SE3910 Real Time Systems

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You may use one (1) 8.5 x 11 sheet of paper with notes on it for the exam.

1. Week #1
   (a) Lecture #1 Course Introduction
      i. Explain what an embedded system is.
      ii. Explain what a Real-Time System is.
      iii. Compare and contrast microcontrollers and microprocessors
      iv. Quantify the importance of embedded systems in the computing domain
      v. Explain the difference between Embedded and PC applications
   (b) Lecture #2 Real Time System Fundamentals
      i. Define the concept of a system
      ii. Define response time
      iii. Define real time system
      iv. Compare and contrast soft, firm, and hard real time systems
      v. Define punctuality
      vi. Define event
      vii. Define release time
      viii. Classify events as either being synchronous or asynchronous, periodic, aperiodic, or sporadic
      ix. Define deterministic system
   (c) Lecture #3 No Class
2. Week #2
   (a) Lecture #1 Response Time
      i. Define Latency
      ii. Construct a system diagram from a real world problem
      iii. Experimentally determine the response time for a system
      iv. Experimentally analyze the latency of various parts of a system.
   (b) Lecture #2 Measuring with an Oscilloscope
      i. Explain the meaning of horizontal scaling on an oscilloscope.
      ii. Understand the meaning of vertical scaling on an oscilloscope.
      iii. Understand the relationship between frequency and period.
      iv. Recognize a square wave, a sine wave, and a saw tooth wave
      v. Using the oscilloscope, measure the peak voltage of a signal
      vi. Explain the concept of a pulse width modulated waveform
      vii. Measure the duty cycle of a pulse width modulated signal
      viii. Explain the concept of rise time and fall time.
      ix. Use an oscilloscope to measure the frequency and offset of two signals.
      x. Using the oscilloscope, measure the time difference between two signals.
   (c) Lecture #3 Real Time Systems Hardware
      i. Explain the difference between a microcontroller and a microprocessor
      ii. Identify the key components of the Beaglebone platform
      iii. Explain why the Beaglebone changes operating frequency under different power conditions

iv. Identify the key hardware interfaces of the beaglebone
v. Explain the concept of a cape
vi. Calculate the software GPIO pin number from an expansion port header definition
vii. Understand how to read a basic schematic
viii. Explain the concept of a dropping resistor
ix. Explain the concept of a pull up and a pull down resistor

3. Week #3
   (a) Lecture #1 Real Time Systems Hardware Part 2
      i. Explain the concept of a cape
      ii. Understand how to read a basic schematic
      iii. Explain the concept of a dropping resistor
      iv. Explain the concept of a pull up and a pull down resistor
      v. Explain the difference between polling and interrupts
      vi. Explain how an interrupt service routine is handled
      vii. Explain the concept of a system on a chip
      viii. Explain the purpose for a watchdog timer
   (b) Lecture #2 Designing Multithreaded Software For the Beaglebone
      i. Explain how to design a simple multithreaded application using POSIX (Review from CS3844)
      ii. Explain the concept of conditional compilation (How can we use conditional compilation to our benefit)
   (c) Lecture #3 Resistor Codes and RTOS Definitions
      i. Lab topic: Be able to calculate the resistance of a given resistor using the color bands
      ii. Understand the CPU Utilization Factor
      iii. Given a set of processes, calculate the CPU utilization factor
      iv. Define the acronym RTOS
      v. Explain the role of the kernel in operating systems
      vi. Compare and contrast Polled loops, polled loops with delay, and cyclic code structures
      vii. Explain switch bounce
      viii. Explain how to construct an interrupt only system
      ix. Explain the concept of background and foreground tasks

4. Week #4
   (a) Lecture #1 Networking and Sockets
      i. Understand the usage of sockets in a POSIX environment
      ii. Construct a basic application using POSIX sockets
   (b) Lecture #2 Scheduling and Theory
      i. Draw the task state diagram
      ii. Explain the concept of Rate Monatonic Analysis.
      iii. Explain the difference between pre-runtime and runtime scheduling
      iv. Explain the operation of round robin scheduling
      v. Explain how round robin scheduling may impact latency for a given process
      vi. Explain cyclic code scheduling

5. Week #5
   (a) Lecture #1 No Class - Emergency Cancelation
   (b) Lecture #2 GSTreamer
      i. Explain the purpose for the GSTREAMER libraries
      ii. Define the concept of pads, bins, and piplines
      iii. Compare and contrast source, sink, and filter elements
      iv. Explain how a pipline can be graphically represented
      v. Explain how we can use an oscilloscope to measure execution time of a method

(c) Lecture #3 Introduction to QT

- i. Explain the purpose for the QT libraries.
- ii. Explain the concepts of signals and slots
- iii. Explain the purpose for QMAKE within the QT framework.
- iv. Explain the concept of a widget.

