Tutorial Letter 101/0/2024

Formal Program Verification

COS4892

Year module

Department of Computer Science

IMPORTANT INFORMATION

Please register on myUnisa, activate your myLife e-mail account and make sure that you have regular access to the myUnisa module website, COS4892-24-Y, as well as your group website.

Note: This is a fully online module. It is, therefore, only available on myUnisa.

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1 INTRODUCTION

Dear Student

Welcome to COS4892 in which we study the basic principles of constructing reliable computer programs. This module covers material that is of great importance to the Computer Scientist, Information Technologist, and especially the *Software Engineer*. In the traditional engineering disciplines (Mechanical Engineering, Electronic Engineering etc.) every component of a large system is verified at each stage of the design before it is finally implemented. The aim of this module is to achieve a measure of precision and reliability for software systems, i.e. develop software that provably achieves a given, mathematical specification.

Because this is a fully online module, you will need to use myUnisa to study and complete the learning activities for this module. Visit the website for COS4892 on myUnisa frequently. The website for your module is COS4892-24-Y.

Owing to the nature of this module, you can read about the module and find your study material online. Go to the website at https://my.unisa.ac.za and log in using your student number and password. Click on "myModules" and select your module from the dropdown list of modules.

We wish you every success with your studies!

2 OVERVIEW OF COS4892

2.1 Purpose

The construction of provably reliable software requires the use of formal methods based on discrete mathematics and mathematical logic, but it is not very common to find graduates (especially not in South Africa) who possess the appropriate theoretical background. Although the module cannot merely concentrate on providing theoretical background, we attempt in this module to provide the bare minimum of theory, and to work through several examples that illustrate how the theory can be applied. For this purpose, various proof rules for several programming constructs are derived and applied to several problems. The notions of preconditions and postconditions as part of the specification of a program are central to verification science.

The core of the module is to teach students how to develop a foundation of reasoning during program design and verification. Logical reasoning forms the basis of proving that programming code is correct. The abstract nature of the module can be applied to real life problems and supports the developmental skills of pseudo programming (algorithm development) understanding. The module does not use a specific programming language: it focuses on and teaches mathematical rules and propositions which can be applied in any programming language environment. As stated before, the main aim of the module is to achieve a measure of precision and reliability for software systems.

2.2 Outcomes

The following are the expected *high-level* outcomes of this module:

Outcome 1 - Employ reasoning techniques to solve problems in propositional and first-order logic.

Outcome 2 - Apply and discuss various mechanisms to illustrate verification techniques, viz converting real numbers to integers.

Outcome 3 - Discharge (i.e. prove) the proof rules developed for the various programming language constructs.

Outcome 4 - Apply the various proof rules to a variety of programming constructs to calculate preconditions and to prove the correctness of the said constructs.

Outcome 5 - Apply the theory of program verification to develop an algorithm for a medium-sized case study.

Th subject provides students the ability to reason logically, which can be applied when developing algorithms and coding them in a specific programming language. Logical reasoning becomes critical when systems become very large and abstraction levels increase as is the case in object-oriented programming where objects are developed and used in many ways. Understanding logic and structure will support students when they are confronted with these real-world problems.

3 CURRICULUM TRANSFORMATION

Unisa has implemented a transformation charter based on five pillars and eight dimensions. In response to this charter, we have placed curriculum transformation high on the teaching and learning agenda. Curriculum transformation includes the following pillars: student-centred scholarship, the pedagogical renewal of teaching and assessment practices, the scholarship of teaching and learning, and the infusion of African epistemologies and philosophies. These pillars and their principles will be integrated at both programme and module levels as a phased-in approach. You will notice a marked change in the teaching and learning strategy implemented by Unisa, together with how the content is conceptualised in your modules. We encourage you to embrace these changes during your studies at Unisa in a responsive way within the framework of transformation.

4 LECTURER(S) AND CONTACT DETAILS

4.1 Lecturer(s)

The lecturer for COS4892 for 2024 is specified on the module webpage. Note that the lecturer may not be available at the time of the query. The response time for emails is generally fast, we try to respond within 48 hours.

