### MicroPython: REPLs everywhere

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 $h = 1_{1}(x_{1}, x_{1}) = (y_{1}(x_{1}, x_{1})) = y_{1}(x_{1}, x_{1})$   $h = y_{1}(x_{1}, x_{1}) = y_{1}(x_{1}, x_{1}) = y_{1}(x_{1}, x_{1})$   $h = y_{1}(x_{1}, x_{1}) = x_{1}(x_{1}, x_{1}) = y_{1}(x_{1}, x_{1})$  $h = hB_{1}(B_{1}(x_{1}) = B_{1}(x_{1}) = hB_{1}(B_{1}(x_{1}) = hB_{1}(B_{1}(x_{1})) = hB_{1}(x_{1}) = hB_{$ 

 $mr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

× B =  $\mu J$  + 1/ $c^2 \partial E / \partial t$  F =  $q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

$$\begin{split} & p_{1}^{(2)} = (p_{1}^{(2)} + p_{2}^{(2)} + p_{2}^{($$



$$\begin{split} & \mathcal{O}^{2}(d) \ll 1 \left[ \Gamma_{\mu\nu\rho} = 1 \left[ 2\beta_{\mu\nu\rho} + \beta_{\mu\nu\rho} - \gamma_{\mu\nu\rho} \right] \right] dv^{\mu}/dv + \Gamma_{\mu\nu}^{\mu} v^{\nu} = 0 \left[ R_{\mu\rho}^{\mu} = \Gamma_{\mu\rho}^{\mu} + \Gamma_{\mu\rho}^{\mu} \Gamma_{\mu\rho}^{\mu} + \Gamma_{\mu}^{\mu} \Gamma_{\mu}^{\mu} - \Gamma_{\mu\rho}^{\mu} \Gamma_{\mu}^{\mu} = R_{\mu\nu}^{\mu} - 1/2 q_{\mu\mu} R = 0 \right] \\ & \mathcal{O}(1)^{-1} - 1/\gamma_{1} \left[ d^{-1} d^{-1}$$

### Part I: Shrinking Python down to run on a microcontroller

× B =  $\mu J$  + 1/ $c^2 \partial E / \partial t$  F =  $q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

 $(2m + V | H|_{h}) = E|_{h}) | U = e^{HU/h} \mathbf{F} = ma \mathbf{F} = GA(mx/r^{\frac{1}{2}} \nabla \cdot \mathbf{E} = \rho/e \nabla \cdot \mathbf{B} = 0 \nabla \cdot \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\mathbf{F} = \mathbf{E} + \mathbf$ 

$$\begin{split} & \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -0 \ B/0 \ \nabla \times \mathbf{B} = \mu J + 1/\delta \ B/0 \ \mathbf{F} = q \ (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2 \mathbf{a} \nabla^2 \mathbf{q} \\ )/(1 - uv/c^2) \ \mu = \gamma uv \mathbf{E} = \gamma uv \mathbf{e}^2 \ E^2 = p^2 \mathbf{e}^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \delta A_i, \\ (j_\mu, \sigma, + g_{\mu\nu,\nu} - g_{\sigma',\mu'}) \ d^\mu / d\mathbf{a} + \Gamma^\mu_{\sigma'} v^{\nu'\sigma} = 0 \ B^\mu_{\mu\rho} = \Gamma^\mu_{\sigma,\mu} - \Gamma^\mu_{\sigma,\mu} + \Gamma^\mu_{\sigma'} \mathbf{e}^\mu_{\sigma'} \\ a - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ f \ \Psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x, t$$

$$\begin{split} & \stackrel{\mu}{}_{\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \\ & \stackrel{\rho}{}_{\rho,\sigma} = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \geq \hbar/2 p_i = -i\hbar \partial_i E = i\hbar \partial/\partial t H = p^2/2m + V . \end{split}$$

# Motivation for MicroPython

Electronics circuits now pack an enormous amount of functionality in a tiny package.

Need a way to control all these sophisticated devices. 
$$\begin{split} & \psi(x)(x,t) = E\psi(x,t) + e^{-x}(x-x)t + e^{-x}(t-x)t^{2} \\ & \psi(x) = R_{\mu\nu}(x)_{\mu\nu} + R_{\mu\nu}(x)_{\mu\nu} = R_{\mu\nu}^{\mu\nu} - R_{\mu\nu}^{\mu$$



 $+ V H|_{a}) = E|_{a}) U = e^{Ht/i\hbar} F = maF = GMmr/r^{3} \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $\Delta \nu \approx -\partial \mathbf{B} / \partial t$   $= \gamma m \nu$   $g_{\nu \sigma, \mu}$   $= 0 \delta = -im \nabla^2 \psi$   $/c \partial A_{i,j}$   $+ \Gamma^{\alpha}_{\nu \sigma}$   $t) = |\psi$   $\gamma (t - \psi)$ 

 $\gamma(t - v) = 1/2e^{\mu t}$ v R = 0

Scripting languages enable rapid development. Is it possible to put Python on a microcontroller?

 $\mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \rho \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar$ 

Why is it hard?

 Very little memory (RAM, ROM) on a microcontroller.



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MicroPython

 $u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \int \psi^* \psi dx = 1 P(x,t) = |\psi(x,t)|^2 \psi(x,t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \geq \hbar/2 \ p_i = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \langle x, t \rangle = |\psi(x,t)|^2 \langle \psi | x \rangle = 0$ 

 $\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = aJ + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = a(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - h^2/2m\nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \alpha(\mathbf{x} - \mathbf{y}t) \mathbf{t}' = \alpha(t - \mathbf{y}) \mathbf{x}' + \alpha($ 

# Why Python?

- High-level language with powerful features (classes, list comprehension, generators, exceptions, ...).
- Large existing community.
- Very easy to learn, powerful for advanced users: shallow but long learning curve.
- Ideal for microcontrollers: native bitwise operations, procedural code, distinction between int and float, robust exceptions.
- Lots of opportunities for optimisation (this may sound surprising, but Python is compiled).

$$\begin{split} & S_{2}(h_{1}^{-1}h_{2$$

 $F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $\mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

# Why can't we use CPython? (or PyPy?)

Integer operations:

Integer object (max 30 bits): 4 words (16 bytes) Preallocates 257+5=262 ints  $\longrightarrow$  4k RAM! Could ROM them, but that's still 4k ROM. And each integer outside the preallocated ones would be another 16 bytes.

Method calls:

led.on(): creates a bound-method object, 5 words (20 bytes) led.intensity(1000)  $\longrightarrow$  36 bytes RAM!

For loops: require heap to allocate a range iterator.

 $+ 1/\epsilon^2 \partial \mathbb{E}/\partial t = a \left(\mathbb{E} + \mathbf{y} \times \mathbb{B}\right) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}^t = \gamma(\mathbf{x} - \mathbf{y}t) \mathbf{t}^t = \gamma(\mathbf{x} - \mathbf{y}t)$ 

 $\nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $\mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

### It's all about the RAM

If you ask me 'why is it done that way?', I will most likely answer: 'to minimise RAM usage'.

- Interned strings, most already in ROM.
- Small integers stuffed in a pointer.
- Optimised method calls (thanks PyPy!).
- Range object is optimised (if possible).
- Python stack frames live on the C stack.
- ROM absolutely everything that can be ROMed!
- Exceptions implemented with custom setjmp/longjmp.

 $\begin{aligned} & (x = b) \left( t = b \right) \left( -x = b \right) \left( -x = -L = L_0 \right) (-x = \gamma 7_0 u' = (u - v) (1 - uv) (^2) y = \gamma mv E = \gamma m^2 E^2 = p^2 e^2 + m^2 e^4 g_0 H = 0 E_1 = -1/c \partial A_1 \\ & (x = b^2 - b^2 - a^2 - b^2 - b^2$ 

 $7Mmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $\mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

 $2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2d\theta^2 - r^2\sin^2\theta d\phi^2 \Delta \nu \approx F - m_{\rm a}F - GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $g_{\mu\nu}(dx^{\mu}/dr)(dx^{\nu}/dr) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $\approx \nu_i GM(1/r_i - 1/r_f) \ d^2u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = -\partial B/\partial t \ \nabla \times B = uJ + 1/c^2 \partial E/\partial t \ \mathbf{F} = g(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 g$ 

 $E = \gamma m c^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$ 

 $F = maF = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\partial B / \partial t \nabla \times B = \mu J + 1/c^2 \partial E / \partial t F = q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$ PC demostry do  $r^{\mu\nu} = r^{\mu} \sigma_{\mu} r^{\mu\nu} = 0 dx^{2} = r^{2} dx^{2} - dx^{2} - dx^{2} dx^{2} = g_{\mu\nu} dx^{\mu} dx^{\mu} dx^{\nu}$  $2m + \nabla H|a\rangle = E|a\rangle U = e^{Ht/i\hbar}$   $\mathbf{F} = m\mathbf{a} \mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $dx^{2} - dy^{2} - dx^{2} dx^{2} = g_{\mu\nu}dx^{\mu}dx^{\nu} g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_4 = -1/c \partial A_4$  $dv^{\mu}fds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - R^{\mu}_{\mu\nu} = R^{\mu}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $t) + V(x)\psi(x, t) = E\psi(x, t) x' + \gamma(x - vt) t' + \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi + t \cosh \xi = -t \sinh \xi + t \sin \xi + t \sinh \xi + t \sin \xi + t$  $=\epsilon_{14k}\partial_{1}A_{k}F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu}F^{\mu\nu} = 1/2\epsilon^{\mu\nu\rho\sigma}F_{\rho\sigma}\partial_{\nu}F^{\mu\nu} = J^{\nu}\partial_{\nu}F^{\mu\nu} = 0 \ \mathrm{d}x^{2} = c^{2}\mathrm{d}t^{2} - \mathrm{d}x^{2} - \mathrm{d}y^{2} - \mathrm{d}x^{2} \ \mathrm{d}x^{2} = g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu}$  $a_{R} = R_{\mu}^{R} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \ \Delta\nu \approx 10^{-10} \ ds^{2} + 10^{-10} \ ds^{2}$  $\Delta x \Delta p \geq h/2 |p_i| = -i\hbar\partial_i |E| = i\hbar\partial/\partial t |H| = p^2/2m + V |H|a| = E|a| |U| = e^{Ht/i\hbar} |\mathbf{F}| = m\mathbf{a} |\mathbf{F}| = GMm\mathbf{r}/r^3 |\nabla \cdot \mathbf{E}| = \rho/\epsilon |\nabla \cdot \mathbf{B}| = 0 |\nabla \times \mathbf{E}| = -\partial \mathbf{B}/\partial t$  $F^{\mu\nu} = J^{\nu} \, \partial_{\nu} F^{\mu\nu} = 0 \, \mathrm{d} s^2 = c^2 \mathrm{d} t^2 - \mathrm{d} s^2 - \mathrm{d} s^2 - \mathrm{d} s^2 \, \mathrm{d} s^2 = g_{\mu\nu} \mathrm{d} s^{\mu} \mathrm{d} s^{\nu} \, g_{\mu\nu} (\mathrm{d} s^{\mu}/\mathrm{d} r) \\ \mathrm{d} s^{\nu}/\mathrm{d} r) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \, \mathrm{d} s^{\mu} \, \mathrm{d} s^{\mu}$  $|a\rangle = E|a\rangle U = e^{Ht/\hbar} F = ma F = GMmr/e^3 \nabla \cdot E = e/e \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/e^2 \partial E/\partial t F = g(E + \mathbf{v} \times B) - \hbar^2/2m\nabla^2 \psi$  $ah\xi \tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial A_i$  $dy^2 = dx^2 - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - \Gamma^\mu_{\mu\rho\sigma} = 0$  $2GM/r) = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta \nu \approx \nu_c GM(1/r_c - 1/r_c) \ d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x$  $mr/r^{2} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^{2} \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^{2}/2m \nabla^{2} \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x}' + \frac{1}{2} (1 - v) \mathbf{x}' + \frac{$  $= (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial A_i / \partial t - \partial_i \phi \ B_i = \epsilon_{ijk} \partial_j A_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu i} / 2 \epsilon^{\mu i} /$  $=1\ \Gamma_{\mu\nu\sigma}=1/2(g_{\mu\nu,\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})\ \mathrm{d}v^{\mu}/\mathrm{d}s+\Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma}=0\ R^{\mu}_{\nu\sigma,\rho}-\Gamma^{\mu}_{\nu\sigma,\sigma}+\Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho}-\Gamma^{\alpha}_{\mu\rho}-\Gamma^{\alpha}_{\mu\rho}\Gamma^{\alpha}_{\alpha}\ R_{\mu\nu}=R^{\rho}_{\mu\nu\rho}\ R=R^{\mu}_{\mu}\ G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0$  $= 1/r_f \int d^2 u / d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \quad \delta = 2GM/R \int \phi^* \psi dx = 1 \quad P(x,t) = |\psi(x,t)|^2 \quad \psi(x,t) = |\psi(t)\rangle \quad \langle x \rangle = \langle \psi | x | \psi \rangle \quad \Delta x \Delta p \geq \hbar/2 \quad p_4 = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = p_4 \quad A = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = -i\hbar \partial_4 \quad$ 

### Internals

- Lexical analyser: simple tokeniser that interns all identifiers and (most) strings.
- Parser: grammar represented in table form, evaluated by a single, non-recursive function.
- Compiler: passes over the parse tree 3-4 times.
- Code emitter: emits bytecode, or machine code.
- Virtual machine: interprets bytecode.
- Runtime: many helper functions, implementing functionality for the objects.

A given port (eg Linux, bare metal) provides specific RAM and I/O hooks, a REPL, and custom modules.

$$\begin{split} & (M/v) = r^2 dv^2 - r^2 - dv^2 - dv^2 - dv^2 - dv = v_0 GM(1/v_1 - 1/v_f) - d^2u/d\phi^2 + u = GM/A^2 - 3GM^2 = 0 \ \delta = 3GM/R \ \int \psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = R^2 \ (\psi(x, t) - R^2) \ (\psi(x, t) -$$

 $R_{\mu}^{\mu} | G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 | G_{\mu\nu} = 8\pi GT_{\mu\nu} | ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2d\theta^2 - r^2 \sin^2\theta d\phi^2 | \Delta\nu \approx -ib\partial_{\tau} E_{\tau} - ib\partial_{\tau} \partial_{\tau} - ib\partial_{\tau} - ib\partial_{$ 

 $Mmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $= \gamma m v E = \gamma m c^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$ 

### Internals



# Object representation

A MicroPython object is a machine word, and has 3 different forms.

Integers:

- Transparent transition to arbitrary precision integers. Strings:  $Ht/i\hbar$  F = ma F =  $GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

  - Certain strings are not interned.

Objects:

- $R^{\mu}_{\ \nu\rho\sigma} = \Gamma^{\mu}_{\ \nu\sigma\sigma} \Gamma^{\mu}_{\ \nu\rho\sigma} + \Gamma^{\alpha}_{\ \nu\sigma} \Gamma^{\mu}_{\ \rho\rho} \Gamma^{\alpha}_{\ \nu\rho} \Gamma^{\mu}_{\ \sigma\sigma} R = R^{\mu}_{\ \mu\nu\rho} R = R^{\mu}_{\ \mu} G_{\mu\nu} = R_{\mu\nu} 1/2g_{\mu\nu}R = 0$ (z - v)  $t' = \gamma (t - vx/c^2) = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t_0$
- A pointer to a structure.
- $-x \sinh \xi \ \tanh \xi \ = \ v/c \ \cosh \xi \ = \ \gamma \ L \ = \ L_0 / \gamma \ T \ = \ \gamma T_0 \ u' \ = \ (u v) / (1 uv/c^2) \ p \ = \ \gamma \ m v$ First element is a pointer to a type object.
- ROMable (type, tuple, dictionary, function, module, ...).  $v^{\sigma} = 0 R^{\mu}_{\nu \sigma \sigma} = \Gamma^{\mu}_{\nu \sigma, \rho} - \Gamma^{\mu}_{\nu \sigma, \sigma} + \Gamma^{\alpha}_{\nu \sigma}$  $a_{1}GM(1/r_{1}-1/r_{3}) d^{2}u/d\phi^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \delta = 2GM/R \left[\psi^{*}\psi dx = 1 P(x,t) = |\psi(x,t)|^{2} \psi(x,t) = |\psi(x,t)|^{2}$

Note: still room for packing truncated floats.  $-g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\mu\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$ 

 $\langle \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

 $dx^{\nu} g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $\mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = g (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

 $(c^2) p = \gamma m v E = \gamma m c^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$ 

 $+ 1/\epsilon^2 \partial \mathbf{E} / \partial t \mathbf{F} = \sigma (\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) \mathbf{x}' = \gamma (\mathbf{x} - \mathbf{y} t) \mathbf{t}' = \gamma (t - \mathbf{y} - t) \mathbf{x}'$ 

 $\mu^{\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \partial_{\nu} F^{\mu\nu} = J^{\nu} \partial_{\nu} \tilde{F}^{\mu\nu} = 0 ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 ds^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} dx^{\mu} dx^{\nu} dx^{\nu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\mu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\mu} dx^{\nu} dx^{\mu} dx^{\mu}$ 

 $R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2 \ \Delta\nu \approx$  $\pm V H|a\rangle = E|a\rangle U = e^{Ht/i\hbar} \mathbf{F} = ma\mathbf{F} = GMmr/e^3 \nabla \cdot \mathbf{E} = a/e \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

### Emitters: bytecode

@micropython.bytecode def add(x, y): return x + y

Compiles to:

00:	b0	LOAD_FAST_0

- 01: b1
- 02: db
- 03: 5b RETURN\_VALUE

 $F = maF = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $= -\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q (E + v \times B) - \hbar^2/2m\nabla^2 \psi$  $= 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^2 = (1 - 2GM/r) dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \ \Delta\nu \approx$  $p^2/(2m + V H)a) = E(a) U = e^{Ht/i\hbar} \mathbf{F} = ma\mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $= dx^{2} = dy^{2} = dx^{2} = dx^{2} = g_{\mu\nu}dx^{\mu}dx^{\nu} = g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \quad \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \phi$  $T = \gamma T_0 \ u' = (u - v)/(1 - uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_u J^{\mu} = 0 \ E_i = -1/c \partial A_i$ LOAD FAST 1  $\varepsilon^{3} - \mu^{2} \varepsilon^{3} + m^{2} \varepsilon^{4} \partial_{\mu} J^{\mu} = 0$   $\varepsilon_{i} = -1/c \partial A_{i} / \partial t - \partial_{i} \phi B_{i} = \epsilon_{ijk} \partial_{j} A_{k} F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu} \partial_{\mu} J^{\mu} = 0$  $^{\prime}v^{\sigma} = 0 R^{\mu}_{\ \ \ 
ho\sigma} = \Gamma^{\mu}_{\ \ \ \sigma,\rho} - \Gamma^{\mu}_{\ \ \ 
ho,\sigma} + \Gamma^{\alpha}_{\ \ \ \sigma}\Gamma^{\mu}_{\ \ \ 
ho} - \Gamma^{\alpha}_{\ \ \ 
ho\sigma}R_{\mu\nu} = R^{\rho}_{\ \ \ \mu\nu\rho}R = R^{\mu}_{\ \ \ \mu}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$ BINARY OP ADD  $P(x, 0) = |v(x, 0)|^2 |v(x, 0) = |v(0)| |x| = |v(0)| |x| = |x|^2 |x| = -i\hbar \partial_x |E| = i\hbar \partial/\partial t |H| = p^2/2m + V$  $x' = \gamma(x - vt) t' = \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi ta$  $-\partial^{\nu}A^{\mu} \ \bar{F}^{\mu\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \ \partial_{\nu}F^{\mu\nu} = J^{\nu} \ \partial_{\nu}\bar{F}^{\mu\nu} = 0 \ \mathrm{d}s^{2} = c^{2}\mathrm{d}t^{2} - \mathrm{d}x^{2} - \mathrm{d}x^{2} \ \mathrm{d}s^{2} = g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu} \ \mathrm{d}x^{\nu} = 0 \ \mathrm{d}x^{2} + c^{2}\mathrm{d}x^{2} + c^{2}\mathrm{d}x^{2}$  $1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2 \ \Delta\nu \approx 1/2g_{\mu\nu}R + 1/2g$  $\mathbb{C} = \hbar\partial/\partial t \ H = p^2/2m + V \ H|a\rangle = E|a\rangle \ U = e^{Ht/\hbar\hbar} \ \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{r}/r^3 \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\beta^{\mu\mu} = J^{\nu} \, \delta_{\nu} \beta^{\mu\nu} = 0 \, \mathrm{d} s^{2} = c^{2} \mathrm{d} t^{2} - \mathrm{d} s^{2} - \mathrm{d} s^{2} - \mathrm{d} s^{2} - \mathrm{d} s^{2} + g_{\mu\nu} \mathrm{d} s^{\mu} \mathrm{d} s^{\nu} \, g_{\mu\nu} \mathrm{d} s^{\mu} \mathrm{d} r) (\mathrm{d} s^{\nu} / \mathrm{d} r) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \mathrm{d} s^{\mu} \mathrm{d} s^{\mu}$  $\forall H[a] = E[a] U = e^{Ht/(h)} \mathbf{F} = \max \mathbf{F} = GMmr/r^{3} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^{2} \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^{2}/2m\nabla^{2}\psi$  $dx^2 = dx^2 - dx^2 - dx^2 - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}dx^{\mu}dr^{\mu}(dx^{\mu}/dr)(dx^{\nu}/dr) = 1 \quad \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \\ dv^{\mu}/ds + \Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma} = 0 \quad R^{\mu}_{\nu\sigma,\rho} = \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma,\rho} + \Gamma$  $\delta v^2 / (1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \ \Delta \nu \approx \nu_4 GM (1/r_4 - 1/r_f) \ d^2 u / d\phi^2 + u - GM/A^2 - 3GM u^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi \, dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x, t)$  $\lim_{n \to \infty} |\nabla \cdot \mathbf{E} = \rho/\epsilon |\nabla \cdot \mathbf{E} = -\rho |\nabla \cdot \mathbf{E} = -\partial |D| \partial t |\nabla \times \mathbf{E} = -\partial |D| \partial t |\nabla \times \mathbf{E} = -\rho |\mathbf{L} + 1/\epsilon^2 \partial |\mathbf{E} / \partial t |\mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) |\mathbf{x}'| = \gamma (\mathbf{x} - \mathbf{v}t) |\mathbf{t}'| = \gamma (t - v) |\mathbf{x}'| = \gamma (t$ 

