SOFTWARE TESTING AND VERIFICATION

CEN6070 Section 1F45
Class Periods: MWF 2, 8:30-9:20 AM
Location: CSE E220

Academic Term: Spring 2022

Instructor:
Steve Thebaut
smt@cise.ufl.edu (the best way to contact me!)
Office Hours via Zoom (tentative): M/W 10:00 – 11:30 AM or by appointment (request appointment via e-mail)
Website: www.cise.ufl.edu/class/cen6070/sp22.html

The course website will be used to post announcements, the course syllabus, self-study lecture notes, etc. In addition, a Canvas course shell will be available via E-Learning (https://elearning.ufl.edu/) to support assignment posts and submissions, Zoom meetings, etc., and to view scores/grades.

Teaching Assistant/Peer Mentor/Supervised Teaching Student: (TBD)

Course (Catalog) Description:
Concepts, principles, and methods for software testing and verification. Topics include human and machine-based testing strategies, formal proofs of correctness, and software reliability. Credits: 3. Prereq: CEN 5035

Course Pre-Requisites / Co-Requisites:
(1) Successful completion of an upper-division undergraduate or graduate-level software engineering survey course (such as UF's CEN 3031/5035), or comparably diverse software engineering experience;
(2) Familiarity with programming using a high-level language (C, C++, Java, SPARK, APL, Lisp, etc.);
(3) Basic knowledge of algorithms, data structures, and discrete math (including symbolic logic);
(4) An interest in fundamental V&V processes used in the development of long-lifetime, high-dependability software systems; and
(5) A desire for deeper insights into programming and program semantics – including iterative constructs (looping and recursion).

In addition, the non-programming, reading, writing, and problem solving-intensive nature of this course is such that students should already be comfortable with English and with using the technical terms necessary for computer scientists/engineers to effectively communicate with each other in small, diverse groups. Therefore, it may be inadvisable for some students whose first or native language is not English to take Software Testing and Verification *during their first semester at UF.*

Students who have already earned credit for CEN4072 at UF may not take CEN6070 for credit.

A self-assessment *pre-test* is available at the course website to assist students in determining their preparedness for the course vis-a-vis coverage of a small subset of prerequisite knowledge.

Course Objectives:
Software Testing and Verification is a survey course on *concepts, principles,* and *techniques* related to software testing and verification for the development of dependable systems. Students will become acquainted with both the strengths and limitations of various functional and structural testing methods, as well as fundamental techniques for *reasoning logically* about the functional correctness of sequential programs.

A significant portion of the course is devoted to introducing fundamental techniques and methods employed by software/test engineers in the development of ***high dependability*** (e.g., safety/mission-critical) systems (as

opposed, for example, to web services/business systems developed using a rapid development/continuous delivery approach). It is NOT a vocational training or professional certification course, and it is NOT "hands-on" tool use-oriented.

Topics include the psychology and economics of testing, black-box and white-box test case *design* strategies, incremental integration testing techniques, overview of testing object-oriented software, reviews and inspections, formal specification, axiomatic verification, predicate transforms, and function-theoretic verification. (See the more detailed "Outline of Course Topics" below.)

Learning Modalities and Course Policies Related to Covid-19:
Students will explore course topics via assigned readings, the review of instructor provided self-study lecture notes, individual and small-group exercises, and various other activities that may or may not involve course content covered in the readings or lecture notes.

UF Provost Joe Glover writes (in e-mail sent to all UF faculty on 12/31/2021):

> *"We anticipate that some number of students will be ill and unable to return to campus in time for the start of classes on January 5. Others may return and discover or develop an illness following January 5. …UF Health and the Florida Department of Health will be withholding those students who test positive, and you will be able to access that information on your class rosters as previously. …It is also likely that some number of faculty will contract the virus and will need to isolate. Those who are able and willing are encouraged to continue delivering coursework remotely through technology, where possible.*

Therefore, in addition to physical face-to-face class meetings, recorded or online-only classes may be utilized when appropriate. The first such recording will be made during the first class held during "drop/add" week on 1/5 and will include an overview of the course Syllabus.