You are welcome to contact the COS4892 lecturer. Whenever you contact a lecturer via e-mail, please include your student number in the subject line to enable the lecturer to help you more effectively.

4.2 Department

You can contact the Department of Computer Science as follows:

E-mail: computing@unisa.ac.za

4.3 University

To contact the University, follow the instructions on the Contact us page on the Unisa website. Remember to have your student number available whenever you contact the University.

5 RESOURCES

5.1 Joining myUnisa

The myUnisa learning management system is the University's online campus which will help you communicate with your lecturers, other students, and the administrative departments within Unisa. To claim your myUnisa account, please follow the steps below:

1. Visit the myUnisa website at https://my.unisa.ac.za/portal
2. Click on the **"Claim Unisa login"** link on the top of the screen under the orange user ID box.
3. A new screen will load, prompting you to **enter your student number**. Please enter your student number and click **"continue"**.
4. Enter your surname, your full name, your date of birth and, finally, your South African ID number (for South African citizens) OR your passport number (for foreign students). Then click "continue". **Remember to enter either an ID number or a passport number, NOT both.**
5. Please read through the guidelines and **click all the check boxes** to acknowledge that you have read all the information provided. Once you are done, click the **"Acknowledge"** button to redirect you to the final page in the process.

6. The final page will display your myLife e-mail address, and your **myLife AND myUnisa password**. This password will also be sent to the cell phone number displayed on the page for safekeeping.
7. Please note that it can take up to 24 hours for your myLife e-mail account to be created.

Remember, the password provided is your myUnisa **AND** myLife password.

5.2 Prescribed book(s)

The prescribed book for this module is:

Backhouse, R. *Program Construction: Calculating Implementations from Specifications*. John Wiley & Sons, 2003, ISBN: 0-470-84882-0.

NOTE: We will refer to the above prescribed book as **RB** or *Backhouse* throughout this tutorial letter and all future material for this module.

You must buy your own copy of the above textbook. Prescribed books can be obtained from the University's official booksellers. Please refer to the list of official booksellers and their addresses in the *Study @ Unisa* brochure.

If you have difficulty in locating your prescribed book at these booksellers, please contact the Prescribed Book Section at Tel: 012 429 4152 or e-mail vospresc@unisa.ac.za

5.3 Recommended book(s)

In addition to the above prescribed book, there is also one (1) recommended book for COS4892 which is given below.

Baber, R.L: *The Spine of Software: Designing Provably Correct Software - Theory and Practice*. John Wiley & Sons, Chichester, 1987.

This book may be outdated, but the content is as relevant to computer scientists as it was the day it was published. Baber's book is unfortunately out of print, but the good news is that it is available in its entirety on the web. You can download it free of charge as a PDF file from the following URL:

http://www.cas.mcmaster.ca/~baber/Books/Books.html

The file to look for on the above URL is 'Spine.pdf'. Simply right-click on this file and select '*Save Target As ...*'. Then save this file on your hard disk and print it from there. *Do not attempt to print it directly from the McMaster server, since your PC will most probably stall*.

Important notice

We will not study the whole of Baber's book but only those parts of the theory of program verification not covered by Backhouse.

Additional reading material

The following book may also be consulted for more information or a different perspective. Note that this book may not necessarily be available from the Study Collection of the library and may, therefore, be difficult to obtain:

Gries, D: *The Science of Programming*, Springer-Verlag, 1981.

Recommended books can be requested online, via the Library catalogue.