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 $(T_0|u' = (u-v)/(1-uv/c^2)|p = \gamma mv|E = \gamma mc^2|E^2 = p^2c^2 + m^2c^4|\partial_\mu J^\mu = 0|E_i = -1/c\partial A_i/\partial t - \partial_i\phi|B_i = \epsilon_{ijk}\partial_iA_k|F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu|\tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$  $=1/2(g_{\mu\nu\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})-g_{\nu\sigma,\mu})-dv^{\mu}/ds+\Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma}=0-R^{\mu}_{\nu\rho\sigma}=\Gamma^{\mu}_{\nu\rho,\rho}-\Gamma^{\mu}_{\nu\rho,\rho}+\Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho}-\Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma}-R^{\mu}_{\mu\nu\rho}-R=R^{\mu}_{\mu}-G_{\mu\nu}-R^{\mu}_{\mu\nu}-1/2g_{\mu\nu}R=0$  $1/r_{x}1d^{2}u/d\phi^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \ \delta = 2GM/R \ \int \psi^{*}\psi dx = 1 \ P(x,t) = |\psi(x,t)|^{2} \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar/2 \ p_{4} = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} \ A = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial_{4} \ E = -i\hbar\partial_{4} \ E = -i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial_{4}$ 

### Emitters: native

@micropython.native
def add(x, y):

return x + y

			$\mathcal{O} = \pi^{H(t)/\hbar} \ \mathcal{F} = \max \mathcal{F} = GMmr/r^3 \ \nabla \cdot \mathcal{E} = \rho/\epsilon \ \nabla \cdot \mathcal{B} = 0 \ \nabla \times \mathcal{E} = -\partial \mathcal{B}/\partial t$
00:	e92d41fe	push	{r1, r2, r3, r4, r5, r6, r7, r8, lr}
04:	e24dd028	sub	sp, sp, #40 ; 0x28
08:	e59f7000	ldr	r7, [pc] ; 0x10
0c:	ea000000	b	0x14 = (1 + 1)(1 + 1)(1 + 1)(1 + 1) = (1 + 1)(1 +
10:	080794e0	.word	0x080794e0
14:	e1a04003	mov	r4, r3
18:	e1a03002	mov	r3, r2
1c:	e1a02001	mov	$\Gamma r2, \Gamma r1 = \Gamma^{\alpha}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\rho} \Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\mu}_{\mu\nu\rho} R = R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$
20:	e1a01000	mov	$\mathbf{r1}, \mathbf{r0}  \psi(x,t) =  \psi(t)\rangle \ (x) = (\psi x \psi)  \Delta x \Delta p \ge h/2 \ p_i = -ih\partial_i \ E = ih\partial/\partial t \ H = p^2/2m + V$
24:	e3a00074	mov	r0, #116 ; 0x74
28:	e58d0000	str	r0, [sp] $\sigma \tau_{\mu\nu} dr^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 sln^2 \theta d\theta^2 \Delta r \approx$
2c:	e3a00080	mov	r0, #128
30:	e58d0004	str	r0, [sp, #4]
34:	e3a00004	mov	r0, #4 $r^{2} = 0.6^{2}$ $\Delta r = r G M(1/r) - 1/r_{0} d^{2} r / d\sigma^{2} + u - G M/A^{2} - 3G Mu^{2} = 0.6 = 0.6$
38:	e58d0014	str	r0, [sp, #20] = -0B/0( $\nabla \times B = \mu J + 1/c^2 \partial E/\partial (F = q(E + v \times B) - \hbar^2/2m\nabla^2 q)$
3c:	e28d0000	add	r0, sp, #0 **/c <sup>2</sup> ) $p = \gamma m e^{E} = \gamma m c^{2} E^{2} = p^{2}c^{2} + m^{2}c^{4} \partial_{\mu}J^{\mu} = 0 E_{i} = -1/c\partial A_{i}/c^{4}$
40:	e92d0010	stmfd	sp!, {r4}
44:	e1a0e00f	mov	$^{2}$ lr, pc $_{0}(E + v \times B) - h^{2}/2m\nabla^{2}\psi(x, t) + V(x)\psi(x, t) = E\psi(x, t) = (v(x, t))^{2} - v(x, t) = (v(x, t))^{2}$
48:	e597f0a0	ldr	pc, [r7, #160] ; 0xa0 = = = = = = = = = = = = = = = = = = =
4c:	e8bd0001	ldmfd	$\sum_{\nu=0}^{n} \sup \{r0\}_{\nu,\sigma}^{\nu} \{r0\}_{\nu,\sigma}^{\nu} + \sum_{\nu=0}^{n} \sum_{\nu=0}^{n} \sum_{\nu=0}^{n} \sum_{\nu=0}^{n} R_{\mu\nu} = R_{\mu\nu}^{\nu} R = R_{\mu\nu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 0$
50:	e59d4024	ldr	r4, [sp, #36] ; 0x24
54:	e59d5020	ldr	$r^{\mu}r5$ , $[sp, #32]r^{\mu\nu} = r^{\nu}\partial_{\nu}\dot{r}^{\mu\nu} = 0 ds^{2} = c^{2}dr^{2} - ds^{2} - dy^{2} - ds^{2} ds^{2} = g_{\mu\nu}ds^{\mu}ds^{\nu}$
58:	e1a02005	mov	$r^{2}C_{\mu}r^{5} = r^{2}G_{\mu\nu} ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \Delta \nu \approx$
5c:	e1a01004	mov	$\frac{2}{2m+V} \frac{H(a)}{F(a)} = E(a) U = e^{HU/bh} \mathbf{F} = \mathbf{maF} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$
60:	e3a00005	mov	$d\mathbf{r}0$ , $d\mathbf{\#}5ds^2 = g_{\mu\nu}dx^{\mu}dx^{\nu}g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1$ $\Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$
64:	e1a0e00f	mov	$1/r \ln r^2 p \hat{c} - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx \nu_i G M (1/r_i - 1/r_f) d^2 u / d\phi^2 + u - G M / A^2 - 3G M u^2 = 0 \delta = 0$
68:	e597f034	ldr	pc, $[r7, #52] \times E$ ; $0x34 \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q(E + v \times B) - \hbar^2/2m \nabla^2 v$
6c:	e28dd028	add	sp, sp, #40 ; 0x28
70:	e8bd81fe	pop	{r1, r2, r3, r4, r5, r6, r7, r8, pc}
	$7 \times E = -\partial B / \partial t \nabla_{\alpha}$	$\times \mathbf{B} = \mu \mathbf{J} + 1/2$	$c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - vt) t' = \gamma(t - vt) \mathbf{x}' = \gamma(t - vt) \mathbf{x} + vt \mathbf{x} + vt \mathbf{x} = \gamma(t - vt) \mathbf{x} + vt $
		$E^{2} = p^{2}c^{2} +$	$m^2 c^a \partial_{\mu} J^{\mu} = 0 E_i = -1/c\partial A_i/\partial t - \partial_i \phi B_i = \epsilon_{ijk} \partial_i A_k F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} F^{\mu\nu} = 1/2\epsilon^{\mu\nu}$

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 $\frac{\partial}{\partial t} \left( s \right) = 1 \Gamma_{\mu\nu\sigma} + 1/2 (g_{\mu\nu\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv^{\mu} / ds + \Gamma_{\mu\sigma}^{\mu} v^{\nu} v^{\sigma} = 0 R_{\mu\rho\sigma}^{\mu} - \Gamma_{\mu\sigma,\sigma}^{\mu} + \Gamma_{\nu\sigma}^{\mu} \Gamma_{\mu\sigma}^{\mu} - \Gamma_{\mu\sigma}^{\mu} \Gamma_{\mu\sigma}^{\mu} R_{\mu\nu\rho} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu\rho} R_{\mu}^{\mu} R_{\mu\nu} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu} R_{\mu\nu} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu} R_{\mu\nu} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu} R_{\mu\nu} R_{\mu\nu} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu} R_{\mu\nu} R_{\mu\nu} - R_{\mu\nu\rho}^{\mu} R_{\mu\nu} R_{\mu\nu}$ 

### Emitters: viper

@micropython.viper
def add(x:int, y:int) -> int:
 return x + y

Compiles to:

00:	e92d41fe	push	{r1, r2, r3, r4, r5, r6, r7, r8, lr}
04:	e59f7000	ldr	r7, [pc] ; 0xc
08:	ea000000	b	$0 \times 10^{-1} = (1/2)^{2} + (1$
0c:	080794e0	.word	0x080794e0
10:	e1a04000	mov	$\begin{split} E^2 &= e^{-e^2} + m^2 e^4 \; \partial_{\mu} J^{\mu} = 0 \; E_i = -1/c \partial A_i / \partial t - \partial_i \phi \; B_i = \epsilon_{ijk} \partial_j A_k \; F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \; \tilde{F}^{\mu\nu} = 1/2 e^{\mu i} \\ e^{i\phi} e^{i\phi} \mathbf{r} 4^{\dagger} \; \mathbf{g}^{\mu}_{\mu\nu} \mathbf{T} \mathbf{O}^{\mu}_{\nu\sigma,\sigma} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\alpha}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\alpha}_{\alpha\sigma} \; R_{\mu\nu} = R^{\mu}_{\mu\nu\rho} \; R = R^{\mu}_{\mu} \; G_{\mu\nu} = R_{\mu\nu} - 1/2 g_{\mu\nu} R = 0 \end{split}$
14:	e1a05001	mov	$\begin{aligned} &ds = 1 P(s, t) = \psi(s, t) ^2 \psi(s, t) =  \psi(t)  (s) = \langle \psi(s)   s \rangle - \langle \psi(s)   s \rangle - \langle \lambda x \Delta y \rangle \geq h/2 p_1 = -ih\delta_1 E = ih\delta/\delta H H = y^2/2m + Y \\ &\delta \psi(s \mathbf{T5} = y(\mathbf{T1})) \psi(s) + y(t - yx/s^2) y = 1/(1 - y^2/s^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi e x \sin \xi t \\ &\delta \psi(s \mathbf{T5} = y(\mathbf{T1})) \psi(s) + y(t - yx/s^2) y = 1/(1 - y^2/s^2)^{1/2} x' = -t \sinh \xi + x \sin \xi t \\ &\delta \psi(s \mathbf{T5} = y(\mathbf{T1})) \psi(s) + y(\mathbf{T5}) = -t \psi(s) + y(\mathbf{T5}) + y(\mathbf{T5}) + y(\mathbf{T5}) + y(\mathbf{T5}) \\ &\delta \psi(s) = -ih\delta/\delta t \\ &\delta \psi(s) = -ih\delta/\delta $
18:	e1a01004	mov	$\prod_{\mu=0}^{n} \prod_{\mu=0}^{n} \prod_{\mu$
1c:	e0811005	add	$\inf \left\{ \begin{array}{c} \sum \\ \mathbf{r} \end{array} \right\} = \sum \left\{ \begin{array}{c} \sum \\ \mathbf{r} \end{array} \right\} = \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum \\ \sum \\ \sum \\ \mathbf{r} \end{array} = \sum \\ \sum$
20:	e1a00001	mov	$\frac{4r^2}{2} \prod_{j=0}^{2} \frac{GM/r_j}{2} = \frac{2}{2} \frac{d\theta^2 - r^2}{d\theta^2} \frac{d\theta^2}{d\theta^2} \frac{d\omega}{d\theta^2} \frac{d\omega}{d\omega} = \frac{r}{2} \frac{GM}{d\theta^2} \frac{GM}{d\theta^2} \frac{d\omega}{d\theta^2} $
24:	e8bd81fe	рор	{r1, r2, r3, r4, r5, r6, r7, r8, pc}
		$^{2} \sin^{2} \overline{\upsilon} d\phi^{2}  \overline{\Delta}\nu \approx \nu_{i} G M$ $0  \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t  \nabla \times$	$(1/r_i - 1/r_f) d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ f \ \psi^* \psi dx = 1 \ P(x, t) =  \psi(x, t) ^2 \ \psi(x, t) =  \psi  =  \psi(x, t) ^2 \ \psi(x, t) =  \psi  $
			$\begin{split} & \mathcal{L}^{-} = \mathcal{L}^{+} \mathcal{L}^{+} \mathcal{L}^{+} = \mathcal{L}_{\mu} \mathcal{L}^{\mu} = \mathcal{L}_{\mu} = -1/coA_{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} = \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} = \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} = \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} = \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} = \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} \mathcal{L}^{\mu} = \mathcal{L}^{\mu} $

 $\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q (E + v \times B) - \hbar^2/2m\nabla^2 \psi$ 

### Emitters: inline assembler

```
@micropython.asm_thumb
def sum_bytes(r0, r1):
    mov(r2, 0)
    b(loop_entry)
    label(loop1)
    ldrb(r3, [r1, 0])
    add(r2, r2, r3)
    add(r1, r1, 1)
    sub(r0, r0, 1)
    label(loop_entry)
    cmp(r0, 0)
    bgt(loop1)
    mov(r0, r2)
```

 $|\mathbf{B}/\partial t| \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t|\mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $G_{\mu\nu} = 8\pi G T_{\mu\nu} ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta\nu \approx 10^{-10}$  $+ V H[a] = E[a] U = e^{Ht/i\hbar}$   $\mathbf{F} = m\mathbf{a} \mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $^{2} = dz^{2} - dz^{2} - dz^{2} = g_{\mu\nu} dx^{\mu} dx^{\nu} - g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $^{3}$   $\nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^{2} \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^{2}/2m\nabla^{2}\psi$  $T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$  $\mathbf{B} = v\mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = \sigma (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(\mathbf{t} - \mathbf{v}t)$  $v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\alpha\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\alpha\sigma}\Gamma^{\mu}_{\alpha\sigma} \ R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} \ R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(t)\rangle \langle x \rangle = \langle \psi(x) \psi \rangle \Delta x \Delta p \ge \hbar/2 \ p_4 = -i\hbar\partial_4 \ E = i\hbar\partial/\partial t \ H = p^2/2m + V$  $= E\psi(x,t) x' + \gamma(x-vt) t' + \gamma(t-vx/c^2) \gamma = 1/(1-v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t t'$  $A^{\nu} - \partial^{\nu} A^{\mu} \ \hat{F}^{\mu\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \ \partial_{\nu} F^{\mu\nu} = J^{\nu} \ \partial_{\nu} \hat{F}^{\mu\nu} = 0 \ \mathrm{d} s^{2} = c^{2} \mathrm{d} t^{2} - \mathrm{d} s^{2} - \mathrm{d} s^{2} \ \mathrm{d} s^{2} = g_{\mu\nu} \mathrm{d} s^{\mu} \mathrm{d} s^{\nu} \mathrm{d} s$  $=R_{\mu\nu}-1/2g_{\mu\nu}R=0\ G_{\mu\nu}=8\pi GT_{\mu\nu}\ \mathrm{d}s^{2}=(1-2GM/r)\mathrm{d}t^{2}-\mathrm{d}r^{2}/(1-2GM/r)-r^{2}\mathrm{d}\theta^{2}-r^{2}\sin^{2}\theta\mathrm{d}\phi^{2}\ \Delta\nu\approx 10^{-2}\mathrm{d}r^{2}/(1-2GM/r)$  $E = 1\hbar\partial/\partial t H = p^2/2m + V H|a\rangle = E|a\rangle U = e^{Ht/\hbar\hbar} \mathbf{F} = m\mathbf{a} \mathbf{F} = GMm\mathbf{r}/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi \tanh \xi = v/c \cosh \xi = \gamma L = L_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv$  $0 \, ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 \, ds^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} \, g_{\mu\nu} (dx^{\mu}/dr) (dx^{\nu}/dr) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + g_{\mu\sigma,\nu} - g_{\mu$ Call as normal: print(sum\_bytes(4, b'abcd'))  $\sin^2 \theta d\phi^2 \quad \Delta \nu \approx \nu_1 GM(1/r_1 - 1/r_2) \ d^2u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^*\psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |y|^2 \ \psi(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x, t)|^2$  $\mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}t) \mathbf{x}' =$  $\psi)/(1-\psi\nu/c^2) = \gamma m\nu E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i / \partial t - \partial_i \phi B_i = \epsilon_{ijk} \partial_j A_k F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu} \partial_i A_i + 2 \epsilon^{\mu} \partial_i A_i$ 

 $1/2(g_{\mu\nu,\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})\,\,\mathrm{d}v^{\mu}/\mathrm{d}s+\Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma}=0\,\,R^{\mu}_{\nu\rho\sigma}=\Gamma^{\mu}_{\nu\sigma,\rho}-\Gamma^{\mu}_{\nu\rho,\sigma}+\Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho}-\Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma}\,\,R_{\mu\nu}=R^{\rho}_{\mu\nu\rho}\,R=R^{\mu}_{\mu}\,G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0\,\,R^{\mu}_{\mu\nu}$  $/ d\phi^2 + u = GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar/2 \ p_i = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = -i\hbar\partial_i \ E = -i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = -i\hbar\partial_i \$ 

### Encoding of source-bytecode map

Histogram showing frequency of having to skip n bytes and n lines.



Encoding optimised for this (very simple Huffman-like).

$$\begin{split} \left[d\tau\right] &= 1 \ \Gamma_{\mu\nu\sigma} = 1/2(\sigma_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ d\nu^{\mu}/ds + \Gamma^{\mu}_{\mu\sigma} \nu^{\nu} \sigma^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} + \Gamma^{\alpha}_{\mu\rho,\sigma} + \Gamma^{\alpha}_{\mu\sigma} \Gamma^{\alpha}_{\mu\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\alpha}_{\mu\sigma} R_{\mu\nu} = R^{\mu}_{\mu\rho\rho} R = R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu} R = C^{\mu}_{\mu\sigma} + C^{\mu}_{\mu\sigma} \Gamma^{\alpha}_{\mu\sigma} R_{\mu\nu} = R^{\mu}_{\mu\sigma} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu} R = C^{\mu}_{\mu\sigma} + C^{\mu}_{\mu\sigma} \Gamma^{\alpha}_{\mu\sigma} R_{\mu\nu} = R^{\mu}_{\mu\sigma} G_{\mu\nu} = R^{\mu}_{\mu\sigma} = R^{\mu}_{\mu\sigma} = R^{\mu}_{\mu\sigma} = R^{\mu}_{\mu\sigma} = R^{\mu}_{\mu\sigma} = R^{\mu}_{\mu\sigma} = R^{\mu}_{\mu$$

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MicroPython

### Example heap usage



### Code dashboard

### http://micropython.org/resources/code-dashboard/



 $7Mmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $J + 1/c^2 \partial E / \partial t F = a (E + y \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

### Coding style

MicroPython does not follow traditional software engineering practices:

- optimise first;
- creative solutions and tricks;
- sacrifice clarity to get smaller code;
- sacrifice efficiency to get smaller code (esp. less-used features);
- use of goto not discouraged;
- optimise to minimise stack usage;
- $(x yt) t' = \gamma(t yx/c^2) \gamma = 1/(1 y^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi x \sinh \xi t$ make decisions based on analysis.

