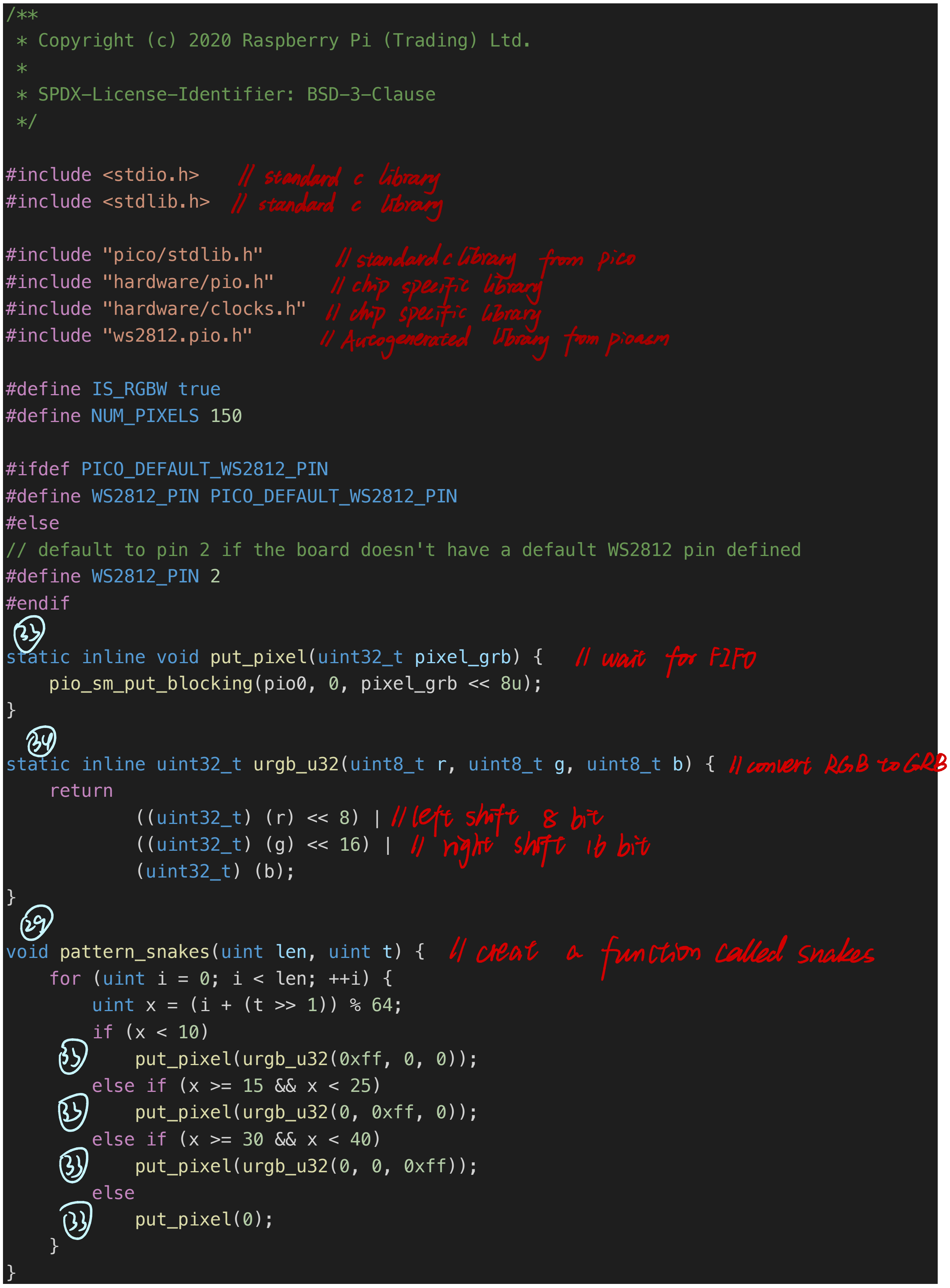
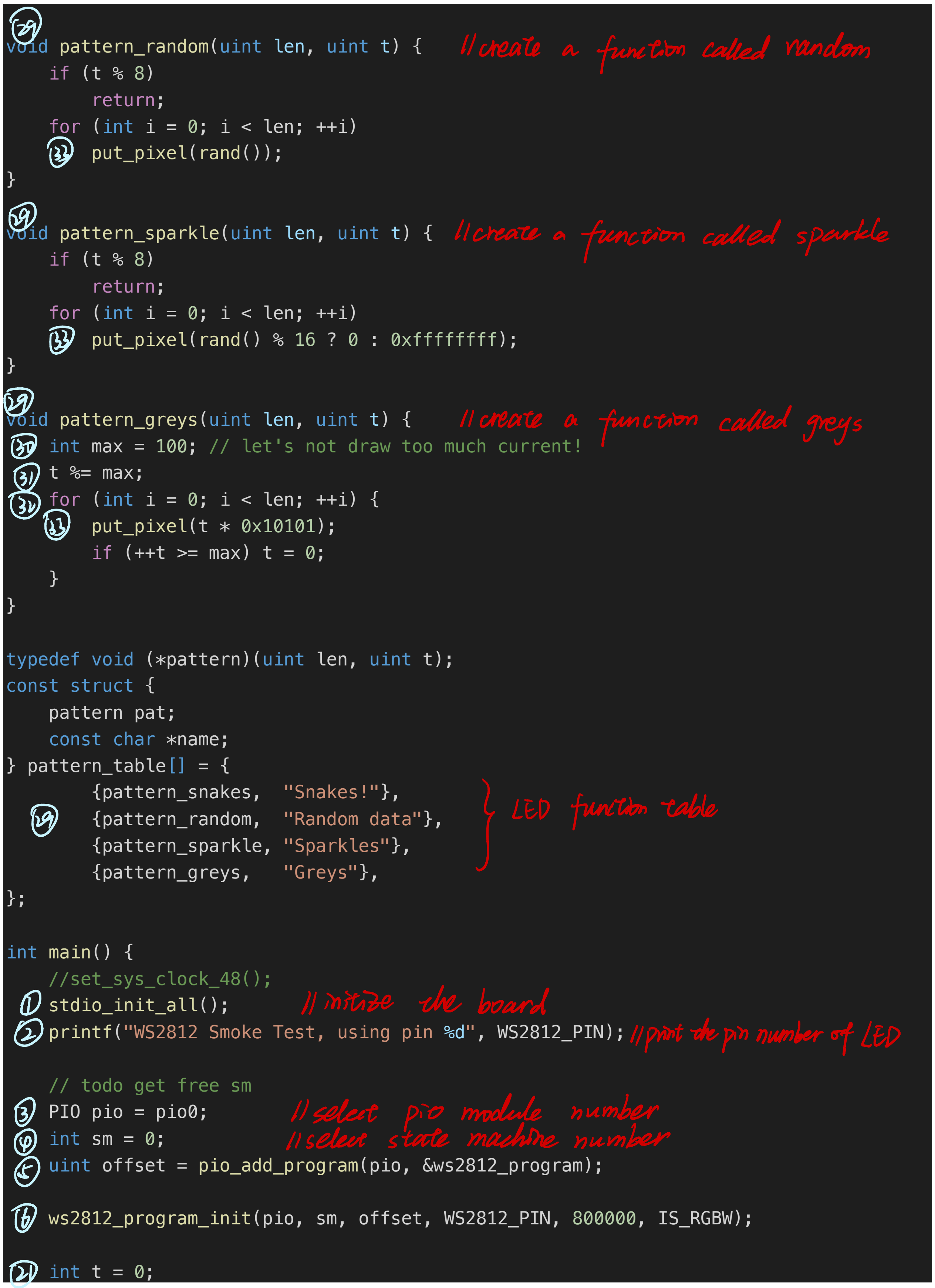
