

**Learning outcome 1** – 14 points / 35 min

1. **[I1\_M, 2 points]** Why do we consider circuits as black boxes most of the time?
2. **[I1\_M, 2 points]** How does signed adding of numbers work? Show a simple example.
3. **[I1\_M, 1 points]** What are basic parts of ALU?
4. **[I1\_M, 4 points]** Explain the computer architecture transformation architecture – computer architecture narrow (2 points) and expanded view (2 points).
5. **[I1\_D, 3 points]** Based on a set of design goals, how would you synthesize an ALU in accordance to the design specification (2 points)? Feel free to use an example to explain the concept (1 point).
6. **[I1\_D, 2 points]** What is the behaviour of N, V i C flags when we subtract \$1 from \$80?

**Learning outcome 2** – 15 points / 40 min

1. **[I2\_M, 4 points]** Using assembly language on the 6502 fill every third location from \$200 to \$2FF starting with the first one with decimal value of 15.
2. **[I2\_M, 2 points]** Modify previous example to include memory from \$300 to \$3FF but first location should be blank.
3. **[I2\_M, 4 points]** Which three stages (plus the potential forth stage) does the instruction go through as a part of its execution cycle?
4. **[I2\_D, 2 points]** What is the size and number of cycles taken by tasks in the previous practical questions?
5. **[I2\_D, 3 points]** How does out-of-order execution (1 point) and speculative execution (2 points) influence **actual** application execution on a CPU?

**Learning outcome 3** – 15 points / 40 min

1. **[I3\_M, 4 points]** Memory locations starting at \$400 and \$410 contain three bytes, in order: empty byte, 16 bit number in big endian notation. Add those numbers and store the result to location starting at \$420 and use the empty byte to store the carry bit.
2. **[I3\_M, 2 points]** Explain Meltdown vulnerability of CPU and its subcomponents and how it influences security.
3. **[I3\_M, 4 points]** Explain how superscalar CPU's work (2 points). What are architectural requirements to create a superscalar CPU (2 points)?
4. **[I3\_D, 3 points]** Solve the task from the previous question using a subroutine (2 points). Enable the user to pass location of the numbers and the result using locations \$10, \$20 and \$30 (1 point).
5. **[I3\_D, 2 points]** Imagine that you're working in a Fab that produces computer chips. You're the head of production of the facility, and you're responsible towards your clients (chip designer companies, for example - NVIDIA) to implement security solutions so that even the vetted (security checked) Fab's staff can't introduce any type of hardware changes to client's chip design. What would you do to make sure that – for example – hardware trojans are never introduced to the chip production phase in your Fab?