1 Introduction to Embedded Programming Using C --2 Agenda --3 Agenda ---

4 Section 1.0 Using C in an Embedded Environment

5 Just the Facts
 6 Busting the Myths
 7 Busting the Myths
 The truth shall set you free...
 The truth shall set you free...

8 Development Tools Data Flow --9 Development Tools Data Flow --10 C Runtime Environment --11 C Runtime Environment ---

12 Fundamentals of C A Simple C Program

13 Section 1.1 Comments

14 Comments ---

15 Comments
16 Comments
17 Comments
Using Block Comments
Using Single Line Comments
Nesting Comments

18 Comments Best Practices

19 Section 1.2 Variables, Identifiers, and Data Types

20 Variables and Data Types A Simple C Program

21 Variables --22 Variables --23 Variables --24 Variables --25 Identifiers --26 Identifiers --27 ANSI C Keywords ---

28 Data Types
29 Data Type Qualifiers
30 Data Type Qualifiers
31 Variables
32 Variables
33 Variables
34 Variables
44 Variables
45 Fundamental Types
46 Modified Integer Types
47 Modified Floating Point Types
48 How to Declare a Variable
49 How to Declare a Variable
40 How to Declare a Variable
40 How to Declare a Variable
41 How to Declare a Variable

35 #include Directive ---

36 #include Directive main.h Header File and main.c Source File

37 #include Directive Equivalent main.c File

38 Lab 01 Variables and Data Types --39 Lab 01 Variables and Data Types --40 Lab 01 Variables and Data Types --41 Lab 01 Variables and Data Types --42 Lab 01 Variables and Data Types --43 Lab 01 Variables and Data Types --44 Lab 01 Variables and Data Types --45 Lab 01 Conclusions ---

46 Section 1.3 Literal Constants

47 A Simple C Program Literal Constants

48 Literal Constants --

49 Constant vs. Literal What's the difference?

50 Literal Constants -

51 Integer Literals Decimal (Base 10)
52 Integer Literals Hexadecimal (Base 16)

53 Integer Literals Octal (Base 8)
54 Integer Literals Binary (Base 2)

55 Integer Literals Qualifiers
56 Floating Point Literals Decimal (Base 10)

57 Character Literals --58 String Literals ---

59 String Literals Declarations

60 String Literals
How to Include Special Characters in Strings
61 String Literals
How to Include Special Characters in Strings

62 Section 1.4 Symbolic Constants

63 Symbolic Constants ---

64 Symbolic Constants Constant Variables Using const
65 Symbolic Constants Text Substitution Labels Using #define

66 Symbolic Constants #define Gotchas

67 Symbolic Constants Initializing Variables When Declared

68 Lab 02 Symbolic Constants --69 Lab 02 Symbolic Constants --70 Lab 02 Symbolic Constants --71 Lab 02 Symbolic Constants --72 Lab 02 Symbolic Constants --73 Lab 02 Symbolic Constants --74 Lab 02 Symbolic Constants --75 Lab 02 Conclusions ---

76 Section 1.5 printf() Function

77 printf() Standard Library Function
78 printf() Standard Library Function

79 printf() Conversion Characters for Control String

80 printf() Gotchas

81 printf() Useful Format String Examples for Debugging 82 printf() Useful Format String Examples for Debugging

83 Lab 03 printf() Library Function --84 Lab 03 printf() Library Function --85 Lab 03 printf() Library Function --86 Lab 03 printf() Library Function --87 Lab 03 printf() Library Function --88 Lab 03 Conclusions ---

89 Section 1.6 Operators

90 Operators How to Code Arithmetic Expressions

91 Operators Arithmetic
92 Operators Division Operator
93 Operators Implicit Type Conversion

94 Operators Implicit Arithmetic Type Conversion Hierarchy
95 Operators Arithmetic Expression Implicit Type Conversion
96 Operators Applications of the Modulus Operator (%)
97 Operators Arithmetic: Increment and Decrement
98 Operators How to Code Assignment Statements

