Course Workbook

1st Edition

BAS PROGRAMMING
FUNDAMENTALS

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Succeed in this course

Over the past year I've created several training courses for my students. As I look back at my past students I've pinpointed two things that make my students successful:

1. Access the program, watch the videos three times, and comment on the videos. The action of watching the videos and engaging with me and fellow students will naturally increase the amount of information you retain.
2. Work through this workbook. This workbook was designed to help you retain key pieces of information that have a direct impact on your performance as a BAS professional. As you move through each lesson I will ask you questions in the workbook that will help you to further expand your knowledge.

Don't skimp on these two actions. The reality is learning anything takes work. Fortunately for you, I've condensed that learning into the shortest time possible.

When you follow the three steps above you will see massive results as you work through this course.

Remember, I am here for you at any time via the discussion section and live office hours.

I look forward to hearing about your success story.

To your success,

-Phil

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Module 1: Introduction to Programming

In this module we what programming is. The lessons in this module are:

- Lesson 1: What is Programming
- Lesson 2: A Look at the Programming Process
- Lesson 3: Structure of Programs

For many programming is some mystical art form more akin to voodoo magic then an actual skill. The reality is programming is nothing more than building.

You may have played with Lego's growing up. When you built with Legos you needed to have the right pieces to create your design.

Programming is very much the same thing. Throughout this module you will learn the program process. This will teach you the what and why of programming and later in this course you will learn the how.

Let's dive in.

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Lesson 1: What is Programming?

Lesson Objectives:

- Describe what programming is

What is programming?

What are the two forms of BAS programming?

What does it mean when I say graphical programming is abstracted?

What are the categories that sequences will fall into?

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Lesson 2: A Look at the Programming Process

Lesson Objectives:

- Explain the programming process

How many steps are in the programming process?

What are each of the steps of the programming process?

Where do you get information on the inputs, outputs, and setpoints for a program?

What is the difference between start/stop logic and control state logic?

Why is it important to write your safety code last?

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Lesson 3: Structure of Programs

Lesson Objectives:

- Describe the structure of programs

Why is important to structure and order your code?

What is the most common way of laying out your programs?

What should you do immediately after adding points to your program?

What is an IDE?

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MODULE 2: POINT OVERVIEWS

In this module we will unpack one of the most important concepts, the point. The lessons in the module are:

- Lesson 1: What are Points
- Lesson 2: Physical Point Types
- Lesson 3: Logical Point Types
- Lesson 4: Global Points

Points make or break your programs. How you use points and what points you use will make the difference between a highly usable BAS and one that requires the owner to call the installer every time they want to change a setpoint.

As we move through this module I encourage you to explore why points are used and how points are used. These two concepts will be very important as we move further into programming.

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Lesson 1: What are Points?

Lesson Objectives:

- Explain what points are in a BAS Program

What are points?

What is the difference between a physical and logical point?

What are the “three” types of points?

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Lesson 2: Physical Point Types

Lesson Objectives:

- Describe the different types of physical points

What are the two categories of physical points?

What are the different point types inside a physical point category?

What is one example of when you would use each point type?

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Lesson 3: Logical Point Types

Lesson Objectives:

- Describe the different types of logical point types

What are the three kinds of logical points?

What are the three kinds of data types?

When would you use a constant point? When would you use a writeable point?

What is the difference between writeable and constant points?

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Lesson 4: Global Point Types

Lesson Objectives:

- Describe what global points are

What are the two types of global points?

What are the two ways peer-to-peer shares can be used?

What is the difference between global broadcasts and multicasts?

MODULE 3: LOGIC BLOCK OVERVIEWS

In this module we are going to start exploring logic blocks. The lessons in the module are:

- Lesson 1: What are Logic Blocks
- Lesson 2: Boolean Blocks
- Lesson 3: Comparative Blocks
- Lesson 4: Math Blocks
- Lesson 5: Limit Blocks
- Lesson 6: Flow Blocks
- Lesson 7: Timer Blocks
- Lesson 8: Sequence Blocks
- Lesson 9: Loop Blocks

Logic blocks are how you build programs. If you remember my Lego analogy earlier in the workbook, logic blocks are the Legos. During this module we are going to explore the most common logic blocks. It is important to focus on what each logic block does as that will determine how efficiently and effectively your program works.

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Lesson 1: What are Logic Blocks

Lesson Objectives:

- Explain what logic blocks are

What are logic blocks?

What are block properties?

What are inputs and outputs used for on blocks?

Why do we use different blocks?

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Lesson 2: Boolean Blocks

Lesson Objectives:

- Describe the different kinds of Boolean logic blocks

What does Boolean mean?

What are the four kinds of Boolean blocks?

What is the difference between an OR, AND, and XOR block?

Why do we use NOT blocks?

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Lesson 3: Comparative Blocks

Lesson Objectives:

- Describe the different kinds of comparative logic blocks

What are the main ways we use comparative blocks?

What are the three kinds of comparative blocks?

What is the purpose of a deadband?

How can you add a deadband if your comparative block doesn't support it?

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Lesson 4: Math Blocks

Lesson Objectives:

- Describe the different kinds of math logic blocks

What are the 7 types of math blocks?

