The Python/C API

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Contents

1 概述 **3**
- 1.1 代码标准 . . . 3
- 1.2 包含文件 . . . 3
- 1.3 有用的宏 . . . 4
- 1.4 对象、类型和引用计数 . . . 6
  - 1.4.1 引用计数 . . . 6
  - 1.4.2 类型 . . . 9
- 1.5 异常 . . . 9
- 1.6 嵌入 Python . . . 11
- 1.7 调试构建 . . . 11

2 C API 的稳定性 **13**
- 2.1 应用程序二进制接口的稳定版 . . . 13
  - 2.1.1 受限 API 的作用域和性能 . . . 14
  - 2.1.2 受限 API 警示 . . . 14
- 2.2 平台的考虑 . . . 14
- 2.3 受限 API 的内容 . . . 15

3 极高层级 API **39**

4 引用计数 **43**

5 异常处理 **45**
- 5.1 打印和清理 . . . 45
- 5.2 抛出异常 . . . 46
- 5.3 发出警告 . . . 48
- 5.4 查询错误指示器 . . . 49
- 5.5 信号处理 . . . 51
- 5.6 Exception 类 . . . 52
- 5.7 异常对象 . . . 52
- 5.8 Unicode 异常对象 . . . 53
- 5.9 递归控制 . . . 54
- 5.10 标准异常 . . . 54
- 5.11 标准警告类别 . . . 56

6 工具 **57**
- 6.1 操作系统实用工具 . . . 57
- 6.2 系统功能 . . . 60
- 6.3 过程控制 . . . 62
- 6.4 导入模块 . . . 62
- 6.5 数据 marshal 操作支持 . . . 65

6.6 解析参数并构建值变量 . . . 66
6.6.1 解析参数 . . . 67
6.6.2 创建变量 . . . 72
6.7 字符串转换与格式化 . . . 73
6.8 反射 . . . 75
6.9 编解码器注册与支持功能 . . . 75
6.9.1 Codec 查找 API . . . 76
6.9.2 用于 Unicode 编码错误处理程序的注册表 API . . . 76

7 抽象对象层 79
7.1 对象协议 . . . 79
7.2 调用协议 . . . 83
7.2.1 *tp_call* 协议 . . . 83
7.2.2 Vectorcall 协议 . . . 83
7.2.3 调用对象的 API . . . 85
7.2.4 调用支持 API . . . 87
7.3 数字协议 . . . 87
7.4 序列协议 . . . 90
7.5 映射协议 . . . 92
7.6 迭代器协议 . . . 93
7.7 缓冲协议 . . . 94
7.7.1 缓冲区结构 . . . 94
7.7.2 缓冲区请求的类型 . . . 96
7.7.3 复杂数组 . . . 98
7.7.4 缓冲区相关函数 . . . 99
7.8 旧缓冲协议 . . . 100

8 具体的对象层 101
8.1 基本对象 . . . 101
8.1.1 类型对象 . . . 101
8.1.2 None 对象 . . . 105
8.2 数值对象 . . . 105
8.2.1 整数型对象 . . . 105
8.2.2 布尔对象 . . . 108
8.2.3 浮点数对象 . . . 108
8.2.4 Pack functions . . . 109
8.2.5 Unpack functions . . . 110
8.2.6 复数对象 . . . 110
8.3 序列对象 . . . 112
8.3.1 bytes 对象 . . . 112
8.3.2 字节数组对象 . . . 114
8.3.3 Unicode 对象和编码解码器 . . . 115
8.3.4 元组对象 . . . 132
8.3.5 结构序列对象 . . . 133
8.3.6 列表对象 . . . 134
8.4 容器对象 . . . 136
8.4.1 字典对象 . . . 136
8.4.2 集合对象 . . . 138
8.5 Function 对象 . . . 140
8.5.1 Function 对象 . . . 140
8.5.2 实例方法对象 . . . 141
8.5.3 方法对象 . . . 141
8.5.4 Cell 对象 . . . 142
8.5.5 代码对象 . . . 142
8.6 其他对象 . . . 144
8.6.1 文件对象 . . . 144
8.6.2 模块对象 . . . 145
8.6.3 迭代器对象 . . . 152

8.6.4 描述符对象 153
8.6.5 切片对象 153
8.6.6 Ellipsis 对象 155
8.6.7 MemoryView 对象 155
8.6.8 弱引用对象 155
8.6.9 Capsule 对象 156
8.6.10 Frame Objects 158
8.6.11 生成器对象 159
8.6.12 协程对象 159
8.6.13 上下文变量对象 160
8.6.14 DateTime 对象 161
8.6.15 类型注解对象 164

9 初始化，终结和线程 165
9.1 在 Python 初始化之前 165
9.2 全局配置变量 166
9.3 Initializing and finalizing the interpreter 168
9.4 Process-wide parameters 169
9.5 线程状态和全局解释器锁 173
9.5.1 Releasing the GIL from extension code 173
9.5.2 非 Python 创建的线程 174
9.5.3 Cautions about fork() 174
9.5.4 高阶 API 175
9.5.5 Low-level API 177
9.6 子解释器支持 180
9.6.1 错误和警告 181
9.7 异步通知 181
9.8 分析和跟踪 182
9.9 高级调试器支持 183
9.10 线程本地存储支持 184
9.10.1 Thread Specific Storage (TSS) API 184
9.10.2 Thread Local Storage (TLS) API 185

10 Python 初始化配置 187
10.1 示例 187
10.2 PyWideStringList 188
10.3 PyStatus 189
10.4 PyPreConfig 190
10.5 Preinitialize Python with PyPreConfig 192
10.6 PyConfig 193
10.7 Initialization with PyConfig 203
10.8 Isolated Configuration 204
10.9 Python Configuration 205
10.10 Python Path Configuration 205
10.11 Py_RunMain() 206
10.12 Py_GetArgcArgv() 206
10.13 Multi-Phase Initialization Private Provisional API 207

11 内存管理 209
11.1 概述 209
11.2 分配器域 210
11.3 原始内存接口 210
11.4 内存接口 211
11.5 对象分配器 212
11.6 默认内存分配器 213
11.7 自定义内存分配器 213
11.8 Python 内存分配器的调试钩子 215
11.9 pymalloc 分配器 216
11.9.1 自定义 pymalloc Arena 分配器 216

11.10 tracemalloc C API . . . 217
11.11 例子 . . . 217

12 对象实现支持 **219**
12.1 在堆上分配对象 . . . 219
12.2 公用对象的结构 . . . 220
12.2.1 基本的对象类型和宏 . . . 220
12.2.2 Implementing functions and methods . . . 222
12.2.3 Accessing attributes of extension types . . . 224
12.3 类型对象 . . . 226
12.3.1 快速参考 . . . 226
12.3.2 PyTypeObject 定义 . . . 231
12.3.3 PyObject 槽位 . . . 232
12.3.4 PyVarObject 槽位 . . . 233
12.3.5 PyTypeObject 槽 . . . 233
12.3.6 Static Types . . . 250
12.3.7 Heap Types . . . 251
12.4 Number Object Structures . . . 251
12.5 Mapping Object Structures . . . 253
12.6 Sequence Object Structures . . . 253
12.7 Buffer Object Structures . . . 254
12.8 Async Object Structures . . . 255
12.9 Slot Type typedefs . . . 256
12.10 例子 . . . 258
12.11 使对象类型支持循环垃圾回收 . . . 260
12.11.1 控制垃圾回收器状态 . . . 262

13 API 和 ABI 版本管理 **263**

A 术语对照表 **265**

B 文档说明 **277**
B.1 Python 文档的贡献者 . . . 277

C 历史和许可证 **279**
C.1 该软件的历史 . . . 279
C.2 获取或以其他方式使用 Python 的条款和条件 . . . 280
C.2.1 用于 PYTHON 3.11.0 的 PSF 许可协议 . . . 280
C.2.2 用于 PYTHON 2.0 的 BEOPEN.COM 许可协议 . . . 281
C.2.3 用于 PYTHON 1.6.1 的 CNRI 许可协议 . . . 282
C.2.4 用于 PYTHON 0.9.0 至 1.2 的 CWI 许可协议 . . . 283
C.2.5 ZERO-CLAUSE BSD LICENSE FOR CODE IN THE PYTHON 3.11.0 DOCUMENTATION . . . 283
C.3 收录软件的许可与鸣谢 . . . 283
C.3.1 Mersenne Twister . . . 284
C.3.2 套接字 . . . 284
C.3.3 异步套接字服务 . . . 285
C.3.4 Cookie 管理 . . . 285
C.3.5 执行追踪 . . . 286
C.3.6 UUencode 与 UUdecode 函数 . . . 286
C.3.7 XML 远程过程调用 . . . 287
C.3.8 test_epoll . . . 287
C.3.9 Select kqueue . . . 288
C.3.10 SipHash24 . . . 288
C.3.11 strtod 和 dtoa . . . 289
C.3.12 OpenSSL . . . 289
C.3.13 expat . . . 292
C.3.14 libffi . . . 292
C.3.15 zlib . . . 293

C.3.16 cfuhash 293
C.3.17 libmpdec 294
C.3.18 W3C C14N 测试套件 294
C.3.19 Audioop 295

D 版权所有 **297**

索引 **299**

本手册描述了希望编写扩展模块并将 Python 解释器嵌入其应用程序中的 C 和 C++ 程序员可用的 API。同时可以参阅 extending-index ，其中描述了扩展编写的一般原则，但没有详细描述 API 函数。

CHAPTER 1

概述

Python 的应用编程接口（API）使得 C 和 C++ 程序员可以在多个层级上访问 Python 解释器。该 API 在 C++ 中同样可用，但为简化描述，通常将其称为 Python/C API。使用 Python/C API 有两个基本的理由。第一个理由是为了特定目的而编写 *扩展模块*；它们是扩展 Python 解释器功能的 C 模块。这可能是最常见的使用场景。第二个理由是将 Python 用作更大规模应用的组件；这种技巧通常被称为在一个应用中 *embedding* Python。

编写扩展模块的过程相对来说更易于理解，可以通过"菜谱"的形式分步骤介绍。使用某些工具可在一定程度上自动化这一过程。虽然人们在其他应用中嵌入 Python 的做法早已有之，但嵌入 Python 的过程没有编写扩展模块那样方便直观。

许多 API 函数在你嵌入或是扩展 Python 这两种场景下都能发挥作用；此外，大多数嵌入 Python 的应用程序也需要提供自定义扩展，因此在尝试在实际应用中嵌入 Python 之前先熟悉编写扩展应该会是个好主意。

1.1 代码标准

如果你想要编写可包含于 CPython 的 C 代码，你 **必须**遵循在 **PEP 7** 中定义的指导原则和标准。这些指导原则适用于任何你所要扩展的 Python 版本。在编写你自己的第三方扩展模块时可以不必遵循这些规范，除非你准备在日后向 Python 贡献这些模块。

1.2 包含文件

使用 Python/C API 所需要的全部函数、类型和宏定义可通过下面这行语句包含到你的代码之中：

```
#define PY_SSIZE_T_CLEAN
#include <Python.h>
```

这意味着包含以下标准头文件：`<stdio.h>`, `<string.h>`, `<errno.h>`, `<limits.h>`, `<assert.h>` 和 `<stdlib.h>`（如果可用）。

备注： 由于 Python 可能会定义一些能在某些系统上影响标准头文件的预处理器定义，因此在包含任何标准头文件之前，你 *必须*先包含 `Python.h`。

推荐总是在 Python.h 前定义 PY_SSIZE_T_CLEAN 。查看解析参数并构建值变量 来了解这个宏的更多内容。

Python.h 所定义的全部用户可见名称（由包含的标准头文件所定义的除外）都带有前缀 Py 或者 _Py。以 _Py 打头的名称是供 Python 实现内部使用的，不应被扩展编写者使用。结构成员名称没有保留前缀。

备注： 用户代码永远不应该定义以 Py 或 _Py 开头的名称。这会使读者感到困惑，并危及用户代码对未来 Python 版本的可移植性，这些版本可能会定义以这些前缀之一开头的其他名称。

头文件通常会与 Python 一起安装。在 Unix 上，它们位于以下目录：*prefix*/include/pythonversion/ 和 *exec_prefix*/include/pythonversion/，其中 prefix 和 exec_prefix 是由向 Python 的 **configure** 脚本传入的对应形参所定义，而 *version* 则为 '%d.%d' % sys.version_info[:2]。在 Windows 上，头文件安装于 *prefix*/include，其中 prefix 是向安装程序指定的安装目录。

要包含头文件，请将两个目录（如果不同）都放到你所用编译器的包含搜索路径中。请 不要将父目录放入搜索路径然后使用 #include <pythonX.Y/Python.h>；这将使得多平台编译不可用，因为 prefix 下平台无关的头文件需要包含来自 exec_prefix 下特定平台的头文件。

C++ 用户应该注意，尽管 API 是完全使用 C 来定义的，但头文件正确地将入口点声明为 extern "C"，因此 API 在 C++ 中使用此 API 不必再做任何特殊处理。

1.3 有用的宏

Python 头文件中定义了一些有用的宏。许多是在靠近它们被使用的地方定义的（例如*Py_RETURN_NONE*）。其他更为通用的则定义在这里。这里所显示的并不是一个完整的列表。

Py_ABS(x)

返回 x 的绝对值。

3.3 新版功能.

Py_ALWAYS_INLINE

Ask the compiler to always inline a static inline function. The compiler can ignore it and decides to not inline the function.

It can be used to inline performance critical static inline functions when building Python in debug mode with function inlining disabled. For example, MSC disables function inlining when building in debug mode.

Marking blindly a static inline function with Py_ALWAYS_INLINE can result in worse performances (due to increased code size for example). The compiler is usually smarter than the developer for the cost/benefit analysis.

If Python is built in debug mode (if the Py_DEBUG macro is defined), the *Py_ALWAYS_INLINE* macro does nothing.

It must be specified before the function return type. Usage:

```
static inline Py_ALWAYS_INLINE int random(void) { return 4; }
```

3.11 新版功能.

Py_CHARMASK(c)

参数必须为 [-128, 127] 或 [0, 255] 范围内的字符或整数类型。这个宏将 c 强制转换为 unsigned char 返回。

Py_DEPRECATED(version)

弃用声明。该宏必须放置在符号名称前。

示例:

```
Py_DEPRECATED(3.8) PyAPI_FUNC(int) Py_OldFunction(void);
```

在 3.8 版更改: 添加了 MSVC 支持。

Py_GETENV(s)

与 getenv(s) 类似，但是如果命令行上传递了 -E ，则返回 NULL （即如果设置了 Py_IgnoreEnvironmentFlag ）。

Py_MAX(x, y)

返回 x 和 y 当中的最大值。

3.3 新版功能.

Py_MEMBER_SIZE(type, member)

返回结构 (type) member 的大小，以字节表示。

3.6 新版功能.

Py_MIN(x, y)

返回 x 和 y 当中的最小值。

3.3 新版功能.

Py_NO_INLINE

Disable inlining on a function. For example, it reduces the C stack consumption: useful on LTO+PGO builds which heavily inline code (see bpo-33720).

Usage:

```
Py_NO_INLINE static int random(void) { return 4; }
```

3.11 新版功能.

Py_STRINGIFY(x)

将 x 转换为 C 字符串。例如 Py_STRINGIFY(123) 返回 "123"。

3.4 新版功能.

Py_UNREACHABLE()

这个可以在你有一个设计上无法到达的代码路径时使用。例如，当一个 switch 语句中所有可能的值都已被 case 子句覆盖了，就可将其用在 default: 子句中。当你非常想在某个位置放一个 assert(0) 或 abort() 调用时也可以用这个。

在 release 模式下，该宏帮助编译器优化代码，并避免发出不可到达代码的警告。例如，在 GCC 的 release 模式下，该宏使用 __builtin_unreachable() 实现。

Py_UNREACHABLE() 的一个用法是调用一个不会返回，但却没有声明 _Py_NO_RETURN 的函数之后。

如果一个代码路径不太可能是正常代码，但在特殊情况下可以到达，就不能使用该宏。例如，在低内存条件下，或者一个系统调用返回超出预期范围值，诸如此类，最好将错误报告给调用者。如果无法将错误报告给调用者，可以使用 *Py_FatalError()* 。

3.7 新版功能.

Py_UNUSED(arg)

用于函数定义中未使用的参数，从而消除编译器警告。例如：int func(int a, int Py_UNUSED(b)) { return a; } 。

3.4 新版功能.

PyDoc_STRVAR(name, str)

创建一个可以在文档字符串中使用的，名字为 name 的变量。如果不和文档字符串一起构建 Python，该值将为空。

如 **PEP 7** 所述，使用*PyDoc_STRVAR* 作为文档字符串，以支持不和文档字符串一起构建 Python 的情况。

示例:

```
PyDoc_STRVAR(pop_doc, "Remove and return the rightmost element.");

static PyMethodDef deque_methods[] = {
    // ...
    {"pop", (PyCFunction)deque_pop, METH_NOARGS, pop_doc},
    // ...
}
```

PyDoc_STR (str)

为给定的字符串输入创建一个文档字符串，或者当文档字符串被禁用时，创建一个空字符串。

如 **PEP 7** 所述，使用*PyDoc_STR* 指定文档字符串，以支持不和文档字符串一起构建 Python 的情况。

示例:

```
static PyMethodDef pysqlite_row_methods[] = {
    {"keys", (PyCFunction)pysqlite_row_keys, METH_NOARGS,
        PyDoc_STR("Returns the keys of the row.")},
    {NULL, NULL}
};
```

1.4 对象、类型和引用计数

Most Python/C API functions have one or more arguments as well as a return value of type *PyObject**. This type is a pointer to an opaque data type representing an arbitrary Python object. Since all Python object types are treated the same way by the Python language in most situations (e.g., assignments, scope rules, and argument passing), it is only fitting that they should be represented by a single C type. Almost all Python objects live on the heap: you never declare an automatic or static variable of type *PyObject*, only pointer variables of type *PyObject** can be declared. The sole exception are the type objects; since these must never be deallocated, they are typically static *PyTypeObject* objects.

所有 Python 对象（甚至 Python 整数）都有一个 *type* 和一个 *reference count*。对象的类型确定它是什么类型的对象（例如整数、列表或用户定义函数；还有更多，如 types 中所述）。对于每个众所周知的类型，都有一个宏来检查对象是否属于该类型；例如，当（且仅当）*a* 所指的对象是 Python 列表时 `PyList_Check(a)` 为真。

1.4.1 引用计数

引用计数非常重要，因为现代计算机内存（通常十分）有限；它计算有多少不同的地方引用同一个对象。这样的地方可以是某个对象，或者是某个全局（或静态）C 变量，亦或是某个 C 函数的局部变量。当一个对象的引用计数变为 0，释放该对象。如果这个已释放的对象包含其它对象的引用计数，则递减这些对象的引用计数。如果这些对象的引用计数减少为零，则可以依次释放这些对象，依此类推。（这里有一个很明显的问题——对象之间相互引用；目前，解决方案是"不要那样做"。）

总是显式操作引用计数。通常的方法是使用宏*Py_INCREF()* 来增加一个对象的引用计数，使用宏*Py_DECREF()* 来减少一个对象的引用计数。宏*Py_DECREF()* 必须检查引用计数是否为零，然后调用对象的释放器，因此它比 incref 宏复杂得多。释放器是一个包含在对象类型结构中的函数指针。如果对象是复合对象类型（例如列表），则类型特定的释放器负责递减包含在对象中的其他对象的引用计数，并执行所需的终结。引用计数不会溢出，至少用与虚拟内存中不同内存位置一样多的位用于保存引用计数（即 `sizeof(Py_ssize_t) >= sizeof(void*)`）。因此，引用计数递增是一个简单的操作。

没有必要为每个包含指向对象的指针的局部变量增加对象的引用计数。理论上，当变量指向对象时，对象的引用计数增加 1 ，当变量超出范围时，对象的引用计数减少 1 。但是，这两者相互抵消，所以最后引

用计数没有改变。使用引用计数的唯一真正原因是只要我们的变量指向它，就可以防止对象被释放。如果知道至少有一个对该对象的其他引用存活时间至少和我们的变量一样长，则没必要临时增加引用计数。一个典型的情形是，对象作为参数从 Python 中传递给被调用的扩展模块中的 C 函数时，调用机制会保证在调用期间持有对所有参数的引用。

但是，有一个常见的陷阱是从列表中提取一个对象，并将其持有一段时间，而不增加其引用计数。某些操作可能会从列表中删除某个对象，减少其引用计数，并有可能重新分配这个对象。真正的危险是，这个看似无害的操作可能会调用任意 Python 代码——也许有一个代码路径允许控制流从`Py_DECREF()` 回到用户，因此在复合对象上的操作都存在潜在的风险。

一个安全的方式是始终使用泛型操作（名称以 `PyObject_`，`PyNumber_`，`PySequence_` 或 `PyMapping_` 开头的函数）。这些操作总是增加它们返回的对象的引用计数。这让调用者有责任在获得结果后调用`Py_DECREF()`。习惯这种方式很简单。

引用计数细节

Python/C API 中函数引用计数行为最好是通过 *引用所有权*来解释。所有权是关联到引用，而不是对象（对象没有所有权：它们总是会被共享）。“获得引用所有权”意味着当不再需要该引用时必须在其上调用 Py_DECREF。所有权也可以被转移，这意味着接受该引用所有权的代码当不再需要该引用时必须通过调用`Py_DECREF()` 或`Py_XDECREF()` 来最终撤销引用 --- 或是将这个责任转移出去（通常是转给其调用方）。当一个函数将引用所有权转给其调用方时，则称调用方收到了一个 *新的*引用。当所有权未被转移时，则称调用方 *借入*该引用。对于*borrowed reference* 来说不需任何额外操作。

相反地，当调用方函数传入一个对象的引用时，存在两种可能：该函数 *窃取*了一个对象的引用，或是没有窃取。*窃取引用*意味着当你向一个函数传入引用时，该函数会假定它拥有该引用，而你将不再对它负有责任。

很少有函数会窃取引用；两个重要的例外是`PyList_SetItem()` 和`PyTuple_SetItem()`，它们会窃取对条目的引用（但不是条目所在的元组或列表！）。这些函数被设计为会窃取引用是因为在使用新创建的对象来填充元组或列表时有一个通常的惯例；例如，创建元组 `(1, 2, "three")` 的代码看起来可以是这样的（暂时不要管错误处理；下面会显示更好的代码编写方式）：

```
PyObject *t;

t = PyTuple_New(3);
PyTuple_SetItem(t, 0, PyLong_FromLong(1L));
PyTuple_SetItem(t, 1, PyLong_FromLong(2L));
PyTuple_SetItem(t, 2, PyUnicode_FromString("three"));
```

在这里，`PyLong_FromLong()` 返回了一个新的引用并且它立即被`PyTuple_SetItem()` 所窃取。当你想要继续使用一个对象而对它的引用将被窃取时，请在调用窃取引用的函数之前使用`Py_INCREF()` 来抓取另一个引用。

顺便提一下，`PyTuple_SetItem()` 是 *设置*元组条目的 *唯一*方式；`PySequence_SetItem()` 和`PyObject_SetItem()` 会拒绝这样做因为元组是不可变数据类型。你应当只对你自己创建的元组使用`PyTuple_SetItem()`。

等价于填充一个列表的代码可以使用`PyList_New()` 和`PyList_SetItem()` 来编写。

然而，在实践中，你很少会使用这些创建和填充元组或列表的方式。有一个通用的函数`Py_BuildValue()` 可以根据 C 值来创建大多数常用对象，由一个 *格式字符串*来指明。例如，上面的两个代码块可以用下面的代码来代替（还会负责错误检测）：

```
PyObject *tuple, *list;

tuple = Py_BuildValue("(iis)", 1, 2, "three");
list = Py_BuildValue("[iis]", 1, 2, "three");
```

使用`PyObject_SetItem()` 等来处理那些你只是借入引用的条目是更为常见的，例如传给你正在编写的函数的参数。在这种情况下，他们对于引用计数的行为会更为理智，因为你不需要递增引用计数以便你可以将引用计数转出去（“让它被窃取”）。例如，这个函数将一个列表（实例上是任何可变序列）中的所有项设置为一个给定的条目:

```
int
set_all(PyObject *target, PyObject *item)
{
    Py_ssize_t i, n;

    n = PyObject_Length(target);
    if (n < 0)
        return -1;
    for (i = 0; i < n; i++) {
        PyObject *index = PyLong_FromSsize_t(i);
        if (!index)
            return -1;
        if (PyObject_SetItem(target, index, item) < 0) {
            Py_DECREF(index);
            return -1;
        }
        Py_DECREF(index);
    }
    return 0;
}
```

对于函数返回值的情况略有不同。虽然向大多数函数传递一个引用不会改变你对该引用的所有权责任，但许多返回一个引用的函数会给你该引用的所有权。原因很简单：在许多情况下，返回的对象是临时创建的，而你得到的引用是对该对象的唯一引用。因此，返回对象引用的通用函数，如*PyObject_GetItem()* 和*PySequence_GetItem()*，将总是返回一个新的引用（调用方将成为该引用的所有者）。

一个需要了解的重点在于你是否拥有一个由函数返回的引用只取决于你所调用的函数 --- 附带物 (作为参数传给函数的对象的类型) 不会带来额外影响！因此，如果你使用*PyList_GetItem()* 从一个列表提取条目，你并不会拥有其引用 --- 但是如果你使用*PySequence_GetItem()* (它恰好接受完全相同的参数) 从同一个列表获取同样的条目，你就会拥有一个对所返回对象的引用。

下面是说明你要如何编写一个函数来计算一个整数列表中条目的示例；一个是使用*PyList_GetItem()*，而另一个是使用*PySequence_GetItem()*。

```
long
sum_list(PyObject *list)
{
    Py_ssize_t i, n;
    long total = 0, value;
    PyObject *item;

    n = PyList_Size(list);
    if (n < 0)
        return -1; /* Not a list */
    for (i = 0; i < n; i++) {
        item = PyList_GetItem(list, i); /* Can't fail */
        if (!PyLong_Check(item)) continue; /* Skip non-integers */
        value = PyLong_AsLong(item);
        if (value == -1 && PyErr_Occurred())
            /* Integer too big to fit in a C long, bail out */
            return -1;
        total += value;
    }
    return total;
}
```

```
long
sum_sequence(PyObject *sequence)
{
    Py_ssize_t i, n;
    long total = 0, value;
    PyObject *item;
```

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```
    n = PySequence_Length(sequence);
    if (n < 0)
        return -1; /* Has no length */
    for (i = 0; i < n; i++) {
        item = PySequence_GetItem(sequence, i);
        if (item == NULL)
            return -1; /* Not a sequence, or other failure */
        if (PyLong_Check(item)) {
            value = PyLong_AsLong(item);
            Py_DECREF(item);
            if (value == -1 && PyErr_Occurred())
                /* Integer too big to fit in a C long, bail out */
                return -1;
            total += value;
        }
        else {
            Py_DECREF(item); /* Discard reference ownership */
        }
    }
    return total;
}
```

1.4.2 类型

There are few other data types that play a significant role in the Python/C API; most are simple C types such as `int`, `long`, `double` and `char*`. A few structure types are used to describe static tables used to list the functions exported by a module or the data attributes of a new object type, and another is used to describe the value of a complex number. These will be discussed together with the functions that use them.

type **Py_ssize_t**

Part of the Stable ABI. 一个使得 `sizeof(Py_ssize_t) == sizeof(size_t)` 的有符号整数类型。C99 没有直接定义这样的东西（size_t 是一个无符号整数类型）。请参阅 **PEP 353** 了解详情。`PY_SSIZE_T_MAX` 是*Py_ssize_t* 类型的最大正数值。

1.5 异常

Python 程序员只需要处理特定需要处理的错误异常；未处理的异常会自动传递给调用者，然后传递给调用者的调用者，依此类推，直到他们到达顶级解释器，在那里将它们报告给用户并伴随堆栈回溯。

然而，对于 C 程序员来说，错误检查必须总是显式进行的。Python/C API 中的所有函数都可以引发异常，除非在函数的文档中另外显式声明。一般来说，当一个函数遇到错误时，它会设置一个异常，丢弃它所拥有的任何对象引用，并返回一个错误标示。如果没有说明例外的文档，这个标示将为 `NULL` 或 `-1`，具体取决于函数的返回类型。有少量函数会返回一个布尔真/假结果值，其中假值表示错误。有极少的函数没有显式的错误标示或是具有不明确的返回值，并需要用*PyErr_Occurred()* 来进行显式的检测。这些例外总是会被明确地记入文档中。

异常状态是在各个线程的存储中维护的（这相当于在一个无线程的应用中使用全局存储）。一个线程可以处在两种状态之一：异常已经发生，或者没有发生。函数*PyErr_Occurred()* 可以被用来检查此状态：当异常发生时它将返回一个借入的异常类型对象的引用，在其他情况下则返回 `NULL`。有多个函数可以设置异常状态：*PyErr_SetString()* 是最常见的（尽管不是最通用的）设置异常状态的函数，而*PyErr_Clear()* 可以清除异常状态。

完整的异常状态由三个对象组成 (它为都可以为 `NULL`): 异常类型、相应的异常值，以及回溯信息。这些对象的含义与 Python 中 `sys.exc_info()` 的结果相同；然而，它们并不是一样的：Python 对象代表由 Python `try` ... `except` 语句所处理的最后一个异常，而 C 层级的异常状态只在异常被传入到 C 函数或在它们之间传递时存在直至其到达 Python 字节码解释器的主事件循环，该事件循环会负责将其转移至 `sys.exc_info()` 等处。

请注意自 Python 1.5 开始，从 Python 代码访问异常状态的首选的、线程安全的方式是调用函数 `sys.exc_info()`，它将返回 Python 代码的分线程异常状态。此外，这两种访问异常状态的方式的语义都发生了变化因而捕获到异常的函数将保存并恢复其线程的异常状态以保留其调用方的异常状态。这将防止异常处理代码中由一个看起来很无辜的函数覆盖了正在处理的异常所造成的常见错误；它还减少了在回溯由栈帧所引用的对象的往往不被需要的生命其延长。

作为一般的原则，一个调用另一个函数来执行某些任务的函数应当检查被调用的函数是否引发了异常，并在引发异常时将异常状态传递给其调用方。它应当丢弃它所拥有的任何对象引用，并返回一个错误标示，但它 不应设置另一个异常 --- 那会覆盖刚引发的异常，并丢失有关错误确切原因的重要信息。

一个检测异常并传递它们的简单例子在上面的 `sum_sequence()` 示例中进行了演示。这个例子恰好在检测到错误时不需要清理所拥有的任何引用。下面的示例函数演示了一些错误清理操作。首先，为了向你提示 Python 的优势，我们展示了等效的 Python 代码:

```
def incr_item(dict, key):
    try:
        item = dict[key]
    except KeyError:
        item = 0
    dict[key] = item + 1
```

下面是对应的闪耀荣光的 C 代码:

```
int
incr_item(PyObject *dict, PyObject *key)
{
    /* Objects all initialized to NULL for Py_XDECREF */
    PyObject *item = NULL, *const_one = NULL, *incremented_item = NULL;
    int rv = -1; /* Return value initialized to -1 (failure) */

    item = PyObject_GetItem(dict, key);
    if (item == NULL) {
        /* Handle KeyError only: */
        if (!PyErr_ExceptionMatches(PyExc_KeyError))
            goto error;

        /* Clear the error and use zero: */
        PyErr_Clear();
        item = PyLong_FromLong(0L);
        if (item == NULL)
            goto error;
    }
    const_one = PyLong_FromLong(1L);
    if (const_one == NULL)
        goto error;

    incremented_item = PyNumber_Add(item, const_one);
    if (incremented_item == NULL)
        goto error;

    if (PyObject_SetItem(dict, key, incremented_item) < 0)
        goto error;
    rv = 0; /* Success */
    /* Continue with cleanup code */

 error:
    /* Cleanup code, shared by success and failure path */

    /* Use Py_XDECREF() to ignore NULL references */
    Py_XDECREF(item);
    Py_XDECREF(const_one);
    Py_XDECREF(incremented_item);
```

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```
    return rv; /* -1 for error, 0 for success */
}
```

这个例子代表了 C 语言中 goto 语句一种受到认可的用法！它说明了如何使用PyErr_ExceptionMatches() 和PyErr_Clear() 来处理特定的异常，以及如何使用Py_XDECREF() 来处理可能为 NULL 的自有引用（注意名称中的 'X'；Py_DECREF() 在遇到 NULL 引用时将会崩溃）。重要的一点在于用来保存自有引用的变量要被初始化为 NULL 才能发挥作用；类似地，建议的返回值也要被初始化为 -1 (失败) 并且只有在最终执行的调用成功后才会被设置为成功。

1.6 嵌入 Python

只有 Python 解释器的嵌入方（相对于扩展编写者而言）才需要担心的一项重要任务是它的初始化，可能还有它的最终化。解释器的大多数功能只有在解释器被初始化之后才能被使用。

基本的初始化函数是Py_Initialize()。此函数将初始化已加载模块表，并创建基本模块 builtins, __main__ 和 sys。它还将初始化模块搜索路径 (sys.path)。

Py_Initialize() does not set the "script argument list" (sys.argv). If this variable is needed by Python code that will be executed later, setting PyConfig.argv and PyConfig.parse_argv must be set: see *Python Initialization Configuration*.

在大多数系统上（特别是 Unix 和 Windows，虽然在细节上有所不同），Py_Initialize() 将根据对标准 Python 解释器可执行文件的位置的最佳猜测来计算模块搜索路径，并设定 Python 库可在相对于 Python 解释器可执行文件的固定位置上找到。特别地，它将相对于在 shell 命令搜索路径 (环境变量 PATH) 上找到的名为 python 的可执行文件所在父目录中查找名为 lib/python*X.Y* 的目录。

举例来说，如果 Python 可执行文件位于 /usr/local/bin/python，它将假定库位于 /usr/local/lib/python*X.Y*。（实际上，这个特定路径还将成为"回退"位置，会在当无法在 PATH 中找到名为 python 的可执行文件时被使用。）用户可以通过设置环境变量 PYTHONHOME，或通过设置 PYTHONPATH 在标准路径之前插入额外的目录来覆盖此行为。

嵌入的应用程序可以通过在调用Py_Initialize() 之前调用 Py_SetProgramName(file) 来改变搜索次序。请注意 PYTHONHOME 仍然会覆盖此设置并且 PYTHONPATH 仍然会被插入到标准路径之前。需要完全控制权的应用程序必须提供它自己的Py_GetPath()，Py_GetPrefix()，Py_GetExecPrefix() 和Py_GetProgramFullPath() 实现（这些函数均在 Modules/getpath.c 中定义）。

有时，还需要对 Python 进行"反初始化"。例如，应用程序可能想要重新启动 (再次调用Py_Initialize()) 或者应用程序对 Python 的使用已经完成并想要释放 Python 所分配的内存。这可以通过调用Py_FinalizeEx() 来实现。如果当前 Python 处于已初始化状态则Py_IsInitialized() 函数将返回真值。有关这些函数的更多信息将在之后的章节中给出。请注意Py_FinalizeEx() 不会释放所有由 Python 解释器所分配的内存，例如由扩展模块所分配的内存目前是不会被释放的。

1.7 调试构建

Python 可以附带某些宏来编译以启用对解释器和扩展模块的额外检查。这些检查会给运行时增加大量额外开销因此它们默认未被启用。

A full list of the various types of debugging builds is in the file Misc/SpecialBuilds.txt in the Python source distribution. Builds are available that support tracing of reference counts, debugging the memory allocator, or low-level profiling of the main interpreter loop. Only the most frequently used builds will be described in the remainder of this section.

附带定义 Py_DEBUG 宏来编译解释器将产生通常所称的 Python 调试编译版。Py_DEBUG 在 Unix 编译中启用是通过添加 --with-pydebug 到 ./configure 命令来实现的。它也可通过提供非 Python 专属的 _DEBUG 宏来启用。当 Py_DEBUG 在 Unix 编译中启用时，编译器优化将被禁用。

除了下文描述的引用计数调试，还会执行额外检查，请参阅 Python Debug Build。

定义 Py_TRACE_REFS 将启用引用追踪 (参见 configure --with-trace-refs 选项)。当定义了此宏时，将通过在每个*PyObject* 上添加两个额外字段来维护一个活动对象的循环双链列表。总的分配量也会被追踪。在退出时，所有现存的引用将被打印出来。(在交互模式下这将在解释器运行每条语句之后发生)。

有关更多详细信息，请参阅 Python 源代码中的 Misc/SpecialBuilds.txt 。

CHAPTER 2

C API 的稳定性

Python 的 C 语言 API 包含于向下兼容政策 **PEP 387** 中。C API 会跟随小版本的发布而发生变化（比如 3.9 到 3.10 的时候），不过大多数变化都是源代码级兼容的，通常只会增加新的 API。已有 API 的修改或删除，只有在废止期过后或修复严重问题时才会进行。

CPython 的应用二进制接口（ABI）可以跨小版本实现前后兼容（只要以同样方式编译；参见下面的平台的考虑 ）。因此，用 Python 3.10.0 编译的代码可以在 3.10.8 上运行，反之亦然，但针对 3.9.x 和 3.10.x 则需分别进行编译。

带下划线前缀的是私有 API，如 `_Py_InternalState`，即便是补丁发布版本中也可能不加通知地进行改动。

2.1 应用程序二进制接口的稳定版

Python 3.2 引入了 *受限 API*，Python 的 C API 的一个子集。只使用受限 API 的扩展可以被一次性编译而适用于多个 Python 版本。受限 API 的内容如下所示。

为了实现这一点，Python 提供了一个 *稳定 ABI*: 一个将在各 Python 3.x 版本中保持兼容性的符号集合。稳定 ABI 包含了在受限 API 中暴露的符号，但还包含其他符号–例如，支持旧版受限 API 所需的函数。

（简单起见，本文档只讨论了 *扩展*，但受限 API 和稳定 ABI 对于 API 的所有用法都同样适用–例如，嵌入 Python 等。）

Py_LIMITED_API

请在包括 `Python.h` 之前定义这个宏以选择只使用受限 API，并选择受限 API 的版本。

将 `Py_LIMITED_API` 定义为对应你的扩展所支持的最低 Python 版本的*PY_VERSION_HEX* 的值。扩展无需重编译即可适用于从指定版本开始的所有 Python 3 发布版，并可使用到该版本为止所引入的受限 API。

不直接使用 `PY_VERSION_HEX` 宏，而是硬编码一个最小的次要版本（例如 `0x030A0000` 表示 Python 3.10）以便在使用未来的 Python 版本进行编译时保持稳定。

你还可以将 `Py_LIMITED_API` 定义为 `3`。其效果与 `0x03020000` 相同（即 Python 3.2，引入受限 API 的版本）。

在 Windows 上，使用稳定 ABI 的扩展应当被链接到 `python3.dll` 而不是版本专属的库如 `python39.dll`。

在某些平台上，Python 将查找并载入名称中带有 abi3 标签的共享库文件 (例如 mymodule.abi3.so)。它不会检查这样的扩展是否兼容稳定 ABI。使用方 (或其打包工具) 需要确保这一些，例如，基于 3.10+ 受限 API 编译的扩展不可被安装于更低版本的 Python 中。

稳定 ABI 中的所有函数都会作为 Python 的共享库中的函数存在，而不仅是作为宏。这使得它们可以在不使用 C 预处理器的语言中使用。

2.1.1 受限 API 的作用域和性能

受限 API 的目标是允许使用在完整 C API 中可用的任何东西，但可能会有性能上的损失。

例如，虽然 *PyList_GetItem()* 是可用的，但其 "不安全的" 宏版本 *PyList_GET_ITEM()* 则是不可用的。这个宏的运行速度更快因为它可以利用版本专属的列表对象实现细节。

在未定义 Py_LIMITED_API 的情况下，某些 C API 函数将由宏来执行内联或替换。定义 Py_LIMITED_API 会禁用这样的内联，允许提升 Python 的数据结构稳定性，但有可能降低性能。

通过省略 Py_LIMITED_API 定义，可以使基于版本专属的 ABI 来编译受限 API 扩展成为可能。这能提升其在相应 Python 版本上的性能，但也将限制其兼容性。基于 Py_LIMITED_API 进行编译将产生一个可在版本专属扩展不可用的场合分发的扩展–例如，针对即将发布的 Python 版本的预发布包。

2.1.2 受限 API 警示

请注意基于 Py_LIMITED_API 进行编译 不能完全保证代码兼容受限 API 或稳定 ABI。Py_LIMITED_API 仅涵盖了定义，但是一个 API 还包括其他因素，例如预期的语义等。

Py_LIMITED_API 不能处理的一个问题是附带在较低 Python 版本中无效的参数调用某个函数。例如，考虑一个接受 NULL 作为参数的函数。在 Python 3.9 中，NULL 现在会选择一个默认行为，但在 Python 3.8 中，该参数将被直接使用，导致一个 NULL 引用被崩溃。类似的参数也适用于结构体的字段。

另一个问题是当定义了 Py_LIMITED_API 时某些结构体字段目前不会被隐藏，即使它们是受限 API 的一部分。

出于这些原因，我们建议用要支持的 *所有* Python 小版本号来测试一个扩展，并最好是用其中 *最低的*版本来编译它。

我们还建议查看所使用 API 的全部文档以检查其是否显式指明为受限 API 的一部分。即使定义了 Py_LIMITED_API，少数私有声明还是会出于技术原因（或者甚至是作为程序缺陷在无意中）被暴露出来。

还要注意受限 API 并不必然是稳定的：在 Python 3.8 上用 Py_LIMITED_API 编译扩展意味着该扩展能在 Python 3.12 上运行，但它将不一定能用 Python 3.12 *编译*。特别地，在稳定 ABI 保持稳定的情况下，部分受限 API 可能会被弃用并被移除。

2.2 平台的考虑

ABI 的稳定性不仅取决于 Python，还取决于所使用的编译器、低层库和编译器选项。对于稳定 ABI 的目标来说，这些细节定义了一个 "平台"。它们通常会取决于 OS 类型和处理器架构。

确保在特定平台上的所有 Python 版本都以不破坏稳定 ABI 的方式构建是每个特定 Python 分发方的责任。来自 python.org 以及许多第三方分发商的 Windows 和 macOS 发布版都必于这种情况。

2.3 受限 API 的内容

目前，受限 API 包括下面这些项:

- *PyAIter_Check()*
- *PyArg_Parse()*
- *PyArg_ParseTuple()*
- *PyArg_ParseTupleAndKeywords()*
- *PyArg_UnpackTuple()*
- *PyArg_VaParse()*
- *PyArg_VaParseTupleAndKeywords()*
- *PyArg_ValidateKeywordArguments()*
- PyBaseObject_Type
- *PyBool_FromLong()*
- PyBool_Type
- *PyBuffer_FillContiguousStrides()*
- *PyBuffer_FillInfo()*
- *PyBuffer_FromContiguous()*
- *PyBuffer_GetPointer()*
- *PyBuffer_IsContiguous()*
- *PyBuffer_Release()*
- *PyBuffer_SizeFromFormat()*
- *PyBuffer_ToContiguous()*
- PyByteArrayIter_Type
- *PyByteArray_AsString()*
- *PyByteArray_Concat()*
- *PyByteArray_FromObject()*
- *PyByteArray_FromStringAndSize()*
- *PyByteArray_Resize()*
- *PyByteArray_Size()*
- *PyByteArray_Type*
- PyBytesIter_Type
- *PyBytes_AsString()*
- *PyBytes_AsStringAndSize()*
- *PyBytes_Concat()*
- *PyBytes_ConcatAndDel()*
- PyBytes_DecodeEscape()
- *PyBytes_FromFormat()*
- *PyBytes_FromFormatV()*

- *PyBytes_FromObject()*
- *PyBytes_FromString()*
- *PyBytes_FromStringAndSize()*
- PyBytes_Repr()
- *PyBytes_Size()*
- *PyBytes_Type*
- *PyCFunction*
- *PyCFunctionWithKeywords*
- PyCFunction_Call()
- PyCFunction_GetFlags()
- PyCFunction_GetFunction()
- PyCFunction_GetSelf()
- PyCFunction_New()
- PyCFunction_NewEx()
- PyCFunction_Type
- PyCMethod_New()
- *PyCallIter_New()*
- *PyCallIter_Type*
- *PyCallable_Check()*
- *PyCapsule_Destructor*
- *PyCapsule_GetContext()*
- *PyCapsule_GetDestructor()*
- *PyCapsule_GetName()*
- *PyCapsule_GetPointer()*
- *PyCapsule_Import()*
- *PyCapsule_IsValid()*
- *PyCapsule_New()*
- *PyCapsule_SetContext()*
- *PyCapsule_SetDestructor()*
- *PyCapsule_SetName()*
- *PyCapsule_SetPointer()*
- PyCapsule_Type
- PyClassMethodDescr_Type
- *PyCodec_BackslashReplaceErrors()*
- *PyCodec_Decode()*
- *PyCodec_Decoder()*
- *PyCodec_Encode()*
- *PyCodec_Encoder()*
- *PyCodec_IgnoreErrors()*

- *PyCodec_IncrementalDecoder()*
- *PyCodec_IncrementalEncoder()*
- *PyCodec_KnownEncoding()*
- *PyCodec_LookupError()*
- *PyCodec_NameReplaceErrors()*
- *PyCodec_Register()*
- *PyCodec_RegisterError()*
- *PyCodec_ReplaceErrors()*
- *PyCodec_StreamReader()*
- *PyCodec_StreamWriter()*
- *PyCodec_StrictErrors()*
- *PyCodec_Unregister()*
- *PyCodec_XMLCharRefReplaceErrors()*
- *PyComplex_FromDoubles()*
- *PyComplex_ImagAsDouble()*
- *PyComplex_RealAsDouble()*
- *PyComplex_Type*
- *PyDescr_NewClassMethod()*
- *PyDescr_NewGetSet()*
- *PyDescr_NewMember()*
- *PyDescr_NewMethod()*
- PyDictItems_Type
- PyDictIterItem_Type
- PyDictIterKey_Type
- PyDictIterValue_Type
- PyDictKeys_Type
- *PyDictProxy_New()*
- PyDictProxy_Type
- PyDictRevIterItem_Type
- PyDictRevIterKey_Type
- PyDictRevIterValue_Type
- PyDictValues_Type
- *PyDict_Clear()*
- *PyDict_Contains()*
- *PyDict_Copy()*
- *PyDict_DelItem()*
- *PyDict_DelItemString()*
- *PyDict_GetItem()*
- *PyDict_GetItemString()*

- *PyDict_GetItemWithError()*
- *PyDict_Items()*
- *PyDict_Keys()*
- *PyDict_Merge()*
- *PyDict_MergeFromSeq2()*
- *PyDict_New()*
- *PyDict_Next()*
- *PyDict_SetItem()*
- *PyDict_SetItemString()*
- *PyDict_Size()*
- *PyDict_Type*
- *PyDict_Update()*
- *PyDict_Values()*
- PyEllipsis_Type
- PyEnum_Type
- *PyErr_BadArgument()*
- *PyErr_BadInternalCall()*
- *PyErr_CheckSignals()*
- *PyErr_Clear()*
- PyErr_Display()
- *PyErr_ExceptionMatches()*
- *PyErr_Fetch()*
- *PyErr_Format()*
- *PyErr_FormatV()*
- *PyErr_GetExcInfo()*
- *PyErr_GetHandledException()*
- *PyErr_GivenExceptionMatches()*
- *PyErr_NewException()*
- *PyErr_NewExceptionWithDoc()*
- *PyErr_NoMemory()*
- *PyErr_NormalizeException()*
- *PyErr_Occurred()*
- *PyErr_Print()*
- *PyErr_PrintEx()*
- PyErr_ProgramText()
- *PyErr_ResourceWarning()*
- *PyErr_Restore()*
- *PyErr_SetExcFromWindowsErr()*
- *PyErr_SetExcFromWindowsErrWithFilename()*

- *PyErr_SetExcFromWindowsErrWithFilenameObject()*
- *PyErr_SetExcFromWindowsErrWithFilenameObjects()*
- *PyErr_SetExcInfo()*
- *PyErr_SetFromErrno()*
- *PyErr_SetFromErrnoWithFilename()*
- *PyErr_SetFromErrnoWithFilenameObject()*
- *PyErr_SetFromErrnoWithFilenameObjects()*
- *PyErr_SetFromWindowsErr()*
- *PyErr_SetFromWindowsErrWithFilename()*
- *PyErr_SetHandledException()*
- *PyErr_SetImportError()*
- *PyErr_SetImportErrorSubclass()*
- *PyErr_SetInterrupt()*
- *PyErr_SetInterruptEx()*
- *PyErr_SetNone()*
- *PyErr_SetObject()*
- *PyErr_SetString()*
- *PyErr_SyntaxLocation()*
- *PyErr_SyntaxLocationEx()*
- *PyErr_WarnEx()*
- *PyErr_WarnExplicit()*
- *PyErr_WarnFormat()*
- *PyErr_WriteUnraisable()*
- *PyEval_AcquireLock()*
- *PyEval_AcquireThread()*
- PyEval_CallFunction()
- PyEval_CallMethod()
- PyEval_CallObjectWithKeywords()
- *PyEval_EvalCode()*
- *PyEval_EvalCodeEx()*
- *PyEval_EvalFrame()*
- *PyEval_EvalFrameEx()*
- *PyEval_GetBuiltins()*
- *PyEval_GetFrame()*
- *PyEval_GetFuncDesc()*
- *PyEval_GetFuncName()*
- *PyEval_GetGlobals()*
- *PyEval_GetLocals()*
- *PyEval_InitThreads()*

- *PyEval_ReleaseLock()*
- *PyEval_ReleaseThread()*
- *PyEval_RestoreThread()*
- *PyEval_SaveThread()*
- *PyEval_ThreadsInitialized()*
- PyExc_ArithmeticError
- PyExc_AssertionError
- PyExc_AttributeError
- PyExc_BaseException
- PyExc_BaseExceptionGroup
- PyExc_BlockingIOError
- PyExc_BrokenPipeError
- PyExc_BufferError
- PyExc_BytesWarning
- PyExc_ChildProcessError
- PyExc_ConnectionAbortedError
- PyExc_ConnectionError
- PyExc_ConnectionRefusedError
- PyExc_ConnectionResetError
- PyExc_DeprecationWarning
- PyExc_EOFError
- PyExc_EncodingWarning
- PyExc_EnvironmentError
- PyExc_Exception
- PyExc_FileExistsError
- PyExc_FileNotFoundError
- PyExc_FloatingPointError
- PyExc_FutureWarning
- PyExc_GeneratorExit
- PyExc_IOError
- PyExc_ImportError
- PyExc_ImportWarning
- PyExc_IndentationError
- PyExc_IndexError
- PyExc_InterruptedError
- PyExc_IsADirectoryError
- PyExc_KeyError
- PyExc_KeyboardInterrupt
- PyExc_LookupError

- PyExc_MemoryError
- PyExc_ModuleNotFoundError
- PyExc_NameError
- PyExc_NotADirectoryError
- PyExc_NotImplementedError
- PyExc_OSError
- PyExc_OverflowError
- PyExc_PendingDeprecationWarning
- PyExc_PermissionError
- PyExc_ProcessLookupError
- PyExc_RecursionError
- PyExc_ReferenceError
- PyExc_ResourceWarning
- PyExc_RuntimeError
- PyExc_RuntimeWarning
- PyExc_StopAsyncIteration
- PyExc_StopIteration
- PyExc_SyntaxError
- PyExc_SyntaxWarning
- PyExc_SystemError
- PyExc_SystemExit
- PyExc_TabError
- PyExc_TimeoutError
- PyExc_TypeError
- PyExc_UnboundLocalError
- PyExc_UnicodeDecodeError
- PyExc_UnicodeEncodeError
- PyExc_UnicodeError
- PyExc_UnicodeTranslateError
- PyExc_UnicodeWarning
- PyExc_UserWarning
- PyExc_ValueError
- PyExc_Warning
- PyExc_WindowsError
- PyExc_ZeroDivisionError
- PyExceptionClass_Name()
- *PyException_GetCause()*
- *PyException_GetContext()*
- *PyException_GetTraceback()*

- *PyException_SetCause()*
- *PyException_SetContext()*
- *PyException_SetTraceback()*
- *PyFile_FromFd()*
- *PyFile_GetLine()*
- *PyFile_WriteObject()*
- *PyFile_WriteString()*
- PyFilter_Type
- *PyFloat_AsDouble()*
- *PyFloat_FromDouble()*
- *PyFloat_FromString()*
- *PyFloat_GetInfo()*
- *PyFloat_GetMax()*
- *PyFloat_GetMin()*
- *PyFloat_Type*
- *PyFrameObject*
- *PyFrame_GetCode()*
- *PyFrame_GetLineNumber()*
- *PyFrozenSet_New()*
- *PyFrozenSet_Type*
- *PyGC_Collect()*
- *PyGC_Disable()*
- *PyGC_Enable()*
- *PyGC_IsEnabled()*
- *PyGILState_Ensure()*
- *PyGILState_GetThisThreadState()*
- *PyGILState_Release()*
- PyGILState_STATE
- *PyGetSetDef*
- PyGetSetDescr_Type
- *PyImport_AddModule()*
- *PyImport_AddModuleObject()*
- *PyImport_AppendInittab()*
- *PyImport_ExecCodeModule()*
- *PyImport_ExecCodeModuleEx()*
- *PyImport_ExecCodeModuleObject()*
- *PyImport_ExecCodeModuleWithPathnames()*
- *PyImport_GetImporter()*
- *PyImport_GetMagicNumber()*

- *PyImport_GetMagicTag()*
- *PyImport_GetModule()*
- *PyImport_GetModuleDict()*
- *PyImport_Import()*
- *PyImport_ImportFrozenModule()*
- *PyImport_ImportFrozenModuleObject()*
- *PyImport_ImportModule()*
- *PyImport_ImportModuleLevel()*
- *PyImport_ImportModuleLevelObject()*
- *PyImport_ImportModuleNoBlock()*
- *PyImport_ReloadModule()*
- *PyIndex_Check()*
- *PyInterpreterState*
- *PyInterpreterState_Clear()*
- *PyInterpreterState_Delete()*
- *PyInterpreterState_Get()*
- *PyInterpreterState_GetDict()*
- *PyInterpreterState_GetID()*
- *PyInterpreterState_New()*
- *PyIter_Check()*
- *PyIter_Next()*
- *PyIter_Send()*
- PyListIter_Type
- PyListRevIter_Type
- *PyList_Append()*
- *PyList_AsTuple()*
- *PyList_GetItem()*
- *PyList_GetSlice()*
- *PyList_Insert()*
- *PyList_New()*
- *PyList_Reverse()*
- *PyList_SetItem()*
- *PyList_SetSlice()*
- *PyList_Size()*
- *PyList_Sort()*
- *PyList_Type*
- *PyLongObject*
- PyLongRangeIter_Type
- *PyLong_AsDouble()*

- *PyLong_AsLong()*
- *PyLong_AsLongAndOverflow()*
- *PyLong_AsLongLong()*
- *PyLong_AsLongLongAndOverflow()*
- *PyLong_AsSize_t()*
- *PyLong_AsSsize_t()*
- *PyLong_AsUnsignedLong()*
- *PyLong_AsUnsignedLongLong()*
- *PyLong_AsUnsignedLongLongMask()*
- *PyLong_AsUnsignedLongMask()*
- *PyLong_AsVoidPtr()*
- *PyLong_FromDouble()*
- *PyLong_FromLong()*
- *PyLong_FromLongLong()*
- *PyLong_FromSize_t()*
- *PyLong_FromSsize_t()*
- *PyLong_FromString()*
- *PyLong_FromUnsignedLong()*
- *PyLong_FromUnsignedLongLong()*
- *PyLong_FromVoidPtr()*
- PyLong_GetInfo()
- *PyLong_Type*
- PyMap_Type
- *PyMapping_Check()*
- *PyMapping_GetItemString()*
- *PyMapping_HasKey()*
- *PyMapping_HasKeyString()*
- *PyMapping_Items()*
- *PyMapping_Keys()*
- *PyMapping_Length()*
- *PyMapping_SetItemString()*
- *PyMapping_Size()*
- *PyMapping_Values()*
- *PyMem_Calloc()*
- *PyMem_Free()*
- *PyMem_Malloc()*
- *PyMem_Realloc()*
- *PyMemberDef*
- PyMemberDescr_Type

- *PyMemoryView_FromBuffer()*
- *PyMemoryView_FromMemory()*
- *PyMemoryView_FromObject()*
- *PyMemoryView_GetContiguous()*
- PyMemoryView_Type
- *PyMethodDef*
- PyMethodDescr_Type
- *PyModuleDef*
- PyModuleDef_Base
- *PyModuleDef_Init()*
- PyModuleDef_Type
- *PyModule_AddFunctions()*
- *PyModule_AddIntConstant()*
- *PyModule_AddObject()*
- *PyModule_AddObjectRef()*
- *PyModule_AddStringConstant()*
- *PyModule_AddType()*
- *PyModule_Create2()*
- *PyModule_ExecDef()*
- *PyModule_FromDefAndSpec2()*
- *PyModule_GetDef()*
- *PyModule_GetDict()*
- *PyModule_GetFilename()*
- *PyModule_GetFilenameObject()*
- *PyModule_GetName()*
- *PyModule_GetNameObject()*
- *PyModule_GetState()*
- *PyModule_New()*
- *PyModule_NewObject()*
- *PyModule_SetDocString()*
- *PyModule_Type*
- *PyNumber_Absolute()*
- *PyNumber_Add()*
- *PyNumber_And()*
- *PyNumber_AsSsize_t()*
- *PyNumber_Check()*
- *PyNumber_Divmod()*
- *PyNumber_Float()*
- *PyNumber_FloorDivide()*

- *PyNumber_InPlaceAdd()*
- *PyNumber_InPlaceAnd()*
- *PyNumber_InPlaceFloorDivide()*
- *PyNumber_InPlaceLshift()*
- *PyNumber_InPlaceMatrixMultiply()*
- *PyNumber_InPlaceMultiply()*
- *PyNumber_InPlaceOr()*
- *PyNumber_InPlacePower()*
- *PyNumber_InPlaceRemainder()*
- *PyNumber_InPlaceRshift()*
- *PyNumber_InPlaceSubtract()*
- *PyNumber_InPlaceTrueDivide()*
- *PyNumber_InPlaceXor()*
- *PyNumber_Index()*
- *PyNumber_Invert()*
- *PyNumber_Long()*
- *PyNumber_Lshift()*
- *PyNumber_MatrixMultiply()*
- *PyNumber_Multiply()*
- *PyNumber_Negative()*
- *PyNumber_Or()*
- *PyNumber_Positive()*
- *PyNumber_Power()*
- *PyNumber_Remainder()*
- *PyNumber_Rshift()*
- *PyNumber_Subtract()*
- *PyNumber_ToBase()*
- *PyNumber_TrueDivide()*
- *PyNumber_Xor()*
- *PyOS_AfterFork()*
- *PyOS_AfterFork_Child()*
- *PyOS_AfterFork_Parent()*
- *PyOS_BeforeFork()*
- *PyOS_CheckStack()*
- *PyOS_FSPath()*
- *PyOS_InputHook*
- PyOS_InterruptOccurred()
- *PyOS_double_to_string()*
- *PyOS_getsig()*

- PyOS_mystricmp()
- PyOS_mystrnicmp()
- *PyOS_setsig()*
- PyOS_sighandler_t
- *PyOS_snprintf()*
- *PyOS_string_to_double()*
- PyOS_strtol()
- PyOS_strtoul()
- *PyOS_vsnprintf()*
- *PyObject*
- *PyObject.ob_refcnt*
- *PyObject.ob_type*
- *PyObject_ASCII()*
- *PyObject_AsCharBuffer()*
- *PyObject_AsFileDescriptor()*
- *PyObject_AsReadBuffer()*
- *PyObject_AsWriteBuffer()*
- *PyObject_Bytes()*
- *PyObject_Call()*
- *PyObject_CallFunction()*
- *PyObject_CallFunctionObjArgs()*
- *PyObject_CallMethod()*
- *PyObject_CallMethodObjArgs()*
- *PyObject_CallNoArgs()*
- *PyObject_CallObject()*
- *PyObject_Calloc()*
- *PyObject_CheckBuffer()*
- *PyObject_CheckReadBuffer()*
- PyObject_ClearWeakRefs()
- *PyObject_CopyData()*
- *PyObject_DelItem()*
- PyObject_DelItemString()
- *PyObject_Dir()*
- PyObject_Format()
- *PyObject_Free()*
- *PyObject_GC_Del()*
- *PyObject_GC_IsFinalized()*
- *PyObject_GC_IsTracked()*
- *PyObject_GC_Track()*

- *PyObject_GC_UnTrack()*
- *PyObject_GenericGetAttr()*
- *PyObject_GenericGetDict()*
- *PyObject_GenericSetAttr()*
- *PyObject_GenericSetDict()*
- *PyObject_GetAIter()*
- *PyObject_GetAttr()*
- *PyObject_GetAttrString()*
- *PyObject_GetBuffer()*
- *PyObject_GetItem()*
- *PyObject_GetIter()*
- *PyObject_HasAttr()*
- *PyObject_HasAttrString()*
- *PyObject_Hash()*
- *PyObject_HashNotImplemented()*
- *PyObject_Init()*
- *PyObject_InitVar()*
- *PyObject_IsInstance()*
- *PyObject_IsSubclass()*
- *PyObject_IsTrue()*
- *PyObject_Length()*
- *PyObject_Malloc()*
- *PyObject_Not()*
- *PyObject_Realloc()*
- *PyObject_Repr()*
- *PyObject_RichCompare()*
- *PyObject_RichCompareBool()*
- PyObject_SelfIter()
- *PyObject_SetAttr()*
- *PyObject_SetAttrString()*
- *PyObject_SetItem()*
- *PyObject_Size()*
- *PyObject_Str()*
- *PyObject_Type()*
- *PyProperty_Type*
- PyRangeIter_Type
- PyRange_Type
- PyReversed_Type
- *PySeqIter_New()*

- *PySeqIter_Type*
- *PySequence_Check()*
- *PySequence_Concat()*
- *PySequence_Contains()*
- *PySequence_Count()*
- *PySequence_DelItem()*
- *PySequence_DelSlice()*
- *PySequence_Fast()*
- *PySequence_GetItem()*
- *PySequence_GetSlice()*
- PySequence_In()
- *PySequence_InPlaceConcat()*
- *PySequence_InPlaceRepeat()*
- *PySequence_Index()*
- *PySequence_Length()*
- *PySequence_List()*
- *PySequence_Repeat()*
- *PySequence_SetItem()*
- *PySequence_SetSlice()*
- *PySequence_Size()*
- *PySequence_Tuple()*
- PySetIter_Type
- *PySet_Add()*
- *PySet_Clear()*
- *PySet_Contains()*
- *PySet_Discard()*
- *PySet_New()*
- *PySet_Pop()*
- *PySet_Size()*
- *PySet_Type*
- *PySlice_AdjustIndices()*
- *PySlice_GetIndices()*
- *PySlice_GetIndicesEx()*
- *PySlice_New()*
- *PySlice_Type*
- *PySlice_Unpack()*
- *PyState_AddModule()*
- *PyState_FindModule()*
- *PyState_RemoveModule()*

- *PyStructSequence_Desc*
- *PyStructSequence_Field*
- *PyStructSequence_GetItem()*
- *PyStructSequence_New()*
- *PyStructSequence_NewType()*
- *PyStructSequence_SetItem()*
- *PyStructSequence_UnnamedField*
- PySuper_Type
- *PySys_AddWarnOption()*
- *PySys_AddWarnOptionUnicode()*
- *PySys_AddXOption()*
- *PySys_FormatStderr()*
- *PySys_FormatStdout()*
- *PySys_GetObject()*
- *PySys_GetXOptions()*
- PySys_HasWarnOptions()
- *PySys_ResetWarnOptions()*
- *PySys_SetArgv()*
- *PySys_SetArgvEx()*
- *PySys_SetObject()*
- *PySys_SetPath()*
- *PySys_WriteStderr()*
- *PySys_WriteStdout()*
- *PyThreadState*
- *PyThreadState_Clear()*
- *PyThreadState_Delete()*
- *PyThreadState_Get()*
- *PyThreadState_GetDict()*
- *PyThreadState_GetFrame()*
- *PyThreadState_GetID()*
- *PyThreadState_GetInterpreter()*
- *PyThreadState_New()*
- *PyThreadState_SetAsyncExc()*
- *PyThreadState_Swap()*
- PyThread_GetInfo()
- *PyThread_ReInitTLS()*
- PyThread_acquire_lock()
- PyThread_acquire_lock_timed()
- PyThread_allocate_lock()

- *PyThread_create_key()*
- *PyThread_delete_key()*
- *PyThread_delete_key_value()*
- PyThread_exit_thread()
- PyThread_free_lock()
- *PyThread_get_key_value()*
- PyThread_get_stacksize()
- PyThread_get_thread_ident()
- PyThread_get_thread_native_id()
- PyThread_init_thread()
- PyThread_release_lock()
- *PyThread_set_key_value()*
- PyThread_set_stacksize()
- PyThread_start_new_thread()
- *PyThread_tss_alloc()*
- *PyThread_tss_create()*
- *PyThread_tss_delete()*
- *PyThread_tss_free()*
- *PyThread_tss_get()*
- *PyThread_tss_is_created()*
- *PyThread_tss_set()*
- PyTraceBack_Here()
- PyTraceBack_Print()
- PyTraceBack_Type
- PyTupleIter_Type
- *PyTuple_GetItem()*
- *PyTuple_GetSlice()*
- *PyTuple_New()*
- *PyTuple_Pack()*
- *PyTuple_SetItem()*
- *PyTuple_Size()*
- *PyTuple_Type*
- *PyTypeObject*
- *PyType_ClearCache()*
- *PyType_FromModuleAndSpec()*
- *PyType_FromSpec()*
- *PyType_FromSpecWithBases()*
- *PyType_GenericAlloc()*
- *PyType_GenericNew()*

- *PyType_GetFlags()*
- *PyType_GetModule()*
- *PyType_GetModuleState()*
- *PyType_GetName()*
- *PyType_GetQualName()*
- *PyType_GetSlot()*
- *PyType_IsSubtype()*
- *PyType_Modified()*
- *PyType_Ready()*
- *PyType_Slot*
- *PyType_Spec*
- *PyType_Type*
- *PyUnicodeDecodeError_Create()*
- *PyUnicodeDecodeError_GetEncoding()*
- *PyUnicodeDecodeError_GetEnd()*
- *PyUnicodeDecodeError_GetObject()*
- *PyUnicodeDecodeError_GetReason()*
- *PyUnicodeDecodeError_GetStart()*
- *PyUnicodeDecodeError_SetEnd()*
- *PyUnicodeDecodeError_SetReason()*
- *PyUnicodeDecodeError_SetStart()*
- *PyUnicodeEncodeError_GetEncoding()*
- *PyUnicodeEncodeError_GetEnd()*
- *PyUnicodeEncodeError_GetObject()*
- *PyUnicodeEncodeError_GetReason()*
- *PyUnicodeEncodeError_GetStart()*
- *PyUnicodeEncodeError_SetEnd()*
- *PyUnicodeEncodeError_SetReason()*
- *PyUnicodeEncodeError_SetStart()*
- PyUnicodeIter_Type
- *PyUnicodeTranslateError_GetEnd()*
- *PyUnicodeTranslateError_GetObject()*
- *PyUnicodeTranslateError_GetReason()*
- *PyUnicodeTranslateError_GetStart()*
- *PyUnicodeTranslateError_SetEnd()*
- *PyUnicodeTranslateError_SetReason()*
- *PyUnicodeTranslateError_SetStart()*
- PyUnicode_Append()
- PyUnicode_AppendAndDel()

- *PyUnicode_AsASCIIString()*
- *PyUnicode_AsCharmapString()*
- PyUnicode_AsDecodedObject()
- PyUnicode_AsDecodedUnicode()
- PyUnicode_AsEncodedObject()
- *PyUnicode_AsEncodedString()*
- PyUnicode_AsEncodedUnicode()
- *PyUnicode_AsLatin1String()*
- *PyUnicode_AsMBCSString()*
- *PyUnicode_AsRawUnicodeEscapeString()*
- *PyUnicode_AsUCS4()*
- *PyUnicode_AsUCS4Copy()*
- *PyUnicode_AsUTF16String()*
- *PyUnicode_AsUTF32String()*
- *PyUnicode_AsUTF8AndSize()*
- *PyUnicode_AsUTF8String()*
- *PyUnicode_AsUnicodeEscapeString()*
- *PyUnicode_AsWideChar()*
- *PyUnicode_AsWideCharString()*
- PyUnicode_BuildEncodingMap()
- *PyUnicode_Compare()*
- *PyUnicode_CompareWithASCIIString()*
- *PyUnicode_Concat()*
- *PyUnicode_Contains()*
- *PyUnicode_Count()*
- *PyUnicode_Decode()*
- *PyUnicode_DecodeASCII()*
- *PyUnicode_DecodeCharmap()*
- PyUnicode_DecodeCodePageStateful()
- *PyUnicode_DecodeFSDefault()*
- *PyUnicode_DecodeFSDefaultAndSize()*
- *PyUnicode_DecodeLatin1()*
- *PyUnicode_DecodeLocale()*
- *PyUnicode_DecodeLocaleAndSize()*
- *PyUnicode_DecodeMBCS()*
- *PyUnicode_DecodeMBCSStateful()*
- *PyUnicode_DecodeRawUnicodeEscape()*
- *PyUnicode_DecodeUTF16()*
- *PyUnicode_DecodeUTF16Stateful()*

- *PyUnicode_DecodeUTF32()*
- *PyUnicode_DecodeUTF32Stateful()*
- *PyUnicode_DecodeUTF7()*
- *PyUnicode_DecodeUTF7Stateful()*
- *PyUnicode_DecodeUTF8()*
- *PyUnicode_DecodeUTF8Stateful()*
- *PyUnicode_DecodeUnicodeEscape()*
- *PyUnicode_EncodeCodePage()*
- *PyUnicode_EncodeFSDefault()*
- *PyUnicode_EncodeLocale()*
- *PyUnicode_FSConverter()*
- *PyUnicode_FSDecoder()*
- *PyUnicode_Find()*
- *PyUnicode_FindChar()*
- *PyUnicode_Format()*
- *PyUnicode_FromEncodedObject()*
- *PyUnicode_FromFormat()*
- *PyUnicode_FromFormatV()*
- *PyUnicode_FromObject()*
- PyUnicode_FromOrdinal()
- *PyUnicode_FromString()*
- *PyUnicode_FromStringAndSize()*
- *PyUnicode_FromWideChar()*
- PyUnicode_GetDefaultEncoding()
- *PyUnicode_GetLength()*
- *PyUnicode_GetSize()*
- *PyUnicode_InternFromString()*
- PyUnicode_InternImmortal()
- *PyUnicode_InternInPlace()*
- *PyUnicode_IsIdentifier()*
- *PyUnicode_Join()*
- PyUnicode_Partition()
- PyUnicode_RPartition()
- PyUnicode_RSplit()
- *PyUnicode_ReadChar()*
- *PyUnicode_Replace()*
- PyUnicode_Resize()
- *PyUnicode_RichCompare()*
- *PyUnicode_Split()*

- *PyUnicode_Splitlines()*
- *PyUnicode_Substring()*
- *PyUnicode_Tailmatch()*
- *PyUnicode_Translate()*
- *PyUnicode_Type*
- *PyUnicode_WriteChar()*
- *PyVarObject*
- PyVarObject.ob_base
- *PyVarObject.ob_size*
- PyWeakReference
- *PyWeakref_GetObject()*
- *PyWeakref_NewProxy()*
- *PyWeakref_NewRef()*
- PyWrapperDescr_Type
- *PyWrapper_New()*
- PyZip_Type
- *Py_AddPendingCall()*
- *Py_AtExit()*
- *Py_BEGIN_ALLOW_THREADS*
- *Py_BLOCK_THREADS*
- *Py_BuildValue()*
- *Py_BytesMain()*
- *Py_CompileString()*
- *Py_DecRef()*
- *Py_DecodeLocale()*
- *Py_END_ALLOW_THREADS*
- *Py_EncodeLocale()*
- *Py_EndInterpreter()*
- *Py_EnterRecursiveCall()*
- *Py_Exit()*
- *Py_FatalError()*
- Py_FileSystemDefaultEncodeErrors
- Py_FileSystemDefaultEncoding
- *Py_Finalize()*
- *Py_FinalizeEx()*
- *Py_GenericAlias()*
- *Py_GenericAliasType*
- *Py_GetBuildInfo()*
- *Py_GetCompiler()*

- *Py_GetCopyright()*
- *Py_GetExecPrefix()*
- *Py_GetPath()*
- *Py_GetPlatform()*
- *Py_GetPrefix()*
- *Py_GetProgramFullPath()*
- *Py_GetProgramName()*
- *Py_GetPythonHome()*
- Py_GetRecursionLimit()
- *Py_GetVersion()*
- Py_HasFileSystemDefaultEncoding
- *Py_IncRef()*
- *Py_Initialize()*
- *Py_InitializeEx()*
- *Py_Is()*
- *Py_IsFalse()*
- *Py_IsInitialized()*
- *Py_IsNone()*
- *Py_IsTrue()*
- *Py_LeaveRecursiveCall()*
- *Py_Main()*
- Py_MakePendingCalls()
- *Py_NewInterpreter()*
- *Py_NewRef()*
- *Py_ReprEnter()*
- *Py_ReprLeave()*
- *Py_SetPath()*
- *Py_SetProgramName()*
- *Py_SetPythonHome()*
- Py_SetRecursionLimit()
- *Py_UCS4*
- *Py_UNBLOCK_THREADS*
- Py_UTF8Mode
- *Py_VaBuildValue()*
- *Py_Version*
- *Py_XNewRef()*
- *Py_buffer*
- Py_intptr_t
- *Py_ssize_t*

- Py_uintptr_t
- *allocfunc*
- *binaryfunc*
- *descrgetfunc*
- *descrsetfunc*
- *destructor*
- *getattrfunc*
- *getattrofunc*
- *getiterfunc*
- getter
- *hashfunc*
- *initproc*
- *inquiry*
- *iternextfunc*
- *lenfunc*
- *newfunc*
- *objobjargproc*
- *objobjproc*
- *reprfunc*
- *richcmpfunc*
- *setattrfunc*
- *setattrofunc*
- setter
- *ssizeargfunc*
- *ssizeobjargproc*
- ssizessizeargfunc
- ssizessizeobjargproc
- symtable
- *ternaryfunc*
- *traverseproc*
- *unaryfunc*
- *visitproc*

CHAPTER 3

极高层级 API

本章节的函数将允许你执行在文件或缓冲区中提供的 Python 源代码，但它们将不允许你在更细节化的方式与解释器进行交互。

这些函数中有几个可以接受特定的前缀语法符号作为形参。可用的前缀符号有 `Py_eval_input`, `Py_file_input` 以及 `Py_single_input`。这些符号会在接受它们作为形参的函数文档中加以说明。

Note also that several of these functions take `FILE*` parameters. One particular issue which needs to be handled carefully is that the `FILE` structure for different C libraries can be different and incompatible. Under Windows (at least), it is possible for dynamically linked extensions to actually use different libraries, so care should be taken that `FILE*` parameters are only passed to these functions if it is certain that they were created by the same library that the Python runtime is using.

int **Py_Main**(int argc, wchar_t **argv)

Part of the Stable ABI. 针对标准解释器的主程序。嵌入了 Python 的程序将可使用此程序。所提供的 *argc* 和 *argv* 形参应当与传给 C 程序的 `main()` 函数的形参相同（将根据用户的语言区域转换为）。一个重要的注意事项是参数列表可能会被修改（但参数列表中字符串所指向的内容不会被修改）。如果解释器正常退出（即未引发异常）则返回值将为 `0`，如果解释器因引发异常而退出则返回 `1`，或者如果形参列表不能表示有效的 Python 命令行则返回 `2`。

请注意如果引发了一个在其他场合下未处理的 `SystemExit`，此函数将不会返回 `1`，而是退出进程，只要 `Py_InspectFlag` 还未被设置。

int **Py_BytesMain**(int argc, char **argv)

Part of the Stable ABI *since version 3.8.* 类似于 *`Py_Main()`* 但 *argv* 是一个包含字节串的数组。

3.8 新版功能.

int **PyRun_AnyFile**(FILE *fp, const char *filename)

这是针对下面 *`PyRun_AnyFileExFlags()`* 的简化版接口，将 *closeit* 设为 `0` 而将 *flags* 设为 `NULL`。

int **PyRun_AnyFileFlags**(FILE *fp, const char *filename, *PyCompilerFlags* *flags)

这是针对下面 *`PyRun_AnyFileExFlags()`* 的简化版接口，将 *closeit* 参数设为 `0`。

int **PyRun_AnyFileEx**(FILE *fp, const char *filename, int closeit)

这是针对下面 *`PyRun_AnyFileExFlags()`* 的简化版接口，将 *flags* 参数设为 `NULL`。

int **PyRun_AnyFileExFlags**(FILE *fp, const char *filename, int closeit, *PyCompilerFlags* *flags)

如果 *fp* 指向一个关联到交互设备（控制台或终端输入或 Unix 伪终端）的文件，则返回 *`PyRun_InteractiveLoop()`* 的值，否则返回 *`PyRun_SimpleFile()`* 的结果。*filename* 会使用文件系统的编码格式（`sys.getfilesystemencoding()`）来解码。如果 *filename* 为 `NULL`，此

函数会使用 "???" 作为文件名。如果 *closeit* 为真值，文件会在 PyRun_SimpleFileExFlags() 返回之前被关闭。

int **PyRun_SimpleString** (const char *command)

This is a simplified interface to *PyRun_SimpleStringFlags()* below, leaving the *PyCompilerFlags** argument set to NULL.

int **PyRun_SimpleStringFlags** (const char *command, *PyCompilerFlags* *flags)

根据 *flags* 参数，在 __main__ 模块中执行 Python 源代码。如果 __main__ 尚不存在，它将被创建。成功时返回 0，如果引发异常则返回 -1。如果发生错误，则将无法获得异常信息。对于 *flags* 的含义，请参阅下文。

请注意如果引发了一个在其他场合下未处理的 SystemExit，此函数将不会返回 -1，而是退出进程，只要 Py_InspectFlag 还未被设置。

int **PyRun_SimpleFile** (FILE *fp, const char *filename)

这是针对下面*PyRun_SimpleFileExFlags()* 的简化版接口，将 *closeit* 设为 0 而将 *flags* 设为 NULL。

int **PyRun_SimpleFileEx** (FILE *fp, const char *filename, int closeit)

这是针对下面*PyRun_SimpleFileExFlags()* 的简化版接口，将 *flags* 设为 NULL。

int **PyRun_SimpleFileExFlags** (FILE *fp, const char *filename, int closeit, *PyCompilerFlags* *flags)

类似于*PyRun_SimpleStringFlags()*，但 Python 源代码是从 *fp* 读取而不是一个内存中的字符串。*filename* 应为文件名，它将使用*filesystem encoding and error handler* 来解码。如果 *closeit* 为真值，则文件将在 PyRun_SimpleFileExFlags() 返回之前被关闭。

备注： 在 Windows 上，*fp* 应当以二进制模式打开 (即 fopen(filename, "rb"))。否则，Python 可能无法正确地处理使用 LF 行结束符的脚本文件。

---

int **PyRun_InteractiveOne** (FILE *fp, const char *filename)

这是针对下面*PyRun_InteractiveOneFlags()* 的简化版接口，将 *flags* 设为 NULL。

int **PyRun_InteractiveOneFlags** (FILE *fp, const char *filename, *PyCompilerFlags* *flags)

根据 *flags* 参数读取并执行来自与交互设备相关联的文件的一条语句。用户将得到使用 sys.ps1 和 sys.ps2 的提示。*filename* 将使用*filesystem encoding and error handler* 来解码。

当输入被成功执行时返回 0，如果引发异常则返回 -1，或者如果存在解析错误则返回来自作为 Python 的组成部分发布的 errcode.h 包括文件的错误代码。（请注意 errcode.h 并未被 Python.h 所包括，因此如果需要则必须专门地包括。）

int **PyRun_InteractiveLoop** (FILE *fp, const char *filename)

这是针对下面*PyRun_InteractiveLoopFlags()* 的简化版接口，将 *flags* 设为 NULL。

int **PyRun_InteractiveLoopFlags** (FILE *fp, const char *filename, *PyCompilerFlags* *flags)

读取并执行来自与交互设备相关联的语句直至到达 EOF。用户将得到使用 sys.ps1 和 sys.ps2 的提示。*filename* 将使用*filesystem encoding and error handler* 来解码。当位于 EOF 时将返回 0，或者当失败时将返回一个负数。

int (***PyOS_InputHook**)(void)

Part of the Stable ABI. 可以被设为指向一个原型为 int func(void) 的函数。该函数将在 Python 的解释器提示符即将空闲并等待用户从终端输入时被调用。返回值会被忽略。重载这个钩子可被用来将解释器的提示符集成到其他事件循环中，就像 Python 码中 Modules/_tkinter.c 所做的那样。

char *(***PyOS_ReadlineFunctionPointer**)(FILE*, FILE*, const char*)

可以被设为指向一个原型为 char *func(FILE *stdin, FILE *stdout, char *prompt) 的函数，重载被用来读取解释器提示符的一行输入的默认函数。该函数被预期为如果字符串 *prompt* 不为 NULL 就输出它，然后从所提供的标准输入文件读取一行输入，并返回结果字符串。例如，readline 模块将这个钩子设置为提供行编辑和 tab 键补全等功能。

结果必须是一个由`PyMem_RawMalloc()`或`PyMem_RawRealloc()`分配的字符串，或者如果发生错误则为 NULL。

在 3.4 版更改：结果必须由`PyMem_RawMalloc()`或`PyMem_RawRealloc()`分配，而不是由`PyMem_Malloc()`或`PyMem_Realloc()`分配。

PyObject ***PyRun_String**(const char *str, int start, *PyObject* *globals, *PyObject* *locals)

Return value: New reference. 这是针对下面`PyRun_StringFlags()`的简化版接口，将 *flags* 设为 NULL。

PyObject ***PyRun_StringFlags**(const char *str, int start, *PyObject* *globals, *PyObject* *locals, *PyCompilerFlags* *flags)

Return value: New reference. 在由对象 *globals* 和 *locals* 指定的上下文中执行来自 *str* 的 Python 源代码，并使用以 *flags* 指定的编译器旗标。*globals* 必须是一个字典；*locals* 可以是任何实现了映射协议的对象。形参 *start* 指定了应当被用来解析源代码的起始形符。

返回将代码作为 Python 对象执行的结果，或者如果引发了异常则返回 NULL。

PyObject ***PyRun_File**(FILE *fp, const char *filename, int start, *PyObject* *globals, *PyObject* *locals)

Return value: New reference. 这是针对下面`PyRun_FileExFlags()`的简化版接口，将 *closeit* 设为 0 并将 *flags* 设为 NULL。

PyObject ***PyRun_FileEx**(FILE *fp, const char *filename, int start, *PyObject* *globals, *PyObject* *locals, int closeit)

Return value: New reference. 这是针对下面`PyRun_FileExFlags()`的简化版接口，将 *flags* 设为 NULL。

PyObject ***PyRun_FileFlags**(FILE *fp, const char *filename, int start, *PyObject* *globals, *PyObject* *locals, *PyCompilerFlags* *flags)

Return value: New reference. 这是针对下面`PyRun_FileExFlags()`的简化版接口，将 *closeit* 设为 0。

PyObject ***PyRun_FileExFlags**(FILE *fp, const char *filename, int start, *PyObject* *globals, *PyObject* *locals, int closeit, *PyCompilerFlags* *flags)

Return value: New reference. 类似于`PyRun_StringFlags()`，但 Python 源代码是从 *fp* 读取而不是一个内存中的字符串。*filename* 应为文件名，它将使用*filesystem encoding and error handler* 来解码。如果 *closeit* 为真值，则文件将在`PyRun_FileExFlags()`返回之前被关闭。

PyObject ***Py_CompileString**(const char *str, const char *filename, int start)

Return value: New reference. Part of the Stable ABI*.* 这是针对下面`Py_CompileStringFlags()`的简化版接口，将 *flags* 设为 NULL。

PyObject ***Py_CompileStringFlags**(const char *str, const char *filename, int start, *PyCompilerFlags* *flags)

Return value: New reference. 这是针对下面`Py_CompileStringExFlags()`的简化版接口，将 *optimize* 设为 -1。

PyObject ***Py_CompileStringObject**(const char *str, *PyObject* *filename, int start, *PyCompilerFlags* *flags, int optimize)

Return value: New reference. 解析并编译 *str* 中的 Python 源代码，返回结果代码对象。开始形符由 *start* 给出；这可被用来限制可被编译的代码并且应为 Py_eval_input, Py_file_input 或 Py_single_input。由 *filename* 指定的文件名会被用来构造代码对象并可能出现在回溯信息或 SyntaxError 异常消息中。如果代码无法被解析或编译则此函数将返回 NULL。

整数 *optimize* 指定编译器的优化级别；值 -1 将选择与 -O 选项相同的解释器优化级别。显式级别为 0 (无优化；__debug__ 为真值)、1 (断言被移除，__debug__ 为假值) 或 2 (文档字符串也被移除)。

3.4 新版功能.

PyObject ***Py_CompileStringExFlags**(const char *str, const char *filename, int start, *PyCompilerFlags* *flags, int optimize)

Return value: New reference. 与*Py_CompileStringObject()* 类似，但 *filename* 是以*filesystem encoding and error handler* 解码出的字节串。

3.2 新版功能.

PyObject ***PyEval_EvalCode**(*PyObject* *co, *PyObject* *globals, *PyObject* *locals)

Return value: New reference. Part of the Stable ABI. 这是针对*PyEval_EvalCodeEx()* 的简化版接口，只附带代码对象，以及全局和局部变量。其他参数均设为 NULL。

PyObject ***PyEval_EvalCodeEx**(*PyObject* *co, *PyObject* *globals, *PyObject* *locals, *PyObject* *const *args, int argcount, *PyObject* *const *kws, int kwcount, *PyObject* *const *defs, int defcount, *PyObject* *kwdefs, *PyObject* *closure)

Return value: New reference. Part of the Stable ABI. 对一个预编译的代码对象求值，为其求值给出特定的环境。此环境由全局变量的字典，局部变量映射对象，参数、关键字和默认值的数组，仅限关键字 参数的默认值的字典和单元的封闭元组构成。

PyObject ***PyEval_EvalFrame**(*PyFrameObject* *f)

Return value: New reference. Part of the Stable ABI. 对一个执行帧求值。这是针对*PyEval_EvalFrameEx()* 的简化版接口，用于保持向下兼容性。

PyObject ***PyEval_EvalFrameEx**(*PyFrameObject* *f, int throwflag)

Return value: New reference. Part of the Stable ABI. 这是 Python 解释运行不带修饰的主函数。与执行帧 *f* 相关联的代码对象将被执行，解释字节码并根据需要执行调用。额外的 *throwflag* 形参基本可以被忽略——如果为真值，则会导致立即抛出一个异常；这会被用于生成器对象的 throw() 方法。

在 3.4 版更改: 该函数现在包含一个调试断言，用以确保不会静默地丢弃活动的异常。

int **PyEval_MergeCompilerFlags**(*PyCompilerFlags* *cf)

此函数会修改当前求值帧的旗标，并在成功时返回真值，失败时返回假值。

int **Py_eval_input**

Python 语法中用于孤立表达式的起始符号；配合*Py_CompileString()* 使用。

int **Py_file_input**

Python 语法中用于从文件或其他源读取语句序列的起始符号；配合*Py_CompileString()* 使用。这是在编译任意长的 Python 源代码时要使用的符号。

int **Py_single_input**

Python 语法中用于单独语句的起始符号；配合*Py_CompileString()* 使用。这是用于交互式解释器循环的符号。

struct **PyCompilerFlags**

这是用来存放编译器旗标的结构体。对于代码仅被编译的情况，它将作为 int flags 传入，而对于代码要被执行的情况，它将作为 PyCompilerFlags *flags 传入。在这种情况下，from __future__ import 可以修改 *flags*。

当 PyCompilerFlags *flags 为 NULL 时，cf_flags 将被当作等于 0 来处理，而任何 from __future__ import 所导致的修改都会被丢弃。

int **cf_flags**

编译器旗标。

int **cf_feature_version**

cf_feature_version 是 Python 的小版本号。它应当被初始化为 PY_MINOR_VERSION。

此字段默认会被忽略，当且仅当在 *cf_flags* 中设置了 PyCF_ONLY_AST 旗标它才会被使用。

在 3.8 版更改: 增加了 *cf_feature_version* 字段。

int **CO_FUTURE_DIVISION**

这个标志位可在 *flags* 中设置以使得除法运算符 / 被解读为 **PEP 238** 所规定的"真除法"。

CHAPTER 4

引用计数

本节介绍的宏被用于管理 Python 对象的引用计数。

void **Py_INCREF** (*PyObject* *o)

增加对象 *o* 的引用计数。

此函数通常被用来将*borrowed reference* 原地转换为*strong reference*。*Py_NewRef()* 函数可被用来创建新的*strong reference*。

此对象必须不为 NULL；如果你不能确定它不为 NULL，请使用*Py_XINCREF()*。

void **Py_XINCREF** (*PyObject* *o)

增加对象 *o* 的引用计数。对象可以为 NULL，在此情况下该宏不产生任何效果。

另请参阅*Py_XNewRef()*。

PyObject ***Py_NewRef** (*PyObject* *o)

Part of the Stable ABI *since version 3.10.* 新建指向一个对象的*strong reference*: 增加对象 *o* 的引用计数并返回对象 *o*。

当不再需要这个*strong reference* 时，应当在对象上调用*Py_DECREF()* 来有减少该对象的引用计数。

对象 *o* 必须不为 NULL；如果 *o* 可以为 NULL 则应改用*Py_XNewRef()*。

例如:

```
Py_INCREF(obj);
self->attr = obj;
```

可以写成:

```
self->attr = Py_NewRef(obj);
```

另请参阅*Py_INCREF()*。

3.10 新版功能.

PyObject ***Py_XNewRef** (*PyObject* *o)

Part of the Stable ABI *since version 3.10.* 类似于*Py_NewRef()*，但对象 *o* 可以为 NULL。

如果对象 *o* 为 NULL，该函数也 · 将返回 NULL。

3.10 新版功能.

void **Py_DECREF**(*PyObject* *o)

减少对象 *o* 的引用计数。

如果引用计数达到零，则会发起调用对象类型的撤销分配函数 (该函数必须不为 `NULL`)。

此函数通常被用于在退出作用域之前删除一个*strong reference*。

此对象必须不为 `NULL`；如果你不能确定它不为 `NULL`，请使用`Py_XDECREF()`。

> **警告：** 释放函数可导致任意 Python 代码被发起调用（例如当一个带有 `__del__()` 方法的类实例被释放时就是如此）。虽然此类代码中的异常不会被传播，但被执行的代码能够自由访问所有 Python 全局变量。这意味着任何可通过全局变量获取的对象在`Py_DECREF()` 被发起调用之前都应当处于完好状态。例如，从一个列表中删除对象的代码应当将被删除对象的引用拷贝到一个临时变量中，更新列表数据结构，然后再为临时变量调用`Py_DECREF()`。

void **Py_XDECREF**(*PyObject* *o)

减少对象 *o* 的引用计数。对象可以为 `NULL`，在此情况下该宏不产生任何效果；在其他情况下其效果与`Py_DECREF()` 相同，并会应用同样的警告。

void **Py_CLEAR**(*PyObject* *o)

减少对象 *o* 的引用计数。对象可以为 `NULL`，在此情况下该宏不产生任何效果；在其他情况下其效果与`Py_DECREF()` 相同，区别在于其参数也会被设为 `NULL`。针对`Py_DECREF()` 的警告不适用于所传递的对象，因为该宏会细心地使用一个临时变量并在减少其引用计数之前将参数设为 `NULL`。

每当要减少在垃圾回收期间可能会被遍历的对象的引用计数时，使用该宏是一个好主意。

void **Py_IncRef**(*PyObject* *o)

Part of the Stable ABI. 增加对象 *o* 的引用计数。`Py_XINCREF()` 的函数版本。它可被用于 Python 的运行时动态嵌入。

void **Py_DecRef**(*PyObject* *o)

Part of the Stable ABI. 增加对象 *o* 的引用计数。`Py_XDECREF()` 的函数版本。它可被用于 Python 的运行时动态嵌入。

以下函数或宏仅可在解释器核心内部使用：`_Py_Dealloc()`，`_Py_ForgetReference()`，`_Py_NewReference()` 以及全局变量 `_Py_RefTotal`。

CHAPTER 5

异常处理

The functions described in this chapter will let you handle and raise Python exceptions. It is important to understand some of the basics of Python exception handling. It works somewhat like the POSIX `errno` variable: there is a global indicator (per thread) of the last error that occurred. Most C API functions don't clear this on success, but will set it to indicate the cause of the error on failure. Most C API functions also return an error indicator, usually `NULL` if they are supposed to return a pointer, or `-1` if they return an integer (exception: the `PyArg_*` functions return `1` for success and `0` for failure).

具体地说，错误指示器由三个对象指针组成：异常的类型，异常的值，和回溯对象。如果没有错误被设置，这些指针都可以是 `NULL`（尽管一些组合使禁止的，例如，如果异常类型是 `NULL`，你不能有一个非 `NULL` 的回溯）。

当一个函数由于它调用的某个函数失败而必须失败时，通常不会设置错误指示器；它调用的那个函数已经设置了它。而它负责处理错误和清理异常，或在清除其拥有的所有资源后返回（如对象应用或内存分配）。如果不准备处理异常，则 不应该正常地继续。如果是由于一个错误返回，那么一定要向调用者表明已经设置了错误。如果错误没有得到处理或小心传播，对 Python/C API 的其它调用可能不会有预期的行为，并且可能会以某种神秘的方式失败。

备注： 错误指示器 **不是** `sys.exc_info()` 的执行结果。前者对应尚未捕获的异常（异常还在传播），而后者在捕获异常后返回这个异常（异常已经停止传播）。

5.1 打印和清理

void **PyErr_Clear**()

Part of the Stable ABI. 清除错误指示器。如果没有设置错误指示器，则不会有作用。

void **PyErr_PrintEx**(int set_sys_last_vars)

Part of the Stable ABI. 将标准回溯打印到 `sys.stderr` 并清除错误指示器。**除非**错误是 `SystemExit`，这种情况下不会打印回溯进程，且会退出 Python 进程，并显示 `SystemExit` 实例指定的错误代码。

只有在错误指示器被设置时才需要调用这个函数，否则这会导致错误！

如果 *set_sys_last_vars* 非零，则变量 `sys.last_type`，`sys.last_value` 和 `sys.last_traceback` 将分别设置为打印异常的类型，值和回溯。

void **PyErr_Print**()

Part of the Stable ABI. PyErr_PrintEx(1) 的别名。

void **PyErr_WriteUnraisable**(*PyObject* *obj)

Part of the Stable ABI. 使用当前异常和 *obj* 参数调用 sys.unraisablehook()。

当设置了异常，但解释器不可能实际地触发异常时，这个实用函数向 sys.stderr 打印一个警告信息。例如，当 __del__() 方法中发生异常时使用这个函数。

该函数使用单个参数 *obj* 进行调用，该参数标识发生不可触发异常的上下文。如果可能，*obj* 的报告将打印在警告消息中。

调用此函数时必须设置一个异常。

5.2 抛出异常

这些函数可帮助你设置当前线程的错误指示器。为了方便起见，一些函数将始终返回 NULL 指针，以便用于 return 语句。

void **PyErr_SetString**(*PyObject* *type, const char *message)

Part of the Stable ABI. 这是设置错误标记最常用的方式。第一个参数指定异常类型；它通常为某个标准异常，例如 PyExc_RuntimeError。你不需要增加它的引用计数。第二个参数是错误消息；它是用 'utf-8' 解码的。

void **PyErr_SetObject**(*PyObject* *type, *PyObject* *value)

Part of the Stable ABI. 此函数类似于*PyErr_SetString()*，但是允许你为异常的“值”指定任意一个 Python 对象。

PyObject ***PyErr_Format**(*PyObject* *exception, const char *format, ...)

Return value: Always NULL. Part of the Stable ABI. 这个函数设置了一个错误指示器并且返回了 NULL，*exception* 应当是一个 Python 中的异常类。*format* 和随后的形参会帮助格式化这个错误的信息；它们与*PyUnicode_FromFormat()* 有着相同的含义和值。*format* 是一个 ASCII 编码的字符串。

PyObject ***PyErr_FormatV**(*PyObject* *exception, const char *format, va_list vargs)

Return value: Always NULL. Part of the Stable ABI *since version 3.5.* 和*PyErr_Format()* 相同，但它接受一个 va_list 类型的参数而不是可变数量的参数集。

3.5 新版功能.

void **PyErr_SetNone**(*PyObject* *type)

Part of the Stable ABI. 这是 PyErr_SetObject(type, Py_None) 的简写。

int **PyErr_BadArgument**()

Part of the Stable ABI. 这是 PyErr_SetString(PyExc_TypeError, message) 的简写，其中 *message* 指出使用了非法参数调用内置操作。它主要用于内部使用。

PyObject ***PyErr_NoMemory**()

Return value: Always NULL. Part of the Stable ABI. 这是 PyErr_SetNone(PyExc_MemoryError) 的简写；它返回 NULL，以便当内存耗尽时，对象分配函数可以写 return PyErr_NoMemory(); 。

PyObject ***PyErr_SetFromErrno**(*PyObject* *type)

Return value: Always NULL. Part of the Stable ABI. 这是个便捷函数，当 C 库函数返回错误并设置 errno 时，这个函数会触发异常。它构造一个元组对象，其第一项是整数值 errno，第二项是相应的错误消息（从 strerror() 获取），然后调用 PyErr_SetObject(type, object)。在 Unix 上，当 errno 值是 EINTR，即中断的系统调用时，这个函数会调用*PyErr_CheckSignals()*，如果设置了错误指示器，则将其设置为该值。该函数永远返回 NULL，因此当系统调用返回错误时，围绕系统调用的包装函数可以写成 return PyErr_SetFromErrno(type);。

PyObject ***PyErr_SetFromErrnoWithFilenameObject**(*PyObject* *type, *PyObject* *filenameObject)

Return value: Always NULL. Part of the Stable ABI. 类似于`PyErr_SetFromErrno()`，附加的行为是如果 *filenameObject* 不为 `NULL`，它将作为第三个参数传递给 *type* 的构造函数。举个例子，在 `OSError` 异常中，*filenameObject* 将用来定义异常实例的 `filename` 属性。

PyObject ***PyErr_SetFromErrnoWithFilenameObjects**(*PyObject* *type, *PyObject* *filenameObject, *PyObject* *filenameObject2)

Return value: Always NULL. Part of the Stable ABI *since version 3.7.* 类似于`PyErr_SetFromErrnoWithFilenameObject()`，但接受第二个 filename 对象，用于当一个接受两个 filename 的函数失败时触发错误。

3.4 新版功能.

PyObject ***PyErr_SetFromErrnoWithFilename**(*PyObject* *type, const char *filename)

Return value: Always NULL. Part of the Stable ABI. 类似于`PyErr_SetFromErrnoWithFilenameObject()`，但文件名以 C 字符串形式给出。*filename* 是用*filesystem encoding and error handler* 解码的。

PyObject ***PyErr_SetFromWindowsErr**(int ierr)

Return value: Always NULL. Part of the Stable ABI *on Windows since version 3.7.* This is a convenience function to raise `WindowsError`. If called with *ierr* of `0`, the error code returned by a call to `GetLastError()` is used instead. It calls the Win32 function `FormatMessage()` to retrieve the Windows description of error code given by *ierr* or `GetLastError()`, then it constructs a tuple object whose first item is the *ierr* value and whose second item is the corresponding error message (gotten from `FormatMessage()`), and then calls `PyErr_SetObject(PyExc_WindowsError, object)`. This function always returns `NULL`.

可用性: Windows。

PyObject ***PyErr_SetExcFromWindowsErr**(*PyObject* *type, int ierr)

Return value: Always NULL. Part of the Stable ABI *on Windows since version 3.7.* 类似于`PyErr_SetFromWindowsErr()`，额外的参数指定要触发的异常类型。

可用性: Windows。

PyObject ***PyErr_SetFromWindowsErrWithFilename**(int ierr, const char *filename)

Return value: Always NULL. Part of the Stable ABI *on Windows since version 3.7.* 类似于 `PyErr_SetFromWindowsErrWithFilenameObject()`，但是 filename 是以 C 字符串形式给出的。*filename* 是从文件系统编码（`os.fsdecode()`）解码出来的。

可用性: Windows。

PyObject ***PyErr_SetExcFromWindowsErrWithFilenameObject**(*PyObject* *type, int ierr, *PyObject* *filename)

Return value: Always NULL. Part of the Stable ABI *on Windows since version 3.7.* 类似于 `PyErr_SetFromWindowsErrWithFilenameObject()`，额外参数指定要触发的异常类型。

可用性: Windows。

PyObject ***PyErr_SetExcFromWindowsErrWithFilenameObjects**(*PyObject* *type, int ierr, *PyObject* *filename, *PyObject* *filename2)

Return value: Always NULL. Part of the Stable ABI *on Windows since version 3.7.* 类似于`PyErr_SetExcFromWindowsErrWithFilenameObject()`，但是接受第二个 filename 对象。

可用性: Windows。

3.4 新版功能.