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 $H = v^2/2m \pm V H[a] = E[a] U = e^{Ht/\hbar} \mathbf{F} = ma\mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = a/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E}$ 

 $\mathrm{d} \delta^2 + u = GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi \mathrm{d} x = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar/2 \ p_i = -\mathrm{i} \hbar \partial_i E = \mathrm{i} \hbar \partial \partial t$ 

 $F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $= \mu J + 1/c^2 \partial E / \partial t F = q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

 $Ht/i\hbar$  F = ma F =  $GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $+\mathbf{v} \times \mathbf{B} = -\hbar^2/2m\nabla^2\psi(\mathbf{x},t) + V(\mathbf{x})\psi(\mathbf{x},t) = E\psi(\mathbf{x},t) \ \mathbf{x}' = \gamma(\mathbf{x}-\mathbf{v}t) \ \mathbf{t}' = \gamma(t-\mathbf{v})$ 

 $= 8\pi G T_{\mu\nu} ds^{2} = (1 - 2GM/r) dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2} d\theta^{2} - r^{2} \sin^{2} \theta d\phi^{2} \Delta \nu \approx$ 

=  $-1/c\partial A_i/\partial t - \partial_i \phi B_i = \epsilon_{ijk}\partial_j A_k F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$  $\mu_{\nu\rho,\sigma}^{\mu} + \Gamma_{\nu\sigma}^{\alpha}\Gamma_{\alpha\rho}^{\mu} - \Gamma_{\nu\rho}^{\alpha}\Gamma_{\alpha\sigma}^{\mu}R_{\mu\nu} = R_{\mu\nu\rho}^{\rho}R = R_{\mu}^{\mu}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $|x, t\rangle = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \ge \hbar/2 \ p_i = -i\hbar \partial_i \ E = i\hbar \partial / \partial t \ H = p^2/2m + V$ 

 $g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$ 

### GitHub and the open-source community

https://github.com/micropython

MicroPython is a *public* project on GitHub.

- A global coding conversation.
- Anyone can clone the code, make a fork, submit issues, make pull requests.
- MicroPython has over 2250 "stars", and more than 410 forks.
- Contributions come from many people, with many different systems.
- Leads to: more robust code and build system, more features, more supported hardware.
- Hard to balance inviting atmosphere with strict code control.

A big project needs many contributors, and open-source allows such projects to exist.

 $J/A^2 = 3GMu^2 = 0.\delta = 2GM/R \int \psi^* \psi dx = 1.P(x,t) = |\psi(x,t)|^2 |\psi(x,t) = |\psi(t)\rangle \langle x \rangle = \langle \psi|x|\psi \rangle \Delta x \Delta p \ge \hbar/2 |p_1| = -\hbar\partial_1 |E| = i\hbar\partial/\partial t |H| = 1.25$ 

 $= R^{\nu}_{\mu\nu\rho} R = R^{\nu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g$ 

 $\mathbf{F} = m\mathbf{a} \mathbf{F} = GMm\mathbf{r}/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

### GitHub stars — all 10 million+ projects

1	twbs/bootstrap	CSS	85,841
2	vhf/free-programming-books	None	42,432
3	angular/angular.js	JavaScript	42,102
4	mbostock/d3	JavaScript	41,149
5	nodejs/node-v0.x-archive	JavaScript	38,004
6	jquery/jquery	JavaScript	35,780
7	FortAwesome/Font-Awesome	HTML	35,663
8	h5bp/html5-boilerplate	JavaScript	30,974
9	meteor/meteor	JavaScript	27,843
10	rails/rails	Ruby	-27,531 E - // V B - 0 V × E0B/0
			$C_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma m u (dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$
1766	apache/couchdb	JavaScript	2,279
1767	lifesinger/lifesinger.github.com	JavaScript	$^{-2}2,276 + ^{-2}c^{4}\partial_{\mu}J^{\mu} = 0 E_{i} = -1/c\partial A_{i}$
1768	googlesamples/android-topeka	Java	$GM/2, 274 - 1 P(x, t) -  \psi(x, t) ^2 \psi(x, t) -  \psi(x, t) ^2 \psi(x, t) = 1$
1769	addyosmani/es6-tools	None	$ + \frac{V}{2}, 27_{4} 4^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} F^{\mu\nu} = 1/2\epsilon^{3} $
1770	activerecord-hackery/ransack	Ruby	$R_{\mu\nu} = 2,274 = R_{\mu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = -1/2g_{\mu\nu}R $
1771	sciactive/pnotify	CSS	2,273 (+ + could ( ' - t could ( - + sinh (
1772	addyosmani/basket.js	JavaScript	$(-d^2, 273^{M/r}) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta v$
1773	PostgresApp/PostgresApp	Objective-C	$= G \sum_{i=1}^{N} \frac{m r_i^2}{2} \frac{3}{7} \frac{3}{6} \sum_{i=1}^{N} \frac{E - \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial}{\sigma_i^2 (u - v)/(1 - uv/c^2)} p = \gamma m$
1774	micropython/micropython	$-dz^2 ds^2 = \mathbf{C}_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} (dx^{\mu}/dr)$	2,272 <<<<<
1775	seanpowell/Email-Boilerplate	$\rho/\epsilon \nabla \cdot \mathbf{B} = \mathbf{HTME} = -\partial \mathbf{B}/\partial \epsilon \nabla \times \mathbf{B}$	$-\mu 2$ , $271^{E/\partial t} F = q (E + v \times B) - \hbar^2/2m\nabla^2$
1776	lipka/piecon	JavaScript	
1777	alfajango/jquery-dynatable	JavaScript	$^{GM}/2$ ,271 $^{-1}P(x,t) =  \psi(x,t) ^2 \psi(x,t) =  \psi(x,t) ^2 \psi(x,t$
	$(2\pi T - \gamma T_0)v^2 - (v - v)/(1 - vv/c^2) p - \gamma mv E - \gamma mc^2 E^2 - p^2c^2 + m^2c^4$ $(2\pi T - \gamma T_0)v^2 - (v - v)/(1 - vv/c^2) p - \gamma mv E - \gamma mc^2 E^2 - p^2c^2 + m^2c^4$	$\partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i / \partial t - \partial_i \phi B_i$ $\Gamma^{\mu} = -\Gamma^{\mu} = +\Gamma^{\alpha} \Gamma^{\mu} = -\Gamma^{\alpha} \Gamma^{\mu}$	$i = \epsilon_{ijk} \partial_j A_k F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^j$ $R_{\mu\nu} = R^{\rho} R = R^{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2\epsilon_{\mu\nu}R = 0$
	$= 3/r_f \left( \delta^2 u/\delta \phi^2 + u - GM/A^2 - 3GMu^2 - 0 \delta - 2GM/R \int \psi^* \psi dx = 1 P(x, t) \right)$	$) =  \psi(x,t) ^2 \ \psi(x,t) =  \psi(t)\rangle \ \langle x \rangle = \langle t \rangle$	$ \begin{array}{l} \mu \nu = -i\mu \nu p  \text{if } \mu \nu = \mu \nu = -i\mu \nu = -i\mu \nu = i\hbar \partial \mu \nu = -i\hbar \partial \mu \mu \nu = -i\hbar \partial \mu \mu \nu = -i\hbar \partial \mu \mu \mu = -i\hbar \partial \mu \mu \mu \mu \mu = -i\hbar \partial \mu \mu \mu \mu \mu = -i\hbar \partial \mu \mu \mu \mu \mu \mu \mu \mu = -i\hbar \partial \mu $
	D.P. George	MicroPython	20/61

### GitHub stars — all C/C++ projects

1	torvalds/linux	С	25,156
2	nwjs/nw.js	C++	24,175
3	atom/electron	C++	15,777
4	ariya/phantomjs	C++	15,084
5	antirez/redis	C	14,701
6	facebook/hhvm	C++	12,497
7	textmate/textmate	C++) -12/2= 22 ers	10,490
8	git/git	C	10,082
			$(\Delta x \Delta p \ge \hbar/2 p_i = -i\hbar \partial_i E = i\hbar \partial/\partial t H = p^a/2m + V$ $(c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t_i$
98	jonas/tig	С	2,361
99	swoole/swoole-src	$+V(H)a) = F\mathbf{C}U = e^{Ht/4\hbar}F = mt$	$F = 02,319$ $E = \rho/e \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial e$
100	raspberrypi/linux	$-\mathrm{d}x^2$ $\mathrm{d}x^2$ $-\mathbf{C}_{\mu\nu}\mathrm{d}x^\mu\mathrm{d}x^\nu$ $g_{\mu\nu}(\mathrm{d}x^\mu)/\mathrm{d}x^\nu$	2,310
101	SFML/SFML	C++	2,282
102	philipl/pifs	$(u - v)/(1 - \mathbf{C}^{w/c^2}) = \gamma m v E =$	$2,281^{+},201^{+},201^{+},200^{+},20$
103	micropython/micropython	$/d\phi^2 + u - C \mathbf{C} / A^2 - 3GMu^2 = 0.8$	2,272 <<<<
104	sqlitebrowser/sqlitebrowser	$/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x})$ $\frac{4}{2} \partial_\mu J^\mu = 0 J \mathbf{C} + \frac{1}{2} 1/c \partial A_i / \partial t - \partial_i \phi$	2,269
105	rswier/c4	$= \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\rho}_{\sigma}$ $= \psi(x, t)^{2} \psi(x, \mathbf{C} -  \psi(t)\rangle (x) - \langle\psi x \psi$	$ a R_{\mu\nu} = R^{\rho} R = R^{\mu} G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2g_{\mu\nu}}R = 0 $ $ \Delta x \Delta 2 , 255 = -i\hbar\partial, E = i\hbar\partial/\partial t H = p^2/2m + V $
106	philsquared/Catch	$v(t) t' = \gamma(t - \mathbf{C} + \mathbf{f}^2) \gamma = 1/(1 - v^2)$	$(2^{-1})^{1/2} 2,228^{1} \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t$
107	joyent/http-parser	$G_{\mu\nu} = 8\pi G T \mathbf{C} e^{-gg} ds^2 = (1 - 2GM/r)$	$dt^2 = d2/(225^{M/r}) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$
108	nanomsg/nanomsg	$(+V H a) = E a\rangle U = e^{Ht/i\hbar} \mathbf{F} = mt$ - $x \sinh \xi \tanh \mathbf{C} = v/c \cosh \xi = \gamma L$	$\mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ = $L_0/\gamma 2 \cdot 220u' = (u - v)/(1 - uv/c^2) p = \gamma mv$
109	ivansafrin/Polycode	$-dx^2 ds^2 = \hat{C}_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} (dx^{\mu}) (d$	$^{(r)}(dx^{\nu}/dr) = \frac{1}{2} \sum_{\mu\nu\sigma} \frac{\Gamma_{\mu\nu\sigma}}{195} = \frac{1}{2} (g_{\mu\nu\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$
110	libuv/libuv	$= \rho / \epsilon \nabla \cdot \mathbf{B} = \mathbf{C} \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \nabla$	$= \mu 2_{+}^{+} 192^{E/\partial t} \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^{2}/2m\nabla^{2} q$
111	mpv-player/mpv	$a = \frac{(u - v)}{(1 - uv/c^2)} p = \frac{1}{2} mv \mu$ $a = \frac{1}{2} (g_{\mu\nu} \mathbf{C} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv$	${}^{\mu}/ds + 2{}^{\mu}_{\sigma} \frac{173}{173} = 0 R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$
112	arut/nginx-rtmp-module	$d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta$ $d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta$ $d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta$	$= 2GM/R \int \psi^* \psi dx = 1 P(x, t) =  \psi(x, t) ^2 \psi(x, t) =  v  \\ (t) + V(2) + \frac{158}{158} E\psi(x, t) x' = \gamma(x - vt) t' = \gamma(t - v)$
113	numpy/numpy	${}^{4} \partial_{\mu} J^{\mu} = 0 E_{i} = -1/c \partial A_{i}/\partial t - \partial_{i} \phi$ = $\Gamma^{\mu}_{\mu\sigma} - \Gamma^{\mu}_{\mu} \mathbf{C}_{\sigma} + \Gamma^{\alpha}_{\mu\sigma} \Gamma^{\mu}_{\mu\sigma} - \Gamma^{\alpha}_{\alpha} \Gamma^{\mu}_{\sigma}$	$B_{i} = e_{\mu\nu} \partial_{\mu} A_{\mu} F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$ $R_{\mu\nu} 2 R \frac{15}{15} R = R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu} R = 1/2\epsilon^{\mu}$
	D.P. George	MicroPython	$\langle \psi   x   \psi \rangle \Delta x \Delta p \ge \hbar/2 \ p_i = -i\hbar \partial_i \ E = i\hbar \partial/\partial t \ H = p 21/61$

### Part II: The pyboard hardware

$$\begin{split} & (1+|x|) = (|x||^2 + |y|| + |x||) = |x|| + |x||^2 \\ & (1+|x|) = (|x||^2 + |x||) = |x||^2 + |x||^2$$

$$\begin{split} & \min \{v - L = L_0/\gamma T = \gamma T_0 \ u' = (u - v)/(1 - uv/\beta^2) \ \mu = \gamma mv \\ & \psi_{B\mu}(u^{\mu}(u^{\mu})(u^{\mu})'(v) = \Gamma_{B\mu\nu}(u - 1/2)g_{\mu\nu}m + g_{B\mu\nu}m + g_{B\mu\nu}m) \\ & \Delta = w \left[ GM(1/\tau_1 - 1/\tau_p) \ d^2w/dv^2 + u - GM(A^2 - 3GM^2 = 0 + u - GM) \\ & \Delta = w \left[ M_1(T_1 - 1/\tau_p) \ d^2w/dv^2 + m - GM(A^2 - 3GM^2 = 0 + u - GM) \\ & (-\pi)w_{\mu\nu}(u) \ dv^{\mu}/dv + \Gamma_{B\nu}^{\mu}w^{\mu}v^{\mu} = 0 \\ & R_{\mu\mu\mu}^{\mu} = \Gamma_{B\mu\mu}^{\mu} + \Gamma_{B\mu\nu}^{\mu} + \Gamma_{B\mu\nu}^{\mu} + \Gamma_{B\mu\mu}^{\mu} + \Gamma_{B\mu\mu}^{\mu} + \Gamma_{B\mu\mu}^{\mu} + \Gamma_{B\mu\nu}^{\mu} + \Gamma_{B\mu\nu}^$$

 $\mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$ 



$$\begin{split} & (1) (1 - 2^{2})^{1/2} \ y' = -t t and (1 + t could (1' - t t could (- x in b) t tank (- x - b) could (- x - b - L_{0})^{\gamma} T = \gamma T_{0} \ y' = (x - t)^{2} (1 - v)^{2} (1 - 2)^{2} y = \gamma w t (1 - 2v)^{2} y = y = 0 \ z = 1 + 2v = 1 + 2v = 0 \ z = 1 + 2v = 2v = 1 + 2v = 1 + 2v = 1 + 2v = 2v = 1 + 2v = 1 + 2v = 1 + 2v = 2v = 1 + 2v = 2v =$$

### The pyboard

 $\begin{aligned} & = (1 + 1) \left( \frac{1}{2} + \frac{1}{2}$ 



$$\begin{split} \mathbf{B} &= 0 \ \nabla \times \mathbf{E} &= -\partial \mathbf{B}/\partial t \\ /(1-uv)/c^2) \ p &= \pi uv \\ /(1-uv)/c^2) \ p &= \pi uv \\ /(1-uv)/c^2) \ p &= \pi uv \\ /(1-uv)/c^2) \ m^2 &= 0 \ k \\ + v \times \mathbf{B} - h^2/m^2 \nabla^2 \\ m^2 &= 0 \ E_i = -1/c\partial A_i / \\ (1-uv)/c^2) \ m^2 = 0 \ (1-uv)/c^2 \\ - (1-uv)/c^2$$

- STM32F405RG: 192k RAM, 1M ROM, 168MHz, Cortex M4F.
  USB micro connector for device (and host).
- Micro SD card.
- ► 3-axis accelerometer (MMA7660).  $\frac{1}{2} \frac{1}{2} \frac$
- ► Real-time clock, 4 LEDs, 2 switches.  $\frac{1}{2} = \frac{1}{2} + \frac{1}$
- 30 GPIO: symmetric pin layout, plus extra pins.<sup>4</sup> 40.<sup>4</sup> 4
- ► Internal file system. "/flash" and "/gd"  $\sum_{k=1}^{n} \sum_{m=1}^{n} \sum_{m=1}^$

#### MicroPython

 $+ u = GM/\Lambda^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar/2 \ p_i = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = p_i \ \partial_i dx = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = p_i \ \partial_i dx = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = p_i \ \partial_i dx = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = p_i \ \partial_i dx = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = p_i \ \partial_i dx = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \partial t \ H = -i\hbar \partial_i \ H$ 

 $\frac{2}{3}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2 \ \Delta\nu \approx 10^{-10} M_{\odot}^2 + 10^$ 

 $\geq h/2 p_{\ell} = -i\hbar\partial_{\ell} E = i\hbar\partial/\partial t H = p^{2}/2m + V H|a\rangle = E|a\rangle U = e^{Ht/i\hbar} \mathbf{F} = m\mathbf{a}\mathbf{F} = GMm\mathbf{r}/r^{3}\nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

# Pyboard usage

- Standard Python prompt (REPL) over USB serial device, or UART.
- Raw prompt: reads a Python script until EOF, executes it, then  $-r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \pi$  $=e^{2}/(2-i+\nabla,H)a) = E(a) U = e^{Ht/1\hbar} \quad \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{r}/r^{3} \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ sends back the result.  $d^{2} = dx^{2} - dx^{2} - dx^{2} - g_{\mu\nu} dx^{\mu} dx^{\nu} - g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$
- A script running from the flash/SD. Serial connection becomes  $T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$ stdin/stdout.
- $B/\delta t \nabla \times B = \mu J + 1/c^2 \delta E/\delta t F = a(E + y \times B) \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} yt) \mathbf{t}' = \gamma(t yt) \mathbf{x}'$ Powered by USB or battery.

