**Mid-term – Part 1 Written Section (Closed Book) – 60-minute time limit**

**Instructions:** There are 5 questions. On separate sheets of paper, write your name and enumerate your answers

**Student Name** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **Final Score** out of 50: \_\_\_\_\_\_\_\_

1. Fill in the blanks for the following – some blanks may be multi-worded ones **(10-points)**
	1. A 10-bit analog-to-digital converter results in (raw) decimal values ranging from 0 to \_\_\_\_
	2. Shannon’s sampling theorem puts a limit on the \_\_\_\_\_sampling time
	3. Motors, relays and pneumatic valves are examples of \_\_\_\_
	4. \_\_\_\_\_\_ is the ratio of times when a signal is on and off
	5. I2C is a low-speed, \_\_\_\_\_\_ data transfer between integrated circuits
	6. I2C has a \_\_\_\_\_\_ interface consisting of data and clock lines
	7. \_\_\_\_\_\_ digital lines means that the lines can be used for both input and output
	8. Like relays, transistors can act as electronic \_\_\_\_\_\_
	9. \_\_\_\_\_\_ are circuits that use switches to reverse the direction of current
	10. MOSFETs are \_\_\_\_\_\_ transistors
2. Convert the following numbers. Show relevant calculations **(10-points)**
	1. 67 (from base 10 to base 2)
	2. 608 (from base 10 to base 3)
	3. 16 (from base 10 to base 8)
	4. FF (from base 16 to base 10)
	5. 1101 (from base 2 to base 3)
3. What are the 2 rules and 5 properties of an ideal op-amp? Use the 2 rules to mathematically derive the input-output relationship of the op-amp below. This op-amp circuit converts what to what? **(10-points)**



1. Sketch a non-inverting op-amp and mathematically derive its input-output relationship **(10-points)**
2. Consider a 4-bit Digital-to-Analog Converter (DAC) **(10-points)**
	1. What is the resolution in volts if the reference voltage is +5V

**Answer:** Recall that have $2^{4}-1=15, $this means that can resolve reference voltage (5V) into 16 discrete values ($\frac{5}{16}=0.3125 V$).

* 1. List all the possible analog voltages this DAC can deliver for +5V reference voltage

**Answer:** 0; 0.3125; 0.625; 0.9375; 1.25; 1.875; 2.1875; 2.5; 2.8175; 3.125; 3.4375; 3.75; 4.02625; 4.375; 4.6875; 5

* 1. Suppose you want an analog voltage of precisely 0.625V. What should the decimal number for a reference voltage of +5V?

**Answer:** $\frac{V\_{ref}}{16}=\frac{V}{Word}$ so $Word=\frac{16∙V}{V\_{ref}}=\frac{16∙0.625}{5}=2$

* 1. For the decimal number calculated above, suppose you want an analog voltage of precisely 0.6V. What should reference voltage be?

**Answer:** $\frac{V\_{ref}}{16}=\frac{V}{Word}$ so, $V\_{ref}=\frac{16∙0.6}{2}=4.8 V$

* 1. What is the resolution in volts if one uses an 8-bit DAC and +5V reference voltage?

**Answer:** Have$2^{8}=256$, so $\frac{5}{256}=0.0195 V$