6. Week #6

(a) Lecture #1 Exam Review

- i. Prepare for the midterm exam.

(b) Lecture #2 Midterm Exam

- i. Successfully pass the exam.

(c) Lecture #3 No Class (Good Friday)

7. Week #7

(a) Lecture #1 Audio and Video Basics

- i. Explain the relationship between bandwidth and image quality for a video stream.
- ii. Calculate the bandwidth needed to deliver a given quality image
- iii. Explain the stroboscopic effect
- iv. Calculate the maximum data rate of a channel under both noiseless and noisy signal conditions
- v. Explain the Nyquist theorem related to sampling
- vi. Calculate the minimum sampling rate necessary to transmit a signal using the Nyquist Theorem
- vii. Explain the relationship between the number of bits and quality when sampling a signal

(b) Lecture #2 Bandwidth

- i. Calculate the maximum data rate of a channel under both noiseless and noisy signal conditions
- ii. Explain the Nyquist theorem related to sampling
- iii. Calculate the minimum sampling rate necessary to transmit a signal using the Nyquist Theorem
- iv. Explain the relationship between the number of bits and quality when sampling a signal
- v. Critique the Java language for usage in Real Time Systems
- vi. Optimize source code using well known optimization techniques, such as Repeated calculations, Constant folding, Loop invariance removal, Induction variance, Loop unrolling, Loop jamming

(c) Lecture #3 Catchup

8. Week #8

(a) Lecture #1 and 2 Coding Standards and MISRA

- i. Understand the difference between static analysis and testing
- ~~ii. Define the halting problem~~
- iii. Explain the difference between a false positive and a false negative
- ~~iv. Construct a primitive static analysis tool using grep~~
- v. Describe the impact of using static analysis tools over time
- vi. Compare and contrast style guides and programming standards
- vii. Explain the steps necessary to integrate static analysis into a development process for New code and Legacy code

(b) Lecture #3 Software Qualities

- i. Explain the difference between internal and external qualities of software
- ~~ii. List the 8 qualities of real-time software~~
- iii. Explain how one might assess the qualities of real time software
- iv. Explain the concept of software reliability
- v. Explain the exponential model of software reliability
- vi. Explain the reliability curves typically exhibited by software
- vii. Calculate the reliability of a software system at a given time
- ~~viii. Explain how one might measure the 8 qualities of real time software~~

9. Week #9

   (a) Lecture #1 Structured Design and Data Flow Diagrams

      i. Define Structured Design
      ii. Explain the purpose for a data flow diagram
      iii. Construct a dataflow diagram for a given problem
      iv. Explain the purpose for a data-dictionary entry
      v. Explain how a data dictionary can be used to keep track of information in an embedded system
      vi. Explain the types of defects that a data flow diagram could aid in detecting in software
      vii. Compare and contrast Structured Analysis approaches versus Object Oriented Approaches toward designing software

   (b) Lecture #2 Performance Analysis

      ~~i. List the complexity of various real time related activities~~
      ~~ii. Explain the relationship between Amdahls and Gustafsons laws~~
      iii. Explain how gprof can be used to aid in analyzing program execution

   (c) Lecture #3 Queuing Theory

      i. Explain the concept of a Poisson queue
      ii. Explain how to calculate the average servicing time for a system
      iii. Explain the concepts of an M/M/1 queue
      iv. For an M/M/1 queue system, calculate the average response time and the average number of customers in the system
      ~~v. Calculate the mean response time for an M/M/2 queue.~~
      ~~vi. Calculate the Average time spent in an M/M/infinite queue system.~~

10. Week #10

   (a) Lecture #1 Memory Utilization

      i. Explain the 1201 and 1202 (1021?) alarms encountered on Apollo 11 and explain the relevance to real time systems.
      ~~ii. Explain how to calculate total memory utilization~~
      ~~iii. Explain how to limit memory utilization~~

   (b) Lecture #2 The Toyota Software Failures

      i. Explain the patriot missile failure
      ii. Explain what is meant by expert testimony
      iii. Understand the ethical responsibility of an engineer when giving expert testimony
      iv. Explain how a bit flip could disable a task in the Toyota operating system, resulting in unintended acceleration

   (c) Lecture #3 Exam Review

      i. Evaluate the effectiveness of the course
      ii. Prepare to pass the final exam.