	-	
D.P.	George	

 $ma F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

 $\sigma_{,\rho} = \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$ 

 $\psi^* \psi \mathrm{d} x = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \geq \hbar/2 \ p_4 = -i\hbar\partial_4 \ E = i\hbar\partial/\partial t \ H = p^2/2m + V \ (h^2/2m)^2 \$  $(x)\psi(x,t) = E\psi(x,t) x' = \gamma(x-yt) t' = \gamma(t-yx/c^2) \gamma = 1/(1-y^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t t'$  $A_{k} F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \partial_{\nu} F^{\mu\nu} = J^{\nu} \partial_{\nu} \tilde{F}^{\mu\nu} = 0 \, \mathrm{d}s^2 = c^2 \mathrm{d}t^2 - \mathrm{d}x^2 - \mathrm{d}y^2 - \mathrm{d}x^2 \, \mathrm{d}s^2 = g_{\mu\nu} \mathrm{d}x^{\mu} \mathrm{d}x^{\nu} \mathrm{d}x^{$  $a_{\mu}R = R_{\mu}^{R}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi GT_{\mu\nu} \ ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \ \Delta\nu \approx 10^{-10} \ ds^{2} + 10^{-10} \ ds^{2} +$  $\geq h/2|p_{s}| = -i\hbar\partial_{s}|E| = i\hbar\partial/\partial t|H| = p^{2}/2m + V|H|a\rangle = E|a\rangle|U| = e^{Ht/i\hbar}|\mathbf{F}| = m\mathbf{a}|\mathbf{F}| = GMm\mathbf{r}/r^{3}|\nabla \cdot \mathbf{E}| = \rho/\epsilon|\nabla \cdot \mathbf{B}| = 0|\nabla \times \mathbf{E}| = -\partial \mathbf{B}/\partial t|H|$  ${}^{i\nu} = J^{\nu} \ \partial_{\nu} \tilde{F}^{\mu\nu} = 0 \ \mathrm{d}s^2 = c^2 \mathrm{d}t^2 - \mathrm{d}x^2 - \mathrm{d}y^2 - \mathrm{d}z^2 \ \mathrm{d}s^2 = g_{\mu\nu} \mathrm{d}x^{\mu} \mathrm{d}x^{\nu} \ g_{\mu\nu} (\mathrm{d}x^{\mu}/\mathrm{d}\tau) (\mathrm{d}x^{\nu}/\mathrm{d}\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + \frac{1}{2} (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\mu\sigma,\mu}) + \frac{1}{2} (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\mu\sigma,\mu}) + \frac{1}{2} (g_{\mu\nu,\sigma} - g_{\mu\sigma,\mu}) +$  $E[a] U = e^{Ht/i\hbar} \quad \mathbf{F} = \max \mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $\tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma me^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \$  $y^2 = dx^2 - dx^2 = g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\sigma}(dx^{\mu}/dr)(dx^{\nu}/dr) = 1 \quad \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - dv^{\mu}/dx + \Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma} = 0 \quad R^{\mu}_{\mu\sigma\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\sigma,\sigma} + \Gamma^{\alpha}_{\nu\sigma} - \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} - \Gamma^{\alpha}_{\nu}$  $|M|r| = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta v \approx v_i G M (1/r_i - 1/r_i) d^2 u / d\phi^2 + u - G M / A^2 - 3G M u^2 = 0 \ \delta = 2G M / R \ [\psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x, t)|^2 \ \psi(x,$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \ \mathbf{F} = q \left( \mathbf{E} + \mathbf{v} \times \mathbf{B} \right) - h^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) \ x' = \gamma (x - vt) \ t' = \gamma (t - v) + (x - v)$  $=\psi)/(1-u\nu/c^2) \ p = \gamma m\nu \ E = \gamma mc^2 \ E^2 = p^2c^2 + m^2c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c\partial A_i/\partial t - \partial_i\phi \ B_i = \epsilon_{ijk}\partial_iA_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \dot{F}^{\mu\nu} = 1/2\epsilon^{\mu} \partial_iA_k \ A^\mu = 0 \ A^\mu \ \dot{F}^{\mu\nu} = 1/2\epsilon^{\mu} \partial_iA_k \ A^\mu = 0 \ \dot{F}^{\mu\nu} = 1/2\epsilon^{\mu} \partial_iA_k \ \dot{F}^{\mu\nu} = 0 \ \dot{F}^{\mu\nu}$  $= 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ \mathrm{d}\nu^{\mu}/\mathrm{d}s + \Gamma^{\mu}_{\nu\sigma}\nu^{\nu}\nu^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \int \psi^* \psi dx = 1 P(x,t) = |\psi(x,t)|^2 \psi(x,t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \geq \hbar/2 \ p_i = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \langle x, t \rangle = |\psi(x,t)|^2 \langle \psi | x \rangle = 0$ 

 $F = maF = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q (E + v \times B) - \hbar^2/2m\nabla^2 \psi$ pyboard demo  $2m + V |H|_{\Phi}$  =  $E|_{\Phi}$   $U = e^{Ht/|h|} \mathbf{F} = m\mathbf{a} \mathbf{F} = GMm\mathbf{r}/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $= dx^{2} - dz^{2} - dz^{2} - dz^{2} - dz^{2} - g_{\mu\nu} dz^{\mu} dz^{\nu} - g_{\mu\nu} (dz^{\mu}/dr) (dz^{\nu}/dr) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $\mathbf{P} = GMin_{\mathbf{r}}/e^{3} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^{2} \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^{2}/2m\nabla^{2}\psi$  $p/\pi T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_4 = -1/c \partial A_4$  $\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = a (E + y \times B) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{y}t) \mathbf{t}' = \gamma(t - \mathbf{y})$  $(1) dv^{\mu} f ds + \Gamma^{\nu}_{\nu\sigma} v^{\nu} v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\mu}_{\alpha\sigma} \ R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $= 2GM/R | \psi^* \psi dx - 1 P(x, t) = |\psi(x, t)|^2 | \psi(x, t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \ge \hbar/2 | p_4 = -i\hbar\partial_4 E = i\hbar\partial/\partial t | H = p^2/2m + V | \psi \rangle \langle x | \psi \rangle = 0$  $t) + V(x)\psi(x, t) = E\psi(x, t) x' + \gamma(x - vt) t' + \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi + t \cosh \xi = -t \sinh \xi + t \sin \xi + t$  $=\epsilon_{14k}\partial_{1}A_{k}F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu}F^{\mu\nu} = 1/2\epsilon^{\mu\nu\rho\sigma}F_{\rho\sigma}\partial_{\nu}F^{\mu\nu} = J^{\nu}\partial_{\nu}F^{\mu\nu} = 0 \ \mathrm{d}x^{2} = c^{2}\mathrm{d}t^{2} - \mathrm{d}x^{2} - \mathrm{d}y^{2} - \mathrm{d}x^{2} \ \mathrm{d}x^{2} = g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu} \ \mathrm{d}x^{\mu}\mathrm{d}x^{\nu} \ \mathrm{d}x^{\mu}\mathrm{d}x^{\nu} = 0 \ \mathrm{d}x^{\mu}\mathrm{d}x^{\mu$  $a_{R} = R_{\mu}^{R} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \ \Delta\nu \approx 10^{-10} \ ds^{2} + 10^{-10} \ ds^{2}$  $\ln \Delta \mu \ge \hbar/2 \ \mu_1 = -i\hbar\partial_1 \ E = i\hbar\partial/\partial t \ H = \mu^2/2m + V \ H|a\rangle = E|a\rangle \ U = e^{Ht/i\hbar} \ \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{r}/r^3 \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $F^{\mu\nu} = J^{\nu} \partial_{\nu} F^{\mu\nu} = 0 \, dx^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 \, dx^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + g_{\mu\nu,\sigma} g_{\mu\nu,\sigma} + g_{$  $a) = E[a) U = e^{Ht/\hbar} F = ma F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q(E + \mathbf{v} \times B) - \hbar^2/2m\nabla^2 \psi$  $ah\xi \tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial A_i$  $dy^2 = dx^2 - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - \Gamma^\mu_{\mu\rho\sigma} = 0$  $2GM/r) = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta \nu \approx \nu_c GM(1/r_c - 1/r_c) \ d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x$  $mr/r^{2} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^{2} \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^{2}/2m \nabla^{2} \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x}' + \frac{1}{2} (1 - v) \mathbf{x}' + \frac{$  $T_{0} u' = (u - v)/(1 - uv/c^{2}) p = \gamma mv E = \gamma mc^{2} E^{2} = p^{2}c^{2} + m^{2}c^{4} \partial_{\mu}J^{\mu} = 0 E_{i} = -1/c\partial A_{i}/\partial t - \partial_{i}\phi B_{i} = \epsilon_{ijk}\partial_{j}A_{k} F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}A^{\mu} F^{\mu\nu} = 0$  $=1\Gamma_{\mu\nu\sigma}=1/2(g_{\mu\nu\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})\,\,\mathrm{d}v^{\mu}/\mathrm{d}s+\Gamma_{\nu\sigma}^{\mu}v^{\nu}v^{\sigma}=0\,\,R_{\nu\rho\sigma}^{\mu}-\Gamma_{\nu\sigma,\rho}^{\mu}-\Gamma_{\nu\sigma,\sigma}^{\mu}\Gamma_{\alpha\rho}^{\mu}-\Gamma_{\alpha\rho}^{\nu}\Gamma_{\alpha\sigma}^{\mu}R_{\mu\nu}=R_{\mu\nu\sigma}^{\rho}R=R_{\mu}^{\mu}G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0$  $= 1/r_f \int d^2 u / d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \quad \delta = 2GM/R \int \phi^* \psi dx = 1 \quad P(x,t) = |\psi(x,t)|^2 \quad \psi(x,t) = |\psi(t)\rangle \quad \langle x \rangle = \langle \psi | x | \psi \rangle \quad \Delta x \Delta p \geq \hbar/2 \quad p_4 = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = p_4 \quad A = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = -i\hbar \partial_4 \quad$ 

### Manufacturing

### Jaltek Systems, Luton UK — manufactured 7000+ boards.



 $\frac{1}{2} = 9 - 9 \cos^2 \theta - 8 \cos^2 \theta^2 - 8 \cos^2 \theta^2 - 8 \cos^2 \theta - 8 \cos^2 \theta - 16 \cos^2 \theta - 17 \cos^2 \theta - 17 \sin^2 \theta - 17 \sin^2$ 



$$\begin{split} & d_{1}^{(2)} = d_{1}^{(2)} = p_{1,0}d^{(2)}d^{(2)}d^{(2)}d^{(2)}d^{(2)}(dx^{(2)}/dx^{(2)}) = 1 \quad \Gamma_{\mu\nu\sigma\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dx^{\mu}/dx + \Gamma_{\mu\sigma}^{\mu}v^{\mu}v^{\mu}v^{\mu} = 0 \quad R_{\mu\rho,\sigma}^{\mu} - \Gamma_{\mu\sigma,\mu}^{\mu} - \Gamma_{\mu\sigma,$$

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 $\nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$ 

### Testing and programming

$$\begin{split} & \psi(x_1(x, x)) = E\psi(x_1) + x^2 - \gamma(x - x) + x^2 - \gamma(x$$



 $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$  $A^{\nu} - \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $E = i\hbar \partial / \partial t H = p^2 / 2m + V$  $\sinh \xi t' = t \cosh \xi - x \sinh \xi t t$  $^{2} - dz^{2} ds^{2} = g_{\mu\nu} dx^{\mu} dx^{\nu}$  $r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$ 

 $S(2, 0) = S(M/v) - v^2 dv^2 - v^2 du^2 du^2 du = w_1 GM(1/v_1 - 1/v_2) d^2 / dv^2 + u - GM/A^2 - 3GMx^2 - 0.8 - 2GM/R \int \Psi^* \psi dx = 1 P(x, 1) = |\psi(x, 1)|^2 \psi(x, 1) = v(1) + 1/v^2 du^2 / dv^2 + u - GM/A^2 - 3GMx^2 - 0.8 - 2GM/R \int \Psi^* \psi dx = 1 P(x, 1) = |\psi(x, 1)|^2 \psi(x, 1) = v(1) + 1/v^2 du^2 / dv^2 / dv^2 + u - GM/A^2 - 3GM/R \int \Psi^* \psi dx = 1 P(x, 1) = |\psi(x, 1)|^2 \psi(x, 1) = v(1) + 1/v^2 du^2 / dv^2 / dv^2 + u - 1/v^2 / du^2 / dv^2 + u - 1/v^2 / du^2 / dv^2 + u - 1/v^2 / du^2 / du^2$ 

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### MicroPython Live — http://micropython.org/live/



 $\mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $E + v \times B$ )  $-\hbar^2/2m\nabla^2\psi$  $\mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}$  $E + \mathbf{v} \times \mathbf{B} = -\hbar^2/(2m\nabla^2 \mathbf{v})$  $J^{\mu} = 0 E_i = -1/c\partial A_i$  $- \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $= R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $i\hbar\partial/\partial t H = p^2/2m + V$  $dz^2 dz^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu}$  $\theta^2 = r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $\mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}$  $M/A^2 - 3GMu^2 = 0.8 =$  $\mathbf{E} + \mathbf{v} \times \mathbf{B} = -\hbar^2/(2m\nabla^2 v)$  $J^{\mu} = 0 E_i = -1/c\partial A_i$  $- \partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $= R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $i\hbar\partial_i E = i\hbar\partial/\partial t H = j$ 

# Other hardware

MicroPython runs on lots of other hardware:

D.P. George

- STM32F4xx discovery boards,
- Espruino Pico (STM32F401),
- CC3200 wi-fi SoC (WiPy),
- ESP8266 wi-fi SoC.
- 16-bit dsPIC33F.

 $\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $\int_{\mu\nu} ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$ (a)  $U = e^{Ht/4\hbar}$   $\mathbf{F} = m\mathbf{a} \mathbf{F} = GMm\mathbf{r}/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $dx^2 = g_{\mu\nu}dx^{\mu}dx^{\nu} g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $i \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 q$  $(u - v)/(1 - uv/c^2) p = \gamma m v E = \gamma m c^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$  $+1/c^2\partial \mathbb{E}/\partial t = a\left(\mathbb{E} + \mathbf{v} \times \mathbf{B}\right) - h^2/2m\nabla^2\psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t)\mathbf{t}' = \gamma(t - \mathbf{v}t)$  $v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\alpha\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\alpha\sigma}\Gamma^{\mu}_{\alpha\sigma} \ R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} \ R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $\psi(x, t) = E\psi(x, t) x' - \gamma(x - vt) t' - \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t t'$  $\lambda_{k} F^{\mu\nu} = \partial^{\mu} \lambda^{\nu} - \partial^{\nu} \lambda^{\mu} \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \partial_{\nu} F^{\mu\nu} = J^{\nu} \partial_{\nu} \tilde{F}^{\mu\nu} = 0 \, \mathrm{d}s^{2} = c^{2} \mathrm{d}t^{2} - \mathrm{d}x^{2} - \mathrm{d}y^{2} - \mathrm{d}z^{2} \, \mathrm{d}z^{2} = g_{\mu\nu} \mathrm{d}x^{\mu} \mathrm{d}x^{\nu} \mathrm{d}z^{\nu} \mathrm{d$  $R = R_{\mu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2 \ \Delta\nu \approx 10^{-10} \ ds^2 + 10^{-10} \ ds^2 = 10^{-10} \ ds^2 + 10^{-10} \ ds^2 + 10^{-10} \ ds^2 = 10^{-10} \ ds^2 + 10^{-10} \ ds^2 = 10^{-10} \ ds^2 + 10$  $\geq h/2|p_{s}| = -i\hbar\partial_{s}|E| = i\hbar\partial/\partial t|H| = p^{2}/2m + V|H|a\rangle = E|a\rangle|U| = e^{Ht/i\hbar}|\mathbf{F}| = m\mathbf{a}|\mathbf{F}| = GMm\mathbf{r}/r^{3}|\nabla \cdot \mathbf{E}| = \rho/\epsilon|\nabla \cdot \mathbf{B}| = 0|\nabla \times \mathbf{E}| = -\partial \mathbf{B}/\partial t|H|$  $s^{\mu\nu} = J^{\nu} \ \delta_{\nu} F^{\mu\nu} = 0 \ \mathrm{d} s^{2} = c^{2} \mathrm{d} t^{2} - \mathrm{d} s^{2} - \mathrm{d} y^{2} - \mathrm{d} s^{2} \ \mathrm{d} s^{2} = g_{\mu\nu} \mathrm{d} s^{\mu} \mathrm{d} s^{\nu} \ g_{\mu\nu} (\mathrm{d} s^{\mu}/\mathrm{d} r) (\mathrm{d} s^{\nu}/\mathrm{d} r) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \mathrm{d} s^{\mu} \mathrm{d} s^{\mu} \ \mathrm{d} s^{\mu} + \mathrm{d} s^{\mu} \mathrm{d} s^$  $= E[a] U = e^{Ht/i\hbar} \quad \mathbf{F} = \max \mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $h \xi \tanh \xi = v/c \cosh \xi = \gamma L = L_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma me^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_4 = -1/c \partial A_4/c^2$  $ly^2 = dz^2 - dz^2 - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\rho}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^{\mu}/ds + \Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\mu\sigma\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\sigma,\sigma} + \Gamma^{\alpha}_{\nu\sigma} - \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} - \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} - \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu$  $2GM/r) = r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta v \approx v_c GM(1/r_c - 1/r_c) d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t)$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \ \mathbf{F} = q \left( \mathbf{E} + \mathbf{v} \times \mathbf{B} \right) - h^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) \ x' = \gamma (x - vt) \ t' = \gamma (t - v) + (x - v)$  $= \upsilon / (1 - \upsilon \nu / c^2) \ p = \gamma m \upsilon \ E = \gamma m c^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial_A_i / \partial t - \partial_i \phi \ B_i = \epsilon_{ijk} \partial_j A_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \dot{F}^{\mu\nu} = 1/2 \epsilon^{\mu \nu}$  $= 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ \mathrm{d}\nu^{\mu}/\mathrm{d}s + \Gamma^{\mu}_{\nu\sigma}\nu^{\nu}\nu^{\sigma} = 0 \ R^{\nu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\rho} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \int \psi^* \psi dx = 1 P(x,t) = |\psi(x,t)|^2 \psi(x,t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \geq \hbar/2 \ p_i = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \langle x, t \rangle = |\psi(x,t)|^2 \langle \psi | x \rangle = 0$ MicroPython 29/61

 $\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ Part III: The Kickstarter campaign  $H[a) = E[a) U = e^{Ht/4\hbar} \mathbf{F} = ma\mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $dx^{2} - dz^{2} dz^{2} = g_{\mu\nu}dz^{\mu}dz^{\nu} g_{\mu\nu}(dz^{\mu}/d\tau)(dz^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $L_{n}/v \ T = \gamma T_{n} \ u' = (u-v)/(1-uv/c^{2}) \ p = \gamma mv \ E = \gamma mc^{2} \ E^{2} = p^{2}c^{2} + m^{2}c^{4} \ \partial_{u} \ J^{\mu} = 0 \ E_{i} = -1/c\partial A_{i}$  $=p^2c^2 + m^2c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c\partial A_i/\partial t - \partial_i\phi \ B_i = \epsilon_{ijk}\partial_j A_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $dv + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\sigma\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\alpha}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\alpha}_{\alpha\sigma} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $\psi^* \psi \, dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge h/2 \ p_4 = -i\hbar\partial_4 \ E = i\hbar\partial/\partial t \ H = p^2/2m + V \ (h/2) \ h/2 \ h/$  $|\psi(x,t) - E\psi(x,t)| x' - \gamma(x-yt)|t' - \gamma(t-yx/c^2)|\gamma = 1/(1-y^2/c^2)^{1/2}|x'| = -t\sinh\xi + x\cosh\xi|t'| = t\cosh\xi - x\sinh\xi|t|$  $F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \ \bar{F}^{\mu\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \ \partial_{\nu} F^{\mu\nu} = J^{\nu} \ \partial_{\nu} \bar{F}^{\mu\nu} = 0 \ \mathrm{d}s^2 = c^2 \mathrm{d}t^2 - \mathrm{d}x^2 - \mathrm{d}y^2 - \mathrm{d}z^2 \ \mathrm{d}s^2 = g_{\mu\nu} \mathrm{d}x^{\mu} \mathrm{d}x^{\nu} \mathrm{d}x^{$  $=R_{\mu}^{\mu}G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0\ G_{\mu\nu}=8\pi GT_{\mu\nu}\ ds^{2}=(1-2GM/r)dt^{2}-dr^{2}/(1-2GM/r)-r^{2}d\theta^{2}-r^{2}\sin^{2}\theta d\phi^{2}\ \Delta\nu\approx 10^{-10}$  $\geq h/2|p_{s}| = -i\hbar\partial_{s}|E| = i\hbar\partial/\partial t|H| = p^{2}/2m + V|H|a\rangle = E|a\rangle|U| = e^{Ht/i\hbar}|\mathbf{F}| = m\mathbf{a}|\mathbf{F}| = GMm\mathbf{r}/r^{3}|\nabla \cdot \mathbf{E}| = \rho/\epsilon|\nabla \cdot \mathbf{B}| = 0|\nabla \times \mathbf{E}| = -\partial \mathbf{B}/\partial t|H|$  $= J^{\mu} \partial_{\nu} \beta^{\mu\nu} = 0 \, ds^2 = c^2 dt^2 - dx^2 - dx^2 - dx^2 - dx^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + g_{\mu\nu,\mu} (dx^{\mu}/d\tau) = 0 \, dx^2 = 0 \, dx^2 + 0 \,$  $E[\phi] U = e^{Ht/\hbar} \quad F = \max F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q(E + \mathbf{v} \times B) - \hbar^2/2m\nabla^2 \psi$  $\xi \tanh \xi = v/c \cosh \xi = \gamma L = L_0/\gamma T = \gamma T_0 u' = (u-v)/(1-uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_4 = -1/c \partial A_4/c^2$  $\mathrm{d} x^2 - \mathrm{d} x^2 - \mathrm{g}_{\mu\nu}\mathrm{d} x^\mu \mathrm{d} x^\nu - \mathrm{g}_{\mu\nu}\mathrm{d} x^\mu \mathrm{d} \tau) \\ + 1 \Gamma_{\mu\sigma} - 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - \mathrm{d} v^\mu \mathrm{d} s \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\nu \mathrm{d} \sigma \\ = 0 \\ R_{\mu\rho\sigma}^\mu \mathrm{d} \sigma \\ - \Gamma_{\mu\sigma}^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} v^\mu \mathrm{d} \sigma \\ + \Gamma_{\mu\sigma}^\mu \mathrm{d} v^\mu \mathrm{d}$  $=r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \Delta \nu \approx \nu_{s}GM(1/r_{t} - 1/r_{f}) d^{2}u/d\phi^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \delta = 2GM/R \int \psi^{*}\psi dx = 1 P(x, t) = |\psi(x, t)|^{2} \psi(x, t) = |$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \ \mathbf{F} = q \left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right) - h^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \ \mathbf{x}' = \gamma(x - vt) \ t' = \gamma(t - vt) \ t' = \gamma(x - vt) \ t' \ t' = \gamma(x - vt) \ t' = \gamma(x - v$  $= \upsilon / (1 - \upsilon \nu / c^2) \ p = \gamma m \upsilon \ E = \gamma m c^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial_A_i / \partial t - \partial_i \phi \ B_i = \epsilon_{ijk} \partial_j A_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \dot{F}^{\mu\nu} = 1/2 \epsilon^{\mu \nu}$  $= 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ \mathrm{d}\nu^{\mu}/\mathrm{d}s + \Gamma^{\mu}_{\nu\sigma}\nu^{\nu}\nu^{\sigma} = 0 \ R^{\nu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\rho} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $2u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar/2 \ p_i = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ E = -i\hbar\partial_i \ E$ 

# Crowd funding

Pitch an idea, get the public to fund it, give them something in return.

