Pyodide

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CONTENTS

Pyodide is a Python distribution for the browser and Node.js based on WebAssembly.

CHAPTER

ONE

WHAT IS PYODIDE?

Pyodide is a port of CPython to WebAssembly/Emscripten.

Pyodide makes it possible to install and run Python packages in the browser with micropip. Any pure Python package with a wheel available on PyPI is supported. Many packages with C extensions have also been ported for use with Pyodide. These include many general-purpose packages such as regex, pyyaml, lxml and scientific Python packages including numpy, pandas, scipy, matplotlib, and scikit-learn.

Pyodide comes with a robust Javascript ↔ Python foreign function interface so that you can freely mix these two languages in your code with minimal friction. This includes full support for error handling (throw an error in one language, catch it in the other), async/await, and much more.

When used inside a browser, Python has full access to the Web APIs.

CHAPTER

TWO

TRY PYODIDE

Try Pyodide in a REPL directly in your browser (no installation needed).

CHAPTER

THREE

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3.1 Using Pyodide

3.1.1 Getting started

Try it online

Try Pyodide in a REPL directly in your browser (no installation needed).

Setup

To include Pyodide in your project you can use the following CDN URL:

```
https://cdn.jsdelivr.net/pyodide/v0.21.1/full/pyodide.js
```

You can also download a release from GitHub releases or build Pyodide yourself. See *Downloading and deploying Pyodide* for more details.

The `pyodide.js` file defines a single async function called *`loadPyodide`* which sets up the Python environment and returns *`the Pyodide top level namespace`*.

```
async function main() {
  let pyodide = await loadPyodide();
  // Pyodide is now ready to use...
  console.log(pyodide.runPython(`
    import sys
    sys.version
  `));
};
main();
```

Running Python code

Python code is run using the *pyodide.runPython* function. It takes as input a string of Python code. If the code ends in an expression, it returns the result of the expression, translated to JavaScript objects (see *Type translations*). For example the following code will return the version string as a JavaScript string:

```
pyodide.runPython(`
  import sys
  sys.version
`);
```

After importing Pyodide, only packages from the standard library are available. See *Loading packages* for information about loading additional packages.

Complete example

Create and save a test `index.html` page with the following contents:

```
<!DOCTYPE html>
<html>
  <head>
      <script src="https://cdn.jsdelivr.net/pyodide/v0.21.1/full/pyodide.js"></script>
  </head>
  <body>
    Pyodide test page <br>
    Open your browser console to see Pyodide output
    <script type="text/javascript">
      async function main(){
        let pyodide = await loadPyodide();
        console.log(pyodide.runPython(`
            import sys
            sys.version
        `));
        pyodide.runPython("print(1 + 2)");
      }
      main();
    </script>
  </body>
</html>
```

Alternative Example

```
<!DOCTYPE html>
<html>
  <head>
    <script src="https://cdn.jsdelivr.net/pyodide/v0.21.1/full/pyodide.js"></script>
  </head>

  <body>
    <p>
      You can execute any Python code. Just enter something in the box below and
```

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```
      click the button.
    </p>
    <input id="code" value="sum([1, 2, 3, 4, 5])" />
    <button onclick="evaluatePython()">Run</button>
    <br />
    <br />
    <div>Output:</div>
    <textarea id="output" style="width: 100%;" rows="6" disabled></textarea>

    <script>
      const output = document.getElementById("output");
      const code = document.getElementById("code");

      function addToOutput(s) {
        output.value += ">>>" + code.value + "\n" + s + "\n";
      }

      output.value = "Initializing...\n";
      // init Pyodide
      async function main() {
        let pyodide = await loadPyodide();
        output.value += "Ready!\n";
        return pyodide;
      }
      let pyodideReadyPromise = main();

      async function evaluatePython() {
        let pyodide = await pyodideReadyPromise;
        try {
          let output = pyodide.runPython(code.value);
          addToOutput(output);
        } catch (err) {
          addToOutput(err);
        }
      }
    </script>
  </body>
</html>
```

Accessing Python scope from JavaScript

All functions and variables defined in the Python global scope are accessible via the *pyodide.globals* object.

For example, if you run the code `x = numpy.ones([3,3])` in Python global scope, you can access the global variable `x` from JavaScript in your browser's developer console with `pyodide.globals.get("x")`. The same goes for functions and imports. See *Type translations* for more details.

You can try it yourself in the browser console. Go to

```
https://cdn.jsdelivr.net/pyodide/v0.21.1/full/console.html
```

and type the following into the browser console:

```
await pyodide.loadPackage("numpy");
pyodide.runPython(`
  import numpy
  x=numpy.ones((3, 4))
`);
pyodide.globals.get('x').toJs();
// >>> [ Float64Array(4), Float64Array(4), Float64Array(4) ]
```

You can assign new values to Python global variables or create new ones from Javascript.

```
// re-assign a new value to an existing variable
pyodide.globals.set("x", 'x will be now string');

// add the js "alert" function to the Python global scope
// this will show a browser alert if called from Python
pyodide.globals.set("alert", alert);

// add a "square" function to Python global scope
pyodide.globals.set("square", x => x*x);

// Test the new "square" Python function
pyodide.runPython("square(3)");
```

Accessing JavaScript scope from Python

The JavaScript scope can be accessed from Python using the `js` module (see *Importing JavaScript objects into Python*). We can use it to access global variables and functions from Python. For instance, we can directly manipulate the DOM:

```
import js

div = js.document.createElement("div")
div.innerHTML = "<h1>This element was created from Python</h1>"
js.document.body.prepend(div)
```

3.1.2 Downloading and deploying Pyodide

Downloading Pyodide

CDN

Pyodide is available from the JsDelivr CDN

channel	indexURL	Comments	REPL
Latest release	`https://cdn.jsdelivr.net/pyodide/v0.21.1/full/`	Recommended, cached by the browser	link
Dev (`main` branch)	`https://cdn.jsdelivr.net/pyodide/dev/full/`	Re-deployed for each commit on main, no browser caching, should only be used for testing	link

Warning: The previous CDN `pyodide-cdn2.iodide.io` is deprecated and should not be used.

GitHub releases

You can also download Pyodide packages from GitHub releases (the `pyodide-build-*.tar.bz2` file).

You will need to serve these files yourself.

Serving Pyodide packages

Serving locally

With Python 3.7.5+ you can serve Pyodide files locally with `http.server`:

```
python -m http.server
```

from the Pyodide distribution folder. Navigate to http://localhost:8000/console.html and the Pyodide repl should load.

Remote deployments

Any service that hosts static files and that correctly sets the WASM MIME type and CORS headers will work. For instance, you can use GitHub Pages or similar services.

For additional suggestions for optimizing the size and load time for Pyodide, see the Emscripten documentation about deployments.

3.1.3 Using Pyodide

Pyodide may be used in a web browser or a backend JavaScript environment.

Web browsers

To use Pyodide in a web page you need to load `pyodide.js` and initialize Pyodide with *`loadPyodide`*.

```
<!DOCTYPE html>
<html>
  <head>
      <script src="https://cdn.jsdelivr.net/pyodide/v0.21.1/full/pyodide.js"></script>
  </head>
  <body>
    <script type="text/javascript">
      async function main(){
        let pyodide = await loadPyodide();
        console.log(pyodide.runPython("1 + 2"));
      }
      main();
    </script>
  </body>
</html>
```

See the *Getting started* for a walk-through tutorial as well as *Loading packages* and *Type translations* for a more in depth discussion about existing capabilities.

You can also use the Pyodide NPM package to integrate Pyodide into your application.

Note: To avoid confusion, note that:

- `cdn.jsdelivr.net/pyodide/` distributes Python packages built with Pyodide as well as `pyodide.js`
- `cdn.jsdelivr.net/npm/pyodide@0.19.0/` is a mirror of the Pyodide NPM package, which includes none of the WASM files

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Supported browsers

Pyodide works in any modern web browser with WebAssembly support.

Tier 1 browsers are tested as part of the test suite with continuous integration,

Browser	Minimal supported version	Release date
Firefox	70.0	22 October 2019
Chrome	71.0	4 December 2018

Chrome 89 and 90 have bugs in the webassembly compiler which makes using Pyodide with them unstable. Known problems occur in numpy and have been observed occasionally in other packages. See #1384.

Note: Latest browser versions generally provide more reliable WebAssembly support and will run Pyodide faster, so their use is recommended.

Tier 2 browsers are known to work, but they are not systematically tested in Pyodide,

Browser	Minimal supported version	Release date
Safari	14.0	15 September 2020
Edge	80	26 February 2020

Other browsers with WebAssembly support might also work however they are not officially supported.

Web Workers

By default, WebAssembly runs in the main browser thread, and it can make UI non-responsive for long-running computations.

To avoid this situation, one solution is to run *Pyodide in a WebWorker*.

Node.js

Note: The following instructions have been tested with Node.js 18.5.0. To use Pyodide with older versions of Node, you might need to use additional command line arguments, see below.

It is now possible to install the Pyodide npm package in Node.js. To follow these instructions you need at least Pyodide 0.21.0. You can explicitly ask npm to use the alpha version:

```
$ npm install "pyodide@>=0.21.0-alpha.2"
```

Once installed, you can run the following simple script:

```
// hello_python.js
const { loadPyodide } = require("pyodide");

async function hello_python() {
  let pyodide = await loadPyodide();
  return pyodide.runPythonAsync("1+1");
}

hello_python().then((result) => {
  console.log("Python says that 1+1 =", result);
});
```

```
$ node hello_python.js
Loading distutils
Loaded distutils
Python initialization complete
Python says that 1+1= 2
```

Or you can use the REPL. To start the Node.js REPL with support for top level await, use `node --experimental-repl-await`:

```
$ node --experimental-repl-await
Welcome to Node.js v18.5.0.
Type ".help" for more information.
> const { loadPyodide } = require("pyodide");
undefined
> let pyodide = await loadPyodide();
Loading distutils
Loaded distutils
Python initialization complete
undefined
> await pyodide.runPythonAsync("1+1");
2
```

Node.js versions <0.17

- `Node.js` versions 14.x and 16.x: to use certain features of Pyodide you need to manually install `node-fetch`, e.g. by doing `npm install node-fetch`.
- `Node.js v14.x`: you need to pass the option `--experimental-wasm-bigint` when starting Node. Note that this flag is not documented by `node --help` and moreover, if you pass `--experimental-wasm-bigint` to node >14 it is an error:

```
$ node -v
v14.20.0

$ node --experimental-wasm-bigint hello_python.js
warning: no blob constructor, cannot create blobs with mimetypes
warning: no BlobBuilder
Loading distutils
Loaded distutils
Python initialization complete
Python says that 1+1= 2
```

Using Pyodide in a web worker

This document describes how to use Pyodide to execute Python scripts asynchronously in a web worker.

Setup

Setup your project to serve `webworker.js`. You should also serve `pyodide.js`, and all its associated `.asm.js`, `.data`, `.json`, and `.wasm` files as well, though this is not strictly required if `pyodide.js` is pointing to a site serving current versions of these files. The simplest way to serve the required files is to use a CDN, such as `https://cdn.jsdelivr.net/pyodide`. This is the solution presented here.

Update the `webworker.js` sample so that it has as valid URL for `pyodide.js`, and sets *indexURL* to the location of the supporting files.

In your application code create a web worker `new Worker(...)`, and attach listeners to it using its `.onerror` and `.onmessage` methods (listeners).

Communication from the worker to the main thread is done via the `Worker.postMessage()` method (and vice versa).

Detailed example

In this example process we will have three parties involved:

- The **web worker** is responsible for running scripts in its own separate thread.
- The **worker API** exposes a consumer-to-provider communication interface.
- The **consumer**s want to run some scripts outside the main thread, so they don't block the main thread.

Consumers

Our goal is to run some Python code in another thread, this other thread will not have access to the main thread objects. Therefore, we will need an API that takes as input not only the Python `script` we want to run, but also the `context` on which it relies (some JavaScript variables that we would normally get access to if we were running the Python script in the main thread). Let's first describe what API we would like to have.

Here is an example of consumer that will exchange with the web worker, via the worker interface/API `py-worker.js`. It runs the following Python `script` using the provided `context` and a function called `asyncRun()`.

```
import { asyncRun } from "./py-worker";

const script = `
    import statistics
    from js import A_rank
    statistics.stdev(A_rank)
`;

const context = {
  A_rank: [0.8, 0.4, 1.2, 3.7, 2.6, 5.8],
};

async function main() {
  try {
    const { results, error } = await asyncRun(script, context);
    if (results) {
      console.log("pyodideWorker return results: ", results);
    } else if (error) {
      console.log("pyodideWorker error: ", error);
    }
  } catch (e) {
    console.log(
      `Error in pyodideWorker at ${e.filename}, Line: ${e.lineno}, ${e.message}`
    );
  }
}

main();
```

Before writing the API, let's first have a look at how the worker operates. How does our web worker run the `script` using a given `context`.

Web worker

Let's start with the definition. A worker is:

> A worker is an object created using a constructor (e.g. Worker()) that runs a named JavaScript file — this file contains the code that will run in the worker thread; workers run in another global context that is different from the current window. This context is represented by either a DedicatedWorkerGlobalScope object (in the case of dedicated workers - workers that are utilized by a single script), or a SharedWorkerGlobalScope (in the case of shared workers - workers that are shared between multiple scripts).

In our case we will use a single worker to execute Python code without interfering with client side rendering (which is done by the main JavaScript thread). The worker does two things:

1. Listen on new messages from the main thread
2. Respond back once it finished executing the Python script

These are the required tasks it should fulfill, but it can do other things. For example, to always load packages `numpy` and `pytz`, you would insert the line `await pyodide.loadPackage(['numpy', 'pytz']);` as shown below:

```
// webworker.js

// Setup your project to serve `py-worker.js`. You should also serve
// `pyodide.js`, and all its associated `.asm.js`, `.data`, `.json`,
// and `.wasm` files as well:
importScripts("https://cdn.jsdelivr.net/pyodide/v0.21.1/full/pyodide.js");

async function loadPyodideAndPackages() {
  self.pyodide = await loadPyodide();
  await self.pyodide.loadPackage(["numpy", "pytz"]);
}
let pyodideReadyPromise = loadPyodideAndPackages();

self.onmessage = async (event) => {
  // make sure loading is done
  await pyodideReadyPromise;
  // Don't bother yet with this line, suppose our API is built in such a way:
  const { id, python, ...context } = event.data;
  // The worker copies the context in its own "memory" (an object mapping name to values)
  for (const key of Object.keys(context)) {
    self[key] = context[key];
  }
  // Now is the easy part, the one that is similar to working in the main thread:
  try {
    await self.pyodide.loadPackagesFromImports(python);
    let results = await self.pyodide.runPythonAsync(python);
    self.postMessage({ results, id });
  } catch (error) {
    self.postMessage({ error: error.message, id });
  }
};
```

The worker API

Now that we established what the two sides need and how they operate, let's connect them using this simple API (`py-worker.js`). This part is optional and only a design choice, you could achieve similar results by exchanging message directly between your main thread and the webworker. You would just need to call `.postMessages()` with the right arguments as this API does.

```
const pyodideWorker = new Worker("./dist/webworker.js");

const callbacks = {};

pyodideWorker.onmessage = (event) => {
  const { id, ...data } = event.data;
  const onSuccess = callbacks[id];
```

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```
  delete callbacks[id];
  onSuccess(data);
};

const asyncRun = (() => {
  let id = 0; // identify a Promise
  return (script, context) => {
    // the id could be generated more carefully
    id = (id + 1) % Number.MAX_SAFE_INTEGER;
    return new Promise((onSuccess) => {
      callbacks[id] = onSuccess;
      pyodideWorker.postMessage({
        ...context,
        python: script,
        id,
      });
    });
  };
})();

export { asyncRun };
```

Caveats

Using a web worker is advantageous because the Python code is run in a separate thread from your main UI, and hence does not impact your application's responsiveness. There are some limitations, however. At present, Pyodide does not support sharing the Python interpreter and packages between multiple web workers or with your main thread. Since web workers are each in their own virtual machine, you also cannot share globals between a web worker and your main thread. Finally, although the web worker is separate from your main thread, the web worker is itself single threaded, so only one Python script will execute at a time.

Loading custom Python code

Pyodide provides a simple API *pyodide.runPython* to run Python code. However, when your Python code grow bigger, putting hundreds of lines inside `runPython` is not scalable.

For larger projects, the best way to run Python code with Pyodide is:

1. create a Python package
2. load your Python package into the Pyodide (Emscripten) virtual file system
3. import the package with `let mypkg = pyodide.pyimport("mypkgname")`
4. call into your package with `mypkg.some_api(some_args)`.

Using wheels

The best way of serving custom Python code is making it a package in the wheel (.whl) format. If the package is built as a `wheel` file, you can use *`micropip.install`* to install the package. See *Loading packages* for more information.

Packages with C extensions

If your Python code contains C extensions, it needs to be built in a specialized way (See *Creating a Pyodide package*).

Loading then importing Python code

It is also possible to download and import Python code from an external source. We recommend that you serve all files in an archive, instead of individually downloading each Python script.

From Python

```
// Downloading an archive
await pyodide.runPythonAsync(`
    from pyodide.http import pyfetch
    response = await pyfetch("https://.../your_package.tar.gz") # .zip, .whl, ...
    await response.unpack_archive() # by default, unpacks to the current dir
`)
pkg = pyodide.pyimport("your_package");
pkg.do_something();
```

```
// Downloading a single file
await pyodide.runPythonAsync(`
    from pyodide.http import pyfetch
    response = await pyfetch("https://.../script.py")
    with open("script.py", "wb") as f:
        f.write(await response.bytes())
`)
pkg = pyodide.pyimport("script");
pkg.do_something();
```

What is pyfetch?

Pyodide provides *`pyodide.http.pyfetch`*, which is a convenient wrapper of JavaScript `fetch`. See *How can I load external files in Pyodide?* for more information.

From JavaScript

```
let response = await fetch("https://.../your_package.tar.gz"); // .zip, .whl, ...
let buffer = await response.arraybuffer();
await pyodide.unpackArchive(buffer); // by default, unpacks to the current dir
pyodide.pyimport("your_package");
```

Warning on unpacking a wheel package

Since a wheel package is actually a zip archive, you can use *pyodide.unpackArchive()* to unpack a wheel package, instead of using *micropip.install*.

However, *micropip* does dependency resolution when installing packages, while *pyodide.unpackArchive()* simply unpacks the archive. So you must be aware of that each dependencies of a package need to be installed manually before unpacking a wheel.

Future plans: we are planning to support a method for a static dependency resolution (See: pyodide#2045).

Running external code directly

If you want to run a single Python script from an external source in a simplest way, you can:

```
pyodide.runPython(await (await fetch("https://some_url/.../code.py")).text());
```

Dealing with the file system

Pyodide includes a file system provided by Emscripten. In JavaScript, the Pyodide file system can be accessed through *pyodide.FS* which re-exports the Emscripten File System API

Example: Reading from the file system

```
pyodide.runPython(`
  with open("/hello.txt", "w") as fh:
      fh.write("hello world!")
`);

let file = pyodide.FS.readFile("/hello.txt", { encoding: "utf8" });
console.log(file); // ==> "hello world!"
```

Example: Writing to the file system

```
let data = "hello world!";
pyodide.FS.writeFile("/hello.txt", data, { encoding: "utf8" });
pyodide.runPython(`
  with open("/hello.txt", "r") as fh:
        data = fh.read()
  print(data)
`);
```

Mounting a file system

The default file system used in Pyodide is MEMFS, which is a virtual in-memory file system. The data stored in MEMFS will be lost when the page is reloaded.

If you wish for files to persist, you can mount other file systems. Other file systems provided by Emscripten are `IDBFS`, `NODEFS`, `PROXYFS`, `WORKERFS`. Note that some filesystems can only be used in specific runtime environments. See Emscripten File System API for more details. For instance, to store data persistently between page reloads, one could mount a folder with the IDBFS file system

```
let mountDir = "/mnt";
pyodide.FS.mkdir(mountDir);
pyodide.FS.mount(pyodide.FS.filesystems.IDBFS, { root: "." }, mountDir);
```

If you are using Node.js you can access the native file system by mounting `NODEFS`.

```
let mountDir = "/mnt";
pyodide.FS.mkdir(mountDir);
pyodide.FS.mount(pyodide.FS.filesystems.NODEFS, { root: "." }, mountDir);
pyodide.runPython("import os; print(os.listdir('/mnt'))");
// ==> The list of files in the Node working directory
```

3.1.4 Loading packages

Only the Python standard library is available after importing Pyodide. To use other packages, you'll need to load them using either:

- *pyodide.loadPackage* for packages built with Pyodide, or
- *micropip.install* for pure Python packages with wheels available on PyPI or from other URLs.

Note: *micropip* can also be used to load packages built in Pyodide (in which case it relies on *pyodide.loadPackage*).

If you use *pyodide.loadPackagesFromImports* Pyodide will automatically download all packages that the code snippet imports. This is particularly useful for making a repl since users might import unexpected packages. At present, *loadPackagesFromImports* will not download packages from PyPI, it will only download packages included in the Pyodide distribution. See *Packages built in Pyodide* to check the full list of packages included in Pyodide.

Loading packages with `pyodide.loadPackage`

Packages included in the official Pyodide repository can be loaded using *pyodide.loadPackage*:

```
await pyodide.loadPackage("numpy");
```

It is also possible to load packages from custom URLs:

```
await pyodide.loadPackage(
  "https://foo/bar/numpy-1.22.3-cp310-cp310-emscripten_3_1_13_wasm32.whl"
);
```

The file name must be a valid wheel name.

When you request a package from the official repository, all of the package's dependencies are also loaded. Dependency resolution is not yet implemented when loading packages from custom URLs.

In general, loading a package twice is not permitted. However, one can override a dependency by loading a custom URL with the same package name before loading the dependent package.

Multiple packages can also be loaded at the same time by passing a list to *pyodide.loadPackage*.

```
await pyodide.loadPackage(["cycler", "pytz"]);
```

pyodide.loadPackage returns a `Promise` which resolves when all the packages are finished loading:

```
let pyodide;
async function main() {
  pyodide = await loadPyodide();
  await pyodide.loadPackage("matplotlib");
  // matplotlib is now available
}
main();
```

Micropip

Installing packages from PyPI

Pyodide supports installing pure Python wheels from PyPI with *micropip*. *micropip.install()* returns a Python Future so you can await the future or otherwise use the Python future API to do work once the packages have finished loading:

```
await pyodide.loadPackage("micropip");
const micropip = pyodide.pyimport("micropip");
await micropip.install('snowballstemmer');
pyodide.runPython(`
  import snowballstemmer
  stemmer = snowballstemmer.stemmer('english')
  print(stemmer.stemWords('go goes going gone'.split()))
`);
```

Micropip implements file integrity validation by checking the hash of the downloaded wheel against pre-recorded hash digests from the PyPI JSON API.

Installing wheels from arbitrary URLs

Pure Python wheels can also be installed from any URL with *micropip*,

```
import micropip
micropip.install(
    'https://example.com/files/snowballstemmer-2.0.0-py2.py3-none-any.whl'
)
```

Micropip decides whether a file is a URL based on whether it ends in ".whl" or not. The wheel name in the URL must follow PEP 427 naming convention, which will be the case if the wheels is made using standard Python tools (`pip wheel`, `setup.py bdist_wheel`). Micropip will also install the dependencies of the wheel. If dependency resolution is not desired, you may pass `deps=False`.

Cross-Origin Resource Sharing (CORS)

If the file is on a remote server, the server must set Cross-Origin Resource Sharing (CORS) headers to allow access. If the server doesn't set CORS headers, you can use a CORS proxy. Note that using third-party CORS proxies has security implications, particularly since we are not able to check the file integrity, unlike with installs from PyPI. See this stack overflow answer for more information about CORS.

Example

```
<html>
  <head>
    <meta charset="utf-8" />
  </head>
  <body>
    <script
      type="text/javascript"
      src="https://cdn.jsdelivr.net/pyodide/v0.21.1/full//pyodide.js"
    ></script>
    <script type="text/javascript">
      async function main() {
        let pyodide = await loadPyodide();
        await pyodide.loadPackage("micropip");
        const micropip = pyodide.pyimport("micropip");
        await micropip.install("snowballstemmer");
        await pyodide.runPython(`
        import snowballstemmer
        stemmer = snowballstemmer.stemmer('english')
        print(stemmer.stemWords('go goes going gone'.split()))
      `);
      }
      main();
    </script>
  </body>
</html>
```

Packages built in Pyodide

This is the list of Python packages included with the current version of Pyodide. These packages can be loaded with *pyodide.loadPackage* or *micropip.install*. See *Loading packages* for information about loading packages. Pure Python packages with wheels on PyPI can be loaded directly from PyPI with *micropip.install*.

Name	Version
_lzma	1.0.0
_ssl	1.0.0
asciitree	0.3.3
astropy	5.1
atomicwrites	1.4.0
attrs	21.4.0

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Table 1 – continued from previous page

Name	Version
autograd	1.4
beautifulsoup4	4.11.1
biopython	1.79
bitarray	2.5.1
bleach	5.0.0
bokeh	2.4.3
boost-histogram	1.3.1
brotli	1.0.9
certifi	2022.6.15
cffi	1.15.0
cffi_example	0.1
cftime	1.6.0
CLAPACK	3.2.1
cloudpickle	2.1.0
cmyt	1.0.4
colorspacious	1.1.2
cryptography	37.0.3
cssselect	1.1.0
cycler	0.11.0
cytoolz	0.11.2
decorator	5.1.1
demes	0.2.2
distlib	0.3.4
docutils	0.18.1
fonttools	4.33.3
freesasa	2.1.0
future	0.18.2
galpy	1.8.0
geos	3.10.3
gmpy2	2.1.2
gsw	3.4.0
h5py	3.7.0
html5lib	1.1
imageio	2.19.3
iniconfig	1.1.1
jedi	0.18.1
Jinja2	3.1.2
joblib	1.1.0
jsonschema	4.6.0
kiwisolver	1.4.3
lazy-object-proxy	1.7.1
libmagic	5.42
logbook	1.5.3
lxml	4.9.0
MarkupSafe	2.1.1
matplotlib	3.5.2
micropip	Pyodide standard library
mne	1.0.3
more-itertools	8.13.0

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Table 1 – continued from previous page

Name	Version
mpmath	1.2.1
msgpack	1.0.4
msprime	1.2.0
networkx	2.8.4
newick	1.3.2
nlopt	2.7.0
nltk	3.7
nose	1.3.7
numcodecs	0.9.1
numpy	1.23.0
opencv-python	4.6.0.66
openssl	1.1.1n
optlang	1.5.2
packaging	21.3
pandas	1.4.2
parso	0.8.3
patsy	0.5.2
Pillow	9.1.1
pkgconfig	1.5.5
pluggy	1.0.0
py	1.11.0
pyb2d	0.7.2
pyclipper	1.3.0.post3
pycparser	2.21
pydantic	1.9.1
pyerfa	2.0.0.1
Pygments	2.12.0
pyparsing	3.0.9
pyproj	3.3.1
pyrsistent	0.18.1
pytest	7.1.2
pytest-benchmark	3.4.1
python-dateutil	2.8.2
python-magic	0.4.27
python-sat	0.1.7.dev19
python_solvespace	3.0.7
pytz	2022.1
pywavelets	1.3.0
pyyaml	6.0
rebound	3.19.8
reboundx	3.7.1
regex	2022.6.2
retrying	1.3.3
RobotRaconteur	0.15.1
ruamel	0.17.21
scikit-image	0.19.3
scikit-learn	1.1.1
scipy	1.8.1
setuptools	62.6.0

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Table 1 – continued from previous page

Name	Version
shapely	1.8.2
six	1.16.0
soupsieve	2.3.2.post1
sparseqr	1.2
sqlalchemy	1.4.37
statsmodels	0.13.2
suitesparse	5.11.0
svgwrite	1.4.2
swiglpk	5.0.3
sympy	1.10.1
tblib	1.7.0
termcolor	1.1.0
threadpoolctl	3.1.0
tomli	2.0.1
tomli-w	1.0.0
toolz	0.11.2
tqdm	4.64.0
traits	6.3.2
tskit	0.4.1
typing-extensions	4.2.0
uncertainties	3.1.7
unyt	2.8.0
webencodings	0.5.1
wrapt	1.14.1
xarray	2022.3.0
xgboost	1.6.1
xlrd	2.0.1
yt	4.0.4
zarr	2.11.3

3.1.5 Type translations

In order to communicate between Python and JavaScript, we "translate" objects between the two languages. Depending on the type of the object we either translate the object by implicitly converting it or by proxying it. By "converting" an object we mean producing a new object in the target language which is the equivalent of the object from the source language, for example converting a Python string to the equivalent a JavaScript string. By "proxying" an object we mean producing a special object in the target language that forwards requests to the source language. When we proxy a JavaScript object into Python, the result is a *JsProxy* object. When we proxy a Python object into JavaScript, the result is a *PyProxy* object. A proxied object can be explicitly converted using the explicit conversion methods *JsProxy.to_py* and *PyProxy.toJs*.

Python to JavaScript translations occur:

- when returning the final expression from a *pyodide.runPython* call,
- when *importing Python objects into JavaScript*
- when passing arguments to a JavaScript function called from Python,
- when returning the results of a Python function called from JavaScript,
- when accessing an attribute of a *PyProxy*

JavaScript to Python translations occur:

- when *importing from the `js` module*
- when passing arguments to a Python function called from JavaScript
- when returning the result of a JavaScript function called from Python
- when accessing an attribute of a *`JsProxy`*

Memory Leaks and Python to JavaScript translations

Any time a Python to JavaScript translation occurs, it may create a *`PyProxy`*. To avoid memory leaks, you must store the *`PyProxy`* and *`destroy`* it when you are done with it. See *Calling Python objects from JavaScript* for more info.

Round trip conversions

Translating an object from Python to JavaScript and then back to Python is guaranteed to give an object that is equal to the original object. Furthermore, if the object is proxied into JavaScript, then translation back unwraps the proxy, and the result of the round trip conversion `is` the original object (in the sense that they live at the same memory address). There are a few exceptions:

1. `nan` is converted to `nan` after a round trip but `nan != nan`
2. proxies created using *`pyodide.ffi.create_proxy`* will be unwrapped.

Translating an object from JavaScript to Python and then back to JavaScript gives an object that is === to the original object. Furthermore, if the object is proxied into Python, then translation back unwraps the proxy, and the result of the round trip conversion is the original object (in the sense that they live at the same memory address). There are a few exceptions:

1. `NaN` is converted to `NaN` after a round trip but `NaN !== NaN`,
2. `null` is converted to `undefined` after a round trip, and
3. a `BigInt` will be converted to a `Number` after a round trip unless its absolute value is greater than `Number.MAX_SAFE_INTEGER` (i.e., 2^53).