PyObject ***PyErr_SetExcFromWindowsErrWithFilename**(*PyObject* *type, int ierr, const char *filename)

Return value: Always NULL. Part of the Stable ABI *on Windows since version 3.7.* 类似于`PyErr_SetFromWindowsErrWithFilename()`，额外参数指定要触发的异常类型。

可用性: Windows。

PyObject ***PyErr_SetImportError***(*PyObject* *msg, *PyObject* *name, *PyObject* *path)

Return value: Always NULL. Part of the Stable ABI *since version 3.7.* 这是触发 `ImportError` 的便捷函数。*msg* 将被设为异常的消息字符串。*name* 和 *path* ,(都可以为 `NULL`), 将用来被设置 `ImportError` 对应的属性 `name` 和 `path`。

3.3 新版功能.

PyObject ***PyErr_SetImportErrorSubclass***(*PyObject* *exception, *PyObject* *msg, *PyObject* *name, *PyObject* *path)

Return value: Always NULL. Part of the Stable ABI *since version 3.6.* 和*PyErr_SetImportError()* 很类似，但这个函数允许指定一个 `ImportError` 的子类来触发。

3.6 新版功能.

void ***PyErr_SyntaxLocationObject***(*PyObject* *filename, int lineno, int col_offset)

设置当前异常的文件，行和偏移信息。如果当前异常不是 `SyntaxError` ，则它设置额外的属性，使异常打印子系统认为异常是 `SyntaxError`。

3.4 新版功能.

void ***PyErr_SyntaxLocationEx***(const char *filename, int lineno, int col_offset)

Part of the Stable ABI *since version 3.7.* 类似于*PyErr_SyntaxLocationObject()*，但 *filename* 是用*filesystem encoding and error handler* 解码的字节串。

3.2 新版功能.

void ***PyErr_SyntaxLocation***(const char *filename, int lineno)

Part of the Stable ABI. 类似于*PyErr_SyntaxLocationEx()*，但省略了 *col_offset* parameter 形参。

void ***PyErr_BadInternalCall***()

Part of the Stable ABI. 这是 `PyErr_SetString(PyExc_SystemError, message)` 的缩写，其中 *message* 表示使用了非法参数调用内部操作（例如，Python/C API 函数）。它主要用于内部使用。

5.3 发出警告

这些函数可以从 C 代码中发出警告。它们仿照了由 Python 模块 `warnings` 导出的那些函数。它们通常向 *sys.stderr* 打印一条警告信息；当然，用户也有可能已经指定将警告转换为错误，在这种情况下，它们将触发异常。也有可能由于警告机制出现问题，使得函数触发异常。如果没有触发异常，返回值为 `0` ；如果触发异常，返回值为 `-1`。(无法确定是否实际打印了警告信息，也无法确定异常触发的原因。这是故意为之)。如果触发了异常，调用者应该进行正常的异常处理（例如，*Py_DECREF()* 持有引用并返回一个错误值)。

int ***PyErr_WarnEx***(*PyObject* *category, const char *message, *Py_ssize_t* stack_level)

Part of the Stable ABI. 发出一个警告信息。参数 *category* 是一个警告类别（见下面）或 `NULL` ；*message* 是一个 UTF-8 编码的字符串。*stack_level* 是一个给出栈帧数量的正数；警告将从该栈帧中当前正在执行的代码行发出。*stack_level* 为 1 的是调用*PyErr_WarnEx()* 的函数，2 是在此之上的函数，以此类推。

警告类别必须是 `PyExc_Warning` 的子类，`PyExc_Warning` 是 `PyExc_Exception` 的子类；默认警告类别是 `PyExc_RuntimeWarning` 。标准 Python 警告类别作为全局变量可用，所有其名称见标准警告类别 。

有关警告控制的信息，参见模块文档 `warnings` 和命令行文档中的 `-W` 选项。没有用于警告控制的 C API。

int ***PyErr_WarnExplicitObject***(*PyObject* *category, *PyObject* *message, *PyObject* *filename, int lineno, *PyObject* *module, *PyObject* *registry)

发出一个对所有警告属性进行显式控制的警告消息。这是位于 Python 函数 `warnings.warn_explicit()` 外层的直接包装；请查看其文档了解详情。*module* 和 *registry* 参数可被设为 `NULL` 以得到相关文档所描述的默认效果。

3.4 新版功能.

int **PyErr_WarnExplicit** (*PyObject* *category, const char *message, const char *filename, int lineno, const char *module, *PyObject* *registry)

Part of the Stable ABI. 类似于`PyErr_WarnExplicitObject()` 不过 *message* 和 *module* 是 UTF-8 编码的字符串，而 *filename* 是由*filesystem encoding and error handler* 解码的。

int **PyErr_WarnFormat** (*PyObject* *category, *Py_ssize_t* stack_level, const char *format, ...)

Part of the Stable ABI. 类似于`PyErr_WarnEx()` 的函数，但使用`PyUnicode_FromFormat()` 来格式化警告消息。*format* 是使用 ASCII 编码的字符串。

3.2 新版功能.

int **PyErr_ResourceWarning** (*PyObject* *source, *Py_ssize_t* stack_level, const char *format, ...)

Part of the Stable ABI *since version 3.6.* 类似于`PyErr_WarnFormat()` 的函数，但 *category* 是 `ResourceWarning` 并且它会将 *source* 传给 `warnings.WarningMessage()`。

3.6 新版功能.

5.4 查询错误指示器

PyObject ***PyErr_Occurred**()

Return value: Borrowed reference. Part of the Stable ABI. Test whether the error indicator is set. If set, return the exception *type* (the first argument to the last call to one of the `PyErr_Set*` functions or to `PyErr_Restore()`). If not set, return `NULL`. You do not own a reference to the return value, so you do not need to `Py_DECREF()` it.

呼叫者必须持有 GIL。

备注: 不要将返回值与特定的异常进行比较；请改为使用`PyErr_ExceptionMatches()`，如下所示。（比较很容易失败因为对于类异常来说，异常可能是一个实例而不是类，或者它可能是预期的异常的一个子类。）

int **PyErr_ExceptionMatches** (*PyObject* *exc)

Part of the Stable ABI. 等价于 `PyErr_GivenExceptionMatches(PyErr_Occurred(), exc)`。此函数应当只在实际设置了异常时才被调用；如果没有任何异常被引发则将发生非法内存访问。

int **PyErr_GivenExceptionMatches** (*PyObject* *given, *PyObject* *exc)

Part of the Stable ABI. 如果 *given* 异常与 *exc* 中的异常类型相匹配则返回真值。如果 *exc* 是一个类对象，则当 *given* 是一个子类的实例时也将返回真值。如果 *exc* 是一个元组，则该元组（以及递归的子元组）中的所有异常类型都将被搜索进行匹配。

void **PyErr_Fetch** (*PyObject* **ptype, *PyObject* **pvalue, *PyObject* **ptraceback)

Part of the Stable ABI. 将错误指示符提取到三个变量中并传递其地址。如果未设置错误指示符，则将三个变量都设为 `NULL`。如果已设置，则将其清除并且你将得到对所提取的每个对象的引用。值和回溯对象可以为 `NULL` 即使类型对象不为空。

备注: 此函数通常只被需要捕获异常的代码或需要临时保存和恢复错误指示符的代码所使用，例如:

```
{
   PyObject *type, *value, *traceback;
   PyErr_Fetch(&type, &value, &traceback);

   /* ... code that might produce other errors ... */

   PyErr_Restore(type, value, traceback);
}
```

void **PyErr_Restore**(*PyObject* *type, *PyObject* *value, *PyObject* *traceback)

Part of the Stable ABI. 基于三个对象设置错误指示符。如果错误指示符已设置，它将首先被清除。如果三个对象均为 NULL，错误指示器将被清除。请不要传入 NULL 类型和非 NULL 值或回溯。异常类型应当是一个类。请不要传入无效的异常类型或值。（违反这些规则将导致微妙的后续问题。）此调用会带走对每个对象的引用：你必须在调用之前拥有对每个对象的引用且在调用之后你将不再拥有这些引用。（如果你不理解这一点，就不要使用此函数。勿谓言之不预。）

备注： 此函数通常只被需要临时保存和恢复错误指示符的代码所使用。请使用 *PyErr_Fetch()* 来保存当前的错误指示符。

void **PyErr_NormalizeException**(*PyObject* **exc, *PyObject* **val, *PyObject* **tb)

Part of the Stable ABI. 在特定情况下，下面 *PyErr_Fetch()* 所返回的值可以是"非正规化的"，即 `*exc` 是一个类对象而 `*val` 不是同一个类的实例。在这种情况下此函数可以被用来实例化类。如果值已经是正规化的，则不做任何操作。实现这种延迟正规化是为了提升性能。

备注： 此函数 不会显式地在异常值上设置 `__traceback__` 属性。如果想要适当地设置回溯，还需要以下附加代码片段:

```
if (tb != NULL) {
  PyException_SetTraceback(val, tb);
}
```

PyObject ***PyErr_GetHandledException**(void)

Part of the Stable ABI *since version 3.11.* Retrieve the active exception instance, as would be returned by `sys.exception()`. This refers to an exception that was *already caught*, not to an exception that was freshly raised. Returns a new reference to the exception or NULL. Does not modify the interpreter's exception state.

备注： This function is not normally used by code that wants to handle exceptions. Rather, it can be used when code needs to save and restore the exception state temporarily. Use *PyErr_SetHandledException()* to restore or clear the exception state.

3.11 新版功能.

void **PyErr_SetHandledException**(*PyObject* *exc)

Part of the Stable ABI *since version 3.11.* Set the active exception, as known from `sys.exception()`. This refers to an exception that was *already caught*, not to an exception that was freshly raised. To clear the exception state, pass NULL.

备注： This function is not normally used by code that wants to handle exceptions. Rather, it can be used when code needs to save and restore the exception state temporarily. Use *PyErr_GetHandledException()* to get the exception state.

3.11 新版功能.

void **PyErr_GetExcInfo**(*PyObject* **ptype, *PyObject* **pvalue, *PyObject* **ptraceback)

Part of the Stable ABI *since version 3.7.* Retrieve the old-style representation of the exception info, as known from `sys.exc_info()`. This refers to an exception that was *already caught*, not to an exception that was freshly raised. Returns new references for the three objects, any of which may be NULL. Does not modify the exception info state. This function is kept for backwards compatibility. Prefer using *PyErr_GetHandledException()*.

备注： 此函数通常不会被需要处理异常的代码所使用。它被使用的场合是在代码需要临时保存并

恢复异常状态的时候。请使用*PyErr_SetExcInfo()* 来恢复或清除异常状态。

3.3 新版功能.

void **PyErr_SetExcInfo**(*PyObject* *type, *PyObject* *value, *PyObject* *traceback)

Part of the Stable ABI *since version 3.7.* Set the exception info, as known from `sys.exc_info()`. This refers to an exception that was *already caught*, not to an exception that was freshly raised. This function steals the references of the arguments. To clear the exception state, pass `NULL` for all three arguments. This function is kept for backwards compatibility. Prefer using *PyErr_SetHandledException()*.

备注: 此函数通常不会被需要处理异常的代码所使用。它被使用的场合是在代码需要临时保存并恢复异常状态的情况。请使用*PyErr_GetExcInfo()* 来读取异常状态。

3.3 新版功能.

在 3.11 版更改: The `type` and `traceback` arguments are no longer used and can be NULL. The interpreter now derives them from the exception instance (the `value` argument). The function still steals references of all three arguments.

5.5 信号处理

int **PyErr_CheckSignals**()

Part of the Stable ABI. 这个函数与 Python 的信号处理交互。

如果在主 Python 解释器下从主线程调用该函数，它将检查是否向进程发送了信号，如果是，则发起调用相应的信号处理句柄。如果支持 `signal` 模块，则可以发起调用以 Python 编写的信号处理句柄。

该函数会尝试处理所有待处理信号，然后返回 `0`。但是，如果 Python 信号处理句柄引发了异常，则设置错误指示符并且函数将立即返回 `-1` (这样其他待处理信号可能还没有被处理：它们将在下次发起调用*PyErr_CheckSignals()* 时被处理)。

如果函数从非主线程调用，或在非主 Python 解释器下调用，则它不执行任何操作并返回 0。

这个函数可以由希望被用户请求 (例如按 Ctrl-C) 中断的长时间运行的 C 代码调用。

备注: 针对 `SIGINT` 的默认 Python 信号处理句柄会引发 `KeyboardInterrupt` 异常。

void **PyErr_SetInterrupt**()

Part of the Stable ABI. 模拟一个 `SIGINT` 信号到达的效果。这等价于 `PyErr_SetInterruptEx(SIGINT)`。

备注: 此函数是异步信号安全的。它可以不带*GIL* 并由 C 信号处理句柄来调用。

int **PyErr_SetInterruptEx**(int signum)

Part of the Stable ABI *since version 3.10.* 模拟一个信号到达的效果。当下次*PyErr_CheckSignals()* 被调用时，将会调用针对指定的信号编号的 Python 信号处理句柄。

此函数可由自行设置信号处理，并希望 Python 信号处理句柄会在请求中断时（例如当用户按下 Ctrl-C 来中断操作时）按照预期被发起调用的 C 代码来调用。

如果给定的信号不是由 Python 来处理的 (即被设为 `signal.SIG_DFL` 或 `signal.SIG_IGN`)，它将会被忽略。

如果 *signum* 在被允许的信号编号范围之外，将返回 `-1`。在其他情况下，则返回 `0`。错误指示符绝不会被此函数所修改。

备注： 此函数是异步信号安全的。它可以不带*GIL* 并由 C 信号处理句柄来调用。

3.10 新版功能.

int **PySignal_SetWakeupFd**(int fd)

这个工具函数指定了一个每当收到信号时将被作为以单个字节的形式写入信号编号的目标的文件描述符。*fd* 必须是非阻塞的。它将返回前一个这样的文件描述符。

设置值 `-1` 将禁用该特性；这是初始状态。这等价于 Python 中的 `signal.set_wakeup_fd()`，但是没有任何错误检查。*fd* 应当是一个有效的文件描述符。此函数应当只从主线程来调用。

在 3.5 版更改: 在 Windows 上，此函数现在也支持套接字处理。

5.6 Exception 类

PyObject ***PyErr_NewException**(const char *name, *PyObject* *base, *PyObject* *dict)

Return value: New reference. Part of the Stable ABI. 这个工具函数会创建并返回一个新的异常类。*name* 参数必须为新异常的名称，是 `module.classname` 形式的 C 字符串。*base* 和 *dict* 参数通常为 `NULL`。这将创建一个派生自 `Exception` 的类对象（在 C 中可以通过 `PyExc_Exception` 访问）。

新类的 `__module__` 属性将被设为 *name* 参数的前半部分（最后一个点号之前），而类名将被设为后半部分（最后一个点号之后）。*base* 参数可被用来指定替代基类；它可以是一个类或是一个由类组成的元组。*dict* 参数可被用来指定一个由类变量和方法组成的字典。

PyObject ***PyErr_NewExceptionWithDoc**(const char *name, const char *doc, *PyObject* *base, *PyObject* *dict)

Return value: New reference. Part of the Stable ABI. 和*`PyErr_NewException()`* 一样，除了可以轻松地给新的异常类一个文档字符串：如果 *doc* 属性非空，它将用作异常类的文档字符串。

3.2 新版功能.

5.7 异常对象

PyObject ***PyException_GetTraceback**(*PyObject* *ex)

Return value: New reference. Part of the Stable ABI. 将与异常相关联的回溯作为一个新引用返回，可以通过 `__traceback__` 在 Python 中访问。如果没有已关联的回溯，则返回 `NULL`。

int **PyException_SetTraceback**(*PyObject* *ex, *PyObject* *tb)

Part of the Stable ABI. 将异常关联的回溯设置为 *tb* 。使用 "Py_None"清除它。

PyObject ***PyException_GetContext**(*PyObject* *ex)

Return value: New reference. Part of the Stable ABI. 将与异常相关联的上下文（在处理 *ex* 的过程中引发的另一个异常实例）作为一个新引用返回，可以通过 `__context__` 在 Python 中访问。如果没有已关联的上下文，则返回 `NULL`。

void **PyException_SetContext**(*PyObject* *ex, *PyObject* *ctx)

Part of the Stable ABI. 将与异常相关联的上下文设置为 *ctx*。使用 `NULL` 来清空它。没有用来确保 *ctx* 是一个异常实例的类型检查。这将窃取一个指向 *ctx* 的引用。

PyObject ***PyException_GetCause**(*PyObject* *ex)

Return value: New reference. Part of the Stable ABI. 将与异常相关联的原因（一个异常实例，或是 `None`，由 `raise ... from ...` 设置）作为一个新引用返回，可在 Python 中通过 `__cause__` 来访问。

void **PyException_SetCause**(*PyObject* *ex, *PyObject* *cause)

Part of the Stable ABI. 将与异常相关联的原因设置为 *cause*。使用 `NULL` 来清空它。它没有用来确保 *cause* 是一个异常实例或 `None` 的类型检查。这将偷取一个指向 *cause* 的引用。

`__suppress_context__` 会被此函数隐式地设为 `True`。

5.8 Unicode 异常对象

下列函数被用于创建和修改来自 C 的 Unicode 异常。

PyObject ***PyUnicodeDecodeError_Create**(const char *encoding, const char *object, *Py_ssize_t* length, *Py_ssize_t* start, *Py_ssize_t* end, const char *reason)

Return value: New reference. Part of the Stable ABI. 创建一个 `UnicodeDecodeError` 对象并附带 *encoding*, *object*, *length*, *start*, *end* 和 *reason* 等属性。*encoding* 和 *reason* 为 UTF-8 编码的字符串。

PyObject ***PyUnicodeDecodeError_GetEncoding**(*PyObject* *exc)

PyObject ***PyUnicodeEncodeError_GetEncoding**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 返回给定异常对象的 *encoding* 属性

PyObject ***PyUnicodeDecodeError_GetObject**(*PyObject* *exc)

PyObject ***PyUnicodeEncodeError_GetObject**(*PyObject* *exc)

PyObject ***PyUnicodeTranslateError_GetObject**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 返回给定异常对象的 *object* 属性

int **PyUnicodeDecodeError_GetStart**(*PyObject* *exc, *Py_ssize_t* *start)

int **PyUnicodeEncodeError_GetStart**(*PyObject* *exc, *Py_ssize_t* *start)

int **PyUnicodeTranslateError_GetStart**(*PyObject* *exc, *Py_ssize_t* *start)

Part of the Stable ABI. 获取给定异常对象的 *start* 属性并将其放入 **start*。*start* 必须不为 `NULL`。成功时返回 `0`，失败时返回 `-1`。

int **PyUnicodeDecodeError_SetStart**(*PyObject* *exc, *Py_ssize_t* start)

int **PyUnicodeEncodeError_SetStart**(*PyObject* *exc, *Py_ssize_t* start)

int **PyUnicodeTranslateError_SetStart**(*PyObject* *exc, *Py_ssize_t* start)

Part of the Stable ABI. 将给定异常对象的 *start* 属性设为 *start*。成功时返回 `0`，失败时返回 `-1`。

int **PyUnicodeDecodeError_GetEnd**(*PyObject* *exc, *Py_ssize_t* *end)

int **PyUnicodeEncodeError_GetEnd**(*PyObject* *exc, *Py_ssize_t* *end)

int **PyUnicodeTranslateError_GetEnd**(*PyObject* *exc, *Py_ssize_t* *end)

Part of the Stable ABI. 获取给定异常对象的 *end* 属性并将其放入 **end*。*end* 必须不为 `NULL`。成功时返回 `0`，失败时返回 `-1`。

int **PyUnicodeDecodeError_SetEnd**(*PyObject* *exc, *Py_ssize_t* end)

int **PyUnicodeEncodeError_SetEnd**(*PyObject* *exc, *Py_ssize_t* end)

int **PyUnicodeTranslateError_SetEnd**(*PyObject* *exc, *Py_ssize_t* end)

Part of the Stable ABI. 将给定异常对象的 *end* 属性设为 *end*。成功时返回 `0`，失败时返回 `-1`。

PyObject ***PyUnicodeDecodeError_GetReason**(*PyObject* *exc)

PyObject ***PyUnicodeEncodeError_GetReason**(*PyObject* *exc)

PyObject ***PyUnicodeTranslateError_GetReason**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 返回给定异常对象的 *reason* 属性

int **PyUnicodeDecodeError_SetReason**(*PyObject* *exc, const char *reason)

int **PyUnicodeEncodeError_SetReason**(*PyObject* *exc, const char *reason)

int **PyUnicodeTranslateError_SetReason**(*PyObject* *exc, const char *reason)

Part of the Stable ABI. 将给定异常对象的 *reason* 属性设为 *reason*。成功时返回 `0`，失败时返回 `-1`。

5.9 递归控制

这两个函数提供了一种在 C 层级上进行安全的递归调用的方式，在核心模块与扩展模块中均适用。当递归代码不一定会发起调用 Python 代码（后者会自动跟踪其递归深度）时就需要用到它们。它们对于 *tp_call* 实现来说也无必要因为调用协议 会负责递归处理。

int **Py_EnterRecursiveCall**(const char *where)

Part of the Stable ABI *since version 3.9.* 标记一个递归的 C 层级调用即将被执行的点位。

如果定义了 `USE_STACKCHECK`，此函数会使用 `PyOS_CheckStack()` 来检查操作系统堆栈是否溢出。在这种情况下，它将设置一个 `MemoryError` 并返回非零值。

随后此函数将检查是否达到递归限制。如果是的话，将设置一个 `RecursionError` 并返回一个非零值。在其他情况下，则返回零。

where 应为一个 UTF-8 编码的字符串如 `" in instance check"`，它将与由递归深度限制所导致的 `RecursionError` 消息相拼接。

在 3.9 版更改: 此函数现在也在受限 API 中可用。

void **Py_LeaveRecursiveCall**(void)

Part of the Stable ABI *since version 3.9.* 结束一个 `Py_EnterRecursiveCall()`。必须针对 `Py_EnterRecursiveCall()` 的每个 成功的发起调用操作执行一次调用。

在 3.9 版更改: 此函数现在也在受限 API 中可用。

正确地针对容器类型实现 `tp_repr` 需要特别的递归处理。在保护栈之外，`tp_repr` 还需要追踪对象以防止出现循环。以下两个函数将帮助完成此功能。从实际效果来说，这两个函数是 C 中对应 `reprlib.recursive_repr()` 的等价物。

int **Py_ReprEnter**(*PyObject* *object)

Part of the Stable ABI. 在 `tp_repr` 实现的开头被调用以检测循环。

如果对象已经被处理，此函数将返回一个正整数。在此情况下 `tp_repr` 实现应当返回一个指明发生循环的字符串对象。例如，`dict` 对象将返回 `{...}` 而 `list` 对象将返回 `[...]`。

如果已达到递归限制则此函数将返回一个负正数。在此情况下 `tp_repr` 实现通常应当返回 `NULL`。

在其他情况下，此函数将返回零而 `tp_repr` 实现将可正常继续。

void **Py_ReprLeave**(*PyObject* *object)

Part of the Stable ABI. 结束一个 `Py_ReprEnter()`。必须针对每个返回零的 `Py_ReprEnter()` 的发起调用操作调用一次。

5.10 标准异常

All standard Python exceptions are available as global variables whose names are `PyExc_` followed by the Python exception name. These have the type `PyObject*`; they are all class objects. For completeness, here are all the variables:

C 名称	Python 名称	备注
`PyExc_BaseException`	`BaseException`	1
`PyExc_Exception`	`Exception`	Page 55, 1
`PyExc_ArithmeticError`	`ArithmeticError`	Page 55, 1
`PyExc_AssertionError`	`AssertionError`	
`PyExc_AttributeError`	`AttributeError`	
`PyExc_BlockingIOError`	`BlockingIOError`	
`PyExc_BrokenPipeError`	`BrokenPipeError`	
`PyExc_BufferError`	`BufferError`	
`PyExc_ChildProcessError`	`ChildProcessError`	

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表 1 – 续上页

C 名称	Python 名称	备注
PyExc_ConnectionAbortedError	ConnectionAbortedError	
PyExc_ConnectionError	ConnectionError	
PyExc_ConnectionRefusedError	ConnectionRefusedError	
PyExc_ConnectionResetError	ConnectionResetError	
PyExc_EOFError	EOFError	
PyExc_FileExistsError	FileExistsError	
PyExc_FileNotFoundError	FileNotFoundError	
PyExc_FloatingPointError	FloatingPointError	
PyExc_GeneratorExit	GeneratorExit	
PyExc_ImportError	ImportError	
PyExc_IndentationError	IndentationError	
PyExc_IndexError	IndexError	
PyExc_InterruptedError	InterruptedError	
PyExc_IsADirectoryError	IsADirectoryError	
PyExc_KeyError	KeyError	
PyExc_KeyboardInterrupt	KeyboardInterrupt	
PyExc_LookupError	LookupError	Page 55, 1
PyExc_MemoryError	MemoryError	
PyExc_ModuleNotFoundError	ModuleNotFoundError	
PyExc_NameError	NameError	
PyExc_NotADirectoryError	NotADirectoryError	
PyExc_NotImplementedError	NotImplementedError	
PyExc_OSError	OSError	Page 55, 1
PyExc_OverflowError	OverflowError	
PyExc_PermissionError	PermissionError	
PyExc_ProcessLookupError	ProcessLookupError	
PyExc_RecursionError	RecursionError	
PyExc_ReferenceError	ReferenceError	
PyExc_RuntimeError	RuntimeError	
PyExc_StopAsyncIteration	StopAsyncIteration	
PyExc_StopIteration	StopIteration	
PyExc_SyntaxError	SyntaxError	
PyExc_SystemError	SystemError	
PyExc_SystemExit	SystemExit	
PyExc_TabError	TabError	
PyExc_TimeoutError	TimeoutError	
PyExc_TypeError	TypeError	
PyExc_UnboundLocalError	UnboundLocalError	
PyExc_UnicodeDecodeError	UnicodeDecodeError	
PyExc_UnicodeEncodeError	UnicodeEncodeError	
PyExc_UnicodeError	UnicodeError	
PyExc_UnicodeTranslateError	UnicodeTranslateError	
PyExc_ValueError	ValueError	
PyExc_ZeroDivisionError	ZeroDivisionError	

3.3 新版功能: `PyExc_BlockingIOError`, `PyExc_BrokenPipeError`, `PyExc_ChildProcessError`, `PyExc_ConnectionError`, `PyExc_ConnectionAbortedError`, `PyExc_ConnectionRefusedError`, `PyExc_ConnectionResetError`, `PyExc_FileExistsError`, `PyExc_FileNotFoundError`, `PyExc_InterruptedError`, `PyExc_IsADirectoryError`, `PyExc_NotADirectoryError`, `PyExc_PermissionError`, `PyExc_ProcessLookupError` and `PyExc_TimeoutError` 介绍如下 **PEP 3151**.

3.5 新版功能: `PyExc_StopAsyncIteration` 和 `PyExc_RecursionError`.

[1] 这是其他标准异常的基类。

3.6 新版功能: PyExc_ModuleNotFoundError.

这些是兼容性别名 PyExc_OSError:

C 名称	备注
PyExc_EnvironmentError	
PyExc_IOError	
PyExc_WindowsError	[2]

在 3.3 版更改: 这些别名曾经是单独的异常类型。

注:

5.11 标准警告类别

All standard Python warning categories are available as global variables whose names are PyExc_ followed by the Python exception name. These have the type *PyObject**; they are all class objects. For completeness, here are all the variables:

C 名称	Python 名称	备注
PyExc_Warning	Warning	[3]
PyExc_BytesWarning	BytesWarning	
PyExc_DeprecationWarning	DeprecationWarning	
PyExc_FutureWarning	FutureWarning	
PyExc_ImportWarning	ImportWarning	
PyExc_PendingDeprecationWarning	PendingDeprecationWarning	
PyExc_ResourceWarning	ResourceWarning	
PyExc_RuntimeWarning	RuntimeWarning	
PyExc_SyntaxWarning	SyntaxWarning	
PyExc_UnicodeWarning	UnicodeWarning	
PyExc_UserWarning	UserWarning	

3.2 新版功能: PyExc_ResourceWarning.

注:

[2] 仅在 Windows 中定义；检测是否定义了预处理程序宏 MS_WINDOWS ，以便保护用到它的代码。

[3] 这是其他标准警告类别的基类。

CHAPTER 6

工具

本章中的函数执行各种实用工具任务，包括帮助 C 代码提升跨平台可移植性，在 C 中使用 Python 模块，以及解析函数参数并根据 C 中的值构建 Python 中的值等等。

6.1 操作系统实用工具

PyObject ***PyOS_FSPath**(*PyObject* *path)

Return value: New reference. Part of the Stable ABI *since version 3.6.* 返回 *path* 在文件系统中的表示形式。如果该对象是一个 `str` 或 `bytes` 对象，则它的引用计数将会增加。如果该对象实现了 `os.PathLike` 接口，则只要它是一个 `str` 或 `bytes` 对象就将返回 `__fspath__()`。在其他情况下将引发 `TypeError` 并返回 `NULL`。

3.6 新版功能.

int **Py_FdIsInteractive**(FILE *fp, const char *filename)

如果名称为 *filename* 的标准 I/O 文件 *fp* 被确认为可交互的则返回真（非零）值。`isatty(fileno(fp))` 为真值的文件均属于这种情况。如果全局旗标 *Py_InteractiveFlag* 为真值，此函数在 *filename* 指针为 `NULL` 或者其名称等于字符串 `'<stdin>'` 或 `'???'` 时也将返回真值。

void **PyOS_BeforeFork**()

Part of the Stable ABI *on platforms with fork() since version 3.7.* 在进程分叉之前准备某些内部状态的函数。此函数应当在调用 `fork()` 或者任何类似的克隆当前进程的函数之前被调用。只适用于定义了 `fork()` 的系统。

> **警告：** C `fork()` 调用应当只在*"main" 线程*（位于*"main" 解释器*）中进行。对于 `PyOS_BeforeFork()` 来说也是如此。

3.7 新版功能.

void **PyOS_AfterFork_Parent**()

Part of the Stable ABI *on platforms with fork() since version 3.7.* 在进程分叉之后更新某些内部状态的函数。此函数应当在调用 `fork()` 或任何类似的克隆当前进程的函数之后被调用，无论进程克隆是否成功。只适用于定义了 `fork()` 的系统。

> **警告:** C fork() 调用应当只在"main" 线程 (位于"main" 解释器) 中进行。对于 PyOS_AfterFork_Parent() 来说也是如此。

3.7 新版功能.

void **PyOS_AfterFork_Child**()

Part of the Stable ABI *on platforms with fork() since version 3.7.* 在进程分叉之后更新内部解释器状态的函数。此函数必须在调用 fork() 或任何类似的克隆当前进程的函数之后在子进程中被调用，如果该进程有机会回调到 Python 解释器的话。只适用于定义了 fork() 的系统。

> **警告:** C fork() 调用应当只在"main" 线程 (位于"main" 解释器) 中进行。对于 PyOS_AfterFork_Child() 来说也是如此。

3.7 新版功能.

参见:

os.register_at_fork() 允许注册可被*PyOS_BeforeFork()*, *PyOS_AfterFork_Parent()* 和*PyOS_AfterFork_Child()* 调用的自定义 Python 函数。

void **PyOS_AfterFork**()

Part of the Stable ABI *on platforms with fork().* 在进程分叉之后更新某些内部状态的函数；如果要继续使用 Python 解释器则此函数应当在新进程中被调用。如果已将一个新的可执行文件载入到新进程中，则不需要调用此函数。

3.7 版后已移除: 此函数已被*PyOS_AfterFork_Child()* 取代。

int **PyOS_CheckStack**()

Part of the Stable ABI *on platforms with USE_STACKCHECK since version 3.7.* Return true when the interpreter runs out of stack space. This is a reliable check, but is only available when USE_STACKCHECK is defined (currently on certain versions of Windows using the Microsoft Visual C++ compiler). USE_STACKCHECK will be defined automatically; you should never change the definition in your own code.

PyOS_sighandler_t **PyOS_getsig**(int i)

Part of the Stable ABI. Return the current signal handler for signal *i*. This is a thin wrapper around either sigaction() or signal(). Do not call those functions directly! PyOS_sighandler_t is a typedef alias for void (*)(int).

PyOS_sighandler_t **PyOS_setsig**(int i, PyOS_sighandler_t h)

Part of the Stable ABI. Set the signal handler for signal *i* to be *h*; return the old signal handler. This is a thin wrapper around either sigaction() or signal(). Do not call those functions directly! PyOS_sighandler_t is a typedef alias for void (*)(int).

wchar_t ***Py_DecodeLocale**(const char *arg, size_t *size)

Part of the Stable ABI *since version 3.7.*

> **警告:** 此函数不应当被直接调用：请使用*PyConfig* API 以及可确保*对 Python 进行预初始化* 的 PyConfig_SetBytesString() 函数。
>
> 此函数不可在 This function must not be called before *对 Python 进行预初始化* 之前被调用以便正确地配置 LC_CTYPE 语言区域：请参阅*Py_PreInitialize()* 函数。

使用*filesystem encoding and error handler* 来解码一个字节串。如果错误处理句柄为 surrogateescape 错误处理句柄，则不可解码的字节将被解码为 U+DC80..U+DCFF 范围内的字符；而如果一个字节序列可被解码为代理字符，则其中的字节会使用 surrogateescape 错误处理句柄来转义而不是解码它们。

返回一个指向新分配的由宽字符组成的字符串的指针，使用`PyMem_RawFree()` 来释放内存。如果 size 不为 `NULL`，则将排除了 null 字符的宽字符数量写入到 `*size`

在解码错误或内存分配错误时返回 `NULL`。如果 *size* 不为 `NULL`，则 `*size` 将在内存错误时设为 `(size_t)-1` 或在解码错误时设为 `(size_t)-2`。

filesystem encoding and error handler 是由 `PyConfig_Read()` 来选择的：参见`PyConfig` 的`filesystem_encoding` 和`filesystem_errors` 等成员。

解码错误绝对不应当发生，除非 C 库有程序缺陷。

请使用`Py_EncodeLocale()` 函数来将字符串编码回字节串。

参见：

`PyUnicode_DecodeFSDefaultAndSize()` 和`PyUnicode_DecodeLocaleAndSize()` 函数。

3.5 新版功能.

在 3.7 版更改: 现在此函数在 Python UTF-8 模式下将使用 UTF-8 编码格式。

在 3.8 版更改: 现在如果在 Windows 上`Py_LegacyWindowsFSEncodingFlag` 为零则此函数将使用 UTF-8 编码格式；

char ***Py_EncodeLocale**(const wchar_t *text, size_t *error_pos)

Part of the Stable ABI *since version 3.7.* 将一个由宽字符组成的字符串编码为*filesystem encoding and error handler*。如果错误处理句柄为 surrogateescape 错误处理句柄，则在 U+DC80..U+DCFF 范围内的代理字符会被转换为字节值 0x80..0xFF。

返回一个指向新分配的字节串的指针，使用`PyMem_Free()` 来释放内存。当发生编码错误或内存分配错误时返回 `NULL`。

如果 error_pos 不为 `NULL`，则成功时会将 `*error_pos` 设为 `(size_t)-1`，或是在发生编码错误时设为无效字符的索引号。

filesystem encoding and error handler 是由 `PyConfig_Read()` 来选择的：参见`PyConfig` 的`filesystem_encoding` 和`filesystem_errors` 等成员。

请使用`Py_DecodeLocale()` 函数来将字节串解码回由宽字符组成的字符串。

> **警告：** 此函数不可在 This function must not be called before *对 Python 进行预初始化* 之前被调用以便正确地配置 LC_CTYPE 语言区域：请参阅`Py_PreInitialize()` 函数。

参见：

`PyUnicode_EncodeFSDefault()` 和`PyUnicode_EncodeLocale()` 函数。

3.5 新版功能.

在 3.7 版更改: 现在此函数在 Python UTF-8 模式下将使用 UTF-8 编码格式。

在 3.8 版更改: 现在如果在 Windows 上`Py_LegacyWindowsFSEncodingFlag` 为零则此函数将使用 UTF-8 编码格式。

6.2 系统功能

这些是使来自 sys 模块的功能可以让 C 代码访问的工具函数。它们都可用于当前解释器线程的 sys 模块的字典，该字典包含在内部线程状态结构体中。

PyObject ***PySys_GetObject** (const char *name)

Return value: Borrowed reference. Part of the Stable ABI. 返回来自 sys 模块的对象 *name* 或者如果它不存在则返回 NULL，并且不会设置异常。

int **PySys_SetObject** (const char *name, *PyObject* *v)

Part of the Stable ABI. 将 sys 模块中的 *name* 设为 *v* 除非 *v* 为 NULL，在此情况下 *name* 将从 sys 模块中被删除。成功时返回 0，发生错误时返回 -1。

void **PySys_ResetWarnOptions** ()

Part of the Stable ABI. 将 sys.warnoptions 重置为空列表。此函数可在*Py_Initialize()* 之前被调用。

void **PySys_AddWarnOption** (const wchar_t *s)

Part of the Stable ABI. This API is kept for backward compatibility: setting *PyConfig.warnoptions* should be used instead, see *Python Initialization Configuration*.

将 *s* 添加到 sys.warnoptions。此函数必须在*Py_Initialize()* 之前被调用以便影响警告过滤器列表。

3.11 版后已移除.

void **PySys_AddWarnOptionUnicode** (*PyObject* *unicode)

Part of the Stable ABI. This API is kept for backward compatibility: setting *PyConfig.warnoptions* should be used instead, see *Python Initialization Configuration*.

将 *unicode* 添加到 sys.warnoptions。

注意：目前此函数不可在 CPython 实现之外使用，因为它必须在*Py_Initialize()* 中的 warnings 显式导入之前被调用，但是要等运行时已初始化到足以允许创建 Unicode 对象时才能被调用。

3.11 版后已移除.

void **PySys_SetPath** (const wchar_t *path)

Part of the Stable ABI. This API is kept for backward compatibility: setting *PyConfig.module_search_paths* and *PyConfig.module_search_paths_set* should be used instead, see *Python Initialization Configuration*.

将 sys.path 设为由在 *path* 中找到的路径组成的列表对象，该参数应为使用特定平台的搜索路径分隔符 (在 Unix 上为 :，在 Windows 上为 ;) 分隔的路径的列表。

3.11 版后已移除.

void **PySys_WriteStdout** (const char *format, ...)

Part of the Stable ABI. 将以 *format* 描述的输出字符串写入到 sys.stdout。不会引发任何异常，即使发生了截断（见下文）。

format 应当将已格式化的输出字符串的总大小限制在 1000 字节以下 -- 超过 1000 字节后，输出字符串会被截断。特别地，这意味着不应出现不受限制的"%s" 格式；它们应当使用"%.<N>s" 来限制，其中 <N> 是一个经计算使得 <N> 与其他已格式化文本的最大尺寸之和不会超过 1000 字节的十进制数字。还要注意"%f"，它可能为非常大的数字打印出数以百计的数位。

如果发生了错误，sys.stdout 会被清空，已格式化的消息将被写入到真正的 (C 层级) *stdout*。

void **PySys_WriteStderr** (const char *format, ...)

Part of the Stable ABI. 类似*PySys_WriteStdout()*，但改为写入到 sys.stderr 或 *stderr*。

void **PySys_FormatStdout** (const char *format, ...)

Part of the Stable ABI. 类似 PySys_WriteStdout() 的函数将会使用PyUnicode_FromFormatV() 来格式化消息并且不会将消息截短至任意长度。

3.2 新版功能.

void **PySys_FormatStderr** (const char *format, ...)

Part of the Stable ABI. 类似PySys_FormatStdout()，但改为写入到 sys.stderr 或 *stderr*。

3.2 新版功能.

void **PySys_AddXOption** (const wchar_t *s)

Part of the Stable ABI *since version 3.7.* This API is kept for backward compatibility: setting PyConfig.xoptions should be used instead, see *Python Initialization Configuration*.

将 *s* 解析为一个由 -X 选项组成的集合并将它们添加到PySys_GetXOptions() 所返回的当前选项映射。此函数可以在Py_Initialize() 之前被调用。

3.2 新版功能.

3.11 版后已移除.

PyObject ***PySys_GetXOptions** ()

Return value: Borrowed reference. Part of the Stable ABI *since version 3.7.* 返回当前 -X 选项的字典，类似于 sys._xoptions。发生错误时，将返回 NULL 并设置一个异常。

3.2 新版功能.

int **PySys_Audit** (const char *event, const char *format, ...)

引发一个审计事件并附带任何激活的钩子。成功时返回零值或在失败时返回非零值并设置一个异常。

如果已添加了任何钩子，则将使用 *format* 和其他参数来构造一个用入传入的元组。除 N 以外，在Py_BuildValue() 中使用的格式字符均可使用。如果构建的值不是一个元组，它将被添加到一个单元素元组中。(格式选项 N 会消耗一个引用，但是由于没有办法知道此函数的参数是否将被消耗，因此使用它可能导致引用泄漏。)

请注意 # 格式字符应当总是被当作Py_ssize_t 来处理，无论是否定义了 PY_SSIZE_T_CLEAN。

sys.audit() 会执行与来自 Python 代码的函数相同的操作。

3.8 新版功能.

在 3.8.2 版更改: 要求Py_ssize_t 用于 # 格式字符。在此之前，会引发一个不可避免的弃用警告。

int **PySys_AddAuditHook** (Py_AuditHookFunction hook, void *userData)

将可调用对象 *hook* 添加到激活的审计钩子列表。在成功时返回零而在失败时返回非零值。如果运行时已经被初始化，还会在失败时设置一个错误。通过此 API 添加的钩子会针对在运行时创建的所有解释器被调用。

userData 指针会被传入钩子函数。因于钩子函数可能由不同的运行时调用，该指针不应直接指向 Python 状态。

此函数可在Py_Initialize() 之前被安全地调用。如果在运行时初始化之后被调用，现有的审计钩子将得到通知并可能通过引发一个从 Exception 子类化的错误静默地放弃操作（其他错误将不会被静默)。

The hook function is of type int (*)(const char *event, PyObject *args, void *userData), where *args* is guaranteed to be a PyTupleObject. The hook function is always called with the GIL held by the Python interpreter that raised the event.

请参阅 **PEP 578** 了解有关审计的详细描述。在运行时和标准库中会引发审计事件的函数清单见 审计事件表。更多细节见每个函数的文档。

引发一个 审计事件 sys.addaudithook，没有附带参数。

3.8 新版功能.

6.3 过程控制

void **Py_FatalError** (const char *message)

Part of the Stable ABI. 打印一个致命错误消息并杀掉进程。不会执行任何清理。此函数应当仅在检测到可能令继续使用 Python 解释器变得危险的条件时被发起调用；例如，当对象管理已被破坏的时候。在 Unix 上，标准 C 库函数 `abort()` 会被调用并将由它来尝试产生一个 `core` 文件。

The `Py_FatalError()` function is replaced with a macro which logs automatically the name of the current function, unless the `Py_LIMITED_API` macro is defined.

在 3.9 版更改: 自动记录函数名称。

void **Py_Exit** (int status)

Part of the Stable ABI. 退出当前进程。这将调用`Py_FinalizeEx()` 然后再调用标准 C 库函数 `exit(status)`。如果`Py_FinalizeEx()` 提示错误，退出状态将被设为 120。

在 3.6 版更改: 来自最终化的错误不会再被忽略。

int **Py_AtExit** (void (*func)())

Part of the Stable ABI. 注册一个由`Py_FinalizeEx()` 调用的清理函数。调用清理函数将不传入任何参数且不应返回任何值。最多可以注册 32 个清理函数。当注册成功时，`Py_AtExit()` 将返回 `0`；失败时，它将返回 `-1`。最后注册的清理函数会最先被调用。每个清理函数将至多被调用一次。由于 Python 的内部最终化将在清理函数之前完成，因此 Python API 不应被 *func* 调用。

6.4 导入模块

PyObject ***PyImport_ImportModule*** (const char *name)

Return value: New reference. Part of the Stable ABI. 这是下面`PyImport_ImportModuleEx()` 的简化版接口，将 *globals* 和 *locals* 参数设为 `NULL` 并将 *level* 设为 0。当 *name* 参数包含一个点号（即指定了一个包的子模块）时，*fromlist* 参数会被设为列表 `['*']` 这样返回值将为所指定的模块而不像在其他情况下那样为包含模块的最高层级包。（不幸的是，这在 *name* 实际上是指定一个子包而非子模块时将有一个额外的副作用：在包的 `__all__` 变量中指定的子模块会被加载。）返回一个对所导入模块的新引用，或是在导入失败时返回 `NULL` 并设置一个异常。模块导入失败同模块不会留在 `sys.modules` 中。

该函数总是使用绝对路径导入。

PyObject ***PyImport_ImportModuleNoBlock*** (const char *name)

Return value: New reference. Part of the Stable ABI. 该函数是`PyImport_ImportModule()` 的一个被遗弃的别名。

在 3.3 版更改: 在导入锁被另一线程掌控时此函数会立即失败。但是从 Python 3.3 起，锁方案在大多数情况下都已切换为针对每个模块加锁，所以此函数的特殊行为已无必要。

PyObject ***PyImport_ImportModuleEx*** (const char *name, *PyObject* *globals, *PyObject* *locals, *PyObject* *fromlist)

Return value: New reference. 导入一个模块。请参阅内置 Python 函数 `__import__()` 获取完善的相关描述。

返回值是一个对所导入模块或最高层级包的新引用，或是在导入失败时则为 `NULL` 并设置一个异常。与 `__import__()` 类似，当请求一个包的子模块时返回值通常为该最高层级包，除非给出了一个非空的 *fromlist*。

导入失败将移动不完整的模块对象，就像`PyImport_ImportModule()` 那样。

PyObject ***PyImport_ImportModuleLevelObject*** (*PyObject* *name, *PyObject* *globals, *PyObject* *locals, *PyObject* *fromlist, int level)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 导入一个模块。关于此函数的最佳说明请参考内置 Python 函数 `__import__()`，因为标准 `__import__()` 函数会直接调用此函数。

返回值是一个对所导入模块或最高层级包的新引用，或是在导入失败时则为 NULL 并设置一个异常。与 __import__() 类似，当请求一个包的子模块时返回值通常为该最高层级包，除非给出了一个非空的 *fromlist*。

3.3 新版功能.

PyObject ***PyImport_ImportModuleLevel**(const char *name, *PyObject* *globals, *PyObject* *locals, *PyObject* *fromlist, int level)

Return value: New reference. Part of the Stable ABI. 类似于*PyImport_ImportModuleLevelObject()*，但其名称为 UTF-8 编码的字符串而不是 Unicode 对象。

在 3.3 版更改: 不再接受 *level* 为负数值。

PyObject ***PyImport_Import**(*PyObject* *name)

Return value: New reference. Part of the Stable ABI. 这是一个调用了当前"导入钩子函数"的更高层级接口（显式指定 *level* 为 0，表示绝对导入）。它将发起调用当前全局作用域下 __builtins__ 中的 __import__() 函数。这意味着将使用当前环境下安装的任何导入钩子来完成导入。

该函数总是使用绝对路径导入。

PyObject ***PyImport_ReloadModule**(*PyObject* *m)

Return value: New reference. Part of the Stable ABI. 重载一个模块。返回一个指向被重载模块的新引用，或者在失败时返回 NULL 并设置一个异常（在此情况下模块仍然会存在）。

PyObject ***PyImport_AddModuleObject**(*PyObject* *name)

Return value: Borrowed reference. Part of the Stable ABI *since version 3.7.* 返回对应于某个模块名称的模块对象。*name* 参数的形式可以为 package.module。如果存在 modules 字典则首先检查该字典，如果找不到，则创建一个新模块并将其插入到 modules 字典。在失败时返回 NULL 并设置一个异常。

备注： 此函数不会加载或导入指定模块；如果模块还未被加载，你将得到一个空的模块对象。请使用*PyImport_ImportModule()* 或它的某个变体形式来导入模块。*name* 使用带点号名称的包结构如果尚不存在则不会被创建。

3.3 新版功能.

PyObject ***PyImport_AddModule**(const char *name)

Return value: Borrowed reference. Part of the Stable ABI. 类似于*PyImport_AddModuleObject()*，但其名称为 UTF-8 编码的字符串而不是 Unicode 对象。object.

PyObject ***PyImport_ExecCodeModule**(const char *name, *PyObject* *co)

Return value: New reference. Part of the Stable ABI. 给定一个模块名称（可能为 package.module 形式）和一个从 Pyhon 字节码文件读取或从内置函数 compile() 获取的代码对象，加载该模块。返回对该模块对象的新引用，或者如果发生错误则返回 NULL 并设置一个异常。在发生错误的情况下 *name* 会从 sys.modules 中被移除，即使 *name* 在进入*PyImport_ExecCodeModule()* 时已存在于 sys.modules 中。在 sys.modules 中保留未完全初始化的模块是危险的，因为导入这样的模块没有办法知道模块对象是否处于一种未知的（对于模块作业的意图来说可能是已损坏的）状态。

模块的 __spec__ 和 __loader__ 如果尚未设置的话，将被设置为适当的值。相应 spec 的加载器（如果已设置）将被设为模块的 __loader__ 而在其他情况下设为 SourceFileLoader 的实例。

模块的 __file__ 属性将被设为代码对象的 co_filename。如果适用，__cached__ 也将被设置。

如果模块已被导入则此函数将重载它。请参阅*PyImport_ReloadModule()* 了解重载模块的预定方式。

如果 *name* 指向一个形式为 package.module 的带点号的名称，则任何尚未创建的包结构仍然不会被创建。

另请参阅*PyImport_ExecCodeModuleEx()* 和*PyImport_ExecCodeModuleWithPathnames()*。

PyObject ***PyImport_ExecCodeModuleEx** (const char *name, *PyObject* *co, const char *pathname)

Return value: New reference. Part of the Stable ABI. 类似于 *PyImport_ExecCodeModule()*，但如果 *pathname* 不为 NULL 则会被设为模块对象的 `__file__` 属性的值。

参见 *PyImport_ExecCodeModuleWithPathnames()*。

PyObject ***PyImport_ExecCodeModuleObject** (*PyObject* *name, *PyObject* *co, *PyObject* *pathname, *PyObject* *cpathname)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 类似于 *PyImport_ExecCodeModuleEx()*，但如果 *cpathname* 不为 NULL 则会被设为模块对象的 `__cached__` 值。在三个函数中，这是推荐使用的一个。

3.3 新版功能.

PyObject ***PyImport_ExecCodeModuleWithPathnames** (const char *name, *PyObject* *co, const char *pathname, const char *cpathname)

Return value: New reference. Part of the Stable ABI. 类似于 *PyImport_ExecCodeModuleObject()*，但 *name*, *pathname* 和 *cpathname* 为 UTF-8 编码的字符串。如果 *pathname* 也被设为 NULL 则还会尝试根据 *cpathname* 推断出前者的值。

3.2 新版功能.

在 3.3 版更改: 如果只提供了字节码路径则会使用 `imp.source_from_cache()` 来计算源路径。

long **PyImport_GetMagicNumber** ()

Part of the Stable ABI. 返回 Python 字节码文件（即 `.pyc` 文件）的魔数。此魔数应当存在于字节码文件的开头四个字节中，按照小端字节序。出错时返回 `-1`。

在 3.3 版更改: 失败时返回值 `-1`。

const char ***PyImport_GetMagicTag** ()

Part of the Stable ABI. 针对 **PEP 3147** 格式的 Python 字节码文件名返回魔术标签字符串。请记住在 `sys.implementation.cache_tag` 上的值是应当被用来代替此函数的更权威的值。

3.2 新版功能.

PyObject ***PyImport_GetModuleDict** ()

Return value: Borrowed reference. Part of the Stable ABI. 返回用于模块管理的字典 (即 `sys.modules`)。请注意这是针对每个解释器的变量。

PyObject ***PyImport_GetModule** (*PyObject* *name)

Return value: New reference. Part of the Stable ABI *since version 3.8.* 返回给定名称的已导入模块。如果模块尚未导入则返回 NULL 但不会设置错误。如果查找失败则返回 NULL 并设置错误。

3.7 新版功能.

PyObject ***PyImport_GetImporter** (*PyObject* *path)

Return value: New reference. Part of the Stable ABI. 返回针对一个 `sys.path`/`pkg.__path__` 中条目 *path* 的查找器对象，可能会通过 `sys.path_importer_cache` 字典来获取。如果它尚未被缓存，则会遍历 `sys.path_hooks` 直至找到一个能处理该 path 条目的钩子。如果没有可用的钩子则返回 `None`；这将告知调用方 *path based finder* 无法为该 path 条目找到查找器。结果将缓存到 `sys.path_importer_cache`。返回一个指向查找器对象的新引用。

int **PyImport_ImportFrozenModuleObject** (*PyObject* *name)

Part of the Stable ABI *since version 3.7.* 加载名称为 *name* 的已冻结模块。成功时返回 `1`，如果未找到模块则返回 `0`，如果初始化失败则返回 `-1` 并设置一个异常。要在加载成功后访问被导入的模块，请使用 *PyImport_ImportModule()*。(请注意此名称有误导性 --- 如果模块已被导入此函数将重载它。)

3.3 新版功能.

在 3.4 版更改: `__file__` 属性将不再在模块上设置。

int **PyImport_ImportFrozenModule** (const char *name)

Part of the Stable ABI. 类似于*PyImport_ImportFrozenModuleObject()*，但其名称为 UTF-8 编码的字符串而不是 Unicode 对象。

struct **_frozen**

这是针对已冻结模块描述器的结构类型定义，与由 **freeze** 工具所生成的一致 (请参看 Python 源代码发行版中的 Tools/freeze/)。其定义可在 Include/import.h 中找到:

```
struct _frozen {
    const char *name;
    const unsigned char *code;
    int size;
    bool is_package;
};
```

在 3.11 版更改: The new is_package field indicates whether the module is a package or not. This replaces setting the size field to a negative value.

const struct *_frozen* ***PyImport_FrozenModules**

This pointer is initialized to point to an array of *_frozen* records, terminated by one whose members are all NULL or zero. When a frozen module is imported, it is searched in this table. Third-party code could play tricks with this to provide a dynamically created collection of frozen modules.

int **PyImport_AppendInittab** (const char *name, *PyObject* *(*initfunc)(void))

Part of the Stable ABI. 向现有的内置模块表添加一个模块。这是对*PyImport_ExtendInittab()* 的便捷包装，如果无法扩展表则返回 -1。新的模块可使用名称 *name* 来导入，并使用函数 *initfunc* 作为在第一次尝试导入时调用的初始化函数。此函数应当在*Py_Initialize()* 之前调用。

struct **_inittab**

描述内置模块列表中的一个条目的结构体。每个结构体都给出了内置在解释器中的某个模块的名称和初始化函数。名称是一个 ASCII 编码的字符串。嵌入了 Python 的程序可以使用该结构体的数组来与*PyImport_ExtendInittab()* 相结合以提供额外的内置模块。该结构体在 Include/import.h 中被定义为:

```
struct _inittab {
    const char *name;           /* ASCII encoded string */
    PyObject* (*initfunc)(void);
};
```

int **PyImport_ExtendInittab** (struct *_inittab* *newtab)

将内置模块表添加一组模块。*newtab* 数组必须以一个包含以 NULL 作为 name 字段的岗哨条目结束；未能提供岗哨值会导致内存错误。成功时返回 0 或者如果无法分配足够内存来扩展内部表则返回 -1。当发生失败时，将不会添加模块到内部表。此函数必须在*Py_Initialize()* 之前调用。

如果 Python 要被多次初始化，则*PyImport_AppendInittab()* 或*PyImport_ExtendInittab()* 必须在每次 Python 初始化之前调用。

6.5 数据 marshal 操作支持

这些例程允许 C 代码处理与 marshal 模块所用相同数据格式的序列化对象。其中有些函数可用来将数据写入这种序列化格式，另一些函数则可用来读取并恢复数据。用于存储 marshal 数据的文件必须以二进制模式打开。

数字值在存储时会将最低位字节放在开头。

此模块支持两种数据格式版本：第 0 版为历史版本，第 1 版本会在文件和 marshal 反序列化中共享固化的字符串。第 2 版本会对浮点数使用二进制格式。Py_MARSHAL_VERSION 指明了当前文件的格式（当前取值为 2）。

void **PyMarshal_WriteLongToFile** (long value, FILE *file, int version)

Marshal a `long` integer, *value*, to *file*. This will only write the least-significant 32 bits of *value*; regardless of the size of the native `long` type. *version* indicates the file format.

void **PyMarshal_WriteObjectToFile** (*PyObject* *value, FILE *file, int version)

将一个 Python 对象 *value* 以 marshal 格式写入 *file*。*version* 指明文件格式的版本。

PyObject ***PyMarshal_WriteObjectToString** (*PyObject* *value, int version)

Return value: New reference. 返回一个包含 *value* 的 marshal 表示形式的字节串对象。*version* 指明文件格式的版本。

以下函数允许读取并恢复存储为 marshal 格式的值。

long **PyMarshal_ReadLongFromFile** (FILE *file)

Return a C `long` from the data stream in a `FILE*` opened for reading. Only a 32-bit value can be read in using this function, regardless of the native size of `long`.

发生错误时，将设置适当的异常 (`EOFError`) 并返回 `-1`。

int **PyMarshal_ReadShortFromFile** (FILE *file)

Return a C `short` from the data stream in a `FILE*` opened for reading. Only a 16-bit value can be read in using this function, regardless of the native size of `short`.

发生错误时，将设置适当的异常 (`EOFError`) 并返回 `-1`。

PyObject ***PyMarshal_ReadObjectFromFile** (FILE *file)

Return value: New reference. Return a Python object from the data stream in a `FILE*` opened for reading.

发生错误时，将设置适当的异常 (`EOFError`, `ValueError` 或 `TypeError`) 并返回 `NULL`。

PyObject ***PyMarshal_ReadLastObjectFromFile** (FILE *file)

Return value: New reference. Return a Python object from the data stream in a `FILE*` opened for reading. Unlike `PyMarshal_ReadObjectFromFile()`, this function assumes that no further objects will be read from the file, allowing it to aggressively load file data into memory so that the de-serialization can operate from data in memory rather than reading a byte at a time from the file. Only use these variant if you are certain that you won't be reading anything else from the file.

发生错误时，将设置适当的异常 (`EOFError`, `ValueError` 或 `TypeError`) 并返回 `NULL`。

PyObject ***PyMarshal_ReadObjectFromString** (const char *data, *Py_ssize_t* len)

Return value: New reference. 从包含指向 *data* 的 *len* 个字节的字节缓冲区对应的数据流返回一个 Python 对象。

发生错误时，将设置适当的异常 (`EOFError`, `ValueError` 或 `TypeError`) 并返回 `NULL`。

6.6 解析参数并构建值变量

在创建你自己的扩展函数和方法时，这些函数是有用的。其它的信息和样例见 extending-index 。

这些函数描述的前三个，`PyArg_ParseTuple()`，`PyArg_ParseTupleAndKeywords()`，以及`PyArg_Parse()`，它们都使用 格式化字符串来将函数期待的参数告知函数。这些函数都使用相同语法规则的格式化字符串。

6.6.1 解析参数

一个格式化字符串包含 0 或者更多的格式单元。一个格式单元用来描述一个 Python 对象；它通常是一个字符或者由括号括起来的格式单元序列。除了少数例外，一个非括号序列的格式单元通常对应这些函数的具有单一地址的参数。在接下来的描述中，双引号内的表达式是格式单元；圆括号 () 内的是对应这个格式单元的 Python 对象类型；方括号 [] 内的是传递的 C 变量 (变量集) 类型。

字符串和缓存区

这些格式允许将对象按照连续的内存块形式进行访问。你没必要提供返回的 unicode 字符或者字节区的原始数据存储。

一般的，当一个表达式设置一个指针指向一个缓冲区，这个缓冲区可以被相应的 Python 对象管理，并且这个缓冲区共享这个对象的生存周期。你不需要人为的释放任何内存空间。除了这些 `es`, `es#`, `et` and `et#`.

然而，当一个*Py_buffer* 结构被赋值，其包含的缓冲区被锁住，所以调用者在随后使用这个缓冲区，即使在*Py_BEGIN_ALLOW_THREADS* 块中，可以避免可变数据因为调整大小或者被销毁所带来的风险。因此，**你不得不调用***PyBuffer_Release()* 在你结束数据的处理时 (或者在之前任何中断事件中)

除非另有说明，缓冲区是不会以空终止的。

某些格式需要只读的*bytes-like object*，并设置指针而不是缓冲区结构。他们通过检查对象的*PyBufferProcs.bf_releasebuffer* 字段是否为 `NULL` 来发挥作用，该字段不允许为 `bytearray` 这样的可变对象。

备注： 对于所有 # 格式的变体 (`s#`、`y#` 等)，宏 `PY_SSIZE_T_CLEAN` 必须在包含 `Python 之前定义。h`。在 Python 3.9 及更早版本上，如果定义了 `PY_SSIZE_T_CLEAN` 宏，则长度参数的类型为*Py_ssize_t*，否则为 int。

s (str) [const char *] 将一个 Unicode 对象转换成一个指向字符串的 C 指针。一个指针指向一个已经存在的字符串，这个字符串存储的是传如的字符指针变量。C 字符串是已空结束的。Python 字符串不能包含嵌入的无效的代码点；如果由，一个 `ValueError` 异常会被引发。Unicode 对象被转化成 `'utf-8'` 编码的 C 字符串。如果转换失败，一个 `UnicodeError` 异常被引发。

备注： 这个表达式不接受*bytes-like objects*。如果你想接受文件系统路径并将它们转化成 C 字符串，建议使用 `O&` 表达式配合*PyUnicode_FSConverter()* 作为 转化函数。

在 3.5 版更改: 以前，当 Python 字符串中遇到了嵌入的 null 代码点会引发 `TypeError` 。

s* (str or *bytes-like object*) [Py_buffer] 这个表达式既接受 Unicode 对象也接受类字节类型对象。它为由调用者提供的*Py_buffer* 结构赋值。这里结果的 C 字符串可能包含嵌入的 NUL 字节。Unicode 对象通过 `'utf-8'` 编码转化成 C 字符串。

s# (str, read-only *bytes-like object*) [const char *, *Py_ssize_t*] 像 `s*`，除了它不接受易变的对象。结果存储在两个 C 变量中，第一个是指向 C 字符串的指针，第二个是它的长度。字符串可能包含嵌入的 null 字节。Unicode 对象都被通过 `'utf-8'` 编码转化成 C 字符串。

z (str or None) [const char *] 与 `s` 类似，但 Python 对象也可能为 `None`，在这种情况下，C 指针设置为 `NULL`。

z* (str, *bytes-like object* or None) [Py_buffer] 与 `s*` 类似，但 Python 对象也可能为 `None`，在这种情况下，*Py_buffer* 结构的 `buf` 成员设置为 `NULL`。

z# (str, read-only *bytes-like object* 或者 None) [const char *, *Py_ssize_t*] 与 `s#` 类似，但 Python 对象也可能为 `None`，在这种情况下，C 指针设置为 `NULL`。

y (read-only *bytes-like object*) [const char *] 这个表达式将一个类字节类型对象转化成一个指向字符串的 C 指针；它不接受 Unicode 对象。字节缓存区必须不包含嵌入的 null 字节；如果包含了 null 字节，会引发一个 `ValueError` 异常。

在 3.5 版更改: 以前，当字节缓冲区中遇到了嵌入的 null 字节会引发 TypeError 。

y* (*bytes-like object*) [Py_buffer] s* 的变式，不接受 Unicode 对象，只接受类字节类型变量。**这是接受二进制数据的推荐方法。**

y# (read-only *bytes-like object*) [const char *, *Py_ssize_t*] s# 的变式，不接受 Unicode 对象，只接受类字节类型变量。

S (bytes) [PyBytesObject *] Requires that the Python object is a bytes object, without attempting any conversion. Raises TypeError if the object is not a bytes object. The C variable may also be declared as *PyObject**.

Y (bytearray) [PyByteArrayObject *] Requires that the Python object is a bytearray object, without attempting any conversion. Raises TypeError if the object is not a bytearray object. The C variable may also be declared as *PyObject**.

u (str) [const Py_UNICODE *] 将一个 Python Unicode 对象转化成指向一个以空终止的 Unicode 字符缓冲区的指针。你必须传入一个*Py_UNICODE* 指针变量的地址，存储了一个指向已经存在的 Unicode 缓冲区的指针。请注意一个*Py_UNICODE* 类型的字符宽度取决于编译选项 (16 位或者 32 位)。Python 字符串必须不能包含嵌入的 null 代码点；如果有，引发一个 ValueError 异常。

在 3.5 版更改: 以前，当 Python 字符串中遇到了嵌入的 null 代码点会引发 TypeError 。

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 这是旧版样式*Py_UNICODE* API; 请迁移至*PyUnicode_AsWideCharString()*.

u# (str) [const Py_UNICODE *, *Py_ssize_t*] u 的变式，存储两个 C 变量，第一个指针指向一个 Unicode 数据缓存区，第二个是它的长度。它允许 null 代码点。

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 这是旧版样式*Py_UNICODE* API; 请迁移至*PyUnicode_AsWideCharString()*.

Z (str 或 None) [const Py_UNICODE *] 与 u 类似，但 Python 对象也可能为 None，在这种情况下*Py_UNICODE* 指针设置为 NULL。

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 这是旧版样式*Py_UNICODE* API; 请迁移至*PyUnicode_AsWideCharString()*.

Z# (str 或 None) [const Py_UNICODE *, *Py_ssize_t*] 与 u# 类似，但 Python 对象也可能为 None，在这种情况下*Py_UNICODE* 指针设置为 NULL。

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 这是旧版样式*Py_UNICODE* API; 请迁移至*PyUnicode_AsWideCharString()*.

U (str) [PyObject *] Requires that the Python object is a Unicode object, without attempting any conversion. Raises TypeError if the object is not a Unicode object. The C variable may also be declared as *PyObject**.

w* (可读写*bytes-like object*) [Py_buffer] 这个表达式接受任何实现可读写缓存区接口的对象。它为调用者提供的*Py_buffer* 结构赋值。缓冲区可能存在嵌入的 null 字节。当缓冲区使用完后调用者需要调用*PyBuffer_Release()*。

es (str) [const char *encoding, char **buffer] s 的变式，它将编码后的 Unicode 字符存入字符缓冲区。它只处理没有嵌 NUL 字节的已编码数据。

This format requires two arguments. The first is only used as input, and must be a const char* which points to the name of an encoding as a NUL-terminated string, or NULL, in which case 'utf-8' encoding is used. An exception is raised if the named encoding is not known to Python. The second argument must be a char**; the value of the pointer it references will be set to a buffer with the contents of the argument text. The text will be encoded in the encoding specified by the first argument.

PyArg_ParseTuple() 会分配一个足够大小的缓冲区，将编码后的数据拷贝进这个缓冲区并且设置 **buffer* 引用这个新分配的内存空间。调用者有责任在使用后调用*PyMem_Free()* 去释放已经分配的缓冲区。

et (str, bytes or bytearray) [const char *encoding, char **buffer] 和 es 相同，除了不用重编码传入的字符串对象。相反，它假设传入的参数是编码后的字符串类型。

es# (str) [const char *encoding, char **buffer, *Py_ssize_t* *buffer_length] s# 的变式，它将已编码的 Unicode 字符存入字符缓冲区。不像 es 表达式，它允许传入的数据包含 NUL 字符。

It requires three arguments. The first is only used as input, and must be a `const char*` which points to the name of an encoding as a NUL-terminated string, or `NULL`, in which case `'utf-8'` encoding is used. An exception is raised if the named encoding is not known to Python. The second argument must be a `char**`; the value of the pointer it references will be set to a buffer with the contents of the argument text. The text will be encoded in the encoding specified by the first argument. The third argument must be a pointer to an integer; the referenced integer will be set to the number of bytes in the output buffer.

有两种操作方式：

如果 **buffer* 指向 `NULL` 指针，则函数将分配所需大小的缓冲区，将编码的数据复制到此缓冲区，并设置 **buffer* 以引用新分配的存储。呼叫者负责调用 `PyMem_Free()` 以在使用后释放分配的缓冲区。

如果 **buffer* 指向非 `NULL` 指针（已分配的缓冲区），则 `PyArg_ParseTuple()` 将使用此位置作为缓冲区，并将 **buffer_length* 的初始值解释为缓冲区大小。然后，它将将编码的数据复制到缓冲区，并终止它。如果缓冲区不够大，将设置一个 `ValueError`。

在这两个例子中，**buffer_length* 被设置为编码后结尾不为 NUL 的数据的长度。

et# (str, bytes 或 bytearray) [const char *encoding, char **buffer, *Py_ssize_t* *buffer_length] 和 es# 相同，除了不用重编码传入的字符串对象。相反，它假设传入的参数是编码后的字符串类型。

数字

b (int) [unsigned char] Convert a nonnegative Python integer to an unsigned tiny int, stored in a C `unsigned char`.

B (int) [unsigned char] Convert a Python integer to a tiny int without overflow checking, stored in a C `unsigned char`.

h (int) [short int] Convert a Python integer to a C `short int`.

H (int) [unsigned short int] Convert a Python integer to a C `unsigned short int`, without overflow checking.

i (int) [int] Convert a Python integer to a plain C `int`.

I (int) [unsigned int] Convert a Python integer to a C `unsigned int`, without overflow checking.

l (int) [long int] Convert a Python integer to a C `long int`.

k (int) [unsigned long] Convert a Python integer to a C `unsigned long` without overflow checking.

L (int) [long long] Convert a Python integer to a C `long long`.

K (int) [unsigned long long] Convert a Python integer to a C `unsigned long long` without overflow checking.

n (int) [*Py_ssize_t*] 将一个 Python 整型转化成一个 C `Py_ssize_t` Python 元大小类型。

c (bytes 或者 bytearray 长度为 1) [char] Convert a Python byte, represented as a `bytes` or `bytearray` object of length 1, to a C `char`.

在 3.3 版更改: 允许 `bytearray` 类型的对象。

C (str 长度为 1) [int] Convert a Python character, represented as a `str` object of length 1, to a C `int`.

f (float) [float] Convert a Python floating point number to a C `float`.

d (float) [double] Convert a Python floating point number to a C `double`.

D (complex) [Py_complex] 将一个 Python 复数类型转化成一个 C `Py_complex` Python 复数类型。

其他对象

O (object) [PyObject *] 将 Python 对象（不进行任何转换）存储在 C 对象指针中。因此，C 程序接收已传递的实际对象。对象的引用计数不会增加。存储的指针不是 NULL。

O! (object) [*typeobject*, PyObject *] Store a Python object in a C object pointer. This is similar to O, but takes two C arguments: the first is the address of a Python type object, the second is the address of the C variable (of type *PyObject**) into which the object pointer is stored. If the Python object does not have the required type, TypeError is raised.

O& (object) [*converter*, *anything*] Convert a Python object to a C variable through a *converter* function. This takes two arguments: the first is a function, the second is the address of a C variable (of arbitrary type), converted to void*. The *converter* function in turn is called as follows:

```
status = converter(object, address);
```

where *object* is the Python object to be converted and *address* is the void* argument that was passed to the PyArg_Parse* function. The returned *status* should be 1 for a successful conversion and 0 if the conversion has failed. When the conversion fails, the *converter* function should raise an exception and leave the content of *address* unmodified.

如果 *converter* 返回 Py_CLEANUP_SUPPORTED，则如果参数解析最终失败，它可能会再次调用该函数，从而使转换器有机会释放已分配的任何内存。在第二个调用中，*object* 参数将为 NULL; 因此，该参数将为 NULL; 因此，该参数将为 NULL，因此，该参数将为 NULL`` (如果值) 为 ``NULL *address* 的值与原始呼叫中的值相同。

在 3.1 版更改: Py_CLEANUP_SUPPORTED 被添加。

p (bool) [int] 测试传入的值是否为真 (一个布尔判断) 并且将结果转化为相对应的 C true/false 整型值。如果表达式为真置 1，假则置 0。它接受任何合法的 Python 值。参见 truth 获取更多关于 Python 如何测试值为真的信息。

3.3 新版功能.

(items) (tuple) [*matching-items*] 对象必须是 Python 序列，它的长度是 *items* 中格式单元的数量。C 参数必须对应 *items* 中每一个独立的格式单元。序列中的格式单元可能有嵌套。

传递"long" 整型 (整型的值超过了平台的 LONG_MAX 限制) 是可能的，然而没有进行适当的范围检测——当接收字段太小而接收不到值时，最重要的位被静默地截断 (实际上，C 语言会在语义继承的基础上强制类型转换——期望的值可能会发生变化)。

格式化字符串中还有一些其他的字符具有特殊的涵义。这些可能并不嵌套在圆括号中。它们是：

| 表明在 Python 参数列表中剩下的参数都是可选的。C 变量对应的可选参数需要初始化为默认值——当一个可选参数没有指定时，*PyArg_ParseTuple()* 不能访问相应的 C 变量 (变量集) 的内容。

$ *PyArg_ParseTupleAndKeywords()* only：表明在 Python 参数列表中剩下的参数都是强制关键字参数。当前，所有强制关键字参数都必须也是可选参数，所以格式化字符串中 | 必须一直在 $ 前面。

3.3 新版功能.

: 格式单元的列表结束标志；冒号后的字符串被用来作为错误消息中的函数名 (*PyArg_ParseTuple()* 函数引发的 "关联值" 异常)。

; 格式单元的列表结束标志；分号后的字符串被用来作为错误消息取代默认的错误消息。**:** 和 **;** 相互排斥。

注意任何由调用者提供的 Python 对象引用是 借来的引用；不要递减它们的引用计数！

传递给这些函数的附加参数必须是由格式化字符串确定的变量的地址；这些都是用来存储输入元组的值。有一些情况，如上面的格式单元列表中所描述的，这些参数作为输入值使用；在这种情况下，它们应该匹配指定的相应的格式单元。

For the conversion to succeed, the *arg* object must match the format and the format must be exhausted. On success, the PyArg_Parse* functions return true, otherwise they return false and raise an appropriate exception. When the PyArg_Parse* functions fail due to conversion failure in one of the format units, the variables at the addresses corresponding to that and the following format units are left untouched.

API 函数

int **PyArg_ParseTuple** (*PyObject* *args, const char *format, ...)

Part of the Stable ABI. 解析一个函数的参数，表达式中的参数按参数位置顺序存入局部变量中。成功返回 true；失败返回 false 并且引发相应的异常。

int **PyArg_VaParse** (*PyObject* *args, const char *format, va_list vargs)

Part of the Stable ABI. 和*PyArg_ParseTuple()* 相同，然而它接受一个 va_list 类型的参数而不是可变数量的参数集。

int **PyArg_ParseTupleAndKeywords** (*PyObject* *args, *PyObject* *kw, const char *format, char *keywords[], ...)

Part of the Stable ABI. 分析将位置参数和关键字参数同时转换为局部变量的函数的参数。*keywords* 参数是关键字参数名称的 NULL 终止数组。空名称表示*positional-only parameters*。成功时返回 true; 发生故障时，它将返回 false 并引发相应的异常。

在 3.6 版更改: 添加了*positional-only parameters* 的支持。

int **PyArg_VaParseTupleAndKeywords** (*PyObject* *args, *PyObject* *kw, const char *format, char *keywords[], va_list vargs)

Part of the Stable ABI. 和*PyArg_ParseTupleAndKeywords()* 相同，然而它接受一个 va_list 类型的参数而不是可变数量的参数集。

int **PyArg_ValidateKeywordArguments** (*PyObject**)

Part of the Stable ABI. 确保字典中的关键字参数都是字符串。这个函数只被使用于*PyArg_ParseTupleAndKeywords()* 不被使用的情况下，后者已经不再做这样的检查。

3.2 新版功能.

int **PyArg_Parse** (*PyObject* *args, const char *format, ...)

Part of the Stable ABI. 函数被用来析构 "旧类型" 函数的参数列表——这些函数使用的 METH_OLDARGS 参数解析方法已从 Python 3 中移除。这不被推荐用于新代码的参数解析，并且在标准解释器中的大多数代码已被修改，已不再用于该目的。它仍然方便于分解其他元组，然而可能因为这个目的被继续使用。

int **PyArg_UnpackTuple** (*PyObject* *args, const char *name, *Py_ssize_t* min, *Py_ssize_t* max, ...)

Part of the Stable ABI. A simpler form of parameter retrieval which does not use a format string to specify the types of the arguments. Functions which use this method to retrieve their parameters should be declared as *METH_VARARGS* in function or method tables. The tuple containing the actual parameters should be passed as *args*; it must actually be a tuple. The length of the tuple must be at least *min* and no more than *max*; *min* and *max* may be equal. Additional arguments must be passed to the function, each of which should be a pointer to a *PyObject** variable; these will be filled in with the values from *args*; they will contain *borrowed references*. The variables which correspond to optional parameters not given by *args* will not be filled in; these should be initialized by the caller. This function returns true on success and false if *args* is not a tuple or contains the wrong number of elements; an exception will be set if there was a failure.

这是一个使用此函数的示例，取自 _weakref 帮助模块用来弱化引用的源代码:

```
static PyObject *
weakref_ref(PyObject *self, PyObject *args)
{
    PyObject *object;
    PyObject *callback = NULL;
    PyObject *result = NULL;

    if (PyArg_UnpackTuple(args, "ref", 1, 2, &object, &callback)) {
        result = PyWeakref_NewRef(object, callback);
```

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```
    }
    return result;
}
```

这个例子中调用*PyArg_UnpackTuple()* 完全等价于调用*PyArg_ParseTuple()*:

```
PyArg_ParseTuple(args, "O|O:ref", &object, &callback)
```

6.6.2 创建变量

PyObject ***Py_BuildValue**(const char *format, ...)

Return value: New reference. Part of the Stable ABI. Create a new value based on a format string similar to those accepted by the `PyArg_Parse*` family of functions and a sequence of values. Returns the value or `NULL` in the case of an error; an exception will be raised if `NULL` is returned.

Py_BuildValue() 并不一直创建一个元组。只有当它的格式化字符串包含两个或更多的格式单元才会创建一个元组。如果格式化字符串是空，它返回 `None`；如果它包含一个格式单元，它返回由格式单元描述的的任一对象。用圆括号包裹格式化字符串可以强制它返回一个大小为 0 或者 1 的元组。

当内存缓存区的数据以参数形式传递用来构建对象时，如 `s` 和 `s#` 格式单元，会拷贝需要的数据。调用者提供的缓冲区从来都不会被由*Py_BuildValue()* 创建的对象来引用。换句话说，如果你的代码调用 `malloc()` 并且将分配的内存空间传递给*Py_BuildValue()*，你的代码就有责任在*Py_BuildValue()* 返回时调用 `free()` 。

在下面的描述中，双引号的表达式使格式单元；圆括号 () 内的是格式单元将要返回的 Python 对象类型；方括号 [] 内的是传递的 C 变量 (变量集) 的类型。

字符例如空格，制表符，冒号和逗号在格式化字符串中会被忽略 (但是不包括格式单元，如 `s#`)。这可以使很长的格式化字符串具有更好的可读性。

s (str 或 None) [const char *] 使用 `'utf-8'` 编码将空终止的 C 字符串转换为 Python `str` 对象。如果 C 字符串指针为 `NULL`，则使用 `None`。

s# (str 或 None) [const char *, *Py_ssize_t*] 使用 `'utf-8'` 编码将 C 字符串及其长度转换为 Python `str` 对象。如果 C 字符串指针为 `NULL`，则长度将被忽略，并返回 `None`。

y (bytes) [const char *] 这将 C 字符串转换为 Python `bytes` 对象。如果 C 字符串指针为 `NULL`，则返回 `None`。

y# (bytes) [const char *, *Py_ssize_t*] 这会将 C 字符串及其长度转换为一个 Python 对象。如果该 C 字符串指针为 `NULL`，则返回 `None`。

z (str or None) [const char *] 和 `s` 一样。

z# (str 或 None) [const char *, *Py_ssize_t*] 和 `s#` 一样。

u (str) [const wchar_t *] Convert a null-terminated `wchar_t` buffer of Unicode (UTF-16 or UCS-4) data to a Python Unicode object. If the Unicode buffer pointer is `NULL`, `None` is returned.

u# (str) [const wchar_t *, *Py_ssize_t*] 将 Unicode （UTF-16 或 UCS-4）数据缓冲区及其长度转换为 Python Unicode 对象。如果 Unicode 缓冲区指针为 `NULL`，则长度将被忽略，并返回 `None`。

U (str 或 None) [const char *] 和 `s` 一样。

U# (str 或 None) [const char *, *Py_ssize_t*] 和 `s#` 一样。

i (int) [int] Convert a plain C `int` to a Python integer object.

b (int) [char] Convert a plain C `char` to a Python integer object.

h (int) [short int] Convert a plain C `short int` to a Python integer object.

l (int) [long int] Convert a C `long int` to a Python integer object.

B (int) [unsigned char] Convert a C `unsigned char` to a Python integer object.

H (int) [unsigned short int] Convert a C `unsigned short int` to a Python integer object.

I (int) [unsigned int] Convert a C `unsigned int` to a Python integer object.

k (int) [unsigned long] Convert a C `unsigned long` to a Python integer object.

L (int) [long long] Convert a C `long long` to a Python integer object.

K (int) [unsigned long long] Convert a C `unsigned long long` to a Python integer object.

n (int) [*Py_ssize_t*] 将一个 C *Py_ssize_t* 类型转化为 Python 整型。

c (bytes 长度为 1) [char] Convert a C `int` representing a byte to a Python `bytes` object of length 1.

C (str 长度为 1) [int] Convert a C `int` representing a character to Python `str` object of length 1.

d (float) [double] Convert a C `double` to a Python floating point number.

f (float) [float] Convert a C `float` to a Python floating point number.

D (complex) [Py_complex *] 将一个 C *Py_complex* 类型的结构转化为 Python 复数类型。

O (object) [PyObject *] 将 Python 对象传递不变（其引用计数除外，该计数由 1 递增）。如果传入的对象是 `NULL` 指针，则假定这是由于生成参数的调用发现错误并设置异常而引起的。因此，*Py_BuildValue()* 将返回 `NULL`，但不会引发异常。如果尚未引发异常，则设置 `SystemError`。

S (object) [PyObject *] 和 `O` 相同。

N (object) [PyObject *] 和 `O` 相同，然而它并不增加对象的引用计数。当通过调用参数列表中的对象构造器创建对象时很实用。

O& (object) [*converter*, *anything*] Convert *anything* to a Python object through a *converter* function. The function is called with *anything* (which should be compatible with `void*`) as its argument and should return a "new" Python object, or `NULL` if an error occurred.

(items) (tuple) [*matching-items*] 将一个 C 变量序列转换成 Python 元组并保持相同的元素数量。

[items] (list) [相关的元素] 将一个 C 变量序列转换成 Python 列表并保持相同的元素数量。

{items} (dict) [相关的元素] 将一个 C 变量序列转换成 Python 字典。每一对连续的 C 变量对作为一个元素插入字典中，分别作为关键字和值。

如果格式字符串中出现错误，则设置 `SystemError` 异常并返回 `NULL`。

PyObject ***Py_VaBuildValue** (const char *format, va_list vargs)

Return value: New reference. Part of the Stable ABI. 和*Py_BuildValue()* 相同，然而它接受一个 va_list 类型的参数而不是可变数量的参数集。

6.7 字符串转换与格式化

用于数字转换和格式化字符串输出的函数

int **PyOS_snprintf** (char *str, size_t size, const char *format, ...)

Part of the Stable ABI. 根据格式字符串 *format* 和额外参数，输出不超过 *size* 个字节到 *str*。参见 Unix 手册页面 *snprintf(3)*。

int **PyOS_vsnprintf** (char *str, size_t size, const char *format, va_list va)

Part of the Stable ABI. 根据格式字符串 *format* 和变量参数列表 *va*，输出不超过 *size* 个字节到 *str*。参见 Unix 手册页面 *vsnprintf(3)*。

PyOS_snprintf() 和*PyOS_vsnprintf()* 包装 C 标准库函数 `snprintf()` 和 `vsnprintf()` 。它们的目的是保证在极端情况下的一致行为，而标准 C 的函数则不然。

The wrappers ensure that `str[size-1]` is always `'\0'` upon return. They never write more than *size* bytes (including the trailing `'\0'`) into str. Both functions require that `str != NULL`, `size > 0`, `format !=`

NULL and size < INT_MAX. Note that this means there is no equivalent to the C99 n = snprintf(NULL, 0, ...) which would determine the necessary buffer size.

这些函数的返回值（*rv*）应按照以下规则被解释：

- 当 0 <= rv < size 时，输出转换即成功并将 *rv* 个字符写入到 *str* (不包括末尾 str[rv] 位置的 '\0' 字节)。
- 当 rv >= size 时，输出转换会被截断并且需要一个具有 rv + 1 字节的缓冲区才能成功执行。在此情况下 str[size-1] 为 '\0'。
- 当 rv < 0 时，"会发生不好的事情。" 在此情况下 str[size-1] 也为 '\0'，但 *str* 的其余部分是未定义的。错误的确切原因取决于底层平台。

以下函数提供与语言环境无关的字符串到数字转换。

double **PyOS_string_to_double**(const char *s, char **endptr, *PyObject* *overflow_exception)

Part of the Stable ABI. Convert a string s to a double, raising a Python exception on failure. The set of accepted strings corresponds to the set of strings accepted by Python's float() constructor, except that s must not have leading or trailing whitespace. The conversion is independent of the current locale.

如果 endptr 是 NULL，转换整个字符串。引发 ValueError 并且返回 -1.0 如果字符串不是浮点数的有效的表达方式。

如果 endptr 不是 NULL，尽可能多的转换字符串并将 *endptr 设置为指向第一个未转换的字符。如果字符串的初始段不是浮点数的有效的表达方式，将 *endptr 设置为指向字符串的开头，引发 ValueError 异常，并且返回 -1.0 。

如果 s 表示一个太大而不能存储在一个浮点数中的值（比方说，"1e500" 在许多平台上是一个字符串）然后如果 overflow_exception 是 NULL 返回 Py_HUGE_VAL （用适当的符号）并且不设置任何异常。在其他方面，overflow_exception 必须指向一个 Python 异常对象；引发异常并返回 -1.0 。在这两种情况下，设置 *endptr 指向转换值之后的第一个字符。

如果在转换期间发生任何其他错误（比如一个内存不足的错误），设置适当的 Python 异常并且返回 -1.0 。

3.1 新版功能.

char ***PyOS_double_to_string**(double val, char format_code, int precision, int flags, int *ptype)

Part of the Stable ABI. Convert a double *val* to a string using supplied *format_code*, *precision*, and *flags*.

格式码必须是以下其中之一，'e'，'E'，'f'，'F'，'g'，'G' 或者 'r'。对于 'r'，提供的 精度必须是 0。'r' 格式码指定了标准函数 repr() 格式。

flags 可以为零或者其他值 Py_DTSF_SIGN，Py_DTSF_ADD_DOT_0 或 Py_DTSF_ALT 或其组合：

- Py_DTSF_SIGN 表示总是在返回的字符串前附加一个符号字符，即使 *val* 为非负数。
- Py_DTSF_ADD_DOT_0 表示确保返回的字符串看起来不像是一个整数。
- Py_DTSF_ALT 表示应用" 替代的" 格式化规则。相关细节请参阅*PyOS_snprintf()* '#' 定义文档。

如果 *ptype* 不为 NULL，则它指向的值将被设为 Py_DTST_FINITE，Py_DTST_INFINITE 或 Py_DTST_NAN 中的一个，分别表示 *val* 是一个有限数字、无限数字或非数字。

返回值是一个指向包含转换后字符串的 *buffer* 的指针，如果转换失败则为 NULL。调用方要负责调用*PyMem_Free()* 来释放返回的字符串。

3.1 新版功能.

int **PyOS_stricmp**(const char *s1, const char *s2)

字符串不区分大小写。该函数几乎与 strcmp() 的工作方式相同，只是它忽略了大小写。

int **PyOS_strnicmp**(const char *s1, const char *s2, *Py_ssize_t* size)

字符串不区分大小写。该函数几乎与 strncmp() 的工作方式相同，只是它忽略了大小写。

6.8 反射

PyObject ***PyEval_GetBuiltins** (void)

Return value: Borrowed reference. Part of the Stable ABI. 返回当前执行帧中内置函数的字典，如果当前没有帧正在执行，则返回线程状态的解释器。

PyObject ***PyEval_GetLocals** (void)

Return value: Borrowed reference. Part of the Stable ABI. 返回当前执行帧中局部变量的字典，如果没有当前执行的帧则返回 `NULL`。

PyObject ***PyEval_GetGlobals** (void)

Return value: Borrowed reference. Part of the Stable ABI. 返回当前执行帧中全局变量的字典，如果没有当前执行的帧则返回 `NULL`。

PyFrameObject ***PyEval_GetFrame** (void)

Return value: Borrowed reference. Part of the Stable ABI. 返回当前线程状态的帧，如果没有当前执行的帧则返回 `NULL`。

另请参阅 *PyThreadState_GetFrame()*。

const char ***PyEval_GetFuncName** (*PyObject* *func)

Part of the Stable ABI. 如果 *func* 是函数、类或实例对象，则返回它的名称，否则返回 *func* 的类型的名称。

const char ***PyEval_GetFuncDesc** (*PyObject* *func)

Part of the Stable ABI. 根据 *func* 的类型返回描述字符串。返回值包括函数和方法的"()", " constructor", " instance" 和" object"。与 *PyEval_GetFuncName()* 的结果连接，结果将是 *func* 的描述。

6.9 编解码器注册与支持功能

int **PyCodec_Register** (*PyObject* *search_function)

Part of the Stable ABI. 注册一个新的编解码器搜索函数。

作为副作用，其尝试加载 `encodings` 包，如果尚未完成，请确保它始终位于搜索函数列表的第一位。

int **PyCodec_Unregister** (*PyObject* *search_function)

Part of the Stable ABI *since version 3.10.* 注销一个编解码器搜索函数并清空注册表缓存。如果指定搜索函数未被注册，则不做任何操作。成功时返回 0。出错时引发一个异常并返回 -1。

3.10 新版功能.

int **PyCodec_KnownEncoding** (const char *encoding)

Part of the Stable ABI. 根据注册的给定 *encoding* 的编解码器是否已存在而返回 `1` 或 `0`。此函数总能成功。

PyObject ***PyCodec_Encode** (*PyObject* *object, const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. 泛型编解码器基本编码 API。

object 使用由 *errors* 所定义的错误处理方法传递给定 *encoding* 的编码器函数。*errors* 可以为 `NULL` 表示使用为编码器所定义的默认方法。如果找不到编码器则会引发 `LookupError`。

PyObject ***PyCodec_Decode** (*PyObject* *object, const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. 泛型编解码器基本解码 API。

object 使用由 *errors* 所定义的错误处理方法传递给定 *encoding* 的解码器函数。*errors* 可以为 `NULL` 表示使用为编解码器所定义的默认方法。如果找不到编解码器则会引发 `LookupError`。

6.9.1 Codec 查找 API

在下列函数中，*encoding* 字符串会被查找并转换为小写字母形式，这使得通过此机制查找编码格式实际上对大小写不敏感。如果未找到任何编解码器，则将设置 `KeyError` 并返回 `NULL`。

PyObject ***PyCodec_Encoder**(const char *encoding)

Return value: New reference. Part of the Stable ABI. 为给定的 *encoding* 获取一个编码器函数。

PyObject ***PyCodec_Decoder**(const char *encoding)

Return value: New reference. Part of the Stable ABI. 为给定的 *encoding* 获取一个解码器函数。

PyObject ***PyCodec_IncrementalEncoder**(const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. 为给定的 *encoding* 获取一个 `IncrementalEncoder` 对象。

PyObject ***PyCodec_IncrementalDecoder**(const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. 为给定的 *encoding* 获取一个 `IncrementalDecoder` 对象。

PyObject ***PyCodec_StreamReader**(const char *encoding, *PyObject* *stream, const char *errors)

Return value: New reference. Part of the Stable ABI. 为给定的 *encoding* 获取一个 `StreamReader` 工厂函数。

PyObject ***PyCodec_StreamWriter**(const char *encoding, *PyObject* *stream, const char *errors)

Return value: New reference. Part of the Stable ABI. 为给定的 *encoding* 获取一个 `StreamWriter` 工厂函数。

6.9.2 用于 Unicode 编码错误处理程序的注册表 API

int **PyCodec_RegisterError**(const char *name, *PyObject* *error)

Part of the Stable ABI. 在给定的 *name* 之下注册错误处理回调函数 *error*。该回调函数将在一个编解码器遇到无法编码的字符/无法解码的字节数据并且 *name* 被指定为 encode/decode 函数调用的 error 形参时由该编解码器来调用。

该回调函数会接受一个 `UnicodeEncodeError`，`UnicodeDecodeError` 或 `UnicodeTranslateError` 的实例作为单独参数，其中包含关于有问题字符或字节序列及其在原始序列的偏移量信息（请参阅*Unicode 异常对象* 了解提取此信息的函数详情）。该回调函数必须引发给定的异常，或者返回一个包含有问题序列及相应替换序列的二元组，以及一个表示偏移量的整数，该整数指明应在什么位置上恢复编码/解码操作。

成功则返回 "0"，失败则返回 "-1"

PyObject ***PyCodec_LookupError**(const char *name)

Return value: New reference. Part of the Stable ABI. 查找在 *name* 之下注册的错误处理回调函数。作为特例还可以传入 `NULL`，在此情况下将返回针对"strict" 的错误处理回调函数。

PyObject ***PyCodec_StrictErrors**(*PyObject* *exc)

Return value: Always NULL. Part of the Stable ABI. 引发 *exc* 作为异常。

PyObject ***PyCodec_IgnoreErrors**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 忽略 unicode 错误，跳过错误的输入。

PyObject ***PyCodec_ReplaceErrors**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 使用 `?` 或 `U+FFFD` 替换 unicode 编码错误。

PyObject ***PyCodec_XMLCharRefReplaceErrors**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 使用 XML 字符引用替换 unicode 编码错误。

PyObject ***PyCodec_BackslashReplaceErrors**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI. 使用反斜杠转义符 (`\x`, `\u` 和 `\U`) 替换 unicode 编码错误。

PyObject ***PyCodec_NameReplaceErrors**(*PyObject* *exc)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 使用 `\N{...}` 转义符替换 unicode 编码错误。

3.5 新版功能.

CHAPTER 7

抽象对象层

本章中的函数与 Python 对象交互，无论其类型，或具有广泛类的对象类型（例如，所有数值类型，或所有序列类型）。当使用对象类型并不适用时，他们会产生一个 Python 异常。

这些函数是不可能用于未正确初始化的对象的，如一个列表对象被`PyList_New()` 创建，但其中的项目没有被设置为一些非 "NULL"的值。

7.1 对象协议

PyObject ***Py_NotImplemented**

`NotImplemented` 单例，用于标记某个操作没有针对给定类型组合的实现。

Py_RETURN_NOTIMPLEMENTED

C 函数内部应正确处理`Py_NotImplemented` 的返回过程（即增加 NotImplemented 的引用计数并返回之）。

int **PyObject_Print**(*PyObject* *o, FILE *fp, int flags)

将对象 *o* 写入到文件 *fp*。出错时返回 `-1` 。旗标参数被用于启用特定的输出选项。目前唯一支持的选项是 `Py_PRINT_RAW`；如果给出该选项，则将写入对象的 `str()` 而不是 `repr()`。

int **PyObject_HasAttr**(*PyObject* *o, *PyObject* *attr_name)

Part of the Stable ABI. 如果 *o* 带有属性 *attr_name*，则返回 `1`，否则返回 `0`。这相当于 Python 表达式 `hasattr(o, attr_name)`。此函数总是成功。

注意，在调用 `__getattr__()` 和 `__getattribute__()` 方法时发生的异常将被抑制。若要获得错误报告，请换用`PyObject_GetAttr()` 。

int **PyObject_HasAttrString**(*PyObject* *o, const char *attr_name)

Part of the Stable ABI. 如果 *o* 带有属性 *attr_name*，则返回 `1`，否则返回 `0`。这相当于 Python 表达式 `hasattr(o, attr_name)`。此函数总是成功。

注意，在调用 `__getattr__()` 和 `__getattribute__()` 方法并创建一个临时字符串对象时，异常将被抑制。若要获得错误报告，请换用`PyObject_GetAttrString()` 。

PyObject ***PyObject_GetAttr**(*PyObject* *o, *PyObject* *attr_name)

Return value: New reference. Part of the Stable ABI. 从对象 *o* 中读取名为 *attr_name* 的属性。成功返回属性值，失败则返回 `NULL`。这相当于 Python 表达式 `o.attr_name`。

PyObject ***PyObject_GetAttrString**(*PyObject* *o, const char *attr_name)

Return value: New reference. Part of the Stable ABI. 从对象 *o* 中读取一个名为 *attr_name* 的属性。成功时返回属性值，失败则返回 NULL。这相当于 Python 表达式 `o.attr_name`。

PyObject ***PyObject_GenericGetAttr**(*PyObject* *o, *PyObject* *name)

Return value: New reference. Part of the Stable ABI. 通用的属性获取函数，用于放入类型对象的 `tp_getattro` 槽中。它在类的字典中（位于对象的 MRO 中）查找某个描述符，并在对象的 `__dict__` 中查找某个属性。正如 descriptors 所述，数据描述符优先于实例属性，而非数据描述符则不优先。失败则会触发 `AttributeError` 。

int **PyObject_SetAttr**(*PyObject* *o, *PyObject* *attr_name, *PyObject* *v)

Part of the Stable ABI. 将对象 *o* 中名为 *attr_name* 的属性值设为 *v* 。失败时引发异常并返回 `-1`；成功时返回 "0" 。这相当于 Python 语句 `o.attr_name = v`。

如果 *v* 为 NULL，该属性将被删除。此行为已被弃用而应改用`PyObject_DelAttr()`，但目前还没有移除它的计划。

int **PyObject_SetAttrString**(*PyObject* *o, const char *attr_name, *PyObject* *v)

Part of the Stable ABI. 将对象 *o* 中名为 *attr_name* 的属性值设为 *v* 。失败时引发异常并返回 `-1`；成功时返回 "0" 。这相当于 Python 语句 `o.attr_name = v`。

如果 *v* 为 NULL，该属性将被删除，但是此功能已被弃用而应改用`PyObject_DelAttrString()`。

int **PyObject_GenericSetAttr**(*PyObject* *o, *PyObject* *name, *PyObject* *value)

Part of the Stable ABI. 通用的属性设置和删除函数，用于放入类型对象的`tp_setattro`槽。它在类的字典中（位于对象的 MRO 中）查找数据描述器，如果找到，则将比在实例字典中设置或删除属性优先执行。否则，该属性将在对象的 `__dict__` 中设置或删除。如果成功将返回 `0`，否则将引发 `AttributeError` 并返回 `-1`。

int **PyObject_DelAttr**(*PyObject* *o, *PyObject* *attr_name)

删除对象 *o* 中名为 *attr_name* 的属性。失败时返回 `-1`。这相当于 Python 语句 `del o.attr_name`。

int **PyObject_DelAttrString**(*PyObject* *o, const char *attr_name)

删除对象 *o* 中名为 *attr_name* 的属性。失败时返回 `-1`。这相当于 Python 语句 `del o.attr_name`。

PyObject ***PyObject_GenericGetDict**(*PyObject* *o, void *context)

Return value: New reference. Part of the Stable ABI *since version 3.10.* `__dict__` 描述符的获取函数的一种通用实现。必要时会创建该字典。

This function may also be called to get the `__dict__` of the object *o*. Pass NULL for *context* when calling it. Since this function may need to allocate memory for the dictionary, it may be more efficient to call `PyObject_GetAttr()` when accessing an attribute on the object.

On failure, returns NULL with an exception set.

3.3 新版功能.

int **PyObject_GenericSetDict**(*PyObject* *o, *PyObject* *value, void *context)

Part of the Stable ABI *since version 3.7.* `__dict__` 描述符设置函数的一种通用实现。这里不允许删除该字典。

3.3 新版功能.

PyObject ****_PyObject_GetDictPtr**(*PyObject* *obj)

Return a pointer to `__dict__` of the object *obj*. If there is no `__dict__`, return NULL without setting an exception.

This function may need to allocate memory for the dictionary, so it may be more efficient to call `PyObject_GetAttr()` when accessing an attribute on the object.

PyObject ***PyObject_RichCompare**(*PyObject* *o1, *PyObject* *o2, int opid)

Return value: New reference. Part of the Stable ABI. 用 *opid* 指定的操作比较 *o1* 和 *o2* 的值，必须是 `Py_LT` 、`Py_LE` 、`Py_EQ` 、`Py_NE` 、`Py_GT` 或 `Py_GE` 之一，分别对应于 "<、``<= 、 == 、 != 、 > 或 >=。这相当于 Python 表达式 `o1 op o2`，其中 `op` 是对应于 *opid* 的操作符。成功时返回比较值，失败时返回 NULL。

int **PyObject_RichCompareBool** (*PyObject* *o1, *PyObject* *o2, int opid)

Part of the Stable ABI. 用 *opid* 指定的操作比较 *o1* 和 *o2* 的值，必须是 `Py_LT` 、`Py_LE` 、`Py_EQ` 、`Py_NE` 、`Py_GT` 或 `Py_GE` 之一，分别对应于 `<` 、`<=`、`==` 、`!=` 、`>` 或 `>=`。错误时返回 `-1`，若结果为 false 则返回 `0`，否则返回 `1`。这相当于 Python 表达式 `o1 op o2`，其中 `op` 是对应于 *opid* 的操作符。

备注： 如果 *o1* 和 *o2* 是同一个对象，`PyObject_RichCompareBool()` 为 `Py_EQ` 则返回 `1` ，为 `Py_NE` 则返回 `0`。

PyObject ***PyObject_Repr** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 计算对象 *o* 的字符串形式。成功时返回字符串，失败时返回 `NULL`。这相当于 Python 表达式 `repr(o)`。由内置函数 `repr()` 调用。

在 3.4 版更改: 该函数现在包含一个调试断言，用以确保不会静默地丢弃活动的异常。

PyObject ***PyObject_ASCII** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 与`PyObject_Repr()` 一样，计算对象 *o* 的字符串形式，但在`PyObject_Repr()` 返回的字符串中用 `\x`、`\u` 或 `\U` 转义非 ASCII 字符。这将生成一个类似于 Python 2 中由`PyObject_Repr()` 返回的字符串。由内置函数 `ascii()` 调用。

PyObject ***PyObject_Str** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 计算对象 *o* 的字符串形式。成功时返回字符串，失败时返回 `NULL`。这相当于 Python 表达式 `str(o)`。由内置函数 `str()` 调用，因此也由 `print()` 函数调用。

在 3.4 版更改: 该函数现在包含一个调试断言，用以确保不会静默地丢弃活动的异常。

PyObject ***PyObject_Bytes** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 计算对象 *o* 的字节形式。失败时返回 `NULL`，成功时返回一个字节串对象。这相当于 *o* 不是整数时的 Python 表达式 `bytes(o)` 。与 `bytes(o)` 不同的是，当 *o* 是整数而不是初始为 0 的字节串对象时，会触发 TypeError。

int **PyObject_IsSubclass** (*PyObject* *derived, *PyObject* *cls)

Part of the Stable ABI. 如果 *derived* 类与 *cls* 类相同或为其派生类，则返回 `1`，否则返回 `0`。如果出错则返回 `-1`。

如果 *cls* 是元组，则会对 *cls* 进行逐项检测。如果至少有一次检测返回 `1`，结果将为 `1`，否则将是 `0`。

正如 **PEP 3119** 所述，如果 *cls* 带有 `__subclasscheck__()` 方法，将会被调用以确定子类的状态。否则，如果 *derived* 是个直接或间接子类，即包含在 `cls.__mro__` 中，那么它就是 *cls* 的一个子类。

通常只有类对象才会被视为类，即 `type` 或派生类的实例。然而，对象可以通过拥有 `__bases__` 属性（必须是基类的元组）来覆盖这一点。

int **PyObject_IsInstance** (*PyObject* *inst, *PyObject* *cls)

Part of the Stable ABI. 如果 *inst* 是 *cls* 类或其子类的实例，则返回 `1`，如果不是则返回 "0"。如果出错则返回 `-1` 并设置一个异常。

如果 *cls* 是元组，则会对 *cls* 进行逐项检测。如果至少有一次检测返回 `1`，结果将为 `1`，否则将是 `0`。

正如 **PEP 3119** 所述，如果 *cls* 带有 `__subclasscheck__()` 方法，将会被调用以确定子类的状态。否则，如果 *derived* 是 *cls* 的子类，那么它就是 *cls* 的一个实例。

实例 *inst* 可以通过 `__class__` 属性来覆盖其所属类。

对象 *cls* 是否被认作类，以及基类是什么，均可通过 `__bases__` 属性（必须是基类的元组）进行覆盖。

Py_hash_t **PyObject_Hash** (*PyObject* *o)

Part of the Stable ABI. 计算并返回对象的哈希值 *o*。失败时返回 `-1`。这相当于 Python 表达式 `hash(o)`。

在 3.2 版更改: 现在的返回类型是 Py_hash_t。这是一个大小与`Py_ssize_t` 相同的有符号整数。

Py_hash_t **PyObject_HashNotImplemented**(*PyObject* *o)

Part of the Stable ABI. 设置一个 `TypeError` 表示 `type(o)` 是不可哈希的，并返回 `-1` 。该函数保存在 `tp_hash` 槽中时会受到特别对待，允许某个类型向解释器显式表明它不可散列。

int **PyObject_IsTrue**(*PyObject* *o)

Part of the Stable ABI. 如果对象 *o* 被认为是 true，则返回 `1`，否则返回 `0`。这相当于 Python 表达式 `not not o`。失败则返回 `-1`。

int **PyObject_Not**(*PyObject* *o)

Part of the Stable ABI. 如果对象 *o* 被认为是 true，则返回 `1`，否则返回 `0`。这相当于 Python 表达式 `not not o`。失败则返回 `-1`。

PyObject ***PyObject_Type**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. When *o* is non-`NULL`, returns a type object corresponding to the object type of object *o*. On failure, raises `SystemError` and returns `NULL`. This is equivalent to the Python expression `type(o)`. This function increments the reference count of the return value. There's really no reason to use this function instead of the *`Py_TYPE()`* function, which returns a pointer of type *`PyTypeObject*`*, except when the incremented reference count is needed.

int **PyObject_TypeCheck**(*PyObject* *o, *PyTypeObject* *type)

如果对象 *o* 是 *type* 类型或其子类型，则返回非零，否则返回 `0`。两个参数都必须非 `NULL`。

Py_ssize_t **PyObject_Size**(*PyObject* *o)

Py_ssize_t **PyObject_Length**(*PyObject* *o)

Part of the Stable ABI. 返回对象 *o* 的长度。如果对象 *o* 支持序列和映射协议，则返回序列长度。出错时返回 `-1`。这等同于 Python 表达式 `len(o)`。

Py_ssize_t **PyObject_LengthHint**(*PyObject* *o, *Py_ssize_t* defaultvalue)

返回对象 *o* 的估计长度。首先尝试返回实际长度，然后用 `__length_hint__()` 进行估计，最后返回默认值。出错时返回 "-1"。这等同于 Python 表达式 `operator.length_hint(o, defaultvalue)`。

3.4 新版功能.

PyObject ***PyObject_GetItem**(*PyObject* *o, *PyObject* *key)

Return value: New reference. Part of the Stable ABI. 返回对象 *key* 对应的 *o* 元素，或在失败时返回 `NULL`。这等同于 Python 表达式 `o[key]`。

int **PyObject_SetItem**(*PyObject* *o, *PyObject* *key, *PyObject* *v)

Part of the Stable ABI. 将对象 *key* 映射到值 *v*。失败时引发异常并返回 `-1`；成功时返回 `0`。这相当于 Python 语句 `o[key] = v`。该函数 不会偷取 *v* 的引用计数。

int **PyObject_DelItem**(*PyObject* *o, *PyObject* *key)

Part of the Stable ABI. 从对象 *o* 中移除对象 *key* 的映射。失败时返回 `-1`。这相当于 Python 语句 `del o[key]`。

PyObject ***PyObject_Dir**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 相当于 Python 表达式 `dir(o)`，返回一个（可能为空）适合对象参数的字符串列表，如果出错则返回 `NULL`。如果参数为 `NULL`，类似 Python 的 `dir()`，则返回当前 locals 的名字；这时如果没有活动的执行框架，则返回 `NULL`，但*`PyErr_Occurred()`* 将返回 false。

PyObject ***PyObject_GetIter**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 等同于 Python 表达式 `iter(o)`。为对象参数返回一个新的迭代器，如果该对象已经是一个迭代器，则返回对象本身。如果对象不能被迭代，会引发 `TypeError` ，并返回 `NULL`。

PyObject ***PyObject_GetAIter**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI *since version 3.10.* 等同于 Python 表达式 `aiter(o)`。接受一个 `AsyncIterable` 对象，并为其返回一个 `AsyncIterator`。通常返回的是一个新迭代器，但如果参数是一个 `AsyncIterator`，将返回其自身。如果该对象不能被迭代，会引发 `TypeError`，并返回 `NULL`。

3.10 新版功能.

7.2 调用协议

CPython 支持两种不同的调用协议：*tp_call* 和矢量调用。

7.2.1 *tp_call* 协议

设置`tp_call` 的类的实例都是可调用的。槽位的签名为:

```
PyObject *tp_call(PyObject *callable, PyObject *args, PyObject *kwargs);
```

一个调用是用一个元组表示位置参数，用一个 dict 表示关键字参数，类似于 Python 代码中的 "callable(*args, **kwargs)"。*args* 必须是非空的（如果没有参数，会使用一个空元组），但如果没有关键字参数，*kwargs* 可以是 *NULL*。

这个约定不仅被 *tp_call* 使用：`tp_new` 和`tp_init` 也这样传递参数。

要调用一个对象，请使用`PyObject_Call()` 或者其他的调用 *API*。

7.2.2 Vectorcall 协议

3.9 新版功能.

vectorcall 协议是在 **PEP 590** 被引入的，它是使调用函数更加有效的附加协议。

作为经验法则，如果可调用程序支持 vectorcall，CPython 会更倾向于内联调用。然而，这并不是一个硬性规定。此外，一些第三方扩展直接使用 *tp_call* (而不是使用`PyObject_Call()`)。因此，一个支持 vectorcall 的类也必须实现`tp_call`。此外，无论使用哪种协议，可调对象的行为都必须是相同的。推荐的方法是将`tp_call` 设置为`PyVectorcall_Call()`。值得一提的是:

警告： 一个支持 Vectorcall 的类 **必须**也实现具有相同语义的`tp_call`。

如果一个类的 vectorcall 比 *tp_call* 慢，就不应该实现 vectorcall。例如，如果被调用者需要将参数转换为 args 元组和 kwargs dict，那么实现 vectorcall 就没有意义。

类可以通过启用`Py_TPFLAGS_HAVE_VECTORCALL` 标志并将`tp_vectorcall_offset` 设置为对象结构中的 *vectorcallfunc* 的 offset 来实现 vectorcall 协议。这是一个指向具有以下签名的函数的指针:

typedef *PyObject* *(***vectorcallfunc**)(*PyObject* *callable, *PyObject* *const *args, size_t nargsf, *PyObject* *kwnames)

- *callable* 是指被调用的对象。
- ***args* 是一个 C 语言数组，由位置参数和后面的** 关键字参数的值。如果没有参数，这个值可以是 *NULL* 。
- ***nargsf* 是位置参数的数量加上可能的** `PY_VECTORCALL_ARGUMENTS_OFFSET` 标志。要从 *nargsf* 获得实际的位置参数数，请使用`PyVectorcall_NARGS()`。
- ***kwnames* 是一包含所有关键字名称的元组。** 换句话说，就是 kwargs 字典的键。这些名字必须是字符串 (`str` 或其子类的实例)，并且它们必须是唯一的。如果没有关键字参数，那么 *kwnames* 可以用 *NULL* 代替。

PY_VECTORCALL_ARGUMENTS_OFFSET

如果在 vectorcall 的 *nargsf* 参数中设置了此标志，则允许被调用者临时更改 `args[-1]` 的值。换句话说，*args* 指向分配向量中的参数 1（不是 0 ）。被调用方必须在返回之前还原 `args[-1]` 的值。

对于*PyObject_VectorcallMethod()*，这个标志的改变意味着 "args[0]" 可能改变了。

当调用方可以以几乎无代价的方式（无额外的内存申请），那么调用者被推荐适用：`PY_VECTORCALL_ARGUMENTS_OFFSET`。这样做将允许诸如绑定方法之类的可调用函数非常有效地进行向前调用（其中包括一个带前缀的 *self* 参数）。

要调用一个实现了 vectorcall 的对象，请使用某个*call API* 函数，就像其他可调对象一样。*PyObject_Vectorcall()* 通常是最有效的。

备注： 在 CPython 3.8 中，vectorcall API 和相关的函数暂定以带开头下划线的名称提供：`_PyObject_Vectorcall`, `_Py_TPFLAGS_HAVE_VECTORCALL`, `_PyObject_VectorcallMethod`, `_PyVectorcall_Function`, `_PyObject_CallOneArg`, `_PyObject_CallMethodNoArgs`, `_PyObject_CallMethodOneArg`。此外，`PyObject_VectorcallDict` 以 `_PyObject_FastCallDict` 的名称提供。旧名称仍然被定义为不带下划线的新名称的别名。

递归控制

在使用 *tp_call* 时，被调用者不必担心*递归*：CPython 对于使用 *tp_call* 进行的调用会使用*Py_EnterRecursiveCall()* 和*Py_LeaveRecursiveCall()*。

为保证效率，这不适用于使用 vectorcall 的调用：被调用方在需要时应当使用 *Py_EnterRecursiveCall* 和 *Py_LeaveRecursiveCall*。

Vectorcall 支持 API

Py_ssize_t **PyVectorcall_NARGS**(size_t nargsf)

给定一个 vectorcall *nargsf* 实参，返回参数的实际数量。目前等同于：

```
(Py_ssize_t)(nargsf & ~PY_VECTORCALL_ARGUMENTS_OFFSET)
```

然而，应使用 `PyVectorcall_NARGS` 函数以便将来扩展。

3.8 新版功能.

vectorcallfunc **PyVectorcall_Function**(*PyObject* *op)

如果 *op* 不支持 vectorcall 协议（要么是因为类型不支持，要么是因为具体实例不支持），返回 *NULL*。否则，返回存储在 *op* 中的 vectorcall 函数指针。这个函数从不触发异常。

这在检查 *op* 是否支持 vectorcall 时最有用处，可以通过检查 `PyVectorcall_Function(op) != NULL` 来实现。

3.8 新版功能.

PyObject ***PyVectorcall_Call**(*PyObject* *callable, *PyObject* *tuple, *PyObject* *dict)

调用 * 可调对象 * 的*vectorcallfunc*，其位置参数和关键字参数分别以元组和 dict 形式给出。

这是一个专门函数，其目的是被放入*tp_call* 槽位或是用于 `tp_call` 的实现。它不会检查*Py_TPFLAGS_HAVE_VECTORCALL* 旗标并且它不会回退到 `tp_call`。

3.8 新版功能.

7.2.3 调用对象的 API

有多个函数可被用来调用 Python 对象。各个函数会将其参数转换为被调用对象所支持的惯例–可以是 *tp_call* 或 vectorcall。为了尽可能少地进行转换，请选择一个适合你所拥有的数据格式的函数。

下表总结了可用的功能；请参阅各个文档以了解详细信息。

函数	可调用对象（Callable）	args	kwargs
`PyObject_Call()`	`PyObject *`	元组	dict/`NULL`
`PyObject_CallNoArgs()`	`PyObject *`	---	---
`PyObject_CallOneArg()`	`PyObject *`	1 个对象	---
`PyObject_CallObject()`	`PyObject *`	元组/`NULL`	---
`PyObject_CallFunction()`	`PyObject *`	format	---
`PyObject_CallMethod()`	对象 + `char*`	format	---
`PyObject_CallFunctionObjArgs()`	`PyObject *`	可变参数	---
`PyObject_CallMethodObjArgs()`	对象 + 名称	可变参数	---
`PyObject_CallMethodNoArgs()`	对象 + 名称	---	---
`PyObject_CallMethodOneArg()`	对象 + 名称	1 个对象	---
`PyObject_Vectorcall()`	`PyObject *`	vectorcall	vectorcall
`PyObject_VectorcallDict()`	`PyObject *`	vectorcall	dict/`NULL`
`PyObject_VectorcallMethod()`	参数 + 名称	vectorcall	vectorcall

PyObject ***PyObject_Call**(*PyObject* *callable, *PyObject* *args, *PyObject* *kwargs)

Return value: New reference. Part of the Stable ABI*.* 调用一个可调用的 Python 对象 *callable*，附带由元组 *args* 所给出的参数，以及由字典 *kwargs* 所给出的关键字参数。

args 必须不为 *NULL*；如果不想要参数请使用一个空元组。如果不想要关键字参数，则 *kwargs* 可以为 *NULL*。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

这等价于 Python 表达式 `callable(*args, **kwargs)`。

PyObject ***PyObject_CallNoArgs**(*PyObject* *callable)

Part of the Stable ABI *since version 3.10.* 调用一个可调用的 Python 对象 *callable* 并不附带任何参数。这是不带参数调用 Python 可调用对象的最有效方式。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

3.9 新版功能.

PyObject ***PyObject_CallOneArg**(*PyObject* *callable, *PyObject* *arg)

调用一个可调用的 Python 对象 *callable* 并附带恰好 1 个位置参数 *arg* 而没有关键字参数。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

3.9 新版功能.

PyObject ***PyObject_CallObject**(*PyObject* *callable, *PyObject* *args)

Return value: New reference. Part of the Stable ABI*.* 调用一个可调用的 Python 对象 *callable*，附带由元组 *args* 所给出的参数。如果不想要传入参数，则 *args* 可以为 *NULL*。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

这等价于 Python 表达式 `callable(*args)`。

PyObject ***PyObject_CallFunction**(*PyObject* *callable, const char *format, ...)

Return value: New reference. Part of the Stable ABI*.* 调用一个可调用的 Python 对象 *callable*，附带可变数量的 C 参数。这些 C 参数使用 `Py_BuildValue()` 风格的格式字符串来描述。format 可以为 *NULL*，表示没有提供任何参数。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

这等价于 Python 表达式 `callable(*args)`。

Note that if you only pass `PyObject*` args, `PyObject_CallFunctionObjArgs()` is a faster alternative.

在 3.4 版更改: 这个 *format* 类型已从 `char *` 更改。

PyObject ***PyObject_CallMethod**(*PyObject* *obj, const char *name, const char *format, ...)

Return value: New reference. Part of the Stable ABI. 调用 *obj* 对象中名为 *name* 的方法并附带可变数量的 C 参数。这些 C 参数由`Py_BuildValue()` 格式字符串来描述并应当生成一个元组。

格式可以为 *NULL* ，表示未提供任何参数。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

这和 Python 表达式 "obj.name(arg1, arg2, ...)"是一样的。

Note that if you only pass `PyObject*` args, `PyObject_CallMethodObjArgs()` is a faster alternative.

在 3.4 版更改: The types of *name* and *format* were changed from `char *`.

PyObject ***PyObject_CallFunctionObjArgs**(*PyObject* *callable, ...)

Return value: New reference. Part of the Stable ABI. Call a callable Python object *callable*, with a variable number of `PyObject*` arguments. The arguments are provided as a variable number of parameters followed by *NULL*.

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

这和 Python 表达式 "callable(arg1, arg2, ...)"是一样的。

PyObject ***PyObject_CallMethodObjArgs**(*PyObject* *obj, *PyObject* *name, ...)

Return value: New reference. Part of the Stable ABI. Call a method of the Python object *obj*, where the name of the method is given as a Python string object in *name*. It is called with a variable number of `PyObject*` arguments. The arguments are provided as a variable number of parameters followed by *NULL*.

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

PyObject ***PyObject_CallMethodNoArgs**(*PyObject* *obj, *PyObject* *name)

调用 Python 对象 *obj* 中的一个方法并不附带任何参数，其中方法名称由 *name* 中的 Python 字符串对象给出。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

3.9 新版功能.

PyObject ***PyObject_CallMethodOneArg**(*PyObject* *obj, *PyObject* *name, *PyObject* *arg)

调用 Python 对象 *obj* 中的一个方法并附带单个位置参数 *arg*，其中方法名称由 *name* 中的 Python 字符串对象给出。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

3.9 新版功能.

PyObject ***PyObject_Vectorcall**(*PyObject* *callable, *PyObject* *const *args, size_t nargsf, *PyObject* *kwnames)

调用一个可调用的 Python 对象 *callable*。附带的参数与`vectorcallfunc` 相同。如果 *callable* 支持*vectorcall*，则它会直接调用存放在 *callable* 中的 vectorcall 函数。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

3.9 新版功能.

PyObject ***PyObject_VectorcallDict**(*PyObject* *callable, *PyObject* *const *args, size_t nargsf, *PyObject* *kwdict)

调用 *callable* 并附带与在*vectorcall* 协议中传入的完全相同的位置参数，但会加上以字典 *kwdict* 形式传入的关键字参数。*args* 数组将只包含位置参数。

无论在内部使用哪种协议，都需要进行参数的转换。因此，此函数应当仅在调用方已经拥有作为关键字参数的字典，但没有作为位置参数的元组时才被使用。

3.9 新版功能.

PyObject ***PyObject_VectorcallMethod**(*PyObject* *name, *PyObject* *const *args, size_t nargsf, *PyObject* *kwnames)

使用 vectorcall 调用惯例来调用一个方法。方法的名称以 Python 字符串 *name* 的形式给出。调用方法的对象为 *args[0]*，而 *args* 数组从 *args[1]* 开始的部分则代表调用用的参数。必须传入至少一个位置参数。*nargsf* 为包括 *args[0]* 在内的位置参数的数量，如果 `args[0]` 的值可能被临时改变则要再加上 `PY_VECTORCALL_ARGUMENTS_OFFSET`。关键字参数可以像在 `PyObject_Vectorcall()` 中一样被传入。

如果对象具有 `Py_TPFLAGS_METHOD_DESCRIPTOR` 特性，此函数将调用调用未绑定的方法对象并附带完整的 *args* vector 作为参数。

成功时返回结果，在失败时抛出一个异常并返回 *NULL*。

3.9 新版功能.

7.2.4 调用支持 API

int **PyCallable_Check**(*PyObject* *o)

Part of the Stable ABI. 确定对象 *o* 是可调对象。如果对象是可调对象则返回 `1`，其他情况返回 `0`。这个函数不会调用失败。

7.3 数字协议

int **PyNumber_Check**(*PyObject* *o)

Part of the Stable ABI. 如果对象 *o* 提供数字的协议，返回真 `1`，否则返回假。这个函数不会调用失败。

在 3.8 版更改: 如果 *o* 是一个索引整数则返回 `1`。

PyObject ***PyNumber_Add**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1*、*o2* 相加的结果，如果失败，返回 `NULL`。等价于 Python 表达式 `o1 + o2`。

PyObject ***PyNumber_Subtract**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 减去 *o2* 的结果，如果失败，返回 `NULL`。等价于 Python 表达式 `o1 - o2`。

PyObject ***PyNumber_Multiply**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1*、*o2* 相乘的结果，如果失败，返回 `NULL`。等价于 Python 表达式 `o1 * o2`。

PyObject ***PyNumber_MatrixMultiply**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 返回 *o1*、*o2* 做矩阵乘法的结果，如果失败，返回 `NULL`。等价于 Python 表达式 `o1 @ o2`。

3.5 新版功能.

PyObject ***PyNumber_FloorDivide**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 除以 *o2* 向下取整的值，失败时返回 `NULL`。这等价于 Python 表达式 `o1 // o2`。

PyObject ***PyNumber_TrueDivide**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 除以 *o2* 的数学值的合理近似值，或失败时返回 `NULL`。返回的是" 近似值" 因为二进制浮点数本身就是近似值；不可能以二进制精确表示所有实数。此函数可以在传入两个整数时返回一个浮点值。此函数等价于 Python 表达式 `o1 / o2`。

PyObject ***PyNumber_Remainder**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 除以 *o2* 得到的余数，如果失败，返回 `NULL`。等价于 Python 表达式 `o1 % o2`。

PyObject ***PyNumber_Divmod**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 参考内置函数 `divmod()`。如果失败，返回 `NULL`。等价于 Python 表达式 `divmod(o1, o2)`。

PyObject ***PyNumber_Power**(*PyObject* *o1, *PyObject* *o2, *PyObject* *o3)

Return value: New reference. Part of the Stable ABI. 请参阅内置函数 `pow()`。如果失败，返回 `NULL`。等价于 Python 中的表达式 `pow(o1, o2, o3)`，其中 *o3* 是可选的。如果要忽略 *o3*，则需传入 `Py_None` 作为代替（如果传入 `NULL` 会导致非法内存访问）。

PyObject ***PyNumber_Negative**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回 *o* 的负值，如果失败，返回 `NULL` 。等价于 Python 表达式 `-o`。

PyObject ***PyNumber_Positive**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回 *o*，如果失败，返回 `NULL` 。等价于 Python 表达式 `+o`。

PyObject ***PyNumber_Absolute**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回 *o* 的绝对值，如果失败，返回 `NULL`。等价于 Python 表达式 `abs(o)`。

PyObject ***PyNumber_Invert**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回 *o* 的按位取反后的结果，如果失败，返回 `NULL`。等价于 Python 表达式 `~o`。

PyObject ***PyNumber_Lshift**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 左移 *o2* 个比特后的结果，如果失败，返回 `NULL`。等价于 Python 表达式 `o1 << o2`。

PyObject ***PyNumber_Rshift**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 右移 *o2* 个比特后的结果，如果失败，返回 `NULL` 。等价于 Python 表达式 `o1 >> o2`。

PyObject ***PyNumber_And**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 和 *o2* "按位与"的结果，如果失败，返回 `NULL` 。等价于 Python 表达式 `o1 & o2`。

PyObject ***PyNumber_Xor**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 和 *o2* "按位异或"的结果，如果失败，返回 `NULL` 。等价于 Python 表达式 `o1 ^ o2`。

PyObject ***PyNumber_Or**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 和 *o2* "按位或"的结果，如果失败，返回 `NULL` 。等价于 Python 表达式 `o1 | o2`。

PyObject ***PyNumber_InPlaceAdd**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 、*o2* 相加的结果，如果失败，返回 `NULL`。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 += o2`。

PyObject ***PyNumber_InPlaceSubtract**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 、*o2* 相减的结果，如果失败，返回 `NULL` 。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 -= o2`。

PyObject ***PyNumber_InPlaceMultiply**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 、*o2* 相乘的结果，如果失败，返回 "NULL"。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 *= o2`。

PyObject ***PyNumber_InPlaceMatrixMultiply**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 返回 *o1* 、*o2* 做矩阵乘法后的结果，如果失败，返回 `NULL` 。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 @= o2`。

3.5 新版功能.

PyObject ***PyNumber_InPlaceFloorDivide**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 除以 *o2* 后向下取整的结果，如果失败，返回 NULL。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 //= o2`。

PyObject ***PyNumber_InPlaceTrueDivide**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 除以 *o2* 的数学值的合理近似值，或失败时返回 NULL。返回的是" 近似值" 因为二进制浮点数本身就是近似值；不可能以二进制精确表示所有实数。此函数可以在传入两个整数时返回一个浮点数。此运算在 *o1* 支持的时候会 原地执行。此函数等价于 Python 语句 `o1 /= o2`。

PyObject ***PyNumber_InPlaceRemainder**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 除以 *o2* 得到的余数，如果失败，返回 NULL。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 %= o2`。

PyObject ***PyNumber_InPlacePower**(*PyObject* *o1, *PyObject* *o2, *PyObject* *o3)

Return value: New reference. Part of the Stable ABI. 请参阅内置函数 `pow()`。如果失败，返回 NULL。当 *o1* 支持时，这个运算直接使用它储存结果。当 *o3* 是 *Py_None* 时，等价于 Python 语句 `o1 **= o2`；否则等价于在原来位置储存结果的 `pow(o1, o2, o3)` 。如果要忽略 *o3*，则需传入 *Py_None* (传入 NULL 会导致非法内存访问)。

PyObject ***PyNumber_InPlaceLshift**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 左移 *o2* 个比特后的结果，如果失败，返回 NULL。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 <<= o2`。

PyObject ***PyNumber_InPlaceRshift**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 返回 *o1* 右移 *o2* 个比特后的结果，如果失败，返回 NULL。当 *o1* 支持时，这个运算直接使用它储存结果。等价于 Python 语句 `o1 >>= o2`。

PyObject ***PyNumber_InPlaceAnd**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o1* 和 *o2* " 按位与" 的结果，失败时返回 NULL。在 *o1* 支持的前提下该操作将 原地执行。等价与 Python 语句 `o1 &= o2`。

PyObject ***PyNumber_InPlaceXor**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o1* 和 *o2* " 按位异或的结果，失败时返回 NULL。在 *o1* 支持的前提下该操作将 原地执行。等价与 Python 语句 `o1 ^= o2`。

PyObject ***PyNumber_InPlaceOr**(*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o1* 和 *o2* " 按位或" 的结果，失败时返回 NULL。在 *o1* 支持的前提下该操作将 原地执行。等价于 Python 语句 `o1 |= o2`。

PyObject ***PyNumber_Long**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o* 转换为整数对象后的结果，失败时返回 NULL。等价于 Python 表达式 `int(o)`。

PyObject ***PyNumber_Float**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o* 转换为浮点对象后的结果，失败时返回 NULL。等价于 Python 表达式 `float(o)`。

PyObject ***PyNumber_Index**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o* 转换为 Python int 类型后的结果，失败时返回 NULL 并引发 `TypeError` 异常。

在 3.10 版更改: 结果总是为 `int` 类型。在之前版本中，结果可能为 `int` 的子类的实例。

PyObject ***PyNumber_ToBase**(*PyObject* *n, int base)

Return value: New reference. Part of the Stable ABI. 返回整数 *n* 转换成以 *base* 为基数的字符串后的结果。这个 *base* 参数必须是 2，8，10 或者 16 。对于基数 2，8，或 16 ，返回的字符串将分别加上基数标识 `'0b'`, `'0o'`, or `'0x'`。如果 *n* 不是 Python 中的整数 *int* 类型，就先通过 *PyNumber_Index()* 将它转换成整数类型。

Py_ssize_t **PyNumber_AsSsize_t** (*PyObject* *o, *PyObject* *exc)

Part of the Stable ABI. 如果 *o* 可以被解读为一个整数则返回 *o* 转换成的`Py_ssize_t` 值。如果调用失败，则会引发一个异常并返回 `-1`。

如果 *o* 可以被转换为 Python 的 int 值但尝试转换为`Py_ssize_t` 值则会引发 `OverflowError`，则 *exc* 参数将为所引发的异常类型 (通常为 `IndexError` 或 `OverflowError`)。如果 *exc* 为 `NULL`，则异常会被清除并且值会在为负整数时被裁剪为 `PY_SSIZE_T_MIN` 而在为正整数时被裁剪为 `PY_SSIZE_T_MAX`。

int **PyIndex_Check** (*PyObject* *o)

Part of the Stable ABI *since version 3.8.* 返回 `1` 如果 *o* 是一个索引整数（将 `nb_index` 槽位填充到 `tp_as_number` 结构体），或者在其他情况下返回 `0`。此函数总是会成功执行。

7.4 序列协议

int **PySequence_Check** (*PyObject* *o)

Part of the Stable ABI. 如果对象提供了序列协议则返回 `1`，否则返回 `0`。请注意它将为具有 `__getitem__()` 方法的 Python 类返回 `1`，除非它们是 `dict` 的子类，因为在通常情况下无法确定这种类支持哪种键类型。此函数总是会成功执行。

Py_ssize_t **PySequence_Size** (*PyObject* *o)

Py_ssize_t **PySequence_Length** (*PyObject* *o)

Part of the Stable ABI. 成功时返回序列中 *o* 的对象数, 失败时返回 "-1". 相当于 Python 的 "len(o)"表达式.

PyObject ***PySequence_Concat** (*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o1* 和 *o2* 的拼接，失败时返回 `NULL`。这等价于 Python 表达式 `o1 + o2`。

PyObject ***PySequence_Repeat** (*PyObject* *o, *Py_ssize_t* count)

Return value: New reference. Part of the Stable ABI. 返回序列对象 *o* 重复 *count* 次的结果，失败时返回 `NULL`。这等价于 Python 表达式 `o * count`。

PyObject ***PySequence_InPlaceConcat** (*PyObject* *o1, *PyObject* *o2)

Return value: New reference. Part of the Stable ABI. 成功时返回 *o1* 和 *o2* 的拼接，失败时返回 `NULL`。在 *o1* 支持的情况下操作将 原地完成。这等价于 Python 表达式 `o1 += o2`。

PyObject ***PySequence_InPlaceRepeat** (*PyObject* *o, *Py_ssize_t* count)

Return value: New reference. Part of the Stable ABI. Return the result of repeating sequence object 返回序列对象 *o* 重复 *count* 次的结果，失败时返回 `NULL`。在 *o* 支持的情况下该操作会 原地完成。这等价于 Python 表达式 `o *= count`。

PyObject ***PySequence_GetItem** (*PyObject* *o, *Py_ssize_t* i)

Return value: New reference. Part of the Stable ABI. 返回 *o* 中的第 *i* 号元素，失败时返回 `NULL`。这等价于 Python 表达式 `o[i]`。

PyObject ***PySequence_GetSlice** (*PyObject* *o, *Py_ssize_t* i1, *Py_ssize_t* i2)

Return value: New reference. Part of the Stable ABI. 返回序列对象 *o* 的 *i1* 到 *i2* 的切片，失败时返回 `NULL`。这等价于 Python 表达式 `o[i1:i2]`。

int **PySequence_SetItem** (*PyObject* *o, *Py_ssize_t* i, *PyObject* *v)

Part of the Stable ABI. 将对象 *v* 赋值给 *o* 的第 *i* 号元素。失败时会引发异常并返回 `-1`；成功时返回 `0`。这相当于 Python 语句 `o[i] = v`。此函数 不会改变对 *v* 的引用。

如果 *v* 为 `NULL`，元素将被删除，但是此特性已被弃用而应改用`PySequence_DelItem()`。

int **PySequence_DelItem** (*PyObject* *o, *Py_ssize_t* i)

Part of the Stable ABI. 删除对象 *o* 的第 *i* 号元素。失败时返回 `-1`。这相当于 Python 语句 `del o[i]`。

int **PySequence_SetSlice** (*PyObject* *o, *Py_ssize_t* i1, *Py_ssize_t* i2, *PyObject* *v)

Part of the Stable ABI. 将序列对象 *v* 赋值给序列对象 *o* 的从 *i1* 到 *i2* 切片。这相当于 Python 语句 `o[i1:i2] = v`。

int **PySequence_DelSlice** (*PyObject* *o, *Py_ssize_t* i1, *Py_ssize_t* i2)

Part of the Stable ABI. 删除序列对象 *o* 的从 *i1* 到 *i2* 的切片。失败时返回 `-1`。这相当于 Python 语句 `del o[i1:i2]`。

Py_ssize_t **PySequence_Count** (*PyObject* *o, *PyObject* *value)

Part of the Stable ABI. 返回 *value* 在 *o* 中出现的次数，即返回使得 `o[key] == value` 的键的数量。失败时返回 `-1`。这相当于 Python 表达式 `o.count(value)`。

int **PySequence_Contains** (*PyObject* *o, *PyObject* *value)

Part of the Stable ABI. 确定 *o* 是否包含 *value*。如果 *o* 中的某一项等于 *value*，则返回 `1`，否则返回 `0`。出错时，返回 `-1`。这相当于 Python 表达式 `value in o`。

Py_ssize_t **PySequence_Index** (*PyObject* *o, *PyObject* *value)

Part of the Stable ABI. 返回第一个索引 *i*, 其中 `o[i] == value`. 出错时, 返回 `-1`. 相当于 Python 的 "o.index(value)"表达式.

PyObject ***PySequence_List** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回一个列表对象，其内容与序列或可迭代对象 *o* 相同，失败时返回 `NULL`。返回的列表保证是一个新对象。这等价于 Python 表达式 `list(o)`。

PyObject ***PySequence_Tuple** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回一个元组对象，其内容与序列或可迭代对象 *o* 相同，失败时返回 `NULL`。如果 *o* 为元组，则将返回一个新的引用，在其他情况下将使用适当的内容构造一个元组。这等价于 Python 表达式 `tuple(o)`。

PyObject ***PySequence_Fast** (*PyObject* *o, const char *m)

Return value: New reference. Part of the Stable ABI. 将序列或可迭代对象 *o* 作为其他 `PySequence_Fast*` 函数族可用的对象返回。如果该对象不是序列或可迭代对象，则会引发 `TypeError` 并将 *m* 作为消息文本。失败时返回 `NULL`。

`PySequence_Fast*` 函数之所以这样命名，是因为它们会假定 *o* 是一个`PyTupleObject` 或`PyListObject` 并直接访问 *o* 的数据字段。

作为 CPython 的实现细节，如果 *o* 已经是一个序列或列表，它将被直接返回。

Py_ssize_t **PySequence_Fast_GET_SIZE** (*PyObject* *o)

在 *o* 由`PySequence_Fast()` 返回且 *o* 不为 `NULL` 的情况下返回 *o* 长度。也可以通过在 *o* 上调用`PySequence_Size()` 来获取大小，但是`PySequence_Fast_GET_SIZE()` 的速度更快因为它可以假定 *o* 为列表或元组。

PyObject ***PySequence_Fast_GET_ITEM** (*PyObject* *o, *Py_ssize_t* i)

Return value: Borrowed reference. 在 *o* 由`PySequence_Fast()` 返回且 *o* 不 `NULL`，并且 *i* d 在索引范围内的情况下返回 *o* 的第 *i* 号元素。

PyObject ****PySequence_Fast_ITEMS** (*PyObject* *o)

返回 PyObject 指针的底层数组。假设 *o* 由`PySequence_Fast()` 返回且 *o* 不为 `NULL`。

请注意, 如果列表调整大小, 重新分配可能会重新定位 items 数组. 因此, 仅在序列无法更改的上下文中使用基础数组指针.

PyObject ***PySequence_ITEM** (*PyObject* *o, *Py_ssize_t* i)

Return value: New reference. 返回 *o* 的第 *i* 个元素或在失败时返回 `NULL`。此形式比`PySequence_GetItem()` 理馔，但不会检查 *o* 上的`PySequence_Check()` 是否为真值，也不会对负序号进行调整。

7.5 映射协议

参见*PyObject_GetItem()*、*PyObject_SetItem()* 与*PyObject_DelItem()*。

int **PyMapping_Check**(*PyObject* *o)

Part of the Stable ABI. 如果对象提供了映射协议或是支持切片则返回 1，否则返回 0。请注意它将为具有 __getitem__() 方法的 Python 类返回 1，因为在通常情况下无法确定该类所支持的键类型。此函数总是会成功执行。

Py_ssize_t **PyMapping_Size**(*PyObject* *o)

Py_ssize_t **PyMapping_Length**(*PyObject* *o)

Part of the Stable ABI. 成功时返回对象 *o* 中键的数量，失败时返回 -1。这相当于 Python 表达式 len(o)。

PyObject ***PyMapping_GetItemString**(*PyObject* *o, const char *key)

Return value: New reference. Part of the Stable ABI. 返回 *o* 中对应于字符串 *key* 的元素，或者失败时返回 NULL。这相当于 Python 表达式 o[key]。另请参见 also *PyObject_GetItem()*。

int **PyMapping_SetItemString**(*PyObject* *o, const char *key, *PyObject* *v)

Part of the Stable ABI. 在对象 *o* 中将字符串 *key* 映射到值 *v*。失败时返回 -1。这相当于 Python 语句 o[key] = v。另请参见*PyObject_SetItem()*。此函数 不会增加对 *v* 的引用。

int **PyMapping_DelItem**(*PyObject* *o, *PyObject* *key)

从对象 *o* 中移除对象 *key* 的映射。失败时返回 -1。这相当于 Python 语句 del o[key]。这是*PyObject_DelItem()* 的一个别名。

int **PyMapping_DelItemString**(*PyObject* *o, const char *key)

从对象 *o* 中移除字符串 *key* 的映射。失败时返回 -1。这相当于 Python 语句 del o[key]。

int **PyMapping_HasKey**(*PyObject* *o, *PyObject* *key)

Part of the Stable ABI. 如果映射对象具有键 *key* 则返回 1，否则返回 0。这相当于 Python 表达式 key in o。此函数总是会成功执行。

请注意在调用 __getitem__() 方法期间发生的异常将会被屏蔽。要获取错误报告请改用*PyObject_GetItem()*。

int **PyMapping_HasKeyString**(*PyObject* *o, const char *key)

Part of the Stable ABI. 如果映射对象具有键 *key* 则返回 1，否则返回 0。这相当于 Python 表达式 key in o。此函数总是会成功执行。

请注意在调用 __getitem__() 方法期间发生的异常将会被屏蔽。要获取错误报告请改用*PyMapping_GetItemString()*。

PyObject ***PyMapping_Keys**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 成功时，返回对象 *o* 中的键的列表。失败时，返回 NULL。

在 3.7 版更改: 在之前版本中，此函数返回一个列表或元组。

PyObject ***PyMapping_Values**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 成功时，返回对象 *o* 中的值的列表。失败时，返回 NULL。

在 3.7 版更改: 在之前版本中，此函数返回一个列表或元组。

PyObject ***PyMapping_Items**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 成功时，返回对象 *o* 中条目的列表，其中每个条目是一个包含键值对的元组。失败时，返回 NULL。

在 3.7 版更改: 在之前版本中，此函数返回一个列表或元组。

7.6 迭代器协议

迭代器有两个函数。

int **PyIter_Check** (*PyObject* *o)

Part of the Stable ABI *since version 3.8.* 如果对象 Return non-zero if the object *o* 可以被安全把传给*PyIter_Next()* 则返回非零值，否则返回 0。此函数总是会成功执行。

int **PyAIter_Check** (*PyObject* *o)

Part of the Stable ABI *since version 3.10.* 如果对象 *o* 提供了 AsyncIterator 协议则返回非零值，否则返回 0。此函数总是会成功执行。

3.10 新版功能.

PyObject ***PyIter_Next** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 从迭代器 *o* 返回下一个值。对象必须可被*PyIter_Check()* 确认为迭代器（需要调用方来负责检查）。如果没有剩余的值，则返回 NULL 并且不设置异常。如果在获取条目时发生了错误，则返回 NULL 并且传递异常。

要为迭代器编写一个一个循环，C 代码应该看起来像这样

```
PyObject *iterator = PyObject_GetIter(obj);
PyObject *item;

if (iterator == NULL) {
    /* propagate error */
}

while ((item = PyIter_Next(iterator))) {
    /* do something with item */
    ...
    /* release reference when done */
    Py_DECREF(item);
}

Py_DECREF(iterator);

if (PyErr_Occurred()) {
    /* propagate error */
}
else {
    /* continue doing useful work */
}
```

type **PySendResult**

用于代表*PyIter_Send()* 的不同结果的枚举值。

3.10 新版功能.

PySendResult **PyIter_Send** (*PyObject* *iter, *PyObject* *arg, *PyObject* **presult)

Part of the Stable ABI *since version 3.10.* 将 *arg* 值发送到迭代器 *iter*。返回:

- PYGEN_RETURN，如果迭代器返回的话。返回值会通过 *presult* 来返回。
- PYGEN_NEXT，如果迭代器生成值的话。生成的值会通过 *presult* 来返回。
- PYGEN_ERROR，如果迭代器引发异常的话。*presult* 会被设为 NULL。

3.10 新版功能.

7.7 缓冲协议

在 Python 中可使用一些对象来包装对底层内存数组或称 缓冲的访问。此类对象包括内置的 `bytes` 和 `bytearray` 以及一些如 `array.array` 这样的扩展类型。第三方库也可能会为了特殊的目的而定义它们自己的类型，例如用于图像处理和数值分析等。

虽然这些类型中的每一种都有自己的语义，但它们具有由可能较大的内存缓冲区支持的共同特征。在某些情况下，希望直接访问该缓冲区而无需中间复制。

Python 以缓冲协议 的形式在 C 层级上提供这样的功能。此协议包括两个方面:

- 在生产者这一方面，该类型的协议可以导出一个"缓冲区接口"，允许公开它的底层缓冲区信息。该接口的描述信息在*Buffer Object Structures* 一节中；
- 在消费者一侧，有几种方法可用于获得指向对象的原始底层数据的指针（例如一个方法的形参）。

一些简单的对象例如 `bytes` 和 `bytearray` 会以面向字节的形式公开它们的底层缓冲区。也可能会用其他形式；例如 `array.array` 所公开的元素可以是多字节值。

缓冲区接口的消费者的一个例子是文件对象的 `write()` 方法：任何可以输出为一系列字节流的对象可以被写入文件。然而 `write()` 方法只需要对于传入对象的只读权限，其他的方法，如 `readinto()` 需要参数内容的写入权限。缓冲区接口使得对象可以选择性地允许或拒绝读写或只读缓冲区的导出。

对于缓冲区接口的使用者而言，有两种方式来获取一个目的对象的缓冲：

- 使用正确的参数来调用`PyObject_GetBuffer()` 函数；
- 调用`PyArg_ParseTuple()` (或其同级对象之一) 并传入 `y*`, `w*` or `s*` 格式代码 中的一个。

在这两种情况下，当不再需要缓冲区时必须调用`PyBuffer_Release()` 。如果此操作失败，可能会导致各种问题，例如资源泄漏。

7.7.1 缓冲区结构

缓冲区结构 (或者简单地称为"buffers") 对于将二进制数据从另一个对象公开给 Python 程序员非常有用。它们还可以用作零拷贝切片机制。使用它们引用内存块的能力，可以很容易地将任何数据公开给 Python 程序员。内存可以是 C 扩展中的一个大的常量数组，也可以是在传递到操作系统库之前用于操作的原始内存块，或者可以用来传递本机内存格式的结构化数据。

与 Python 解释器公开的大多部数据类型不同，缓冲区不是`PyObject` 指针而是简单的 C 结构。这使得它们可以非常简单地创建和复制。当需要为缓冲区加上泛型包装器时，可以创建一个内存视图 对象。

有关如何编写并导出对象的简短说明，请参阅缓冲区对象结构。要获取缓冲区对象，请参阅`PyObject_GetBuffer()`。

type **`Py_buffer`**

Part of the Stable ABI *(including all members) since version 3.11.*

void ***`buf`**

指向由缓冲区字段描述的逻辑结构开始的指针。这可以是导出程序底层物理内存块中的任何位置。例如，使用负的`strides` 值可能指向内存块的末尾。

对于*contiguous* ，'邻接'数组，值指向内存块的开头。

PyObject ***`obj`**

对导出对象的新引用。该引用归使用者所有，并由`PyBuffer_Release()` 自动递减并设置为 `NULL`。该字段等于任何标准 C-API 函数的返回值。

作为一种特殊情况，对于由`PyMemoryView_FromBuffer()` 或`PyBuffer_FillInfo()` 包装的 *temporary* 缓冲区，此字段为 `NULL`。通常，导出对象不得使用此方案。

Py_ssize_t **len**

product(shape) * itemsize。对于连续数组，这是基础内存块的长度。对于非连续数组，如果逻辑结构复制到连续表示形式，则该长度将具有该长度。

仅当缓冲区是通过保证连续性的请求获取时，才访问 ((char *)buf)[0] up to ((char *)buf)[len-1] 时才有效。在大多数情况下，此类请求将为*PyBUF_SIMPLE* 或*PyBUF_WRITABLE*。

int **readonly**

缓冲区是否为只读的指示器。此字段由*PyBUF_WRITABLE* 标志控制。

Py_ssize_t **itemsize**

单个元素的项大小（以字节为单位）。与 struct.calcsize() 调用非 NULL *format* 的值相同。

重要例外：如果使用者请求的缓冲区没有*PyBUF_FORMAT* 标志，*format* 将设置为 NULL，但*itemsize* 仍具有原始格式的值。

如果*shape* 存在，则相等的 product(shape) * itemsize == len 仍然存在，使用者可以使用*itemsize* 来导航缓冲区。

如果*shape* 是 NULL，因为结果为*PyBUF_SIMPLE* 或*PyBUF_WRITABLE* 请求，则使用者必须忽略*itemsize*，并假设 itemsize == 1。

const char ***format**

在 struct 模块样式语法中 *NUL* 字符串，描述单个项的内容。如果这是 NULL，则假定为 "”B”" (无符号字节) 。

此字段由*PyBUF_FORMAT* 标志控制。

int **ndim**

内存表示为 n 维数组的维数。如果是 "0"，*buf* 指向表示标量的单个项目。在这种情况下，*shape*、*strides* 和*suboffsets* 必须是 "NULL" 。

宏 PyBUF_MAX_NDIM 将最大维度数限制为 64。导出程序必须遵守这个限制，多维缓冲区的使用者应该能够处理最多 PyBUF_MAX_NDIM 维度。

Py_ssize_t ***shape**

一个长度为*Py_ssize_t* 的数组*ndim* 表示作为 n 维数组的内存形状。请注意，shape[0] * ... * shape[ndim-1] * itemsize 必须等于*len*。

Shape 形状数组中的值被限定在 shape[n] >= 0 。shape[n] == 0 这一情形需要特别注意。更多信息请参阅*complex arrays* 。

shape 数组对于使用者来说是只读的。

Py_ssize_t ***strides**

一个长度为*Py_ssize_t* 的数组*ndim* 给出要跳过的字节数以获取每个尺寸中的新元素。

Stride 步幅数组中的值可以为任何整数。对于常规数组，步幅通常为正数，但是使用者必须能够处理 strides[n] <= 0 的情况。更多信息请参阅*complex arrays* 。

strides 数组对用户来说是只读的。

Py_ssize_t ***suboffsets**

一个长度为*ndim* 类型为*Py_ssize_t* 的数组。如果 suboffsets[n] >= 0，则第 n 维存储的是指针，suboffset 值决定了解除引用时要给指针增加多少字节的偏移。suboffset 为负值，则表示不应解除引用（在连续内存块中移动）。

如果所有子偏移均为负（即无需取消引用），则此字段必须为 NULL （默认值）。

Python Imaging Library (PIL) 中使用了这种类型的数组表达方式。请参阅*complex arrays* 来了解如何从这样一个数组中访问元素。

suboffsets 数组对于使用者来说是只读的。

void ***internal**

供输出对象内部使用。比如可能被输出程序重组为一个整数，用于存储一个标志，标明在缓冲区释放时是否必须释放 shape、strides 和 suboffsets 数组。消费者程序 不得修改该值。

7.7.2 缓冲区请求的类型

通常，通过*PyObject_GetBuffer()* 向输出对象发送缓冲区请求，即可获得缓冲区。由于内存的逻辑结构复杂，可能会有很大差异，缓冲区使用者可用 *flags* 参数指定其能够处理的缓冲区具体类型。

所有*Py_buffer* 字段均由请求类型明确定义。

与请求无关的字段

以下字段不会被 *flags* 影响，并且必须总是用正确的值填充：*obj*, *buf*，*len*，*itemsize*，*ndim*。

只读，格式

PyBUF_WRITABLE

控制*readonly* 字段。如果设置了，输出程序 必须提供一个可写的缓冲区，否则报告失败。若未设置，输出程序 可以提供只读或可写的缓冲区，但对所有消费者程序 必须保持一致。

PyBUF_FORMAT

控制*format* 字段。如果设置，则必须正确填写此字段。其他情况下，此字段必须为"NULL"。

PyBUF_WRITABLE 可以和下一节的所有标志联用。由于*PyBUF_SIMPLE* 定义为 0，所以*PyBUF_WRITABLE* 可以作为一个独立的标志，用于请求一个简单的可写缓冲区。

PyBUF_FORMAT 可以被设为除了*PyBUF_SIMPLE* 之外的任何标志。后者已经按暗示了 "B"(无符号字节串) 格式。

形状，步幅，子偏移量

控制内存逻辑结构的标志按照复杂度的递减顺序列出。注意，每个标志包含它下面的所有标志。

请求	形状	步幅	子偏移量
PyBUF_INDIRECT	是	是	如果需要的话
PyBUF_STRIDES	是	是	NULL
PyBUF_ND	是	NULL	NULL
PyBUF_SIMPLE	NULL	NULL	NULL

连续性的请求

可以显式地请求 C 或 Fortran 连续，不管有没有步幅信息。若没有步幅信息，则缓冲区必须是 C-连续的。

请求	形状	步幅	子偏移量	邻接
PyBUF_C_CONTIGUOUS	是	是	NULL	C
PyBUF_F_CONTIGUOUS	是	是	NULL	F
PyBUF_ANY_CONTIGUOUS	是	是	NULL	C 或 F
PyBUF_ND	是	NULL	NULL	C

复合请求

所有可能的请求都由上一节中某些标志的组合完全定义。为方便起见，缓冲区协议提供常用的组合作为单个标志。

在下表中，*U* 代表连续性未定义。消费者程序必须调用 `PyBuffer_IsContiguous()` 以确定连续性。

请求	形状	步幅	子偏移量	邻接	只读	format
PyBUF_FULL	是	是	如果需要的话	U	0	是
PyBUF_FULL_RO	是	是	如果需要的话	U	1 或 0	是
PyBUF_RECORDS	是	是	NULL	U	0	是
PyBUF_RECORDS_RO	是	是	NULL	U	1 或 0	是
PyBUF_STRIDED	是	是	NULL	U	0	NULL
PyBUF_STRIDED_RO	是	是	NULL	U	1 或 0	NULL
PyBUF_CONTIG	是	NULL	NULL	C	0	NULL
PyBUF_CONTIG_RO	是	NULL	NULL	C	1 或 0	NULL

7.7.3 复杂数组

NumPy-风格：形状和步幅

NumPy 风格数组的逻辑结构由 *itemsize* 、*ndim* 、*shape* 和 *strides* 定义。

如果 `ndim == 0`，*buf* 指向的内存位置被解释为大小为 *itemsize* 的标量。这时，*shape* 和 *strides* 都为 `NULL`。

如果 *strides* 为 `NULL`，则数组将被解释为一个标准的 n 维 C 语言数组。否则，消费者程序必须按如下方式访问 n 维数组：

```
ptr = (char *)buf + indices[0] * strides[0] + ... + indices[n-1] * strides[n-1];
item = *((typeof(item) *)ptr);
```

如上所述，*buf* 可以指向实际内存块中的任意位置。输出者程序可以用该函数检查缓冲区的有效性。

```
def verify_structure(memlen, itemsize, ndim, shape, strides, offset):
    """Verify that the parameters represent a valid array within
       the bounds of the allocated memory:
           char *mem: start of the physical memory block
           memlen: length of the physical memory block
           offset: (char *)buf - mem
    """
    if offset % itemsize:
        return False
    if offset < 0 or offset+itemsize > memlen:
        return False
    if any(v % itemsize for v in strides):
        return False

    if ndim <= 0:
        return ndim == 0 and not shape and not strides
    if 0 in shape:
        return True

    imin = sum(strides[j]*(shape[j]-1) for j in range(ndim)
               if strides[j] <= 0)
    imax = sum(strides[j]*(shape[j]-1) for j in range(ndim)
               if strides[j] > 0)

    return 0 <= offset+imin and offset+imax+itemsize <= memlen
```

PIL-风格：形状，步幅和子偏移量

除了常规项之外，PIL 风格的数组还可以包含指针，必须跟随这些指针才能到达维度的下一个元素。例如，常规的三维 C 语言数组 `char v[2][2][3]` 可以看作是一个指向 2 个二维数组的 2 个指针：`char (*v[2])[2][3]`。在子偏移表示中，这两个指针可以嵌入在 *buf* 的开头，指向两个可以位于内存任何位置的 `char x[2][3]` 数组。

这是一个函数，当 n 维索引所指向的 N-D 数组中有 "NULL"步长和子偏移量时，它返回一个指针

```
void *get_item_pointer(int ndim, void *buf, Py_ssize_t *strides,
                       Py_ssize_t *suboffsets, Py_ssize_t *indices) {
    char *pointer = (char*)buf;
    int i;
    for (i = 0; i < ndim; i++) {
        pointer += strides[i] * indices[i];
        if (suboffsets[i] >=0 ) {
            pointer = *((char**)pointer) + suboffsets[i];
        }
```

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```
    }
    return (void*)pointer;
}
```

7.7.4 缓冲区相关函数

int **PyObject_CheckBuffer**(*PyObject* *obj)

Part of the Stable ABI *since version 3.11.* 如果 *obj* 支持缓冲区接口，则返回 1，否则返回 0。返回 1 时不保证*PyObject_GetBuffer()* 一定成功。本函数一定调用成功。

int **PyObject_GetBuffer**(*PyObject* *exporter, *Py_buffer* *view, int flags)

Part of the Stable ABI *since version 3.11.* 向输出器程序发送请求，按照 *flags* 指定的内容填充 *view*。如果输出器程序不能提供准确类型的缓冲区，必须触发 PyExc_BufferError，设置 view->obj 为 NULL 并返回 -1。

成功时，填充 *view*，将 view->obj 设为对 *exporter* 的新引用，并返回 0。当链式缓冲区提供程序将请求重定向到一个对象时，view->obj 可以引用该对象而不是 *exporter* (参见缓冲区对象结构)。

PyObject_GetBuffer() 必须与*PyBuffer_Release()* 同时调用成功，类似于 malloc() 和 free()。因此，消费者程序用完缓冲区后，*PyBuffer_Release()* 必须保证被调用一次。

void **PyBuffer_Release**(*Py_buffer* *view)

Part of the Stable ABI *since version 3.11.* 释放缓冲区 *view* 并递减 view->obj 的引用计数。该函数必须在缓冲区不再使用时才能调用，否则可能会发生引用泄漏。

若该函数针对的缓冲区不是通过*PyObject_GetBuffer()* 获得的，将会出错。

Py_ssize_t **PyBuffer_SizeFromFormat**(const char *format)

Part of the Stable ABI *since version 3.11.* 返回*itemsize* 中隐含的*format* 。如果出错，会触发异常并返回 -1。

3.9 新版功能.

int **PyBuffer_IsContiguous**(const *Py_buffer* *view, char order)

Part of the Stable ABI *since version 3.11.* 如果 *view* 定义的内存是 C 风格（*order* 为 'C'）或 Fortran 风格（*order* 为 'F'）*contiguous* 或其中之一（*order* 是 'A'），则返回 1。否则返回 0。该函数总会成功。

void ***PyBuffer_GetPointer**(const *Py_buffer* *view, const *Py_ssize_t* *indices)

Part of the Stable ABI *since version 3.11.* 获取给定 *view* 内的 *indices* 所指向的内存区域。*indices* 必须指向一个 view->ndim 索引的数组。

int **PyBuffer_FromContiguous**(const *Py_buffer* *view, const void *buf, *Py_ssize_t* len, char fort)

Part of the Stable ABI *since version 3.11.* 从 *buf* 复制连续的 *len* 字节到 *view* 。*fort* 可以是 'C' 或 'F'`` (对应于 C 风格或 Fortran 风格的顺序)。成功时返回 ``0，错误时返回 -1。

int **PyBuffer_ToContiguous**(void *buf, const *Py_buffer* *src, *Py_ssize_t* len, char order)

Part of the Stable ABI *since version 3.11.* 从 *src* 复制 *len* 字节到 *buf* ，成为连续字节串的形式。*order* 可以是 'C' 或 'F' 或 'A'`` (对应于 C 风格、Fortran 风格的顺序或其中任意一种)。成功时返回 ``0，出错时返回 -1。

如果 *len* != *src->len* 则此函数将报错。

int **PyObject_CopyData**(*Py_buffer* *dest, *Py_buffer* *src)

Part of the Stable ABI *since version 3.11.* Copy data from *src* to *dest* buffer. Can convert between C-style and or Fortran-style buffers.

0 is returned on success, -1 on error.

void **PyBuffer_FillContiguousStrides** (int ndims, *Py_ssize_t* *shape, *Py_ssize_t* *strides, int itemsize, char order)

Part of the Stable ABI *since version 3.11.* 用给定形状的*contiguous* 字节串数组 (如果 *order* 为 `'C'` 则为 C 风格，如果 *order* 为 `'F'` 则为 Fortran 风格) 来填充 *strides* 数组，每个元素具有给定的字节数。

int **PyBuffer_FillInfo** (*Py_buffer* *view, *PyObject* *exporter, void *buf, *Py_ssize_t* len, int readonly, int flags)

Part of the Stable ABI *since version 3.11.* 处理导出程序的缓冲区请求，该导出程序要公开大小为 *len* 的 *buf*，并根据 *readonly* 设置可写性。*bug* 被解释为一个无符号字节序列。

参数 *flags* 表示请求的类型。该函数总是按照 flag 指定的内容填入 *view*，除非 *buf* 设为只读，并且 *flag* 中设置了`PyBUF_WRITABLE` 标志。

成功时，将 `view->obj` 设为 *exporter* 的新引用，并返回 0。否则，引发 `PyExc_BufferError`，将 `view->obj` 设为 `NULL`，并返回 `-1`。

如果此函数用作*getbufferproc* 的一部分，则 *exporter* 必须设置为导出对象，并且必须在未修改的情况下传递 *flags*。否则，*exporter* 必须是 `NULL`。

7.8 旧缓冲协议

3.0 版后已移除.

这些函数是 Python 2 中"旧缓冲协议"API 的组成部分。在 Python 3 中，此协议已不复存在，但这些函数仍然被公开以便移植 2.x 的代码。它们被用作新缓冲协议 的兼容性包装器，但它们并不会在缓冲被导出时向你提供对所获资源的生命周期控制。

因此，推荐你调用`PyObject_GetBuffer()` (或者配合`PyArg_ParseTuple()` 函数族使用 `y*` 或 `w*` 格式码) 来获取一个对象的缓冲视图，并在缓冲视图可被释放时调用`PyBuffer_Release()`。

int **PyObject_AsCharBuffer** (*PyObject* *obj, const char **buffer, *Py_ssize_t* *buffer_len)

Part of the Stable ABI. 返回一个指向可用作基于字符的输入的只读内存地址的指针。*obj* 参数必须支持单段字符缓冲接口。成功时返回 `0`，将 *buffer* 设为内存地址并将 *buffer_len* 设为缓冲区长度。出错时返回 `-1` 并设置一个 `TypeError`。

int **PyObject_AsReadBuffer** (*PyObject* *obj, const void **buffer, *Py_ssize_t* *buffer_len)

Part of the Stable ABI. 返回一个指向包含任意数据的只读内存地址的指针。*obj* 参数必须支持单段可读缓冲接口。成功时返回 `0`，将 *buffer* 设为内存地址并将 *buffer_len* 设为缓冲区长度。出错时返回 `-1` 并设置一个 `TypeError`。

int **PyObject_CheckReadBuffer** (*PyObject* *o)

Part of the Stable ABI. 如果 *o* 支持单段可读缓冲接口则返回 `1`。否则返回 `0`。此函数总是会成功执行。

请注意此函数会尝试获取并释放一个缓冲区，并且在调用对应函数期间发生的异常会被屏蔽。要获取错误报告则应改用`PyObject_GetBuffer()`。

int **PyObject_AsWriteBuffer** (*PyObject* *obj, void **buffer, *Py_ssize_t* *buffer_len)

Part of the Stable ABI. 返回一个指向可写内存地址的指针。*obj* 必须支持单段字符缓冲接口。成功时返回 `0`，将 *buffer* 设为内存地址并将 *buffer_len* 设为缓冲区长度。出错时返回 `-1` 并设置一个 `TypeError`。

CHAPTER 8

具体的对象层

本章中的函数特定于某些 Python 对象类型。将错误类型的对象传递给它们并不是一个好主意；如果您从 Python 程序接收到一个对象，但不确定它是否具有正确的类型，则必须首先执行类型检查；例如，要检查对象是否为字典，请使用`PyDict_Check()`。本章的结构类似于 Python 对象类型的“家族树”。

> **警告：** 虽然本章所描述的函数会仔细检查传入对象的类型，但是其中许多函数不会检查传入的对象是否为 `NULL`。允许传入 `NULL` 可能导致内存访问冲突和解释器的立即终止。

8.1 基本对象

本节描述 Python 类型对象和单一实例对象 象 None。

8.1.1 类型对象

type **PyTypeObject**

Part of the Limited API *(as an opaque struct).* 对象的 C 结构用于描述 built-in 类型。

PyTypeObject **PyType_Type**

Part of the Stable ABI. 这是属于 type 对象的 type object，它在 Python 层面和 `type` 是相同的对象。

int **PyType_Check** (*PyObject* *o)

如果对象 *o* 是一个类型对象，包括派生自标准类型对象的类型实例则返回非零值。在所有其它情况下都返回 0。此函数将总是成功执行。

int **PyType_CheckExact** (*PyObject* *o)

如果对象 *o* 是一个类型对象，但不是标准类型对象的子类型则返回非零值。在所有其它情况下都返回 0。此函数将总是成功执行。

unsigned int **PyType_ClearCache** ()

Part of the Stable ABI. 清空内部查找缓存。返回当前版本标签。

unsigned long **PyType_GetFlags** (*PyTypeObject* *type)

Part of the Stable ABI. Return the `tp_flags` member of *type*. This function is primarily meant for use with `Py_LIMITED_API`; the individual flag bits are guaranteed to be stable across Python releases, but access to `tp_flags` itself is not part of the limited API.

3.2 新版功能.

在 3.4 版更改: 返回类型现在是 `unsigned long` 而不是 `long`。

void **PyType_Modified** (*PyTypeObject* *type)

Part of the Stable ABI. 使该类型及其所有子类型的内部查找缓存失效。此函数必须在对该类型的属性或基类进行任何手动修改之后调用。

int **PyType_HasFeature** (*PyTypeObject* *o, int feature)

如果类型对象 *o* 设置了特性 *feature* 则返回非零值。类型特性是用单个比特位旗标来表示的。

int **PyType_IS_GC** (*PyTypeObject* *o)

如果类型对象包括对循环检测器的支持则返回真值；这会测试类型旗标 `Py_TPFLAGS_HAVE_GC`。

int **PyType_IsSubtype** (*PyTypeObject* *a, *PyTypeObject* *b)

Part of the Stable ABI. 如果 *a* 是 *b* 的子类型则返回真值。

此函数只检查实际的子类型，这意味着 `__subclasscheck__()` 不会在 *b* 上被调用。请调用 `PyObject_IsSubclass()` 来执行与 `issubclass()` 所做的相同检查。

PyObject ***PyType_GenericAlloc** (*PyTypeObject* *type, *Py_ssize_t* nitems)

Return value: New reference. Part of the Stable ABI. 类型对象的 `tp_alloc` 槽位的通用处理句柄。请使用 Python 的默认内存分配机制来分配一个新的实例并将其所有内容初始化为 `NULL`。

PyObject ***PyType_GenericNew** (*PyTypeObject* *type, *PyObject* *args, *PyObject* *kwds)

Return value: New reference. Part of the Stable ABI. 类型对象的 `tp_new` 槽位的通用处理句柄。请使用类型的 `tp_alloc` 槽位来创建一个新的实例。

int **PyType_Ready** (*PyTypeObject* *type)

Part of the Stable ABI. 最终化一个类型对象。这应当在所有类型对象上调用以完成它们的初始化。此函数会负责从一个类型的基类添加被继承的槽位。成功时返回 `0`，或是在出错时返回 `-1` 并设置一个异常。

备注： 如果某些基类实现了 GC 协议并且所提供的类型的旗标中未包括 `Py_TPFLAGS_HAVE_GC`，则将自动从其父类实现 GC 协议。相反地，如果被创建的类型的旗标中未包括 `Py_TPFLAGS_HAVE_GC` 则它 **必须** 自己通过实现 `tp_traverse` 句柄来实现 GC 协议。

PyObject ***PyType_GetName** (*PyTypeObject* *type)

Return value: New reference. Part of the Stable ABI *since version 3.11.* Return the type's name. Equivalent to getting the type's `__name__` attribute.

3.11 新版功能.

PyObject ***PyType_GetQualName** (*PyTypeObject* *type)

Return value: New reference. Part of the Stable ABI *since version 3.11.* Return the type's qualified name. Equivalent to getting the type's `__qualname__` attribute.

3.11 新版功能.

void ***PyType_GetSlot** (*PyTypeObject* *type, int slot)

Part of the Stable ABI *since version 3.4.* 返回存储在给定槽位中的函数指针。如果结果为 `NULL`，则表示或者该槽位为 `NULL`，或者该函数调用传入了无效的形参。调用方通常要将结果指针转换到适当的函数类型。

请参阅 `PyType_Slot.slot` 查看可用的 *slot* 参数值。

3.4 新版功能.

在 3.10 版更改: `PyType_GetSlot()` 现在可以接受所有类型。在此之前，它被限制为堆类型。

PyObject ***PyType_GetModule**(*PyTypeObject* *type)

Part of the Stable ABI *since version 3.10.* 返回当使用`PyType_FromModuleAndSpec()` 创建类型时关联到给定类型的模块对象。

如果没有关联到给定类型的模块，则设置 `TypeError` 并返回 `NULL`。

This function is usually used to get the module in which a method is defined. Note that in such a method, `PyType_GetModule(Py_TYPE(self))` may not return the intended result. `Py_TYPE(self)` may be a *subclass* of the intended class, and subclasses are not necessarily defined in the same module as their superclass. See `PyCMethod` to get the class that defines the method. See `PyType_GetModuleByDef()` for cases when `PyCMethod` cannot be used.

3.9 新版功能.

void ***PyType_GetModuleState**(*PyTypeObject* *type)

Part of the Stable ABI *since version 3.10.* 返回关联到给定类型的模块对象的状态。这是一个在`PyType_GetModule()` 的结果上调用`PyModule_GetState()` 的快捷方式。

如果没有关联到给定类型的模块，则设置 `TypeError` 并返回 `NULL`。

如果 *type* 有关联的模块但其状态为 `NULL`，则返回 `NULL` 且不设置异常。

3.9 新版功能.

PyObject ***PyType_GetModuleByDef**(*PyTypeObject* *type, struct *PyModuleDef* *def)

Find the first superclass whose module was created from the given `PyModuleDef` *def*, and return that module.

If no module is found, raises a `TypeError` and returns `NULL`.

This function is intended to be used together with `PyModule_GetState()` to get module state from slot methods (such as `tp_init` or `nb_add`) and other places where a method's defining class cannot be passed using the `PyCMethod` calling convention.

3.11 新版功能.

创建堆分配类型

下列函数和结构体可被用来创建堆类型。

PyObject ***PyType_FromModuleAndSpec**(*PyObject* *module, *PyType_Spec* *spec, *PyObject* *bases)

Return value: New reference. *Part of the* Stable ABI *since version 3.10.* 根据 *spec* (`Py_TPFLAGS_HEAPTYPE`) 创建并返回一个堆类型。

bases 参数可被用来指定基类；它可以是单个类或由多个类组成的元组。如果 *bases* 为 `NULL`，则会改用 *Py_tp_bases* 槽位。如果该槽位也为 `NULL`，则会改用 *Py_tp_base* 槽位。如果该槽位同样为 `NULL`，则新类型将派生自 `object`。

module 参数可被用来记录新类定义所在的模块。它必须是一个模块对象或为 `NULL`。如果不为 `NULL`，则该模块会被关联到新类型并且可在之后通过`PyType_GetModule()` 来获取。这个关联模块不可被子类继承；它必须为每个类单独指定。

此函数会在新类型上调用`PyType_Ready()`。

3.9 新版功能.

在 3.10 版更改: 此函数现在接受一个单独类作为 *bases* 参数并接受 `NULL` 作为 `tp_doc` 槽位。

PyObject ***PyType_FromSpecWithBases**(*PyType_Spec* *spec, *PyObject* *bases)

Return value: New reference. *Part of the* Stable ABI *since version 3.3.* 等价于 `PyType_FromModuleAndSpec(NULL, spec, bases)`。

3.3 新版功能.

PyObject ***PyType_FromSpec**(*PyType_Spec* *spec)

Return value: New reference. *Part of the* Stable ABI. 等价于 `PyType_FromSpecWithBases(spec, NULL)`。

type **PyType_Spec**

Part of the Stable ABI *(including all members).* 定义一个类型的行为的结构体。

const char *PyType_Spec.**name**

类型的名称，用来设置*PyTypeObject.tp_name*。

int PyType_Spec.**basicsize**

int PyType_Spec.**itemsize**

以字节数表示的实例大小，用来设置*PyTypeObject.tp_basicsize* 和*PyTypeObject.tp_itemsize*。

int PyType_Spec.**flags**

类型旗标，用来设置*PyTypeObject.tp_flags*。

如果未设置 Py_TPFLAGS_HEAPTYPE 旗标，则*PyType_FromSpecWithBases()* 会自动设置它。

PyType_Slot *PyType_Spec.**slots**

PyType_Slot 结构体的数组。以特殊槽位值 {0, NULL} 来结束。

type **PyType_Slot**

Part of the Stable ABI *(including all members).* 定义一个类型的可选功能的结构体，包含一个槽位 ID 和一个值指针。

int PyType_Slot.**slot**

槽位 ID。

槽位 ID 的类名像是结构体*PyTypeObject*, *PyNumberMethods*, *PySequenceMethods*, *PyMappingMethods* 和*PyAsyncMethods* 的字段名附加一个 Py_ 前缀。举例来说，使用:

- Py_tp_dealloc 设置*PyTypeObject.tp_dealloc*
- Py_nb_add 设置*PyNumberMethods.nb_add*
- Py_sq_length 设置*PySequenceMethods.sq_length*

下列字段完全无法使得*PyType_Spec* 和 PyType_Slot 来设置:

- *tp_dict*
- *tp_mro*
- *tp_cache*
- *tp_subclasses*
- *tp_weaklist*
- *tp_vectorcall*
- *tp_weaklistoffset* (参见*PyMemberDef*)
- *tp_dictoffset* (参见*PyMemberDef*)
- *tp_vectorcall_offset* (参见*PyMemberDef*)

设置 Py_tp_bases 或 Py_tp_base 在某些平台上可能会有问题。为了避免问题，请改用 PyType_FromSpecWithBases() 的 *bases* 参数。

在 3.9 版更改: *PyBufferProcs* 中的槽位可能会在不受限 API 中被设置。

在 3.11 版更改: *bf_getbuffer* and *bf_releasebuffer* are now available under the limited API.

void *PyType_Slot.**pfunc**

该槽位的预期值。在大多数情况下，这将是一个指向函数的指针。

Py_tp_doc 以外的槽位均不可为 NULL。

8.1.2 None 对象

请注意，None 的*PyTypeObject* 不会直接在 Python / C API 中公开。由于 None 是单例，测试对象标识（在 C 中使用 == ）就足够了。由于同样的原因，没有 PyNone_Check() 函数。

PyObject ***Py_None**

Python None 对象，表示缺乏值。这个对象没有方法。它需要像引用计数一样处理任何其他对象。

Py_RETURN_NONE

正确处理来自 C 函数内的*Py_None* 返回（也就是说，增加 None 的引用计数并返回它。）

8.2 数值对象

8.2.1 整数型对象

所有整数都实现为长度任意的长整数对象。

在出错时，大多数 PyLong_As* API 都会返回 (return type)-1，这与数字无法区分开。请采用*PyErr_Occurred()* 来加以区分。

type **PyLongObject**

Part of the Limited API *(as an opaque struct).* 表示 Python 整数对象的*PyObject* 子类型。

PyTypeObject **PyLong_Type**

Part of the Stable ABI. 这个*PyTypeObject* 的实例表示 Python 的整数类型。与 Python 语言中的 int 相同。

int **PyLong_Check** (*PyObject* *p)

如果参数是*PyLongObject* 或*PyLongObject* 的子类型，则返回 True。该函数一定能够执行成功。

int **PyLong_CheckExact** (*PyObject* *p)

如果其参数属于*PyLongObject*，但不是*PyLongObject* 的子类型则返回真值。此函数总是会成功执行。

PyObject ***PyLong_FromLong** (long v)

Return value: New reference. Part of the Stable ABI. 由 *v* 返回一个新的*PyLongObject* 对象，失败时返回 NULL 。

当前的实现维护着一个整数对象数组，包含 -5 和 256 之间的所有整数对象。若创建一个位于该区间的 int 时，实际得到的将是对已有对象的引用。

PyObject ***PyLong_FromUnsignedLong** (unsigned long v)

Return value: New reference. Part of the Stable ABI. Return a new *PyLongObject* object from a C unsigned long, or NULL on failure.

PyObject ***PyLong_FromSsize_t** (*Py_ssize_t* v)

Return value: New reference. Part of the Stable ABI. 由 C *Py_ssize_t* 返回一个新的*PyLongObject* 对象，失败时返回 NULL 。

PyObject ***PyLong_FromSize_t** (size_t v)

Return value: New reference. Part of the Stable ABI. 由 C size_t 返回一个新的*PyLongObject* 对象，失败则返回 NULL 。

PyObject ***PyLong_FromLongLong*** (long long v)

Return value: New reference. Part of the Stable ABI. Return a new `PyLongObject` object from a C `long long`, or `NULL` on failure.

PyObject ***PyLong_FromUnsignedLongLong*** (unsigned long long v)

Return value: New reference. Part of the Stable ABI. Return a new `PyLongObject` object from a C `unsigned long long`, or `NULL` on failure.

PyObject ***PyLong_FromDouble*** (double v)

Return value: New reference. Part of the Stable ABI. 由 *v* 的整数部分返回一个新的`PyLongObject` 对象，失败则返回 `NULL` 。

PyObject ***PyLong_FromString*** (const char *str, char **pend, int base)

Return value: New reference. Part of the Stable ABI. 根据 *str* 字符串值返回一个新的`PyLongObject` ，*base* 指定了整数的基。如果 *pend* 不为 `NULL` ，则 */*pend* 将指向 *str* 中表示数字部分后面的第一个字符。如果 *base* 为 `0` ，*str* 将采用 integers 的定义进行解释；这时非零十进制数的前导零会触发 `ValueError` 。如果 *base* 不为 `0` ，则须位于 `2` 和 `36` 之间（含 2 和 36）。基之后及数字之间的前导空格、单下划线将被忽略。如果不存在数字，将触发 `ValueError`。

PyObject ***PyLong_FromUnicodeObject*** (*PyObject* *u, int base)

Return value: New reference. 将字符串 *u* 中的 Unicode 数字序列转换为 Python 整数值。

3.3 新版功能.

PyObject ***PyLong_FromVoidPtr*** (void *p)

Return value: New reference. Part of the Stable ABI. 从指针 *p* 创建一个 Python 整数。可以使用`PyLong_AsVoidPtr()` 返回的指针值。

long **PyLong_AsLong** (*PyObject* *obj)

Part of the Stable ABI. Return a C `long` representation of *obj*. If *obj* is not an instance of `PyLongObject`, first call its `__index__()` method (if present) to convert it to a `PyLongObject`.

Raise `OverflowError` if the value of *obj* is out of range for a `long`.

出错则返回 `-1` 。请用`PyErr_Occurred()` 找出具体问题。

在 3.8 版更改: 如果可用将使用 `__index__()`。

在 3.10 版更改: 本函数不再使用 `__int__()` 。

long **PyLong_AsLongAndOverflow** (*PyObject* *obj, int *overflow)

Part of the Stable ABI. Return a C `long` representation of *obj*. If *obj* is not an instance of `PyLongObject`, first call its `__index__()` method (if present) to convert it to a `PyLongObject`.

如果 *obj* 的值大于 `LONG_MAX` 或小于 `LONG_MIN`，则会把 **overflow* 分别置为 "1" 或 `-1`，并返回 `1`；否则，将 **overflow* 置为 *0*。如果发生其他异常，则会按常规把 **overflow* 置为 `0`，并返回 `-1`。

出错则返回 `-1` 。请用`PyErr_Occurred()` 找出具体问题。

在 3.8 版更改: 如果可用将使用 `__index__()`。

在 3.10 版更改: 本函数不再使用 `__int__()` 。

long long **PyLong_AsLongLong** (*PyObject* *obj)

Part of the Stable ABI. Return a C `long long` representation of *obj*. If *obj* is not an instance of `PyLongObject`, first call its `__index__()` method (if present) to convert it to a `PyLongObject`.

Raise `OverflowError` if the value of *obj* is out of range for a `long long`.

出错则返回 `-1` 。请用`PyErr_Occurred()` 找出具体问题。

在 3.8 版更改: 如果可用将使用 `__index__()`。

在 3.10 版更改: 本函数不再使用 `__int__()` 。

long long **PyLong_AsLongLongAndOverflow** (*PyObject* *obj, int *overflow)

Part of the Stable ABI. Return a C `long long` representation of *obj*. If *obj* is not an instance of `PyLongObject`, first call its `__index__()` method (if present) to convert it to a `PyLongObject`.

如果 *obj* 的值大于 `LLONG_MAX` 或小于 `LLONG_MIN`，则按常规将 **overflow* 分别置为 `1` 或 `-1`，并返回 -1，否则将 **overflow* 置为 0。如果触发其他异常则 **overflow* 置为 0 并返回 -1。

出错则返回 `-1` 。请用`PyErr_Occurred()` 找出具体问题。

3.2 新版功能.

在 3.8 版更改: 如果可用将使用 `__index__()`。

在 3.10 版更改: 本函数不再使用 `__int__()` 。

Py_ssize_t **PyLong_AsSsize_t** (*PyObject* *pylong)

Part of the Stable ABI. 返回 *pylong* 的 C 语言`Py_ssize_t` 形式。*pylong* 必须是`PyLongObject` 的实例。

如果 *pylong* 的值超出了`Py_ssize_t` 的取值范围则会引发 `OverflowError`。

出错则返回 `-1` 。请用`PyErr_Occurred()` 找出具体问题。

unsigned long **PyLong_AsUnsignedLong** (*PyObject* *pylong)

Part of the Stable ABI. Return a C `unsigned long` representation of *pylong*. *pylong* must be an instance of `PyLongObject`.

Raise `OverflowError` if the value of *pylong* is out of range for a `unsigned long`.

出错时返回 `(unsigned long)-1` ，请利用`PyErr_Occurred()` 辨别具体问题。

size_t **PyLong_AsSize_t** (*PyObject* *pylong)

Part of the Stable ABI. 返回 *pylong* 的 C 语言 `size_t` 形式。*pylong* 必须是`PyLongObject` 的实例。

如果 *pylong* 的值超出了 `size_t` 的取值范围则会引发 `OverflowError`。

出错时返回 `(size_t)-1` ，请利用`PyErr_Occurred()` 辨别具体问题。

unsigned long long **PyLong_AsUnsignedLongLong** (*PyObject* *pylong)

Part of the Stable ABI. Return a C `unsigned long long` representation of *pylong*. *pylong* must be an instance of `PyLongObject`.

Raise `OverflowError` if the value of *pylong* is out of range for an `unsigned long long`.

出错时返回 `(unsigned long long)-1`，请利用`PyErr_Occurred()` 辨别具体问题。

在 3.1 版更改: 现在 *pylong* 为负值会触发 `OverflowError`，而不是 `TypeError`。

unsigned long **PyLong_AsUnsignedLongMask** (*PyObject* *obj)

Part of the Stable ABI. Return a C `unsigned long` representation of *obj*. If *obj* is not an instance of `PyLongObject`, first call its `__index__()` method (if present) to convert it to a `PyLongObject`.

If the value of *obj* is out of range for an `unsigned long`, return the reduction of that value modulo `ULONG_MAX + 1`.

出错时返回 `(unsigned long)-1`，请利用`PyErr_Occurred()` 辨别具体问题。

在 3.8 版更改: 如果可用将使用 `__index__()`。

在 3.10 版更改: 本函数不再使用 `__int__()` 。

unsigned long long **PyLong_AsUnsignedLongLongMask** (*PyObject* *obj)

Part of the Stable ABI. Return a C `unsigned long long` representation of *obj*. If *obj* is not an instance of `PyLongObject`, first call its `__index__()` method (if present) to convert it to a `PyLongObject`.

If the value of *obj* is out of range for an `unsigned long long`, return the reduction of that value modulo `ULLONG_MAX + 1`.

出错时返回 `(unsigned long long)-1`，请利用`PyErr_Occurred()` 辨别具体问题。

在 3.8 版更改: 如果可用将使用 `__index__()`。

在 3.10 版更改: 本函数不再使用 `__int__()` 。

double **PyLong_AsDouble**(*PyObject* *pylong)

Part of the Stable ABI. Return a C `double` representation of *pylong*. *pylong* must be an instance of *PyLongObject*.

Raise `OverflowError` if the value of *pylong* is out of range for a `double`.

出错时返回 `-1.0` ，请利用*PyErr_Occurred()* 辨别具体问题。

void ***PyLong_AsVoidPtr**(*PyObject* *pylong)

Part of the Stable ABI. Convert a Python integer *pylong* to a C `void` pointer. If *pylong* cannot be converted, an `OverflowError` will be raised. This is only assured to produce a usable `void` pointer for values created with *PyLong_FromVoidPtr()*.

出错时返回 NULL，请利用*PyErr_Occurred()* 辨别具体问题。

8.2.2 布尔对象

Python 中的布尔值是作为整数的子类实现的。只有 `Py_False` 和 `Py_True` 两个布尔值。因此，正常的创建和删除功能不适用于布尔值。但是，下列宏可用。

int **PyBool_Check**(*PyObject* *o)

如果 *o* 的类型为 `PyBool_Type` 则返回真值。此函数总是会成功执行。

PyObject ***Py_False**

Python 的 "False"对象。该对象没有任何方法。它应该象其它使用引用计数管理的对象一样使用。

PyObject ***Py_True**

Python 的 "True"对象。该对象没有任何方法。它应该象其它使用引用计数管理的对象一样使用。

Py_RETURN_FALSE

从函数返回 `Py_False` 时，需要增加它的引用计数。

Py_RETURN_TRUE

从函数返回 `Py_True` 时，需要增加它的引用计数。

PyObject ***PyBool_FromLong**(long v)

Return value: New reference. Part of the Stable ABI. 根据 *v* 的实际值，返回一个 `Py_True` 或者 `Py_False` 的新引用。

8.2.3 浮点数对象

type **PyFloatObject**

这个 C 类型*PyObject* 的子类型代表一个 Python 浮点数对象。

PyTypeObject **PyFloat_Type**

Part of the Stable ABI. 这是个属于 C 类型*PyTypeObject* 的代表 Python 浮点类型的实例。在 Python 层面的类型 `float` 是同一个对象。

int **PyFloat_Check**(*PyObject* *p)

如果它的参数是一个*PyFloatObject* 或者*PyFloatObject* 的子类型则返回真值。此函数总是会成功执行。

int **PyFloat_CheckExact**(*PyObject* *p)

如果它的参数是一个*PyFloatObject* 但不是*PyFloatObject* 的子类型则返回真值。此函数总是会成功执行。

PyObject ***PyFloat_FromString***(*PyObject* *str)

Return value: New reference. Part of the Stable ABI. 根据字符串 *str* 的值创建一个 `PyFloatObject`，失败时返回 NULL。

PyObject ***PyFloat_FromDouble***(double v)

Return value: New reference. Part of the Stable ABI. 根据 *v* 创建一个 `PyFloatObject` 对象，失败时返回 NULL。

double **PyFloat_AsDouble**(*PyObject* *pyfloat)

Part of the Stable ABI. Return a C `double` representation of the contents of *pyfloat*. If *pyfloat* is not a Python floating point object but has a `__float__()` method, this method will first be called to convert *pyfloat* into a float. If `__float__()` is not defined then it falls back to `__index__()`. This method returns `-1.0` upon failure, so one should call `PyErr_Occurred()` to check for errors.

在 3.8 版更改: 如果可用将使用 `__index__()`。

double **PyFloat_AS_DOUBLE**(*PyObject* *pyfloat)

Return a C `double` representation of the contents of *pyfloat*, but without error checking.

PyObject ***PyFloat_GetInfo***(void)

Return value: New reference. Part of the Stable ABI. 返回一个 structseq 实例，其中包含有关 float 的精度、最小值和最大值的信息。它是头文件 `float.h` 的一个简单包装。

double **PyFloat_GetMax**()

Part of the Stable ABI. Return the maximum representable finite float *DBL_MAX* as C `double`.

double **PyFloat_GetMin**()

Part of the Stable ABI. Return the minimum normalized positive float *DBL_MIN* as C `double`.

Pack and Unpack functions

The pack and unpack functions provide an efficient platform-independent way to store floating-point values as byte strings. The Pack routines produce a bytes string from a C `double`, and the Unpack routines produce a C `double` from such a bytes string. The suffix (2, 4 or 8) specifies the number of bytes in the bytes string.

On platforms that appear to use IEEE 754 formats these functions work by copying bits. On other platforms, the 2-byte format is identical to the IEEE 754 binary16 half-precision format, the 4-byte format (32-bit) is identical to the IEEE 754 binary32 single precision format, and the 8-byte format to the IEEE 754 binary64 double precision format, although the packing of INFs and NaNs (if such things exist on the platform) isn't handled correctly, and attempting to unpack a bytes string containing an IEEE INF or NaN will raise an exception.

On non-IEEE platforms with more precision, or larger dynamic range, than IEEE 754 supports, not all values can be packed; on non-IEEE platforms with less precision, or smaller dynamic range, not all values can be unpacked. What happens in such cases is partly accidental (alas).

3.11 新版功能.

8.2.4 Pack functions

The pack routines write 2, 4 or 8 bytes, starting at *p*. *le* is an `int` argument, non-zero if you want the bytes string in little-endian format (exponent last, at `p+1`, `p+3`, or `p+6 p+7`), zero if you want big-endian format (exponent first, at *p*). The `PY_BIG_ENDIAN` constant can be used to use the native endian: it is equal to `1` on big endian processor, or `0` on little endian processor.

Return value: `0` if all is OK, `-1` if error (and an exception is set, most likely `OverflowError`).

There are two problems on non-IEEE platforms:

- What this does is undefined if *x* is a NaN or infinity.
- `-0.0` and `+0.0` produce the same bytes string.

int **PyFloat_Pack2** (double x, unsigned char *p, int le)

Pack a C double as the IEEE 754 binary16 half-precision format.

int **PyFloat_Pack4** (double x, unsigned char *p, int le)

Pack a C double as the IEEE 754 binary32 single precision format.

int **PyFloat_Pack8** (double x, unsigned char *p, int le)

Pack a C double as the IEEE 754 binary64 double precision format.

8.2.5 Unpack functions

The unpack routines read 2, 4 or 8 bytes, starting at *p*. *le* is an `int` argument, non-zero if the bytes string is in little-endian format (exponent last, at `p+1`, `p+3` or `p+6` and `p+7`), zero if big-endian (exponent first, at *p*). The `PY_BIG_ENDIAN` constant can be used to use the native endian: it is equal to `1` on big endian processor, or `0` on little endian processor.

Return value: The unpacked double. On error, this is `-1.0` and `PyErr_Occurred()` is true (and an exception is set, most likely `OverflowError`).

Note that on a non-IEEE platform this will refuse to unpack a bytes string that represents a NaN or infinity.

double **PyFloat_Unpack2** (const unsigned char *p, int le)

Unpack the IEEE 754 binary16 half-precision format as a C double.

double **PyFloat_Unpack4** (const unsigned char *p, int le)

Unpack the IEEE 754 binary32 single precision format as a C double.

double **PyFloat_Unpack8** (const unsigned char *p, int le)

Unpack the IEEE 754 binary64 double precision format as a C double.

8.2.6 复数对象

从 C API 看，Python 的复数对象由两个不同的部分实现：一个是在 Python 程序使用的 Python 对象，另外的是一个代表真正复数值的 C 结构体。API 提供了函数共同操作两者。

表示复数的 C 结构体

需要注意的是接受这些结构体的作为参数并当做结果返回的函数，都是传递“值”而不是引用指针。此规则适用于整个 API。

type **Py_complex**

这是一个对应 Python 复数对象的值部分的 C 结构体。绝大部分处理复数对象的函数都用这类型的结构体作为输入或者输出值，它可近似地定义为：

```
typedef struct {
   double real;
   double imag;
} Py_complex;
```

Py_complex **_Py_c_sum** (*Py_complex* left, *Py_complex* right)

返回两个复数的和，用 C 类型`Py_complex` 表示。

Py_complex **_Py_c_diff** (*Py_complex* left, *Py_complex* right)

返回两个复数的差，用 C 类型`Py_complex` 表示。

Py_complex **_Py_c_neg** (*Py_complex* num)

返回复数 *num* 的负值，用 C `Py_complex` 表示。

Py_complex **_Py_c_prod** (*Py_complex* left, *Py_complex* right)

返回两个复数的乘积，用 C 类型`Py_complex` 表示。

Py_complex **_Py_c_quot** (*Py_complex* dividend, *Py_complex* divisor)

返回两个复数的商，用 C 类型`Py_complex` 表示。

如果 *divisor* 为空，这个方法返回零并设置 `errno` 为 `EDOM`。

Py_complex **_Py_c_pow** (*Py_complex* num, *Py_complex* exp)

返回 *num* 的 *exp* 次幂，用 C 类型`Py_complex` 表示。

如果 *num* 为空且 *exp* 不是正实数，这个方法返回零并设置 `errno` 为 `EDOM`。

表示复数的 Python 对象

type **PyComplexObject**

这个 C 类型`PyObject` 的子类型代表一个 Python 复数对象。

PyTypeObject **PyComplex_Type**

Part of the Stable ABI. 这是个属于`PyTypeObject` 的代表 Python 复数类型的实例。在 Python 层面的类型 `complex` 是同一个对象。

int **PyComplex_Check** (*PyObject* *p)

如果它的参数是一个`PyComplexObject` 或者`PyComplexObject` 的子类型则返回真值。此函数总是会成功执行。

int **PyComplex_CheckExact** (*PyObject* *p)

如果它的参数是一个`PyComplexObject` 但不是`PyComplexObject` 的子类型则返回真值。此函数总是会成功执行。

PyObject ***PyComplex_FromCComplex** (*Py_complex* v)

Return value: New reference. 根据 C 类型`Py_complex` 的值生成一个新的 Python 复数对象。

PyObject ***PyComplex_FromDoubles** (double real, double imag)

Return value: New reference. Part of the Stable ABI. 根据 *real* 和 *imag* 返回一个新的 C 类型`PyComplexObject` 对象。

double **PyComplex_RealAsDouble** (*PyObject* *op)

Part of the Stable ABI. Return the real part of *op* as a C `double`.

double **PyComplex_ImagAsDouble** (*PyObject* *op)

Part of the Stable ABI. Return the imaginary part of *op* as a C `double`.

Py_complex **PyComplex_AsCComplex** (*PyObject* *op)

返回复数 *op* 的 C 类型`Py_complex` 值。

如果 *op* 不是一个 Python 复数对象，但是具有 `__complex__()` 方法，此方法将首先被调用，将 *op* 转换为一个 Python 复数对象。如果 `__complex__()` 未定义则将回退至 `__float__()`，如果 `__float__()` 未定义则将回退至 `__index__()`。如果失败，此方法将返回 `-1.0` 作为实数值。

在 3.8 版更改: 如果可用将使用 `__index__()`。

8.3 序列对象

序列对象的一般操作在前一章中讨论过; 本节介绍 Python 语言固有的特定类型的序列对象。

8.3.1 bytes 对象

这些函数在期望附带一个字节串形参但却附带了一个非字节串形参被调用时会引发 `TypeError`。

type **PyBytesObject**

这种 `PyObject` 的子类型表示一个 Python 字节对象。

PyTypeObject **PyBytes_Type**

Part of the Stable ABI. `PyTypeObject` 的实例代表一个 Python 字节类型，在 Python 层面它与 `bytes` 是相同的对象。

int **PyBytes_Check** (*PyObject* *o)

如果对象 *o* 是一个 bytes 对象或者 bytes 类型的子类型的实例则返回真值。此函数总是会成功执行。

int **PyBytes_CheckExact** (*PyObject* *o)

如果对象 *o* 是一个 bytes 对象但不是 bytes 类型的子类型的实例则返回真值。此函数总是会成功执行。

PyObject ***PyBytes_FromString** (const char *v)

Return value: New reference. Part of the Stable ABI. 成功时返回一个以字符串 *v* 的副本为值的新字节串对象，失败时返回 `NULL`。形参 *v* 不可为 `NULL`；它不会被检查。

PyObject ***PyBytes_FromStringAndSize** (const char *v, *Py_ssize_t* len)

Return value: New reference. Part of the Stable ABI. 成功时返回一个以字符串 *v* 的副本为值且长度为 *len* 的新字节串对象，失败时返回 `NULL`。如果 *v* 为 `NULL`，则不初始化字节串对象的内容。

PyObject ***PyBytes_FromFormat** (const char *format, ...)

Return value: New reference. Part of the Stable ABI. 接受一个 C `printf()` 风格的 *format* 字符串和可变数量的参数，计算结果 Python 字节串对象的大小并返回参数值经格式化后的字节串对象。可变数量的参数必须均为 C 类型并且必须恰好与 *format* 字符串中的格式字符相对应。允许使用下列格式字符串:

格式字符	类型	注释
`%%`	不适用	文字% 字符。
`%c`	int	一个字节，被表示为一个 C 语言的整型
`%d`	int	相当于 `printf("%d")`.[1]
`%u`	unsigned int	相当于 `printf("%u")`.[1]
`%ld`	长整型	相当于 `printf("%ld")`.[1]
`%lu`	unsigned long	相当于 `printf("%lu")`.[1]
`%zd`	`Py_ssize_t`	相当于 `printf("%zd")`.[1]
`%zu`	size_t	相当于 `printf("%zu")`.[1]
`%i`	int	相当于 `printf("%i")`.[1]
`%x`	int	相当于 `printf("%x")`.[1]
`%s`	const char*	以 null 为终止符的 C 字符数组。
`%p`	const void*	一个 C 指针的十六进制表示形式。基本等价于 `printf("%p")` 但它会确保以字面值 `0x` 开头，不论系统平台上 `printf` 的输出是什么。

无法识别的格式字符会导致将格式字符串的其余所有内容原样复制到结果对象，并丢弃所有多余的参数。

[1] 对于整数说明符（d，u，ld，lu，zd，zu，i，x）：当给出精度时，0 转换标志是有效的。

PyObject ***PyBytes_FromFormatV**(const char *format, va_list vargs)

Return value: New reference. Part of the Stable ABI. 与`PyBytes_FromFormat()`完全相同，除了它需要两个参数。

PyObject ***PyBytes_FromObject**(*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 返回字节表示实现缓冲区协议的对象 *o*。

Py_ssize_t **PyBytes_Size**(*PyObject* *o)

Part of the Stable ABI. 返回字节对象 *o* 中字节的长度。

Py_ssize_t **PyBytes_GET_SIZE**(*PyObject* *o)

Similar to `PyBytes_Size()`, but without error checking.

char ***PyBytes_AsString**(*PyObject* *o)

Part of the Stable ABI. 返回对应 *o* 的内容的指针。该指针指向 *o* 的内部缓冲区，其中包含 `len(o) + 1` 个字节。缓冲区的最后一个字节总是为空，不论是否存在其他空字节。该数据不可通过任何形式来修改，除非是刚使用 `PyBytes_FromStringAndSize(NULL, size)` 创建该对象。它不可被撤销分配。如果 *o* 根本不是一个字节串对象，则`PyBytes_AsString()`将返回 `NULL` 并引发 `TypeError`。

char ***PyBytes_AS_STRING**(*PyObject* *string)

Similar to `PyBytes_AsString()`, but without error checking.

int **PyBytes_AsStringAndSize**(*PyObject* *obj, char **buffer, *Py_ssize_t* *length)

Part of the Stable ABI. 通过输出变量 *buffer* 和 *length* 返回以 null 为终止符的对象 *obj* 的内容。

如果 *length* 为 `NULL`，字节串对象就不包含嵌入的空字节；如果包含，则该函数将返回 `-1` 并引发 `ValueError`。

该缓冲区指向 *obj* 的内部缓冲，它的末尾包含一个额外的空字节（不算在 *length* 当中）。该数据不可通过任何方式来修改，除非是刚使用 `PyBytes_FromStringAndSize(NULL, size)` 创建该对象。它不可被撤销分配。如果 *obj* 根本不是一个字节串对象，则`PyBytes_AsStringAndSize()`将返回 `-1` 并引发 `TypeError`。

在 3.5 版更改: 以前，当字节串对象中出现嵌入的空字节时将引发 `TypeError`。

void **PyBytes_Concat**(*PyObject* **bytes, *PyObject* *newpart)

Part of the Stable ABI. 在 **bytes* 中创建新的字节串对象，其中包含添加到 *bytes* 的 *newpart* 的内容；调用者将获得新的引用。对 *bytes* 原值的引用将被收回。如果无法创建新对象，对 *bytes* 的旧引用仍将被丢弃且 **bytes* 的值将被设为 `NULL`；并将设置适当的异常。

void **PyBytes_ConcatAndDel**(*PyObject* **bytes, *PyObject* *newpart)

Part of the Stable ABI. 在 **bytes* 中创建新的字节串对象，其中包含添加到 *bytes* 的 *newpart* 的内容。此版本会减少 *newpart* 的引用计数。

int **_PyBytes_Resize**(*PyObject* **bytes, *Py_ssize_t* newsize)

改变字节串大小的一种方式，即使其为"不可变对象"。此方式仅用于创建全新的字节串对象；如果字节串在代码的其他部分已知则不可使用此方式。如果输入字节串对象的引用计数不为一则调用此函数将报错。传入一个现有字节串对象的地址作为 lvalue（它可能会被写入），并传入希望的新大小。当成功时，**bytes* 将存放改变大小后的字节串对象并返回 `0`；**bytes* 中的地址可能与其输入值不同。如果重新分配失败，则 **bytes* 上的原字节串对象将被撤销分配，**bytes* 会被设为 `NULL`，同时设置 `MemoryError` 并返回 `-1`。

8.3.2 字节数组对象

type **PyByteArrayObject**

这个*PyObject* 的子类型表示一个 Python 字节数组对象。

PyTypeObject **PyByteArray_Type**

Part of the Stable ABI. Python bytearray 类型表示为*PyTypeObject* 的实例；这与 Python 层面的 bytearray 是相同的对象。

类型检查宏

int **PyByteArray_Check** (*PyObject* *o)

如果对象 *o* 是一个 bytearray 对象或者 bytearray 类型的子类型的实例则返回真值。此函数总是会成功执行。

int **PyByteArray_CheckExact** (*PyObject* *o)

如果对象 *o* 是一个 bytearray 对象但不是 bytearray 类型的子类型的实例则返回真值。此函数总是会成功执行。

直接 API 函数

PyObject ***PyByteArray_FromObject** (*PyObject* *o)

Return value: New reference. Part of the Stable ABI. 根据任何实现了缓冲区协议 的对象 *o*，返回一个新的字节数组对象。

PyObject ***PyByteArray_FromStringAndSize** (const char *string, *Py_ssize_t* len)

Return value: New reference. Part of the Stable ABI. 根据 *string* 及其长度 *len* 创建一个新的 bytearray 对象。当失败时返回 NULL。

PyObject ***PyByteArray_Concat** (*PyObject* *a, *PyObject* *b)

Return value: New reference. Part of the Stable ABI. 连接字节数组 *a* 和 *b* 并返回一个带有结果的新的字节数组。

Py_ssize_t **PyByteArray_Size** (*PyObject* *bytearray)

Part of the Stable ABI. 在检查 NULL 指针后返回 *bytearray* 的大小。

char ***PyByteArray_AsString** (*PyObject* *bytearray)

Part of the Stable ABI. 在检查 NULL 指针后返回将 *bytearray* 返回为一个字符数组。返回的数组总是会附加一个额外的空字节。

int **PyByteArray_Resize** (*PyObject* *bytearray, *Py_ssize_t* len)

Part of the Stable ABI. 将 *bytearray* 的内部缓冲区的大小调整为 *len*。

宏

这些宏减低安全性以换取性能，它们不检查指针。

char ***PyByteArray_AS_STRING** (*PyObject* *bytearray)

Similar to *PyByteArray_AsString()*, but without error checking.