Started by ArtistShare in 2003. IndieGoGo in 2008, Kickstarter in 2009, plus many others.

- Musicians, photographers, writers, video games, hardware, ....
- Science projects
- Roll your own

2012: US\$2.7 billion, more than one million individual campaigns2013: crowdfunding industry grew to over \$5.1 billion

Kickstarter: collected so far over US\$1 billion in funds

$$\begin{split} & = 0^{-2} (11 + 30M/r) + r^2 dr^2 - r^2 dr^2 du^2 du^2 - due = v_0 GM(1/r_1 - 1/r_2) r^2 a^2 u/d\theta^2 + u - GM/A^2 - 3GMA^2 = 0 d + 2GM/B \int \phi^2 \phi^2 dx = 1 P(x, 1) = [\phi(x, 1)^2 - \phi(x, 1) - [\phi(x, 1)^2 - \phi(x, 1) - [\phi(x, 1)^2 - \phi(x, 1) -$$

 $Mmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $\mu J + 1/c^2 \partial E / \partial t F = a (E + y \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

 $dy^2 = dx^2 - dx^2 - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$ 

 $w/v^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $v = \gamma T_0 \ u' = (u - v)/(1 - uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2c^2 + m^2c^4 \ \partial_{\mu}J^{\mu} = 0 \ E_4 = -1/c\partial A_4$ 

 $\begin{array}{l} & (z + 1)^{-2} \partial E_i (\partial t \ F = q \ (E + v \ X)) - \lambda^2 / 2m^{2/2} (\psi_i \ t) + V(u) \psi(u, t) = E_i \psi(u, t) = U(u - 1)^{-2} (z - 1)^{-2} (t - 1)^{-2} (t - 1)^{-2} (z - 1$ 

### The stages

Stage 1: the idea!

- Prototyping.
- Fear that someone will beat you.
- Rush to get it online.
- Making the campaign, including video.

Stage 2: the campaign.

Stage 3: fulfillment.

- Spend all the money, buy lots of stuff.
- Finalise your idea and mass produce it.
- Lots of delays.
- ► Work out how to post 1000s of parcels.
- Packing and shipping.  $\sum_{n=1}^{L} (\sum_{j=1}^{L} \tau \tau_{D_{n}} \tau_{j}^{n} (z_{n-j})^{2} (z_{n-j})^{2} y_{n-k} y_{n-k-2} y_{n-k} y_{n-k} y_{n-k} y_{n-k-2} y$ 
  - Returns, complaints, support, etc.  $r_{\mu,\mu} = r_{\mu,\mu} = r_{\mu,\mu}$

 $\times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

 $\log GT_{\mu\nu} ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta\nu \approx$ =  $E(s) U = e^{Ht/i\hbar} \mathbf{F} = ma \mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $b_{1}^{-2} - dx^{2} - dx^{2} = g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}(dx^{\mu}/dr)(dx^{\mu}/dr) = 1 - \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$   $v_{1} - v^{2}dt^{2} - v^{2} - dx^{2} - dx^{2} - dx^{2} - \omega v_{1}(M/t_{1}^{r} - t/r_{f}) - d^{2}w/d\sigma^{2} + u - GM/A^{2} - 3GMu^{2} = 0 =$   $E = \rho/v \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/c^{2}\partial E/\partial t F = q (E + v \times B) - \hbar^{2}/2m\nabla^{2}q$  $v_{1}^{r} = (u - w)(r_{1} - w)c^{2} - m v = m w E = -mu^{2}E^{2} - \mu^{2}c^{2} + m^{2}c^{4} - g_{\mu}H = 0 = R_{1} = -1/c\partial M_{1}$ 

 $\nu = 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^2 = (1 - 2GM/r)dt^2 - dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2 \ \Delta\nu \approx 10^{-10} \ ds^2 + 10^{-10} \ ds^2$ 

 $\partial t H = p^2 / 2m + V H |a\rangle = E |a\rangle U = e^{Ht/\hbar\hbar} \mathbf{F} = m\mathbf{a} \mathbf{F} = GMm\mathbf{r} / r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$ 

 $\partial B / \partial t \nabla \times B = \mu J + 1/c^2 \partial E / \partial t F = q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$  $(\varepsilon - vx/c^2) \ \gamma = 1/(1 - v^2/c^2)^{1/2} \ x' = -t \sinh \xi + x \cosh \xi \ t' = t \cosh \xi - x \sinh \xi \tan \xi$ Stage 1: the idea  $\mathcal{U} = e^{2}/(2m + V | H| a) = E|a| \mathcal{U} = e^{Ht/i\hbar} |\mathbf{F}| = m\mathbf{a} |\mathbf{F}| = GMm\mathbf{r}/r^3 |\nabla \cdot \mathbf{E}| = \rho/\epsilon |\nabla \cdot \mathbf{B}| = 0 |\nabla \times \mathbf{E}| = -\partial \mathbf{B}/\partial t$  $dx^{2} - dy^{2} - dz^{2} dz^{2} = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} (dx^{\mu}/dr) (dx^{\nu}/dr) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$  $dv^{\mu}/ds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\mu\rho} - \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\mu}_{\mu\rho}R = R^{\mu}_{\mu}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $2GM/R \int \psi^* \psi \, \mathrm{d}x = 1 P(x,t) = |\psi(x,t)|^2 \psi(x,t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \ge \hbar/2 \ p_4 = -i\hbar\partial_4 \ E = i\hbar\partial/\partial t \ H = p^2/2m + V$  $+ V(x)\psi(x, t) - E\psi(x, t) x' - \gamma(x - vt) t' - \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t t'$  $s_{\ell+1,k}\partial_{\ell}A_{k}F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu}\tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu\rho\sigma}F_{\rho\sigma}\partial_{\nu}F^{\mu\nu} = J^{\nu}\partial_{\nu}\tilde{F}^{\mu\nu} = 0 \ \mathrm{d}x^{2} = \epsilon^{2}\mathrm{d}t^{2} - \mathrm{d}x^{2} - \mathrm{d}y^{2} - \mathrm{d}x^{2} \ \mathrm{d}x^{2} = g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu}$  $a_{\mu}R = R_{\mu}^{R}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi GT_{\mu\nu} \ ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \ \Delta\nu \approx 10^{-10} \ ds^{2} + 10^{-10} \ ds^{2} +$  $e^{\Delta p} \geq \hbar/2 \ p_{z} = -i\hbar\partial_{z} \ E = i\hbar\partial/\partial t \ H = p^{2}/2m + V \ H|a\rangle = E|a\rangle \ U = e^{Ht/i\hbar} \ \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{r}/r^{3} \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $f^{\mu\nu} = J^{\nu} \, \delta_{\nu} f^{\mu\nu} = 0 \, ds^2 = c^2 dt^2 - dx^2 - dx^2 - dz^2 \, ds^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} \, g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \, dx^{\mu} \,$  $= E[a] U = e^{Ht/\hbar h} F = ma F = GMmr/e^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/e^2 \partial E/\partial t F = g(E + \mathbf{v} \times B) - \hbar^2/2m\nabla^2 \psi$  $dh\xi \tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_4 = -1/c \partial A_4$  $|y^2 - dx^2 - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^{\mu}/ds + \Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} - \Gamma^{\mu}_{\mu\rho,\sigma} + \Gamma^{\sigma}_{\mu\rho} + \Gamma^{\sigma}_{\mu\rho,\sigma} + \Gamma^{\sigma}_{\mu$  $2GM/r) = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta \nu \approx \nu_c GM(1/r_c - 1/r_c) \ d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x$  $e^{\frac{1}{2}} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x} + \frac{1}{2} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{E} = -\partial \mathbf{E}/\partial t \nabla \mathbf{x} + \frac{1}{2} \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x} + \frac{1}{2} \partial \mathbf{E}/\partial t \mathbf{x} + \frac{1}{2$  $=(u-v)/(1-uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c\partial A_i/\partial t - \partial_i \phi B_i = \epsilon_{ijk} \partial_j A_k F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu} (1-v)^2 (1-v)^2$  $1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma_{\nu\sigma}^{\mu}v^{\nu}v^{\sigma} = 0 \ R_{\nu\sigma\sigma}^{\mu} = \Gamma_{\nu\sigma,\rho}^{\mu} - \Gamma_{\nu\rho}^{\mu} + \Gamma_{\nu\sigma}^{\alpha}\Gamma_{\mu\sigma}^{\mu} - \Gamma_{\nu\rho}^{\alpha}\Gamma_{\mu\sigma}^{\alpha} R_{\mu\nu} = R_{\mu\nu\sigma}^{\beta}R = R_{\mu}^{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ R_{\mu\nu\sigma}^{\mu} + R_{\mu\sigma}^{\mu}R_{\mu\nu}^{\mu} + R_{\mu\nu\sigma}^{\mu}R_{\mu\nu}^{\mu}R_{\mu\nu}^{\mu} + R_{\mu\nu\sigma}^{\mu}R_{\mu\nu}^$  $1/r_{f} \int d^{2}u/d\phi^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \quad \delta = 2GM/R \quad \int \phi^{*} \psi dx = 1 \quad P(x,t) = |\psi(x,t)|^{2} \quad \psi(x,t) = |\psi(t)\rangle \quad \langle x \rangle = \langle \psi|x|\psi \rangle \quad \Delta x \Delta p \geq \hbar/2 \quad p_{\xi} = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = i\hbar\partial/\partial t \quad H = p_{\xi} \quad (h = -i\hbar) = -i\hbar\partial_{\xi} \quad E = -i\hbar\partial_{\xi}$ 

### Idea for MicroPython

- System on a Chip: CPU, RAM, flash memory, timers, USB, Ethernet.
- Sensors: touch, accelerometer, gyroscope, compass, barometer.
- Outputs: LEDs, LCDs, DC motors, servos.  $v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$

 $\times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 



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Goal: Make it easy for people to program their electronics projects.  $\psi(x,t) = E\psi(x,t) \ x' = \gamma(x-yt) \ t' = \gamma(t-yx/c^2) \ \gamma = 1/(1-y^2/c^2)^{1/2} \ x' = -t \sinh \xi + x \cosh \xi \ t' = t \cosh \xi - x \sinh \xi \ t_0$ Idea: Shrink Python to run on a  $p_1 = -i\hbar \partial_1 E = i\hbar \partial/\partial t H = p^2/2m + V H|a\rangle = E|a\rangle U = e^H$ microcontroller.  $-t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi \tanh \xi = v/c \cosh \xi - y u = u \mu$  $\hat{r}^{\mu\nu} = 0 \, \mathrm{d}x^2 = \hat{c}^2 \mathrm{d}t^2 - \mathrm{d}x^2 - \mathrm{d}y^2 - \mathrm{d}z^2 \, \mathrm{d}x^2 = g_{\mu\nu} \mathrm{d}x^{\mu} \mathrm{d}x^{\nu} \, g_{\mu\nu} (\mathrm{d}x^{\mu}/\mathrm{d}\tau) (\mathrm{d}x^{\nu}/\mathrm{d}\tau) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\mu\sigma,\nu}) \, \mathrm{d}x^{\mu} \mathrm{d}$ gur.u)  $\mathbb{E}[a] U = e^{Ht/\hbar} = ma \mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \mathbf{X} \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \mathbf{X} \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = g(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $\tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0 \ J^\mu = -1/c \partial A_i \ J^\mu = 0$  $e^{2} = dz^{2} - dz^{2} - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\sigma}(dx^{\mu}/dr)(dx^{\nu}/dr) = 1 \Gamma_{\mu\nu\sigma} - 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - dv^{\mu}/ds + \Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma} = 0 R^{\mu}_{\mu\sigma,\rho} - \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} - \Gamma^{\mu}_{\nu\sigma} - \Gamma^{\mu}_{\nu$ 

 $2GM/r) = r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta v \approx v_c GM(1/r_c - 1/r_c) d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t)$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \ \mathbf{F} = q \left( \mathbf{E} + \mathbf{v} \times \mathbf{B} \right) - h^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) \ x' = \gamma (x - vt) \ t' = \gamma (t - v) + (x - v)$  $=v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i / \partial t - \partial_i \phi \ B_i = \epsilon_{ijk} \partial_j A_k \ F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \ \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu} \partial_i A_i \ A_i = -1/c \partial A_i / \partial t - \partial_i \phi \ B_i = -1/c \partial_i A_i \ A_i = -1/c \partial_i$  $= 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ \mathrm{d}\nu^{\mu}/\mathrm{d}s + \Gamma^{\mu}_{\nu\sigma}\nu^{\nu}\nu^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $dd\phi^2 + u - GM/\lambda^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ (x) = \langle \psi|x|\psi \rangle \ \Delta x \Delta p \ge h/2 \ p_i = -i\hbar \partial_i \ E = i\hbar \partial/\partial t \ H = 1 \ h/2 \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \ H = -i\hbar \partial_i \ E = i\hbar \partial_i \ H = -i\hbar \partial_i \ H =$ 

D.P. George

MicroPython

### Initial development

- 30th April 2013: start!
- 17th September: flashing LED with switch in bytecode Python.
- 21st October: REPL, filesystem, USB VCP and MSD on PYBv2.



# 1 weekend to make the video. Kickstarter launched on 13 November 2013, ran for 30 days. Officially finished 12 April 2015.

 $a) = E[a) U = e^{Ht/\hbar} F = ma F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $J + 1/c^2 \partial E / \partial t F = q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

$$\begin{split} \nabla \cdot \mathbf{B} &= 0 \ \nabla \times \mathbf{E} = -0 \mathbf{B}/0t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\varepsilon^2 \partial \mathbf{E}/0t \ \mathbf{F} = q \left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right) - \hbar^2/2m\nabla^2 \psi \\ &= v/(1 - w(\varepsilon^2) \ p = \gamma m \ \mathbf{E} = \gamma m \varepsilon^2 \mathbf{E}^2 = p^2 \varepsilon^2 + m^2 \varepsilon^4 \ \mu_\mu \mathcal{I}^\mu = 0 \ \mathbf{E}_i = -1/\varepsilon \partial A_i \\ &/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^\mu / ds + \Gamma^\mu_{\mu\sigma} v^\nu v^\sigma = 0 \ R^\mu_{\mu\rho\sigma} = \Gamma^\mu_{\nu\sigma,\mu} - \Gamma^\mu_{\nu\rho,\sigma} + \Gamma^\sigma_{\mu\sigma} \end{split}$$

$$\begin{split} & d^{2} \left( m^{2} f (1 - m^{2}) d^{2} - r^{2} dm^{2} dm$$

D.P. George

MicroPython

 $\partial B / \partial t \nabla \times B = \mu J + 1/c^2 \partial E / \partial t F = q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$  $=\gamma(t-vx/c^2)$   $\gamma = 1/(1-v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi ta$ Stage 2: the campaign and a start of the campaign and the start of the  $(a + \nabla H)a) = E[a) U = e^{H\overline{i}/i\hbar}$  F = ma F =  $GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $= dx^{2} = dy^{2} = dx^{2} = dx^{2} = g_{\mu\nu}dx^{\mu}dx^{\nu} = g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \quad \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_4 = -1/c \partial A_4$  $dv^{\mu}/ds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\mu\rho} - \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\sigma} R_{\mu\nu} = R^{\mu}_{\mu\rho}R = R^{\mu}_{\mu}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $+ V(x)\psi(x, t) - E\psi(x, t) x' - \gamma(x - vt) t' - \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi t t'$  $\epsilon_{11k} \partial_1 A_k \ F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \ \bar{F}^{\mu\nu} = 1/2 \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \ \partial_{\nu} F^{\mu\nu} = J^{\nu} \ \partial_{\nu} \bar{F}^{\mu\nu} = 0 \ \mathrm{d}s^2 = c^2 \mathrm{d}t^2 - \mathrm{d}s^2 - \mathrm{d}s^2 - \mathrm{d}s^2 = g_{\mu\nu} \mathrm{d}s^{\mu} \mathrm{d}s^{\nu} f^{\mu\nu} = 0 \ \mathrm{d}s^2 = c^2 \mathrm{d}s^2 + c^2 \mathrm{d}s^2 +$  $a_{\mu}R = R_{\mu}^{R}G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi GT_{\mu\nu} \ ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \ \Delta\nu \approx 10^{-10} \ ds^{2} + 10^{-10} \ ds^{2} +$  $\Delta p \ge \hbar/2 \ p_1 = -\hbar \partial_1 \ E = i\hbar \partial/\partial t \ H = p^2/2m + V \ H|a\rangle = E|a\rangle \ U = e^{Ht/i\hbar} \ \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{r}/r^3 \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $p^{\mu} = J^{\mu} \, \partial_{\nu} \bar{r}^{\mu\nu} = 0 \, ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 \, ds^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} \, g_{\mu\nu} (dx^{\mu}/dr) (dx^{\nu}/dr) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + g_{\mu\nu} (dx^{\mu}/dr) + g_{$  $= E[a] U = e^{Ht/h} F = ma F = GMmr/e^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/e^2 \partial E/\partial t F = q(E + \mathbf{v} \times B) - h^2/2m\nabla^2 \psi$  $dh\xi \tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_4 = -1/c \partial A_4$  $dy^2 = dx^2 - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - \Gamma^\mu_{\mu\rho\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - dv^\mu dx + \Gamma^\mu_{\mu\sigma}v^\mu v^\sigma = 0 - R^\mu_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\alpha_{\mu\rho,\sigma}$  $2GM/r) = r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta v \approx v_c GM(1/r_c - 1/r_c) d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2 d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R \left[\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t)$  $e^{\frac{1}{2}} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x} + \frac{1}{2} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{E} = -\partial \mathbf{E}/\partial t \nabla \mathbf{x} + \frac{1}{2} \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x} + \frac{1}{2} \partial \mathbf{E}/\partial t \mathbf{x} + \frac{1}{2$  $=(u-v)/(1-uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c\partial A_i/\partial t - \partial_i \phi B_i = \epsilon_{ijk} \partial_j A_k F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu} (1-v)^2 (1-v)^2$  $1 \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma_{\nu\sigma}^{\mu} v^{\nu} v^{\sigma} = 0 R_{\nu\sigma,\sigma}^{\mu} - \Gamma_{\nu\sigma,\sigma}^{\mu} - \Gamma_{\nu\sigma}^{\mu} \Gamma_{\alpha\sigma}^{\mu} - \Gamma_{\nu\sigma}^{\alpha} \Gamma_{\alpha\sigma}^{\mu} R_{\mu\nu} = R_{\mu\nu}^{\sigma} R_{\mu\nu} = R_{\mu\nu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2 g_{\mu\nu} R_{\mu\nu} = 0$  $1/r_f \| d^2 u / d\phi^2 + u - GM / A^2 - 3GM u^2 = 0 \ \delta = 2GM / R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar / 2 \ p_4 = -i\hbar \partial_4 \ E = i\hbar \partial/\partial t \ H = p_4 \ A^2 - 3GM u^2 = 0 \ \delta = 2GM / R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar / 2 \ p_4 = -i\hbar \partial_4 \ E = i\hbar \partial/\partial t \ H = p_4 \ A^2 - 3GM u^2 = 0 \ \delta = 2GM / R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar / 2 \ p_4 = -i\hbar \partial_4 \ E = i\hbar \partial/\partial t \ H = p_4 \ A^2 - 3GM u^2 = 0 \ \delta = 2GM / R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar / 2 \ p_4 = -i\hbar \partial_4 \ E = i\hbar \partial/\partial t \ H = p_4 \ A^2 - 3GM u^2 = 0 \ \delta = 2GM / R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge \hbar / 2 \ p_4 = -i\hbar \partial_4 \ E = i\hbar \partial/\partial t \ H = p_4 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 + i\hbar \partial_4 \ A^2 = 0 \ A^2 + i\hbar \partial_4 \ A^2 + i\hbar \partial_4$ 

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 $S(1)p_{1} = 1/r_{1})d^{2}w/d\delta^{2} + u = GM/A^{2} - 3GMu^{2} = 0 \delta = 2GM/B \int \psi^{*}\psi dx = 1 P(x, t) = |\psi(x, t)|^{2} \psi(x, t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \geq h/2 p_{1} = -i\hbar\partial_{1} E = i\hbar\partial/\partial t H = p_{1} = -i\hbar\partial_{1} E = i\hbar\partial/\partial t H = p_{1} = -i\hbar\partial_{1} E = i\hbar\partial/\partial t H = p_{1} = -i\hbar\partial_{1} E = i\hbar\partial/\partial t H = p_{2} = -i\hbar\partial_{1} E = -i\hbar\partial_{1}$ 

