

The Kinetrix Programming Language

Version 3.1: Enterprise Ecosystem & Multi-Target Release

Kinetrix is a modern, domain-specific programming language engineered for robotics, embedded systems, and IoT devices. It combines the readability of plain-English instructions with the raw execution speed of compiled C++, making it the ultimate tool for both beginners building their first robot and enterprise teams managing swarms of autonomous agents.

1. Why Kinetrix? (Versus the Alternatives)

When building robots and embedded devices, developers typically have to choose between **Simplicity** and **Performance**. Kinetrix provides both.

Feature	Kinetrix	C / C++	MicroPython / Python	Block Languages (Scratch)
Readability	High (Plain English)	Low (Boilerplate heavy)	Medium/High	High (Visual)
Execution Speed	Native (Fast)	Native (Fast)	Interpreted (Slow)	Interpreted (Slow)
Memory Footprint	Minimal (KB)	Minimal (KB)	Large (MB)	Large
Ecosystem	Built-in Package Manager (kpm)	Fragmented (CMake, Make)	pip / upip	Closed ecosystems
Multi-Hardware	Yes (5+ architectures)	Manual porting required	Firmware dependent	Very limited

The Kinetrix Advantage

1. **Zero-Overhead Compilation:** Kinetrix doesn't run an interpreter on your Arduino or ESP32. Our compiler translates your plain-English logic into highly optimized C++ code before it touches the hardware. You get Python-like readability with 100x the speed of MicroPython and zero Garbage Collection (GC) pauses—essential for real-time motor control.
2. **Write Once, Deploy Anywhere:** The Phase 3 abstracted backend allows the exact same Kinetrix .kx script to compile to an Arduino Uno, an ESP32, a Raspberry Pi, a Pico, or a full ROS2 Node.

3. **Enterprise Pipeline:** With the integrated Kinetrix Package Manager (**kpm**) and Over-The-Air (OTA) deployment system, managing a swarm of robots is as easy as pushing code to a web server.
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2. Performance Measures

- **Compilation Speed:** The compiler is written in pure C and processes Kinetrix code at >100,000 lines per second.
 - **Runtime Execution (Microcontrollers):** 0(1) translation to C++. A turn on pin 13 instruction maps directly to a single `digitalWrite(13, HIGH)` hardware call or direct register manipulation.
 - **Firmware Size:** Because Kinetrix generates bare-metal C++, a simple robot program takes under 2 KB of flash memory, compared to >1 MB required just to boot the MicroPython interpreter.
 - **Real-Time Determinism:** Since Kinetrix has no garbage collector, execution timing is perfectly deterministic, allowing for precise microsecond-level pulsing required for servo motors and stepper drives.
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3. How to Use Kinetrix

The CLI Compiler (**kcc**)

Write your code in a `.kx` file and use the compiler to target your specific hardware:

```
# Compile for Arduino (Default)
./kcc robot.kx -o output.ino

# Compile for ESP32
./kcc robot.kx --target esp32 -o robot.cpp

# Compile for Raspberry Pi (generates Python with RPi.GPIO)
./kcc robot.kx --target rpi -o robot.py

# Compile for Raspberry Pi Pico (generates MicroPython)
./kcc robot.kx --target pico -o robot_pico.py

# Compile for ROS2 (generates an rclcpp Node)
./kcc robot.kx --target ros2 -o robot_node.cpp
```

The Package Manager (**kpm**)

Manage libraries and shared robot behaviors.

```
# Initialize a new project
kpm init

# Install a third-party behavior package
kpm install line_follower

# Publish your code to the cloud registry
kpm publish
```

4. Complete Language Feature Guide

4.1. Core Structure

Every Kinetrix program is wrapped in a `program { ... }` block.

```
program {
    # Your code goes here
}
```

*(Note: Functions and **extern** bindings can be declared at the top-level outside the program block).*

4.2. Variables and Math

Variables use `make var` and support complex expressions.

```
make var speed = 100
make var offset = 20
make var target = (speed * 2) + offset / 5
```

```
set speed to 150          # Re-assign a variable
change target by 0 - 10    # Decrement target by 10 (target -= 10)
```

4.3. Hardware I/O (Pins & Sensors)

Kinetrix is aware of hardware natively.

Digital / Analog Write:

```
turn on pin 13            # digitalWrite(13, HIGH)
turn off pin 13           # digitalWrite(13, LOW)
set pin 9 to 128          # analogWrite(9, 128) - Generates PWM signal
```

Digital / Analog Read:

```
make var button = read pin 2
make var sensor = read analog pin A0
```

4.4. Control Flow (Conditions)

Standard boolean logic using English operators (**and**, **or**, **not**).

```
if sensor > 500 and button == 1 {
    turn on pin 13
} else if sensor < 100 {
    turn off pin 13
} else {
    set pin 9 to sensor
}
```

Supported Operators: ==, !=, <, >, <=, >=, and, or, not

4.5. Loops

Kinetrix provides 4 types of loops for different robotic behaviors.

1. The Infinite Loop (Standard for microcontroller main loops)

```
loop forever {
    print "Running..."
}
```

2. The Repeat Loop (Execute N times)

```
repeat 5 {
    turn on pin 13
    wait 1000
    turn off pin 13
    wait 1000
}
```

3. The For Loop (Iterate a variable)

```
for i from 0 to 255 {
    set pin 9 to i
    wait 10
}
```

4. The While Loop

```
while sensor < 1000 {
    change sensor by 10
}
```

*(Use **break** to exit any loop early).*

4.6. Timing and Delay

```
wait 1000          # Wait 1000 milliseconds (1 second)
wait_us 500        # Wait 500 microseconds (used for precise sensor pinging)
```

4.7. Functions

Define custom, reusable behaviors.

```
def calculate_speed(distance, time) {
  if time == 0 { return 0 }
  return distance / time
}

program {
  make var spd = calculate_speed(100, 5)
  print spd
}
```

4.8. Standard Library (Built-in Math)

Kinetrix comes with built-in mapping and trigonometric functions that compile optimally.

```
make var mapped = map(sensor, 0, 1023, 0, 255)
make var clamped = constrain(speed, 0, 100)
make var rand_val = random(0, 10)
make var dist = abs(0 - 50)
```

```
# Trigonometry
make var angle = sin(1.57)
```

4.9. Enterprise Foreign Function Interface (FFI)

Call highly optimized native C++ libraries (or Python implementations depending on your target) directly from Kinetrix without rewriting them.

```
# Declare the external function binding
extern "C++" def fast_fourier_transform(signal)

program {
  make var data = read analog pin A0

  # Kinetrix automatically emits the native C++ call to the compiled library
  make var frequency = fast_fourier_transform(data)
  print frequency
}
```

Conclusion

With **Kinetrix V3.1**, you no longer have to compromise. You get the developer velocity and low barrier-to-entry of an educational language, backed by the

industrial performance of a multi-target, zero-overhead C++ compiler, wrapped in a scalable cloud ecosystem.