Additional information/guidelines recently distributed to the Campus Community by UF admistrators:

> *As we prepare for classes to start next week for the Spring semester, we want to make you aware of some important new information regarding the university's response to the significant rise in Florida and nationally in cases of COVID-19 due to the omicron variant. … First and foremost, since return to campus is imminent, testing is key. We strongly encourage everyone to get tested before returning to campus if they have symptoms or have been in recent contact with someone with COVID-19. If you test positive, please stay home and follow Centers for Disease Control and Prevention guidelines for ending isolation. …All of the services previously provided under UF Health Screen, Test & Protect are still available at UF or through the Florida Department of Health. These services have now been integrated into the existing health infrastructure. As the pandemic evolves, our response to it will evolve as well. Student and employee testing for COVID-19 has been transferred to the Student Health Care Center. Visit UFHealth.org/covid-19-test/locations for a list of additional testing locations. We are prepared to ramp up testing capacity quickly as needed and in fact are already doing so in response to the current situation.*
> *Second, our experts at UF Health tell us your best protection against the omicron variant is to get your booster shot and wear a mask, preferably…the more form fitting N95 or KN95 pouches instead of looser blue surgical or cloth masks…if available, in indoor public settings. …If you haven't yet been vaccinated or received a booster, please visit ONE.UF to make an appointment or visit UF Health's webpage for a list of community vaccination sites.*

Online Course Recording
Our class sessions may be audio/visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Note that synchronous attendance (i.e., participating in whole-class Zoom meetings as they are being held) may be required with advance notice on an infrequent basis in connection with some class activities.

Materials and Supply Fees: N/A

Required Textbooks and Software:
None. Reference sources are identified in class. Self-Study Lecture Notes will be made available (often on a *just-in-time* basis) on the course website, along with Lesson Plans, Problem Sets, Course Announcements, etc. Required readings will be available via the course website, the WWW, or the UF Libraries website (select the Course Reserves tab at http://www.uflib.ufl.edu) at NO CHARGE. (Note: Before accessing UF Course Reserves from a NON-UF network, you must log into the UF VPN client. To download the UF VPN client, visit:
https://net-services.ufl.edu/provided-services/vpn/clients/

A Canvas course shell will be available via E-Learning to support assignment posts and submissions, Zoom meetings, etc., and to view scores/grades.

Outline of Course Topics: The following topical areas will be covered in the order listed.

- Intro to V&V Techniques and Principles
- Requirements and Specifications
- Black-Box Test Case Design Strategies
  - Partition Testing
  - Combinatorial Approaches
  - Other Strategies
- White-Box Test Case Design Strategies
  - Logic Coverage
  - Dataflow Coverage
  - Path Conditions and Symbolic Evaluation
  - Other Strategies
- Integration and Higher Level Testing
- Object-Oriented Software Testing Overview
- Reviews and Inspections
- Testing Tools and Automation
- Formal Specification
- Axiomatic Verification
  - Weak Correctness
  - Rules of Inference
  - Strong Correctness
- Predicate Transforms
  - Computing Predicate Transforms
  - Predicate Transforms and Loops
- Functional Verification
  - Complete and Sufficient Correctness
  - Axiom of Replacement
  - Correctness Conditions
  - Iteration Recursion Lemma
  - Invariant Status Theorem
- Cleanroom Software Engineering

Problem Sets: There are seven Self-Study Problem Sets, covering the areas:

(1) Black-box Testing
(2) Logic Coverage
(3) Dataflow Coverage
(4) Path Conditions and Symbolic Evaluation
(5) Axiomatic Verification
(6) Predicate Transforms
(7) Functional Verification

They are important learning tools, and may introduce significant course content that is not included in the lecture notes or discussed in class. Some may involve problems that are non-trivial and/or require a *creative ("clinical") application* of techniques introduced in the course. Problem Set introductions and solution hints/notes will be provided, and students may work together on some of the problems in small-groups.

Attendance Policy, Class Expectations, and Make-Up Policy
Physical face-to-face or synchronous online class attendance (i.e., participating in whole-class Zoom meetings as they are being held) may be required with advance notice on an infrequent basis in connection with some class activities (e.g., scheduled exams, small group exercises). Students are expected to complete all assignments in a timely manner. Late submissions will not be accepted except in extenuating circumstances associated with a period of excused absence. Excused absences must be in compliance with university policies and require appropriate documentation.

In particular, please do NOT schedule elective activities (family gatherings, interview trips, weddings, divorces, vacations, visa application trips, etc.) that could interfere with completing course assignments on-time.

Grading Policy/Evaluation of Grades: Course grades will be based **solely** on:

(1) face-to-face or synchronous online attendance + acceptable performance in focused individual or group learning activities, (2) a 1- or 2-part, in-class, closed-notes/closed-book Mid-Term Exam ("Exam 1") tentatively scheduled for Monday, Feb. 28 and/or Wednesday, March 2, and (3) a 1- or 2-part, in-class, closed-notes/closed-book End-of-Term Exam ("Exam 2") tentatively scheduled for Monday, April 18 and/or Wednesday, April 20).