Py_ssize_t **PyByteArray_GET_SIZE** (*PyObject* *bytearray)

Similar to *PyByteArray_Size()*, but without error checking.

8.3.3 Unicode 对象和编码解码器

Unicode 对象

自从 python3.3 中实现了 **PEP 393** 以来，Unicode 对象在内部使用各种表示形式，以便在保持内存效率的同时处理完整范围的 Unicode 字符。对于所有代码点都低于 128、256 或 65536 的字符串，有一些特殊情况；否则，代码点必须低于 1114112（这是完整的 Unicode 范围）。

`Py_UNICODE*` and UTF-8 representations are created on demand and cached in the Unicode object. The `Py_UNICODE*` representation is deprecated and inefficient.

Due to the transition between the old APIs and the new APIs, Unicode objects can internally be in two states depending on how they were created:

- ”canonical” Unicode objects are all objects created by a non-deprecated Unicode API. They use the most efficient representation allowed by the implementation.
- ”legacy” Unicode objects have been created through one of the deprecated APIs (typically `PyUnicode_FromUnicode()`) and only bear the `Py_UNICODE*` representation; you will have to call `PyUnicode_READY()` on them before calling any other API.

备注： The ”legacy” Unicode object will be removed in Python 3.12 with deprecated APIs. All Unicode objects will be ”canonical” since then. See **PEP 623** for more information.

Unicode 类型

These are the basic Unicode object types used for the Unicode implementation in Python:

type **Py_UCS4**

type **Py_UCS2**

type **Py_UCS1**

Part of the Stable ABI. These types are typedefs for unsigned integer types wide enough to contain characters of 32 bits, 16 bits and 8 bits, respectively. When dealing with single Unicode characters, use `Py_UCS4`.

3.3 新版功能.

type **Py_UNICODE**

This is a typedef of `wchar_t`, which is a 16-bit type or 32-bit type depending on the platform.

在 3.3 版更改: In previous versions, this was a 16-bit type or a 32-bit type depending on whether you selected a ”narrow” or ”wide” Unicode version of Python at build time.

type **PyASCIIObject**

type **PyCompactUnicodeObject**

type **PyUnicodeObject**

These subtypes of `PyObject` represent a Python Unicode object. In almost all cases, they shouldn’t be used directly, since all API functions that deal with Unicode objects take and return `PyObject` pointers.

3.3 新版功能.

PyTypeObject **PyUnicode_Type**

Part of the Stable ABI. This instance of `PyTypeObject` represents the Python Unicode type. It is exposed to Python code as `str`.

The following APIs are C macros and static inlined functions for fast checks and access to internal read-only data of Unicode objects:

int **PyUnicode_Check**(*PyObject* *o)

Return true if the object *o* is a Unicode object or an instance of a Unicode subtype. This function always succeeds.

int **PyUnicode_CheckExact** (*PyObject* *o)

Return true if the object *o* is a Unicode object, but not an instance of a subtype. This function always succeeds.

int **PyUnicode_READY** (*PyObject* *o)

Ensure the string object *o* is in the "canonical" representation. This is required before using any of the access macros described below.

Returns `0` on success and `-1` with an exception set on failure, which in particular happens if memory allocation fails.

3.3 新版功能.

从版本 3.10 开始标记为过时，将在版本 3.12 中移除。: This API will be removed with `PyUnicode_FromUnicode()`.

Py_ssize_t **PyUnicode_GET_LENGTH** (*PyObject* *o)

Return the length of the Unicode string, in code points. *o* has to be a Unicode object in the "canonical" representation (not checked).

3.3 新版功能.

Py_UCS1 ***PyUnicode_1BYTE_DATA** (*PyObject* *o)

Py_UCS2 ***PyUnicode_2BYTE_DATA** (*PyObject* *o)

Py_UCS4 ***PyUnicode_4BYTE_DATA** (*PyObject* *o)

Return a pointer to the canonical representation cast to UCS1, UCS2 or UCS4 integer types for direct character access. No checks are performed if the canonical representation has the correct character size; use `PyUnicode_KIND()` to select the right macro. Make sure `PyUnicode_READY()` has been called before accessing this.

3.3 新版功能.

PyUnicode_WCHAR_KIND

PyUnicode_1BYTE_KIND

PyUnicode_2BYTE_KIND

PyUnicode_4BYTE_KIND

返回`PyUnicode_KIND()` 宏的值。

3.3 新版功能.

从版本 3.10 开始标记为过时，将在版本 3.12 中移除。: `PyUnicode_WCHAR_KIND` 已被弃用。

int **PyUnicode_KIND** (*PyObject* *o)

Return one of the PyUnicode kind constants (see above) that indicate how many bytes per character this Unicode object uses to store its data. *o* has to be a Unicode object in the "canonical" representation (not checked).

3.3 新版功能.

void ***PyUnicode_DATA** (*PyObject* *o)

Return a void pointer to the raw Unicode buffer. *o* has to be a Unicode object in the "canonical" representation (not checked).

3.3 新版功能.

void **PyUnicode_WRITE** (int kind, void *data, *Py_ssize_t* index, *Py_UCS4* value)

Write into a canonical representation *data* (as obtained with `PyUnicode_DATA()`). This function performs no sanity checks, and is intended for usage in loops. The caller should cache the *kind* value and *data* pointer as obtained from other calls. *index* is the index in the string (starts at 0) and *value* is the new code point value which should be written to that location.

3.3 新版功能.

Py_UCS4 **PyUnicode_READ** (int kind, void *data, *Py_ssize_t* index)

Read a code point from a canonical representation *data* (as obtained with `PyUnicode_DATA()`). No checks or ready calls are performed.

3.3 新版功能.

Py_UCS4 **PyUnicode_READ_CHAR** (*PyObject* *o, *Py_ssize_t* index)

Read a character from a Unicode object *o*, which must be in the "canonical" representation. This is less efficient than `PyUnicode_READ()` if you do multiple consecutive reads.

3.3 新版功能.

Py_UCS4 **PyUnicode_MAX_CHAR_VALUE** (*PyObject* *o)

Return the maximum code point that is suitable for creating another string based on *o*, which must be in the "canonical" representation. This is always an approximation but more efficient than iterating over the string.

3.3 新版功能.

Py_ssize_t **PyUnicode_GET_SIZE** (*PyObject* *o)

Return the size of the deprecated `Py_UNICODE` representation, in code units (this includes surrogate pairs as 2 units). *o* has to be a Unicode object (not checked).

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 旧式 Unicode API 的一部分，请迁移到使用`PyUnicode_GET_LENGTH()`。

Py_ssize_t **PyUnicode_GET_DATA_SIZE** (*PyObject* *o)

Return the size of the deprecated `Py_UNICODE` representation in bytes. *o* has to be a Unicode object (not checked).

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 旧式 Unicode API 的一部分，请迁移到使用`PyUnicode_GET_LENGTH()`。

Py_UNICODE ***PyUnicode_AS_UNICODE** (*PyObject* *o)

const char ***PyUnicode_AS_DATA** (*PyObject* *o)

Return a pointer to a `Py_UNICODE` representation of the object. The returned buffer is always terminated with an extra null code point. It may also contain embedded null code points, which would cause the string to be truncated when used in most C functions. The `AS_DATA` form casts the pointer to `const char*`. The *o* argument has to be a Unicode object (not checked).

在 3.3 版更改: This function is now inefficient -- because in many cases the `Py_UNICODE` representation does not exist and needs to be created -- and can fail (return `NULL` with an exception set). Try to port the code to use the new `PyUnicode_nBYTE_DATA()` macros or use `PyUnicode_WRITE()` or `PyUnicode_READ()`.

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 旧式 Unicode API 的一部分，请迁移到使用 `PyUnicode_nBYTE_DATA()` 宏族。

int **PyUnicode_IsIdentifier** (*PyObject* *o)

Part of the Stable ABI. Return `1` if the string is a valid identifier according to the language definition, section identifiers. Return `0` otherwise.

在 3.9 版更改: The function does not call `Py_FatalError()` anymore if the string is not ready.

Unicode 字符属性

Unicode provides many different character properties. The most often needed ones are available through these macros which are mapped to C functions depending on the Python configuration.

int **Py_UNICODE_ISSPACE**(*Py_UCS4* ch)

根据 *ch* 是否为空白字符返回 `1` 或 `0`。

int **Py_UNICODE_ISLOWER**(*Py_UCS4* ch)

根据 *ch* 是否为小写字符返回 `1` 或 `0`。

int **Py_UNICODE_ISUPPER**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is an uppercase character.

int **Py_UNICODE_ISTITLE**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is a titlecase character.

int **Py_UNICODE_ISLINEBREAK**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is a linebreak character.

int **Py_UNICODE_ISDECIMAL**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is a decimal character.

int **Py_UNICODE_ISDIGIT**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is a digit character.

int **Py_UNICODE_ISNUMERIC**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is a numeric character.

int **Py_UNICODE_ISALPHA**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is an alphabetic character.

int **Py_UNICODE_ISALNUM**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is an alphanumeric character.

int **Py_UNICODE_ISPRINTABLE**(*Py_UCS4* ch)

Return `1` or `0` depending on whether *ch* is a printable character. Nonprintable characters are those characters defined in the Unicode character database as "Other" or "Separator", excepting the ASCII space (0x20) which is considered printable. (Note that printable characters in this context are those which should not be escaped when `repr()` is invoked on a string. It has no bearing on the handling of strings written to `sys.stdout` or `sys.stderr`.)

These APIs can be used for fast direct character conversions:

Py_UCS4 **Py_UNICODE_TOLOWER**(*Py_UCS4* ch)

Return the character *ch* converted to lower case.

3.3 版后已移除: This function uses simple case mappings.

Py_UCS4 **Py_UNICODE_TOUPPER**(*Py_UCS4* ch)

Return the character *ch* converted to upper case.

3.3 版后已移除: This function uses simple case mappings.

Py_UCS4 **Py_UNICODE_TOTITLE**(*Py_UCS4* ch)

Return the character *ch* converted to title case.

3.3 版后已移除: This function uses simple case mappings.

int **Py_UNICODE_TODECIMAL**(*Py_UCS4* ch)

Return the character *ch* converted to a decimal positive integer. Return `-1` if this is not possible. This macro does not raise exceptions.

int **Py_UNICODE_TODIGIT**(*Py_UCS4* ch)

Return the character *ch* converted to a single digit integer. Return `-1` if this is not possible. This macro does not raise exceptions.

double **Py_UNICODE_TONUMERIC**(*Py_UCS4* ch)

Return the character *ch* converted to a double. Return `-1.0` if this is not possible. This macro does not raise exceptions.

These APIs can be used to work with surrogates:

Py_UNICODE_IS_SURROGATE(ch)

Check if *ch* is a surrogate (`0xD800 <= ch <= 0xDFFF`).

Py_UNICODE_IS_HIGH_SURROGATE(ch)

Check if *ch* is a high surrogate (`0xD800 <= ch <= 0xDBFF`).

Py_UNICODE_IS_LOW_SURROGATE(ch)

Check if *ch* is a low surrogate (`0xDC00 <= ch <= 0xDFFF`).

Py_UNICODE_JOIN_SURROGATES(high, low)

Join two surrogate characters and return a single Py_UCS4 value. *high* and *low* are respectively the leading and trailing surrogates in a surrogate pair.

Creating and accessing Unicode strings

To create Unicode objects and access their basic sequence properties, use these APIs:

PyObject ***PyUnicode_New**(*Py_ssize_t* size, *Py_UCS4* maxchar)

Return value: New reference. Create a new Unicode object. *maxchar* should be the true maximum code point to be placed in the string. As an approximation, it can be rounded up to the nearest value in the sequence 127, 255, 65535, 1114111.

This is the recommended way to allocate a new Unicode object. Objects created using this function are not resizable.

3.3 新版功能.

PyObject ***PyUnicode_FromKindAndData**(int kind, const void *buffer, *Py_ssize_t* size)

Return value: New reference. Create a new Unicode object with the given *kind* (possible values are `PyUnicode_1BYTE_KIND` etc., as returned by `PyUnicode_KIND()`). The *buffer* must point to an array of *size* units of 1, 2 or 4 bytes per character, as given by the kind.

If necessary, the input *buffer* is copied and transformed into the canonical representation. For example, if the *buffer* is a UCS4 string (`PyUnicode_4BYTE_KIND`) and it consists only of codepoints in the UCS1 range, it will be transformed into UCS1 (`PyUnicode_1BYTE_KIND`).

3.3 新版功能.

PyObject ***PyUnicode_FromStringAndSize**(const char *u, *Py_ssize_t* size)

Return value: New reference. Part of the Stable ABI. Create a Unicode object from the char buffer *u*. The bytes will be interpreted as being UTF-8 encoded. The buffer is copied into the new object. If the buffer is not `NULL`, the return value might be a shared object, i.e. modification of the data is not allowed.

If *u* is `NULL`, this function behaves like `PyUnicode_FromUnicode()` with the buffer set to `NULL`. This usage is deprecated in favor of `PyUnicode_New()`, and will be removed in Python 3.12.

PyObject ***PyUnicode_FromString**(const char *u)

Return value: New reference. Part of the Stable ABI. Create a Unicode object from a UTF-8 encoded null-terminated char buffer *u*.

PyObject ***PyUnicode_FromFormat*** (const char *format, ...)

Return value: New reference. Part of the Stable ABI. Take a C `printf()`-style *format* string and a variable number of arguments, calculate the size of the resulting Python Unicode string and return a string with the values formatted into it. The variable arguments must be C types and must correspond exactly to the format characters in the *format* ASCII-encoded string. The following format characters are allowed:

格式字符	类型	注释
`%%`	不适用	文字% 字符。
`%c`	int	单个字符，表示为 C 语言的整型。
`%d`	int	相当于 `printf("%d")`.[1]
`%u`	unsigned int	相当于 `printf("%u")`.[1]
`%ld`	长整型	相当于 `printf("%ld")`.[1]
`%li`	长整型	相当于 `printf("%li")`.[1]
`%lu`	unsigned long	相当于 `printf("%lu")`.[1]
`%lld`	long long	相当于 `printf("%lld")`.[1]
`%lli`	long long	相当于 `printf("%lli")`.[1]
`%llu`	unsigned long long	相当于 `printf("%llu")`.[1]
`%zd`	*Py_ssize_t*	相当于 `printf("%zd")`.[1]
`%zi`	*Py_ssize_t*	相当于 `printf("%zi")`.[1]
`%zu`	size_t	相当于 `printf("%zu")`.[1]
`%i`	int	相当于 `printf("%i")`.[1]
`%x`	int	相当于 `printf("%x")`.[1]
`%s`	const char*	以 null 为终止符的 C 字符数组。
`%p`	const void*	一个 C 指针的十六进制表示形式。基本等价于 `printf("%p")` 但它会确保以字面值 `0x` 开头，不论系统平台上 `printf` 的输出是什么。
`%A`	PyObject*	`ascii()` 调用的结果。
`%U`	PyObject*	A Unicode object.
`%V`	PyObject*, const char*	A Unicode object (which may be `NULL`) and a null-terminated C character array as a second parameter (which will be used, if the first parameter is `NULL`).
`%S`	PyObject*	The result of calling *PyObject_Str()*.
`%R`	PyObject*	The result of calling *PyObject_Repr()*.

An unrecognized format character causes all the rest of the format string to be copied as-is to the result string, and any extra arguments discarded.

备注： The width formatter unit is number of characters rather than bytes. The precision formatter unit is number of bytes for `"%s"` and `"%V"` (if the `PyObject*` argument is `NULL`), and a number of characters for `"%A"`, `"%U"`, `"%S"`, `"%R"` and `"%V"` (if the `PyObject*` argument is not `NULL`).

在 3.2 版更改: Support for `"%lld"` and `"%llu"` added.

在 3.3 版更改: Support for `"%li"`, `"%lli"` and `"%zi"` added.

在 3.4 版更改: Support width and precision formatter for `"%s"`, `"%A"`, `"%U"`, `"%V"`, `"%S"`, `"%R"` added.

PyObject ***PyUnicode_FromFormatV*** (const char *format, va_list vargs)

Return value: New reference. Part of the Stable ABI. Identical to *PyUnicode_FromFormat()* except that it takes exactly two arguments.

PyObject ***PyUnicode_FromEncodedObject*** (*PyObject* *obj, const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. Decode an encoded object *obj* to a Unicode object.

`bytes`, `bytearray` and other *bytes-like objects* are decoded according to the given *encoding* and using the error handling defined by *errors*. Both can be `NULL` to have the interface use the default values (see *Built-in Codecs* for details).

[1] For integer specifiers (d, u, ld, li, lu, lld, lli, llu, zd, zi, zu, i, x): the 0-conversion flag has effect even when a precision is given.

All other objects, including Unicode objects, cause a `TypeError` to be set.

The API returns `NULL` if there was an error. The caller is responsible for decref'ing the returned objects.

Py_ssize_t **PyUnicode_GetLength**(*PyObject* *unicode)

Part of the Stable ABI *since version 3.7.* Return the length of the Unicode object, in code points.

3.3 新版功能.

Py_ssize_t **PyUnicode_CopyCharacters**(*PyObject* *to, *Py_ssize_t* to_start, *PyObject* *from, *Py_ssize_t* from_start, *Py_ssize_t* how_many)

Copy characters from one Unicode object into another. This function performs character conversion when necessary and falls back to `memcpy()` if possible. Returns `-1` and sets an exception on error, otherwise returns the number of copied characters.

3.3 新版功能.

Py_ssize_t **PyUnicode_Fill**(*PyObject* *unicode, *Py_ssize_t* start, *Py_ssize_t* length, *Py_UCS4* fill_char)

Fill a string with a character: write *fill_char* into `unicode[start:start+length]`.

Fail if *fill_char* is bigger than the string maximum character, or if the string has more than 1 reference.

Return the number of written character, or return `-1` and raise an exception on error.

3.3 新版功能.

int **PyUnicode_WriteChar**(*PyObject* *unicode, *Py_ssize_t* index, *Py_UCS4* character)

Part of the Stable ABI *since version 3.7.* Write a character to a string. The string must have been created through *`PyUnicode_New()`*. Since Unicode strings are supposed to be immutable, the string must not be shared, or have been hashed yet.

This function checks that *unicode* is a Unicode object, that the index is not out of bounds, and that the object can be modified safely (i.e. that it its reference count is one).

3.3 新版功能.

Py_UCS4 **PyUnicode_ReadChar**(*PyObject* *unicode, *Py_ssize_t* index)

Part of the Stable ABI *since version 3.7.* Read a character from a string. This function checks that *unicode* is a Unicode object and the index is not out of bounds, in contrast to *`PyUnicode_READ_CHAR()`*, which performs no error checking.

3.3 新版功能.

PyObject ***PyUnicode_Substring**(*PyObject* *str, *Py_ssize_t* start, *Py_ssize_t* end)

Return value: New reference. Part of the Stable ABI *since version 3.7.* Return a substring of *str*, from character index *start* (included) to character index *end* (excluded). Negative indices are not supported.

3.3 新版功能.

Py_UCS4 ***PyUnicode_AsUCS4**(*PyObject* *u, *Py_UCS4* *buffer, *Py_ssize_t* buflen, int copy_null)

Part of the Stable ABI *since version 3.7.* Copy the string *u* into a UCS4 buffer, including a null character, if *copy_null* is set. Returns `NULL` and sets an exception on error (in particular, a `SystemError` if *buflen* is smaller than the length of *u*). *buffer* is returned on success.

3.3 新版功能.

Py_UCS4 ***PyUnicode_AsUCS4Copy**(*PyObject* *u)

Part of the Stable ABI *since version 3.7.* Copy the string *u* into a new UCS4 buffer that is allocated using *`PyMem_Malloc()`*. If this fails, `NULL` is returned with a `MemoryError` set. The returned buffer always has an extra null code point appended.

3.3 新版功能.

Deprecated Py_UNICODE APIs

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。.

These API functions are deprecated with the implementation of **PEP 393**. Extension modules can continue using them, as they will not be removed in Python 3.x, but need to be aware that their use can now cause performance and memory hits.

PyObject ***PyUnicode_FromUnicode**(const *Py_UNICODE* *u, *Py_ssize_t* size)

Return value: New reference. Create a Unicode object from the Py_UNICODE buffer *u* of the given size. *u* may be `NULL` which causes the contents to be undefined. It is the user's responsibility to fill in the needed data. The buffer is copied into the new object.

If the buffer is not `NULL`, the return value might be a shared object. Therefore, modification of the resulting Unicode object is only allowed when *u* is `NULL`.

If the buffer is `NULL`, `PyUnicode_READY()` must be called once the string content has been filled before using any of the access macros such as `PyUnicode_KIND()`.

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: Part of the old-style Unicode API, please migrate to using `PyUnicode_FromKindAndData()`, `PyUnicode_FromWideChar()`, or `PyUnicode_New()`.

Py_UNICODE ***PyUnicode_AsUnicode**(*PyObject* *unicode)

Return a read-only pointer to the Unicode object's internal `Py_UNICODE` buffer, or `NULL` on error. This will create the `Py_UNICODE*` representation of the object if it is not yet available. The buffer is always terminated with an extra null code point. Note that the resulting `Py_UNICODE` string may also contain embedded null code points, which would cause the string to be truncated when used in most C functions.

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: Part of the old-style Unicode API, please migrate to using `PyUnicode_AsUCS4()`, `PyUnicode_AsWideChar()`, `PyUnicode_ReadChar()` or similar new APIs.

Py_UNICODE ***PyUnicode_AsUnicodeAndSize**(*PyObject* *unicode, *Py_ssize_t* *size)

Like `PyUnicode_AsUnicode()`, but also saves the `Py_UNICODE()` array length (excluding the extra null terminator) in *size*. Note that the resulting `Py_UNICODE*` string may contain embedded null code points, which would cause the string to be truncated when used in most C functions.

3.3 新版功能.

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: Part of the old-style Unicode API, please migrate to using `PyUnicode_AsUCS4()`, `PyUnicode_AsWideChar()`, `PyUnicode_ReadChar()` or similar new APIs.

Py_ssize_t **PyUnicode_GetSize**(*PyObject* *unicode)

Part of the Stable ABI. Return the size of the deprecated `Py_UNICODE` representation, in code units (this includes surrogate pairs as 2 units).

从版本 3.3 开始标记为过时，将在版本 3.12 中移除。: 旧式 Unicode API 的一部分，请迁移到使用`PyUnicode_GET_LENGTH()`。

PyObject ***PyUnicode_FromObject**(*PyObject* *obj)

Return value: New reference. Part of the Stable ABI. Copy an instance of a Unicode subtype to a new true Unicode object if necessary. If *obj* is already a true Unicode object (not a subtype), return the reference with incremented refcount.

Objects other than Unicode or its subtypes will cause a `TypeError`.

Locale Encoding

The current locale encoding can be used to decode text from the operating system.

PyObject ***PyUnicode_DecodeLocaleAndSize**(const char *str, *Py_ssize_t* len, const char *errors)

Return value: New reference. Part of the Stable ABI *since version 3.7.* Decode a string from UTF-8 on Android and VxWorks, or from the current locale encoding on other platforms. The supported error handlers are `"strict"` and `"surrogateescape"` (**PEP 383**). The decoder uses `"strict"` error handler if *errors* is `NULL`. *str* must end with a null character but cannot contain embedded null characters.

Use *`PyUnicode_DecodeFSDefaultAndSize()`* to decode a string from `Py_FileSystemDefaultEncoding` (the locale encoding read at Python startup).

This function ignores the Python UTF-8 Mode.

参见:

The *`Py_DecodeLocale()`* 函数。

3.3 新版功能.

在 3.7 版更改: The function now also uses the current locale encoding for the `surrogateescape` error handler, except on Android. Previously, *`Py_DecodeLocale()`* was used for the `surrogateescape`, and the current locale encoding was used for `strict`.

PyObject ***PyUnicode_DecodeLocale**(const char *str, const char *errors)

Return value: New reference. Part of the Stable ABI *since version 3.7.* Similar to *`PyUnicode_DecodeLocaleAndSize()`*, but compute the string length using `strlen()`.

3.3 新版功能.

PyObject ***PyUnicode_EncodeLocale**(*PyObject* *unicode, const char *errors)

Return value: New reference. Part of the Stable ABI *since version 3.7.* Encode a Unicode object to UTF-8 on Android and VxWorks, or to the current locale encoding on other platforms. The supported error handlers are `"strict"` and `"surrogateescape"` (**PEP 383**). The encoder uses `"strict"` error handler if *errors* is `NULL`. Return a `bytes` object. *unicode* cannot contain embedded null characters.

Use *`PyUnicode_EncodeFSDefault()`* to encode a string to `Py_FileSystemDefaultEncoding` (the locale encoding read at Python startup).

This function ignores the Python UTF-8 Mode.

参见:

The *`Py_EncodeLocale()`* function.

3.3 新版功能.

在 3.7 版更改: The function now also uses the current locale encoding for the `surrogateescape` error handler, except on Android. Previously, *`Py_EncodeLocale()`* was used for the `surrogateescape`, and the current locale encoding was used for `strict`.

文件系统编码格式

To encode and decode file names and other environment strings, `Py_FileSystemDefaultEncoding` should be used as the encoding, and `Py_FileSystemDefaultEncodeErrors` should be used as the error handler (**PEP 383** and **PEP 529**). To encode file names to `bytes` during argument parsing, the `"O&"` converter should be used, passing *`PyUnicode_FSConverter()`* as the conversion function:

int **PyUnicode_FSConverter**(*PyObject* *obj, void *result)

Part of the Stable ABI. ParseTuple converter: encode `str` objects -- obtained directly or through the `os.PathLike` interface -- to `bytes` using *`PyUnicode_EncodeFSDefault()`*; `bytes` objects are output as-is. *result* must be a *`PyBytesObject`** which must be released when it is no longer used.

3.1 新版功能.

在 3.6 版更改: 接受一个*path-like object*。

To decode file names to `str` during argument parsing, the `"O&"` converter should be used, passing `PyUnicode_FSDecoder()` as the conversion function:

int **PyUnicode_FSDecoder** (*PyObject* *obj, void *result)

Part of the Stable ABI. ParseTuple converter: decode `bytes` objects -- obtained either directly or indirectly through the `os.PathLike` interface -- to `str` using `PyUnicode_DecodeFSDefaultAndSize()`; `str` objects are output as-is. *result* must be a `PyUnicodeObject*` which must be released when it is no longer used.

3.2 新版功能.

在 3.6 版更改: 接受一个*path-like object*。

PyObject ***PyUnicode_DecodeFSDefaultAndSize** (const char *s, *Py_ssize_t* size)

Return value: New reference. Part of the Stable ABI. Decode a string from the *filesystem encoding and error handler*.

If `Py_FileSystemDefaultEncoding` is not set, fall back to the locale encoding.

`Py_FileSystemDefaultEncoding` is initialized at startup from the locale encoding and cannot be modified later. If you need to decode a string from the current locale encoding, use `PyUnicode_DecodeLocaleAndSize()`.

参见:

The `Py_DecodeLocale()` 函数。

在 3.6 版更改: Use `Py_FileSystemDefaultEncodeErrors` error handler.

PyObject ***PyUnicode_DecodeFSDefault** (const char *s)

Return value: New reference. Part of the Stable ABI. Decode a null-terminated string from the *filesystem encoding and error handler*.

If `Py_FileSystemDefaultEncoding` is not set, fall back to the locale encoding.

Use `PyUnicode_DecodeFSDefaultAndSize()` if you know the string length.

在 3.6 版更改: Use `Py_FileSystemDefaultEncodeErrors` error handler.

PyObject ***PyUnicode_EncodeFSDefault** (*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object to `Py_FileSystemDefaultEncoding` with the `Py_FileSystemDefaultEncodeErrors` error handler, and return `bytes`. Note that the resulting `bytes` object may contain null bytes.

If `Py_FileSystemDefaultEncoding` is not set, fall back to the locale encoding.

`Py_FileSystemDefaultEncoding` is initialized at startup from the locale encoding and cannot be modified later. If you need to encode a string to the current locale encoding, use `PyUnicode_EncodeLocale()`.

参见:

The `Py_EncodeLocale()` function.

3.2 新版功能.

在 3.6 版更改: Use `Py_FileSystemDefaultEncodeErrors` error handler.

wchar_t Support

`wchar_t` support for platforms which support it:

PyObject ***PyUnicode_FromWideChar**(const wchar_t *w, *Py_ssize_t* size)

Return value: New reference. Part of the Stable ABI. Create a Unicode object from the `wchar_t` buffer *w* of the given *size*. Passing `-1` as the *size* indicates that the function must itself compute the length, using wcslen. Return `NULL` on failure.

Py_ssize_t **PyUnicode_AsWideChar**(*PyObject* *unicode, wchar_t *w, *Py_ssize_t* size)

Part of the Stable ABI. Copy the Unicode object contents into the `wchar_t` buffer *w*. At most *size* `wchar_t` characters are copied (excluding a possibly trailing null termination character). Return the number of `wchar_t` characters copied or `-1` in case of an error. Note that the resulting `wchar_t*` string may or may not be null-terminated. It is the responsibility of the caller to make sure that the `wchar_t*` string is null-terminated in case this is required by the application. Also, note that the `wchar_t*` string might contain null characters, which would cause the string to be truncated when used with most C functions.

wchar_t ***PyUnicode_AsWideCharString**(*PyObject* *unicode, *Py_ssize_t* *size)

Part of the Stable ABI *since version 3.7.* Convert the Unicode object to a wide character string. The output string always ends with a null character. If *size* is not `NULL`, write the number of wide characters (excluding the trailing null termination character) into **size*. Note that the resulting `wchar_t` string might contain null characters, which would cause the string to be truncated when used with most C functions. If *size* is `NULL` and the `wchar_t*` string contains null characters a `ValueError` is raised.

Returns a buffer allocated by `PyMem_Alloc()` (use *`PyMem_Free()`* to free it) on success. On error, returns `NULL` and **size* is undefined. Raises a `MemoryError` if memory allocation is failed.

3.2 新版功能.

在 3.7 版更改: Raises a `ValueError` if *size* is `NULL` and the `wchar_t*` string contains null characters.

Built-in Codecs

Python provides a set of built-in codecs which are written in C for speed. All of these codecs are directly usable via the following functions.

Many of the following APIs take two arguments encoding and errors, and they have the same semantics as the ones of the built-in `str()` string object constructor.

Setting encoding to `NULL` causes the default encoding to be used which is UTF-8. The file system calls should use *`PyUnicode_FSConverter()`* for encoding file names. This uses the variable `Py_FileSystemDefaultEncoding` internally. This variable should be treated as read-only: on some systems, it will be a pointer to a static string, on others, it will change at run-time (such as when the application invokes setlocale).

Error handling is set by errors which may also be set to `NULL` meaning to use the default handling defined for the codec. Default error handling for all built-in codecs is "strict" (`ValueError` is raised).

The codecs all use a similar interface. Only deviations from the following generic ones are documented for simplicity.

Generic Codecs

These are the generic codec APIs:

PyObject ***PyUnicode_Decode**(const char *s, *Py_ssize_t* size, const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the encoded string *s*. *encoding* and *errors* have the same meaning as the parameters of the same name in the `str()` built-in function. The codec to be used is looked up using the Python codec registry. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_AsEncodedString** (*PyObject* *unicode, const char *encoding, const char *errors)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object and return the result as Python bytes object. *encoding* and *errors* have the same meaning as the parameters of the same name in the Unicode `encode()` method. The codec to be used is looked up using the Python codec registry. Return `NULL` if an exception was raised by the codec.

UTF-8 编解码器

以下是 UTF-8 编解码器 API:

PyObject ***PyUnicode_DecodeUTF8** (const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the UTF-8 encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_DecodeUTF8Stateful** (const char *s, *Py_ssize_t* size, const char *errors, *Py_ssize_t* *consumed)

Return value: New reference. Part of the Stable ABI. If *consumed* is `NULL`, behave like *`PyUnicode_DecodeUTF8()`*. If *consumed* is not `NULL`, trailing incomplete UTF-8 byte sequences will not be treated as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

PyObject ***PyUnicode_AsUTF8String** (*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object using UTF-8 and return the result as Python bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

const char ***PyUnicode_AsUTF8AndSize** (*PyObject* *unicode, *Py_ssize_t* *size)

Part of the Stable ABI *since version 3.10.* Return a pointer to the UTF-8 encoding of the Unicode object, and store the size of the encoded representation (in bytes) in *size*. The *size* argument can be `NULL`; in this case no size will be stored. The returned buffer always has an extra null byte appended (not included in *size*), regardless of whether there are any other null code points.

In the case of an error, `NULL` is returned with an exception set and no *size* is stored.

This caches the UTF-8 representation of the string in the Unicode object, and subsequent calls will return a pointer to the same buffer. The caller is not responsible for deallocating the buffer. The buffer is deallocated and pointers to it become invalid when the Unicode object is garbage collected.

3.3 新版功能.

在 3.7 版更改: The return type is now `const char *` rather of `char *`.

在 3.10 版更改: This function is a part of the *limited API*.

const char ***PyUnicode_AsUTF8** (*PyObject* *unicode)

As *`PyUnicode_AsUTF8AndSize()`*, but does not store the size.

3.3 新版功能.

在 3.7 版更改: The return type is now `const char *` rather of `char *`.

UTF-32 Codecs

These are the UTF-32 codec APIs:

PyObject ***PyUnicode_DecodeUTF32** (const char *s, *Py_ssize_t* size, const char *errors, int *byteorder)

Return value: New reference. Part of the Stable ABI. Decode *size* bytes from a UTF-32 encoded buffer string and return the corresponding Unicode object. *errors* (if non-`NULL`) defines the error handling. It defaults to "strict".

If *byteorder* is non-`NULL`, the decoder starts decoding using the given byte order:

```
*byteorder == -1: little endian
*byteorder == 0:  native order
*byteorder == 1:  big endian
```

If `*byteorder` is zero, and the first four bytes of the input data are a byte order mark (BOM), the decoder switches to this byte order and the BOM is not copied into the resulting Unicode string. If `*byteorder` is `-1` or `1`, any byte order mark is copied to the output.

After completion, **byteorder* is set to the current byte order at the end of input data.

If *byteorder* is `NULL`, the codec starts in native order mode.

Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_DecodeUTF32Stateful**(const char *s, *Py_ssize_t* size, const char *errors, int *byteorder, *Py_ssize_t* *consumed)

Return value: New reference. Part of the Stable ABI. If *consumed* is `NULL`, behave like `PyUnicode_DecodeUTF32()`. If *consumed* is not `NULL`, `PyUnicode_DecodeUTF32Stateful()` will not treat trailing incomplete UTF-32 byte sequences (such as a number of bytes not divisible by four) as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

PyObject ***PyUnicode_AsUTF32String**(*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Return a Python byte string using the UTF-32 encoding in native byte order. The string always starts with a BOM mark. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

UTF-16 Codecs

These are the UTF-16 codec APIs:

PyObject ***PyUnicode_DecodeUTF16**(const char *s, *Py_ssize_t* size, const char *errors, int *byteorder)

Return value: New reference. Part of the Stable ABI. Decode *size* bytes from a UTF-16 encoded buffer string and return the corresponding Unicode object. *errors* (if non-`NULL`) defines the error handling. It defaults to "strict".

If *byteorder* is non-`NULL`, the decoder starts decoding using the given byte order:

```
*byteorder == -1: little endian
*byteorder == 0:  native order
*byteorder == 1:  big endian
```

If `*byteorder` is zero, and the first two bytes of the input data are a byte order mark (BOM), the decoder switches to this byte order and the BOM is not copied into the resulting Unicode string. If `*byteorder` is `-1` or `1`, any byte order mark is copied to the output (where it will result in either a `\ufeff` or a `\uffe` character).

After completion, `*byteorder` is set to the current byte order at the end of input data.

If *byteorder* is `NULL`, the codec starts in native order mode.

Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_DecodeUTF16Stateful**(const char *s, *Py_ssize_t* size, const char *errors, int *byteorder, *Py_ssize_t* *consumed)

Return value: New reference. Part of the Stable ABI. If *consumed* is `NULL`, behave like `PyUnicode_DecodeUTF16()`. If *consumed* is not `NULL`, `PyUnicode_DecodeUTF16Stateful()` will not treat trailing incomplete UTF-16 byte sequences (such as an odd number of bytes or a split surrogate pair) as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

PyObject ***PyUnicode_AsUTF16String**(*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Return a Python byte string using the UTF-16 encoding in native byte order. The string always starts with a BOM mark. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

UTF-7 Codecs

These are the UTF-7 codec APIs:

PyObject ***PyUnicode_DecodeUTF7**(const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the UTF-7 encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_DecodeUTF7Stateful**(const char *s, *Py_ssize_t* size, const char *errors, *Py_ssize_t* *consumed)

Return value: New reference. Part of the Stable ABI. If *consumed* is `NULL`, behave like `PyUnicode_DecodeUTF7()`. If *consumed* is not `NULL`, trailing incomplete UTF-7 base-64 sections will not be treated as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

Unicode-Escape 编解码器

These are the "Unicode Escape" codec APIs:

PyObject ***PyUnicode_DecodeUnicodeEscape**(const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the Unicode-Escape encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_AsUnicodeEscapeString**(*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object using Unicode-Escape and return the result as a bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

Raw-Unicode-Escape Codecs

These are the "Raw Unicode Escape" codec APIs:

PyObject ***PyUnicode_DecodeRawUnicodeEscape**(const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the Raw-Unicode-Escape encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_AsRawUnicodeEscapeString**(*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object using Raw-Unicode-Escape and return the result as a bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

Latin-1 Codecs

These are the Latin-1 codec APIs: Latin-1 corresponds to the first 256 Unicode ordinals and only these are accepted by the codecs during encoding.

PyObject ***PyUnicode_DecodeLatin1**(const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the Latin-1 encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_AsLatin1String**(*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object using Latin-1 and return the result as Python bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

ASCII Codecs

These are the ASCII codec APIs. Only 7-bit ASCII data is accepted. All other codes generate errors.

PyObject ***PyUnicode_DecodeASCII**(const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the ASCII encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_AsASCIIString**(*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object using ASCII and return the result as Python bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

Character Map Codecs

This codec is special in that it can be used to implement many different codecs (and this is in fact what was done to obtain most of the standard codecs included in the `encodings` package). The codec uses mappings to encode and decode characters. The mapping objects provided must support the `__getitem__()` mapping interface; dictionaries and sequences work well.

These are the mapping codec APIs:

PyObject ***PyUnicode_DecodeCharmap**(const char *data, *Py_ssize_t* size, *PyObject* *mapping, const char *errors)

Return value: New reference. Part of the Stable ABI. Create a Unicode object by decoding *size* bytes of the encoded string *s* using the given *mapping* object. Return `NULL` if an exception was raised by the codec.

If *mapping* is `NULL`, Latin-1 decoding will be applied. Else *mapping* must map bytes ordinals (integers in the range from 0 to 255) to Unicode strings, integers (which are then interpreted as Unicode ordinals) or `None`. Unmapped data bytes -- ones which cause a `LookupError`, as well as ones which get mapped to `None`, `0xFFFE` or `'\uffffe'`, are treated as undefined mappings and cause an error.

PyObject ***PyUnicode_AsCharmapString**(*PyObject* *unicode, *PyObject* *mapping)

Return value: New reference. Part of the Stable ABI. Encode a Unicode object using the given *mapping* object and return the result as a bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

The *mapping* object must map Unicode ordinal integers to bytes objects, integers in the range from 0 to 255 or `None`. Unmapped character ordinals (ones which cause a `LookupError`) as well as mapped to `None` are treated as "undefined mapping" and cause an error.

The following codec API is special in that maps Unicode to Unicode.

PyObject ***PyUnicode_Translate**(*PyObject* *str, *PyObject* *table, const char *errors)

Return value: New reference. Part of the Stable ABI. Translate a string by applying a character mapping table to it and return the resulting Unicode object. Return `NULL` if an exception was raised by the codec.

The mapping table must map Unicode ordinal integers to Unicode ordinal integers or `None` (causing deletion of the character).

Mapping tables need only provide the `__getitem__()` interface; dictionaries and sequences work well. Unmapped character ordinals (ones which cause a `LookupError`) are left untouched and are copied as-is.

errors has the usual meaning for codecs. It may be `NULL` which indicates to use the default error handling.

MBCS codecs for Windows

These are the MBCS codec APIs. They are currently only available on Windows and use the Win32 MBCS converters to implement the conversions. Note that MBCS (or DBCS) is a class of encodings, not just one. The target encoding is defined by the user settings on the machine running the codec.

PyObject ***PyUnicode_DecodeMBCS** (const char *s, *Py_ssize_t* size, const char *errors)

Return value: New reference. Part of the Stable ABI *on Windows since version 3.7.* Create a Unicode object by decoding *size* bytes of the MBCS encoded string *s*. Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_DecodeMBCSStateful** (const char *s, *Py_ssize_t* size, const char *errors, *Py_ssize_t* *consumed)

Return value: New reference. Part of the Stable ABI *on Windows since version 3.7.* If *consumed* is `NULL`, behave like `PyUnicode_DecodeMBCS()`. If *consumed* is not `NULL`, `PyUnicode_DecodeMBCSStateful()` will not decode trailing lead byte and the number of bytes that have been decoded will be stored in *consumed*.

PyObject ***PyUnicode_AsMBCSString** (*PyObject* *unicode)

Return value: New reference. Part of the Stable ABI *on Windows since version 3.7.* Encode a Unicode object using MBCS and return the result as Python bytes object. Error handling is "strict". Return `NULL` if an exception was raised by the codec.

PyObject ***PyUnicode_EncodeCodePage** (int code_page, *PyObject* *unicode, const char *errors)

Return value: New reference. Part of the Stable ABI *on Windows since version 3.7.* Encode the Unicode object using the specified code page and return a Python bytes object. Return `NULL` if an exception was raised by the codec. Use `CP_ACP` code page to get the MBCS encoder.

3.3 新版功能.

Methods & Slots

方法与槽位函数

The following APIs are capable of handling Unicode objects and strings on input (we refer to them as strings in the descriptions) and return Unicode objects or integers as appropriate.

They all return `NULL` or `-1` if an exception occurs.

PyObject ***PyUnicode_Concat** (*PyObject* *left, *PyObject* *right)

Return value: New reference. Part of the Stable ABI. Concat two strings giving a new Unicode string.

PyObject ***PyUnicode_Split** (*PyObject* *s, *PyObject* *sep, *Py_ssize_t* maxsplit)

Return value: New reference. Part of the Stable ABI. Split a string giving a list of Unicode strings. If *sep* is `NULL`, splitting will be done at all whitespace substrings. Otherwise, splits occur at the given separator. At most *maxsplit* splits will be done. If negative, no limit is set. Separators are not included in the resulting list.

PyObject ***PyUnicode_Splitlines** (*PyObject* *s, int keepend)

Return value: New reference. Part of the Stable ABI. Split a Unicode string at line breaks, returning a list of Unicode strings. CRLF is considered to be one line break. If *keepend* is `0`, the line break characters are not included in the resulting strings.

PyObject ***PyUnicode_Join** (*PyObject* *separator, *PyObject* *seq)

Return value: New reference. Part of the Stable ABI. Join a sequence of strings using the given *separator* and return the resulting Unicode string.

Py_ssize_t **PyUnicode_Tailmatch** (*PyObject* *str, *PyObject* *substr, *Py_ssize_t* start, *Py_ssize_t* end, int direction)

Part of the Stable ABI. Return `1` if *substr* matches `str[start:end]` at the given tail end (*direction* == `-1` means to do a prefix match, *direction* == `1` a suffix match), `0` otherwise. Return `-1` if an error occurred.

Py_ssize_t **PyUnicode_Find** (*PyObject* *str, *PyObject* *substr, *Py_ssize_t* start, *Py_ssize_t* end, int direction)

Part of the Stable ABI. Return the first position of *substr* in `str[start:end]` using the given *direction* (*direction* == `1` means to do a forward search, *direction* == `-1` a backward search). The return value is the index of the first match; a value of `-1` indicates that no match was found, and `-2` indicates that an error occurred and an exception has been set.

Py_ssize_t **PyUnicode_FindChar** (*PyObject* *str, *Py_UCS4* ch, *Py_ssize_t* start, *Py_ssize_t* end, int direction)

Part of the Stable ABI *since version 3.7.* Return the first position of the character *ch* in `str[start:end]` using the given *direction* (*direction* == `1` means to do a forward search, *direction* == `-1` a backward search). The return value is the index of the first match; a value of `-1` indicates that no match was found, and `-2` indicates that an error occurred and an exception has been set.

3.3 新版功能.

在 3.7 版更改: *start* and *end* are now adjusted to behave like `str[start:end]`.

Py_ssize_t **PyUnicode_Count** (*PyObject* *str, *PyObject* *substr, *Py_ssize_t* start, *Py_ssize_t* end)

Part of the Stable ABI. Return the number of non-overlapping occurrences of *substr* in `str[start:end]`. Return `-1` if an error occurred.

PyObject ***PyUnicode_Replace** (*PyObject* *str, *PyObject* *substr, *PyObject* *replstr, *Py_ssize_t* maxcount)

Return value: New reference. Part of the Stable ABI. Replace at most *maxcount* occurrences of *substr* in *str* with *replstr* and return the resulting Unicode object. *maxcount* == `-1` means replace all occurrences.

int **PyUnicode_Compare** (*PyObject* *left, *PyObject* *right)

Part of the Stable ABI. Compare two strings and return `-1`, `0`, `1` for less than, equal, and greater than, respectively.

This function returns `-1` upon failure, so one should call `PyErr_Occurred()` to check for errors.

int **PyUnicode_CompareWithASCIIString** (*PyObject* *uni, const char *string)

Part of the Stable ABI. Compare a Unicode object, *uni*, with *string* and return `-1`, `0`, `1` for less than, equal, and greater than, respectively. It is best to pass only ASCII-encoded strings, but the function interprets the input string as ISO-8859-1 if it contains non-ASCII characters.

This function does not raise exceptions.

PyObject ***PyUnicode_RichCompare** (*PyObject* *left, *PyObject* *right, int op)

Return value: New reference. Part of the Stable ABI. 对两个 Unicode 字符串执行富比较并返回以下值之一:

- `NULL` in case an exception was raised
- `Py_True` or `Py_False` for successful comparisons
- `Py_NotImplemented` in case the type combination is unknown

Possible values for *op* are `Py_GT`, `Py_GE`, `Py_EQ`, `Py_NE`, `Py_LT`, and `Py_LE`.

PyObject ***PyUnicode_Format** (*PyObject* *format, *PyObject* *args)

Return value: New reference. Part of the Stable ABI. Return a new string object from *format* and *args*; this is analogous to `format % args`.

int **PyUnicode_Contains**(*PyObject* *container, *PyObject* *element)

Part of the Stable ABI. Check whether *element* is contained in *container* and return true or false accordingly.

element has to coerce to a one element Unicode string. `-1` is returned if there was an error.

void **PyUnicode_InternInPlace**(*PyObject* **string)

Part of the Stable ABI. Intern the argument **string* in place. The argument must be the address of a pointer variable pointing to a Python Unicode string object. If there is an existing interned string that is the same as **string*, it sets **string* to it (decrementing the reference count of the old string object and incrementing the reference count of the interned string object), otherwise it leaves **string* alone and interns it (incrementing its reference count). (Clarification: even though there is a lot of talk about reference counts, think of this function as reference-count-neutral; you own the object after the call if and only if you owned it before the call.)

PyObject ***PyUnicode_InternFromString**(const char *v)

Return value: New reference. Part of the Stable ABI. A combination of `PyUnicode_FromString()` and `PyUnicode_InternInPlace()`, returning either a new Unicode string object that has been interned, or a new ("owned") reference to an earlier interned string object with the same value.

8.3.4 元组对象

type **PyTupleObject**

这个`PyObject`的子类型代表一个 Python 的元组对象。

PyTypeObject **PyTuple_Type**

Part of the Stable ABI. `PyTypeObject` 的实例代表一个 Python 元组类型，这与 Python 层面的 `tuple` 是相同的对象。

int **PyTuple_Check**(*PyObject* *p)

如果 *p* 是一个 tuple 对象或者 tuple 类型的子类型的实例则返回真值。此函数总是会成功执行。

int **PyTuple_CheckExact**(*PyObject* *p)

如果 *p* 是一个 tuple 对象但不是 tuple 类型的子类型的实例则返回真值。此函数总是会成功执行。

PyObject ***PyTuple_New**(*Py_ssize_t* len)

Return value: New reference. Part of the Stable ABI. 成功时返回一个新的元组对象，长度为 *len*，失败时返回 "NULL"。

PyObject ***PyTuple_Pack**(*Py_ssize_t* n, ...)

Return value: New reference. Part of the Stable ABI. 成功时返回一个新的元组对象，大小为 *n*，失败时返回 `NULL`。元组值初始化为指向 Python 对象的后续 *n* 个 C 参数。`PyTuple_Pack(2, a, b)` 和 `Py_BuildValue("(OO)", a, b)` 相等。

Py_ssize_t **PyTuple_Size**(*PyObject* *p)

Part of the Stable ABI. 获取指向元组对象的指针，并返回该元组的大小。

Py_ssize_t **PyTuple_GET_SIZE**(*PyObject* *p)

返回元组 *p* 的大小，它必须为非 `NULL` 并且指向一个元组；不执行错误检查。

PyObject ***PyTuple_GetItem**(*PyObject* *p, *Py_ssize_t* pos)

Return value: Borrowed reference. Part of the Stable ABI. 返回 *p* 所指向的元组中位于 *pos* 处的对象。如果 *pos* 为负值或超出范围，则返回 `NULL` 并设置一个 `IndexError` 异常。

PyObject ***PyTuple_GET_ITEM**(*PyObject* *p, *Py_ssize_t* pos)

Return value: Borrowed reference. 类似于`PyTuple_GetItem()`，但不检查其参数。

PyObject ***PyTuple_GetSlice**(*PyObject* *p, *Py_ssize_t* low, *Py_ssize_t* high)

Return value: New reference. Part of the Stable ABI. 返回 *p* 所指向的元组的切片，在 *low* 和 *high* 之间，或者在失败时返回 `NULL`。这等同于 Python 表达式 `p[low:high]`。不支持从列表末尾索引。

int **PyTuple_SetItem**(*PyObject* *p, *Py_ssize_t* pos, *PyObject* *o)

Part of the Stable ABI. 在 *p* 指向的元组的 *pos* 位置插入对对象 *o* 的引用。成功时返回 0；如果 *pos* 越界，则返回 -1，并抛出一个 IndexError 异常。

备注： 此函数会“窃取”对 *o* 的引用，并丢弃对元组中已在受影响位置的条目的引用。

void **PyTuple_SET_ITEM**(*PyObject* *p, *Py_ssize_t* pos, *PyObject* *o)

类似于*PyTuple_SetItem()*，但不进行错误检查，并且应该 只是被用来填充全新的元组。

备注： This function "steals" a reference to *o*, and, unlike *PyTuple_SetItem()*, does *not* discard a reference to any item that is being replaced; any reference in the tuple at position *pos* will be leaked.

int **_PyTuple_Resize**(*PyObject* **p, *Py_ssize_t* newsize)

可以用于调整元组的大小。*newsize* 将是元组的新长度。因为元组 被认为是不可变的，所以只有在对象仅有一个引用时，才应该使用它。如果元组已经被代码的其他部分所引用，请不要使用此项。元组在最后总是会增长或缩小。把它看作是销毁旧元组并创建一个新元组，只会更有效。成功时返回 0 。客户端代码不应假定 *p 的结果值将与调用此函数之前的值相同。如果替换了 *p 引用的对象，则原始的 *p 将被销毁。失败时，返回 "-1"，将 *p 设置为 NULL，并引发 MemoryError 或者 SystemError。

8.3.5 结构序列对象

结构序列对象是等价于 namedtuple() 的 C 对象，即一个序列，其中的条目也可以通过属性访问。要创建结构序列，你首先必须创建特定的结构序列类型。

PyTypeObject ***PyStructSequence_NewType**(*PyStructSequence_Desc* *desc)

Return value: New reference. Part of the Stable ABI. 根据 *desc* 中的数据创建一个新的结构序列类型，如下所述。可以使用*PyStructSequence_New()* 创建结果类型的实例。

void **PyStructSequence_InitType**(*PyTypeObject* *type, *PyStructSequence_Desc* *desc)

从 *desc* 就地初始化结构序列类型 *type*。

int **PyStructSequence_InitType2**(*PyTypeObject* *type, *PyStructSequence_Desc* *desc)

与 PyStructSequence_InitType 相同，但成功时返回 0 ，失败时返回 -1 。

3.4 新版功能.

type **PyStructSequence_Desc**

Part of the Stable ABI *(including all members)*. 包含要创建的结构序列类型的元信息。

域	C 类型	含意
name	const char *	结构序列类型的名称
doc	const char *	指向要忽略类型的文档字符串或 NULL 的指针
fields	PyStructSequence_Field *	指向以 NULL 结尾的数组的指针，其字段名称为新类型
n_in_sequence	int	Python 侧可见的字段数（如果用作元组）

type **PyStructSequence_Field**

Part of the Stable ABI *(including all members)*. Describes a field of a struct sequence. As a struct sequence is modeled as a tuple, all fields are typed as *PyObject**. The index in the fields array of the *PyStructSequence_Desc* determines which field of the struct sequence is described.

域	C 类型	含意
name	const char *	字段的名称或 NULL，若要结束命名字段的列表，请设置为PyStructSequence_UnnamedField 以保留未命名字段
doc	const char *	要忽略的字段文档字符串或 NULL

const char *const **PyStructSequence_UnnamedField**

Part of the Stable ABI *since version 3.11.* 字段名的特殊值将保持未命名状态。

在 3.9 版更改: 这个类型已从 char * 更改。

PyObject ***PyStructSequence_New**(*PyTypeObject* *type)

Return value: New reference. Part of the Stable ABI. 创建 *type* 的实例，该实例必须使用PyStructSequence_NewType() 创建。

PyObject ***PyStructSequence_GetItem**(*PyObject* *p, *Py_ssize_t* pos)

Return value: Borrowed reference. Part of the Stable ABI. 返回 *p* 所指向的结构序列中，位于 *pos* 处的对象。不需要进行边界检查。

PyObject ***PyStructSequence_GET_ITEM**(*PyObject* *p, *Py_ssize_t* pos)

Return value: Borrowed reference. PyStructSequence_GetItem() 的宏版本。

void **PyStructSequence_SetItem**(*PyObject* *p, *Py_ssize_t* pos, *PyObject* *o)

Part of the Stable ABI. 将结构序列 *p* 的索引 *pos* 处的字段设置为值 *o*。与PyTuple_SET_ITEM() 一样，它应该只用于填充全新的实例。

备注： 这个函数"窃取"了指向 *o* 的一个引用。

void **PyStructSequence_SET_ITEM**(*PyObject* *p, *Py_ssize_t* *pos, *PyObject* *o)

Similar to PyStructSequence_SetItem(), but implemented as a static inlined function.

备注： 这个函数"窃取"了指向 *o* 的一个引用。

8.3.6 列表对象

type **PyListObject**

这个 C 类型PyObject 的子类型代表一个 Python 列表对象。

PyTypeObject **PyList_Type**

Part of the Stable ABI. 这是个属于PyTypeObject 的代表 Python 列表类型的实例。在 Python 层面和类型 list 是同一个对象。

int **PyList_Check**(*PyObject* *p)

如果 *p* 是一个 list 对象或者 list 类型的子类型的实例则返回真值。此函数总是会成功执行。

int **PyList_CheckExact**(*PyObject* *p)

如果 *p* 是一个 list 对象但不是 list 类型的子类型的实例则返回真值。此函数总是会成功执行。

PyObject ***PyList_New**(*Py_ssize_t* len)

Return value: New reference. Part of the Stable ABI. 成功时返回一个长度为 *len* 的新列表，失败时返回 NULL。

备注： 当 *len* 大于零时，被返回的列表对象项目被设成 NULL。因此你不能用类似 C 函数PySequence_SetItem() 的抽象 API 或者用 C 函数PyList_SetItem() 将所有项目设置成真实对象前对 Python 代码公开这个对象。

Py_ssize_t **PyList_Size** (*PyObject* *list)

Part of the Stable ABI. 返回 *list* 中列表对象的长度；这等于在列表对象调用 `len(list)` 。

Py_ssize_t **PyList_GET_SIZE** (*PyObject* *list)

Similar to `PyList_Size()`, but without error checking.

PyObject ***PyList_GetItem** (*PyObject* *list, *Py_ssize_t* index)

Return value: Borrowed reference. Part of the Stable ABI. 返回 *list* 所指向列表中 *index* 位置上的对象。位置值必须为非负数；不支持从列表末尾进行索引。如果 *index* 超出边界 (<0 or >=len(list))，则返回 `NULL` 并设置 `IndexError` 异常。

PyObject ***PyList_GET_ITEM** (*PyObject* *list, *Py_ssize_t* i)

Return value: Borrowed reference. Similar to `PyList_GetItem()`, but without error checking.

int **PyList_SetItem** (*PyObject* *list, *Py_ssize_t* index, *PyObject* *item)

Part of the Stable ABI. 将列表中索引为 *index* 的项设为 *item*。成功时返回 `0`。如果 *index* 超出范围则返回 `-1` 并设定 `IndexError` 异常。

备注： 此函数会“偷走”一个对 *item* 的引用并丢弃一个对列表中受影响位置上的已有条目的引用。

void **PyList_SET_ITEM** (*PyObject* *list, *Py_ssize_t* i, *PyObject* *o)

不带错误检测的宏版本`PyList_SetItem()`。这通常只被用于新列表中之前没有内容的位置进行填充。

备注： 该宏会“偷走”一个对 *item* 的引用，但与`PyList_SetItem()` 不同的是它 不会丢弃对任何被替换条目的引用；在 *list* 的 *i* 位置上的任何引用都将被泄露。

int **PyList_Insert** (*PyObject* *list, *Py_ssize_t* index, *PyObject* *item)

Part of the Stable ABI. 将条目 *item* 插入到列表 *list* 索引号 *index* 之前的位置。如果成功将返回 `0`；如果不成功则返回 `-1` 并设置一个异常。相当于 `list.insert(index, item)`。

int **PyList_Append** (*PyObject* *list, *PyObject* *item)

Part of the Stable ABI. 将对象 *item* 添加到列表 *list* 的末尾。如果成功将返回 `0`；如果不成功则返回 `-1` 并设置一个异常。相当于 `list.append(item)`。

PyObject ***PyList_GetSlice** (*PyObject* *list, *Py_ssize_t* low, *Py_ssize_t* high)

Return value: New reference. Part of the Stable ABI. 返回一个对象列表，包含 *list* 当中位于 *low* 和 *high* 之间的对象。如果不成功则返回 `NULL` 并设置异常。相当于 `list[low:high]`。不支持从列表末尾进行索引。

int **PyList_SetSlice** (*PyObject* *list, *Py_ssize_t* low, *Py_ssize_t* high, *PyObject* *itemlist)

Part of the Stable ABI. 将 *list* 当中 *low* 与 *high* 之间的切片设为 *itemlist* 的内容。相当于 `list[low:high] = itemlist`。*itemlist* 可以为 `NULL`，表示赋值为一个空列表（删除切片）。成功时返回 `0`，失败时返回 `-1`。这里不支持从列表末尾进行索引。

int **PyList_Sort** (*PyObject* *list)

Part of the Stable ABI. 对 *list* 中的条目进行原地排序。成功时返回 `0`，失败时返回 `-1`。这等价于 `list.sort()`。

int **PyList_Reverse** (*PyObject* *list)

Part of the Stable ABI. 对 *list* 中的条目进行原地反转。成功时返回 `0`，失败时返回 `-1`。这等价于 `list.reverse()`。

PyObject ***PyList_AsTuple** (*PyObject* *list)

Return value: New reference. Part of the Stable ABI. 返回一个新的元组对象，其中包含 *list* 的内容；等价于 `tuple(list)`。

8.4 容器对象

8.4.1 字典对象

type **PyDictObject**

这个*PyObject* 的子类型代表一个 Python 字典对象。

PyTypeObject **PyDict_Type**

Part of the Stable ABI. Python 字典类型表示为*PyTypeObject* 的实例。这与 Python 层面的 `dict` 是相同的对象。

int **PyDict_Check**(*PyObject* *p)

如果 *p* 是一个 dict 对象或者 dict 类型的子类型的实例则返回真值。此函数总是会成功执行。

int **PyDict_CheckExact**(*PyObject* *p)

如果 *p* 是一个 dict 对象但不是 dict 类型的子类型的实例则返回真值。此函数总是会成功执行。

PyObject ***PyDict_New**()

Return value: New reference. Part of the Stable ABI. 返回一个新的空字典，失败时返回 `NULL`。

PyObject ***PyDictProxy_New**(*PyObject* *mapping)

Return value: New reference. Part of the Stable ABI. 返回 `types.MappingProxyType` 对象，用于强制执行只读行为的映射。这通常用于创建视图以防止修改非动态类类型的字典。

void **PyDict_Clear**(*PyObject* *p)

Part of the Stable ABI. 清空现有字典的所有键值对。

int **PyDict_Contains**(*PyObject* *p, *PyObject* *key)

Part of the Stable ABI. 确定 *key* 是否包含在字典 *p* 中。如果 *key* 匹配上 *p* 的某一项，则返回 `1` ，否则返回 `0` 。返回 `-1` 表示出错。这等同于 Python 表达式 `key in p` 。

PyObject ***PyDict_Copy**(*PyObject* *p)

Return value: New reference. Part of the Stable ABI. 返回与 *p* 包含相同键值对的新字典。

int **PyDict_SetItem**(*PyObject* *p, *PyObject* *key, *PyObject* *val)

Part of the Stable ABI. 使用 *key* 作为键将 *val* 插入字典 *p*。*key* 必须为*hashable*；如果不是，则将引发 `TypeError`。成功时返回 `0`，失败时返回 `-1`。此函数 不会附带对 *val* 的引用。

int **PyDict_SetItemString**(*PyObject* *p, const char *key, *PyObject* *val)

Part of the Stable ABI. Insert *val* into the dictionary *p* using *key* as a key. *key* should be a `const char*`. The key object is created using `PyUnicode_FromString(key)`. Return `0` on success or `-1` on failure. This function *does not* steal a reference to *val*.

int **PyDict_DelItem**(*PyObject* *p, *PyObject* *key)

Part of the Stable ABI. 移除字典 *p* 中键为 *key* 的条目。*key* 必须是可哈希的；如果不是，则会引发 `TypeError`。如果字典中没有 *key*，则会引发 `KeyError`。成功时返回 `0`，失败时返回 `-1`。

int **PyDict_DelItemString**(*PyObject* *p, const char *key)

Part of the Stable ABI. 移除字典 *p* 中由字符串 *key* 指定的键的条目。如果字典中没有 *key*，则会引发 `KeyError`。成功时返回 `0`，失败时返回 `-1`。

PyObject ***PyDict_GetItem**(*PyObject* *p, *PyObject* *key)

Return value: Borrowed reference. Part of the Stable ABI. 从字典 *p* 中返回以 *key* 为键的对象。如果键名 *key* 不存在但 没有设置一个异常则返回 `NULL`。

需要注意的是，调用 `__hash__()` 和 `__eq__()` 方法产生的异常不会被抛出。改用*PyDict_GetItemWithError()* 获得错误报告。

在 3.10 版更改: 在不保持*GIL* 的情况下调用此 API 曾因历史原因而被允许。现在已不再被允许。

PyObject ***PyDict_GetItemWithError**(*PyObject* *p, *PyObject* *key)

Return value: Borrowed reference. Part of the Stable ABI. `PyDict_GetItem()` 的变种，它不会屏蔽异常。当异常发生时将返回 NULL **并且**设置一个异常。如果键不存在则返回 NULL **并且不会**设置一个异常。

PyObject ***PyDict_GetItemString**(*PyObject* *p, const char *key)

Return value: Borrowed reference. Part of the Stable ABI. This is the same as `PyDict_GetItem()`, but *key* is specified as a `const char*`, rather than a `PyObject*`.

需要注意的是，调用 `__hash__()` 、`__eq__()` 方法和创建一个临时的字符串对象时产生的异常不会被抛出。改用`PyDict_GetItemWithError()` 获得错误报告。

PyObject ***PyDict_SetDefault**(*PyObject* *p, *PyObject* *key, *PyObject* *defaultobj)

Return value: Borrowed reference. 这跟 Python 层面的 `dict.setdefault()` 一样。如果键 *key* 存在，它返回在字典 *p* 里面对应的值。如果键不存在，它会和值 *defaultobj* 一起插入并返回 *defaultobj* 。这个函数只计算 *key* 的哈希函数一次，而不是在查找和插入时分别计算它。

3.4 新版功能.

PyObject ***PyDict_Items**(*PyObject* *p)

Return value: New reference. Part of the Stable ABI. 返回一个包含字典中所有键值项的`PyListObject`。

PyObject ***PyDict_Keys**(*PyObject* *p)

Return value: New reference. Part of the Stable ABI. 返回一个包含字典中所有键 (keys) 的`PyListObject`。

PyObject ***PyDict_Values**(*PyObject* *p)

Return value: New reference. Part of the Stable ABI. 返回一个包含字典中所有值 (values) 的`PyListObject`。

Py_ssize_t **PyDict_Size**(*PyObject* *p)

Part of the Stable ABI. 返回字典中项目数，等价于对字典 *p* 使用 `len(p)`。

int **PyDict_Next**(*PyObject* *p, *Py_ssize_t* *ppos, *PyObject* **pkey, *PyObject* **pvalue)

Part of the Stable ABI. Iterate over all key-value pairs in the dictionary *p*. The `Py_ssize_t` referred to by *ppos* must be initialized to `0` prior to the first call to this function to start the iteration; the function returns true for each pair in the dictionary, and false once all pairs have been reported. The parameters *pkey* and *pvalue* should either point to `PyObject*` variables that will be filled in with each key and value, respectively, or may be `NULL`. Any references returned through them are borrowed. *ppos* should not be altered during iteration. Its value represents offsets within the internal dictionary structure, and since the structure is sparse, the offsets are not consecutive.

例如：

```
PyObject *key, *value;
Py_ssize_t pos = 0;

while (PyDict_Next(self->dict, &pos, &key, &value)) {
    /* do something interesting with the values... */
    ...
}
```

字典 *p* 不应该在遍历期间发生改变。在遍历字典时，改变键中的值是安全的，但仅限于键的集合不发生改变。例如:

```
PyObject *key, *value;
Py_ssize_t pos = 0;

while (PyDict_Next(self->dict, &pos, &key, &value)) {
    long i = PyLong_AsLong(value);
    if (i == -1 && PyErr_Occurred()) {
        return -1;
```

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```
    }
    PyObject *o = PyLong_FromLong(i + 1);
    if (o == NULL)
        return -1;
    if (PyDict_SetItem(self->dict, key, o) < 0) {
        Py_DECREF(o);
        return -1;
    }
    Py_DECREF(o);
}
```

int **PyDict_Merge**(*PyObject* *a, *PyObject* *b, int override)

Part of the Stable ABI. 对映射对象 *b* 进行迭代，将键值对添加到字典 *a*。*b* 可以是一个字典，或任何支持`PyMapping_Keys()` 和`PyObject_GetItem()` 的对象。如果 *override* 为真值，则如果在 *b* 中找到相同的键则 *a* 中已存在的相应键值对将被替换，否则如果在 *a* 中没有相同的键则只是添加键值对。当成功时返回 0 或者当引发异常时返回 -1。

int **PyDict_Update**(*PyObject* *a, *PyObject* *b)

Part of the Stable ABI. 这与 C 中的 `PyDict_Merge(a, b, 1)` 一样，也类似于 Python 中的 `a.update(b)`，差别在于`PyDict_Update()` 在第二个参数没有"keys" 属性时不会回退到迭代键值对的序列。当成功时返回 0 或者当引发异常时返回 -1。

int **PyDict_MergeFromSeq2**(*PyObject* *a, *PyObject* *seq2, int override)

Part of the Stable ABI. 将 *seq2* 中的键值对更新或合并到字典 *a*。*seq2* 必须为产生长度为 2 的用作键值对的元素的可迭代对象。当存在重复的键时，如果 *override* 真值则最后出现的键胜出。当成功时返回 0 或者当引发异常时返回 -1。等价的 Python 代码（返回值除外）：

```
def PyDict_MergeFromSeq2(a, seq2, override):
    for key, value in seq2:
        if override or key not in a:
            a[key] = value
```

8.4.2 集合对象

这一节详细介绍了针对 `set` 和 `frozenset` 对象的公共 API。任何未在下面列出的功能最好是使用抽象对象协议 (包括`PyObject_CallMethod()`, `PyObject_RichCompareBool()`, `PyObject_Hash()`, `PyObject_Repr()`, `PyObject_IsTrue()`, `PyObject_Print()` 以及`PyObject_GetIter()`) 或者抽象数字协议 (包括`PyNumber_And()`, `PyNumber_Subtract()`, `PyNumber_Or()`, `PyNumber_Xor()`, `PyNumber_InPlaceAnd()`, `PyNumber_InPlaceSubtract()`, `PyNumber_InPlaceOr()` 以及`PyNumber_InPlaceXor()`)。

type **PySetObject**

这个`PyObject` 的子类型被用来保存 `set` 和 `frozenset` 对象的内部数据。它类似于`PyDictObject` 的地方在于对小尺寸集合来说它是固定大小的（很像元组的存储方式），而对于中等和大尺寸集合来说它将指向单独的可变大小的内存块（很像列表的存储方式）。此结构体的字段不应被视为公有并且可能发生改变。所有访问都应当通过已写入文档的 API 来进行而不可通过直接操纵结构体中的值。

PyTypeObject **PySet_Type**

Part of the Stable ABI. 这是一个`PyTypeObject` 实例，表示 Python `set` 类型。

PyTypeObject **PyFrozenSet_Type**

Part of the Stable ABI. 这是一个`PyTypeObject` 实例，表示 Python `frozenset` 类型。

下列类型检查宏适用于指向任意 Python 对象的指针。类似地，这些构造函数也适用于任意可迭代的 Python 对象。

int **PySet_Check** (*PyObject* *p)

如果 *p* 是一个 set 对象或者是其子类型的实例则返回真值。此函数总是会成功执行。

int **PyFrozenSet_Check** (*PyObject* *p)

如果 *p* 是一个 frozenset 对象或者是其子类型的实例则返回真值。此函数总是会成功执行。

int **PyAnySet_Check** (*PyObject* *p)

如果 *p* 是一个 set 对象、frozenset 对象或者是其子类型的实例则返回真值。此函数总是会成功执行。

int **PySet_CheckExact** (*PyObject* *p)

如果 *p* 是一个 set 对象但不是其子类型的实例则返回真值。此函数总是会成功执行。

3.10 新版功能.

int **PyAnySet_CheckExact** (*PyObject* *p)

如果 *p* 是一个 set 或 frozenset 对象但不是其子类型的实例则返回真值。此函数总是会成功执行。

int **PyFrozenSet_CheckExact** (*PyObject* *p)

如果 *p* 是一个 frozenset 对象但不是其子类型的实例则返回真值。此函数总是会成功执行。

PyObject ***PySet_New** (*PyObject* *iterable)

Return value: New reference. Part of the Stable ABI. 返回一个新的 set，其中包含 *iterable* 所返回的对象。*iterable* 可以为 NULL 表示创建一个新的空集合。成功时返回新的集合，失败时返回 NULL。如果 *iterable* 实际上不是可迭代对象则引发 TypeError。该构造器也适用于拷贝集合 (c=set(s))。

PyObject ***PyFrozenSet_New** (*PyObject* *iterable)

Return value: New reference. Part of the Stable ABI. 返回一个新的 frozenset，其中包含 *iterable* 所返回的对象。*iterable* 可以为 NULL 表示创建一个新的空冻结集合。成功时返回新的冻结集合，失败时返回 NULL。如果 *iterable* 实际上不是可迭代对象则引发 TypeError。

下列函数和宏适用于 set 或 frozenset 的实例或是其子类型的实例。

Py_ssize_t **PySet_Size** (*PyObject* *anyset)

Part of the Stable ABI. 返回 set 或 frozenset 对象的长度。等价于 len(anyset)。如果 *anyset* 不是 set, frozenset 或其子类型的实例则会引发 PyExc_SystemError。

Py_ssize_t **PySet_GET_SIZE** (*PyObject* *anyset)

宏版本的 *PySet_Size()*，不带错误检测。

int **PySet_Contains** (*PyObject* *anyset, *PyObject* *key)

Part of the Stable ABI. 如果找到返回 1，如果未找到返回 0，如果遇到错误则返回 -1。不同于 Python __contains__() 方法，此函数不会自动将不可哈希的集合转换为临时的冻结集合。如果 *key* 为不可哈希对象则会引发 TypeError。如果 *anyset* 不是 set, frozenset 或其子类型的实例则会引发 PyExc_SystemError。

int **PySet_Add** (*PyObject* *set, *PyObject* *key)

Part of the Stable ABI. 添加 *key* 到一个 set 实例。也可用于 frozenset 实例 (与 *PyTuple_SetItem()* 的类似之处是它也可被用来为全新的冻结集合在公开给其他代码之前填充全新的值）。成功时返回 0 而失败时返回 -1。如果 *key* 为不可哈希对象则会引发 TypeError。如果没有增长空间则会引发 MemoryError。如果 *set* 不是 set 或其子类型的实例则会引发 SystemError。

下列函数适用于 set 或其子类型的实例，但不可用于 frozenset 或其子类型的实例。

int **PySet_Discard** (*PyObject* *set, *PyObject* *key)

Part of the Stable ABI. 如果找到并移除返回 1，如果未找到（无操作）返回 0，如果遇到错误则返回 -1。对于不存在的键不会引发 KeyError。如果 *key* 为不可哈希对象则会引发 TypeError。不同于 Python discard() 方法，此函数不会自动将不可哈希的集合转换为临时的冻结集合。如果 *set* 不是 set 或其子类型的实例则会引发 PyExc_SystemError。

PyObject ***PySet_Pop** (*PyObject* *set)

Return value: New reference. Part of the Stable ABI. 返回 *set* 中任意对象的新引用，并从 *set* 中移除该对象。失败时返回 `NULL`。如果集合为空则会引发 `KeyError`。如果 *set* 不是 `set` 或其子类型的实例则会引发 `SystemError`。

int **PySet_Clear** (*PyObject* *set)

Part of the Stable ABI. 清空现有字典的所有键值对。

8.5 Function 对象

8.5.1 Function 对象

有一些特定于 Python 函数的函数。

type **PyFunctionObject**

用于函数的 C 结构体。

PyTypeObject **PyFunction_Type**

这是一个 `PyTypeObject` 实例并表示 Python 函数类型。它作为 `types.FunctionType` 向 Python 程序员公开。

int **PyFunction_Check** (*PyObject* *o)

如果 *o* 是一个函数对象 (类型为 `PyFunction_Type`) 则返回真值。形参必须不为 `NULL`。此函数总是会成功执行。

PyObject ***PyFunction_New** (*PyObject* *code, *PyObject* *globals)

Return value: New reference. 返回与代码对象 *code* 关联的新函数对象。*globals* 必须是一个字典，该函数可以访问全局变量。

The function's docstring and name are retrieved from the code object. *__module__* is retrieved from *globals*. The argument defaults, annotations and closure are set to `NULL`. *__qualname__* is set to the same value as the code object's `co_qualname` field.

PyObject ***PyFunction_NewWithQualName** (*PyObject* *code, *PyObject* *globals, *PyObject* *qualname)

Return value: New reference. As `PyFunction_New()`, but also allows setting the function object's `__qualname__` attribute. *qualname* should be a unicode object or `NULL`; if `NULL`, the `__qualname__` attribute is set to the same value as the code object's `co_qualname` field.

3.3 新版功能.

PyObject ***PyFunction_GetCode** (*PyObject* *op)

Return value: Borrowed reference. 返回与函数对象 *op* 关联的代码对象。

PyObject ***PyFunction_GetGlobals** (*PyObject* *op)

Return value: Borrowed reference. 返回与函数对象 *op* 相关联的全局字典。

PyObject ***PyFunction_GetModule** (*PyObject* *op)

Return value: Borrowed reference. 向函数对象 *op* 的 *__module__* 属性返回一个*borrowed reference*。该值可以为 *NULL*。

这通常为一个包含模块名称的字符串，但可以通过 Python 代码设为任何其他对象。

PyObject ***PyFunction_GetDefaults** (*PyObject* *op)

Return value: Borrowed reference. 返回函数对象 *op* 的参数默认值。这可以是一个参数元组或 `NULL`。

int **PyFunction_SetDefaults** (*PyObject* *op, *PyObject* *defaults)

为函数对象 *op* 设置参数默认值。*defaults* 必须为 `Py_None` 或一个元组。

失败时引发 `SystemError` 异常并返回 `-1` 。

PyObject ***PyFunction_GetClosure**(*PyObject* *op)

Return value: Borrowed reference. 返回关联到函数对象 *op* 的闭包。这可以是 NULL 或 cell 对象的元组。

int **PyFunction_SetClosure**(*PyObject* *op, *PyObject* *closure)

设置关联到函数对象 *op* 的闭包。*closure* 必须为 Py_None 或 cell 对象的元组。

失败时引发 SystemError 异常并返回 -1 。

PyObject ***PyFunction_GetAnnotations**(*PyObject* *op)

Return value: Borrowed reference. 返回函数对象 *op* 的标注。这可以是一个可变字典或 NULL。

int **PyFunction_SetAnnotations**(*PyObject* *op, *PyObject* *annotations)

设置函数对象 *op* 的标注。*annotations* 必须为一个字典或 Py_None。

失败时引发 SystemError 异常并返回 -1 。

8.5.2 实例方法对象

实例方法是*PyCFunction* 的包装器，也是将*PyCFunction* 绑定到类对象的一种新方式。它替代了原先的调用 PyMethod_New(func, NULL, class)。

PyTypeObject **PyInstanceMethod_Type**

这个*PyTypeObject* 实例代表 Python 实例方法类型。它并不对 Python 程序公开。

int **PyInstanceMethod_Check**(*PyObject* *o)

如果 *o* 是一个实例方法对象 (类型为*PyInstanceMethod_Type*) 则返回真值。形参必须不为 NULL。此函数总是会成功执行。

PyObject ***PyInstanceMethod_New**(*PyObject* *func)

Return value: New reference. 返回一个新的实例方法对象，*func* 应为任意可调用对象。*func* 将在实例方法被调用时作为函数被调用。

PyObject ***PyInstanceMethod_Function**(*PyObject* *im)

Return value: Borrowed reference. 返回关联到实例方法 *im* 的函数对象。

PyObject ***PyInstanceMethod_GET_FUNCTION**(*PyObject* *im)

Return value: Borrowed reference. 宏版本的*PyInstanceMethod_Function()*，略去了错误检测。

8.5.3 方法对象

方法是绑定的函数对象。方法总是会被绑定到一个用户自定义类的实例。未绑定方法（绑定到一个类的方法）已不再可用。

PyTypeObject **PyMethod_Type**

这个*PyTypeObject* 实例代表 Python 方法类型。它作为 types.MethodType 向 Python 程序公开。

int **PyMethod_Check**(*PyObject* *o)

如果 *o* 是一个方法对象 (类型为*PyMethod_Type*) 则返回真值。形参必须不为 NULL。此函数总是会成功执行。

PyObject ***PyMethod_New**(*PyObject* *func, *PyObject* *self)

Return value: New reference. 返回一个新的方法对象，*func* 应为任意可调用对象，*self* 为该方法应绑定的实例。在方法被调用时 *func* 将作为函数被调用。*self* 必须不为 NULL。

PyObject ***PyMethod_Function**(*PyObject* *meth)

Return value: Borrowed reference. 返回关联到方法 *meth* 的函数对象。

PyObject ***PyMethod_GET_FUNCTION**(*PyObject* *meth)

Return value: Borrowed reference. 宏版本的*PyMethod_Function()*，略去了错误检测。

PyObject ***PyMethod_Self**(*PyObject* *meth)

Return value: Borrowed reference. 返回关联到方法 *meth* 的实例。

PyObject ***PyMethod_GET_SELF**(*PyObject* *meth)

Return value: Borrowed reference. 宏版本的`PyMethod_Self()`，略去了错误检测。

8.5.4 Cell 对象

"Cell" 对象用于实现由多个作用域引用的变量。对于每个这样的变量，一个 "Cell" 对象为了存储该值而被创建；引用该值的每个堆栈框架的局部变量包含同样使用该变量的对外部作用域的 "Cell" 引用。访问该值时，将使用 "Cell" 中包含的值而不是单元格对象本身。这种对 "Cell" 对象的非关联化的引用需要支持生成的字节码；访问时不会自动非关联化这些内容。"Cell" 对象在其他地方可能不太有用。

type **PyCellObject**

用于 Cell 对象的 C 结构体。

PyTypeObject **PyCell_Type**

与 Cell 对象对应的类型对 象。

int **PyCell_Check**(ob)

如果 *ob* 是一个 cell 对象则返回真值；*ob* 必须不为 `NULL`。此函数总是会成功执行。

PyObject ***PyCell_New**(*PyObject* *ob)

Return value: New reference. 创建并返回一个包含值 *ob* 的新 cell 对象。形参可以为 `NULL`。

PyObject ***PyCell_Get**(*PyObject* *cell)

Return value: New reference. 返回 cell 对象 *cell* 的内容。

PyObject ***PyCell_GET**(*PyObject* *cell)

Return value: Borrowed reference. 返回 cell 对象 *cell* 的内容，但是不检测 *cell* 是否非 `NULL` 并且为一个 cell 对象。

int **PyCell_Set**(*PyObject* *cell, *PyObject* *value)

将 cell 对象 *cell* 的内容设为 *value*。这将释放任何对 cell 对象当前内容的引用。*value* 可以为 `NULL`。*cell* 必须为非 `NULL`；如果它不是一个 cell 对象则将返回 `-1`。如果设置成功则将返回 `0`。

void **PyCell_SET**(*PyObject* *cell, *PyObject* *value)

将 cell 对象 *cell* 的值设为 *value*。不会调整引用计数，并且不会进行检测以保证安全；*cell* 必须为非 `NULL` 并且为一个 cell 对象。

8.5.5 代码对象

代码对象是 CPython 实现的低级细节。每个代表一块尚未绑定到函数中的可执行代码。

type **PyCodeObject**

用于描述代码对象的对象的 C 结构。此类型字段可随时更改。

PyTypeObject **PyCode_Type**

这是一个`PyTypeObject` 实例，其表示 Python 的 `code` 类型。

int **PyCode_Check**(*PyObject* *co)

如果 *co* 是一个 `code` 对象则返回真值。此函数总是会成功执行。

int **PyCode_GetNumFree**(*PyCodeObject* *co)

返回 *co* 中的自由变量数。

PyCodeObject ***PyCode_New**(int argcount, int kwonlyargcount, int nlocals, int stacksize, int flags, *PyObject* *code, *PyObject* *consts, *PyObject* *names, *PyObject* *varnames, *PyObject* *freevars, *PyObject* *cellvars, *PyObject* *filename, *PyObject* *name, int firstlineno, *PyObject* *linetable, *PyObject* *exceptiontable)

Return value: New reference. Return a new code object. If you need a dummy code object to create a frame, use `PyCode_NewEmpty()` instead. Calling `PyCode_New()` directly will bind you to a precise Python version since the definition of the bytecode changes often. The many arguments of this function are inter-dependent in complex ways, meaning that subtle changes to values are likely to result in incorrect execution or VM crashes. Use this function only with extreme care.

在 3.11 版更改: Added `exceptiontable` parameter.

PyCodeObject ***PyCode_NewWithPosOnlyArgs**(int argcount, int posonlyargcount, int kwonlyargcount, int nlocals, int stacksize, int flags, *PyObject* *code, *PyObject* *consts, *PyObject* *names, *PyObject* *varnames, *PyObject* *freevars, *PyObject* *cellvars, *PyObject* *filename, *PyObject* *name, int firstlineno, *PyObject* *linetable, *PyObject* *exceptiontable)

Return value: New reference. Similar to `PyCode_New()`, but with an extra "posonlyargcount" for positional-only arguments. The same caveats that apply to `PyCode_New` also apply to this function.

3.8 新版功能.

在 3.11 版更改: Added `exceptiontable` parameter.

PyCodeObject ***PyCode_NewEmpty**(const char *filename, const char *funcname, int firstlineno)

Return value: New reference. Return a new empty code object with the specified filename, function name, and first line number. The resulting code object will raise an `Exception` if executed.

int **PyCode_Addr2Line**(*PyCodeObject* *co, int byte_offset)

返回在 `byte_offset` 位置或之前以及之后发生的指令的行号。如果你只需要一个帧的行号，请改用`PyFrame_GetLineNumber()`。

For efficiently iterating over the line numbers in a code object, use the API described in PEP 626.

int **PyCode_Addr2Location**(*PyObject* *co, int byte_offset, int *start_line, int *start_column, int *end_line, int *end_column)

Sets the passed `int` pointers to the source code line and column numbers for the instruction at `byte_offset`. Sets the value to `0` when information is not available for any particular element.

Returns `1` if the function succeeds and 0 otherwise.

PyObject ***PyCode_GetCode**(*PyCodeObject* *co)

Equivalent to the Python code `getattr(co, 'co_code')`. Returns a strong reference to a `PyBytesObject` representing the bytecode in a code object. On error, `NULL` is returned and an exception is raised.

This `PyBytesObject` may be created on-demand by the interpreter and does not necessarily represent the bytecode actually executed by CPython. The primary use case for this function is debuggers and profilers.

3.11 新版功能.

PyObject ***PyCode_GetVarnames**(*PyCodeObject* *co)

Equivalent to the Python code `getattr(co, 'co_varnames')`. Returns a new reference to a `PyTupleObject` containing the names of the local variables. On error, `NULL` is returned and an exception is raised.

3.11 新版功能.

PyObject ***PyCode_GetCellvars**(*PyCodeObject* *co)

Equivalent to the Python code `getattr(co, 'co_cellvars')`. Returns a new reference to a `PyTupleObject` containing the names of the local variables that are referenced by nested functions. On error, `NULL` is returned and an exception is raised.

3.11 新版功能.

PyObject ***PyCode_GetFreevars***(*PyCodeObject* *co)

Equivalent to the Python code `getattr(co, 'co_freevars')`. Returns a new reference to a *PyTupleObject* containing the names of the free variables. On error, `NULL` is returned and an exception is raised.

3.11 新版功能.

8.6 其他对象

8.6.1 文件对象

These APIs are a minimal emulation of the Python 2 C API for built-in file objects, which used to rely on the buffered I/O (`FILE*`) support from the C standard library. In Python 3, files and streams use the new `io` module, which defines several layers over the low-level unbuffered I/O of the operating system. The functions described below are convenience C wrappers over these new APIs, and meant mostly for internal error reporting in the interpreter; third-party code is advised to access the `io` APIs instead.

PyObject ***PyFile_FromFd***(int fd, const char *name, const char *mode, int buffering, const char *encoding, const char *errors, const char *newline, int closefd)

Return value: New reference. Part of the Stable ABI. 根据已打开文件 *fd* 的文件描述符创建一个 Python 文件对象。参数 *name*, *encoding*, *errors* 和 *newline* 可以为 `NULL` 表示使用默认值；*buffering* 可以为 *-1* 表示使用默认值。*name* 会被忽略仅保留用于向下兼容。失败时返回 `NULL`。有关参数的更全面描述，请参阅 `io.open()` 函数的文档。

> **警告：** 由于 Python 流具有自己的缓冲层，因此将它们与 OS 级文件描述符混合会产生各种问题（例如数据的意外排序）。

在 3.2 版更改: 忽略 *name* 属性。

int ***PyObject_AsFileDescriptor***(*PyObject* *p)

Part of the Stable ABI. Return the file descriptor associated with *p* as an `int`. If the object is an integer, its value is returned. If not, the object's `fileno()` method is called if it exists; the method must return an integer, which is returned as the file descriptor value. Sets an exception and returns `-1` on failure.

PyObject ***PyFile_GetLine***(*PyObject* *p, int n)

Return value: New reference. Part of the Stable ABI. 等价于 `p.readline([n])` ，这个函数从对象 *p* 中读取一行。*p* 可以是文件对象或具有 `readline()` 方法的任何对象。如果 *n* 是 `0` ，则无论该行的长度如何，都会读取一行。如果 *n* 大于 "0"，则从文件中读取不超过 *n* 个字节；可以返回行的一部分。在这两种情况下，如果立即到达文件末尾，则返回空字符串。但是，如果 *n* 小于 `0` ，则无论长度如何都会读取一行，但是如果立即到达文件末尾，则引发 `EOFError`。

int ***PyFile_SetOpenCodeHook***(Py_OpenCodeHookFunction handler)

重载 `io.open_code()` 的正常行为，将其形参通过所提供的处理程序来传递。

The handler is a function of type `PyObject *(*)(PyObject *path, void *userData)`, where *path* is guaranteed to be *PyUnicodeObject*.

userData 指针会被传入钩子函数。因于钩子函数可能由不同的运行时调用，该指针不应直接指向 Python 状态。

鉴于这个钩子专门在导入期间使用的，请避免在新模块执行期间进行导入操作，除非已知它们为冻结状态或者是在 `sys.modules` 中可用。

一旦钩子被设定，它就不能被移除或替换，之后对`PyFile_SetOpenCodeHook()` 的调用也将失败，如果解释器已经被初始化，函数将返回 -1 并设置一个异常。

此函数可以安全地在`Py_Initialize()` 之前调用。

引发一个 审计事件 setopencodehook，不附带任何参数。

3.8 新版功能.

int **PyFile_WriteObject** (*PyObject* *obj, *PyObject* *p, int flags)

Part of the Stable ABI. 将对象 *obj* 写入文件对象 *p* 。*flags* 唯一支持的标志是 Py_PRINT_RAW；如果给定，则写入对象的 str() 而不是 repr()。成功时返回 0，失败时返回 -1。将设置适当的例外。

int **PyFile_WriteString** (const char *s, *PyObject* *p)

Part of the Stable ABI. 将字符串 *s* 写入文件对象 *p*。成功返回 0 失败返回 -1；将设定相应的异常。

8.6.2 模块对象

PyTypeObject **PyModule_Type**

Part of the Stable ABI. 这个 C 类型实例*PyTypeObject* 用来表示 Python 中的模块类型。在 Python 程序中该实例被暴露为 "types.ModuleType"。

int **PyModule_Check** (*PyObject* *p)

当 *p* 为模块类型的对象，或是模块子类型的对象时返回真值。该函数永远有返回值。

int **PyModule_CheckExact** (*PyObject* *p)

当 *p* 为模块类型的对象且不是*PyModule_Type* 的子类型的对象时返回真值。该函数永远有返回值。

PyObject ***PyModule_NewObject** (*PyObject* *name)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 返回新的模块对象，其属性 __name__ 为 *name* 。模块的如下属性 __name__, __doc__, __package__, and __loader__ 都会被自动填充。(所有属性除了 __name__ 都被设为 "None")。调用时应当提供 __file__ 属性。

3.3 新版功能.

在 3.4 版更改: 属性 __package__ 和 __loader__ 被设为 "None"。

PyObject ***PyModule_New** (const char *name)

Return value: New reference. Part of the Stable ABI. 这类似于*PyModule_NewObject()*，但其名称为 UTF-8 编码的字符串而不是 Unicode 对象。

PyObject ***PyModule_GetDict** (*PyObject* *module)

Return value: Borrowed reference. Part of the Stable ABI. 返回实现 *module* 的命名空间的字典对象；此对象与模块对象的 __dict__ 属性相同。如果 *module* 不是一个模块对象（或模块对象的子类型），则会引发 SystemError 并返回 NULL。

It is recommended extensions use other PyModule_* and PyObject_* functions rather than directly manipulate a module's __dict__.

PyObject ***PyModule_GetNameObject** (*PyObject* *module)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 返回 *module* 的 __name__ 值。如果模块未提供该值，或者如果它不是一个字符串，则会引发 SystemError 并返回 NULL。

3.3 新版功能.

const char ***PyModule_GetName** (*PyObject* *module)

Part of the Stable ABI. 类似于*PyModule_GetNameObject()* 但返回 'utf-8' 编码的名称。

void ***PyModule_GetState** (*PyObject* *module)

Part of the Stable ABI. 返回模块的 "状态"，也就是说，返回指向在模块创建时分配的内存块的指针，或者 NULL。参见*PyModuleDef.m_size*。

PyModuleDef ***PyModule_GetDef** (*PyObject* *module)

Part of the Stable ABI. 返回指向模块创建所使用的*PyModuleDef* 结构体的指针，或者如果模块不是使用结构体定义创建的则返回 NULL。

PyObject ***PyModule_GetFilenameObject**(*PyObject* *module)

Return value: New reference. Part of the Stable ABI. 返回使用 *module* 的 `__file__` 属性所加载的 模块的文件名。如果属性未定义，或者如果它不是一个 Unicode 字符串，则会引发 `SystemError` 并返回 `NULL`；在其他情况下将返回一个指向 Unicode 对象的引用。

3.2 新版功能.

const char ***PyModule_GetFilename**(*PyObject* *module)

Part of the Stable ABI. Similar to *PyModule_GetFilenameObject()* but return the filename encoded to 'utf-8'.

3.2 版后已移除: *PyModule_GetFilename()* raises `UnicodeEncodeError` on unencodable filenames, use *PyModule_GetFilenameObject()* instead.

初始化 C 模块

Modules objects are usually created from extension modules (shared libraries which export an initialization function), or compiled-in modules (where the initialization function is added using *PyImport_AppendInittab()*). See building or extending-with-embedding for details.

The initialization function can either pass a module definition instance to *PyModule_Create()*, and return the resulting module object, or request "multi-phase initialization" by returning the definition struct itself.

type **PyModuleDef**

Part of the Stable ABI *(including all members).* The module definition struct, which holds all information needed to create a module object. There is usually only one statically initialized variable of this type for each module.

PyModuleDef_Base **m_base**

Always initialize this member to `PyModuleDef_HEAD_INIT`.

const char ***m_name**

新模块的名称。

const char ***m_doc**

Docstring for the module; usually a docstring variable created with *PyDoc_STRVAR* is used.

Py_ssize_t **m_size**

Module state may be kept in a per-module memory area that can be retrieved with *PyModule_GetState()*, rather than in static globals. This makes modules safe for use in multiple sub-interpreters.

This memory area is allocated based on *m_size* on module creation, and freed when the module object is deallocated, after the *m_free* function has been called, if present.

Setting `m_size` to `-1` means that the module does not support sub-interpreters, because it has global state.

Setting it to a non-negative value means that the module can be re-initialized and specifies the additional amount of memory it requires for its state. Non-negative `m_size` is required for multi-phase initialization.

请参阅 **PEP 3121** 了解详情。

PyMethodDef ***m_methods**

A pointer to a table of module-level functions, described by *PyMethodDef* values. Can be `NULL` if no functions are present.

PyModuleDef_Slot ***m_slots**

An array of slot definitions for multi-phase initialization, terminated by a `{0, NULL}` entry. When using single-phase initialization, *m_slots* must be `NULL`.

在 3.5 版更改: Prior to version 3.5, this member was always set to `NULL`, and was defined as:

inquiry **m_reload**

traverseproc **m_traverse**

A traversal function to call during GC traversal of the module object, or NULL if not needed.

This function is not called if the module state was requested but is not allocated yet. This is the case immediately after the module is created and before the module is executed (*Py_mod_exec* function). More precisely, this function is not called if *m_size* is greater than 0 and the module state (as returned by *PyModule_GetState()*) is NULL.

在 3.9 版更改: No longer called before the module state is allocated.

inquiry **m_clear**

A clear function to call during GC clearing of the module object, or NULL if not needed.

This function is not called if the module state was requested but is not allocated yet. This is the case immediately after the module is created and before the module is executed (*Py_mod_exec* function). More precisely, this function is not called if *m_size* is greater than 0 and the module state (as returned by *PyModule_GetState()*) is NULL.

Like *PyTypeObject.tp_clear*, this function is not *always* called before a module is deallocated. For example, when reference counting is enough to determine that an object is no longer used, the cyclic garbage collector is not involved and *m_free* is called directly.

在 3.9 版更改: No longer called before the module state is allocated.

freefunc **m_free**

A function to call during deallocation of the module object, or NULL if not needed.

This function is not called if the module state was requested but is not allocated yet. This is the case immediately after the module is created and before the module is executed (*Py_mod_exec* function). More precisely, this function is not called if *m_size* is greater than 0 and the module state (as returned by *PyModule_GetState()*) is NULL.

在 3.9 版更改: No longer called before the module state is allocated.

Single-phase initialization

The module initialization function may create and return the module object directly. This is referred to as "single-phase initialization", and uses one of the following two module creation functions:

PyObject ***PyModule_Create**(*PyModuleDef* *def)

Return value: New reference. Create a new module object, given the definition in *def*. This behaves like *PyModule_Create2()* with *module_api_version* set to PYTHON_API_VERSION.

PyObject ***PyModule_Create2**(*PyModuleDef* *def, int module_api_version)

Return value: New reference. Part of the Stable ABI. Create a new module object, given the definition in *def*, assuming the API version *module_api_version*. If that version does not match the version of the running interpreter, a RuntimeWarning is emitted.

备注: Most uses of this function should be using *PyModule_Create()* instead; only use this if you are sure you need it.

Before it is returned from in the initialization function, the resulting module object is typically populated using functions like *PyModule_AddObjectRef()*.

Multi-phase initialization

An alternate way to specify extensions is to request "multi-phase initialization". Extension modules created this way behave more like Python modules: the initialization is split between the *creation phase*, when the module object is created, and the *execution phase*, when it is populated. The distinction is similar to the `__new__()` and `__init__()` methods of classes.

Unlike modules created using single-phase initialization, these modules are not singletons: if the *sys.modules* entry is removed and the module is re-imported, a new module object is created, and the old module is subject to normal garbage collection -- as with Python modules. By default, multiple modules created from the same definition should be independent: changes to one should not affect the others. This means that all state should be specific to the module object (using e.g. using `PyModule_GetState()`), or its contents (such as the module's `__dict__` or individual classes created with `PyType_FromSpec()`).

All modules created using multi-phase initialization are expected to support *sub-interpreters*. Making sure multiple modules are independent is typically enough to achieve this.

To request multi-phase initialization, the initialization function (PyInit_modulename) returns a `PyModuleDef` instance with non-empty `m_slots`. Before it is returned, the `PyModuleDef` instance must be initialized with the following function:

PyObject ***PyModuleDef_Init**(*PyModuleDef* *def)

Return value: Borrowed reference. Part of the Stable ABI *since version 3.5.* Ensures a module definition is a properly initialized Python object that correctly reports its type and reference count.

Returns *def* cast to `PyObject*`, or `NULL` if an error occurred.

3.5 新版功能.

The *m_slots* member of the module definition must point to an array of `PyModuleDef_Slot` structures:

type **PyModuleDef_Slot**

int **slot**

A slot ID, chosen from the available values explained below.

void ***value**

Value of the slot, whose meaning depends on the slot ID.

3.5 新版功能.

The *m_slots* array must be terminated by a slot with id 0.

The available slot types are:

Py_mod_create

Specifies a function that is called to create the module object itself. The *value* pointer of this slot must point to a function of the signature:

PyObject ***create_module**(*PyObject* *spec, *PyModuleDef* *def)

The function receives a `ModuleSpec` instance, as defined in **PEP 451**, and the module definition. It should return a new module object, or set an error and return `NULL`.

This function should be kept minimal. In particular, it should not call arbitrary Python code, as trying to import the same module again may result in an infinite loop.

Multiple `Py_mod_create` slots may not be specified in one module definition.

If `Py_mod_create` is not specified, the import machinery will create a normal module object using `PyModule_New()`. The name is taken from *spec*, not the definition, to allow extension modules to dynamically adjust to their place in the module hierarchy and be imported under different names through symlinks, all while sharing a single module definition.

There is no requirement for the returned object to be an instance of `PyModule_Type`. Any type can be used, as long as it supports setting and getting import-related attributes. However, only `PyModule_Type` instances may be returned if the `PyModuleDef` has non-`NULL` `m_traverse`, `m_clear`, `m_free`; non-zero `m_size`; or slots other than `Py_mod_create`.

Py_mod_exec

Specifies a function that is called to *execute* the module. This is equivalent to executing the code of a Python module: typically, this function adds classes and constants to the module. The signature of the function is:

int **exec_module** (*PyObject* *module)

If multiple `Py_mod_exec` slots are specified, they are processed in the order they appear in the *m_slots* array.

See **PEP 489** for more details on multi-phase initialization.

Low-level module creation functions

The following functions are called under the hood when using multi-phase initialization. They can be used directly, for example when creating module objects dynamically. Note that both `PyModule_FromDefAndSpec` and `PyModule_ExecDef` must be called to fully initialize a module.

PyObject ***PyModule_FromDefAndSpec** (*PyModuleDef* *def, *PyObject* *spec)

Return value: New reference. Create a new module object, given the definition in *module* and the ModuleSpec *spec*. This behaves like `PyModule_FromDefAndSpec2()` with *module_api_version* set to `PYTHON_API_VERSION`.

3.5 新版功能.

PyObject ***PyModule_FromDefAndSpec2** (*PyModuleDef* *def, *PyObject* *spec, int module_api_version)

Return value: New reference. Part of the Stable ABI *since version 3.7.* Create a new module object, given the definition in *module* and the ModuleSpec *spec*, assuming the API version *module_api_version*. If that version does not match the version of the running interpreter, a `RuntimeWarning` is emitted.

备注： Most uses of this function should be using `PyModule_FromDefAndSpec()` instead; only use this if you are sure you need it.

3.5 新版功能.

int **PyModule_ExecDef** (*PyObject* *module, *PyModuleDef* *def)

Part of the Stable ABI *since version 3.7.* Process any execution slots (`Py_mod_exec`) given in *def*.

3.5 新版功能.

int **PyModule_SetDocString** (*PyObject* *module, const char *docstring)

Part of the Stable ABI *since version 3.7.* Set the docstring for *module* to *docstring*. This function is called automatically when creating a module from `PyModuleDef`, using either `PyModule_Create` or `PyModule_FromDefAndSpec`.

3.5 新版功能.

int **PyModule_AddFunctions** (*PyObject* *module, *PyMethodDef* *functions)

Part of the Stable ABI *since version 3.7.* Add the functions from the `NULL` terminated *functions* array to *module*. Refer to the `PyMethodDef` documentation for details on individual entries (due to the lack of a shared module namespace, module level "functions" implemented in C typically receive the module as their first parameter, making them similar to instance methods on Python classes). This function is called automatically when creating a module from `PyModuleDef`, using either `PyModule_Create` or `PyModule_FromDefAndSpec`.

3.5 新版功能.

Support functions

The module initialization function (if using single phase initialization) or a function called from a module execution slot (if using multi-phase initialization), can use the following functions to help initialize the module state:

int **PyModule_AddObjectRef**(*PyObject* *module, const char *name, *PyObject* *value)

Part of the Stable ABI *since version 3.10.* Add an object to *module* as *name*. This is a convenience function which can be used from the module's initialization function.

On success, return `0`. On error, raise an exception and return `-1`.

Return `NULL` if *value* is `NULL`. It must be called with an exception raised in this case.

用法示例:

```
static int
add_spam(PyObject *module, int value)
{
    PyObject *obj = PyLong_FromLong(value);
    if (obj == NULL) {
        return -1;
    }
    int res = PyModule_AddObjectRef(module, "spam", obj);
    Py_DECREF(obj);
    return res;
 }
```

The example can also be written without checking explicitly if *obj* is `NULL`:

```
static int
add_spam(PyObject *module, int value)
{
    PyObject *obj = PyLong_FromLong(value);
    int res = PyModule_AddObjectRef(module, "spam", obj);
    Py_XDECREF(obj);
    return res;
 }
```

Note that `Py_XDECREF()` should be used instead of `Py_DECREF()` in this case, since *obj* can be `NULL`.

3.10 新版功能.

int **PyModule_AddObject**(*PyObject* *module, const char *name, *PyObject* *value)

Part of the Stable ABI. Similar to *`PyModule_AddObjectRef()`*, but steals a reference to *value* on success (if it returns `0`).

The new *`PyModule_AddObjectRef()`* function is recommended, since it is easy to introduce reference leaks by misusing the *`PyModule_AddObject()`* function.

备注: Unlike other functions that steal references, `PyModule_AddObject()` only decrements the reference count of *value* **on success**.

This means that its return value must be checked, and calling code must *`Py_DECREF()`* *value* manually on error.

用法示例:

```
static int
add_spam(PyObject *module, int value)
{
    PyObject *obj = PyLong_FromLong(value);
    if (obj == NULL) {
```

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```
        return -1;
    }
    if (PyModule_AddObject(module, "spam", obj) < 0) {
        Py_DECREF(obj);
        return -1;
    }
    // PyModule_AddObject() stole a reference to obj:
    // Py_DECREF(obj) is not needed here
    return 0;
}
```

The example can also be written without checking explicitly if *obj* is `NULL`:

```
static int
add_spam(PyObject *module, int value)
{
    PyObject *obj = PyLong_FromLong(value);
    if (PyModule_AddObject(module, "spam", obj) < 0) {
        Py_XDECREF(obj);
        return -1;
    }
    // PyModule_AddObject() stole a reference to obj:
    // Py_DECREF(obj) is not needed here
    return 0;
}
```

Note that `Py_XDECREF()` should be used instead of `Py_DECREF()` in this case, since *obj* can be `NULL`.

int **PyModule_AddIntConstant**(*PyObject* *module, const char *name, long value)

Part of the Stable ABI. Add an integer constant to *module* as *name*. This convenience function can be used from the module's initialization function. Return `-1` on error, `0` on success.

int **PyModule_AddStringConstant**(*PyObject* *module, const char *name, const char *value)

Part of the Stable ABI. Add a string constant to *module* as *name*. This convenience function can be used from the module's initialization function. The string *value* must be `NULL`-terminated. Return `-1` on error, `0` on success.

int **PyModule_AddIntMacro**(*PyObject* *module, macro)

Add an int constant to *module*. The name and the value are taken from *macro*. For example `PyModule_AddIntMacro(module, AF_INET)` adds the int constant *AF_INET* with the value of *AF_INET* to *module*. Return `-1` on error, `0` on success.

int **PyModule_AddStringMacro**(*PyObject* *module, macro)

Add a string constant to *module*.

int **PyModule_AddType**(*PyObject* *module, *PyTypeObject* *type)

Part of the Stable ABI *since version 3.10.* Add a type object to *module*. The type object is finalized by calling internally `PyType_Ready()`. The name of the type object is taken from the last component of `tp_name` after dot. Return `-1` on error, `0` on success.

