# Linux from Scratch

# Turing Completeness

*[If] somebody says "my new thing is Turing Complete" that means in principle (although often not in practice) it could be used to solve any computation problem.*

*If something is said to be Turing-complete [...] it can be used to simulate any Turing machine*

*The Turing machine mathematically models a machine that mechanically operates on a tape. On this tape are symbols, which the machine can read and write, one at a time, using a tape head.*

*Operation is fully determined by a finite set of [...] instructions such as "in state 42, if the symbol seen is 0, write a 1; if the symbol seen is 1, change into state 17; in state 17, if the symbol seen is 0, write a 1 and change to state 6;" etc. [...]*

# RISC-V

## ARM (Advanced RISC Machine)

## x86

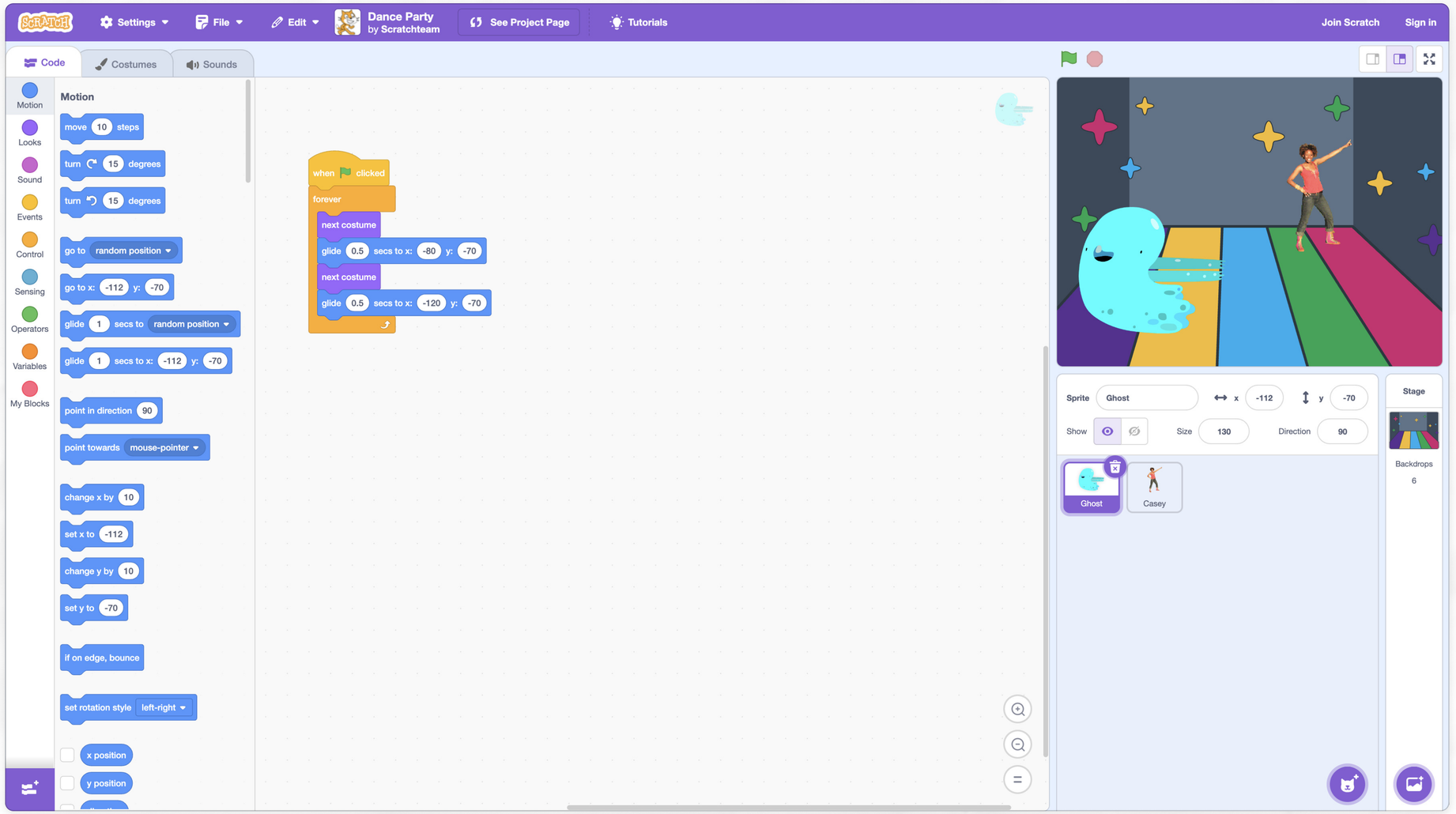
| Mnemonic, Operands | | Description | Cycles | 14-Bit Instruction Word | | | | Status Affected | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | MSb | | | LSb | | |
| **BYTE-ORIENTED FILE REGISTER OPERATIONS** | | | | | | | | | |
| ADDWF | f, d | Add W and f | 1 | 00 | 0111 | dfff | ffff | C,DC,Z | 1,2 |
| ANDWF | f, d | AND W with f | 1 | 00 | 0101 | dfff | ffff | Z | 1,2 |
| CLRF | f | Clear f | 1 | 00 | 0001 | lfff | ffff | Z | 2 |
| CLRW | - | Clear W | 1 | 00 | 0001 | 0xxx | xxxx | Z | |
| COMF | f, d | Complement f | 1 | 00 | 1001 | dfff | ffff | Z | 1,2 |
| DECF | f, d | Decrement f | 1 | 00 | 0011 | dfff | ffff | Z | 1,2 |
| DECFSZ | f, d | Decrement f, Skip if 0 | 1(2) | 00 | 1011 | dfff | ffff | | 1,2,3 |
| INCF | f, d | Increment f | 1 | 00 | 1010 | dfff | ffff | Z | 1,2 |
| INCFSZ | f, d | Increment f, Skip if 0 | 1(2) | 00 | 1111 | dfff | ffff | | 1,2,3 |
| IORWF | f, d | Inclusive OR W with f | 1 | 00 | 0100 | dfff | ffff | Z | 1,2 |
| MOVF | f, d | Move f | 1 | 00 | 1000 | dfff | ffff | Z | 1,2 |
| MOVWF | f | Move W to f | 1 | 00 | 0000 | lfff | ffff | | |