Implicit conversions

We implicitly convert immutable types but not mutable types. This ensures that mutable Python objects can be modified from JavaScript and vice-versa. Python has immutable types such as `tuple` and `bytes` that have no equivalent in JavaScript. In order to ensure that round trip translations yield an object of the same type as the original object, we proxy `tuple` and `bytes` objects.

Python to JavaScript

The following immutable types are implicitly converted from Python to JavaScript:

Python	JavaScript
`int`	`Number` or `BigInt`*
`float`	`Number`
`str`	`String`
`bool`	`Boolean`
`None`	`undefined`

* An `int` is converted to a `Number` if the `int` is between -2^53 and 2^53 inclusive, otherwise it is converted to a `BigInt`. (If the browser does not support `BigInt` then a `Number` will be used instead. In this case, conversion of large integers from Python to JavaScript is lossy.)

JavaScript to Python

The following immutable types are implicitly converted from JavaScript to Python:

JavaScript	Python
`Number`	`int` or `float` as appropriate*
`BigInt`	`int`
`String`	`str`
`Boolean`	`bool`
`undefined`	`None`
`null`	`None`

* A number is converted to an `int` if it is between -2^53 and 2^53 inclusive and its fractional part is zero. Otherwise, it is converted to a float.

Proxying

Any of the types not listed above are shared between languages using proxies that allow methods and some operations to be called on the object from the other language.

Proxying from JavaScript into Python

When most JavaScript objects are translated into Python a *JsProxy* is returned. The following operations are currently supported on a *JsProxy*:

Python	JavaScript
`str(proxy)`	`x.toString()`
`proxy.foo`	`x.foo`
`proxy.foo = bar`	`x.foo = bar`
`del proxy.foo`	`delete x.foo`
`hasattr(proxy, "foo")`	`"foo" in x`
`proxy(...)`	`x(...)`
`proxy.foo(...)`	`x.foo(...)`
`proxy.new(...)`	`new X(...)`
`len(proxy)`	`x.length` or `x.size`
`foo in proxy`	`x.has(foo)` or `x.includes(foo)`
`proxy[foo]`	`x.get(foo)`
`proxy[foo] = bar`	`x.set(foo, bar)`
`del proxy[foo]`	`x.delete(foo)`
`proxy1 == proxy2`	`x === y`
`proxy.typeof`	`typeof x`
`iter(proxy)`	`x[Symbol.iterator]()`
`next(proxy)`	`x.next()`
`await proxy`	`await x`

Note that each of these operations is only supported if the proxied JavaScript object supports the corresponding operation. See *the JsProxy API docs* for the rest of the methods supported on *JsProxy*. Some other code snippets:

```
for v in proxy:
    # do something
```

is equivalent to:

```
for (let v of x) {
  // do something
}
```

The `dir` method has been overloaded to return all keys on the prototype chain of `x`, so `dir(x)` roughly translates to:

```
function dir(x) {
  let result = [];
  do {
    result.push(...Object.getOwnPropertyNames(x));
  } while ((x = Object.getPrototypeOf(x)));
  return result;
}
```

As a special case, JavaScript `Array`, `HTMLCollection`, and `NodeList` are container types, but instead of using `array.get(7)` to get the 7th element, JavaScript uses `array[7]`. For these cases, we translate:

Python	JavaScript
`proxy[idx]`	`array[idx]`
`proxy[idx] = val`	`array[idx] = val`
`idx in proxy`	`idx in array`
`del proxy[idx]`	`array.splice(idx)`

Proxying from Python into JavaScript

When most Python objects are translated to JavaScript a *PyProxy* is produced.

Fewer operations can be overloaded in JavaScript than in Python, so some operations are more cumbersome on a *PyProxy* than on a *JsProxy*. The following operations are supported:

JavaScript	Python
`foo in proxy`	`hasattr(x, 'foo')`
`proxy.foo`	`x.foo`
`proxy.foo = bar`	`x.foo = bar`
`delete proxy.foo`	`del x.foo`
`Object.getOwnPropertyNames(proxy)`	`dir(x)`
`proxy(...)`	`x(...)`
`proxy.foo(...)`	`x.foo(...)`
`proxy.length`	`len(x)`
`proxy.has(foo)`	`foo in x`
`proxy.get(foo)`	`x[foo]`
`proxy.set(foo, bar)`	`x[foo] = bar`
`proxy.delete(foo)`	`del x[foo]`
`proxy.type`	`type(x)`
`proxy[Symbol.iterator]()`	`iter(x)`
`proxy.next()`	`next(x)`
`await proxy`	`await x`

Memory Leaks and PyProxy

Make sure to destroy PyProxies when you are done with them to avoid memory leaks.

```
let foo = pyodide.globals.get('foo');
foo();
foo.destroy();
foo(); // throws Error: Object has already been destroyed
```

Explicit Conversion of Proxies

Python to JavaScript

Explicit conversion of a *PyProxy* into a native JavaScript object is done with the *PyProxy.toJs* method. You can also perform such a conversion in Python using *to_js* which behaves in much the same way. By default, the `toJs` method does a recursive "deep" conversion, to do a shallow conversion use `proxy.toJs({depth : 1})`. In addition to *the normal type conversion*, `toJs` method performs the following explicit conversions:

Python	JavaScript
`list`, `tuple`	`Array`
`dict`	`Map`
`set`	`Set`
a buffer*	`TypedArray`

* Examples of buffers include bytes objects and numpy arrays.

If you need to convert `dict` instead to `Object`, you can pass `Object.fromEntries` as the `dict_converter` argument: `proxy.toJs({dict_converter : Object.fromEntries})`.

In JavaScript, `Map` and `Set` keys are compared using object identity unless the key is an immutable type (meaning a string, a number, a bigint, a boolean, `undefined`, or `null`). On the other hand, in Python, `dict` and `set` keys

are compared using deep equality. If a key is encountered in a `dict` or `set` that would have different semantics in JavaScript than in Python, then a `ConversionError` will be thrown.

See *Using Python Buffer objects from JavaScript* for the behavior of `toJs` on buffers.

Memory Leaks and toJs

The *toJs* method can create many proxies at arbitrary depth. It is your responsibility to manually `destroy` these proxies if you wish to avoid memory leaks. The `pyproxies` argument to `toJs` is designed to help with this:

```
let pyproxies = [];
proxy.toJs({pyproxies});
// Do stuff
// pyproxies contains the list of proxies created by `toJs`. We can destroy them
// when we are done with them
for(let px of pyproxies){
    px.destroy();
}
proxy.destroy();
```

As an alternative, if you wish to assert that the object should be fully converted and no proxies should be created, you can use `proxy.toJs({create_proxies : false})`. If a proxy would be created, an error is raised instead.

JavaScript to Python

Explicit conversion of a *JsProxy* into a native Python object is done with the *JsProxy.to_py* method. By default, the `to_py` method does a recursive "deep" conversion, to do a shallow conversion use `proxy.to_py(depth=1)` The `to_py` method performs the following explicit conversions:

JavaScript	Python
`Array`	`list`
`Object*`	`dict`
`Map`	`dict`
`Set`	`set`

* `to_py` will only convert an object into a dictionary if its constructor is `Object`, otherwise the object will be left alone. Example:

```
class Test {};
window.x = { "a" : 7, "b" : 2};
window.y = { "a" : 7, "b" : 2};
Object.setPrototypeOf(y, Test.prototype);
pyodide.runPython(`
    from js import x, y
    # x is converted to a dictionary
    assert x.to_py() == { "a" : 7, "b" : 2}
    # y is not a "Plain Old JavaScript Object", it's an instance of type Test so it's not␣
↪converted
    assert y.to_py() == y
`);
```

In JavaScript, `Map` and `Set` keys are compared using object identity unless the key is an immutable type (meaning a string, a number, a bigint, a boolean, `undefined`, or `null`). On the other hand, in Python, `dict` and `set` keys are compared using deep equality. If a key is encountered in a `Map` or `Set` that would have different semantics in Python than in JavaScript, then a `ConversionError` will be thrown. Also, in JavaScript, `true !== 1` and `false !== 0`, but in Python, `True == 1` and `False == 0`. This has the result that a JavaScript map can use `true` and `1` as distinct keys but a Python `dict` cannot. If the JavaScript map contains both `true` and `1` a `ConversionError` will be thrown.

Functions

Calling Python objects from JavaScript

If a Python object is callable, the proxy will be callable too. The arguments will be translated from JavaScript to Python as appropriate, and the return value will be translated from JavaScript back to Python. If the return value is a `PyProxy`, you must explicitly destroy it or else it will be leaked.

An example:

```
let test = pyodide.runPython(`
    def test(x):
        return [n*n for n in x]
    test
`);
let result_py = test([1,2,3,4]);
// result_py is a PyProxy of a list.
let result_js = result_py.toJs();
// result_js is the array [1, 4, 9, 16]
result_py.destroy();
```

If a function is intended to be used from JavaScript, you can use *to_js* on the return value. This prevents the return value from leaking without requiring the JavaScript code to explicitly destroy it. This is particularly important for callbacks.

```
let test = pyodide.runPython(`
    from pyodide.ffi import to_js
    def test(x):
        return to_js([n*n for n in x])
    test
`);
let result = test([1,2,3,4]);
// result is the array [1, 4, 9, 16], nothing needs to be destroyed.
```

If you need to use a key word argument, use *callKwargs*. The last argument should be a JavaScript object with the key value arguments.

```
let test = pyodide.runPython(`
    from pyodide.ffi import to_js
    def test(x, *, offset):
        return to_js([n*n + offset for n in x])
    to_js(test)
`);
let result = test.callKwargs([1,2,3,4], { offset : 7});
// result is the array [8, 12, 16, 23]
```

Calling JavaScript functions from Python

What happens when calling a JavaScript function from Python is a bit more complicated than calling a Python function from JavaScript. If there are any keyword arguments, they are combined into a JavaScript object and used as the final argument. Thus, if you call:

```
f(a=2, b=3)
```

then the JavaScript function receives one argument which is a JavaScript object `{a : 2, b : 3}`.

When a JavaScript function is called, and it returns anything but a promise, if the result is a `PyProxy` it is destroyed. Also, any arguments that are PyProxies that were created in the process of argument conversion are also destroyed. If the `PyProxy` was created in Python using *pyodide.ffi.create_proxy* it is not destroyed.

When a JavaScript function returns a `Promise` (for example, if the function is an `async` function), it is assumed that the `Promise` is going to do some work that uses the arguments of the function, so it is not safe to destroy them until the `Promise` resolves. In this case, the proxied function returns a Python `Future` instead of the original `Promise`. When the `Promise` resolves, the result is converted to Python and the converted value is used to resolve the `Future`. Then if the result is a `PyProxy` it is destroyed. Any PyProxies created in converting the arguments are also destroyed at this point.

As a result of this, if a `PyProxy` is persisted to be used later, then it must either be copied using *PyProxy.copy* in JavaScript, or it must be created with *pyodide.ffi.create_proxy* or *pyodide.ffi.create_once_callable*. If it's only going to be called once use *pyodide.ffi.create_once_callable*:

```
from pyodide import create_once_callable
from js import setTimeout
def my_callback():
    print("hi")
setTimeout(create_once_callable(my_callback), 1000)
```

If it's going to be called many times use `create_proxy`:

```
from pyodide import create_proxy
from js import document
def my_callback():
    print("hi")
proxy = pyodide.create_proxy(my_callback)
document.body.addEventListener("click", proxy)
# ...
# make sure to hold on to proxy
document.body.removeEventListener("click", proxy)
proxy.destroy()
```

Buffers

Using JavaScript Typed Arrays from Python

JavaScript ArrayBuffers and ArrayBuffer views (`Int8Array` and friends) are proxied into Python. Python can't directly access arrays if they are outside the WASM heap, so it's impossible to directly use these proxied buffers as Python buffers. You can convert such a proxy to a Python `memoryview` using the `to_py` api. This makes it easy to correctly convert the array to a Numpy array using `numpy.asarray`:

```
self.jsarray = new Float32Array([1,2,3, 4, 5, 6]);
pyodide.runPython(`
    from js import jsarray
    array = jsarray.to_py()
    import numpy as np
    numpy_array = np.asarray(array).reshape((2,3))
    print(numpy_array)
`);
```

After manipulating `numpy_array` you can assign the value back to `jsarray` using *JsProxy.assign*:

```
pyodide.runPython(`
    numpy_array[1,1] = 77
    jsarray.assign(a)
`);
console.log(jsarray); // [1, 2, 3, 4, 77, 6]
```

The *JsProxy.assign* and *JsProxy.assign_to* methods can be used to assign a JavaScript buffer from / to a Python buffer which is appropriately sized and contiguous. The assignment methods will only work if the data types match, the total length of the buffers match, and the Python buffer is contiguous.

These APIs are currently experimental, hopefully we will improve them in the future.

Using Python Buffer objects from JavaScript

Python objects supporting the Python Buffer protocol are proxied into JavaScript. The data inside the buffer can be accessed via the *PyProxy.toJs* method or the *PyProxy.getBuffer* method. The `toJs` API copies the buffer into JavaScript, whereas the `getBuffer` method allows low level access to the WASM memory backing the buffer. The `getBuffer` API is more powerful but requires care to use correctly. For simple use cases the `toJs` API should be preferred.

If the buffer is zero or one-dimensional, then `toJs` will in most cases convert it to a single `TypedArray`. However, in the case that the format of the buffer is `'s'`, we will convert the buffer to a string and if the format is `'?'` we will convert it to an Array of booleans.

If the dimension is greater than one, we will convert it to a nested JavaScript array, with the innermost dimension handled in the same way we would handle a 1d array.

An example of a case where you would not want to use the `toJs` method is when the buffer is bitmapped image data. If for instance you have a 3d buffer shaped 1920 x 1080 x 4, then `toJs` will be extremely slow. In this case you could use *PyProxy.getBuffer*. On the other hand, if you have a 3d buffer shaped 1920 x 4 x 1080, the performance of `toJs` will most likely be satisfactory. Typically, the innermost dimension won't matter for performance.

The *PyProxy.getBuffer* method can be used to retrieve a reference to a JavaScript typed array that points to the data backing the Python object, combined with other metadata about the buffer format. The metadata is suitable for use with a JavaScript ndarray library if one is present. For instance, if you load the JavaScript ndarray package, you can do:

```
let proxy = pyodide.globals.get("some_numpy_ndarray");
let buffer = proxy.getBuffer();
proxy.destroy();
try {
  if (buffer.readonly) {
    // We can't stop you from changing a readonly buffer, but it can cause undefined␣
↪behavior.
    throw new Error("Uh-oh, we were planning to change the buffer");
```

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```
  }
  let array = new ndarray(
    buffer.data,
    buffer.shape,
    buffer.strides,
    buffer.offset
  );
  // manipulate array here
  // changes will be reflected in the Python ndarray!
} finally {
  buffer.release(); // Release the memory when we're done
}
```

Errors

All entrypoints and exit points from Python code are wrapped in JavaScript `try` blocks. At the boundary between Python and JavaScript, errors are caught, converted between languages, and rethrown.

JavaScript errors are wrapped in a *JsException*. Python exceptions are converted to a *PythonError*. At present if an exception crosses between Python and JavaScript several times, the resulting error message won't be as useful as one might hope.

In order to reduce memory leaks, the *PythonError* has a formatted traceback, but no reference to the original Python exception. The original exception has references to the stack frame and leaking it will leak all the local variables from that stack frame. The actual Python exception will be stored in `sys.last_value` so if you need access to it (for instance to produce a traceback with certain functions filtered out), use that.

Be careful Proxying Stack Frames

If you make a *PyProxy* of `sys.last_value`, you should be especially careful to *destroy()* it when you are done with it, or you may leak a large amount of memory if you don't.

The easiest way is to only handle the exception in Python:

```
pyodide.runPython(`
def reformat_exception():
    from traceback import format_exception
    # Format a modified exception here
    # this just prints it normally but you could for instance filter some frames
    return "".join(
        traceback.format_exception(sys.last_type, sys.last_value, sys.last_traceback)
    )
`);
let reformat_exception = pyodide.globals.get("reformat_exception");
try {
    pyodide.runPython(some_code);
} catch(e){
    // replace error message
    e.message = reformat_exception();
    throw e;
}
```

Importing Objects

It is possible to access objects in one language from the global scope in the other language. It is also possible to create custom namespaces and access objects on the custom namespaces.

Importing Python objects into JavaScript

A Python global variable in the `__main__` global scope can be imported into JavaScript using the *pyodide.globals.get* method. Given the name of the Python global variable, it returns the value of the variable translated to JavaScript.

```
let x = pyodide.globals.get("x");
```

As always, if the result is a `PyProxy` and you care about not leaking the Python object, you must destroy it when you are done. It's also possible to set values in the Python global scope with *pyodide.globals.set* or remove them with *pyodide.globals.delete*:

```
pyodide.globals.set("x", 2);
pyodide.runPython("print(x)"); // Prints 2
```

If you execute code with a custom globals dictionary, you can use a similar approach:

```
let my_py_namespace = pyodide.globals.get("dict")();
pyodide.runPython("x=2", my_py_namespace);
let x = my_py_namespace.get("x");
```

To access a Python module from JavaScript, use *pyodide.pyimport*:

```
let sys = pyodide.pyimport("sys");
```

Importing JavaScript objects into Python

JavaScript objects in the `globalThis` global scope can be imported into Python using the `js` module.

When importing a name from the `js` module, the `js` module looks up JavaScript attributes of the `globalThis` scope and translates the JavaScript objects into Python.

```
import js
js.document.title = 'New window title'
from js.document.location import reload as reload_page
reload_page()
```

You can also assign to JavaScript global variables in this way:

```
pyodide.runPython("js.x = 2");
console.log(window.x); // 2
```

You can create your own custom JavaScript modules using *pyodide.registerJsModule* and they will behave like the `js` module except with a custom scope:

```
let my_js_namespace = { x : 3 };
pyodide.registerJsModule("my_js_namespace", my_js_namespace);
pyodide.runPython(`
```

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```
    from my_js_namespace import x
    print(x) # 3
    my_js_namespace.y = 7
`);
console.log(my_js_namespace.y); // 7
```

3.1.6 Pyodide Python compatibility

Python Standard library

Most of the Python standard library is functional, except for the modules listed in the sections below. A large part of the CPython test suite passes except for tests skipped in `src/tests/python_tests.yaml` or via patches.

Optional modules

The following stdlib modules are included by default, however they can be excluded with `loadPyodide({ fullStdLib : false })`. Individual modules can then be loaded as necessary using *`pyodide.loadPackage`*,

- distutils
- test: it is an exception to the above, since it is excluded by default.

Removed modules

The following modules are removed from the standard library to reduce download size and since they currently wouldn't work in the WebAssembly VM,

- curses
- dbm
- ensurepip
- idlelib
- lib2to3
- tkinter
- turtle.py
- turtledemo
- venv
- pwd

Included but not working modules

The following modules can be imported, but are not functional due to the limitations of the WebAssembly VM:

- multiprocessing
- threading
- sockets

as well as any functionality that requires these.

3.1.7 Interrupting execution

The native Python interrupt system is based on preemptive multitasking but Web Assembly has no support for preemptive multitasking. Because of this, interrupting execution in Pyodide must be achieved via a different mechanism which takes some effort to set up.

Setting up interrupts

In order to use interrupts you must be using Pyodide in a webworker. You also will need to use a `SharedArrayBuffer`, which means that your server must set appropriate security headers. See the MDN docs for more information.

To use the interrupt system, you should create a `SharedArrayBuffer` on either the main thread or the worker thread and share it with the other thread. You should use *`pyodide.setInterruptBuffer`* to set the interrupt buffer on the Pyodide thread. When you want to indicate an interrupt, write a `2` into the interrupt buffer. When the interrupt signal is processed, Pyodide will set the value of the interrupt buffer back to `0`.

By default, when the interrupt fires, a `KeyboardInterrupt` is raised. Using the `signal` module, it is possible to register a custom Python function to handle `SIGINT`. If you register a custom handler function it will be called instead.

Here is a very basic example. Main thread code:

```
let pyodideWorker = new Worker("pyodideWorker.js");
let interruptBuffer = new Uint8Array(new SharedArrayBuffer(1));
pyodideWorker.postMessage({ cmd: "setInterruptBuffer", interruptBuffer });
function interruptExecution() {
  // 2 stands for SIGINT.
  interruptBuffer[0] = 2;
}
// imagine that interruptButton is a button we want to trigger an interrupt.
interruptButton.addEventListener("click", interruptExecution);
async function runCode(code) {
  // Clear interruptBuffer in case it was accidentally left set after previous code␣
↪completed.
  interruptBuffer[0] = 0;
  pyodideWorker.postMessage({ cmd: "runCode", code });
}
```

Worker code:

```
self.addEventListener("message", (msg) => {
  if (msg.data.cmd === "setInterruptBuffer") {
    pyodide.setInterruptBuffer(msg.data.interruptBuffer);
    return;
```

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```
  }
  if (msg.data.cmd === "runCode") {
    pyodide.runPython(msg.data.code);
    return;
  }
});
```

Allowing JavaScript code to be interrupted

The interrupt system above allows interruption of Python code and also of C code that opts to allow itself to be interrupted by periodically calling `PyErr_CheckSignals`. There is also a function *`pyodide.checkInterrupt`* that allows JavaScript functions called from Python to check for an interrupt. As a simple example, we can implement an interruptible sleep function using `Atomics.wait`:

```
let blockingSleepBuffer = new Int32Array(new SharedArrayBuffer(4));
function blockingSleep(t) {
  for (let i = 0; i < t * 20; i++) {
    // This Atomics.wait call blocks the thread until the buffer changes or a 50ms␣
↪timeout elapses.
    // Since we won't change the value in the buffer, this blocks for 50ms.
    Atomics.wait(blockingSleepBuffer, 0, 0, 50);
    // Periodically check for an interrupt to allow a KeyboardInterrupt.
    pyodide.checkInterrupt();
  }
}
```

3.1.8 API Reference

JavaScript API

Backward compatibility of the API is not guaranteed at this point.

Globals

Functions:

async *`loadPyodide`*(options)	Load the main Pyodide wasm module and initialize it.

`globalThis.`**`loadPyodide`**(*options*)

Load the main Pyodide wasm module and initialize it.

Only one copy of Pyodide can be loaded in a given JavaScript global scope because Pyodide uses global variables to load packages. If an attempt is made to load a second copy of Pyodide, *`loadPyodide`* will throw an error. (This can be fixed once Firefox adopts support for ES6 modules in webworkers.)

Arguments

- **`options.fullStdLib`** (`boolean()`) – Load the full Python standard library. Setting this to false excludes following modules: distutils. Default: true

- **options.homedir** (string()) – The home directory which Pyodide will use inside virtual file system. Default: "/home/pyodide"
- **options.indexURL** (string()) – The URL from which Pyodide will load the main Pyodide runtime and packages. Defaults to the url that pyodide is loaded from with the file name (pyodide.js or pyodide.mjs) removed. It is recommended that you leave this undefined, providing an incorrect value can cause broken behavior.
- **options.jsglobals** (object()) –
- **options.lockFileURL** (string()) – The URL from which Pyodide will load the Pyodide "repodata.json" lock file. Defaults to ${indexURL}/repodata.json. You can produce custom lock files with *micropip.freeze*
- **options.stderr** ((msg: string) => void()) – Override the standard error output callback. Default: undefined
- **options.stdin** (() => string()) – Override the standard input callback. Should ask the user for one line of input.
- **options.stdout** ((msg: string) => void()) – Override the standard output callback. Default: undefined

Returns **Promise<PyodideInterface>** – The *pyodide* module.

pyodide

Attributes:

ERRNO_CODES	An alias to the Emscripten ERRNO_CODES map of standard error codes.
FS	An alias to the Emscripten File System API.
PATH	An alias to the Emscripten Path API.
globals	An alias to the global Python namespace.
loadedPackages	The list of packages that Pyodide has loaded.
pyodide_py	An alias to the Python pyodide package.
version	The Pyodide version.

Functions:

checkInterrupt()	Throws a KeyboardInterrupt error if a KeyboardInterrupt has been requested via the interrupt buffer.
isPyProxy(jsobj)	Is the argument a *PyProxy*?
async loadPackage(names, messageCallback, errorCallback)	Load a package or a list of packages over the network.
async loadPackagesFromImports(code, messageCallback, errorCallback)	Inspect a Python code chunk and use *pyodide.loadPackage()* to install any known packages that the code chunk imports.
pyimport(mod_name)	Imports a module and returns it.
registerComlink(Comlink)	Tell Pyodide about Comlink.
registerJsModule(name, module)	Registers the JavaScript object module as a JavaScript module named name.
runPython(code, options)	Runs a string of Python code from JavaScript, using *pyodide.code.eval_code* to evaluate the code.

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Table 4 – continued from previous page

async runPythonAsync(code, options)	Run a Python code string with top level await using pyodide.code.eval_code_async to evaluate the code.
setInterruptBuffer(interrupt_buffer)	Sets the interrupt buffer to be interrupt_buffer.
toPy(obj, options)	Convert the JavaScript object to a Python object as best as possible.
unpackArchive(buffer, format, options)	Unpack an archive into a target directory.
unregisterJsModule(name)	Unregisters a JavaScript module with given name that has been previously registered with pyodide.registerJsModule() or pyodide.register_js_module().

Classes:

PyBuffer	A class to allow access to a Python data buffers from JavaScript.
PythonError	A JavaScript error caused by a Python exception.

pyodide.**ERRNO_CODES**

type: any

An alias to the Emscripten ERRNO_CODES map of standard error codes.

pyodide.**FS**

type: any

An alias to the Emscripten File System API.

This provides a wide range of POSIX-*like* file/device operations, including mount which can be used to extend the in-memory filesystem with features like persistence.

While all the file systems implementations are enabled, only the default MEMFS is guaranteed to work in all runtime settings. The implementations are available as members of FS.filesystems: IDBFS, NODEFS, PROXYFS, WORKERFS.

pyodide.**PATH**

type: any

An alias to the Emscripten Path API.

This provides a variety of operations for working with file system paths, such as dirname, normalize, and splitPath.

pyodide.**globals**

type: PyProxy

An alias to the global Python namespace.

For example, to access a variable called foo in the Python global scope, use pyodide.globals.get("foo")

pyodide.**loadedPackages**

type: {[key: string]: string}

The list of packages that Pyodide has loaded. Use Object.keys(pyodide.loadedPackages) to get the list of names of loaded packages, and pyodide.loadedPackages[package_name] to access install location for a particular package_name.

pyodide.**pyodide_py**

type: PyProxy

An alias to the Python `pyodide` package.

You can use this to call functions defined in the Pyodide Python package from JavaScript.

pyodide.**version**

type: string

The Pyodide version.

It can be either the exact release version (e.g. `0.1.0`), or the latest release version followed by the number of commits since, and the git hash of the current commit (e.g. `0.1.0-1-bd84646`).

pyodide.**checkInterrupt**()

Throws a KeyboardInterrupt error if a KeyboardInterrupt has been requested via the interrupt buffer.

This can be used to enable keyboard interrupts during execution of JavaScript code, just as `PyErr_CheckSignals` is used to enable keyboard interrupts during execution of C code.

pyodide.**isPyProxy**(*jsobj*)

Is the argument a *PyProxy*?

Arguments

- **jsobj** (any()) – Object to test.

Returns **boolean (typeguard for PyProxy)** – Is `jsobj` a *PyProxy*?

pyodide.**loadPackage**(*names*, *messageCallback*, *errorCallback*)

Load a package or a list of packages over the network. This installs the package in the virtual filesystem. The package needs to be imported from Python before it can be used.

Arguments

- **names** (string|PyProxy|string[]()) – Either a single package name or URL or a list of them. URLs can be absolute or relative. The URLs must have file name <package-name>.js and there must be a file called <package-name>.data in the same directory. The argument can be a `PyProxy` of a list, in which case the list will be converted to JavaScript and the `PyProxy` will be destroyed.
- **messageCallback** ({}()) – A callback, called with progress messages (optional)
- **errorCallback** ({}()) – A callback, called with error/warning messages (optional)

Returns **Promise<void>** –

pyodide.**loadPackagesFromImports**(*code*, *messageCallback*, *errorCallback*)

Inspect a Python code chunk and use *pyodide.loadPackage()* to install any known packages that the code chunk imports. Uses the Python API *pyodide.code.find_imports()* to inspect the code.

For example, given the following code as input

```
import numpy as np x = np.array([1, 2, 3])
```

loadPackagesFromImports() will call `pyodide.loadPackage(['numpy'])`.

Arguments

- **code** (string()) – The code to inspect.
- **messageCallback** ({}()) – The `messageCallback` argument of *pyodide.loadPackage* (optional).

- **errorCallback** ({}()) – The errorCallback argument of *pyodide.loadPackage* (optional).

Returns **Promise<void>** –

pyodide.**pyimport**(*mod_name*)

Imports a module and returns it.

Warning

This function has a completely different behavior than the old removed pyimport function!

pyimport is roughly equivalent to:

```
pyodide.runPython(`import ${pkgname}; ${pkgname}`);
```

except that the global namespace will not change.

Example:

```
let sysmodule = pyodide.pyimport("sys");
let recursionLimit = sysmodule.getrecursionlimit();
```

Arguments

- **mod_name** (string()) – The name of the module to import

Returns **PyProxy** – A PyProxy for the imported module

pyodide.**registerComlink**(*Comlink*)

Tell Pyodide about Comlink. Necessary to enable importing Comlink proxies into Python.

Arguments

- **Comlink** (any()) –

pyodide.**registerJsModule**(*name*, *module*)

Registers the JavaScript object module as a JavaScript module named name. This module can then be imported from Python using the standard Python import system. If another module by the same name has already been imported, this won't have much effect unless you also delete the imported module from sys.modules. This calls the {any}`pyodide_py` API pyodide.register_js_module().

Arguments

- **name** (string()) – Name of the JavaScript module to add
- **module** (object()) – JavaScript object backing the module

pyodide.**runPython**(*code*, *options*)

Runs a string of Python code from JavaScript, using *pyodide.code.eval_code* to evaluate the code. If the last statement in the Python code is an expression (and the code doesn't end with a semicolon), the value of the expression is returned.

Positional globals argument

In Pyodide v0.19, this function took the globals parameter as a positional argument rather than as a named argument. In v0.20 this will still work but it is deprecated. It will be removed in v0.21.

Arguments

- **code** (string()) – Python code to evaluate
- **options.globals** (*PyProxy()*) – An optional Python dictionary to use as the globals. Defaults to *pyodide.globals*.

Returns **any** – The result of the Python code translated to JavaScript. See the documentation for *pyodide.code.eval_code* for more info.

pyodide.**runPythonAsync**(*code*, *options*)

Run a Python code string with top level await using *pyodide.code.eval_code_async* to evaluate the code. Returns a promise which resolves when execution completes. If the last statement in the Python code is an expression (and the code doesn't end with a semicolon), the returned promise will resolve to the value of this expression.

For example:

```
let result = await pyodide.runPythonAsync(`
    from js import fetch
    response = await fetch("./repodata.json")
    packages = await response.json()
    # If final statement is an expression, its value is returned to JavaScript
    len(packages.packages.object_keys())
`);
console.log(result); // 79
```

Python imports

Since pyodide 0.18.0, you must call *loadPackagesFromImports()* to import any python packages referenced via *import* statements in your code. This function will no longer do it for you.

Positional globals argument

In Pyodide v0.19, this function took the globals parameter as a positional argument rather than as a named argument. In v0.20 this will still work but it is deprecated. It will be removed in v0.21.

Arguments

- **code** (string()) – Python code to evaluate
- **options.globals** (*PyProxy()*) – An optional Python dictionary to use as the globals. Defaults to *pyodide.globals*.

Returns **Promise<any>** – The result of the Python code translated to JavaScript.

pyodide.**setInterruptBuffer**(*interrupt_buffer*)

Sets the interrupt buffer to be `interrupt_buffer`. This is only useful when Pyodide is used in a webworker. The buffer should be a `SharedArrayBuffer` shared with the main browser thread (or another worker). In that case, signal `signum` may be sent by writing `signum` into the interrupt buffer. If `signum` does not satisfy 0 < `signum` < `NSIG` it will be silently ignored. NSIG is 65 (internally signals are indicated by a bitflag).

You can disable interrupts by calling *setInterruptBuffer(undefined)*.

If you wish to trigger a `KeyboardInterrupt`, write `SIGINT` (a 2), into the interrupt buffer.

By default SIGINT raises a KeyboardInterrupt and all other signals are ignored. You can install custom signal handlers with the signal module. Even signals that normally have special meaning and can't be overridden like SIGKILL and SIGSEGV are ignored by default and can be used for any purpose you like.

Arguments

- **interrupt_buffer** (TypedArray()) –

pyodide.**toPy**(*obj*, *options*)

Convert the JavaScript object to a Python object as best as possible.

This is similar to *JsProxy.to_py* but for use from JavaScript. If the object is immutable or a *PyProxy*, it will be returned unchanged. If the object cannot be converted into Python, it will be returned unchanged.

See *JavaScript to Python* for more information.

Arguments

- **obj** (any()) –
- **options.depth** (number()) – Optional argument to limit the depth of the conversion.
- **options.defaultConverter** ((value: any, converter: {}, cacheConversion: {}) => any()) – Optional argument to convert objects with no default conversion. See the documentation of *JsProxy.to_py*.

Returns **any** – The object converted to Python.

pyodide.**unpackArchive**(*buffer*, *format*, *options*)

Unpack an archive into a target directory.

Positional globals argument :class: warning

In Pyodide v0.19, this function took the extract_dir parameter as a positional argument rather than as a named argument. In v0.20 this will still work but it is deprecated. It will be removed in v0.21.

Arguments

- **buffer** (TypedArray|ArrayBuffer()) – The archive as an ArrayBuffer or TypedArray.
- **format** (string()) – The format of the archive. Should be one of the formats recognized by *shutil.unpack_archive*. By default the options are 'bztar', 'gztar', 'tar', 'zip', and 'wheel'. Several synonyms are accepted for each format, e.g., for 'gztar' any of '.gztar', '.tar.gz', '.tgz', 'tar.gz' or 'tgz' are considered to be synonyms.
- **options.extractDir** (string()) – The directory to unpack the archive into. Defaults to the working directory.

pyodide.**unregisterJsModule**(*name*)

Unregisters a JavaScript module with given name that has been previously registered with *pyodide.registerJsModule()* or pyodide.register_js_module(). If a JavaScript module with that name does not already exist, will throw an error. Note that if the module has already been imported, this won't have much effect unless you also delete the imported module from sys.modules. This calls the *pyodide_py* API pyodide.unregister_js_module().

Arguments

- **name** (string()) – Name of the JavaScript module to remove

class pyodide.**PyBuffer**()

A class to allow access to a Python data buffers from JavaScript. These are produced by *PyProxy.getBuffer* and cannot be constructed directly. When you are done, release it with the *release* method. See Python buffer protocol documentation for more information.

To find the element `x[a_1, ..., a_n]`, you could use the following code:

```
function multiIndexToIndex(pybuff, multiIndex){
   if(multindex.length !==pybuff.ndim){
      throw new Error("Wrong length index");
   }
   let idx = pybuff.offset;
   for(let i = 0; i < pybuff.ndim; i++){
      if(multiIndex[i] < 0){
         multiIndex[i] = pybuff.shape[i] - multiIndex[i];
      }
      if(multiIndex[i] < 0 || multiIndex[i] >= pybuff.shape[i]){
         throw new Error("Index out of range");
      }
      idx += multiIndex[i] * pybuff.stride[i];
   }
   return idx;
}
console.log("entry is", pybuff.data[multiIndexToIndex(pybuff, [2, 0, -1])]);
```

Contiguity

If the buffer is not contiguous, the `data` TypedArray will contain data that is not part of the buffer. Modifying this data may lead to undefined behavior.

Readonly buffers

If `buffer.readonly` is `true`, you should not modify the buffer. Modifying a readonly buffer may lead to undefined behavior.

Converting between TypedArray types

The following naive code to change the type of a typed array does not work:

```
// Incorrectly convert a TypedArray.
// Produces a Uint16Array that points to the entire WASM memory!
let myarray = new Uint16Array(buffer.data.buffer);
```

Instead, if you want to convert the output TypedArray, you need to say:

```
// Correctly convert a TypedArray.
let myarray = new Uint16Array(
    buffer.data.buffer,
    buffer.data.byteOffset,
    buffer.data.byteLength
);
```

PyBuffer.**c_contiguous**

type: boolean

Is it C contiguous?

PyBuffer.**data**

type: TypedArray

The actual data. A typed array of an appropriate size backed by a segment of the WASM memory.

The `type` argument of *PyProxy.getBuffer* determines which sort of `TypedArray` this is. By default *PyProxy.getBuffer* will look at the format string to determine the most appropriate option.

PyBuffer.**f_contiguous**

type: boolean

Is it Fortran contiguous?

PyBuffer.**format**

type: string

The format string for the buffer. See the Python documentation on format strings.

PyBuffer.**itemsize**

type: number

How large is each entry (in bytes)?

PyBuffer.**nbytes**

type: number

The total number of bytes the buffer takes up. This is equal to `buff.data.byteLength`.

PyBuffer.**ndim**

type: number

The number of dimensions of the buffer. If `ndim` is 0, the buffer represents a single scalar or struct. Otherwise, it represents an array.

PyBuffer.**offset**

type: number

The offset of the first entry of the array. For instance if our array is 3d, then you will find `array[0,0,0]` at `pybuf.data[pybuf.offset]`

PyBuffer.**readonly**

type: boolean

If the data is readonly, you should not modify it. There is no way for us to enforce this, but it may cause very weird behavior.

PyBuffer.**shape**

type: number[]

The shape of the buffer, that is how long it is in each dimension. The length will be equal to `ndim`. For instance, a 2x3x4 array would have shape `[2, 3, 4]`.

PyBuffer.**strides**

type: number[]

An array of of length `ndim` giving the number of elements to skip to get to a new element in each dimension. See the example definition of a `multiIndexToIndex` function above.

PyBuffer.**release**()

Release the buffer. This allows the memory to be reclaimed.

class pyodide.**PythonError**(*message*, *error_address*)

A JavaScript error caused by a Python exception.

In order to reduce the risk of large memory leaks, the `PythonError` contains no reference to the Python exception that caused it. You can find the actual Python exception that caused this error as sys.last_value.

See *Errors* for more information.

Avoid Stack Frames

If you make a *PyProxy* of `sys.last_value`, you should be especially careful to *destroy()* it when you are done. You may leak a large amount of memory including the local variables of all the stack frames in the traceback if you don't. The easiest way is to only handle the exception in Python.

Arguments

- **message** (string()) –
- **error_address** (number()) –

PyProxy

A PyProxy is an object that allows idiomatic use of a Python object from JavaScript. See *Proxying from Python into JavaScript*.

Attributes:

[toStringTag]
length
type

Functions:

[iterator]()	This translates to the Python code `iter(obj)`.
apply(jsthis, jsargs)	
bind(placeholder)	No-op bind function for compatibility with existing libraries
call(jsthis, ...jsargs)	
callKwargs(...jsargs)	Call the function with key word arguments.
async catch(onRejected)	Runs `asyncio.ensure_future(awaitable)` and executes `onRejected(error)` if the future fails.
copy()	Make a new PyProxy pointing to the same Python object.
delete(key)	This translates to the Python code `del obj[key]`.
destroy(destroyed_msg)	Destroy the `PyProxy`.

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Table 7 – continued from previous page

async *finally*(onFinally)	Runs `asyncio.ensure_future(awaitable)` and executes `onFinally(error)` when the future resolves.
get(key)	This translates to the Python code `obj[key]`.
getBuffer(type)	Get a view of the buffer data which is usable from JavaScript.
has(key)	This translates to the Python code `key in obj`.
isAwaitable()	Check whether the PyProxy is awaitable.
isBuffer()	Check whether the PyProxy is a buffer.
isCallable()	Check whether the PyProxy is a Callable.
isIterable()	Check whether the PyProxy is iterable.
isIterator()	Check whether the PyProxy is iterable.
new PyProxyClass()	
next(arg=undefined)	This translates to the Python code `next(obj)`.
set(key, value)	This translates to the Python code `obj[key] = value`.
supportsGet()	Check whether the *PyProxy.get* method is available on this PyProxy.
supportsHas()	Check whether the *PyProxy.has* method is available on this PyProxy.
supportsLength()	Check whether the *PyProxy.length* getter is available on this PyProxy.
supportsSet()	Check whether the *PyProxy.set* method is available on this PyProxy.
async *then*(onFulfilled, onRejected)	Runs `asyncio.ensure_future(awaitable)`, executes `onFulfilled(result)` when the `Future` resolves successfully, executes `onRejected(error)` when the `Future` fails.
toJs(options)	Converts the `PyProxy` into a JavaScript object as best as possible.
toString()	

PyProxy.**[toStringTag]**

type: string

PyProxy.**length**

type: number

PyProxy.**type**

type: string

PyProxy.**[iterator]**()

This translates to the Python code `iter(obj)`. Return an iterator associated to the proxy. See the documentation for Symbol.iterator.

Present only if the proxied Python object is iterable (i.e., has an `__iter__` method).

This will be used implicitly by `for(let x of proxy){}`.

Returns **Iterator<any, any, any>** –

PyProxy.**apply**(*jsthis*, *jsargs*)

Arguments

- **jsthis** (`PyProxyClass()`) –

- **jsargs** (any()) –

Returns **any** –

PyProxy.**bind**(*placeholder*)

No-op bind function for compatibility with existing libraries

Arguments

- **placeholder** (any()) –

Returns **PyProxyCallableMethods** –

PyProxy.**call**(*jsthis*, *...jsargs*)

Arguments

- **jsthis** (PyProxyClass()) –
- **jsargs** (any()) –

Returns **any** –

PyProxy.**callKwargs**(*...jsargs*)

Call the function with key word arguments. The last argument must be an object with the keyword arguments.

Arguments

- **jsargs** (any()) –

Returns **any** –

PyProxy.**catch**(*onRejected*)

Runs asyncio.ensure_future(awaitable) and executes onRejected(error) if the future fails.

See the documentation for Promise.catch.

Present only if the proxied Python object is awaitable.

Arguments

- **onRejected** ({}()) – A handler called with the error as an argument if the awaitable fails.

Returns **Promise<any>** – The resulting Promise.

PyProxy.**copy**()

Make a new PyProxy pointing to the same Python object. Useful if the PyProxy is destroyed somewhere else.

Returns **PyProxy** –

PyProxy.**delete**(*key*)

This translates to the Python code del obj[key].

Present only if the proxied Python object has a __delitem__ method.

Arguments

- **key** (any()) – The key to delete.

PyProxy.**destroy**(*destroyed_msg*)

Destroy the PyProxy. This will release the memory. Any further attempt to use the object will raise an error.

In a browser supporting FinalizationRegistry Pyodide will automatically destroy the PyProxy when it is garbage collected, however there is no guarantee that the finalizer will be run in a timely manner so it is better to destroy the proxy explicitly.

Arguments

- **destroyed_msg** (string()) – The error message to print if use is attempted after destroying. Defaults to "Object has already been destroyed".

PyProxy.**finally**(*onFinally*)

Runs asyncio.ensure_future(awaitable) and executes onFinally(error) when the future resolves.

See the documentation for Promise.finally.

Present only if the proxied Python object is awaitable.

Arguments

- **onFinally** ({}()) – A handler that is called with zero arguments when the awaitable resolves.

Returns **Promise<any>** – A Promise that resolves or rejects with the same result as the original Promise, but only after executing the onFinally handler.

PyProxy.**get**(*key*)

This translates to the Python code obj[key].

Present only if the proxied Python object has a __getitem__ method.

Arguments

- **key** (any()) – The key to look up.

Returns **any** – The corresponding value.

PyProxy.**getBuffer**(*type*)

Get a view of the buffer data which is usable from JavaScript. No copy is ever performed.

Present only if the proxied Python object supports the Python Buffer Protocol.

We do not support suboffsets, if the buffer requires suboffsets we will throw an error. JavaScript nd array libraries can't handle suboffsets anyways. In this case, you should use the *toJs* api or copy the buffer to one that doesn't use suboffets (using e.g., numpy.ascontiguousarray).

If the buffer stores big endian data or half floats, this function will fail without an explicit type argument. For big endian data you can use toJs. DataViews have support for big endian data, so you might want to pass 'dataview' as the type argument in that case.

Arguments

- **type** (string()) – The type of the *PyBuffer.data* field in the output. Should be one of: "i8", "u8", "u8clamped", "i16", "u16", "i32", "u32", "i32", "u32", "i64", "u64", "f32", "f64, or "dataview". This argument is optional, if absent getBuffer will try to determine the appropriate output type based on the buffer format string.

Returns **PyBuffer** – *PyBuffer*

PyProxy.**has**(*key*)

This translates to the Python code key in obj.

Present only if the proxied Python object has a __contains__ method.

Arguments

- **key** (any()) – The key to check for.

Returns **boolean** – Is key present?

PyProxy.**isAwaitable**()

Check whether the PyProxy is awaitable. A Typescript type guard, if this function returns true Typescript considers the PyProxy to be a `Promise`.

Returns **boolean (typeguard for PyProxyAwaitable)** –

PyProxy.**isBuffer**()

Check whether the PyProxy is a buffer. A Typescript type guard for *PyProxy.getBuffer*.

Returns **boolean (typeguard for PyProxyBuffer)** –

PyProxy.**isCallable**()

Check whether the PyProxy is a Callable. A Typescript type guard, if this returns true then Typescript considers the Proxy to be callable of signature `(args... : any[]) => PyProxy | number | bigint | string | boolean | undefined`.

Returns **boolean (typeguard for PyProxyCallable)** –

PyProxy.**isIterable**()

Check whether the PyProxy is iterable. A Typescript type guard for *PyProxy.[iterator]*.

Returns **boolean (typeguard for PyProxyIterable)** –

PyProxy.**isIterator**()

Check whether the PyProxy is iterable. A Typescript type guard for *PyProxy.next*.

Returns **boolean (typeguard for PyProxyIterator)** –

PyProxy.**new PyProxyClass**()

PyProxy.**next**(*arg=undefined*)

This translates to the Python code `next(obj)`. Returns the next value of the generator. See the documentation for Generator.prototype.next. The argument will be sent to the Python generator.

This will be used implicitly by `for(let x of proxy){}`.

Present only if the proxied Python object is a generator or iterator (i.e., has a `send` or `__next__` method).

Arguments

- **arg** (any()) –

Returns **IteratorResult<any, any>** – An Object with two properties: `done` and `value`. When the generator yields `some_value`, `next` returns `{done : false, value : some_value}`. When the generator raises a `StopIteration(result_value)` exception, `next` returns `{done : true, value : result_value}`.

PyProxy.**set**(*key*, *value*)

This translates to the Python code `obj[key] = value`.

Present only if the proxied Python object has a `__setitem__` method.

Arguments

- **key** (any()) – The key to set.
- **value** (any()) – The value to set it to.

PyProxy.**supportsGet**()

Check whether the *PyProxy.get* method is available on this PyProxy. A Typescript type guard.

Returns **boolean (typeguard for PyProxyWithGet)** –

PyProxy.supportsHas()

Check whether the *PyProxy.has* method is available on this PyProxy. A Typescript type guard.

Returns boolean (typeguard for PyProxyWithHas) –

PyProxy.supportsLength()

Check whether the *PyProxy.length* getter is available on this PyProxy. A Typescript type guard.

Returns boolean (typeguard for PyProxyWithLength) –

PyProxy.supportsSet()

Check whether the *PyProxy.set* method is available on this PyProxy. A Typescript type guard.

Returns boolean (typeguard for PyProxyWithSet) –

PyProxy.then(*onFulfilled*, *onRejected*)

Runs `asyncio.ensure_future(awaitable)`, executes `onFulfilled(result)` when the `Future` resolves successfully, executes `onRejected(error)` when the `Future` fails. Will be used implicitly by `await obj`.

See the documentation for Promise.then

Present only if the proxied Python object is awaitable.

Arguments

- **onFulfilled** (`{}()`) – A handler called with the result as an argument if the awaitable succeeds.
- **onRejected** (`{}()`) – A handler called with the error as an argument if the awaitable fails.

Returns Promise<any> – The resulting Promise.

PyProxy.toJs(*options*)

Converts the `PyProxy` into a JavaScript object as best as possible. By default does a deep conversion, if a shallow conversion is desired, you can use `proxy.toJs({depth : 1})`. See *Explicit Conversion of PyProxy* for more info.

Arguments

- **options.create_pyproxies** (`boolean()`) – If false, `toJs` will throw a `ConversionError` rather than producing a `PyProxy`.
- **options.depth** (`number()`) – How many layers deep to perform the conversion. Defaults to infinite
- **options.pyproxies** (`PyProxy[]()`) – If provided, `toJs` will store all PyProxies created in this list. This allows you to easily destroy all the PyProxies by iterating the list without having to recurse over the generated structure. The most common use case is to create a new empty list, pass the list as *pyproxies*, and then later iterate over *pyproxies* to destroy all of created proxies.
- **options.default_converter** (`((obj: PyProxy, convert: {}, cacheConversion: {}) => any())`) – Optional argument to convert objects with no default conversion. See the documentation of *pyodide.ffi.to_js*.
- **options.dict_converter** (`((array: Iterable<[key: string, value: any]>) => any())`) – A function to be called on an iterable of pairs `[key, value]`. Convert this iterable of pairs to the desired output. For instance, `Object.fromEntries` would convert the dict to an object, `Array.from` converts it to an array of entries, and `(it) => new Map(it)` converts it to a `Map` (which is the default behavior).

Returns any – The JavaScript object resulting from the conversion.

PyProxy.**toString**()

Returns **string** –

Python API

Backward compatibility of the API is not guaranteed at this point.

JavaScript Modules

By default there are two JavaScript modules. More can be added with *pyodide.registerJsModule*. You can import these modules using the Python `import` statement in the normal way.

`js`	The global JavaScript scope.
pyodide_js	The JavaScript Pyodide module.

Python Modules

pyodide.code	Utilities for evaluating Python and JavaScript code.
pyodide.console	Similar to the Python builtin *code* module but handles top level await. Used for implementing the Pyodide console.
pyodide.ffi	The *JsProxy* class and utilities to help interact with JavaScript code.
pyodide.http	Defines *pyfetch* and other functions for making network requests.
pyodide.webloop	The Pyodide event loop implementation. This is automatically configured correctly for most use cases it is unlikely you will need it outside of niche use cases.

pyodide.code

Classes:

CodeRunner(source, *[, return_mode, mode, ...])	This class allows fine control over the execution of a code block.

Functions:

eval_code(source[, globals, locals, ...])	Runs a string as Python source code.
eval_code_async(source[, globals, locals, ...])	Runs a code string asynchronously.
find_imports(source)	Finds the imports in a Python source code string
run_js(code, /)	A wrapper for the JavaScript 'eval' function.
should_quiet(source)	Should we suppress output?

class pyodide.code.**CodeRunner**(*source: str*, *, *return_mode: Literal['last_expr', 'last_expr_or_assign', 'none'] = 'last_expr'*, *mode: str = 'exec'*, *quiet_trailing_semicolon: bool = True*, *filename: str = '<exec>'*, *flags: int = 0*)

This class allows fine control over the execution of a code block.

It is primarily intended for REPLs and other sophisticated consumers that may wish to add their own AST transformations, separately signal to the user when parsing is complete, etc. The simpler *eval_code* and *eval_code_async* apis should be preferred when their flexibility suffices.

Parameters

- **source** (str) – The Python source code to run.
- **return_mode** (str) – Specifies what should be returned, must be one of 'last_expr', 'last_expr_or_assign' or 'none'. On other values an exception is raised. 'last_expr' by default.
  - 'last_expr' – return the last expression
  - 'last_expr_or_assign' – return the last expression or the last assignment.
  - 'none' – always return None.
- **quiet_trailing_semicolon** (bool) – Specifies whether a trailing semicolon should suppress the result or not. When this is True executing "1+1 ;" returns None, when it is False, executing "1+1 ;" return 2. True by default.
- **filename** (str) – The file name to use in error messages and stack traces. '<exec>' by default.
- **mode** (str) – The "mode" to compile in. One of "exec", "single", or "eval". Defaults to "exec". For most purposes it's unnecessary to use this argument. See the documentation for the built-in *compile <https://docs.python.org/3/library/functions.html#compile>* function.
- **flags** (int) – The flags to compile with. See the documentation for the built-in *compile <https://docs.python.org/3/library/functions.html#compile>* function.
- **Attributes** –

  ast [The ast from parsing source. If you wish to do an ast transform,] modify this variable before calling *CodeRunner.compile*.

  code [Once you call *CodeRunner.compile* the compiled code will] be available in the code field. You can modify this variable before calling *CodeRunner.run* to do a code transform.

compile() → *_pyodide._base.CodeRunner*

Compile the current value of self.ast and store the result in self.code.

Can only be used once. Returns self (chainable).

run(*globals: Optional[dict[str, Any]] = None*, *locals: Optional[dict[str, Any]] = None*) → Optional[Any]

Executes self.code.

Can only be used after calling compile. The code may not use top level await, use *CodeRunner.run_async* for code that uses top level await.

Parameters

- **globals** (dict) – The global scope in which to execute code. This is used as the globals parameter for exec. If globals is absent, a new empty dictionary is used. See the exec documentation for more info.
- **locals** (dict) – The local scope in which to execute code. This is used as the locals parameter for exec. If locals is absent, the value of globals is used. See the exec documentation for more info.

Returns If the last nonwhitespace character of source is a semicolon, return None. If the last statement is an expression, return the result of the expression. Use the return_mode and quiet_trailing_semicolon parameters to modify this default behavior.

Return type Any

async run_async(*globals: Optional[dict[str, Any]] = None*, *locals: Optional[dict[str, Any]] = None*) → None

Runs `self.code` which may use top level await.

Can only be used after calling *CodeRunner.compile*. If `self.code` uses top level await, automatically awaits the resulting coroutine.

Parameters

- **globals** (`dict`) – The global scope in which to execute code. This is used as the `globals` parameter for `exec`. If `globals` is absent, a new empty dictionary is used. See the exec documentation for more info.
- **locals** (`dict`) – The local scope in which to execute code. This is used as the `locals` parameter for `exec`. If `locals` is absent, the value of `globals` is used. See the exec documentation for more info.

Returns If the last nonwhitespace character of `source` is a semicolon, return `None`. If the last statement is an expression, return the result of the expression. Use the `return_mode` and `quiet_trailing_semicolon` parameters to modify this default behavior.

Return type Any

pyodide.code.**eval_code**(*source: str*, *globals: Optional[dict[str, Any]] = None*, *locals: Optional[dict[str, Any]] = None*, ***, *return_mode: Literal['last_expr', 'last_expr_or_assign', 'none'] = 'last_expr'*, *quiet_trailing_semicolon: bool = True*, *filename: str = '<exec>'*, *flags: int = 0*) → Any

Runs a string as Python source code.

Parameters

- **source** (`str`) – The Python source code to run.
- **globals** (`dict`) – The global scope in which to execute code. This is used as the `globals` parameter for `exec`. If `globals` is absent, a new empty dictionary is used. See the exec documentation for more info.
- **locals** (`dict`) – The local scope in which to execute code. This is used as the `locals` parameter for `exec`. If `locals` is absent, the value of `globals` is used. See the exec documentation for more info.
- **return_mode** (`str`) – Specifies what should be returned, must be one of `'last_expr'`, `'last_expr_or_assign'` or `'none'`. On other values an exception is raised. `'last_expr'` by default.
  - `'last_expr'` – return the last expression
  - `'last_expr_or_assign'` – return the last expression or the last assignment.
  - `'none'` – always return `None`.
- **quiet_trailing_semicolon** (`bool`) – Specifies whether a trailing semicolon should suppress the result or not. When this is `True` executing `"1+1 ;"` returns `None`, when it is `False`, executing `"1+1 ;"` return `2`. `True` by default.
- **filename** (`str`) – The file name to use in error messages and stack traces. `'<exec>'` by default.

Returns If the last nonwhitespace character of `source` is a semicolon, return `None`. If the last statement is an expression, return the result of the expression. Use the `return_mode` and `quiet_trailing_semicolon` parameters to modify this default behavior.

Return type Any

async pyodide.code.**eval_code_async**(*source: str*, *globals: Optional[dict[str, Any]] = None*, *locals: Optional[dict[str, Any]] = None*, ***, *return_mode: Literal['last_expr', 'last_expr_or_assign', 'none'] = 'last_expr'*, *quiet_trailing_semicolon: bool = True*, *filename: str = '<exec>'*, *flags: int = 0*) → Any

Runs a code string asynchronously.

Uses PyCF_ALLOW_TOP_LEVEL_AWAIT to compile the code.

Parameters

- **source** (str) – The Python source code to run.
- **globals** (dict) – The global scope in which to execute code. This is used as the globals parameter for exec. If globals is absent, a new empty dictionary is used. See the exec documentation for more info.
- **locals** (dict) – The local scope in which to execute code. This is used as the locals parameter for exec. If locals is absent, the value of globals is used. See the exec documentation for more info.
- **return_mode** (str) – Specifies what should be returned, must be one of 'last_expr', 'last_expr_or_assign' or 'none'. On other values an exception is raised. 'last_expr' by default.
  - 'last_expr' – return the last expression
  - 'last_expr_or_assign' – return the last expression or the last assignment.
  - 'none' – always return None.
- **quiet_trailing_semicolon** (bool) – Specifies whether a trailing semicolon should suppress the result or not. When this is True executing "1+1 ;" returns None, when it is False, executing "1+1 ;" return 2. True by default.
- **filename** (str) – The file name to use in error messages and stack traces. '<exec>' by default.

Returns If the last nonwhitespace character of source is a semicolon, return None. If the last statement is an expression, return the result of the expression. Use the return_mode and quiet_trailing_semicolon parameters to modify this default behavior.

Return type Any

pyodide.code.**find_imports**(*source: str*) → list[str]

Finds the imports in a Python source code string

Parameters **source** (*str*) – The Python source code to inspect for imports.

Returns A list of module names that are imported in source. If source is not syntactically correct Python code (after dedenting), returns an empty list.

Return type List[str]

Examples

```
>>> from pyodide import find_imports
>>> source = "import numpy as np; import scipy.stats"
>>> find_imports(source)
['numpy', 'scipy']
```

pyodide.code.**run_js**(*code: str*, */*) → Any

A wrapper for the JavaScript 'eval' function.

Runs 'code' as a Javascript code string and returns the result. Unlike JavaScript's 'eval', if 'code' is not a string we raise a TypeError.

pyodide.code.**should_quiet**(*source: str*) → bool

Should we suppress output?

Returns `True` if the last nonwhitespace character of `code` is a semicolon.

Examples

```
>>> should_quiet('1 + 1')
False
>>> should_quiet('1 + 1 ;')
True
>>> should_quiet('1 + 1 # comment ;')
False
```

pyodide.console

Classes:

Console([globals, stdin_callback, ...])	Interactive Pyodide console
ConsoleFuture(syntax_check)	A future with extra fields used as the return value for *Console* apis.
PyodideConsole([globals, stdin_callback, ...])	A subclass of *Console* that uses *pyodide.loadPackagesFromImports* before running the code.

Functions:

repr_shorten(value[, limit, split, separator])	Compute the string representation of `value` and shorten it if necessary.

class pyodide.console.**Console**(*globals: Optional[dict[str, Any]] = None*, ***, *stdin_callback: Optional[collections.abc.Callable[[int], str]] = None*, *stdout_callback: Optional[collections.abc.Callable[[str], None]] = None*, *stderr_callback: Optional[collections.abc.Callable[[str], None]] = None*, *persistent_stream_redirection: bool = False*, *filename: str = '<console>'*)

Interactive Pyodide console

An interactive console based on the Python standard library *code.InteractiveConsole* that manages stream redirections and asynchronous execution of the code.

The stream callbacks can be modified directly as long as *persistent_stream_redirection* isn't in effect.

Parameters

- **globals** (dict) – The global namespace in which to evaluate the code. Defaults to a new empty dictionary.
- **stdin_callback** (Callable[[int], str]) – Function to call at each read from sys.stdin. Defaults to None.
- **stdout_callback** (Callable[[str], None]) – Function to call at each write to sys.stdout. Defaults to None.
- **stderr_callback** (Callable[[str], None]) – Function to call at each write to sys.stderr. Defaults to None.
- **persistent_stream_redirection** (bool) – Should redirection of standard streams be kept between calls to *runcode*? Defaults to False.
- **filename** (str) – The file name to report in error messages. Defaults to <console>.

globals

The namespace used as the global

Type Dict[str, Any]

stdin_callback

Function to call at each read from sys.stdin.

Type Callback[[], str]

stdout_callback

Function to call at each write to sys.stdout.

Type Callback[[str], None]

stderr_callback

Function to call at each write to sys.stderr.

Type Callback[[str], None]

buffer

The list of strings that have been *pushed* to the console.

Type List[str]

completer_word_break_characters

The set of characters considered by *complete* to be word breaks.

Type str

complete(*source: str*) → tuple[list[str], int]

Use Python's rlcompleter to complete the source string using the *globals* namespace.

Finds last "word" in the source string and completes it with rlcompleter. Word breaks are determined by the set of characters in *completer_word_break_characters*.

Parameters **source** (*str*) – The source string to complete at the end.

Returns

- **completions** (*List[str]*) – A list of completion strings.
- **start** (*int*) – The index where completion starts.

Examples