Why would you use a SUM block?

What are the two kinds of AVERAGE blocks?

How do SPAN blocks work?

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Lesson 5: Limit Blocks

Lesson Objectives:

- Describe the different kinds of limit logic blocks

What are the five types of limit blocks?

What is the difference between a LOW LIMIT, HI LIMIT, and LIMITER block?

How are LIMIT and SELECT blocks different?

Why can you use HI and LOW LIMIT blocks but not HI and LOW SELECT blocks?

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Lesson 6: Flow Blocks

Lesson Objectives:

- Describe the different kinds of flow logic blocks

What are the four kinds of flow blocks?

What is the main purpose of flow blocks?

What triggers a SWITCH block?

What is the purpose of a FLIPFLOP block?

Why do we use sometime use MUX blocks instead of SWITCH blocks?

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Lesson 7: Timer Blocks

Lesson Objectives:

- Describe the different kinds of timer logic blocks

What are the four kinds of timer blocks?

What is the purpose of an ON block with delay?

Why do we use ONESHOT blocks?

How are TICKTOCK blocks used?

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Lesson 8: Sequence Blocks

Lesson Objectives:

- Describe the different kinds of sequence logic blocks

What are the two types of sequence blocks?

What are multioutput blocks?

What are the two main things that require multioutput control?

What is the difference between incremental control and staging control?

What are the important variables for controlling a SEQUENCER block?

What is hysteresis?

Why is stroke timing so important for FLOAT control blocks?

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Lesson 9: Loop Blocks

Lesson Objectives:

- Describe the different kinds of loop logic blocks

What is the PI block?

What is proportional integral derivative control?

What is a proportional response?

What is error?

What is the startup value?

What is loop wind up and wind down?

How can you counter loop wind up and wind down?

What is the difference between direct acting and reverse acting loop control?

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MODULE 4: INTRODUCTION TO DESIGN PATTERNS

In this module we are going to discuss design patterns. The lessons in the module are:

- Lesson 1: What are Design Patterns
- Lesson 2: How to Create and Apply Design Patterns

You may have never heard the term design pattern. But chances are you use them every day.

Have you ever used a file template? Or have you ever used a blueprint to build something?

Those are design patterns. Design patterns show you how to achieve a result using a common design that can be repeated again and again.

By learning design patterns, you will be able to quickly create programs based on what you need to achieve.

In this module you are going to learn how design patterns work and how they can be used in your programs.

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Lesson 1: What are Design Patterns

Lesson Objectives:

- Explain what design patterns are

What is a design pattern?

What are the three scenarios where you could use design patterns?

What is a great benefit to learning design patterns?

What are the three steps for designing a design pattern library?

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Lesson 2: How to Create and Apply Design Patterns

Lesson Objectives:

- Explain how to create a design pattern

What is the first step to take when creating a design pattern using a sequence snippet?

Why is important to refer to manufacturer documentation when using logic blocks?

How can you document your completed design pattern?

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MODULE 5: BASIC DESIGN PATTERNS

In this module we will be looking at the most common design patterns you will use. The lessons in the module are:

- Lesson 1: Start-Stop (temperature)
- Lesson 2: Start-Stop (occupancy with status)
- Lesson 3: Start-Stop (occupancy with status, latching alarm)
- Lesson 4: Fan Speed Control (auto reset)
- Lesson 5: Fan Speed Control (manual reset)
- Lesson 6: Cooling Valve Control
- Lesson 7: Heating Valve Control
- Lesson 8: Preheat Valve Control
- Lesson 9: Economizer Valve Control
- Lesson 10: Fan Start (with damper status)
- Lesson 11: Temperature Reset (based on outside value)

Design patterns exist to increase your ability to rapidly create code for your program. In this module you will explore the most common design patterns.

Pay attention, you will use these design patterns again and again. By learning these design patterns you can easily write new code and troubleshoot existing code.

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Lesson 1: Start-Stop (temperature)

Lesson Objectives:

- Create a Start-Stop (temperature) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 2: Start-Stop (occupancy with status)

Lesson Objectives:

- Create a Start-Stop (occupancy with status) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 3: Start-Stop (occupancy with status, latching alarm)

Lesson Objectives:

- Create a Start-Stop (occupancy with status, latching alarm) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 4: Fan Speed Control (auto reset)

Lesson Objectives:

- Create a Fan Speed Control (auto reset) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 5: Fan Speed Control (manual reset)

Lesson Objectives:

- Create a Fan Speed Control (manual reset) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 6: Cooling Valve Control

Lesson Objectives:

- Create a Cooling Valve Control design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 7: Heating Valve Control

Lesson Objectives:

- Create a Heating Valve Control design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 8: Preheat Valve Control

Lesson Objectives:

- Create a Preheat Valve Control design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 9: Economizer Control

Lesson Objectives:

- Create a Economizer Control design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 10: Fan Start (with damper status)

Lesson Objectives:

- Create a Fan Start (with damper status) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 11: Temperature Reset (based on outside value)

Lesson Objectives:

- Create a Temperature Reset (based on outside value) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 12: Staged Timed On/Off

Lesson Objectives:

- Create a Staged Timed On/Off design pattern

No questions, practice hands-on coding by following the lesson.

