ELEC 371
MICROPROCESSOR INTERFACING AND EMBEDDED SYSTEMS

Course Syllabus – Fall 2024

This is your course syllabus. Please download the file and keep it for future reference.

LAND ACKNOWLEDGEMENT

Queen's University is situated on traditional Anishinaabe and Haudenosaunee Territory.
See: http://www.queensu.ca/encyclopedia/t/traditional-territories

INCLUSIVITY STATEMENT

Queen's students, faculty, and staff come from every imaginable background – small towns and suburbs, urban high rises, Indigenous communities, and from more than 100 countries around the world. You belong here: https://www.queensu.ca/inclusive/.

TEACHING TEAM

COURSE INSTRUCTOR

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ELEC 371 Microprocessor Interfacing and Embedded Systems (F 3-0.5-0.5 4)

Course Description

Microprocessor bus organization and memory interfaces; parallel input/output interface design; assembly-language and high-level-language programming; interrupts and exceptions; timers; embedded systems organization and design considerations; integration in microcontrollers and programmable logic chips; interfacing with sensors and actuators; embedded system case studies.

Prerequisites: ELEC 271, CISC 231 or ELEC 274

(0/0/0/36/12) (Mathematics/Natural Sciences/Complementary Studies/Engineering Science/Engineering Design)

Course Learning Outcomes (CLO)

By the end of this course, students should be able to:

CLO	Description	Indicator
CLO 1	Describe the organization and behavior of hardware for supporting interrupts, and write appropriate code sequences in assembly language to initialize hardware for and respond to interrupt requests.	KB-Engineering Science
CLO 2	Describe concepts and design issues related to embedded systems and system-on-chip implementation involving microcontrollers and field-programmable logic chips, highlighting similarities and differences.	KB-Engineering Science
CLO 3	Design the address space and the address decoding logic for specified memory and input/output components in an embedded system, and analyze the memory-interface timing for execution of load/store instructions.	DE-Solutions PA-Solve
CLO 4	Write a program in the C language for a specified embedded application involving the use of parallel input/output ports and a hardware timer with interrupt capability.	ET-Apply

(Information about Indicators is available in a document provided on the Smith Engineering Website.)

COURSE OUTLINE

Week	Topics
1-2	Bus interconnection of processor and system components, address decoding, parallel input/output interfaces, interface logic design, software programming
3-4	Interrupt concepts, programming considerations for interrupts, hardware registers in processor and input/output interfaces to support interrupts, details of programming for interrupts, use of timer interfaces with interrupts
5-6	Software issues, code-generation tools, use of C for input/output and interrupts
7-9	Embedded systems concepts, design issues, microcontrollers, sensors/actuators
10-11	System-on-chip integration with FPGA technology, embedded processors
12	Additional concepts and examples, course summary and review

COURSE EVALUATION

Labs 10%; in-class midterm quiz 25%; final examination 65%.

ASSESSMENT DESCRIPTIONS

Laboratory Exercises

There are four in-person laboratory exercises during the term. All students should consult their individual SOLUS timetables to note their lab section and the days/times of their four official lab sessions. There will be no accommodation and no credit for attending the wrong day/time. Each session will have an attendance sheet with the names of only those students who can receive credit for attending that session. Other students will be directed to leave and attend the correct day/time for their section. *There will be **no** arbitrary switching between sessions for any reason; only a formal change in lab section registration is acceptable*. The handling of absences for lab activity is discussed in a later section of this document.

In-Class Midterm Quiz

The in-class quiz will be on **Tues., October 8, 2024** at **10:30am for Section 001** and at **2:30pm for Section 002**. Both times are official lecture slots for this course in the university timetable. *PLAN ACCORDINGLY*.

Additional rooms will be reserved for double seating, and students will be assigned to specific rooms. Those room assignments will be communicated directly to students by email in advance of the quiz. An announcement will be posted in onQ to confirm that such email communication has occurred. Students are then responsible for ensuring that they have received their room assignments and that they have recorded their room assignments in their personal calendars. (Students with university-approved academic accommodations are handled through the Exams Office, and those students would not be assigned a room by the instructor.)

Students who do not attend the specific room to which they have been assigned by the instructor as described above will receive an automatic 20% penalty to their quiz mark for failure to follow clearly communicated directives.

Students requiring academic accommodations must use the Ventus system, and that should be done as soon as possible (particularly if other courses have assessments earlier than this course.)

The quiz in this course is **closed-book with no aids of any kind** --- only writing tools.

The duration of the quiz is 40 minutes to enable preparation of quiz papers in each room for double seating and to allow for collection of papers at the end, all within the scheduled slot for a lecture.