```
>>> shell = Console()
>>> shell.complete("str.isa")
(['str.isalnum(', 'str.isalpha(', 'str.isascii('], 0)
>>> shell.complete("a = 5 ; str.isa")
(['str.isalnum(', 'str.isalpha(', 'str.isascii('], 8)
```

formatsyntaxerror(*e: Exception*) → str

Format the syntax error that just occurred.

This doesn't include a stack trace because there isn't one. The actual error object is stored into *sys.last_value*.

formattraceback(*e: BaseException*) → str

Format the exception that just occurred.

The actual error object is stored into *sys.last_value*.

persistent_redirect_streams() → None

Redirect stdin/stdout/stderr persistently

persistent_restore_streams() → None

Restore stdin/stdout/stderr if they have been persistently redirected

push(*line: str*) → *pyodide.console.ConsoleFuture*

Push a line to the interpreter.

The line should not have a trailing newline; it may have internal newlines. The line is appended to a buffer and the interpreter's runsource() method is called with the concatenated contents of the buffer as source. If this indicates that the command was executed or invalid, the buffer is reset; otherwise, the command is incomplete, and the buffer is left as it was after the line was appended.

The return value is the result of calling *Console.runsource* on the current buffer contents.

redirect_streams() → collections.abc.Generator[None, None, None]

A context manager to redirect standard streams.

This supports nesting.

async runcode(*source: str*, *code:* _pyodide._base.CodeRunner) → Any

Execute a code object and return the result.

runsource(*source: str*, *filename: str = '<console>'*) → *pyodide.console.ConsoleFuture*

Compile and run source code in the interpreter.

Returns

Return type *ConsoleFuture*

class pyodide.console.**ConsoleFuture**(*syntax_check: Literal['incomplete', 'syntax-error', 'complete']*)

A future with extra fields used as the return value for *Console* apis.

syntax_check

One of `"incomplete"`, `"syntax-error"`, or `"complete"`. If the value is `"incomplete"` then the future has already been resolved with result equal to `None`. If the value is `"syntax-error"`, the `Future` has already been rejected with a `SyntaxError`. If the value is `"complete"`, then the input complete and syntactically correct.

Type str

formatted_error

If the `Future` is rejected, this will be filled with a formatted version of the code. This is a convenience that simplifies code and helps to avoid large memory leaks when using from JavaScript.

Type str

class pyodide.console.**PyodideConsole**(*globals: Optional[dict[str, Any]] = None*, ***, *stdin_callback: Optional[collections.abc.Callable[[int], str]] = None*, *stdout_callback: Optional[collections.abc.Callable[[str], None]] = None*, *stderr_callback: Optional[collections.abc.Callable[[str], None]] = None*, *persistent_stream_redirection: bool = False*, *filename: str = '<console>'*)

A subclass of *Console* that uses *pyodide.loadPackagesFromImports* before running the code.

pyodide.console.**repr_shorten**(*value: Any*, *limit: int = 1000*, *split: Optional[int] = None*, *separator: str = '...'*) → str

Compute the string representation of `value` and shorten it if necessary.

If it is longer than `limit` then return the firsts `split` characters and the last `split` characters separated by '...'. Default value for `split` is *limit // 2*.

pyodide.ffi

Exceptions:

ConversionError	An error thrown when conversion between JavaScript and Python fails.
JsException	A wrapper around a JavaScript Error to allow it to be thrown in Python.

Classes:

JsProxy()	A proxy to make a JavaScript object behave like a Python object

Functions:

create_once_callable(obj, /)	Wrap a Python callable in a JavaScript function that can be called once.
create_proxy(obj, /)	Create a `JsProxy` of a `PyProxy`.
destroy_proxies(pyproxies, /)	Destroy all PyProxies in a JavaScript array.
register_js_module(name, jsproxy)	Registers `jsproxy` as a JavaScript module named `name`.
to_js(obj, /, *[, depth, pyproxies, ...])	Convert the object to JavaScript.
unregister_js_module(name)	Unregisters a JavaScript module with given name that has been previously registered with *pyodide.registerJsModule* or *pyodide.ffi.register_js_module*.

exception pyodide.ffi.**ConversionError**

An error thrown when conversion between JavaScript and Python fails.

exception pyodide.ffi.**JsException**

A wrapper around a JavaScript Error to allow it to be thrown in Python. See *Errors*.

property js_error: *pyodide.JsProxy*

The original JavaScript error

class pyodide.ffi.**JsProxy**

A proxy to make a JavaScript object behave like a Python object

For more information see the *Type translations* documentation. In particular, see *the list of __dunder__ methods* that are (conditionally) implemented on `JsProxy`.

assign(*rhs: Any*, */*) → None

Assign from a Python buffer into the JavaScript buffer.

Present only if the wrapped JavaScript object is an ArrayBuffer or an ArrayBuffer view.

assign_to(*to: Any*, */*) → None

Assign to a Python buffer from the JavaScript buffer.

Present only if the wrapped JavaScript object is an ArrayBuffer or an ArrayBuffer view.

catch(*onrejected: collections.abc.Callable[[Any], Any]*, */*) → pyodide.Promise

The `Promise.catch` API, wrapped to manage the lifetimes of the handler.

Present only if the wrapped JavaScript object has a "then" method. Pyodide will automatically release the references to the handler when the promise resolves.

extend(*other: collections.abc.Iterable[Any]*) → None

Extend array by appending elements from the iterable.

Present only if the wrapped Javascript object is an array.

finally_(*onfinally: collections.abc.Callable[[Any], Any]*, */*) → pyodide.Promise

The `Promise.finally` API, wrapped to manage the lifetimes of the handler.

Present only if the wrapped JavaScript object has a "then" method. Pyodide will automatically release the references to the handler when the promise resolves. Note the trailing underscore in the name; this is needed because `finally` is a reserved keyword in Python.

from_file(*file: io.IOBase*, */*) → None

Reads from a file into a buffer.

Will try to read a chunk of data the same size as the buffer from the current position of the file.

Present only if the wrapped Javascript object is an ArrayBuffer or an ArrayBuffer view.

Example

```
>>> import pytest; pytest.skip()
>>> from js import Uint8Array
>>> # the JsProxy need to be pre-allocated
>>> x = Uint8Array.new(range(10))
>>> with open('file.bin', 'rb') as fh:
...     x.read_file(fh)
which is equivalent to
>>> x = Uint8Array.new(range(10))
>>> with open('file.bin', 'rb') as fh:
```

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```
...     chunk = fh.read(size=x.byteLength)
...     x.assign(chunk)
but the latter copies the data twice whereas the former only copies the
data once.
```

property js_id: int

An id number which can be used as a dictionary/set key if you want to key on JavaScript object identity.

If two *JsProxy* are made with the same backing JavaScript object, they will have the same *js_id*. The reault is a "pseudorandom" 32 bit integer.

new(**args: Any*, ***kwargs: Any*) → *pyodide.JsProxy*

Construct a new instance of the JavaScript object

object_entries() → *pyodide.JsProxy*

The JavaScript API `Object.entries(object)`

object_keys() → *pyodide.JsProxy*

The JavaScript API `Object.keys(object)`

object_values() → *pyodide.JsProxy*

The JavaScript API `Object.values(object)`

then(*onfulfilled: collections.abc.Callable[[Any], Any]*, *onrejected: collections.abc.Callable[[Any], Any]*) → pyodide.Promise

The `Promise.then` API, wrapped to manage the lifetimes of the handlers.

Present only if the wrapped JavaScript object has a "then" method. Pyodide will automatically release the references to the handlers when the promise resolves.

to_bytes() → bytes

Convert a buffer to a bytes object.

Copies the data once. Present only if the wrapped Javascript object is an ArrayBuffer or an ArrayBuffer view.

to_file(*file: io.IOBase*, */*) → None

Writes a buffer to a file.

Will write the entire contents of the buffer to the current position of the file.

Present only if the wrapped Javascript object is an ArrayBuffer or an ArrayBuffer view.

Example

```
>>> import pytest; pytest.skip()
>>> from js import Uint8Array
>>> x = Uint8Array.new(range(10))
>>> with open('file.bin', 'wb') as fh:
...     x.to_file(fh)
which is equivalent to,
>>> with open('file.bin', 'wb') as fh:
...     data = x.to_bytes()
...     fh.write(data)
but the latter copies the data twice whereas the former only copies the
data once.
```

to_memoryview() → memoryview

Convert a buffer to a memoryview.

Copies the data once. This currently has the same effect as *to_py*. Present only if the wrapped Javascript object is an ArrayBuffer or an ArrayBuffer view.

to_py(*, *depth: int = - 1*, *default_converter: Optional[collections.abc.Callable[[*JsProxy*, *collections.abc.Callable[[*JsProxy*], Any], collections.abc.Callable[[*JsProxy*, Any], None]], Any]] = None*) → Any

Convert the *JsProxy* to a native Python object as best as possible.

By default, does a deep conversion, if a shallow conversion is desired, you can use `proxy.to_py(depth=1)`. See *JavaScript to Python* for more information.

`default_converter` if present will be invoked whenever Pyodide does not have some built in conversion for the object. If `default_converter` raises an error, the error will be allowed to propagate. Otherwise, the object returned will be used as the conversion. `default_converter` takes three arguments. The first argument is the value to be converted.

Here are a couple examples of converter functions. In addition to the normal conversions, convert `Date` to `datetime`:

```
from datetime import datetime
def default_converter(value, _ignored1, _ignored2):
    if value.constructor.name == "Date":
        return datetime.fromtimestamp(d.valueOf()/1000)
    return value
```

Don't create any JsProxies, require a complete conversion or raise an error:

```
def default_converter(_value, _ignored1, _ignored2):
    raise Exception("Failed to completely convert object")
```

The second and third arguments are only needed for converting containers. The second argument is a conversion function which is used to convert the elements of the container with the same settings. The third argument is a "cache" function which is needed to handle self referential containers. Consider the following example. Suppose we have a Javascript `Pair` class:

```
class Pair {
    constructor(first, second){
        this.first = first;
        this.second = second;
    }
}
```

We can use the following `default_converter` to convert `Pair` to `list`:

```
def default_converter(value, convert, cache):
    if value.constructor.name != "Pair":
        return value
    result = []
    cache(value, result);
    result.append(convert(value.first))
    result.append(convert(value.second))
    return result
```

Note that we have to cache the conversion of `value` before converting `value.first` and `value.second`. To see why, consider a self referential pair:

```
let p = new Pair(0, 0);
p.first = p;
```

Without `cache(value, result);`, converting `p` would lead to an infinite recurse. With it, we can successfully convert `p` to a list such that `l[0] is l`.

to_string(*encoding: Optional[str] = None*) → str

Convert a buffer to a string object.

Copies the data twice.

The encoding argument will be passed to the Javascript [TextDecoder](https://developer.mozilla.org/en-US/docs/Web/API/TextDecoder) constructor. It should be one of the encodings listed in the table here: *https://encoding.spec.whatwg.org/#names-and-labels*. The default encoding is utf8.

Present only if the wrapped Javascript object is an ArrayBuffer or an ArrayBuffer view.

property typeof: str

Returns the JavaScript type of the JsProxy.

Corresponds to *typeof obj;* in JavaScript. You may also be interested in the *constuctor* attribute which returns the type as an object.

pyodide.ffi.**create_once_callable**(*obj: collections.abc.Callable[[...], Any]*, */*) → *pyodide.JsProxy*

Wrap a Python callable in a JavaScript function that can be called once.

After being called the proxy will decrement the reference count of the Callable. The JavaScript function also has a `destroy` API that can be used to release the proxy without calling it.

pyodide.ffi.**create_proxy**(*obj: Any*, */*) → *pyodide.JsProxy*

Create a `JsProxy` of a `PyProxy`.

This allows explicit control over the lifetime of the `PyProxy` from Python: call the `destroy` API when done.

pyodide.ffi.**destroy_proxies**(*pyproxies:* pyodide.JsProxy, */*) → None

Destroy all PyProxies in a JavaScript array.

pyproxies must be a JsProxy of type PyProxy[]. Intended for use with the arrays created from the "pyproxies" argument of *PyProxy.toJs* and *to_js*. This method is necessary because indexing the Array from Python automatically unwraps the PyProxy into the wrapped Python object.

pyodide.ffi.**register_js_module**(*name: str*, *jsproxy: Any*) → None

Registers `jsproxy` as a JavaScript module named `name`. The module can then be imported from Python using the standard Python import system. If another module by the same name has already been imported, this won't have much effect unless you also delete the imported module from `sys.modules`. This is called by the JavaScript API *pyodide.registerJsModule*.

Parameters

- **name** (*str*) – Name of js module
- **jsproxy** (JsProxy) – JavaScript object backing the module

pyodide.ffi.**to_js**(*obj: Any*, */*, ***, *depth: int = - 1*, *pyproxies: Optional[*pyodide.JsProxy*] = None*, *create_pyproxies: bool = True*, *dict_converter: Optional[collections.abc.Callable[[collections.abc.Iterable[*pyodide.JsProxy*]], *pyodide.JsProxy*]] = None*, *default_converter: Optional[collections.abc.Callable[[Any, collections.abc.Callable[[Any], *pyodide.JsProxy*], collections.abc.Callable[[Any, *pyodide.JsProxy*], None]], *pyodide.JsProxy*]] = None*) → *pyodide.JsProxy*

Convert the object to JavaScript.

This is similar to *PyProxy.toJs*, but for use from Python. If the object can be implicitly translated to JavaScript, it will be returned unchanged. If the object cannot be converted into JavaScript, this method will return a *JsProxy* of a *PyProxy*, as if you had used *pyodide.ffi.create_proxy*.

See *Python to JavaScript* for more information.

Parameters

- **obj** (*Any*) – The Python object to convert
- **depth** (*int, default=-1*) – The maximum depth to do the conversion. Negative numbers are treated as infinite. Set this to 1 to do a shallow conversion.
- **pyproxies** (*JsProxy, default = None*) – Should be a JavaScript `Array`. If provided, any `PyProxies` generated will be stored here. You can later use *destroy_proxies* if you want to destroy the proxies from Python (or from JavaScript you can just iterate over the `Array` and destroy the proxies).
- **create_pyproxies** (*bool, default=True*) – If you set this to False, *to_js* will raise an error
- **dict_converter** (*Callable[[Iterable[JsProxy]], JsProxy], default = None*) – This converter if provided receives a (JavaScript) iterable of (JavaScript) pairs [key, value]. It is expected to return the desired result of the dict conversion. Some suggested values for this argument:

  js.Map.new – similar to the default behavior js.Array.from – convert to an array of entries js.Object.fromEntries – convert to a JavaScript object
- **default_converter** (*Callable[[Any, Callable[[Any], JsProxy], Callable[[Any, JsProxy], None]], JsProxy], default=None*) – If present will be invoked whenever Pyodide does not have some built in conversion for the object. If `default_converter` raises an error, the error will be allowed to propagate. Otherwise, the object returned will be used as the conversion. `default_converter` takes three arguments. The first argument is the value to be converted.

  Here are a couple examples of converter functions. In addition to the normal conversions, convert `Date` to `datetime`:

```
from datetime import datetime
from js import Date
def default_converter(value, _ignored1, _ignored2):
    if isinstance(value, datetime):
        return Date.new(value.timestamp() * 1000)
    return value
```

  Don't create any PyProxies, require a complete conversion or raise an error:

```
def default_converter(_value, _ignored1, _ignored2):
    raise Exception("Failed to completely convert object")
```

  The second and third arguments are only needed for converting containers. The second argument is a conversion function which is used to convert the elements of the container with the same settings. The third argument is a "cache" function which is needed to handle self referential containers. Consider the following example. Suppose we have a Python `Pair` class:

```
class Pair:
    def __init__(self, first, second):
        self.first = first
        self.second = second
```

We can use the following `default_converter` to convert `Pair` to `Array`:

```
from js import Array
def default_converter(value, convert, cache):
    if not isinstance(value, Pair):
        return value
    result = Array.new()
    cache(value, result);
    result.push(convert(value.first))
    result.push(convert(value.second))
    return result
```

Note that we have to cache the conversion of `value` before converting `value.first` and `value.second`. To see why, consider a self referential pair:

```
p = Pair(0, 0);
p.first = p;
```

Without `cache(value, result);`, converting `p` would lead to an infinite recurse. With it, we can successfully convert `p` to an Array such that `l[0] === l`.

pyodide.ffi.**unregister_js_module**(*name: str*) → None

Unregisters a JavaScript module with given name that has been previously registered with *pyodide.registerJsModule* or *pyodide.ffi.register_js_module*. If a JavaScript module with that name does not already exist, will raise an error. If the module has already been imported, this won't have much effect unless you also delete the imported module from `sys.modules`. This is called by the JavaScript API *pyodide.unregisterJsModule*.

Parameters **name** (*str*) – Name of js module

Functions:

add_event_listener(elt, event, listener)	Wrapper for JavaScript's addEventListener() which automatically manages the lifetime of a JsProxy corresponding to the listener param.
clear_interval(interval_retval)	Wrapper for JavaScript's clearInterval() which automatically manages the lifetime of a JsProxy corresponding to the callback param.
clear_timeout(timeout_retval)	Wrapper for JavaScript's clearTimeout() which automatically manages the lifetime of a JsProxy corresponding to the callback param.
remove_event_listener(elt, event, listener)	Wrapper for JavaScript's removeEventListener() which automatically manages the lifetime of a JsProxy corresponding to the listener param.
set_interval(callback, interval)	Wrapper for JavaScript's setInterval() which automatically manages the lifetime of a JsProxy corresponding to the callback param.
set_timeout(callback, timeout)	Wrapper for JavaScript's setTimeout() which automatically manages the lifetime of a JsProxy corresponding to the callback param.

pyodide.ffi.wrappers.**add_event_listener**(*elt:* pyodide.JsProxy, *event: str*, *listener: collections.abc.Callable[[Any], None]*) → None

Wrapper for JavaScript's addEventListener() which automatically manages the lifetime of a JsProxy corresponding to the listener param.

pyodide.ffi.wrappers.**clear_interval**(*interval_retval: int* | pyodide.JsProxy) → None

Wrapper for JavaScript's clearInterval() which automatically manages the lifetime of a JsProxy corresponding to the callback param.

pyodide.ffi.wrappers.**clear_timeout**(*timeout_retval: int* | pyodide.JsProxy) → None

Wrapper for JavaScript's clearTimeout() which automatically manages the lifetime of a JsProxy corresponding to the callback param.

pyodide.ffi.wrappers.**remove_event_listener**(*elt:* pyodide.JsProxy, *event: str*, *listener: collections.abc.Callable[[Any], None]*) → None

Wrapper for JavaScript's removeEventListener() which automatically manages the lifetime of a JsProxy corresponding to the listener param.

pyodide.ffi.wrappers.**set_interval**(*callback: collections.abc.Callable[[], None]*, *interval: int*) → int | *pyodide.JsProxy*

Wrapper for JavaScript's setInterval() which automatically manages the lifetime of a JsProxy corresponding to the callback param.

pyodide.ffi.wrappers.**set_timeout**(*callback: collections.abc.Callable[[], None]*, *timeout: int*) → int | *pyodide.JsProxy*

Wrapper for JavaScript's setTimeout() which automatically manages the lifetime of a JsProxy corresponding to the callback param.

pyodide.http

Classes:

FetchResponse(url, js_response)	A wrapper for a Javascript fetch response.

Functions:

open_url(url)	Fetches a given URL synchronously.
pyfetch(url, **kwargs)	Fetch the url and return the response.

class pyodide.http.**FetchResponse**(*url: str*, *js_response:* pyodide.JsProxy)

A wrapper for a Javascript fetch response.

See also the Javascript fetch Response api docs.

Parameters

- **url** – URL to fetch
- **js_response** – A JsProxy of the fetch response

property body_used: bool

Has the response been used yet?

(If so, attempting to retrieve the body again will raise an OSError.)

async buffer() → *pyodide.JsProxy*

Return the response body as a Javascript ArrayBuffer

async bytes() → bytes

Return the response body as a bytes object

clone() → *pyodide.http.FetchResponse*

Return an identical copy of the FetchResponse.

This method exists to allow multiple uses of response objects. See Response.clone

async json(***kwargs: Any*) → Any

Return the response body as a Javascript JSON object.

Any keyword arguments are passed to json.loads.

async memoryview() → memoryview

Return the response body as a memoryview object

property ok: bool

Was the request successful?

property redirected: bool

Was the request redirected?

property status: str

Response status code

property status_text: str

Response status text

async string() → str

Return the response body as a string

property type: str

The type of the response.

async unpack_archive(*, *extract_dir: Optional[str] = None*, *format: Optional[str] = None*) → None

Treat the data as an archive and unpack it into target directory.

Assumes that the file is an archive in a format that shutil has an unpacker for. The arguments extract_dir and format are passed directly on to `shutil.unpack_archive`.

Parameters

- **extract_dir** (*str*) – Directory to extract the archive into. If not provided, the current working directory is used.
- **format** (*str*) – The archive format: one of "zip", "tar", "gztar", "bztar". Or any other format registered with `shutil.register_unpack_format()`. If not provided, `unpack_archive()` will use the archive file name extension and see if an unpacker was registered for that extension. In case none is found, a `ValueError` is raised.

property url: str

The url of the response.

It may be different than the url passed to fetch.

pyodide.http.**open_url**(*url: str*) → _io.StringIO

Fetches a given URL synchronously.

The download of binary files is not supported. To download binary files use *pyodide.http.pyfetch()* which is asynchronous.

Parameters **url** (*str*) – URL to fetch

Returns the contents of the URL.

Return type io.StringIO

async pyodide.http.**pyfetch**(*url: str*, ***kwargs: Any*) → *pyodide.http.FetchResponse*

Fetch the url and return the response.

This functions provides a similar API to the JavaScript fetch function however it is designed to be convenient to use from Python. The *pyodide.http.FetchResponse* has methods with the output types already converted to Python objects.

Parameters

- **url** (*str*) – URL to fetch.
- ****kwargs** (*Any*) – keyword arguments are passed along as optional parameters to the fetch API.

pyodide.webloop

Classes:

WebLoop()	A custom event loop for use in Pyodide.
WebLoopPolicy()	A simple event loop policy for managing WebLoop based event loops.

class pyodide.webloop.**WebLoop**

A custom event loop for use in Pyodide.

Schedules tasks on the browser event loop. Does no lifecycle management and runs forever.

`run_forever` and `run_until_complete` cannot block like a normal event loop would because we only have one thread so blocking would stall the browser event loop and prevent anything from ever happening.

We defer all work to the browser event loop using the setTimeout function. To ensure that this event loop doesn't stall out UI and other browser handling, we want to make sure that each task is scheduled on the browser event loop as a task not as a microtask. `setTimeout(callback, 0)` enqueues the callback as a task so it works well for our purposes.

See Event Loop Methods.

class pyodide.webloop.**WebLoopPolicy**

A simple event loop policy for managing WebLoop based event loops.

Micropip API

micropip.**freeze**() → str

Produce a json string which can be used as the contents of the `repodata.json` lock file.

If you later load Pyodide with this lock file, you can use `pyodide.loadPackage` to load packages that were loaded with *micropip* this time. Loading packages with `pyodide.loadPackage` is much faster and you will always get consistent versions of all your dependencies.

You can use your custom lock file by passing an appropriate url to the *lockFileURL* argument to `loadPyodide`.

async micropip.**install**(*requirements: str | list[str]*, *keep_going: bool = False*, *deps: bool = True*, *credentials: Optional[str] = None*, *pre: bool = False*) → None

Install the given package and all of its dependencies.

See *loading packages* for more information.

If a package is not found in the Pyodide repository it will be loaded from PyPI. Micropip can only load pure Python packages or for packages with C extensions that are built for Pyodide.

When used in web browsers, downloads from PyPI will be cached. When run in Node.js, packages are currently not cached, and will be re-downloaded each time `micropip.install` is run.

Parameters **requirements** (`str | List[str]`) – A requirement or list of requirements to install. Each requirement is a string, which should be either a package name or a wheel URI:

- If the requirement does not end in `.whl`, it will be interpreted as a package name. A package with this name must either be present in the Pyodide lock file or on PyPI.
- If the requirement ends in `.whl`, it is a wheel URI. The part of the requirement after the last `/` must be a valid wheel name in compliance with the PEP 427 naming convention.
- If a wheel URI starts with `emfs:`, it will be interpreted as a path in the Emscripten file system (Pyodide's file system). E.g., *emfs:../relative/path/wheel.whl* or *emfs:/absolute/path/wheel.whl*. In this case, only .whl files are supported.
- If a wheel URI requirement starts with `http:` or `https:` it will be interpreted as a URL.
- In node, you can access the native file system using a URI that starts with `file:`. In the browser this will not work.

keep_going : `bool`, default: False

This parameter decides the behavior of the micropip when it encounters a Python package without a pure Python wheel while doing dependency resolution:

- If `False`, an error will be raised on first package with a missing wheel.
- If `True`, the micropip will keep going after the first error, and report a list of errors at the end.

deps : `bool`, default: True

If `True`, install dependencies specified in METADATA file for each package. Otherwise do not install dependencies.

credentials : `Optional[str]`

This parameter specifies the value of `credentials` when calling the fetch() function which is used to download the package.

When not specified, `fetch()` is called without `credentials`.

pre : `bool`, default: False

If `True`, include pre-release and development versions. By default, micropip only finds stable versions.

Returns A `Future` that resolves to `None` when all packages have been downloaded and installed.

Return type `Future`

micropip.**list**()

Get the dictionary of installed packages.

Returns

packages – A dictionary of installed packages.

```
>>> import micropip
>>> await micropip.install('regex')
>>> package_list = micropip.list()
>>> print(package_list)
Name              | Version  | Source
----------------- | -------- | -------
regex             | 2021.7.6 | pyodide
>>> "regex" in package_list
True
```

Return type *micropip.package.PackageDict*

class package.**PackageDict**(*dict=None*, */*, ***kwargs*)

A dictionary that holds list of metadata on packages. This class is used in micropip to keep the list of installed packages.

pyodide-build CLI

A command line interface (CLI) for pyodide_build

```
pyodide-build [-h] {serve,mkpkg,create_xbuildenv,install_xbuildenv} ...
```

pyodide-build options

- ***-h***, ***--help*** - show this help message and exit

pyodide serve

Start a server with the supplied dist-dir and port.

```
pyodide serve [-h] [--dist-dir DIST_DIR] [--port PORT]
```

pyodide serve options

- ***-h***, ***--help*** - show this help message and exit
- ***--dist-dir*** DIST_DIR - set the dist directory (default: %(default)s) (default: dist)
- ***--port*** PORT - set the PORT number (default: %(default)s) (default: 8000)

pyodide mkpkg

Make a new pyodide package. Creates a simple template that will work for most pure Python packages, but will have to be edited for more complex things.

```
pyodide mkpkg [-h] [--update] [--update-if-not-patched] [--source-format SOURCE_FORMAT]
              [--version VERSION]
              package
```

pyodide mkpkg positional arguments

- ***package*** - The package name on PyPI (default: None)

pyodide mkpkg options

- ***-h***, ***--help*** - show this help message and exit
- ***--update*** - Update existing package (default: False)
- ***--update-if-not-patched*** - Update existing package if it has no patches (default: False)
- ***--source-format*** SOURCE_FORMAT - Which source format is preferred. Options are wheel or sdist. If none is provided, then either a wheel or an sdist will be used. When updating a package, the type will be kept the same if possible. (default: None)
- ***--version*** VERSION - Package version string, e.g. v1.2.1 (defaults to latest stable release)

pyodide create_xbuildenv

Create xbuild env.

Note: this is a private endpoint that should not be used outside of the Pyodide Makefile.

```
pyodide create_xbuildenv [-h]
```

pyodide create_xbuildenv options

- ***-h***, ***--help*** - show this help message and exit

pyodide install_xbuildenv

Install xbuild env.

The installed environment is the same as the one that would result from `PYODIDE_PACKAGES='scipy' make` except that it is much faster. The goal is to enable out-of-tree builds for binary packages that depend on numpy or scipy. Note: this is a private endpoint that should not be used outside of the Pyodide Makefile.

```
pyodide install_xbuildenv [-h] [--download] xbuild_env
```

pyodide install_xbuildenv positional arguments

- ***xbuild_env*** (default: `None`)

pyodide install_xbuildenv options

- ***-h***, ***--help*** - show this help message and exit
- ***--download*** - Download xbuild env (default: `False`)

3.1.9 Frequently Asked Questions

How can I load external files in Pyodide?

If you are using Pyodide in the browser, you should download external files and save them to the virtual file system. The recommended way to do this is to zip the files and unpack them into the file system with *pyodide.unpackArchive*:

```
let zipResponse = await fetch("myfiles.zip");
let zipBinary = await zipResponse.arrayBuffer();
pyodide.unpackArchive(zipBinary, "zip");
```

You can also download the files from Python using *pyodide.http.pyfetch*, which is a convenient wrapper of JavaScript `fetch`:

```
await pyodide.runPythonAsync(`
  from pyodide.http import pyfetch
  response = await pyfetch("https://some_url/myfiles.zip")
  await response.unpack_archive()
`)
```

If you are working in Node.js, you can mount a native folder into the file system as follows:

```
FS.mkdir("/local_directory");
FS.mount(NODEFS, { root: "some/local/filepath" }, "/local_directory");
```

Then you can access the mounted folder from Python via the `/local_directory` mount.

Why can't I just use urllib or requests?

We currently can't use such packages since sockets are not available in Pyodide. See *Write http.client in terms of Web APIs* for more information.

Why can't I load files from the local file system?

For security reasons JavaScript in the browser is not allowed to load local data files (for example, `file:///path/to/local/file.data`). You will run into Network Errors, due to the Same Origin Policy. There is a File System API supported in Chrome but not in Firefox or Safari.

For development purposes, you can serve your files with a web server.

How can I execute code in a custom namespace?

The second argument to *pyodide.runPython* is an options object which may include a `globals` element which is a namespace for code to read from and write to. The provided namespace must be a Python dictionary.

```
let my_namespace = pyodide.globals.get("dict")();
pyodide.runPython(`x = 1 + 1`, { globals: my_namespace });
pyodide.runPython(`y = x ** x`, { globals: my_namespace });
my_namespace.get("y"); // ==> 4
```

You can also use this approach to inject variables from JavaScript into the Python namespace, for example:

```
let my_namespace = pyodide.toPy({ x: 2, y: [1, 2, 3] });
pyodide.runPython(
  `
  assert x == y[1]
  z = x ** x
  `,
  { globals: my_namespace }
);
my_namespace.get("z"); // ==> 4
```

How to detect that code is run with Pyodide?