| NOP | - | No Operation | 1 | 00 | 0000 | 0xx0 | 0000 | | |
| RLF | f, d | Rotate Left f through Carry | 1 | 00 | 1101 | dfff | ffff | C | 1,2 |
| RRF | f, d | Rotate Right f through Carry | 1 | 00 | 1100 | dfff | ffff | C | 1,2 |
| SUBWF | f, d | Subtract W from f | 1 | 00 | 0010 | dfff | ffff | C,DC,Z | 1,2 |
| SWAPF | f, d | Swap nibbles in f | 1 | 00 | 1110 | dfff | ffff | | 1,2 |
| XORWF | f, d | Exclusive OR W with f | 1 | 00 | 0110 | dfff | ffff | Z | 1,2 |
| **BIT-ORIENTED FILE REGISTER OPERATIONS** | | | | | | | | | |
| BCF | f, b | Bit Clear f | 1 | 01 | 00bb | bfff | ffff | | 1,2 |
| BSF | f, b | Bit Set f | 1 | 01 | 01bb | bfff | ffff | | 1,2 |
| BTFSC | f, b | Bit Test f, Skip if Clear | 1 (2) | 01 | 10bb | bfff | ffff | | 3 |
| BTFSS | f, b | Bit Test f, Skip if Set | 1 (2) | 01 | 11bb | bfff | ffff | | 3 |
| **LITERAL AND CONTROL OPERATIONS** | | | | | | | | | |
| ADDLW | k | Add literal and W | 1 | 11 | 111x | kkkk | kkkk | C,DC,Z | |
| ANDLW | k | AND literal with W | 1 | 11 | 1001 | kkkk | kkkk | Z | |
| CALL | k | Call subroutine | 2 | 10 | 0kkk | kkkk | kkkk | | |
| CLRWDT | - | Clear Watchdog Timer | 1 | 00 | 0000 | 0110 | 0100 | $\overline{TO}$,$\overline{PD}$ | |
| GOTO | k | Go to address | 2 | 10 | 1kkk | kkkk | kkkk | | |
| IORLW | k | Inclusive OR literal with W | 1 | 11 | 1000 | kkkk | kkkk | Z | |
| MOVLW | k | Move literal to W | 1 | 11 | 00xx | kkkk | kkkk | | |
| RETFIE | - | Return from interrupt | 2 | 00 | 0000 | 0000 | 1001 | | |
| RETLW | k | Return with literal in W | 2 | 11 | 01xx | kkkk | kkkk | | |
| RETURN | - | Return from Subroutine | 2 | 00 | 0000 | 0000 | 1000 | | |
| SLEEP | - | Go into standby mode | 1 | 00 | 0000 | 0110 | 0011 | $\overline{TO}$,$\overline{PD}$ | |
| SUBLW | k | Subtract W from literal | 1 | 11 | 110x | kkkk | kkkk | C,DC,Z | |
| XORLW | k | Exclusive OR literal with W | 1 | 11 | 1010 | kkkk | kkkk | Z | |

