

**Course Outline (W2023)**

**COE838: Systems-on-Chip Design**

<b>Instructor(s)</b>	Dr. Gul Khan [Coordinator] Office: ENG448 Phone: (416) 979-5000 x 556084 Email: gnkhan@torontomu.ca Office Hours: 3:00-4:00PM Monday
<b>Calendar Description</b>	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.
<b>Prerequisites</b>	COE 718 or ELE 734
<b>Antirequisites</b>	None
<b>Corerequisites</b>	None
<b>Compulsory Text(s):</b>	<ol style="list-style-type: none"> <li>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</li> <li>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)</li> </ol>
<b>Reference Text(s):</b>	<ol style="list-style-type: none"> <li>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</li> <li>2. Some relevant review articles to be identified by the instructor and will be available at the course web page.</li> </ol>
<b>Learning Objectives (Indicators)</b>	<p>At the end of this course, the successful student will be able to:</p> <ol style="list-style-type: none"> <li>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. <b>(1c), (1d)</b></li> <li>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. <b>(4a), (4c)</b></li> <li>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. <b>(5a)</b></li> </ol>

	<p>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. <b>(7a), (7b)</b></p> <p><b>NOTE:</b>Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).</p>														
<b>Course Organization</b>	<p>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</p>														
<b>Teaching Assistants</b>	<p>Ms. Huma Inayat  Mr. Yoga Suhas Kuruba Manjunath</p>														
<b>Course Evaluation</b>	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="2" style="text-align: left;"><b>Theory</b></th> </tr> </thead> <tbody> <tr> <td>Midterm Exam</td> <td style="text-align: right;">25 %</td> </tr> <tr> <td>Final Exam</td> <td style="text-align: right;">45 %</td> </tr> <tr> <th colspan="2" style="text-align: left;"><b>Laboratory</b></th> </tr> <tr> <td>Labs with formal Reports</td> <td style="text-align: right;">20 %</td> </tr> <tr> <td>Project</td> <td style="text-align: right;">10 %</td> </tr> <tr> <td><b>TOTAL:</b></td> <td style="text-align: right;"><b>100 %</b></td> </tr> </tbody> </table> <p><b>Note:</b> 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 "<b>Theory and Laboratory</b>" 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 "<b>Course Evaluation</b>" section above for details on the Theory and Laboratory components (if applicable).</p>	<b>Theory</b>		Midterm Exam	25 %	Final Exam	45 %	<b>Laboratory</b>		Labs with formal Reports	20 %	Project	10 %	<b>TOTAL:</b>	<b>100 %</b>
<b>Theory</b>															
Midterm Exam	25 %														
Final Exam	45 %														
<b>Laboratory</b>															
Labs with formal Reports	20 %														
Project	10 %														
<b>TOTAL:</b>	<b>100 %</b>														
<b>Examinations</b>	<p>Midterm Exam in Week 6, 70-75 minutes.  Final Exam, during exam period, 2 hours.</p>														
<b>Other Evaluation Information</b>	<p>None</p>														
<b>Other Information</b>	<p>None</p>														

## 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 <a href="http://www.doulos.com/knowhow/systemc/">http://www.doulos.com/knowhow/systemc/</a>
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. <a href="http://www.doulos.com/knowhow/systemc/">http://www.doulos.com/knowhow/systemc/</a>
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
----	--------	---------------------------------------

## 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](#)

1. In accordance with the Policy on TMU Student E-mail Accounts (Policy 157), Toronto Metropolitan University (TMU) **requires** that any electronic communication by students to TMU faculty or staff be sent from their official university email account;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Familiarize yourself with the tools you will need to use for remote learning. The [Continuity of Learning Guide](#) for students includes guides to completing quizzes or exams in D2L or Respondus, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
5. The University has issued a minimum technology requirement for remote learning. Details can be found at: <https://torontomu.ca/covid-19/students/minimum-technology-requirements-remote-learning>. Please ensure you meet the minimum technology requirements as specified in the above link.
6. Toronto Metropolitan University COVID-19 Information and Updates (available <https://www.torontomu.ca/covid-19/students>) for Students summarizes the variety of resources available to students during the pandemic.
7. Refer to our **Departmental FAQ** page for information on common questions and issues at the following link: <https://www.ecb.torontomu.ca/guides/Student.Academic.FAQ.html>.

