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

**Instructions:** Complete your answers in the space below (do not use back of paper).

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

1. Fill in the blanks for the following – some blanks may be 2 worded ones (10 points)
	1. \_\_\_\_\_\_\_\_\_ is the international standard to represent alpha-numeric characters
	2. A \_\_\_\_\_\_\_\_\_ emulator is used to establish serial communications
	3. \_\_\_\_\_\_\_\_\_ is used to permanently hold device information like identifiers (like device ID)
	4. RAM holds temporary information whereas \_\_\_\_\_\_\_\_\_\_\_\_\_ stores more permanent information like read/write instructions.
	5. A \_\_\_\_\_\_\_\_ is information, typically in the form of bytes to read and/or write instructions
	6. Little Endian means that the \_\_\_\_\_\_\_ significant bits are stored in the first byte, and the higher ones in the second byte.
	7. \_\_\_\_\_\_\_\_\_\_\_ is often employed to verify packets were correctly transferred between devices
	8. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ is a standard notation for labeling and locating a robot’s reference frames
	9. The \_\_\_\_\_\_\_\_\_\_\_\_ transformation matrix maps reference frames $i-1$ to $i$ in a robot
	10. The \_\_\_\_\_\_\_\_\_ frame is the transformation from the robot’s base (origin) to the robot’s end-effector frame
2. The ASCII decimal value for the uppercase character G is 71. Sketch what should be seen on the scope when G is transmitted serially at 4800 bits/second. Annotate your photo clearly showing the spacing between any HI and LO voltage values and the timing in seconds between any widths. (10-points)
3. What is Little Endian? Provide an example using a Hex value 16-bit number (i.e. 2-bytes). Show the calculations (decimal, hexadecimal, and binary) to demonstrate Little Endian representation (10-points)
4. For the 2-link planar manipulator sketched below derive (show calculations and/or derivations)



* 1. The Denavit-Hartenberg parameter table (2.5-points)
	2. Forward kinematic equations for end point locations $x\_{p0}$ and $y\_{p0}$ based on the link lengths $l\_{1}$ and $l\_{2}$ and their angles $θ\_{1}$and $θ\_{2}$(2.5-points)
	3. The tool frame $T\_{2}^{0}$ (5-points)
	4. Derive the inverse kinematics equation for the second angle $θ\_{2}$such that (10-points):

$$θ\_{2}=atan2\left(\pm \left\{1-\left(\frac{x\_{p}^{2}+y\_{p}^{2}-l\_{1}^{2}-l\_{2}^{2}}{2l\_{1}l\_{2}}\right)^{2}\right\}^{1/2},  \frac{x\_{p}^{2}+y\_{p}^{2}-l\_{1}^{2}-l\_{2}^{2}}{2l\_{1}l\_{2}}\right)$$