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		$L_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv E = \gamma mc^2 E^2$	$= p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$
		$(r)(dx^{\nu}/dr) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma^{\mu}_{\nu\sigma}$	$v^{\nu}v^{\sigma} = 0 R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$
		$M(1/r_1 - 1/r_f) d^2u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta = 2GM/R f$	$\psi^* \psi dx = 1 P(x, t) =  \psi(x, t) ^2 \psi(x, t) =  \psi(x, t) ^2$
	$= \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla$	$7 \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi$	$(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \ \mathbf{x}' = \gamma(\mathbf{x} - vt) \ t' = \gamma(t - vt)$
	$v)/(1 - uv/c^x) p = \gamma mv E = \gamma mc$	$e^x E^x = p^x e^x + m^x e^x \partial_{\mu} J^{\mu} = 0$ $E_i = -1/c \partial A_i / \partial t - \partial_i \phi$ $B_i = \epsilon_{ijk} \phi$	$\partial_j A_k F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu F^{\mu\nu} = 1/2\epsilon^{\mu\nu}$
		$\Gamma_{\nu\sigma}v^{\nu}v^{\sigma} = 0 R_{\nu\rho\sigma}^{\sigma} = \Gamma_{\nu\sigma,\rho}^{\sigma} - \Gamma_{\nu\rho,\sigma}^{\sigma} + \Gamma_{\nu\sigma}^{\alpha}\Gamma_{\alpha\rho}^{\mu} - \Gamma_{\nu\rho}^{\alpha}\Gamma_{\alpha\sigma}^{\mu} R_{\mu\nu} = I$	$R_{\mu\nu\rho} R = R_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$
	D.P. Coorgo	$m \neq \psi \cdot \psi dx = 1 P(x, t) =  \psi(x, t) ^2 \psi(x, t) =  \psi(t)\rangle \langle x \rangle = \langle \psi   x   \psi \rangle \Delta$ MicroDython	$E\Delta p \ge h/2 \ p_i = -ih\partial_i \ E = ih\partial/\partial t \ H = p$ $29/61$
	D.F. George	witcropython	50/01

 $F = \max F = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ Micro Python: Python for microcontrollers by Damien George Home Updates Backers Comments 💡 Cambridge, United Kingdom 🛛 🧬 Hardware Your project has launched! £0.00  $\Delta \nu \approx$ Congratulations, your project is live on Kickstarter 013 / 04 pledged of £15,000 doal Drummall 29 Here's your project URL: http://www.kickstarter.com/projects/214379695/micro-pythondays to go python-for-microcontrollers The countdown begins now. You know what to do: tell people about it! GOOD LUCK! Kickstarter -R = 010:09am GMT m + VFunding period  $\mu_{dx}\nu_{j}$ f Share (n) V Tweet (> Embed  $\Delta \nu \approx$ 

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Micro Python: Pytho

The Python language made lean and fast to run on microcontrollers. For beginners and experts, control your electronic project with ease Project by Damien George Cambridge, United Kingdom

 $\begin{aligned} & 4 \sin(1 + \sin(1 + w)c + \sin(1 + w)c + m)c = L_{0}(\gamma - m) \gamma_{0}^{2} \delta^{2} - ((n - w))(1 + w)c^{2} \right) p - \gamma \sin k = \gamma \sin^{2} k^{2} - p^{2}c^{2} + m^{2}c^{4} - \delta_{\mu}B - 0 - E_{\mu} - m'(2d_{\mu})c + m'(2d_{\mu}$ 

#### D.P. George

#### MicroPython

#### 1

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 $2m\nabla^2 \omega$ 

#### The Kickstarter journey What Is KICKSTARTER Help Signup Log in Kickstarter? Micro Python: Python for microcontrollers by Damien George Home Updates 2 Backers 228 Comments 11 328 backers $\Delta \nu \approx$ £15,005 DER / Det pledged of £15,000 goal Micro Python 27 days to go £1 minimum pledge This project will be funded on Friday Dec 13, 5:09am EST. $_{\nu}R = 0$ Funding period inh £ to Nov 13, 2013 - Dec 13, 2013 (20 days) "dz" ; f Share (556 Y Tweet <> Embed \* Remind me $\Delta \nu \approx$ 0B/01 Project by The Python language made lean and fast to run on Damien George microcontrollers. For beginners and experts, control your Cambridge, United Kingdom electronic project with ease First created - 2 backed What is Micro Python? $= 2GM/r) = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta \mu \approx \nu_c GM(1/r_c - 1/r_c) \ d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^*\psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi($ $GMmrfr^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{F} = g(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x}' + 2(1 - 1)\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{x}' = 2(1 - 1)\epsilon^2 \partial \mathbf{x}' + 2(1 - 1)\epsilon^2 \partial \mathbf{x}$ $=(u-v)/(1-uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c\partial A_i/\partial t - \partial_i \phi B_i = \epsilon_{ijk} \partial_j A_k F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu} (1-v)^2 (1-v)^2$ $1 \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma_{\nu\sigma}^{\mu} v^{\nu} v^{\sigma} = 0 R_{\nu\sigma,\sigma}^{\mu} - \Gamma_{\nu\sigma,\sigma}^{\mu} - \Gamma_{\nu\sigma}^{\mu} \Gamma_{\alpha\sigma}^{\mu} - \Gamma_{\nu\sigma}^{\alpha} \Gamma_{\alpha\sigma}^{\mu} R_{\mu\nu} = R_{\mu\nu}^{\sigma} R_{\mu\nu} = R_{\mu\nu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2 g_{\mu\nu} R_{\mu\nu} = 0$

D.P. George

MicroPython

 $\int e_x |d^2 u/d\phi^2 + u = GM/A^2 - 3GMu^2 = 0 \quad \delta = 2GM/R \int |\phi^* \psi dx = 1 \quad P(x,t) = |\psi(x,t)|^2 \quad \psi(x,t) = |\psi(t)\rangle \quad \langle x \rangle = \langle \psi | x | \psi \rangle \quad \Delta x \Delta p \geq h/2 \quad p_1 = -ih\partial_1 \quad E = ih\partial_1 \partial t \quad H = 1 \quad A = ih\partial_1 \partial t \quad H = ih\partial_1 \partial t \quad H = 1 \quad A = ih\partial_1 \partial$ 

$$\begin{split} & R_{11}(1) = R_{11}(1) + R_{12}(1) +$$



# Campaign timeline

### Funding progress

 $F = \max F = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 



- z sinn  $\xi$  tann  $\xi = v/c \cos \xi = \gamma L = L_0/\gamma I = \gamma I_0 u = (u - v)/(1 - uv/c) p = \gamma mv$  $\partial_{\nu}F^{\mu\nu} = 2^{\nu} \ \partial_{\nu}F^{\mu\nu} = 0 \ ds^2 = c^2 dt^2 - dx^2 - dy^2 - dx^2 \ ds^2 = g_{\mu\nu}dx^{\mu}dx^{\nu} \ g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $\forall H[a] = E[a] U = e^{Ht/(h)} \mathbf{F} = \max \mathbf{F} = GMmr/r^{3} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^{2} \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^{2}/2m\nabla^{2}\psi$  $= d_3^2 = d_4^2 - d_4^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} - g_{\mu\nu} dx^{\mu} dr^{\nu} = 1 \quad \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - dv^{\mu} dx + \Gamma^{\mu}_{\mu\sigma} v^{\nu} v^{\sigma} = 0 \quad R^{\mu}_{\mu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} = 0 \quad R^{\mu}_{\mu\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma} = 0 \quad R^{\mu}_{\mu\sigma} = 0 \quad R^{\mu$  $e^{2}(1) = 2GM/r) = r^{2}d\theta^{2} - r^{2}d\theta^{2} + e^{2}d\theta^{2} + \Delta r \approx \nu_{c}GM(1/r_{c} - 1/r_{c}) + d^{2}u/d\theta^{2} + u - GM/A^{2} - 3GMu^{2} = 0 = \delta = 2GM/R + \frac{1}{2}\psi^{*}\psi dx = 1 + \frac{1}{2}(r_{c}, t) = |\psi(x, t)|^{2} + \frac{1}{2}(r_{c}, t) = |\psi(x, t)|^$  $artr^3 \nabla \cdot \mathbf{E} = \rho/c \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x} + \frac{1}{2} (1 - v) \mathbf{x} + \frac{1}{2} (1 - v)$  $T_{0} u' = (u - v)/(1 - uv/c^{2}) p = \gamma mv E = \gamma mc^{2} E^{2} = p^{2}c^{2} + m^{2}c^{4} \partial_{\mu}J^{\mu} = 0 E_{i} = -1/c\partial A_{i}/\partial t - \partial_{i}\phi B_{i} = \epsilon_{ijk}\partial_{j}A_{k} F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}A^{\mu} F^{\mu\nu} = 0$  $e^{\dagger} = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^{\mu}/ds + \Gamma^{\mu}_{\nu\sigma} v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\alpha}_{\mu\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\alpha}_{\mu\sigma} \ R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} \ R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2 g_{\mu\nu}R = 0 \ R^{\mu}_{\mu\nu\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\alpha}_{\nu\rho} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\alpha}_{\mu\sigma} - \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\alpha}_{\mu\sigma} - \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_$  $=1/r_{x})d^{2}u/d\phi^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \ \delta = 2GM/R \ \int \psi^{*}\psi dx = 1 \ P(x,t) = |\psi(x,t)|^{2} \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi|x|\psi \rangle \ \Delta x \Delta p \geq \hbar/2 \ p_{4} = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} \ A = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial_{4} \ E$ D.P. George

#### MicroPython



20 10 30 10 20 30 Day of campaign Day of campaign "dz" i  $\Delta \nu \approx$  $4\hbar\partial_{+}E = 4\hbar\partial/\partial t H = p^{2}/2m + V H|a\rangle = E|a\rangle U = e^{i\pi t/m} F = maF = GMmr/r^{\alpha}\nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$  $F_{\mu\nu} \ \delta_{\mu} F^{\mu\nu} = J^{\nu} \ \delta_{\nu} F^{\mu\nu} = 0 \ ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 \ ds^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} \ g_{\mu\nu} (dx^{\mu}/dr) (dx^{\nu}/dr) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + g_{\mu\sigma,\nu} - g_{\mu\sigma,\mu} - g$ Total backers: 1,931 Total raised: £97,803  $\left(g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^{\mu}/ds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}v^{\mu}/ds + \Gamma^{\alpha}_{\nu}v^{\mu}/ds + \Gamma^{\alpha}_{\nu$  $2GM/r) = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta \nu \approx \nu_c GM(1/r_c - 1/r_c) \ d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^* \psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x$  $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \ \mathbf{F} = q \left( \mathbf{E} + \mathbf{v} \times \mathbf{B} \right) - h^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) \ x' = \gamma (x - vt) \ t' = \gamma (t - v) + (x - v)$  $= (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial A_i / \partial t - \partial_i \phi \ B_i = \epsilon_{ijk} \partial_j A_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \tilde{F}^{\mu\nu} = 1/2 \epsilon^{\mu i} / \partial_i A_k \ F^{\mu\nu} = -1/c \partial_i A_i \ F^{\mu\nu} =$  $=1/2(g_{\mu\nu,\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu}) dv^{\mu}/dx + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\nu}_{\nu\rho,\sigma} + \Gamma^{\nu}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho} - \Gamma^{\nu}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma} \ R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} \ R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ R^{\mu}_{\mu\nu} = R^{\mu}_{\mu\nu} \ R_{\mu\nu} \ R$  $||^2 u/d\phi^2 + u = GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge h/2 \ p_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ \Delta x \Delta p \ge h/2 \ \mu_i = -ih\partial_i \ A = ih\partial_i \partial t \ H = p_i \ A = ih\partial_i \partial t \ H = ih\partial_i \partial t \ H = ih\partial_i \partial t \ H = ih\partial_i \partial t \ A = ih\partial_i \partial t \ H = ih$ 

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# Pledge levels



 $mr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ No reward, just donation. 002 A single board, £20 and £24.  $= -\partial \mathbf{B} / \partial t$ Multiple boards at  $\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$ and  $\pounds 90.r^{2} + m^{2} + m^{$ Kits at £40, £60, £80 and £130;  $R = R_{\mu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} r_{\mu\nu}^{\mu\nu} + V$ Special items at £150, £300 and £1,000.  $0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = g (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$  $-uv/c^2$ )  $p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c\partial A_i$  $f(a\tau) = i \ i \ \mu \nu \sigma = i \ f^2(g \mu \nu, \sigma + g \mu \sigma, \nu - g \nu \sigma, \mu) \ d\nu^{\mu} / ds + \Gamma^{\mu}_{\nu \sigma} v^{\nu} v^{\sigma} = 0 \ R^{\mu}_{\nu \rho \sigma} = \Gamma^{\mu}_{\nu \sigma, \rho} - \Gamma^{\mu}_{\nu \rho, \sigma} + \Gamma^{\alpha}_{\nu \sigma}$ 

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MicroPython

### A few weeks later ...

 $\mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$ 

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 $\mathbf{E} = \rho / \epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $\nu \sigma = 1/2(g_{\mu\nu}, \sigma + g_{\mu\sigma}, \nu - g_{\nu\sigma}, \mu)$  $\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$  $\nu = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $= R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $-i\hbar \partial_i E = i\hbar \partial/\partial t H = p^2/2m + V$  $+ x \cosh \xi t' = t \cosh \xi - x \sinh \xi ta$  $dx^2 - dy^2 - dz^2 dz^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu}$ 

 $=R_{\mu\nu\mu}^{0}R=R_{\mu}^{0}G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0\ G_{\mu\nu}=8\pi GT_{\mu\nu}\ ds^{2}=(1-2GM/r)dt^{2}-dr^{2}/(1-2GM/r)-r^{2}d\theta^{2}-r^{2}\sin^{2}\theta d\phi^{2}\ \Delta\nu\approx 2\pi GT_{\mu\nu}\ ds^{2}=(1-2GM/r)dt^{2}-dr^{2}/(1-2GM/r)-r^{2}d\theta^{2}-r^{2}$  $(\phi) \Delta \epsilon \Delta \rho \geq \hbar/2 \ p_1 = -\hbar\partial_1 \ E = \hbar\partial/\partial t \ H = \rho^2/2m + V \ H|a\rangle = E|a\rangle \ U = e^{Ht/\hbar\hbar} \ \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{F}/r^3 \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{E} = -\partial \mathbf{E}/\partial t \ H = -\partial \mathbf{E}/\partial t \ H = h/2 \ (h/2)^2 \ \mathbf{E} = h/2 \ \mathbf{E}/r^2 \ \mathbf{E}/r^2 \ \mathbf{E} = h/2 \ \mathbf{E}/r^2 \ \mathbf{E}$  $= s_{\nu} \delta_{\nu} T^{\mu\nu} = J^{\nu} \delta_{\nu} T^{\mu\nu} = 0 \ ds^{2} = c^{2} dt^{2} - dz^{2} - dy^{2} - dz^{2} \ dz^{2} = g_{\mu\nu} dx^{\mu} dx^{\nu} \ g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + 2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + 2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + 2 (g_{\mu\nu,\sigma} - g_{\mu\sigma,\mu}) + 2 (g_{\mu\nu,\sigma} - g_{\mu\nu,\sigma}) + 2 (g_{\mu\nu,\sigma} - g_{\mu\nu,\sigma}) + 2 (g_{\mu\nu,\sigma} - g_{\mu\nu,\sigma}) + 2 (g_{\mu\nu,\sigma}) + 2 (g_{\mu\nu,\sigma} - g_{\mu\nu,\sigma}) + 2 (g_{\mu\nu,\sigma} - g_{\mu\nu,\sigma}$  $\forall H[a] = E[a] U = e^{Ht/(h)} \mathbf{F} = \max \mathbf{F} = GMmr/r^{3} \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^{2} \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^{2}/2m\nabla^{2}\psi$  $= \sinh\{\xi \tanh\{\xi = v/c \cosh\xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u - v)/(1 - uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i \ J^{\mu} = 0 \ D^{\mu} = 0$  $= dy^2 - dz^2 - dz^2 - g_{\mu\nu}dz^\mu dz^\nu - g_{\mu\nu}(dz^\mu/d\tau) (dz^\nu/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^\mu/dz + \Gamma^\mu_{\mu\sigma}v^\nu v^\sigma = 0 \ R^\mu_{\mu\rho\sigma} = \Gamma^\mu_{\nu\sigma,\rho} - \Gamma^\mu_{\nu\rho,\sigma} + \Gamma^\alpha_{\nu\sigma} = \Gamma^\mu_{\nu\sigma,\nu} - \Gamma^\mu_{\nu\sigma,\nu} + \Gamma^\alpha_{\nu\sigma} = 0 \ R^\mu_{\mu\sigma} - \Gamma^\mu_{\nu\sigma,\nu} - \Gamma^\mu_{\nu\sigma,\nu} + \Gamma^\alpha_{\nu\sigma} = 0 \ R^\mu_{\mu\sigma} - \Gamma^\mu_{\nu\sigma,\nu} + \Gamma^\alpha_{\nu\sigma} - \Gamma^\alpha_{\nu\sigma} + \Gamma^\alpha_{\nu\sigma} - \Gamma^\alpha_{\nu\sigma} + \Gamma^\alpha_{\nu\sigma} - \Gamma^\alpha_{\nu\sigma} - \Gamma^\alpha_{\nu\sigma} + \Gamma^\alpha_{\nu\sigma} - \Gamma^\alpha_{\nu\sigma}$  $(r^{2}/l) = 2GM/r) = r^{2}d\theta^{2} - r^{2}d\theta^{2} - r^{2}d\theta^{2} + Q_{0}(1/r_{1} - 1/r_{2})d\theta^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \delta = 2GM/R \left[\psi^{*}\psi dx = 1 P(x, t) = |\psi(x, t)|^{2}\psi(x, t) = |\psi(x, t)|^{2} + Q_{0}(x, t) + Q_{0}(x, t)$  $\lim_{t\to\infty} |\nabla^{\beta} \nabla \cdot \mathbf{E} = \rho/\epsilon |\nabla \cdot \mathbf{B} = 0 |\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t |\nabla \times \mathbf{B} = \rho \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t |\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) |\mathbf{x}'| = \gamma(\mathbf{x} - \mathbf{v}t) |\mathbf{t}'| = \gamma(t - \mathbf{v}) |\mathbf{x}'| = \gamma(t - \mathbf{v}$  $T_{0} u^{i} = (u-v)/(1-uv/c^{2}) \ p = \gamma mv \ E = \gamma mc^{2} \ E^{2} = p^{2}c^{2} + m^{2}c^{4} \ \partial_{\mu}J^{\mu} = 0 \ E_{4} = -1/c\partial A_{4}/\partial t - \partial_{4}\phi \ B_{4} = \epsilon_{44k}\partial_{4}A_{k} \ F^{\mu\nu} = \partial^{\mu}A^{\mu} \ \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$  $=1/2(g_{\mu\nu\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})-g_{\nu\sigma,\mu})-dv^{\mu}/ds+\Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma}=0-R^{\mu}_{\nu\rho\sigma}=\Gamma^{\mu}_{\nu\rho,\rho}-\Gamma^{\mu}_{\nu\rho,\rho}+\Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho}-\Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma}-R^{\mu}_{\mu\nu\rho}-R=R^{\mu}_{\mu}-G_{\mu\nu}-R^{\mu}_{\mu\nu}-1/2g_{\mu\nu}R=0$  $3/r_{2}) d^{2}u/d\phi^{2} + u = GM/A^{2} - 3GMu^{2} = 0 \delta = 2GM/R \int \psi^{*}\psi dx = 1 P(x,t) = |\psi(x,t)|^{2} \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi|x|\psi \rangle \ \Delta x \Delta p \geq \hbar/2 \ p_{4} = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} + i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} + i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} + i\hbar\partial/\partial t \ H = p_{4} + i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} + i\hbar\partial/\partial t \ H = p_{4}$ D.P. George

MicroPython

### Internet coverage



2. A HTML5 Video in Safari on OS X Yosemite (netflix con)

 $\max F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $a(\mathbf{E} + \mathbf{y} \times \mathbf{B}) = \hbar^2/2m\nabla^2 \psi$ 

t)  $x' = \gamma(x - vt) t' = \gamma(t - v$ 

 $G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$ 

 $\cosh \xi t' = t \cosh \xi - x \sinh \xi t t$ 

 $e \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$ 

 $= q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c\partial A_i$ 

 $\rho \sigma = \Gamma^{\mu}_{\nu \sigma, \rho} - \Gamma^{\mu}_{\nu \rho, \sigma} + \Gamma^{\alpha}_{\nu \sigma}$ 

t)  $x' = \gamma(x - vt) t' = \gamma(t - v)$ 

 $\mu_{A}\nu_{-} = \partial^{\nu}_{A}\mu_{-} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$ 

 $G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$ 





[Damien George] Just created Micro P (Rickstarter alert), a lean and fast implementation of the Python scripting language that is optimized to run on a microcontroller. It includes a complete parser, compiler, virtual machine, runtime system garbage collector and was written from scratch. Micro Python currently supports 32-bit ARM processors like the STM32F405 (168MHz Cortex-M4, 1MB flash, 192KB ram) shown in the picture above and will be open source once the already successful campaign finishes. Running your owthon program is as simple as copying your file to the platform (detected as a mass storage device) and rebooting it. The official micro python board includes a micro SD card slot. 4 LEDs, a switch, a real-time clock, an accelerometer and has plenty of I/O plns to Interface many peripherals. A nice video can be found on the campaign page and an interview with the project creator is embedded after the break.

