



NVIDIA CUDA GETTING STARTED GUIDE FOR MAC OS X

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Installation and Verification on Mac OS X



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Chapter 1.

INTRODUCTION

NVIDIA® CUDA™ is a general purpose parallel computing architecture introduced by NVIDIA. It includes the *CUDA Instruction Set Architecture (ISA)* and the parallel compute engine in the GPU. To program to the CUDA architecture, developers can use C, one of the most widely used high-level programming languages, which can then be run at great performance on a CUDA-capable processor.

The CUDA architecture and its associated software were developed with several design goals in mind:

- ▶ Provide a small set of extensions to standard programming languages, like C, that enable a straightforward implementation of parallel algorithms. With CUDA and C for CUDA, programmers can focus on the task of parallelization of the algorithms rather than spending time on their implementation.
- ▶ Support heterogeneous computation where applications use both the CPU and GPU. Serial portions of applications are run on the CPU, and parallel portions are offloaded to the GPU. As such, CUDA can be incrementally applied to existing applications. The CPU and GPU are treated as separate devices that have their own memory spaces. This configuration also allows simultaneous computation on both the CPU and GPU without contention for memory resources.

CUDA-capable GPUs have hundreds of cores that can collectively run thousands of computing threads. Each core has shared resources, including registers and memory. The on-chip shared memory allows parallel tasks running on these cores to share data without sending it over the system memory bus.

This guide will show you how to install and check the correct operation of the CUDA Development Tools.

1.1 SYSTEM REQUIREMENTS

To use CUDA on your system, you will need the following:

- ▶ CUDA-capable GPU
- ▶ Mac OSX v. 10.7 or later
- ▶ The *gcc* compiler and toolchain installed using Xcode

- ▶ NVIDIA CUDA Toolkit (available at no cost from <http://www.nvidia.com/content/cuda/cuda-downloads.html>)

1.2 ABOUT THIS DOCUMENT

This document is intended for readers familiar with the Mac OS X environment and the compilation of C programs from the command line. You do not need previous experience with CUDA or experience with parallel computation.

Chapter 2.

INSTALLING CUDA DEVELOPMENT TOOLS

The setup of CUDA development tools on a system running Mac OS X consists of a few simple steps:

- ▶ Verify the system has a CUDA-capable GPU.
- ▶ Verify the system is running a supported version of Mac OS X.
- ▶ Verify the system has gcc installed via Xcode.
- ▶ Download the NVIDIA CUDA Toolkit.
- ▶ Install the NVIDIA CUDA Toolkit.
- ▶ Test that the installed software runs correctly and communicates with the hardware.

2.1 VERIFY YOU HAVE A CUDA-CAPABLE GPU

To verify that your system is CUDA-capable, under the **Apple** menu select **About This Mac**, click the **More Info ...** button, and then select **Graphics/Displays** under the **Hardware** list. There you will find the vendor name and model of your graphics card. If it is an NVIDIA card that is listed in http://www.nvidia.com/object/cuda_gpus.html, your GPU is CUDA-capable.

The Release Notes for the CUDA Toolkit also contain a list of supported products.

2.2 VERIFY THE CORRECT VERSION OF MAC OS X

The CUDA Development Tools require an Intel-based Mac running Mac OSX v. 10.7 or later. To check which version you have, go to the **Apple** menu on the desktop and select **About This Mac**. You should see a dialog box similar to [Figure 1 About This Mac Dialog Box](#).



Figure 1 About This Mac Dialog Box

2.2.1 Verify the System Has gcc Installed

The `gcc` compiler and toolchain are installed using the installation of Xcode. The Xcode development environment is found on the *Xcode Developer Tools DVD* that ships with new Mac systems and with Leopard, if you buy the operating-system upgrade. When installing Xcode, the package that contains `gcc` and the necessary tools is called *Developer Tools Essentials*. You can verify that `gcc` is installed entering the command `/usr/bin/gcc --help` from a **Terminal** window.

2.3 DOWNLOAD THE CUDA SOFTWARE

Once you have verified that you have a supported NVIDIA GPU, a supported version the MAC OS, and `gcc`, you need to download the NVIDIA CUDA Toolkit.


The NVIDIA CUDA Toolkit is available at no cost from the main CUDA download site at <http://www.nvidia.com/content/cuda/cuda-downloads.html>. It contains the driver and tools needed to create, build and run a CUDA application as well as libraries, header files, CUDA samples source code, and other resources.