99 Operators Assignment

100 Operators Compound Assignment 101 Operators Compound Assignment

102 Operators Relational

103 Operators Difference Between = and == 104 Operators Difference Between = and ==

105 OperatorsLogical106 OperatorsBitwise

107 Operators Difference Between & and && Difference Between & and &&

109 Operators Logical Operators and Short Circuit Evaluation

110 Operators Logical Operators and Short Circuit Evaluation 111 Operators Shift 112 Operators Shift - Special Cases 113 Operators Power of 2 Integer Divide vs. Shift Right 114 Operators Power of 2 Integer Divide vs. Shift in MPLAB® C30 Power of 2 Integer Divide vs. Shift in MPLAB® C18 115 Operators 116 Operators Memory Addressing 117 Operators Other 118 Operators The Conditional Operator 119 Operators The Explicit Type Cast Operator 120 Operators Precedence 121 Operators Precedence 122 Operators Precedence 123 Operators Precedence 124 Operators Associativity 125 Lab 04 Operators 126 Lab 04 Operators 127 Lab 04 Operators 128 Lab 04 Operators 129 Lab 04 Operators 130 Lab 04 Conclusions 131 Section 1.7 Expressions and Statements 132 Expressions 133 Expressions Examples 134 Statements 135 Expression Statements ---136 Compound Statements ---137 Compound Statements Example 138 Control Statements 139 Section 1.8 Making Decisions 140 Boolean Expressions 141 Boolean Expressions **Equivalent Expressions** 142 if Statement 143 if Statement Flow Diagram 144 if Statement 145 if Statement Solution to Trick Question 146 if Statement Testing for TRUE 147 Nested if Statements ---148 if-else Statement 149 if-else Statement Flow Diagram 150 if-else Statement 151 if-else if Statement 152 if-else if Statement Flow Diagram 153 if-else if Statement 154 Lab 05 Making Decisions (if) 155 Lab 05 Making Decisions (if) 156 Lab 05 Making Decisions (if) 157 Lab 05 Making Decisions (if) 158 Lab 05 Conclusions 159 switch Statement 160 switch Statement Flow Diagram (default) 161 switch Statement Flow Diagram (modified) 162 switch Statement 163 switch Statement

164 switch Statement

165 Lab 06 Making Decisions (switch)

166 Lab 06 Making Decisions (switch)---167 Lab 06 Making Decisions (switch)---168 Lab 06 Making Decisions (switch)---169 Lab 06 Making Decisions (switch)---170 Lab 06 Conclusions---

171 Section 1.9 Loops

172 for Loop ---

173 for Loop Flow Diagram

 174 for Loop
 --

 175 for Loop
 --

 176 while Loop
 --

177 while LoopFlow Diagram178 while LoopExample179 while Loop---180 do-while Loop---

181 do-while Loop Flow Diagram
182 do-while Loop Example
183 break Statement ---

184 break Statement Flow Diagram Within a while Loop

185 break Statement Example

186 continue Statement ---

187 continue Statement Flow Diagram Within a while Loop

 188 continue Statement
 Example

 189 Lab 07 Loops
 --

 190 Lab 07 Loops
 --

 191 Lab 07 Loops
 --

 192 Lab 07 Loops
 --

 193 Lab 07 Loops
 --

 194 Lab 07 Conclusions
 --

195 Section 1.10 Functions

196 FunctionsProgram Structure197 FunctionsWhat is a function?198 FunctionsRemember Algebra Class?

199 Functions Definitions

200 Functions
201 Functions
202 Functions
202 Functions
203 Functions
204 Functions
205 Functions
206 Functions
206 Functions
207 Functions
208 Functions
209 Functions
209 Functions
200 Functions
20

207 Functions

208 Functions

Function Prototypes

Function Prototypes

210 FunctionsDeclaration and Use: Example 1211 FunctionsDeclaration and Use: Example 2212 FunctionsPassing Parameters by Value213 FunctionsPassing Parameters by Value

214 Functions Recursion

215 Functions Evaluation of Recursive Functions

216 Functions and Scope Parameters

217 Functions and Scope Variables Declared Within a Function 218 Functions and Scope Variables Declared Within a Function

219 Functions and Scope Global versus Local Variables

220 Functions and Scope Parameters
221 Functions and Scope Parameters

222 Functions and Scope #define Within a Function
 223 Functions Historical Note

 224 Lab 08 Functions
 --

 225 Lab 08 Functions
 --

 226 Lab 08 Functions
 --

 227 Lab 08 Functions
 --

 228 Lab 08 Functions
 --

 229 Lab 08 Conclusions
 --

230 Section 1.11 Multi-File Projects and Storage Class Specifiers

231 Storage Class Specifiers Scope and Lifetime of Variables

232 Storage Class Specifiers Automatic Variables

233 Storage Class Specifiers auto Keyword with Variables

234 Storage Class Specifiers Static Variables

235 Storage Class Specifiers static Keyword with Variables

236 Storage Class SpecifiersExternal Variables237 Storage Class SpecifiersExternal Variables238 Storage Class SpecifiersExternal Variables239 Storage Class SpecifiersRegister Variables240 Storage Class SpecifiersScope of Functions241 Storage Class SpecifiersExternal Functions242 Storage Class SpecifiersStatic Functions

243 Lab 09 Multi-File Projects --244 Lab 09 Multi-File Projects --245 Lab 09 Multi-File Projects --246 Lab 09 Multi-File Projects --247 Lab 09 Conclusions ---

248 Section 1.12 Arrays

249 Arrays ---

250 Arrays How to Create an Array

251 Arrays How to Initialize an Array at Declaration

252 Arrays How to Use an Array

253 Arrays Creating Multidimensional Arrays

254 Arrays Initializing Multidimensional Arrays at Declaration

255 Arrays
256 Arrays
257 Arrays
258 Strings
259 Strings
250 Strings
250 Strings
251 Strings
252 Strings
253 Strings
254 Strings
255 Strings
256 Strings
257 Arrays
258 Strings
259 Strings
259 Strings
250 Strings
250 Strings
250 Strings
251 Strings
252 Strings
253 How to Initialize a String in Code

262 Strings Comparing Strings
263 Functions Array Parameters

264 Lab 10 Arrays --265 Lab 10 Arrays --266 Lab 10 Arrays --267 Lab 10 Arrays --268 Lab 10 Conclusions ---

269 Section 1.13 Data Pointers

270 Pointers A Variable's Address versus A Variable's Value

271 Pointers What are pointers?
272 Pointers What do they do?

273 Pointers

Why would I want to do that?

274 Pointers

Why would I want to do that?

Where else are they used?

Where else are they used?

How to Create a Pointer Variable

277 Pointers	How to Create a Pointer Type with typedef
278 Pointers	Initialization
279 Pointers	Usage
280 Pointers	Another Way To Look At The Syntax
281 Pointers	Another Way To Look At The Syntax
282 Pointers	Another Way To Look At The Syntax
283 Pointers	How Pointers Work
284 Pointers	How Pointers Work
285 Pointers	How Pointers Work
286 Pointers	How Pointers Work
287 Pointers	How Pointers Work
288 Pointers	How Pointers Work
289 Pointers	How Pointers Work
290 Pointers and Arrays	A Quick Reminder
291 Pointers and Arrays	Initializing a Pointer to an Array
292 Pointers and Arrays	A Preview of Pointer Arithmetic
293 Pointers and Arrays	A Preview of Pointer Arithmetic
294 Pointers and Arrays	A Preview of Pointer Arithmetic
295 Pointer Arithmetic	Incrementing Pointers
296 Pointer Arithmetic	Incrementing Pointers
297 Pointer Arithmetic	Larger Jumps
298 Pointer Arithmetic	Larger Jumps
299 Pointers	Pointer Arithmetic
300 Pointers	Pointer Arithmetic
301 Pointers	Pointer Arithmetic
302 Pointers	Pointer Arithmetic
303 Pointers	Pointer Arithmetic
304 Pointers	Pointer Arithmetic
305 Pointers	Pointer Arithmetic
306 Pointers	Pointer Arithmetic
307 Pointers	Post-Increment/Decrement Syntax Rule
308 Pointers	Post-Increment/Decrement Syntax Rule
309 Pointers	Post-Increment/Decrement Syntax Rule
310 Pointers	Post-Increment/Decrement Syntax Rule
311 Pointers	Post-Increment/Decrement Syntax Rule
312 Pointers	Post-Increment/Decrement Syntax Rule
313 Pointers	Pre-Increment / Decrement Syntax
314 Pointers	Pre-Increment / Decrement Syntax
315 Pointers	Pre-Increment / Decrement Syntax
316 Pointers	Pre-Increment / Decrement Syntax
317 Pointers	Pre-Increment / Decrement Syntax
318 Pointers	Pre-Increment / Decrement Syntax
319 Pointers	Pre- and Post- Increment/Decrement Summary
320 Pointers	Initialization Tip
321 Lab 11 Pointers and Pointer Arithmetic	
322 Lab 11 Pointers and Pointer Arithmetic	
323 Lab 11 Pointers and Pointer Arithmetic	
324 Lab 11 Pointers and Pointer Arithmetic	
325 Lab 11 Conclusions	
326 Pointers and Functions	Passing Pointers to Functions
327 Pointers and Functions	Passing Pointers to Functions
328 Pointers and Functions	Passing Pointers to Functions
329 Pointers and Functions	Passing Parameters By Reference
330 Pointers and Functions	Passing Parameters By Reference
331 Pointers and Strings	
332 Pointers and Strings	
333 Pointers and Strings	

334 Pointers and Strings Pointer versus Array: Initialization at Declaration 335 Pointers and Strings Pointer versus Array: Assignment in Code 336 Pointers and Strings **Comparing Strings** 337 Pointers and Strings **Comparing Strings** 338 Pointers and Strings **Comparing Strings** 339 Arrays of Pointers Declaration 340 Arrays of Pointers Array Elements are Pointers Themselves 341 Arrays of Pointers Initialization 342 Arrays of Pointers Dereferencing 343 Arrays of Pointers **Accessing Strings** 344 Lab 12 Pointers, Arrays, and Functions 345 Lab 12 Pointers, Arrays, and Functions 346 Lab 12 Pointers, Arrays, and Functions 347 Lab 12 Pointers, Arrays, and Functions 348 Lab 12 Conclusions 349 Section 1.14 Function Pointers 350 Function Pointers 351 Function Pointers Declaration 352 Function Pointers Initialization 353 Function Pointers Calling a Function via a Function Pointer 354 Function Pointers Passing a Function to a Function 355 Function Pointers Passing a Function to a Function 356 Lab 13 Function Pointers 357 Lab 13 Function Pointers 358 Lab 13 Function Pointers 359 Lab 13 Function Pointers 360 Lab 13 Function Pointers 361 Lab 13 Function Pointers 362 Lab 13 Conclusions 363 Section 1.15 Structures 364 Structures 365 Structures How to Create a Structure Definition 366 Structures How to Declare a Structure Variable (Method 1) 367 Structures How to Declare a Structure Variable (Method 2) How to Use a Structure Variable 368 Structures 369 Structures How to Create a Structure Type with typedef 370 Structures How to Declare a Structure Type Variable 371 Structures How to Initialize a Structure Variable at Declaration 372 Structures **Nesting Structures** 373 Structures Arrays and Pointers with Strings 374 Structures How to Declare a Pointer to a Structure 375 Structures How to Use a Pointer to Access Structure Members 376 Structures **Creating Arrays of Structures** 377 Structures Initializing Arrays of Structures at Declaration 378 Structures **Using Arrays of Structures** 379 Structures How to Pass Structures to Functions 380 Lab 14 Structures 381 Lab 14 Structures 382 Lab 14 Structures 383 Lab 14 Conclusions 384 Lab 15 Arrays of Structures 385 Lab 15 Arrays of Structures 386 Lab 15 Arrays of Structures 387 Lab 15 Conclusions

388 Section 1.16 Unions

389 Unions 390 Unions How to Create a Union How to Create a Union Type with typedef 391 Unions 392 Unions How Unions Are Stored In Memory 393 Unions How Unions Are Stored In Memory 394 Unions How Unions Are Stored In Memory 395 Unions How Unions Are Stored In Memory 396 Lab 16 Unions 397 Lab 16 Unions 398 Lab 16 Unions 399 Lab 16 Conclusions 400 Section 1.17 Bit Fields 401 Bit Fields 402 Bit Fields How to Create a Bit Field 403 Bit Fields How to Use a Bit Field 404 Lab 17 Bit Fields 405 Lab 17 Bit Fields 406 Lab 17 Bit Fields 407 Lab 17 Bit Fields 408 Lab 17 Bit Fields 409 Lab 17 Bit Fields 410 Lab 17 Bit Fields 411 Lab 17 Bit Fields 412 Lab 17 Conclusions 413 Section 1.18 Enumerations 414 Enumerations 415 Enumerations How to Create an Enumeration Type 416 Enumerations How to Create an Enumeration Type 417 Enumerations How to Declare an Enumeration Type Variable 418 Enumerations How to Declare a 'Tagless' Enumeration Variable 419 Enumerations How to Declare an Enumeration Type with typedef 420 Enumerations How to Use an Enumeration Type Variable 421 Lab 18 Enumerations 422 Lab 18 Enumerations 423 Lab 18 Enumerations 424 Lab 18 Enumerations 425 Lab 18 Conclusions 426 Section 1.19 Macros with #define 427 Macros with #define 428 Macros with #define Simple Macros 429 Macros with #define **Argument Macros** 430 Macros with #define Argument Macros - Side Effects 431 Lab 19 #define Macros 432 Lab 19 #define Macros 433 Lab 19 #define Macros 434 Lab 19 #define Macros 435 Lab 19 Conclusions 436 Resources A Selection of C Compilers 437 Resources Books - General C Language 438 Resources Books - General C Language Books - PIC® MCU Specific 439 Resources 440 Resources Books - Compiler Specific 441 Resources Books - Compiler Specific 442 Thank you!

443 Trademarks