At run time, you can check if Python is built with Emscripten (which is the case for Pyodide) with,

```
import sys

if sys.platform == 'emscripten':
    # running in Pyodide or other Emscripten based build
```

To detect that a code is running with Pyodide specifically, you can check for the loaded `pyodide` module,

```
import sys
```

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```
if "pyodide" in sys.modules:
   # running in Pyodide
```

This however will not work at build time (i.e. in a `setup.py`) due to the way the Pyodide build system works. It first compiles packages with the host compiler (e.g. gcc) and then re-runs the compilation commands with emsdk. So the `setup.py` is never run inside the Pyodide environment.

To detect Pyodide, **at build time** use,

```
import os

if "PYODIDE" in os.environ:
    # building for Pyodide
```

We used to use the environment variable `PYODIDE_BASE_URL` for this purpose, but this usage is deprecated.

How do I create custom Python packages from JavaScript?

Put a collection of functions into a JavaScript object and use *pyodide.registerJsModule*: JavaScript:

```
let my_module = {
  f: function (x) {
    return x * x + 1;
  },
  g: function (x) {
    console.log(`Calling g on argument ${x}`);
    return x;
  },
  submodule: {
    h: function (x) {
      return x * x - 1;
    },
    c: 2,
  },
};
pyodide.registerJsModule("my_js_module", my_module);
```

You can import your package like a normal Python package:

```
import my_js_module
from my_js_module.submodule import h, c
assert my_js_module.f(7) == 50
assert h(9) == 80
assert c == 2
```

How can I send a Python object from my server to Pyodide?

The best way to do this is with pickle. If the version of Python used in the server exactly matches the version of Python used in the client, then objects that can be successfully pickled can be sent to the client and unpickled in Pyodide. If the versions of Python are different then for instance sending AST is unlikely to work since there are breaking changes to Python AST in most Python minor versions.

Similarly when pickling Python objects defined in a Python package, the package version needs to match exactly between the server and pyodide.

Generally, pickles are portable between architectures (here amd64 and wasm32). The rare cases when they are not portable, for instance currently tree based models in scikit-learn, can be considered as a bug in the upstream library.

Security Issues with pickle

Unpickling data is similar to `eval`. On any public-facing server it is a really bad idea to unpickle any data sent from the client. For sending data from client to server, try some other serialization format like JSON.

How can I use a Python function as an event handler?

Note that the most straight forward way of doing this will not work:

```
from js import document
def f(*args):
    document.querySelector("h1").innerHTML += "(>.<)"

document.body.addEventListener('click', f)
```

Now every time you click, an error will be raised (see *Calling JavaScript functions from Python*).

To do this correctly use `pyodide.create_proxy()` as follows:

```
from js import document
from pyodide import create_proxy
def f(*args):
    document.querySelector("h1").innerHTML += "(>.<)"

proxy_f = create_proxy(f)
document.body.addEventListener('click', proxy_f)
# Store proxy_f in Python then later:
document.body.removeEventListener('click', proxy_f)
proxy_f.destroy()
```

How can I use fetch with optional arguments from Python?

The most obvious translation of the JavaScript code won't work:

```
import json
resp = await js.fetch('/someurl', {
  "method": "POST",
  "body": json.dumps({ "some" : "json" }),
  "credentials": "same-origin",
```

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```
  "headers": { "Content-Type": "application/json" }
})
```

The `fetch` API ignores the options that we attempted to provide. You can do this correctly in one of two ways:

```
import json
from pyodide.ffi import to_js
from js import Object
resp = await js.fetch('example.com/some_api',
  method= "POST",
  body= json.dumps({ "some" : "json" }),
  credentials= "same-origin",
  headers= Object.fromEntries(to_js({ "Content-Type": "application/json" })),
)
```

or:

```
import json
from pyodide.ffi import to_js
from js import Object
resp = await js.fetch('example.com/some_api', to_js({
  "method": "POST",
  "body": json.dumps({ "some" : "json" }),
  "credentials": "same-origin",
  "headers": { "Content-Type": "application/json" }
}, dict_converter=Object.fromEntries)
```

How can I control the behavior of stdin / stdout / stderr?

If you wish to override `stdin`, `stdout` or `stderr` for the entire Pyodide runtime, you can pass options to *`loadPyodide`*: If you say

```
loadPyodide({
  stdin: stdin_func, stdout: stdout_func, stderr: stderr_func
});
```

then every time a line is written to `stdout` (resp. `stderr`), `stdout_func` (resp `stderr_func`) will be called on the line. Every time `stdin` is read, `stdin_func` will be called with zero arguments. It is expected to return a string which is interpreted as a line of text.

Temporary redirection works much the same as it does in native Python: you can overwrite `sys.stdin`, `sys.stdout`, and `sys.stderr` respectively. If you want to do it temporarily, it's recommended to use `contextlib.redirect_stdout` and `contextlib.redirect_stderr`. There is no `contextlib.redirect_stdin` but it is easy to make your own as follows:

```
from contextlib import _RedirectStream
class redirect_stdin(_RedirectStream):
    _stream = "stdin"
```

For example, if you do:

```
from io import StringIO
with redirect_stdin(StringIO("\n".join(["eval", "asyncio.ensure_future", "functools.
↪reduce", "quit"]))):
  help()
```

it will print:

```
Welcome to Python 3.10's help utility!
<...OMITTED LINES>
Help on built-in function eval in module builtins:
eval(source, globals=None, locals=None, /)
    Evaluate the given source in the context of globals and locals.
<...OMITTED LINES>
Help on function ensure_future in asyncio:
asyncio.ensure_future = ensure_future(coro_or_future, *, loop=None)
    Wrap a coroutine or an awaitable in a future.
<...OMITTED LINES>
Help on built-in function reduce in functools:
functools.reduce = reduce(...)
    reduce(function, sequence[, initial]) -> value
    Apply a function of two arguments cumulatively to the items of a sequence,
<...OMITTED LINES>
You are now leaving help and returning to the Python interpreter.
```

Micropip can't find a pure Python wheel

When installing a Python package from PyPI, micropip will produce an error if it cannot find a pure Python wheel. To determine if a package has a pure Python wheel manually, you can open its PyPi page (for instance https://pypi.org/project/snowballstemmer/) and go to the "Download files" tab. If this tab doesn't contain a file `*py3-none-any.whl` then the pure Python wheel is missing.

This can happen for two reasons,

1. either the package is pure Python (you can check language composition for a package on Github), and its maintainers didn't upload a wheel. In this case, you can report this issue to the package issue tracker. As a temporary solution, you can also build the wheel yourself, upload it to some temporary location and install it with micropip from the corresponding URL.
2. or the package has binary extensions (e.g. C, Fortran or Rust), in which case it needs to be packaged in Pyodide. Please open an issue after checking than an issue for this opackage doesn't exist already. Then follow *Creating a Pyodide package*.

How can I change the behavior of `runPython` and `runPythonAsync`?

You can directly call Python functions from JavaScript. For most purposes it makes sense to make your own Python function as an entrypoint and call that instead of redefining `runPython`. The definitions of *`runPython`* and *`runPythonAsync`* are very simple:

```
function runPython(code) {
  pyodide.pyodide_py.code.eval_code(code, pyodide.globals);
}
```

```
async function runPythonAsync(code) {
  return await pyodide.pyodide_py.code.eval_code_async(code, pyodide.globals);
}
```

To make your own version of *runPython* you could do:

```
const my_eval_code = pyodide.runPython(`
  from pyodide.code import eval_code
  def my_eval_code(code, ns):
    extra_info = None
    result = eval_code(code, ns)
    return ns["extra_info"], result
  my_eval_code
`)

function myRunPython(code){
  return my_eval_code(code, pyodide.globals);
}
```

Then `myRunPython("2+7")` returns `[None, 9]` and `myRunPython("extra_info='hello' ; 2 + 2")` returns `['hello', 4]`. If you want to change which packages *pyodide.loadPackagesFromImports* loads, you can monkey patch *pyodide.code.find_imports* which takes `code` as an argument and returns a list of packages imported.

3.2 Development

The Development section helps Pyodide contributors to find information about the development process including making packages to support third party libraries.

3.2.1 Building from sources

Warning: If you are building the latest development version of Pyodide from the `main` branch, please make sure to follow the build instructions from the dev version of the documentation at pyodide.org/en/latest/

Building Pyodide is easiest using the Pyodide Docker image. This approach works with any native operating system as long as Docker is installed. You can also build on your native Linux OS if the correct build prerequisites are installed. Building on MacOS is possible, but there are known issues as of version 0.18 that you will need to work around. It is not possible to build on Windows, but you can use Windows Subsystem for Linux to create a Linux build environment.

Build instructions

Using Docker

We provide a Debian-based Docker image (`pyodide/pyodide-env`) on Docker Hub with the dependencies already installed to make it easier to build Pyodide. On top of that we provide a pre-built image (`pyodide/pyodide`) which can be used for fast custom and partial builds. Note that building from the non pre-built Docker image is *very* slow on Mac, building on the host machine is preferred if at all possible.

Note: These Docker images are also available from the Github packages at `github.com/orgs/pyodide/packages`.

1. Install Docker
2. From a git checkout of Pyodide, run `./run_docker` or `./run_docker --pre-built`
3. Run `make` to build.

Note: You can control the resources allocated to the build by setting the env vars `EMSDK_NUM_CORE`, `EMCC_CORES` and `PYODIDE_JOBS` (the default for each is 4).

If running `make` deterministically stops at some point, increasing the maximum RAM usage available to the docker container might help. (The RAM available to the container is different from the physical RAM capacity of the machine.) Ideally, at least 3 GB of RAM should be available to the docker container to build Pyodide smoothly. These settings can be changed via Docker preferences (see here).

You can edit the files in the shared `pyodide` source folder on your host machine (outside of Docker), and then repeatedly run `make` inside the Docker environment to test your changes.

Using `make`

Make sure the prerequisites for emsdk are installed. Pyodide will build a custom, patched version of emsdk, so there is no need to build it yourself prior.

You need Python 3.10.2 to run the build scripts. To make sure that the correct Python is used during the build it is recommended to use a virtual environment,

Linux

Additional build prerequisites are:

- A working native compiler toolchain, enough to build CPython.
- CMake
- FreeType 2 development libraries to compile Matplotlib.
- gfortran (GNU Fortran 95 compiler)
- f2c
- ccache (optional) *highly* recommended for much faster rebuilds.
- (optional) SWIG to compile NLopt
- (optional) sqlite3 to compile libproj

MacOS

To build on MacOS, you need:

- Homebrew for installing dependencies
- System libraries in the root directory (`sudo installer -pkg /Library/Developer/CommandLineTools/Packages/macOS_SDK_headers_for_macOS_10.14.pkg -target /` should do it, see https://github.com/pyenv/pyenv/issues/1219#issuecomment-428305417)
- coreutils for md5sum and other essential Unix utilities (`brew install coreutils`).
- cmake (`brew install cmake`)
- pkg-config (`brew install pkg-config`)
- openssl (`brew install openssl`)
- autoconf, automaker & libtool (`brew install autoconf automaker libtool`)
- gfortran (`brew cask install gfortran`)
- f2c: Install wget (`brew install wget`), and then run the buildf2c script from the root directory (`sudo ./tools/buildf2c`)
- It is also recommended installing the GNU patch (`brew install gpatch`), and GNU sed (`brew install gnu-sed`) and re-defining them temporarily as `patch` and `sed`.
- (optional) SWIG to compile NLopt (`brew install swig`)
- (optional) sqlite3 to compile libproj (`brew install sqlite3`)

Note: If you encounter issues with the requirements, it is useful to check the exact list in the Dockerfile which is tested in the CI.

You can install the Python dependencies from the requirement file at the root of Pyodide folder: `pip install -r requirements.txt`

After installing the build prerequisites, run from the command line:

```
make
```

Partial builds

To build a subset of available packages in Pyodide, set the environment variable `PYODIDE_PACKAGES` to a comma separated list of packages. For instance,

```
PYODIDE_PACKAGES="toolz,attrs" make
```

Dependencies of the listed packages will be built automatically as well. The package names must match the folder names in `packages/` exactly; in particular they are case-sensitive.

If `PYODIDE_PACKAGES` is not set, a minimal set of packages necessary to run the core test suite is installed, including "micropip", "pyparsing", "pytz", "packaging", "Jinja2", "regex". This is equivalent to setting `PYODIDE_PACKAGES='core'` meta-package. Other supported meta-packages are,

- "min-scipy-stack": includes the "core" meta-package as well as some core packages from the scientific python stack and their dependencies: "numpy", "scipy", "pandas", "matplotlib", "scikit-learn", "joblib", "pytest". This option is non exhaustive and is mainly intended to make build faster while testing a diverse set of scientific packages.

- "*" builds all packages
- You can exclude a package by prefixing it with "!".

micropip and distutils are always automatically included.

The cryptography package is a Rust extension. If you want to build it, you will need Rust >= 1.41, you need the CARGO_HOME environment variable set appropriately, and you need the `wasm32-unknown-emscripten` toolchain installed. If you run `make rust`, Pyodide will install this stuff automatically. If you want to build every package except for cryptography, you can set `PYODIDE_PACKAGES="*,!cryptography"`.

Environment variables

The following environment variables additionally impact the build:

- `PYODIDE_JOBS`: the `-j` option passed to the `emmake make` command when applicable for parallel compilation. Default: 3.
- `PYODIDE_BASE_URL`: Base URL where Pyodide packages are deployed. It must end with a trailing `/`. Default: `./` to load Pyodide packages from the same base URL path as where `pyodide.js` is located. Example: `https://cdn.jsdelivr.net/pyodide/v0.21.1/full/`
- `EXTRA_CFLAGS` : Add extra compilation flags.
- `EXTRA_LDFLAGS` : Add extra linker flags.

Setting `EXTRA_CFLAGS="-D DEBUG_F"` provides detailed diagnostic information whenever error branches are taken inside the Pyodide core code. These error messages are frequently helpful even when the problem is a fatal configuration problem and Pyodide cannot even be initialized. These error branches occur also in correctly working code, but they are relatively uncommon so in practice the amount of noise generated isn't too large. The shorthand `make debug` automatically sets this flag.

In certain cases, setting `EXTRA_LDFLAGS="-s ASSERTIONS=1` or `ASSERTIONS=2` can also be helpful, but this slows down the linking and the runtime speed of Pyodide a lot and generates a large amount of noise in the console.

3.2.2 Creating a Pyodide package

It is recommended to look into how other similar packages are built in Pyodide. If you encounter difficulties in building your package after trying the steps listed here, open a new Pyodide issue.

Determining if creating a Pyodide package is necessary

If you wish to use a package in Pyodide that is not already included in the `packages` folder, first you need to determine whether it is necessary to package it for Pyodide. Ideally, you should start this process with package dependencies.

Most pure Python packages can be installed directly from PyPI with *`micropip.install()`* if they have a pure Python wheel. Check if this is the case by trying `micropip.install("package-name")`.

If there is no wheel on PyPI, but you believe there is nothing preventing it (it is a Python package without C extensions):

- you can create the wheel yourself by running

```
python -m pip install build
python -m build
```

  from within the package folder where the `setup.py` are located. See the Python packaging guide for more details. Then upload the wheel file somewhere (not to PyPI) and install it with micropip via its URL.

- please open an issue in the package repository asking the authors to upload the wheel.

If however the package has C extensions or its code requires patching, then continue to the next steps.

Note: To determine if a package has C extensions, check if its `setup.py` contains any compilation commands.

Building Python wheels (out of tree)

Warning: This feature is still experimental in Pyodide 0.21.0.

It is now possible to build Python wheels for WASM/Emscripten separately from the Pyodide package tree using the following steps,

1. Install pyodide-build,

   ```
   pip install pyodide-build
   ```

2. Build the WASM/Emscripten package wheel by running,

   ```
   pyodide build
   ```

   in the package folder (where the `setup.py` or `pyproject.toml` file is located). This command would produce a binary wheel in the `dist/` folder, similarly to the PyPa build command.

3. Make the resulting file accessible as part of your web applications, and install it with `micropip.install` by URL.

Below is a more complete example for building a Python wheel out of tree with Github Actions CI,

```
runs-on: ubuntu-latest
  steps:
  - uses: actions/checkout@v3
  - uses: actions/setup-python@v4
     with:
       python-version: 3.10.2
  - uses: mymindstorm/setup-emsdk@v11
     with:
       version: 3.1.14
  - run: pip install pyodide-build==0.21.0
  - run: pyodide build
```

Notes

- the resulting package wheels have a file name of the form `*-cp310-cp310-emscripten_3_1_14_wasm32.whl` and are compatible only for a given Python and Emscripten versions. In the Pyodide distribution, Python and Emscripten are updated simultaneously.
- PyPi for now does not support wasm32 wheels so you will not be able to upload them there.

Building a Python package (in tree)

This section documents how to add a new package to the Pyodide distribution.

1. Creating the `meta.yaml` file

To build a Python package, you need to create a `meta.yaml` file that defines a "recipe" which may include build commands and "patches" (source code edits), amongst other things.

If your package is on PyPI, the easiest place to start is with the *mkpkg tool*.

First clone and build the Pyodide git repo like this:

```
git clone https://github.com/pyodide/pyodide
cd pyodide
```

If you'd like to use a Docker container, you can now run this command:

```
./run_docker --pre-built
```

This will mount the current working directory as `/src` within the container.

Now run `make` to build the relevant Pyodide tools:

```
make
```

Now install `pyodide_build` with:

```
pip install ./pyodide-build
```

And now you can run `mkpkg`:

```
python -m pyodide_build mkpkg <package-name>
```

This will generate a `meta.yaml` file under `packages/<package-name>/` (see *The meta.yaml specification*) that should work out of the box for many simple Python packages. This tool will populate the latest version, download link and sha256 hash by querying PyPI. It doesn't currently handle package dependencies, so you will need to specify those yourself.

You can also use the `meta.yaml` of other Pyodide packages in the `packages/` folder as a starting point.

Note: To reliably determine build and runtime dependencies, including for non Python libraries, it is often useful to verify if the package was already built on conda-forge and open the corresponding `meta.yaml` file. This can be done either by checking if the URL `https://github.com/conda-forge/<package-name>-feedstock/blob/master/recipe/meta.yaml` exists, or by searching the conda-forge GitHub org for the package name.

The Pyodide `meta.yaml` file format was inspired by the one in conda, however it is not strictly compatible.

The package may have special build requirements - e.g. specified in its Github README. If so, you can add extra build commands to the `meta.yaml` like this:

```
build:
  script: |
    wget https://example.com/file.tar.gz
    export MY_ENV_VARIABLE=FOO
```

2. Building the package and investigating issues

Once the `meta.yaml` file is ready, build the package with the following command

```
python -m pyodide_build buildall --only 'package-name' packages dist
```

and see if there are any errors.

If there are errors you might need to

- patch the package by adding `.patch` files to `packages/<package-name>/patches`
- add the patch files to the `source/patches` field in the `meta.yaml` file

then restart the build.

If the build succeeds you can try to load the package by

1. Serve the dist directory with `python -m http.server`
2. Open `localhost:<port>/console.html` and try to import the package
3. You can test the package in the repl

Writing tests for your package

The tests should go in one or more files like `packages/<package-name>/test_xxx.py`. Most packages have one test file named `test_<package-name>.py`. The tests should look like:

```
from pytest_pyodide import run_in_pyodide

@run_in_pyodide(packages=["<package-name>"])
def test_mytestname(selenium):
  import <package-name>
  assert package.do_something() == 5
  # ...
```

If you want to run your package's full pytest test suite and your package vendors tests you can do it like:

```
from pytest_pyodide import run_in_pyodide

@run_in_pyodide(packages=["<package-name>-tests", "pytest"])
def test_mytestname(selenium):
  import pytest
  pytest.main(["--pyargs", "<package-name>", "-k", "some_filter", ...])
```

you can put whatever command line arguments you would pass to `pytest` as separate entries in the list. For more info on `run_in_pyodide` see pytest-pyodide.

Generating patches

If the package has a git repository, the easiest way to make a patch is usually:

1. Clone the git repository of the package. You might want to use the options `git clone --depth 1 --branch <version>`. Find the appropriate tag given the version of the package you are trying to modify.
2. Make a new branch with `git checkout -b pyodide-version` (e.g., `pyodide-1.21.4`).
3. Make whatever changes you want. Commit them. Please split your changes up into focused commits. Write detailed commit messages! People will read them in the future, particularly when migrating patches or trying to decide if they are no longer needed. The first line of each commit message will also be used in the patch file name.
4. Use `git format-patch <version> -o <pyodide-root>/packages/<package-name>/patches/` to generate a patch file for your changes and store it directly into the patches folder.

Migrating Patches

When you want to upgrade the version of a package, you will need to migrate the patches. To do this:

1. Clone the git repository of the package. You might want to use the options `git clone --depth 1 --branch <version-tag>`.
2. Make a new branch with `git checkout -b pyodide-old-version` (e.g., `pyodide-1.21.4`).
3. Apply the current patches with `git am <pyodide-root>/packages/<package-name>/patches/*`.
4. Make a new branch `git checkout -b pyodide-new-version` (e.g., `pyodide-1.22.0`)
5. Rebase the patches with `git rebase old-version --onto new-version` (e.g., `git rebase pyodide-1.21.4 --onto pyodide-1.22.0`). Resolve any rebase conflicts. If a patch has been upstreamed, you can drop it with `git rebase --skip`.
6. Remove old patches with `rm <pyodide-root>/packages/<package-name>/patches/*`.
7. Use `git format-patch <version-tag> -o <pyodide-root>/packages/<package-name>/patches/` to generate new patch files.

Upstream your patches!

Please create PRs or issues to discuss with the package maintainers to try to find ways to include your patches into the package. Many package maintainers are very receptive to including Pyodide-related patches and they reduce future maintenance work for us.

The package build pipeline

Pyodide includes a toolchain to add new third-party Python libraries to the build. We automate the following steps:

- If source is a url (not in-tree):
  - Download a source archive or a pure python wheel (usually from PyPI)
  - Confirm integrity of the package by comparing it to a checksum
  - If building from source (not from a wheel):
    - Apply patches, if any, to the source distribution

        * Add extra files, if any, to the source distribution

- If the source is not a wheel (building from a source archive or an in-tree source):
  - Run `build/script` if present
  - Modify the `PATH` to point to wrappers for `gfortran`, `gcc`, `g++`, `ar`, and `ld` that preempt compiler calls, rewrite the arguments, and pass them to the appropriate emscripten compiler tools.
  - Using `pypa/build`:
    * Create an isolated build environment. Install symbolic links from this isolated environment to "host" copies of certain unisolated packages.
    * Install the build dependencies requested in the package `build-requires`. (We ignore all version constraints on the unisolated packages, but version constraints on other packages are respected.
    * Run the PEP 517 build backend associated to the project to generate a wheel.
- Unpack the wheel with `python -m wheel unpack`.
- Run the `build/post` script in the unpacked wheel directory if it's present.
- Unvendor unit tests included in the installation folder to a separate zip file `<package name>-tests.zip`
- Repack the wheel with `python -m wheel pack`

Lastly, a `repodata.json` file is created containing the dependency tree of all packages, so *pyodide.loadPackage* can load a package's dependencies automatically.

Partial Rebuilds

By default, each time you run `buildpkg`, `pyodide-build` will delete the entire source directory and replace it with a fresh copy from the download url. This is to ensure build repeatability. For debugging purposes, this is likely to be undesirable. If you want to try out a modified source tree, you can pass the flag `--continue` and `buildpkg` will try to build from the existing source tree. This can cause various issues, but if it works it is much more convenient.

Using the `--continue` flag, you can modify the sources in tree to fix the build, then when it works, copy the modified sources into your checked out copy of the package source repository and use `git format-patch` to generate the patch.

C library dependencies

Some Python packages depend on certain C libraries, e.g. `lxml` depends on `libxml`.

To package a C library, create a directory in `packages/` for the C library. In the directory, you should write `meta.yaml` that specifies metadata about the library. See *The meta.yaml specification* for more details.

The minimal example of `meta.yaml` for a C library is:

```
package:
  name: <name>
  version: <version>

source:
  url: <url>
  sha256: <sha256>

requirements:
  run:
```

