The Kinetrix Programming Language

Version 2.0: 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.

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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):** `O(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
```

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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 V2.0**u 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.