## Missed Classes and/or Evaluations

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. **Academic Consideration Requests for missed work** (e.g. missing tests, labs, etc) - According to [Senate Policy 134](#), Section 1.2.3, if you miss any exams, quizzes, tests, labs, and/or assignments for health or compassionate reasons you need to inform your instructor(s) (via email whenever possible) in advance when you will be missing an exam, test or assignment deadline. When circumstances do not permit this, you must inform the instructor(s) as soon as reasonably possible". *In the case of illness, a [Toronto Metropolitan Student Health Certificate](#), or a letter on letterhead from an appropriate regulated health professional with the student declaration portion of the Student Health Certificate attached. For reasons other than illness, proper documentation is also required (e.g. death certificate, police report, TTC report). **ALL supporting documentation for illness or compassionate grounds MUST be submitted within three (3) working days of the missed work.** **NOTE: You are required to submit all of your pertinent documentation through the University's online Academic Consideration Request system at the following link: [prod.apps.ccs.torontomu.ca/senateapps](http://prod.apps.ccs.torontomu.ca/senateapps).***
2. **Religious, Aboriginal and Spiritual observance** - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at [www.torontomu.ca/senate/forms/reobservforminstr.pdf](http://www.torontomu.ca/senate/forms/reobservforminstr.pdf). **If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;**
3. **Academic Accommodation Support** - Before the first graded work is due, students registered with the [Academic Accommodation Support office](#) (AAS - [prod.apps.ccs.torontomu.ca/senateapps](http://prod.apps.ccs.torontomu.ca/senateapps)) should provide their instructors with an Academic Accommodation letter that describes their academic accommodation plan.

## Virtual Proctoring Information (if used in this course)

Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of any such virtually proctored exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to ensure academic integrity is maintained and then will be deleted.

**Access to a computer that can support remote recording is your responsibility as a student.** The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a typical high-speed internet connection. Please note that you will be required to show your Toronto Metropolitan University OneCard prior to beginning to write the exam. In cases where you do not have a Toronto Metropolitan University OneCard, government issued ID is permitted.

Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam, please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

## Academic Integrity

Toronto Metropolitan University's [Policy 60 \(the Academic Integrity policy\)](#) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspensions of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to and including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams

For more detailed information on these issues, please refer to the [Academic Integrity policy](#) (<https://www.torontomu.ca/senate/policies/pol60.pdf>) and to the Academic Integrity Office website (<https://www.torontomu.ca/academicintegrity>).

## Academic Accommodation Support

Toronto Metropolitan University acknowledges that students have diverse learning styles and a variety of academic needs. If you have a diagnosed disability that impacts your academic experience, connect with Academic Accommodation Support (AAS). Visit the [AAS website](#) or contact [asadmin@torontomu.ca](mailto:asadmin@torontomu.ca) for more information.

Note: All communication with AAS is voluntary and confidential, and will not appear on your transcript.

## Important Resources Available at Toronto Metropolitan University

1. [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 at <https://library.torontomu.ca/ask> to speak with a librarian.
2. [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](#).
3. 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 radial button on the top right hand side entitled: Academic Consideration Request (ACR) to submit this request).

Please note that the Provost/Vice President Academic and Deans approved a COVID-19 statement for Fall 2022 related to academic consideration. This statement will be built into the Online Academic Consideration System and will also be on the [Senate website \(www.torontomu.ca/senate\)](http://www.torontomu.ca/senate) in time for the Fall term:

*Policy 167: Academic Consideration for Fall 2022 due to COVID-19: Students who miss an assessment due to cold or flu-like symptoms, or due to self-isolation, are required to provide a health certificate. All absences must follow Senate [Policy 167: Academic Consideration](#).*

Also NOTE: Policy 167: Academic Consideration does allow for a once per term academic consideration request without supporting documentation if the absence is less than 3 days in duration and is **not for a final exam/final assessment**. If the absence is more than 3 days in duration and/or is for a final exam/final assessment, documentation is required. For more information please see Senate [Policy 167: Academic Consideration](#).

4. [TMU COVID-19 Information and Updates for Students](#) summarizes the variety of resources available to students during the pandemic.
5. [TMU COVID-19 Vaccination Policy](#).
6. 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.
7. Information on Copyright for [students](#).
8. At Toronto Metropolitan University (TMU), 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:

- o **Distress Line:** 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- o **Good2Talk:** 24/7 hour line for postsecondary students (phone: 1-866-925-5454)
- o **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](mailto:csdc@torontomu.ca)
- Consent Comes First - Office of Sexual Violence Support and Education: 416-919-5000 ext: 553596 or email [osvse@torontomu.ca](mailto:osvse@torontomu.ca)

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](#).