An Undergraduate Curriculum for Software Testing

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Underlying Philosophy

Software testing is a fundamentally interdisciplinary area. The competent tester needs to understand how software is built, how it can be broken, and how to expose the underlying faults. The faults can be coding errors or errors in the relationship of the software to other software, other devices, or to humans. Most (arguably, all) testing is done with reference to a model, and testers often build highly complex models of the system under test. One of the core problems of the field is that one can make an infinitely large expenditure on the testing of any nontrivial product. Cost/benefit tradeoffs lie at the essence of test planning and design.

Disciplines that seem obviously involved in testing include:

- Computer science
- Epistemology
- Human factors
- Quality control
- Engineering economics
- Safety
- Management
- Mathematics
- The subject matter of the software under test

This document does not attempt to define a core body of knowledge of the field of software testing. Instead, we start from the preface that a bachelor's-level graduate of a testing program will be best served by a degree that meets the following objectives:

- The degree should be an accredited C.S. degree. The student should be able to enter a Masters or Ph.D. program in C.S. in another university.
- The graduate should know the usual fundamentals of testing.
- The graduate should understand the theoretical background of testing as a means of gaining knowledge, and the limits of this approach as a means of controlling quality.
- The graduate should learn the fundamental technologies of testing: how to analyze software, how to build and use tools, how to build and use models.
- The graduate should have realistic experience in the application of theoretical constructs to software under test.
- The graduate should understand how to make cost/benefit decisions in nontrivial engineering situations.

- The graduate should be able to analyze system requirements, from the points of view of varying stakeholders and varying types of hardware and software, to make informed choices about what system behavior should be considered acceptable and should be able to use this knowledge to make credible arguments that a given system behavior is unacceptable.
- The graduate should be articulate and persuasive.

Four Year Structure

This is the sequence within which students will take the classes:

Proposed Required Courses

The following courses fit within the core curriculum of a software testing degree. Course names and numbers are cross-referenced to the course descriptions in the Appendix.

Department	Course	Course Name	Units	Notes
Academic Support	ASC 1000	University Experience	1	Waivable, discretion of dept chair or adviser. *Non-credit*
Communication	COM 1101	Composition & Rhetoric	3	
	COM 1102	Writing About Literature	3	
	COM 2012	Research Sources & Systems	1	
	COM 2223	Scientific & Technical Communication	3	10 total communications
Computer Science	CSE 1001	Fundamentals of Software Development 1	4	
	CSE 1002	Fundamentals of Software Development 2	4	
	CSE 2010	Algorithms & Data Structures	4	
	CSE 2410	Introduction to Software Engineering	3	
	CSE 2601	Fundamentals of Software Testing 1 (with lab)	4	Previously CSE 4431 / SWE 5410
	CSE 2602	Fundamentals of Software Testing 2 (with lab)	4	NEW
	CSE 3030	Computer Law, Ethics & Society	3	
	CSE 3101	Machine & Assembly Language	3	

	CSE 3601	Modeling of Software Applications	3	NEW
	CSE 3602	Advanced Testing Techniques (with lab)	4	NEW
	CSE 3603	Engineering Accounting and Economics	3	NEW
	CSE 4001	Operating Systems Concepts	3	
	CSE 4081	Introduction to Analysis of Algorithms	3	
	CSE 4701	Requirements Engineering	3	Cross-listed as SWE 5110
	CSE 4601	Software Testing Project 1	3	OK to swap with CS 4201
	CSE 4602	Software Testing Project 2	3	OK to swap with CS 4202
	CSE 4603	Empirical Research Methods in Computer Science	3	NEW
		CS electives	6	Encourage • 3001 Programming language concepts • 3002 Compiler theory • 3103 Networks • 4020 Database systems • 4257 Graphical UI • 4410 Project Mgmt • SWE 5510 Maintenance • SWE 5610 Measurement • 3 credits of co-op ***63 TOTAL CS***
Humanities	HUM 2051	Civilization 1	3	
	HUM 2052	Civilization 2	3	
	HUM 2510	Logic	3	
	HUM ????	Philosophy of Science, Epistemology	3	May not be available at Florida Tech 9 total humanities, not counting philosophy of science
Math	MTH 1001	Calculus 1	4	