5.4 Library services and resources

The Unisa Library offers a range of information services and resources. The library has created numerous library guides, available at http://libguides.unisa.ac.za

Recommended guides:

- For brief information on the library, go to https://www.unisa.ac.za/library/libatglance
- For more detailed library information, go to http://www.unisa.ac.za/sites/corporate/default/Library
- Frequently Asked Questions, visit https://www.unisa.ac.za/sites/corporate/default/Library/Frequently-Asked-Questions
- For research support and services such as the Personal Librarian service and the Information Search Librarian's Literature Search Request (on your research topic) service, visit http://www.unisa.ac.za/sites/corporate/default/Library/Library-services/Research-support.
- For library training for undergraduate students, visit https://www.unisa.ac.za/sites/corporate/default/Library/Library-services/Training
- Lending Services https://www.unisa.ac.za/sites/corporate/default/Library/Library-services/Lending-services
- Services for Postgraduate students - https://www.unisa.ac.za/sites/corporate/default/Library/Services-for-Postgraduates
- Support and Services for students with disabilities - https://www.unisa.ac.za/sites/corporate/default/Library/Services-for-students-with-special-needs
- Library Technology Support -https://libguides.unisa.ac.za/techsupport
- Finding and using library resources and tools -http://libguides.unisa.ac.za/Research_skills
- A–Z list of library databases – https://libguides.unisa.ac.za/az.php

Important contact information:

- Technical problems encountered in accessing library online services: Lib-help@unisa.ac.za
- General library-related queries: Library-enquiries@unisa.ac.za
- Queries related to library fines and payments: Library-fines@unisa.ac.za
- Interlibrary loan service for postgraduate students: libr-ill@unisa.ac.za
- Literature Search Service: Lib-search@unisa.ac.za
- Social media channels: Facebook: UnisaLibrary and Twitter: @UnisaLibrary

6 STUDENT SUPPORT SERVICES

The *Study @ Unisa* brochure is available on myUnisa: www.unisa.ac.za/brochures/studies

This brochure contains important information and guidelines for successful studies through Unisa.

If you need assistance regarding the myModules system, you are welcome to use the following contact details:

- Toll-free landline: 0800 00 1870 (Select option 07 for myModules)
- E-mail: mymodules22@unisa.ac.za or myUnisaHelp@unisa.ac.za

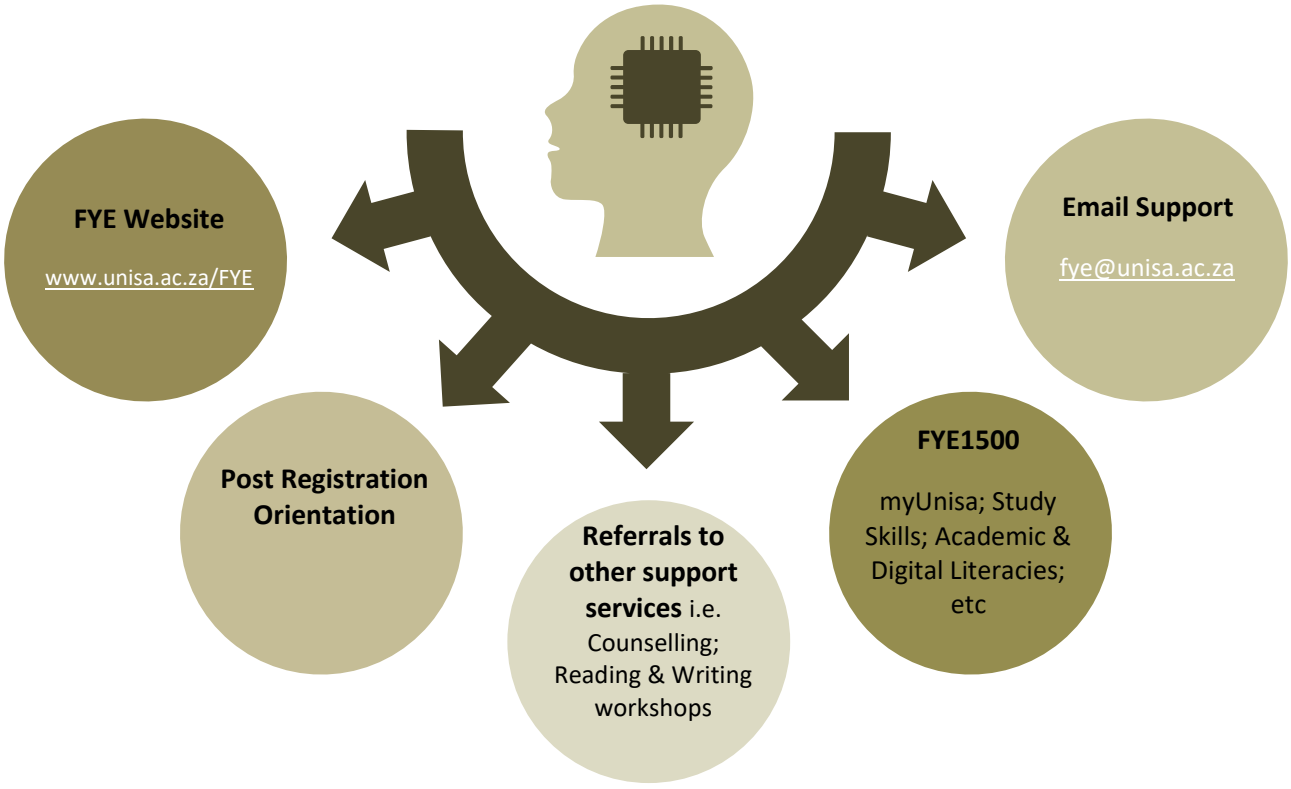
You can access and view short videos on topics such as how to view your calendar, how to access module content, how to view announcements for modules, how to submit assessment and how to participate in forum activities via the following link: https://dtls-qa.unisa.ac.za/course/view.php?id=32130