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MODULE 6: Advanced Design Patterns

In this module we will discussing some advanced design patterns. The lessons in the module are:

- Lesson 1: Fan Speed (with DP reset)
- Lesson 2: Two-Fan Volumetric Offset
- Lesson 3: Two-Fan Volumetric Matching
- Lesson 4: Lead-Lag (auto reset)
- Lesson 5: Lead-Lag (manual reset)
- Lesson 6: CO2 Reset
- Lesson 7: CO2 Reset with Economizer (minimum select)
- Lesson 8: CO2 Reset with Economizer (high select)
- Lesson 9: Building Static Pressure Control (EF and dampers)

Advanced design patterns exist to provide a way for you to program complex systems like central utility plans and complex air handlers.

Often times folks get overwhelmed when they see a 10-page sequence of operations?

How do you start? Where do you start?

These design patterns will help prepare you for those scenarios.

Lesson 1: Fan Speed (with DP reset)

Lesson Objectives:

- Create a Fan Speed (with DP reset) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 2: Two Fan Volumetric Offset

Lesson Objectives:

- Create a Two Fan Volumetric Offset Control design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 3: Two Fan Volumetric Matching

Lesson Objectives:

- Create a Two Fan Volumetric Matching design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 4: Lead-Lag (auto reset)

Lesson Objectives:

- Create a Lead-Lag (auto reset) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 5: Lead-Lag (manual reset)

Lesson Objectives:

- Create a Lead-Lag (manual reset) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 6: CO2 Reset

Lesson Objectives:

- Create a CO2 Reset design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 7: CO2 Reset with Economizer (minimum select)

Lesson Objectives:

- Create a CO2 Reset with Economizer (minimum select) design pattern

No questions, practice hands-on coding by following the lesson.

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Lesson 8: CO2 Reset with Economizer (high select)

Lesson Objectives:

- Create a CO2 Reset with Economizer (high select)

No questions, practice hands-on coding by following the lesson.

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Lesson 9: Building Static Pressure Control (EF and dampers)

Lesson Objectives:

- Building Static Pressure Control (EF and dampers)

No questions, practice hands-on coding by following the lesson.

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MODULE 7: CAPSTONE PROGRAM

In this module we will be applying everything we learned and writing some programs from scratch. The lessons in the module are:

- Lesson 1: Module Overview
- Lesson 2: VAV Box Sequence
- Lesson 3: VAV Box Program Walkthrough
- Lesson 4: RTU Sequence
- Lesson 5: RTU Program Walkthrough
- Lesson 6: Air Cooled Chiller Sequence
- Lesson 7: Air Cooled Chiller Program Walkthrough

Yes, the moment is finally here! We are now ready to create our own programs. As you move through this module I encourage you to try. You may be new to programming and this may feel overwhelming.

If it does that is ok, it's perfectly normal to feel overwhelmed. But don't let that stop you from attempting to write your programs.

Put your best foot forward and take the first step of your programming journey!

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Lesson 1: Module Overview

Lesson Objectives:

- Explain the purpose of module 7

No questions, just an explanation of this module.

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Lesson 2: VAV Box Sequence

Sequences

- VAV box Sequence PDF

Lesson Objectives:

- Write a VAV Box program

No questions, practice writing your VAV box sequence program.

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Lesson 3: VAV Box Program Walkthrough

Lesson Objectives:

- Review the VAV box program

Why do you think I am not using latching alarms in the VAV box program?

Why am I using switches to change my setpoints for occupied and unoccupied modes?

Why do I have two PID loops one for heating and cooling?

Why am I using an analog switch to pass through a different cfm before my reset block?

Why did I disable the damper PID loop based on air handler flow?

Why do I command the damper to 100% when there is no AHU status?

What does it mean to decouple the alarm and trend from the program?

How does using a highlighter on the sequence file make programming easier?

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Lesson 4: RTU Sequence

Sequences

- RTU Sequence PDF

Lesson Objectives:

- Write a RTU program

No questions, practice writing your RTU sequence program.

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Lesson 5: RTU Program Walkthrough

Lesson Objectives:

- Review the RTU program

Why do you think I used delays on my alarms?

Why do you want to measure accumulated and not current runtime?

Why is it important to think from an users perspective when writing the program?

Why is it important to think through how you link up inputs to your logic blocks?

Why did I lay out the program in the order I did? (hint look at the sequence)

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Lesson 6: Air Cooled Chiller Sequence

Sequences

- Air cooled chiller sequence PDF

Lesson Objectives:

- Write a Air Cooled Chiller program

No questions, practice writing your Air Cooled Chiller sequence program.

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Lesson 7: Air Cooled Chiller Program Walkthrough

Lesson Objectives:

- Review the air cooled chiller program

Why is it important to always pay attention to the sequence?

What is a fragmented sequence chunk?

Why do you need to fully understand the on and off scenarios when using timers?

When will you be using latching blocks in your programs?

Where will you usually “do” alarming, trending, and runtime totalization?