3.9 新版功能.

Module lookup

Single-phase initialization creates singleton modules that can be looked up in the context of the current interpreter. This allows the module object to be retrieved later with only a reference to the module definition.

These functions will not work on modules created using multi-phase initialization, since multiple such modules can be created from a single definition.

PyObject ***PyState_FindModule**(*PyModuleDef* *def)

Return value: Borrowed reference. Part of the Stable ABI. Returns the module object that was created from *def* for the current interpreter. This method requires that the module object has been attached to the interpreter state with `PyState_AddModule()` beforehand. In case the corresponding module object is not found or has not been attached to the interpreter state yet, it returns `NULL`.

int **PyState_AddModule**(*PyObject* *module, *PyModuleDef* *def)

Part of the Stable ABI *since version 3.3.* Attaches the module object passed to the function to the interpreter state. This allows the module object to be accessible via `PyState_FindModule()`.

Only effective on modules created using single-phase initialization.

Python calls `PyState_AddModule` automatically after importing a module, so it is unnecessary (but harmless) to call it from module initialization code. An explicit call is needed only if the module's own init code subsequently calls `PyState_FindModule`. The function is mainly intended for implementing alternative import mechanisms (either by calling it directly, or by referring to its implementation for details of the required state updates).

调用时必须携带 GIL。

Return 0 on success or -1 on failure.

3.3 新版功能.

int **PyState_RemoveModule**(*PyModuleDef* *def)

Part of the Stable ABI *since version 3.3.* Removes the module object created from *def* from the interpreter state. Return 0 on success or -1 on failure.

调用时必须携带 GIL。

3.3 新版功能.

8.6.3 迭代器对象

Python 提供了两个通用迭代器对象。第一个是序列迭代器，它使用支持 `__getitem__()` 方法的任意序列。第二个使用可调用对象和一个 sentinel 值，为序列中的每个项调用可调用对象，并在返回 sentinel 值时结束迭代。

PyTypeObject **PySeqIter_Type**

Part of the Stable ABI. `PySeqIter_New()` 返回迭代器对象的类型对象和内置序列类型内置函数 `iter()` 的单参数形式。

int **PySeqIter_Check**(op)

如果 *op* 的类型为 `PySeqIter_Type` 则返回真值。此函数总是会成功执行。

PyObject ***PySeqIter_New**(*PyObject* *seq)

Return value: New reference. Part of the Stable ABI. 返回一个与常规序列对象一起使用的迭代器 *seq*。当序列订阅操作引发 `IndexError` 时，迭代结束。

PyTypeObject **PyCallIter_Type**

Part of the Stable ABI. 由函数 `PyCallIter_New()` 和 `iter()` 内置函数的双参数形式返回的迭代器对象类型对象。

int **PyCallIter_Check**(op)

如果 *op* 的类型为 `PyCallIter_Type` 则返回真值。此函数总是会成功执行。

PyObject ***PyCallIter_New**(*PyObject* *callable, *PyObject* *sentinel)

Return value: New reference. Part of the Stable ABI. 返回一个新的迭代器。第一个参数 *callable* 可以是任何可以在没有参数的情况下调用的 Python 可调用对象；每次调用都应该返回迭代中的下一个项目。当 *callable* 返回等于 *sentinel* 的值时，迭代将终止。

8.6.4 描述符对象

"描述符"是描述对象的某些属性的对象。它们存在于类型对象的字典中。

PyTypeObject **PyProperty_Type**

Part of the Stable ABI. 内建描述符类型的类型对象。

PyObject ***PyDescr_NewGetSet**(*PyTypeObject* *type, struct *PyGetSetDef* *getset)

Return value: New reference. Part of the Stable ABI.

PyObject ***PyDescr_NewMember**(*PyTypeObject* *type, struct *PyMemberDef* *meth)

Return value: New reference. Part of the Stable ABI.

PyObject ***PyDescr_NewMethod**(*PyTypeObject* *type, struct *PyMethodDef* *meth)

Return value: New reference. Part of the Stable ABI.

PyObject ***PyDescr_NewWrapper**(*PyTypeObject* *type, struct wrapperbase *wrapper, void *wrapped)

Return value: New reference.

PyObject ***PyDescr_NewClassMethod**(*PyTypeObject* *type, *PyMethodDef* *method)

Return value: New reference. Part of the Stable ABI.

int **PyDescr_IsData**(*PyObject* *descr)

如果描述符对象 *descr* 描述的是一个数据属性则返回非零值，或者如果它描述的是一个方法则返回 `0`。*descr* 必须为一个描述符对象；不会进行错误检测。

PyObject ***PyWrapper_New**(*PyObject**, *PyObject**)

Return value: New reference. Part of the Stable ABI.

8.6.5 切片对象

PyTypeObject **PySlice_Type**

Part of the Stable ABI. 切片对象的类型对象。它与 Python 层面的 `slice` 是相同的对象。

int **PySlice_Check**(*PyObject* *ob)

如果 *ob* 是一个 slice 对象则返回真值；*ob* 必须不为 `NULL`。此函数总是会成功执行。

PyObject ***PySlice_New**(*PyObject* *start, *PyObject* *stop, *PyObject* *step)

Return value: New reference. Part of the Stable ABI. 返回一个具有给定值的新切片对象。*start*, *stop* 和 *step* 形参会被用作 slice 对象相应名称的属性的值。这些值中的任何一个都可以为 `NULL`，在这种情况下将使用 `None` 作为对应属性的值。如果新对象无法被分配则返回 `NULL`。

int **PySlice_GetIndices**(*PyObject* *slice, *Py_ssize_t* length, *Py_ssize_t* *start, *Py_ssize_t* *stop, *Py_ssize_t* *step)

Part of the Stable ABI. 从切片对象 *slice* 提取 start, stop 和 step 索引号，将序列长度视为 *length*。大于 *length* 的序列号将被当作错误。

成功时返回 `0`，出错时返回 `-1` 并且不设置异常（除非某个序列号不为 `None` 且无法被转换为整数，在这种情况下会返回 `-1` 并且设置一个异常）。

你可能不会打算使用此函数。

在 3.2 版更改: 之前 *slice* 形参的形参类型是 `PySliceObject*`。

int **PySlice_GetIndicesEx** (*PyObject* *slice, *Py_ssize_t* length, *Py_ssize_t* *start, *Py_ssize_t* *stop, *Py_ssize_t* *step, *Py_ssize_t* *slicelength)

Part of the Stable ABI. `PySlice_GetIndices()` 的可用替代。从切片对象 *slice* 提取 start, stop 和 step 索引号，将序列长度视为 *length*，并将切片的长度保存在 *slicelength* 中，超出范围的索引号会以与普通切片一致的方式进行剪切。

成功时返回 `0`，出错时返回 `-1` 并且不设置异常。

备注： 此函数对于可变大小序列来说是不安全的。对它的调用应被替换为 `PySlice_Unpack()` 和 `PySlice_AdjustIndices()` 的组合，其中

```
if (PySlice_GetIndicesEx(slice, length, &start, &stop, &step, &slicelength) <
0) {
    // return error
}
```

会被替换为

```
if (PySlice_Unpack(slice, &start, &stop, &step) < 0) {
    // return error
}
slicelength = PySlice_AdjustIndices(length, &start, &stop, step);
```

在 3.2 版更改: 之前 *slice* 形参的形参类型是 `PySliceObject*`。

在 3.6.1 版更改: 如果 `Py_LIMITED_API` 未设置或设置为 `0x03050400` 与 `0x03060000` 之间的值（不包括边界）或 `0x03060100` 或更大则 `PySlice_GetIndicesEx()` 会被实现为一个使用 `PySlice_Unpack()` 和 `PySlice_AdjustIndices()` 的宏。参数 *start*, *stop* 和 *step* 会被多被求值。

3.6.1 版后已移除: 如果 `Py_LIMITED_API` 设置为小于 `0x03050400` 或 `0x03060000` 与 `0x03060100` 之间的值（不包括边界）则 `PySlice_GetIndicesEx()` 为已弃用的函数。

int **PySlice_Unpack** (*PyObject* *slice, *Py_ssize_t* *start, *Py_ssize_t* *stop, *Py_ssize_t* *step)

Part of the Stable ABI *since version 3.7.* 从切片对象中将 start, stop 和 step 数据成员提取为 C 整数。会静默地将大于 `PY_SSIZE_T_MAX` 的值减小为 `PY_SSIZE_T_MAX`，静默地将小于 `PY_SSIZE_T_MIN` 的 start 和 stop 值增大为 `PY_SSIZE_T_MIN`，并静默地将小于 `-PY_SSIZE_T_MAX` 的 step 值增大为 `-PY_SSIZE_T_MAX`。

出错时返回 `-1`，成功时返回 `0`。

3.6.1 新版功能.

Py_ssize_t **PySlice_AdjustIndices** (*Py_ssize_t* length, *Py_ssize_t* *start, *Py_ssize_t* *stop, *Py_ssize_t* step)

Part of the Stable ABI *since version 3.7.* 将 start/end 切片索引号根据指定的序列长度进行调整。超出范围的索引号会以与普通切片一致的方式进行剪切。

返回切片的长度。此操作总是会成功。不会调用 Python 代码。

3.6.1 新版功能.

8.6.6 Ellipsis 对象

PyObject ***Py_Ellipsis**

Python 的 `Ellipsis` 对象。该对象没有任何方法。它必须以与任何其他对象一样的方式遵循引用计数。它与`Py_None` 一样属于单例对象。

8.6.7 MemoryView 对象

一个 `memoryview` 对象 C 级别的缓冲区接口 暴露为一个可以像任何其他对象一样传递的 Python 对象。

PyObject ***PyMemoryView_FromObject** (*PyObject* *obj)

Return value: New reference. Part of the Stable ABI. 从提供缓冲区接口的对象创建 memoryview 对象。如果 *obj* 支持可写缓冲区导出，则 memoryview 对象将可以被读/写，否则它可能是只读的，也可以是导出器自行决定的读/写。

PyObject ***PyMemoryView_FromMemory** (char *mem, *Py_ssize_t* size, int flags)

Return value: New reference. Part of the Stable ABI *since version 3.7.* 使用 *mem* 作为底层缓冲区创建一个 memoryview 对象。*flags* 可以是 `PyBUF_READ` 或者 `PyBUF_WRITE` 之一.

3.3 新版功能.

PyObject ***PyMemoryView_FromBuffer** (const *Py_buffer* *view)

Return value: New reference. Part of the Stable ABI *since version 3.11.* 创建一个包含给定缓冲区结构 *view* 的 memoryview 对象。对于简单的字节缓冲区，`PyMemoryView_FromMemory()` 是首选函数。

PyObject ***PyMemoryView_GetContiguous** (*PyObject* *obj, int buffertype, char order)

Return value: New reference. Part of the Stable ABI. 从定义缓冲区接口的对象创建一个 memoryview 对象*contiguous* 内存块（在'C' 或'F'ortran *order* 中）。如果内存是连续的，则 memoryview 对象指向原始内存。否则，复制并且 memoryview 指向新的 bytes 对象。

int **PyMemoryView_Check** (*PyObject* *obj)

如果 *obj* 是一个 memoryview 对象则返回真值。目前不允许创建 `memoryview` 的子类。此函数总是会成功执行。

Py_buffer ***PyMemoryView_GET_BUFFER** (*PyObject* *mview)

返回指向 memoryview 的导出缓冲区私有副本的指针。*mview* **必须**是一个 memoryview 实例；这个宏不检查它的类型，你必须自己检查，否则你将面临崩溃风险。

PyObject ***PyMemoryView_GET_BASE** (*PyObject* *mview)

返回 memoryview 所基于的导出对象的指针，或者如果 memoryview 已由函数`PyMemoryView_FromMemory()` 或`PyMemoryView_FromBuffer()` 创建则返回 `NULL`。*mview* **必须**是一个 memoryview 实例。

8.6.8 弱引用对象

Python 支持 "弱引用" 作为一类对象。具体来说，有两种直接实现弱引用的对象。第一种就是简单的引用对象，第二种尽可能地作用为一个原对象的代理。

int **PyWeakref_Check** (ob)

如果 *ob* 是一个引用或代理对象则返回真值。此函数总是会成功执行。

int **PyWeakref_CheckRef** (ob)

如果 *ob* 是一个引用对象则返回真值。此函数总是会成功执行。

int **PyWeakref_CheckProxy** (ob)

如果 *ob* 是一个代理对象则返回真值。此函数总是会成功执行。

PyObject ***PyWeakref_NewRef***(*PyObject* *ob, *PyObject* *callback)

Return value: New reference. Part of the Stable ABI. Return a weak reference object for the object *ob*. This will always return a new reference, but is not guaranteed to create a new object; an existing reference object may be returned. The second parameter, *callback*, can be a callable object that receives notification when *ob* is garbage collected; it should accept a single parameter, which will be the weak reference object itself. *callback* may also be `None` or `NULL`. If *ob* is not a weakly referencable object, or if *callback* is not callable, `None`, or `NULL`, this will return `NULL` and raise `TypeError`.

PyObject ***PyWeakref_NewProxy***(*PyObject* *ob, *PyObject* *callback)

Return value: New reference. Part of the Stable ABI. Return a weak reference proxy object for the object *ob*. This will always return a new reference, but is not guaranteed to create a new object; an existing proxy object may be returned. The second parameter, *callback*, can be a callable object that receives notification when *ob* is garbage collected; it should accept a single parameter, which will be the weak reference object itself. *callback* may also be `None` or `NULL`. If *ob* is not a weakly referencable object, or if *callback* is not callable, `None`, or `NULL`, this will return `NULL` and raise `TypeError`.

PyObject ***PyWeakref_GetObject***(*PyObject* *ref)

Return value: Borrowed reference. Part of the Stable ABI. 返回弱引用对象 ref 的被引用对象。如果被引用对象不再存在，则返回 `Py_None`。

备注： 该函数返回被引用对象的一个*borrowed reference*。这意味着应该总是在该对象上调用`Py_INCREF()`，除非是当它在借入引用的最后一次被使用之前无法被销毁的时候。

PyObject ***PyWeakref_GET_OBJECT***(*PyObject* *ref)

Return value: Borrowed reference. Similar to `PyWeakref_GetObject()`, but does no error checking.

8.6.9 Capsule 对象

有关使用这些对象的更多信息请参阅 using-capsules。

3.1 新版功能.

type **PyCapsule**

This subtype of `PyObject` represents an opaque value, useful for C extension modules who need to pass an opaque value (as a `void*` pointer) through Python code to other C code. It is often used to make a C function pointer defined in one module available to other modules, so the regular import mechanism can be used to access C APIs defined in dynamically loaded modules.

type **PyCapsule_Destructor**

Part of the Stable ABI. Capsule 的析构器回调的类型。定义如下：

```
typedef void (*PyCapsule_Destructor)(PyObject *);
```

参阅`PyCapsule_New()` 来获取 PyCapsule_Destructor 返回值的语义。

int **PyCapsule_CheckExact**(*PyObject* *p)

如果参数是一个`PyCapsule` 则返回真值。此函数总是会成功执行。

PyObject ***PyCapsule_New***(void *pointer, const char *name, *PyCapsule_Destructor* destructor)

Return value: New reference. Part of the Stable ABI. 创建一个封装了 *pointer* 的`PyCapsule`。*pointer* 参考可以不为 `NULL`。

在失败时设置一个异常并返回 `NULL`。

字符串 *name* 可以是 `NULL` 或是一个指向有效的 C 字符串的指针。如果不为 `NULL`，则此字符串必须比 capsule 长（虽然也允许在 *destructor* 中释放它。）

如果 *destructor* 参数不为 `NULL`，则当它被销毁时将附带 capsule 作为参数来调用。

如果此 capsule 将被保存为一个模块的属性，则 *name* 应当被指定为 `modulename.attributename`。这将允许其他模块使用 *PyCapsule_Import()* 来导入此 capsule。

void ***PyCapsule_GetPointer**(*PyObject* *capsule, const char *name)

Part of the Stable ABI. 提取保存在 capsule 中的 *pointer*。在失败时设置一个异常并返回 `NULL`。

name 形参必须与保存在 capsule 中的名称进行精确比较。如果保存在 capsule 中的名称为 `NULL`，则传入的 *name* 也必须为 `NULL`。Python 会使用 C 函数 `strcmp()` 来比较 capsule 名称。

PyCapsule_Destructor **PyCapsule_GetDestructor**(*PyObject* *capsule)

Part of the Stable ABI. 返回保存在 capsule 中的当前析构器。在失败时设置一个异常并返回 `NULL`。

capsule 具有 `NULL` 析构器是合法的。这会使得 `NULL` 返回码有些歧义；请使用 *PyCapsule_IsValid()* 或 *PyErr_Occurred()* 来消除歧义。

void ***PyCapsule_GetContext**(*PyObject* *capsule)

Part of the Stable ABI. 返回保存在 capsule 中的当前上下文。在失败时设置一个异常并返回 `NULL`。

capsule 具有 `NULL` 上下文是全法的。这会使得 `NULL` 返回码有些歧义；请使用 *PyCapsule_IsValid()* 或 *PyErr_Occurred()* 来消除歧义。

const char ***PyCapsule_GetName**(*PyObject* *capsule)

Part of the Stable ABI. 返回保存在 capsule 中的当前名称。在失败时设置一个异常并返回 `NULL`。

capsule 具有 `NULL` 名称是合法的。这会使得 `NULL` 返回码有些歧义；请使用 *PyCapsule_IsValid()* 或 *PyErr_Occurred()* 来消除歧义。

void ***PyCapsule_Import**(const char *name, int no_block)

Part of the Stable ABI. Import a pointer to a C object from a capsule attribute in a module. The *name* parameter should specify the full name to the attribute, as in `module.attribute`. The *name* stored in the capsule must match this string exactly.

成功时返回 capsule 的内部 指针。在失败时设置一个异常并返回 `NULL`。

在 3.3 版更改: *no_block* has no effect anymore.

int **PyCapsule_IsValid**(*PyObject* *capsule, const char *name)

Part of the Stable ABI. 确定 *capsule* 是否是一个有效的。有效的 capsule 必须不为 `NULL`，传递 *PyCapsule_CheckExact()*，在其中存储一个不为 `NULL` 的指针，并且其内部名称与 *name* 形参相匹配。(请参阅 *PyCapsule_GetPointer()* 了解如何对 capsule 名称进行比较的有关信息。)

换句话说，如果 *PyCapsule_IsValid()* 返回真值，则任何对访问器（以 `PyCapsule_Get()` 开头的任何函数）的调用都保证会成功。

如果对象有效并且匹配传入的名称则返回非零值。否则返回 `0`。此函数一定不会失败。

int **PyCapsule_SetContext**(*PyObject* *capsule, void *context)

Part of the Stable ABI. 将 *capsule* 内部的上下文指针设为 *context*。

成功时返回 `0`。失败时返回非零值并设置一个异常。

int **PyCapsule_SetDestructor**(*PyObject* *capsule, *PyCapsule_Destructor* destructor)

Part of the Stable ABI. 将 *capsule* 内部的析构器设为 *destructor*。

成功时返回 `0`。失败时返回非零值并设置一个异常。

int **PyCapsule_SetName**(*PyObject* *capsule, const char *name)

Part of the Stable ABI. 将 *capsule* 内部的名称设为 *name*。如果不为 `NULL`，则名称的存在期必须比 capsule 更长。如果之前保存在 capsule 中的 *name* 不为 `NULL`，则不会尝试释放它。

成功时返回 `0`。失败时返回非零值并设置一个异常。

int **PyCapsule_SetPointer**(*PyObject* *capsule, void *pointer)

Part of the Stable ABI. 将 *capsule* 内部的空指针设为 *pointer*。指针不可为 `NULL`。

成功时返回 `0`。失败时返回非零值并设置一个异常。

8.6.10 Frame Objects

type **PyFrameObject**

Part of the Limited API *(as an opaque struct).* The C structure of the objects used to describe frame objects.

There are no public members in this structure.

在 3.11 版更改: The members of this structure were removed from the public C API. Refer to the What's New entry for details.

The *PyEval_GetFrame()* and *PyThreadState_GetFrame()* functions can be used to get a frame object.

See also *Reflection*.

PyTypeObject **PyFrame_Type**

The type of frame objects. It is the same object as `types.FrameType` in the Python layer.

在 3.11 版更改: Previously, this type was only available after including `<frameobject.h>`.

int **PyFrame_Check**(*PyObject* *obj)

Return non-zero if *obj* is a frame object.

在 3.11 版更改: Previously, this function was only available after including `<frameobject.h>`.

PyFrameObject ***PyFrame_GetBack**(*PyFrameObject* *frame)

Get the *frame* next outer frame.

Return a *strong reference*, or `NULL` if *frame* has no outer frame.

3.9 新版功能.

PyObject ***PyFrame_GetBuiltins**(*PyFrameObject* *frame)

Get the *frame*'s `f_builtins` attribute.

Return a *strong reference*. The result cannot be `NULL`.

3.11 新版功能.

PyCodeObject ***PyFrame_GetCode**(*PyFrameObject* *frame)

Part of the Stable ABI *since version 3.10.* Get the *frame* code.

Return a *strong reference*.

The result (frame code) cannot be `NULL`.

3.9 新版功能.

PyObject ***PyFrame_GetGenerator**(*PyFrameObject* *frame)

Get the generator, coroutine, or async generator that owns this frame, or `NULL` if this frame is not owned by a generator. Does not raise an exception, even if the return value is `NULL`.

Return a *strong reference*, or `NULL`.

3.11 新版功能.

PyObject ***PyFrame_GetGlobals**(*PyFrameObject* *frame)

Get the *frame*'s `f_globals` attribute.

Return a *strong reference*. The result cannot be `NULL`.

3.11 新版功能.

int **PyFrame_GetLasti**(*PyFrameObject* *frame)

Get the *frame*'s `f_lasti` attribute.

Returns -1 if `frame.f_lasti` is `None`.

3.11 新版功能.

PyObject ***PyFrame_GetLocals**(*PyFrameObject* *frame)

Get the *frame*'s `f_locals` attribute (`dict`).

Return a *strong reference*.

3.11 新版功能.

int **PyFrame_GetLineNumber**(*PyFrameObject* *frame)

Part of the Stable ABI *since version 3.10.* Return the line number that *frame* is currently executing.

8.6.11 生成器对象

生成器对象是 Python 用来实现生成器迭代器的对象。它们通常通过迭代产生值的函数来创建，而不是显式调用`PyGen_New()` 或`PyGen_NewWithQualName()`。

type **PyGenObject**

用于生成器对象的 C 结构体。

PyTypeObject **PyGen_Type**

与生成器对象对应的类型对 象。

int **PyGen_Check**(*PyObject* *ob)

如果 *ob* 是一个 generator 对象则返回真值；*ob* 必须不为 `NULL`。此函数总是会成功执行。

int **PyGen_CheckExact**(*PyObject* *ob)

如果 *ob* 的类型是`PyGen_Type` 则返回真值；*ob* 必须不为 `NULL`。此函数总是会成功执行。

PyObject ***PyGen_New**(*PyFrameObject* *frame)

Return value: New reference. 基于 *frame* 对象创建并返回一个新的生成器对象。此函数会取走一个对 *frame* 的引用。参数必须不为 `NULL`。

PyObject ***PyGen_NewWithQualName**(*PyFrameObject* *frame, *PyObject* *name, *PyObject* *qualname)

Return value: New reference. 基于 *frame* 对象创建并返回一个新的生成器对象，其中 `__name__` 和 `__qualname__` 设为 *name* 和 *qualname*。此函数会取走一个对 *frame* 的引用。*frame* 参数必须不为 `NULL`。

8.6.12 协程对象

3.5 新版功能.

协程对象是使用 `async` 关键字声明的函数返回的。

type **PyCoroObject**

用于协程对象的 C 结构体。

PyTypeObject **PyCoro_Type**

与协程对象对应的类型对 象。

int **PyCoro_CheckExact**(*PyObject* *ob)

如果 *ob* 的类型是`PyCoro_Type` 则返回真值；*ob* 必须不为 `NULL`。此函数总是会成功执行。

PyObject ***PyCoro_New**(*PyFrameObject* *frame, *PyObject* *name, *PyObject* *qualname)

Return value: New reference. 基于 *frame* 对象创建并返回一个新的协程对象，其中 `__name__` 和 `__qualname__` 设为 *name* 和 *qualname*。此函数会取得一个对 *frame* 的引用。*frame* 参数必须不为 `NULL`。

8.6.13 上下文变量对象

在 3.7.1 版更改:

备注: 在 Python 3.7.1 中，所有上下文变量 C API 的签名被 **更改**为使用*PyObject* 指针而不是*PyContext*, *PyContextVar* 以及*PyContextToken*，例如:

```
// in 3.7.0:
PyContext *PyContext_New(void);

// in 3.7.1+:
PyObject *PyContext_New(void);
```

请参阅 bpo-34762 了解详情。

3.7 新版功能.

本节深入介绍了 contextvars 模块的公用 C API。

type **PyContext**

用于表示 contextvars.Context 对象的 C 结构体。

type **PyContextVar**

用于表示 contextvars.ContextVar 对象的 C 结构体。

type **PyContextToken**

用于表示 contextvars.Token 对象的 C 结构体。

PyTypeObject **PyContext_Type**

表示 *context* 类型的类型对象。

PyTypeObject **PyContextVar_Type**

表示 *context variable* 类型的类型对象。

PyTypeObject **PyContextToken_Type**

表示 *context variable token* 类型的类型对象。

类型检查宏:

int **PyContext_CheckExact**(*PyObject* *o)

如果 *o* 的类型为*PyContext_Type* 则返回真值。*o* 必须不为 NULL。此函数总是会成功执行。

int **PyContextVar_CheckExact**(*PyObject* *o)

如果 *o* 的类型为*PyContextVar_Type* 则返回真值。*o* 必须不为 NULL。此函数总是会成功执行。

int **PyContextToken_CheckExact**(*PyObject* *o)

如果 *o* 的类型为*PyContextToken_Type* 则返回真值。*o* 必须不为 NULL。此函数总是会成功执行。

上下文对象管理函数:

PyObject ***PyContext_New**(void)

Return value: New reference. 创建一个新的空上下文对象。如果发生错误则返回 NULL。

PyObject ***PyContext_Copy**(*PyObject* *ctx)

Return value: New reference. 创建所传入的 *ctx* 上下文对象的浅拷贝。如果发生错误则返回 NULL。

PyObject ***PyContext_CopyCurrent**(void)

Return value: New reference. 创建当前线程上下文的浅拷贝。如果发生错误则返回 NULL。

int **PyContext_Enter**(*PyObject* *ctx)

将 *ctx* 设为当前线程的当前上下文。成功时返回 0，出错时返回 -1。

int **PyContext_Exit** (*PyObject* *ctx)

取消激活 *ctx* 上下文并将之前的上下文恢复为当前线程的当前上下文。成功时返回 `0`，出错时返回 `-1`。

上下文变量函数:

PyObject ***PyContextVar_New** (const char *name, *PyObject* *def)

Return value: New reference. 创建一个新的 `ContextVar` 对象。形参 *name* 用于自我检查和调试目的。形参 *def* 为上下文变量指定默认值，或为 `NULL` 表示无默认值。如果发生错误，这个函数会返回 `NULL`。

int **PyContextVar_Get** (*PyObject* *var, *PyObject* *default_value, *PyObject* **value)

获取上下文变量的值。如果在查找过程中发生错误，返回''-1''，如果没有发生错误，无论是否找到值，都返回''0''，

如果找到上下文变量，*value* 将是指向它的指针。如果上下文变量 没有找到，*value* 将指向:

- *default_value*，如果非 "NULL";
- *var* 的默认值，如果不是 `NULL`;
- `NULL`

除了返回 `NULL`，这个函数会返回一个新的引用。

PyObject ***PyContextVar_Set** (*PyObject* *var, *PyObject* *value)

Return value: New reference. 在当前上下文中将 *var* 设为 *value*。返回针对此修改的新凭据对象，或者如果发生错误则返回 `NULL`。

int **PyContextVar_Reset** (*PyObject* *var, *PyObject* *token)

将上下文变量 *var* 的状态重置为它在返回 *token* 的 `PyContextVar_Set()` 被调用之前的状态。此函数成功时返回 `0`，出错时返回 `-1`。

8.6.14 DateTime 对象

`datetime` 模块提供了各种日期和时间对象。在使用任何这些函数之前，必须在你的源码中包含头文件 `datetime.h` (请注意此文件并未包含在 `Python.h` 中)，并且宏 `PyDateTime_IMPORT` 必须被发起调用，通常是作为模块初始化函数的一部分。这个宏会将指向特定 C 结构的指针放入一个静态变量 `PyDateTimeAPI` 中，它会由下面的宏来使用。

宏访问 UTC 单例:

PyObject ***PyDateTime_TimeZone_UTC**

返回表示 UTC 的时区单例，与 `datetime.timezone.utc` 为同一对象。

3.7 新版功能.

类型检查宏:

int **PyDate_Check** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_DateType` 类型或 `PyDateTime_DateType` 的某个子类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyDate_CheckExact** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_DateType` 类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyDateTime_Check** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_DateTimeType` 类型或 `PyDateTime_DateTimeType` 的某个子类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyDateTime_CheckExact** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_DateTimeType` 类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyTime_Check** (*PyObject* *ob)

如果 *ob* 的类型是 `PyDateTime_TimeType` 或是 `PyDateTime_TimeType` 的子类型则返回真值。*ob* 必须不为 `NULL`。此函数总是会成功执行。

int **PyTime_CheckExact** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_TimeType` 类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyDelta_Check** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_DeltaType` 类型或 `PyDateTime_DeltaType` 的某个子类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyDelta_CheckExact** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_DeltaType` 类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

int **PyTZInfo_Check** (*PyObject* *ob)

如果 *ob* 的类型是 `PyDateTime_TZInfoType` 或是 `PyDateTime_TZInfoType` 的子类型则返回真值。*ob* 必须不为 `NULL`。此函数总是会成功执行。

int **PyTZInfo_CheckExact** (*PyObject* *ob)

如果 *ob* 为 `PyDateTime_TZInfoType` 类型则返回真值。*ob* 不能为 `NULL`。此函数总是会成功执行。

用于创建对象的宏：

PyObject ***PyDate_FromDate** (int year, int month, int day)

Return value: New reference. 返回指定年、月、日的 `datetime.date` 对象。

PyObject ***PyDateTime_FromDateAndTime** (int year, int month, int day, int hour, int minute, int second, int usecond)

Return value: New reference. 返回具有指定 year, month, day, hour, minute, second 和 microsecond 属性的 `datetime.datetime` 对象。

PyObject ***PyDateTime_FromDateAndTimeAndFold** (int year, int month, int day, int hour, int minute, int second, int usecond, int fold)

Return value: New reference. 返回具有指定 year, month, day, hour, minute, second, microsecond 和 fold 属性的 `datetime.datetime` 对象。

3.6 新版功能.

PyObject ***PyTime_FromTime** (int hour, int minute, int second, int usecond)

Return value: New reference. 返回具有指定 hour, minute, second and microsecond 属性的 `datetime.time` 对象。

PyObject ***PyTime_FromTimeAndFold** (int hour, int minute, int second, int usecond, int fold)

Return value: New reference. 返回具有指定 hour, minute, second, microsecond 和 fold 属性的 `datetime.time` 对象。

3.6 新版功能.

PyObject ***PyDelta_FromDSU** (int days, int seconds, int useconds)

Return value: New reference. 返回代表给定天、秒和微秒数的 `datetime.timedelta` 对象。将执行正规化操作以使最终的微秒和秒数处在 `datetime.timedelta` 对象的文档指明的区间之内。

PyObject ***PyTimeZone_FromOffset** (PyDateTime_DeltaType *offset)

Return value: New reference. 返回一个 `datetime.timezone` 对象，该对象具有以 *offset* 参数表示的未命名固定时差。

3.7 新版功能.

PyObject ***PyTimeZone_FromOffsetAndName** (PyDateTime_DeltaType *offset, PyUnicode *name)

Return value: New reference. 返回一个 `datetime.timezone` 对象，该对象具有以 *offset* 参数表示的固定时差和时区名称 *name*。

3.7 新版功能.

一些用来从 date 对象中提取字段的宏。参数必须是 PyDateTime_Date 包括其子类 (例如 PyDateTime_DateTime) 的实例。参数必须不为 NULL，并且类型不被会检查:

int **PyDateTime_GET_YEAR** (PyDateTime_Date *o)

以正整数的形式返回年份值。

int **PyDateTime_GET_MONTH** (PyDateTime_Date *o)

返回月，从 0 到 12 的整数。

int **PyDateTime_GET_DAY** (PyDateTime_Date *o)

返回日期，从 0 到 31 的整数。

一些用来从 datetime 对象中提取字段的宏。参数必须是 PyDateTime_DateTime 包括其子类的实例。参数必须不为 NULL，并且类型不会被检查:

int **PyDateTime_DATE_GET_HOUR** (PyDateTime_DateTime *o)

返回小时，从 0 到 23 的整数。

int **PyDateTime_DATE_GET_MINUTE** (PyDateTime_DateTime *o)

返回分钟，从 0 到 59 的整数。

int **PyDateTime_DATE_GET_SECOND** (PyDateTime_DateTime *o)

返回秒，从 0 到 59 的整数。

int **PyDateTime_DATE_GET_MICROSECOND** (PyDateTime_DateTime *o)

返回微秒，从 0 到 999999 的整数。

int **PyDateTime_DATE_GET_FOLD** (PyDateTime_DateTime *o)

Return the fold, as an int from 0 through 1.

3.6 新版功能.

PyObject ***PyDateTime_DATE_GET_TZINFO** (PyDateTime_DateTime *o)

返回 tzinfo (可以为 None)。

3.10 新版功能.

一些用来从 time 对象中提取字段的宏。参数必须是 PyDateTime_Time 包括其子类的实例。参数必须不为 NULL，并且类型不会被检查:

int **PyDateTime_TIME_GET_HOUR** (PyDateTime_Time *o)

返回小时，从 0 到 23 的整数。

int **PyDateTime_TIME_GET_MINUTE** (PyDateTime_Time *o)

返回分钟，从 0 到 59 的整数。

int **PyDateTime_TIME_GET_SECOND** (PyDateTime_Time *o)

返回秒，从 0 到 59 的整数。

int **PyDateTime_TIME_GET_MICROSECOND** (PyDateTime_Time *o)

返回微秒，从 0 到 999999 的整数。

int **PyDateTime_TIME_GET_FOLD** (PyDateTime_Time *o)

Return the fold, as an int from 0 through 1.

3.6 新版功能.

PyObject ***PyDateTime_TIME_GET_TZINFO** (PyDateTime_Time *o)

返回 tzinfo (可以为 None)。

3.10 新版功能.

一些用来从 timedelta 对象中提取字段的宏。参数必须是 PyDateTime_Delta 包括其子类的实例。参数必须不为 NULL，并且类型不会被检查:

int **PyDateTime_DELTA_GET_DAYS** (PyDateTime_Delta *o)

返回天数，从-999999999 到 999999999 的整数。

3.3 新版功能.

int **PyDateTime_DELTA_GET_SECONDS** (PyDateTime_Delta *o)

返回秒数，从 0 到 86399 的整数。

3.3 新版功能.

int **PyDateTime_DELTA_GET_MICROSECONDS** (PyDateTime_Delta *o)

返回微秒数，从 0 到 999999 的整数。

3.3 新版功能.

一些便于模块实现 DB API 的宏:

PyObject ***PyDateTime_FromTimestamp** (*PyObject* *args)

Return value: New reference. 创建并返回一个给定元组参数的新 `datetime.datetime` 对象，适合传给 `datetime.datetime.fromtimestamp()`。

PyObject ***PyDate_FromTimestamp** (*PyObject* *args)

Return value: New reference. 创建并返回一个给定元组参数的新 `datetime.date` 对象，适合传给 `datetime.date.fromtimestamp()`。

8.6.15 类型注解对象

提供几种用于类型提示的内置类型。目前存在两种类型 -- GenericAlias 和 Union。只有 `GenericAlias` 会向 C 开放。

PyObject ***Py_GenericAlias** (*PyObject* *origin, *PyObject* *args)

Part of the Stable ABI *since version 3.9.* Create a GenericAlias object. Equivalent to calling the Python class `types.GenericAlias`. The *origin* and *args* arguments set the `GenericAlias`'s `__origin__` and `__args__` attributes respectively. *origin* should be a `PyTypeObject*`, and *args* can be a `PyTupleObject*` or any `PyObject*`. If *args* passed is not a tuple, a 1-tuple is automatically constructed and `__args__` is set to `(args,)`. Minimal checking is done for the arguments, so the function will succeed even if *origin* is not a type. The `GenericAlias`'s `__parameters__` attribute is constructed lazily from `__args__`. On failure, an exception is raised and `NULL` is returned.

下面是一个如何创建一个扩展类型泛型的例子:

```
...
static PyMethodDef my_obj_methods[] = {
    // Other methods.
    ...
    {"__class_getitem__", Py_GenericAlias, METH_O|METH_CLASS, "See PEP 585"}
    ...
}
```

参见:

数据模型的方法 `__class_getitem__()` 。

3.9 新版功能.

PyTypeObject **Py_GenericAliasType**

Part of the Stable ABI *since version 3.9.* 由 *Py_GenericAlias()* 所返回的对象的 C 类型。等价于 Python 中的 `types.GenericAlias` 。

3.9 新版功能.

CHAPTER 9

初始化，终结和线程

请参阅*Python 初始化配置* 。

9.1 在 Python 初始化之前

在一个植入了 Python 的应用程序中，*Py_Initialize()* 函数必须在任何其他 Python/C API 函数之前被调用；例外的只有个别函数和全局配置变量。

在初始化 Python 之前，可以安全地调用以下函数：

- 配置函数：
  - *PyImport_AppendInittab()*
  - *PyImport_ExtendInittab()*
  - PyInitFrozenExtensions()
  - *PyMem_SetAllocator()*
  - *PyMem_SetupDebugHooks()*
  - *PyObject_SetArenaAllocator()*
  - *Py_SetPath()*
  - *Py_SetProgramName()*
  - *Py_SetPythonHome()*
  - *Py_SetStandardStreamEncoding()*
  - *PySys_AddWarnOption()*
  - *PySys_AddXOption()*
  - *PySys_ResetWarnOptions()*
- 信息函数：
  - *Py_IsInitialized()*
  - *PyMem_GetAllocator()*
  - *PyObject_GetArenaAllocator()*

    - *Py_GetBuildInfo()*
    - *Py_GetCompiler()*
    - *Py_GetCopyright()*
    - *Py_GetPlatform()*
    - *Py_GetVersion()*
- 工具
    - *Py_DecodeLocale()*
- 内存分配器:
    - *PyMem_RawMalloc()*
    - *PyMem_RawRealloc()*
    - *PyMem_RawCalloc()*
    - *PyMem_RawFree()*

备 注: 以 下 函 数 **不 应 该** 在*Py_Initialize()*: *Py_EncodeLocale()*, *Py_GetPath()*, *Py_GetPrefix()*, *Py_GetExecPrefix()*, *Py_GetProgramFullPath()*, *Py_GetPythonHome()*, *Py_GetProgramName()* 和*PyEval_InitThreads()* 前调用。

9.2 全局配置变量

Python 有负责控制全局配置中不同特性和选项的变量。这些标志默认被 命令行选项。

当一个选项设置一个旗标时，该旗标的值将是设置选项的次数。例如，`-b` 会将*Py_BytesWarningFlag* 设为 1 而 `-bb` 会将*Py_BytesWarningFlag* 设为 2.

int **Py_BytesWarningFlag**

Issue a warning when comparing `bytes` or `bytearray` with `str` or `bytes` with `int`. Issue an error if greater or equal to `2`.

由 `-b` 选项设置。

int **Py_DebugFlag**

开启解析器调试输出（限专家使用，依赖于编译选项）。

由 `-d` 选项和 `PYTHONDEBUG` 环境变量设置。

int **Py_DontWriteBytecodeFlag**

如果设置为非零, Python 不会在导入源代码时尝试写入 `.pyc` 文件

由 `-B` 选项和 `PYTHONDONTWRITEBYTECODE` 环境变量设置。

int **Py_FrozenFlag**

Suppress error messages when calculating the module search path in *Py_GetPath()*.

Private flag used by `_freeze_module` and `frozenmain` programs.

int **Py_HashRandomizationFlag**

Set to `1` if the `PYTHONHASHSEED` environment variable is set to a non-empty string.

If the flag is non-zero, read the `PYTHONHASHSEED` environment variable to initialize the secret hash seed.

int **Py_IgnoreEnvironmentFlag**

忽略所有 `PYTHON*` 环境变量，例如，已设置的 `PYTHONPATH` 和 `PYTHONHOME`。

由 `-E` 和 `-I` 选项设置。

int **Py_InspectFlag**

When a script is passed as first argument or the `-c` option is used, enter interactive mode after executing the script or the command, even when `sys.stdin` does not appear to be a terminal.

Set by the `-i` option and the `PYTHONINSPECT` environment variable.

int **Py_InteractiveFlag**

由 `-i` 选项设置。

int **Py_IsolatedFlag**

Run Python in isolated mode. In isolated mode `sys.path` contains neither the script's directory nor the user's site-packages directory.

由 `-I` 选项设置。

3.4 新版功能.

int **Py_LegacyWindowsFSEncodingFlag**

If the flag is non-zero, use the `mbcs` encoding with `replace` error handler, instead of the UTF-8 encoding with `surrogatepass` error handler, for the *filesystem encoding and error handler*.

Set to `1` if the `PYTHONLEGACYWINDOWSFSENCODING` environment variable is set to a non-empty string.

更多详情请参阅 **PEP 529**。

可用性: Windows。

int **Py_LegacyWindowsStdioFlag**

If the flag is non-zero, use `io.FileIO` instead of `WindowsConsoleIO` for `sys` standard streams.

Set to `1` if the `PYTHONLEGACYWINDOWSSTDIO` environment variable is set to a non-empty string.

有关更多详细信息，请参阅 **PEP 528**。

可用性: Windows。

int **Py_NoSiteFlag**

禁用 `site` 的导入及其所附带的基于站点对 `sys.path` 的操作。如果 `site` 会在稍后被显式地导入也会禁用这些操作 (如果你希望触发它们则应调用 `site.main()`)。

由 `-S` 选项设置。

int **Py_NoUserSiteDirectory**

不要将 用户 `site-packages` 目录添加到 `sys.path`。

Set by the `-s` and `-I` options, and the `PYTHONNOUSERSITE` environment variable.

int **Py_OptimizeFlag**

Set by the `-O` option and the `PYTHONOPTIMIZE` environment variable.

int **Py_QuietFlag**

即使在交互模式下也不显示版权和版本信息。

由 `-q` 选项设置。

3.2 新版功能.

int **Py_UnbufferedStdioFlag**

强制 stdout 和 stderr 流不带缓冲。

Set by the `-u` option and the `PYTHONUNBUFFERED` environment variable.

int **Py_VerboseFlag**

Print a message each time a module is initialized, showing the place (filename or built-in module) from which it is loaded. If greater or equal to `2`, print a message for each file that is checked for when searching for a module. Also provides information on module cleanup at exit.

Set by the `-v` option and the `PYTHONVERBOSE` environment variable.

9.3 Initializing and finalizing the interpreter

void **Py_Initialize**()

Part of the Stable ABI. Initialize the Python interpreter. In an application embedding Python, this should be called before using any other Python/C API functions; see *Before Python Initialization* for the few exceptions.

This initializes the table of loaded modules (sys.modules), and creates the fundamental modules builtins, __main__ and sys. It also initializes the module search path (sys.path). It does not set sys.argv; use *PySys_SetArgvEx()* for that. This is a no-op when called for a second time (without calling *Py_FinalizeEx()* first). There is no return value; it is a fatal error if the initialization fails.

备注: 在 Windows 上，将控制台模式从 O_TEXT 改为 O_BINARY，这还将影响使用 C 运行时的非 Python 的控制台使用。

---

void **Py_InitializeEx**(int initsigs)

Part of the Stable ABI. This function works like *Py_Initialize()* if *initsigs* is 1. If *initsigs* is 0, it skips initialization registration of signal handlers, which might be useful when Python is embedded.

int **Py_IsInitialized**()

Part of the Stable ABI. Return true (nonzero) when the Python interpreter has been initialized, false (zero) if not. After *Py_FinalizeEx()* is called, this returns false until *Py_Initialize()* is called again.

int **Py_FinalizeEx**()

Part of the Stable ABI *since version 3.6.* Undo all initializations made by *Py_Initialize()* and subsequent use of Python/C API functions, and destroy all sub-interpreters (see *Py_NewInterpreter()* below) that were created and not yet destroyed since the last call to *Py_Initialize()*. Ideally, this frees all memory allocated by the Python interpreter. This is a no-op when called for a second time (without calling *Py_Initialize()* again first). Normally the return value is 0. If there were errors during finalization (flushing buffered data), -1 is returned.

This function is provided for a number of reasons. An embedding application might want to restart Python without having to restart the application itself. An application that has loaded the Python interpreter from a dynamically loadable library (or DLL) might want to free all memory allocated by Python before unloading the DLL. During a hunt for memory leaks in an application a developer might want to free all memory allocated by Python before exiting from the application.

Bugs and caveats: The destruction of modules and objects in modules is done in random order; this may cause destructors (__del__() methods) to fail when they depend on other objects (even functions) or modules. Dynamically loaded extension modules loaded by Python are not unloaded. Small amounts of memory allocated by the Python interpreter may not be freed (if you find a leak, please report it). Memory tied up in circular references between objects is not freed. Some memory allocated by extension modules may not be freed. Some extensions may not work properly if their initialization routine is called more than once; this can happen if an application calls *Py_Initialize()* and *Py_FinalizeEx()* more than once.

Raises an auditing event cpython._PySys_ClearAuditHooks with no arguments.

3.6 新版功能.

void **Py_Finalize**()

Part of the Stable ABI. This is a backwards-compatible version of *Py_FinalizeEx()* that disregards the return value.

9.4 Process-wide parameters

int **Py_SetStandardStreamEncoding**(const char *encoding, const char *errors)

This API is kept for backward compatibility: setting *PyConfig.stdio_encoding* and *PyConfig.stdio_errors* should be used instead, see *Python Initialization Configuration*.

This function should be called before *Py_Initialize()*, if it is called at all. It specifies which encoding and error handling to use with standard IO, with the same meanings as in `str.encode()`.

It overrides `PYTHONIOENCODING` values, and allows embedding code to control IO encoding when the environment variable does not work.

encoding and/or *errors* may be `NULL` to use `PYTHONIOENCODING` and/or default values (depending on other settings).

Note that `sys.stderr` always uses the "backslashreplace" error handler, regardless of this (or any other) setting.

If *Py_FinalizeEx()* is called, this function will need to be called again in order to affect subsequent calls to *Py_Initialize()*.

Returns `0` if successful, a nonzero value on error (e.g. calling after the interpreter has already been initialized).

3.4 新版功能.

3.11 版后已移除.

void **Py_SetProgramName**(const wchar_t *name)

Part of the Stable ABI. This API is kept for backward compatibility: setting *PyConfig.program_name* should be used instead, see *Python Initialization Configuration*.

This function should be called before *Py_Initialize()* is called for the first time, if it is called at all. It tells the interpreter the value of the `argv[0]` argument to the `main()` function of the program (converted to wide characters). This is used by *Py_GetPath()* and some other functions below to find the Python run-time libraries relative to the interpreter executable. The default value is `'python'`. The argument should point to a zero-terminated wide character string in static storage whose contents will not change for the duration of the program's execution. No code in the Python interpreter will change the contents of this storage.

Use *Py_DecodeLocale()* to decode a bytes string to get a `wchar_*` string.

3.11 版后已移除.

wchar ***Py_GetProgramName**()

Part of the Stable ABI. Return the program name set with *Py_SetProgramName()*, or the default. The returned string points into static storage; the caller should not modify its value.

This function should not be called before *Py_Initialize()*, otherwise it returns `NULL`.

在 3.10 版更改: It now returns `NULL` if called before *Py_Initialize()*.

wchar_t ***Py_GetPrefix**()

Part of the Stable ABI. Return the *prefix* for installed platform-independent files. This is derived through a number of complicated rules from the program name set with *Py_SetProgramName()* and some environment variables; for example, if the program name is `'/usr/local/bin/python'`, the prefix is `'/usr/local'`. The returned string points into static storage; the caller should not modify its value. This corresponds to the **prefix** variable in the top-level `Makefile` and the `--prefix` argument to the **configure** script at build time. The value is available to Python code as `sys.prefix`. It is only useful on Unix. See also the next function.

This function should not be called before *Py_Initialize()*, otherwise it returns `NULL`.

在 3.10 版更改: It now returns `NULL` if called before *Py_Initialize()*.

wchar_t ***Py_GetExecPrefix**()

Part of the Stable ABI. Return the *exec-prefix* for installed platform-*dependent* files. This is derived through a number of complicated rules from the program name set with *Py_SetProgramName()* and some environment variables; for example, if the program name is `'/usr/local/bin/python'`, the exec-prefix is `'/usr/local'`. The returned string points into static storage; the caller should not modify its value. This corresponds to the **exec_prefix** variable in the top-level `Makefile` and the `--exec-prefix` argument to the **configure** script at build time. The value is available to Python code as `sys.exec_prefix`. It is only useful on Unix.

Background: The exec-prefix differs from the prefix when platform dependent files (such as executables and shared libraries) are installed in a different directory tree. In a typical installation, platform dependent files may be installed in the `/usr/local/plat` subtree while platform independent may be installed in `/usr/local`.

Generally speaking, a platform is a combination of hardware and software families, e.g. Sparc machines running the Solaris 2.x operating system are considered the same platform, but Intel machines running Solaris 2.x are another platform, and Intel machines running Linux are yet another platform. Different major revisions of the same operating system generally also form different platforms. Non-Unix operating systems are a different story; the installation strategies on those systems are so different that the prefix and exec-prefix are meaningless, and set to the empty string. Note that compiled Python bytecode files are platform independent (but not independent from the Python version by which they were compiled!).

System administrators will know how to configure the **mount** or **automount** programs to share `/usr/local` between platforms while having `/usr/local/plat` be a different filesystem for each platform.

This function should not be called before *Py_Initialize()*, otherwise it returns `NULL`.

在 3.10 版更改: It now returns `NULL` if called before *Py_Initialize()*.

wchar_t ***Py_GetProgramFullPath**()

Part of the Stable ABI. Return the full program name of the Python executable; this is computed as a side-effect of deriving the default module search path from the program name (set by *Py_SetProgramName()* above). The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.executable`.

This function should not be called before *Py_Initialize()*, otherwise it returns `NULL`.

在 3.10 版更改: It now returns `NULL` if called before *Py_Initialize()*.

wchar_t ***Py_GetPath**()

Part of the Stable ABI. Return the default module search path; this is computed from the program name (set by *Py_SetProgramName()* above) and some environment variables. The returned string consists of a series of directory names separated by a platform dependent delimiter character. The delimiter character is `':'` on Unix and macOS, `';'` on Windows. The returned string points into static storage; the caller should not modify its value. The list `sys.path` is initialized with this value on interpreter startup; it can be (and usually is) modified later to change the search path for loading modules.

This function should not be called before *Py_Initialize()*, otherwise it returns `NULL`.

在 3.10 版更改: It now returns `NULL` if called before *Py_Initialize()*.

void **Py_SetPath**(const wchar_t*)

Part of the Stable ABI *since version 3.7*. This API is kept for backward compatibility: setting *PyConfig.module_search_paths* and *PyConfig.module_search_paths_set* should be used instead, see *Python Initialization Configuration*.

Set the default module search path. If this function is called before *Py_Initialize()*, then *Py_GetPath()* won't attempt to compute a default search path but uses the one provided instead. This is useful if Python is embedded by an application that has full knowledge of the location of all modules. The path components should be separated by the platform dependent delimiter character, which is `':'` on Unix and macOS, `';'` on Windows.

This also causes `sys.executable` to be set to the program full path (see *Py_GetProgramFullPath()*) and for `sys.prefix` and `sys.exec_prefix` to be empty. It is up to the caller to modify these if required after calling `Py_Initialize()`.

Use `Py_DecodeLocale()` to decode a bytes string to get a `wchar_*` string.

The path argument is copied internally, so the caller may free it after the call completes.

在 3.8 版更改: The program full path is now used for `sys.executable`, instead of the program name.

3.11 版后已移除.

const char ***Py_GetVersion**()

Part of the Stable ABI. Return the version of this Python interpreter. This is a string that looks something like

```
"3.0a5+ (py3k:63103M, May 12 2008, 00:53:55) \n[GCC 4.2.3]"
```

The first word (up to the first space character) is the current Python version; the first characters are the major and minor version separated by a period. The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.version`.

See also the `Py_Version` constant.

const char ***Py_GetPlatform**()

Part of the Stable ABI. Return the platform identifier for the current platform. On Unix, this is formed from the "official" name of the operating system, converted to lower case, followed by the major revision number; e.g., for Solaris 2.x, which is also known as SunOS 5.x, the value is `'sunos5'`. On macOS, it is `'darwin'`. On Windows, it is `'win'`. The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.platform`.

const char ***Py_GetCopyright**()

Part of the Stable ABI. Return the official copyright string for the current Python version, for example

`'Copyright 1991-1995 Stichting Mathematisch Centrum, Amsterdam'`

The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.copyright`.

const char ***Py_GetCompiler**()

Part of the Stable ABI. Return an indication of the compiler used to build the current Python version, in square brackets, for example:

```
"[GCC 2.7.2.2]"
```

The returned string points into static storage; the caller should not modify its value. The value is available to Python code as part of the variable `sys.version`.

const char ***Py_GetBuildInfo**()

Part of the Stable ABI. Return information about the sequence number and build date and time of the current Python interpreter instance, for example

```
"#67, Aug  1 1997, 22:34:28"
```

The returned string points into static storage; the caller should not modify its value. The value is available to Python code as part of the variable `sys.version`.

void **PySys_SetArgvEx**(int argc, wchar_t **argv, int updatepath)

Part of the Stable ABI. This API is kept for backward compatibility: setting `PyConfig.argv`, `PyConfig.parse_argv` and `PyConfig.safe_path` should be used instead, see *Python Initialization Configuration*.

Set `sys.argv` based on *argc* and *argv*. These parameters are similar to those passed to the program's `main()` function with the difference that the first entry should refer to the script file to be executed rather than the executable hosting the Python interpreter. If there isn't a script that will be run, the first entry in *argv* can be an empty string. If this function fails to initialize `sys.argv`, a fatal condition is signalled using `Py_FatalError()`.

If *updatepath* is zero, this is all the function does. If *updatepath* is non-zero, the function also modifies `sys.path` according to the following algorithm:

- If the name of an existing script is passed in `argv[0]`, the absolute path of the directory where the script is located is prepended to `sys.path`.
- Otherwise (that is, if *argc* is `0` or `argv[0]` doesn't point to an existing file name), an empty string is prepended to `sys.path`, which is the same as prepending the current working directory (`"."`).

Use `Py_DecodeLocale()` to decode a bytes string to get a `wchar_*` string.

See also `PyConfig.orig_argv` and `PyConfig.argv` members of the *Python Initialization Configuration*.

备注: It is recommended that applications embedding the Python interpreter for purposes other than executing a single script pass `0` as *updatepath*, and update `sys.path` themselves if desired. See CVE-2008-5983.

On versions before 3.1.3, you can achieve the same effect by manually popping the first `sys.path` element after having called `PySys_SetArgv()`, for example using:

```
PyRun_SimpleString("import sys; sys.path.pop(0)\n");
```

3.1.3 新版功能.

3.11 版后已移除.

void **PySys_SetArgv**(int argc, wchar_t **argv)

Part of the Stable ABI. This API is kept for backward compatibility: setting `PyConfig.argv` and `PyConfig.parse_argv` should be used instead, see *Python Initialization Configuration*.

This function works like `PySys_SetArgvEx()` with *updatepath* set to `1` unless the **python** interpreter was started with the `-I`.

Use `Py_DecodeLocale()` to decode a bytes string to get a `wchar_*` string.

See also `PyConfig.orig_argv` and `PyConfig.argv` members of the *Python Initialization Configuration*.

在 3.4 版更改: The *updatepath* value depends on `-I`.

3.11 版后已移除.

void **Py_SetPythonHome**(const wchar_t *home)

Part of the Stable ABI. This API is kept for backward compatibility: setting `PyConfig.home` should be used instead, see *Python Initialization Configuration*.

Set the default "home" directory, that is, the location of the standard Python libraries. See `PYTHONHOME` for the meaning of the argument string.

The argument should point to a zero-terminated character string in static storage whose contents will not change for the duration of the program's execution. No code in the Python interpreter will change the contents of this storage.

Use `Py_DecodeLocale()` to decode a bytes string to get a `wchar_*` string.

3.11 版后已移除.

w_char ***Py_GetPythonHome**()

Part of the Stable ABI. Return the default "home", that is, the value set by a previous call to `Py_SetPythonHome()`, or the value of the `PYTHONHOME` environment variable if it is set.

This function should not be called before `Py_Initialize()`, otherwise it returns `NULL`.

在 3.10 版更改: It now returns `NULL` if called before `Py_Initialize()`.

9.5 线程状态和全局解释器锁

The Python interpreter is not fully thread-safe. In order to support multi-threaded Python programs, there's a global lock, called the *global interpreter lock* or *GIL*, that must be held by the current thread before it can safely access Python objects. Without the lock, even the simplest operations could cause problems in a multi-threaded program: for example, when two threads simultaneously increment the reference count of the same object, the reference count could end up being incremented only once instead of twice.

Therefore, the rule exists that only the thread that has acquired the *GIL* may operate on Python objects or call Python/C API functions. In order to emulate concurrency of execution, the interpreter regularly tries to switch threads (see `sys.setswitchinterval()`). The lock is also released around potentially blocking I/O operations like reading or writing a file, so that other Python threads can run in the meantime.

The Python interpreter keeps some thread-specific bookkeeping information inside a data structure called `PyThreadState`. There's also one global variable pointing to the current `PyThreadState`: it can be retrieved using `PyThreadState_Get()`.

9.5.1 Releasing the GIL from extension code

Most extension code manipulating the *GIL* has the following simple structure:

```
Save the thread state in a local variable.
Release the global interpreter lock.
... Do some blocking I/O operation ...
Reacquire the global interpreter lock.
Restore the thread state from the local variable.
```

This is so common that a pair of macros exists to simplify it:

```
Py_BEGIN_ALLOW_THREADS
... Do some blocking I/O operation ...
Py_END_ALLOW_THREADS
```

The `Py_BEGIN_ALLOW_THREADS` macro opens a new block and declares a hidden local variable; the `Py_END_ALLOW_THREADS` macro closes the block.

上面的代码块可扩展为下面的代码:

```
PyThreadState *_save;

_save = PyEval_SaveThread();
... Do some blocking I/O operation ...
PyEval_RestoreThread(_save);
```

Here is how these functions work: the global interpreter lock is used to protect the pointer to the current thread state. When releasing the lock and saving the thread state, the current thread state pointer must be retrieved before the lock is released (since another thread could immediately acquire the lock and store its own thread state in the global variable). Conversely, when acquiring the lock and restoring the thread state, the lock must be acquired before storing the thread state pointer.

备注： Calling system I/O functions is the most common use case for releasing the GIL, but it can also be useful before calling long-running computations which don't need access to Python objects, such as compression or cryptographic functions operating over memory buffers. For example, the standard `zlib` and `hashlib` modules release the GIL when compressing or hashing data.

9.5.2 非 Python 创建的线程

When threads are created using the dedicated Python APIs (such as the `threading` module), a thread state is automatically associated to them and the code showed above is therefore correct. However, when threads are created from C (for example by a third-party library with its own thread management), they don't hold the GIL, nor is there a thread state structure for them.

If you need to call Python code from these threads (often this will be part of a callback API provided by the aforementioned third-party library), you must first register these threads with the interpreter by creating a thread state data structure, then acquiring the GIL, and finally storing their thread state pointer, before you can start using the Python/C API. When you are done, you should reset the thread state pointer, release the GIL, and finally free the thread state data structure.

The *PyGILState_Ensure()* and *PyGILState_Release()* functions do all of the above automatically. The typical idiom for calling into Python from a C thread is:

```
PyGILState_STATE gstate;
gstate = PyGILState_Ensure();

/* Perform Python actions here. */
result = CallSomeFunction();
/* evaluate result or handle exception */

/* Release the thread. No Python API allowed beyond this point. */
PyGILState_Release(gstate);
```

Note that the `PyGILState_*` functions assume there is only one global interpreter (created automatically by *Py_Initialize()*). Python supports the creation of additional interpreters (using *Py_NewInterpreter()*), but mixing multiple interpreters and the `PyGILState_*` API is unsupported.

9.5.3 Cautions about fork()

Another important thing to note about threads is their behaviour in the face of the C `fork()` call. On most systems with `fork()`, after a process forks only the thread that issued the fork will exist. This has a concrete impact both on how locks must be handled and on all stored state in CPython's runtime.

The fact that only the "current" thread remains means any locks held by other threads will never be released. Python solves this for `os.fork()` by acquiring the locks it uses internally before the fork, and releasing them afterwards. In addition, it resets any lock-objects in the child. When extending or embedding Python, there is no way to inform Python of additional (non-Python) locks that need to be acquired before or reset after a fork. OS facilities such as `pthread_atfork()` would need to be used to accomplish the same thing. Additionally, when extending or embedding Python, calling `fork()` directly rather than through `os.fork()` (and returning to or calling into Python) may result in a deadlock by one of Python's internal locks being held by a thread that is defunct after the fork. *PyOS_AfterFork_Child()* tries to reset the necessary locks, but is not always able to.

The fact that all other threads go away also means that CPython's runtime state there must be cleaned up properly, which `os.fork()` does. This means finalizing all other *PyThreadState* objects belonging to the current interpreter and all other *PyInterpreterState* objects. Due to this and the special nature of the *"main" interpreter*, `fork()` should only be called in that interpreter's "main" thread, where the CPython global runtime was originally initialized. The only exception is if `exec()` will be called immediately after.

9.5.4 高阶 API

These are the most commonly used types and functions when writing C extension code, or when embedding the Python interpreter:

type **PyInterpreterState**

Part of the Limited API *(as an opaque struct).* This data structure represents the state shared by a number of cooperating threads. Threads belonging to the same interpreter share their module administration and a few other internal items. There are no public members in this structure.

Threads belonging to different interpreters initially share nothing, except process state like available memory, open file descriptors and such. The global interpreter lock is also shared by all threads, regardless of to which interpreter they belong.

type **PyThreadState**

Part of the Limited API *(as an opaque struct).* This data structure represents the state of a single thread. The only public data member is `interp` (*PyInterpreterState**), which points to this thread's interpreter state.

void **PyEval_InitThreads**()

Part of the Stable ABI. Deprecated function which does nothing.

在 Python 3.6 及更老的版本中，此函数会在 GIL 不存在时创建它。

在 3.9 版更改: The function now does nothing.

在 3.7 版更改: This function is now called by *Py_Initialize()*, so you don't have to call it yourself anymore.

在 3.2 版更改: This function cannot be called before *Py_Initialize()* anymore.

从版本 3.9 起弃用，在版本 3.11 中移除。.

int **PyEval_ThreadsInitialized**()

Part of the Stable ABI. Returns a non-zero value if *PyEval_InitThreads()* has been called. This function can be called without holding the GIL, and therefore can be used to avoid calls to the locking API when running single-threaded.

在 3.7 版更改: The *GIL* is now initialized by *Py_Initialize()*.

从版本 3.9 起弃用，在版本 3.11 中移除。.

PyThreadState ***PyEval_SaveThread**()

Part of the Stable ABI. Release the global interpreter lock (if it has been created) and reset the thread state to `NULL`, returning the previous thread state (which is not `NULL`). If the lock has been created, the current thread must have acquired it.

void **PyEval_RestoreThread**(*PyThreadState* *tstate)

Part of the Stable ABI. Acquire the global interpreter lock (if it has been created) and set the thread state to *tstate*, which must not be `NULL`. If the lock has been created, the current thread must not have acquired it, otherwise deadlock ensues.

备注： Calling this function from a thread when the runtime is finalizing will terminate the thread, even if the thread was not created by Python. You can use `_Py_IsFinalizing()` or `sys.is_finalizing()` to check if the interpreter is in process of being finalized before calling this function to avoid unwanted termination.

PyThreadState ***PyThreadState_Get**()

Part of the Stable ABI. Return the current thread state. The global interpreter lock must be held. When the current thread state is `NULL`, this issues a fatal error (so that the caller needn't check for `NULL`).

PyThreadState ***PyThreadState_Swap**(*PyThreadState* *tstate)

Part of the Stable ABI. Swap the current thread state with the thread state given by the argument *tstate*, which may be NULL. The global interpreter lock must be held and is not released.

The following functions use thread-local storage, and are not compatible with sub-interpreters:

PyGILState_STATE **PyGILState_Ensure**()

Part of the Stable ABI. Ensure that the current thread is ready to call the Python C API regardless of the current state of Python, or of the global interpreter lock. This may be called as many times as desired by a thread as long as each call is matched with a call to *PyGILState_Release()*. In general, other thread-related APIs may be used between *PyGILState_Ensure()* and *PyGILState_Release()* calls as long as the thread state is restored to its previous state before the Release(). For example, normal usage of the *Py_BEGIN_ALLOW_THREADS* and *Py_END_ALLOW_THREADS* macros is acceptable.

The return value is an opaque "handle" to the thread state when *PyGILState_Ensure()* was called, and must be passed to *PyGILState_Release()* to ensure Python is left in the same state. Even though recursive calls are allowed, these handles *cannot* be shared - each unique call to *PyGILState_Ensure()* must save the handle for its call to *PyGILState_Release()*.

When the function returns, the current thread will hold the GIL and be able to call arbitrary Python code. Failure is a fatal error.

备注： Calling this function from a thread when the runtime is finalizing will terminate the thread, even if the thread was not created by Python. You can use `_Py_IsFinalizing()` or `sys.is_finalizing()` to check if the interpreter is in process of being finalized before calling this function to avoid unwanted termination.

---

void **PyGILState_Release**(PyGILState_STATE)

Part of the Stable ABI. Release any resources previously acquired. After this call, Python's state will be the same as it was prior to the corresponding *PyGILState_Ensure()* call (but generally this state will be unknown to the caller, hence the use of the GILState API).

Every call to *PyGILState_Ensure()* must be matched by a call to *PyGILState_Release()* on the same thread.

PyThreadState ***PyGILState_GetThisThreadState**()

Part of the Stable ABI. Get the current thread state for this thread. May return NULL if no GILState API has been used on the current thread. Note that the main thread always has such a thread-state, even if no auto-thread-state call has been made on the main thread. This is mainly a helper/diagnostic function.

int **PyGILState_Check**()

Return 1 if the current thread is holding the GIL and 0 otherwise. This function can be called from any thread at any time. Only if it has had its Python thread state initialized and currently is holding the GIL will it return 1. This is mainly a helper/diagnostic function. It can be useful for example in callback contexts or memory allocation functions when knowing that the GIL is locked can allow the caller to perform sensitive actions or otherwise behave differently.

3.4 新版功能.

The following macros are normally used without a trailing semicolon; look for example usage in the Python source distribution.

Py_BEGIN_ALLOW_THREADS

Part of the Stable ABI. This macro expands to `{ PyThreadState *_save; _save = PyEval_SaveThread();`. Note that it contains an opening brace; it must be matched with a following *Py_END_ALLOW_THREADS* macro. See above for further discussion of this macro.

Py_END_ALLOW_THREADS

Part of the Stable ABI. 此宏扩展为 `PyEval_RestoreThread(_save); }`。注意它包含一个右花括号；它必须与之前的*Py_BEGIN_ALLOW_THREADS* 宏匹配。请参阅上文以进一步讨论此宏。

Py_BLOCK_THREADS

Part of the Stable ABI. This macro expands to `PyEval_RestoreThread(_save);`: it is equivalent to *Py_END_ALLOW_THREADS* without the closing brace.

Py_UNBLOCK_THREADS

Part of the Stable ABI. This macro expands to `_save = PyEval_SaveThread();`: it is equivalent to *Py_BEGIN_ALLOW_THREADS* without the opening brace and variable declaration.

9.5.5 Low-level API

All of the following functions must be called after *Py_Initialize()*.

在 3.7 版更改: *Py_Initialize()* now initializes the *GIL*.

PyInterpreterState ***PyInterpreterState_New**()

Part of the Stable ABI. Create a new interpreter state object. The global interpreter lock need not be held, but may be held if it is necessary to serialize calls to this function.

Raises an auditing event `cpython.PyInterpreterState_New` with no arguments.

void **PyInterpreterState_Clear**(*PyInterpreterState* *interp)

Part of the Stable ABI. Reset all information in an interpreter state object. The global interpreter lock must be held.

Raises an auditing event `cpython.PyInterpreterState_Clear` with no arguments.

void **PyInterpreterState_Delete**(*PyInterpreterState* *interp)

Part of the Stable ABI. Destroy an interpreter state object. The global interpreter lock need not be held. The interpreter state must have been reset with a previous call to *PyInterpreterState_Clear()*.

PyThreadState ***PyThreadState_New**(*PyInterpreterState* *interp)

Part of the Stable ABI. Create a new thread state object belonging to the given interpreter object. The global interpreter lock need not be held, but may be held if it is necessary to serialize calls to this function.

void **PyThreadState_Clear**(*PyThreadState* *tstate)

Part of the Stable ABI. Reset all information in a thread state object. The global interpreter lock must be held.

在 3.9 版更改: This function now calls the `PyThreadState.on_delete` callback. Previously, that happened in *PyThreadState_Delete()*.

void **PyThreadState_Delete**(*PyThreadState* *tstate)

Part of the Stable ABI. Destroy a thread state object. The global interpreter lock need not be held. The thread state must have been reset with a previous call to *PyThreadState_Clear()*.

void **PyThreadState_DeleteCurrent**(void)

Destroy the current thread state and release the global interpreter lock. Like *PyThreadState_Delete()*, the global interpreter lock need not be held. The thread state must have been reset with a previous call to *PyThreadState_Clear()*.

PyFrameObject ***PyThreadState_GetFrame**(*PyThreadState* *tstate)

Part of the Stable ABI *since version 3.10.* Get the current frame of the Python thread state *tstate*.

Return a *strong reference*. Return `NULL` if no frame is currently executing.

See also *PyEval_GetFrame()*.

tstate must not be `NULL`.

3.9 新版功能.

uint64_t **PyThreadState_GetID** (*PyThreadState* *tstate)

Part of the Stable ABI *since version 3.10.* Get the unique thread state identifier of the Python thread state *tstate*.

tstate must not be NULL.

3.9 新版功能.

PyInterpreterState ***PyThreadState_GetInterpreter** (*PyThreadState* *tstate)

Part of the Stable ABI *since version 3.10.* Get the interpreter of the Python thread state *tstate*.

tstate must not be NULL.

3.9 新版功能.

void **PyThreadState_EnterTracing** (*PyThreadState* *tstate)

Suspend tracing and profiling in the Python thread state *tstate*.

Resume them using the `PyThreadState_LeaveTracing()` function.

3.11 新版功能.

void **PyThreadState_LeaveTracing** (*PyThreadState* *tstate)

Resume tracing and profiling in the Python thread state *tstate* suspended by the `PyThreadState_EnterTracing()` function.

See also `PyEval_SetTrace()` and `PyEval_SetProfile()` functions.

3.11 新版功能.

PyInterpreterState ***PyInterpreterState_Get** (void)

Part of the Stable ABI *since version 3.9.* 获取当前解释器。

Issue a fatal error if there no current Python thread state or no current interpreter. It cannot return NULL.

呼叫者必须持有 GIL。

3.9 新版功能.

int64_t **PyInterpreterState_GetID** (*PyInterpreterState* *interp)

Part of the Stable ABI *since version 3.7.* Return the interpreter's unique ID. If there was any error in doing so then -1 is returned and an error is set.

呼叫者必须持有 GIL。

3.7 新版功能.

PyObject ***PyInterpreterState_GetDict** (*PyInterpreterState* *interp)

Part of the Stable ABI *since version 3.8.* Return a dictionary in which interpreter-specific data may be stored. If this function returns NULL then no exception has been raised and the caller should assume no interpreter-specific dict is available.

This is not a replacement for `PyModule_GetState()`, which extensions should use to store interpreter-specific state information.

3.8 新版功能.

typedef *PyObject* *(***_PyFrameEvalFunction**)(*PyThreadState* *tstate, _PyInterpreterFrame *frame, int throwflag)

Type of a frame evaluation function.

The *throwflag* parameter is used by the `throw()` method of generators: if non-zero, handle the current exception.

在 3.9 版更改: 此函数现在可接受一个 *tstate* 形参。

在 3.11 版更改: The *frame* parameter changed from `PyFrameObject*` to `_PyInterpreterFrame*`.

_PyFrameEvalFunction **_PyInterpreterState_GetEvalFrameFunc**(*PyInterpreterState* *interp)

Get the frame evaluation function.

See the **PEP 523** "Adding a frame evaluation API to CPython".

3.9 新版功能.

void **_PyInterpreterState_SetEvalFrameFunc**(*PyInterpreterState* *interp, *_PyFrameEvalFunction* eval_frame)

Set the frame evaluation function.

See the **PEP 523** "Adding a frame evaluation API to CPython".

3.9 新版功能.

PyObject ***PyThreadState_GetDict**()

Return value: Borrowed reference. Part of the Stable ABI. Return a dictionary in which extensions can store thread-specific state information. Each extension should use a unique key to use to store state in the dictionary. It is okay to call this function when no current thread state is available. If this function returns `NULL`, no exception has been raised and the caller should assume no current thread state is available.

int **PyThreadState_SetAsyncExc**(unsigned long id, *PyObject* *exc)

Part of the Stable ABI. Asynchronously raise an exception in a thread. The *id* argument is the thread id of the target thread; *exc* is the exception object to be raised. This function does not steal any references to *exc*. To prevent naive misuse, you must write your own C extension to call this. Must be called with the GIL held. Returns the number of thread states modified; this is normally one, but will be zero if the thread id isn't found. If *exc* is `NULL`, the pending exception (if any) for the thread is cleared. This raises no exceptions.

在 3.7 版更改: The type of the *id* parameter changed from `long` to `unsigned long`.

void **PyEval_AcquireThread**(*PyThreadState* *tstate)

Part of the Stable ABI. Acquire the global interpreter lock and set the current thread state to *tstate*, which must not be `NULL`. The lock must have been created earlier. If this thread already has the lock, deadlock ensues.

备注： Calling this function from a thread when the runtime is finalizing will terminate the thread, even if the thread was not created by Python. You can use `_Py_IsFinalizing()` or `sys.is_finalizing()` to check if the interpreter is in process of being finalized before calling this function to avoid unwanted termination.

在 3.8 版更改: Updated to be consistent with `PyEval_RestoreThread()`, `Py_END_ALLOW_THREADS()`, and `PyGILState_Ensure()`, and terminate the current thread if called while the interpreter is finalizing.

`PyEval_RestoreThread()` is a higher-level function which is always available (even when threads have not been initialized).

void **PyEval_ReleaseThread**(*PyThreadState* *tstate)

Part of the Stable ABI. Reset the current thread state to `NULL` and release the global interpreter lock. The lock must have been created earlier and must be held by the current thread. The *tstate* argument, which must not be `NULL`, is only used to check that it represents the current thread state --- if it isn't, a fatal error is reported.

`PyEval_SaveThread()` is a higher-level function which is always available (even when threads have not been initialized).

void **PyEval_AcquireLock**()

Part of the Stable ABI. Acquire the global interpreter lock. The lock must have been created earlier. If this thread already has the lock, a deadlock ensues.

3.2 版后已移除: This function does not update the current thread state. Please use `PyEval_RestoreThread()` or `PyEval_AcquireThread()` instead.

备注： Calling this function from a thread when the runtime is finalizing will terminate the thread, even if the thread was not created by Python. You can use `_Py_IsFinalizing()` or `sys.is_finalizing()` to check if the interpreter is in process of being finalized before calling this function to avoid unwanted termination.

在 3.8 版更改: Updated to be consistent with *PyEval_RestoreThread()*, *Py_END_ALLOW_THREADS()*, and *PyGILState_Ensure()*, and terminate the current thread if called while the interpreter is finalizing.

void **PyEval_ReleaseLock**()

Part of the Stable ABI. Release the global interpreter lock. The lock must have been created earlier.

3.2 版后已移除: This function does not update the current thread state. Please use *PyEval_SaveThread()* or *PyEval_ReleaseThread()* instead.

9.6 子解释器支持

While in most uses, you will only embed a single Python interpreter, there are cases where you need to create several independent interpreters in the same process and perhaps even in the same thread. Sub-interpreters allow you to do that.

The "main" interpreter is the first one created when the runtime initializes. It is usually the only Python interpreter in a process. Unlike sub-interpreters, the main interpreter has unique process-global responsibilities like signal handling. It is also responsible for execution during runtime initialization and is usually the active interpreter during runtime finalization. The *PyInterpreterState_Main()* function returns a pointer to its state.

You can switch between sub-interpreters using the *PyThreadState_Swap()* function. You can create and destroy them using the following functions:

PyThreadState ***Py_NewInterpreter**()

Part of the Stable ABI. Create a new sub-interpreter. This is an (almost) totally separate environment for the execution of Python code. In particular, the new interpreter has separate, independent versions of all imported modules, including the fundamental modules `builtins`, `__main__` and `sys`. The table of loaded modules (`sys.modules`) and the module search path (`sys.path`) are also separate. The new environment has no `sys.argv` variable. It has new standard I/O stream file objects `sys.stdin`, `sys.stdout` and `sys.stderr` (however these refer to the same underlying file descriptors).

The return value points to the first thread state created in the new sub-interpreter. This thread state is made in the current thread state. Note that no actual thread is created; see the discussion of thread states below. If creation of the new interpreter is unsuccessful, `NULL` is returned; no exception is set since the exception state is stored in the current thread state and there may not be a current thread state. (Like all other Python/C API functions, the global interpreter lock must be held before calling this function and is still held when it returns; however, unlike most other Python/C API functions, there needn't be a current thread state on entry.)

Extension modules are shared between (sub-)interpreters as follows:

- For modules using multi-phase initialization, e.g. *PyModule_FromDefAndSpec()*, a separate module object is created and initialized for each interpreter. Only C-level static and global variables are shared between these module objects.
- For modules using single-phase initialization, e.g. *PyModule_Create()*, the first time a particular extension is imported, it is initialized normally, and a (shallow) copy of its module's dictionary is squirreled away. When the same extension is imported by another (sub-)interpreter, a new module is initialized and filled with the contents of this copy; the extension's `init` function is not called. Objects in the module's dictionary thus end up shared across (sub-)interpreters, which might cause unwanted behavior (see *Bugs and caveats* below).

  Note that this is different from what happens when an extension is imported after the interpreter has been completely re-initialized by calling *Py_FinalizeEx()* and *Py_Initialize()*; in that case, the extension's `initmodule` function *is* called again. As with multi-phase initialization, this means that only C-level static and global variables are shared between these modules.

void **Py_EndInterpreter**(*PyThreadState* *tstate)

Part of the Stable ABI. Destroy the (sub-)interpreter represented by the given thread state. The given thread state must be the current thread state. See the discussion of thread states below. When the call returns, the current thread state is `NULL`. All thread states associated with this interpreter are destroyed. (The global interpreter lock must be held before calling this function and is still held when it returns.) *Py_FinalizeEx()* will destroy all sub-interpreters that haven't been explicitly destroyed at that point.

9.6.1 错误和警告

Because sub-interpreters (and the main interpreter) are part of the same process, the insulation between them isn't perfect --- for example, using low-level file operations like `os.close()` they can (accidentally or maliciously) affect each other's open files. Because of the way extensions are shared between (sub-)interpreters, some extensions may not work properly; this is especially likely when using single-phase initialization or (static) global variables. It is possible to insert objects created in one sub-interpreter into a namespace of another (sub-)interpreter; this should be avoided if possible.

Special care should be taken to avoid sharing user-defined functions, methods, instances or classes between sub-interpreters, since import operations executed by such objects may affect the wrong (sub-)interpreter's dictionary of loaded modules. It is equally important to avoid sharing objects from which the above are reachable.

Also note that combining this functionality with `PyGILState_*` APIs is delicate, because these APIs assume a bijection between Python thread states and OS-level threads, an assumption broken by the presence of sub-interpreters. It is highly recommended that you don't switch sub-interpreters between a pair of matching *PyGILState_Ensure()* and *PyGILState_Release()* calls. Furthermore, extensions (such as `ctypes`) using these APIs to allow calling of Python code from non-Python created threads will probably be broken when using sub-interpreters.

9.7 异步通知

A mechanism is provided to make asynchronous notifications to the main interpreter thread. These notifications take the form of a function pointer and a void pointer argument.

int **Py_AddPendingCall**(int (*func)(void*), void *arg)

Part of the Stable ABI. Schedule a function to be called from the main interpreter thread. On success, `0` is returned and *func* is queued for being called in the main thread. On failure, `-1` is returned without setting any exception.

When successfully queued, *func* will be *eventually* called from the main interpreter thread with the argument *arg*. It will be called asynchronously with respect to normally running Python code, but with both these conditions met:

- on a *bytecode* boundary;
- with the main thread holding the *global interpreter lock* (*func* can therefore use the full C API).

func must return `0` on success, or `-1` on failure with an exception set. *func* won't be interrupted to perform another asynchronous notification recursively, but it can still be interrupted to switch threads if the global interpreter lock is released.

This function doesn't need a current thread state to run, and it doesn't need the global interpreter lock.

To call this function in a subinterpreter, the caller must hold the GIL. Otherwise, the function *func* can be scheduled to be called from the wrong interpreter.

> **警告：** This is a low-level function, only useful for very special cases. There is no guarantee that *func* will be called as quick as possible. If the main thread is busy executing a system call, *func* won't be called before the system call returns. This function is generally **not** suitable for calling Python code from arbitrary C threads. Instead, use the *PyGILState API*.

在 3.9 版更改: If this function is called in a subinterpreter, the function *func* is now scheduled to be called from the subinterpreter, rather than being called from the main interpreter. Each subinterpreter now has its own list of scheduled calls.

3.1 新版功能.

9.8 分析和跟踪

The Python interpreter provides some low-level support for attaching profiling and execution tracing facilities. These are used for profiling, debugging, and coverage analysis tools.

This C interface allows the profiling or tracing code to avoid the overhead of calling through Python-level callable objects, making a direct C function call instead. The essential attributes of the facility have not changed; the interface allows trace functions to be installed per-thread, and the basic events reported to the trace function are the same as had been reported to the Python-level trace functions in previous versions.

typedef int (***Py_tracefunc**)(*PyObject* *obj, *PyFrameObject* *frame, int what, *PyObject* *arg)

The type of the trace function registered using `PyEval_SetProfile()` and `PyEval_SetTrace()`. The first parameter is the object passed to the registration function as *obj*, *frame* is the frame object to which the event pertains, *what* is one of the constants `PyTrace_CALL`, `PyTrace_EXCEPTION`, `PyTrace_LINE`, `PyTrace_RETURN`, `PyTrace_C_CALL`, `PyTrace_C_EXCEPTION`, `PyTrace_C_RETURN`, or `PyTrace_OPCODE`, and *arg* depends on the value of *what*:

what 的值	*arg* 的含义
PyTrace_CALL	总是*Py_None*.
PyTrace_EXCEPTION	sys.exc_info() 返回的异常信息。
PyTrace_LINE	总是*Py_None*.
PyTrace_RETURN	返回给调用方的值，或者如果是由异常导致的则返回 NULL。
PyTrace_C_CALL	正在调用函数对象。
PyTrace_C_EXCEPTION	正在调用函数对象。
PyTrace_C_RETURN	正在调用函数对象。
PyTrace_OPCODE	总是*Py_None*.

int **PyTrace_CALL**

The value of the *what* parameter to a `Py_tracefunc` function when a new call to a function or method is being reported, or a new entry into a generator. Note that the creation of the iterator for a generator function is not reported as there is no control transfer to the Python bytecode in the corresponding frame.

int **PyTrace_EXCEPTION**

The value of the *what* parameter to a `Py_tracefunc` function when an exception has been raised. The callback function is called with this value for *what* when after any bytecode is processed after which the exception becomes set within the frame being executed. The effect of this is that as exception propagation causes the Python stack to unwind, the callback is called upon return to each frame as the exception propagates. Only trace functions receives these events; they are not needed by the profiler.

int **PyTrace_LINE**

The value passed as the *what* parameter to a `Py_tracefunc` function (but not a profiling function) when a line-number event is being reported. It may be disabled for a frame by setting `f_trace_lines` to *0* on that frame.

int **PyTrace_RETURN**

The value for the *what* parameter to *Py_tracefunc* functions when a call is about to return.

int **PyTrace_C_CALL**

The value for the *what* parameter to *Py_tracefunc* functions when a C function is about to be called.

int **PyTrace_C_EXCEPTION**

The value for the *what* parameter to *Py_tracefunc* functions when a C function has raised an exception.

int **PyTrace_C_RETURN**

The value for the *what* parameter to *Py_tracefunc* functions when a C function has returned.

int **PyTrace_OPCODE**

The value for the *what* parameter to *Py_tracefunc* functions (but not profiling functions) when a new opcode is about to be executed. This event is not emitted by default: it must be explicitly requested by setting `f_trace_opcodes` to *1* on the frame.

void **PyEval_SetProfile**(*Py_tracefunc* func, *PyObject* *obj)

Set the profiler function to *func*. The *obj* parameter is passed to the function as its first parameter, and may be any Python object, or `NULL`. If the profile function needs to maintain state, using a different value for *obj* for each thread provides a convenient and thread-safe place to store it. The profile function is called for all monitored events except `PyTrace_LINE` `PyTrace_OPCODE` and `PyTrace_EXCEPTION`.

See also the `sys.setprofile()` function.

The caller must hold the *GIL*.

void **PyEval_SetTrace**(*Py_tracefunc* func, *PyObject* *obj)

Set the tracing function to *func*. This is similar to *PyEval_SetProfile()*, except the tracing function does receive line-number events and per-opcode events, but does not receive any event related to C function objects being called. Any trace function registered using *PyEval_SetTrace()* will not receive `PyTrace_C_CALL`, `PyTrace_C_EXCEPTION` or `PyTrace_C_RETURN` as a value for the *what* parameter.

See also the `sys.settrace()` function.

The caller must hold the *GIL*.

9.9 高级调试器支持

These functions are only intended to be used by advanced debugging tools.

PyInterpreterState ***PyInterpreterState_Head**()

Return the interpreter state object at the head of the list of all such objects.

PyInterpreterState ***PyInterpreterState_Main**()

Return the main interpreter state object.

PyInterpreterState ***PyInterpreterState_Next**(*PyInterpreterState* *interp)

Return the next interpreter state object after *interp* from the list of all such objects.

PyThreadState ***PyInterpreterState_ThreadHead**(*PyInterpreterState* *interp)

Return the pointer to the first *PyThreadState* object in the list of threads associated with the interpreter *interp*.

PyThreadState ***PyThreadState_Next**(*PyThreadState* *tstate)

Return the next thread state object after *tstate* from the list of all such objects belonging to the same *PyInterpreterState* object.

9.10 线程本地存储支持

The Python interpreter provides low-level support for thread-local storage (TLS) which wraps the underlying native TLS implementation to support the Python-level thread local storage API (`threading.local`). The CPython C level APIs are similar to those offered by pthreads and Windows: use a thread key and functions to associate a `void*` value per thread.

The GIL does *not* need to be held when calling these functions; they supply their own locking.

Note that `Python.h` does not include the declaration of the TLS APIs, you need to include `pythread.h` to use thread-local storage.

备注: None of these API functions handle memory management on behalf of the `void*` values. You need to allocate and deallocate them yourself. If the `void*` values happen to be `PyObject*`, these functions don't do refcount operations on them either.

9.10.1 Thread Specific Storage (TSS) API

TSS API is introduced to supersede the use of the existing TLS API within the CPython interpreter. This API uses a new type `Py_tss_t` instead of `int` to represent thread keys.

3.7 新版功能.

参见:

"A New C-API for Thread-Local Storage in CPython" (**PEP 539**)

type **`Py_tss_t`**

This data structure represents the state of a thread key, the definition of which may depend on the underlying TLS implementation, and it has an internal field representing the key's initialization state. There are no public members in this structure.

When *Py_LIMITED_API* is not defined, static allocation of this type by `Py_tss_NEEDS_INIT` is allowed.

`Py_tss_NEEDS_INIT`

This macro expands to the initializer for `Py_tss_t` variables. Note that this macro won't be defined with *Py_LIMITED_API*.

Dynamic Allocation

Dynamic allocation of the `Py_tss_t`, required in extension modules built with *Py_LIMITED_API*, where static allocation of this type is not possible due to its implementation being opaque at build time.

Py_tss_t ***`PyThread_tss_alloc`**`()`

Part of the Stable ABI *since version 3.7.* Return a value which is the same state as a value initialized with `Py_tss_NEEDS_INIT`, or `NULL` in the case of dynamic allocation failure.

void **`PyThread_tss_free`**`(`*Py_tss_t* *key`)`

Part of the Stable ABI *since version 3.7.* Free the given *key* allocated by `PyThread_tss_alloc()`, after first calling `PyThread_tss_delete()` to ensure any associated thread locals have been unassigned. This is a no-op if the *key* argument is `NULL`.

备注: A freed key becomes a dangling pointer. You should reset the key to `NULL`.

方法

The parameter *key* of these functions must not be NULL. Moreover, the behaviors of PyThread_tss_set() and PyThread_tss_get() are undefined if the given Py_tss_t has not been initialized by PyThread_tss_create().

int **PyThread_tss_is_created**(*Py_tss_t* *key)

Part of the Stable ABI *since version 3.7.* Return a non-zero value if the given Py_tss_t has been initialized by PyThread_tss_create().

int **PyThread_tss_create**(*Py_tss_t* *key)

Part of the Stable ABI *since version 3.7.* Return a zero value on successful initialization of a TSS key. The behavior is undefined if the value pointed to by the *key* argument is not initialized by Py_tss_NEEDS_INIT. This function can be called repeatedly on the same key -- calling it on an already initialized key is a no-op and immediately returns success.

void **PyThread_tss_delete**(*Py_tss_t* *key)

Part of the Stable ABI *since version 3.7.* Destroy a TSS key to forget the values associated with the key across all threads, and change the key's initialization state to uninitialized. A destroyed key is able to be initialized again by PyThread_tss_create(). This function can be called repeatedly on the same key -- calling it on an already destroyed key is a no-op.

int **PyThread_tss_set**(*Py_tss_t* *key, void *value)

Part of the Stable ABI *since version 3.7.* Return a zero value to indicate successfully associating a void* value with a TSS key in the current thread. Each thread has a distinct mapping of the key to a void* value.

void ***PyThread_tss_get**(*Py_tss_t* *key)

Part of the Stable ABI *since version 3.7.* Return the void* value associated with a TSS key in the current thread. This returns NULL if no value is associated with the key in the current thread.

9.10.2 Thread Local Storage (TLS) API

3.7 版后已移除: This API is superseded by *Thread Specific Storage (TSS) API*.

备注: This version of the API does not support platforms where the native TLS key is defined in a way that cannot be safely cast to int. On such platforms, PyThread_create_key() will return immediately with a failure status, and the other TLS functions will all be no-ops on such platforms.

由于上面提到的兼容性问题，不应在新代码中使用此版本的 API。

int **PyThread_create_key**()

Part of the Stable ABI.

void **PyThread_delete_key**(int key)

Part of the Stable ABI.

int **PyThread_set_key_value**(int key, void *value)

Part of the Stable ABI.

void ***PyThread_get_key_value**(int key)

Part of the Stable ABI.

void **PyThread_delete_key_value**(int key)

Part of the Stable ABI.

void **PyThread_ReInitTLS**()

Part of the Stable ABI.

CHAPTER 10

Python 初始化配置

3.8 新版功能.

Python 可以使用`Py_InitializeFromConfig()` 和`PyConfig` 结构体来初始化。它可以使用`Py_PreInitialize()` 和`PyPreConfig` 结构体来预初始化。

有两种配置方式：

- The *Python Configuration* can be used to build a customized Python which behaves as the regular Python. For example, environment variables and command line arguments are used to configure Python.
- The *Isolated Configuration* can be used to embed Python into an application. It isolates Python from the system. For example, environment variables are ignored, the LC_CTYPE locale is left unchanged and no signal handler is registered.

`Py_RunMain()` 函数可被用来编写定制的 Python 程序。

参见*Initialization, Finalization, and Threads*.

参见：

PEP 587 "Python 初始化配置".

10.1 示例

定制的 Python 的示例总是会以隔离模式运行：

```
int main(int argc, char **argv)
{
    PyStatus status;

    PyConfig config;
    PyConfig_InitPythonConfig(&config);
    config.isolated = 1;

    /* Decode command line arguments.
       Implicitly preinitialize Python (in isolated mode). */
    status = PyConfig_SetBytesArgv(&config, argc, argv);
    if (PyStatus_Exception(status)) {
        goto exception;
```

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```
    }

    status = Py_InitializeFromConfig(&config);
    if (PyStatus_Exception(status)) {
        goto exception;
    }
    PyConfig_Clear(&config);

    return Py_RunMain();

exception:
    PyConfig_Clear(&config);
    if (PyStatus_IsExit(status)) {
        return status.exitcode;
    }
    /* Display the error message and exit the process with
       non-zero exit code */
    Py_ExitStatusException(status);
}
```

10.2 PyWideStringList

type **PyWideStringList**

由 wchar_t* 字符串组成的列表。

如果 *length* 为非零值，则 *items* 必须不为 NULL 并且所有字符串均必须不为 NULL。

方法

PyStatus **PyWideStringList_Append**(*PyWideStringList* *list, const wchar_t *item)

将 *item* 添加到 *list*。

Python 必须被预初始化以便调用此函数。

PyStatus **PyWideStringList_Insert**(*PyWideStringList* *list, *Py_ssize_t* index, const wchar_t *item)

将 *item* 插入到 *list* 的 *index* 位置上。

如果 *index* 大于等于 *list* 的长度，则将 *item* 添加到 *list*。

index must be greater than or equal to 0.

Python 必须被预初始化以便调用此函数。

Structure fields:

Py_ssize_t **length**

List 长度。

wchar_t ****items**

列表项目。

10.3 PyStatus

type **PyStatus**

Structure to store an initialization function status: success, error or exit.

For an error, it can store the C function name which created the error.

Structure fields:

int **exitcode**

Exit code. Argument passed to `exit()`.

const char ***err_msg**

错误信息

const char ***func**

Name of the function which created an error, can be `NULL`.

Functions to create a status:

PyStatus **PyStatus_Ok** (void)

完成。

PyStatus **PyStatus_Error** (const char *err_msg)

Initialization error with a message.

err_msg must not be `NULL`.

PyStatus **PyStatus_NoMemory** (void)

Memory allocation failure (out of memory).

PyStatus **PyStatus_Exit** (int exitcode)

以指定的退出代码退出 Python。

Functions to handle a status:

int **PyStatus_Exception** (*PyStatus* status)

Is the status an error or an exit? If true, the exception must be handled; by calling `Py_ExitStatusException()` for example.

int **PyStatus_IsError** (*PyStatus* status)

结果错误吗?

int **PyStatus_IsExit** (*PyStatus* status)

结果是否退出?

void **Py_ExitStatusException** (*PyStatus* status)

Call `exit(exitcode)` if *status* is an exit. Print the error message and exit with a non-zero exit code if *status* is an error. Must only be called if `PyStatus_Exception(status)` is non-zero.

备注: Internally, Python uses macros which set `PyStatus.func`, whereas functions to create a status set `func` to `NULL`.

示例:

```
PyStatus alloc(void **ptr, size_t size)
{
    *ptr = PyMem_RawMalloc(size);
    if (*ptr == NULL) {
        return PyStatus_NoMemory();
    }
```

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```
    return PyStatus_Ok();
}

int main(int argc, char **argv)
{
    void *ptr;
    PyStatus status = alloc(&ptr, 16);
    if (PyStatus_Exception(status)) {
        Py_ExitStatusException(status);
    }
    PyMem_Free(ptr);
    return 0;
}
```

10.4 PyPreConfig

type **PyPreConfig**

Structure used to preinitialize Python.