Filed Under: ARM, Crowd Funding, Interviews, software hacks - Tagged With: arm, compiler,

 $E = i\hbar \partial / \partial t H = p^2 / 2m + V$  $y^2 - dz^2 dz^2 = g_{\mu\nu} dz^{\mu} dz^{\nu} g_{\mu\nu}$  $\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$  $= \sigma R_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$  $1/r_{f} = \frac{1}{2} \left[ \frac{d^{2}u}{d\phi^{2}} + u - \frac{GM}{A^{2}} - \frac{3GM}{a^{2}} + \frac{1}{2} \frac{1}{a^{2}} + \frac{1}{2} \frac{1}{a^{2}} \frac{1}{a^{2}} \frac{1}{a^{2}} + \frac{1}{2} \frac{1}{a^{2}} \frac{1}{a$  $= GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/r \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/r^2 \partial \mathbf{E}/\partial t \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(x - vt) \mathbf{t}' = \gamma(t - vt) \mathbf{x}' = \gamma(x - vt) \mathbf{x}'$  $\gamma T_0 \ u^\prime = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c\partial A_i/\partial t - \partial_i \phi \ B_i = \epsilon_{ijk} \partial_i A_k \ F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu \ \bar{F}^{\mu\nu} = 1/2 \epsilon^{\mu i} \partial_i A_i \ A^\mu = 0 \ \bar{F}^{\mu\nu} = 1/2 \epsilon^{\mu i} \partial_i A^\mu \ \bar{F}^{\mu\nu} = 0$  $=1\Gamma_{\mu\nu\sigma}=1/2(g_{\mu\nu\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})\,\,\mathrm{d}v^{\mu}/\mathrm{d}s+\Gamma_{\nu\sigma}^{\mu}v^{\nu}v^{\sigma}=0\,\,R_{\nu\rho\sigma}^{\mu}-\Gamma_{\nu\sigma,\rho}^{\mu}-\Gamma_{\nu\sigma,\sigma}^{\mu}\Gamma_{\alpha\rho}^{\mu}-\Gamma_{\alpha\rho}^{\nu}\Gamma_{\alpha\sigma}^{\mu}R_{\mu\nu}=R_{\mu\nu\sigma}^{\rho}R=R_{\mu}^{\mu}G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0$  $|^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge h/2 \ p_i = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = p_i \ A = -i\hbar\partial_i \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_i \ A = -i\hbar$ 

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 $F = maF = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = q (E + v \times B) - \hbar^2/2m\nabla^2 \psi$ Stage 3: fulfillment  $2m + V H[a] = E[a] U = e^{Ht/i\hbar} F = maF = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$  $e^{2}dt^{2} = dx^{2} = dy^{2} - dx^{2} - dx^{2} - g_{\mu\nu}dx^{\mu}dx^{\nu} - g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 - \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $\mathbf{F} = GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/r \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 q$  $E_0/2$   $T = 2T_0 u' = (u - v)/(1 - uv/c^2)$   $p = 2mv E = 2mc^2 E^2 = p^2c^2 + m^2c^4 \partial_{\mu}J^{\mu} = 0$   $E_4 = -1/c\partial A_4$  $\partial H/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = a(E + \mathbf{y} \times B) - h^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{y}t) \mathbf{t}' = \gamma(t - \mathbf{y})$  $a) d\nu^{\mu}/dx + \Gamma^{\mu}_{\nu\sigma} v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\alpha\sigma} \Gamma^{\mu}_{\alpha\rho} - \Gamma^{\alpha}_{\alpha\rho} \Gamma^{\mu}_{\alpha\sigma} R^{\mu}_{\alpha\sigma} R^{\mu}_{\alpha$  $= 2GM/R | \psi^* \psi dx - 1 P(x, t) = |\psi(x, t)|^2 | \psi(x, t) = |\psi(t)\rangle \langle x \rangle = \langle \psi | x | \psi \rangle \Delta x \Delta p \ge \hbar/2 | p_4 = -i\hbar\partial_4 E = i\hbar\partial/\partial t | H = p^2/2m + V | \psi \rangle \langle x | \psi \rangle = 0$  $t) + V(x)\psi(x, t) = E\psi(x, t) x' + \gamma(x - vt) t' + \gamma(t - vx/c^2) \gamma = 1/(1 - v^2/c^2)^{1/2} x' = -t \sinh \xi + x \cosh \xi t' = t \cosh \xi - x \sinh \xi + t \cosh \xi = -t \sinh \xi + t \sin \xi + t$  $=\epsilon_{14k}\partial_{1}A_{k}F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu}F^{\mu\nu} = 1/2\epsilon^{\mu\nu\rho\sigma}F_{\rho\sigma}\partial_{\nu}F^{\mu\nu} = J^{\nu}\partial_{\nu}F^{\mu\nu} = 0 \ \mathrm{d}x^{2} = c^{2}\mathrm{d}t^{2} - \mathrm{d}x^{2} - \mathrm{d}y^{2} - \mathrm{d}x^{2} \ \mathrm{d}x^{2} = g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu} \ \mathrm{d}x^{\mu}\mathrm{d}x^{\nu} \ \mathrm{d}x^{\mu}\mathrm{d}x^{\nu} = 0 \ \mathrm{d}x^{\mu}\mathrm{d}x^{\mu$  $a_{R} = R_{\mu}^{R} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0 \ G_{\mu\nu} = 8\pi G T_{\mu\nu} \ ds^{2} = (1 - 2GM/r)dt^{2} - dr^{2}/(1 - 2GM/r) - r^{2}d\theta^{2} - r^{2}\sin^{2}\theta d\phi^{2} \ \Delta\nu \approx 10^{-10} \ ds^{2} + 10^{-10} \ ds^{2}$  $\ln \Delta \mu \ge \hbar/2 \ \mu_1 = -i\hbar\partial_1 \ E = i\hbar\partial/\partial t \ H = \mu^2/2m + V \ H|a\rangle = E|a\rangle \ U = e^{Ht/i\hbar} \ \mathbf{F} = m\mathbf{a} \ \mathbf{F} = GMm\mathbf{r}/r^3 \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $F^{\mu\nu} = J^{\nu} \partial_{\nu} F^{\mu\nu} = 0 \, dx^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 \, dx^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu} (dx^{\mu}/d\tau) (dx^{\nu}/d\tau) = 1 \, \Gamma_{\mu\nu\sigma} = 1/2 (g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) + g_{\mu\nu,\sigma} g_{\mu\nu,\sigma} + g$  $a) = E[a) U = e^{Ht/\hbar} F = maF = GMmr/r^3 \nabla \cdot E = e/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/c^2 \partial E/\partial t F = e(E + \mathbf{v} \times B) - \hbar^2/2m\nabla^2 \psi$  $ah\xi \tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u-v)/(1-uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_\mu J^\mu = 0 \ E_i = -1/c \partial A_i$  $dy^2 = dx^2 - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - g_{\mu\nu}dx^\mu dx^\nu - \Gamma^\mu_{\mu\rho\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) - dv^\mu dx + \Gamma^\mu_{\mu\sigma}v^\mu v^\sigma = 0 - R^\mu_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\mu_{\mu\rho,\sigma} + \Gamma^\alpha_{\mu\rho,\sigma} - \Gamma^\alpha_{\mu\rho,\sigma}$  $2GM/r) = r^2 d\theta^2 = r^2 \sin^2 \theta d\phi^2 \quad \Delta \nu \approx \nu_c GM(1/r_c - 1/r_c) \ d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ [\psi^*\psi dx = 1 \ P(x, t) = |\psi(x, t)|^2 \ \psi(x, t) = |\psi(x,$  $mr/e^{2} \nabla \cdot \mathbf{E} = \rho/e \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/e^{2} \partial \mathbf{E}/\partial t \mathbf{F} = \rho(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^{2}/2m \nabla^{2} \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) \mathbf{t}' = \gamma(t - \mathbf{v}) \mathbf{x}' + 2\pi \nabla^{2} \mathbf{x} + 2\pi \nabla^{2} \mathbf$  $u^{\prime} = (u-v)/(1-uv/c^{2}) \ p = \gamma mv \ E = \gamma mc^{2} \ E^{2} = p^{2}c^{2} + m^{2}c^{4} \ \partial_{\mu}J^{\mu} = 0 \ E_{i} = -1/c\partial A_{i}/\partial t - \partial_{i}\phi \ B_{i} = \epsilon_{ijk}\partial_{i}A_{k} \ F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \ \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$  $=1\ \Gamma_{\mu\nu\sigma}=1/2(g_{\mu\nu,\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})\ \mathrm{d}v^{\mu}/\mathrm{d}s+\Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma}=0\ R^{\mu}_{\nu\sigma,\rho}-\Gamma^{\mu}_{\nu\sigma,\sigma}+\Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\rho}-\Gamma^{\alpha}_{\mu\rho}-\Gamma^{\alpha}_{\mu\rho}\Gamma^{\alpha}_{\alpha}\ R_{\mu\nu}=R^{\rho}_{\mu\nu\rho}\ R=R^{\mu}_{\mu}\ G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0$  $= 1/r_f \int d^2 u / d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \quad \delta = 2GM/R \int \phi^* \psi dx = 1 \quad P(x,t) = |\psi(x,t)|^2 \quad \psi(x,t) = |\psi(t)\rangle \quad \langle x \rangle = \langle \psi | x | \psi \rangle \quad \Delta x \Delta p \geq \hbar/2 \quad p_4 = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = p_4 \quad A = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = i\hbar \partial/\partial t \quad H = -i\hbar \partial_4 \quad E = -i\hbar \partial_4 \quad$ 

### Hand made boards



 $B = 0 \nabla \times E = -\partial B/\partial t \nabla \times B = \mu J + 1/2^2 \partial E/\partial t F = q (E + v \times B) - \hbar^2/2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) x' = \gamma(x - vt) t' = \gamma(t - vt) + 2\pi V + 2\pi$  $=1/2(y_{\mu\nu,\sigma}+y_{\mu\sigma,\nu}-y_{\nu\sigma,\mu}) \ \mathrm{d}\nu^{\mu}/\mathrm{d}\varepsilon + \Gamma^{\mu}_{\nu\sigma} \nu^{\nu}\nu^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\alpha}_{\mu\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\alpha}_{\mu\sigma} \ R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} \ R = R^{\mu}_{\mu} \ G_{\mu\nu} = R^{\rho}_{\mu\nu} \ G_{\mu\nu} = R^{\mu}_{\mu\nu} \ G_{\mu\nu} \ G_{\mu\nu} = R^{\mu}_{\mu\nu} \ G_{\mu\nu} \ G_{\mu\nu} = R^{\mu}_{\mu\nu} \ G_{\mu\nu} \ G_{\mu\nu} = R^{\mu}_{\mu\nu} \ G_{\mu\nu} \$  $P(x) = \delta^2 u / \delta \phi^2 + u = GM/A^2 - 3GMu^2 = 0 = \delta = 2GM/A \int \phi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 |\psi(x, t) = |\psi(t)\rangle \langle x \rangle = \langle \psi|x|\psi \rangle \Delta x \Delta p \geq h/2 |p_1| = -ih\partial_1 E = ih\partial/\partial t H = 1 P(x, t) = h/2 |p_1| = -ih\partial_1 E = ih\partial/\partial t H = 1 P(x, t) = h/2 |u| = h/2 |u|$ 

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### Boards, headers, servo motors, ...



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 $\frac{M/R}{4} = \frac{1}{2} \frac{P(x,t)}{P(x,t)} = \frac{1}{10} \frac{(x,t)}{P(x,t)} = \frac{1}{10} \frac{(x,t)}{P(x,t)} = \frac{1}{10} \frac{1}$ 

 $1/2a_{\mu\nu}R = 0$ 

 $\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $e \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$ 

> $= p^2 / 2m + V$  $s^2 = g_{\mu\nu} dx^{\mu} dx^{\nu} g_{\mu\nu}$  $2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $\nabla \times \mathbf{E} = -$ 0B/01  $+ g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $(\mathbf{B}) = \hbar^2/2m\nabla^2\psi$

### Programming and packing



 $d^{12} - d^{12} - d^{12} - d^{12} - g_{\mu\nu}dd^{12} dd^{12}$   $e^{-T}d^{12} - e^{-T}d^{12} - d^{12} - d^{12} - d^{12}$   $e^{-T}d^{12} - e^{-T}d^{12} - d^{12} - d^{12}$   $e^{-T}d^{12} - e^{-T}d^{12} - d^{12} - d^{12}$   $e^{-T}d^{12} - d^{12} - d^{12} - d^{12} - d^{12}$   $e^{-T}d^{12} - d^{12} - d^{12} - d^{12} - d^{12} - d^{12}$  $e^{-T}d^{12} - d^{12} - d^{12}$ 

 $F = ma F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$  $(u_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv$  $(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = g (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $nc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$  $ds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$  $2M/R \int \psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 \psi(x, t) = |\psi(x, t)|^2$  $R_{\mu\nu} = R^{\rho}_{\mu\nu\rho} R = R^{\mu}_{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $x \Delta p \ge \hbar/2 p_1 = -i\hbar \partial_1 E = i\hbar \partial/\partial t H = p^2/2m + V$ 1/2  $x' = -t \sinh \xi + x \cosh \xi$   $t' = t \cosh \xi - x \sinh \xi$  to  $ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 ds^2 = g_{\mu\nu} dx^{\mu} dx^{\nu}$  $- dr^2/(1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $= GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $a_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv$  $(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $= \mu \mathbf{J} + 1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $nc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$  $ds + \Gamma^{\mu}_{\nu\sigma}v^{\nu}v^{\sigma} = 0 R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$  $GM/R | [\psi^* \psi dx = 1 P(x, t) = |\psi(x, t)|^2 |\psi(x, t) = |\psi(x, t)|^2$  $+ V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}' = \gamma(\mathbf{x} - vt) \mathbf{t}' = \gamma(t - v)$ 



$$\begin{split} & = ST_0 \, s^{-1} \phi \left( u - u \right) \left( 1 - u_{\lambda} r_{\lambda}^{-2} \right) p - s_{\lambda \nu} E - s_{\lambda \nu} T_{\lambda}^{-2} e^{-2} A - u_{\lambda}^{-2} A - g_{\lambda} A^{\mu} P = 0 E_{\mu} - 1 / c \partial A_{\mu} (M - u_{\mu} \partial_{\mu} B_{\mu} - u_{\mu} \partial_{\mu} B_{\mu} - u_{\mu} \partial_{\mu} B_{\mu} - u_{\mu} \partial_{\mu} A_{\mu} - b^{\mu} A_{\mu} - b^{\mu}$$

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 $a F = GMmr/r^3 \nabla \cdot E = \rho/\epsilon \nabla \cdot B = 0 \nabla \times E = -\partial B/\partial t$ 

 $\Delta \nu \approx$ 

OB/Or

 $\partial^{\nu} A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$ 

 $\nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $= 1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $m^2 c^4 \partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$ 

 $\mathbf{x}, t$   $\mathbf{x}' = \gamma(\mathbf{x} - \mathbf{v}t) t' = \gamma(t - \mathbf{v})$ 



 $-x \sinh \xi \tanh \xi = v/c \cosh \xi = \gamma L = L_0/\gamma T = \gamma T_0 u' = (u - v)/(1 - uv/c^2) p$  $\mathrm{d}x^2 - \mathrm{d}x^2 \,\mathrm{d}x^2 = g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu} \,g_{\mu\nu}(\mathrm{d}x^{\mu}/\mathrm{d}\tau)(\mathrm{d}x^{\nu}/\mathrm{d}\tau) = 1 \,\,\Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $\mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/\epsilon^2 \partial \mathbf{E}/\partial t \mathbf{F} = g(\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2/2m\nabla^2 g$  $1/(1 - uv/c^2) = 2mv E = 2mc^2 E^2 = p^2c^2 + m^2c^4 \partial_{\mu}J^{\mu} = 0 E_i = -1/c\partial A_i$ 

Stamps!





 $(u-v)/(1-uv/c^2) p = \gamma mv E = \gamma mc^2 E^2 = p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_4 = -1/c\partial A_4/\partial t - \partial_4 \phi B_4 = \epsilon_{ijk}\partial_j A_k F^{\mu\nu} = \theta^\mu A^\nu - \theta^\nu A^\mu F^{\mu\nu} = 1/2\epsilon^{\mu i} - 2\epsilon^{\mu i} e^{-i\beta i} e^{ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu\sigma,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dv^{\mu}/dv + \Gamma^{\mu}_{\mu\sigma} v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\mu\rho\sigma} = \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\alpha}_{\mu\sigma} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\alpha}_{\alpha\sigma} R^{\mu}_{\mu\nu} = R^{\mu}_{\mu\nu\rho} R = R^{\mu}_{\mu} \ G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu} R = 0$  $d^2u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \ \delta = 2GM/R \ \int \psi^* \psi dx = 1 \ P(x,t) = |\psi(x,t)|^2 \ \psi(x,t) = |\psi(t)\rangle \ \langle x \rangle = \langle \psi | x | \psi \rangle \ \Delta x \Delta p \ge h/2 \ p_i = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ A = -ih\partial_i \ E = ih\partial_i \partial t \ H = p_i \ A = -ih\partial_i \ A = -ih\partial_i$ D.P. George MicroPython 51/61

### Packing and shipping

$$\begin{split} &(\psi(x), e) = B(\psi, e) \ y' = e(e - e) \ y' = e(e - e) \\ &(\psi(x), e) \ z' = e(e - ex)e^{i} \\ &(\psi(x), e) \ z' = e^{i} (e^{i} - e^{i} (e^{i} - e^{i} ) e^{i} - e^{i} e^{i} e^{i} - e^{i} e^{i} e^{i} e^{i} e^{i} e^{i} e^{i} \\ &(\psi(x), e) \ z' = e^{i} (e^{i} - e^{i} ) e^{i} \\ &(\psi(x), e) \ z' = e^{i} (e^{i} - e^{i} ) e^{i} e^{i}$$





 $|1\rangle = 1 \left[ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu\sigma} + g_{\mu\sigma,\mu} - g_{\nu\sigma,\mu}) \right] dv^{\mu}/ds + \Gamma_{\mu\sigma}^{\mu} v^{\nu\sigma} = 0 \left[ R_{\mu\rho\sigma}^{\mu} - \Gamma_{\mu\rho,\sigma}^{\mu} + \Gamma_{\mu\sigma}^{\mu} \Gamma_{\mu\sigma}^{\mu} - \Gamma_{\mu\rho}^{\mu} \Gamma_{\mu\sigma}^{\mu} - R_{\mu\nu\rho} \right] R^{\mu} R^{\mu}$ 

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### Packing and shipping

 $\begin{aligned} & (\psi_1(x_1) = B(\psi_1, t) \; x' = (\mu - v) t' = (\mu - v) t' = (\mu - v) t' \\ & (\psi_1(x_1) = v_1(y_1) d_{X_1} \; x'' = 0^{-1} A'' = 0^{-2} A'$ 



 $(1 + 1) \Gamma_{\mu\nu\sigma} = 1/2 (y_{\mu\nu\sigma} + y_{\mu\sigma,\nu} - y_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma_{\mu\sigma}^{\mu} v^{\mu}v^{\sigma} = 0 \quad R_{\mu\sigma\sigma}^{\mu} = \Gamma_{\mu\sigma,\mu}^{\mu} - \Gamma_{\mu\sigma}^{\mu} R_{\mu\sigma}^{\mu} - \Gamma_{\nu\sigma}^{\mu} R_{\mu\sigma}^{\mu} R_{\mu\sigma} R_{\mu\sigma}^{\mu} R_{\mu\sigma}^{$ 

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# Other Kickstarter campaigns



### Machine Vision With Python

Add machine vision to your projects by scripting Python. Small, affordable, and expandable with shields.

Follow along

Created by Bot Thoughts LLC

900 backers pledged \$104,498 to help bring this project to life.