Handling of an absence for the quiz is discussed in a later section of this document.

Final Exam

The final exam for this course is **closed book with no aids of any kind** with the standard 3-hour duration. Students must write their exam on the day and time scheduled by the University (unless accommodations are arranged by the Exams Office). You should not schedule vacations, travel, etc., during the exam period. The Term and Session Dates will indicate the final exam period session dates in each term.

Handling of an absence for the final examination is covered by Smith Engineering policies/procedures.

GRADING

Marks for each assessment will be reflected as numerical percentage scores. The course evaluation scheme shown earlier will be used to calculate the overall numerical percentage for the course. The final official grade you receive for the course will be derived by converting your numerical percentage for the course to a letter grade according to the established Grade Point Index.

Your final course grade will appear on SOLUS after the results are submitted by the instructor. Official transcripts showing final grades will be available on the Official Grade Release Date. Please note that in official transcripts, a mark of IN (incomplete) is considered a grade, and your transcript is released with this grade.

COURSE MATERIALS

Reference Textbook

C. Hamacher, Z. Vranesic, S. Zaky, and N. Manjikian, *Computer Organization and Embedded Systems*, 6th edition, McGraw-Hill, 2012.

Course Material and Other Relevant Documentation

Course material and other documents prepared by the instructor are posted at the course onQ site.

Suggested Time Commitment

This course represents a study period of one semester spanning 12 weeks. Learners should plan to invest 7-9 hours per week in this course. Learners who make efforts to methodically learn the course material throughout the term are more likely to successfully complete the course.

COURSE ANNOUNCEMENTS

The instructor will routinely post course news in the Announcements section on the main course homepage on onQ. Take the responsibility to regularly check the Announcements section during the term, and attend class regularly for verbal reminders of such announcements and other information. You can also change the onQ settings to notify you by email when a new announcement is posted. In the onQ course page, click on *Communications*, select *Announcements*. Under *More Actions*, select *Notifications*. In the list of notification options, under the *Email* column, click in the checkbox under for *Announcements – new announcement available*. Finally, click on *Save*.

CONSULTING TIMES

Outside of scheduled class times, your instructor is available at the consulting times posted in onQ.

EMAIL POLICY FOR COURSE

In this course, email communication will be from the instructor to students and only for important or urgent administrative matters. Email will not be used to answer questions about the course material. Students must use in-class opportunities or scheduled consulting times (see above). There is no need to directly contact the instructor for illness and other circumstances covered under the Smith Engineering policies/procedures. Students must follow those procedures and contact Student Services, which leads to instructors being notified. Once the instructor of *this course* has been notified, the *policies specific to this course are **automatically** applied and **no** email communication is required*. See the next section.

ABSENCES (ACADEMIC CONSIDERATIONS) AND MISSED ASSESSMENTS/LABORATORIES

[For academic accommodations that relate to the university recognizing and making adjustments for documented issues or challenges, review relevant information on the Smith Engineering Website. *The remainder of this section covers situations other than those in the category of accommodations*.]

For information on absences and academic considerations due to extenuating circumstances, review the valid instances listed on the Smith Engineering Website. For absences due to valid reasons, complete the online form that is submitted to Student Services. Invalid reasons include extra-curricular activities, travel plans, family events, poor time management, problems with classmates, etc. Do not schedule travel during midterms and final exams, as travel is not a valid reason for granting academic considerations.

DO NOT contact the instructor when circumstances such as illness or family emergencies arise. Follow the Smith Engineering policy/procedure by completing the online form. If possible, submit your information before the lab/quiz/exam that may be missed. If that is not possible, submit your information with as short a delay as is feasible after the missed activity. Contact Smith Engineering Student Services for guidance.

Once a student submission due to illness/emergency has been approved by Smith Engineering, instructors are notified. *Everything is documented, so in this course, there is NO NEED for students to contact the instructor*. The notifications from Smith Engineering are carefully recorded by the instructor of this course and will be used to modify the final course mark computation for affected students (see below).

Although the notification from Smith Engineering directs students to subsequently contact instructors, *in this course there is NO NEED to pursue such follow-up communication*. This course has simple policies: **there will be reweighting of other labs if there is an excused absence for a lab, or there will be a transfer of the weight of the quiz to the final examination if there is an excused absence for the quiz**. *Again, DO NOT contact the instructor.* There is nothing to discuss because an approval from Smith Engineering results in automatic application of the aforementioned course-level policies. This approach prevents unnecessary stress and loss of time, allowing for an affected student to concentrate on addressing the particular illness/emergency in question.

A student who misses a lab (excused or not) should individually pursue the work later for learning.
A student who misses the quiz (excused or not) should write it later as practice for learning.