Function to initialize a preconfiguration:

void **PyPreConfig_InitPythonConfig**(*PyPreConfig* *preconfig)

Initialize the preconfiguration with *Python Configuration*.

void **PyPreConfig_InitIsolatedConfig**(*PyPreConfig* *preconfig)

Initialize the preconfiguration with *Isolated Configuration*.

Structure fields:

int **allocator**

Name of the Python memory allocators:

- `PYMEM_ALLOCATOR_NOT_SET` (`0`): don't change memory allocators (use defaults).
- `PYMEM_ALLOCATOR_DEFAULT` (`1`): *default memory allocators*.
- `PYMEM_ALLOCATOR_DEBUG` (`2`): *default memory allocators* with *debug hooks*.
- `PYMEM_ALLOCATOR_MALLOC` (`3`): use `malloc()` of the C library.
- `PYMEM_ALLOCATOR_MALLOC_DEBUG` (`4`): force usage of `malloc()` with *debug hooks*.
- `PYMEM_ALLOCATOR_PYMALLOC` (`5`): *Python pymalloc memory allocator*.
- `PYMEM_ALLOCATOR_PYMALLOC_DEBUG` (`6`): *Python pymalloc memory allocator* with *debug hooks*.

`PYMEM_ALLOCATOR_PYMALLOC` and `PYMEM_ALLOCATOR_PYMALLOC_DEBUG` are not supported if Python is `configured using --without-pymalloc`.

参见*Memory Management*.

Default: `PYMEM_ALLOCATOR_NOT_SET`.

int **configure_locale**

Set the LC_CTYPE locale to the user preferred locale.

If equals to `0`, set *`coerce_c_locale`* and *`coerce_c_locale_warn`* members to `0`.

See the *locale encoding*.

Default: `1` in Python config, `0` in isolated config.

int **coerce_c_locale**

If equals to `2`, coerce the C locale.

If equals to `1`, read the LC_CTYPE locale to decide if it should be coerced.

See the *locale encoding*.

Default: `-1` in Python config, `0` in isolated config.

int **coerce_c_locale_warn**

If non-zero, emit a warning if the C locale is coerced.

Default: `-1` in Python config, `0` in isolated config.

int **dev_mode**

Python Development Mode: see `PyConfig.dev_mode`.

Default: `-1` in Python mode, `0` in isolated mode.

int **isolated**

Isolated mode: see `PyConfig.isolated`.

Default: `0` in Python mode, `1` in isolated mode.

int **legacy_windows_fs_encoding**

If non-zero:

- 设置`PyPreConfig.utf8_mode` 为 `0`,
- 设置`PyConfig.filesystem_encoding` 为 `"mbcs"`,
- 设置`PyConfig.filesystem_errors` 为 `"replace"`.

Initialized the from `PYTHONLEGACYWINDOWSFSENCODING` environment variable value.

Only available on Windows. `#ifdef MS_WINDOWS` macro can be used for Windows specific code.

默认值: `0`.

int **parse_argv**

If non-zero, `Py_PreInitializeFromArgs()` and `Py_PreInitializeFromBytesArgs()` parse their `argv` argument the same way the regular Python parses command line arguments: see Command Line Arguments.

Default: `1` in Python config, `0` in isolated config.

int **use_environment**

Use environment variables? See `PyConfig.use_environment`.

Default: `1` in Python config and `0` in isolated config.

int **utf8_mode**

If non-zero, enable the Python UTF-8 Mode.

Set to `0` or `1` by the `-X utf8` command line option and the `PYTHONUTF8` environment variable.

Also set to `1` if the `LC_CTYPE` locale is `C` or `POSIX`.

Default: `-1` in Python config and `0` in isolated config.

10.5 Preinitialize Python with PyPreConfig

The preinitialization of Python:

- Set the Python memory allocators (*PyPreConfig.allocator*)
- Configure the LC_CTYPE locale (*locale encoding*)
- Set the Python UTF-8 Mode (*PyPreConfig.utf8_mode*)

The current preconfiguration (`PyPreConfig` type) is stored in `_PyRuntime.preconfig`.

Functions to preinitialize Python:

PyStatus **Py_PreInitialize**(const *PyPreConfig* *preconfig)

Preinitialize Python from *preconfig* preconfiguration.

preconfig must not be `NULL`.

PyStatus **Py_PreInitializeFromBytesArgs**(const *PyPreConfig* *preconfig, int argc, char *const *argv)

Preinitialize Python from *preconfig* preconfiguration.

Parse *argv* command line arguments (bytes strings) if *parse_argv* of *preconfig* is non-zero.

preconfig must not be `NULL`.

PyStatus **Py_PreInitializeFromArgs**(const *PyPreConfig* *preconfig, int argc, wchar_t *const *argv)

Preinitialize Python from *preconfig* preconfiguration.

Parse *argv* command line arguments (wide strings) if *parse_argv* of *preconfig* is non-zero.

preconfig must not be `NULL`.

The caller is responsible to handle exceptions (error or exit) using `PyStatus_Exception()` and `Py_ExitStatusException()`.

For *Python Configuration* (`PyPreConfig_InitPythonConfig()`), if Python is initialized with command line arguments, the command line arguments must also be passed to preinitialize Python, since they have an effect on the pre-configuration like encodings. For example, the `-X utf8` command line option enables the Python UTF-8 Mode.

`PyMem_SetAllocator()` can be called after *Py_PreInitialize()* and before *Py_InitializeFromConfig()* to install a custom memory allocator. It can be called before *Py_PreInitialize()* if *PyPreConfig.allocator* is set to `PYMEM_ALLOCATOR_NOT_SET`.

Python memory allocation functions like *PyMem_RawMalloc()* must not be used before the Python preinitialization, whereas calling directly `malloc()` and `free()` is always safe. *Py_DecodeLocale()* must not be called before the Python preinitialization.

Example using the preinitialization to enable the Python UTF-8 Mode:

```
PyStatus status;
PyPreConfig preconfig;
PyPreConfig_InitPythonConfig(&preconfig);

preconfig.utf8_mode = 1;

status = Py_PreInitialize(&preconfig);
if (PyStatus_Exception(status)) {
    Py_ExitStatusException(status);
}

/* at this point, Python speaks UTF-8 */

Py_Initialize();
/* ... use Python API here ... */
Py_Finalize();
```

10.6 PyConfig

type **PyConfig**

Structure containing most parameters to configure Python.

When done, the `PyConfig_Clear()` function must be used to release the configuration memory.

Structure methods:

void **PyConfig_InitPythonConfig**(*PyConfig* *config)

Initialize configuration with the *Python Configuration*.

void **PyConfig_InitIsolatedConfig**(*PyConfig* *config)

Initialize configuration with the *Isolated Configuration*.

PyStatus **PyConfig_SetString**(*PyConfig* *config, wchar_t *const *config_str, const wchar_t *str)

Copy the wide character string *str* into `*config_str`.

Preinitialize Python if needed.

PyStatus **PyConfig_SetBytesString**(*PyConfig* *config, wchar_t *const *config_str, const char *str)

Decode *str* using `Py_DecodeLocale()` and set the result into `*config_str`.

Preinitialize Python if needed.

PyStatus **PyConfig_SetArgv**(*PyConfig* *config, int argc, wchar_t *const *argv)

Set command line arguments (`argv` member of *config*) from the *argv* list of wide character strings.

Preinitialize Python if needed.

PyStatus **PyConfig_SetBytesArgv**(*PyConfig* *config, int argc, char *const *argv)

Set command line arguments (`argv` member of *config*) from the *argv* list of bytes strings. Decode bytes using `Py_DecodeLocale()`.

Preinitialize Python if needed.

PyStatus **PyConfig_SetWideStringList**(*PyConfig* *config, *PyWideStringList* *list, *Py_ssize_t* length, wchar_t **items)

Set the list of wide strings *list* to *length* and *items*.

Preinitialize Python if needed.

PyStatus **PyConfig_Read**(*PyConfig* *config)

Read all Python configuration.

Fields which are already initialized are left unchanged.

Fields for *path configuration* are no longer calculated or modified when calling this function, as of Python 3.11.

The `PyConfig_Read()` function only parses `PyConfig.argv` arguments once: `PyConfig.parse_argv` is set to `2` after arguments are parsed. Since Python arguments are strippped from `PyConfig.argv`, parsing arguments twice would parse the application options as Python options.

Preinitialize Python if needed.

在 3.10 版更改: The `PyConfig.argv` arguments are now only parsed once, `PyConfig.parse_argv` is set to `2` after arguments are parsed, and arguments are only parsed if `PyConfig.parse_argv` equals `1`.

在 3.11 版更改: `PyConfig_Read()` no longer calculates all paths, and so fields listed under *Python Path Configuration* may no longer be updated until `Py_InitializeFromConfig()` is called.

void **PyConfig_Clear**(*PyConfig* *config)

Release configuration memory.

Most PyConfig methods *preinitialize Python* if needed. In that case, the Python preinitialization configuration (*PyPreConfig*) in based on the *PyConfig*. If configuration fields which are in common with *PyPreConfig* are tuned, they must be set before calling a *PyConfig* method:

- *PyConfig.dev_mode*
- *PyConfig.isolated*
- *PyConfig.parse_argv*
- *PyConfig.use_environment*

Moreover, if *PyConfig_SetArgv()* or *PyConfig_SetBytesArgv()* is used, this method must be called before other methods, since the preinitialization configuration depends on command line arguments (if *parse_argv* is non-zero).

The caller of these methods is responsible to handle exceptions (error or exit) using PyStatus_Exception() and Py_ExitStatusException().

Structure fields:

PyWideStringList **argv**

Command line arguments: sys.argv.

Set *parse_argv* to 1 to parse *argv* the same way the regular Python parses Python command line arguments and then to strip Python arguments from *argv*.

If *argv* is empty, an empty string is added to ensure that sys.argv always exists and is never empty.

默认值: NULL.

See also the *orig_argv* member.

int **safe_path**

If equals to zero, Py_RunMain() prepends a potentially unsafe path to sys.path at startup:

- If *argv[0]* is equal to L"-m" (python -m module), prepend the current working directory.
- If running a script (python script.py), prepend the script's directory. If it's a symbolic link, resolve symbolic links.
- Otherwise (python -c code and python), prepend an empty string, which means the current working directory.

Set to 1 by the -P command line option and the PYTHONSAFEPATH environment variable.

Default: 0 in Python config, 1 in isolated config.

3.11 新版功能.

wchar_t ***base_exec_prefix**

sys.base_exec_prefix.

默认值: NULL.

Part of the *Python Path Configuration* output.

wchar_t ***base_executable**

Python base executable: sys._base_executable.

Set by the __PYVENV_LAUNCHER__ environment variable.

Set from *PyConfig.executable* if NULL.

默认值: NULL.

Part of the *Python Path Configuration* output.

wchar_t ***base_prefix**

sys.base_prefix.

默认值: NULL.

Part of the *Python Path Configuration* output.

int **buffered_stdio**

If equals to 0 and *configure_c_stdio* is non-zero, disable buffering on the C streams stdout and stderr.

Set to 0 by the -u command line option and the PYTHONUNBUFFERED environment variable.

stdin is always opened in buffered mode.

默认值: 1.

int **bytes_warning**

If equals to 1, issue a warning when comparing bytes or bytearray with str, or comparing bytes with int.

If equal or greater to 2, raise a BytesWarning exception in these cases.

Incremented by the -b command line option.

默认值: 0.

int **warn_default_encoding**

If non-zero, emit a EncodingWarning warning when io.TextIOWrapper uses its default encoding. See io-encoding-warning for details.

默认值: 0.

3.10 新版功能.

int **code_debug_ranges**

If equals to 0, disables the inclusion of the end line and column mappings in code objects. Also disables traceback printing carets to specific error locations.

Set to 0 by the PYTHONNODEBUGRANGES environment variable and by the -X no_debug_ranges command line option.

默认值: 1.

3.11 新版功能.

wchar_t ***check_hash_pycs_mode**

Control the validation behavior of hash-based .pyc files: value of the --check-hash-based-pycs command line option.

Valid values:

- L"always": Hash the source file for invalidation regardless of value of the 'check_source' flag.
- L"never": Assume that hash-based pycs always are valid.
- L"default": The 'check_source' flag in hash-based pycs determines invalidation.

默认值： L"default"。

参见 **PEP 552** "Deterministic pycs"。

int **configure_c_stdio**

If non-zero, configure C standard streams:

- On Windows, set the binary mode (O_BINARY) on stdin, stdout and stderr.
- If *buffered_stdio* equals zero, disable buffering of stdin, stdout and stderr streams.
- If *interactive* is non-zero, enable stream buffering on stdin and stdout (only stdout on Windows).

Default: `1` in Python config, `0` in isolated config.

int **dev_mode**

If non-zero, enable the Python Development Mode.

Set to `1` by the `-X dev` option and the `PYTHONDEVMODE` environment variable.

Default: `-1` in Python mode, `0` in isolated mode.

int **dump_refs**

转储 Python 引用?

If non-zero, dump all objects which are still alive at exit.

Set to `1` by the `PYTHONDUMPREFS` environment variable.

Need a special build of Python with the `Py_TRACE_REFS` macro defined: see the `configure --with-trace-refs option`.

默认值: `0`.

wchar_t ***exec_prefix**

The site-specific directory prefix where the platform-dependent Python files are installed: `sys.exec_prefix`.

默认值: `NULL`.

Part of the *Python Path Configuration* output.

wchar_t ***executable**

The absolute path of the executable binary for the Python interpreter: `sys.executable`.

默认值: `NULL`.

Part of the *Python Path Configuration* output.

int **faulthandler**

Enable faulthandler?

If non-zero, call `faulthandler.enable()` at startup.

Set to `1` by `-X faulthandler` and the `PYTHONFAULTHANDLER` environment variable.

Default: `-1` in Python mode, `0` in isolated mode.

wchar_t ***filesystem_encoding**

Filesystem encoding: `sys.getfilesystemencoding()`.

On macOS, Android and VxWorks: use `"utf-8"` by default.

On Windows: use `"utf-8"` by default, or `"mbcs"` if *legacy_windows_fs_encoding* of *PyPreConfig* is non-zero.

Default encoding on other platforms:

- `"utf-8"` if *PyPreConfig.utf8_mode* is non-zero.
- `"ascii"` if Python detects that `nl_langinfo(CODESET)` announces the ASCII encoding, whereas the `mbstowcs()` function decodes from a different encoding (usually Latin1).
- `"utf-8"` if `nl_langinfo(CODESET)` returns an empty string.
- Otherwise, use the *locale encoding*: `nl_langinfo(CODESET)` result.

At Python startup, the encoding name is normalized to the Python codec name. For example, `"ANSI_X3.4-1968"` is replaced with `"ascii"`.

参见 *filesystem_errors* 的成员。

wchar_t ***filesystem_errors**

Filesystem error handler: `sys.getfilesystemencodeerrors()`.

On Windows: use `"surrogatepass"` by default, or `"replace"` if *legacy_windows_fs_encoding* of *PyPreConfig* is non-zero.

On other platforms: use `"surrogateescape"` by default.

Supported error handlers:

- `"strict"`
- `"surrogateescape"`
- `"surrogatepass"` (仅支持 UTF-8 编码格式)

参见*filesystem_encoding* 的成员。

unsigned long **hash_seed**

int **use_hash_seed**

Randomized hash function seed.

If *use_hash_seed* is zero, a seed is chosen randomly at Python startup, and *hash_seed* is ignored.

Set by the `PYTHONHASHSEED` environment variable.

Default *use_hash_seed* value: `-1` in Python mode, `0` in isolated mode.

wchar_t ***home**

Python home directory.

If *Py_SetPythonHome()* has been called, use its argument if it is not `NULL`.

Set by the `PYTHONHOME` environment variable.

默认值: `NULL`.

Part of the *Python Path Configuration* input.

int **import_time**

If non-zero, profile import time.

Set the `1` by the `-X importtime` option and the `PYTHONPROFILEIMPORTTIME` environment variable.

默认值: `0`.

int **inspect**

Enter interactive mode after executing a script or a command.

If greater than `0`, enable inspect: when a script is passed as first argument or the -c option is used, enter interactive mode after executing the script or the command, even when `sys.stdin` does not appear to be a terminal.

Incremented by the `-i` command line option. Set to `1` if the `PYTHONINSPECT` environment variable is non-empty.

默认值: `0`.

int **install_signal_handlers**

Install Python signal handlers?

Default: `1` in Python mode, `0` in isolated mode.

int **interactive**

If greater than `0`, enable the interactive mode (REPL).

Incremented by the `-i` command line option.

默认值: `0`.

int **isolated**

If greater than 0, enable isolated mode:

- Set *safe_path* to 1: don't prepend a potentially unsafe path to sys.path at Python startup.
- Set *use_environment* to 0.
- Set *user_site_directory* to 0: don't add the user site directory to sys.path.
- Python REPL doesn't import readline nor enable default readline configuration on interactive prompts.

Set to 1 by the -I command line option.

Default: 0 in Python mode, 1 in isolated mode.

See also *PyPreConfig.isolated*.

int **legacy_windows_stdio**

If non-zero, use io.FileIO instead of io.WindowsConsoleIO for sys.stdin, sys.stdout and sys.stderr.

Set to 1 if the PYTHONLEGACYWINDOWSSTDIO environment variable is set to a non-empty string.

Only available on Windows. #ifdef MS_WINDOWS macro can be used for Windows specific code.

默认值: 0.

See also the **PEP 528** (Change Windows console encoding to UTF-8).

int **malloc_stats**

If non-zero, dump statistics on *Python pymalloc memory allocator* at exit.

Set to 1 by the PYTHONMALLOCSTATS environment variable.

The option is ignored if Python is configured using the --without-pymalloc option.

默认值: 0.

wchar_t ***platlibdir**

Platform library directory name: sys.platlibdir.

Set by the PYTHONPLATLIBDIR environment variable.

Default: value of the PLATLIBDIR macro which is set by the configure --with-platlibdir option (default: "lib", or "DLLs" on Windows).

Part of the *Python Path Configuration* input.

3.9 新版功能.

在 3.11 版更改: This macro is now used on Windows to locate the standard library extension modules, typically under DLLs. However, for compatibility, note that this value is ignored for any non-standard layouts, including in-tree builds and virtual environments.

wchar_t ***pythonpath_env**

Module search paths (sys.path) as a string separated by DELIM (os.path.pathsep).

Set by the PYTHONPATH environment variable.

默认值: NULL.

Part of the *Python Path Configuration* input.

PyWideStringList **module_search_paths** int **module_search_paths_set**

Module search paths: `sys.path`.

If *module_search_paths_set* is equal to `0`, *Py_InitializeFromConfig()* will replace *module_search_paths* and sets *module_search_paths_set* to `1`.

Default: empty list (`module_search_paths`) and `0` (`module_search_paths_set`).

Part of the *Python Path Configuration* output.

int **optimization_level**

Compilation optimization level:

- `0`: Peephole optimizer, set `__debug__` to `True`.
- `1`: Level 0, remove assertions, set `__debug__` to `False`.
- `2`: Level 1, strip docstrings.

Incremented by the `-O` command line option. Set to the `PYTHONOPTIMIZE` environment variable value.

默认值: `0`.

PyWideStringList **orig_argv**

The list of the original command line arguments passed to the Python executable: `sys.orig_argv`.

If *orig_argv* list is empty and *argv* is not a list only containing an empty string, *PyConfig_Read()* copies *argv* into *orig_argv* before modifying *argv* (if *parse_argv* is non-zero).

See also the *argv* member and the *Py_GetArgcArgv()* function.

Default: empty list.

3.10 新版功能.

int **parse_argv**

Parse command line arguments?

If equals to `1`, parse *argv* the same way the regular Python parses command line arguments, and strip Python arguments from *argv*.

The *PyConfig_Read()* function only parses *PyConfig.argv* arguments once: *PyConfig.parse_argv* is set to `2` after arguments are parsed. Since Python arguments are strippped from *PyConfig.argv*, parsing arguments twice would parse the application options as Python options.

Default: `1` in Python mode, `0` in isolated mode.

在 3.10 版更改: The *PyConfig.argv* arguments are now only parsed if *PyConfig.parse_argv* equals to `1`.

int **parser_debug**

Parser debug mode. If greater than `0`, turn on parser debugging output (for expert only, depending on compilation options).

Incremented by the `-d` command line option. Set to the `PYTHONDEBUG` environment variable value.

默认值: `0`.

int **pathconfig_warnings**

If non-zero, calculation of path configuration is allowed to log warnings into `stderr`. If equals to `0`, suppress these warnings.

Default: `1` in Python mode, `0` in isolated mode.

Part of the *Python Path Configuration* input.

在 3.11 版更改: Now also applies on Windows.

wchar_t ***prefix**

The site-specific directory prefix where the platform independent Python files are installed: `sys.prefix`.

默认值: `NULL`.

Part of the *Python Path Configuration* output.

wchar_t ***program_name**

Program name used to initialize *executable* and in early error messages during Python initialization.

- If `Py_SetProgramName()` has been called, use its argument.
- On macOS, use `PYTHONEXECUTABLE` environment variable if set.
- If the `WITH_NEXT_FRAMEWORK` macro is defined, use `__PYVENV_LAUNCHER__` environment variable if set.
- Use `argv[0]` of *argv* if available and non-empty.
- Otherwise, use `L"python"` on Windows, or `L"python3"` on other platforms.

默认值: `NULL`.

Part of the *Python Path Configuration* input.

wchar_t ***pycache_prefix**

Directory where cached `.pyc` files are written: `sys.pycache_prefix`.

Set by the `-X pycache_prefix=PATH` command line option and the `PYTHONPYCACHEPREFIX` environment variable.

If `NULL`, `sys.pycache_prefix` is set to `None`.

默认值: `NULL`.

int **quiet**

Quiet mode. If greater than `0`, don't display the copyright and version at Python startup in interactive mode.

Incremented by the `-q` command line option.

默认值: `0`.

wchar_t ***run_command**

Value of the `-c` command line option.

Used by *Py_RunMain()*.

默认值: `NULL`.

wchar_t ***run_filename**

Filename passed on the command line: trailing command line argument without `-c` or `-m`. It is used by the *Py_RunMain()* function.

For example, it is set to `script.py` by the `python3 script.py arg` command line.

See also the *PyConfig.skip_source_first_line* option.

默认值: `NULL`.

wchar_t ***run_module**

Value of the `-m` command line option.

Used by *Py_RunMain()*.

默认值: `NULL`.

int **show_ref_count**

Show total reference count at exit?

Set to `1` by `-X showrefcount` command line option.

Need a debug build of Python (the `Py_REF_DEBUG` macro must be defined).

默认值: `0`.

int **site_import**

Import the `site` module at startup?

If equal to zero, disable the import of the module site and the site-dependent manipulations of `sys.path` that it entails.

Also disable these manipulations if the `site` module is explicitly imported later (call `site.main()` if you want them to be triggered).

Set to `0` by the `-S` command line option.

`sys.flags.no_site` is set to the inverted value of *`site_import`*.

默认值: `1`.

int **skip_source_first_line**

If non-zero, skip the first line of the *`PyConfig.run_filename`* source.

It allows the usage of non-Unix forms of `#!cmd`. This is intended for a DOS specific hack only.

Set to `1` by the `-x` command line option.

默认值: `0`.

wchar_t ***stdio_encoding**

wchar_t ***stdio_errors**

Encoding and encoding errors of `sys.stdin`, `sys.stdout` and `sys.stderr` (but `sys.stderr` always uses `"backslashreplace"` error handler).

If *`Py_SetStandardStreamEncoding()`* has been called, use its *error* and *errors* arguments if they are not `NULL`.

Use the `PYTHONIOENCODING` environment variable if it is non-empty.

Default encoding:

- `"UTF-8"` if *`PyPreConfig.utf8_mode`* is non-zero.
- Otherwise, use the *locale encoding*.

Default error handler:

- On Windows: use `"surrogateescape"`.
- `"surrogateescape"` if *`PyPreConfig.utf8_mode`* is non-zero, or if the LC_CTYPE locale is "C" or "POSIX".
- `"strict"` otherwise.

int **tracemalloc**

Enable tracemalloc?

If non-zero, call `tracemalloc.start()` at startup.

Set by `-X tracemalloc=N` command line option and by the `PYTHONTRACEMALLOC` environment variable.

Default: `-1` in Python mode, `0` in isolated mode.

int **use_environment**

Use environment variables?

If equals to zero, ignore the environment variables.

Set to `0` by the `-E` environment variable.

Default: `1` in Python config and `0` in isolated config.

int **user_site_directory**

If non-zero, add the user site directory to `sys.path`.

Set to `0` by the `-s` and `-I` command line options.

Set to `0` by the `PYTHONNOUSERSITE` environment variable.

Default: `1` in Python mode, `0` in isolated mode.

int **verbose**

Verbose mode. If greater than `0`, print a message each time a module is imported, showing the place (filename or built-in module) from which it is loaded.

If greater or equal to `2`, print a message for each file that is checked for when searching for a module. Also provides information on module cleanup at exit.

Incremented by the `-v` command line option.

Set to the `PYTHONVERBOSE` environment variable value.

默认值: `0`.

PyWideStringList **warnoptions**

Options of the `warnings` module to build warnings filters, lowest to highest priority: `sys.warnoptions`.

The `warnings` module adds `sys.warnoptions` in the reverse order: the last *`PyConfig.warnoptions`* item becomes the first item of `warnings.filters` which is checked first (highest priority).

The `-W` command line options adds its value to *`warnoptions`*, it can be used multiple times.

The `PYTHONWARNINGS` environment variable can also be used to add warning options. Multiple options can be specified, separated by commas (`,`).

Default: empty list.

int **write_bytecode**

If equal to `0`, Python won't try to write `.pyc` files on the import of source modules.

Set to `0` by the `-B` command line option and the `PYTHONDONTWRITEBYTECODE` environment variable.

`sys.dont_write_bytecode` is initialized to the inverted value of *`write_bytecode`*.

默认值: `1`.

PyWideStringList **xoptions**

Values of the `-X` command line options: `sys._xoptions`.

Default: empty list.

If *`parse_argv`* is non-zero, *`argv`* arguments are parsed the same way the regular Python parses command line arguments, and Python arguments are stripped from *`argv`*.

The *`xoptions`* options are parsed to set other options: see the `-X` command line option.

在 3.9 版更改: The `show_alloc_count` field has been removed.

10.7 Initialization with PyConfig

Function to initialize Python:

PyStatus **Py_InitializeFromConfig**(const *PyConfig* *config)

Initialize Python from *config* configuration.

The caller is responsible to handle exceptions (error or exit) using `PyStatus_Exception()` and `Py_ExitStatusException()`.

If `PyImport_FrozenModules()`, `PyImport_AppendInittab()` or `PyImport_ExtendInittab()` are used, they must be set or called after Python preinitialization and before the Python initialization. If Python is initialized multiple times, `PyImport_AppendInittab()` or `PyImport_ExtendInittab()` must be called before each Python initialization.

The current configuration (`PyConfig` type) is stored in `PyInterpreterState.config`.

Example setting the program name:

```
void init_python(void)
{
    PyStatus status;

    PyConfig config;
    PyConfig_InitPythonConfig(&config);

    /* Set the program name. Implicitly preinitialize Python. */
    status = PyConfig_SetString(&config, &config.program_name,
                                L"/path/to/my_program");
    if (PyStatus_Exception(status)) {
        goto exception;
    }

    status = Py_InitializeFromConfig(&config);
    if (PyStatus_Exception(status)) {
        goto exception;
    }
    PyConfig_Clear(&config);
    return;

exception:
    PyConfig_Clear(&config);
    Py_ExitStatusException(status);
}
```

More complete example modifying the default configuration, read the configuration, and then override some parameters. Note that since 3.11, many parameters are not calculated until initialization, and so values cannot be read from the configuration structure. Any values set before initialize is called will be left unchanged by initialization:

```
PyStatus init_python(const char *program_name)
{
    PyStatus status;

    PyConfig config;
    PyConfig_InitPythonConfig(&config);

    /* Set the program name before reading the configuration
       (decode byte string from the locale encoding).

       Implicitly preinitialize Python. */
    status = PyConfig_SetBytesString(&config, &config.program_name,
                                     program_name);
```

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```
    if (PyStatus_Exception(status)) {
        goto done;
    }

    /* Read all configuration at once */
    status = PyConfig_Read(&config);
    if (PyStatus_Exception(status)) {
        goto done;
    }

    /* Specify sys.path explicitly */
    /* If you want to modify the default set of paths, finish
       initialization first and then use PySys_GetObject("path") */
    config.module_search_paths_set = 1;
    status = PyWideStringList_Append(&config.module_search_paths,
                                     L"/path/to/stdlib");
    if (PyStatus_Exception(status)) {
        goto done;
    }
    status = PyWideStringList_Append(&config.module_search_paths,
                                     L"/path/to/more/modules");
    if (PyStatus_Exception(status)) {
        goto done;
    }

    /* Override executable computed by PyConfig_Read() */
    status = PyConfig_SetString(&config, &config.executable,
                                L"/path/to/my_executable");
    if (PyStatus_Exception(status)) {
        goto done;
    }

    status = Py_InitializeFromConfig(&config);

done:
    PyConfig_Clear(&config);
    return status;
}
```

10.8 Isolated Configuration

`PyPreConfig_InitIsolatedConfig()` and `PyConfig_InitIsolatedConfig()` functions create a configuration to isolate Python from the system. For example, to embed Python into an application.

This configuration ignores global configuration variables, environment variables, command line arguments (*PyConfig.argv* is not parsed) and user site directory. The C standard streams (ex: `stdout`) and the LC_CTYPE locale are left unchanged. Signal handlers are not installed.

Configuration files are still used with this configuration to determine paths that are unspecified. Ensure *PyConfig.home* is specified to avoid computing the default path configuration.

10.9 Python Configuration

`PyPreConfig_InitPythonConfig()` and `PyConfig_InitPythonConfig()` functions create a configuration to build a customized Python which behaves as the regular Python.

Environments variables and command line arguments are used to configure Python, whereas global configuration variables are ignored.

This function enables C locale coercion (**PEP 538**) and Python UTF-8 Mode (**PEP 540**) depending on the LC_CTYPE locale, `PYTHONUTF8` and `PYTHONCOERCECLOCALE` environment variables.

10.10 Python Path Configuration

PyConfig contains multiple fields for the path configuration:

- 路径配置输入：
  - *PyConfig.home*
  - *PyConfig.platlibdir*
  - *PyConfig.pathconfig_warnings*
  - *PyConfig.program_name*
  - *PyConfig.pythonpath_env*
  - current working directory: to get absolute paths
  - `PATH` environment variable to get the program full path (from *PyConfig.program_name*)
  - `__PYVENV_LAUNCHER__` environment variable
  - (Windows only) Application paths in the registry under "SoftwarePythonPythonCoreX.YPythonPath" of HKEY_CURRENT_USER and HKEY_LOCAL_MACHINE (where X.Y is the Python version).
- Path configuration output fields:
  - *PyConfig.base_exec_prefix*
  - *PyConfig.base_executable*
  - *PyConfig.base_prefix*
  - *PyConfig.exec_prefix*
  - *PyConfig.executable*
  - *PyConfig.module_search_paths_set*, *PyConfig.module_search_paths*
  - *PyConfig.prefix*

If at least one "output field" is not set, Python calculates the path configuration to fill unset fields. If *module_search_paths_set* is equal to `0`, *module_search_paths* is overridden and *module_search_paths_set* is set to `1`.

It is possible to completely ignore the function calculating the default path configuration by setting explicitly all path configuration output fields listed above. A string is considered as set even if it is non-empty. `module_search_paths` is considered as set if `module_search_paths_set` is set to `1`. In this case, `module_search_paths` will be used without modification.

Set *pathconfig_warnings* to `0` to suppress warnings when calculating the path configuration (Unix only, Windows does not log any warning).

If *base_prefix* or *base_exec_prefix* fields are not set, they inherit their value from *prefix* and *exec_prefix* respectively.

Py_RunMain() and *Py_Main()* modify `sys.path`:

- If *run_filename* is set and is a directory which contains a `__main__.py` script, prepend *run_filename* to `sys.path`.
- If *isolated* is zero:
  - If *run_module* is set, prepend the current directory to `sys.path`. Do nothing if the current directory cannot be read.
  - If *run_filename* is set, prepend the directory of the filename to `sys.path`.
  - Otherwise, prepend an empty string to `sys.path`.

If *site_import* is non-zero, `sys.path` can be modified by the `site` module. If *user_site_directory* is non-zero and the user's site-package directory exists, the `site` module appends the user's site-package directory to `sys.path`.

The following configuration files are used by the path configuration:

- `pyvenv.cfg`
- `._pth` file (ex: `python._pth`)
- `pybuilddir.txt` (仅 Unix)

If a `._pth` file is present:

- Set *isolated* to `1`.
- Set *use_environment* to `0`.
- Set *site_import* to `0`.
- Set *safe_path* to `1`.

The `__PYVENV_LAUNCHER__` environment variable is used to set *PyConfig.base_executable*

10.11 Py_RunMain()

int **Py_RunMain**(void)

Execute the command (*PyConfig.run_command*), the script (*PyConfig.run_filename*) or the module (*PyConfig.run_module*) specified on the command line or in the configuration.

By default and when if `-i` option is used, run the REPL.

Finally, finalizes Python and returns an exit status that can be passed to the `exit()` function.

See *Python Configuration* for an example of customized Python always running in isolated mode using *Py_RunMain()*.

10.12 Py_GetArgcArgv()

void **Py_GetArgcArgv**(int *argc, wchar_t ***argv)

Get the original command line arguments, before Python modified them.

See also *PyConfig.orig_argv* member.

10.13 Multi-Phase Initialization Private Provisional API

This section is a private provisional API introducing multi-phase initialization, the core feature of **PEP 432**:

- "Core" initialization phase, "bare minimum Python":
  - Builtin types;
  - Builtin exceptions;
  - Builtin and frozen modules;
  - The `sys` module is only partially initialized (ex: `sys.path` doesn't exist yet).
- "Main" initialization phase, Python is fully initialized:
  - Install and configure `importlib`;
  - Apply the *Path Configuration*;
  - Install signal handlers;
  - Finish `sys` module initialization (ex: create `sys.stdout` and `sys.path`);
  - Enable optional features like `faulthandler` and `tracemalloc`;
  - Import the `site` module;
  - 等等.

私有临时 API：

- `PyConfig._init_main`: if set to `0`, `Py_InitializeFromConfig()` stops at the "Core" initialization phase.
- `PyConfig._isolated_interpreter`: if non-zero, disallow threads, subprocesses and fork.

PyStatus **`_Py_InitializeMain`**(void)

Move to the "Main" initialization phase, finish the Python initialization.

No module is imported during the "Core" phase and the `importlib` module is not configured: the *Path Configuration* is only applied during the "Main" phase. It may allow to customize Python in Python to override or tune the *Path Configuration*, maybe install a custom `sys.meta_path` importer or an import hook, etc.

It may become possible to calculatin the *Path Configuration* in Python, after the Core phase and before the Main phase, which is one of the **PEP 432** motivation.

The "Core" phase is not properly defined: what should be and what should not be available at this phase is not specified yet. The API is marked as private and provisional: the API can be modified or even be removed anytime until a proper public API is designed.

Example running Python code between "Core" and "Main" initialization phases:

```
void init_python(void)
{
    PyStatus status;

    PyConfig config;
    PyConfig_InitPythonConfig(&config);
    config._init_main = 0;

    /* ... customize 'config' configuration ... */

    status = Py_InitializeFromConfig(&config);
    PyConfig_Clear(&config);
    if (PyStatus_Exception(status)) {
        Py_ExitStatusException(status);
    }
```

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```
    /* Use sys.stderr because sys.stdout is only created
       by _Py_InitializeMain() */
    int res = PyRun_SimpleString(
        "import sys; "
        "print('Run Python code before _Py_InitializeMain', "
               "file=sys.stderr)");
    if (res < 0) {
        exit(1);
    }

    /* ... put more configuration code here ... */

    status = _Py_InitializeMain();
    if (PyStatus_Exception(status)) {
        Py_ExitStatusException(status);
    }
}
```

CHAPTER 11

内存管理

11.1 概述

在 Python 中，内存管理涉及到一个包含所有 Python 对象和数据结构的私有堆（heap）。这个私有堆的管理由内部的 *Python* 内存管理器（*Python memory manager*）保证。Python 内存管理器有不同的组件来处理各种动态存储管理方面的问题，如共享、分割、预分配或缓存。

在最底层，一个原始内存分配器通过与操作系统的内存管理器交互，确保私有堆中有足够的空间来存储所有与 Python 相关的数据。在原始内存分配器的基础上，几个对象特定的分配器在同一堆上运行，并根据每种对象类型的特点实现不同的内存管理策略。例如，整数对象在堆内的管理方式不同于字符串、元组或字典，因为整数需要不同的存储需求和速度与空间的权衡。因此，Python 内存管理器将一些工作分配给对象特定分配器，但确保后者在私有堆的范围内运行。

Python 堆内存的管理是由解释器来执行，用户对它没有控制权，即使他们经常操作指向堆内内存块的对象指针，理解这一点十分重要。Python 对象和其他内部缓冲区的堆空间分配是由 Python 内存管理器按需通过本文档中列出的 Python/C API 函数进行的。

为了避免内存破坏，扩展的作者永远不应该试图用 C 库函数导出的函数来对 Python 对象进行操作，这些函数包括：`malloc()`，`calloc()`，`realloc()` 和 `free()`。这将导致 C 分配器和 Python 内存管理器之间的混用，引发严重后果，这是由于它们实现了不同的算法，并在不同的堆上操作。但是，我们可以安全地使用 C 库分配器为单独的目的分配和释放内存块，如下例所示：

```
PyObject *res;
char *buf = (char *) malloc(BUFSIZ); /* for I/O */

if (buf == NULL)
    return PyErr_NoMemory();
...Do some I/O operation involving buf...
res = PyBytes_FromString(buf);
free(buf); /* malloc'ed */
return res;
```

在这个例子中，I/O 缓冲区的内存请求是由 C 库分配器处理的。Python 内存管理器只参与了分配作为结果返回的字节对象。

In most situations, however, it is recommended to allocate memory from the Python heap specifically because the latter is under control of the Python memory manager. For example, this is required when the interpreter is extended with new object types written in C. Another reason for using the Python heap is the desire to *inform* the Python memory manager about the memory needs of the extension module. Even when the requested memory is used exclusively for internal, highly specific purposes, delegating all memory requests to the Python memory manager causes the interpreter to have a more accurate image of its memory footprint as a whole. Consequently, under certain circumstances, the Python memory manager may or may not trigger appropriate actions, like garbage collection, memory compaction or other preventive procedures. Note that by using the C library allocator as shown in the previous example, the allocated memory for the I/O buffer escapes completely the Python memory manager.

参见:

环境变量 PYTHONMALLOC 可被用来配置 Python 所使用的内存分配器。

环境变量 PYTHONMALLOCSTATS 可以用来在每次创建和关闭新的 pymalloc 对象区域时打印*pymalloc 内存分配器* 的统计数据。

11.2 分配器域

所有分配函数都属于三个不同的“分配器域”之一（见`PyMemAllocatorDomain`）。这些域代表了不同的分配策略，并为不同目的进行了优化。每个域如何分配内存和每个域调用哪些内部函数的具体细节被认为是实现细节，但是出于调试目的，可以在此处 找到一张简化的表格。没有硬性要求将属于给定域的分配函数返回的内存，仅用于该域提示的目的（虽然这是推荐的做法）。例如，你可以将`PyMem_RawMalloc()` 返回的内存用于分配 Python 对象，或者将`PyObject_Malloc()` 返回的内存用作缓冲区。

三个分配域分别是:

- 原始域: 用于为通用内存缓冲区分配内存，分配 * 必须 * 转到系统分配器并且分配器可以在没有*GIL* 的情况下运行。内存直接请求自系统。
- ”Mem” 域: 用于为 Python 缓冲区和通用内存缓冲区分配内存，分配时必须持有*GIL*。内存取自于 Python 私有堆。
- 对象域: 用于分配属于 Python 对象的内存。内存取自于 Python 私有堆。

当释放属于给定域的分配函数先前分配的内存时，必须使用对应的释放函数。例如，`PyMem_Free()` 来释放`PyMem_Malloc()` 分配的内存。

11.3 原始内存接口

以下函数集封装了系统分配器。这些函数是线程安全的，不需要持有全局解释器锁。

default raw memory allocator 使用这些函数: `malloc()`、`calloc()`、`realloc()` 和 `free()`; 申请零字节时则调用 `malloc(1)` （或 `calloc(1, 1)`）

3.4 新版功能.

void ***PyMem_RawMalloc**(size_t n)

Allocates *n* bytes and returns a pointer of type `void*` to the allocated memory, or `NULL` if the request fails.

请求零字节可能返回一个独特的非 `NULL` 指针，就像调用了 `PyMem_RawMalloc(1)` 一样。但是内存不会以任何方式被初始化。

void ***PyMem_RawCalloc**(size_t nelem, size_t elsize)

Allocates *nelem* elements each whose size in bytes is *elsize* and returns a pointer of type `void*` to the allocated memory, or `NULL` if the request fails. The memory is initialized to zeros.

请求零字节可能返回一个独特的非 `NULL` 指针，就像调用了 `PyMem_RawCalloc(1, 1)` 一样。

3.5 新版功能.

void ***PyMem_RawRealloc**(void *p, size_t n)

将 *p* 指向的内存块大小调整为 *n* 字节。以新旧内存块大小中的最小值为准，其中内容保持不变，

如果 *p* 是 `NULL`，则相当于调用 `PyMem_RawMalloc(n)`；如果 *n* 等于 0，则内存块大小会被调整，但不会被释放，返回非 `NULL` 指针。

除非 *p* 是 `NULL`，否则它必须是之前调用用 *`PyMem_RawMalloc()`*、*`PyMem_RawRealloc()`* 或 *`PyMem_RawCalloc()`* 所返回的。

如果请求失败，*`PyMem_RawRealloc()`* 返回 `NULL`，*p* 仍然是指向先前内存区域的有效指针。

void **PyMem_RawFree**(void *p)

释放 *p* 指向的内存块。*p* 必须是之前调用用 *`PyMem_RawMalloc()`*、*`PyMem_RawRealloc()`* 或 *`PyMem_RawCalloc()`* 所返回的指针。否则，或在 `PyMem_RawFree(p)` 之前已经调用过的情况下，未定义的行为会发生。

如果 *p* 是 `NULL`, 那么什么操作也不会进行。

11.4 内存接口

以下函数集，仿照 ANSI C 标准，并指定了请求零字节时的行为，可用于从 Python 堆分配和释放内存。

默认内存分配器 使用了 *pymalloc 内存分配器*.

> **警告：** 在使用这些函数时，必须持有全局解释器锁（*GIL*）。

在 3.6 版更改: 现在默认的分配器是 pymalloc 而非系统的 `malloc()`。

void ***PyMem_Malloc**(size_t n)

Part of the Stable ABI. Allocates *n* bytes and returns a pointer of type `void*` to the allocated memory, or `NULL` if the request fails.

请求零字节可能返回一个独特的非 `NULL` 指针，就像调用了 `PyMem_Malloc(1)` 一样。但是内存不会以任何方式被初始化。

void ***PyMem_Calloc**(size_t nelem, size_t elsize)

Part of the Stable ABI *since version 3.7.* Allocates *nelem* elements each whose size in bytes is *elsize* and returns a pointer of type `void*` to the allocated memory, or `NULL` if the request fails. The memory is initialized to zeros.

请求零字节可能返回一个独特的非 `NULL` 指针，就像调用了 `PyMem_Calloc(1, 1)` 一样。

3.5 新版功能.

void ***PyMem_Realloc**(void *p, size_t n)

Part of the Stable ABI. 将 *p* 指向的内存块大小调整为 *n* 字节。以新旧内存块大小中的最小值为准，其中内容保持不变，

如果 *p* 是 `NULL`，则相当于调用 `PyMem_Malloc(n)`；如果 *n* 等于 0，则内存块大小会被调整，但不会被释放，返回非 `NULL` 指针。

除非 *p* 是 `NULL`，否则它必须是之前调用用 *`PyMem_Malloc()`*、*`PyMem_Realloc()`* 或 *`PyMem_Calloc()`* 所返回的。

如果请求失败，*`PyMem_Realloc()`* 返回 `NULL`，*p* 仍然是指向先前内存区域的有效指针。

void **PyMem_Free**(void *p)

Part of the Stable ABI. 释放 *p* 指向的内存块。*p* 必须是之前调用用 *`PyMem_Malloc()`*、*`PyMem_Realloc()`* 或 *`PyMem_Calloc()`* 所返回的指针。否则，或在 `PyMem_Free(p)` 之前已经调用过的情况下，未定义的行为会发生。

如果 *p* 是 `NULL`, 那么什么操作也不会进行。

以下面向类型的宏为方便而提供。注意 *TYPE* 可以指任何 C 类型。

TYPE ***PyMem_New**(TYPE, size_t n)

Same as *PyMem_Malloc()*, but allocates (n * sizeof(TYPE)) bytes of memory. Returns a pointer cast to TYPE*. The memory will not have been initialized in any way.

TYPE ***PyMem_Resize**(void *p, TYPE, size_t n)

Same as *PyMem_Realloc()*, but the memory block is resized to (n * sizeof(TYPE)) bytes. Returns a pointer cast to TYPE*. On return, *p* will be a pointer to the new memory area, or NULL in the event of failure.

这是一个 C 预处理宏，*p* 总是被重新赋值。请保存 *p* 的原始值，以避免在处理错误时丢失内存。

void **PyMem_Del**(void *p)

与*PyMem_Free()* 相同

此外，我们还提供了以下宏集用于直接调用 Python 内存分配器，而不涉及上面列出的 C API 函数。但是请注意，使用它们并不能保证跨 Python 版本的二进制兼容性，因此在扩展模块被弃用。

- PyMem_MALLOC(size)
- PyMem_NEW(type, size)
- PyMem_REALLOC(ptr, size)
- PyMem_RESIZE(ptr, type, size)
- PyMem_FREE(ptr)
- PyMem_DEL(ptr)

11.5 对象分配器

以下函数集，仿照 ANSI C 标准，并指定了请求零字节时的行为，可用于从 Python 堆分配和释放内存。

备注： 当通过*自定义内存分配器* 部分描述的方法拦截该域中的分配函数时，无法保证这些分配器返回的内存可以被成功地转换成 Python 对象。

默认对象分配器 使用*pymalloc 内存分配器*.

警告： 在使用这些函数时，必须持有*全局解释器锁（GIL）* 。

void ***PyObject_Malloc**(size_t n)

Part of the Stable ABI. Allocates *n* bytes and returns a pointer of type void* to the allocated memory, or NULL if the request fails.

请求零字节可能返回一个独特的非 NULL 指针，就像调用了 PyObject_Malloc(1) 一样。但是内存不会以任何方式被初始化。

void ***PyObject_Calloc**(size_t nelem, size_t elsize)

Part of the Stable ABI *since version 3.7.* Allocates *nelem* elements each whose size in bytes is *elsize* and returns a pointer of type void* to the allocated memory, or NULL if the request fails. The memory is initialized to zeros.

请求零字节可能返回一个独特的非 NULL 指针，就像调用了 PyObject_Calloc(1, 1) 一样。

3.5 新版功能.

void *`PyObject_Realloc`(void *p, size_t n)

Part of the Stable ABI. 将 *p* 指向的内存块大小调整为 *n* 字节。以新旧内存块大小中的最小值为准，其中内容保持不变，

如果 *p* 是 "NULL"，则相当于调用 `PyObject_Malloc(n)` ；如果 *n* 等于 0，则内存块大小会被调整，但不会被释放，返回非 `NULL` 指针。

除非 *p* 是 `NULL` ，否则它必须是之前调用用 *PyObject_Malloc()* 、*PyObject_Realloc()* 或 *PyObject_Calloc()* 所返回的。

如果请求失败，*PyObject_Realloc()* 返回 `NULL` ，*p* 仍然是指向先前内存区域的有效指针。

void `PyObject_Free`(void *p)

Part of the Stable ABI. 释放 *p* 指向的内存块。*p* 必须是之前调用用 *PyObject_Malloc()* 、*PyObject_Realloc()* 或 *PyObject_Calloc()* 所返回的指针。否则，或在 `PyObject_Free(p)` 之前已经调用过的情况下，未定义行为会发生。

如果 *p* 是 `NULL`, 那么什么操作也不会进行。

11.6 默认内存分配器

默认内存分配器：

配置	名称	PyMem_RawMalloc	PyMem_Malloc	PyObject_Malloc
发布版本	`"pymalloc"`	`malloc`	`pymalloc`	`pymalloc`
调试构建	`"pymalloc_debug"`	`malloc` + debug	`pymalloc` + debug	`pymalloc` + debug
没有 pymalloc 的发布版本	`"malloc"`	`malloc`	`malloc`	`malloc`
没有 pymalloc 的调试构建	`"malloc_debug"`	`malloc` + debug	`malloc` + debug	`malloc` + debug

说明：

- 名称：`PYTHONMALLOC` 环境变量的值。
- `malloc`：来自 C 标准库的系统分配器，C 函数：`malloc()`、`calloc()`、`realloc()` 和 `free()`。
- `pymalloc`：*pymalloc 内存分配器*.
- "+ debug": 附带*Python 内存分配器的调试钩子*.
- "调试构建"：调试模式下的 Python 构建。

11.7 自定义内存分配器

3.4 新版功能.

type `PyMemAllocatorEx`

用于描述内存块分配器的结构体。该结构体下列字段:

域	含意
`void *ctx`	作为第一个参数传入的用户上下文
`void* malloc(void *ctx, size_t size)`	分配一个内存块
`void* calloc(void *ctx, size_t nelem, size_t elsize)`	分配一个初始化为 0 的内存块
`void* realloc(void *ctx, void *ptr, size_t new_size)`	分配一个内存块或调整其大小
`void free(void *ctx, void *ptr)`	释放一个内存块

在 3.5 版更改: The `PyMemAllocator` structure was renamed to *PyMemAllocatorEx* and a new `calloc` field was added.

type **PyMemAllocatorDomain**

用来识别分配器域的枚举类。域有：

PYMEM_DOMAIN_RAW

函数

- *PyMem_RawMalloc()*
- *PyMem_RawRealloc()*
- *PyMem_RawCalloc()*
- *PyMem_RawFree()*

PYMEM_DOMAIN_MEM

函数

- *PyMem_Malloc()*,
- *PyMem_Realloc()*
- *PyMem_Calloc()*
- *PyMem_Free()*

PYMEM_DOMAIN_OBJ

函数

- *PyObject_Malloc()*
- *PyObject_Realloc()*
- *PyObject_Calloc()*
- *PyObject_Free()*

void **PyMem_GetAllocator**(*PyMemAllocatorDomain* domain, *PyMemAllocatorEx* *allocator)

获取指定域的内存块分配器。

void **PyMem_SetAllocator**(*PyMemAllocatorDomain* domain, *PyMemAllocatorEx* *allocator)

设置指定域的内存块分配器。

当请求零字节时，新的分配器必须返回一个独特的非 `NULL` 指针。

对于 `PYMEM_DOMAIN_RAW` 域，分配器必须是线程安全的：当分配器被调用时，不持有*全局解释器锁* 。

如果新的分配器不是钩子（不调用之前的分配器），必须调用*PyMem_SetupDebugHooks()* 函数在新分配器上重新安装调试钩子。

See also *PyPreConfig.allocator* and *Preinitialize Python with PyPreConfig*.

> **警告:** `PyMem_SetAllocator()` does have the following contract:
>
> - It can be called after `Py_PreInitialize()` and before `Py_InitializeFromConfig()` to install a custom memory allocator. There are no restrictions over the installed allocator other than the ones imposed by the domain (for instance, the Raw Domain allows the allocator to be called without the GIL held). See *the section on allocator domains* for more information.
> - If called after Python has finish initializing (after `Py_InitializeFromConfig()` has been called) the allocator **must** wrap the existing allocator. Substituting the current allocator for some other arbitrary one is **not supported**.

void **PyMem_SetupDebugHooks**(void)

设置*Python 内存分配器的调试钩子* 以检测内存错误。

11.8 Python 内存分配器的调试钩子

当 Python 在调试模式下构建，`PyMem_SetupDebugHooks()` 函数在*Python 预初始化* 时被调用，以在 Python 内存分配器上设置调试钩子以检测内存错误。

`PYTHONMALLOC` 环境变量可被用于在以发行模式下编译的 Python 上安装调试钩子（例如：`PYTHONMALLOC=debug`）。

`PyMem_SetupDebugHooks()` 函数可被用于在调用了`PyMem_SetAllocator()` 之后设置调试钩子。

这些调试钩子用特殊的、可辨认的位模式填充动态分配的内存块。新分配的内存用字节 `0xCD``` (```PYMEM_CLEANBYTE`) 填充，释放的内存用字节 `0xDD``` (```PYMEM_DEADBYTE`) 填充。内存块被填充了字节 `0xFD``` (```PYMEM_FORBIDDENBYTE`) 的"禁止字节"包围。这些字节串不太可能是合法的地址、浮点数或 ASCII 字符串

运行时检查：

- 检测对 API 的违反。例如：检测对`PyMem_Malloc()` 分配的内存块调用`PyObject_Free()`。
- 检测缓冲区起始位置前的写入（缓冲区下溢）。
- 检测缓冲区终止位置后的写入（缓冲区溢出）。
- 检测当调用 `PYMEM_DOMAIN_OBJ` (如: `PyObject_Malloc()`) 和 `PYMEM_DOMAIN_MEM` (如: `PyMem_Malloc()`) 域的分配器函数时*GIL* 已被持有。

在出错时，调试钩子使用 `tracemalloc` 模块来回溯内存块被分配的位置。只有当 `tracemalloc` 正在追踪 Python 内存分配，并且内存块被追踪时，才会显示回溯。

让 S = `sizeof(size_t)`。将 `2*S` 个字节添加到每个被请求的 N 字节数据块的两端。内存的布局像是这样，其中 p 代表由类似 malloc 或类似 realloc 的函数所返回的地址 (`p[i:j]` 表示从 `*(p+i)` 左侧开始到 `*(p+j)` 左侧止的字节数据切片；请注意对负索引号的处理与 Python 切片是不同的)：

`p[-2*S:-S]` 最初所要求的字节数。这是一个 size_t，为大端序（易于在内存转储中读取）。

`p[-S]` API 标识符（ASCII 字符）：

- `'r'` 表示 `PYMEM_DOMAIN_RAW`。
- `'m'` 表示 `PYMEM_DOMAIN_MEM`。
- `'o'` 表示 `PYMEM_DOMAIN_OBJ`。

`p[-S+1:0]` PYMEM_FORBIDDENBYTE 的副本。用于捕获下层的写入和读取。

`p[0:N]` 所请求的内存，用 PYMEM_CLEANBYTE 的副本填充，用于捕获对未初始化内存的引用。当调用 realloc 之类的函数来请求更大的内存块时，额外新增的字节也会用 PYMEM_CLEANBYTE 来填充。当调用 free 之类的函数时，这些字节会用 PYMEM_DEADBYTE 来重写，以捕获对已释放内存的引用。当调用 realloc 之类的函数来请求更小的内存块时，多余的旧字节也会用 PYMEM_DEADBYTE 来填充。

p[N:N+S] PYMEM_FORBIDDENBYTE 的副本。用于捕获超限的写入和读取。

p[N+S:N+2*S] 仅当定义了 `PYMEM_DEBUG_SERIALNO` 宏时会被使用（默认情况下将不定义）。

一个序列号，每次调用 malloc 之类或 realloc 之类的函数时自增 1。大端序的 `size_t`。如果之后检测到了"被破坏的内存"，此序列号提供了一个很好的手段用来在下次运行时设置中断点，以捕获该内存块被破坏的瞬间。obmalloc.c 中的静态函数 bumpserialno() 是此序列号会发生自增的唯一地方，它的存在使你可以方便地设置这样的中断点。

一个 realloc 之类或 free 之类的函数会先检查两端的 PYMEM_FORBIDDENBYTE 字节是否完好。如果它们被改变了，则会将诊断输出写入到 stderr，并且程序将通过 Py_FatalError() 中止。另一种主要的失败模式是当程序读到某种特殊的比特模式并试图将其用作地址时触发内存错误。如果你随即进入调试器并查看该对象，你很可能会看到它已完全被填充为 PYMEM_DEADBYTE (意味着已释放的内存被使用) 或 PYMEM_CLEANBYTE (意味着未初始货摊内存被使用)。

在 3.6 版更改: *PyMem_SetupDebugHooks()* 函数现在也能在使用发布模式编译的 Python 上工作。当发生错误时，调试钩子现在会使用 `tracemalloc` 来获取已分配内存块的回溯信息。调试钩子现在还会在 `PYMEM_DOMAIN_OBJ` 和 `PYMEM_DOMAIN_MEM` 作用域的函数被调用时检查是否持有 GIL。

在 3.8 版更改: 字节模式 `0xCB` (`PYMEM_CLEANBYTE`)、`0xDB` (`PYMEM_DEADBYTE`) 和 `0xFB` (`PYMEM_FORBIDDENBYTE`) 已被 `0xCD`、`0xDD` 和 `0xFD` 替代以使用与 Windows CRT 调试 `malloc()` 和 `free()` 相同的值。

11.9 pymalloc 分配器

Python 有为具有短生命周期的小对象（小于或等于 512 字节）优化的 *pymalloc* 分配器。它使用固定大小为 256 KiB 的称为"arenas" 的内存映射。对于大于 512 字节的分配，它回到使用*PyMem_RawMalloc()* 和*PyMem_RawRealloc()* 。

pymalloc 是 `PYMEM_DOMAIN_MEM` (例如: *PyMem_Malloc()*) 和 `PYMEM_DOMAIN_OBJ` (例如: *PyObject_Malloc()*) 域的默认分配器 。

arena 分配器使用以下函数:

- Windows 上的 `VirtualAlloc()` 和 `VirtualFree()` ,
- `mmap()` 和 `munmap()` ，如果可用，
- 否则，`malloc()` 和 `free()` 。

如果 Python 配置了 `--without-pymalloc` 选项，那么此分配器将被禁用。也可以在运行时使用 `PYTHONMALLOC`` （例如：``PYTHONMALLOC=malloc`` ）环境变量来禁用它。

11.9.1 自定义 pymalloc Arena 分配器

3.4 新版功能.

type **PyObjectArenaAllocator**

用来描述一个 arena 分配器的结构体。这个结构体有三个字段:

域	含意
`void *ctx`	作为第一个参数传入的用户上下文
`void* alloc(void *ctx, size_t size)`	分配一块 size 字节的区域
`void free(void *ctx, void *ptr, size_t size)`	释放一块区域

void **PyObject_GetArenaAllocator**(*PyObjectArenaAllocator* *allocator)

获取 arena 分配器

void **PyObject_SetArenaAllocator** (*PyObjectArenaAllocator* *allocator)

设置 arena 分配器

11.10 tracemalloc C API

3.7 新版功能.

int **PyTraceMalloc_Track** (unsigned int domain, uintptr_t ptr, size_t size)

在 `tracemalloc` 模块中跟踪一个已分配的内存块。

成功时返回 `0`，出错时返回 `-1` (无法分配内存来保存跟踪信息)。如果禁用了 tracemalloc 则返回 `-2`。

如果内存块已被跟踪，则更新现有跟踪信息。

int **PyTraceMalloc_Untrack** (unsigned int domain, uintptr_t ptr)

在 `tracemalloc` 模块中取消跟踪一个已分配的内存块。如果内存块未被跟踪则不执行任何操作。

如果 tracemalloc 被禁用则返回 `-2`，否则返回 `0`。

11.11 例子

以下是来自概述 小节的示例，经过重写以使 I/O 缓冲区是通过使用第一个函数集从 Python 堆中分配的:

```
PyObject *res;
char *buf = (char *) PyMem_Malloc(BUFSIZ); /* for I/O */

if (buf == NULL)
    return PyErr_NoMemory();
/* ...Do some I/O operation involving buf... */
res = PyBytes_FromString(buf);
PyMem_Free(buf); /* allocated with PyMem_Malloc */
return res;
```

使用面向类型函数集的相同代码:

```
PyObject *res;
char *buf = PyMem_New(char, BUFSIZ); /* for I/O */

if (buf == NULL)
    return PyErr_NoMemory();
/* ...Do some I/O operation involving buf... */
res = PyBytes_FromString(buf);
PyMem_Del(buf); /* allocated with PyMem_New */
return res;
```

请注意在以上两个示例中，缓冲区总是通过归属于相同集的函数来操纵的。事实上，对于一个给定的内存块必须使用相同的内存 API 族，以便使得混合不同分配器的风险减至最低。以下代码序列包含两处错误，其中一个被标记为 *fatal* 因为它混合了两种在不同堆上操作的不同分配器。

```
char *buf1 = PyMem_New(char, BUFSIZ);
char *buf2 = (char *) malloc(BUFSIZ);
char *buf3 = (char *) PyMem_Malloc(BUFSIZ);
...
PyMem_Del(buf3);  /* Wrong -- should be PyMem_Free() */
free(buf2);       /* Right -- allocated via malloc() */
free(buf1);       /* Fatal -- should be PyMem_Del()  */
```

除了旨在处理来自 Python 堆的原始内存块的函数之外，Python 中的对象是通过`PyObject_New()`，`PyObject_NewVar()` 和`PyObject_Del()` 来分配和释放的。

这些将在有关如何在 C 中定义和实现新对象类型的下一章中讲解。

CHAPTER 12

对象实现支持

本章描述了定义新对象类型时所使用的函数、类型和宏。

12.1 在堆上分配对象

PyObject ***_PyObject_New**(*PyTypeObject* *type)

Return value: New reference.

PyVarObject ***_PyObject_NewVar**(*PyTypeObject* *type, *Py_ssize_t* size)

Return value: New reference.

PyObject ***PyObject_Init**(*PyObject* *op, *PyTypeObject* *type)

Return value: Borrowed reference. Part of the Stable ABI. Initialize a newly allocated object *op* with its type and initial reference. Returns the initialized object. If *type* indicates that the object participates in the cyclic garbage detector, it is added to the detector's set of observed objects. Other fields of the object are not affected.

PyVarObject ***PyObject_InitVar**(*PyVarObject* *op, *PyTypeObject* *type, *Py_ssize_t* size)

Return value: Borrowed reference. Part of the Stable ABI. 它的功能和`PyObject_Init()` 一样，并且会初始化变量大小对象的长度信息。

TYPE ***PyObject_New**(TYPE, *PyTypeObject* *type)

Return value: New reference. 使用 C 结构类型 *TYPE* 和 Python 类型对象 *type* 分配一个新的 Python 对象。未在该 Python 对象标头中定义的字段不会被初始化；对象的引用计数将为一。内存分配大小由 type 对象的`tp_basicsize` 字段来确定。

TYPE ***PyObject_NewVar**(TYPE, *PyTypeObject* *type, *Py_ssize_t* size)

Return value: New reference. 使用 C 的数据结构类型 *TYPE* 和 Python 的类型对象 *type* 分配一个新的 Python 对象。Python 对象头文件中没有定义的字段不会被初始化。被分配的内存空间预留了 *TYPE* 结构加 *type* 对象中`tp_itemsize` 字段提供的 *size* 字段的值。这对于实现类似元组这种能够在构造期决定自己大小的对象是很实用的。将字段的数组嵌入到相同的内存分配中可以减少内存分配的次数，这提高了内存分配的效率。

void **PyObject_Del**(void *op)

释放由`PyObject_New()` 或者`PyObject_NewVar()` 分配内存的对象。这通常由对象的 type 字段定义的`tp_dealloc` 处理函数来调用。调用这个函数以后 op 对象中的字段都不可以被访问，因为原分配的内存空间已不再是一个有效的 Python 对象。

PyObject **_Py_NoneStruct**

这个对象是像 `None` 一样的 Python 对象。它可以使用`Py_None` 宏访问，该宏的拿到指向该对象的指针。

参见:

`PyModule_Create()` 分配内存和创建扩展模块

12.2 公用对象的结构

大量的结构体被用于定义 Python 的对象类型。这一节描述了这些的结构体和它们的使用方法。

12.2.1 基本的对象类型和宏

所有的 Python 对象都在对象的内存表示的开始部分共享少量的字段。这些字段用`PyObject` 或`PyVarObject` 类型来表示，这些类型又由一些宏定义，这些宏也直接或间接地用于所有其他 Python 对象的定义。

type **PyObject**

Part of the Limited API. *(Only some members are part of the stable ABI.)* All object types are extensions of this type. This is a type which contains the information Python needs to treat a pointer to an object as an object. In a normal "release" build, it contains only the object's reference count and a pointer to the corresponding type object. Nothing is actually declared to be a `PyObject`, but every pointer to a Python object can be cast to a `PyObject*`. Access to the members must be done by using the macros `Py_REFCNT` and `Py_TYPE`.

type **PyVarObject**

Part of the Limited API. *(Only some members are part of the stable ABI.)* This is an extension of `PyObject` that adds the `ob_size` field. This is only used for objects that have some notion of *length*. This type does not often appear in the Python/C API. Access to the members must be done by using the macros `Py_REFCNT`, `Py_TYPE`, and `Py_SIZE`.

PyObject_HEAD

This is a macro used when declaring new types which represent objects without a varying length. The PyObject_HEAD macro expands to:

```
PyObject ob_base;
```

See documentation of `PyObject` above.

PyObject_VAR_HEAD

This is a macro used when declaring new types which represent objects with a length that varies from instance to instance. The PyObject_VAR_HEAD macro expands to:

```
PyVarObject ob_base;
```

参见上面`PyVarObject` 的文档。

int **Py_Is** (*PyObject* *x, *PyObject* *y)

Part of the Stable ABI *since version 3.10.* 测试 *x* 是否为 *y* 对象，与 Python 中的 `x is y` 相同。

3.10 新版功能.

int **Py_IsNone** (*PyObject* *x)

Part of the Stable ABI *since version 3.10.* 测试一个对象是否为 `None` 单例，与 Python 中的 `x is None` 相同。

3.10 新版功能.

int **Py_IsTrue** (*PyObject* *x)

Part of the Stable ABI *since version 3.10.* 测试一个对象是否为 `True` 单例，与 Python 中的 `x is True` 相同。

3.10 新版功能.

int **Py_IsFalse** (*PyObject* *x)

Part of the Stable ABI *since version 3.10.* 测试一个对象是否为 `False` 单例，与 Python 中的 `x is False` 相同。

3.10 新版功能.

PyTypeObject ***Py_TYPE** (*PyObject* *o)

获取 Python 对象 *o* 的类型。

返回一个*borrowed reference*。

Use the `Py_SET_TYPE()` function to set an object type.

在 3.11 版更改: `Py_TYPE()` is changed to an inline static function. The parameter type is no longer `const PyObject*`.

int **Py_IS_TYPE** (*PyObject* *o, *PyTypeObject* *type)

Return non-zero if the object *o* type is *type*. Return zero otherwise. Equivalent to: `Py_TYPE(o) == type`.

3.9 新版功能.

void **Py_SET_TYPE** (*PyObject* *o, *PyTypeObject* *type)

Set the object *o* type to *type*.

3.9 新版功能.

Py_ssize_t **Py_REFCNT** (*PyObject* *o)

Get the reference count of the Python object *o*.

Use the `Py_SET_REFCNT()` function to set an object reference count.

在 3.11 版更改: The parameter type is no longer `const PyObject*`.

在 3.10 版更改: `Py_REFCNT()` is changed to the inline static function.

void **Py_SET_REFCNT** (*PyObject* *o, *Py_ssize_t* refcnt)

Set the object *o* reference counter to *refcnt*.

3.9 新版功能.

Py_ssize_t **Py_SIZE** (*PyVarObject* *o)

Get the size of the Python object *o*.

Use the `Py_SET_SIZE()` function to set an object size.

在 3.11 版更改: `Py_SIZE()` is changed to an inline static function. The parameter type is no longer `const PyVarObject*`.

void **Py_SET_SIZE** (*PyVarObject* *o, *Py_ssize_t* size)

Set the object *o* size to *size*.

3.9 新版功能.

PyObject_HEAD_INIT (type)

This is a macro which expands to initialization values for a new `PyObject` type. This macro expands to:

```
_PyObject_EXTRA_INIT
1, type,
```

PyVarObject_HEAD_INIT (type, size)

This is a macro which expands to initialization values for a new *PyVarObject* type, including the ob_size field. This macro expands to:

```
_PyObject_EXTRA_INIT
1, type, size,
```

12.2.2 Implementing functions and methods

type **PyCFunction**

Part of the Stable ABI. Type of the functions used to implement most Python callables in C. Functions of this type take two *PyObject** parameters and return one such value. If the return value is NULL, an exception shall have been set. If not NULL, the return value is interpreted as the return value of the function as exposed in Python. The function must return a new reference.

The function signature is:

```
PyObject *PyCFunction(PyObject *self,
                      PyObject *args);
```

type **PyCFunctionWithKeywords**

Part of the Stable ABI. Type of the functions used to implement Python callables in C with signature METH_VARARGS | METH_KEYWORDS. The function signature is:

```
PyObject *PyCFunctionWithKeywords(PyObject *self,
                                  PyObject *args,
                                  PyObject *kwargs);
```

type **_PyCFunctionFast**

Type of the functions used to implement Python callables in C with signature *METH_FASTCALL*. The function signature is:

```
PyObject *_PyCFunctionFast(PyObject *self,
                           PyObject *const *args,
                           Py_ssize_t nargs);
```

type **_PyCFunctionFastWithKeywords**

Type of the functions used to implement Python callables in C with signature METH_FASTCALL | METH_KEYWORDS. The function signature is:

```
PyObject *_PyCFunctionFastWithKeywords(PyObject *self,
                                       PyObject *const *args,
                                       Py_ssize_t nargs,
                                       PyObject *kwnames);
```

type **PyCMethod**

Type of the functions used to implement Python callables in C with signature METH_METHOD | METH_FASTCALL | METH_KEYWORDS. The function signature is:

```
PyObject *PyCMethod(PyObject *self,
                    PyTypeObject *defining_class,
                    PyObject *const *args,
                    Py_ssize_t nargs,
                    PyObject *kwnames)
```

3.9 新版功能.

type **PyMethodDef**

Part of the Stable ABI *(including all members).* Structure used to describe a method of an extension type. This structure has four fields:

域	C 类型	含意
ml_name	const char *	name of the method
ml_meth	PyCFunction	pointer to the C implementation
ml_flags	int	flag bits indicating how the call should be constructed
ml_doc	const char *	points to the contents of the docstring

The ml_meth is a C function pointer. The functions may be of different types, but they always return *PyObject**. If the function is not of the *PyCFunction*, the compiler will require a cast in the method table. Even though *PyCFunction* defines the first parameter as *PyObject**, it is common that the method implementation uses the specific C type of the *self* object.

The ml_flags field is a bitfield which can include the following flags. The individual flags indicate either a calling convention or a binding convention.

There are these calling conventions:

METH_VARARGS

This is the typical calling convention, where the methods have the type *PyCFunction*. The function expects two *PyObject** values. The first one is the *self* object for methods; for module functions, it is the module object. The second parameter (often called *args*) is a tuple object representing all arguments. This parameter is typically processed using *PyArg_ParseTuple()* or *PyArg_UnpackTuple()*.

METH_VARARGS | METH_KEYWORDS

Methods with these flags must be of type *PyCFunctionWithKeywords*. The function expects three parameters: *self*, *args*, *kwargs* where *kwargs* is a dictionary of all the keyword arguments or possibly NULL if there are no keyword arguments. The parameters are typically processed using *PyArg_ParseTupleAndKeywords()*.

METH_FASTCALL

Fast calling convention supporting only positional arguments. The methods have the type *_PyCFunctionFast*. The first parameter is *self*, the second parameter is a C array of *PyObject** values indicating the arguments and the third parameter is the number of arguments (the length of the array).

3.7 新版功能.

在 3.10 版更改: METH_FASTCALL is now part of the stable ABI.

METH_FASTCALL | METH_KEYWORDS

Extension of *METH_FASTCALL* supporting also keyword arguments, with methods of type *_PyCFunctionFastWithKeywords*. Keyword arguments are passed the same way as in the *vectorcall protocol*: there is an additional fourth *PyObject** parameter which is a tuple representing the names of the keyword arguments (which are guaranteed to be strings) or possibly NULL if there are no keywords. The values of the keyword arguments are stored in the *args* array, after the positional arguments.

3.7 新版功能.

METH_METHOD | METH_FASTCALL | METH_KEYWORDS

Extension of METH_FASTCALL | METH_KEYWORDS supporting the *defining class*, that is, the class that contains the method in question. The defining class might be a superclass of Py_TYPE(self).

The method needs to be of type *PyCMethod*, the same as for METH_FASTCALL | METH_KEYWORDS with defining_class argument added after self.

3.9 新版功能.

METH_NOARGS

Methods without parameters don't need to check whether arguments are given if they are listed with the *METH_NOARGS* flag. They need to be of type *PyCFunction*. The first parameter is typically named *self* and will hold a reference to the module or object instance. In all cases the second parameter will be NULL.

The function must have 2 parameters. Since the second parameter is unused, *Py_UNUSED* can be used to prevent a compiler warning.

METH_O

Methods with a single object argument can be listed with the *METH_O* flag, instead of invoking *PyArg_ParseTuple()* with a "O" argument. They have the type *PyCFunction*, with the *self* parameter, and a *PyObject** parameter representing the single argument.

These two constants are not used to indicate the calling convention but the binding when use with methods of classes. These may not be used for functions defined for modules. At most one of these flags may be set for any given method.

METH_CLASS

The method will be passed the type object as the first parameter rather than an instance of the type. This is used to create *class methods*, similar to what is created when using the `classmethod()` built-in function.

METH_STATIC

The method will be passed `NULL` as the first parameter rather than an instance of the type. This is used to create *static methods*, similar to what is created when using the `staticmethod()` built-in function.

One other constant controls whether a method is loaded in place of another definition with the same method name.

METH_COEXIST

The method will be loaded in place of existing definitions. Without *METH_COEXIST*, the default is to skip repeated definitions. Since slot wrappers are loaded before the method table, the existence of a *sq_contains* slot, for example, would generate a wrapped method named `__contains__()` and preclude the loading of a corresponding PyCFunction with the same name. With the flag defined, the PyCFunction will be loaded in place of the wrapper object and will co-exist with the slot. This is helpful because calls to PyCFunctions are optimized more than wrapper object calls.

12.2.3 Accessing attributes of extension types

type **PyMemberDef**

Part of the Stable ABI *(including all members).* Structure which describes an attribute of a type which corresponds to a C struct member. Its fields are:

域	C 类型	含意
`name`	const char *	name of the member
`type`	int	the type of the member in the C struct
`offset`	Py_ssize_t	the offset in bytes that the member is located on the type's object struct
`flags`	int	flag bits indicating if the field should be read-only or writable
`doc`	const char *	points to the contents of the docstring

`type` can be one of many `T_` macros corresponding to various C types. When the member is accessed in Python, it will be converted to the equivalent Python type.

Macro name	C 类型
T_SHORT	short
T_INT	int
T_LONG	长整型
T_FLOAT	float
T_DOUBLE	double
T_STRING	const char *
T_OBJECT	PyObject *
T_OBJECT_EX	PyObject *
T_CHAR	字符
T_BYTE	字符
T_UBYTE	unsigned char
T_UINT	unsigned int
T_USHORT	unsigned short
T_ULONG	unsigned long
T_BOOL	字符
T_LONGLONG	long long
T_ULONGLONG	unsigned long long
T_PYSSIZET	Py_ssize_t

`T_OBJECT` and `T_OBJECT_EX` differ in that `T_OBJECT` returns `None` if the member is `NULL` and `T_OBJECT_EX` raises an `AttributeError`. Try to use `T_OBJECT_EX` over `T_OBJECT` because `T_OBJECT_EX` handles use of the `del` statement on that attribute more correctly than `T_OBJECT`.

`flags` can be `0` for write and read access or `READONLY` for read-only access. Using `T_STRING` for `type` implies `READONLY`. `T_STRING` data is interpreted as UTF-8. Only `T_OBJECT` and `T_OBJECT_EX` members can be deleted. (They are set to `NULL`).

Heap allocated types (created using `PyType_FromSpec()` or similar), `PyMemberDef` may contain definitions for the special members `__dictoffset__`, `__weaklistoffset__` and `__vectorcalloffset__`, corresponding to `tp_dictoffset`, `tp_weaklistoffset` and `tp_vectorcall_offset` in type objects. These must be defined with `T_PYSSIZET` and `READONLY`, for example:

```
static PyMemberDef spam_type_members[] = {
    {"__dictoffset__", T_PYSSIZET, offsetof(Spam_object, dict), READONLY},
    {NULL}  /* Sentinel */
};
```

PyObject ***PyMember_GetOne**(const char *obj_addr, struct *PyMemberDef* *m)

Get an attribute belonging to the object at address *obj_addr*. The attribute is described by `PyMemberDef` *m*. Returns `NULL` on error.

int **PyMember_SetOne**(char *obj_addr, struct *PyMemberDef* *m, *PyObject* *o)

Set an attribute belonging to the object at address *obj_addr* to object *o*. The attribute to set is described by `PyMemberDef` *m*. Returns `0` if successful and a negative value on failure.

type **PyGetSetDef**

Part of the Stable ABI *(including all members).* Structure to define property-like access for a type. See also description of the `PyTypeObject.tp_getset` slot.

域	C 类型	含意
名称	const char *	attribute name
get	getter	C function to get the attribute
set	setter	optional C function to set or delete the attribute, if omitted the attribute is readonly
doc	const char *	optional docstring
closure	void *	optional function pointer, providing additional data for getter and setter

The get function takes one *PyObject** parameter (the instance) and a function pointer (the associated closure):

```
typedef PyObject *(*getter)(PyObject *, void *);
```

It should return a new reference on success or NULL with a set exception on failure.

set functions take two *PyObject** parameters (the instance and the value to be set) and a function pointer (the associated closure):

```
typedef int (*setter)(PyObject *, PyObject *, void *);
```

In case the attribute should be deleted the second parameter is NULL. Should return 0 on success or -1 with a set exception on failure.

12.3 类型对象

Perhaps one of the most important structures of the Python object system is the structure that defines a new type: the *PyTypeObject* structure. Type objects can be handled using any of the PyObject_* or PyType_* functions, but do not offer much that's interesting to most Python applications. These objects are fundamental to how objects behave, so they are very important to the interpreter itself and to any extension module that implements new types.

与大多数标准类型相比，类型对象相当大。这么大的原因是每个类型对象存储了大量的值，大部分是 C 函数指针，每个指针实现了类型功能的一小部分。本节将详细描述类型对象的字段。这些字段将按照它们在结构中出现的顺序进行描述。

除了下面的快速参考，*例子* 小节提供了快速了解*PyTypeObject* 的含义和用法的例子。

12.3.1 快速参考

"tp_ 方法槽"

PyTypeObject 槽[Page 227, 1]	*Type*	特殊方法/属性	信息[Page 227, 2]			
			O	T	D	I
<R> *tp_name*	const char *	__name__	X	X		
tp_basicsize	*Py_ssize_t*		X	X		X
tp_itemsize	*Py_ssize_t*			X		X
tp_dealloc	*destructor*		X	X		X
tp_vectorcall_offset	*Py_ssize_t*			X		X
(*tp_getattr*)	*getattrfunc*	__getattribute__, __getattr__				G
(*tp_setattr*)	*setattrfunc*	__setattr__, __delattr__				G
tp_as_async	*PyAsyncMethods* *	子方法槽（方法域）				%
tp_repr	*reprfunc*	__repr__	X	X		X
tp_as_number	*PyNumberMethods* *	子方法槽（方法域）				%
tp_as_sequence	*PySequenceMethods* *	子方法槽（方法域）				%
tp_as_mapping	*PyMappingMethods* *	子方法槽（方法域）				%
tp_hash	*hashfunc*	__hash__	X			G
tp_call	*ternaryfunc*	__call__		X		X
tp_str	*reprfunc*	__str__	X			X
tp_getattro	*getattrofunc*	__getattribute__, __getattr__	X	X		G
tp_setattro	*setattrofunc*	__setattr__, __delattr__	X	X		G
tp_as_buffer	*PyBufferProcs* *					%
tp_flags	unsigned long		X	X		?
tp_doc	const char *	__doc__	X	X		

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表 1 – 续上页

PyTypeObject 槽[Page 227, 1]	*Type*	特殊方法/属性	信息[Page 227, 2]			
			O	T	D	I
tp_traverse	*traverseproc*			X		G
tp_clear	*inquiry*			X		G
tp_richcompare	*richcmpfunc*	__lt__, __le__, __eq__, __ne__, __gt__, __ge__	X			G
tp_weaklistoffset	*Py_ssize_t*			X		?
tp_iter	*getiterfunc*	__iter__				X
tp_iternext	*iternextfunc*	__next__				X
tp_methods	*PyMethodDef* []		X	X		
tp_members	*PyMemberDef* []			X		
tp_getset	*PyGetSetDef* []		X	X		
tp_base	*PyTypeObject* *	__base__			X	
tp_dict	*PyObject* *	__dict__			?	
tp_descr_get	*descrgetfunc*	__get__				X
tp_descr_set	*descrsetfunc*	__set__, __delete__				X
tp_dictoffset	*Py_ssize_t*			X		?
tp_init	*initproc*	__init__	X	X		X
tp_alloc	*allocfunc*		X		?	?
tp_new	*newfunc*	__new__	X	X	?	?
tp_free	*freefunc*		X	X	?	?
tp_is_gc	*inquiry*			X		X
<*tp_bases*>	*PyObject* *	__bases__			~	
<*tp_mro*>	*PyObject* *	__mro__			~	
[*tp_cache*]	*PyObject* *					
[*tp_subclasses*]	*PyObject* *	__subclasses__				
[*tp_weaklist*]	*PyObject* *					
(*tp_del*)	*destructor*					
[*tp_version_tag*]	unsigned int					
tp_finalize	*destructor*	__del__				X
tp_vectorcall	*vectorcallfunc*					

[1] (): A slot name in parentheses indicates it is (effectively) deprecated.

<>: Names in angle brackets should be initially set to `NULL` and treated as read-only.

[]: Names in square brackets are for internal use only.

<R> (as a prefix) means the field is required (must be non-`NULL`).

[2] 列：

"O": `PyBaseObject_Type` 必须设置

"T": *PyType_Type* 必须设置

"D": 默认设置 (如果方法槽被设置为 NULL)

```
X - PyType_Ready sets this value if it is NULL
~ - PyType_Ready always sets this value (it should be NULL)
? - PyType_Ready may set this value depending on other slots

Also see the inheritance column ("I").
```

"I": 继承

```
X - type slot is inherited via *PyType_Ready* if defined with a *NULL* value
% - the slots of the sub-struct are inherited individually
G - inherited, but only in combination with other slots; see the slot's description
? - it's complicated; see the slot's description
```

注意，有些方法槽是通过普通属性查找链有效继承的。

子方法槽（方法域）

方法槽	*Type*	特殊方法
am_await	*unaryfunc*	__await__
am_aiter	*unaryfunc*	__aiter__
am_anext	*unaryfunc*	__anext__
am_send	*sendfunc*	
nb_add	*binaryfunc*	__add__ __radd__
nb_inplace_add	*binaryfunc*	__iadd__
nb_subtract	*binaryfunc*	__sub__ __rsub__
nb_inplace_subtract	*binaryfunc*	__isub__
nb_multiply	*binaryfunc*	__mul__ __rmul__
nb_inplace_multiply	*binaryfunc*	__imul__
nb_remainder	*binaryfunc*	__mod__ __rmod__
nb_inplace_remainder	*binaryfunc*	__imod__
nb_divmod	*binaryfunc*	__divmod__ __rdivmod__
nb_power	*ternaryfunc*	__pow__ __rpow__
nb_inplace_power	*ternaryfunc*	__ipow__
nb_negative	*unaryfunc*	__neg__
nb_positive	*unaryfunc*	__pos__
nb_absolute	*unaryfunc*	__abs__
nb_bool	*inquiry*	__bool__
nb_invert	*unaryfunc*	__invert__
nb_lshift	*binaryfunc*	__lshift__ __rlshift__
nb_inplace_lshift	*binaryfunc*	__ilshift__
nb_rshift	*binaryfunc*	__rshift__ __rrshift__
nb_inplace_rshift	*binaryfunc*	__irshift__
nb_and	*binaryfunc*	__and__ __rand__
nb_inplace_and	*binaryfunc*	__iand__
nb_xor	*binaryfunc*	__xor__ __rxor__
nb_inplace_xor	*binaryfunc*	__ixor__
nb_or	*binaryfunc*	__or__ __ror__
nb_inplace_or	*binaryfunc*	__ior__
nb_int	*unaryfunc*	__int__
nb_reserved	void *	
nb_float	*unaryfunc*	__float__
nb_floor_divide	*binaryfunc*	__floordiv__
nb_inplace_floor_divide	*binaryfunc*	__ifloordiv__
nb_true_divide	*binaryfunc*	__truediv__
nb_inplace_true_divide	*binaryfunc*	__itruediv__
nb_index	*unaryfunc*	__index__
nb_matrix_multiply	*binaryfunc*	__matmul__ __rmatmul__
nb_inplace_matrix_multiply	*binaryfunc*	__imatmul__
mp_length	*lenfunc*	__len__
mp_subscript	*binaryfunc*	__getitem__
mp_ass_subscript	*objobjargproc*	__setitem__, __delitem__
sq_length	*lenfunc*	__len__
sq_concat	*binaryfunc*	__add__

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表 2 – 续上页

方法槽	*Type*	特殊方法
sq_repeat	*ssizeargfunc*	__mul__
sq_item	*ssizeargfunc*	__getitem__
sq_ass_item	*ssizeobjargproc*	__setitem__ __delitem__
sq_contains	*objobjproc*	__contains__
sq_inplace_concat	*binaryfunc*	__iadd__
sq_inplace_repeat	*ssizeargfunc*	__imul__
bf_getbuffer	*getbufferproc()*	
bf_releasebuffer	*releasebufferproc()*	

槽位 typedef

typedef	参数类型	返回类型
allocfunc	PyTypeObject * Py_ssize_t	PyObject *
destructor	void *	void
freefunc	void *	void
traverseproc	void * visitproc void *	int
newfunc	PyObject * PyObject * PyObject *	PyObject *
initproc	PyObject * PyObject * PyObject *	int
reprfunc	PyObject *	PyObject *
getattrfunc	PyObject * const char *	PyObject *
setattrfunc	PyObject * const char * PyObject *	int
getattrofunc	PyObject * PyObject *	PyObject *
setattrofunc	PyObject * PyObject * PyObject *	int
descrgetfunc	PyObject * PyObject * PyObject *	PyObject *
descrsetfunc	PyObject * PyObject * PyObject *	int
hashfunc	PyObject *	Py_hash_t
richcmpfunc		PyObject *

请参阅*Slot Type typedefs* 里有更多详细信息。

12.3.2 PyTypeObject 定义

PyTypeObject 的结构定义可以在 `Include/object.h` 中找到。为了方便参考，此处复述了其中的定义:

```
typedef struct _typeobject {
    PyObject_VAR_HEAD
    const char *tp_name; /* For printing, in format "<module>.<name>" */
    Py_ssize_t tp_basicsize, tp_itemsize; /* For allocation */

    /* Methods to implement standard operations */

    destructor tp_dealloc;
    Py_ssize_t tp_vectorcall_offset;
    getattrfunc tp_getattr;
    setattrfunc tp_setattr;
    PyAsyncMethods *tp_as_async; /* formerly known as tp_compare (Python 2)
                                    or tp_reserved (Python 3) */
    reprfunc tp_repr;

    /* Method suites for standard classes */

    PyNumberMethods *tp_as_number;
    PySequenceMethods *tp_as_sequence;
    PyMappingMethods *tp_as_mapping;

    /* More standard operations (here for binary compatibility) */

    hashfunc tp_hash;
    ternaryfunc tp_call;
    reprfunc tp_str;
    getattrofunc tp_getattro;
    setattrofunc tp_setattro;

    /* Functions to access object as input/output buffer */
    PyBufferProcs *tp_as_buffer;

    /* Flags to define presence of optional/expanded features */
    unsigned long tp_flags;

    const char *tp_doc; /* Documentation string */

    /* Assigned meaning in release 2.0 */
    /* call function for all accessible objects */
    traverseproc tp_traverse;

    /* delete references to contained objects */
    inquiry tp_clear;

    /* Assigned meaning in release 2.1 */
    /* rich comparisons */
    richcmpfunc tp_richcompare;

    /* weak reference enabler */
    Py_ssize_t tp_weaklistoffset;

    /* Iterators */
    getiterfunc tp_iter;
    iternextfunc tp_iternext;
```

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```
    /* Attribute descriptor and subclassing stuff */
    struct PyMethodDef *tp_methods;
    struct PyMemberDef *tp_members;
    struct PyGetSetDef *tp_getset;
    // Strong reference on a heap type, borrowed reference on a static type
    struct _typeobject *tp_base;
    PyObject *tp_dict;
    descrgetfunc tp_descr_get;
    descrsetfunc tp_descr_set;
    Py_ssize_t tp_dictoffset;
    initproc tp_init;
    allocfunc tp_alloc;
    newfunc tp_new;
    freefunc tp_free; /* Low-level free-memory routine */
    inquiry tp_is_gc; /* For PyObject_IS_GC */
    PyObject *tp_bases;
    PyObject *tp_mro; /* method resolution order */
    PyObject *tp_cache;
    PyObject *tp_subclasses;
    PyObject *tp_weaklist;
    destructor tp_del;

    /* Type attribute cache version tag. Added in version 2.6 */
    unsigned int tp_version_tag;

    destructor tp_finalize;
    vectorcallfunc tp_vectorcall;
} PyTypeObject;
```

12.3.3 PyObject 槽位

类型对象结构扩展了*PyVarObject* 结构。ob_size 字段用于动态类型 (由 type_new() 创建，通常通过类语句来调用)。注意*PyType_Type* (元类型) 会初始化*tp_itemsize*，这意味着它的实例 (即类型对象) 必须具有 ob_size 字段。

Py_ssize_t *PyObject*.**ob_refcnt**

Part of the Stable ABI. 这是类型对象的引用计数，由 PyObject_HEAD_INIT 宏初始化为 1。请注意对于静态分配的类型对象，类型的实例 (对象的 ob_type 指回该类型) 不会被加入引用计数。但对于动态分配的类型对象，实例 确实会被算作引用。

继承：

子类型不继承此字段。

PyTypeObject **PyObject*.**ob_type**

Part of the Stable ABI. This is the type's type, in other words its metatype. It is initialized by the argument to the PyObject_HEAD_INIT macro, and its value should normally be &PyType_Type. However, for dynamically loadable extension modules that must be usable on Windows (at least), the compiler complains that this is not a valid initializer. Therefore, the convention is to pass NULL to the PyObject_HEAD_INIT macro and to initialize this field explicitly at the start of the module's initialization function, before doing anything else. This is typically done like this:

```
Foo_Type.ob_type = &PyType_Type;
```

This should be done before any instances of the type are created. *PyType_Ready()* checks if ob_type is NULL, and if so, initializes it to the ob_type field of the base class. *PyType_Ready()* will not change this field if it is non-zero.

继承：

此字段会被子类型继承。

PyObject *`PyObject._ob_next`

PyObject *`PyObject._ob_prev`

These fields are only present when the macro `Py_TRACE_REFS` is defined (see the `configure --with-trace-refs` option).

Their initialization to `NULL` is taken care of by the `PyObject_HEAD_INIT` macro. For *statically allocated objects*, these fields always remain `NULL`. For *dynamically allocated objects*, these two fields are used to link the object into a doubly linked list of *all* live objects on the heap.

This could be used for various debugging purposes; currently the only uses are the `sys.getobjects()` function and to print the objects that are still alive at the end of a run when the environment variable `PYTHONDUMPREFS` is set.

继承：

这些字段不会被子类型继承。

12.3.4 PyVarObject 槽位

Py_ssize_t `PyVarObject.ob_size`

Part of the Stable ABI. For *statically allocated type objects*, this should be initialized to zero. For *dynamically allocated type objects*, this field has a special internal meaning.

继承：

子类型不继承此字段。

12.3.5 PyTypeObject 槽

Each slot has a section describing inheritance. If `PyType_Ready()` may set a value when the field is set to `NULL` then there will also be a "Default" section. (Note that many fields set on `PyBaseObject_Type` and `PyType_Type` effectively act as defaults.)

const char *`PyTypeObject.tp_name`

Pointer to a NUL-terminated string containing the name of the type. For types that are accessible as module globals, the string should be the full module name, followed by a dot, followed by the type name; for built-in types, it should be just the type name. If the module is a submodule of a package, the full package name is part of the full module name. For example, a type named `T` defined in module `M` in subpackage `Q` in package `P` should have the `tp_name` initializer `"P.Q.M.T"`.

For *dynamically allocated type objects*, this should just be the type name, and the module name explicitly stored in the type dict as the value for key `'__module__'`.

For *statically allocated type objects*, the *tp_name* field should contain a dot. Everything before the last dot is made accessible as the `__module__` attribute, and everything after the last dot is made accessible as the `__name__` attribute.

If no dot is present, the entire `tp_name` field is made accessible as the `__name__` attribute, and the `__module__` attribute is undefined (unless explicitly set in the dictionary, as explained above). This means your type will be impossible to pickle. Additionally, it will not be listed in module documentations created with pydoc.

This field must not be `NULL`. It is the only required field in `PyTypeObject()` (other than potentially `tp_itemsize`).

继承：

子类型不继承此字段。

Py_ssize_t `PyTypeObject.tp_basicsize`

Py_ssize_t *PyTypeObject*.**tp_itemsize**

These fields allow calculating the size in bytes of instances of the type.

There are two kinds of types: types with fixed-length instances have a zero *tp_itemsize* field, types with variable-length instances have a non-zero *tp_itemsize* field. For a type with fixed-length instances, all instances have the same size, given in *tp_basicsize*.

For a type with variable-length instances, the instances must have an `ob_size` field, and the instance size is *tp_basicsize* plus N times *tp_itemsize*, where N is the "length" of the object. The value of N is typically stored in the instance's `ob_size` field. There are exceptions: for example, ints use a negative `ob_size` to indicate a negative number, and N is `abs(ob_size)` there. Also, the presence of an `ob_size` field in the instance layout doesn't mean that the instance structure is variable-length (for example, the structure for the list type has fixed-length instances, yet those instances have a meaningful `ob_size` field).

The basic size includes the fields in the instance declared by the macro *PyObject_HEAD* or *PyObject_VAR_HEAD* (whichever is used to declare the instance struct) and this in turn includes the `_ob_prev` and `_ob_next` fields if they are present. This means that the only correct way to get an initializer for the *tp_basicsize* is to use the `sizeof` operator on the struct used to declare the instance layout. The basic size does not include the GC header size.

A note about alignment: if the variable items require a particular alignment, this should be taken care of by the value of *tp_basicsize*. Example: suppose a type implements an array of `double`. *tp_itemsize* is `sizeof(double)`. It is the programmer's responsibility that *tp_basicsize* is a multiple of `sizeof(double)` (assuming this is the alignment requirement for `double`).

For any type with variable-length instances, this field must not be `NULL`.

继承：

These fields are inherited separately by subtypes. If the base type has a non-zero *tp_itemsize*, it is generally not safe to set *tp_itemsize* to a different non-zero value in a subtype (though this depends on the implementation of the base type).

destructor *PyTypeObject*.**tp_dealloc**

A pointer to the instance destructor function. This function must be defined unless the type guarantees that its instances will never be deallocated (as is the case for the singletons `None` and `Ellipsis`). The function signature is:

```
void tp_dealloc(PyObject *self);
```

The destructor function is called by the *Py_DECREF()* and *Py_XDECREF()* macros when the new reference count is zero. At this point, the instance is still in existence, but there are no references to it. The destructor function should free all references which the instance owns, free all memory buffers owned by the instance (using the freeing function corresponding to the allocation function used to allocate the buffer), and call the type's *tp_free* function. If the type is not subtypable (doesn't have the *Py_TPFLAGS_BASETYPE* flag bit set), it is permissible to call the object deallocator directly instead of via *tp_free*. The object deallocator should be the one used to allocate the instance; this is normally *PyObject_Del()* if the instance was allocated using *PyObject_New()* or `PyObject_VarNew()`, or *PyObject_GC_Del()* if the instance was allocated using *PyObject_GC_New()* or *PyObject_GC_NewVar()*.

If the type supports garbage collection (has the *Py_TPFLAGS_HAVE_GC* flag bit set), the destructor should call *PyObject_GC_UnTrack()* before clearing any member fields.