2.4 INSTALL THE CUDA DRIVER AND SOFTWARE

Use the following procedure to successfully install the CUDA driver and software. For information not listed here, see the documentation under `/Developer/NVIDIA/CUDA-5.0/doc` in the download location.

Before installing the CUDA Toolkit, you should read the *Release Notes*, as they provide important details on installation and software functionality.

Then, follow these few steps for a successful installation.

1.  The driver and toolkit must be installed for CUDA to function. If you have not installed a stand-alone driver, install the driver from the NVIDIA CUDA Toolkit.

Install the CUDA Toolkit.

Install the CUDA toolkit by executing the installer and following the on-screen prompts. You will be able to choose which packages you wish to install. The packages are:

- ▶ **CUDA Driver**

This will install `/Library/Frameworks/CUDA.framework` and the UNIX-compatibility stub `/usr/local/cuda/lib/libcuda.dylib` that refers to it.

- ▶ **CUDA Toolkit**

The CUDA Toolkit supplements the CUDA Driver with compilers and additional libraries and header files that are installed into `/Developer/NVIDIA/CUDA-5.0` by default. Symlinks are created in `/usr/local/cuda/` pointing to their respective files in `/Developer/NVIDIA/CUDA-5.0/`.

Previous installations of the toolkit will be moved to `/Developer/NVIDIA/CUDA-#. #` to better support side-by-side installations.

- ▶ **CUDA Samples**

The CUDA Samples are installed to `/Developer/NVIDIA/CUDA-5.0/samples`.

Previous installations of the samples will be moved to `/Developer/NVIDIA/CUDA-#. #/samples` to better support side-by-side installations.

2. Define the environment variables.

- ▶ The `PATH` variable needs to include `/Developer/NVIDIA/CUDA-5.0/bin`.
- ▶ `DYLD_LIBRARY_PATH` needs to contain `/Developer/NVIDIA/CUDA-5.0/lib`.

The typical way to place these values in your environment is with the following commands:

```
export PATH=/Developer/NVIDIA/CUDA-5.0/bin:$PATH
export DYLD_LIBRARY_PATH=/Developer/NVIDIA/CUDA-5.0/lib:
$DYLD_LIBRARY_PATH
```

To make these settings permanent, place them in `~/.bash_profile`.

2.5 VERIFY THE INSTALLATION

Before continuing, it is important to verify that the CUDA programs can find and communicate correctly with the CUDA-capable hardware. To do this, you need to compile and run some of the included sample programs.



Ensure the `PATH` and `DYLD_LIBRARY_PATH` variables are set correctly as described in step 2 of section 2.4.

2.5.1 Verify the Driver Installation

If the CUDA Driver is installed correctly, the CUDA kernel extension (`/System/Library/Extensions/CUDA.kext`) should be loaded automatically at boot time. To verify that it is loaded, use the command

```
kextstat | grep -i cuda
```

2.5.2 Compiling the Examples

The version of the CUDA Toolkit can be checked by running `nvcc -V` in a terminal window. The `nvcc` command runs the compiler driver that compiles CUDA programs. It calls the `gcc` compiler for C code and the NVIDIA PTX compiler for the CUDA code.

The NVIDIA CUDA Toolkit includes sample programs in source form. You should compile them by changing to `/Developer/NVIDIA/CUDA-5.0/samples` and typing `make`. The resulting binaries will be placed under `/Developer/NVIDIA/CUDA-5.0/samples/C/bin/darwin/release`.

