BUAS 2020 COURSE

GEORGIA PIEDMONT TECHNICAL COLLEGE
INDUSTRIAL & TRANSPORTATION TECHNOLOGIES

Building Automation Systems Program

BUAS 2020 Building Automation Systems Logic & Programming

National Science Foundation - National Center for Building Technician Education

GEORGIA PIEDMONT TECHNICAL COLLEGE

BEST
Building Efficiency for a Sustainable Tomorrow

NSF

Updated 8/1/17

BUILDING AUTOMATION SYSTEMS FUNDAMENTALS

Course Documentation

This material is based upon work supported by the National Science Foundation under Grant Number (DUE 1204930).

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Industrial & Transportation Technologies Division
495 N. Indian Creek Dr.
Clarkston, GA 30021
Phone 404.297.9522 ext. 0

Table of Contents

Catalog description 1
- Class hours 1
- Units 1
- Entry skills needed 1
- Syllabus 1

Student learning outcomes 1
- History of Logic 1
- Logical Form 1
- Truth Tables 2
- Rules of Inference 2
- Boolean Expressions 2
- Combinational Boolean Logic 2
- Digital Logic Circuits 2
- Programming Introduction 2
- Elements of Programming Languages 2
- Object Oriented Programming 2
- Data Types 2
- Programming Style 2
- Decision-Making in Programs 2
- Modular Program Design 2

Exit skills 2
- History of Logic 3
- Logical Form 3
- Truth Tables 3
- Rules of Inference 3
- Boolean Expressions 3
- Combinational Boolean Logic 4
- Digital Logic Circuits 4
- Programming Introduction 4
- Elements of Programming Languages 4
- Object - Oriented Programming 4
- Data Types 5
- Programming Style 5
- Decision - Making in Programs 5
- Modular Programming Design 5

Course materials 5
Principal text 5
Lecture materials and handouts 6
Other reference materials 6
Software needed 6
Lab setup and materials 6
Equipment & instruments required 7
Samples of weekly assignments 7
Project 8
Assessment 8
Methods 8
Sample test questions 9
Adaptability to on-line format 10
Appendix A – Sample syllabus 11

Catalog description

Building Automation Systems (BAS) Logic and Programming introduces concepts of logic, truth tables, logical equivalences, conditionals, Boolean expressions, logic gates, digital logic circuits, number systems, object-oriented programming, data types, decision making, and programming style.

Class hours

Lecture Hours: 34

Laboratory Hours: 39

Units

Semester Credit Hours: 3

Entry skills needed

- BUAS 1030 – Basic Electrical Concepts II
- BUAS 2010 – Commercial HVAC and Controls
- Basic computer skills
- College-level reading and writing skills
- College-level math skills

Syllabus

See Appendix A for sample syllabus, course schedule, and policies. For lesson topics to include in course, see Exit Skills.

Student learning outcomes

History of Logic

Understand the important historical elements of the development of the subject of logic.

Logical Form

Understand how to develop a proper logical statement.

Truth Tables

Understand how to develop and construct a truth table.

Rules of Inference

Understand how to apply rules of inference to logical tables.

Boolean Expressions

Gain an understanding of Boolean expressions and their application.

Combinational Boolean Logic

Understand how to combine Boolean expressions in more complex combinations.

Digital Logic Circuits

Apply logic principles to relay circuits.

Programming Introduction

Understand the basic elements of programming.

Elements of Programming Languages

Understand the various common elements of programming languages.

Object Oriented Programming

Gain an appreciation of programming objects.

Data Types

Understand and apply the various data types found in programming languages.

Programming Style

Understand the elements of programming style and apply them.

Decision-Making in Programs

Understand the various types of decision-making statements and their proper application in programs.

Modular Program Design

Understand how to program in a modular style.

Exit skills

Course content to achieve outcomes listed above:

History of Logic

1. Name key figures in the development of the subject of logic throughout recorded history.
2. Point out the reasons why the study of logic is an important endeavor.
3. Defend the statement 'to study logic is to study the underpinnings of our society in the information age.'

Logical Form

1. Define the terms logical form, statements, premises, conclusions, valid, and invalid.
2. Recognize a valid and invalid argument form.
3. Construct a logically valid argument form from given statements and conclusion.

Truth Tables

1. Define the term logical equivalence.
2. Cite the purposes and uses of truth tables.
3. Construct a truth table to analyze the effect of all possible combinations of true and false premises on the conclusion.
4. Construct a truth table to assess whether or not two complex statement forms are logically equivalent.

Rules of Inference

1. Name commonly encountered rules of inference.
2. Define modus ponens and modus tollens.
3. Demonstrate the ability to apply rules of inference to a complex logical problem to simplify the problem into a logically equivalent form.