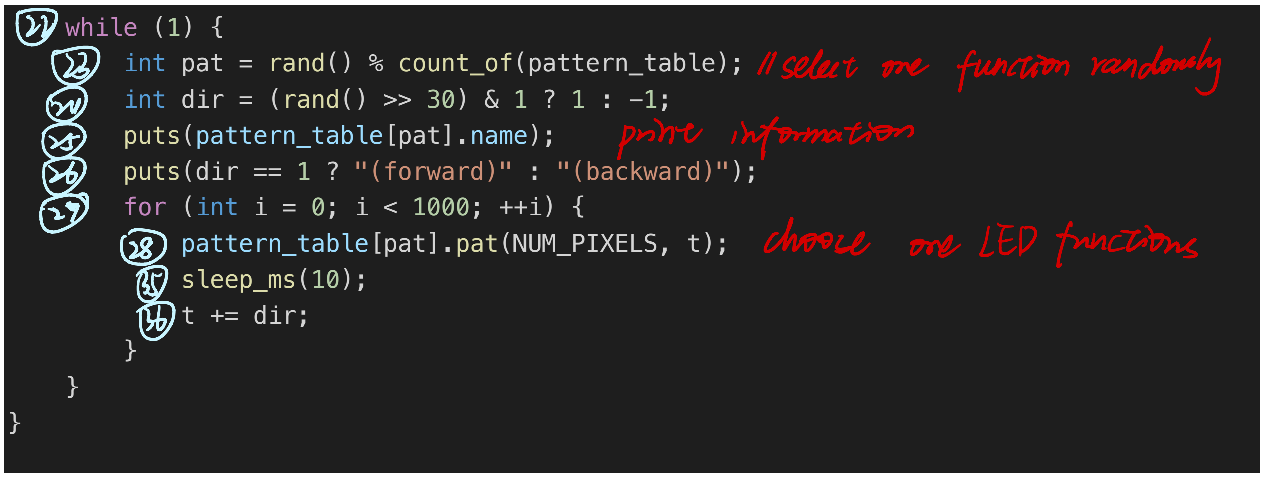


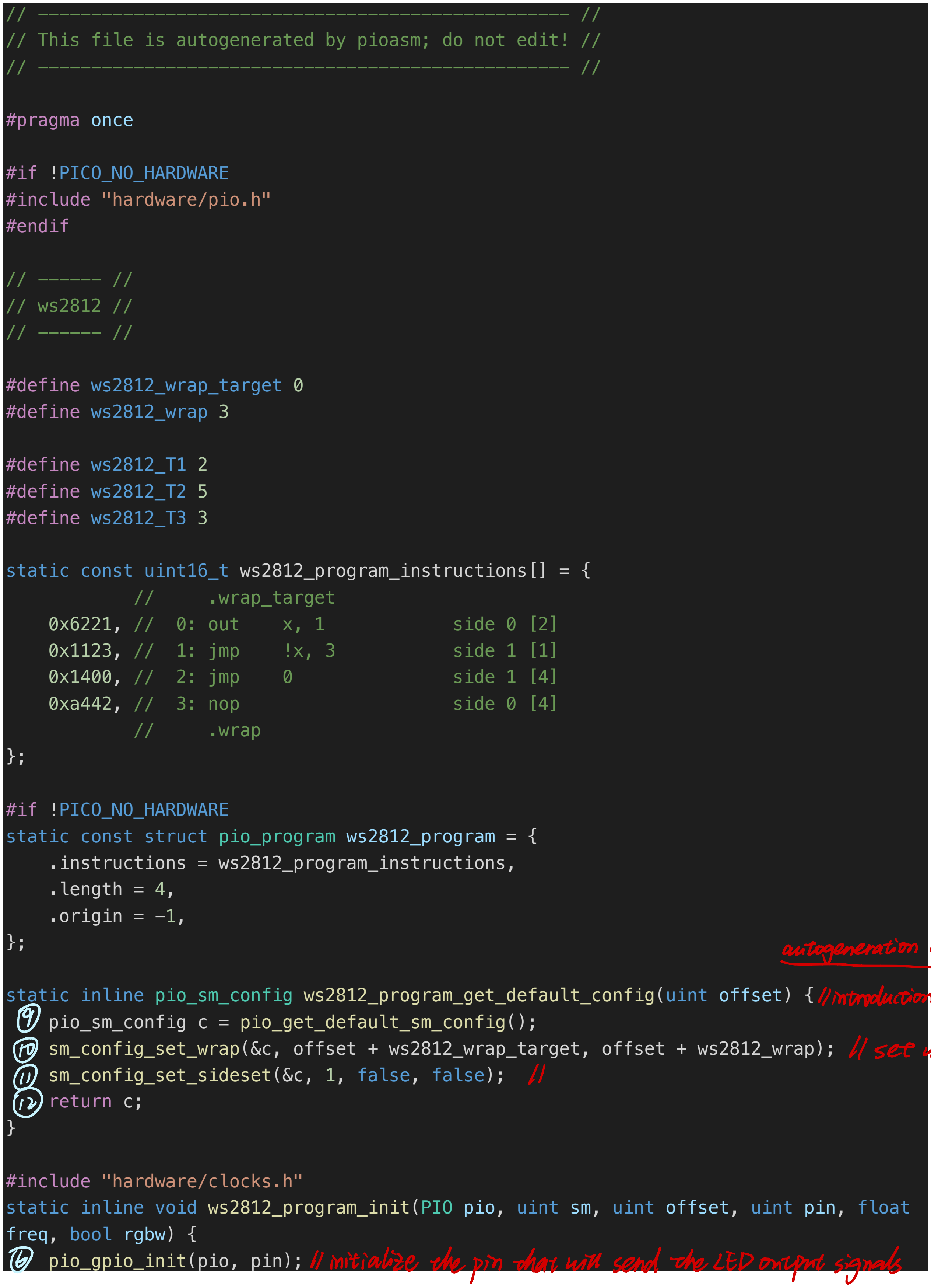
```c
/**
 * Copyright (c) 2020 Raspberry Pi (Trading) Ltd.