STANDARD QUEEN'S AND SMITH ENGINEERING POLICIES

STUDENT CODE OF CONDUCT

Queen's University values maintaining an environment free of, and will not tolerate, harassment, discrimination, and reprisal. The Student Code of Conduct applies to all students at Queen's. It outlines the activities and behaviours that could be considered Non-Academic Misconduct (NAM). The Code also describes the NAM process and the sanctions that could be imposed on a student found responsible for a violation.

All students should be familiar with the Student code of conduct and related policies on sexual violence prevention and response and harassment and discrimination prevention and response.
https://www.queensu.ca/nonacademicmisconduct/policies

COPYRIGHT

Course materials created by the course instructor, including all slides, presentations, synchronous and asynchronous course recordings, handouts, tests, exams, and other similar course materials, are the intellectual property of the instructor. It is a departure from academic integrity to distribute, publicly post, sell or otherwise disseminate an instructor's course materials or to provide an instructor's course materials to anyone else for distribution, posting, sale or other means of dissemination, without the instructor's ***express consent***. A student who engages in such conduct may be subject to penalty for a departure from academic integrity and may also face adverse legal consequences for infringement of intellectual property rights and, with respect to recordings, potentially privacy violations of other students.

ACADEMIC INTEGRITY

As an engineering student, you have made a decision to join us in the profession of engineering, a long-respected profession with high standards of behaviour. As future engineers, we expect you to behave with integrity at all times. Engineers have a duty to:

- Act at all times with devotion to the high ideals of personal honour and professional integrity.
- Give proper credit for engineering work.

The standard of behaviour expected of professional engineers is explained in the Professional Engineers Ontario Code of Ethics. Information on policies concerning academic integrity is available in the Queen's University Code of Conduct, in the Senate Academic Integrity Policy Statement, on the Smith Engineering website, and from your instructor.

Departures from academic integrity include plagiarism, use of unauthorized materials or services, facilitation, forgery, falsification, unauthorized use of intellectual property, and collaboration, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the University.

In the case of online or remotely proctored exams, impersonating another student, copying from another student, making information available to another student about the exam questions or possible answers, posting materials to online services, communicating with another person during an exam or about an exam during the exam window, or accessing unauthorized materials, including internet sources and using unauthorized materials, including smart devices, are actions in contravention of academic integrity.

GENERATIVE ARTIFICIAL INTELLIGENCE (AI) TOOLS, LIKE CHATGPT

For this course, the formal supervised written assessments – quiz and final examination – constitute a substantial portion of the overall grade. No aids of any kind are permitted for the quiz and final examination. Therefore, AI tools are clearly not available and not applicable for these assessments.

Furthermore, the individual learning pursued by students leading up to these assessments should not rely on AI tools. Students should strive to individually complete tutorial questions, lab preparation, and other independent learning activities described by the instructor to truly learn the course concepts and

their practical realization. For in-lab activity, students should work within their lab groups, relying on their individual preparation, active discussion among group members, relevant course material, and practical experience to solve problems and enhance their learning. Seeking shortcuts through AI tools and other Internet-based resources does not contribute to true individual learning that must ultimately be demonstrated without any aids during the formal supervised written assessments for this course.

INVALID EXAMS

An exam may be declared invalid if there is an interruption during the administration of in an in-person examination or if a situation arises where the integrity of the exam cannot be verified. If an exam is declared invalid, the student may be granted a re-write. Note that the preceding statement covers situations with broad scope that are not under the control of an individual student. Any student who individually engages in any type of improper/inappropriate behavior during a formal supervised written assessment that ultimately leads to sanctions cannot claim the aforementioned benefit of a re-write.

WEEKLY COURSE LEARNING OUTCOMES

Week	Learning Outcomes	Assessment
1,2	**System org. with mem. and I/O; asm.-lang. software considerations** Understand bus interconnection of processor and other system components; draw diagrams for system organization. Design address decoding logic for given system specification. Understand system bus/memory timing behavior and draw waveforms for functional timing diagrams to reflect cycle-by-cycle behavior. Understand parallel input/output interfaces and their logic design. Write asm.-lang. code for program-controlled (polling-based) software for using parallel input/output interfaces.	**Quiz;** **Final Exam** **[CLO 3]**