There will be no online proctored (e.g., "Honorlock") exams.

There are currently no plans to use the scheduled final exam periods (week of April 23-29), but students are expected to be available at this time should this become necessary for some reason.

The *nominal* grading break-down is as follows:

- Class attendance + acceptable performance in focused individual or group learning activities: 33.3%
- Mid-Term Exam ("Exam 1"): 33.3%
- End-of-Term Exam ("Exam 2)": 33.3%

"Acceptable performance" for in-class group problem solving exercises will be based on receiving a grade of "COMPLETE" on group solution submissions (or re-submissions, in the case of initial submissions with moderately low scores). For example, a group scoring at least 75% may receive a "COMPLETE" with no further re-work required. A group scoring at least 30% but less than 75% may be required to continue work outside of class and re-submit their solutions with a score near 100% in order to receive a "COMPLETE". Finally, a group receiving an initial score below 30% may be assigned an "INCOMPLETE" with no re-submission option. Note that the actual scores required will vary depending on the relative difficulty of the assignment.

All assignments will concern *course-related* topics but *may* require research or creative insights not directly provided in the readings or lecture notes.

While the *quantitative* evaluation ("grading") of most assignments should be relatively straightforward, evaluating their *quality* can be inherently subjective. However, rubrics that identify specific participatory behaviors in discussions and the assignment attributes that one should aspire to will be provided. Obviously, evidence of having completed all assigned readings together with any other required or suggested preparatory activities in

advance of undertaking assignments, together with providing thoughtful, creative assignment submissions, is paramount in this regard!

Course letter grades will be determined at the end of the semester. In the past, the typical (BUT NOT PRE-DETERMINED) grade distribution for CEN6070 has been A (4.00 grade points): 10-20% of students completing the course, A- (3.67 grade points): 25-35%, B+ (3.33 grade points): 25-35%, B (3.00 grade points): 10-20%, lower than a B (0.00-2.67 grade points): 0-5%.

Grade requirements for graduation: Note that graduate students must have an overall GPA of 3.0 (B average) or better. (A B- average is equivalent to a GPA of 2.67, and therefore does NOT satisfy this requirement.)

More information on UF grading policy for graduate courses may be found at:

http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades

Fishbowl Group Discussion Format: Various forms of "fishbowl discussions/conversations" may be employed in this class. In a fishbowl activity, a small group of students is chosen to discuss and/or demonstrate their knowledge and understanding of a topic, provide logical arguments for a position concerning a topic, etc. The rest of the class watches, listens, evaluates the arguments being presented, and reflects on new insights provided by the discussion. The presenter/observer roles change on a regular basis.

> *The fishbowl is a method to organize presentations and group discussions that offers the benefits of small group discussions – most notably, a spontaneous, conversational approach to discussing issues – within large group settings. This is done by arranging the room so that the speakers are seated in the center of the room with other participants sitting around them in a circle watching their conversation 'in the fishbowl.'*
>
> - *https://www.unicef.org/knowledge-exchange/files/Fishbowl_production.pdf*

Course Feedback: Please provide the instructor with your feedback/recommendations about this course at any time during or after the semester in which you are enrolled. This may be done verbally (e.g., during online office hours), in writing or via the end-of-semester course evaluation. Suggestions about how to improve the course *at any time* will be especially appreciated.

Instructor Biography: Steve Thebaut received the BA in Mathematics from Duke University in 1977, and the MS and PhD in Computer Science from Purdue University in 1979 and 1983, respectively. His research interests have included software requirements engineering, testing and verification, and software engineering technology transfer. He has received funding from the National Science Foundation, IBM, the Florida Department of Education, the Florida High Technology and Industry Council, the Sino-Software Research Center at Hong Kong University of Science and Technology (HKUST), the Software Engineering Research Center (SERC-an NSF I/UCRC), and the Software Engineering Institute (SEI) at Carnegie Mellon University, where he was an invited lecturer in the SEI production of "Software Project Management," a nationally distributed video-based continuing education course. In 2009 he was an Educational Consultant and Visiting Lecturer in Software Engineering at Infosys Technologies, Ltd., Mysore, India. He has been a course developer and consultant for IBM's IS&PG Technical Education program, and has served on the program committee of the Conference on Software Engineering Education. He was Associate Editor of the International Journal of Computer and Software Engineering from 1990-1996.

Additional Important Information/Resources for Students:

Students Requiring Accommodations:

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation:
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy:
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment:
The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every

person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you believe that your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use:
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy:
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.