Boolean Expressions

1. Cite the seven commonly encountered Boolean logic gates.
2. Draw the truth tables for the seven commonly encountered logic gates along with the common symbols used to denote them.
3. Compare and contrast the seven common Boolean logic gates of NOT, AND, OR, NAND, NOR, XOR, and XNOR.

Combinational Boolean Logic

1. Convert a complex combinational logic diagram into a simplified, logically equivalent diagram with fewer Boolean logic gates.

2. Construct a combinational Boolean logic diagram from a logical expression which is provided.

3. Create a logical expression from a complex combinational logic diagram.

Digital Logic Circuits

1. Describe how truth tables and the principles of logic are directly applied to digital logic circuits.

2. Convert a truth table into its equivalent digital logic circuit using relays.

3. Construct a truth table logically equivalent to a given digital logic circuit of wires and relays.

4. Create a complex digital logic training apparatus which solves a given problem.

Programming Introduction

1. Define the terms program, algorithm, machine language, low-level programming language, high-level programming language, executable file, pre-processor, compiler, linker, and integrated development environment.

2. Compare and contrast the programming languages Basic, Visual Basic, Fortran, C++, Visual C++, and Java.

3. Describe how programming skills are important in the building automation industry.

Elements of Programming Languages

1. Describe the purpose of key words in Java.

2. Recite a number of key words in Java and describe their function.

3. Describe what is meant by programmer-defined identifiers, operators, programming punctuation, and programming syntax.

Object - Oriented Programming

1. Explain the characteristics of objects and how they are utilized in object-oriented programming.

2. Describe instances of classes in object-oriented programming.

3. Create instances of classes in ALICE.

4. Program a routine in ALICE as per instructions.

Data Types

1. Load an IDE for Java like JGrasp on a computer.
2. Compare and contrast the various data types available in Java.
3. Create a program which defines each of the data types available.

Programming Style

1. Describe how the Java language handles I/O functions.
2. Describe the Java order of operations.
3. Create a program with documentation comments and modular format to solve a problem assigned by the instructor.

Decision - Making in Programs

1. Compare and contrast various decision structures in Java.
2. Employ relational operators and logical operators in a nested loop program in Java.
3. Create programs to simulate economizer control, variable air volume air-handling unit proportional control of fan speed by static pressure, and chiller free-cooling/mechanical changeover control.

Modular Programming Design

1. Describe the principles and reasons for modular programming design.
2. Create a comprehensive program which simulates a complete chilled water system with a centrifugal chiller and one VAV air-handling unit for each of eight floors, along with 8 powered induction units and 6 variable air volume boxes per floor with a separate module responsible for each system component.

Course materials

Principal text

Gaddis, T. (2010). Starting out with ALICE (2nd ed.). Boston, MA: Addison-Wesley Publishers. ISBN #: 978-0321545879

Gaddis, T. (2010). Starting out with Java (4th ed.). Boston, MA: Addison-Wesley Publishers. ISBN #: 978-0136080206

Lecture materials and handouts

This course is strictly an overview course and makes significant use of online resources.

DDC Online (Intro. to digital control systems, Input/Output tutorials):
www.ddc-online.org

Purdue Owl writing & style resources: https://owl.english.purdue.edu

Other reference materials

Online references for logic gates – OR / XOR / AND / NAND / etc

Software needed

Carnegie Mellon University ALICE software Version 2 or 3 – free download

Java iGrasp software – free download

Lab setup and materials

- Workstations with electrical outlets
- DC power supply
- 120/24 volt, 40 VA transformer
- 8-bit adder trainer
- Encoder / Decoder trainer
- Sequences of operation
- Points list generated from control spec builder
- Electrical symbols plastic tracing templates
- Perforated backplate boards for mounting din rail & devices
- Ladders
- Hard hat
- Safety goggles
- Safety gloves
- Safety mask
- Flashlight
- Electromechanical relays (SPDT, DPDT)
- 14, 16, & 18 gauge THHN wire of various colors
- Fork terminals of various sizes
- Blue, orange, & yellow wire nuts
- Wire strippers
- Control screwdrivers
- Regular size screwdrivers

- Electrical tape
- Assorted resistor types & values
- LED & 24 volt DC indicator lights
- Pushbutton switches

Equipment & instruments required

- 8-bit adder trainer
- Encoder / Decoder trainer
- Multi-meter & clamp-on meter
- Voltage proximity sensor
- Scopemeter

Samples of weekly assignments

BUAS 2020 – BAS Logic & Programming Assignment # 1 -

Location: Anywhere

Purpose: Practice programming in the Alice environment

Materials: Alice software – free download from www.Alice.org

Description: Students will program Alice avatar to perform prescribed routine with loops responding to keystroke entries and timings dictated in the student handout. Avatar will follow this sequence:

1. Run toward the viewer to a distance of 1 meter and wait for the keystroke G.

2. On keystroke G, the avatar will run to each of the 10 controller objects spaced at intervals of 10 meters, pausing at each for exactly 2 seconds before proceeding to the next controller.

