Московский Авиационный Институт

(Национальный Исследовательский Университет)

Институт №8 “Компьютерные науки и прикладная математика”

Кафедра №806 “Вычислительная математика и программирование”

**Лабораторная работа №4 по курсу**

**«Операционные системы»**

Группа: М8О-215Б-23

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**Постановка задачи**

**Вариант 13.**

Требуется создать динамические библиотеки, реализующие заданный вариантом функционал. Далее использовать данные библиотеки 2-мя способами:

Во время компиляции (на этапе «линковки»/linking)

Во время исполнения программы. Библиотеки загружаются в память с помощью интерфейса ОС для работы с динамическими библиотеками.

В конечном итоге, в лабораторной работе необходимо получить следующие части:

Динамические библиотеки, реализующие контракты, которые заданы вариантом;

Тестовая программа (программа №1), которая использует одну из библиотек, используя информацию, полученную на этапе компиляции;

Тестовая программа (программа №2), которая загружает библиотеки, используя только их относительные пути и контракты;

Провести анализ двух типов использования библиотек.

**Пользовательский ввод для обеих программ:**

Если пользователь вводит команду «0», то программа переключает одну реализацию контрактов на другую (необходимо только для программы №2). Если не реализовать данную функцию, максимальная оценка в этом случае будет «хорошо».

«1 arg1 arg2» – после «1» идут аргументы для первой функции, предусмотренной контрактами. После ввода команды происходит вызов первой функции, и на экране появляется результат её выполнения.

«2 arg1 arg2» – после «2» идут аргументы для второй функции, предусмотренной контрактами. После ввода команды происходит вызов второй функции, и на экране появляется результат её выполнения.

**Функции:**

1. Вычисление производной функции cos(x) в точке A с приращением deltaX:
   1. Первая реализация: односторонняя разностная схема  
      f'(A) ≈ (cos(A + Δx) - cos(A)) / Δx
   2. Вторая реализация: центральная разностная схема  
      f'(A) ≈ (cos(A + Δx) - cos(A - Δx)) / (2Δx)
2. Подсчёт площади плоской фигуры по двум сторонам (A и B):
   1. Первая реализация: площадь прямоугольника: S = A \* B
   2. Вторая реализация: площадь прямоугольного треугольника: S = (A \* B) / 2

**Общий метод и алгоритм решения**

Использованные системные вызовы:

* void\* dlopen(const char\* filename, int flag); – загружает динамическую библиотеку.
* int dlclose(void\* handle); – выгружает ранее загруженную библиотеку.
* void\* dlsym(void\* handle, const char\* symbol); – возвращает адрес функции по её имени.

**Алгоритм решения**

Программа разделена на две части:

* **Program 1**: Использует динамические библиотеки, подключённые на этапе компиляции. При запуске Program 1 уже «знает» о функциях Derivative и Square из первых реализаций библиотек. Переключение (команда «0») здесь не реализовано.
* **Program 2**: Загрузку библиотек осуществляет динамически при помощи dlopen/dlsym. Изначально загружается первый набор (например, libderivative1.so и libsquare1.so). При вводе «0» программа выгружает эти библиотеки (dlclose) и загружает второй набор (libderivative2.so и libsquare2.so), после чего обновляет указатели на функции Derivative и Square. Таким образом, реализация функций может переключаться «на лету».

Обе программы принимают команды от пользователя:

* «1 A deltaX» вызывает Derivative(A, deltaX)
* «2 A B» вызывает Square(A, B)

**Makefile**

С помощью Makefile выполняется сборка и компиляция программы, makefile состоит из целей, реквизитами и командами. Для успешной компиляции нужно описать все цели, реквизиты и указать команды. Для компиляции С++ используем компилятор g++. Так как мы берем на себя линковку, то при компиляции нужно использовать флаг -c, чтобы получить объектный файл.