	MTH 1002	Calculus 2	4	
	MTH 2051	Discrete Math	3	
	MTH 2401	Probability & Statistics	3	
MATH ELECTIVE	MTH	Math elective	3	***17 TOTAL MATH*** Recommended: • 3051 combinatorics & graph theory • 3102 intro to linear algebra • 4311 numerical analysis
Physics	PHY 1001	Physics 1	4	
	PHY 2091	Physics 1 Lab	1	
	PHY 2002	Physics 2	4	
	PHY 2092	Physics 2 Lab	1	10 total physics
Psychology	PSY 1411	Introduction to Psychology	3	
	PSY 3424	Introduction to Human Factors	3	6 total psychology
SCIENCE ELECTIVE		Science elective	3	***13 TOTAL SCIENCE***
SOCIAL SCIENCE OR HUMANITIES ELECTIVE		Social science or humanities electives	5	Assumes that epistemology is not offered ***30 TOTAL HOURS IN SOCIAL SCIENCES, HUMANITIES AND COMMUNICATIONS***, not counting the engineering economics
FREE ELECTIVES		Free electives	4	
				128 TOTAL HOURS
Computer sciences required			57	
Computer sciences option			6	63 CS
Science required / options			13	
Math required / options			17	
Humanities			19	Plus philosophy of science if offered
Social sciences required			6	
Social sciences & humanities electives			5	
Free electives			5	
TOTAL			128	

CSAB Requirements

The Computer Science Accrediting Commission publishes the following minimum requirements for a CS degree

- 40 semester hours of study in computer science topics
- 30 hours of study in mathematics and science
- 30 semester hours of study in humanities, social sciences, arts, and other disciplines that serve to broaden background
- 16 semester hours of fundamental computer science material
- core materials must cover algorithms, data structures, software design, concepts of programming languages, and computer organization and architecture
- theoretical foundations, analysis, and design must be stressed within the program's core materials
- students must be exposed to a variety of programming languages and must become proficient in at least one higher-level language
- 16 hours of advanced course work that provides breadth and builds on the core to provide depth
- 15 hours of mathematics
- discrete math, differential & integral calculus, and probability & statistics
- 12 semester hours of science
- 2 semester sequence in laboratory science for science or engineering majors
- additional science courses beyond the laboratory science courses must be in science courses that enhance the student's ability to apply the scientific method
- oral communication skills of the student must be developed and applied in the program
- written communication skills must be developed and applied in the program
- coverage of social and ethical implications of computing

Appendix: Course Descriptions

Course	Course Name	Units	Course Description
ASC 1000	University Experience	1	UNIVERSITY EXPERIENCE (1 credit). Helps first-year students adjust to the university and acquire essential academic survival skills (classroom behavior, academic honesty, study skills, etc.) that will enhance academic and social integration into college. This course cannot be applied toward degree requirements.
COM 1101	Composition & Rhetoric	3	COMPOSITION AND RHETORIC (3 credits). The first of two courses in college-level writing skills, Composition and Rhetoric focuses on writing essays using various rhetorical modes: persuasion, description, comparison and analysis. Basic methods of library research are presented, as well as the MLA documentation system. Students write one research paper and several essays. (Prerequisite: COM 1100 or a passing grade on the placement test.)

COM 1102	Writing About Literature	3	WRITING ABOUT LITERATURE (3 credits). The second of two courses in college-level writing skills. This course focuses on reading and analyzing poems, plays and short works of fiction. Students write several essays and one research paper on literary topics. (Prerequisite: COM 1101.)
COM 2012	Research Sources & Systems	1	RESEARCH SOURCES AND SYSTEMS (1 credit). This course is a survey of information resources designed to acquaint the student with a variety of library services and materials. It focuses on conducting research in traditional sources and computerized bibliographic data files.
COM 2223	Scientific & Technical Communication	3	SCIENTIFIC AND TECHNICAL COMMUNICATION (3 credits). Practice in the technical and scientific writing style and format, including gathering and using data to prepare reports. Included are abstracts, reports, letters, technical descriptions, proposals and at least two oral presentations. (Prerequisite: COM 1102.)
CSE 1001	Fundamentals of Software Development 1	4	Fundamentals of Software Development 1 (4 credits, including lab). An introduction to software development as it applies to small programs. Students learn to program in a higher-level language and to read, understand, write and evolve typical small higher-level programs.
CSE 1002	Fundamentals of Software Development 2	4	Fundamentals of Software Development 2 (4 credits, including lab). In this second course in the fundamentals of software development, students are introduced to the basic data structures and algorithms used in software design and implementation. Sorting and searching techniques are also introduced. (Prerequisite: CSE 1001.)
CSE 2010	Algorithms & Data Structures	4	Algorithms and Data Structures (4 credits). This course is an expansion of CSE 1002 to include algorithms and data structures fundamental to software systems development. Topics include abstraction, recursion, algorithm design and complexity analysis, linked lists, stacks, queues, trees and sorting and searching methods. (Prerequisite: CSE 1002.)
CSE 2410	Introduction to Software Engineering	3	Introduction to Software Engineering (3 credits). Principals of software engineering and preparation for productive team membership. Team exercises focus on topics such as requirements definition, change management, project planning, estimating, test planning, quality assurance and configuration management planning. (Prerequisites: CSE 2010 or CSE 2502 or ECE 2552.)
CSE 2601	Fundamentals of Software Testing 1 (with lab)	4	(NEW) Fundamentals of Software Testing 1: Black Box Methods. (4 credits, with lab). This course introduces black box methods for testing software systems. Special emphasis is paid to competing methods for designing black box tests, risk analysis, troubleshooting and problem reporting. Lab work involves a range of testing attacks on commercial software. (Prerequisite: CSE 1001; Corequisites: CSE 1002) Previously CSE 4431 / SWE 5410