Registered Unisa students get a free myLife e-mail account. Important information, notices and updates are sent exclusively to this account. Please note that it can take up to 24 hours for your account to be activated after you have claimed it. Please do this immediately after registering at Unisa, by following this link: myLifeHelp@unisa.ac.za

Your myLife account is the **only** e-mail account recognised by Unisa for official correspondence with the university and will remain the official primary e-mail address on record at Unisa. You remain responsible for the management of this e-mail account.

6.1 First-Year Experience Programme @ Unisa

Many students find the transition from school education to tertiary education stressful. This is also true in the case of students enrolling at Unisa for the first time. Unisa is a dedicated open distance and e-learning institution, and it is very different from face-to-face/contact institutions. It is a mega university, and all our programmes are offered through either blended learning or fully online learning. It is for this reason that we thought it necessary to offer first-time students additional/extended support to help them seamlessly navigate the Unisa teaching and learning journey with little difficulty and few barriers. We therefore offer a specialised student support programme to students enrolling at Unisa for the first time – this is Unisa's First-Year Experience (FYE) Programme, designed to provide you with prompt and helpful information about services that the institution offers and how you can access information. The following FYE services are currently offered:



To ensure that you do not miss out on important academic and support communication from the SRU, please check your myLife inbox regularly.

7 HOW TO STUDY ONLINE

7.1 What does it mean to study fully online?

Studying fully online modules differs completely from studying some of your other modules at Unisa.

- **All your study material and learning activities for online modules are designed to be delivered online on myUnisa.**
- **All your assignments must be submitted online.** This means that you will do all your activities and submit all your assignments on myUnisa. In other words, you may **NOT** post your assignments to Unisa using the South African Post Office.
- **All communication between you and the University happens online.** Lecturers will communicate with you via e-mail and SMS, and use the **Announcements,** the **Discussion Forums** and the **Questions and Answers** tools. You can also use all these platforms to ask questions and contact your lecturers.

7.2 myUnisa tools

The main tool that we will use is the **Lessons tool**. This tool will provide the content of and the assessments for your module. At times you will be directed to join discussions with fellow students and complete activities and assessments before you can continue with the module.