**Код программы**

**Makefile**

CXX= g++

CXXFLAGS= -Wall -Wextra -O2 -fPIC

LDFLAGS=

LIBS=

DLFLAGS= -ldl

# Имя целевых файлов

DERIV1\_LIB= libderivative1.so

DERIV2\_LIB= libderivative2.so

SQUARE1\_LIB= libsquare1.so

SQUARE2\_LIB= libsquare2.so

PROG1= program1

PROG2= program2

all: $(DERIV1\_LIB)$(DERIV2\_LIB)$(SQUARE1\_LIB)$(SQUARE2\_LIB)$(PROG1)$(PROG2)

# Правила сборки динамических библиотек

$(DERIV1\_LIB): derivative1.cpp derivative.h

$(CXX)$(CXXFLAGS)-shared -o $@derivative1.cpp -lm

$(DERIV2\_LIB): derivative2.cpp derivative.h

$(CXX)$(CXXFLAGS)-shared -o $@derivative2.cpp -lm

$(SQUARE1\_LIB): square1.cpp square.h

$(CXX)$(CXXFLAGS)-shared -o $@square1.cpp

$(SQUARE2\_LIB): square2.cpp square.h

$(CXX)$(CXXFLAGS)-shared -o $@square2.cpp

# Сборка программ

# program1 линкуется с первой реализацией библиотек (derivative1 и square1)

$(PROG1): program1.cpp derivative.h square.h $(DERIV1\_LIB)$(SQUARE1\_LIB)

$(CXX)$(CXXFLAGS)-o $(PROG1)program1.cpp -L. -lderivative1 -lsquare1

# program2 использует dlopen, поэтому линкуем с -ldl

$(PROG2): program2.cpp derivative.h square.h $(DERIV1\_LIB)$(DERIV2\_LIB)$(SQUARE1\_LIB)$(SQUARE2\_LIB)

$(CXX)$(CXXFLAGS)-o $(PROG2)program2.cpp $(DLFLAGS)

clean:

rm -f $(PROG1)$(PROG2)$(DERIV1\_LIB)$(DERIV2\_LIB)$(SQUARE1\_LIB)$(SQUARE2\_LIB)

.PHONY: all clean

**Derivative.h**

extern"C"{

Float Derivative(float A, float deltaX);

}

**Square.h**

extern"C"{

Float Square(float A, float B);

}

**Derivative1.cpp**

#include<cmath>

#include"derivative.h"

extern"C"floatDerivative(floatA, floatdeltaX) {

return(cosf(A+deltaX) -cosf(A)) /deltaX;

}

**Derivative2.cpp**

#include<cmath>

#include"derivative.h"

extern"C"floatDerivative(floatA, floatdeltaX) {

return(cosf(A+deltaX) -cosf(A-deltaX)) /(2.0f\*deltaX);

}

**Square1.cpp**

#include"square.h"

extern"C"floatSquare(floatA, floatB) {

returnA\*B;

}

**Square2.cpp**

#include"square.h"

extern"C"floatSquare(floatA, floatB) {

return(A\*B) /2.0f;

}

**Program\_1.cpp**

#include<iostream>

#include<string>

#include<sstream>

#include"derivative.h"

#include"square.h"

intmain() {

std::cout<<"Program1 (Linked at compile time with libderivative1 and libsquare1)\n";

std::stringline;

while(true) {

std::cout<<"> ";

if(!std::getline(std::cin, line)) break;

if(line.empty()) continue;

std::istringstreamiss(line);

intcmd;

iss>>cmd;

if(!iss) continue;

if(cmd==0) {

std::cout<<"Program1: Switching contracts is not supported here.\n";

} elseif(cmd==1) {

floatA, deltaX;

iss>>A>>deltaX;

if(iss) {

floatres=Derivative(A, deltaX);

std::cout<<"Derivative("<<A<<", "<<deltaX<<") = "<<res<<"\n";

} else{

std::cout<<"Invalid input for cmd=1\n";

}

} elseif(cmd==2) {

floatA, B;

iss>>A>>B;

if(iss) {

floatres=Square(A, B);

std::cout<<"Square("<<A<<", "<<B<<") = "<<res<<"\n";

} else{

std::cout<<"Invalid input for cmd=2\n";

}

} else{

std::cout<<"Unknown command.\n";