CSE 2602	Fundamentals of Software Testing 2 (with lab)	4	(NEW) Fundamentals of Software Testing 2: Structural Methods (4 credits, with lab). This course introduces methods that programmers use to test their code and the code of software that their programs include or interface with. The course covers such topics as path testing, code coverage analysis, state models, unit and integration testing, testing APIs, and errors common in object-oriented programs. Along with testing methods and tools, the course teaches code reviews and other static methods for finding defects and ambiguities.
CSE 3030	Computer Law, Ethics & Society	3	Computer Law and Ethics (3 credits). An overview of legal, ethical and moral consideration for the computing professions. The impact of legal concepts on the computerized society of the present and future. The need for ethical considerations in software systems development and the potential need for professional certification. (Prerequisite: CSE 1502, or CSE 1503, or CSE 1002.)
CSE 3101	Machine & Assembly Language	3	Machine and Assembly Language (3 credits). A processor's instruction set and programming structures available to the assembly language programmer are presented. Relations between architecture, machine language and assembly language. Assembly program interfaces with the operating system and higher-level languages. (Prerequisite: CSE 1002 or CSE 1502 or CSE 1503.)
CSE 3601	Modeling of Software Applications	3	(NEW) Modeling of Software Applications (3 credits) Most (or all) software testing involves comparing software behavior against a model. Testers use a wide range of models, including those based on state machines, data flow and storage, user task analyses, physical systems, etc. This course examines several different theoretical and empirical modeling techniques and their applicability to software under test. Load testing, usability testing, and the testing of safety of embedded systems are examples of topics of interest in this course.
CSE 3602	Advanced Testing Techniques (with lab)	4	(NEW) Advanced Testing Techniques (with lab) (4 credits). This course focuses on the use of tools and techniques that help the tester understand the software's relationship with the operating system (including its device drivers and data files), and other software that interacts with the software under test. The course includes studies of tools for detecting time-related errors, load-related errors, and weaknesses in network security.
CSE 3603	Engineering Accounting and Economics	3	(NEW) Engineering Accounting and Economics (3 credits). This course studies the cost/benefit tradeoffs that a software testing manager or executive routinely faces. Topics include project accounting (how to create and read development project budgets), risk analysis (especially risk-related economic implications), quality/cost analysis, and some types of metrics. On completion, the student should know how to lay out a resource plan for a testing project and estimate its costs, how to collect cost-related data involving defects or customer dissatisfaction, and how to present cost/benefit arguments for (or against) making changes in the code.

CSE 4001	Operating Systems Concepts	3	Operating Systems Concepts (3 credits). Examines the design and implementation of operating systems. Topics include file management processes, input/output devices, memory hierarchies and CPUs. Issues involved in moving from a single-user system to a multitasking, multiprocessing and multiprocessor systems are explored. (Prerequisites: CSE 3101, or ECE 2552 and ECE 4551.)
CSE 4081	Introduction to Analysis of Algorithms	3	INTRODUCTION TO ANALYSIS OF ALGORITHMS (3 credits). This course covers time and space complexity of algorithms. Algorithms for sorting, searching, string processing and graph problems are analyzed. Strategies such as divide-and-conquer, greedy and dynamic programming are presented as problem-solution techniques. (Prerequisite: CSE 2010 and MTH 2051.)
CSE 4701	Requirements Engineering	3	Cross-listed as SWE 5110. REQUIREMENTS ENGINEERING (3 credits). This course provides an in-depth study of software requirements, engineering tools and techniques. Topics will include gathering user requirements, formal specification of system behavior, system interfaces, end-user and system documentation and validation techniques. The end-user aspect of gathering and formalizing or user requirements is emphasized.
CSE 4601	Software Testing Project 1	3	(NEW) Software Testing Projects 1 (3 credits). First course in a two-semester senior-year project sequence that serves as the capstone to the project-intensive courses in the Software Testing option. Students team with students in Computer Science or Software Development options to implement a software project from conception to completion. (Prerequisite: Senior standing in Software Testing option.)
CSE 4602	Software Testing Project 2	3	(NEW) Software Testing Projects 2 (3 credits). This course builds on the topics and project started in Software Testing Project 1. (Prerequisite: CSE 4201.)
CSE 4603	Empirical Research Methods in Computer Science	3	(NEW) EMPIRICAL RESEARCH METHODS IN COMPUTER SCIENCE (3 credits). A survey of research methods used by computer scientists. Examples of classic experiments and multi-experiment, multi-year research strategies.
HUM 2051	Civilization 1	3	CIVILIZATION 1: ANCIENT THROUGH MEDIEVAL (3 credits). An introduction to civilization from its early development to the European Renaissance. The emphasis is on the interpretation of primary texts that reflect the intellectual and historical changes in society. This is the first of two interdisciplinary courses. (Prerequisite: COM 1102.)