It is very important that you log in to myUnisa regularly. We recommend that you log in at least once a week to do the following:

- **Check for new announcements.** You can also set your myLife e-mail account so that you receive the announcement e-mails on your cell phone.
- **Do the Discussion Forum activities.** When you do the activities for each learning unit, we want you to share your answers with the other students in your group. You can read the instructions and even prepare your answers offline, but you will need to go online to post your messages.
- **Do other online activities.** For some of the learning unit activities you might need to post something on the **Blog tool**, take a quiz or complete a survey under the **Self-Assessment** tool. Do not skip these activities because they will help you complete the assignments and the activities for the module.

We hope that by giving you extra ways to study the material and practise all the activities, this will help you succeed in the online module. To get the most out of the online module, you **MUST** go online regularly to complete the activities and assignments on time.

8 ASSESSMENT

8.1 Assessment plan

The prescribed book (i.e. *Backhouse* or **RB**) consists of sixteen chapters which are covered in this module. The topics covered by the book are roughly as follows:

- Motivation: Chapters 1 and 2 set the scene for why reasoning about algorithms is important.

- Arithmetic preliminaries: Chapters 3, 6, 8, 11 and 12 cover various aspects often needed in the verification of programs. Assignments 01 and 02 cover this part.

- Logic: Chapters 5, 7 and 11 deal with logical reasoning including a thorough treatment of equivalence. These three chapters do not form part of the curriculum, although it is recommended that you read through them.

- Implementation: Chapter 4 is a short chapter and shows how to correctly implement some algorithms in Java.

- Verification principles: Chapters 9, 10 and 13 in **RB** as well as Chapter 3 in **Baber** develop the theory needed to

reason about familiar program constructs, e.g. assignments, if-then-else, sequences of statements, loops, etc. Assignment 02 covers this part.

- Practice: Chapters 14, 15 and 16 look at a variety of concrete examples. Assignment 03 covers this part.

Please see *Study @ Unisa* brochure for general time management and planning skills.

8.2 Assignment due dates

There are *three* assignments, each of which must be submitted **before or on** its due date. The assignments will be made available through tutorial letters on myUnisa. Model solutions to the assignments will be loaded on Additional Resources for this module after the respective due date. The due dates will be provided via an announcement on myUnisa.

Assignment no.	Chapters
1	**RB** Chapters 1 - 8
2	**RB** Chapters 9 - 13 **Baber** Chapter 3
3	**RB** Chapters 14 - 16

8.3 Year mark and final examination/other options

COS4892 uses a year-mark system. The mark (percentage) you get for each assignment counts towards your year mark. Every assignment has a total and a weight allocated to it. The weight for Assignment 01 is 0.30 i.e. 30% of your year mark; the weight for Assignment 02 is 0.40 (40%) and the weight for Assignment 03 is 0.30 (30%).

In other words, your year mark (YM) is calculated as: YM = (0.30 * Ass01) + (0.40 * Ass02) + (0.30 * Ass03), where

Ass01 = Percentage obtained for Assignment 01
Ass02 = Percentage obtained for Assignment 02
Ass03 = Percentage obtained for Assignment 03

Your year mark counts 20% towards your final mark and the examination mark makes up the other 80%.

8.4 Submission of assessments

For written assessments, please note the due date by which the assessment must be submitted. Ensure that you follow the guidelines given by your lecturer to complete the assessment. Click on the submission button on the relevant assessment shell on myModules. You will then be able to upload your written assessment on the myModules site of the modules that you are registered for. Before you finalise the upload, double check that you have selected the correct file for upload. Remember, no marks can be allocated for incorrectly submitted assessments.

8.5 Types of assignments and descriptions

All assignments are defined as either optional, mandatory, compulsory, or elective.

- **Elective assignments** - If not submitted, the student gets no mark for this item. The best of the required submissions will count.
- **Mandatory assignments** - If not submitted, the student gets no mark for this item.

- **Compulsory assignments** - If not submitted, the result on the student's academic record will be *absent.*
- **Optional assignments** – You are encouraged as a student to do optional assignment so that it may benefit your learning.

All the assignments for COS4892 are elective assignments. But please note that you must submit at least one assignment by its due date to obtain admission to the COS4892 examination.