 *
 * SPDX-License-Identifier: BSD-3-Clause
 */

#include <stdio.h>    // standard c library
#include <stdlib.h>   // standard c library

#include "pico/stdlib.h"        // standard c library from pico
#include "hardware/pio.h"       // chip specific library
#include "hardware/clocks.h"    // chip specific library
#include "ws2812.pio.h"         // Autogenerated library from pioasm

#define IS_RGBW true
#define NUM_PIXELS 150

#ifdef PICO_DEFAULT_WS2812_PIN
#define WS2812_PIN PICO_DEFAULT_WS2812_PIN
#else
// default to pin 2 if the board doesn't have a default WS2812 pin defined
#define WS2812_PIN 2
#endif
33
static inline void put_pixel(uint32_t pixel_grb) {   // wait for FIFO
    pio_sm_put_blocking(pio0, 0, pixel_grb << 8u);
}
 34
static inline uint32_t urgb_u32(uint8_t r, uint8_t g, uint8_t b) { // convert RGB to GRB
    return
            ((uint32_t) (r) << 8) | // left shift 8 bit
            ((uint32_t) (g) << 16) |  // right shift 16 bit
            (uint32_t) (b);
}
 29
void pattern_snakes(uint len, uint t) {  // creat a function called snakes
    for (uint i = 0; i < len; ++i) {
        uint x = (i + (t >> 1)) % 64;
        if (x < 10)
     33     put_pixel(urgb_u32(0xff, 0, 0));
        else if (x >= 15 && x < 25)
     33     put_pixel(urgb_u32(0, 0xff, 0));
        else if (x >= 30 && x < 40)
     33     put_pixel(urgb_u32(0, 0, 0xff));
        else
     33     put_pixel(0);
    }
}
```



```
29
void pattern_random(uint len, uint t) {    //create a function called random
    if (t % 8)
        return;
    for (int i = 0; i < len; ++i)
32      put_pixel(rand());
}

29
void pattern_sparkle(uint len, uint t) {  //create a function called sparkle
    if (t % 8)
        return;
    for (int i = 0; i < len; ++i)
33      put_pixel(rand() % 16 ? 0 : 0xffffffff);
}

29
void pattern_greys(uint len, uint t) {    //create a function called greys
30  int max = 100; // let's not draw too much current!
31  t %= max;
32  for (int i = 0; i < len; ++i) {
33      put_pixel(t * 0x10101);
        if (++t >= max) t = 0;
    }
}

typedef void (*pattern)(uint len, uint t);
const struct {
    pattern pat;
    const char *name;
} pattern_table[] = {
        {pattern_snakes,  "Snakes!"},         } LED function table
  29    {pattern_random,  "Random data"},     }
        {pattern_sparkle, "Sparkles"},        }
        {pattern_greys,   "Greys"},           }
};

int main() {
    //set_sys_clock_48();
1   stdio_init_all();        //initize the board
2   printf("WS2812 Smoke Test, using pin %d", WS2812_PIN); //print the pin number of LED

    // todo get free sm
3   PIO pio = pio0;          //select pio module number
4   int sm = 0;              //select state machine number
5   uint offset = pio_add_program(pio, &ws2812_program);

6   ws2812_program_init(pio, sm, offset, WS2812_PIN, 800000, IS_RGBW);

21  int t = 0;
```



```
21 while (1) {
22     int pat = rand() % count_of(pattern_table); // select one function randomly
24     int dir = (rand() >> 30) & 1 ? 1 : -1;
25     puts(pattern_table[pat].name);       print information
26     puts(dir == 1 ? "(forward)" : "(backward)");
27     for (int i = 0; i < 1000; ++i) {
28         pattern_table[pat].pat(NUM_PIXELS, t);   choose one LED functions
35         sleep_ms(10);
36         t += dir;
        }
    }
}
```



```
// -------------------------------------------------- //
// This file is autogenerated by pioasm; do not edit! //
// -------------------------------------------------- //

#pragma once

#if !PICO_NO_HARDWARE
#include "hardware/pio.h"
#endif

// ------ //
// ws2812 //
// ------ //

#define ws2812_wrap_target 0
#define ws2812_wrap 3

#define ws2812_T1 2
#define ws2812_T2 5
#define ws2812_T3 3