HUM 2052	Civilization 2	3	CIVILIZATION 2: RENAISSANCE THROUGH MODERN (3 credits). Similar in purpose and method to Civilization 1, this course continues the interpretation of primary texts in which the emphasis is on the Renaissance period, the Enlightenment, Romanticism and the Modern Age. (Prerequisite: COM 1102.)
HUM 2510	Logic	3	LOGIC (3 credits). This course deals mainly with deductive logic, although all the fallacies of reasoning are examined in both an informal and a formal context. The role of logic in both science and law is brought out, as well as ways of making formal proofs of validity. (Prerequisite: COM 1101.)
HUM ????	Philosophy of Science, Epistemology	3	Not currently available at Florida Tech 9 total humanities, not counting philosophy of science
MTH 1001	Calculus 1	4	Calculus 1 (4 credits). Functions and graphs, limits and continuity, derivatives of algebraic and trigonometric functions, chain rule; applications to maxima and minima and to related rates, integration and applications of integration. (Prerequisites: High school algebra, trig and a passing score on the placement test, or MTH 1000.)
MTH 1002	Calculus 2	4	MTH 1002, CHM 1102.) Calculus 2 (4 credits). Exponential, logarithmic, circular and hyperbolic functions: their inverses, derivatives and integrals; further techniques of integration; improper integrals; limits, L'Hospital's rule; sequences and series, numerical methods; polar coordinates; and introductory differential equations. (Prerequisite: MTH 1001.)
MTH 2051	Discrete Math	3	Discrete Mathematics (3 credits). Formulation of precise definitions and their negations using propositional and predicate logic; argument analysis and proof techniques including induction; number theory; and sets, relations, functions, directed graphs and elementary counting arguments. (Prerequisite: MTH 1000 or MTH 1001.)
MTH 2401	Probability & Statistics	3	Probability and Statistics (3 credits). Random variables, expectations, sampling and estimation of parameters, normal and other distributions and central-limit theorem, tests of hypothesis, linear regression and design experiments. (Prerequisite: MTH 1002.)
PHY 1001	Physics 1	4	PHYSICS 1 (4 credits). Topics include a study of vectors; mechanics of particles; Newton's laws of motion; work, energy and power; impulse and momentum; conservation laws; mechanics of rigid bodies, rotation, equilibrium; fluids, heat and thermodynamics; and periodic motion. (Prerequisite: MTH 1001; corequisite: MTH 1002.)

PHY 2091	Physics 1 Lab	1	PHYSICS LABORATORY 1 (1 credit). Experiments to elucidate concepts and relationships presented in PHY 1001, to develop understanding of the inductive approach and the significance of a physical measurement, and to provide some practice in experimental techniques and methods. (Corequisite: PHY 1001.)
PHY 2002	Physics 2	4	PHYSICS 2 (4 credits). Topics include electricity and magnetism, Coulomb's law, electric fields, potential capacitance, resistance, D.C. circuits, magnetic fields, fields due to currents, induction, magnetic properties; and wave motion, vibration and sound, interference and diffraction. (Prerequisite: PHY 1001.)
PHY 2092	Physics 2 Lab	1	PHYSICS LABORATORY 2 (1 credit). A continuation of Physics Laboratory 1, including experiments pertaining to PHY 2002. (Prerequisite: PHY 2091; corequisite: PHY 2002.)
PSY 1411	Introduction to Psychology	3	INTRODUCTION TO PSYCHOLOGY (3 credits). An overview of psychological processes, including both areas in which psychology is a natural science (physiological psychology, sensation and perception, basic learning and cognition) and a social science (motivation, human development, personality, social interaction, psychopathology and psychotherapy). (SS elective.)
PSY 3424	Introduction to Human Factors	3	INTRODUCTION TO HUMAN FACTORS (3 credits). Introduces the area of engineering psychology/ergonomics, the field that examines human-machine-environment relationships. Fundamental principles in applying human capabilities and limitations for improved performance and efficiency in the design of complex systems are examined. (Prerequisite: Junior standing.) (Technical elective).