| Mnemonic, Operands | | Description | Cycles | 14-Bit Instruction Word | | | | Status Affected | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | MSb | | | LSb | | |
| **BYTE-ORIENTED FILE REGISTER OPERATIONS** | | | | | | | | | |
| ADDWF | f, d | Add W and f | 1 | 00 | 0111 | dfff | ffff | C,DC,Z | 1,2 |
| ANDWF | f, d | AND W with f | 1 | 00 | 0101 | dfff | ffff | Z | 1,2 |
| CLRF | f | Clear f | 1 | 00 | 0001 | lfff | ffff | Z | 2 |
| CLRW | - | Clear W | 1 | 00 | 0001 | 0xxx | xxxx | Z | |
| COMF | f, d | Complement f | 1 | 00 | 1001 | dfff | ffff | Z | 1,2 |
| DECF | f, d | Decrement f | 1 | 00 | 0011 | dfff | ffff | Z | 1,2 |
| DECFSZ | f, d | Decrement f, Skip if 0 | 1(2) | 00 | 1011 | dfff | ffff | | 1,2,3 |
| INCF | f, d | Increment f | 1 | 00 | 1010 | dfff | ffff | Z | 1,2 |
| INCFSZ | f, d | Increment f, Skip if 0 | 1(2) | 00 | 1111 | dfff | ffff | | 1,2,3 |
| IORWF | f, d | Inclusive OR W with f | 1 | 00 | 0100 | dfff | ffff | Z | 1,2 |
| MOVF | f, d | Move f | 1 | 00 | 1000 | dfff | ffff | Z | 1,2 |
| MOVWF | f | Move W to f | 1 | 00 | 0000 | lfff | ffff | | |
| NOP | - | No Operation | 1 | 00 | 0000 | 0xx0 | 0000 | | |
| RLF | f, d | Rotate Left f through Carry | 1 | 00 | 1101 | dfff | ffff | C | 1,2 |
| RRF | f, d | Rotate Right f through Carry | 1 | 00 | 1100 | dfff | ffff | C | 1,2 |
| SUBWF | f, d | Subtract W from f | 1 | 00 | 0010 | dfff | ffff | C,DC,Z | 1,2 |
| SWAPF | f, d | Swap nibbles in f | 1 | 00 | 1110 | dfff | ffff | | 1,2 |
| XORWF | f, d | Exclusive OR W with f | 1 | 00 | 0110 | dfff | ffff | Z | 1,2 |
| **BIT-ORIENTED FILE REGISTER OPERATIONS** | | | | | | | | | |
| BCF | f, b | Bit Clear f | 1 | 01 | 00bb | bfff | ffff | | 1,2 |
| BSF | f, b | Bit Set f | 1 | 01 | 01bb | bfff | ffff | | 1,2 |
| BTFSC | f, b | Bit Test f, Skip if Clear | 1 (2) | 01 | 10bb | bfff | ffff | | 3 |
| BTFSS | f, b | Bit Test f, Skip if Set | 1 (2) | 01 | 11bb | bfff | ffff | | 3 |
| **LITERAL AND CONTROL OPERATIONS** | | | | | | | | | |
| ADDLW | k | Add literal and W | 1 | 11 | 111x | kkkk | kkkk | C,DC,Z | |
| ANDLW | k | AND literal with W | 1 | 11 | 1001 | kkkk | kkkk | Z | |
| CALL | k | Call subroutine | 2 | 10 | 0kkk | kkkk | kkkk | | |
| CLRWDT | - | Clear Watchdog Timer | 1 | 00 | 0000 | 0110 | 0100 | $\overline{TO}$,$\overline{PD}$ | |
| GOTO | k | Go to address | 2 | 10 | 1kkk | kkkk | kkkk | | |
| IORLW | k | Inclusive OR literal with W | 1 | 11 | 1000 | kkkk | kkkk | Z | |
| MOVLW | k | Move literal to W | 1 | 11 | 00xx | kkkk | kkkk | | |
| RETFIE | - | Return from interrupt | 2 | 00 | 0000 | 0000 | 1001 | | |
| RETLW | k | Return with literal in W | 2 | 11 | 01xx | kkkk | kkkk | | |
| RETURN | - | Return from Subroutine | 2 | 00 | 0000 | 0000 | 1000 | | |
| SLEEP | - | Go into standby mode | 1 | 00 | 0000 | 0110 | 0011 | $\overline{TO}$,$\overline{PD}$ | |
| SUBLW | k | Subtract W from literal | 1 | 11 | 110x | kkkk | kkkk | C,DC,Z | |
| XORLW | k | Exclusive OR literal with W | 1 | 11 | 1010 | kkkk | kkkk | Z | |

