CSE 474 Midterm Winter, 2017

Name _____

This take-home exam has 100 points and is due at the beginning of class on **Tuesday, February 14.** (!!!)

Please submit printed output if possible. Otherwise, write legibly. Both the Word document and the PDF are posted. Points will be awarded to the extent that we understand an answer or how a design works. Turn in this document and all code print-outs stapled into a single document.

Problem	Points	Score
1.	20	
2.	20	
3.	25	
4.	35	
Total	100	

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1. Hardware: (short specific answer—no more than two sentences)

a. What is the purpose of a **current limiting resistor** in a circuit, and why is it needed?

b. Why do we need to use **pull-up resistors**? What is an example where you would need to use one?

c. Describe (in your own words) how a Disc Resonating Gyroscope works:

d. Is the Freescale MK20DX64 (Teensy) categorized as a RISC machine or a CISC machine?

What is the main difference between these two architectures?

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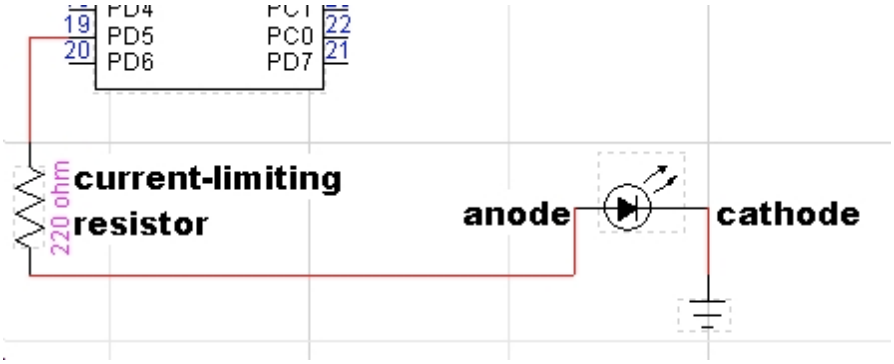
e. Calculate the current through the LED given the following:



- LED Forward Voltage = 2V
- LED Capacitance = 35 pf
- **I/O High Voltage = 5V**
- Resistor Value = 220 ohms
- CPU Leakage Current = 1 micro amp

Current:_____

f. Describe the sequence of events when an interrupt occurs on the Freescale MK20DX64 (Teensy). Indicate what elements of the interrupt sequence are managed by the hardware and what elements must be managed by the software/programmer.

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2a. Explain three modes of serial communication from serial devices with one example of each:

'synchronous':

'isochronous' :

'asynchronous' :

2b. How do the following protocols indicate **start** and **end** of a byte or data frame?

(a) RS-232/UART

(b) SPI

(c) I2C

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3. The LIS3L02DQ (datasheet) https://courses.cs.washington.edu/courses/cse474/17wi/pdfs/accel.pdf is a three axis digital output linear accelerometer. Your job is to connect this part using the I2C (TWI) interface to an Freescale MK20DX64 Teensy microcontroller. (The SPI interface is taken by another peripheral in this design).

a. List pins on the Freescale MK20DX64 Teensy that connect to pins on the LIS3L02DQ. In addition, show any other pin connections that need to be made on the LIS3L02DQ to ensure proper operation of the I2C interface. The LIS3L02DQ is the only peripheral on this I2C bus. You do **not** need to show power and ground connections.

Teensy pins	LIS3L02DQ pins	Function

b. Write software to **initialize** the LIS3L02DQ, and to **acquire data** from it. **Hand in a print-out** of your driver, properly commented so that we can understand how it works.

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4. Your job is to design a combination frequency meter/voltmeter, using the MK20DX64 Teensy and a Serial Liquid Crystal Display Module, the NHD-0216K3Z, https://courses.cs.washington.edu/courses/cse474/17wi/pdfs/NHD-0216K3Z-NSRGB-FBW-V3.pdf, in **a 3 volt version** which will interface with the MK20DX64 Teensy via an SPI interface. The display shows two rows of 16 characters each.

Your meter has a single input for frequency measurement and for voltage measurement. The input range is +- 6 volts, for a total range of 12 volts. **A buffer circuit scales the signal by 4 and shifts the signal to the range of 0 to 3 volts.** This scaled signal can be routed by you to the appropriate input as part of your design.

a. List pins and names on the MK20DX64 Teensy that connect to pins on J2 of the NHD-0216K3Z. In addition, show any other pin connections that need to be made on the NHD-0216K3Z to ensure proper operation of the SPI interface. The NHD-0216K3Z is the only peripheral on this SPI bus. You do **not** need to show power and ground connections.
In addition, you must show where the **buffered input** connects to the MK20DX64 Teensy.

Teensy pins	NHD-0216K3Z J2 pins	Function

b. Write software to **initialize** a timer to use in your frequency measurement**. Show how you intend this to work in your comments.**

c. Write software to **initialize** the input A/D converter, and an interrupt routine to store the converted data. **In addition, your routine must detect the positive transition of the signal above a preset threshold, and record the running timer value for the frequency measurement.**

d. Write software to **initialize** the NHD-0216K3Z, and to **display frequency and voltage data** on it, appropriately labeled. Your display should take into account the scaling of the input buffer, and match the resolution of your input (voltage) and your time base (frequency), showing the appropriate number of digits.

Hand in a print-out of your code, properly commented so that we can understand how it works. Include an explanation of your resolution calculations.