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```
    - <requirement>

build:
  library: true
  script: |
    emconfigure ./configure
    emmake make -j ${PYODIDE_JOBS:-3}
```

You can use the `meta.yaml` of other C libraries such as libxml as a starting point.

After packaging a C library, it can be added as a dependency of a Python package like a normal dependency. See `lxml` and `libxml` for an example (and also `scipy` and `CLAPACK`).

Remark: Certain C libraries come as emscripten ports, and do not have to be built manually. They can be used by adding e.g. `-s USE_ZLIB` in the `cflags` of the Python package. See e.g. `matplotlib` for an example. The full list of libraries with Emscripten ports is here.

Structure of a Pyodide package

Pyodide is obtained by compiling CPython into WebAssembly. As such, it loads packages the same way as CPython — it looks for relevant files `.py` and `.so` files in the directories in `sys.path`. When installing a package, our job is to install our `.py` and `.so` files in the right location in emscripten's virtual filesystem.

Wheels are just zip archives, and to install them we unzip them into the `site-packages` directory. If there are any `.so` files, we also need to load them at install time: WebAssembly must be loaded asynchronously, but Python imports are synchronous so it is impossible to load `.so` files lazily.

The meta.yaml specification

Packages are defined by writing a `meta.yaml` file. The format of these files is based on the `meta.yaml` files used to build Conda packages, though it is much more limited. The most important limitation is that Pyodide assumes there will only be one version of a given library available, whereas Conda allows the user to specify the versions of each package that they want to install. Despite the limitations, it is recommended to use existing conda package definitions as a starting point to create Pyodide packages. In general, however, one should not expect Conda packages to "just work" with Pyodide, see #795

This is unstable

The Pyodide build system is under fairly active development (as of 2022/03/13). The next couple of releases are likely to include breaking changes.

The supported keys in the `meta.yaml` file are described below.

package

package/name

The name of the package. It must match the name of the package used when expanding the tarball, which is sometimes different from the name of the package in the Python namespace when installed. It must also match the name of the directory in which the `meta.yaml` file is placed. It can only contain alphanumeric characters, `-`, and `_`.

package/version

The version of the package.

source

source/url

The URL of the source tarball.

The tarball may be in any of the formats supported by Python's `shutil.unpack_archive`: `tar`, `gztar`, `bztar`, `xztar`, and `zip`.

source/extract_dir

The top level directory name of the contents of the source tarball (i.e. once you extract the tarball, all the contents are in the directory named `source/extract_dir`). This defaults to the tarball name (sans extension).

source/path

Alternatively to `source/url`, a relative or absolute path can be specified as package source. This is useful for local testing or building packages which are not available online in the required format.

If a path is specified, any provided checksums are ignored.

source/md5

The MD5 checksum of the tarball. It is recommended to use SHA256 instead of MD5. At most one checksum entry should be provided per package.

source/sha256

The SHA256 checksum of the tarball. It is recommended to use SHA256 instead of MD5. At most one checksum entry should be provided per package.

source/patches

A list of patch files to apply after expanding the tarball. These are applied using `patch -p1` from the root of the source tree.

source/extras

Extra files to add to the source tree. This should be a list where each entry is a pair of the form `(src, dst)`. The `src` path is relative to the directory in which the `meta.yaml` file resides. The `dst` path is relative to the root of source tree (the expanded tarball).

build

build/cflags

Extra arguments to pass to the compiler when building for WebAssembly.

(This key is not in the Conda spec).

build/cxxflags

Extra arguments to pass to the compiler when building C++ files for WebAssembly. Note that both `cflags` and `cxxflags` will be used when compiling C++ files. A common example would be to use `-std=c++11` for code that makes use of C++11 features.

(This key is not in the Conda spec).

build/ldflags

Extra arguments to pass to the linker when building for WebAssembly.

(This key is not in the Conda spec).

build/exports

Which symbols should be exported from the shared object files. Possible values are:

- `pyinit`: The default. Only export Python module initialization symbols of the form `PyInit_some_module`.
- `requested`: Export the functions that are marked as exported in the object files. Switch to this if `pyinit` doesn't work. Useful for packages that use `ctypes` or `dlsym` to access symbols.
- `whole_archive`: Uses `-Wl,--whole-archive` to force inclusion of all symbols. Use this when neither `pyinit` nor `explicit` work.

build/backend-flags

Extra flags to pass to the build backend (e.g., `setuptools`, `flit`, etc).

build/library

Should be set to true for library packages. Library packages are packages that are needed for other packages but are not Python packages themselves. For library packages, the script specified in the `build/script` section is run to compile the library. See the zlib meta.yaml for an example of a library package specification.

build/sharedlibrary

Should be set to true for shared library packages. Shared library packages are packages that are needed for other packages, but are loaded dynamically when Pyodide is run. For shared library packages, the script specified in the `build/script` section is run to compile the library. The script should build the shared library and copy it into a subfolder of the source folder called `install`. Files or folders in this install folder will be packaged to make the Pyodide package. See the CLAPACK meta.yaml for an example of a shared library specification.

build/script

The script section is required for a library package (`build/library` set to true). For a Python package this section is optional. If it is specified for a Python package, the script section will be run before the build system runs `setup.py`. This script is run by `bash` in the directory where the tarball was extracted.

build/cross-script

This script will run *after* `build/script`. The difference is that it runs with the target environment variables and `sysconfigdata` and with the `pywasmcross` compiler symlinks. Any changes to the environment will persist to the main build step but will not be seen in the `build/post` step (or anything else done outside of the cross build environment). The working directory for this script is the source directory.

build/post

Shell commands to run after building the library. These are run with `bash`, and there are two special environment variables defined:

- `$SITEPACKAGES`: The `site-packages` directory into which the package has been installed.
- `$PKGDIR`: The directory in which the `meta.yaml` file resides.

(This key is not in the Conda spec).

build/unvendor-tests

Whether to unvendor tests found in the installation folder to a separate package `<package-name>-tests`. If this option is true and no tests are found, the test package will not be created. Default: true.

requirements

requirements/run

A list of required packages.

(Unlike conda, this only supports package names, not versions).

test

test/imports

List of imports to test after the package is built.

Supported Environment Variables

The following environment variables can be used in the scripts in the meta.yaml files:

- PYODIDE_ROOT: The path to the base Pyodide directory
- PYMAJOR: Current major Python version
- PYMINOR: Current minor Python version
- PYMICRO: Current micro Python version
- SIDE_MODULE_CFLAGS: The standard CFLAGS for a side module. Use when compiling libraries or shared libraries.
- SIDE_MODULE_LDFLAGS: The standard LDFLAGS for a side module. Use when linking a shared library.
- NUMPY_LIB: Use `-L$NUMPY_LIB` as a ldflag when linking `-lnpymath` or `-lnpyrandom`.

Rust/PyO3 Packages

We currently build `cryptography` which is a Rust extension built with PyO3 and `setuptools-rust`. It should be reasonably easy to build other Rust extensions. Currently it is necessary to run `source $CARGO_HOME/env` in the build script as shown here, but other than that there may be no other issues if you are lucky.

As mentioned here, by default certain wasm-related `RUSTFLAGS` are set during `build.script` and can be removed with `export RUSTFLAGS=""`.

3.2.3 How to Contribute

Thank you for your interest in contributing to Pyodide! There are many ways to contribute, and we appreciate all of them. Here are some guidelines & pointers for diving into it.

Development Workflow

To contribute code, see the following steps,

1. Fork the Pyodide repository https://github.com/pyodide/pyodide on Github.
2. If you are on Linux, you can skip this step. On Windows and MacOS you have a choice. The first option is to manually install Docker:
   - on MacOS follow these instructions
   - on Windows, install WSL 2, then Docker. Note that Windows filesystem access from WSL2 is very slow and should be avoided when building Pyodide.

   The second option is to use a service that provides a Linux development environment, such as
   - Github Codespaces
   - gitpod.io
   - or a remote Linux VM with SSH connection.
3. Clone your fork of Pyodide

   ```
   git clone https://github.com/<your-username>/pyodide.git
   ```

   and add the upstream remote,

   ```
   git remote add upstream https://github.com/pyodide/pyodide.git
   ```
4. While the build will happen inside Docker you still need a development environment with Python 3.10 and ideally Node.js. These can be installed for instance with,

   ```
   conda create -c conda-forge -n pyodide-env python=3.10.2 nodejs
   conda activate pyodide-env
   ```

   or via your system package manager.
5. Install requirements (it's recommended to use a virtualenv or a conda env),

   ```
   pip install -r requirements.txt
   ```
6. Enable pre-commit for code style,

   ```
   pre-commit install
   ```

   This will run a set of linters for each commit.
7. Follow *Building from sources* instructions.
8. See *Testing and benchmarking* documentation.

Code of Conduct

Pyodide has adopted a *Code of Conduct* that we expect all contributors and core members to adhere to.

Development

Work on Pyodide happens on GitHub. Core members and contributors can make Pull Requests to fix issues and add features, which all go through the same review process. We'll detail how you can start making PRs below.

We'll do our best to keep `main` in a non-breaking state, ideally with tests always passing. The unfortunate reality of software development is sometimes things break. As such, `main` cannot be expected to remain reliable at all times. We recommend using the latest stable version of Pyodide.

Pyodide follows semantic versioning - major versions for breaking changes (x.0.0), minor versions for new features (0.x.0), and patches for bug fixes (0.0.x).

We keep a file, *docs/changelog.md*, outlining changes to Pyodide in each release. We like to think of the audience for changelogs as non-developers who primarily run the latest stable. So the change log will primarily outline user-visible changes such as new features and deprecations, and will exclude things that might otherwise be inconsequential to the end user experience, such as infrastructure or refactoring.

Bugs & Issues

We use Github Issues for announcing and discussing bugs and features. Use this link to report a bug or issue. We provide a template to give you a guide for how to file optimally. If you have the chance, please search the existing issues before reporting a bug. It's possible that someone else has already reported your error. This doesn't always work, and sometimes it's hard to know what to search for, so consider this extra credit. We won't mind if you accidentally file a duplicate report.

Core contributors are monitoring new issues & comments all the time, and will label & organize issues to align with development priorities.

How to Contribute

Pull requests are the primary mechanism we use to change Pyodide. GitHub itself has some great documentation on using the Pull Request feature. We use the "fork and pull" model described here, where contributors push changes to their personal fork and create pull requests to bring those changes into the source repository.

Please make pull requests against the `main` branch.

If you're looking for a way to jump in and contribute, our list of good first issues is a great place to start.

If you'd like to fix a currently-filed issue, please take a look at the comment thread on the issue to ensure no one is already working on it. If no one has claimed the issue, make a comment stating you'd like to tackle it in a PR. If someone has claimed the issue but has not worked on it in a few weeks, make a comment asking if you can take over, and we'll figure it out from there.

We use pytest, driving Selenium as our testing framework. Every PR will automatically run through our tests, and our test framework will alert you on GitHub if your PR doesn't pass all of them. If your PR fails a test, try to figure out whether or not you can update your code to make the test pass again, or ask for help. As a policy we will not accept a PR that fails any of our tests, and will likely ask you to add tests if your PR adds new functionality. Writing tests can be scary, but they make open-source contributions easier for everyone to assess. Take a moment and look through how we've written our tests, and try to make your tests match. If you are having trouble, we can help you get started on our test-writing journey.

All code submissions should pass `make lint`. Python is checked with `flake8`, `black` and `mypy`. JavaScript is checked with `prettier`. C is checked against the Mozilla style in `clang-format`.

Contributing to the "core" C Code

See *Contributing to the "core" C Code*.

Documentation

Documentation is a critical part of any open source project, and we are very welcome to any documentation improvements. Pyodide has a documentation written in Markdown in the `docs/` folder. We use the MyST for parsing Markdown in sphinx. You may want to have a look at the MyST syntax guide when contributing, in particular regarding cross-referencing sections.

Building the docs

From the directory `docs`, first install the Python dependencies with `pip install -r requirements-doc.txt`. You also need to install JsDoc, which is a `node` dependency. Install it with `sudo npm install -g jsdoc`. Then to build the docs run `make html`. The built documentation will be in the subdirectory `docs/_build/html`. To view them, cd into `_build/html` and start a file server, for instance `http-server`.

Migrating patches

It often happens that patches need to be migrated between different versions of upstream packages.

If patches fail to apply automatically, one solution can be to

1. Checkout the initial version of the upstream package in a separate repo, and create a branch from it.
2. Add existing patches with `git apply <path.path>`
3. Checkout the new version of the upstream package and create a branch from it.
4. Cherry-pick patches to the new version,

   ```
   git cherry-pick <commit-hash>
   ```

   and resolve conflicts.
5. Re-export last `N` commits as patches e.g.

   ```
   git format-patch -<N> -N --no-stat HEAD -o <out_dir>
   ```

Maintainer information

For information about making releases see *Maintainer information*.

License

All contributions to Pyodide will be licensed under the Mozilla Public License 2.0 (MPL 2.0). This is considered a "weak copyleft" license. Check out the tl;drLegal entry for more information, as well as Mozilla's MPL 2.0 FAQ if you need further clarification on what is and isn't permitted.

Get in Touch

- **Gitter:** #pyodide channel at gitter.im

Contributing to the "core" C Code

This file is intended as guidelines to help contributors trying to modify the C source files in `src/core`.

What the files do

The primary purpose of `core` is to implement *type translations* between Python and JavaScript. Here is a breakdown of the purposes of the files.

- `main` – responsible for configuring and initializing the Python interpreter, initializing the other source files, and creating the `_pyodide_core` module which is used to expose Python objects to `pyodide_py`. `main.c` also tries to generate fatal initialization error messages to help with debugging when there is a mistake in the initialization code.
- `keyboard_interrupt` – This sets up the keyboard interrupts system for using Pyodide with a webworker.

Backend utilities

- `hiwire` – A helper framework. It is impossible for wasm to directly hold owning references to JavaScript objects. The primary purpose of hiwire is to act as a surrogate owner for JavaScript references by holding the references in a JavaScript `Map`. `hiwire` also defines a wide variety of `EM_JS` helper functions to do JavaScript operations on the held objects. The primary type that hiwire exports is `JsRef`. References are created with `Hiwire.new_value` (only can be done from JavaScript) and must be destroyed from C with `hiwire_decref` or `hiwire_CLEAR`, or from JavaScript with `Hiwire.decref`.
- `error_handling` – defines macros useful for error propagation and for adapting JavaScript functions to the CPython calling convention. See more in the *Error Handling Macros* section.

Type conversion from JavaScript to Python

- `js2python` – Translates basic types from JavaScript to Python, leaves more complicated stuff to jsproxy.
- `jsproxy` – Defines Python classes to proxy complex JavaScript types into Python. A complex file responsible for many of the core behaviors of Pyodide.

Type conversion from Python to JavaScript

- `python2js` – Translates types from Python to JavaScript, implicitly converting basic types and creating pyproxies for others. It also implements explicit conversion from Python to JavaScript (the `toJs` method).
- `python2js_buffer` – Attempts to convert Python objects that implement the Python Buffer Protocol. This includes `bytes` objects, `memoryviews`, `array.array` and a wide variety of types exposed by extension modules like `numpy`. If the data is a 1d array in a contiguous block it can be sliced directly out of the wasm heap to produce a JavaScript `TypedArray`, but JavaScript does not have native support for pointers, so higher dimensional arrays are more complicated.
- `pyproxy` – Defines a JavaScript `Proxy` object that passes calls through to a Python object. Another important core file, `PyProxy.apply` is the primary entrypoint into Python code. `pyproxy.c` is much simpler than `jsproxy.c` though.

CPython APIs

Conventions for indicating errors

The two main ways to indicate errors:

1. If the function returns a pointer, (most often `PyObject*`, `char*`, or `const char*`) then to indicate an error set an exception and return `NULL`.
2. If the function returns `int` or `float` and a correct output must be nonnegative, to indicate an error set an exception and return `-1`.

Certain functions have "successful errors" like `PyIter_Next` (successful error is `StopIteration`) and `PyDict_GetItemWithError` (successful error is `KeyError`). These functions will return `NULL` without setting an exception to indicate the "successful error" occurred. Check what happened with `PyErr_Occurred`. Also, functions that return `int` for which `-1` is a valid return value will return `-1` with no error set to indicate that the result is `-1` and `-1` with an error set if an error did occur. The simplest way to handle this is to always check `PyErr_Occurred`.

Lastly, the argument parsing functions `PyArg_ParseTuple`, `PyArg_Parse`, etc are edge cases. These return `true` on success and return `false` and set an error on failure.

Python APIs to avoid:

- `PyDict_GetItem`, `PyDict_GetItemString`, and `_PyDict_GetItemId` These APIs do not do correct error reporting and there is talk in the Python community of deprecating them going forward. Instead, use `PyDict_GetItemWithError` and `_PyDict_GetItemIdWithError` (there is no `PyDict_GetItemStringWithError` API because use of `GetXString` APIs is also discouraged).
- `PyObject_HasAttrString`, `PyObject_GetAttrString`, `PyDict_GetItemString`, `PyDict_SetItemString`, `PyMapping_HasKeyString` etc, etc. These APIs cause wasteful repeated string conversion. If the string you are using is a constant, e.g., `PyDict_GetItemString(dict, "identifier")`, then make an id with `Py_Identifier(identifier)` and then use `_PyDict_GetItemId(&PyId_identifier)`. If the string is not constant, convert it to a Python object with `PyUnicode_FromString()` and then use e.g., `PyDict_GetItem`.
- `PyModule_AddObject`. This steals a reference on success but not on failure and requires unique cleanup code. Instead, use `PyObject_SetAttr`.

Error Handling Macros

The file `error_handling.h` defines several macros to help make error handling as simple and uniform as possible.

Error Propagation Macros

In a language with exception handling as a feature, error propagation requires no explicit code, it is only if you want to prevent an error from propagating that you use a `try/catch` block. On the other hand, in C all error propagation must be done explicitly.

We define macros to help make error propagation look as simple and uniform as possible. They can only be used in a function with a `finally:` label which should handle resource cleanup for both the success branch and all the failing branches (see structure of functions section below). When compiled with `DEBUG_F`, these commands will write a message to `console.error` reporting the line, function, and file where the error occurred.

- `FAIL()` – unconditionally `goto finally;`.
- `FAIL_IF_NULL(ptr)` – `goto finally;` if `ptr == NULL`. This should be used with any function that returns a pointer and follows the standard Python calling convention.
- `FAIL_IF_MINUS_ONE(num)` – `goto finally;` if `num == -1`. This should be used with any function that returns a number and follows the standard Python calling convention.
- `FAIL_IF_NONZERO(num)` – `goto finally;` if `num != 0`. Can be used with functions that return any nonzero error code on failure.
- `FAIL_IF_ERR_OCCURRED()` – `goto finally;` if the Python error indicator is set (in other words if `PyErr_Occurred()`).
- `FAIL_IF_ERR_MATCHES(python_err_type)` – `goto finally;` if `PyErr_ExceptionMatches(python_err_type)`, for example `FAIL_IF_ERR_MATCHES(PyExc_AttributeError);`

JavaScript to CPython calling convention adaptors

If we call a JavaScript function from C and that JavaScript function throws an error, it is impossible to catch it in C. We define two `EM_JS` adaptors to convert from the JavaScript calling convention to the CPython calling convention. The point of this is to ensure that errors that occur in `EM_JS` functions can be handled in C code using the `FAIL_*`` macros. When compiled with DEBUG_F, when a JavaScript error is thrown a message will also be written to` console.error`. The wrappers do roughly the following:

```
try {
  // body of function here
} catch (e) {
  // wrap e in a Python exception and set the Python error indicator
  // return error code
}
```

There are two variants: `EM_JS_NUM` returns `-1` as the error code, `EM_JS_REF` returns `NULL == 0` as the error code. A couple of simple examples: Use `EM_JS_REF` when return value is a `JsRef`:

```
EM_JS_REF(JsRef, hiwire_call, (JsRef idfunc, JsRef idargs), {
  let jsfunc = Hiwire.get_value(idfunc);
  let jsargs = Hiwire.get_value(idargs);
  return Hiwire.new_value(jsfunc(... jsargs));
});
```

Use `EM_JS_REF` when return value is a `PyObject`:

```
EM_JS_REF(PyObject*, __js2python, (JsRef id), {
  // body here
});
```

If the function returns `void`, use `EM_JS_NUM` with return type `errcode`. `errcode` is a typedef for `int`. `EM_JS_NUM` will automatically return `-1` if an error occurs and `0` if not:

```
EM_JS_NUM(errcode, hiwire_set_member_int, (JsRef idobj, int idx, JsRef idval), {
  Hiwire.get_value(idobj)[idx] = Hiwire.get_value(idval);
});
```

If the function returns `int` or `bool` use `EM_JS_NUM`:

```
EM_JS_NUM(int, hiwire_get_length, (JsRef idobj), {
  return Hiwire.get_value(idobj).length;
});
```

These wrappers enable the following sort of code:

```
try:
  jsfunc()
except JsException:
  print("Caught an exception thrown in JavaScript!")
```

Structure of functions

In C it takes special care to correctly and cleanly handle both reference counting and exception propagation. In Python (or other higher level languages), all references are released in an implicit finally block at the end of the function. Implicitly, it is as if you wrote:

```
def f():
  try: # implicit
    a = do_something()
    b = do_something_else()
    c = a + b
    return some_func(c)
  finally:
    # implicit, free references both on successful exit and on exception
    decref(a)
    decref(b)
    decref(c)
```

Freeing all references at the end of the function allows us to separate reference counting boilerplate from the "actual logic" of the function definition. When a function does correct error propagation, there will be many different execution paths, roughly linearly many in the length of the function. For example, the above pseudocode could exit in five different ways: `do_something` could raise an exception, `do_something_else` could raise an exception, `a + b` could raise an exception, `some_func` could raise an exception, or the function could return successfully. (Even a Python function like `def f(a,b,c,d): return (a + b) * c - d` has four execution paths.) The point of the `try/finally` block is that we know the resources are freed correctly without checking once for each execution path.

To do this, we divide any function that produces more than a couple of owned `PyObject*`s or `JsRef`s into several "segments". The more owned references there are in a function and the longer it is, the more important it becomes

to follow this style carefully. By being as consistent as possible, we reduce the burden on people reading the code to double-check that you are not leaking memory or errors. In short functions it is fine to do something ad hoc.

1. The guard block. The first block of a function does sanity checks on the inputs and argument parsing, but only to the extent possible without creating any owned references. If you check more complicated invariants on the inputs in a way that requires creating owned references, this logic belongs in the body block.

Here's an example of a `METH_VARARGS` function:

```
PyObject*
JsImport_CreateModule(PyObject* self, PyObject* args)
{
  // Guard
  PyObject* name;
  PyObject* jsproxy;
  // PyArg_UnpackTuple uses an unusual calling convention:
  // It returns `false` on failure...
  if (!PyArg_UnpackTuple(args, "create_module", 2, 2, &spec, &jsproxy)) {
    return NULL;
  }
  if (!JsProxy_Check(jsproxy)) {
    PyErr_SetString(PyExc_TypeError, "package is not an instance of jsproxy");
    return NULL;
  }
```

2. Forward declaration of owned references. This starts by declaring a success flag `bool success = false`. This will be used in the finally block to decide whether the finally block was entered after a successful execution or after an error. Then declare every reference counted variable that we will create during execution of the function. Finally, declare the variable that we are planning to return. Typically, this will be called `result`, but in this case the function is named `CreateModule` so we name the return variable `module`.

```
  bool success = false;
  // Note: these are all the objects that we will own. If a function returns
  // a borrow, we XINCREF the result so that we can CLEAR it in the finally block.
  // Reference counting is hard, so it's good to be as explicit and consistent
  // as possible!
  PyObject* sys_modules = NULL;
  PyObject* importlib_machinery = NULL;
  PyObject* ModuleSpec = NULL;
  PyObject* spec = NULL;
  PyObject* __dir__ = NULL;
  PyObject* module_dict = NULL;
  // result
  PyObject* module = NULL;
```

3. The body of the function. The vast majority of API calls can return error codes. You MUST check every fallible API for an error. Also, as you are writing the code, you should look up every Python API you use that returns a reference to determine whether it returns a borrowed reference or a new one. If it returns a borrowed reference, immediately `Py_XINCREF()` the result to convert it into an owned reference (before `FAIL_IF_NULL`, to be consistent with the case where you use custom error handling).

```
  name = PyUnicode_FromString(name_utf8);
  FAIL_IF_NULL(name);
  sys_modules = PyImport_GetModuleDict(); // returns borrow
  Py_XINCREF(sys_modules);
```

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```
  FAIL_IF_NULL(sys_modules);
  module = PyDict_GetItemWithError(sys_modules, name); // returns borrow
  Py_XINCREF(module);
  FAIL_IF_NULL(module);
  if(module && !JsImport_Check(module)){
    PyErr_Format(PyExc_KeyError,
      "Cannot mount with name '%s': there is an existing module by this name that was␣
↪not mounted with 'pyodide.mountPackage'."
      , name
    );
    FAIL();
  }
// ... [SNIP]
```

4. The `finally` block. Here we will clear all the variables we declared at the top in exactly the same order. Do not clear the arguments! They are borrowed. According to the standard Python function calling convention, they are the responsibility of the calling code.

```
  success = true;
finally:
  Py_CLEAR(sys_modules);
  Py_CLEAR(importlib_machinery);
  Py_CLEAR(ModuleSpec);
  Py_CLEAR(spec);
  Py_CLEAR(__dir__);
  Py_CLEAR(module_dict);
  if(!success){
    Py_CLEAR(result);
  }
  return result;
}
```

One case where you do need to `Py_CLEAR` a variable in the body of a function is if that variable is allocated in a loop:

```
  // refcounted variable declarations
  PyObject* pyentry = NULL;
  // ... other stuff
  Py_ssize_t n = PySequence_Length(pylist);
  for (Py_ssize_t i = 0; i < n; i++) {
    pyentry = PySequence_GetItem(pydir, i);
    FAIL_IF_MINUS_ONE(do_something(pyentry));
    Py_CLEAR(pyentry); // important to use Py_CLEAR and not Py_decref.
  }

  success = true
finally:
  // have to clear pyentry at end too in case do_something failed in the loop body
  Py_CLEAR(pyentry);
```

Testing

Any nonstatic C function called `some_name` defined not using `EM_JS` will be exposed as `pyodide._module._some_name`, and this can be used in tests to good effect. If the arguments / return value are not just numbers and booleans, it may take some effort to set up the function call.

If you want to test an `EM_JS` function, consider moving the body of the function to an API defined on `Module`. You should still wrap the function with `EM_JS_REF` or `EM_JS_NUM` in order to get a function with the CPython calling convention.

Maintainer information

Making a release

For branch organization we use a variation of the GitHub Flow with the latest release branch named `stable` (due to ReadTheDocs constraints).

Release Instructions

1. From the root directory of the repository run

   ```
   ./tools/bump_version.py --new-version <new_version>
   # ./tools/bump_version.py --new_version <new_version> --dry-run
   ```

   and check that the diff is correct with `git diff`. Try using `ripgrep` to make sure there are no extra old versions lying around e.g., `rg -F "0.18"`, `rg -F dev0`, `rg -F dev.0`.

2. Make sure the change log is up-to-date. (Skip for alpha releases.)

   - Indicate the release date in the change log.
   - Generate the list of contributors for the release at the end of the changelog entry with,

     ```
     git shortlog -s LAST_TAG.. | cut -f2- | grep -v '\[bot\]' | sort --ignore-case␣
     ↪| tr '\n' ';' | sed 's/;/, /g;s/, $//' | fold -s
     ```

     where `LAST_TAG` is the tag for the last release.

3. Make a PR with the updates from steps 1 and 2. Merge the PR.

4. (Major release only.) Assuming the upstream `stable` branch exists, rename it to a release branch for the previous major version. For instance if last release was, `0.20.0`, the corresponding release branch would be `0.20.X`,

   ```
   git fetch upstream
   git checkout stable
   git checkout -b 0.20.X
   git push upstream 0.20.X
   git branch -D stable    # delete locally
   ```

5. Create a tag `X.Y.Z` (without leading `v`) and push it to upstream,

   ```
   git tag X.Y.Z
   git push upstream X.Y.Z
   ```

   Wait for the CI to pass and create the release on GitHub.

6. (Major release only). Create a new `stable` branch from this tag,

```
git checkout -b stable
git push upstream stable --force
```

7. Revert the release commit. If making a major release, increment the version to the next development version specified by Semantic Versioning.

```
# If you just released 0.22.0, then set the next version to 0.23.0
./tools/bump_version.py --new-version 0.23.0.dev0
```

8. Update these instructions with any relevant changes.

Making a minor release

For a minor release, commits need to be added to the `stable` branch, ideally via a PR. This can be done with either,

- git cherry picking individual commits,

```
git checkout stable
git pull
git checkout -b backport-branch
git cherry-pick <commit-hash>
```

- or with interactive rebase,

```
git fetch upstream
git checkout stable
git pull
git checkout -b backport-branch
git rebase -i upstream/main
```

  and indicate which commits to take from `main` in the UI.

Then follow the relevant steps from *Release Instructions*.

Making an alpha release

Name the first alpha release `x.x.xa1` and in subsequent alphas increment the final number. Follow the relevant steps from *Release Instructions*.

Fixing documentation for a released version

Cherry pick the corresponding documentation commits to the `stable` branch. Use `[skip ci]` in the commit message.

3.2.4 Testing and benchmarking

Testing

Running the Python test suite

1. Install the following dependencies into the default Python installation:

```
pip install pytest-pyodide pytest-httpserver
```

`pytest-pyodide` is a pytest plugin for testing Pyodide and third-party applications that use Pyodide.

See: pytest-pyodide for more information.

2. Install geckodriver or chromedriver and check that they are in your `PATH`.
3. To run the test suite, run `pytest` from the root directory of Pyodide:

```
pytest
```

There are 3 test locations that are collected by pytest,

- `src/tests/`: general Pyodide tests and tests running the CPython test suite
- `pyodide-build/pyodide_build/tests/`: tests related to Pyodide build system (do not require selenium or playwright to run)
- `packages/*/test_*`: package specific tests.

You can run the tests from a specific file with:

```
pytest path/to/test/file.py
```

Some browsers sometimes produce informative errors than others so if you are getting confusing errors it is worth rerunning the test on each browser. You can use `--runtime` commandline option to specify the browser runtime.

```
pytest --runtime firefox
pytest --runtime chrome
pytest --runtime node
```

Custom test marks

We support custom test marks:

`@pytest.mark.skip_refcount_check` and `pytest.mark.skip_pyproxy_check` disable respectively the check for JavaScript references and the check for PyProxies. If a test creates JavaScript references or PyProxies and does not clean them up, by default the tests will fail. If a test is known to leak objects, it is possible to disable these checks with these markers.

Running the JavaScript test suite

To run tests on the JavaScript Pyodide package using Mocha, run the following commands,

```
cd src/js
npm test
```

To check TypeScript type definitions run,

```
npx tsd
```

Manual interactive testing

To run tests manually:

1. Build Pyodide, perhaps in the docker image
2. From outside of the docker image, `cd` into the `dist` directory and run `python -m http.server`.
3. Once the webserver is running, simple interactive testing can be run by visiting the URL: `http://localhost:<PORT>/console.html`. It's recommended to use `pyodide.runPython` in the browser console rather than using the repl.

Benchmarking

To run common benchmarks to understand Pyodide's performance, begin by installing the same prerequisites as for testing. Then run:

```
PYODIDE_PACKAGES="numpy,matplotlib" make benchmark
```

Linting

We lint with `pre-commit`.

Python is linted with `flake8`, `black` and `mypy`. JavaScript, markdown, yaml, and html are linted with `prettier`. C is linted with `clang-format`.

To lint the code, run:

```
pre-commit run -a
```

You can have the linter automatically run whenever you commit by running

```
pip install pre-commit
pre-commit install
```

and this can later be disabled with

```
pre-commit uninstall
```

If you don't lint your code, certain lint errors will be fixed automatically by `pre-commit.ci` which will push fixes to your branch. If you want to push more commits, you will either have to pull in the remote changes or force push.

3.2.5 Debugging tips

See Emscripten's page about debugging which has extensive info about the various debugging options available. The Wasm Binary Toolkit is super helpful for analyzing `.wasm`, `.so`, `.a`, and `.o` files.

Also whenever you can reproduce a bug in chromium make sure to use a chromium-based browser (e.g., chrome) for debugging. They are better at it.

Run `prettier` on `pyodide.asm.js`

Before doing any debugger I strongly recommend running `npx prettier -w pyodide.asm.js`. This makes everything much easier.

Linker error: function signature mismatch

You may get linker errors as follows:

```
wasm-ld: error: function signature mismatch: some_func
>>> defined as (i32, i32) -> i32 in some_static_lib.a(a.o)
>>> defined as (i32) -> i32 in b.o
```

This is especially common in Scipy. Oftentimes it isn't too hard to figure out what is going wrong because it told you the both the symbol name (`some_func`) and the object files involved (this is much easier than the runtime version of this error!). If you can't tell what is going on from looking at the source files, it's time to pull out `wasm-objdump`. In this case `a.o` is part of `some_static_lib.a` so you first need to get it out with `ar -x some_static_lib.a a.o`. Now we can check if `a.o` imports or defines `some_func`. To check for imports, use `wasm-objdump a.o -j Import -x | grep some_func`. If `a.o` is importing `some_func` you should see a line like: `- func[0] sig=1 <env.some_func> <- env.some_func` in the output.

If not, you will see nothing or things like `some_func2`. To check if `a.o` defines `some_func` (this is a bit redundant because you can conclude whether or not does from whether it imports it) we can use: `wasm-objdump a.o -j Function -x | grep some_func`, if `a.o` defines `some_func` you will see something like: `- func[0] sig=0 <some_func>`.

Now the question is what these signatures mean (though we already know this from the linker error). To find out what signature 0 is, you can use `wasm-objdump a.o -j Type -x | grep "type\[0\]"`.

Using this, we can verify that `a.o` imports `some_func` with signature `(i32, i32) -> i32` but `b.o` exports it with signature `(i32) -> i32`, hence the linker error.

This process works in basically the same way for already-linked `.so` and `.wasm` files, which can help if you get the load-time version of this linker error.

Misencoded Wasm

On a very rare occasion you may run into a misencoded object file. This can cause different tools to crash, `wasm-ld` may panic, etc. `wasm-objdump` will just generate a useless error message. In this case, I recommend `wasm-objdump -s --debug 2>&1 | grep -i error -C 20` (or pipe to `less`), which will result in more diagnostic information. Sometimes the crash happens quite a lot later than the actual error, look for suspiciously large constants, these are often the first sign of something gone haywire.

After this, you can get out a hex editor and consult the WebAssembly binary specification Cross reference against the hex addresses appearing in `wasm-objdump --debug`. With enough diligence you can locate the problem.

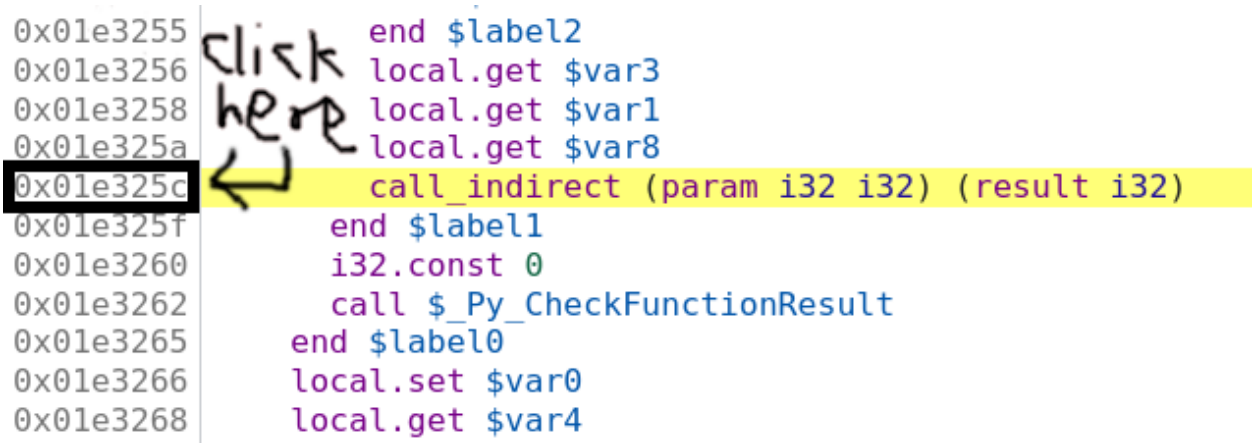
Debugging RuntimeError: function signature mismatch

First recompile with `-g2`. `-g2` keeps symbols but won't try to use C source maps which mostly make our life harder (though it may be helpful to link one copy with `-g2` and one with `-g3` and run them at the same time cf *Using C source maps*).