Week	Learning Outcomes	Assessment
2,3	**Interrupts for I/O – hardware and software considerations** Understand the concepts for interrupts and the contrast with the program-controlled approach. Understand asm.-lang programming considerations for interrupts. Understand and identify hardware registers in processor and input/output interfaces to support interrupts. Write proper asm.-lang. code for interrupt initialization and for an interrupt service routine. Understand interrupt-capable I/O interfaces, especially timer interfaces, and write proper asm.-lang. code to use them in interrupt mode.	**Quiz;** **Final Exam** **[CLO 1][CLO 4]**
5,6	**Software issues/tools; high-level I/O programming in C** Understand the full code-generation tool flow that includes compiler, assembler, and linker to support asm.-lang. and high-level languages. Understand the correspondence of asm.-lang. vs. high-level lang. code for program-controlled and interrupt-based input/output software. Write proper C code for program-controlled and interrupt-based input/output software, and for interrupt-based software in particular, write proper C code within the specific environment for the target platform for practical work in the course.	**Final Exam** **[CLO 4]**
7,8,9	**Embedded systems** Understand embedded systems concepts and terminology. Identify and explain various design issues for embedded systems. Understand the purpose and features of microcontroller chips, and their application in embedded systems. Understand the different types of sensors/actuators that may be involved in embedded systems.	**Final Exam** **[CLO 2]**

Week	Learning Outcomes	Assessment
10,11	**System-on-chip design** Understand system-on-chip integration concepts and design issues as they relate to custom-chip design and to the use of FPGA technology. Understand the variations and configurability of embedded processors for system-on-chip design, particularly for FPGA technology.	**Final Exam [CLO 2]**
12	**Wrap-up** Understand additional concepts and examples that are presented as time permits. Use the course summary as an opportunity review understanding of all course material.	

ACADEMIC AND STUDENT SUPPORT

Queen's has a robust set of supports available to you including the Library, Student Academic Success Services (Learning Strategies and Writing Centre), and Career Services. Learners are encouraged to visit the Smith Engineering Current Students web portal for information about various other policies such as academic advisors, registration, student exchanges, awards and scholarships, etc. Students are also encouraged to review the information that is available in the EngQ Hub, posted in onQ.

ABSENCES (ACADEMIC CONSIDERATIONS) AND ACADEMIC ACCOMMODATIONS

For academic accommodations and considerations please review the information on the Smith Engineering website. This document has a separate section that discusses the *course-specific* policies for handling absences.

ACCOMMODATIONS FOR DISABILITIES

Queen's University is committed to working with students with disabilities to remove barriers to their academic goals. Queen's Student Accessibility Services (QSAS), students with disabilities, instructors, and faculty staff work together to provide and implement academic accommodations designed to allow students with disabilities equitable access to all course material (including in-class as well as exams). If you are a student currently experiencing barriers to your academics due to disability related reasons, and you would like to understand whether academic accommodations could support the removal of those barriers, please visit the QSAS website (https://www.queensu.ca/studentwellness/accessibility-services) to learn more about academic accommodations. To start the registration process with QSAS, click the ***Access Ventus*** button found on the Ventus student portal: https://www.queensu.ca/studentwellness/accessibility-services/ventus

Ventus is an online portal that connects students, instructors, Queen's Student Accessibility Services, the Exam's Office, and other support services in the process to request, assess, and implement academic

accommodations. To learn more about Ventus, visit A Visual Guide to Ventus for Students: https://www.queensu.ca/ventus-support/students/visual-guide-ventus-students

For questions or assistance with requesting Academic Consideration or Accommodation, contact the Smith Engineering Program Advisor (Accommodations and Considerations) at engineering.aac@queensu.ca

Every effort has been made to provide course materials that are accessible. For further information on accessibility compliance of the educational technologies used in this course, please consult the links below.

EDUCATIONAL TECHNOLOGY	ACCESSIBILITY COMPLIANCE INFORMATION
onQ (Brightspace Learning Management System by D2L)	https://www.d2l.com/accessibility/standards/

If you find any element of this course difficult to access, please discuss with your instructor how you can obtain an accommodation.

RELIGIOUS OBSERVANCE

Students in need of accommodation for religious observance are asked to speak to their professor within a week of receiving their syllabus. Note also that alternative assignments are considered a "reasonable accommodation" under the Ontario Human Rights Code. Students with questions about their rights and responsibilities regarding religious accommodation should contact the Chaplain Chaplain@queensu.ca.

OTHER HUMAN-RIGHTS BASED ACCESSIBILITY NEEDS

Students with accessibility needs based on human-rights covered grounds should inform instructors within a week of receiving their syllabus. Student can also contact the contact the Smith Engineering Program Advisor (Accommodations and Considerations) at engineering.aac@queensu.ca for guidance.

TECHNICAL SUPPORT

Some basic comfort level with basic hardware and software skills are required for this course. If you require technical assistance, please contact Technical Support.

SUPPORTIVE PERSONAL COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential personal counselling and wellness services offered by Smith Engineering and the Queen's student wellness services.