GCC C/C++ compiler

START HERE

`gcc hello.c -o hello`
Compile and link

`gcc -O2 x.c`
Optimize

`gcc -Wall -Wextra -g -O0 x.c`
Warnings plus debug info

`g++ x.cpp -o x`
Compile C++

`gcc -c x.c`
Compile to x.o only

`gcc -fsanitize=address -g x.c`
Catch memory bugs

`gcc a.o b.o -o app`
Link objects

`gcc --version`
Which compiler?

x.c source → (-E) **x.i** preprocessed → (-S) **x.s** assembly → (-c) **x.o** object → (link) **a.out** executable

Each stage has a flag that stops after it

CONCEPTS

gcc drives four stages: preprocess, compile, assemble, link. -E, -S and -c stop after the first three.

Put libraries (-l) after the files that use them: the linker resolves symbols left to right.

clang accepts most of these flags; GCC-only ones may differ. Link C++ with g++.

COMPILE AND LINK

`gcc <file.c> -o <out>`
Build an executable

`gcc -c <file.c>`
Compile to an object file

`gcc -E <file.c>`
Preprocess only, print result

`gcc -S <file.c>`
Compile to assembly (.s)

`gcc <a.o> <b.o> -o <out>`
Link objects together

`gcc <a.c> <b.c> -o <out>`
Compile several files at once

`gcc -v <file.c>`
Show every sub-command run

LANGUAGE STANDARD

`gcc -std=c17 <file.c>`
Pick the C standard

`gcc -std=gnu11 <file.c>`
C11 plus GNU extensions

`g++ -std=c++20 <file.cpp>`
Pick the C++ standard

`gcc -pedantic <file.c>`
Warn on non-standard code

WARNINGS

`gcc -Wall <file.c>`
Common warnings

`gcc -Wextra <file.c>`
Extra warnings on top of -Wall

`gcc -Werror <file.c>`
Treat warnings as errors

WARNINGS (cont.)

`gcc -Werror=<name> <file.c>`
Make one warning an error

`gcc -Wno-<name> <file.c>`
Silence one warning

`gcc -Wshadow -Wconversion <file.c>`
Stricter, noisier checks

`gcc -fanalyzer <file.c>`
Static analysis pass (C)

OPTIMIZATION

`gcc -O0 <file.c>`
No optimization (default)

`gcc -O2 <file.c>`
Standard release optimization

`gcc -O3 <file.c>`
More aggressive, bigger code

`gcc -Os <file.c>`
Optimize for size

`gcc -Og <file.c>`
Optimize but stay debuggable

`gcc -Ofast <file.c>`
-O3 plus unsafe math
Enables -ffast-math, which breaks strict IEEE behaviour (NaN, ordering).

`gcc -march=native <file.c>`
Tune for this CPU
Binaries may crash on older CPUs.

`gcc -flto <file.c>`
Link-time optimization
Pass the same -O and -flto flags at compile and link time.

DEBUG AND PROFILE

`gcc -g <file.c>`
Add debug info for gdb

`gcc --coverage <file.c>`
Instrument for gcov

SANITIZERS

`gcc -fsanitize=address -g <file.c>`
AddressSanitizer: memory errors

`gcc -fsanitize=undefined -g <file.c>`
UBSan: undefined behavior

SANITIZERS (cont.)

`gcc -fsanitize=address,undefined -g <file.c>`
Combine ASan and UBSan

`gcc -fsanitize=thread -g <file.c>`
ThreadSanitizer: data races
Cannot be combined with address.

INCLUDE AND LINK PATHS

`gcc -I<dir> <file.c>`
Add a header search dir

`gcc -L<dir> <file.c> -l<name>`
Add a library search dir

`gcc <file.c> -l<name>`
Link libname.so or libname.a

`gcc <file.c> -lm`
Link the math library

`gcc -pthread <file.c>`
Enable POSIX threads

`gcc -static <file.c>`
Link statically

`gcc -Wl,<opt> <file.c>`
Pass an option to the linker

`gcc -Wl,-rpath,<dir> <file.c>`
Embed runtime library path

`gcc $(pkg-config --cflags --libs <pkg>) <file.c>`
Flags from pkg-config

MACROS

`gcc -D<name> <file.c>`
Define a macro as 1

`gcc -D<name>=<value> <file.c>`
Define a macro with a value

`gcc -dM -E -x c /dev/null`
List predefined macros

DEPENDENCIES AND LIBRARIES

`gcc -MMD -MP -c <file.c>`
Write .d dependency file with build

`gcc -M <file.c>`
Print all header dependencies

DEPENDENCIES AND LIBRARIES (cont.)

`gcc -MM <file.c>`
Same, skipping system headers

`gcc -fPIC -c <file.c>`
Position-independent object

`gcc -shared -o lib<name>.so <a.o>`
Build a shared library

`ar rcs lib<name>.a <a.o> <b.o>`
Build a static library

`LD_LIBRARY_PATH=<dir> ./<app>`
Find shared libs at run time

INSPECT THE COMPILER

`gcc --version`
Show the GCC version

`gcc -dumpmachine`
Show target triplet

`gcc -fverbose-asm -S <file.c>`
Annotate generated assembly

RECIPES

Strict debug build with sanitizers

```
gcc -std=c17 -Wall -Wextra -Werror \
    -g -O0 -fsanitize=address,undefined \
    src/*.c -o app
```

Release build with header dependencies

```
# compile
gcc -O2 -MMD -MP -c src/main.c -o build/main.o
# link
gcc build/main.o -o app -lm
# make: -include build/*.d
```

Shared library and a program using it

```
gcc -fPIC -shared -o libfoo.so foo.c
gcc main.c -L. -lfoo -Wl,-rpath,'$ORIGIN' -o app
./app
```

Look at the generated assembly

```
gcc -O2 -S -fverbose-asm x.c -o x.s
gcc -g -c x.c && objdump -dS x.o | less
```