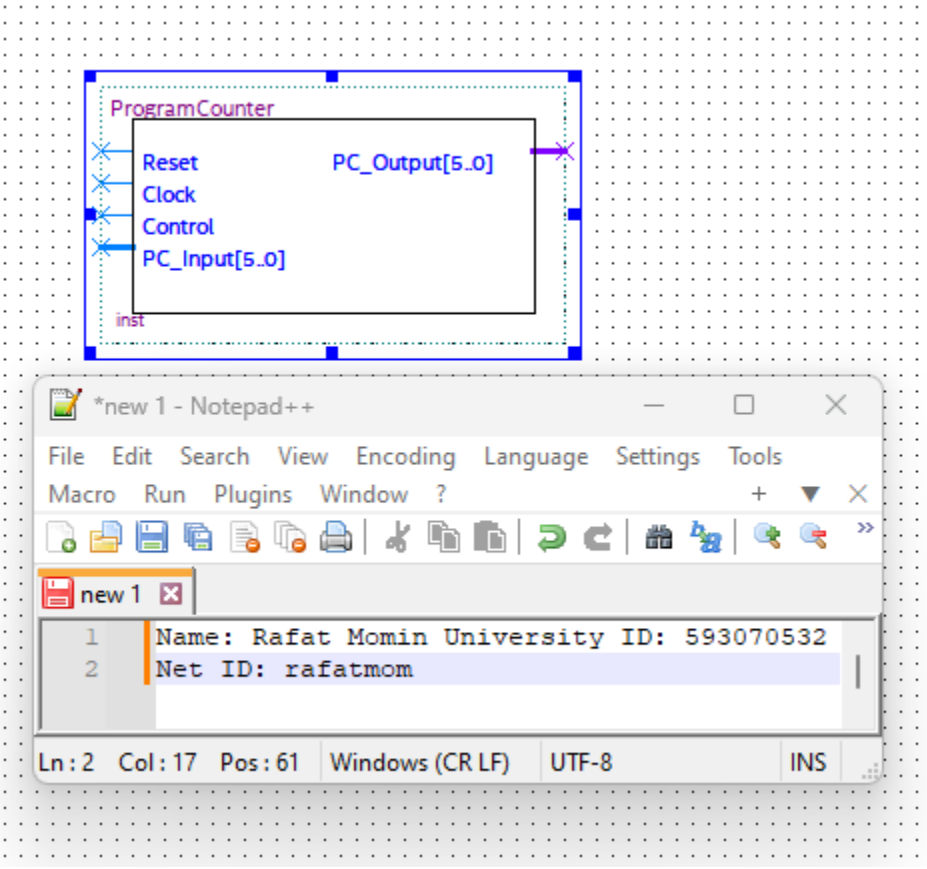
- <<< screenshot of the shifter symbol >>>



- **Screenshot for Q3**

Q4. Find the **program counter** and answer the following:

- What is the name of this component?
- **Answer:** ProgramCounter
- What is the size of the output bus in bits?
- **Answer:** 6
- How many control lines does it have?
- **Answer: 1**
- What type of high-level circuit does it implement?
- **Answer:** Parallel Load Resgister
- <<< screenshot of the program counter symbol >>>

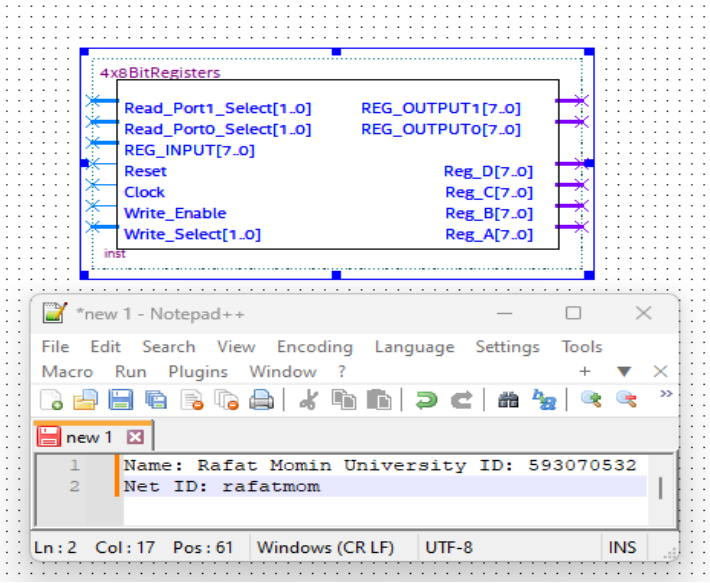


Screenshot for Q4

Q5. Find a **register file** with exactly 4 registers and answer the following:

- What is the name of this component?
- **Answer:** 4x8BitRegisters
- What is the size of each register in bits?
- **Answer:** 8 bits
- What type of Flip-Flops are used to construct each register?
- **Answer:** D flip-flop
- The contents of how many registers can be read at the same time?
- **Answer:** 2

- <<< screenshot of the register file symbol >>>



- **Screenshot for Q5**

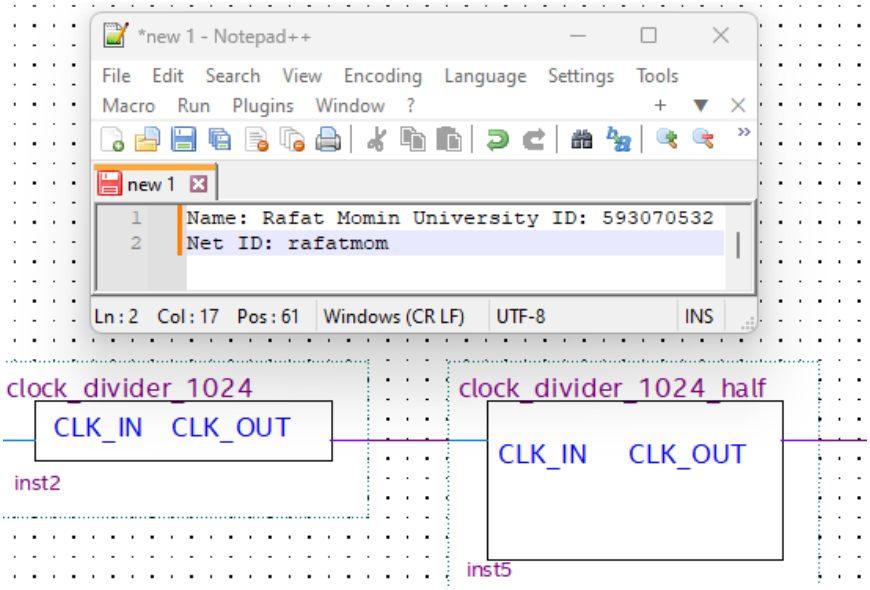
Q6. Find the two **clock dividers** for the **VideoGame_Clock** and answer the following:

- How are they implemented?
- **Answer:** It has 10 flip-flops and the clock-divider is a counter, implemented with counters.

- They slow down the clock by a factor of X and Y. What are X and Y?

- **Answer:** X= 512, Y= 1024. The reason is : every total clock cycle takes about 2^9 for the counter to go through the cycle of the 8 bit combinations. Therefore, X = 512 (the first bit remains intact). And for the second factor, it could also reset the whole cycle of the 9 bits so it is 2^{10} = 1024.

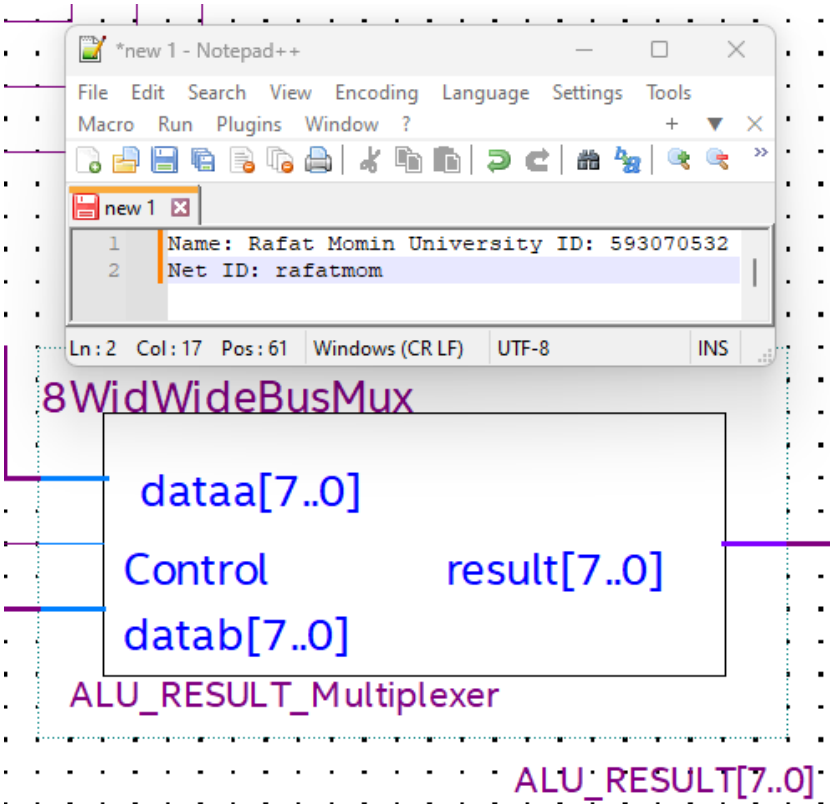
- <<< screenshot of the two clock dividers >>>