2.5.3 Running Binaries

After compilation, go to `/Developer/NVIDIA/CUDA-5.0/samples/C/bin/darwin/release` and run `deviceQuery`. If the CUDA software is installed and configured correctly, the output for `deviceQuery` should look similar to [Figure 2 Valid Results from Sample CUDA deviceQuery Program](#).

```

release — bash — 125x50
/Developer/NVIDIA/CUDA-5.0/samples/C/bin/darwin/release
eyoung-mlt:release ericy$ ./deviceQuery
[deviceQuery] starting...

./deviceQuery Starting...

  CUDA Device Query (Runtime API) version (CUDA static linking)

Found 1 CUDA Capable device(s)

Device 0: "GeForce 320M"
  CUDA Driver Version / Runtime Version      5.0 / 5.0
  CUDA Capability Major/Minor version number: 1.2
  Total amount of global memory:             253 MBytes (265027584 bytes)
  ( 6) Multiprocessors x ( 8) CUDA Cores/MP: 48 CUDA Cores
  GPU Clock rate:                           950 MHz (0.95 GHz)
  Memory Clock rate:                        1064 Mhz
  Memory Bus Width:                         128-bit
  Max Texture Dimension Size (x,y,z)        1D=(8192), 2D=(65536,32768), 3D=(2048,2048,2048)
  Max Layered Texture Size (dim) x layers    1D=(8192) x 512, 2D=(8192,8192) x 512
  Total amount of constant memory:           65536 bytes
  Total amount of shared memory per block:   16384 bytes
  Total number of registers available per block: 16384
  Warp size:                                32
  Maximum number of threads per multiprocessor: 1024
  Maximum number of threads per block:       512
  Maximum sizes of each dimension of a block: 512 x 512 x 64
  Maximum sizes of each dimension of a grid: 65535 x 65535 x 1
  Maximum memory pitch:                     2147483647 bytes
  Texture alignment:                        256 bytes
  Concurrent copy and execution:             Yes with 1 copy engine(s)
  Run time limit on kernels:                 Yes
  Integrated GPU sharing Host Memory:         Yes
  Support host page-locked memory mapping:    Yes
  Concurrent kernel execution:               No
  Alignment requirement for Surfaces:         Yes
  Device has ECC support enabled:             No
  Device is using TCC driver mode:           No
  Device supports Unified Addressing (UVA):   No
  Device PCI Bus ID / PCI location ID:       0 / 0
  Compute Mode:
    < Default (multiple host threads can use ::cudaSetDevice() with device simultaneously) >

deviceQuery, CUDA Driver = CUDART, CUDA Driver Version = 5.0, CUDA Runtime Version = 5.0, NumDevs = 1, Device = GeForce 320M
[deviceQuery] test results...
PASSED

> exiting in 3 seconds: 3...2...1...done!

eyoung-mlt:release ericy$ █

```

Figure 2 Valid Results from Sample CUDA deviceQuery Program

Note that the parameters for your CUDA device will vary. The key lines are the first and second ones that confirm a device was found and what model it is. Also, the next-to-last line, as indicated, should show that the test passed.

Running the `bandwidthTest` program ensures that the system and the CUDA device are able to communicate correctly. Figure 3 shows a sample of the output.



```

dhcp-172-16-194-59:release apple$ pwd
/Developer/NVIDIA/CUDA-5.0/samples/C/bin/darwin/release
dhcp-172-16-194-59:release apple$ ./bandwidthTest
[bandwidthTest] starting...

./bandwidthTest Starting...

Running on...

Device 0: Quadro FX 4800
Quick Mode

Host to Device Bandwidth, 1 Device(s)
PINNED Memory Transfers
  Transfer Size (Bytes)      Bandwidth(MB/s)
  33554432                  5736.5

Device to Host Bandwidth, 1 Device(s)
PINNED Memory Transfers
  Transfer Size (Bytes)      Bandwidth(MB/s)
  33554432                  3851.1

Device to Device Bandwidth, 1 Device(s)
PINNED Memory Transfers
  Transfer Size (Bytes)      Bandwidth(MB/s)
  33554432                  57220.8

[bandwidthTest] test results...
PASSED

> exiting in 3 seconds: 3...2...1...done!

dhcp-172-16-194-59:release apple$

```

Figure 3 Valid Results from Sample CUDA bandwidthTest Program

Note that the measurements for your CUDA-capable device description will vary from system to system. The important point is that you obtain measurements, and that the second-to-last line (in [Figure 3 Valid Results from Sample CUDA bandwidthTest Program](#)) confirms that all necessary tests passed.

Should the tests not pass, make sure you have a CUDA-capable NVIDIA GPU on your system and make sure it is properly installed.

If you run into difficulties with the link step (such as libraries not being found), consult the *Release Notes* found in the doc folder in the SDK directory.

To see a graphical representation of what CUDA can do, run the particles executable.

Chapter 3.

ADDITIONAL CONSIDERATIONS

Now that you have CUDA-capable hardware and the software installed, you can examine and enjoy the numerous included programs. To begin using CUDA to accelerate the performance of your own applications, consult the *CUDA C Programming Guide*, located in `/Developer/NVIDIA/CUDA-5.0/doc`.

For technical support on programming questions, consult and participate in the bulletin board and mailing list at <http://forums.nvidia.com/index.php?showforum=71>.

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