```
static void foo_dealloc(foo_object *self) {
    PyObject_GC_UnTrack(self);
    Py_CLEAR(self->ref);
    Py_TYPE(self)->tp_free((PyObject *)self);
}
```

Finally, if the type is heap allocated (*Py_TPFLAGS_HEAPTYPE*), the deallocator should decrement the reference count for its type object after calling the type deallocator. In order to avoid dangling pointers, the recommended way to achieve this is:

```
static void foo_dealloc(foo_object *self) {
    PyTypeObject *tp = Py_TYPE(self);
    // free references and buffers here
    tp->tp_free(self);
    Py_DECREF(tp);
}
```

继承:

此字段会被子类型继承。

Py_ssize_t *PyTypeObject*.**tp_vectorcall_offset**

An optional offset to a per-instance function that implements calling the object using the *vectorcall protocol*, a more efficient alternative of the simpler *tp_call*.

This field is only used if the flag *Py_TPFLAGS_HAVE_VECTORCALL* is set. If so, this must be a positive integer containing the offset in the instance of a *vectorcallfunc* pointer.

The *vectorcallfunc* pointer may be NULL, in which case the instance behaves as if *Py_TPFLAGS_HAVE_VECTORCALL* was not set: calling the instance falls back to *tp_call*.

Any class that sets Py_TPFLAGS_HAVE_VECTORCALL must also set *tp_call* and make sure its behaviour is consistent with the *vectorcallfunc* function. This can be done by setting *tp_call* to *PyVectorcall_Call()*.

> **警告:** It is not recommended for *mutable heap types* to implement the vectorcall protocol. When a user sets `__call__` in Python code, only *tp_call* is updated, likely making it inconsistent with the vectorcall function.

在 3.8 版更改: Before version 3.8, this slot was named tp_print. In Python 2.x, it was used for printing to a file. In Python 3.0 to 3.7, it was unused.

继承:

This field is always inherited. However, the *Py_TPFLAGS_HAVE_VECTORCALL* flag is not always inherited. If it's not, then the subclass won't use *vectorcall*, except when *PyVectorcall_Call()* is explicitly called. This is in particular the case for types without the *Py_TPFLAGS_IMMUTABLETYPE* flag set (including subclasses defined in Python).

getattrfunc *PyTypeObject*.**tp_getattr**

An optional pointer to the get-attribute-string function.

This field is deprecated. When it is defined, it should point to a function that acts the same as the *tp_getattro* function, but taking a C string instead of a Python string object to give the attribute name.

继承:

分组: tp_getattr, tp_getattro

This field is inherited by subtypes together with *tp_getattro*: a subtype inherits both *tp_getattr* and *tp_getattro* from its base type when the subtype's *tp_getattr* and *tp_getattro* are both NULL.

setattrfunc *PyTypeObject*.**tp_setattr**

An optional pointer to the function for setting and deleting attributes.

This field is deprecated. When it is defined, it should point to a function that acts the same as the *tp_setattro* function, but taking a C string instead of a Python string object to give the attribute name.

继承:

Group: tp_setattr, tp_setattro

This field is inherited by subtypes together with *tp_setattro*: a subtype inherits both *tp_setattr* and *tp_setattro* from its base type when the subtype's *tp_setattr* and *tp_setattro* are both NULL.

PyAsyncMethods **PyTypeObject*.tp_as_async**

Pointer to an additional structure that contains fields relevant only to objects which implement *awaitable* and *asynchronous iterator* protocols at the C-level. See *Async Object Structures* for details.

3.5 新版功能: Formerly known as `tp_compare` and `tp_reserved`.

继承:

The `tp_as_async` field is not inherited, but the contained fields are inherited individually.

reprfunc **PyTypeObject.tp_repr**

An optional pointer to a function that implements the built-in function `repr()`.

The signature is the same as for `PyObject_Repr()`:

```
PyObject *tp_repr(PyObject *self);
```

The function must return a string or a Unicode object. Ideally, this function should return a string that, when passed to `eval()`, given a suitable environment, returns an object with the same value. If this is not feasible, it should return a string starting with `'<'` and ending with `'>'` from which both the type and the value of the object can be deduced.

继承:

此字段会被子类型继承。

默认:

When this field is not set, a string of the form `<%s object at %p>` is returned, where `%s` is replaced by the type name, and `%p` by the object's memory address.

PyNumberMethods **PyTypeObject*.tp_as_number**

Pointer to an additional structure that contains fields relevant only to objects which implement the number protocol. These fields are documented in *Number Object Structures*.

继承:

The `tp_as_number` field is not inherited, but the contained fields are inherited individually.

PySequenceMethods **PyTypeObject*.tp_as_sequence**

Pointer to an additional structure that contains fields relevant only to objects which implement the sequence protocol. These fields are documented in *Sequence Object Structures*.

继承:

The `tp_as_sequence` field is not inherited, but the contained fields are inherited individually.

PyMappingMethods **PyTypeObject*.tp_as_mapping**

Pointer to an additional structure that contains fields relevant only to objects which implement the mapping protocol. These fields are documented in *Mapping Object Structures*.

继承:

The `tp_as_mapping` field is not inherited, but the contained fields are inherited individually.

hashfunc **PyTypeObject.tp_hash**

An optional pointer to a function that implements the built-in function `hash()`.

The signature is the same as for `PyObject_Hash()`:

```
Py_hash_t tp_hash(PyObject *);
```

The value `-1` should not be returned as a normal return value; when an error occurs during the computation of the hash value, the function should set an exception and return `-1`.

When this field is not set (*and* `tp_richcompare` is not set), an attempt to take the hash of the object raises `TypeError`. This is the same as setting it to `PyObject_HashNotImplemented()`.

This field can be set explicitly to *PyObject_HashNotImplemented()* to block inheritance of the hash method from a parent type. This is interpreted as the equivalent of `__hash__ = None` at the Python level, causing `isinstance(o, collections.Hashable)` to correctly return `False`. Note that the converse is also true - setting `__hash__ = None` on a class at the Python level will result in the `tp_hash` slot being set to *PyObject_HashNotImplemented()*.

继承：

Group: `tp_hash`, `tp_richcompare`

This field is inherited by subtypes together with *tp_richcompare*: a subtype inherits both of *tp_richcompare* and *tp_hash*, when the subtype's *tp_richcompare* and *tp_hash* are both `NULL`.

ternaryfunc PyTypeObject.**tp_call**

An optional pointer to a function that implements calling the object. This should be `NULL` if the object is not callable. The signature is the same as for *PyObject_Call()*:

```
PyObject *tp_call(PyObject *self, PyObject *args, PyObject *kwargs);
```

继承：

此字段会被子类型继承。

reprfunc PyTypeObject.**tp_str**

An optional pointer to a function that implements the built-in operation `str()`. (Note that `str` is a type now, and `str()` calls the constructor for that type. This constructor calls *PyObject_Str()* to do the actual work, and *PyObject_Str()* will call this handler.)

The signature is the same as for *PyObject_Str()*:

```
PyObject *tp_str(PyObject *self);
```

The function must return a string or a Unicode object. It should be a "friendly" string representation of the object, as this is the representation that will be used, among other things, by the `print()` function.

继承：

此字段会被子类型继承。

默认：

When this field is not set, *PyObject_Repr()* is called to return a string representation.

getattrofunc PyTypeObject.**tp_getattro**

An optional pointer to the get-attribute function.

The signature is the same as for *PyObject_GetAttr()*:

```
PyObject *tp_getattro(PyObject *self, PyObject *attr);
```

It is usually convenient to set this field to *PyObject_GenericGetAttr()*, which implements the normal way of looking for object attributes.

继承：

分组: `tp_getattr`, `tp_getattro`

This field is inherited by subtypes together with *tp_getattr*: a subtype inherits both *tp_getattr* and *tp_getattro* from its base type when the subtype's *tp_getattr* and *tp_getattro* are both `NULL`.

默认：

`PyBaseObject_Type` uses *PyObject_GenericGetAttr()*.

setattrofunc PyTypeObject.**tp_setattro**

An optional pointer to the function for setting and deleting attributes.

The signature is the same as for *PyObject_SetAttr()*:

```
int tp_setattro(PyObject *self, PyObject *attr, PyObject *value);
```

In addition, setting *value* to NULL to delete an attribute must be supported. It is usually convenient to set this field to *PyObject_GenericSetAttr()*, which implements the normal way of setting object attributes.

继承:

Group: tp_setattr, tp_setattro

This field is inherited by subtypes together with *tp_setattr*: a subtype inherits both *tp_setattr* and *tp_setattro* from its base type when the subtype's *tp_setattr* and *tp_setattro* are both NULL.

默认:

PyBaseObject_Type 使用*PyObject_GenericSetAttr()*.

PyBufferProcs **PyTypeObject*.**tp_as_buffer**

Pointer to an additional structure that contains fields relevant only to objects which implement the buffer interface. These fields are documented in *Buffer Object Structures*.

继承:

The *tp_as_buffer* field is not inherited, but the contained fields are inherited individually.

unsigned long *PyTypeObject*.**tp_flags**

This field is a bit mask of various flags. Some flags indicate variant semantics for certain situations; others are used to indicate that certain fields in the type object (or in the extension structures referenced via *tp_as_number*, *tp_as_sequence*, *tp_as_mapping*, and *tp_as_buffer*) that were historically not always present are valid; if such a flag bit is clear, the type fields it guards must not be accessed and must be considered to have a zero or NULL value instead.

继承:

Inheritance of this field is complicated. Most flag bits are inherited individually, i.e. if the base type has a flag bit set, the subtype inherits this flag bit. The flag bits that pertain to extension structures are strictly inherited if the extension structure is inherited, i.e. the base type's value of the flag bit is copied into the subtype together with a pointer to the extension structure. The *Py_TPFLAGS_HAVE_GC* flag bit is inherited together with the *tp_traverse* and *tp_clear* fields, i.e. if the *Py_TPFLAGS_HAVE_GC* flag bit is clear in the subtype and the *tp_traverse* and *tp_clear* fields in the subtype exist and have NULL values.

默认:

PyBaseObject_Type uses Py_TPFLAGS_DEFAULT | Py_TPFLAGS_BASETYPE.

Bit Masks:

The following bit masks are currently defined; these can be ORed together using the | operator to form the value of the *tp_flags* field. The macro *PyType_HasFeature()* takes a type and a flags value, *tp* and *f*, and checks whether tp->tp_flags & f is non-zero.

Py_TPFLAGS_HEAPTYPE

This bit is set when the type object itself is allocated on the heap, for example, types created dynamically using *PyType_FromSpec()*. In this case, the ob_type field of its instances is considered a reference to the type, and the type object is INCREF'ed when a new instance is created, and DECREF'ed when an instance is destroyed (this does not apply to instances of subtypes; only the type referenced by the instance's ob_type gets INCREF'ed or DECREF'ed).

继承:

???

Py_TPFLAGS_BASETYPE

This bit is set when the type can be used as the base type of another type. If this bit is clear, the type cannot be subtyped (similar to a "final" class in Java).

继承:

???

Py_TPFLAGS_READY

This bit is set when the type object has been fully initialized by *PyType_Ready()*.

继承：

???

Py_TPFLAGS_READYING

This bit is set while *PyType_Ready()* is in the process of initializing the type object.

继承：

???

Py_TPFLAGS_HAVE_GC

This bit is set when the object supports garbage collection. If this bit is set, instances must be created using *PyObject_GC_New()* and destroyed using *PyObject_GC_Del()*. More information in section 使对象类型支持循环垃圾回收. This bit also implies that the GC-related fields *tp_traverse* and *tp_clear* are present in the type object.

继承：

Group: *Py_TPFLAGS_HAVE_GC*, `tp_traverse`, `tp_clear`

The *Py_TPFLAGS_HAVE_GC* flag bit is inherited together with the `tp_traverse` and `tp_clear` fields, i.e. if the *Py_TPFLAGS_HAVE_GC* flag bit is clear in the subtype and the `tp_traverse` and `tp_clear` fields in the subtype exist and have `NULL` values.

Py_TPFLAGS_DEFAULT

This is a bitmask of all the bits that pertain to the existence of certain fields in the type object and its extension structures. Currently, it includes the following bits: `Py_TPFLAGS_HAVE_STACKLESS_EXTENSION`.

继承：

???

Py_TPFLAGS_METHOD_DESCRIPTOR

This bit indicates that objects behave like unbound methods.

If this flag is set for `type(meth)`, then:

- `meth.__get__(obj, cls)(*args, **kwds)` (with `obj` not None) must be equivalent to `meth(obj, *args, **kwds)`.
- `meth.__get__(None, cls)(*args, **kwds)` must be equivalent to `meth(*args, **kwds)`.

This flag enables an optimization for typical method calls like `obj.meth()`: it avoids creating a temporary "bound method" object for `obj.meth`.

3.8 新版功能.

继承：

This flag is never inherited by types without the *Py_TPFLAGS_IMMUTABLETYPE* flag set. For extension types, it is inherited whenever *tp_descr_get* is inherited.

Py_TPFLAGS_LONG_SUBCLASS

Py_TPFLAGS_LIST_SUBCLASS

Py_TPFLAGS_TUPLE_SUBCLASS

Py_TPFLAGS_BYTES_SUBCLASS

Py_TPFLAGS_UNICODE_SUBCLASS

Py_TPFLAGS_DICT_SUBCLASS

Py_TPFLAGS_BASE_EXC_SUBCLASS

Py_TPFLAGS_TYPE_SUBCLASS

These flags are used by functions such as `PyLong_Check()` to quickly determine if a type is a subclass of a built-in type; such specific checks are faster than a generic check, like `PyObject_IsInstance()`. Custom types that inherit from built-ins should have their `tp_flags` set appropriately, or the code that interacts with such types will behave differently depending on what kind of check is used.

Py_TPFLAGS_HAVE_FINALIZE

This bit is set when the `tp_finalize` slot is present in the type structure.

3.4 新版功能.

3.8 版后已移除: This flag isn't necessary anymore, as the interpreter assumes the `tp_finalize` slot is always present in the type structure.

Py_TPFLAGS_HAVE_VECTORCALL

This bit is set when the class implements the *vectorcall protocol*. See `tp_vectorcall_offset` for details.

继承：

This bit is inherited for types with the `Py_TPFLAGS_IMMUTABLETYPE` flag set, if `tp_call` is also inherited.

3.9 新版功能.

Py_TPFLAGS_IMMUTABLETYPE

This bit is set for type objects that are immutable: type attributes cannot be set nor deleted.

`PyType_Ready()` automatically applies this flag to *static types*.

继承：

This flag is not inherited.

3.10 新版功能.

Py_TPFLAGS_DISALLOW_INSTANTIATION

Disallow creating instances of the type: set `tp_new` to NULL and don't create the `__new__` key in the type dictionary.

The flag must be set before creating the type, not after. For example, it must be set before `PyType_Ready()` is called on the type.

The flag is set automatically on *static types* if `tp_base` is NULL or `&PyBaseObject_Type` and `tp_new` is NULL.

继承：

This flag is not inherited. However, subclasses will not be instantiable unless they provide a non-NULL `tp_new` (which is only possible via the C API).

备注： To disallow instantiating a class directly but allow instantiating its subclasses (e.g. for an *abstract base class*), do not use this flag. Instead, make `tp_new` only succeed for subclasses.

3.10 新版功能.

Py_TPFLAGS_MAPPING

This bit indicates that instances of the class may match mapping patterns when used as the subject of a `match` block. It is automatically set when registering or subclassing `collections.abc.Mapping`, and unset when registering `collections.abc.Sequence`.

备注： *Py_TPFLAGS_MAPPING* and *Py_TPFLAGS_SEQUENCE* are mutually exclusive; it is an error to enable both flags simultaneously.

继承：

This flag is inherited by types that do not already set *Py_TPFLAGS_SEQUENCE*.

参见：

PEP 634 ——结构化模式匹配：规范

3.10 新版功能.

Py_TPFLAGS_SEQUENCE

This bit indicates that instances of the class may match sequence patterns when used as the subject of a `match` block. It is automatically set when registering or subclassing `collections.abc.Sequence`, and unset when registering `collections.abc.Mapping`.

备注： *Py_TPFLAGS_MAPPING* and *Py_TPFLAGS_SEQUENCE* are mutually exclusive; it is an error to enable both flags simultaneously.

继承：

This flag is inherited by types that do not already set *Py_TPFLAGS_MAPPING*.

参见：

PEP 634 ——结构化模式匹配：规范

3.10 新版功能.

const char **PyTypeObject*.**tp_doc**

An optional pointer to a NUL-terminated C string giving the docstring for this type object. This is exposed as the `__doc__` attribute on the type and instances of the type.

继承：

This field is *not* inherited by subtypes.

traverseproc *PyTypeObject*.**tp_traverse**

An optional pointer to a traversal function for the garbage collector. This is only used if the *Py_TPFLAGS_HAVE_GC* flag bit is set. The signature is:

```
int tp_traverse(PyObject *self, visitproc visit, void *arg);
```

More information about Python's garbage collection scheme can be found in section 使对象类型支持循环垃圾回收.

The *tp_traverse* pointer is used by the garbage collector to detect reference cycles. A typical implementation of a *tp_traverse* function simply calls *Py_VISIT()* on each of the instance's members that are Python objects that the instance owns. For example, this is function `local_traverse()` from the `_thread` extension module:

```
static int
local_traverse(localobject *self, visitproc visit, void *arg)
{
    Py_VISIT(self->args);
```

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```
    Py_VISIT(self->kw);
    Py_VISIT(self->dict);
    return 0;
}
```

Note that *Py_VISIT()* is called only on those members that can participate in reference cycles. Although there is also a `self->key` member, it can only be `NULL` or a Python string and therefore cannot be part of a reference cycle.

On the other hand, even if you know a member can never be part of a cycle, as a debugging aid you may want to visit it anyway just so the `gc` module's `get_referents()` function will include it.

> **警告:** When implementing *tp_traverse*, only the members that the instance *owns* (by having *strong references* to them) must be visited. For instance, if an object supports weak references via the *tp_weaklist* slot, the pointer supporting the linked list (what *tp_weaklist* points to) must **not** be visited as the instance does not directly own the weak references to itself (the weakreference list is there to support the weak reference machinery, but the instance has no strong reference to the elements inside it, as they are allowed to be removed even if the instance is still alive).

Note that *Py_VISIT()* requires the *visit* and *arg* parameters to `local_traverse()` to have these specific names; don't name them just anything.

Instances of *heap-allocated types* hold a reference to their type. Their traversal function must therefore either visit *Py_TYPE(self)*, or delegate this responsibility by calling `tp_traverse` of another heap-allocated type (such as a heap-allocated superclass). If they do not, the type object may not be garbage-collected.

在 3.9 版更改: Heap-allocated types are expected to visit `Py_TYPE(self)` in `tp_traverse`. In earlier versions of Python, due to bug 40217, doing this may lead to crashes in subclasses.

继承:

Group: *Py_TPFLAGS_HAVE_GC*, `tp_traverse`, `tp_clear`

This field is inherited by subtypes together with *tp_clear* and the *Py_TPFLAGS_HAVE_GC* flag bit: the flag bit, *tp_traverse*, and *tp_clear* are all inherited from the base type if they are all zero in the subtype.

inquiry `PyTypeObject`.**tp_clear**

An optional pointer to a clear function for the garbage collector. This is only used if the *Py_TPFLAGS_HAVE_GC* flag bit is set. The signature is:

```
int tp_clear(PyObject *);
```

The *tp_clear* member function is used to break reference cycles in cyclic garbage detected by the garbage collector. Taken together, all *tp_clear* functions in the system must combine to break all reference cycles. This is subtle, and if in any doubt supply a *tp_clear* function. For example, the tuple type does not implement a *tp_clear* function, because it's possible to prove that no reference cycle can be composed entirely of tuples. Therefore the *tp_clear* functions of other types must be sufficient to break any cycle containing a tuple. This isn't immediately obvious, and there's rarely a good reason to avoid implementing *tp_clear*.

Implementations of *tp_clear* should drop the instance's references to those of its members that may be Python objects, and set its pointers to those members to `NULL`, as in the following example:

```
static int
local_clear(localobject *self)
{
    Py_CLEAR(self->key);
    Py_CLEAR(self->args);
    Py_CLEAR(self->kw);
    Py_CLEAR(self->dict);
```

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```
    return 0;
}
```

The *Py_CLEAR()* macro should be used, because clearing references is delicate: the reference to the contained object must not be decremented until after the pointer to the contained object is set to NULL. This is because decrementing the reference count may cause the contained object to become trash, triggering a chain of reclamation activity that may include invoking arbitrary Python code (due to finalizers, or weakref callbacks, associated with the contained object). If it's possible for such code to reference *self* again, it's important that the pointer to the contained object be NULL at that time, so that *self* knows the contained object can no longer be used. The *Py_CLEAR()* macro performs the operations in a safe order.

Note that *tp_clear* is not *always* called before an instance is deallocated. For example, when reference counting is enough to determine that an object is no longer used, the cyclic garbage collector is not involved and *tp_dealloc* is called directly.

Because the goal of *tp_clear* functions is to break reference cycles, it's not necessary to clear contained objects like Python strings or Python integers, which can't participate in reference cycles. On the other hand, it may be convenient to clear all contained Python objects, and write the type's *tp_dealloc* function to invoke *tp_clear*.

More information about Python's garbage collection scheme can be found in section 使对象类型支持循环垃圾回收.

继承：

Group: *Py_TPFLAGS_HAVE_GC*, tp_traverse, tp_clear

This field is inherited by subtypes together with *tp_traverse* and the *Py_TPFLAGS_HAVE_GC* flag bit: the flag bit, *tp_traverse*, and *tp_clear* are all inherited from the base type if they are all zero in the subtype.

richcmpfunc *PyTypeObject*.**tp_richcompare**

An optional pointer to the rich comparison function, whose signature is:

```
PyObject *tp_richcompare(PyObject *self, PyObject *other, int op);
```

The first parameter is guaranteed to be an instance of the type that is defined by *PyTypeObject*.

The function should return the result of the comparison (usually Py_True or Py_False). If the comparison is undefined, it must return Py_NotImplemented, if another error occurred it must return NULL and set an exception condition.

The following constants are defined to be used as the third argument for *tp_richcompare* and for *PyObject_RichCompare()*:

常量	对照
Py_LT	<
Py_LE	<=
Py_EQ	==
Py_NE	!=
Py_GT	>
Py_GE	>=

定义以下宏是为了简化编写丰富的比较函数：

Py_RETURN_RICHCOMPARE(VAL_A, VAL_B, op)

Return Py_True or Py_False from the function, depending on the result of a comparison. VAL_A and VAL_B must be orderable by C comparison operators (for example, they may be C ints or floats). The third argument specifies the requested operation, as for *PyObject_RichCompare()*.

The return value's reference count is properly incremented.

On error, sets an exception and returns `NULL` from the function.

3.7 新版功能.

继承：

Group: `tp_hash`, `tp_richcompare`

This field is inherited by subtypes together with *tp_hash*: a subtype inherits *tp_richcompare* and *tp_hash* when the subtype's *tp_richcompare* and *tp_hash* are both `NULL`.

默认：

`PyBaseObject_Type` provides a `tp_richcompare` implementation, which may be inherited. However, if only `tp_hash` is defined, not even the inherited function is used and instances of the type will not be able to participate in any comparisons.

Py_ssize_t *PyTypeObject*.**tp_weaklistoffset**

If the instances of this type are weakly referenceable, this field is greater than zero and contains the offset in the instance structure of the weak reference list head (ignoring the GC header, if present); this offset is used by `PyObject_ClearWeakRefs()` and the `PyWeakref_*` functions. The instance structure needs to include a field of type *PyObject** which is initialized to `NULL`.

Do not confuse this field with *tp_weaklist*; that is the list head for weak references to the type object itself.

继承：

This field is inherited by subtypes, but see the rules listed below. A subtype may override this offset; this means that the subtype uses a different weak reference list head than the base type. Since the list head is always found via *tp_weaklistoffset*, this should not be a problem.

When a type defined by a class statement has no `__slots__` declaration, and none of its base types are weakly referenceable, the type is made weakly referenceable by adding a weak reference list head slot to the instance layout and setting the *tp_weaklistoffset* of that slot's offset.

When a type's `__slots__` declaration contains a slot named `__weakref__`, that slot becomes the weak reference list head for instances of the type, and the slot's offset is stored in the type's *tp_weaklistoffset*.

When a type's `__slots__` declaration does not contain a slot named `__weakref__`, the type inherits its *tp_weaklistoffset* from its base type.

getiterfunc *PyTypeObject*.**tp_iter**

An optional pointer to a function that returns an *iterator* for the object. Its presence normally signals that the instances of this type are *iterable* (although sequences may be iterable without this function).

This function has the same signature as *PyObject_GetIter()*:

```
PyObject *tp_iter(PyObject *self);
```

继承：

此字段会被子类型继承。

iternextfunc *PyTypeObject*.**tp_iternext**

An optional pointer to a function that returns the next item in an *iterator*. The signature is:

```
PyObject *tp_iternext(PyObject *self);
```

When the iterator is exhausted, it must return `NULL`; a `StopIteration` exception may or may not be set. When another error occurs, it must return `NULL` too. Its presence signals that the instances of this type are iterators.

Iterator types should also define the *tp_iter* function, and that function should return the iterator instance itself (not a new iterator instance).

This function has the same signature as *PyIter_Next()*.

继承：

此字段会被子类型继承。

struct *PyMethodDef* *`PyTypeObject`**.tp_methods**

An optional pointer to a static `NULL`-terminated array of `PyMethodDef` structures, declaring regular methods of this type.

For each entry in the array, an entry is added to the type's dictionary (see `tp_dict` below) containing a method descriptor.

继承：

This field is not inherited by subtypes (methods are inherited through a different mechanism).

struct *PyMemberDef* *`PyTypeObject`**.tp_members**

An optional pointer to a static `NULL`-terminated array of `PyMemberDef` structures, declaring regular data members (fields or slots) of instances of this type.

For each entry in the array, an entry is added to the type's dictionary (see `tp_dict` below) containing a member descriptor.

继承：

This field is not inherited by subtypes (members are inherited through a different mechanism).

struct *PyGetSetDef* *`PyTypeObject`**.tp_getset**

An optional pointer to a static `NULL`-terminated array of `PyGetSetDef` structures, declaring computed attributes of instances of this type.

For each entry in the array, an entry is added to the type's dictionary (see `tp_dict` below) containing a getset descriptor.

继承：

This field is not inherited by subtypes (computed attributes are inherited through a different mechanism).

PyTypeObject *`PyTypeObject`**.tp_base**

An optional pointer to a base type from which type properties are inherited. At this level, only single inheritance is supported; multiple inheritance require dynamically creating a type object by calling the metatype.

备注： Slot initialization is subject to the rules of initializing globals. C99 requires the initializers to be "address constants". Function designators like `PyType_GenericNew()`, with implicit conversion to a pointer, are valid C99 address constants.

However, the unary '&' operator applied to a non-static variable like `PyBaseObject_Type()` is not required to produce an address constant. Compilers may support this (gcc does), MSVC does not. Both compilers are strictly standard conforming in this particular behavior.

Consequently, `tp_base` should be set in the extension module's init function.

继承：

This field is not inherited by subtypes (obviously).

默认：

This field defaults to `&PyBaseObject_Type` (which to Python programmers is known as the type `object`).

PyObject *`PyTypeObject`**.tp_dict**

The type's dictionary is stored here by `PyType_Ready()`.

This field should normally be initialized to `NULL` before PyType_Ready is called; it may also be initialized to a dictionary containing initial attributes for the type. Once `PyType_Ready()` has initialized the type, extra attributes for the type may be added to this dictionary only if they don't correspond to overloaded operations (like `__add__()`).

继承：

This field is not inherited by subtypes (though the attributes defined in here are inherited through a different mechanism).

默认：

If this field is NULL, *PyType_Ready()* will assign a new dictionary to it.

> **警告：** It is not safe to use *PyDict_SetItem()* on or otherwise modify *tp_dict* with the dictionary C-API.

descrgetfunc *PyTypeObject*.**tp_descr_get**

An optional pointer to a "descriptor get" function.

The function signature is:

```
PyObject * tp_descr_get(PyObject *self, PyObject *obj, PyObject *type);
```

继承：

此字段会被子类型继承。

descrsetfunc *PyTypeObject*.**tp_descr_set**

An optional pointer to a function for setting and deleting a descriptor's value.

The function signature is:

```
int tp_descr_set(PyObject *self, PyObject *obj, PyObject *value);
```

The *value* argument is set to NULL to delete the value.

继承：

此字段会被子类型继承。

Py_ssize_t *PyTypeObject*.**tp_dictoffset**

If the instances of this type have a dictionary containing instance variables, this field is non-zero and contains the offset in the instances of the type of the instance variable dictionary; this offset is used by *PyObject_GenericGetAttr()*.

Do not confuse this field with *tp_dict*; that is the dictionary for attributes of the type object itself.

If the value of this field is greater than zero, it specifies the offset from the start of the instance structure. If the value is less than zero, it specifies the offset from the *end* of the instance structure. A negative offset is more expensive to use, and should only be used when the instance structure contains a variable-length part. This is used for example to add an instance variable dictionary to subtypes of str or tuple. Note that the *tp_basicsize* field should account for the dictionary added to the end in that case, even though the dictionary is not included in the basic object layout. On a system with a pointer size of 4 bytes, *tp_dictoffset* should be set to -4 to indicate that the dictionary is at the very end of the structure.

The *tp_dictoffset* should be regarded as write-only. To get the pointer to the dictionary call *PyObject_GenericGetDict()*. Calling *PyObject_GenericGetDict()* may need to allocate memory for the dictionary, so it is may be more efficient to call *PyObject_GetAttr()* when accessing an attribute on the object.

继承：

This field is inherited by subtypes, but see the rules listed below. A subtype may override this offset; this means that the subtype instances store the dictionary at a difference offset than the base type. Since the dictionary is always found via *tp_dictoffset*, this should not be a problem.

When a type defined by a class statement has no __slots__ declaration, and none of its base types has an instance variable dictionary, a dictionary slot is added to the instance layout and the *tp_dictoffset* is set to that slot's offset.

When a type defined by a class statement has a `__slots__` declaration, the type inherits its *tp_dictoffset* from its base type.

(Adding a slot named `__dict__` to the `__slots__` declaration does not have the expected effect, it just causes confusion. Maybe this should be added as a feature just like `__weakref__` though.)

默认：

This slot has no default. For *static types*, if the field is `NULL` then no `__dict__` gets created for instances.

initproc *PyTypeObject*.**tp_init**

An optional pointer to an instance initialization function.

This function corresponds to the `__init__()` method of classes. Like `__init__()`, it is possible to create an instance without calling `__init__()`, and it is possible to reinitialize an instance by calling its `__init__()` method again.

The function signature is:

```
int tp_init(PyObject *self, PyObject *args, PyObject *kwds);
```

The self argument is the instance to be initialized; the *args* and *kwds* arguments represent positional and keyword arguments of the call to `__init__()`.

The *tp_init* function, if not `NULL`, is called when an instance is created normally by calling its type, after the type's *tp_new* function has returned an instance of the type. If the *tp_new* function returns an instance of some other type that is not a subtype of the original type, no *tp_init* function is called; if *tp_new* returns an instance of a subtype of the original type, the subtype's *tp_init* is called.

Returns `0` on success, `-1` and sets an exception on error.

继承：

此字段会被子类型继承。

默认：

For *static types* this field does not have a default.

allocfunc *PyTypeObject*.**tp_alloc**

An optional pointer to an instance allocation function.

The function signature is:

```
PyObject *tp_alloc(PyTypeObject *self, Py_ssize_t nitems);
```

继承：

This field is inherited by static subtypes, but not by dynamic subtypes (subtypes created by a class statement).

默认：

For dynamic subtypes, this field is always set to *PyType_GenericAlloc()*, to force a standard heap allocation strategy.

For static subtypes, `PyBaseObject_Type` uses *PyType_GenericAlloc()*. That is the recommended value for all statically defined types.

newfunc *PyTypeObject*.**tp_new**

An optional pointer to an instance creation function.

The function signature is:

```
PyObject *tp_new(PyTypeObject *subtype, PyObject *args, PyObject *kwds);
```

The *subtype* argument is the type of the object being created; the *args* and *kwds* arguments represent positional and keyword arguments of the call to the type. Note that *subtype* doesn't have to equal the type whose *tp_new* function is called; it may be a subtype of that type (but not an unrelated type).

The *tp_new* function should call `subtype->tp_alloc(subtype, nitems)` to allocate space for the object, and then do only as much further initialization as is absolutely necessary. Initialization that can safely be ignored or repeated should be placed in the *tp_init* handler. A good rule of thumb is that for immutable types, all initialization should take place in *tp_new*, while for mutable types, most initialization should be deferred to *tp_init*.

Set the *Py_TPFLAGS_DISALLOW_INSTANTIATION* flag to disallow creating instances of the type in Python.

继承：

This field is inherited by subtypes, except it is not inherited by *static types* whose *tp_base* is `NULL` or `&PyBaseObject_Type`.

默认：

For *static types* this field has no default. This means if the slot is defined as `NULL`, the type cannot be called to create new instances; presumably there is some other way to create instances, like a factory function.

freefunc *PyTypeObject*.**tp_free**

An optional pointer to an instance deallocation function. Its signature is:

```
void tp_free(void *self);
```

An initializer that is compatible with this signature is *PyObject_Free()*.

继承：

This field is inherited by static subtypes, but not by dynamic subtypes (subtypes created by a class statement)

默认：

In dynamic subtypes, this field is set to a deallocator suitable to match *PyType_GenericAlloc()* and the value of the *Py_TPFLAGS_HAVE_GC* flag bit.

For static subtypes, `PyBaseObject_Type` uses PyObject_Del.

inquiry *PyTypeObject*.**tp_is_gc**

An optional pointer to a function called by the garbage collector.

The garbage collector needs to know whether a particular object is collectible or not. Normally, it is sufficient to look at the object's type's *tp_flags* field, and check the *Py_TPFLAGS_HAVE_GC* flag bit. But some types have a mixture of statically and dynamically allocated instances, and the statically allocated instances are not collectible. Such types should define this function; it should return `1` for a collectible instance, and `0` for a non-collectible instance. The signature is:

```
int tp_is_gc(PyObject *self);
```

(The only example of this are types themselves. The metatype, *PyType_Type*, defines this function to distinguish between statically and *dynamically allocated types*.)

继承：

此字段会被子类型继承。

默认：

This slot has no default. If this field is `NULL`, *Py_TPFLAGS_HAVE_GC* is used as the functional equivalent.

PyObject **PyTypeObject*.**tp_bases**

Tuple of base types.

This field should be set to `NULL` and treated as read-only. Python will fill it in when the type is *initialized*.

For dynamically created classes, the `Py_tp_bases` *slot* can be used instead of the *bases* argument of *PyType_FromSpecWithBases()*. The argument form is preferred.

> **警告：** Multiple inheritance does not work well for statically defined types. If you set tp_bases to a tuple, Python will not raise an error, but some slots will only be inherited from the first base.

继承：

This field is not inherited.

PyObject **PyTypeObject*.**tp_mro**

Tuple containing the expanded set of base types, starting with the type itself and ending with object, in Method Resolution Order.

This field should be set to NULL and treated as read-only. Python will fill it in when the type is *initialized*.

继承：

This field is not inherited; it is calculated fresh by *PyType_Ready()*.

PyObject **PyTypeObject*.**tp_cache**

Unused. Internal use only.

继承：

This field is not inherited.

PyObject **PyTypeObject*.**tp_subclasses**

List of weak references to subclasses. Internal use only.

继承：

This field is not inherited.

PyObject **PyTypeObject*.**tp_weaklist**

Weak reference list head, for weak references to this type object. Not inherited. Internal use only.

继承：

This field is not inherited.

destructor *PyTypeObject*.**tp_del**

This field is deprecated. Use *tp_finalize* instead.

unsigned int *PyTypeObject*.**tp_version_tag**

Used to index into the method cache. Internal use only.

继承：

This field is not inherited.

destructor *PyTypeObject*.**tp_finalize**

An optional pointer to an instance finalization function. Its signature is:

```
void tp_finalize(PyObject *self);
```

If *tp_finalize* is set, the interpreter calls it once when finalizing an instance. It is called either from the garbage collector (if the instance is part of an isolated reference cycle) or just before the object is deallocated. Either way, it is guaranteed to be called before attempting to break reference cycles, ensuring that it finds the object in a sane state.

tp_finalize should not mutate the current exception status; therefore, a recommended way to write a non-trivial finalizer is:

```
static void
local_finalize(PyObject *self)
{
    PyObject *error_type, *error_value, *error_traceback;
```

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```
    /* Save the current exception, if any. */
    PyErr_Fetch(&error_type, &error_value, &error_traceback);

    /* ... */

    /* Restore the saved exception. */
    PyErr_Restore(error_type, error_value, error_traceback);
}
```

Also, note that, in a garbage collected Python, `tp_dealloc` may be called from any Python thread, not just the thread which created the object (if the object becomes part of a refcount cycle, that cycle might be collected by a garbage collection on any thread). This is not a problem for Python API calls, since the thread on which tp_dealloc is called will own the Global Interpreter Lock (GIL). However, if the object being destroyed in turn destroys objects from some other C or C++ library, care should be taken to ensure that destroying those objects on the thread which called tp_dealloc will not violate any assumptions of the library.

继承：

此字段会被子类型继承。

3.4 新版功能.

在 3.8 版更改: Before version 3.8 it was necessary to set the `Py_TPFLAGS_HAVE_FINALIZE` flags bit in order for this field to be used. This is no longer required.

参见:

"Safe object finalization" (**PEP 442**)

vectorcallfunc `PyTypeObject`.**`tp_vectorcall`**

Vectorcall function to use for calls of this type object. In other words, it is used to implement *vectorcall* for `type.__call__`. If `tp_vectorcall` is `NULL`, the default call implementation using `__new__` and `__init__` is used.

继承：

This field is never inherited.

3.9 新版功能: (the field exists since 3.8 but it's only used since 3.9)

12.3.6 Static Types

Traditionally, types defined in C code are *static*, that is, a static `PyTypeObject` structure is defined directly in code and initialized using `PyType_Ready()`.

This results in types that are limited relative to types defined in Python:

- Static types are limited to one base, i.e. they cannot use multiple inheritance.
- Static type objects (but not necessarily their instances) are immutable. It is not possible to add or modify the type object's attributes from Python.
- Static type objects are shared across *sub-interpreters*, so they should not include any subinterpreter-specific state.

Also, since `PyTypeObject` is only part of the *Limited API* as an opaque struct, any extension modules using static types must be compiled for a specific Python minor version.

12.3.7 Heap Types

An alternative to *static types* is *heap-allocated types*, or *heap types* for short, which correspond closely to classes created by Python's `class` statement. Heap types have the `Py_TPFLAGS_HEAPTYPE` flag set.

This is done by filling a `PyType_Spec` structure and calling `PyType_FromSpec()`, `PyType_FromSpecWithBases()`, or `PyType_FromModuleAndSpec()`.

12.4 Number Object Structures

type **`PyNumberMethods`**

This structure holds pointers to the functions which an object uses to implement the number protocol. Each function is used by the function of similar name documented in the 数字协议 section.

Here is the structure definition:

```
typedef struct {
     binaryfunc nb_add;
     binaryfunc nb_subtract;
     binaryfunc nb_multiply;
     binaryfunc nb_remainder;
     binaryfunc nb_divmod;
     ternaryfunc nb_power;
     unaryfunc nb_negative;
     unaryfunc nb_positive;
     unaryfunc nb_absolute;
     inquiry nb_bool;
     unaryfunc nb_invert;
     binaryfunc nb_lshift;
     binaryfunc nb_rshift;
     binaryfunc nb_and;
     binaryfunc nb_xor;
     binaryfunc nb_or;
     unaryfunc nb_int;
     void *nb_reserved;
     unaryfunc nb_float;

     binaryfunc nb_inplace_add;
     binaryfunc nb_inplace_subtract;
     binaryfunc nb_inplace_multiply;
     binaryfunc nb_inplace_remainder;
     ternaryfunc nb_inplace_power;
     binaryfunc nb_inplace_lshift;
     binaryfunc nb_inplace_rshift;
     binaryfunc nb_inplace_and;
     binaryfunc nb_inplace_xor;
     binaryfunc nb_inplace_or;

     binaryfunc nb_floor_divide;
     binaryfunc nb_true_divide;
     binaryfunc nb_inplace_floor_divide;
     binaryfunc nb_inplace_true_divide;

     unaryfunc nb_index;

     binaryfunc nb_matrix_multiply;
     binaryfunc nb_inplace_matrix_multiply;
} PyNumberMethods;
```

备注： Binary and ternary functions must check the type of all their operands, and implement the necessary conversions (at least one of the operands is an instance of the defined type). If the operation is not defined for the given operands, binary and ternary functions must return `Py_NotImplemented`, if another error occurred they must return `NULL` and set an exception.

备注： The *nb_reserved* field should always be `NULL`. It was previously called `nb_long`, and was renamed in Python 3.0.1.

---

binaryfunc *PyNumberMethods*.**nb_add**

binaryfunc *PyNumberMethods*.**nb_subtract**

binaryfunc *PyNumberMethods*.**nb_multiply**

binaryfunc *PyNumberMethods*.**nb_remainder**

binaryfunc *PyNumberMethods*.**nb_divmod**

ternaryfunc *PyNumberMethods*.**nb_power**

unaryfunc *PyNumberMethods*.**nb_negative**

unaryfunc *PyNumberMethods*.**nb_positive**

unaryfunc *PyNumberMethods*.**nb_absolute**

inquiry *PyNumberMethods*.**nb_bool**

unaryfunc *PyNumberMethods*.**nb_invert**

binaryfunc *PyNumberMethods*.**nb_lshift**

binaryfunc *PyNumberMethods*.**nb_rshift**

binaryfunc *PyNumberMethods*.**nb_and**

binaryfunc *PyNumberMethods*.**nb_xor**

binaryfunc *PyNumberMethods*.**nb_or**

unaryfunc *PyNumberMethods*.**nb_int**

void **PyNumberMethods*.**nb_reserved**

unaryfunc *PyNumberMethods*.**nb_float**

binaryfunc *PyNumberMethods*.**nb_inplace_add**

binaryfunc *PyNumberMethods*.**nb_inplace_subtract**

binaryfunc *PyNumberMethods*.**nb_inplace_multiply**

binaryfunc *PyNumberMethods*.**nb_inplace_remainder**

ternaryfunc *PyNumberMethods*.**nb_inplace_power**

binaryfunc *PyNumberMethods*.**nb_inplace_lshift**

binaryfunc *PyNumberMethods*.**nb_inplace_rshift**

binaryfunc *PyNumberMethods*.**nb_inplace_and**

binaryfunc *PyNumberMethods*.**nb_inplace_xor** *binaryfunc* *PyNumberMethods*.**nb_inplace_or**

binaryfunc *PyNumberMethods*.**nb_floor_divide**

binaryfunc *PyNumberMethods*.**nb_true_divide**

binaryfunc *PyNumberMethods*.**nb_inplace_floor_divide**

binaryfunc *PyNumberMethods*.**nb_inplace_true_divide**

unaryfunc *PyNumberMethods*.**nb_index**

binaryfunc *PyNumberMethods*.**nb_matrix_multiply**

binaryfunc *PyNumberMethods*.**nb_inplace_matrix_multiply**

12.5 Mapping Object Structures

type **PyMappingMethods**

This structure holds pointers to the functions which an object uses to implement the mapping protocol. It has three members:

lenfunc *PyMappingMethods*.**mp_length**

This function is used by *PyMapping_Size()* and *PyObject_Size()*, and has the same signature. This slot may be set to NULL if the object has no defined length.

binaryfunc *PyMappingMethods*.**mp_subscript**

This function is used by *PyObject_GetItem()* and *PySequence_GetSlice()*, and has the same signature as PyObject_GetItem(). This slot must be filled for the *PyMapping_Check()* function to return 1, it can be NULL otherwise.

objobjargproc *PyMappingMethods*.**mp_ass_subscript**

This function is used by *PyObject_SetItem()*, *PyObject_DelItem()*, PyObject_SetSlice() and PyObject_DelSlice(). It has the same signature as PyObject_SetItem(), but *v* can also be set to NULL to delete an item. If this slot is NULL, the object does not support item assignment and deletion.

12.6 Sequence Object Structures

type **PySequenceMethods**

This structure holds pointers to the functions which an object uses to implement the sequence protocol.

lenfunc *PySequenceMethods*.**sq_length**

This function is used by *PySequence_Size()* and *PyObject_Size()*, and has the same signature. It is also used for handling negative indices via the *sq_item* and the *sq_ass_item* slots.

binaryfunc *PySequenceMethods*.**sq_concat**

This function is used by *PySequence_Concat()* and has the same signature. It is also used by the + operator, after trying the numeric addition via the *nb_add* slot.

ssizeargfunc *PySequenceMethods*.**sq_repeat**

This function is used by *PySequence_Repeat()* and has the same signature. It is also used by the * operator, after trying numeric multiplication via the *nb_multiply* slot.

ssizeargfunc `PySequenceMethods`.**sq_item**

This function is used by `PySequence_GetItem()` and has the same signature. It is also used by `PyObject_GetItem()`, after trying the subscription via the `mp_subscript` slot. This slot must be filled for the `PySequence_Check()` function to return `1`, it can be `NULL` otherwise.

Negative indexes are handled as follows: if the `sq_length` slot is filled, it is called and the sequence length is used to compute a positive index which is passed to `sq_item`. If `sq_length` is `NULL`, the index is passed as is to the function.

ssizeobjargproc `PySequenceMethods`.**sq_ass_item**

This function is used by `PySequence_SetItem()` and has the same signature. It is also used by `PyObject_SetItem()` and `PyObject_DelItem()`, after trying the item assignment and deletion via the `mp_ass_subscript` slot. This slot may be left to `NULL` if the object does not support item assignment and deletion.

objobjproc `PySequenceMethods`.**sq_contains**

This function may be used by `PySequence_Contains()` and has the same signature. This slot may be left to `NULL`, in this case `PySequence_Contains()` simply traverses the sequence until it finds a match.

binaryfunc `PySequenceMethods`.**sq_inplace_concat**

This function is used by `PySequence_InPlaceConcat()` and has the same signature. It should modify its first operand, and return it. This slot may be left to `NULL`, in this case `PySequence_InPlaceConcat()` will fall back to `PySequence_Concat()`. It is also used by the augmented assignment `+=`, after trying numeric in-place addition via the `nb_inplace_add` slot.

ssizeargfunc `PySequenceMethods`.**sq_inplace_repeat**

This function is used by `PySequence_InPlaceRepeat()` and has the same signature. It should modify its first operand, and return it. This slot may be left to `NULL`, in this case `PySequence_InPlaceRepeat()` will fall back to `PySequence_Repeat()`. It is also used by the augmented assignment `*=`, after trying numeric in-place multiplication via the `nb_inplace_multiply` slot.

12.7 Buffer Object Structures

type **PyBufferProcs**

This structure holds pointers to the functions required by the *Buffer protocol*. The protocol defines how an exporter object can expose its internal data to consumer objects.

getbufferproc `PyBufferProcs`.**bf_getbuffer**

The signature of this function is:

```
int (PyObject *exporter, Py_buffer *view, int flags);
```

Handle a request to *exporter* to fill in *view* as specified by *flags*. Except for point (3), an implementation of this function MUST take these steps:

(1) Check if the request can be met. If not, raise `PyExc_BufferError`, set `view->obj` to `NULL` and return `-1`.

(2) Fill in the requested fields.

(3) Increment an internal counter for the number of exports.

(4) Set `view->obj` to *exporter* and increment `view->obj`.

(5) Return `0`.

If *exporter* is part of a chain or tree of buffer providers, two main schemes can be used:

- Re-export: Each member of the tree acts as the exporting object and sets `view->obj` to a new reference to itself.

- Redirect: The buffer request is redirected to the root object of the tree. Here, `view->obj` will be a new reference to the root object.

The individual fields of *view* are described in section *Buffer structure*, the rules how an exporter must react to specific requests are in section *Buffer request types*.

All memory pointed to in the `Py_buffer` structure belongs to the exporter and must remain valid until there are no consumers left. `format`, `shape`, `strides`, `suboffsets` and `internal` are read-only for the consumer.

`PyBuffer_FillInfo()` provides an easy way of exposing a simple bytes buffer while dealing correctly with all request types.

`PyObject_GetBuffer()` is the interface for the consumer that wraps this function.

releasebufferproc `PyBufferProcs`.**bf_releasebuffer**

The signature of this function is:

```
void (PyObject *exporter, Py_buffer *view);
```

Handle a request to release the resources of the buffer. If no resources need to be released, `PyBufferProcs.bf_releasebuffer` may be `NULL`. Otherwise, a standard implementation of this function will take these optional steps:

(1) Decrement an internal counter for the number of exports.

(2) If the counter is `0`, free all memory associated with *view*.

The exporter MUST use the `internal` field to keep track of buffer-specific resources. This field is guaranteed to remain constant, while a consumer MAY pass a copy of the original buffer as the *view* argument.

This function MUST NOT decrement `view->obj`, since that is done automatically in `PyBuffer_Release()` (this scheme is useful for breaking reference cycles).

`PyBuffer_Release()` is the interface for the consumer that wraps this function.

12.8 Async Object Structures

3.5 新版功能.

type **PyAsyncMethods**

This structure holds pointers to the functions required to implement *awaitable* and *asynchronous iterator* objects.

Here is the structure definition:

```
typedef struct {
    unaryfunc am_await;
    unaryfunc am_aiter;
    unaryfunc am_anext;
    sendfunc am_send;
} PyAsyncMethods;
```

unaryfunc `PyAsyncMethods`.**am_await**

The signature of this function is:

```
PyObject *am_await(PyObject *self);
```

The returned object must be an *iterator*, i.e. `PyIter_Check()` must return `1` for it.

This slot may be set to `NULL` if an object is not an *awaitable*.

unaryfunc `PyAsyncMethods.am_aiter`

The signature of this function is:

```
PyObject *am_aiter(PyObject *self);
```

必须返回一个*asynchronous iterator* 对象。请参阅 `__anext__()` 了解详情。

This slot may be set to `NULL` if an object does not implement asynchronous iteration protocol.

unaryfunc `PyAsyncMethods.am_anext`

The signature of this function is:

```
PyObject *am_anext(PyObject *self);
```

Must return an *awaitable* object. See `__anext__()` for details. This slot may be set to `NULL`.

sendfunc `PyAsyncMethods.am_send`

The signature of this function is:

```
PySendResult am_send(PyObject *self, PyObject *arg, PyObject **result);
```

See `PyIter_Send()` for details. This slot may be set to `NULL`.

3.10 新版功能.

12.9 Slot Type typedefs

typedef *PyObject* *(***allocfunc**)(*PyTypeObject* *cls, *Py_ssize_t* nitems)

Part of the Stable ABI. The purpose of this function is to separate memory allocation from memory initialization. It should return a pointer to a block of memory of adequate length for the instance, suitably aligned, and initialized to zeros, but with `ob_refcnt` set to `1` and `ob_type` set to the type argument. If the type's `tp_itemsize` is non-zero, the object's `ob_size` field should be initialized to *nitems* and the length of the allocated memory block should be `tp_basicsize + nitems*tp_itemsize`, rounded up to a multiple of `sizeof(void*)`; otherwise, *nitems* is not used and the length of the block should be `tp_basicsize`.

This function should not do any other instance initialization, not even to allocate additional memory; that should be done by `tp_new`.

typedef void (***destructor**)(*PyObject**)

Part of the Stable ABI.

typedef void (***freefunc**)(void*)

See `tp_free`.

typedef *PyObject* *(***newfunc**)(*PyObject**, *PyObject**, *PyObject**)

Part of the Stable ABI. See `tp_new`.

typedef int (***initproc**)(*PyObject**, *PyObject**, *PyObject**)

Part of the Stable ABI. See `tp_init`.

typedef *PyObject* *(***reprfunc**)(*PyObject**)

Part of the Stable ABI. See `tp_repr`.

typedef *PyObject* *(***getattrfunc**)(*PyObject* *self, char *attr)

Part of the Stable ABI. Return the value of the named attribute for the object.

typedef int (***setattrfunc**)(*PyObject* *self, char *attr, *PyObject* *value)

Part of the Stable ABI. Set the value of the named attribute for the object. The value argument is set to `NULL` to delete the attribute.

typedef *PyObject* *(***getattrofunc**)(*PyObject* *self, *PyObject* *attr)

Part of the Stable ABI. Return the value of the named attribute for the object.

See `tp_getattro`.

typedef int (***setattrofunc**)(*PyObject* *self, *PyObject* *attr, *PyObject* *value)

Part of the Stable ABI. Set the value of the named attribute for the object. The value argument is set to `NULL` to delete the attribute.

See `tp_setattro`.

typedef *PyObject* *(***descrgetfunc**)(*PyObject**, *PyObject**, *PyObject**)

Part of the Stable ABI. See `tp_descr_get`.

typedef int (***descrsetfunc**)(*PyObject**, *PyObject**, *PyObject**)

Part of the Stable ABI. See `tp_descr_set`.

typedef Py_hash_t (***hashfunc**)(*PyObject**)

Part of the Stable ABI. See `tp_hash`.

typedef *PyObject* *(***richcmpfunc**)(*PyObject**, *PyObject**, int)

Part of the Stable ABI. See `tp_richcompare`.

typedef *PyObject* *(***getiterfunc**)(*PyObject**)

Part of the Stable ABI. See `tp_iter`.

typedef *PyObject* *(***iternextfunc**)(*PyObject**)

Part of the Stable ABI. See `tp_iternext`.

typedef *Py_ssize_t* (***lenfunc**)(*PyObject**)

Part of the Stable ABI.

typedef int (***getbufferproc**)(*PyObject**, *Py_buffer**, int)

typedef void (***releasebufferproc**)(*PyObject**, *Py_buffer**)

typedef *PyObject* *(***unaryfunc**)(*PyObject**)

Part of the Stable ABI.

typedef *PyObject* *(***binaryfunc**)(*PyObject**, *PyObject**)

Part of the Stable ABI.

typedef *PySendResult* (***sendfunc**)(*PyObject**, *PyObject**, *PyObject***)

See `am_send`.

typedef *PyObject* *(***ternaryfunc**)(*PyObject**, *PyObject**, *PyObject**)

Part of the Stable ABI.

typedef *PyObject* *(***ssizeargfunc**)(*PyObject**, *Py_ssize_t*)

Part of the Stable ABI.

typedef int (***ssizeobjargproc**)(*PyObject**, *Py_ssize_t*)

Part of the Stable ABI.

typedef int (***objobjproc**)(*PyObject**, *PyObject**)

Part of the Stable ABI.

typedef int (***objobjargproc**)(*PyObject**, *PyObject**, *PyObject**)

Part of the Stable ABI.

12.10 例子

The following are simple examples of Python type definitions. They include common usage you may encounter. Some demonstrate tricky corner cases. For more examples, practical info, and a tutorial, see defining-new-types and new-types-topics.

A basic *static type*:

```
typedef struct {
    PyObject_HEAD
    const char *data;
} MyObject;

static PyTypeObject MyObject_Type = {
    PyVarObject_HEAD_INIT(NULL, 0)
    .tp_name = "mymod.MyObject",
    .tp_basicsize = sizeof(MyObject),
    .tp_doc = PyDoc_STR("My objects"),
    .tp_new = myobj_new,
    .tp_dealloc = (destructor)myobj_dealloc,
    .tp_repr = (reprfunc)myobj_repr,
};
```

You may also find older code (especially in the CPython code base) with a more verbose initializer:

```
static PyTypeObject MyObject_Type = {
    PyVarObject_HEAD_INIT(NULL, 0)
    "mymod.MyObject",               /* tp_name */
    sizeof(MyObject),               /* tp_basicsize */
    0,                              /* tp_itemsize */
    (destructor)myobj_dealloc,      /* tp_dealloc */
    0,                              /* tp_vectorcall_offset */
    0,                              /* tp_getattr */
    0,                              /* tp_setattr */
    0,                              /* tp_as_async */
    (reprfunc)myobj_repr,           /* tp_repr */
    0,                              /* tp_as_number */
    0,                              /* tp_as_sequence */
    0,                              /* tp_as_mapping */
    0,                              /* tp_hash */
    0,                              /* tp_call */
    0,                              /* tp_str */
    0,                              /* tp_getattro */
    0,                              /* tp_setattro */
    0,                              /* tp_as_buffer */
    0,                              /* tp_flags */
    PyDoc_STR("My objects"),        /* tp_doc */
    0,                              /* tp_traverse */
    0,                              /* tp_clear */
    0,                              /* tp_richcompare */
    0,                              /* tp_weaklistoffset */
    0,                              /* tp_iter */
    0,                              /* tp_iternext */
    0,                              /* tp_methods */
    0,                              /* tp_members */
    0,                              /* tp_getset */
    0,                              /* tp_base */
    0,                              /* tp_dict */
    0,                              /* tp_descr_get */
    0,                              /* tp_descr_set */
    0,                              /* tp_dictoffset */
    0,                              /* tp_init */
```

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```
    0,                              /* tp_alloc */
    myobj_new,                      /* tp_new */
};
```

A type that supports weakrefs, instance dicts, and hashing:

```
typedef struct {
    PyObject_HEAD
    const char *data;
    PyObject *inst_dict;
    PyObject *weakreflist;
} MyObject;

static PyTypeObject MyObject_Type = {
    PyVarObject_HEAD_INIT(NULL, 0)
    .tp_name = "mymod.MyObject",
    .tp_basicsize = sizeof(MyObject),
    .tp_doc = PyDoc_STR("My objects"),
    .tp_weaklistoffset = offsetof(MyObject, weakreflist),
    .tp_dictoffset = offsetof(MyObject, inst_dict),
    .tp_flags = Py_TPFLAGS_DEFAULT | Py_TPFLAGS_BASETYPE | Py_TPFLAGS_HAVE_GC,
    .tp_new = myobj_new,
    .tp_traverse = (traverseproc)myobj_traverse,
    .tp_clear = (inquiry)myobj_clear,
    .tp_alloc = PyType_GenericNew,
    .tp_dealloc = (destructor)myobj_dealloc,
    .tp_repr = (reprfunc)myobj_repr,
    .tp_hash = (hashfunc)myobj_hash,
    .tp_richcompare = PyBaseObject_Type.tp_richcompare,
};
```

A str subclass that cannot be subclassed and cannot be called to create instances (e.g. uses a separate factory func) using `Py_TPFLAGS_DISALLOW_INSTANTIATION` flag:

```
typedef struct {
    PyUnicodeObject raw;
    char *extra;
} MyStr;

static PyTypeObject MyStr_Type = {
    PyVarObject_HEAD_INIT(NULL, 0)
    .tp_name = "mymod.MyStr",
    .tp_basicsize = sizeof(MyStr),
    .tp_base = NULL,  // set to &PyUnicode_Type in module init
    .tp_doc = PyDoc_STR("my custom str"),
    .tp_flags = Py_TPFLAGS_DEFAULT | Py_TPFLAGS_DISALLOW_INSTANTIATION,
    .tp_repr = (reprfunc)myobj_repr,
};
```

The simplest *static type* with fixed-length instances:

```
typedef struct {
    PyObject_HEAD
} MyObject;

static PyTypeObject MyObject_Type = {
    PyVarObject_HEAD_INIT(NULL, 0)
    .tp_name = "mymod.MyObject",
};
```

The simplest *static type* with variable-length instances:

```
typedef struct {
    PyObject_VAR_HEAD
    const char *data[1];
} MyObject;

static PyTypeObject MyObject_Type = {
    PyVarObject_HEAD_INIT(NULL, 0)
    .tp_name = "mymod.MyObject",
    .tp_basicsize = sizeof(MyObject) - sizeof(char *),
    .tp_itemsize = sizeof(char *),
};
```

12.11 使对象类型支持循环垃圾回收

Python 对循环引用的垃圾检测与回收需要“容器”对象类型的支持，此类型的容器对象中可能包含其它容器对象。不保存其它对象的引用的类型，或者只保存原子类型（如数字或字符串）的引用的类型，不需要显式提供垃圾回收的支持。

若要创建一个容器类，类型对象的*tp_flags* 字段必须包含*Py_TPFLAGS_HAVE_GC* 并提供一个*tp_traverse* 处理的实现。如果该类型的实例是可变的，还需要实现*tp_clear* 。

Py_TPFLAGS_HAVE_GC

设置了此标志位的类型的对象必须符合此处记录的规则。为方便起见，下文把这些对象称为容器对象。

容器类型的构造函数必须符合两个规则：

1. 必须使用*PyObject_GC_New()* 或*PyObject_GC_NewVar()* 为这些对象分配内存。
2. 初始化了所有可能包含其他容器的引用的字段后，它必须调用*PyObject_GC_Track()* 。

同样的，对象的释放器必须符合两个类似的规则：

1. 在引用其它容器的字段失效前，必须调用*PyObject_GC_UnTrack()* 。
2. 必须使用*PyObject_GC_Del()* 释放对象的内存。

> **警告：** 如果一个类型添加了 Py_TPFLAGS_HAVE_GC，则它 必须实现至少一个*tp_traverse* 句柄或显式地使用来自其一个或多个子类的句柄。
>
> 当调用*PyType_Ready()* 或者 API 中某些间接调用它的函数例如*PyType_FromSpecWithBases()* 或*PyType_FromSpec()* 时解释器就自动填充*tp_flags*, *tp_traverse* 和*tp_clear* 字段，如果该类型是继承自实现了垃圾回收器协议的类并且该子类 没有包括*Py_TPFLAGS_HAVE_GC* 旗标的话。

TYPE ***PyObject_GC_New**(TYPE, *PyTypeObject* *type)

类似于*PyObject_New()* ，适用于设置了*Py_TPFLAGS_HAVE_GC* 标签的容器对象。

TYPE ***PyObject_GC_NewVar**(TYPE, *PyTypeObject* *type, *Py_ssize_t* size)

类似于*PyObject_NewVar()* ，适用于设置了*Py_TPFLAGS_HAVE_GC* 标签的容器对象。

TYPE ***PyObject_GC_Resize**(TYPE, *PyVarObject* *op, *Py_ssize_t* newsize)

为*PyObject_NewVar()* 所分配对象重新调整大小。返回调整大小后的对象或在失败时返回 NULL。*op* 必须尚未被垃圾回收器追踪。

void **PyObject_GC_Track**(*PyObject* *op)

Part of the Stable ABI. 把对象 *op* 加入到垃圾回收器跟踪的容器对象中。对象在被回收器跟踪时必须保持有效的，因为回收器可能在任何时候开始运行。在*tp_traverse* 处理前的所有字段变为有效后，必须调用此函数，通常在靠近构造函数末尾的位置。

int **PyObject_IS_GC**(*PyObject* *obj)

如果对象实现了垃圾回收器协议则返回非零值，否则返回 0。

如果此函数返回 0 则对象无法被垃圾回收器追踪。

int **PyObject_GC_IsTracked**(*PyObject* *op)

Part of the Stable ABI *since version 3.9.* 如果 *op* 对象的类型实现了 GC 协议且 *op* 目前正被垃圾回收器追踪则返回 1，否则返回 0。

这类似于 Python 函数 `gc.is_tracked()`。

3.9 新版功能.

int **PyObject_GC_IsFinalized**(*PyObject* *op)

Part of the Stable ABI *since version 3.9.* 如果 *op* 对象的类型实现了 GC 协议且 *op* 已经被垃圾回收器终结则返回 1，否则返回 0。

这类似于 Python 函数 `gc.is_finalized()`。

3.9 新版功能.

void **PyObject_GC_Del**(void *op)

Part of the Stable ABI. 释放对象的内存，该对象初始化时由`PyObject_GC_New()`或`PyObject_GC_NewVar()`分配内存。

void **PyObject_GC_UnTrack**(void *op)

Part of the Stable ABI. 从回收器跟踪的容器对象集合中移除 *op* 对象。请注意可以在此对象上再次调用`PyObject_GC_Track()`以将其加回到被跟踪对象集合。释放器 (`tp_dealloc` 句柄) 应当在`tp_traverse`句柄所使用的任何字段失效之前为对象调用此函数。

在 3.8 版更改: `_PyObject_GC_TRACK()` 和 `_PyObject_GC_UNTRACK()` 宏已从公有 C API 中移除。

`tp_traverse` 处理接收以下类型的函数形参。

typedef int (***visitproc**)(*PyObject* *object, void *arg)

Part of the Stable ABI. 传给`tp_traverse`处理的访问函数的类型。*object* 是容器中需要被遍历的一个对象，第三个形参对应于`tp_traverse`处理的 *arg* 。Python 核心使用多个访问者函数实现循环引用的垃圾检测，不需要用户自行实现访问者函数。

`tp_traverse` 处理必须是以下类型：

typedef int (***traverseproc**)(*PyObject* *self, *visitproc* visit, void *arg)

Part of the Stable ABI. 用于容器对象的遍历函数。它的实现必须对 *self* 所直接包含的每个对象调用 *visit* 函数，*visit* 的形参为所包含对象和传给处理程序的 *arg* 值。*visit* 函数调用不可附带 `NULL` 对象作为参数。如果 *visit* 返回非零值，则该值应当被立即返回。

为了简化`tp_traverse`处理的实现，Python 提供了一个`Py_VISIT()`宏。若要使用这个宏，必须把`tp_traverse`的参数命名为 *visit* 和 *arg* 。

void **Py_VISIT**(*PyObject* *o)

如果 *o* 不为 `NULL`，则调用 *visit* 回调函数，附带参数 *o* 和 *arg*。如果 *visit* 返回一个非零值，则返回该值。使用此宏之后，`tp_traverse` 处理程序的形式如下：

```
static int
my_traverse(Noddy *self, visitproc visit, void *arg)
{
    Py_VISIT(self->foo);
    Py_VISIT(self->bar);
    return 0;
}
```

`tp_clear` 处理程序必须为`inquiry` 类型，如果对象不可变则为 `NULL`。

typedef int (***inquiry**)(*PyObject* *self)

Part of the Stable ABI. 丢弃产生循环引用的引用。不可变对象不需要声明此方法，因为他们不可能直接产生循环引用。需要注意的是，对象在调用此方法后必须仍是有效的（不能对引用只调用 `Py_DECREF()` 方法）。当垃圾回收器检测到该对象在循环引用中时，此方法会被调用。

12.11.1 控制垃圾回收器状态

这个 C-API 提供了以下函数用于控制垃圾回收的运行。

Py_ssize_t **PyGC_Collect**(void)

Part of the Stable ABI. 执行完全的垃圾回收，如果垃圾回收器已启用的话。(请注意 `gc.collect()` 会无条件地执行它。)

返回已回收的 + 无法回收的不可获取对象的数量。如果垃圾回收器被禁用或已在执行回收，则立即返回 `0`。在垃圾回收期间发生的错误会被传给 `sys.unraisablehook`。此函数不会引发异常。

int **PyGC_Enable**(void)

Part of the Stable ABI *since version 3.10.* 启用垃圾回收器：类似于 `gc.enable()`。返回之前的状态，0 为禁用而 1 为启用。

3.10 新版功能.

int **PyGC_Disable**(void)

Part of the Stable ABI *since version 3.10.* 禁用垃圾回收器：类似于 `gc.disable()`。返回之前的状态，0 为禁用而 1 为启用。

3.10 新版功能.

int **PyGC_IsEnabled**(void)

Part of the Stable ABI *since version 3.10.* 查询垃圾回收器的状态：类似于 `gc.isenabled()`。返回当前的状态，0 为禁用而 1 为启用。

3.10 新版功能.

CHAPTER 13

API 和 ABI 版本管理

CPython 在下列宏中暴露其版本号。请注意这对应于 **编译**用版本代码，而不是 **运行时**使用的版本。

请参阅*C API 的稳定性* 查看跨版本的 API 和 ABI 稳定情。

PY_MAJOR_VERSION

3 (3.4.1a2 中的第一段)。

PY_MINOR_VERSION

4 (3.4.1a2 中的第二段)。

PY_MICRO_VERSION

1 (3.4.1a2 中第三段的数字)。

PY_RELEASE_LEVEL

a (3.4.1a2 中第 3 段的字母)。可能为 0xA 即 alpha, 0xB 即 beta, 0xC 即 release candidate 或 0xF 即 final。

PY_RELEASE_SERIAL

2 (3.4.1a2 中的末尾数字)。零代表最终发布版。

PY_VERSION_HEX

编码为单个整数形式的 Python 版本号。

底层的版本信息可通过按以下方式将其当作 32 比特的数字处理来获取:

字节串	位数（大端字节序）	含意	3.4.1a2 的值
1	1-8	PY_MAJOR_VERSION	0x03
2	9-16	PY_MINOR_VERSION	0x04
3	17-24	PY_MICRO_VERSION	0x01
4	25-28	PY_RELEASE_LEVEL	0xA
	29-32	PY_RELEASE_SERIAL	0x2

这样 3.4.1a2 即十六进制版本号的 0x030401a2 而 3.10.0 即十六进制版本号的 0x030a00f0。

This version is also available via the symbol Py_Version.

const unsigned long **Py_Version**

Part of the Stable ABI *since version 3.11.* The Python runtime version number encoded in a single constant integer, with the same format as the *PY_VERSION_HEX* macro. This contains the Python version used at run time.

3.11 新版功能.

所有提到的宏都定义在 Include/patchlevel.h。

APPENDIX A

术语对照表

>>> 交互式终端中默认的 Python 提示符。往往会显示于能以交互方式在解释器里执行的样例代码之前。

... 具有以下含义：

- 交互式终端中输入特殊代码行时默认的 Python 提示符，包括：缩进的代码块，成对的分隔符之内（圆括号、方括号、花括号或三重引号），或是指定一个装饰器之后。
- `Ellipsis` 内置常量。

2to3 把 Python 2.x 代码转换为 Python 3.x 代码的工具，通过解析源码，遍历解析树，处理绝大多数检测到的不兼容问题。

2to3 包含在标准库中，模块名为 `lib2to3`；提供了独立入口点 `Tools/scripts/2to3`。详见 2to3-reference。

abstract base class -- 抽象基类 抽象基类简称 ABC，是对*duck-typing* 的补充，它提供了一种定义接口的新方式，相比之下其他技巧例如 `hasattr()` 显得过于笨拙或有微妙错误（例如使用 魔术方法）。ABC 引入了虚拟子类，这种类并非继承自其他类，但却仍能被 `isinstance()` 和 `issubclass()` 所认可；详见 `abc` 模块文档。Python 自带许多内置的 ABC 用于实现数据结构（在 `collections.abc` 模块中）、数字（在 `numbers` 模块中）、流（在 `io` 模块中）、导入查找器和加载器（在 `importlib.abc` 模块中）。你可以使用 `abc` 模块来创建自己的 ABC。

annotation -- 标注 关联到某个变量、类属性、函数形参或返回值的标签，被约定作为类型注解 来使用。

局部变量的标注在运行时不可访问，但全局变量、类属性和函数的标注会分别存放模块、类和函数的 `__annotations__` 特殊属性中。

参见*variable annotation*, *function annotation*, **PEP 484** 和 **PEP 526**，对此功能均有介绍。另请参见 annotations-howto 了解使用标注的最佳实践。

argument -- 参数 在调用函数时传给*function* （或*method* ）的值。参数分为两种：

- 关键字参数: 在函数调用中前面带有标识符（例如 `name=`）或者作为包含在前面带有 `**` 的字典里的值传入。举例来说，`3` 和 `5` 在以下对 `complex()` 的调用中均属于关键字参数:

```
complex(real=3, imag=5)
complex(**{'real': 3, 'imag': 5})
```

- 位置参数: 不属于关键字参数的参数。位置参数可出现于参数列表的开头以及/或者作为前面带有 `*` 的*iterable* 里的元素被传入。举例来说，`3` 和 `5` 在以下调用中均属于位置参数:

```
complex(3, 5)
complex(*(3, 5))
```

参数会被赋值给函数体中对应的局部变量。有关赋值规则参见 calls 一节。根据语法，任何表达式都可用来表示一个参数；最终算出的值会被赋给对应的局部变量。

另参见*parameter* 术语表条目，常见问题中 参数与形参的区别以及 **PEP 362**。

asynchronous context manager -- 异步上下文管理器 此种对象通过定义 `__aenter__()` 和 `__aexit__()` 方法来对 `async with` 语句中的环境进行控制。由 **PEP 492** 引入。

asynchronous generator -- 异步生成器 返回值为*asynchronous generator iterator* 的函数。它与使用 `async def` 定义的协程函数很相似，不同之处在于它包含 `yield` 表达式以产生一系列可在 `async for` 循环中使用的值。

此术语通常是指异步生成器函数，但在某些情况下则可能是指 异步生成器迭代器。如果需要清楚表达具体含义，请使用全称以避免歧义。

一个异步生成器函数可能包含 `await` 表达式或者 `async for` 以及 `async with` 语句。

asynchronous generator iterator -- 异步生成器迭代器 *asynchronous generator* 函数所创建的对象。

此对象属于*asynchronous iterator*，当使用 `__anext__()` 方法调用时会返回一个可等待对象来执行异步生成器函数的代码直到下一个 `yield` 表达式。

每个 `yield` 会临时暂停处理，记住当前位置执行状态 (包括局部变量和挂起的 try 语句)。当该 异步生成器迭代器与其他 `__anext__()` 返回的可等待对象有效恢复时，它会从离开位置继续执行。参见 **PEP 492** 和 **PEP 525**。

asynchronous iterable -- 异步可迭代对象 可在 `async for` 语句中被使用的对象。必须通过它的 `__aiter__()` 方法返回一个*asynchronous iterator*。由 **PEP 492** 引入。

asynchronous iterator -- 异步迭代器 实现了 `__aiter__()` 和 `__anext__()` 方法的对象。`__anext__` 必须返回一个*awaitable* 对象。`async for` 会处理异步迭代器的 `__anext__()` 方法所返回的可等待对象，直到其引发一个 `StopAsyncIteration` 异常。由 **PEP 492** 引入。

attribute -- 属性 A value associated with an object which is usually referenced by name using dotted expressions. For example, if an object *o* has an attribute *a* it would be referenced as *o.a*.

It is possible to give an object an attribute whose name is not an identifier as defined by identifiers, for example using `setattr()`, if the object allows it. Such an attribute will not be accessible using a dotted expression, and would instead need to be retrieved with `getattr()`.

awaitable -- 可等待对象 能在 `await` 表达式中使用的对象。可以是*coroutine* 或是具有 `__await__()` 方法的对象。参见 **PEP 492**。

BDFL "终身仁慈独裁者"的英文缩写，即 Guido van Rossum，Python 的创造者。

binary file -- 二进制文件 *file object* 能够读写字节类对象。二进制文件的例子包括以二进制模式（`'rb'`, `'wb'` or `'rb+'`）打开的文件、`sys.stdin.buffer`、`sys.stdout.buffer` 以及 `io.BytesIO` 和 `gzip.GzipFile` 的实例。

另请参见*text file* 了解能够读写 `str` 对象的文件对象。

borrowed reference -- 借入引用 在 Python 的 C API 中，借入引用是指一种对象引用。它不会修改对象引用计数。如果对象被销毁则它会成为一个无目标指针。例如，垃圾回收器可以移除对象的最后一个*strong reference* 来销毁它。

推荐在*borrowed reference* 上调用*`Py_INCREF()`* 以将其原地转换为*strong reference*，除非是当该对象无法在借入引用的最后一次使用之前被销毁。*`Py_NewRef()`* 函数可以被用来创建一个新的*strong reference*。

bytes-like object -- 字节类对象 支持缓冲协议 并且能导出 C-*contiguous* 缓冲的对象。这包括所有 `bytes`、`bytearray` 和 `array.array` 对象，以及许多普通 `memoryview` 对象。字节类对象可在多种二进制数据操作中使用；这些操作包括压缩、保存为二进制文件以及通过套接字发送等。

某些操作需要可变的二进制数据。这种对象在文档中常被称为 "可读写字节类对象"。可变缓冲对象的例子包括 `bytearray` 以及 `bytearray` 的 `memoryview`。其他操作要求二进制数据存放于不可变对象 (" 只读字节类对象"); 这种对象的例子包括 `bytes` 以及 `bytes` 对象的 `memoryview`。

bytecode -- 字节码 Python 源代码会被编译为字节码，即 CPython 解释器中表示 Python 程序的内部代码。字节码还会缓存在 `.pyc` 文件中，这样第二次执行同一文件时速度更快（可以免去将源码重新编译为字节码）。这种" 中间语言" 运行在根据字节码执行相应机器码的*virtual machine* 之上。请注意不同 Python 虚拟机上的字节码不一定通用，也不一定能在不同 Python 版本上兼容。

字节码指令列表可以在 dis 模块的文档中查看。

可调用对象（Callable） A callable is an object that can be called, possibly with a set of arguments (see *argument*), with the following syntax:

```
callable(argument1, argument2, ...)
```

A *function*, and by extension a *method*, is a callable. An instance of a class that implements the `__call__()` method is also a callable.

callback -- 回调 一个作为参数被传入以用以在未来的某个时刻被调用的子例程函数。

class -- 类 用来创建用户定义对象的模板。类定义通常包含对该类的实例进行操作的方法定义。

class variable -- 类变量 在类中定义的变量，并且仅限在类的层级上修改 (而不是在类的实例中修改)。

complex number -- 复数 对普通实数系统的扩展，其中所有数字都被表示为一个实部和一个虚部的和。虚数是虚数单位（`-1` 的平方根）的实倍数，通常在数学中写为 `i`，在工程学中写为 `j`。Python 内置了对复数的支持，采用工程学标记方式；虚部带有一个 `j` 后缀，例如 `3+1j`。如果需要 `math` 模块内对象的对应复数版本，请使用 `cmath`，复数的使用是一个比较高级的数学特性。如果你感觉没有必要，忽略它们也几乎不会有任何问题。

context manager -- 上下文管理器 在 `with` 语句中使用，通过定义 `__enter__()` 和 `__exit__()` 方法来控制环境状态的对象。参见 **PEP 343**。

context variable -- 上下文变量 一种根据其所属的上下文可以具有不同的值的变量。这类似于在线程局部存储中每个执行线程可以具有不同的变量值。不过，对于上下文变量来说，一个执行线程中可能会有多个上下文，而上下文变量的主要用途是对并发异步任务中变量进行追踪。参见 `contextvars`。

contiguous -- 连续 一个缓冲如果是 *C* 连续或 *Fortran* 连续就会被认为是连续的。零维缓冲是 C 和 Fortran 连续的。在一维数组中，所有条目必须在内存中彼此相邻地排列，采用从零开始的递增索引顺序。在多维 C-连续数组中，当按内存地址排列时用最后一个索引访问条目时速度最快。但是在 Fortran 连续数组中则是用第一个索引最快。

coroutine -- 协程 协程是子例程的更一般形式。子例程可以在某一点进入并在另一点退出。协程则可以在许多不同的点上进入、退出和恢复。它们可通过 `async def` 语句来实现。参见 **PEP 492**。

coroutine function -- 协程函数 返回一个*coroutine* 对象的函数。协程函数可通过 `async def` 语句来定义，并可能包含 `await`、`async for` 和 `async with` 关键字。这些特性是由 **PEP 492** 引入的。

CPython Python 编程语言的规范实现，在 python.org 上发布。"CPython" 一词用于在必要时将此实现与其他实现例如 Jython 或 IronPython 相区别。

decorator -- 装饰器 返回值为另一个函数的函数，通常使用 `@wrapper` 语法形式来进行函数变换。装饰器的常见例子包括 `classmethod()` 和 `staticmethod()`。

装饰器语法只是一种语法糖，以下两个函数定义在语义上完全等价:

```
def f(arg):
    ...
f = staticmethod(f)

@staticmethod
def f(arg):
    ...
```

同样的概念也适用于类，但通常较少这样使用。有关装饰器的详情可参见 函数定义和 类定义的文档。

descriptor -- 描述器 任何定义了 `__get__()`，`__set__()` 或 `__delete__()` 方法的对象。当一个类属性为描述器时，它的特殊绑定行为就会在属性查找时被触发。通常情况下，使用 *a.b* 来获取、设置或删除一个属性时会在 *a* 的类字典中查找名称为 *b* 的对象，但如果 *b* 是一个描述器，则会调用对应的描述器方法。理解描述器的概念是更深层次理解 Python 的关键，因为这是许多重要特性的基础，包括函数、方法、属性、类方法、静态方法以及对超类的引用等等。

有关描述器的方法的更多信息，请参阅 descriptors 或 描述器使用指南。

dictionary -- 字典 一个关联数组，其中的任意键都映射到相应的值。键可以是任何具有 `__hash__()` 和 `__eq__()` 方法的对象。在 Perl 语言中称为 hash。

dictionary comprehension -- 字典推导式 处理一个可迭代对象中的所有或部分元素并返回结果字典的一种紧凑写法。`results = {n: n ** 2 for n in range(10)}` 将生成一个由键 `n` 到值 `n ** 2` 的映射构成的字典。参见 comprehensions。

dictionary view -- 字典视图 从 `dict.keys()`，`dict.values()` 和 `dict.items()` 返回的对象被称为字典视图。它们提供了字典条目的一个动态视图，这意味着当字典改变时，视图也会相应改变。要将字典视图强制转换为真正的列表，可使用 `list(dictview)`。参见 dict-views。

docstring -- 文档字符串 作为类、函数或模块之内的第一个表达式出现的字符串字面值。它在代码执行时会被忽略，但会被解释器识别并放入所在类、函数或模块的 `__doc__` 属性中。由于它可用于代码内省，因此是对象存放文档的规范位置。

duck-typing -- 鸭子类型 指一种编程风格，它并不依靠查找对象类型来确定其是否具有正确的接口，而是直接调用或使用其方法或属性（"看起来像鸭子，叫起来也像鸭子，那么肯定就是鸭子。"）由于强调接口而非特定类型，设计良好的代码可通过允许多态替代来提升灵活性。鸭子类型避免使用 `type()` 或 `isinstance()` 检测。(但要注意鸭子类型可以使用抽象基类 作为补充。) 而往往会采用 `hasattr()` 检测或是*EAFP* 编程。

EAFP "求原谅比求许可更容易"的英文缩写。这种 Python 常用代码编写风格会假定所需的键或属性存在，并在假定错误时捕获异常。这种简洁快速风格的特点就是大量运用 `try` 和 `except` 语句。于其相对的则是所谓*LBYL* 风格，常见于 C 等许多其他语言。

expression -- 表达式 可以求出某个值的语法单元。换句话说，一个表达式就是表达元素例如字面值、名称、属性访问、运算符或函数调用的汇总，它们最终都会返回一个值。与许多其他语言不同，并非所有语言构件都是表达式。还存在不能被用作表达式的*statement*，例如 `while`。赋值也是属于语句而非表达式。

extension module -- 扩展模块 以 C 或 C++ 编写的模块，使用 Python 的 C API 来与语言核心以及用户代码进行交互。

f-string -- f-字符串 带有 `'f'` 或 `'F'` 前缀的字符串字面值通常被称为"f-字符串"即 格式化字符串字面值的简写。参见 **PEP 498**。

file object -- 文件对象 对外提供面向文件 API 以使用下层资源的对象（带有 `read()` 或 `write()` 这样的方法）。根据其创建方式的不同，文件对象可以处理对真实磁盘文件，对其他类型存储，或是对通讯设备的访问（例如标准输入/输出、内存缓冲区、套接字、管道等等）。文件对象也被称为 文件类对象或 流。

实际上共有三种类别的文件对象: 原始二进制文件, 缓冲二进制文件 以及文本文件。它们的接口定义均在 `io` 模块中。创建文件对象的规范方式是使用 `open()` 函数。

file-like object -- 文件类对象 *file object* 的同义词。

filesystem encoding and error handler -- 文件系统编码格式与错误处理句柄 Python 用来从操作系统解码字节串和向操作系统编码 Unicode 的编码格式与错误处理句柄。

文件系统编码格式必须保证能成功解码长度在 128 以下的所有字节串。如果文件系统编码格式无法提供此保证，则 API 函数可能会引发 `UnicodeError`。

`sys.getfilesystemencoding()` 和 `sys.getfilesystemencodeerrors()` 函数可被用来获取文件系统编码格式与错误处理句柄。

filesystem encoding and error handler 是在 Python 启动时通过 `PyConfig_Read()` 函数来配置的：请参阅*PyConfig* 的*filesystem_encoding* 和*filesystem_errors* 等成员。

另请参见*locale encoding*。

finder -- 查找器 一种会尝试查找被导入模块的*loader* 的对象。

从 Python 3.3 起存在两种类型的查找器: 元路径查找器 配合 sys.meta_path 使用，以及*path entry finders* 配合 sys.path_hooks 使用。

更多详情可参见 **PEP 302**, **PEP 420** 和 **PEP 451**。

floor division -- 向下取整除法 向下舍入到最接近的整数的数学除法。向下取整除法的运算符是 // 。例如，表达式 11 // 4 的计算结果是 2 ，而与之相反的是浮点数的真正除法返回 2.75 。注意 (-11) // 4 会返回 -3 因为这是 -2.75 向下舍入得到的结果。见 **PEP 238** 。

function -- 函数 可以向调用者返回某个值的一组语句。还可以向其传入零个或多个参数 并在函数体执行中被使用。另见*parameter*, *method* 和 function 等节。

function annotation -- 函数标注 即针对函数形参或返回值的*annotation* 。

函数标注通常用于类型提示：例如以下函数预期接受两个 int 参数并预期返回一个 int 值:

```
def sum_two_numbers(a: int, b: int) -> int:
    return a + b
```

函数标注语法的详解见 function 一节。

参见*variable annotation* 和 **PEP 484**，其中描述了此功能。另请参阅 annotations-howto 以了解使用标的最佳实践。

__future__ future 语句, from __future__ import <feature> 指示编译器使用将在未来的 Python 发布版中成为标准的语法和语义来编译当前模块。__future__ 模块文档记录了可能的 *feature* 取值。通过导入此模块并对其变量求值，你可以看到每项新特性在何时被首次加入到该语言中以及它将（或已）在何时成为默认:

```
>>> import __future__
>>> __future__.division
_Feature((2, 2, 0, 'alpha', 2), (3, 0, 0, 'alpha', 0), 8192)
```

garbage collection -- 垃圾回收 释放不再被使用的内存空间的过程。Python 是通过引用计数和一个能够检测和打破循环引用的循环垃圾回收器来执行垃圾回收的。可以使用 gc 模块来控制垃圾回收器。

generator -- 生成器 返回一个*generator iterator* 的函数。它看起来很像普通函数，不同点在于其包含 yield 表达式以便产生一系列值供给 for-循环使用或是通过 next() 函数逐一获取。

通常是指生成器函数，但在某些情况下也可能是指 生成器迭代器。如果需要清楚表达具体含义，请使用全称以避免歧义。

generator iterator -- 生成器迭代器 *generator* 函数所创建的对象。

每个 yield 会临时暂停处理，记住当前位置执行状态（包括局部变量和挂起的 try 语句）。当该 生成器迭代器恢复时，它会从离开位置继续执行（这与每次调用都从新开始的普通函数差别很大）。

generator expression -- 生成器表达式 返回一个迭代器的表达式。它看起来很像普通表达式后面带有定义了一个循环变量、范围的 for 子句，以及一个可选的 if 子句。以下复合表达式会为外层函数生成一系列值:

```
>>> sum(i*i for i in range(10))         # sum of squares 0, 1, 4, ... 81
285
```

generic function -- 泛型函数 为不同的类型实现相同操作的多个函数所组成的函数。在调用时会由调度算法来确定应该使用哪个实现。

另请参见*single dispatch* 术语表条目、functools.singledispatch() 装饰器以及 **PEP 443**。

generic type -- 泛型类型 可被形参化的*type*；通常为诸如 list 和 dict 的 container class。可用于类型注解 和标注。

更多细节，请参见 通用别名类型, **PEP 483** , **PEP 484** , **PEP 585** , 和 typing 模块。

GIL 参见*global interpreter lock*。

global interpreter lock -- 全局解释器锁 *CPython* 解释器所采用的一种机制，它确保同一时刻只有一个线程在执行 Python *bytecode*。此机制通过设置对象模型（包括 dict 等重要内置类型）针对并发访问的隐式安全简化了 CPython 实现。给整个解释器加锁使得解释器多线程运行更方便，其代价则是牺牲了在多处理器上的并行性。

However, some extension modules, either standard or third-party, are designed so as to release the GIL when doing computationally intensive tasks such as compression or hashing. Also, the GIL is always released when doing I/O.

创建一个（以更精细粒度来锁定共享数据的）"自由线程"解释器的努力从未获得成功，因为这会牺牲在普通单处理器情况下的性能。据信克服这种性能问题的措施将导致实现变得更复杂，从而更难以维护。

hash-based pyc -- 基于哈希的 pyc 使用对应源文件的哈希值而非最后修改时间来确定其有效性的字节码缓存文件。参见 pyc-invalidation。

hashable -- 可哈希 一个对象的哈希值如果在其生命周期内绝不改变，就被称为 可哈希（它需要具有 `__hash__()` 方法），并可以同其他对象进行比较（它需要具有 `__eq__()` 方法）。可哈希对象必须具有相同的哈希值比较结果才会相同。

可哈希性使得对象能够作为字典键或集合成员使用，因为这些数据结构要在内部使用哈希值。

大多数 Python 中的不可变内置对象都是可哈希的；可变容器（例如列表或字典）都不可哈希；不可变容器（例如元组和 frozenset）仅当它们的元素均为可哈希时才是可哈希的。用户定义类的实例对象默认是可哈希的。它们在比较时一定不相同（除非是与自己比较），它们的哈希值的生成是基于它们的 `id()`。

IDLE An Integrated Development and Learning Environment for Python. idle is a basic editor and interpreter environment which ships with the standard distribution of Python.

immutable -- 不可变对象 具有固定值的对象。不可变对象包括数字、字符串和元组。这样的对象不能被改变。如果必须存储一个不同的值，则必须创建新的对象。它们在需要常量哈希值的地方起着重要作用，例如作为字典中的键。

import path -- 导入路径 由多个位置（或路径条目）组成的列表，会被模块的*path based finder* 用来查找导入目标。在导入时，此位置列表通常来自 `sys.path`，但对次级包来说也可能来自上级包的 `__path__` 属性。

importing -- 导入 令一个模块中的 Python 代码能为另一个模块中的 Python 代码所使用的过程。

importer -- 导入器 查找并加载模块的对象；此对象既属于*finder* 又属于*loader*。

interactive -- 交互 Python 带有一个交互式解释器，即你可以在解释器提示符后输入语句和表达式，立即执行并查看其结果。只需不带参数地启动 `python` 命令（也可以在你的计算机开始菜单中选择相应菜单项）。在测试新想法或检验模块和包的时候用这种方式会非常方便（请记得使用 `help(x)`）。

interpreted -- 解释型 Python 一是种解释型语言，与之相对的是编译型语言，虽然两者的区别由于字节码编译器的存在而会有所模糊。这意味着源文件可以直接运行而不必显式地创建可执行文件再运行。解释型语言通常具有比编译型语言更短的开发/调试周期，但是其程序往往运行得更慢。参见*interactive*。

interpreter shutdown -- 解释器关闭 当被要求关闭时，Python 解释器将进入一个特殊运行阶段并逐步释放所有已分配资源，例如模块和各种关键内部结构等。它还会多次调用垃圾回收器。这会触发用户定义析构器或弱引用回调中的代码执行。在关闭阶段执行的代码可能会遇到各种异常，因为其所依赖的资源已不再有效（常见的例子有库模块或警告机制等）。

解释器需要关闭的主要原因有 `__main__` 模块或所运行的脚本已完成执行。

iterable -- 可迭代对象 An object capable of returning its members one at a time. Examples of iterables include all sequence types (such as `list`, `str`, and `tuple`) and some non-sequence types like `dict`, *file objects*, and objects of any classes you define with an `__iter__()` method or with a `__getitem__()` method that implements *sequence* semantics.

可迭代对象被可用于 `for` 循环以及许多其他需要一个序列的地方（`zip()`、`map()` ...）。当一个可迭代对象作为参数传给内置函数 `iter()` 时，它会返回该对象的迭代器。这种迭代器适用于对值集合的一次性遍历。在使用可迭代对象时，你通常不需要调用 `iter()` 或者自己处理迭代器对象。

for 语句会为你自动处理那些操作，创建一个临时的未命名变量用来在循环期间保存迭代器。参见*iterator*、*sequence* 以及*generator*。

iterator -- 迭代器 用来表示一连串数据流的对象。重复调用迭代器的 `__next__()` 方法（或将其传给内置函数 `next()`）将逐个返回流中的项。当没有数据可用时则将引发 `StopIteration` 异常。到这时迭代器对象中的数据项已耗尽，继续调用其 `__next__()` 方法只会再次引发 `StopIteration` 异常。迭代器必须具有 `__iter__()` 方法用来返回该迭代器对象自身，因此迭代器必定也是可迭代对象，可被用于其他可迭代对象适用的大部分场合。一个显著的例外是那些会多次重复访问迭代项的代码。容器对象（例如 `list`）在你每次向其传入 `iter()` 函数或是在 `for` 循环中使用它时都会产生一个新的迭代器。如果在此情况下你尝试用迭代器则会返回在之前迭代过程中被耗尽的同一迭代器对象，使其看起来就像是一个空容器。

更多信息可查看 typeiter。

CPython 实现细节： CPython 没有统一应用迭代器定义 `__iter__()` 的要求。

key function -- 键函数 键函数或称整理函数，是能够返回用于排序或排位的值的可调用对象。例如，`locale.strxfrm()` 可用于生成一个符合特定区域排序约定的排序键。

Python 中有许多工具都允许用键函数来控制元素的排位或分组方式。其中包括 `min()`, `max()`, `sorted()`, `list.sort()`, `heapq.merge()`, `heapq.nsmallest()`, `heapq.nlargest()` 以及 `itertools.groupby()`。

There are several ways to create a key function. For example. the `str.lower()` method can serve as a key function for case insensitive sorts. Alternatively, a key function can be built from a `lambda` expression such as `lambda r: (r[0], r[2])`. Also, `operator.attrgetter()`, `operator.itemgetter()`, and `operator.methodcaller()` are three key function constructors. See the Sorting HOW TO for examples of how to create and use key functions.

keyword argument -- 关键字参数 参见*argument*。

lambda 由一个单独*expression* 构成的匿名内联函数，表达式会在调用时被求值。创建 lambda 函数的句法为 `lambda [parameters]: expression`

LBYL "先查看后跳跃"的英文缩写。这种代码编写风格会在进行调用或查找之前显式地检查前提条件。此风格与*EAFP* 方式恰成对比，其特点是大量使用 `if` 语句。

在多线程环境中，LBYL 方式会导致"查看"和"跳跃"之间发生条件竞争风险。例如，以下代码 `if key in mapping: return mapping[key]` 可能由于在检查操作之后其他线程从 *mapping* 中移除了 *key* 而出错。这种问题可通过加锁或使用 EAFP 方式来解决。

locale encoding -- 语言区域编码格式 On Unix, it is the encoding of the LC_CTYPE locale. It can be set with `locale.setlocale(locale.LC_CTYPE, new_locale)`.

On Windows, it is the ANSI code page (ex: `"cp1252"`).

On Android and VxWorks, Python uses `"utf-8"` as the locale encoding.

`locale.getencoding()` can be used to get the locale encoding.

See also the *filesystem encoding and error handler*.

list -- 列表 Python 内置的一种*sequence*。虽然名为列表，但更类似于其他语言中的数组而非链接列表，因为访问元素的时间复杂度为 O(1)。

list comprehension -- 列表推导式 处理一个序列中的所有或部分元素并返回结果列表的一种紧凑写法。`result = ['{:#04x}'.format(x) for x in range(256) if x % 2 == 0]` 将生成一个 0 到 255 范围内的十六进制偶数对应字符串（0x..）的列表。其中 `if` 子句是可选的，如果省略则 `range(256)` 中的所有元素都会被处理。

loader -- 加载器 负责加载模块的对象。它必须定义名为 `load_module()` 的方法。加载器通常由一个*finder* 返回。详情参见 **PEP 302**，对于*abstract base class* 可参见 `importlib.abc.Loader`。

magic method -- 魔术方法 *special method* 的非正式同义词。

mapping -- 映射 A container object that supports arbitrary key lookups and implements the methods specified in the `collections.abc.Mapping` or `collections.abc.MutableMapping` abstract base classes. Examples include dict, collections.defaultdict, collections.OrderedDict and collections.Counter.

meta path finder -- 元路径查找器 sys.meta_path 的搜索所返回的*finder*。元路径查找器与*path entry finders* 存在关联但并不相同。

请查看 importlib.abc.MetaPathFinder 了解元路径查找器所实现的方法。

metaclass -- 元类 一种用于创建类的类。类定义包含类名、类字典和基类列表。元类负责接受上述三个参数并创建相应的类。大部分面向对象的编程语言都会提供一个默认实现。Python 的特别之处在于可以创建自定义元类。大部分用户永远不需要这个工具，但当需要出现时，元类可提供强大而优雅的解决方案。它们已被用于记录属性访问日志、添加线程安全性、跟踪对象创建、实现单例，以及其他许多任务。

更多详情参见 metaclasses。

method -- 方法 在类内部定义的函数。如果作为该类的实例的一个属性来调用，方法将会获取实例对象作为其第一个*argument* (通常命名为 self)。参见*function* 和*nested scope*。

method resolution order -- 方法解析顺序 方法解析顺序就是在查找成员时搜索全部基类所用的先后顺序。请查看 Python 2.3 方法解析顺序 了解自 2.3 版起 Python 解析器所用相关算法的详情。

module -- 模块 此对象是 Python 代码的一种组织单位。各模块具有独立的命名空间，可包含任意 Python 对象。模块可通过*importing* 操作被加载到 Python 中。

另见*package*。

module spec -- 模块规格 一个命名空间，其中包含用于加载模块的相关导入信息。是 importlib.machinery.ModuleSpec 的实例。

MRO 参见*method resolution order*。

mutable -- 可变对象 可变对象可以在其 id() 保持固定的情况下改变其取值。另请参见*immutable*。

named tuple -- 具名元组 术语"具名元组"可用于任何继承自元组，并且其中的可索引元素还能使用名称属性来访问的类型或类。这样的类型或类还可能拥有其他特性。

有些内置类型属于具名元组，包括 time.localtime() 和 os.stat() 的返回值。另一个例子是 sys.float_info:

```
>>> sys.float_info[1]                   # indexed access
1024
>>> sys.float_info.max_exp              # named field access
1024
>>> isinstance(sys.float_info, tuple)   # kind of tuple
True
```

有些具名元组是内置类型（例如上面的例子）。此外，具名元组还可通过常规类定义从 tuple 继承并定义名称字段的方式来创建。这样的类可以手工编写，或者使用工厂函数 collections.namedtuple() 创建。后一种方式还会添加一些手工编写或内置具名元组所没有的额外方法。

namespace -- 命名空间 命名空间是存放变量的场所。命名空间有局部、全局和内置的，还有对象中的嵌套命名空间（在方法之内）。命名空间通过防止命名冲突来支持模块化。例如，函数 builtins.open 与 os.open() 可通过各自的命名空间来区分。命名空间还通过明确哪个模块实现那个函数来帮助提高可读性和可维护性。例如，random.seed() 或 itertools.islice() 这种写法明确了这些函数是由 random 与 itertools 模块分别实现的。

namespace package -- 命名空间包 **PEP 420** 所引入的一种仅被用作子包的容器的*package*，命名空间包可以没有实体表示物，其描述方式与*regular package* 不同，因为它们没有 __init__.py 文件。

另可参见*module*。

nested scope -- 嵌套作用域 在一个定义范围内引用变量的能力。例如，在另一函数之内定义的函数可以引用前者的变量。请注意嵌套作用域默认只对引用有效而对赋值无效。局部变量的读写都受限于最内层作用域。类似的，全局变量的读写则作用于全局命名空间。通过 nonlocal 关键字可允许写入外层作用域。

new-style class -- 新式类 对于目前已被应于所有类对象的类形式的旧称谓。在早先的 Python 版本中，只有新式类能够使用 Python 新增的更灵活特性，例如 `__slots__`、描述符、特征属性、`__getattribute__()`、类方法和静态方法等。

object -- 对象 任何具有状态（属性或值）以及预定义行为（方法）的数据。object 也是任何*new-style class* 的最顶层基类名。

package -- 包 A Python *module* which can contain submodules or recursively, subpackages. Technically, a package is a Python module with a `__path__` attribute.

另参见*regular package* 和*namespace package*。

parameter -- 形参 *function* （或方法）定义中的命名实体，它指定函数可以接受的一个*argument* （或在某些情况下，多个实参）。有五种形参：

- *positional-or-keyword*：位置或关键字，指定一个可以作为位置参数 传入也可以作为关键字参数 传入的实参。这是默认的形参类型，例如下面的 *foo* 和 *bar*:

```
def func(foo, bar=None): ...
```

- *positional-only*：仅限位置，指定一个只能通过位置传入的参数。仅限位置形参可通过在函数定义的形参列表中它们之后包含一个 / 字符来定义，例如下面的 *posonly1* 和 *posonly2*:

```
def func(posonly1, posonly2, /, positional_or_keyword): ...
```

- *keyword-only*：仅限关键字，指定一个只能通过关键字传入的参数。仅限关键字形参可通过在函数定义的形参列表中包含单个可变位置形参或者在多个可变位置形参之前放一个 * 来定义，例如下面的 *kw_only1* 和 *kw_only2*:

```
def func(arg, *, kw_only1, kw_only2): ...
```

- *var-positional*：可变位置，指定可以提供由一个任意数量的位置参数构成的序列（附加在其他形参已接受的位置参数之后）。这种形参可通过在形参名称前加缀 * 来定义，例如下面的 *args*:

```
def func(*args, **kwargs): ...
```

- *var-keyword*：可变关键字，指定可以提供任意数量的关键字参数（附加在其他形参已接受的关键字参数之后）。这种形参可通过在形参名称前加缀 ** 来定义，例如上面的 *kwargs*。

形参可以同时指定可选和必选参数，也可以为某些可选参数指定默认值。

另参见*argument* 术语表条目、参数与形参的区别中的常见问题、`inspect.Parameter` 类、function 一节以及 **PEP 362**。

path entry -- 路径入口 *import path* 中的一个单独位置，会被*path based finder* 用来查找要导入的模块。

path entry finder -- 路径入口查找器 任一可调用对象使用 `sys.path_hooks` (即*path entry hook*) 返回的*finder*，此种对象能通过*path entry* 来定位模块。

请参看 `importlib.abc.PathEntryFinder` 以了解路径入口查找器所实现的各个方法。

path entry hook -- 路径入口钩子 一种可调用对象，在知道如何查找特定*path entry* 中的模块的情况下能够使用 `sys.path_hook` 列表返回一个*path entry finder*。

path based finder -- 基于路径的查找器 默认的一种元路径查找器，可在一个*import path* 中查找模块。

path-like object -- 路径类对象 代表一个文件系统路径的对象。类路径对象可以是一个表示路径的 `str` 或者 `bytes` 对象，还可以是一个实现了 `os.PathLike` 协议的对象。一个支持 `os.PathLike` 协议的对象可通过调用 `os.fspath()` 函数转换为 `str` 或者 `bytes` 类型的文件系统路径；`os.fsdecode()` 和 `os.fsencode()` 可被分别用来确保获得 `str` 或 `bytes` 类型的结果。此对象是由 **PEP 519** 引入的。

PEP “Python 增强提议”的英文缩写。一个 PEP 就是一份设计文档，用来向 Python 社区提供信息，或描述一个 Python 的新增特性及其进度或环境。PEP 应当提供精确的技术规格和所提议特性的原理说明。

PEP 应被作为提出主要新特性建议、收集社区对特定问题反馈以及为必须加入 Python 的设计决策编写文档的首选机制。PEP 的作者有责任在社区内部建立共识，并应将不同意见也记入文档。

参见 **PEP 1**。

portion -- 部分 构成一个命名空间包的单个目录内文件集合（也可能存放于一个 zip 文件内），具体定义见 **PEP 420**。

positional argument -- 位置参数 参见*argument*。

provisional API -- 暂定 API 暂定 API 是指被有意排除在标准库的向后兼容性保证之外的应用编程接口。虽然此类接口通常不会再有重大改变，但只要其被标记为暂定，就可能在核心开发者确定有必要的情况下进行向后不兼容的更改（甚至包括移除该接口）。此种更改并不会随意进行 -- 仅在 API 被加入之前未考虑到的严重基础性缺陷被发现时才可能会这样做。

即便是对暂定 API 来说，向后不兼容的更改也会被视为“最后的解决方案”——任何问题被确认时都会尽可能先尝试找到一种向后兼容的解决方案。

这种处理过程允许标准库持续不断地演进，不至于被有问题的长期性设计缺陷所困。详情见 **PEP 411**。

provisional package -- 暂定包 参见*provisional API*。

Python 3000 Python 3.x 发布路线的昵称（这个名字在版本 3 的发布还遥遥无期的时候就已出现了）。有时也被缩写为“Py3k”。

Pythonic 指一个思路或一段代码紧密遵循了 Python 语言最常用的风格和理念，而不是使用其他语言中通用的概念来实现代码。例如，Python 的常用风格是使用 `for` 语句循环来遍历一个可迭代对象中的所有元素。许多其他语言没有这样的结构，因此不熟悉 Python 的人有时会选择使用一个数字计数器:

```
for i in range(len(food)):
    print(food[i])
```

而相应的更简洁更 Pythonic 的方法是这样的:

```
for piece in food:
    print(piece)
```

qualified name -- 限定名称 一个以点号分隔的名称，显示从模块的全局作用域到该模块中定义的某个类、函数或方法的“路径”，相关定义见 **PEP 3155**。对于最高层级的函数和类，限定名称与对象名称一致:

```
>>> class C:
...     class D:
...         def meth(self):
...             pass
...
>>> C.__qualname__
'C'
>>> C.D.__qualname__
'C.D'
>>> C.D.meth.__qualname__
'C.D.meth'
```

当被用于引用模块时，完整限定名称意为标示该模块的以点号分隔的整个路径，其中包含其所有的父包，例如 `email.mime.text`:

```
>>> import email.mime.text
>>> email.mime.text.__name__
'email.mime.text'
```

reference count -- 引用计数 The number of references to an object. When the reference count of an object drops to zero, it is deallocated. Reference counting is generally not visible to Python code, but it is a key element of the *CPython* implementation. Programmers can call the `sys.getrefcount()` function to return the reference count for a particular object.

regular package -- 常规包 传统型的*package*，例如包含有一个 `__init__.py` 文件的目录。

另参见*namespace package*。

__slots__ 一种写在类内部的声明，通过预先声明实例属性等对象并移除实例字典来节省内存。虽然这种技巧很流行，但想要用好却并不容易，最好是只保留在少数情况下采用，例如极耗内存的应用程序，并且其中包含大量实例。

sequence -- 序列 一种*iterable*，它支持通过 `__getitem__()` 特殊方法来使用整数索引进行高效的元素访问，并定义了一个返回序列长度的 `__len__()` 方法。内置的序列类型有 `list`、`str`、`tuple` 和 `bytes`。注意虽然 `dict` 也支持 `__getitem__()` 和 `__len__()`，但它被认为属于映射而非序列，因为它查找时使用任意的*immutable* 键而非整数。

`collections.abc.Sequence` 抽象基类定义了一个更丰富的接口，它在 `__getitem__()` 和 `__len__()` 之外又添加了 `count()`, `index()`, `__contains__()` 和 `__reversed__()`。实现此扩展接口的类型可以使用 `register()` 来显式地注册。

set comprehension -- 集合推导式 处理一个可迭代对象中的所有或部分元素并返回结果集合的一种紧凑写法。`results = {c for c in 'abracadabra' if c not in 'abc'}` 将生成字符串集合 `{'r', 'd'}`。参见 comprehensions。

single dispatch -- 单分派 一种*generic function* 分派形式，其实现是基于单个参数的类型来选择的。

slice -- 切片 通常只包含了特定*sequence* 的一部分的对象。切片是通过使用下标标记来创建的，在 `[]` 中给出几个以冒号分隔的数字，例如 `variable_name[1:3:5]`。方括号（下标）标记在内部使用 `slice` 对象。

special method -- 特殊方法 一种由 Python 隐式调用的方法，用来对某个类型执行特定操作例如相加等等。这种方法的名称的首尾都为双下划线。特殊方法的文档参见 specialnames。

statement -- 语句 语句是程序段（一个代码"块"）的组成单位。一条语句可以是一个*expression* 或某个带有关键字的结构，例如 `if`、`while` 或 `for`。

strong reference -- 强引用 在 Python 的 C API 中，强引用是对象引用的一种，当它被创建时将会增加对象引用计数而当它被删除时则会减少对象引用计数。

`Py_NewRef()` 函数可被用于创建一个对象的强引用。通常，必须在退出某个强引用的作用域时在该强引用上调用*`Py_DECREF()`* 函数，以避免引用的泄漏。

另请参阅*borrowed reference*。

text encoding -- 文本编码 在 Python 中，一个字符串是一串 Unicode 代码点（范围为 "U+0000"-- `U+10FFFF`）。为了存储或传输一个字符串，它需要被序列化为一串字节。

将一个字符串序列化为一个字节序列被称为" 编码"，而从字节序列中重新创建字符串被称为" 解码"。

有各种不同的文本序列化 编码器，它们被统称为" 文本编码"。

text file -- 文本文件 一种能够读写 `str` 对象的*file object*。通常一个文本文件实际是访问一个面向字节的数据流并自动处理*text encoding*。文本文件的例子包括以文本模式（`'r'` 或 `'w'`）打开的文件、`sys.stdin`、`sys.stdout` 以及 `io.StringIO` 的实例。

另请参看*binary file* 了解能够读写字节类对象 的文件对象。

triple-quoted string -- 三引号字符串 首尾各带三个连续双引号（"）或者单引号（'）的字符串。它们在功能上与首尾各用一个引号标注的字符串没有什么不同，但是有多种用处。它们允许你在字符串内包含未经转义的单引号和双引号，并且可以跨越多行而无需使用连接符，在编写文档字符串时特别好用。

type -- 类型 类型决定一个 Python 对象属于什么种类；每个对象都具有一种类型。要知道对象的类型，可以访问它的 `__class__` 属性，或是通过 `type(obj)` 来获取。

type alias -- 类型别名 一个类型的同义词，创建方式是把类型赋值给特定的标识符。

类型别名的作用是简化类型注解。例如:

```
def remove_gray_shades(
        colors: list[tuple[int, int, int]]) -> list[tuple[int, int, int]]:
    pass
```

可以这样提高可读性:

```
Color = tuple[int, int, int]

def remove_gray_shades(colors: list[Color]) -> list[Color]:
    pass
```

参见 `typing` 和 **PEP 484**，其中有对此功能的详细描述。

type hint -- 类型注解 *annotation* 为变量、类属性、函数的形参或返回值指定预期的类型。

类型注解属于可选项，Python 不要求提供，但其可对静态类型分析工具起作用，并可协助 IDE 实现代码补全与重构。

全局变量、类属性和函数的类型注解可以使用 `typing.get_type_hints()` 来访问，但局部变量则不可以。

参见 `typing` 和 **PEP 484**，其中有对此功能的详细描述。

universal newlines -- 通用换行 一种解读文本流的方式，将以下所有符号都识别为行结束标志：Unix 的行结束约定 `'\n'`、Windows 的约定 `'\r\n'` 以及旧版 Macintosh 的约定 `'\r'`。参见 **PEP 278** 和 **PEP 3116** 和 `bytes.splitlines()` 了解更多用法说明。

variable annotation -- 变量标注 对变量或类属性的*annotation*。

在标注变量或类属性时，还可选择为其赋值:

```
class C:
    field: 'annotation'
```

变量标注通常被用作类型注解：例如以下变量预期接受 `int` 类型的值:

```
count: int = 0
```

变量标注语法的详细解释见 annassign 一节。

参见*function annotation*, **PEP 484** 和 **PEP 526**，其中描述了此功能。另请参阅 annotations-howto 以了解使用标注的最佳实践。

virtual environment -- 虚拟环境 一种采用协作式隔离的运行时环境，允许 Python 用户和应用程序在安装和升级 Python 分发包时不会干扰到同一系统上运行的其他 Python 应用程序的行为。

另参见 `venv`。

virtual machine -- 虚拟机 一台完全通过软件定义的计算机。Python 虚拟机可执行字节码编译器所生成的*bytecode*。

Zen of Python -- Python 之禅 列出 Python 设计的原则与哲学，有助于理解与使用这种语言。查看其具体内容可在交互模式提示符中输入"`import this`"。

APPENDIX B

文档说明

这些文档是用 Sphinx 从 reStructuredText 源生成的，*Sphinx* 是一个专为处理 Python 文档而编写的文档生成器。

本文档及其工具链之开发，皆在于志愿者之努力，亦恰如 Python 本身。如果您想为此作出贡献，请阅读 reporting-bugs 了解如何参与。我们随时欢迎新的志愿者！

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- the Docutils project for creating reStructuredText and the Docutils suite;
- Fredrik Lundh 的 Alternative Python Reference 项目，Sphinx 从中得到了许多好的想法。

B.1 Python 文档的贡献者

有很多对 Python 语言，Python 标准库和 Python 文档有贡献的人，随 Python 源代码分发的 Misc/ACKS 文件列出了部分贡献者。

有了 Python 社区的输入和贡献，Python 才有了如此出色的文档——谢谢你们！

APPENDIX C

历史和许可证

C.1 该软件的历史

Python 由荷兰数学和计算机科学研究学会（CWI，见 https://www.cwi.nl/ ）的 Guido van Rossum 于 1990 年代初设计，作为一门叫做 ABC 的语言的替代品。尽管 Python 包含了许多来自其他人的贡献，Guido 仍是其主要作者。

1995 年，Guido 在弗吉尼亚州的国家创新研究公司（CNRI，见 https://www.cnri.reston.va.us/ ）继续他在 Python 上的工作，并在那里发布了该软件的多个版本。

2000 年五月，Guido 和 Python 核心开发团队转到 BeOpen.com 并组建了 BeOpen PythonLabs 团队。同年十月，PythonLabs 团队转到 Digital Creations (现为 Zope 公司；见 https://www.zope.org/)。2001 年，Python 软件基金会 (PSF，见 https://www.python.org/psf/) 成立，这是一个专为拥有 Python 相关知识产权而创建的非营利组织。Zope 公司现在是 Python 软件基金会的赞助成员。

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C.3.1 Mersenne Twister

_random 模块包含基于 http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/MT2002/emt19937ar.html 下载的代码。以下是原始代码的完整注释（声明）：

```
A C-program for MT19937, with initialization improved 2002/1/26.
Coded by Takuji Nishimura and Makoto Matsumoto.

