Toronto Metropolitan University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (W2025)

COE838: Systems-on-Chip Design

Instructor(s)	Dr. Gul Khan [Coordinator] Office: ENG448 Phone: (416) 979-5000 x 556084 Email: gnkhan@torontomu.ca Office Hours: 1:45-3:00PM Monday
Calendar Description	This course will cover the basics of system-on-chip (SoC) design, hardware-software co-specification, co-synthesis and network-on-chip (NoC) systems. It provides the advance knowledge required for system-on-chip design, multi-core architectures and embedded systems on a chip. Students will also be introduced to the main principles of SoC modeling and design using SystemC. Various soft processor cores such as Nios-II and other IPs will be explored. Interconnection structures such as AMBA, Avalon and IBM Core-connect for SoC design will be covered in detail. Various SoC development tools will be utilized in the labs and projects.
Prerequisites	COE 718 or ELE 734
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. D.C. Black, J Donovan, B. Bunton, A. Keist, SystemC: From the Ground Up, 2nd Edition, Springer 2010, ISBN 978-0-387-69958-5 2. Michael J. Flynn, Wayne Luk, Computer System Design: System on Chip, John Wiley and Sons Inc. 2011, ISBN 978-0-470-64336-5 (Not-Compulsory)
Reference Text(s):	1. M. Wolf, Computer as Components: Principles of Embedded Computing System Design, 3rd or 4th Edition, Morgan Kaufman Publishers 2016, ISBN 978-0-12-805387-4 2. Some relevant review articles to be identified by the instructor and will be available at the course web page.
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Interconnect engineering concepts related to soft-processor cores, hardware and software systems to design an SoC for real-world applications. Learn to employ specialized knowledge of subsystems like processor cores and other SoC components to design an embedded SoC. (**1c**), (**1d**) 2. Improve students' capabilities of using the technical knowledge of processor architecture, peripherals, programming, and CAD tools to design application specific SoCs. Solve various challenges of high performance SoC design in multiple stages by employing hardware/software co-design methodologies to test and verify each stage and then integrate different stages into an efficient SoC architecture. (**4a**), (**4c**) 3. Learn and efficient use of different SoC simulation, modeling and prototyping tools including SystemC, QSys and Quartus-II. These tools facilitate co-simulation and co-design of SoCs. (**5a**)

	4. Demonstrate the main features of the course-project and answer critical and project specific questions during project demo and oral sessions. Write project report by following a standard IEEE like format, where all the lab and project reports are evaluated based on their completeness, English, and citations. (**7a**), (**7b**) **NOTE:***Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*
Course Organization	3.0 hours of lecture per week for 13 weeks 1.0 hours of lab per week for 12 weeks 0.0 hours of tutorial per week for 12 weeks
Teaching Assistants	TBA
Course Evaluation	<table><tr><th>**Theory**</th><th></th></tr><tr><td>Midterm Exam</td><td>25 %</td></tr><tr><td>Final Exam</td><td>43 %</td></tr><tr><th>**Laboratory**</th><th></th></tr><tr><td>Labs with formal Reports</td><td>20 %</td></tr><tr><td>Project</td><td>12 %</td></tr><tr><td>TOTAL:</td><td>100 %</td></tr></table> **Note:** In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).
Examinations	Midterm Exam in Week 6, 70-80 minutes. Final Exam, during exam period, 2 hours.
Other Evaluation Information	None
Other Information	None

Course Content

Week	Hours	Chapters / Section	Topic, description

1	3		Introduction to System on Chip (SoC) SoC Design Approach
2	3		Introduction to SystemC, SoC Co-specification http://www.doulos.com/knowhow/systemc/
3	3		SystemC based Modeling and Analysis of SoCs
4	3		Hardware-Software Cosynthesis and Accelerators based Embedded System Design
5	3		Basics of Chips and SoC ICs
6	3		Midterm Exam SoPC (System on Programmable Chips) and SoC Design
7	3		SoC-Platforms and DE1-SoC Design Methods for SoC Project and Labs
8	3		NoC (Network on Chip) and NoC based Interconnection.
9	3		NoC based Interconnection: Regular (Mesh, Torus, Tree, etc.) and Application Specific NoC Topologies.
10	3		On-Chip Interconnection: On-Chip Busses including AMBA, Core-connect, Avalon, etc.
11	3		Soft CPU Cores: ARM-A9, OpenRISC, Leon4, OpenSPARC, etc.

12	3		SoC Verification and UVM
13	3		SoC Application Case Studies (If time permits) Catching up and Review

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2	ENG412	Lab1: SystemC: Introduction and Tutorial. http://www.doulos.com/knowhow/systemc/
3	ENG412	Lab 2a: SystemC based Accelerator for SoC. Lab1 Demo and Submission
4	ENG412	Lab 2b: JPEG Encoder/Decoder SoC Design using SystemC.
5	ENG412	Lab2a and Lab2b Demo and Submission
6	ENG412	Introduction to Course Project Lab 3: DE1-SoC Tutorial - Creating SoCs using FPGA and Hard A9 (CPU) Systems.
7	ENG412	Lab4: Designing and Interfacing Custom IP with an FPGA/HPS System. Lab3 Completion and Demo
8	ENG412	Lab4 Completion and Demo Project Summary and Approach (1-2 pages)
9	ENG412	Project Progress
10	ENG412	Project Progress and Interim Report
11	ENG412	Project Progress

12	ENG412	Project Demo and Completion
13	ENG412	Project Presentation and Final Report

University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

Refer to the Departmental FAQ page for furhter information on common questions.

Important Resources Available at Toronto Metropolitan University

- The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service to speak with a librarian.
- Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.
- You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

  For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.
- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning Guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for Faculty and students.

Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.
- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:**24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:**24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.