3. At the final controller, avatar will stop, turn 180^0 and say 'waiting for instructions.'

4. On the keystroke of F, the avatar will return to the position of 1 meter from the user, spin around twice in 1 second, and then say 'I'm heading off the jobsite.'

Grading:

Grading will be based upon adherence to the sequence of avatar actions prescribed in the handout. The timings for movements and the avatar's response to keystrokes constitute the bulk of grading for this assignment. The assignment must be turned in on time to receive full credit.

Project

BUAS 2020 – BAS Logic & Programming Course Project Assignment

Location: Anywhere

Purpose: Develop a controls database complete with I/O and programming logic to meet a sequence of operation for a variable air volume system complete with a central plant as provided by CtrlSpecBuilder (Control Spec Builder).

Materials: Digital controls software (Delta ORCAview used for this project at GPTC), CtrlSpecBuilder, and www.ctrlspecbuilder.com.

Description: Students are given the selection criteria to enter into www.ctrlspecbuilder.com for a VAV system and central plant for a hypothetical project. CtrlSpecBuilder generates a points list for objects and develops a set of project specifications with a sequence of operation.

Students take the generated documents and create all the associated objects in the control system, using identical nomenclature with that from the points list. The logic is then programmed and debugged based upon the sequences of operation provided. A report is written and submitted along with a complete printing of all the BACnet objects created for grading.

Grading:

Grading will be by rubric which is available for review in Angel LMS. Elements of the rubric include completeness of the project, detailed printing of all the BACnet objects created in the control system database, a demonstration of how the programming logic meets the intended sequence of operation, and if the construction of the written report meets the guidelines for content.

Assessment

Methods

- Discussion board participation (Each week in Angel learning management system)
- Homework – Pre-lab completion prior to class
- Classroom participation & attendance
- Quizzes (8) – Delivered through Angel learning management system & due by Sunday night of each respective week
- Course exams (2, mid-term & final exams) – Delivered through Angel learning management system & due by Sunday night of each respective week
- Student team presentations (1 at term end, using Prezi) – Presenting their project findings

- Course project (1 assigned at mid-term) – Turned in prior to student team presentations at the end of the term

Sample test questions

From final exam:

1. Each individual object of a class is known as a/an _____ (ANS: instance)

2. Basic behaviors for objects within the ALICE environment are known as _____ methods. (ANS: primitive)

3. Complex programs are broken down into a collection of simpler programs called _____ (ANS: modules)

4. Select all that are phases of the software development cycle:

- ☐ implement (correct selection)
- ☐ decode
- ☐ copy
- ☐ debug (correct selection)

5. What graphing technique is commonly used to diagram complex algorithm designs? (ANS: Flowcharting)

6. A programming environment which contains a text editor, compiler, and debugger in one package is known as what?

- ☐ integrated development environment (correct answer)
- ☐ compiler software
- ☐ application

7. Which data type requires the most storage space?

- ☐ int
- ☐ long (correct answer)
- ☐ float
- ☐ short

8. What is the result of the following calculation in Java?
(8 – 3) * (4 + 6) / 5 (ANS: 10)

9. What does the relational operator, != , mean in Java? (ANS: Not equal to)

10. What does (x > y && a < b) mean in Java?

- ☐ x is greater than y and a is less than b (correct answer)
- ☐ x is greater than y if and only if a is less than b
- ☐ x is greater than y only when a is less than b

11. A programming structure that causes a group of statements to repeat is known as a _____ (ANS: loop)

12. A type of loop which continues to execute a block of statements until the tested conditional turns false is known as a/an

- ☐ if-then-else loop
- ☐ while loop (correct answer)
- ☐ do-while loop

13. A loop which resides in another loop is known as a _____ loop. (ANS: nested)

14. What Java statement is used to terminate a loop early?

- ☐ stop
- ☐ break (correct answer)
- ☐ pause
- ☐ retest

15. Select the two primary methods of programming in common use today:

- ☐ procedural (correct selection)
- ☐ graphical
- ☐ object-oriented (correct selection)
- ☐ recursive

Adaptability to on-line format

Much of this course content can be delivered online with links to soft skills videos, manufacturer's presentations, tutorials, wholesaler websites, and others.

