The exam is closed-book, closed friends, closed-notes and closed-Internet. **Do not open any browser window** during exam!

You may use:
- Your own cheat-sheet\(^1\) (2 sheets front and back = 4 pages). Please **attach at the end** of the exam when finished.
- Windows calculator
- Your own lab programs in MARIE assembly from T-drive\(^2\). Please **no copy/paste, all code has to be written from scratch**!

Types of problems for midterm: see all the problems we covered in
- Quizzes
- Lab
- Homework

Problems that have high probability to be on the exam:
- Multiplication using Booth’s algorithm
- Converting decimal fractions to/from 15-bit floating point
- Additions and multiplications in 15-bit floating point
- Encoding and decoding convolutional codes
- Design a memory out of given chips (and decoder)
- Reverse-assembly MARIE machine code
- Write simple programs in MARIE assembly

1. Perform the following additions/subtractions in 8-bit binary, using **two’s complement** when needed. Check in decimal.
   
   i. \(90_{10} + 41_{10} = \)
   
   ii. \(73_{10} - 44_{10} = \)

---

\(^1\) E.g. Mealy machines for convolutional coder and decoder, list of MARIE instructions with opcodes, ASCII table, etc.

\(^2\) Or wherever else you keep them.
iii. \( 27_{10} - 63_{10} = \)

iv. \( -17_{10} - 85_{10} = \)

2. Perform the following \textbf{integer divisions} in binary (result is quotient \textit{and} remainder). Check in decimal.
   a. \( 85 : 7 = \)

   b. \( 125 : 10 = \)

   c. \( 42 : 17 = \)

3. What are the \textbf{ranges} of numbers (max positive, max negative) possible to represent with the following binary codes? Show all the work, not only results!
4. What is the range of numbers (max positive, min positive) possible to represent with the following binary code?

- 9-bit floating-point code\(^3\) with:
  a. 1 sign bit
  b. 4 exponent bits represented as two’s complement (not biased!)
  c. 4 significand bits, normalized as in our text (first one to the right of the binary point, with the implied bit left in place)

\(^3\) Similar to homework Ex. 45/123.
5. Perform the following integer **multiplications** using **Booth’s algorithm**\(^4\). The factors are in 4-bit two’s complement, and the result in 8-bit two’s complement. Show all the work and check the result in decimal!

\[
7 \times 9 =
\]

---

\(^4\) Remember: in Booth’s algorithm the **first** factor can be **positive or negative**, but the **second** factor **must be positive**. Change the signs accordingly.
-7 \times 9 =

7 \times -9 =

-7 \times -9 =
6. The following 14 bits encode a **floating-point** number, **with bias**. What is the number? Show all your work, not just the final result!

\[
110101111001
\]

7. Show the **output bit sequence** when the following inputs are **encoded** with the PRML convolutional code\(^5\). In each case, specify the **final state** of the encoder:

- 1001 1010 1111 →
- 0111 0001 1000 →

8. The following PRML-encoded bit sequences have been received and they must be **decoded**\(^6\). In each case, find if the sequence has been corrupted or not. If it has been, circle the **first bit (pair)** in error. (Do not attempt to correct the error!)

- 01 00 11 10
- 00 00 11 11 00 10
- 11 01 10 10 00 11 00 11

\(^5\) Use encoder Mealy machine on cheat-sheet.
\(^6\) Use decoder Mealy machine on cheat-sheet.
9. The PRML-encoded bit sequences above have errors and they must be decoded. **Correct** the first error using a partial response of 4 pairs (including the one in error). Show the **trellis diagrams** with all possible paths!

01 00 11 10 10 10

00 00 11 11 00 10

11 01 10 10 00 11 00 11

10. **Extra-credit:** In each example above, correct the **second** error.

---

7 Use decoder Mealy machine on cheat-sheet.
11. Write a program in MARIE assembly to do the following:
   a. Declare two integer variables NUM1 and NUM2 and initialize them with the numbers 1 and -3, respectively.
   b. Calculate NUM + NUM2 and store the result in a variable SUM
   c. Calculate NUM1 – NUM2 and store the result in a variable DIF
   d. Output SUM and DIF

Attach simulator window showing the end of execution.

15. What does this figure represent?

Explain each element:
17. Name the circuit:
19. In the following 1-bit ALU what operation performed for each of the possible selections of the MUX?

S_1S_0 = 00: ____________________

S_1S_0 = 01: ____________________

S_1S_0 = 10: ____________________

S_1S_0 = 11: ____________________

20. In the following 8-bit ALU, show the gate-level implementation of the zero-detect circuit:
21. Draw the FSM for a Moore machine with one input and one output, having the property that the output is 1 if and only if the previous three inputs were 1 0 1:

23. List 3 differences between FSB and BSB:

25. What is a non-deterministic bus arbitration algorithm?

26. We have to design a 64 KB memory out of RAM chips of size 14 KB. Draw the system diagram, including the decoder: