

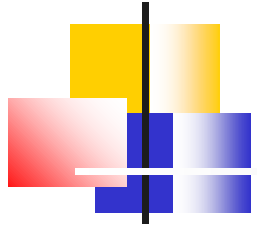


**esp32forth\_84**

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**Silicon Valley  
Forth Interest Group**

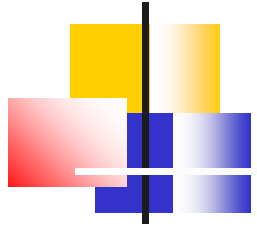
**Chen-Hanson Ting  
September 25, 2021**



# ceForth

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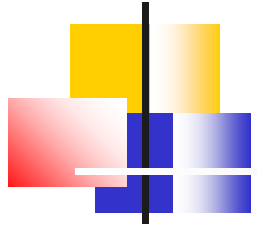
- **ceForth was eForth written in C.**
- **ceForth\_21 in Cygwin cpp needed a Forth dictionary meta-compiled by F#.**
- **ceForth\_33 in Visual Studio 2017 had a meta-compiler to build Forth dictionary in runtime.**



## ceforth\_403

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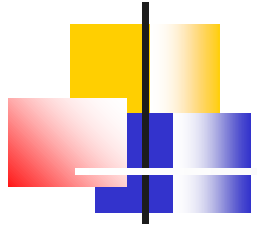
- **It was written by Chochain Lee as a C++ console application in Visual Studio 2019 Community.**
- **It runs in a console window like an old-fashion Forth program with an ADM3 terminal.**



## wineforth\_502

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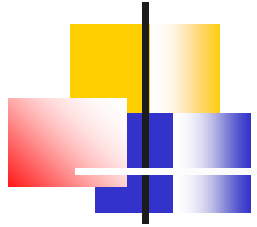
- **Chochain changed ceforth\_403 to wineforth\_502.**
- **A simple Windows interface allowed text in an input box to be evaluated and output characters are sent to an output box.**



# esp32forth\_84

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- Chochain ported wineforth\_502 to ESP32 and it became esp32forth\_82.
- ESP32 is now connected remotely via WiFi.
- Improved speed and dictionary space in esp32forth\_84.



# Firmware Engineering

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- **Forth Virtual Machine is coded in a single esp32forth\_84.ino file.**
- **Application Forth program is stored in ESP32 flash memory as a text file \data\load.txt.**
- **On power up, ESP32 compiles load.txt to run an embedded application.**



# Forth Virtual Machine

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- **A set of Forth words stored in a dictionary**
- **An outer interpreter**
- **An inner interpreter**
- **A return stack**
- **A parameter stack**
- **A terminal**

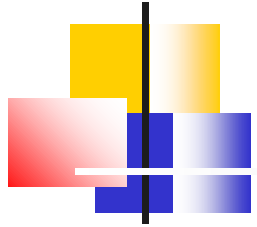


# Forth Virtual Machine

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- **Forth words are objects.**
- **Primitive words, outer interpreter, and inner interpreter are all coded in C++.**
- **Applications will be coded as colon words.**
- **Code is very tight and looks like poetry.**



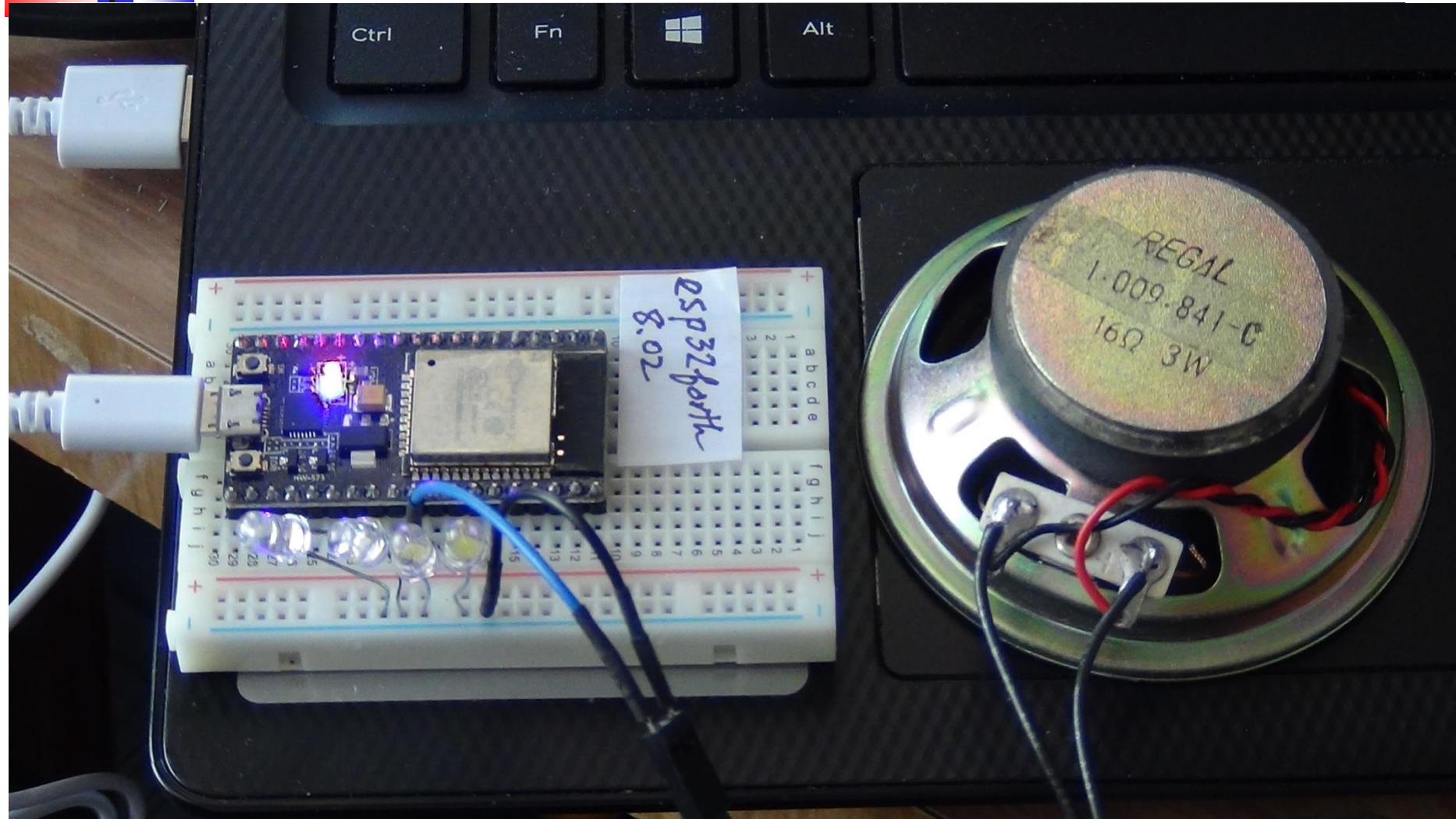


# esp32forth\_84

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- **ESP32 is no mainframe computer.**
- **It is meant for embedded applications.**
- **OOP can be shoe-horned into an ESP32 chip.**
- **It has a very nice web page to control and program an ESP32 remotely.**

# ESP32S Devkit

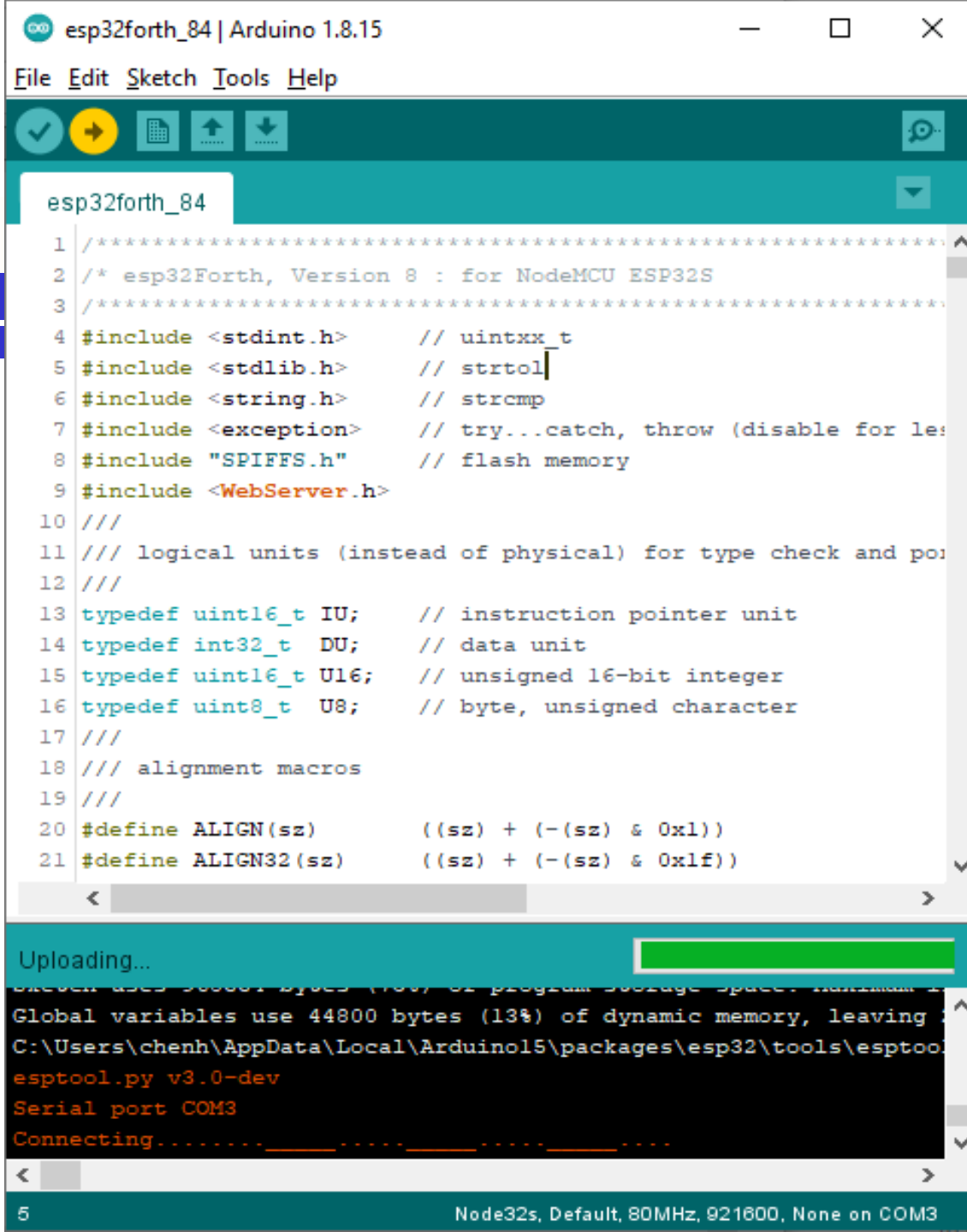




esp32forth\_84

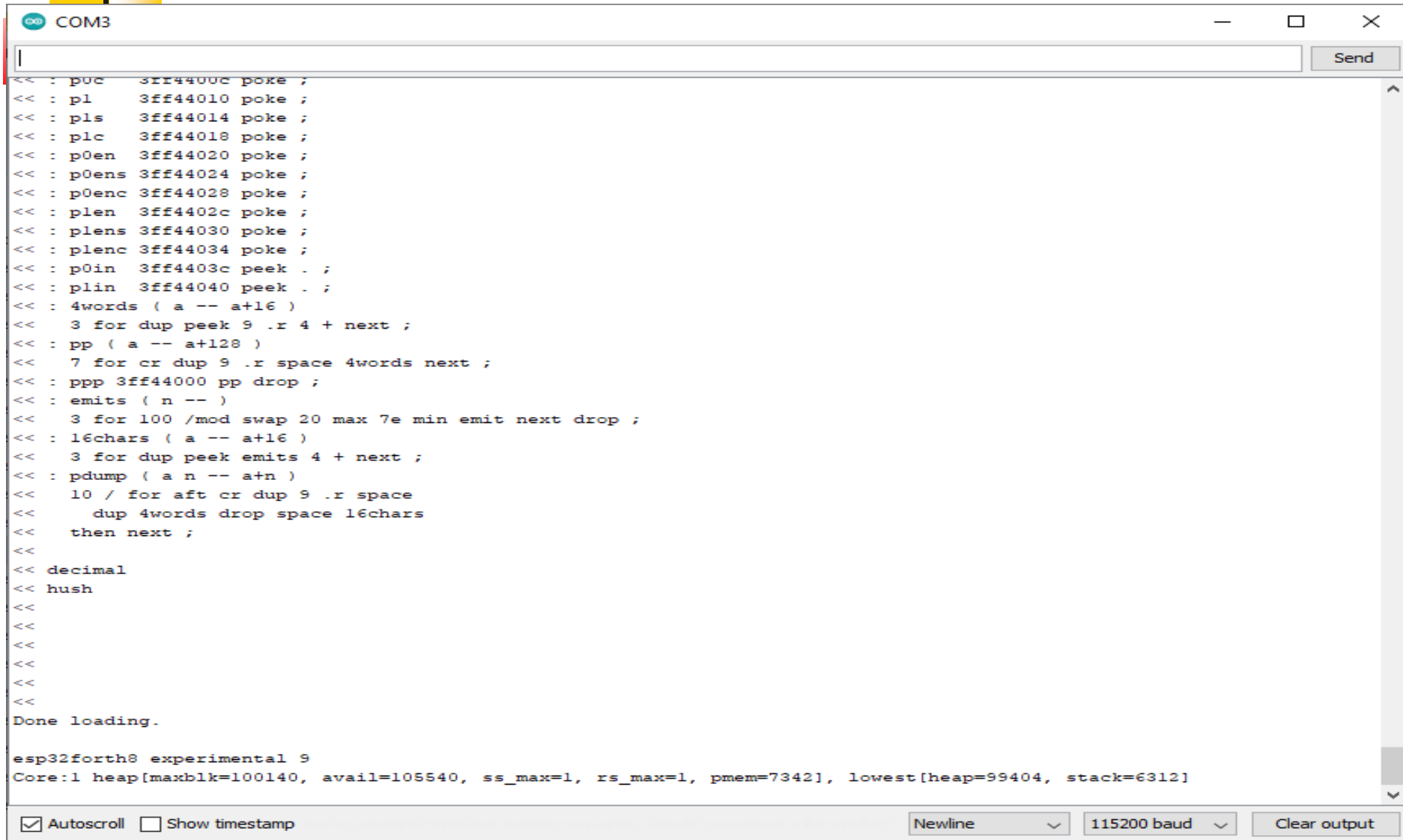
```
1 /*****
2 /* esp32Forth, Version 8 : for NodeMCU ESP32S
3 /*****
4 #include <stdint.h>    // uintxx_t
5 #include <stdlib.h>    // strtol
6 #include <string.h>    // strcmp
7 #include <exception>  // try...catch, throw (disable for les
8 #include "SPIFFS.h"   // flash memory
9 #include <WebServer.h>
10 ///
11 /// logical units (instead of physical) for type check and pos
12 ///
13 typedef uint16_t IU;   // instruction pointer unit
14 typedef int32_t DU;   // data unit
15 typedef uint16_t U16; // unsigned 16-bit integer
16 typedef uint8_t U8;  // byte, unsigned character
17 ///
18 /// alignment macros
19 ///
20 #define ALIGN(sz)      ((sz) + (-(sz) & 0x1))
21 #define ALIGN32(sz)    ((sz) + (-(sz) & 0x1f))
```

# Arduino IDE



# Arduino IDE

# Serial Monitor



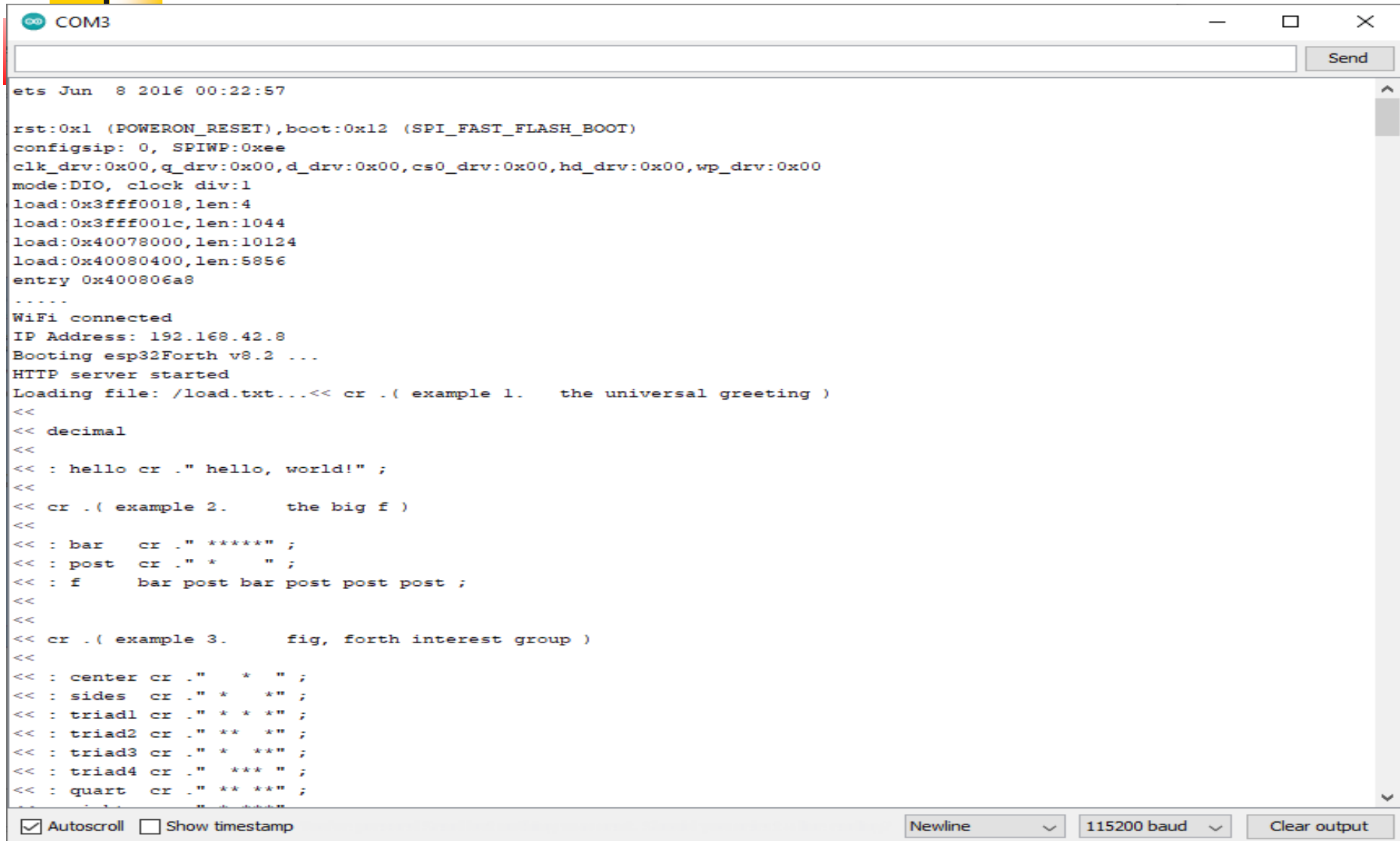
```
COM3
<< : poke 3ff4400c poke ;
<< : pl 3ff44010 poke ;
<< : pls 3ff44014 poke ;
<< : plc 3ff44018 poke ;
<< : p0en 3ff44020 poke ;
<< : p0ens 3ff44024 poke ;
<< : p0enc 3ff44028 poke ;
<< : plen 3ff4402c poke ;
<< : plens 3ff44030 poke ;
<< : plenc 3ff44034 poke ;
<< : p0in 3ff4403c peek . ;
<< : plin 3ff44040 peek . ;
<< : 4words ( a -- a+16 )
<< 3 for dup peek 9 .r 4 + next ;
<< : pp ( a -- a+128 )
<< 7 for cr dup 9 .r space 4words next ;
<< : ppp 3ff44000 pp drop ;
<< : emits ( n -- )
<< 3 for 100 /mod swap 20 max 7e min emit next drop ;
<< : 16chars ( a -- a+16 )
<< 3 for dup peek emits 4 + next ;
<< : pdump ( a n -- a+n )
<< 10 / for aft cr dup 9 .r space
<< dup 4words drop space 16chars
<< then next ;
<<
<< decimal
<< hush
<<
<<
<<
<<
<<
Done loading.

esp32forth8 experimental 9
Core:1 heap[maxblk=100140, avail=105540, ss_max=1, rs_max=1, pmem=7342], lowest[heap=99404, stack=6312]
```

Autoscroll  Show timestamp

Newline  115200 baud  Clear output

# Serial Monitor



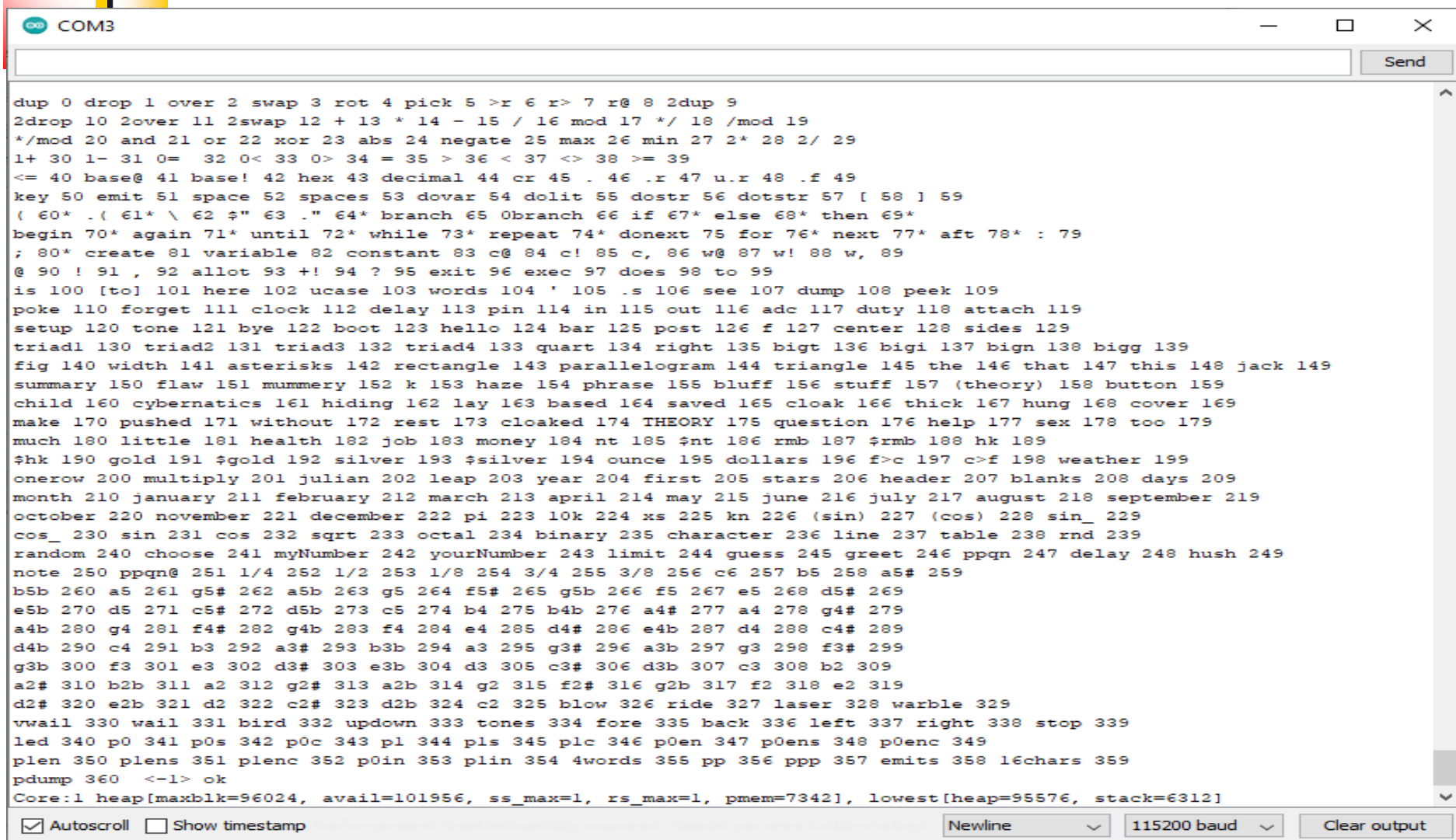
The image shows a serial monitor window titled "COM3". The window contains the following text:

```
ets Jun  8 2016 00:22:57

rst:0x1 (POWERON_RESET),boot:0x12 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0xee
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0018,len:4
load:0x3fff001c,len:1044
load:0x40078000,len:10124
load:0x40080400,len:5856
entry 0x400806a8
.....
WiFi connected
IP Address: 192.168.42.8
Booting esp32Forth v8.2 ...
HTTP server started
Loading file: /load.txt...<< cr .( example 1.   the universal greeting )
<<
<< decimal
<<
<< : hello cr ." hello, world!" ;
<<
<< cr .( example 2.   the big f )
<<
<< : bar   cr ." *****" ;
<< : post  cr ." *      " ;
<< : f     bar post bar post post ;
<<
<<
<< cr .( example 3.   fig, forth interest group )
<<
<< : center cr ." *  " ;
<< : sides  cr ." *  *" ;
<< : triad1 cr ." * * *" ;
<< : triad2 cr ." ** *" ;
<< : triad3 cr ." * ***" ;
<< : triad4 cr ." *** " ;
<< : quart  cr ." ** ***" ;
```

At the bottom of the window, there are several controls: a checked "Autoscroll" checkbox, an unchecked "Show timestamp" checkbox, a "Newline" dropdown menu, a "115200 baud" dropdown menu, and a "Clear output" button.

# Serial Monitor



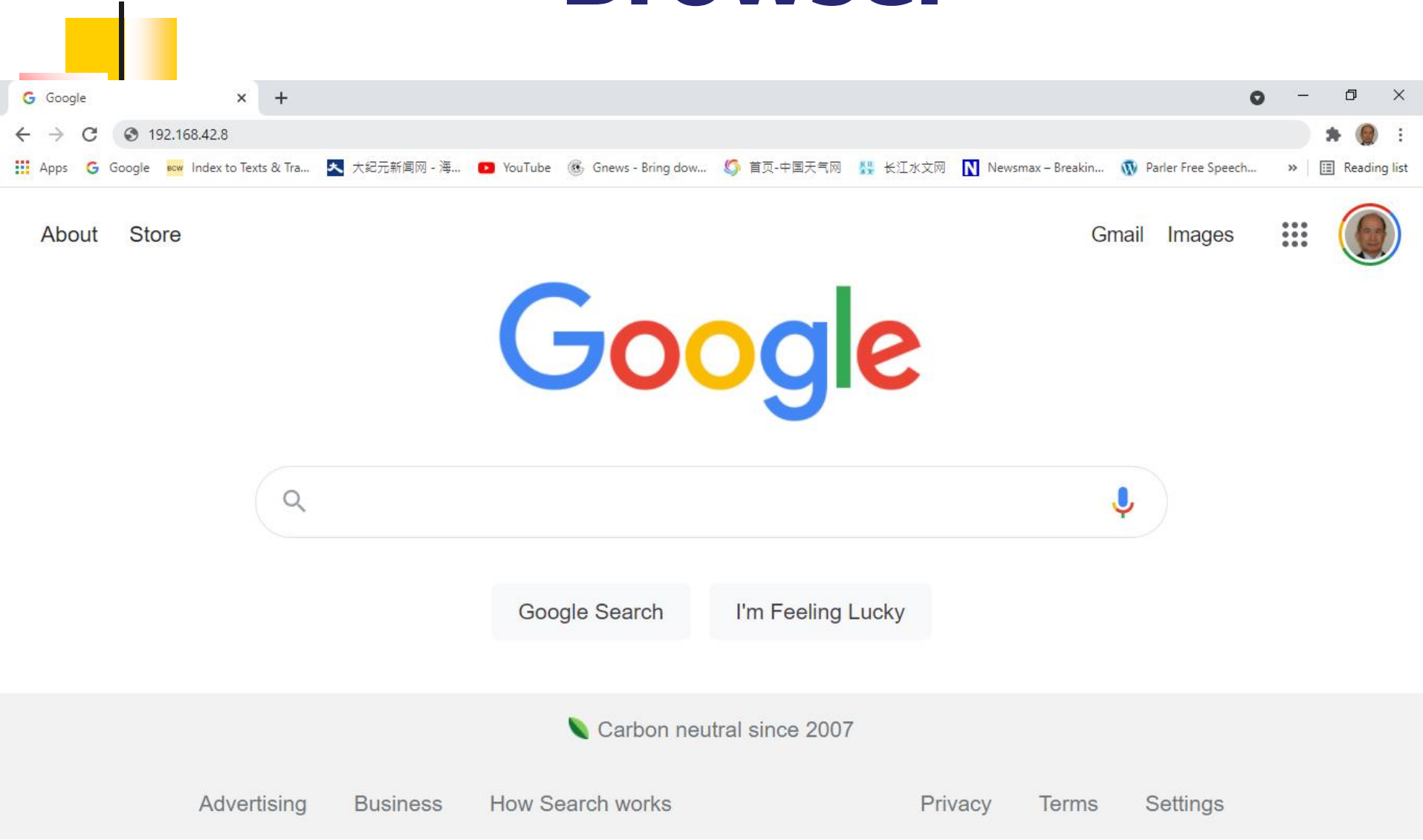
```
COM3
Send

dup 0 drop 1 over 2 swap 3 rot 4 pick 5 >r 6 r> 7 r@ 8 2dup 9
2drop 10 2over 11 2swap 12 + 13 * 14 - 15 / 16 mod 17 */ 18 /mod 19
*/mod 20 and 21 or 22 xor 23 abs 24 negate 25 max 26 min 27 2* 28 2/ 29
1+ 30 1- 31 0= 32 0< 33 0> 34 = 35 > 36 < 37 <> 38 >= 39
<= 40 base@ 41 base! 42 hex 43 decimal 44 cr 45 . 46 .r 47 u.r 48 .f 49
key 50 emit 51 space 52 spaces 53 dovar 54 dolit 55 dostr 56 dotstr 57 [ 58 ] 59
( 60* .( 61* \ 62 $" 63 ." 64* branch 65 0branch 66 if 67* else 68* then 69*
begin 70* again 71* until 72* while 73* repeat 74* donext 75 for 76* next 77* aft 78* : 79
; 80* create 81 variable 82 constant 83 c@ 84 c! 85 c, 86 w@ 87 w! 88 w, 89
@ 90 ! 91 , 92 allot 93 +! 94 ? 95 exit 96 exec 97 does 98 to 99
is 100 [to] 101 here 102 ucase 103 words 104 ' 105 .s 106 see 107 dump 108 peek 109
poke 110 forget 111 clock 112 delay 113 pin 114 in 115 out 116 adc 117 duty 118 attach 119
setup 120 tone 121 bye 122 boot 123 hello 124 bar 125 post 126 f 127 center 128 sides 129
triad1 130 triad2 131 triad3 132 triad4 133 quart 134 right 135 bigt 136 bigi 137 bign 138 bigg 139
fig 140 width 141 asterisks 142 rectangle 143 parallelogram 144 triangle 145 the 146 that 147 this 148 jack 149
summary 150 flaw 151 mummery 152 k 153 haze 154 phrase 155 bluff 156 stuff 157 (theory) 158 button 159
child 160 cybernatics 161 hiding 162 lay 163 based 164 saved 165 cloak 166 thick 167 hung 168 cover 169
make 170 pushed 171 without 172 rest 173 cloaked 174 THEORY 175 question 176 help 177 sex 178 too 179
much 180 little 181 health 182 job 183 money 184 nt 185 $nt 186 rmb 187 $rmb 188 hk 189
$hk 190 gold 191 $gold 192 silver 193 $silver 194 ounce 195 dollars 196 f>c 197 c>f 198 weather 199
onerow 200 multiply 201 julian 202 leap 203 year 204 first 205 stars 206 header 207 blanks 208 days 209
month 210 january 211 february 212 march 213 april 214 may 215 june 216 july 217 august 218 september 219
october 220 november 221 december 222 pi 223 10k 224 xs 225 kn 226 (sin) 227 (cos) 228 sin_ 229
cos_ 230 sin 231 cos 232 sqrt 233 octal 234 binary 235 character 236 line 237 table 238 rnd 239
random 240 choose 241 myNumber 242 yourNumber 243 limit 244 guess 245 greet 246 ppqn 247 delay 248 hush 249
note 250 ppqn@ 251 1/4 252 1/2 253 1/8 254 3/4 255 3/8 256 c6 257 b5 258 a5# 259
b5b 260 a5 261 g5# 262 a5b 263 g5 264 f5# 265 g5b 266 f5 267 e5 268 d5# 269
e5b 270 d5 271 c5# 272 d5b 273 c5 274 b4 275 b4b 276 a4# 277 a4 278 g4# 279
a4b 280 g4 281 f4# 282 g4b 283 f4 284 e4 285 d4# 286 e4b 287 d4 288 c4# 289
d4b 290 c4 291 b3 292 a3# 293 b3b 294 a3 295 g3# 296 a3b 297 g3 298 f3# 299
g3b 300 f3 301 e3 302 d3# 303 e3b 304 d3 305 c3# 306 d3b 307 c3 308 b2 309
a2# 310 b2b 311 a2 312 g2# 313 a2b 314 g2 315 f2# 316 g2b 317 f2 318 e2 319
d2# 320 e2b 321 d2 322 c2# 323 d2b 324 c2 325 blow 326 ride 327 laser 328 warble 329
vwail 330 wail 331 bird 332 updown 333 tones 334 fore 335 back 336 left 337 right 338 stop 339
led 340 p0 341 p0s 342 p0c 343 p1 344 pls 345 plc 346 p0en 347 p0ens 348 p0enc 349
plen 350 plens 351 plenc 352 p0in 353 plin 354 4words 355 pp 356 ppp 357 emits 358 16chars 359
pdump 360 <-1> ok
Core:1 heap[maxblk=96024, avail=101956, ss_max=1, rs_max=1, pmem=7342], lowest[heap=95576, stack=6312]
```

Autoscroll  Show timestamp

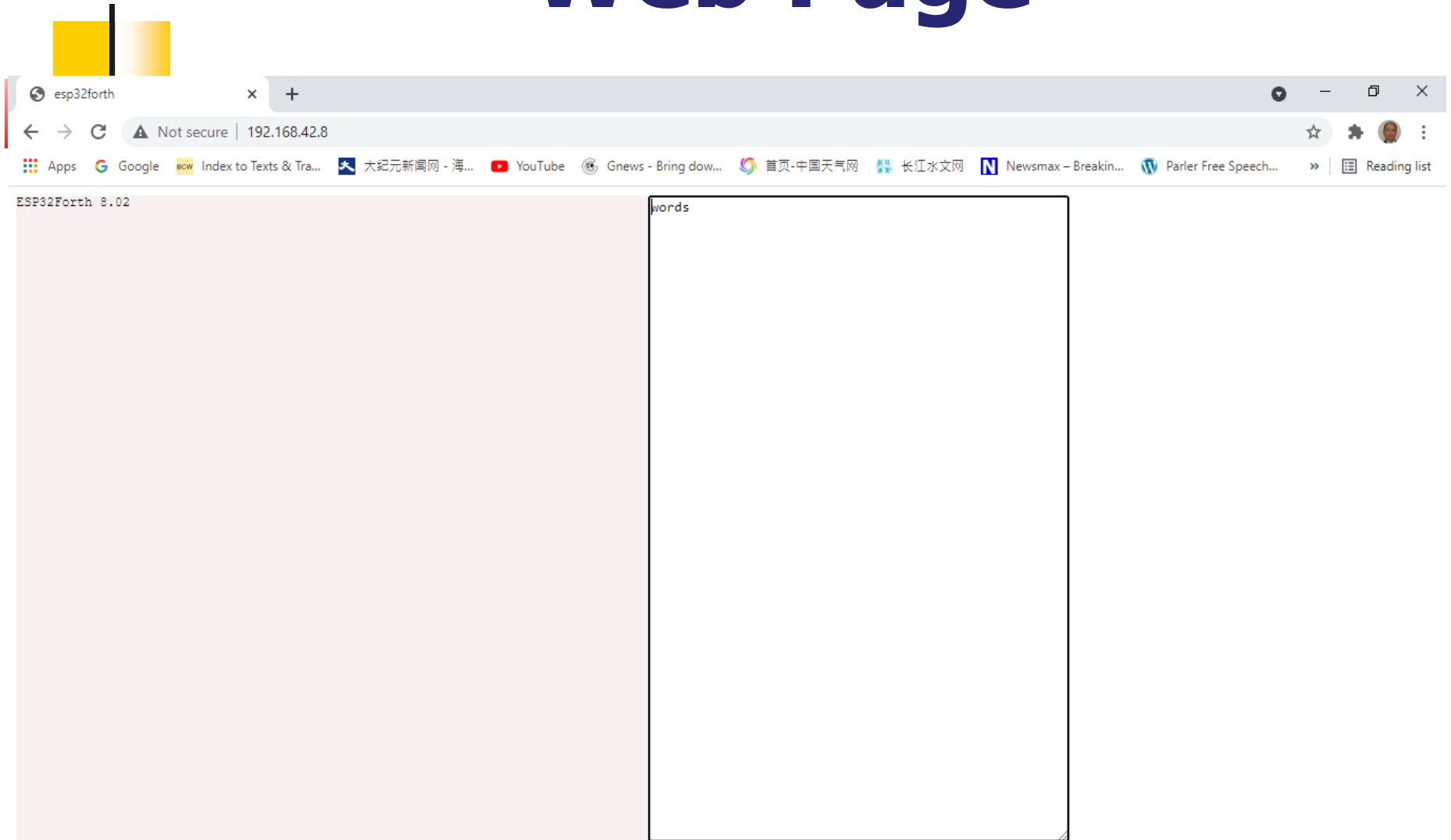
Newline 115200 baud Clear output

# Browser

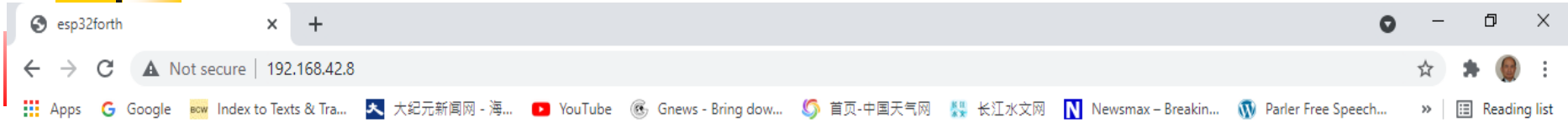




# Web Page



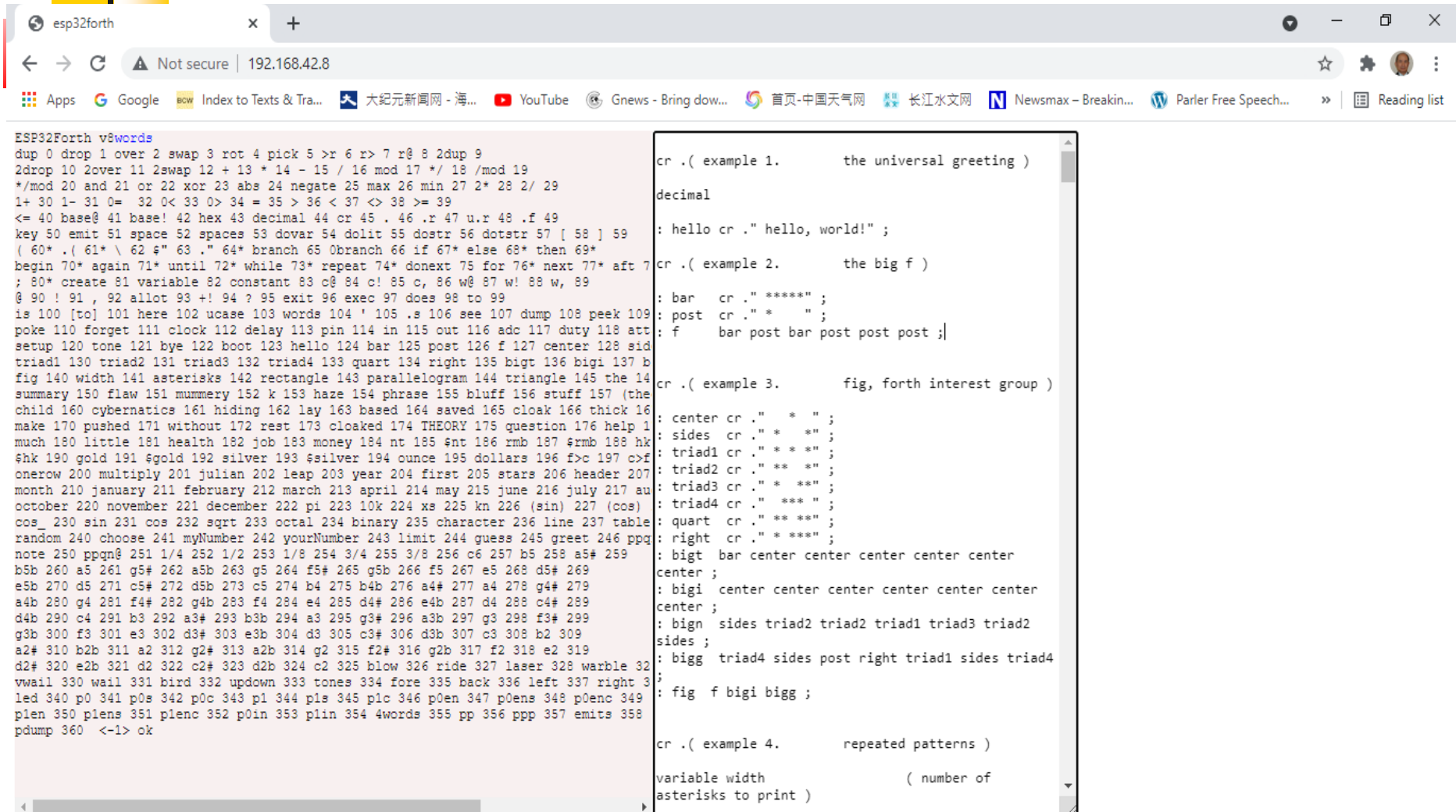
# Web Page



```
ESP32Forth v8words
dup 0 drop 1 over 2 swap 3 rot 4 pick 5 >r 6 r> 7 r@ 8 2dup 9
2drop 10 2over 11 2swap 12 + 13 * 14 - 15 / 16 mod 17 */ 18 /mod 19
*/mod 20 and 21 or 22 xor 23 abs 24 negate 25 max 26 min 27 2* 28 2/ 29
1+ 30 1- 31 0= 32 0< 33 0> 34 = 35 > 36 < 37 <> 38 >= 39
<= 40 base@ 41 base! 42 hex 43 decimal 44 cr 45 . 46 .r 47 u.r 48 .f 49
key 50 emit 51 space 52 spaces 53 dovar 54 dolit 55 dostr 56 dotstr 57 [ 58 ] 59
( 60* .( 61* \ 62 $" 63 ." 64* branch 65 0branch 66 if 67* else 68* then 69*
begin 70* again 71* until 72* while 73* repeat 74* donext 75 for 76* next 77* aft 7
; 80* create 81 variable 82 constant 83 c@ 84 c! 85 c, 86 w@ 87 w! 88 w, 89
@ 90 ! 91 , 92 allot 93 +! 94 ? 95 exit 96 exec 97 does 98 to 99
is 100 [to] 101 here 102 ucase 103 words 104 ' 105 .s 106 see 107 dump 108 peek 109
poke 110 forget 111 clock 112 delay 113 pin 114 in 115 out 116 adc 117 duty 118 att
setup 120 tone 121 bye 122 boot 123 hello 124 bar 125 post 126 f 127 center 128 sid
triad1 130 triad2 131 triad3 132 triad4 133 quart 134 right 135 bigt 136 bigi 137 b
fig 140 width 141 asterisks 142 rectangle 143 parallelogram 144 triangle 145 the 14
summary 150 flaw 151 mummery 152 k 153 haze 154 phrase 155 bluff 156 stuff 157 (the
child 160 cybernatics 161 hiding 162 lay 163 based 164 saved 165 cloak 166 thick 16
make 170 pushed 171 without 172 rest 173 cloaked 174 THEORY 175 question 176 help 1
much 180 little 181 health 182 job 183 money 184 nt 185 $nt 186 rmb 187 $rmb 188 hk
$hk 190 gold 191 $gold 192 silver 193 $silver 194 ounce 195 dollars 196 f>c 197 c>f
onerow 200 multiply 201 julian 202 leap 203 year 204 first 205 stars 206 header 207
month 210 january 211 february 212 march 213 april 214 may 215 june 216 july 217 au
october 220 november 221 december 222 pi 223 10k 224 xs 225 km 226 (sin) 227 (cos)
cos_ 230 sin 231 cos 232 sqrt 233 octal 234 binary 235 character 236 line 237 table
random 240 choose 241 myNumber 242 yourNumber 243 limit 244 guess 245 greet 246 ppq
note 250 ppqn@ 251 1/4 252 1/2 253 1/8 254 3/4 255 3/8 256 c6 257 b5 258 a5# 259
b5b 260 a5 261 g5# 262 a5b 263 g5 264 f5# 265 g5b 266 f5 267 e5 268 d5# 269
e5b 270 d5 271 c5# 272 d5b 273 c5 274 b4 275 b4b 276 a4# 277 a4 278 g4# 279
a4b 280 g4 281 f4# 282 g4b 283 f4 284 e4 285 d4# 286 e4b 287 d4 288 c4# 289
d4b 290 c4 291 b3 292 a3# 293 b3b 294 a3 295 g3# 296 a3b 297 g3 298 f3# 299
g3b 300 f3 301 e3 302 d3# 303 e3b 304 d3 305 c3# 306 d3b 307 c3 308 b2 309
a2# 310 b2b 311 a2 312 g2# 313 a2b 314 g2 315 f2# 316 g2b 317 f2 318 e2 319
d2# 320 e2b 321 d2 322 c2# 323 d2b 324 c2 325 blow 326 ride 327 laser 328 warble 32
wvail 330 wail 331 bird 332 updown 333 tones 334 fore 335 back 336 left 337 right 3
led 340 p0 341 p0s 342 p0c 343 p1 344 pl# 345 plc 346 p0en 347 p0ens 348 p0enc 349
plen 350 plens 351 plenc 352 p0in 353 plin 354 4words 355 pp 356 ppp 357 emits 358
pdump 360 <-1> ok
```



# Web Page



The screenshot shows a web browser window with the address bar displaying "Not secure | 192.168.42.8". The page content is divided into two main sections. The left section contains a list of words, starting with "ESP32Forth v8words" and listing various terms like "dup", "drop", "swap", "pick", etc. The right section is a code editor with a dark background, containing four examples of code snippets for a Forth-like language. Each example is enclosed in a function call: "cr .( example 1. the universal greeting )", "cr .( example 2. the big f )", "cr .( example 3. fig, forth interest group )", and "cr .( example 4. repeated patterns )".

```
ESP32Forth v8words
dup 0 drop 1 over 2 swap 3 rot 4 pick 5 > r 6 r> 7 r@ 8 2dup 9
2drop 10 2over 11 2swap 12 + 13 * 14 - 15 / 16 mod 17 */ 18 /mod 19
*/mod 20 and 21 or 22 xor 23 abs 24 negate 25 max 26 min 27 2* 28 2/ 29
1+ 30 1- 31 0= 32 0< 33 0> 34 = 35 > 36 < 37 <> 38 >= 39
<= 40 base@ 41 base! 42 hex 43 decimal 44 cr 45 . 46 .r 47 u.r 48 .f 49
key 50 emit 51 space 52 spaces 53 dovar 54 dolit 55 dostr 56 dotstr 57 [ 58 ] 59
( 60* .( 61* \ 62 $" 63 ." 64* branch 65 Obranch 66 if 67* else 68* then 69*
begin 70* again 71* until 72* while 73* repeat 74* donext 75 for 76* next 77* aft 7
; 80* create 81 variable 82 constant 83 c@ 84 c! 85 c, 86 w@ 87 w! 88 w, 89
@ 90 ! 91 , 92 allot 93 +! 94 ? 95 exit 96 exec 97 does 98 to 99
is 100 [to] 101 here 102 ucase 103 words 104 ' 105 .s 106 see 107 dump 108 peek 109
poke 110 forget 111 clock 112 delay 113 pin 114 in 115 out 116 adc 117 duty 118 att
setup 120 tone 121 bye 122 boot 123 hello 124 bar 125 post 126 f 127 center 128 sid
triad1 130 triad2 131 triad3 132 triad4 133 quart 134 right 135 bigt 136 bigi 137 b
fig 140 width 141 asterisks 142 rectangle 143 parallelogram 144 triangle 145 the 14
summary 150 flaw 151 mummery 152 k 153 haze 154 phrase 155 bluff 156 stuff 157 (the
child 160 cybernatics 161 hiding 162 lay 163 based 164 saved 165 cloak 166 thick 16
make 170 pushed 171 without 172 rest 173 cloaked 174 THEORY 175 question 176 help 1
much 180 little 181 health 182 job 183 money 184 nt 185 $nt 186 rmb 187 $rmb 188 hk
$hk 190 gold 191 $gold 192 silver 193 $silver 194 ounce 195 dollars 196 f>c 197 c>f
onerow 200 multiply 201 julian 202 leap 203 year 204 first 205 stars 206 header 207
month 210 january 211 february 212 march 213 april 214 may 215 june 216 july 217 au
october 220 november 221 december 222 pi 223 10k 224 xs 225 kn 226 (sin) 227 (cos)
cos_ 230 sin 231 cos 232 sqrt 233 octal 234 binary 235 character 236 line 237 table
random 240 choose 241 myNumber 242 yourNumber 243 limit 244 guess 245 greet 246 ppg
note 250 ppgn@ 251 1/4 252 1/2 253 1/8 254 3/4 255 3/8 256 c 257 b 258 a 259
b5b 260 a5 261 g5# 262 a5b 263 g5 264 f5# 265 g5b 266 f5 267 e5 268 d5# 269
e5b 270 d5 271 c5# 272 d5b 273 c5 274 b4 275 b4b 276 a4# 277 a4 278 g4# 279
a4b 280 g4 281 f4# 282 g4b 283 f4 284 e4 285 d4# 286 e4b 287 d4 288 c4# 289
d4b 290 c4 291 b3 292 a3# 293 b3b 294 a3 295 g3# 296 a3b 297 g3 298 f3# 299
g3b 300 f3 301 e3 302 d3# 303 e3b 304 d3 305 c3# 306 d3b 307 c3 308 b2 309
a2# 310 b2b 311 a2 312 g2# 313 a2b 314 g2 315 f2# 316 g2b 317 f2 318 e2 319
d2# 320 e2b 321 d2 322 c2# 323 d2b 324 c2 325 blow 326 ride 327 laser 328 warble 32
vwall 330 wail 331 bird 332 updown 333 tones 334 fore 335 back 336 left 337 right 3
led 340 p0 341 p0s 342 p0c 343 p1 344 pl 345 p1c 346 p0en 347 p0ens 348 p0enc 349
plen 350 plens 351 plenc 352 p0in 353 plin 354 4words 355 pp 356 ppp 357 emits 358
pdump 360 <-> ok

cr .( example 1. the universal greeting )

decimal

: hello cr ." hello, world!" ;

cr .( example 2. the big f )

: bar cr ." *****" ;
: post cr ." * " ;
: f bar post bar post post ;

cr .( example 3. fig, forth interest group )

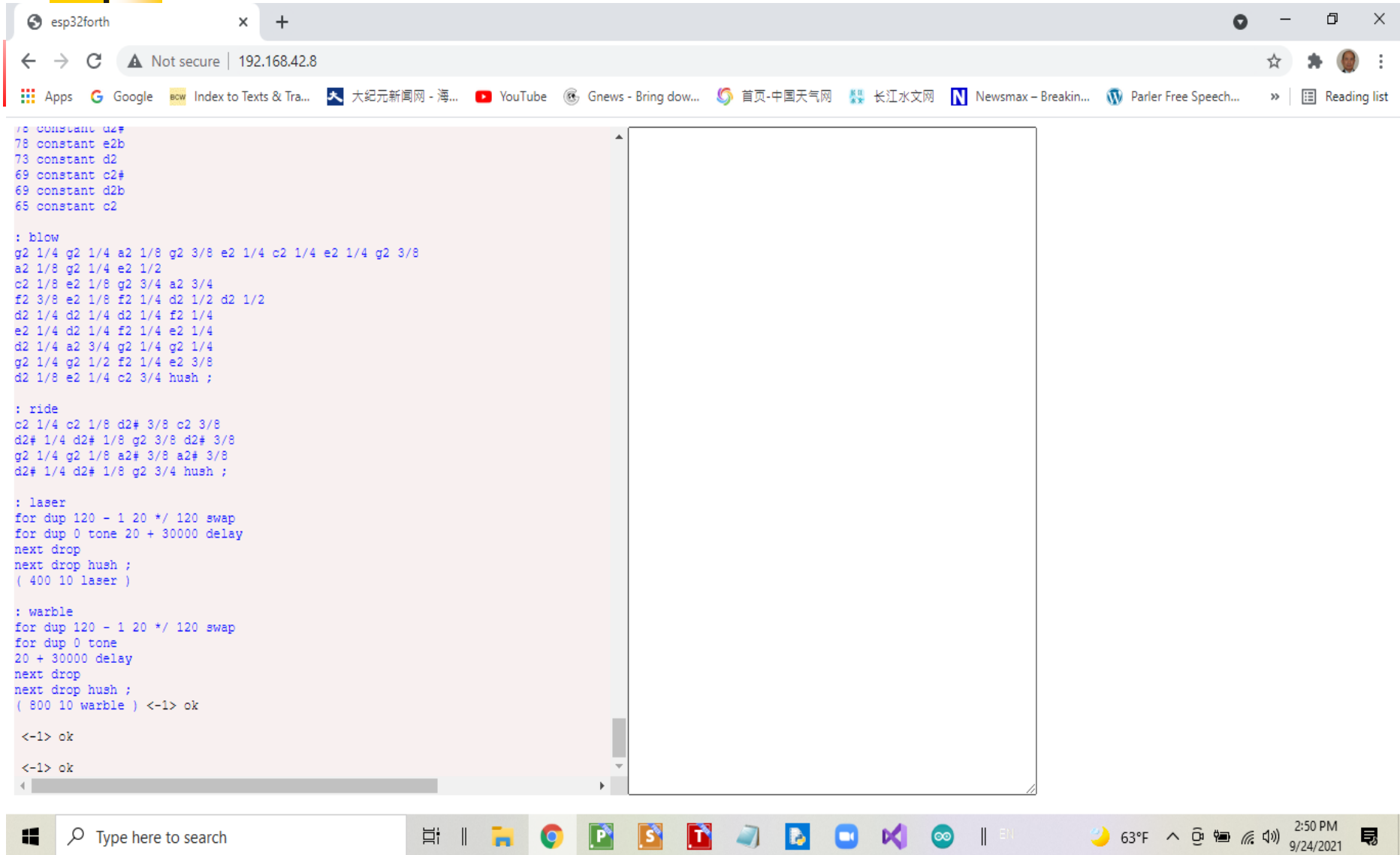
: center cr ." * " ;
: sides cr ." * * " ;
: triad1 cr ." * * * " ;
: triad2 cr ." * * * " ;
: triad3 cr ." * * * " ;
: triad4 cr ." * * * " ;
: quart cr ." * * * * " ;
: right cr ." * * * * " ;
: bigt bar center center center center center
center ;
: bigi center center center center center center
center ;
: bign sides triad2 triad2 triad1 triad3 triad2
sides ;
: bigg triad4 sides post right triad1 sides triad4
;

: fig f bigi bigg ;

cr .( example 4. repeated patterns )

variable width ( number of
asterisks to print )
```

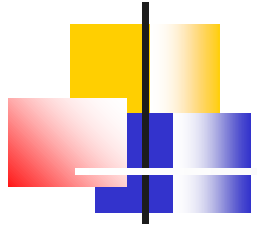
# Web Page



The screenshot shows a web browser window with the address bar displaying "Not secure | 192.168.42.8". The browser's address bar and tabs are visible at the top. The main content area displays a Forth interpreter interface with a text input field on the left and a large empty rectangular area on the right. The text in the input field is as follows:

```
76 constant d2#  
78 constant e2b  
73 constant d2  
69 constant c2#  
69 constant d2b  
65 constant c2  
  
: blow  
g2 1/4 g2 1/4 a2 1/8 g2 3/8 e2 1/4 c2 1/4 e2 1/4 g2 3/8  
a2 1/8 g2 1/4 e2 1/2  
c2 1/8 e2 1/8 g2 3/4 a2 3/4  
f2 3/8 e2 1/8 f2 1/4 d2 1/2 d2 1/2  
d2 1/4 d2 1/4 d2 1/4 f2 1/4  
e2 1/4 d2 1/4 f2 1/4 e2 1/4  
d2 1/4 a2 3/4 g2 1/4 g2 1/4  
g2 1/4 g2 1/2 f2 1/4 e2 3/8  
d2 1/8 e2 1/4 c2 3/4 hush ;  
  
: ride  
c2 1/4 c2 1/8 d2# 3/8 c2 3/8  
d2# 1/4 d2# 1/8 g2 3/8 d2# 3/8  
g2 1/4 g2 1/8 a2# 3/8 a2# 3/8  
d2# 1/4 d2# 1/8 g2 3/4 hush ;  
  
: laser  
for dup 120 - 1 20 */ 120 swap  
for dup 0 tone 20 + 30000 delay  
next drop  
next drop hush ;  
( 400 10 laser )  
  
: warble  
for dup 120 - 1 20 */ 120 swap  
for dup 0 tone  
20 + 30000 delay  
next drop  
next drop hush ;  
( 800 10 warble ) <-1> ok  
  
<-1> ok  
  
<-1> ok
```

The browser's taskbar at the bottom shows the Windows logo, a search bar with the text "Type here to search", and several application icons including File Explorer, Google Chrome, Microsoft Word, and others. The system tray on the right shows the date and time as "2:50 PM 9/24/2021" and the temperature as "63°F".



# Demo

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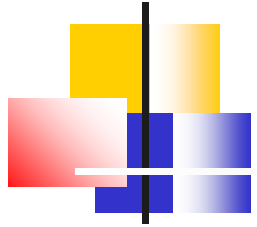
- **ESP32S Devkit**
- **Arduino IDE**
- **WiFi connection**
- **Motor drives**
- **LEDs**
- **Small speaker**
- **ADC**



# Conclusion

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- **ESP32S Devkit is by far the most powerful and the cheapest microcontroller kit.**
- **Esp32forth\_84 allows us to develop embedded or IoT applications very conveniently.**
- **It is the best system for firmware engineering.**



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**Thank You!**