Appendix A – Sample syllabus

Georgia Piedmont Technical College

BUILDING AUTOMATION SYSTEMS LOGIC & PROGRAMMING

COURSE BUAS 2020 CRN 52713
SEMESTER SUMMER 2012

OUTLINE, SYLLABUS, & ORIENTATION INFORMATION

FACULTY INFO

Mr. Leroy Daniels
Clarkston Campus Office: C-13 Email: danielsl@gptc.edu Phone: 404-297-9522 Ext.: 1211
Office Hours: M, T 9:00 - Noon (By Appointment Only)

Division Chair: Ms. Natalie Kostas
Clarkston Campus Office: Industrial Dept.
Email: kostasn@gptc.edu Phone: 404-297-9522 Ext.: 1216

CLASS TIMES

Thursdays: 7:00 pm - 9:45 pm

CREDIT HOURS & PREREQUISITES

The federal definition of a semester credit hour is one hour of classroom instruction and two hours out of class student work each week.

4 / Prerequisite: BUAS 1030 / Corequisite: BUAS 2010

INTRODUCTION & COURSE DESCRIPTION

Introductory concepts of logic and programming are covered in this course. Topics include history of logic, logical form, truth tables, logical equivalences, rules of inference, conditionals, Boolean expressions, logic gates, digital logic circuits, number systems, programming basics, object-oriented programming, data types, decision making, programming style, and an introduction to languages.

STUDENT LEARNING OUTCOMES

History of logic / Logical form / Truth tables / Rules of inference / Boolean expressions / Combinational boolean logic / Digital logic circuits / Programming introduction / Common elements of programming languages / Object-oriented programming / Data types / Programming style / Decision-making in programs / Modular program design

COURSE COMPETENCIES

See Exit Skills in this document.

TEXTBOOK TITLE (required)

"Starting out with ALICE, 2e" / ISBN: 978-0-321-54587-9
"Starting out with Java, 4e" / ISBN: 978-0-13-608020-6

OTHER TEXTBOOK INFORMATION

N/A

ADDITIONAL RESOURCES

Throughout the semester, additional resources may be used. They may include the Internet, newspapers, and professional publications.

EVALUATION

Discussion Board Activity……10%
Classroom Participation……10%
Homework Assignments…….20%
Weekly Quizzes…..10%
Course Assessments……..….20%
Written Final…….15%
Course Project……...15%

SCHEDULE

5/24 - Review Syllabus

5/31 - Introduction / Logical Form & Introduction to Truth Tables (Virtual Lecture in ANGEL - Quiz 1 - Due Sunday, 6/03 NLT 11:55pm

6/07 - Truth Tables / Logical Equivalences
Quiz 2 - Due Sunday, 2/5 NLT 11:55 pm

6/14 - Number Systems
Quiz 3 - Due Sunday, 6/10 NLT 11:55 pm

6/21 - Logic Gates
Quiz 4 - Due Sunday, 6/17 NLT 11:55 pm

7/05 - Digital Logic Gates Applied to Relays
Reading Assignment - Chapter 1 "Starting out with Java, 4e"
Mid-Term Assessment - Due Sunday, 7/08NLT 11:55 pm (Covers all material through 2/20)

7/12 - Java Introduction (Ch. 1) Lecture
Reading Assignment - Chapter 2 "Starting out with Java, 4e"
Compiling Assignment - Due 7/15 NLT 11:55 pm

7/19 - Java Fundamentals (Ch. 2) Lecture
Reading Assignment - Chapter 3 "Starting out with Java, 4e"
Chapter 2 Programming Assignment - Due 3/11 NLT 11:55 pm
Student Project Assigned
Quiz 5 - Due Sunday, 7/22 NLT 11:55 pm

7/26 - Java Decision Structures (Ch. 3) Lecture I
Reading Assignment - Chapter 3 "Starting out with Java, 4e" Due 7/29

8/02 - Java Decision Structures (Ch. 3) Lecture II
Reading Assignment - Chapter 4 "Starting out with Java, 4e"
Chapter 3 Programming Assignment - Due 3/25 NLT 11:55 pm
Quiz 6 - Due Sunday, 8/05 NLT 11:55 pm

8/09 - Loops and Files (Ch. 4) Lecture I
Reading Assignment - Chapter 4 "Starting out with Java, 4e"

8/ 16- Loops and Files (Ch. 4) Lecture II
Reading Assignment - Chapter 5 "Starting out with Java, 4e"
Chapter 4 Programming Assignment - Due NLT 11:55 pm
Quiz 7 - Due Sunday NLT 11:55 pm
- Methods (Ch. 5) Lecture
Reading Assignment - None
Chapter 5 Programming Assignment - Due 8/15 NLT 11:55 pm
Quiz 8 - Due Sunday 8/15 NLT 11:55 pm
- Working Session for Student Projects / Review for Final Exam
- Project Presentations
- Written Final Assessment Due Wednesday, 8/25 NLT 11:55pm (Cumulative)

COLLEGE POLICIES

Please refer to documentation for courses BUAS 1010, 1020, 1030 or 1040 for specifics of GPTC's policies re: grading, attendance, etc.

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation