EECS 498 Midterm Exam

Fall 2012

Name: _____ unique name: _____

Sign the honor code:

I have neither given nor received aid on this exam nor observed anyone else doing so.

_____

Scores:

Problem #	Points
1	/15
2	/10
3	/25
4	/15
5	/35
Total	**/100**

NOTES:

1. Closed book and Closed notes
2. There are **9** pages total. Count them to be sure you have them all.
3. Calculators are allowed, but no PDAs, Portables, Cell phones, etc. Using a calculator to store notes is not allowed.
4. You have about 80 minutes for the exam.
5. **Be sure to show work and explain what you've done when asked to do so. That will be very significant in the grading of this exam.**

1) Short answer **[15 points]**
   a) Briefly explain what busybox is and why embedded Linux distributions tend to use it. **[5]**

   b) Loadable Kernel Modules
      - Why might one wish to write a kernel module for an embedded system rather than writing code in user space? **[5]**

      - What does the "loadable" part of LKM mean? Why is this useful? **[5]**

2) Consider the following scenarios. Indicate which of the following device you would recommend be used to address the problem and why. Assume these are your only choices. **[10 points]**

   (i) Off-the-shelf Arduino (16KB Flash, 1KB SRAM, 512 bytes EEPROM, 10 MIPS) with the same form factor as used in labs 1 and 2. $30.
   (ii) Off-the-shelf MSP430 board (64KB Flash, 256KB SRAM, 10 MIPS) with the same form factor as the LaunchPad used in lab 2. $10
   (iii) Custom PCB with a MSP430 chip (64KB Flash, 256KB SRAM, 10 MIPS)
   (iv) Custom PCB with a MSP430 chip (1MB Flash, 1MB SRAM, 20 MIPS)
   (v) Custom ASIC (arbitrary specifications)

   a) A faculty member wants a device for a science demo he will be taking around to high schools that raises and lowers a conductor's baton based upon the volume of noise in the room. He has a total budget of $300 including labor and parts for the embedded system (the servo and baton aren't a part of this budget). **[5]**

   b) A local company has an idea for a child's toy. It has 10 LEDs, 8 buttons and a speaker. It needs to play music on the speaker and flash certain lights when buttons are pressed in a given order. (If other music/lights have already been triggered it will stop the old music/lights and start the new). The music can fit in 128KB and the rest of the program/data required seems fairly small (say 8KB at most). They have a target sales number of 100,000 units with a retail price of $30. The part must be small and light (needs to fit in a 1 inch cubic volume). Beyond that cost is the first priority and power consumption is important to them. **[5]**

3) Consider an embedded application which consists of 4 tasks named A, B, and C. Each task is CPU bound (that is, there is no I/O or memory operations which take significant time to execute) and periodic. Each task must complete before the next instance of the task is ready to start. These tasks have the following properties and requirements. You are to assume there is no overhead of any type (including scheduling overhead) and that this machine runs any given instruction in exactly the same amount of time. **[25 points]**

Task	Maximum number instructions executed by a single instance of the task	How often the task needs to run
A	6 Million	90ms
B	14 Million	120ms
C	4 Million	300ms

a) Which task do you give the highest priority under RM scheduling? The lowest? **[2]**

- Highest _____
- Lowest _____

b) You are choosing between 4 different processors. Which of these would be the lowest MIPS processor which would be able to schedule these tasks using ***EDF***? You must *clearly* explain your work to get any credit. **[6]**

(1) 150 MIPS
(2) 200 MIPS
(3) 250 MIPS
(4) 300 MIPS

<continued on next page>

Task	Maximum number instructions executed by a single instance of the task	How often the task needs to run
A	6 Million	90ms
B	14 Million	120ms
C	4 Million	300ms

c) You are choosing between 4 different processors. Which of these would be the lowest MIPS processor which would be able to RM schedule these tasks? (The table has been copied here for your convenience.) You must *clearly* explain your work to get any credit. **[10]**

(1) 150 MIPS
(2) 200 MIPS
(3) 250 MIPS
(4) 300 MIPS

d) Using the FreeRTOS system, write the task creation functions you would call to schedule this application? (Parts of the FreeRTOS documentation are attached). The task functions take no arguments and are named A(), B(), and C(). We are **just** asking you to create the tasks, not write the rest of the main or the task functions themselves! **[7]**

4) Say you've done a PCB design at work. There is one power trace that is highly sensitive to additional resistance (it is the power line for an FPGA that has strict voltage requirements). Your boss says that "Your trace is too long. You'll get a lower resistance if you neck down the trace and shorten it." **[15 points]**

   a) Sketch and label a diagram that illustrates the situation (including why your trace was so long to begin with) and how your boss wants you to fix the problem **[5]**