Screenshot for Q6

Q7. Find the **multiplexer** that sits after the ALU and takes the output of the ALU as one of its inputs. Then, answer the following:

- What is the name of this component?
- **Answer:** 8WidWidebusMux
- Where does the other input come from?
- **Answer:** From the box IMEM. (It is taking 8 bits out of the 16).
- What is the size of each input in bits?
- **Answer:** 8
- How many select lines does it have in bits?
- **Answer:** A single line.
- <<< screenshot of the multiplexer symbol >>>



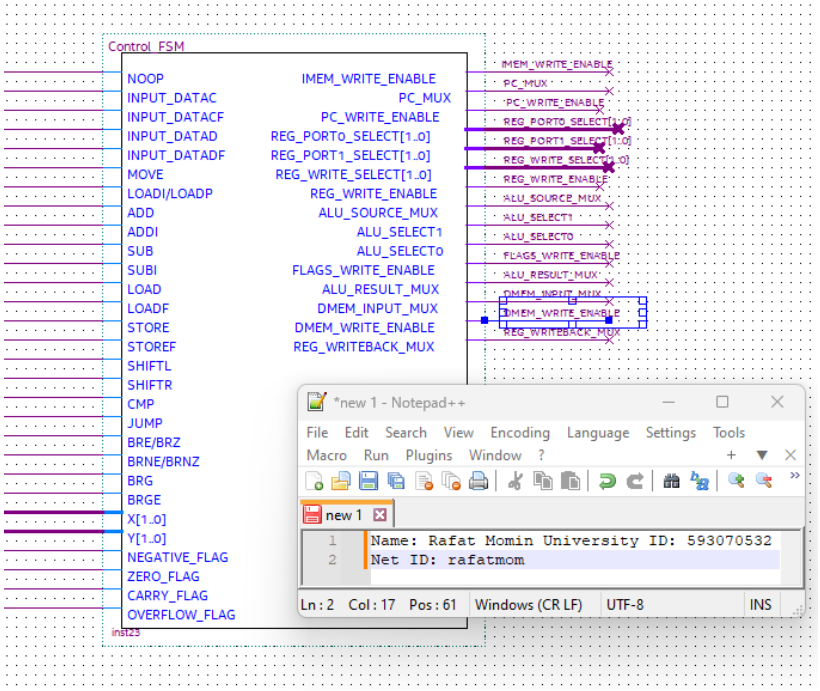
- **Screenshot for Q7**

Q8. Find the circuit that outputs the signal **DMEM_WRITE_ENABLE** and then answer the following:

- In which block is this circuit located?
- **Answer:** Control FSM.

- What is the Boolean expression for this signal?
  Answer: INPUT_DATAD + INPUT_DATAF + STOREF + STORE