| Register name | Symbolic name | Description | Saved by |
|---|---|---|---|
| **32 integer registers** | | | |
| x0 | zero | Always zero | |
| x1 | ra | Return address | Caller |
| x2 | sp | Stack pointer | Callee |
| x3 | gp | Global pointer | |
| x4 | tp | Thread pointer | |
| x5 | t0 | Temporary / alternate return address | Caller |
| x6–7 | t1–2 | Temporaries | Caller |
| x8 | s0/fp | Saved register / frame pointer | Callee |
| x9 | s1 | Saved register | Callee |
| x10–11 | a0–1 | Function arguments / return values | Caller |
| x12–17 | a2–7 | Function arguments | Caller |
| x18–27 | s2–11 | Saved registers | Callee |
| x28–31 | t3–6 | Temporaries | Caller |
| **32 floating-point extension registers** | | | |
| f0–7 | ft0–7 | Floating-point temporaries | Caller |
| f8–9 | fs0–1 | Floating-point saved registers | Callee |
| f10–11 | fa0–1 | Floating-point arguments/return values | Caller |
| f12–17 | fa2–7 | Floating-point arguments | Caller |
| f18–27 | fs2–11 | Floating-point saved registers | Callee |
| f28–31 | ft8–11 | Floating-point temporaries | Caller |