static const uint16_t ws2812_program_instructions[] = {
            //     .wrap_target
    0x6221, //  0: out    x, 1            side 0 [2]
    0x1123, //  1: jmp    !x, 3           side 1 [1]
    0x1400, //  2: jmp    0               side 1 [4]
    0xa442, //  3: nop                    side 0 [4]
            //     .wrap
};

#if !PICO_NO_HARDWARE
static const struct pio_program ws2812_program = {
    .instructions = ws2812_program_instructions,
    .length = 4,
    .origin = -1,
};
                                                                    autogeneration of pioasm
static inline pio_sm_config ws2812_program_get_default_config(uint offset) { //introduction about the
 9  pio_sm_config c = pio_get_default_sm_config();
 10 sm_config_set_wrap(&c, offset + ws2812_wrap_target, offset + ws2812_wrap); // set wrap
 11 sm_config_set_sideset(&c, 1, false, false);  //
 12 return c;
}

#include "hardware/clocks.h"
static inline void ws2812_program_init(PIO pio, uint sm, uint offset, uint pin, float
freq, bool rgbw) {
 6  pio_gpio_init(pio, pin); // initialize the pin that will send the LED output signals
7  pio_sm_set_consecutive_pindirs(pio, sm, pin, 1, true);// set direction of state machine pin
8  pio_sm_config c = ws2812_program_get_default_config(offset); // get default configuration
13 sm_config_set_sideset_pins(&c, pin); // side set pins
14 sm_config_set_out_shift(&c, false, true, rgbw ? 32 : 24); // configure the output shift register
15 sm_config_set_fifo_join(&c, PIO_FIFO_JOIN_TX);      // manipulate the FIFOs
16 int cycles_per_bit = ws2812_T1 + ws2812_T2 + ws2812_T3;  // caculate cycles per bit
17 float div = clock_get_hz(clk_sys) / (freq * cycles_per_bit);   // slowing state machine
18 sm_config_set_clkdiv(&c, div);
19 pio_sm_init(pio, sm, offset, &c);
20 pio_sm_set_enabled(pio, sm, true);     // enable state machine
}

#endif

// --------------- //
// ws2812_parallel //
// --------------- //

#define ws2812_parallel_wrap_target 0
#define ws2812_parallel_wrap 3

#define ws2812_parallel_T1 2
#define ws2812_parallel_T2 5
#define ws2812_parallel_T3 3

static const uint16_t ws2812_parallel_program_instructions[] = {
            //     .wrap_target
    0x6020, //  0: out    x, 32
    0xa10b, //  1: mov    pins, !null            [1]
    0xa401, //  2: mov    pins, x                [4]
    0xa103, //  3: mov    pins, null             [1]
            //     .wrap
};

#if !PICO_NO_HARDWARE
static const struct pio_program ws2812_parallel_program = {
    .instructions = ws2812_parallel_program_instructions,
    .length = 4,
    .origin = -1,
};

static inline pio_sm_config ws2812_parallel_program_get_default_config(uint offset) {
    pio_sm_config c = pio_get_default_sm_config();
    sm_config_set_wrap(&c, offset + ws2812_parallel_wrap_target, offset +
ws2812_parallel_wrap);
    return c;
}
```

```c
#include "hardware/clocks.h"
static inline void ws2812_parallel_program_init(PIO pio, uint sm, uint offset, uint
pin_base, uint pin_count, float freq) {
    for(uint i=pin_base; i<pin_base+pin_count; i++) {
        pio_gpio_init(pio, i);
    }
    pio_sm_set_consecutive_pindirs(pio, sm, pin_base, pin_count, true);
    pio_sm_config c = ws2812_parallel_program_get_default_config(offset);
    sm_config_set_out_shift(&c, true, true, 32);
    sm_config_set_out_pins(&c, pin_base, pin_count);
    sm_config_set_set_pins(&c, pin_base, pin_count);
    sm_config_set_fifo_join(&c, PIO_FIFO_JOIN_TX);
    int cycles_per_bit = ws2812_parallel_T1 + ws2812_parallel_T2 + ws2812_parallel_T3;
    float div = clock_get_hz(clk_sys) / (freq * cycles_per_bit);
    sm_config_set_clkdiv(&c, div);
    pio_sm_init(pio, sm, offset, &c);
    pio_sm_set_enabled(pio, sm, true);
}

#endif
```