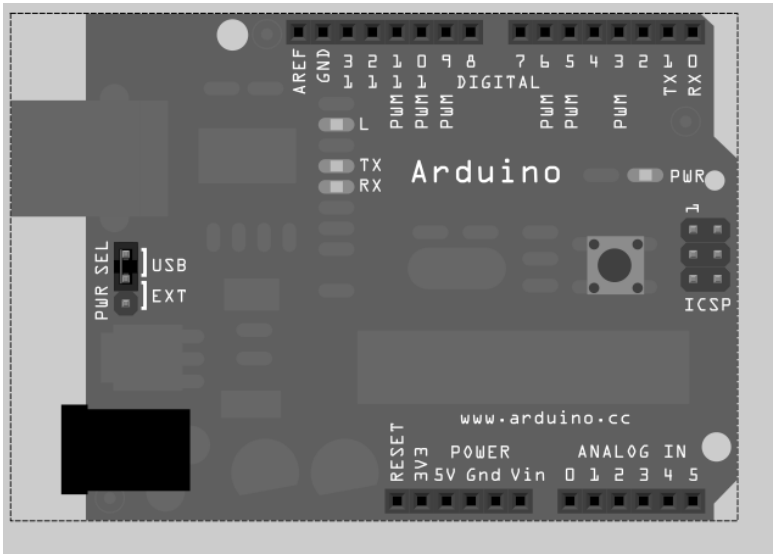
   b) Say that the original trace was 5 cm long and 30mil wide and that after your follow her suggestion, the new trace is 2 cm long and 30 mil wide for all but 5 mm of those 2 cm where it is 6 mil wide. Would you expect the new or old trace would have a lower resistance? Show and explain your work. **[5]**

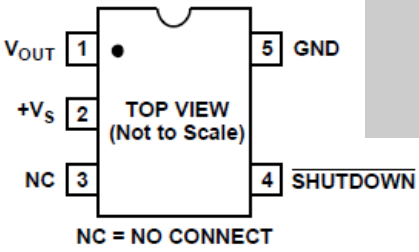
   c) Assuming her solution does reduce the resistance and still meets the PCB design rules; identify the biggest problem that should none-the-less concern you with this change. **[5]**

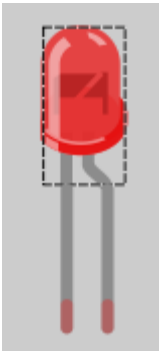
5) Consider the TMP37 temperature sensor (much of the datasheet is supplied). For this question, you will A) answer a few questions about the device and then B) show how to have an Arduino light single LED light if and only if the sensor is reading a value above 25 degrees centigrade. **Use 5V for the device's power.** A simple Arduino sketch and definitions of some Arduino functions are also attached as the last page of this exam. Please feel free to rip them out of the exam if you desire. **[35 points]**

a) Assuming Vout is connected directly to the Arduino (which has a large input resistance), how much *power* will this device typically use at room temperature? **[3]**

b) Say you wish to use less power, what would you expect the best average power draw you could achieve if you only wanted to take one sample per second? Assume you are still at room temperature. Also assume while the device is powering up or powering down it draws power as if it were not in low-power mode. Show and explain your work. **[5]**







c) Indicate, by drawing wires, how you will connect the three components and draw any other components needed. Assume you will want to shutdown the device when it's not in use. **[5]**

d) Write an Arduino sketch that lights the LED if the temperature sensor reads a value above 25 degrees. If you can't quite do that due to quantization[1] issues it is required that the light be on when the temperature if 25 degrees or above and desired that the light not come on at any lower temperature than necessary to meet that requirement. You should sample the sensor about once a second and should power down the sensor when it is not being used. **[22]**

[1] That is, you may have some rounding issues that make detecting exactly 25 degrees exactly. If that occurs, you must insure that when you get to 25 degrees the LED comes on, even if that means you may turn the light on at temperatures below 25 degees.

Sample sketch:

```
int ledPin = 13;                // LED connected to digital pin 13

void setup()                    // run once, when the sketch starts
{
  pinMode(ledPin, OUTPUT);      // sets the digital pin as output
}
void loop()                     // run over and over again
{
  digitalWrite(ledPin, HIGH);   // sets the LED on
  delay(1000);                  // waits for a second
  digitalWrite(ledPin, LOW);    // sets the LED off
  delay(1000);                  // waits for a second
}
```

analogReference(type)

Description
Configures the reference voltage used for analog input (i.e. the value used as the top of the input range). The options are:

- DEFAULT: the default analog reference of 5 volts (on 5V Arduino boards) or 3.3 volts (on 3.3V Arduino boards)
- INTERNAL: an built-in reference, equal to 1.1 volts on the ATmega168 or ATmega328 and 2.56 volts on the ATmega8 (*not available on the Arduino Mega*)
- EXTERNAL: the voltage applied to the AREF pin (**0 to 5V only**) is used as the reference.

Parameters
type: which type of reference to use (DEFAULT, INTERNAL, INTERNAL1V1, INTERNAL2V56, or EXTERNAL).

Returns
None.

analogRead(pin)

Description
Reads the value from the specified analog pin. The Arduino board contains a 6 channel (8 channels on the Mini and Nano, 16 on the Mega), 10-bit analog to digital converter. This means that it will map input voltages between 0 and 5 volts into integer values between 0 and 1023. This yields a resolution between readings of: 5 volts / 1024 units or, .0049 volts (4.9 mV) per unit. The input range and resolution can be changed using analogReference().

Syntax
analogRead(pin)

Parameters
pin: the number of the analog input pin to read from (0 to 5 on most boards, 0 to 7 on the Mini and Nano, 0 to 15 on the Mega)

Returns
int (0 to 1023)