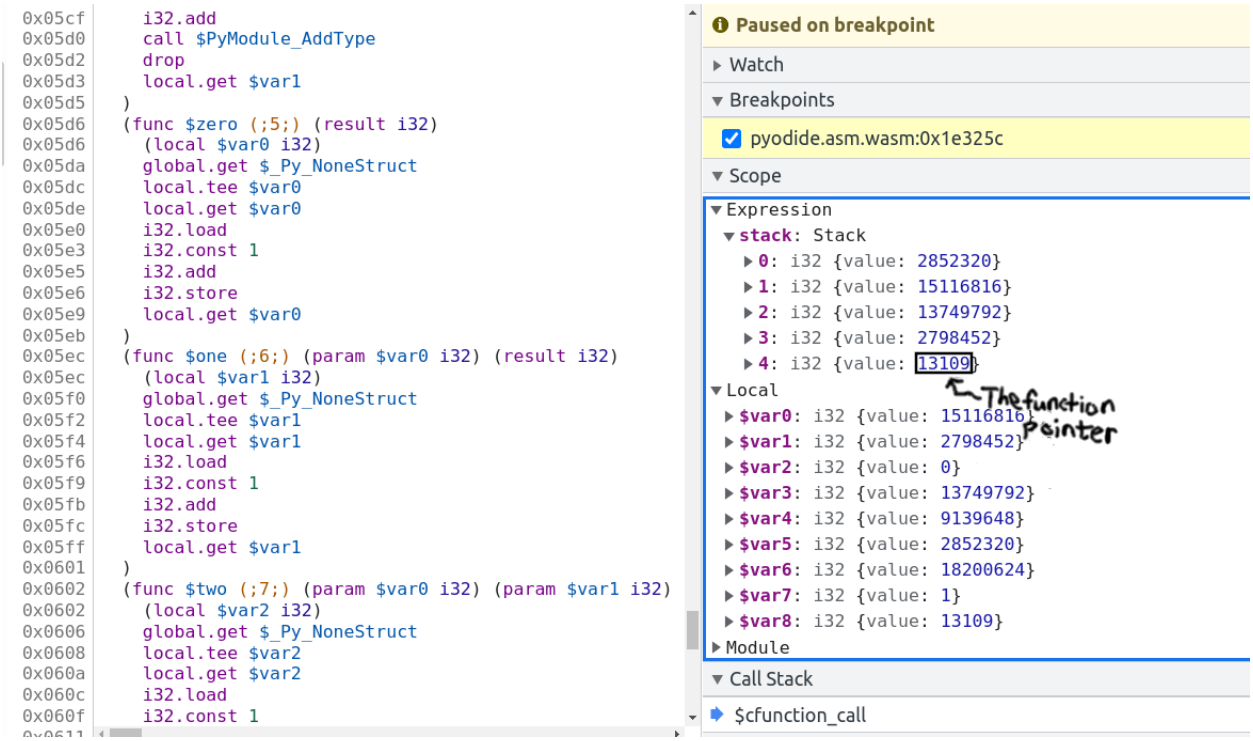
The browser console will show something like the following. Click on the innermost stack trace:

```
Stack (most recent call first):
  File "<console>", line 1 in <module>
  File "/lib/python3.11/site-packages/_pyodide/_base.py", line 351 in run_async
  File "/lib/python3.11/site-packages/pyodide/console.py", line 362 in runcode
  File "/lib/python3.11/site-packages/pyodide/console.py", line 474 in runcode
  File "/lib/python3.11/asyncio/events.py", line 80 in _run
  File "/lib/python3.11/site-packages/pyodide/webloop.py", line 151 in run_handle
▸Uncaught RuntimeError: null function or function signature mismatch
    at cfunction_call (pyodide.asm.wasm:0x1e325c)
    at _PyObject_MakeTpCall (pyodide.asm.wasm:0x1a16b7)
    at PyObject_Vectorcall (pyodide.asm.wasm:0x1a1ca6)
    at _PyEval_EvalFrameDefault (pyodide.asm.wasm:0x271855)
    at PyEval_EvalCode (pyodide.asm.wasm:0x269262)
    at builtin_eval (pyodide.asm.wasm:0x266613)
    at cfunction_vectorcall_FASTCALL (pyodide.asm.wasm:0x1e2e61)
    at PyObject_Vectorcall (pyodide.asm.wasm:0x1a1cb8)
    at _PyEval_EvalFrameDefault (pyodide.asm.wasm:0x271855)
    at gen_send_ex2 (pyodide.asm.wasm:0x1b548a)
```


Clicking the offset will (hopefully) take you to the corresponding wasm instruction, which should be a `call_indirect`. If the offset is too large (somewhere between `0x0200000` and `0x0300000`) you will instead see `;; text is truncated due to size`, see *Dealing with ;; text is truncated due to size*. In this example we see the following:



So we think we are calling a function pointer with signature `(param i32 i32) (result i32)` meaning that it takes two `i32` inputs and returns one `i32` output. Set a breakpoint by clicking on the address, then refresh the page and run the reproduction again. Sometimes these are on really hot code paths (as in the present example) so you probably only want to set the breakpoint once Pyodide is finished loading. If your reproduction passes through the breakpoint multiple times before crashing you can do the usual chore of counting how many times you have to press "Resume" before the crash. Suppose you've done all this, and we've got the vm stopped at the bad instruction just before crashing:



The bottom value on the stack is the function pointer. In this case it's the fourth item on the stack, so you can type the following into the console:

```
> pyodide._module.wasmTable.get(stack[4].value) // stack[4].value === 13109
< f $one() { [native code] }
```

So the bad function pointer's symbol is `one`! Now clicking on `$one` brings you to the source for it:

```
(func $one (;6;) (param $var0 i32) (result i32)
  (local $var1 i32)
  global.get $_Py_NoneStruct
  local.tee $var1
  local.get $var1
```

and we see the function pointer has signature `(param $var0 i32) (result i32)`, meaning it takes one `i32` input and returns one `i32` output. Note that if the function had `void` return type it might look like `(param $var0 i32 $var1 i32)` (with no `result`). Confusion between `i32` and `void` return type is the single most common cause of this error.

Now we basically know the cause of the trouble. You can look up `cfunction_call` in the CPython source code with the help of ripgrep and locate the line that generates this call, and look up `one` in the appropriate source and find the signature. Another approach to locate the call site would be to recompile with `-g3` and use source maps *Using C source maps* to locate the problematic source code. With the same process of reproduce crash ==> click innermost stack frame ==> see source file and line where the error occurs. In this case we see that the crash is on the line:

```
result = _PyCFunction_TrampolineCall(meth, self, args);
```

in the file `/src/cpython/build/Python-3.11.0dev0/Objects/methodobject.c`. Unfortunately, source maps are useless for the harder problem of finding the callee because compiling with `-g3` increases the number of function pointers so the function pointer we are calling is in a different spot. I know of no way to determine the bad function pointer when compiling with `-g3`.

Sometimes (particularly with Scipy/CLAPACK) the issue will be a mismatch between `(param i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32) (result i32)` and `(param i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32 i32) (result i32)`

(14 vs 15 parameters) which might be a little hard to discern. I copy the signature into the Javascript console and run `"i32 ... i32".split(" ").length` in this case.

Dealing with `;; text is truncated due to size`

If you are debugging and run into the dreaded `;; text is truncated due to size` error message, the solution is to compile a modified version of Chrome devtools with a larger wasm size cap. Surprisingly, this is not actually all that hard.

These instructions are adapted from here: https://www.diverto.hr/en/blog/2020-08-15-WebAssembly-limit/

In short,

```
git clone https://chromium.googlesource.com/chromium/tools/depot_tools.git
./fetch devtools-frontend
cd devtools-frontend
```

Apply the following change:

```
--- a/front_end/entrypoints/wasmparser_worker/WasmParserWorker.ts
+++ b/front_end/entrypoints/wasmparser_worker/WasmParserWorker.ts
@@ -55,7 +55,7 @@ export function dissambleWASM(
     const lines = [];
     const offsets = [];
     const functionBodyOffsets = [];
-    const MAX_LINES = 1000 * 1000;
+    const MAX_LINES = 12 * 1000 * 1000;
     let chunkSize: number = 128 * 1024;
     let buffer: Uint8Array = new Uint8Array(chunkSize);
     let pendingSize = 0;
```

Then build with:

```
gn gen out/Default
autoninja -C out/Default
```

then

```
cd out/Default/resources/inspector_overlay/
python http.server <some_port>
```

and then you can start a version of chrome using the modified devtools:

```
chrome --custom-devtools-frontend=http://localhost:<some_port>/
```

Using C source maps

Chromium has support for DWARF info which can be very helpful for debugging in certain circumstances.

I haven't used this very much because it is often not very beneficial. The biggest issue is that I have found no way to toggle between viewing the C source and the WebAssembly. In particular, if source maps are available, the debugger gives no way to view the current line in the wasm. What's worse is that even if it fails to find the source map, it won't fall back to displaying the source map. To *prevent* this, relink the code with `-g2`.

Typically once I have isolated the interesting line of C code, I need to see what is going on at an instruction-level. This limitation means that it is generally easier to work directly with instructions. One work around is to load a copy of Pyodide with the source maps next to one without the source maps. This situation is rapidly improving both on Emscripten's side and on the browser side. To build Pyodide with DWARF, you should set `DBGFLAGS="-g3 -gseparate-dwarf`.

If you are building in the docker image, you will get error 404s when the browser tries to look up the source maps because the path `/src/cpython/...` doesn't exist. One dumb solution is `sudo ln -s $(pwd) /src`. It might not be the best idea to link some random directory into root, if you manage to destroy your computer with this please don't blame me. In particular, if you later want to remove this link make sure not to remove `/srv` instead! The correct solution is to use `--source-map-base`, but I can't seem to get it to work.

3.3 Project

The Project section gives additional information about the project's organization and latest releases.

3.3.1 What is Pyodide?

Pyodide is a Python distribution for the browser and Node.js based on WebAssembly/Emscripten.

Pyodide makes it possible to install and run Python packages in the browser with micropip. Any pure Python package with a wheel available on PyPI is supported. Many packages with C extensions have also been ported for use with Pyodide. These include many general-purpose packages such as regex, PyYAML, lxml and scientific Python packages including NumPy, pandas, SciPy, Matplotlib, and scikit-learn.

Pyodide comes with a robust Javascript Python foreign function interface so that you can freely mix these two languages in your code with minimal friction. This includes full support for error handling (throw an error in one language, catch it in the other), async/await, and much more.

When used inside a browser, Python has full access to the Web APIs.

History

Pyodide was created in 2018 by Michael Droettboom at Mozilla as part of the Iodide project. Iodide is an experimental web-based notebook environment for literate scientific computing and communication.

Contributing

See the *contributing guide* for tips on filing issues, making changes, and submitting pull requests. Pyodide is an independent and community-driven open-source project. The decision-making process is outlined in *Governance and Decision-making*.

Citing

If you use Pyodide for a scientific publication, we would appreciate citations. Please find us on Zenodo and use the citation for the version you are using. You can replace the full author list from there with "The Pyodide development team" like in the example below:

```
@software{pyodide_2021,
  author       = {The Pyodide development team},
  title        = {pyodide/pyodide},
  month        = aug,
  year         = 2021,
  publisher    = {Zenodo},
  version      = {0.21.1},
  doi          = {10.5281/zenodo.5156931},
  url          = {https://doi.org/10.5281/zenodo.5156931}
}
```

Communication

- Blog: blog.pyodide.org
- Mailing list: mail.python.org/mailman3/lists/pyodide.python.org/
- Gitter: gitter.im/pyodide/community
- Twitter: twitter.com/pyodide
- Stack Overflow: stackoverflow.com/questions/tagged/pyodide

Donations

We accept donations to the Pyodide project at opencollective.com/pyodide. All donations are processed by the Open Source Collective – a nonprofit organization that acts as our fiscal host.

Funds will be mostly spent to organize in-person code sprints and to cover infrastructure costs for distributing packages built with Pyodide.

License

Pyodide uses the Mozilla Public License Version 2.0.

Infrastructure support

We would like to thank,

- Mozilla and CircleCl for Continuous Integration resources
- JsDelivr for providing a CDN for Pyodide packages
- ReadTheDocs for hosting the documentation.

3.3.2 Roadmap

This document lists general directions that core developers are interested to see developed in Pyodide. The fact that an item is listed here is in no way a promise that it will happen, as resources are limited. Rather, it is an indication that help is welcomed on this topic.

Reducing download sizes and initialization times

At present a first load of Pyodide requires a 6.4 MB download, and the environment initialization takes 4 to 5 seconds. Subsequent page loads are faster since assets are cached in the browser. Both of these indicators can likely be improved, by optimizing compilation parameters, minifying the Python standard library and packages, reducing the number of exported symbols. To figure out where to devote the effort, we need a better profiling system for the load process.

See issue #646.

Improve performance of Python code in Pyodide

Across benchmarks Pyodide is currently around 3x to 5x slower than native Python.

At the same type, C code compiled to WebAssembly typically runs between near native speed and 2x to 2.5x times slower (Jangda et al. 2019 PDF). It is therefore very likely that the performance of Python code in Pyodide can be improved with some focused effort.

In addition, scientific Python code would benefit from packaging a high performance BLAS library such as BLIS.

See issue #1120.

Better support and documentation for loading user Python code

Currently, most of our documentation suggests using `pyodide.runPython` to run code. This makes code difficult to maintain, because it won't work with `mypy`, `black`, or other code analysis tools, doesn't get good syntax highlighting in editors, etc. It also may lead to passing "arguments" to code via string formatting, missing out on the type conversion utilities.

Our goal is to develop and document a better workflow for users to develop Python code for use in Pyodide.

See issue #1940.

Improvements to package loading system

Currently, Pyodide has two ways of loading packages:

- *pyodide.loadPackage* for packages built with Pyodide and
- *micropip.install* for pure Python packages from PyPI.

The relationship between these tools is currently confusing.

Our goal is to have three ways to load packages: one with no dependency resolution at all, one with static dependency resolution which is done ahead of time, and one for dynamic dependency resolution. Ideally most applications can use static dependency resolution and repls can use dynamic dependency resolution.

See issues #2045 and #1100.

Find a better way to compile Fortran

Currently, we use f2c to cross compile Fortran to C. This does not work very well because f2c only fully supports Fortran 77 code. LAPACK has used more modern Fortran features since 2008 and Scipy has adopted more recent Fortran as well. f2c still successfully generates code for all but 6 functions in Scipy + LAPACK, but much of the generated code is slightly wrong and requires extensive patching. There are still a large number of fatal errors due to call signature incompatibilities.

If we could use an LLVM-based Fortran compiler as a part of the Emscripten toolchain, most of these problems would be solved. There are several promising projects heading in that direction including flang and lfortran.

See scipy/scipy#15290.

Better project sustainability

Some of the challenges that Pyodide faces, such as maintaining a collection of build recipes, dependency resolution from PyPI, etc are already solved in either Python or JavaScript ecosystems. We should therefore strive to better re-use existing tooling, and seeking synergies with existing initiatives in this space, such as conda-forge.

See issue #795.

Improve support for WebWorkers

WebWorkers are necessary in order to run computational tasks in the browser without hanging the user interface. Currently, Pyodide can run in a WebWorker, however the user experience and reliability can be improved.

See issue #1504.

Synchronous IO

The majority of existing I/O APIs are synchronous. Unless we can support synchronous IO, much of the existing Python ecosystem cannot be ported. There are several different approaches to this, we would like to support at least one method.

See issue #1503.

Write http.client in terms of Web APIs

Python packages make an extensive use of packages such as `requests` to synchronously fetch data. We currently can't use such packages since sockets are not available in Pyodide. We could however try to re-implement some stdlib libraries with Web APIs, potentially making this possible.

Because http.client is a synchronous API, we first need support for synchronous IO.

See issue #140.

3.3.3 Code of Conduct

Conduct

We are committed to providing a friendly, safe and welcoming environment for all, regardless of level of experience, gender identity and expression, sexual orientation, disability, personal appearance, body size, race, ethnicity, age, religion, nationality, or other similar characteristic.

- Please be kind and courteous. There's no need to be mean or rude.
- Please avoid using usernames that are overtly sexual or otherwise might detract from a friendly, safe, and welcoming environment for all.
- Respect that people have differences of opinion and that every design or implementation choice carries trade-offs. There is seldom a single right answer.
- We borrow the Recurse Center's "social rules": no feigning surprise, no well-actually's, no backseat driving, and no subtle -isms.
- Please keep unstructured critique to a minimum. If you have solid ideas you want to experiment with, make a fork and see how it works. All feedback should be constructive in nature. If you need more detailed guidance around giving feedback, consult Digital Ocean's Code of Conduct
- It is unacceptable to insult, demean, or harass anyone. We interpret the term "harassment" as defined in the Citizen Code of Conduct; if you are not sure about what harassment entails, please read their definition. In particular, we don't tolerate behavior that excludes people in socially marginalized groups.
- Private harassment is also unacceptable. No matter who you are, please contact any of the Pyodide core team members immediately if you are being harassed or made uncomfortable by a community member. Whether you are a regular contributor or a newcomer, we care about making this community a safe place for you and we've got your back.
- Likewise spamming, trolling, flaming, baiting or other attention-stealing behavior is not welcome.

Moderation

These are the policies for upholding our community's standards of conduct. If you feel that a thread needs moderation, please contact the Pyodide core team.

1. Remarks that violate the Pyodide standards of conduct are not allowed. This includes hateful, hurtful, oppressive, or exclusionary remarks. (Cursing is allowed, but never targeting another community member, and never in a hateful manner.)
2. Remarks that moderators find inappropriate are not allowed, even if they do not break a rule explicitly listed in the code of conduct.
3. Moderators will first respond to such remarks with a warning.
4. If the warning is unheeded, the offending community member will be temporarily banned.

5. If the community member comes back and continues to make trouble, they will be permanently banned.
6. Moderators may choose at their discretion to un-ban the community member if they offer the offended party a genuine apology.
7. If a moderator bans someone and you think it was unjustified, please take it up with that moderator, or with a different moderator, in private. Complaints about bans in-channel are not allowed.
8. Moderators are held to a higher standard than other community members. If a moderator creates an inappropriate situation, they should expect less leeway than others.
9. In the Pyodide community we strive to go the extra mile to look out for each other. Don't just aim to be technically unimpeachable, try to be your best self. In particular, avoid flirting with offensive or sensitive issues, particularly if they're off-topic; this all too often leads to unnecessary fights, hurt feelings, and damaged trust; worse, it can drive people away from the community entirely.
10. If someone takes issue with something you said or did, resist the urge to be defensive. Just stop doing what it was they complained about and apologize. Even if you feel you were misinterpreted or unfairly accused, chances are good there was something you could have communicated better — remember that it's your responsibility to make your fellow Pyodide community members comfortable. Everyone wants to get along and we are all here first and foremost because we want to talk about science and cool technology. You will find that people will be eager to assume good intent and forgive as long as you earn their trust.
11. The enforcement policies listed above apply to all official Pyodide venues. If you wish to use this code of conduct for your own project, consider making a copy with your own moderation policy so as to avoid confusion.

Adapted from the the Rust Code of Conduct, with further reference from Digital Ocean Code of Conduct, the Recurse Center, the Citizen Code of Conduct, and the Contributor Covenant.

3.3.4 Governance and Decision-making

The purpose of this document is to formalize the governance process used by the Pyodide project, to clarify how decisions are made and how the various members of our community interact. This document establishes a decision-making structure that takes into account feedback from all members of the community and strives to find consensus, while avoiding deadlocks.

Anyone with an interest in the project can join the community, contribute to the project design and participate in the decision making process. This document describes how to participate and earn merit in the Pyodide community.

Roles And Responsibilities

Contributors

Contributors are community members who contribute in concrete ways to the project. Anyone can become a contributor, and contributions can take many forms, for instance, answering user questions – not only code – as detailed in *How to Contribute*.

Community members team

The community members team is composed of community members who have permission on Github to label and close issues. Their work is crucial to improve the communication in the project.

After participating in Pyodide development with pull requests and reviews for a period of time, any contributor may become a member of the team. The process for adding team members is modeled on the CPython project. Any core developer is welcome to propose a Pyodide contributor to join the community members team. Other core developers are then consulted: while it is expected that most acceptances will be unanimous, a two-thirds majority is enough.

Core developers

Core developers are community members who have shown that they are dedicated to the continued development of the project through ongoing engagement with the community. They have shown they can be trusted to maintain Pyodide with care. Being a core developer allows contributors to more easily carry on with their project related activities by giving them direct access to the project's repository and is represented as being a member of the core team on the Pyodide GitHub organization. Core developers are expected to review code contributions, can merge approved pull requests, can cast votes for and against merging a pull-request, and can make decisions about major changes to the API (all contributors are welcome to participate in the discussion).

New core developers can be nominated by any existing core developers. Once they have been nominated, there will be a vote by the current core developers. Voting on new core developers is one of the few activities that takes place on the project's private communication channels. While it is expected that most votes will be unanimous, a two-thirds majority of the cast votes is enough. The vote needs to be open for at least one week.

Core developers that have not contributed to the project (commits or GitHub comments) in the past two years will be asked if they want to become emeritus core developers and recant their commit and voting rights until they become active again.

Decision Making Process

Decisions about the future of the project are made through discussion with all members of the community. All non-sensitive project management discussion takes place on the project contributors' issue tracker and on Github discussion. Occasionally, sensitive discussion occurs on a private communication channels.

Pyodide uses a "consensus seeking" process for making decisions. The group tries to find a resolution that has no open objections among core developers. At any point during the discussion, any core-developer can call for a vote, which will conclude two weeks from the call for the vote. This is what we hereafter may refer to as "the decision making process".

Decisions (in addition to adding core developers as above) are made according to the following rules:

- **Maintenance changes**, include for instance improving the wording in the documentation, updating CI or dependencies. Core developers are expected to give "reasonable time" to others to give their opinion on the Pull Request in case they're not confident that others would agree. If no further review on the Pull Request is received within this time, it can be merged. If a review is received, then the consensus rules from the following section apply.
- **Code changes in general, and especially those impacting user facing APIs**, as well as more significant documentation changes, require review and approval by a core developer and no objections raised by any core developer (lazy consensus). This process happens on the pull-request page.
- **Changes to the governance model** use the same decision process outlined above.

3.3.5 Change Log

Version 0.21.1

- New packages: the standard library lzma module #2939
- Enhancement Pyodide now shows more helpful error messages when importing unvendored or removed stdlib modules fails. #2973
- Enhancement `pyodide build` now checks that the correct version of the Emscripten compiler is used. #2975, #2990
- Fix Pyodide works in Safari v14 again. It was broken in v0.21.0 #2994

Version 0.21.0

August 9, 2022

See the release notes for a summary.

Build system

- Enhancement Emscripten was updated to Version 3.1.14 #2775, #2679, #2672
- Fix Fix building on macOS #2360 #2554
- Enhancement Update Typescript target to ES2017 to generate more modern Javascript code. #2471
- Enhancement We now put our built files into the `dist` directory rather than the `build` directory. #2387
- Fix The build will error out earlier if `cmake` or `libtool` are not installed. #2423
- Enhancement The platform tags of wheels now include the Emscripten version in them. This should help ensure ABI compatibility if Emscripten wheels are distributed outside of the main Pyodide distribution. #2610
- Enhancement The build system now uses the sysconfigdata from the target Python rather than the host Python. #2516
- Enhancement Pyodide now builds with `-sWASM_BIGINT`. #2643
- Enhancement Added `cross-script` key to the `meta.yaml` spec to allow executing custom logic in the cross build environment. #2734

Pyodide Module and type conversions

- API Change All functions were moved out of the root `pyodide` package into various submodules. For backwards compatibility, they will be available from the root package (raising a `FutureWarning`) until v0.23.0. #2787, #2790
- Enhancement `loadPyodide` no longer uses any global state, so it can be used more than once in the same thread. This is recommended if a network request causes a loading failure, if there is a fatal error, if you damage the state of the runtime so badly that it is no longer usable, or for certain testing purposes. It is not recommended for creating multiple execution environments, for which you should use `pyodide.runPython(code, { globals : some_dict})`; #2391
- Enhancement `pyodide.unpackArchive` now accepts any `ArrayBufferView` or `ArrayBuffer` as first argument, rather than only a `Uint8Array`. #2451
- Feature Added `pyodide.code.run_js` API. #2426

- Fix BigInt's between 2^{32*n - 1} and 2^{32*n} no longer get translated to negative Python ints. #2484
- Fix Pyodide now correctly handles JavaScript objects with `null` constructor. #2520
- Fix Fix garbage collection of `once_callable` #2401
- Enhancement Added the `js_id` attribute to `JsProxy` to allow using JavaScript object identity as a dictionary key. #2515
- Fix Fixed a bug with `toJs` when used with recursive structures and the `dictConverter` argument. #2533
- Enhancement Added Python wrappers `set_timeout`, `clear_timeout`, `set_interval`, `clear_interval`, `add_event_listener` and `remove_event_listener` for the corresponding JavaScript functions. #2456
- Fix If a request fails due to CORS, `pyfetch` now raises an `OSError` not a `JSException`. #2598
- Enhancement Pyodide now directly exposes the Emscripten `PATH` and `ERRNO_CODES` APIs. #2582
- Fix The `bool` operator on a `JsProxy` now behaves more consistently: it returns `False` if JavaScript would say that `!!x` is `false`, or if `x` is an empty container. Otherwise it returns `True`. #2803
- Fix Fix `loadPyodide` errors for the Windows Node environment. #2888
- Enhancement Implemented slice subscripting, +=, and `extend` for `JsProxy` of Javascript arrays. #2907

REPL

- Enhancement Add a spinner while the REPL is loading #2635
- Enhancement Cursor blinking in the REPL can be disabled by setting `noblink` in URL search params. #2666
- Fix Fix a REPL error in printing high-dimensional lists. #2517 #2919
- Fix Fix output bug with using `input()` on online console #2509

micropip and package loading

- API Change `packages.json` which contains the dependency graph for packages was renamed to `repodata.json` to avoid confusion with `package.json` used in JavaScript packages.
- Enhancement Added SHA-256 hash of package to entries in `repodata.json` #2455
- Enhancement Integrity of Pyodide packages is now verified before loading them. This is for now limited to browser environments. #2513
- Enhancement `micropip` supports loading wheels from the Emscripten file system using the `emfs:` protocol now. #2767
- Enhancement It is now possible to use an alternate `repodata.json` lockfile by passing the `lockFileURL` option to *`loadPyodide`*. This is particularly intended to be used with *`micropip.freeze`*. #2645
- Fix micropip now correctly handles package names that include dashes #2414
- Enhancement Allow passing `credentials` to `micropip.install()` #2458
- Enhancement *`micropip.install()`* now accepts a `deps` parameter. If set to `False`, micropip will not install dependencies of the package. #2433
- Fix micropip now correctly compares packages with prerelease version #2532
- Enhancement *`micropip.install()`* now accepts a `pre` parameter. If set to `True`, micropip will include pre-release and development versions. #2542

- Enhancement `micropip` was refactored to improve readability and ease of maintenance. #2561, #2563, #2564, #2565, #2568
- Enhancement Various error messages were fine tuned and improved. #2562, #2558
- Enhancement `micropip` was adjusted to keep its state in the wheel `.dist-info` directories which improves consistenency with the Python standard library and other tools used to install packages. #2572
- Enhancement `micropip` can now be used to install Emscripten binary wheels. #2591
- Enhancement Added `micropip.freeze` to record the current set of loaded packages into a `repodata.json` file. #2581
- Fix `micropip.list` now works correctly when there are packages that are installed via `pyodide.loadPackage` from a custom URL. #2743
- Fix micropip now skips package versions which do not follow PEP440. #2754
- Fix `micropip` supports extra markers in packages correctly now. #2584

Packages

- Enhancement Update sqlite version to latest stable release #2477 and #2518
- Enhancement Pillow now supports WEBP image format #2407.
- Enhancement Pillow and opencv-python now support the TIFF image format. #2762
- Pandas is now compiled with `-Oz`, which significantly speeds up loading the library on Chrome #2457
- New packages: opencv-python #2305, ffmpeg #2305, libwebp #2305, h5py, pkgconfig and libhdf5 #2411, bitarray #2459, gsw #2511, cftime #2504, svgwrite, jsonschema, tskit #2506, xarray #2538, demes, libgsl, newick, ruamel, msprime #2548, gmpy2 #2665, xgboost #2537, galpy #2676, shapely, geos #2725, suitesparse, sparseqr #2685, libtiff #2762, pytest-benchmark #2799, termcolor #2809, sqlite3, libproj, pyproj, certifi #2555, rebound #2868, reboundx #2909, pyclipper #2886, brotli #2925, python-magic #2941

Miscellaneous

- Fix We now tell packagers (e.g., Webpack) to ignore npm-specific imports when packing files for the browser. #2468
- Enhancement `run_in_pyodide` now has support for pytest assertion rewriting and decorators such as `pytest.mark.parametrize` and hypothesis. #2510, #2541
- BREAKING CHANGE `pyodide_build.testing` is removed. `run_in_pyodide` decorator can now be accessed through `pytest-pyodide` package. #2418

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Version 0.20.0

See the release notes for a summary.

CPython and stdlib

- Update Pyodide now runs Python 3.10.2. #2225
- Enhancement All `ctypes` tests pass now except for `test_callback_too_many_args` (and we have a plan to fix `test_callback_too_many_args` upstream). `libffi-emscripten` now also passes all libffi tests. #2350

Packages

- Fix matplotlib now loads multiple fonts correctly #2271
- New packages: boost-histogram #2174, cryptography v3.3.2 #2263, the standard library ssl module #2263, python-solvespace v3.0.7, lazy-object-proxy #2320.
- Many more scipy linking errors were fixed, mostly related to the Fortran f2c ABI for string arguments. There are still some fatal errors in the Scipy test suite, but none seem to be simple linker errors. #2289
- Removed pyodide-interrupts. If you were using this for some reason, use *`setInterruptBuffer`* instead. #2309
- Most included packages were updated to the latest version. See *Packages built in Pyodide* for a full list.

Type translations

- Fix Python tracebacks now include Javascript frames when Python calls a Javascript function. #2123
- Enhancement Added a `default_converter` argument to *`JsProxy.to_py`* and *`pyodide.toPy`* which is used to process any object that doesn't have a built-in conversion to Python. Also added a `default_converter` argument to *`PyProxy.toJs`* and *`pyodide.ffi.to_js`* to convert. #2170 and #2208
- Enhancement Async Python functions called from Javascript now have the resulting coroutine automatically scheduled. For instance, this makes it possible to use an async Python function as a Javascript event handler. #2319

Javascript package

- Enhancement It is no longer necessary to provide `indexURL` to *`loadPyodide`*. #2292
- BREAKING CHANGE The `globals` argument to *`runPython`* and *`runPythonAsync`* is now passed as a named argument. The old usage still works with a deprecation warning. #2300
- Enhancement The Javascript package was migrated to Typescript. #2130 and #2133
- Fix Fix importing pyodide with ESM syntax in a module type web worker. #2220
- Enhancement When Pyodide is loaded as an ES6 module, no global *`loadPyodide`* variable is created (instead, it should be accessed as an attribute on the module). #2249
- Fix The type `Py2JsResult` has been replaced with `any` which is more accurate. For backwards compatibility, we still export `Py2JsResult` as an alias for `any`. #2277
- Fix Pyodide now loads correctly even if requirejs is included. #2283

- Enhancement Added robust handling for non-`Error` objects thrown by Javascript code. This mostly should never happen since well behaved Javascript code ought to throw errors. But it's better not to completely crash if it throws something else. #2294

pyodide_build

- Enhancement Pyodide now uses Python wheel files to distribute packages rather than the emscripten `file_packager.py` format. #2027
- Enhancement Pyodide now uses `pypa/build` to build packages. We (mostly) use build isolation, so we can build packages that require conflicting versions of setuptools or alternative build backends. #2272
- Enhancement Most pure Python packages were switched to use the wheels directly from PyPI rather than re-building them. #2126
- Enhancement Added support for C++ exceptions in packages. Now C++ extensions compiled and linked with `-fexceptions` can catch C++ exceptions. Furthermore, uncaught C++ exceptions will be formatted in a human-readable way. #2178
- BREAKING CHANGE Removed the `skip-host` key from the `meta.yaml` format. If needed, install a host copy of the package with pip instead. #2256

Uncategorized

- Enhancement The interrupt buffer can be used to raise all 64 signals now, not just `SIGINT`. Write a number between `1<= signum <= 64` into the interrupt buffer to trigger the corresponding signal. By default everything but `SIGINT` will be ignored. Any value written into the interrupt buffer outside of the range from 1 to 64 will be silently discarded. #2301
- Enhancement Updated to Emscripten 2.0.27. #2295
- BREAKING CHANGE The `extractDir` argument to *`unpackArchive`* is now passed as a named argument. The old usage still works with a deprecation warning. #2300
- Enhancement Support ANSI escape codes in the Pyodide console. #2345
- Fix `pyodide_build` can now be installed in non-editable ways. #2351

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Version 0.19.1

February 19, 2022

Packages

- New packages: sqlalchemy #2112, pydantic #2117, wrapt #2165
- Update Upgraded packages: pyb2d (0.7.2), #2117
- Fix A fatal error in `scipy.stats.binom.ppf` has been fixed. #2109
- Fix Type signature mismatches in some numpy comparators have been fixed. #2110

Type translations

- Fix The "PyProxy has already been destroyed" error message has been improved with some context information. #2121

REPL

- Enhancement Pressing TAB in REPL no longer triggers completion when input is whitespace. #2125

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Version 0.19.0

January 10, 2021

See the release notes for a summary.