}

}

return0;

}

**Program\_2.cpp**

#include<iostream>

#include<string>

#include<sstream>

#include<dlfcn.h>

intmain() {

std::cout<<"Program2 (Runtime loading)\n";

std::stringderivativeLibName="./libderivative1.so";

std::stringsquareLibName="./libsquare1.so";

typedeffloat(\*DerivativeFunc)(float, float);

typedeffloat(\*SquareFunc)(float, float);

autoloadLibraries=[&](conststd::string&dName, conststd::string&sName,

void\*&dHandle, void\*&sHandle,

DerivativeFunc&dFunc, SquareFunc&sFunc) {

dHandle=dlopen(dName.c\_str(), RTLD\_LAZY);

if(!dHandle) {

std::cerr<<"Error loading "<<dName<<": "<<dlerror() <<"\n";

returnfalse;

}

sHandle=dlopen(sName.c\_str(), RTLD\_LAZY);

if(!sHandle) {

std::cerr<<"Error loading "<<sName<<": "<<dlerror() <<"\n";

dlclose(dHandle);

returnfalse;

}

dlerror();// очистка ошибок

dFunc=(DerivativeFunc)dlsym(dHandle, "Derivative");

constchar\*err=dlerror();

if(err) {

std::cerr<<"Error dlsym Derivative: "<<err<<"\n";

dlclose(dHandle);

dlclose(sHandle);

returnfalse;

}

dlerror();// очистка ошибок

sFunc=(SquareFunc)dlsym(sHandle, "Square");

err=dlerror();

if(err) {

std::cerr<<"Error dlsym Square: "<<err<<"\n";

dlclose(dHandle);

dlclose(sHandle);

returnfalse;

}

returntrue;

};

void\*dHandle=nullptr;

void\*sHandle=nullptr;

DerivativeFuncDerivativePtr=nullptr;

SquareFuncSquarePtr=nullptr;

// Загрузка начальных библиотек

if(!loadLibraries(derivativeLibName, squareLibName, dHandle, sHandle, DerivativePtr, SquarePtr)) {

return1;

}

std::stringline;

booluseFirstSet=true;// true - первая пара, false - вторая пара

while(true) {

std::cout<<"> ";

if(!std::getline(std::cin, line)) break;

if(line.empty()) continue;

std::istringstreamiss(line);

intcmd;

iss>>cmd;

if(!iss) continue;

if(cmd==0) {

// Переключаем реализацию

dlclose(dHandle);

dlclose(sHandle);

useFirstSet=!useFirstSet;

if(useFirstSet) {

derivativeLibName="./libderivative1.so";

squareLibName="./libsquare1.so";

std::cout<<"Switched to first set of libraries.\n";

} else{

derivativeLibName="./libderivative2.so";

squareLibName="./libsquare2.so";

std::cout<<"Switched to second set of libraries.\n";

}

if(!loadLibraries(derivativeLibName, squareLibName, dHandle, sHandle, DerivativePtr, SquarePtr)) {

return1;// ошибка при повторной загрузке

}

} elseif(cmd==1) {

floatA, deltaX;

iss>>A>>deltaX;

if(iss) {

floatres=DerivativePtr(A, deltaX);

std::cout<<"Derivative("<<A<<", "<<deltaX<<") = "<<res<<"\n";

} else{

std::cout<<"Invalid input for cmd=1\n";

}

} elseif(cmd==2) {

floatA, B;

iss>>A>>B;

if(iss) {

floatres=SquarePtr(A, B);

std::cout<<"Square("<<A<<", "<<B<<") = "<<res<<"\n";

} else{

std::cout<<"Invalid input for cmd=2\n";

}

} else{

std::cout<<"Unknown command.\n";

}

}

// Освобождение ресурсов

dlclose(dHandle);

dlclose(sHandle);

return0;

}

**Протокол работы программы**

**Тестирование:**

**Тест 1:**

root@55217656a245:/workspaces/MAI\_OS\_Labs/Lab4/src# ./program1

Program1 (Linked at compile time with libderivative1 and libsquare1)

> 1 0.0 0.001

Derivative(0, 0.001) = -0.000476837

> 2 3 4

Square(3, 4) = 12

> ^C

root@55217656a245:/workspaces/MAI\_OS\_Labs/Lab4/src# ./program2

Program2 (Runtime loading)

> 1 0.0 0.001

Derivative(0, 0.001) = -0.000476837

> 2 3 4

Square(3, 4) = 12

> 0

Switched to second set of libraries.