Before using, initialize the state by using init_genrand(seed)
or init_by_array(init_key, key_length).

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http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html
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C.3.2 套接字

The socket module uses the functions, getaddrinfo(), and getnameinfo(), which are coded in separate source files from the WIDE Project, https://www.wide.ad.jp/.

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C.3.6 UUencode 与 UUdecode 函数

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Modified by Jack Jansen, CWI, July 1995:
- Use binascii module to do the actual line-by-line conversion
  between ascii and binary. This results in a 1000-fold speedup. The C
  version is still 5 times faster, though.
- Arguments more compliant with Python standard
```

C.3.7 XML 远程过程调用

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```
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C.3.10 SipHash24

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Original location:
   https://github.com/majek/csiphash/

Solution inspired by code from:
   Samuel Neves (supercop/crypto_auth/siphash24/little)
   djb (supercop/crypto_auth/siphash24/little2)
   Jean-Philippe Aumasson (https://131002.net/siphash/siphash24.c)
```

C.3.11 strtod 和 dtoa

The file `Python/dtoa.c`, which supplies C functions dtoa and strtod for conversion of C doubles to and from strings, is derived from the file of the same name by David M. Gay, currently available from https://web.archive.org/web/20220517033456/http://www.netlib.org/fp/dtoa.c. The original file, as retrieved on March 16, 2009, contains the following copyright and licensing notice:

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C.3.12 OpenSSL

如果操作系统可用，则 `hashlib`、`posix`、`ssl`、`crypt` 模块使用 OpenSSL 库来提高性能。此外，适用于 Python 的 Windows 和 macoS 安装程序可能包括 OpenSSL 库的拷贝，所以在此处也列出了 OpenSSL 许可证的拷贝:

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C.3.13 expat

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C.3.14 libffi

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C.3.15 zlib

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C.3.16 cfuhash

`tracemalloc` 使用的哈希表的实现基于 cfuhash 项目:

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C.3.17 libmpdec

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C.3.18 W3C C14N 测试套件

`test` 包中的 C14N 2.0 测试集 (`Lib/test/xmltestdata/c14n-20/`) 提取自 W3C 网站 https://www.w3.org/TR/xml-c14n2-testcases/ 并根据 3 条款版 BSD 许可证发行:

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C.3.19 Audioop

The audioop module uses the code base in g771.c file of the SoX project:

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索引

非字母

..., **265**
2to3, **265**
>>>, **265**
__all__ (*package variable*), 62
__dict__ (*module attribute*), 145
__doc__ (*module attribute*), 145
__file__ (*module attribute*), 145, 146
__future__, **269**
__import__
　　内置函数, 62
__loader__ (*module attribute*), 145
__main__
　　模块, 11, 168, 180
__name__ (*module attribute*), 145
__package__ (*module attribute*), 145
__PYVENV_LAUNCHER__, 194, 200
__slots__, **275**
_frozen (*C struct*), 65
_inittab (*C struct*), 65
_Py_c_diff (*C function*), 110
_Py_c_neg (*C function*), 110
_Py_c_pow (*C function*), 111
_Py_c_prod (*C function*), 110
_Py_c_quot (*C function*), 111
_Py_c_sum (*C function*), 110
_Py_InitializeMain (*C function*), 207
_Py_NoneStruct (*C var*), 219
_PyBytes_Resize (*C function*), 113
_PyCFunctionFast (*C type*), 222
_PyCFunctionFastWithKeywords (*C type*), 222
_PyFrameEvalFunction (*C type*), 178
_PyInterpreterState_GetEvalFrameFunc (*C function*), 178
_PyInterpreterState_SetEvalFrameFunc (*C function*), 179
_PyObject_GetDictPtr (*C function*), 80
_PyObject_New (*C function*), 219
_PyObject_NewVar (*C function*), 219
_PyTuple_Resize (*C function*), 133
_thread
　　模块, 175
环境变量
　　__PYVENV_LAUNCHER__, 194, 200
　　exec_prefix, 4
　　PATH, 11
　　prefix, 4
　　PYTHON*, 166
　　PYTHONCOERCECLOCALE, 205
　　PYTHONDEBUG, 166, 199
　　PYTHONDEVMODE, 196
　　PYTHONDONTWRITEBYTECODE, 166, 202
　　PYTHONDUMPREFS, 196, 233
　　PYTHONEXECUTABLE, 200
　　PYTHONFAULTHANDLER, 196
　　PYTHONHASHSEED, 166, 197
　　PYTHONHOME, 11, 166, 172, 197
　　PYTHONINSPECT, 167, 197
　　PYTHONIOENCODING, 169, 201
　　PYTHONLEGACYWINDOWSFSENCODING, 167, 191
　　PYTHONLEGACYWINDOWSSTDIO, 167, 198
　　PYTHONMALLOC, 210, 213, 215
　　PYTHONMALLOC` (例 如: ``PYTHONMALLOC=malloc`, 216
　　PYTHONMALLOCSTATS, 198, 210
　　PYTHONNODEBUGRANGES, 195
　　PYTHONNOUSERSITE, 167, 202
　　PYTHONOPTIMIZE, 167, 199
　　PYTHONPATH, 11, 166, 198
　　PYTHONPLATLIBDIR, 198
　　PYTHONPROFILEIMPORTTIME, 197
　　PYTHONPYCACHEPREFIX, 200
　　PYTHONSAFEPATH, 194
　　PYTHONTRACEMALLOC, 201
　　PYTHONUNBUFFERED, 167, 195
　　PYTHONUTF8, 191, 205
　　PYTHONVERBOSE, 167, 202
　　PYTHONWARNINGS, 202

A

abort(), 62
abs
　　内置函数, 88
abstract base class -- 抽象基类, **265**
allocfunc (*C type*), 256
annotation -- 标注, **265**

argument -- 参数, **265**
argv (*in module sys*), 171
ascii
  内置函数, 81
asynchronous context manager -- 异步上下文管理器, **266**
asynchronous generator -- 异步生成器, **266**
asynchronous generator iterator -- 异步生成器迭代器, **266**
asynchronous iterable -- 异步可迭代对象, **266**
asynchronous iterator -- 异步迭代器, **266**
attribute -- 属性, **266**
awaitable -- 可等待对象, **266**

B

BDFL, **266**
binary file -- 二进制文件, **266**
binaryfunc (*C type*), 257
borrowed reference -- 借入引用, **266**
buffer interface
  (see buffer protocol), 93
buffer object
  (see buffer protocol), 93
buffer protocol, 93
builtins
  模块, 11, 168, 180
bytearray
  对象, 114
bytecode -- 字节码, **267**
bytes
  内置函数, 81
  对象, 112
bytes-like object -- 字节类对象, **266**

C

callback -- 回调, **267**
calloc(), 209
Capsule
  对象, 156
C-contiguous, 96, 267
class -- 类, **267**
class variable -- 类变量, **267**
classmethod
  内置函数, 224
cleanup functions, 62
close() (*in module os*), 181
CO_FUTURE_DIVISION (*C var*), 42
code object, 142
compile
  内置函数, 63
complex number
  对象, 110
complex number -- 复数, **267**
context manager -- 上下文管理器, **267**
context variable -- 上下文变量, **267**
contiguous, 96
contiguous -- 连续, **267**
copyright (*in module sys*), 171
coroutine -- 协程, **267**
coroutine function -- 协程函数, **267**
CPython, **267**

D

decorator -- 装饰器, **267**
descrgetfunc (*C type*), 257
descriptor -- 描述器, **268**
descrsetfunc (*C type*), 257
destructor (*C type*), 256
dictionary
  对象, 136
dictionary -- 字典, **268**
dictionary comprehension -- 字典推导式, **268**
dictionary view -- 字典视图, **268**
divmod
  内置函数, 88
docstring -- 文档字符串, **268**
duck-typing -- 鸭子类型, **268**

E

EAFP, **268**
EOFError (*built-in exception*), 144
exc_info() (*in module sys*), 9
exec_prefix, 4
executable (*in module sys*), 170
exit(), 62
expression -- 表达式, **268**
extension module -- 扩展模块, **268**

F

f-string -- f-字符串, **268**
file
  对象, 144
file object -- 文件对象, **268**
file-like object -- 文件类对象, **268**
filesystem encoding and error handler -- 文件系统编码格式与错误处理句柄, **268**
finder -- 查找器, **269**
float
  内置函数, 89
floating point
  对象, 108
floor division -- 向下取整除法, **269**
Fortran contiguous, 96, 267
free(), 209
freefunc (*C type*), 256
freeze utility, 65
frozenset
  对象, 138
function
  对象, 140
function -- 函数, **269**
function annotation -- 函数标注, **269**

G

garbage collection -- 垃圾回收, **269**
generator, 269
generator -- 生成器, **269**
generator expression, 269
generator expression -- 生成器表达式, **269**
generator iterator -- 生成器迭代器, **269**
generic function -- 泛型函数, **269**
generic type -- 泛型类型, **269**
getattrfunc (*C type*), 256
getattrofunc (*C type*), 256
getbufferproc (*C type*), 257
getiterfunc (*C type*), 257
GIL, **269**
global interpreter lock, 173
global interpreter lock -- 全局解释器锁, **270**

H

hash
    🄵置函数, 81, 236
hash-based pyc -- 基于哈希的 pyc, **270**
hashable -- 可哈希, **270**
hashfunc (*C type*), 257

I

IDLE, **270**
immutable -- 不可变对象, **270**
import path -- 导入路径, **270**
importer -- 导入器, **270**
importing -- 导入, **270**
incr_item(), 10, 11
initproc (*C type*), 256
inquiry (*C type*), 261
instancemethod
    对象, 141
int
    🄵置函数, 89
integer
    对象, 105
interactive -- 交互, **270**
interpreted -- 解释型, **270**
interpreter lock, 173
interpreter shutdown -- 解释器关闭, **270**
iterable -- 可迭代对象, **270**
iterator -- 迭代器, **271**
iternextfunc (*C type*), 257

K

key function -- 键函数, **271**
KeyboardInterrupt (*built-in exception*), 51
keyword argument -- 关键字参数, **271**

L

lambda, **271**
LBYL, **271**
len
    🄵置函数, 82, 90, 92, 135, 137, 139
lenfunc (*C type*), 257
list
    对象, 134
list -- 列表, **271**
list comprehension -- 列表推导式, **271**
loader -- 加载器, **271**
locale encoding -- 语言区域编码格式, **271**
lock, interpreter, 173
long integer
    对象, 105
LONG_MAX, 106

M

magic
    method, 271
magic method -- 魔术方法, **271**
main(), 169, 171
malloc(), 209
mapping
    对象, 136
mapping -- 映射, **271**
memoryview
    对象, 155
meta path finder -- 元路径查找器, **272**
metaclass -- 元类, **272**
METH_CLASS (🄵置变量), 224
METH_COEXIST (🄵置变量), 224
METH_FASTCALL (🄵置变量), 223
METH_NOARGS (🄵置变量), 223
METH_O (🄵置变量), 224
METH_STATIC (🄵置变量), 224
METH_VARARGS (🄵置变量), 223
method
    magic, 271
    special, 275
    对象, 141
method -- 方法, **272**
method resolution order -- 方法解析顺序, **272**
MethodType (*in module types*), 140, 141
module
    search path, 11, 168, 170
    对象, 145
module -- 模块, **272**
module spec -- 模块规格, **272**
modules (*in module sys*), 62, 168
ModuleType (*in module types*), 145
MRO, **272**
mutable -- 可变对象, **272**

N

named tuple -- 具名元组, **272**
namespace -- 命名空间, **272**
namespace package -- 命名空间包, **272**
nested scope -- 嵌套作用域, **272**
new-style class -- 新式类, **273**

newfunc (*C type*), 256
None
    对象, 105
numeric
    对象, 105

O

object
    code, 142
object -- 对象, **273**
objobjargproc (*C type*), 257
objobjproc (*C type*), 257
OverflowError (*built-in exception*), 106, 107

P

package -- 包, **273**
package variable
    __all__, 62
parameter -- 形参, **273**
PATH, 11
path
    module search, 11, 168, 170
path (*in module sys*), 11, 168, 170
path based finder -- 基于路径的查找器, **273**
path entry -- 路径入口, **273**
path entry finder -- 路径入口查找器, **273**
path entry hook -- 路径入口钩子, **273**
path-like object -- 路径类对象, **273**
PEP, **273**
platform (*in module sys*), 171
portion -- 部分, **274**
positional argument -- 位置参数, **274**
pow
    F置函数, 88, 89
prefix, 4
provisional API -- 暂定 API, **274**
provisional package -- 暂定包, **274**
Py_ABS (*C macro*), 4
Py_AddPendingCall (*C function*), 181
Py_AddPendingCall(), 181
Py_ALWAYS_INLINE (*C macro*), 4
Py_AtExit (*C function*), 62
Py_BEGIN_ALLOW_THREADS, 173
Py_BEGIN_ALLOW_THREADS (*C macro*), 176
Py_BLOCK_THREADS (*C macro*), 176
Py_buffer (*C type*), 94
Py_buffer.buf (*C member*), 94
Py_buffer.format (*C member*), 95
Py_buffer.internal (*C member*), 95
Py_buffer.itemsize (*C member*), 95
Py_buffer.len (*C member*), 94
Py_buffer.ndim (*C member*), 95
Py_buffer.obj (*C member*), 94
Py_buffer.readonly (*C member*), 95
Py_buffer.shape (*C member*), 95
Py_buffer.strides (*C member*), 95
Py_buffer.suboffsets (*C member*), 95
Py_BuildValue (*C function*), 72
Py_BytesMain (*C function*), 39
Py_BytesWarningFlag (*C var*), 166
Py_CHARMASK (*C macro*), 4
Py_CLEAR (*C function*), 44
Py_CompileString (*C function*), 41
Py_CompileString(), 42
Py_CompileStringExFlags (*C function*), 41
Py_CompileStringFlags (*C function*), 41
Py_CompileStringObject (*C function*), 41
Py_complex (*C type*), 110
Py_DebugFlag (*C var*), 166
Py_DecodeLocale (*C function*), 58
Py_DECREF (*C function*), 43
Py_DecRef (*C function*), 44
Py_DECREF(), 6
Py_DEPRECATED (*C macro*), 4
Py_DontWriteBytecodeFlag (*C var*), 166
Py_Ellipsis (*C var*), 155
Py_EncodeLocale (*C function*), 59
Py_END_ALLOW_THREADS, 173
Py_END_ALLOW_THREADS (*C macro*), 176
Py_EndInterpreter (*C function*), 181
Py_EnterRecursiveCall (*C function*), 54
Py_eval_input (*C var*), 42
Py_Exit (*C function*), 62
Py_False (*C var*), 108
Py_FatalError (*C function*), 62
Py_FatalError(), 171
Py_FdIsInteractive (*C function*), 57
Py_file_input (*C var*), 42
Py_Finalize (*C function*), 168
Py_FinalizeEx (*C function*), 168
Py_FinalizeEx(), 62, 168, 180, 181
Py_FrozenFlag (*C var*), 166
Py_GenericAlias (*C function*), 164
Py_GenericAliasType (*C var*), 164
Py_GetArgcArgv (*C function*), 206
Py_GetBuildInfo (*C function*), 171
Py_GetCompiler (*C function*), 171
Py_GetCopyright (*C function*), 171
Py_GETENV (*C macro*), 5
Py_GetExecPrefix (*C function*), 169
Py_GetExecPrefix(), 11
Py_GetPath (*C function*), 170
Py_GetPath(), 11, 169, 170
Py_GetPlatform (*C function*), 171
Py_GetPrefix (*C function*), 169
Py_GetPrefix(), 11
Py_GetProgramFullPath (*C function*), 170
Py_GetProgramFullPath(), 11
Py_GetProgramName (*C function*), 169
Py_GetPythonHome (*C function*), 172
Py_GetVersion (*C function*), 171
Py_HashRandomizationFlag (*C var*), 166
Py_IgnoreEnvironmentFlag (*C var*), 166
Py_INCREF (*C function*), 43
Py_IncRef (*C function*), 44

Py_INCREF(), 6
Py_Initialize (C function), 168
Py_Initialize(), 11, 169, 180
Py_InitializeEx (C function), 168
Py_InitializeFromConfig (C function), 203
Py_InspectFlag (C var), 166
Py_InteractiveFlag (C var), 167
Py_Is (C function), 220
Py_IS_TYPE (C function), 221
Py_IsFalse (C function), 221
Py_IsInitialized (C function), 168
Py_IsInitialized(), 11
Py_IsNone (C function), 220
Py_IsolatedFlag (C var), 167
Py_IsTrue (C function), 220
Py_LeaveRecursiveCall (C function), 54
Py_LegacyWindowsFSEncodingFlag (C var), 167
Py_LegacyWindowsStdioFlag (C var), 167
Py_LIMITED_API (C macro), 13
Py_Main (C function), 39
PY_MAJOR_VERSION (C macro), 263
Py_MAX (C macro), 5
Py_MEMBER_SIZE (C macro), 5
PY_MICRO_VERSION (C macro), 263
Py_MIN (C macro), 5
PY_MINOR_VERSION (C macro), 263
Py_mod_create (C macro), 148
Py_mod_create.create_module (C function), 148
Py_mod_exec (C macro), 149
Py_mod_exec.exec_module (C function), 149
Py_NewInterpreter (C function), 180
Py_NewRef (C function), 43
Py_NO_INLINE (C macro), 5
Py_None (C var), 105
Py_NoSiteFlag (C var), 167
Py_NotImplemented (C var), 79
Py_NoUserSiteDirectory (C var), 167
Py_OptimizeFlag (C var), 167
Py_PreInitialize (C function), 192
Py_PreInitializeFromArgs (C function), 192
Py_PreInitializeFromBytesArgs (C function), 192
Py_PRINT_RAW, 145
Py_QuietFlag (C var), 167
Py_REFCNT (C function), 221
PY_RELEASE_LEVEL (C macro), 263
PY_RELEASE_SERIAL (C macro), 263
Py_ReprEnter (C function), 54
Py_ReprLeave (C function), 54
Py_RETURN_FALSE (C macro), 108
Py_RETURN_NONE (C macro), 105
Py_RETURN_NOTIMPLEMENTED (C macro), 79
Py_RETURN_TRUE (C macro), 108
Py_RunMain (C function), 206
Py_SET_REFCNT (C function), 221
Py_SET_SIZE (C function), 221
Py_SET_TYPE (C function), 221
Py_SetPath (C function), 170
Py_SetPath(), 170
Py_SetProgramName (C function), 169
Py_SetProgramName(), 11, 168170
Py_SetPythonHome (C function), 172
Py_SetStandardStreamEncoding (C function), 169
Py_single_input (C var), 42
Py_SIZE (C function), 221
Py_ssize_t (C type), 9
PY_SSIZE_T_MAX, 107
Py_STRINGIFY (C macro), 5
Py_TPFLAGS_BASE_EXC_SUBCLASS (F置变量), 240
Py_TPFLAGS_BASETYPE (F置变量), 238
Py_TPFLAGS_BYTES_SUBCLASS (F置变量), 239
Py_TPFLAGS_DEFAULT (F置变量), 239
Py_TPFLAGS_DICT_SUBCLASS (F置变量), 240
Py_TPFLAGS_DISALLOW_INSTANTIATION (F置变量), 240
Py_TPFLAGS_HAVE_FINALIZE (F置变量), 240
Py_TPFLAGS_HAVE_GC (F置变量), 239
Py_TPFLAGS_HAVE_VECTORCALL (F置变量), 240
Py_TPFLAGS_HEAPTYPE (F置变量), 238
Py_TPFLAGS_IMMUTABLETYPE (F置变量), 240
Py_TPFLAGS_LIST_SUBCLASS (F置变量), 239
Py_TPFLAGS_LONG_SUBCLASS (F置变量), 239
Py_TPFLAGS_MAPPING (F置变量), 240
Py_TPFLAGS_METHOD_DESCRIPTOR (F置变量), 239
Py_TPFLAGS_READY (F置变量), 239
Py_TPFLAGS_READYING (F置变量), 239
Py_TPFLAGS_SEQUENCE (F置变量), 241
Py_TPFLAGS_TUPLE_SUBCLASS (F置变量), 239
Py_TPFLAGS_TYPE_SUBCLASS (F置变量), 240
Py_TPFLAGS_UNICODE_SUBCLASS (F置变量), 239
Py_tracefunc (C type), 182
Py_True (C var), 108
Py_tss_NEEDS_INIT (C macro), 184
Py_tss_t (C type), 184
Py_TYPE (C function), 221
Py_UCS1 (C type), 115
Py_UCS2 (C type), 115
Py_UCS4 (C type), 115
Py_UNBLOCK_THREADS (C macro), 177
Py_UnbufferedStdioFlag (C var), 167
Py_UNICODE (C type), 115
Py_UNICODE_IS_HIGH_SURROGATE (C macro), 119
Py_UNICODE_IS_LOW_SURROGATE (C macro), 119
Py_UNICODE_IS_SURROGATE (C macro), 119
Py_UNICODE_ISALNUM (C function), 118
Py_UNICODE_ISALPHA (C function), 118
Py_UNICODE_ISDECIMAL (C function), 118

Py_UNICODE_ISDIGIT (*C function*), 118
Py_UNICODE_ISLINEBREAK (*C function*), 118
Py_UNICODE_ISLOWER (*C function*), 118
Py_UNICODE_ISNUMERIC (*C function*), 118
Py_UNICODE_ISPRINTABLE (*C function*), 118
Py_UNICODE_ISSPACE (*C function*), 118
Py_UNICODE_ISTITLE (*C function*), 118
Py_UNICODE_ISUPPER (*C function*), 118
Py_UNICODE_JOIN_SURROGATES (*C macro*), 119
Py_UNICODE_TODECIMAL (*C function*), 118
Py_UNICODE_TODIGIT (*C function*), 118
Py_UNICODE_TOLOWER (*C function*), 118
Py_UNICODE_TONUMERIC (*C function*), 119
Py_UNICODE_TOTITLE (*C function*), 118
Py_UNICODE_TOUPPER (*C function*), 118
Py_UNREACHABLE (*C macro*), 5
Py_UNUSED (*C macro*), 5
Py_VaBuildValue (*C function*), 73
PY_VECTORCALL_ARGUMENTS_OFFSET (*C macro*), 83
Py_VerboseFlag (*C var*), 167
Py_Version (*C var*), 263
PY_VERSION_HEX (*C macro*), 263
Py_VISIT (*C function*), 261
Py_XDECREF (*C function*), 44
Py_XDECREF(), 11
Py_XINCREF (*C function*), 43
Py_XNewRef (*C function*), 43
PyAIter_Check (*C function*), 93
PyAnySet_Check (*C function*), 139
PyAnySet_CheckExact (*C function*), 139
PyArg_Parse (*C function*), 71
PyArg_ParseTuple (*C function*), 71
PyArg_ParseTupleAndKeywords (*C function*), 71
PyArg_UnpackTuple (*C function*), 71
PyArg_ValidateKeywordArguments (*C function*), 71
PyArg_VaParse (*C function*), 71
PyArg_VaParseTupleAndKeywords (*C function*), 71
PyASCIIObject (*C type*), 115
PyAsyncMethods (*C type*), 255
PyAsyncMethods.am_aiter (*C member*), 255
PyAsyncMethods.am_anext (*C member*), 256
PyAsyncMethods.am_await (*C member*), 255
PyAsyncMethods.am_send (*C member*), 256
PyBool_Check (*C function*), 108
PyBool_FromLong (*C function*), 108
PyBUF_ANY_CONTIGUOUS (*C macro*), 97
PyBUF_C_CONTIGUOUS (*C macro*), 97
PyBUF_CONTIG (*C macro*), 97
PyBUF_CONTIG_RO (*C macro*), 97
PyBUF_F_CONTIGUOUS (*C macro*), 97
PyBUF_FORMAT (*C macro*), 96
PyBUF_FULL (*C macro*), 97
PyBUF_FULL_RO (*C macro*), 97
PyBUF_INDIRECT (*C macro*), 96
PyBUF_ND (*C macro*), 96
PyBUF_RECORDS (*C macro*), 97
PyBUF_RECORDS_RO (*C macro*), 97
PyBUF_SIMPLE (*C macro*), 96
PyBUF_STRIDED (*C macro*), 97
PyBUF_STRIDED_RO (*C macro*), 97
PyBUF_STRIDES (*C macro*), 96
PyBUF_WRITABLE (*C macro*), 96
PyBuffer_FillContiguousStrides (*C function*), 99
PyBuffer_FillInfo (*C function*), 100
PyBuffer_FromContiguous (*C function*), 99
PyBuffer_GetPointer (*C function*), 99
PyBuffer_IsContiguous (*C function*), 99
PyBuffer_Release (*C function*), 99
PyBuffer_SizeFromFormat (*C function*), 99
PyBuffer_ToContiguous (*C function*), 99
PyBufferProcs, 94
PyBufferProcs (*C type*), 254
PyBufferProcs.bf_getbuffer (*C member*), 254
PyBufferProcs.bf_releasebuffer (*C member*), 255
PyByteArray_AS_STRING (*C function*), 114
PyByteArray_AsString (*C function*), 114
PyByteArray_Check (*C function*), 114
PyByteArray_CheckExact (*C function*), 114
PyByteArray_Concat (*C function*), 114
PyByteArray_FromObject (*C function*), 114
PyByteArray_FromStringAndSize (*C function*), 114
PyByteArray_GET_SIZE (*C function*), 114
PyByteArray_Resize (*C function*), 114
PyByteArray_Size (*C function*), 114
PyByteArray_Type (*C var*), 114
PyByteArrayObject (*C type*), 114
PyBytes_AS_STRING (*C function*), 113
PyBytes_AsString (*C function*), 113
PyBytes_AsStringAndSize (*C function*), 113
PyBytes_Check (*C function*), 112
PyBytes_CheckExact (*C function*), 112
PyBytes_Concat (*C function*), 113
PyBytes_ConcatAndDel (*C function*), 113
PyBytes_FromFormat (*C function*), 112
PyBytes_FromFormatV (*C function*), 112
PyBytes_FromObject (*C function*), 113
PyBytes_FromString (*C function*), 112
PyBytes_FromStringAndSize (*C function*), 112
PyBytes_GET_SIZE (*C function*), 113
PyBytes_Size (*C function*), 113
PyBytes_Type (*C var*), 112
PyBytesObject (*C type*), 112
PyCallable_Check (*C function*), 87
PyCallIter_Check (*C function*), 152
PyCallIter_New (*C function*), 152
PyCallIter_Type (*C var*), 152
PyCapsule (*C type*), 156
PyCapsule_CheckExact (*C function*), 156

PyCapsule_Destructor (*C type*), 156
PyCapsule_GetContext (*C function*), 157
PyCapsule_GetDestructor (*C function*), 157
PyCapsule_GetName (*C function*), 157
PyCapsule_GetPointer (*C function*), 157
PyCapsule_Import (*C function*), 157
PyCapsule_IsValid (*C function*), 157
PyCapsule_New (*C function*), 156
PyCapsule_SetContext (*C function*), 157
PyCapsule_SetDestructor (*C function*), 157
PyCapsule_SetName (*C function*), 157
PyCapsule_SetPointer (*C function*), 157
PyCell_Check (*C function*), 142
PyCell_GET (*C function*), 142
PyCell_Get (*C function*), 142
PyCell_New (*C function*), 142
PyCell_SET (*C function*), 142
PyCell_Set (*C function*), 142
PyCell_Type (*C var*), 142
PyCellObject (*C type*), 142
PyCFunction (*C type*), 222
PyCFunctionWithKeywords (*C type*), 222
PyCMethod (*C type*), 222
PyCode_Addr2Line (*C function*), 143
PyCode_Addr2Location (*C function*), 143
PyCode_Check (*C function*), 142
PyCode_GetCellvars (*C function*), 143
PyCode_GetCode (*C function*), 143
PyCode_GetFreevars (*C function*), 144
PyCode_GetNumFree (*C function*), 142
PyCode_GetVarnames (*C function*), 143
PyCode_New (*C function*), 142
PyCode_NewEmpty (*C function*), 143
PyCode_NewWithPosOnlyArgs (*C function*), 143
PyCode_Type (*C var*), 142
PyCodec_BackslashReplaceErrors (*C function*), 76
PyCodec_Decode (*C function*), 75
PyCodec_Decoder (*C function*), 76
PyCodec_Encode (*C function*), 75
PyCodec_Encoder (*C function*), 76
PyCodec_IgnoreErrors (*C function*), 76
PyCodec_IncrementalDecoder (*C function*), 76
PyCodec_IncrementalEncoder (*C function*), 76
PyCodec_KnownEncoding (*C function*), 75
PyCodec_LookupError (*C function*), 76
PyCodec_NameReplaceErrors (*C function*), 76
PyCodec_Register (*C function*), 75
PyCodec_RegisterError (*C function*), 76
PyCodec_ReplaceErrors (*C function*), 76
PyCodec_StreamReader (*C function*), 76
PyCodec_StreamWriter (*C function*), 76
PyCodec_StrictErrors (*C function*), 76
PyCodec_Unregister (*C function*), 75
PyCodec_XMLCharRefReplaceErrors (*C function*), 76
PyCodeObject (*C type*), 142
PyCompactUnicodeObject (*C type*), 115
PyCompilerFlags (*C struct*), 42
PyCompilerFlags.cf_feature_version (*C member*), 42
PyCompilerFlags.cf_flags (*C member*), 42
PyComplex_AsCComplex (*C function*), 111
PyComplex_Check (*C function*), 111
PyComplex_CheckExact (*C function*), 111
PyComplex_FromCComplex (*C function*), 111
PyComplex_FromDoubles (*C function*), 111
PyComplex_ImagAsDouble (*C function*), 111
PyComplex_RealAsDouble (*C function*), 111
PyComplex_Type (*C var*), 111
PyComplexObject (*C type*), 111
PyConfig (*C type*), 193
PyConfig.argv (*C member*), 194
PyConfig.base_exec_prefix (*C member*), 194
PyConfig.base_executable (*C member*), 194
PyConfig.base_prefix (*C member*), 194
PyConfig.buffered_stdio (*C member*), 195
PyConfig.bytes_warning (*C member*), 195
PyConfig.check_hash_pycs_mode (*C member*), 195
PyConfig.code_debug_ranges (*C member*), 195
PyConfig.configure_c_stdio (*C member*), 195
PyConfig.dev_mode (*C member*), 196
PyConfig.dump_refs (*C member*), 196
PyConfig.exec_prefix (*C member*), 196
PyConfig.executable (*C member*), 196
PyConfig.faulthandler (*C member*), 196
PyConfig.filesystem_encoding (*C member*), 196
PyConfig.filesystem_errors (*C member*), 196
PyConfig.hash_seed (*C member*), 197
PyConfig.home (*C member*), 197
PyConfig.import_time (*C member*), 197
PyConfig.inspect (*C member*), 197
PyConfig.install_signal_handlers (*C member*), 197
PyConfig.interactive (*C member*), 197
PyConfig.isolated (*C member*), 198
PyConfig.legacy_windows_stdio (*C member*), 198
PyConfig.malloc_stats (*C member*), 198
PyConfig.module_search_paths (*C member*), 198
PyConfig.module_search_paths_set (*C member*), 198
PyConfig.optimization_level (*C member*), 199
PyConfig.orig_argv (*C member*), 199
PyConfig.parse_argv (*C member*), 199
PyConfig.parser_debug (*C member*), 199
PyConfig.pathconfig_warnings (*C member*), 199
PyConfig.platlibdir (*C member*), 198

PyConfig.prefix (*C member*), 199
PyConfig.program_name (*C member*), 200
PyConfig.pycache_prefix (*C member*), 200
PyConfig.PyConfig_Clear (*C function*), 193
PyConfig.PyConfig_InitIsolatedConfig (*C function*), 193
PyConfig.PyConfig_InitPythonConfig (*C function*), 193
PyConfig.PyConfig_Read (*C function*), 193
PyConfig.PyConfig_SetArgv (*C function*), 193
PyConfig.PyConfig_SetBytesArgv (*C function*), 193
PyConfig.PyConfig_SetBytesString (*C function*), 193
PyConfig.PyConfig_SetString (*C function*), 193
PyConfig.PyConfig_SetWideStringList (*C function*), 193
PyConfig.pythonpath_env (*C member*), 198
PyConfig.quiet (*C member*), 200
PyConfig.run_command (*C member*), 200
PyConfig.run_filename (*C member*), 200
PyConfig.run_module (*C member*), 200
PyConfig.safe_path (*C member*), 194
PyConfig.show_ref_count (*C member*), 200
PyConfig.site_import (*C member*), 201
PyConfig.skip_source_first_line (*C member*), 201
PyConfig.stdio_encoding (*C member*), 201
PyConfig.stdio_errors (*C member*), 201
PyConfig.tracemalloc (*C member*), 201
PyConfig.use_environment (*C member*), 201
PyConfig.use_hash_seed (*C member*), 197
PyConfig.user_site_directory (*C member*), 202
PyConfig.verbose (*C member*), 202
PyConfig.warn_default_encoding (*C member*), 195
PyConfig.warnoptions (*C member*), 202
PyConfig.write_bytecode (*C member*), 202
PyConfig.xoptions (*C member*), 202
PyContext (*C type*), 160
PyContext_CheckExact (*C function*), 160
PyContext_Copy (*C function*), 160
PyContext_CopyCurrent (*C function*), 160
PyContext_Enter (*C function*), 160
PyContext_Exit (*C function*), 160
PyContext_New (*C function*), 160
PyContext_Type (*C var*), 160
PyContextToken (*C type*), 160
PyContextToken_CheckExact (*C function*), 160
PyContextToken_Type (*C var*), 160
PyContextVar (*C type*), 160
PyContextVar_CheckExact (*C function*), 160
PyContextVar_Get (*C function*), 161
PyContextVar_New (*C function*), 161
PyContextVar_Reset (*C function*), 161
PyContextVar_Set (*C function*), 161
PyContextVar_Type (*C var*), 160
PyCoro_CheckExact (*C function*), 159
PyCoro_New (*C function*), 159
PyCoro_Type (*C var*), 159
PyCoroObject (*C type*), 159
PyDate_Check (*C function*), 161
PyDate_CheckExact (*C function*), 161
PyDate_FromDate (*C function*), 162
PyDate_FromTimestamp (*C function*), 164
PyDateTime_Check (*C function*), 161
PyDateTime_CheckExact (*C function*), 161
PyDateTime_DATE_GET_FOLD (*C function*), 163
PyDateTime_DATE_GET_HOUR (*C function*), 163
PyDateTime_DATE_GET_MICROSECOND (*C function*), 163
PyDateTime_DATE_GET_MINUTE (*C function*), 163
PyDateTime_DATE_GET_SECOND (*C function*), 163
PyDateTime_DATE_GET_TZINFO (*C function*), 163
PyDateTime_DELTA_GET_DAYS (*C function*), 163
PyDateTime_DELTA_GET_MICROSECONDS (*C function*), 164
PyDateTime_DELTA_GET_SECONDS (*C function*), 164
PyDateTime_FromDateAndTime (*C function*), 162
PyDateTime_FromDateAndTimeAndFold (*C function*), 162
PyDateTime_FromTimestamp (*C function*), 164
PyDateTime_GET_DAY (*C function*), 163
PyDateTime_GET_MONTH (*C function*), 163
PyDateTime_GET_YEAR (*C function*), 163
PyDateTime_TIME_GET_FOLD (*C function*), 163
PyDateTime_TIME_GET_HOUR (*C function*), 163
PyDateTime_TIME_GET_MICROSECOND (*C function*), 163
PyDateTime_TIME_GET_MINUTE (*C function*), 163
PyDateTime_TIME_GET_SECOND (*C function*), 163
PyDateTime_TIME_GET_TZINFO (*C function*), 163
PyDateTime_TimeZone_UTC (*C var*), 161
PyDelta_Check (*C function*), 162
PyDelta_CheckExact (*C function*), 162
PyDelta_FromDSU (*C function*), 162
PyDescr_IsData (*C function*), 153
PyDescr_NewClassMethod (*C function*), 153
PyDescr_NewGetSet (*C function*), 153
PyDescr_NewMember (*C function*), 153
PyDescr_NewMethod (*C function*), 153
PyDescr_NewWrapper (*C function*), 153
PyDict_Check (*C function*), 136
PyDict_CheckExact (*C function*), 136
PyDict_Clear (*C function*), 136
PyDict_Contains (*C function*), 136

PyDict_Copy (*C function*), 136
PyDict_DelItem (*C function*), 136
PyDict_DelItemString (*C function*), 136
PyDict_GetItem (*C function*), 136
PyDict_GetItemString (*C function*), 137
PyDict_GetItemWithError (*C function*), 136
PyDict_Items (*C function*), 137
PyDict_Keys (*C function*), 137
PyDict_Merge (*C function*), 138
PyDict_MergeFromSeq2 (*C function*), 138
PyDict_New (*C function*), 136
PyDict_Next (*C function*), 137
PyDict_SetDefault (*C function*), 137
PyDict_SetItem (*C function*), 136
PyDict_SetItemString (*C function*), 136
PyDict_Size (*C function*), 137
PyDict_Type (*C var*), 136
PyDict_Update (*C function*), 138
PyDict_Values (*C function*), 137
PyDictObject (*C type*), 136
PyDictProxy_New (*C function*), 136
PyDoc_STR (*C macro*), 6
PyDoc_STRVAR (*C macro*), 5
PyErr_BadArgument (*C function*), 46
PyErr_BadInternalCall (*C function*), 48
PyErr_CheckSignals (*C function*), 51
PyErr_Clear (*C function*), 45
PyErr_Clear(), 9, 11
PyErr_ExceptionMatches (*C function*), 49
PyErr_ExceptionMatches(), 11
PyErr_Fetch (*C function*), 49
PyErr_Format (*C function*), 46
PyErr_FormatV (*C function*), 46
PyErr_GetExcInfo (*C function*), 50
PyErr_GetHandledException (*C function*), 50
PyErr_GivenExceptionMatches (*C function*), 49
PyErr_NewException (*C function*), 52
PyErr_NewExceptionWithDoc (*C function*), 52
PyErr_NoMemory (*C function*), 46
PyErr_NormalizeException (*C function*), 50
PyErr_Occurred (*C function*), 49
PyErr_Occurred(), 9
PyErr_Print (*C function*), 45
PyErr_PrintEx (*C function*), 45
PyErr_ResourceWarning (*C function*), 49
PyErr_Restore (*C function*), 49
PyErr_SetExcFromWindowsErr (*C function*), 47
PyErr_SetExcFromWindowsErrWithFilename (*C function*), 47
PyErr_SetExcFromWindowsErrWithFilenameObject (*C function*), 47
PyErr_SetExcFromWindowsErrWithFilenameObjects (*C function*), 47
PyErr_SetExcInfo (*C function*), 51
PyErr_SetFromErrno (*C function*), 46
PyErr_SetFromErrnoWithFilename (*C function*), 47
PyErr_SetFromErrnoWithFilenameObject (*C function*), 46
PyErr_SetFromErrnoWithFilenameObjects (*C function*), 47
PyErr_SetFromWindowsErr (*C function*), 47
PyErr_SetFromWindowsErrWithFilename (*C function*), 47
PyErr_SetHandledException (*C function*), 50
PyErr_SetImportError (*C function*), 47
PyErr_SetImportErrorSubclass (*C function*), 48
PyErr_SetInterrupt (*C function*), 51
PyErr_SetInterruptEx (*C function*), 51
PyErr_SetNone (*C function*), 46
PyErr_SetObject (*C function*), 46
PyErr_SetString (*C function*), 46
PyErr_SetString(), 9
PyErr_SyntaxLocation (*C function*), 48
PyErr_SyntaxLocationEx (*C function*), 48
PyErr_SyntaxLocationObject (*C function*), 48
PyErr_WarnEx (*C function*), 48
PyErr_WarnExplicit (*C function*), 49
PyErr_WarnExplicitObject (*C function*), 48
PyErr_WarnFormat (*C function*), 49
PyErr_WriteUnraisable (*C function*), 46
PyEval_AcquireLock (*C function*), 179
PyEval_AcquireThread (*C function*), 179
PyEval_AcquireThread(), 175
PyEval_EvalCode (*C function*), 42
PyEval_EvalCodeEx (*C function*), 42
PyEval_EvalFrame (*C function*), 42
PyEval_EvalFrameEx (*C function*), 42
PyEval_GetBuiltins (*C function*), 75
PyEval_GetFrame (*C function*), 75
PyEval_GetFuncDesc (*C function*), 75
PyEval_GetFuncName (*C function*), 75
PyEval_GetGlobals (*C function*), 75
PyEval_GetLocals (*C function*), 75
PyEval_InitThreads (*C function*), 175
PyEval_InitThreads(), 168
PyEval_MergeCompilerFlags (*C function*), 42
PyEval_ReleaseLock (*C function*), 180
PyEval_ReleaseThread (*C function*), 179
PyEval_ReleaseThread(), 175
PyEval_RestoreThread (*C function*), 175
PyEval_RestoreThread(), 173, 175
PyEval_SaveThread (*C function*), 175
PyEval_SaveThread(), 173, 175
PyEval_SetProfile (*C function*), 183
PyEval_SetTrace (*C function*), 183
PyEval_ThreadsInitialized (*C function*), 175
PyExc_ArithmeticError, 54
PyExc_AssertionError, 54
PyExc_AttributeError, 54
PyExc_BaseException, 54
PyExc_BlockingIOError, 54
PyExc_BrokenPipeError, 54
PyExc_BufferError, 54

PyExc_BytesWarning, 56
PyExc_ChildProcessError, 54
PyExc_ConnectionAbortedError, 54
PyExc_ConnectionError, 54
PyExc_ConnectionRefusedError, 54
PyExc_ConnectionResetError, 54
PyExc_DeprecationWarning, 56
PyExc_EnvironmentError, 56
PyExc_EOFError, 54
PyExc_Exception, 54
PyExc_FileExistsError, 54
PyExc_FileNotFoundError, 54
PyExc_FloatingPointError, 54
PyExc_FutureWarning, 56
PyExc_GeneratorExit, 54
PyExc_ImportError, 54
PyExc_ImportWarning, 56
PyExc_IndentationError, 54
PyExc_IndexError, 54
PyExc_InterruptedError, 54
PyExc_IOError, 56
PyExc_IsADirectoryError, 54
PyExc_KeyboardInterrupt, 54
PyExc_KeyError, 54
PyExc_LookupError, 54
PyExc_MemoryError, 54
PyExc_ModuleNotFoundError, 54
PyExc_NameError, 54
PyExc_NotADirectoryError, 54
PyExc_NotImplementedError, 54
PyExc_OSError, 54
PyExc_OverflowError, 54
PyExc_PendingDeprecationWarning, 56
PyExc_PermissionError, 54
PyExc_ProcessLookupError, 54
PyExc_RecursionError, 54
PyExc_ReferenceError, 54
PyExc_ResourceWarning, 56
PyExc_RuntimeError, 54
PyExc_RuntimeWarning, 56
PyExc_StopAsyncIteration, 54
PyExc_StopIteration, 54
PyExc_SyntaxError, 54
PyExc_SyntaxWarning, 56
PyExc_SystemError, 54
PyExc_SystemExit, 54
PyExc_TabError, 54
PyExc_TimeoutError, 54
PyExc_TypeError, 54
PyExc_UnboundLocalError, 54
PyExc_UnicodeDecodeError, 54
PyExc_UnicodeEncodeError, 54
PyExc_UnicodeError, 54
PyExc_UnicodeTranslateError, 54
PyExc_UnicodeWarning, 56
PyExc_UserWarning, 56
PyExc_ValueError, 54
PyExc_Warning, 56
PyExc_WindowsError, 56
PyExc_ZeroDivisionError, 54
PyException_GetCause (*C function*), 52
PyException_GetContext (*C function*), 52
PyException_GetTraceback (*C function*), 52
PyException_SetCause (*C function*), 52
PyException_SetContext (*C function*), 52
PyException_SetTraceback (*C function*), 52
PyFile_FromFd (*C function*), 144
PyFile_GetLine (*C function*), 144
PyFile_SetOpenCodeHook (*C function*), 144
PyFile_WriteObject (*C function*), 145
PyFile_WriteString (*C function*), 145
PyFloat_AS_DOUBLE (*C function*), 109
PyFloat_AsDouble (*C function*), 109
PyFloat_Check (*C function*), 108
PyFloat_CheckExact (*C function*), 108
PyFloat_FromDouble (*C function*), 109
PyFloat_FromString (*C function*), 108
PyFloat_GetInfo (*C function*), 109
PyFloat_GetMax (*C function*), 109
PyFloat_GetMin (*C function*), 109
PyFloat_Pack2 (*C function*), 109
PyFloat_Pack4 (*C function*), 110
PyFloat_Pack8 (*C function*), 110
PyFloat_Type (*C var*), 108
PyFloat_Unpack2 (*C function*), 110
PyFloat_Unpack4 (*C function*), 110
PyFloat_Unpack8 (*C function*), 110
PyFloatObject (*C type*), 108
PyFrame_Check (*C function*), 158
PyFrame_GetBack (*C function*), 158
PyFrame_GetBuiltins (*C function*), 158
PyFrame_GetCode (*C function*), 158
PyFrame_GetGenerator (*C function*), 158
PyFrame_GetGlobals (*C function*), 158
PyFrame_GetLasti (*C function*), 158
PyFrame_GetLineNumber (*C function*), 159
PyFrame_GetLocals (*C function*), 158
PyFrame_Type (*C var*), 158
PyFrameObject (*C type*), 158
PyFrozenSet_Check (*C function*), 139
PyFrozenSet_CheckExact (*C function*), 139
PyFrozenSet_New (*C function*), 139
PyFrozenSet_Type (*C var*), 138
PyFunction_Check (*C function*), 140
PyFunction_GetAnnotations (*C function*), 141
PyFunction_GetClosure (*C function*), 140
PyFunction_GetCode (*C function*), 140
PyFunction_GetDefaults (*C function*), 140
PyFunction_GetGlobals (*C function*), 140
PyFunction_GetModule (*C function*), 140
PyFunction_New (*C function*), 140
PyFunction_NewWithQualName (*C function*), 140
PyFunction_SetAnnotations (*C function*), 141
PyFunction_SetClosure (*C function*), 141
PyFunction_SetDefaults (*C function*), 140

PyFunction_Type (*C var*), 140
PyFunctionObject (*C type*), 140
PyGC_Collect (*C function*), 262
PyGC_Disable (*C function*), 262
PyGC_Enable (*C function*), 262
PyGC_IsEnabled (*C function*), 262
PyGen_Check (*C function*), 159
PyGen_CheckExact (*C function*), 159
PyGen_New (*C function*), 159
PyGen_NewWithQualName (*C function*), 159
PyGen_Type (*C var*), 159
PyGenObject (*C type*), 159
PyGetSetDef (*C type*), 225
PyGILState_Check (*C function*), 176
PyGILState_Ensure (*C function*), 176
PyGILState_GetThisThreadState (*C function*), 176
PyGILState_Release (*C function*), 176
PyImport_AddModule (*C function*), 63
PyImport_AddModuleObject (*C function*), 63
PyImport_AppendInittab (*C function*), 65
PyImport_ExecCodeModule (*C function*), 63
PyImport_ExecCodeModuleEx (*C function*), 63
PyImport_ExecCodeModuleObject (*C function*), 64
PyImport_ExecCodeModuleWithPathnames (*C function*), 64
PyImport_ExtendInittab (*C function*), 65
PyImport_FrozenModules (*C var*), 65
PyImport_GetImporter (*C function*), 64
PyImport_GetMagicNumber (*C function*), 64
PyImport_GetMagicTag (*C function*), 64
PyImport_GetModule (*C function*), 64
PyImport_GetModuleDict (*C function*), 64
PyImport_Import (*C function*), 63
PyImport_ImportFrozenModule (*C function*), 64
PyImport_ImportFrozenModuleObject (*C function*), 64
PyImport_ImportModule (*C function*), 62
PyImport_ImportModuleEx (*C function*), 62
PyImport_ImportModuleLevel (*C function*), 63
PyImport_ImportModuleLevelObject (*C function*), 62
PyImport_ImportModuleNoBlock (*C function*), 62
PyImport_ReloadModule (*C function*), 63
PyIndex_Check (*C function*), 90
PyInstanceMethod_Check (*C function*), 141
PyInstanceMethod_Function (*C function*), 141
PyInstanceMethod_GET_FUNCTION (*C function*), 141
PyInstanceMethod_New (*C function*), 141
PyInstanceMethod_Type (*C var*), 141
PyInterpreterState (*C type*), 175
PyInterpreterState_Clear (*C function*), 177
PyInterpreterState_Delete (*C function*), 177
PyInterpreterState_Get (*C function*), 178
PyInterpreterState_GetDict (*C function*), 178
PyInterpreterState_GetID (*C function*), 178
PyInterpreterState_Head (*C function*), 183
PyInterpreterState_Main (*C function*), 183
PyInterpreterState_New (*C function*), 177
PyInterpreterState_Next (*C function*), 183
PyInterpreterState_ThreadHead (*C function*), 183
PyIter_Check (*C function*), 93
PyIter_Next (*C function*), 93
PyIter_Send (*C function*), 93
PyList_Append (*C function*), 135
PyList_AsTuple (*C function*), 135
PyList_Check (*C function*), 134
PyList_CheckExact (*C function*), 134
PyList_GET_ITEM (*C function*), 135
PyList_GET_SIZE (*C function*), 135
PyList_GetItem (*C function*), 135
PyList_GetItem(), 8
PyList_GetSlice (*C function*), 135
PyList_Insert (*C function*), 135
PyList_New (*C function*), 134
PyList_Reverse (*C function*), 135
PyList_SET_ITEM (*C function*), 135
PyList_SetItem (*C function*), 135
PyList_SetItem(), 7
PyList_SetSlice (*C function*), 135
PyList_Size (*C function*), 134
PyList_Sort (*C function*), 135
PyList_Type (*C var*), 134
PyListObject (*C type*), 134
PyLong_AsDouble (*C function*), 108
PyLong_AsLong (*C function*), 106
PyLong_AsLongAndOverflow (*C function*), 106
PyLong_AsLongLong (*C function*), 106
PyLong_AsLongLongAndOverflow (*C function*), 106
PyLong_AsSize_t (*C function*), 107
PyLong_AsSsize_t (*C function*), 107
PyLong_AsUnsignedLong (*C function*), 107
PyLong_AsUnsignedLongLong (*C function*), 107
PyLong_AsUnsignedLongLongMask (*C function*), 107
PyLong_AsUnsignedLongMask (*C function*), 107
PyLong_AsVoidPtr (*C function*), 108
PyLong_Check (*C function*), 105
PyLong_CheckExact (*C function*), 105
PyLong_FromDouble (*C function*), 106
PyLong_FromLong (*C function*), 105
PyLong_FromLongLong (*C function*), 105
PyLong_FromSize_t (*C function*), 105
PyLong_FromSsize_t (*C function*), 105
PyLong_FromString (*C function*), 106
PyLong_FromUnicodeObject (*C function*), 106
PyLong_FromUnsignedLong (*C function*), 105
PyLong_FromUnsignedLongLong (*C function*), 106

PyLong_FromVoidPtr (*C function*), 106
PyLong_Type (*C var*), 105
PyLongObject (*C type*), 105
PyMapping_Check (*C function*), 92
PyMapping_DelItem (*C function*), 92
PyMapping_DelItemString (*C function*), 92
PyMapping_GetItemString (*C function*), 92
PyMapping_HasKey (*C function*), 92
PyMapping_HasKeyString (*C function*), 92
PyMapping_Items (*C function*), 92
PyMapping_Keys (*C function*), 92
PyMapping_Length (*C function*), 92
PyMapping_SetItemString (*C function*), 92
PyMapping_Size (*C function*), 92
PyMapping_Values (*C function*), 92
PyMappingMethods (*C type*), 253
PyMappingMethods.mp_ass_subscript (*C member*), 253
PyMappingMethods.mp_length (*C member*), 253
PyMappingMethods.mp_subscript (*C member*), 253
PyMarshal_ReadLastObjectFromFile (*C function*), 66
PyMarshal_ReadLongFromFile (*C function*), 66
PyMarshal_ReadObjectFromFile (*C function*), 66
PyMarshal_ReadObjectFromString (*C function*), 66
PyMarshal_ReadShortFromFile (*C function*), 66
PyMarshal_WriteLongToFile (*C function*), 65
PyMarshal_WriteObjectToFile (*C function*), 66
PyMarshal_WriteObjectToString (*C function*), 66
PyMem_Calloc (*C function*), 211
PyMem_Del (*C function*), 212
PyMem_Free (*C function*), 211
PyMem_GetAllocator (*C function*), 214
PyMem_Malloc (*C function*), 211
PyMem_New (*C function*), 212
PyMem_RawCalloc (*C function*), 210
PyMem_RawFree (*C function*), 211
PyMem_RawMalloc (*C function*), 210
PyMem_RawRealloc (*C function*), 210
PyMem_Realloc (*C function*), 211
PyMem_Resize (*C function*), 212
PyMem_SetAllocator (*C function*), 214
PyMem_SetupDebugHooks (*C function*), 215
PyMemAllocatorDomain (*C type*), 214
PyMemAllocatorDomain.PYMEM_DOMAIN_MEM (*C macro*), 214
PyMemAllocatorDomain.PYMEM_DOMAIN_OBJ (*C macro*), 214
PyMemAllocatorDomain.PYMEM_DOMAIN_RAW (*C macro*), 214
PyMemAllocatorEx (*C type*), 213
PyMember_GetOne (*C function*), 225
PyMember_SetOne (*C function*), 225
PyMemberDef (*C type*), 224
PyMemoryView_Check (*C function*), 155
PyMemoryView_FromBuffer (*C function*), 155
PyMemoryView_FromMemory (*C function*), 155
PyMemoryView_FromObject (*C function*), 155
PyMemoryView_GET_BASE (*C function*), 155
PyMemoryView_GET_BUFFER (*C function*), 155
PyMemoryView_GetContiguous (*C function*), 155
PyMethod_Check (*C function*), 141
PyMethod_Function (*C function*), 141
PyMethod_GET_FUNCTION (*C function*), 141
PyMethod_GET_SELF (*C function*), 142
PyMethod_New (*C function*), 141
PyMethod_Self (*C function*), 141
PyMethod_Type (*C var*), 141
PyMethodDef (*C type*), 222
PyModule_AddFunctions (*C function*), 149
PyModule_AddIntConstant (*C function*), 151
PyModule_AddIntMacro (*C function*), 151
PyModule_AddObject (*C function*), 150
PyModule_AddObjectRef (*C function*), 150
PyModule_AddStringConstant (*C function*), 151
PyModule_AddStringMacro (*C function*), 151
PyModule_AddType (*C function*), 151
PyModule_Check (*C function*), 145
PyModule_CheckExact (*C function*), 145
PyModule_Create (*C function*), 147
PyModule_Create2 (*C function*), 147
PyModule_ExecDef (*C function*), 149
PyModule_FromDefAndSpec (*C function*), 149
PyModule_FromDefAndSpec2 (*C function*), 149
PyModule_GetDef (*C function*), 145
PyModule_GetDict (*C function*), 145
PyModule_GetFilename (*C function*), 146
PyModule_GetFilenameObject (*C function*), 145
PyModule_GetName (*C function*), 145
PyModule_GetNameObject (*C function*), 145
PyModule_GetState (*C function*), 145
PyModule_New (*C function*), 145
PyModule_NewObject (*C function*), 145
PyModule_SetDocString (*C function*), 149
PyModule_Type (*C var*), 145
PyModuleDef (*C type*), 146
PyModuleDef_Init (*C function*), 148
PyModuleDef_Slot (*C type*), 148
PyModuleDef_Slot.slot (*C member*), 148
PyModuleDef_Slot.value (*C member*), 148
PyModuleDef.m_base (*C member*), 146
PyModuleDef.m_clear (*C member*), 147
PyModuleDef.m_doc (*C member*), 146
PyModuleDef.m_free (*C member*), 147
PyModuleDef.m_methods (*C member*), 146
PyModuleDef.m_name (*C member*), 146

PyModuleDef.m_size (*C member*), 146
PyModuleDef.m_slots (*C member*), 146
PyModuleDef.m_slots.m_reload (*C member*), 146
PyModuleDef.m_traverse (*C member*), 147
PyNumber_Absolute (*C function*), 88
PyNumber_Add (*C function*), 87
PyNumber_And (*C function*), 88
PyNumber_AsSsize_t (*C function*), 89
PyNumber_Check (*C function*), 87
PyNumber_Divmod (*C function*), 87
PyNumber_Float (*C function*), 89
PyNumber_FloorDivide (*C function*), 87
PyNumber_Index (*C function*), 89
PyNumber_InPlaceAdd (*C function*), 88
PyNumber_InPlaceAnd (*C function*), 89
PyNumber_InPlaceFloorDivide (*C function*), 89
PyNumber_InPlaceLshift (*C function*), 89
PyNumber_InPlaceMatrixMultiply (*C function*), 88
PyNumber_InPlaceMultiply (*C function*), 88
PyNumber_InPlaceOr (*C function*), 89
PyNumber_InPlacePower (*C function*), 89
PyNumber_InPlaceRemainder (*C function*), 89
PyNumber_InPlaceRshift (*C function*), 89
PyNumber_InPlaceSubtract (*C function*), 88
PyNumber_InPlaceTrueDivide (*C function*), 89
PyNumber_InPlaceXor (*C function*), 89
PyNumber_Invert (*C function*), 88
PyNumber_Long (*C function*), 89
PyNumber_Lshift (*C function*), 88
PyNumber_MatrixMultiply (*C function*), 87
PyNumber_Multiply (*C function*), 87
PyNumber_Negative (*C function*), 88
PyNumber_Or (*C function*), 88
PyNumber_Positive (*C function*), 88
PyNumber_Power (*C function*), 88
PyNumber_Remainder (*C function*), 87
PyNumber_Rshift (*C function*), 88
PyNumber_Subtract (*C function*), 87
PyNumber_ToBase (*C function*), 89
PyNumber_TrueDivide (*C function*), 87
PyNumber_Xor (*C function*), 88
PyNumberMethods (*C type*), 251
PyNumberMethods.nb_absolute (*C member*), 252
PyNumberMethods.nb_add (*C member*), 252
PyNumberMethods.nb_and (*C member*), 252
PyNumberMethods.nb_bool (*C member*), 252
PyNumberMethods.nb_divmod (*C member*), 252
PyNumberMethods.nb_float (*C member*), 252
PyNumberMethods.nb_floor_divide (*C member*), 253
PyNumberMethods.nb_index (*C member*), 253
PyNumberMethods.nb_inplace_add (*C member*), 252
PyNumberMethods.nb_inplace_and (*C member*), 252
PyNumberMethods.nb_inplace_floor_divide (*C member*), 253
PyNumberMethods.nb_inplace_lshift (*C member*), 252
PyNumberMethods.nb_inplace_matrix_multiply (*C member*), 253
PyNumberMethods.nb_inplace_multiply (*C member*), 252
PyNumberMethods.nb_inplace_or (*C member*), 252
PyNumberMethods.nb_inplace_power (*C member*), 252
PyNumberMethods.nb_inplace_remainder (*C member*), 252
PyNumberMethods.nb_inplace_rshift (*C member*), 252
PyNumberMethods.nb_inplace_subtract (*C member*), 252
PyNumberMethods.nb_inplace_true_divide (*C member*), 253
PyNumberMethods.nb_inplace_xor (*C member*), 252
PyNumberMethods.nb_int (*C member*), 252
PyNumberMethods.nb_invert (*C member*), 252
PyNumberMethods.nb_lshift (*C member*), 252
PyNumberMethods.nb_matrix_multiply (*C member*), 253
PyNumberMethods.nb_multiply (*C member*), 252
PyNumberMethods.nb_negative (*C member*), 252
PyNumberMethods.nb_or (*C member*), 252
PyNumberMethods.nb_positive (*C member*), 252
PyNumberMethods.nb_power (*C member*), 252
PyNumberMethods.nb_remainder (*C member*), 252
PyNumberMethods.nb_reserved (*C member*), 252
PyNumberMethods.nb_rshift (*C member*), 252
PyNumberMethods.nb_subtract (*C member*), 252
PyNumberMethods.nb_true_divide (*C member*), 253
PyNumberMethods.nb_xor (*C member*), 252
PyObject (*C type*), 220
PyObject_AsCharBuffer (*C function*), 100
PyObject_ASCII (*C function*), 81
PyObject_AsFileDescriptor (*C function*), 144
PyObject_AsReadBuffer (*C function*), 100
PyObject_AsWriteBuffer (*C function*), 100
PyObject_Bytes (*C function*), 81
PyObject_Call (*C function*), 85
PyObject_CallFunction (*C function*), 85
PyObject_CallFunctionObjArgs (*C function*), 86

PyObject_CallMethod (*C function*), 86
PyObject_CallMethodNoArgs (*C function*), 86
PyObject_CallMethodObjArgs (*C function*), 86
PyObject_CallMethodOneArg (*C function*), 86
PyObject_CallNoArgs (*C function*), 85
PyObject_CallObject (*C function*), 85
PyObject_Calloc (*C function*), 212
PyObject_CallOneArg (*C function*), 85
PyObject_CheckBuffer (*C function*), 99
PyObject_CheckReadBuffer (*C function*), 100
PyObject_CopyData (*C function*), 99
PyObject_Del (*C function*), 219
PyObject_DelAttr (*C function*), 80
PyObject_DelAttrString (*C function*), 80
PyObject_DelItem (*C function*), 82
PyObject_Dir (*C function*), 82
PyObject_Free (*C function*), 213
PyObject_GC_Del (*C function*), 261
PyObject_GC_IsFinalized (*C function*), 261
PyObject_GC_IsTracked (*C function*), 261
PyObject_GC_New (*C function*), 260
PyObject_GC_NewVar (*C function*), 260
PyObject_GC_Resize (*C function*), 260
PyObject_GC_Track (*C function*), 260
PyObject_GC_UnTrack (*C function*), 261
PyObject_GenericGetAttr (*C function*), 80
PyObject_GenericGetDict (*C function*), 80
PyObject_GenericSetAttr (*C function*), 80
PyObject_GenericSetDict (*C function*), 80
PyObject_GetAIter (*C function*), 82
PyObject_GetArenaAllocator (*C function*), 216
PyObject_GetAttr (*C function*), 79
PyObject_GetAttrString (*C function*), 79
PyObject_GetBuffer (*C function*), 99
PyObject_GetItem (*C function*), 82
PyObject_GetIter (*C function*), 82
PyObject_HasAttr (*C function*), 79
PyObject_HasAttrString (*C function*), 79
PyObject_Hash (*C function*), 81
PyObject_HashNotImplemented (*C function*), 81
PyObject_HEAD (*C macro*), 220
PyObject_HEAD_INIT (*C macro*), 221
PyObject_Init (*C function*), 219
PyObject_InitVar (*C function*), 219
PyObject_IS_GC (*C function*), 260
PyObject_IsInstance (*C function*), 81
PyObject_IsSubclass (*C function*), 81
PyObject_IsTrue (*C function*), 82
PyObject_Length (*C function*), 82
PyObject_LengthHint (*C function*), 82
PyObject_Malloc (*C function*), 212
PyObject_New (*C function*), 219
PyObject_NewVar (*C function*), 219
PyObject_Not (*C function*), 82
PyObject._ob_next (*C member*), 233
PyObject._ob_prev (*C member*), 233
PyObject_Print (*C function*), 79
PyObject_Realloc (*C function*), 212
PyObject_Repr (*C function*), 81
PyObject_RichCompare (*C function*), 80
PyObject_RichCompareBool (*C function*), 81
PyObject_SetArenaAllocator (*C function*), 216
PyObject_SetAttr (*C function*), 80
PyObject_SetAttrString (*C function*), 80
PyObject_SetItem (*C function*), 82
PyObject_Size (*C function*), 82
PyObject_Str (*C function*), 81
PyObject_Type (*C function*), 82
PyObject_TypeCheck (*C function*), 82
PyObject_VAR_HEAD (*C macro*), 220
PyObject_Vectorcall (*C function*), 86
PyObject_VectorcallDict (*C function*), 86
PyObject_VectorcallMethod (*C function*), 87
PyObjectArenaAllocator (*C type*), 216
PyObject.ob_refcnt (*C member*), 232
PyObject.ob_type (*C member*), 232
PyOS_AfterFork (*C function*), 58
PyOS_AfterFork_Child (*C function*), 58
PyOS_AfterFork_Parent (*C function*), 57
PyOS_BeforeFork (*C function*), 57
PyOS_CheckStack (*C function*), 58
PyOS_double_to_string (*C function*), 74
PyOS_FSPath (*C function*), 57
PyOS_getsig (*C function*), 58
PyOS_InputHook (*C var*), 40
PyOS_ReadlineFunctionPointer (*C var*), 40
PyOS_setsig (*C function*), 58
PyOS_snprintf (*C function*), 73
PyOS_stricmp (*C function*), 74
PyOS_string_to_double (*C function*), 74
PyOS_strnicmp (*C function*), 74
PyOS_vsnprintf (*C function*), 73
PyPreConfig (*C type*), 190
PyPreConfig.allocator (*C member*), 190
PyPreConfig.coerce_c_locale (*C member*), 190
PyPreConfig.coerce_c_locale_warn (*C member*), 191
PyPreConfig.configure_locale (*C member*), 190
PyPreConfig.dev_mode (*C member*), 191
PyPreConfig.isolated (*C member*), 191
PyPreConfig.legacy_windows_fs_encoding (*C member*), 191
PyPreConfig.parse_argv (*C member*), 191
PyPreConfig.PyPreConfig_InitIsolatedConfig (*C function*), 190
PyPreConfig.PyPreConfig_InitPythonConfig (*C function*), 190
PyPreConfig.use_environment (*C member*), 191
PyPreConfig.utf8_mode (*C member*), 191
PyProperty_Type (*C var*), 153

PyRun_AnyFile (*C function*), 39
PyRun_AnyFileEx (*C function*), 39
PyRun_AnyFileExFlags (*C function*), 39
PyRun_AnyFileFlags (*C function*), 39
PyRun_File (*C function*), 41
PyRun_FileEx (*C function*), 41
PyRun_FileExFlags (*C function*), 41
PyRun_FileFlags (*C function*), 41
PyRun_InteractiveLoop (*C function*), 40
PyRun_InteractiveLoopFlags (*C function*), 40
PyRun_InteractiveOne (*C function*), 40
PyRun_InteractiveOneFlags (*C function*), 40
PyRun_SimpleFile (*C function*), 40
PyRun_SimpleFileEx (*C function*), 40
PyRun_SimpleFileExFlags (*C function*), 40
PyRun_SimpleString (*C function*), 40
PyRun_SimpleStringFlags (*C function*), 40
PyRun_String (*C function*), 41
PyRun_StringFlags (*C function*), 41
PySendResult (*C type*), 93
PySeqIter_Check (*C function*), 152
PySeqIter_New (*C function*), 152
PySeqIter_Type (*C var*), 152
PySequence_Check (*C function*), 90
PySequence_Concat (*C function*), 90
PySequence_Contains (*C function*), 91
PySequence_Count (*C function*), 91
PySequence_DelItem (*C function*), 90
PySequence_DelSlice (*C function*), 91
PySequence_Fast (*C function*), 91
PySequence_Fast_GET_ITEM (*C function*), 91
PySequence_Fast_GET_SIZE (*C function*), 91
PySequence_Fast_ITEMS (*C function*), 91
PySequence_GetItem (*C function*), 90
PySequence_GetItem(), 8
PySequence_GetSlice (*C function*), 90
PySequence_Index (*C function*), 91
PySequence_InPlaceConcat (*C function*), 90
PySequence_InPlaceRepeat (*C function*), 90
PySequence_ITEM (*C function*), 91
PySequence_Length (*C function*), 90
PySequence_List (*C function*), 91
PySequence_Repeat (*C function*), 90
PySequence_SetItem (*C function*), 90
PySequence_SetSlice (*C function*), 90
PySequence_Size (*C function*), 90
PySequence_Tuple (*C function*), 91
PySequenceMethods (*C type*), 253
PySequenceMethods.sq_ass_item (*C member*), 254
PySequenceMethods.sq_concat (*C member*), 253
PySequenceMethods.sq_contains (*C member*), 254
PySequenceMethods.sq_inplace_concat (*C member*), 254
PySequenceMethods.sq_inplace_repeat (*C member*), 254
PySequenceMethods.sq_item (*C member*), 253
PySequenceMethods.sq_length (*C member*), 253
PySequenceMethods.sq_repeat (*C member*), 253
PySet_Add (*C function*), 139
PySet_Check (*C function*), 138
PySet_CheckExact (*C function*), 139
PySet_Clear (*C function*), 140
PySet_Contains (*C function*), 139
PySet_Discard (*C function*), 139
PySet_GET_SIZE (*C function*), 139
PySet_New (*C function*), 139
PySet_Pop (*C function*), 139
PySet_Size (*C function*), 139
PySet_Type (*C var*), 138
PySetObject (*C type*), 138
PySignal_SetWakeupFd (*C function*), 52
PySlice_AdjustIndices (*C function*), 154
PySlice_Check (*C function*), 153
PySlice_GetIndices (*C function*), 153
PySlice_GetIndicesEx (*C function*), 153
PySlice_New (*C function*), 153
PySlice_Type (*C var*), 153
PySlice_Unpack (*C function*), 154
PyState_AddModule (*C function*), 152
PyState_FindModule (*C function*), 152
PyState_RemoveModule (*C function*), 152
PyStatus (*C type*), 189
PyStatus.err_msg (*C member*), 189
PyStatus.exitcode (*C member*), 189
PyStatus.func (*C member*), 189
PyStatus.Py_ExitStatusException (*C function*), 189
PyStatus.PyStatus_Error (*C function*), 189
PyStatus.PyStatus_Exception (*C function*), 189
PyStatus.PyStatus_Exit (*C function*), 189
PyStatus.PyStatus_IsError (*C function*), 189
PyStatus.PyStatus_IsExit (*C function*), 189
PyStatus.PyStatus_NoMemory (*C function*), 189
PyStatus.PyStatus_Ok (*C function*), 189
PyStructSequence_Desc (*C type*), 133
PyStructSequence_Field (*C type*), 133
PyStructSequence_GET_ITEM (*C function*), 134
PyStructSequence_GetItem (*C function*), 134
PyStructSequence_InitType (*C function*), 133
PyStructSequence_InitType2 (*C function*), 133
PyStructSequence_New (*C function*), 134
PyStructSequence_NewType (*C function*), 133
PyStructSequence_SET_ITEM (*C function*), 134
PyStructSequence_SetItem (*C function*), 134
PyStructSequence_UnnamedField (*C var*), 134
PySys_AddAuditHook (*C function*), 61
PySys_AddWarnOption (*C function*), 60

PySys_AddWarnOptionUnicode (*C function*), 60
PySys_AddXOption (*C function*), 61
PySys_Audit (*C function*), 61
PySys_FormatStderr (*C function*), 61
PySys_FormatStdout (*C function*), 60
PySys_GetObject (*C function*), 60
PySys_GetXOptions (*C function*), 61
PySys_ResetWarnOptions (*C function*), 60
PySys_SetArgv (*C function*), 172
PySys_SetArgv(), 168
PySys_SetArgvEx (*C function*), 171
PySys_SetArgvEx(), 168
PySys_SetObject (*C function*), 60
PySys_SetPath (*C function*), 60
PySys_WriteStderr (*C function*), 60
PySys_WriteStdout (*C function*), 60
Python 3000, **274**
Python 提高建议
 PEP 1, 274
 PEP 7, 3, 6
 PEP 238, 42, 269
 PEP 278, 276
 PEP 302, 269, 271
 PEP 343, 267
 PEP 353, 9
 PEP 362, 266, 273
 PEP 383, 123
 PEP 387, 13
 PEP 393, 115, 122
 PEP 411, 274
 PEP 420, 269, 272, 274
 PEP 432, 207
 PEP 442, 250
 PEP 443, 269
 PEP 451, 148, 269
 PEP 483, 269
 PEP 484, 265, 269, 276
 PEP 489, 149
 PEP 492, 266, 267
 PEP 498, 268
 PEP 519, 273
 PEP 523, 179
 PEP 525, 266
 PEP 526, 265, 276
 PEP 528, 167, 198
 PEP 529, 123, 167
 PEP 538, 205
 PEP 539, 184
 PEP 540, 205
 PEP 552, 195
 PEP 578, 61
 PEP 585, 269
 PEP 587, 187
 PEP 590, 83
 PEP 623, 115
 PEP 634, 241
 PEP 3116, 276
 PEP 3119, 81
 PEP 3121, 146
 PEP 3147, 64
 PEP 3151, 55
 PEP 3155, 274
PYTHON*, 166
PYTHONCOERCECLOCALE, 205
PYTHONDEBUG, 166, 199
PYTHONDEVMODE, 196
PYTHONDONTWRITEBYTECODE, 166, 202
PYTHONDUMPREFS, 196, 233
PYTHONEXECUTABLE, 200
PYTHONFAULTHANDLER, 196
PYTHONHASHSEED, 166, 197
PYTHONHOME, 11, 166, 172, 197
Pythonic, **274**
PYTHONINSPECT, 167, 197
PYTHONIOENCODING, 169, 201
PYTHONLEGACYWINDOWSFSENCODING, 167, 191
PYTHONLEGACYWINDOWSSTDIO, 167, 198
PYTHONMALLOC, 210, 213, 215
PYTHONMALLOC` (例 如: ``PYTHONMALLOC=malloc`, 216
PYTHONMALLOCSTATS, 198, 210
PYTHONNODEBUGRANGES, 195
PYTHONNOUSERSITE, 167, 202
PYTHONOPTIMIZE, 167, 199
PYTHONPATH, 11, 166, 198
PYTHONPLATLIBDIR, 198
PYTHONPROFILEIMPORTTIME, 197
PYTHONPYCACHEPREFIX, 200
PYTHONSAFEPATH, 194
PYTHONTRACEMALLOC, 201
PYTHONUNBUFFERED, 167, 195
PYTHONUTF8, 191, 205
PYTHONVERBOSE, 167, 202
PYTHONWARNINGS, 202
PyThread_create_key (*C function*), 185
PyThread_delete_key (*C function*), 185
PyThread_delete_key_value (*C function*), 185
PyThread_get_key_value (*C function*), 185
PyThread_ReInitTLS (*C function*), 185
PyThread_set_key_value (*C function*), 185
PyThread_tss_alloc (*C function*), 184
PyThread_tss_create (*C function*), 185
PyThread_tss_delete (*C function*), 185
PyThread_tss_free (*C function*), 184
PyThread_tss_get (*C function*), 185
PyThread_tss_is_created (*C function*), 185
PyThread_tss_set (*C function*), 185
PyThreadState, 173
PyThreadState (*C type*), 175
PyThreadState_Clear (*C function*), 177
PyThreadState_Delete (*C function*), 177
PyThreadState_DeleteCurrent (*C function*), 177
PyThreadState_EnterTracing (*C function*), 178
PyThreadState_Get (*C function*), 175

PyThreadState_GetDict (*C function*), 179
PyThreadState_GetFrame (*C function*), 177
PyThreadState_GetID (*C function*), 177
PyThreadState_GetInterpreter (*C function*), 178
PyThreadState_LeaveTracing (*C function*), 178
PyThreadState_New (*C function*), 177
PyThreadState_Next (*C function*), 183
PyThreadState_SetAsyncExc (*C function*), 179
PyThreadState_Swap (*C function*), 175
PyTime_Check (*C function*), 161
PyTime_CheckExact (*C function*), 162
PyTime_FromTime (*C function*), 162
PyTime_FromTimeAndFold (*C function*), 162
PyTimeZone_FromOffset (*C function*), 162
PyTimeZone_FromOffsetAndName (*C function*), 162
PyTrace_C_CALL (*C var*), 183
PyTrace_C_EXCEPTION (*C var*), 183
PyTrace_C_RETURN (*C var*), 183
PyTrace_CALL (*C var*), 182
PyTrace_EXCEPTION (*C var*), 182
PyTrace_LINE (*C var*), 182
PyTrace_OPCODE (*C var*), 183
PyTrace_RETURN (*C var*), 182
PyTraceMalloc_Track (*C function*), 217
PyTraceMalloc_Untrack (*C function*), 217
PyTuple_Check (*C function*), 132
PyTuple_CheckExact (*C function*), 132
PyTuple_GET_ITEM (*C function*), 132
PyTuple_GET_SIZE (*C function*), 132
PyTuple_GetItem (*C function*), 132
PyTuple_GetSlice (*C function*), 132
PyTuple_New (*C function*), 132
PyTuple_Pack (*C function*), 132
PyTuple_SET_ITEM (*C function*), 133
PyTuple_SetItem (*C function*), 132
PyTuple_SetItem(), 7
PyTuple_Size (*C function*), 132
PyTuple_Type (*C var*), 132
PyTupleObject (*C type*), 132
PyType_Check (*C function*), 101
PyType_CheckExact (*C function*), 101
PyType_ClearCache (*C function*), 101
PyType_FromModuleAndSpec (*C function*), 103
PyType_FromSpec (*C function*), 103
PyType_FromSpecWithBases (*C function*), 103
PyType_GenericAlloc (*C function*), 102
PyType_GenericNew (*C function*), 102
PyType_GetFlags (*C function*), 101
PyType_GetModule (*C function*), 103
PyType_GetModuleByDef (*C function*), 103
PyType_GetModuleState (*C function*), 103
PyType_GetName (*C function*), 102
PyType_GetQualName (*C function*), 102
PyType_GetSlot (*C function*), 102
PyType_HasFeature (*C function*), 102
PyType_IS_GC (*C function*), 102
PyType_IsSubtype (*C function*), 102
PyType_Modified (*C function*), 102
PyType_Ready (*C function*), 102
PyType_Slot (*C type*), 104
PyType_Slot.PyType_Slot.pfunc (*C member*), 104
PyType_Slot.PyType_Slot.slot (*C member*), 104
PyType_Spec (*C type*), 103
PyType_Spec.PyType_Spec.basicsize (*C member*), 104
PyType_Spec.PyType_Spec.flags (*C member*), 104
PyType_Spec.PyType_Spec.itemsize (*C member*), 104
PyType_Spec.PyType_Spec.name (*C member*), 104
PyType_Spec.PyType_Spec.slots (*C member*), 104
PyType_Type (*C var*), 101
PyTypeObject (*C type*), 101
PyTypeObject.tp_alloc (*C member*), 247
PyTypeObject.tp_as_async (*C member*), 235
PyTypeObject.tp_as_buffer (*C member*), 238
PyTypeObject.tp_as_mapping (*C member*), 236
PyTypeObject.tp_as_number (*C member*), 236
PyTypeObject.tp_as_sequence (*C member*), 236
PyTypeObject.tp_base (*C member*), 245
PyTypeObject.tp_bases (*C member*), 248
PyTypeObject.tp_basicsize (*C member*), 233
PyTypeObject.tp_cache (*C member*), 249
PyTypeObject.tp_call (*C member*), 237
PyTypeObject.tp_clear (*C member*), 242
PyTypeObject.tp_dealloc (*C member*), 234
PyTypeObject.tp_del (*C member*), 249
PyTypeObject.tp_descr_get (*C member*), 246
PyTypeObject.tp_descr_set (*C member*), 246
PyTypeObject.tp_dict (*C member*), 245
PyTypeObject.tp_dictoffset (*C member*), 246
PyTypeObject.tp_doc (*C member*), 241
PyTypeObject.tp_finalize (*C member*), 249
PyTypeObject.tp_flags (*C member*), 238
PyTypeObject.tp_free (*C member*), 248
PyTypeObject.tp_getattr (*C member*), 235
PyTypeObject.tp_getattro (*C member*), 237
PyTypeObject.tp_getset (*C member*), 245
PyTypeObject.tp_hash (*C member*), 236
PyTypeObject.tp_init (*C member*), 247
PyTypeObject.tp_is_gc (*C member*), 248
PyTypeObject.tp_itemsize (*C member*), 233
PyTypeObject.tp_iter (*C member*), 244
PyTypeObject.tp_iternext (*C member*), 244
PyTypeObject.tp_members (*C member*), 245
PyTypeObject.tp_methods (*C member*), 245

PyTypeObject.tp_mro (*C member*), 249
PyTypeObject.tp_name (*C member*), 233
PyTypeObject.tp_new (*C member*), 247
PyTypeObject.tp_repr (*C member*), 236
PyTypeObject.tp_richcompare (*C member*), 243
PyTypeObject.tp_richcompare.Py_RETURN_RICHCOMPARE (*C macro*), 243
PyTypeObject.tp_setattr (*C member*), 235
PyTypeObject.tp_setattro (*C member*), 237
PyTypeObject.tp_str (*C member*), 237
PyTypeObject.tp_subclasses (*C member*), 249
PyTypeObject.tp_traverse (*C member*), 241
PyTypeObject.tp_vectorcall (*C member*), 250
PyTypeObject.tp_vectorcall_offset (*C member*), 235
PyTypeObject.tp_version_tag (*C member*), 249
PyTypeObject.tp_weaklist (*C member*), 249
PyTypeObject.tp_weaklistoffset (*C member*), 244
PyTZInfo_Check (*C function*), 162
PyTZInfo_CheckExact (*C function*), 162
PyUnicode_1BYTE_DATA (*C function*), 116
PyUnicode_1BYTE_KIND (*C macro*), 116
PyUnicode_2BYTE_DATA (*C function*), 116
PyUnicode_2BYTE_KIND (*C macro*), 116
PyUnicode_4BYTE_DATA (*C function*), 116
PyUnicode_4BYTE_KIND (*C macro*), 116
PyUnicode_AS_DATA (*C function*), 117
PyUnicode_AS_UNICODE (*C function*), 117
PyUnicode_AsASCIIString (*C function*), 129
PyUnicode_AsCharmapString (*C function*), 129
PyUnicode_AsEncodedString (*C function*), 125
PyUnicode_AsLatin1String (*C function*), 129
PyUnicode_AsMBCSString (*C function*), 130
PyUnicode_AsRawUnicodeEscapeString (*C function*), 128
PyUnicode_AsUCS4 (*C function*), 121
PyUnicode_AsUCS4Copy (*C function*), 121
PyUnicode_AsUnicode (*C function*), 122
PyUnicode_AsUnicodeAndSize (*C function*), 122
PyUnicode_AsUnicodeEscapeString (*C function*), 128
PyUnicode_AsUTF8 (*C function*), 126
PyUnicode_AsUTF8AndSize (*C function*), 126
PyUnicode_AsUTF8String (*C function*), 126
PyUnicode_AsUTF16String (*C function*), 127
PyUnicode_AsUTF32String (*C function*), 127
PyUnicode_AsWideChar (*C function*), 125
PyUnicode_AsWideCharString (*C function*), 125
PyUnicode_Check (*C function*), 115
PyUnicode_CheckExact (*C function*), 115
PyUnicode_Compare (*C function*), 131
PyUnicode_CompareWithASCIIString (*C function*), 131
PyUnicode_Concat (*C function*), 130
PyUnicode_Contains (*C function*), 131
PyUnicode_CopyCharacters (*C function*), 121
PyUnicode_Count (*C function*), 131
PyUnicode_DATA (*C function*), 116
PyUnicode_Decode (*C function*), 125
PyUnicode_DecodeASCII (*C function*), 129
PyUnicode_DecodeCharmap (*C function*), 129
PyUnicode_DecodeFSDefault (*C function*), 124
PyUnicode_DecodeFSDefaultAndSize (*C function*), 124
PyUnicode_DecodeLatin1 (*C function*), 129
PyUnicode_DecodeLocale (*C function*), 123
PyUnicode_DecodeLocaleAndSize (*C function*), 123
PyUnicode_DecodeMBCS (*C function*), 130
PyUnicode_DecodeMBCSStateful (*C function*), 130
PyUnicode_DecodeRawUnicodeEscape (*C function*), 128
PyUnicode_DecodeUnicodeEscape (*C function*), 128
PyUnicode_DecodeUTF7 (*C function*), 128
PyUnicode_DecodeUTF7Stateful (*C function*), 128
PyUnicode_DecodeUTF8 (*C function*), 126
PyUnicode_DecodeUTF8Stateful (*C function*), 126
PyUnicode_DecodeUTF16 (*C function*), 127
PyUnicode_DecodeUTF16Stateful (*C function*), 127
PyUnicode_DecodeUTF32 (*C function*), 126
PyUnicode_DecodeUTF32Stateful (*C function*), 127
PyUnicode_EncodeCodePage (*C function*), 130
PyUnicode_EncodeFSDefault (*C function*), 124
PyUnicode_EncodeLocale (*C function*), 123
PyUnicode_Fill (*C function*), 121
PyUnicode_Find (*C function*), 131
PyUnicode_FindChar (*C function*), 131
PyUnicode_Format (*C function*), 131
PyUnicode_FromEncodedObject (*C function*), 120
PyUnicode_FromFormat (*C function*), 119
PyUnicode_FromFormatV (*C function*), 120
PyUnicode_FromKindAndData (*C function*), 119
PyUnicode_FromObject (*C function*), 122
PyUnicode_FromString (*C function*), 119
PyUnicode_FromString(), 136
PyUnicode_FromStringAndSize (*C function*), 119
PyUnicode_FromUnicode (*C function*), 122
PyUnicode_FromWideChar (*C function*), 125
PyUnicode_FSConverter (*C function*), 123
PyUnicode_FSDecoder (*C function*), 124
PyUnicode_GET_DATA_SIZE (*C function*), 117

PyUnicode_GET_LENGTH (*C function*), 116
PyUnicode_GET_SIZE (*C function*), 117
PyUnicode_GetLength (*C function*), 121
PyUnicode_GetSize (*C function*), 122
PyUnicode_InternFromString (*C function*), 132
PyUnicode_InternInPlace (*C function*), 132
PyUnicode_IsIdentifier (*C function*), 117
PyUnicode_Join (*C function*), 130
PyUnicode_KIND (*C function*), 116
PyUnicode_MAX_CHAR_VALUE (*C function*), 117
PyUnicode_New (*C function*), 119
PyUnicode_READ (*C function*), 116
PyUnicode_READ_CHAR (*C function*), 117
PyUnicode_ReadChar (*C function*), 121
PyUnicode_READY (*C function*), 116
PyUnicode_Replace (*C function*), 131
PyUnicode_RichCompare (*C function*), 131
PyUnicode_Split (*C function*), 130
PyUnicode_Splitlines (*C function*), 130
PyUnicode_Substring (*C function*), 121
PyUnicode_Tailmatch (*C function*), 131
PyUnicode_Translate (*C function*), 129
PyUnicode_Type (*C var*), 115
PyUnicode_WCHAR_KIND (*C macro*), 116
PyUnicode_WRITE (*C function*), 116
PyUnicode_WriteChar (*C function*), 121
PyUnicodeDecodeError_Create (*C function*), 53
PyUnicodeDecodeError_GetEncoding (*C function*), 53
PyUnicodeDecodeError_GetEnd (*C function*), 53
PyUnicodeDecodeError_GetObject (*C function*), 53
PyUnicodeDecodeError_GetReason (*C function*), 53
PyUnicodeDecodeError_GetStart (*C function*), 53
PyUnicodeDecodeError_SetEnd (*C function*), 53
PyUnicodeDecodeError_SetReason (*C function*), 53
PyUnicodeDecodeError_SetStart (*C function*), 53
PyUnicodeEncodeError_GetEncoding (*C function*), 53
PyUnicodeEncodeError_GetEnd (*C function*), 53
PyUnicodeEncodeError_GetObject (*C function*), 53
PyUnicodeEncodeError_GetReason (*C function*), 53
PyUnicodeEncodeError_GetStart (*C function*), 53
PyUnicodeEncodeError_SetEnd (*C function*), 53
PyUnicodeEncodeError_SetReason (*C function*), 53
PyUnicodeEncodeError_SetStart (*C function*), 53
PyUnicodeObject (*C type*), 115
PyUnicodeTranslateError_GetEnd (*C function*), 53
PyUnicodeTranslateError_GetObject (*C function*), 53
PyUnicodeTranslateError_GetReason (*C function*), 53
PyUnicodeTranslateError_GetStart (*C function*), 53
PyUnicodeTranslateError_SetEnd (*C function*), 53
PyUnicodeTranslateError_SetReason (*C function*), 53
PyUnicodeTranslateError_SetStart (*C function*), 53
PyVarObject (*C type*), 220
PyVarObject_HEAD_INIT (*C macro*), 221
PyVarObject.ob_size (*C member*), 233
PyVectorcall_Call (*C function*), 84
PyVectorcall_Function (*C function*), 84
PyVectorcall_NARGS (*C function*), 84
PyWeakref_Check (*C function*), 155
PyWeakref_CheckProxy (*C function*), 155
PyWeakref_CheckRef (*C function*), 155
PyWeakref_GET_OBJECT (*C function*), 156
PyWeakref_GetObject (*C function*), 156
PyWeakref_NewProxy (*C function*), 156
PyWeakref_NewRef (*C function*), 155
PyWideStringList (*C type*), 188
PyWideStringList.items (*C member*), 188
PyWideStringList.length (*C member*), 188
PyWideStringList.PyWideStringList_Append (*C function*), 188
PyWideStringList.PyWideStringList_Insert (*C function*), 188
PyWrapper_New (*C function*), 153

Q

qualified name -- 限定名称, **274**

R

realloc(), 209
reference count -- 引用计数, **274**
regular package -- 常规包, **275**
releasebufferproc (*C type*), 257
repr
    F置函数, 81, 236
reprfunc (*C type*), 256
richcmpfunc (*C type*), 257

S

sdterr
    stdin stdout, 169
search

path, module, 11, 168, 170
sendfunc (*C type*), 257
sequence
对象, 112
sequence -- 序列, **275**
set
对象, 138
set comprehension -- 集合推导式, **275**
set_all(), 8
setattrfunc (*C type*), 256
setattrofunc (*C type*), 257
setswitchinterval() (*in module sys*), 173
SIGINT, 51
signal
模块, 51
single dispatch -- 单分派, **275**
SIZE_MAX, 107
slice -- 切片, **275**
special
method, 275
special method -- 特殊方法, **275**
ssizeargfunc (*C type*), 257
ssizeobjargproc (*C type*), 257
statement -- 语句, **275**
staticmethod
F置函数, 224
stderr (*in module sys*), 180
stdin
stdout sdterr, 169
stdin (*in module sys*), 180
stdout
sdterr, stdin, 169
stdout (*in module sys*), 180
strerror(), 46
string
PyObject_Str (*C function*), 81
strong reference -- 强引用, **275**
sum_list(), 8
sum_sequence(), 9, 10
sys
模块, 11, 168, 180
SystemError (*built-in exception*), 145, 146

T

ternaryfunc (*C type*), 257
text encoding -- 文本编码, **275**
text file -- 文本文件, **275**
traverseproc (*C type*), 261
triple-quoted string -- 三引号字符串, **275**
tuple
F置函数, 91, 135
对象, 132
type
F置函数, 82
对象, 6, 101
type -- 类型, **275**
type alias -- 类型别名, **275**
type hint -- 类型注解, **276**

U

ULONG_MAX, 107
unaryfunc (*C type*), 257
universal newlines -- 通用换行, **276**

V

variable annotation -- 变量标注, **276**
F置函数
__import__, 62
abs, 88
ascii, 81
bytes, 81
classmethod, 224
compile, 63
divmod, 88
float, 89
hash, 81, 236
int, 89
len, 82, 90, 92, 135, 137, 139
pow, 88, 89
repr, 81, 236
staticmethod, 224
tuple, 91, 135
type, 82
可调用对象 (Callable), **267**
vectorcallfunc (*C type*), 83
version (*in module sys*), 171
virtual environment -- 虚拟环境, **276**
virtual machine -- 虚拟机, **276**
visitproc (*C type*), 261
对象
bytearray, 114
bytes, 112
Capsule, 156
complex number, 110
dictionary, 136
file, 144
floating point, 108
frozenset, 138
function, 140
instancemethod, 141
integer, 105
list, 134
long integer, 105
mapping, 136
memoryview, 155
method, 141
module, 145
None, 105
numeric, 105
sequence, 112
set, 138
tuple, 132
type, 6, 101

W

模块
    __main__, 11, 168, 180
    _thread, 175
    builtins, 11, 168, 180
    signal, 51
    sys, 11, 168, 180

Z

Zen of Python -- Python 之禅, **276**