Elec Eng 2EI5
Design Project #5 (Bonus)

Problem Statement
Design, simulate, and build a 3-bit Digital-to-Analog Converter with full-scale analog voltage, V_{FS} = 5V.

Note that some terms used in this document refer to concepts and/or quantities that we do not explicitly study in 2EI4. Part of the project is for you to conduct research to learn the meaning of these concepts and/or quantities to be able to complete the design and write the report. Examples of these are the full-scale analog voltage (VFS), the gain error, the maximum differential non-linearity, etc.

Design Contraints
1. You are limited to the dc supplies available from your Digilent module.
2. You are limited to op-amps, transistors, and resistors from your 2EI4 and 2CI4 kits.
3. Current drawn from the digital bit lines cannot exceed 1μA (ideally 0).
4. The bit levels are 0V (logic low) and 5V (logic high).
5. For convenience, you <u>are allowed to</u> treat 0V on a bit line as logic-1 and 5V as logic-0 (i.e. if your design requires the inversion of the bit lines, you don't actually have to build the three inverters).

Report Requirements
1. File name: student #-macid-last name-first name.
2. Cover page.
3. Pages 1-2:
    a. (5 pts) Summary: a concise statement of the problem and description of the basic design and its performance.
    b. (20 pts) Design:
        i.   Circuit diagram
        ii. Description of how the circuit works
        iii. Any calculations that are required as part of the design
        iv. Reference for the circuit (i.e. where did you find this design)
4. Pages 3-5:
    a. (50 pts) Measurement and analysis:
        i.   Include a photograph of your actual circuit. The photo must include a paper with your name, student number, and the date.
        ii. Describe how you generated the digital inputs (for a 3-bit D/A, we need three digital inputs).
        iii. Demonstrate the full transfer characteristics of the circuit.
        iv. Measure the gain error. Explain how you made the measurement. Explain the meaning of the gain error.
        v.   Measure the maximum differential non-linearity. Explain how you made the measurement. Explain the meaning of this error.

vi. Measure the offset error. Explain how you made the measurement. Explain the meaning of the offset error. (Note: the offset error may be too small to measure. If so, it will appear to be 0 and you can report that as your result. You would still need to explain how you measured it and what it means.)

5. Page 6:
    a. (15 pts) Discussion:
        i. Explain the origin of the various errors measured. You may (optional) use simulation to back up your discussion.
        ii. If your research covered different D/A implementations, discuss why you chose the design you used and discuss the advantages of at least one alternate design.

In addition to the above, 10 points will be assessed on presentation. This includes the layout of the report according to the above sections, quality of figures, neatness, and clarity of presentation in a professional style.