 $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $\mathbf{c} \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c\partial A_i$  $^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $E = i\hbar \partial / \partial t H = p^2 / 2m + V$  $ah \xi t' = t \cosh \xi - x \sinh \xi t_i$  $^{2} - dz^{2} dz^{2} = g_{\mu\nu} dz^{\mu} dz^{\nu} g_{\mu\nu}$  $r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $\mathbf{r} \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$ 

 $H[a] = E[a] U = e^{Ht/\hbar\hbar} \quad \mathbf{F} = \mathrm{ma} \ \mathbf{F} = GMmr/r^3 \ \nabla \cdot \mathbf{E} = \rho/\epsilon \ \nabla \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \ \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \ \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi$  $= \sinh \xi \tanh \xi = v/c \cosh \xi = \gamma \ L = L_0/\gamma \ T = \gamma T_0 \ u' = (u - v)/(1 - uv/c^2) \ p = \gamma mv \ E = \gamma mc^2 \ E^2 = p^2 c^2 + m^2 c^4 \ \partial_{\mu} J^{\mu} = 0 \ E_i = -1/c \partial A_i \ d_{\mu} J^{\mu} = 0 \ E_i = -1/c$  $= dg^2 - dz^2 - dz^2 - g_{\mu\nu}dz^{\mu}dz^{\nu} - g_{\mu\nu}dz^{\mu}dz^{\nu} - g_{\mu\nu}dz^{\mu}d\tau) \\ (dz^{\mu}/d\tau) = 1 \ \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dz^{\mu}/dz + \Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma} = 0 \ R^{\mu}_{\mu\sigma\sigma} - \Gamma^{\mu}_{\nu\sigma,\rho} + \Gamma^{\alpha}_{\nu\sigma} + \Gamma^{\alpha}_{$  $\theta^{-2}(0) = 2GM/r) = r^{2}d\theta^{2} - r^{2}d\theta^{2} - r^{2}d\theta^{2} + 2gM(1/r_{1} - 1/r_{2}) d^{2}u/d\theta^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \delta = 2GM/R \left[\psi^{*}\psi dx = 1 P(x, t) + \psi(x, t)\right]^{2}\psi(x, t) = \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t)\right]^{2} + 2GM/R \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t)\right]^{2} + 2GM/R \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t)\right]^{2} + 2GM/R \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t)\right]^{2} + 2GM/R \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t)\right]^{2} + 2GM/R \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}(x, t)\right]^{2} + 2GM/R \left[\psi^{*}(x, t) + \psi^{*}(x, t) + \psi^{*}$  $\lim_{n \to \infty} |\nabla \cdot \mathbf{E} = \rho/\epsilon |\nabla \cdot \mathbf{E} = -\rho |\nabla \cdot \mathbf{E} = -\partial |D| \partial t |\nabla \times \mathbf{E} = -\partial |D| \partial t |\nabla \times \mathbf{E} = -\rho |\mathbf{L} + 1/\epsilon^2 \partial |\mathbf{E} / \partial t |\mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x}) \psi(\mathbf{x}, t) = E \psi(\mathbf{x}, t) |\mathbf{x}'| = \gamma (\mathbf{x} - \mathbf{v}t) |\mathbf{t}'| = \gamma (t - v) |\mathbf{x}'| = \gamma (t$  $(T_0|u' = (u-v)/(1-uv/c^2)|p = \gamma mv|E = \gamma mc^2|E^2 = p^2c^2 + m^2c^4|\partial_\mu J^\mu = 0|E_i = -1/c\partial A_i/\partial t - \partial_i\phi|B_i = \epsilon_{ijk}\partial_iA_k|F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu|\tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu}$  $=1\ \Gamma_{\mu\nu\sigma}=1/2(g_{\mu\nu,\sigma}+g_{\mu\sigma,\nu}-g_{\nu\sigma,\mu})\ dv^{\mu}/ds+\Gamma^{\mu}_{\mu\sigma}v^{\nu}v^{\sigma}=0\ R^{\mu}_{\nu\sigma,\rho}-\Gamma^{\mu}_{\nu\sigma,\rho}+\Gamma^{\alpha}_{\nu\sigma}\Gamma^{\mu}_{\alpha\sigma}-\Gamma^{\alpha}_{\nu\rho}\Gamma^{\mu}_{\alpha\sigma}\ R_{\mu\nu}=R^{\mu}_{\mu\nu\rho}\ R=R^{\mu}_{\mu}\ G_{\mu\nu}=R_{\mu\nu}-1/2g_{\mu\nu}R=0$  $\left[P_{4}\right] d^{2}u / d\phi^{2} + u - GM/A^{2} - 3GMu^{2} = 0 \ \delta = 2GM/R \int \psi^{*} \psi dx = 1 \ P(x, t) = \left|\psi(x, t)\right|^{2} \psi(x, t) = \left|\psi(t)\right\rangle \ \langle x \rangle = \langle \psi|x|\psi \rangle \ \Delta x \Delta p \geq \hbar/2 \ p_{4} = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = p_{4} \ A = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = i\hbar\partial/\partial t \ H = -i\hbar\partial_{4} \ E = -i\hbar\partial_$ 

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### Other Kickstarter campaigns

### The WiPy: The Internet of Things Taken to the Next Level



The IoT development platform that runs Python in real time, and features the perfect blend of power, friendliness and flexibility.



The WiPy

### 1,382 backers pledged €75,564 to help bring this project to life.

 $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $\mathbf{c} \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c\partial A_i$  $^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tilde{F}^{\mu\nu} = 1/2\epsilon^{\mu\nu}$  $G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $E = i\hbar \partial / \partial t H = p^2 / 2m + V$  $ah \xi t' = t \cosh \xi - x \sinh \xi t t$  $^{2} - dz^{2} dz^{2} = g_{\mu\nu} dz^{\mu} dz^{\nu} g_{\mu\nu}$  $r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $\mathbf{\nabla} \cdot \mathbf{B} = 0 \ \nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$  $1/2(g_{\mu\nu},\sigma + g_{\mu\sigma},\nu - g_{\nu\sigma},\mu)$  $q (\mathbf{E} + \mathbf{y} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $\partial_{\mu} J^{\mu} = 0 E_i = -1/c \partial A_i$ 

 $\sigma = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$ 

$$\begin{split} & d^{2} \otimes b^{2}(1-2)(1/r) = r^{2} \sin^{2} + d^{2} - r^{2} \sin^{2} + d\phi^{2} \Delta x = n_{1}(2M(1/r_{1}^{2} - 1/r_{2}^{2}) d^{2} n_{1}/d\phi^{2} + u = GM/R^{2} - 3GM/R^{2} = 0.8 = 2GM/R^{2} \int \phi^{2} \, dx = 1.7(z_{1})^{2} \, \phi(z_{1}, 0) = |\phi(z_{1}, 0)|^{2} \, \phi(z_{1}, 0) = |\phi(z_{1}, 0)|^{2}$$

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### Lessons and tips

- Why do want to do a crowd funding campaign (fun, money, have an idea, start a business)?
- Work quick to bring it to the public:
  - might be beaten!
  - learn earlier if it's not a good idea
  - spend too long and the idea gets stale
- Make a video that shows yourself, your idea and your excitement.
- Plan your rewards carefully and offer a range (people like options) but don't make them too complicated (for your own sake).
- Don't over-promise; have a core single idea and deliver on that as best you can.
- Be prepared to respond to a lot of emails!

$$\begin{split} dy^2 - dz^2 & dz^2 = g_{\mu\nu}dz^{\mu}dz^{\mu} g_{\mu\nu}(dz^{\mu}/dr)(dz^{\nu}/dr) = 1 \ \Gamma_{\mu\nu\sigma\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) \ dz^{\mu}/ds + \Gamma_{\mu\sigma}^{\mu}v^{\nu}v^{\sigma} = 0 \ R_{\mu\sigma,\sigma}^{\mu} - \Gamma_{\mu\sigma,\sigma}^{\mu} - \Gamma_{\mu$$

 $Mmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $\mathbf{F} = m\mathbf{a} \, \mathbf{F} = GMmr/r^3 \, \nabla \cdot \mathbf{E} = \rho/\epsilon \, \nabla \cdot \mathbf{B} = 0 \, \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $g_{\mu\nu}(\mathrm{d}x^{\mu}/\mathrm{d}\tau)(\mathrm{d}x^{\nu}/\mathrm{d}\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$ 

### Part IV: The future

 $GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

× B =  $\mu J$  + 1/ $c^2 \partial E / \partial t$  F =  $q (E + v \times B) - \hbar^2 / 2m \nabla^2 \psi$ 

$$\begin{split} \mathcal{V}(H) &= E(u) U = e^{H/(H_0} F u = u_0 F = GMma/r^3 \nabla V = \pi/e \nabla V = 0 = 0 \nabla V = e^{-\partial B}/dV \\ &= OM + u_0^2 + omb(-u_0 + U = L_D/r) T = -Try_0 u'' = (u = v/r)(1 = u_0/r^3) = \gamma mu \\ &= dr^2 dr^2 = \rho_{\mu\nu}dh^{\mu}dw^{\mu} g_{\mu\nu}(du^{\mu}/d\nu)(du^{\mu}/d\nu) = 1 \Gamma_{\mu\mu\nu} = 1/2(g_{\mu\nu} + g_{\mu\nu}, v = g_{\mu\nu}, u) \\ &= r^2 dr^2 - r^2 \sin^2 \sigma d\sigma^2 \Delta u = u_0(GM/r^2)(du^{\mu}/d\nu)(du^{\mu}/d\nu) = 1 \Gamma_{\mu\mu\nu} = 1/2(g_{\mu\nu} + g_{\mu\nu}, v = g_{\mu\nu}, u) \\ &= r^2 dr^2 - r^2 \sin^2 \sigma d\sigma^2 \Delta u = u_0(GM/r^2) + 1/r^2 dr^2 d\mu d\sigma^2 + u = GM/r^2 - 2GMm^2 d\sigma d\nu \\ &= (u = v)(1 = u_0/r^3) = \gamma mv E = \gamma mv E = 2\pi e^2 E^2 = \mu^2 e^2 u^2 d^2 d\mu^2 = 0 E_0 = -1/e \partial d\mu \\ &= (u = v)(1 = u_0/r^3) = \gamma mv E = \gamma mv E = 2\pi e^2 E^2 = u^2 e^2 d\mu^2 = 0 E_0 = 0 E_0 = -1/e \partial d\mu \\ &= (2 e^2 u_0 - u_0 - u_0) dr^2 d\sigma + 1 E^2 e^{-v} u^2 = 0 R_0 = R_0 = 0 E_0 = -1/e^2 d\mu \\ &= (2 e^2 u_0 - u_0) dr^2 d\mu^2 = 0 E^2 e^{-\partial \mu} d\nu^2 = 0 R_0 = 1 P(u_0, 1)^2 = (u_0, 1)^2 = (u_0, 1)^2 = 0 \\ &= (2 e^2 u_0 - u_0) du^2 = 0 E = 0 = 2M/R \int e^2 \sigma du dv = 1 P(u_0, 1) = 0 (v_0, 1)^2 = (u_0, 1)^2 = (u_0, 1) = 0 \\ &= (2 e^2 u_0 - u_0) du^2 = 0 E = 0 = 2M/R + 1 P(u_0, 1) = 0 (v_0, 1)^2 = (u_0, 1)^2 = (u_0, 1)^2 = (u_0, 1) = 0 \\ &= (2 e^2 u_0 - u_0) du^2 = 0 E = 1 = 2M/R + 1 P(u_0, 1) = 0 (v_0, 1)^2 = (u_0, 1)^2 = (u$$

 $\begin{array}{c} 0 \quad n_{1} = -n_{1}(\lambda_{1}) \quad d_{1} \quad d_{2} \quad m_{1} = -n_{1}(\lambda_{1}) \quad d_{2} \quad d_$ 

### Post Kickstarter

We now have a private limited company.

Continue to sell the pyboard and accessories online.

$$\begin{split} & (x+y) = e^{2} (x^{2})^{2} (x^{2} - x^{2} - x \tanh(\xi - x \th(\xi - x \th(\xi$$



#### CERTIFICATE OF INCORPORATION OF A PRIVATE LIMITED COMPANY

Company Number 8861687

The Registrar of Companies for England and Wales, hereby certifies that

GEORGE ROBOTICS LIMITED

is this day incorporated under the Companies Act 2006 as a private company, that the company is limited by shares, and the situation of its registered office is in England and Wales.

Given at Companies House, Cardiff, on 27th January 2014.

 $\Delta \nu \approx$ 013 / 04 R = 0"dz" s  $\Delta \nu \approx$ 0**B**/01

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														$\Gamma_{\mu}$	~ ~		1/2	(g <sub>p</sub>	w. 0	+ 1	140		94	σ.µ)	) da	μJ.	14.4	$\Gamma^{\mu}_{\nu_{1}}$	, w <sup>22</sup>	$v^{\sigma}$	= 0	$R_{\nu}^{\mu}$	00	- 1	the.	e -	$\Gamma^{\mu}_{\nu\rho}$	10	$\in \Gamma_{1}^{0}$	0.1
														$d^2$	u/d	$10^{2}$	+ +		GM	$1/A^2$		3GM	$(u^2)$	- 0	18.	- 20	GM	(R J	÷*	ýdz	-	1 P(	(x, t	<li>i) =</li>	10-(1	z, t)	12 01	(x. 1	() =	14
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									c <sup>2</sup>	$E^2$	- )		4	m <sup>2</sup>	а,	$\partial_{\mu}$	ηµ.,	- 0	$E_{i}$	-	-1/	$c\partial A$	1/0	e	010	B	-	eijk	0,1	ik F	, µw	- 1	рй д	1 <sup>27</sup> -	$\partial^{\nu}$	$A^{\mu}$	ŕμν	-	1/2	e <sup>pt</sup>
											, er		R		-	$\Gamma_{b'}^{\mu}$	σ.ρ	— I	Pp.	.σ +	$\Gamma_{\mu}^{0}$	ς Γ <sup>μ</sup>	p -	$-\Gamma^{\alpha}_{\nu}$	$_{\rho}\Gamma_{\sigma}^{\rho}$	ι 3σ	$R_{\mu\nu}$	-	$R^{\rho}_{\mu\nu}$	p B	t —	$R^{\mu}_{\mu}$	$G_{\mu}$		$R_p$		1/2	3 µ.v	R =	i= 6
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MicroPython

# Code improvements

- Option for 64-bit NaN boxing model.
- Option for 30-bit floats packed into current pointer model.
- Allow pre-compiled bytecode to be loaded.
- ▶ 100% test coverage (at 94% right now).
- Define a consistent hardware API for all MCUs / boards.

# New hardware

- Cheaper board.
- More powerful board (eg Ethernet, SDRAM).
- More add-on boards (all with a standard form factor).
- Any new, interesting MCU: make a board out of it!

 $\begin{aligned} \sin \delta t & \sinh \delta t & \sinh \delta t & = \sqrt{c} \cosh \delta t & = \sqrt{L} = L_0/(T = \pi_0) u^2 = (u - v)/(1 - uv/c^2) p - \gamma m v E = \gamma m c^2 E^2 - p^2 c^2 + m^2 c$ 

 $= 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma_{\mu\sigma}^{\mu}v^{\nu}e^{\sigma} = 0 R_{\mu\sigma\sigma}^{\mu} - \Gamma_{\nu\sigma,\mu}^{\mu} - \Gamma_{\mu\sigma,\sigma}^{\mu} - \Gamma_{\mu\sigma}^{\mu}\Gamma_{\mu\sigma}^{\mu} - \Gamma_{\mu\sigma}^{\mu}\Gamma_{\mu\sigma}^{\mu} R_{\mu\nu} - R_{\mu\nu\sigma}^{\mu}R_{\mu\nu} R_{\mu\nu} - 1/2g_{\mu\nu}R_{\mu\nu} = 0$   $= r_{\mu}^{\mu} d^{\mu} d^{\mu} d^{\mu} + 0 M/R_{\mu}^{\mu} d^{\mu} d^{\mu} d^{\mu} d^{\mu} + 0 R_{\mu\sigma}^{\mu} d^{\mu} d^{\mu$ 

 $= dy^{2} - dx^{2} dx^{2} - g_{\mu\nu}dx^{\mu}dx^{\nu} g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$ 

 ${}^{\beta} \nabla : \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \nabla \times \mathbf{B} = \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m \nabla^2 \psi$  $\gamma T_0 | u' = (u - v)/(1 - uv/c^2) | p = \gamma mv | \mathbf{E} = \gamma mc^2 | \mathbf{E}^2 = p^2 c^2 + m^2 c^4 | \partial_{\mu} J^{\mu} = 0 | \mathbf{E}_4 = -1/c \partial A_4$ 

 $+ 1/\epsilon^2 \partial \mathbb{E}/\partial t = a \left(\mathbb{E} + \mathbf{y} \times \mathbb{B}\right) - \hbar^2 / 2m \nabla^2 \psi(\mathbf{x}, t) + V(\mathbf{x})\psi(\mathbf{x}, t) = E\psi(\mathbf{x}, t) \mathbf{x}^t = \gamma(\mathbf{x} - \mathbf{y}t) \mathbf{t}^t = \gamma(\mathbf{x} - \mathbf{y}t)$ 

 $Mmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

### Future of MicroPython

Continue to improve documentation, write tutorials, support more peripherals, build a community.

Not just for bare metal: works very well on standard systems and anyone can build and run it easily on \*nix/Windows/Mac.

Great potential for Internet of Things (IoT): much easier to develop a small internet connected device using Python than C.

Embedding MicroPython in games and mobile apps.

Industrial use — use in space? Determinism is a key point.

 $\delta^{(2)}(b) = 1 \Gamma_{\mu\nu\sigma} - 1/2(g_{\mu\nu\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}) dv^{\mu}/ds + \Gamma_{\mu\sigma}^{0} v^{\nu}v^{\sigma} = 0 R_{\nu\sigma,\rho}^{0} - \Gamma_{\mu\sigma,\rho}^{0} - \Gamma_{\mu\sigma,\rho}^{0} - \Gamma_{\mu\sigma}^{0} \Gamma_{\mu\sigma}^{0} - \Gamma_{\mu\sigma}^{0} \Gamma_{\mu\sigma}^{0} R_{\mu\nu} - R_{\mu\nu\rho}^{0} R_{\mu\nu} - R_{\mu\nu\rho}^{0} R_{\mu\nu} - 1/2g_{\mu\nu} R_{\mu\nu} R$ 

 $-GMmr/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $g_{\mu\nu}dx^{\mu}dx^{\nu}$   $g_{\mu\nu}(dx^{\mu}/d\tau)(dx^{\nu}/d\tau) = 1$   $\Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$ 

### micropython.org

forum.micropython.org
github.com/micropython



 $r/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $= 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m \nabla^2 \psi$  $p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$  $P_{\mu\nu\rho}^{\rho} R = R_{\mu}^{\mu} G_{\mu\nu} = R_{\mu\nu} - 1/2g_{\mu\nu}R = 0$  $/2 p_i = -i\hbar \partial_i E = i\hbar \partial/\partial t H = p^2/2m + V$  $-t \sinh \xi + x \cosh \xi \ t' = t \cosh \xi - x \sinh \xi \ ta$  $^{2}dt^{2} - dx^{2} - dy^{2} - dz^{2} dz^{2} = g_{\mu\nu}dx^{\mu}dx^{\nu}$  $1 - 2GM/r) - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2 \Delta \nu \approx$  $r/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$  $\gamma T_0 u' = (u - v)/(1 - uv/c^2) p = \gamma mv$  $= 1 \Gamma_{\mu\nu\sigma} = 1/2(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$  $d^2 u/d\phi^2 + u - GM/A^2 - 3GMu^2 = 0 \delta =$  $1/c^2 \partial \mathbf{E} / \partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2 / 2m\nabla^2 \psi$  $p^2 c^2 + m^2 c^4 \partial_\mu J^\mu = 0 E_i = -1/c \partial A_i$  $v^{\nu}v^{\sigma} = 0 R^{\mu}_{\nu\rho\sigma} = \Gamma^{\mu}_{\nu\sigma,\rho} - \Gamma^{\mu}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}$ 

 $\sigma r/r^3 \nabla \cdot \mathbf{E} = \rho/\epsilon \nabla \cdot \mathbf{B} = 0 \nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ 

 $= \mu \mathbf{J} + 1/c^2 \partial \mathbf{E}/\partial t \mathbf{F} = q (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \hbar^2/2m\nabla^2 \psi$ 

 $\frac{1}{2} \left( 1 - \frac{1}{2} 0 M \right)^{-1} \left[ 1 - \frac{1}{2} M^2 - 1 - \frac{1}{2} M^2 + \frac{1}{2} M^$ 

D.P. George

MicroPython

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