8.6 The assessments

There are no assignments included in this tutorial letter. Assignments and due dates will be made available to you on myModules for this module. We envisage that the due dates will be available to you upon registration.

8.7 The examination

Examination information and details on the format of the examination will be made available to you online via the myUnisa site. Look out for information that will be shared with you by your lecturer and e-tutors (where relevant) and for communication from the university.

8.8 Invigilation/proctoring

Since 2020 Unisa conducts all its assessments online. Given stringent requirements from professional bodies and increased solicitations of Unisa's students by third parties to unlawfully assist them with the completion of assignments and examinations, the University is obliged to assure its assessment integrity through the utilisation of various proctoring tools: Turnitin, Moodle Proctoring, the Invigilator App and IRIS. These tools will authenticate the student's identity and flag suspicious behaviour to assure credibility of students' responses during assessments. The description below is for your benefit as you may encounter any or all of these in your registered modules:

Turnitin is a plagiarism software that facilitates checks for originality in students' submissions against internal and external sources. Turnitin assists in identifying academic fraud and ghost writing. Students are expected to submit **typed** responses for utilisation of the Turnitin software.

The **Moodle Proctoring tool** is a facial recognition software that authenticates students' identity during their Quiz assessments. This tool requires access to a student's **mobile or laptop camera**. Students must ensure their camera is activated in their browser settings prior to their assessments.

The Invigilator "mobile application-based service does verification" of the identity of an assessment participant. The Invigilator Mobile Application detects student dishonesty-by-proxy and ensures that the assessment participant is the registered student. This invigilation tool requires students to download the app from their Play Store (Google, Huawei and Apple) on their **mobile devices** (camera enabled) prior to their assessment.

IRIS Invigilation software verifies the identity of a student during assessment and provides for both manual and automated facial verification. It can record and review a student's assessment session. It flags suspicious behaviour by the students for review by an academic administrator. IRIS software requires installation on students' **laptop devices** that are enabled with a webcam.

Students who are identified and flagged for suspicious dishonest behaviour arising from the invigilation and proctoring reports are referred to the disciplinary office for formal proceeding.

Please note:

Students must refer to their module assessment information on their myModule sites to determine which proctoring or invigilation tool will be utilised for their formative and summative assessments.

9 ACADEMIC DISHONESTY

9.1 Plagiarism

Plagiarism is the act of taking the words, ideas and thoughts of others and presenting them as your own. It is a form of theft. Plagiarism includes the following forms of academic dishonesty:

- Copying and pasting from any source without acknowledging the source.
- Not including references or deliberately inserting incorrect bibliographic information.
- Paraphrasing without acknowledging the original source of the information.

9.2 Cheating

Cheating includes, but is not limited to, the following:

- Completing assessments on behalf of another student, copying the work of another student during an assessment, or allowing another student to copy your work.
- Using social media (e.g. WhatsApp, Telegram) or other platforms to disseminate assessment information.
- Submitting corrupt or irrelevant files, this forms part of examination guidelines
- Buying completed answers from so-called “tutors” or internet sites (contract cheating).

For more information about plagiarism, follow the link below:

https://www.unisa.ac.za/sites/myunisa/default/Study-@-Unisa/Student-values-and-rules

10 STUDENTS LIVING WITH DISABILITIES

The Advocacy and Resource Centre for Students with Disabilities (ARCSWiD) provides an opportunity for staff to interact with first-time and returning students with disabilities.

If you are a student with a disability and would like additional support or need additional time for assessments, you are invited to contact (name and e-mail address of the lecturer must be inserted) to discuss the assistance that you need.

11 CONCLUSION

Do not hesitate to contact us by e-mail if you are experiencing problems with the content of this tutorial letter or with any academic aspect of the module.

We wish you a fascinating and satisfying journey through the learning material, and trust that you will complete the module successfully.

Enjoy the journey!

COS4892 team

DEPARTMENT OF COMPUTER SCIENCE

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