# What is Turing Complete?

# Scratch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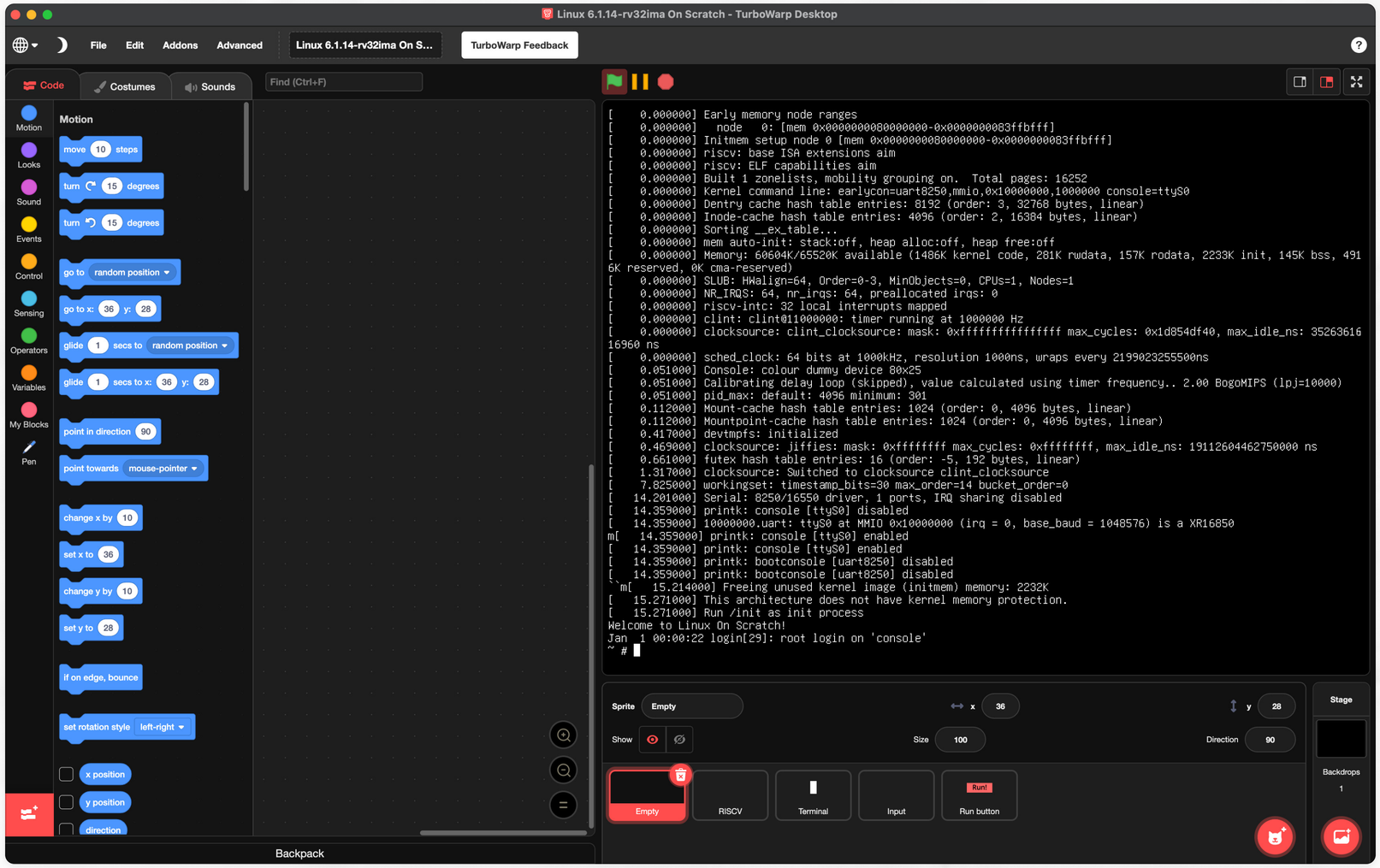
Events
Control
Sensing
Operators
Variables
My Blocks
Motion
move 10 steps
turn 15 degrees
turn 15 degrees
go to random position
go to x: -112 y: -70
glide 1 secs to random position
glide 1 secs to x: -112 y: -70
point in direction 90
point towards mouse-pointer
change x by 10
set x to -112
change y by 10
set y to -70
if on edge, bounce
set rotation style left-right
x position
y position
when clicked
forever
next costume
glide 0.5 secs to x: -80 y: -70
next costume
glide 0.5 secs to x: -120 y: -70
Sprite
Ghost
x
-112
y
-70
Show
Size
130
Direction
90
Ghost
Casey
Stage
Backdrops
6

# Linux in Scratch



# References & sources


⓪ https://stackoverflow.com/questions/7284/what-is-turing-complete

① https://en.wikipedia.org/wiki/Turing_completeness

② https://en.wikipedia.org/wiki/Turing_machine

③ https://ww1.microchip.com/downloads/en/DeviceDoc/31029a.pdf

④ https://en.wikipedia.org/wiki/RISC-V

⑤ https://scratch.mit.edu/projects/10128067/editor/

⑥ https://experiments.turbowarp.org/next/892602496

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