- <<< screenshot of the block in which the circuit is located >>>



- **Screenshot for Q8**

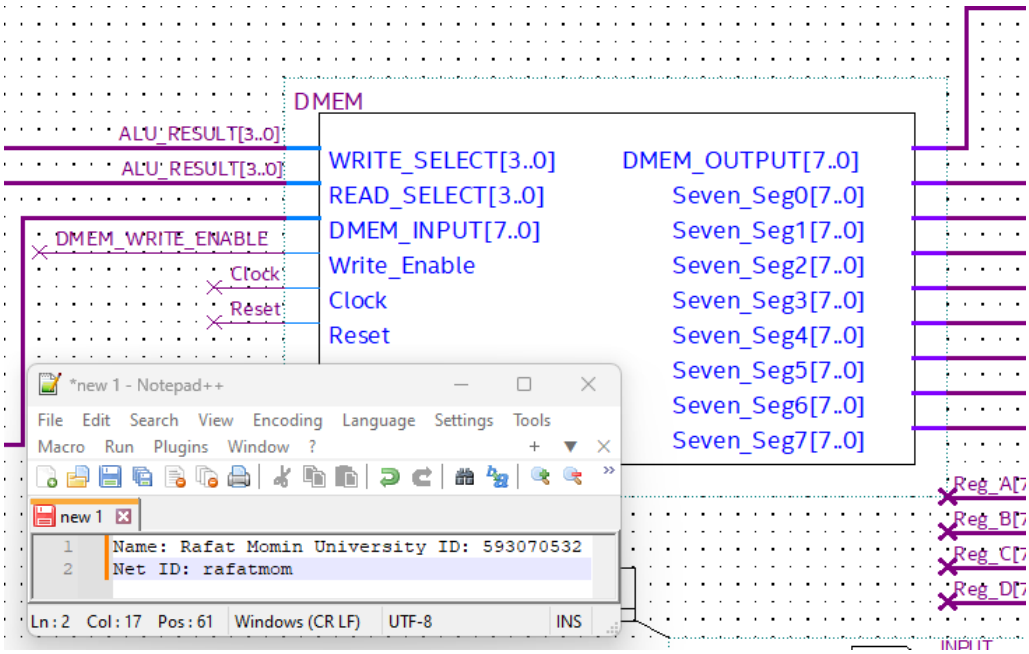
Q9. Examine the **DMEM** box and answer the following:

- What are the names of the control lines for this box?
- **Answer:** READ_SELECT[3..0]
- WRITE_SELECT[3..0]

- What the high-level component is used to store the data?
  Answer: Register file

- What is the size of the data memory in bytes?
  Answer: 16 bytes

- <<< screenshot of the high-level component symbol >>>

- 

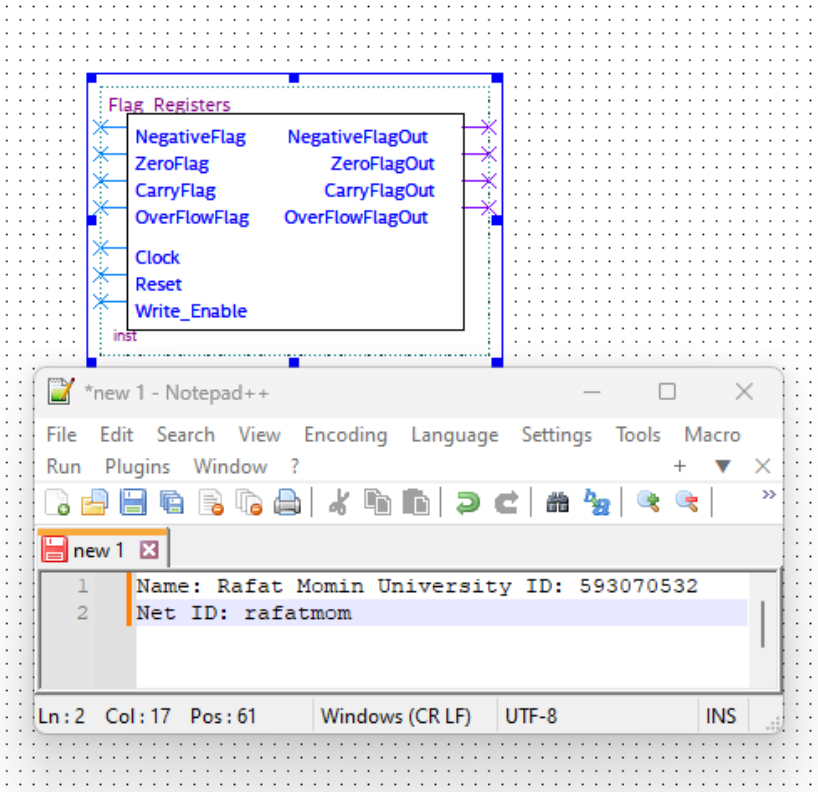
- **Screenshot for Q9**

Q10. Find the **flags register** and answer the following:

- How many flags does it store?
  Answer: 4

- What are the names of these flags?
  Answer: Negative_Flag, Zero_Flag, Carry_Flag, Overflow_flag

- <<< screenshot >>>



Screenshot for Q10

Part 2: PONG. Take a cellphone picture of the board as you are playing the game. Selfies are OK too as long as the game is visible in the background ☺

- <<< picture >>>

Screenshot for Part 2