Python package

- Enhancement If `find_imports` is used on code that contains a syntax error, it will return an empty list instead of raising a `SyntaxError`. #1819
- Enhancement Added the *`pyodide.http.pyfetch`* API which provides a convenience wrapper for the Javascript `fetch` API. The API returns a response object with various methods that convert the data into various types while minimizing the number of times the data is copied. #1865
- Enhancement Added the *`unpack_archive`* API to the *`FetchResponse`* object which treats the response body as an archive and uses `shutil` to unpack it. #1935
- Fix The Pyodide event loop now works correctly with cancelled handles. In particular, `asyncio.wait_for` now functions as expected. #2022

JavaScript package

- Fix *loadPyodide* no longer fails in the presence of a user-defined global named `process`. #1849
- Fix Various webpack buildtime and runtime compatibility issues were fixed. #1900
- Enhancement Added the *pyodide.pyimport* API to import a Python module and return it as a `PyProxy`. Warning: this is different from the original `pyimport` API which was removed in this version. #1944
- Enhancement Added the *pyodide.unpackArchive* API which unpacks an archive represented as an ArrayBuffer into the working directory. This is intended as a way to install packages from a local application. #1944
- API Change *loadPyodide* now accepts a `homedir` parameter which sets home directory of Pyodide virtual file system. #1936
- BREAKING CHANGE The default working directory(home directory) inside the Pyodide virtual file system has been changed from `/` to `/home/pyodide`. To get the previous behavior, you can
  - call `os.chdir("/")` in Python to change working directory or
  - call *loadPyodide* with the `homedir="/"` argument #1936

Python / JavaScript type conversions

- BREAKING CHANGE Updated the calling convention when a JavaScript function is called from Python to improve memory management of PyProxies. PyProxy arguments and return values are automatically destroyed when the function is finished. #1573
- Enhancement Added *JsProxy.to_string*, *JsProxy.to_bytes*, and *JsProxy.to_memoryview* to allow for conversion of `TypedArray` to standard Python types without unneeded copies. #1864
- Enhancement Added *JsProxy.to_file* and *JsProxy.from_file* to allow reading and writing Javascript buffers to files as a byte stream without unneeded copies. #1864
- Fix It is now possible to destroy a borrowed attribute `PyProxy` of a `PyProxy` (as introduced by #1636) before destroying the root `PyProxy`. #1854
- Fix If `__iter__()` raises an error, it is now handled correctly by the `PyProxy[Symbol.iterator()]` method. #1871
- Fix Borrowed attribute `PyProxy`s are no longer destroyed when the root `PyProxy` is garbage collected (because it was leaked). Doing so has no benefit to nonleaky code and turns some leaky code into broken code (see #1855 for an example). #1870
- Fix Improved the way that `pyodide.globals.get("builtin_name")` works. Before we used `__main__.__dict__.update(builtins.__dict__)` which led to several undesirable effects such as `__name__` being equal to `"builtins"`. Now we use a proxy wrapper to replace `pyodide.globals.get` with a function that looks up the name on `builtins` if lookup on `globals` fails. #1905
- Enhancement Coroutines have their memory managed in a more convenient way. In particular, now it is only necessary to either `await` the coroutine or call one of `.then`, `.except` or `.finally` to prevent a leak. It is no longer necessary to manually destroy the coroutine. Example: before:

```
async function runPythonAsync(code, globals) {
  let coroutine = Module.pyodide_py.eval_code_async(code, globals);
  try {
    return await coroutine;
  } finally {
    coroutine.destroy();
```

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```
  }
}
```

After:

```
async function runPythonAsync(code, globals) {
  return await Module.pyodide_py.eval_code_async(code, globals);
}
```

#2030

pyodide-build

- API Change By default only a minimal set of packages is built. To build all packages set `PYODIDE_PACKAGES='*'` In addition, `make minimal` was removed, since it is now equivalent to `make` without extra arguments. #1801
- Enhancement It is now possible to use `pyodide-build buildall` and `pyodide-build buildpkg` directly. #2063
- Enhancement Added a `--force-rebuild` flag to `buildall` and `buildpkg` which rebuilds the package even if it looks like it doesn't need to be rebuilt. Added a `--continue` flag which keeps the same source tree for the package and can continue from the middle of a build. #2069
- Enhancement Changes to environment variables in the build script are now seen in the compile and post build scripts. #1706
- Fix Fix usability issues with `pyodide-build mkpkg` CLI. #1828
- Enhancement Better support for ccache when building Pyodide #1805
- Fix Fix compile error `wasm-ld: error: unknown argument: --sort-common` and `wasm-ld: error: unknown argument: --as-needed` in ArchLinux. #1965

micropip

- Fix micropip now raises an error when installing a non-pure python wheel directly from a url. #1859
- Enhancement *`micropip.install()`* now accepts a `keep_going` parameter. If set to `True`, micropip reports all identifiable dependencies that don't have pure Python wheels, instead of failing after processing the first one. #1976
- Enhancement Added a new API *`micropip.list()`* which returns the list of installed packages by micropip. #2012

Packages

- Enhancement Unit tests are now unvendored from Python packages and included in a separate package <package name>-tests. This results in a 20% size reduction on average for packages that vendor tests (e.g. numpy, pandas, scipy). #1832
- Update Upgraded SciPy to 1.7.3. There are known issues with some SciPy components, the current status of the scipy test suite is here #2065
- Fix The built-in pwd module of Python, which provides a Unix specific feature, is now unvendored. #1883
- Fix pillow and imageio now correctly encode/decode grayscale and black-and-white JPEG images. #2028
- Fix The numpy fft module now works correctly. #2028
- New packages: logbook #1920, pyb2d #1968, and threadpoolctl (a dependency of scikit-learn) #2065
- Upgraded packages: numpy (1.21.4) #1934, scikit-learn (1.0.2) #2065, scikit-image (0.19.1) #2005, msgpack (1.0.3) #2071, astropy (5.0.3) #2086, statsmodels (0.13.1) #2073, pillow (9.0.0) #2085. This list is not exhaustive, refer to `packages.json` for the full list.

Uncategorized

- Enhancement `PyErr_CheckSignals` now works with the keyboard interrupt system so that cooperative C extensions can be interrupted. Also, added the `pyodide.checkInterrupt` function so Javascript code can opt to be interrupted. #1294
- Fix The _ variable is now set by the Pyodide repl just like it is set in the native Python repl. #1904
- Enhancement `pyodide-env` and `pyodide` Docker images are now available from both the Docker Hub and from the Github Package registry. #1995
- Fix The console now correctly handles it when an object's `__repr__` function raises an exception. #2021
- Enhancement Removed the `-s EMULATE_FUNCTION_POINTER_CASTS` flag, yielding large benefits in speed, stack usage, and code size. #2019

List of contributors

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Version 0.18.1

September 16, 2021

Console

- Fix Ctrl+C handling in console now works correctly with multiline input. New behavior more closely approximates the behavior of the native Python console. #1790
- Fix Fix the repr of Python objects (including lists and dicts) in console #1780
- Fix The "long output truncated" message now appears on a separate line as intended. #1814
- Fix The streams that are used to redirect stdin and stdout in the console now define `isatty` to return `True`. This fixes pytest. #1822

Python package

- Fix Avoid circular references when runsource raises SyntaxError #1758

JavaScript package

- Fix The *`pyodide.setInterruptBuffer`* command is now publicly exposed again, as it was in v0.17.0. #1797

Python / JavaScript type conversions

- Fix Conversion of very large strings from JavaScript to Python works again. #1806
- Fix Fixed a use after free bug in the error handling code. #1816

Packages

- Fix pillow now correctly encodes/decodes RGB JPEG image format. #1818

Micellaneous

- Fix Patched emscripten to make the system calls to duplicate file descriptors closer to posix-compliant. In particular, this fixes the use of `dup` on pipes and temporary files, as needed by `pytest`. #1823

Version 0.18.0

August 3rd, 2021

General

- Update Pyodide now runs Python 3.9.5. #1637
- Enhancement Pyodide can experimentally be used in Node.js #1689
- Enhancement Pyodide now directly exposes the Emscripten filesystem API, allowing for direct manipulation of the in-memory filesystem #1692
- Enhancement Pyodide's support of emscripten file systems is expanded from the default `MEMFS` to include `IDBFS`, `NODEFS`, `PROXYFS`, and `WORKERFS`, allowing for custom persistence strategies depending on execution environment #1596

- API Change The `packages.json` schema for Pyodide was redesigned for better compatibility with conda. #1700
- API Change `run_docker` no longer binds any port to the docker image by default. #1750

Standard library

- API Change The following standard library modules are now available as standalone packages
  - distlib

  They are loaded by default in *loadPyodide*, however this behavior can be disabled with the `fullStdLib` parameter set to `false`. All optional stdlib modules can then be loaded as needed with *pyodide.loadPackage*. #1543
- Enhancement The standard library module `audioop` is now included, making the `wave`, `sndhdr`, `aifc`, and `sunau` modules usable. #1623
- Enhancement Added support for `ctypes`. #1656

JavaScript package

- Enhancement The Pyodide JavaScript package is released to npm under npmjs.com/package/pyodide #1762
- API Change *loadPyodide* no longer automatically stores the API into a global variable called `pyodide`. To get old behavior, say `globalThis.pyodide = await loadPyodide({...})`. #1597
- Enhancement *loadPyodide* now accepts callback functions for `stdin`, `stdout` and `stderr` #1728
- Enhancement Pyodide now ships with first party typescript types for the entire JavaScript API (though no typings are available for `PyProxy` fields). #1601
- Enhancement It is now possible to import `Comlink` objects into Pyodide after using *pyodide.registerComlink* #1642
- Enhancement If a Python error occurs in a reentrant `runPython` call, the error will be propagated into the outer `runPython` context as the original error type. This is particularly important if the error is a `KeyboardInterrupt`. #1447

Python package

- Enhancement Added a new *CodeRunner* API for finer control than *eval_code* and *eval_code_async*. Designed with the needs of REPL implementations in mind. #1563
- Enhancement Added *Console* class closely based on the Python standard library `code.InteractiveConsole` but with support for top level await and stream redirection. Also added the subclass *PyodideConsole* which automatically uses *pyodide.loadPackagesFromImports* on the code before running it. #1125, #1155, #1635
- Fix *eval_code_async* no longer automatically awaits a returned coroutine or attempts to await a returned generator object (which triggered an error). #1563

Python / JavaScript type conversions

- API Change *pyodide.runPythonAsync* no longer automatically calls *pyodide.loadPackagesFromImports*. #1538.
- Enhancement Added the *PyProxy.callKwargs* method to allow using Python functions with keyword arguments from JavaScript. #1539
- Enhancement Added the *PyProxy.copy* method. #1549 #1630
- API Change Updated the method resolution order on `PyProxy`. Performing a lookup on a `PyProxy` will prefer to pick a method from the `PyProxy` api, if no such method is found, it will use `getattr` on the proxied object. Prefixing a name with `$` forces `getattr`. For instance, *PyProxy.destroy* now always refers to the method that destroys the proxy, whereas `PyProxy.$destroy` refers to an attribute or method called `destroy` on the proxied object. #1604
- API Change It is now possible to use `Symbol` keys with PyProxies. These `Symbol` keys put markers on the PyProxy that can be used by external code. They will not currently be copied by *PyProxy.copy*. #1696
- Enhancement Memory management of `PyProxy` fields has been changed so that fields looked up on a `PyProxy` are "borrowed" and have their lifetime attached to the base `PyProxy`. This is intended to allow for more idiomatic usage. (See #1617.) #1636
- API Change The depth argument to `toJs` is now passed as an option, so `toJs(n)` in v0.17 changed to `toJs({depth : n})`. Similarly, `pyodide.toPy` now takes `depth` as a named argument. Also `to_js` and `to_py` only take depth as a keyword argument. #1721
- API Change *PyProxy.toJs* and *to_js* now take an option `pyproxies`, if a JavaScript Array is passed for this, then any proxies created during conversion will be placed into this array. This allows easy cleanup later. The `create_pyproxies` option can be used to disable creation of pyproxies during conversion (instead a `ConversionError` is raised). #1726
- API Change `toJs` and `to_js` now take an option `dict_converter` which will be called on a JavaScript iterable of two-element Arrays as the final step of converting dictionaries. For instance, pass `Object.fromEntries` to convert to an object or `Array.from` to convert to an array of pairs. #1742

pyodide-build

- API Change pyodide-build is now an installable Python package, with an identically named CLI entrypoint that replaces `bin/pyodide` which is removed #1566

micropip

- Fix micropip now correctly handles packages that have mixed case names. (See #1614). #1615
- Enhancement micropip now resolves dependencies correctly for old versions of packages (it used to always use the dependencies from the most recent version, see #1619 and #1745). micropip also will resolve dependencies for wheels loaded from custom urls. #1753

Packages

- Enhancement matplotlib now comes with a new renderer based on the html5 canvas element. #1579 It is optional and the current default backend is still the agg backend compiled to wasm.
- Enhancement Updated a number of packages included in Pyodide.

List of contributors

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Version 0.17.0

April 21, 2021

See the 0-17-0-release-notes for more information.

Improvements to package loading and dynamic linking

- Enhancement Uses the emscripten preload plugin system to preload .so files in packages
- Enhancement Support for shared library packages. This is used for CLAPACK which makes scipy a lot smaller. #1236
- Fix Pyodide and included packages can now be used with Safari v14+. Safari v13 has also been observed to work on some (but not all) devices.

Python / JS type conversions

- Feature A `JsProxy` of a JavaScript `Promise` or other awaitable object is now a Python awaitable. #880
- API Change Instead of automatically converting Python lists and dicts into JavaScript, they are now wrapped in `PyProxy`. Added a new *`PyProxy.toJs`* API to request the conversion behavior that used to be implicit. #1167
- API Change Added *`JsProxy.to_py`* API to convert a JavaScript object to Python. #1244
- Feature Flexible jsimports: it now possible to add custom Python "packages" backed by JavaScript code, like the `js` package. The `js` package is now implemented using this system. #1146
- Feature A `PyProxy` of a Python coroutine or awaitable is now an awaitable JavaScript object. Awaiting a coroutine will schedule it to run on the Python event loop using `asyncio.ensure_future`. #1170
- Enhancement Made `PyProxy` of an iterable Python object an iterable Js object: defined the `[Symbol.iterator]` method, can be used like `for(let x of proxy)`. Made a `PyProxy` of a Python iterator an iterator: `proxy.next()` is translated to `next(it)`. Made a `PyProxy` of a Python generator into a JavaScript generator: `proxy.next(val)` is translated to `gen.send(val)`. #1180
- API Change Updated `PyProxy` so that if the wrapped Python object supports `__getitem__` access, then the wrapper has `get`, `set`, `has`, and `delete` methods which do `obj[key]`, `obj[key] = val`, `key in obj` and `del obj[key]` respectively. #1175

- API Change The `pyodide.pyimport` function is deprecated in favor of using `pyodide.globals.get('key')`. #1367
- API Change Added *`PyProxy.getBuffer`* API to allow direct access to Python buffers as JavaScript TypedArrays. #1215
- API Change The innermost level of a buffer converted to JavaScript used to be a TypedArray if the buffer was contiguous and otherwise an Array. Now the innermost level will be a TypedArray unless the buffer format code is a '?' in which case it will be an Array of booleans, or if the format code is a "s" in which case the innermost level will be converted to a string. #1376
- Enhancement JavaScript `BigInt`s are converted into Python `int` and Python `int`s larger than 2^53 are converted into `BigInt`. #1407
- API Change Added *`pyodide.isPyProxy`* to test if an object is a `PyProxy`. #1456
- Enhancement `PyProxy` and `PyBuffer` objects are now garbage collected if the browser supports `FinalizationRegistry`. #1306
- Enhancement Automatic conversion of JavaScript functions to CPython calling conventions. #1051, #1080
- Enhancement Automatic detection of fatal errors. In this case Pyodide will produce both a JavaScript and a Python stack trace with explicit instruction to open a bug report. pr`{1151}`, pr`{1390}`, pr`{1478}`.
- Enhancement Systematic memory leak detection in the test suite and a large number of fixed to memory leaks. pr`{1340}`
- Fix getattr and dir on JsProxy now report consistent results and include all names defined on the Python dictionary backing JsProxy. #1017
- Fix `JsProxy.__bool__` now produces more consistent results: both `bool(window)` and `bool(zero-arg-callback)` were `False` but now are `True`. Conversely, `bool(empty_js_set)` and `bool(empty_js_map)` were `True` but now are `False`. #1061
- Fix When calling a JavaScript function from Python without keyword arguments, Pyodide no longer passes a `PyProxy`-wrapped `NULL` pointer as the last argument. #1033
- Fix JsBoundMethod is now a subclass of JsProxy, which fixes nested attribute access and various other strange bugs. #1124
- Fix JavaScript functions imported like `from js import fetch` no longer trigger "invalid invocation" errors (issue #461) and `js.fetch("some_url")` also works now (issue #768). #1126
- Fix JavaScript bound method calls now work correctly with keyword arguments. #1138
- Fix JavaScript constructor calls now work correctly with keyword arguments. #1433

pyodide-py package

- Feature Added a Python event loop to support asyncio by scheduling coroutines to run as jobs on the browser event loop. This event loop is available by default and automatically enabled by any relevant asyncio API, so for instance `asyncio.ensure_future` works without any configuration. #1158
- API Change Removed `as_nested_list` API in favor of `JsProxy.to_py`. #1345

pyodide-js

- API Change Removed iodide-specific code in `pyodide.js`. This breaks compatibility with iodide. #878, #981
- API Change Removed the `pyodide.autocomplete` API, use Jedi directly instead. #1066
- API Change Removed `pyodide.repr` API. #1067
- Fix If `messageCallback` and `errorCallback` are supplied to `pyodide.loadPackage`, `pyodide.runPythonAsync` and `pyodide.loadPackagesFromImport`, then the messages are no longer automatically logged to the console.
- Feature `runPythonAsync` now runs the code with `eval_code_async`. In particular, it is possible to use top-level await inside of `runPythonAsync`.
- `eval_code` now accepts separate `globals` and `locals` parameters. #1083
- Added the `pyodide.setInterruptBuffer` API. This can be used to set a `SharedArrayBuffer` to be the keyboard interrupt buffer. If Pyodide is running on a webworker, the main thread can signal to the webworker that it should raise a `KeyboardInterrupt` by writing to the interrupt buffer. #1148 and #1173
- Changed the loading method: added an async function `loadPyodide` to load Pyodide to use instead of `languagePluginURL` and `languagePluginLoader`. The change is currently backwards compatible, but the old approach is deprecated. #1363
- `runPythonAsync` now accepts `globals` parameter. #1914

micropip

- Feature `micropip` now supports installing wheels from relative URLs. #872
- API Change `micropip.install` now returns a Python `Future` instead of a JavaScript `Promise`. #1324
- Fix *`micropip.install`* now interacts correctly with *`pyodide.loadPackage`*. #1457
- Fix *`micropip.install`* now handles version constraints correctly even if there is a version of the package available from the Pyodide `indexURL`.

Build system

- Enhancement Updated to latest emscripten 2.0.13 with the upstream LLVM backend #1102
- API Change Use upstream `file_packager.py`, and stop checking package abi versions. The `PYODIDE_PACKAGE_ABI` environment variable is no longer used, but is still set as some packages use it to detect whether it is being built for Pyodide. This usage is deprecated, and a new environment variable `PYODIDE` is introduced for this purpose.

  As part of the change, Module.checkABI is no longer present. #991
- uglifyjs and lessc no longer need to be installed in the system during build #878.
- Enhancement Reduce the size of the core Pyodide package #987.
- Enhancement Optionally to disable docker port binding #1423.
- Enhancement Run arbitrary command in docker #1424
- Docker images for Pyodide are now accessible at pyodide/pyodide-env and pyodide/pyodide.
- Enhancement Option to run docker in non-interactive mode #1641

REPL

- Fix In console.html: sync behavior, full stdout/stderr support, clean namespace, bigger font, correct result representation, clean traceback #1125 and #1141
- Fix Switched from Jedi to rlcompleter for completion in `pyodide.console.InteractiveConsole` and so in `console.html`. This fixes some completion issues (see #821 and #1160)
- Enhancement Support top-level await in the console #1459

Packages

- six, jedi and parso are no longer vendored in the main Pyodide package, and need to be loaded explicitly #1010, #987.
- Updated packages #1021, #1338, #1460.
- Added Plotly version 4.14.3 and retrying dependency #1419

List of contributors

(in alphabetic order)

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Version 0.16.1

December 25, 2020

Note: due to a CI deployment issue the 0.16.0 release was skipped and replaced by 0.16.1 with identical contents.

- Pyodide files are distributed by JsDelivr, `https://cdn.jsdelivr.net/pyodide/v0.16.1/full/pyodide.js` The previous CDN `pyodide-cdn2.iodide.io` still works and there are no plans for deprecating it. However please use JsDelivr as a more sustainable solution, including for earlier Pyodide versions.

Python and the standard library

- Pyodide includes CPython 3.8.2 #712
- ENH Patches for the threading module were removed in all packages. Importing the module, and a subset of functionality (e.g. locks) works, while starting a new thread will produce an exception, as expected. #796. See #237 for the current status of the threading support.
- ENH The multiprocessing module is now included, and will not fail at import, thus avoiding the necessity to patch included packages. Starting a new process will produce an exception due to the limitation of the WebAssembly VM with the following message: `Resource temporarily unavailable` #796.

Python / JS type conversions

- FIX Only call `Py_INCREF()` once when proxied by PyProxy #708
- JavaScript exceptions can now be raised and caught in Python. They are wrapped in pyodide.JsException. #891

pyodide-py package and micropip

- The `pyodide.py` file was transformed to a pyodide-py package. The imports remain the same so this change is transparent to the users #909.
- FIX Get last version from PyPI when installing a module via micropip #846.
- Suppress REPL results returned by `pyodide.eval_code` by adding a semicolon #876.
- Enable monkey patching of `eval_code` and `find_imports` to customize behavior of `runPython` and `runPythonAsync` #941.

Build system

- Updated docker image to Debian buster, resulting in smaller images. #815
- Pre-built docker images are now available as `iodide-project/pyodide` #787
- Host Python is no longer compiled, reducing compilation time. This also implies that Python 3.8 is now required to build Pyodide. It can for instance be installed with conda. #830
- FIX Infer package tarball directory from source URL #687
- Updated to emscripten 1.38.44 and binaryen v86 (see related commits)
- Updated default `--ldflags` argument to `pyodide_build` scripts to equal what Pyodide actually uses. #817
- Replace C lz4 implementation with the (upstream) JavaScript implementation. #851
- Pyodide deployment URL can now be specified with the `PYODIDE_BASE_URL` environment variable during build. The `pyodide_dev.js` is no longer distributed. To get an equivalent behavior with `pyodide.js`, set

```
window.languagePluginUrl = "./";
```

  before loading it. #855
- Build runtime C libraries (e.g. libxml) via package build system with correct dependency resolution #927
- Pyodide can now be built in a conda virtual environment #835

Other improvements

- Modify MEMFS timestamp handling to support better caching. This in particular allows to import newly created Python modules without invalidating import caches #893

Packages

- New packages: freesasa, lxml, python-sat, traits, astropy, pillow, scikit-image, imageio, numcodecs, msgpack, asciitree, zarr

  Note that due to the large size and the experimental state of the scipy package, packages that depend on scipy (including scikit-image, scikit-learn) will take longer to load, use a lot of memory and may experience failures.

- Updated packages: numpy 1.15.4, pandas 1.0.5, matplotlib 3.3.3 among others.
- New package pyodide-interrupt, useful for handling interrupts in Pyodide (see project description for details).

Backward incompatible changes

- Dropped support for loading .wasm files with incorrect MIME type, following #851

List of contributors

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Version 0.15.0

May 19, 2020

- Upgrades Pyodide to CPython 3.7.4.
- micropip no longer uses a CORS proxy to install pure Python packages from PyPI. Packages are now installed from PyPI directly.
- micropip can now be used from web workers.
- Adds support for installing pure Python wheels from arbitrary URLs with micropip.
- The CDN URL for Pyodide changed to https://pyodide-cdn2.iodide.io/v0.15.0/full/pyodide.js It now supports versioning and should provide faster downloads. The latest release can be accessed via https://pyodide-cdn2.iodide.io/latest/full/
- Adds `messageCallback` and `errorCallback` to *`pyodide.loadPackage`*.
- Reduces the initial memory footprint (`TOTAL_MEMORY`) from 1 GiB to 5 MiB. More memory will be allocated as needed.
- When building from source, only a subset of packages can be built by setting the `PYODIDE_PACKAGES` environment variable. See *partial builds documentation* for more details.
- New packages: future, autograd

Version 0.14.3

Dec 11, 2019

- Convert JavaScript numbers containing integers, e.g. `3.0`, to a real Python long (e.g. `3`).
- Adds `__bool__` method to for `JsProxy` objects.
- Adds a JavaScript-side auto completion function for Iodide that uses jedi.
- New packages: nltk, jeudi, statsmodels, regex, cytoolz, xlrd, uncertainties

Version 0.14.0

Aug 14, 2019

- The built-in `sqlite` and `bz2` modules of Python are now enabled.
- Adds support for auto-completion based on jedi when used in iodide

Version 0.13.0

May 31, 2019

- Tagged versions of Pyodide are now deployed to Netlify.

Version 0.12.0

May 3, 2019

User improvements:

- Packages with pure Python wheels can now be loaded directly from PyPI. See *Micropip* for more information.
- Thanks to PEP 562, you can now `import js` from Python and use it to access anything in the global JavaScript namespace.
- Passing a Python object to JavaScript always creates the same object in JavaScript. This makes APIs like `removeEventListener` usable.
- Calling `dir()` in Python on a JavaScript proxy now works.
- Passing an `ArrayBuffer` from JavaScript to Python now correctly creates a `memoryview` object.
- Pyodide now works on Safari.

Version 0.11.0

Apr 12, 2019

User improvements:

- Support for built-in modules:
  - `sqlite`, `crypt`
- New packages: `mne`

Developer improvements:

- The `mkpkg` command will now select an appropriate archive to use, rather than just using the first.

- The included version of emscripten has been upgraded to 1.38.30 (plus a bugfix).
- New packages: `jinja2`, `MarkupSafe`

Version 0.10.0

Mar 21, 2019

User improvements:

- New packages: `html5lib`, `pygments`, `beautifulsoup4`, `soupsieve`, `docutils`, `bleach`, `mne`

Developer improvements:

- `console.html` provides a simple text-only interactive console to test local changes to Pyodide. The existing notebooks based on legacy versions of Iodide have been removed.
- The `run_docker` script can now be configured with environment variables.

Pyodide Deprecation Timeline

Each Pyodide release may deprecate certain features from previous releases in a backward incompatible way. If a feature is deprecated, it will continue to work until its removal, but raise warnings. We try to ensure deprecations are done over at least two minor(feature) releases, however, as Pyodide is still in beta state, this list is subject to change and some features can be removed without deprecation warnings. More details about each item can often be found in the *Change Log*.

0.23.0

Names that used to be in the root `pyodide` module and were moved to submodules will no longer be available in the root module.

0.21.0

- The `globals` argument to `runPython` and `runPythonAsync` will be passed as a named argument only.
- The `extractDir` argument to `unpackArchive` will be passed as a named argument only.

0.20.0

- The skip-host key will be removed from the meta.yaml format. If needed, install a host copy of the package with pip instead.
- `pyodide-interrupts` module will be removed. If you were using this for some reason, use *`setInterruptBuffer`* instead.

0.19.0

- The default working directory (home directory) inside the Pyodide virtual file system has been changed from `/` to `/home/pyodide`. To get the previous behavior, you can
  - call `os.chdir("/")` in Python to change working directory or
  - call *`loadPyodide`* with the `homedir="/"` argument
- When a JavaScript function is called from Python, PyProxy arguments and return values will be automatically destroyed when the function is finished.

3.3.6 Related Projects

WebAssembly ecosystem

- emscripten is the compiler toolchain for WebAssembly that made Pyodide possible.

Notebook environments, IDEs, and REPLs

- Iodide is a notebook-like environment for literate scientific computing and communication for the web. It is no longer actively maintained. Historically, Pyodide started as plugin for iodide.
- Starboard notebook is an in-browser literal notebook runtime that uses Pyodide for Python.
- Basthon notebook is a static fork of Jupyter notebook with a Pyodide kernel (currently in French).
- JupyterLite is a JupyterLab distribution that runs entirely in the browser, based on Pyodide.
- futurecoder is an interactive Python course running on Pyodide. It includes an IDE with a REPL, debuggers, and automatic installation of any imported packages supported by Pyodide's `micropip`.

Dashboards and visualization

- WebDash is a Plotly Dash distribution that runs entirely in the browser, using Pyodide.

Other projects

- wc-code is a library to run JavaScript, Python, and Theme in the browser with inline code blocks. It uses Pyodide to execute Python code.
- SymPy Beta is a fork of SymPy Gamma. It's an in-browser answer engine with a Pyodide backend.

CHAPTER

FOUR

COMMUNICATION

- Blog: blog.pyodide.org
- Mailing list: mail.python.org/mailman3/lists/pyodide.python.org/
- Gitter: gitter.im/pyodide/community
- Twitter: twitter.com/pyodide
- Stack Overflow: stackoverflow.com/questions/tagged/pyodide

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