> 1 0.0 0.001

Derivative(0, 0.001) = 0

> 2 3 4

Square(3, 4) = 6

> ^C

**Strace**

**Program 1**

*21142 execve("./program1", ["./program1"], 0x7ffc76498648 /\* 27 vars /) = 0  
21142 brk(NULL) = 0x40323000  
21142 mmap(NULL, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_ANONYMOUS, -1, 0) = 0x7ff25bdfe000  
21142 access("/etc/ld.so.preload", R\_OK) = -1 ENOENT (No such file or directory)****21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/x86\_64/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libderivative1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./libderivative1.so", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
21142 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=15288, ...}, AT\_EMPTY\_PATH) = 0  
21142 getcwd("/workspaces/MAI\_OS\_Labs/Lab4/src", 128) = 33  
21142 mmap(NULL, 16408, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7ff25bdf9000  
21142 mmap(0x7ff25bdfa000, 4096, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1000) = 0x7ff25bdfa000  
21142 mmap(0x7ff25bdfb000, 4096, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7ff25bdfb000  
21142 mmap(0x7ff25bdfc000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7ff25bdfc000  
21142 close(3) = 0****21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/x86\_64/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libsquare1.so", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./libsquare1.so", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
21142 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=15160, ...}, AT\_EMPTY\_PATH) = 0  
21142 getcwd("/workspaces/MAI\_OS\_Labs/Lab4/src", 128) = 33  
21142 mmap(NULL, 16400, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7ff25bdf4000  
21142 mmap(0x7ff25bdf5000, 4096, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1000) = 0x7ff25bdf5000  
21142 mmap(0x7ff25bdf6000, 4096, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7ff25bdf6000  
21142 mmap(0x7ff25bdf7000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7ff25bdf7000  
21142 close(3) = 0****21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "/etc/ld.so.cache", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 newfstatat(3, "", {st\_mode=S\_IFREG|0644, st\_size=25258, ...}, AT\_EMPTY\_PATH) = 0  
21142 mmap(NULL, 25258, PROT\_READ, MAP\_PRIVATE, 3, 0) = 0x7ff25bded000  
21142 close(3) = 0****21142 openat(AT\_FDCWD, "/usr/local/lib64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
21142 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=2530008, ...}, AT\_EMPTY\_PATH) = 0  
21142 mmap(NULL, 2543808, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7ff25bb7f000  
21142 mmap(0x7ff25bc24000, 1216512, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0xa5000) = 0x7ff25bc24000  
21142 mmap(0x7ff25bd4d000, 581632, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1ce000) = 0x7ff25bd4d000  
21142 mmap(0x7ff25bddb000, 57344, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x25c000) = 0x7ff25bddb000  
21142 mmap(0x7ff25bde9000, 12480, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_ANONYMOUS, -1, 0) = 0x7ff25bde9000  
21142 close(3) = 0****21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "/lib/x86\_64-linux-gnu/libm.so.6", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
21142 newfstatat(3, "", {st\_mode=S\_IFREG|0644, st\_size=907784, ...}, AT\_EMPTY\_PATH) = 0  
21142 mmap(NULL, 909560, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7ff25baa0000  
21142 mmap(0x7ff25bab0000, 471040, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x10000) = 0x7ff25bab0000  
21142 mmap(0x7ff25bb23000, 368640, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x83000) = 0x7ff25bb23000  
21142 mmap(0x7ff25bb7d000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0xdc000) = 0x7ff25bb7d000  
21142 close(3) = 0****21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "/usr/local/lib64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
21142 newfstatat(3, "", {st\_mode=S\_IFREG|0644, st\_size=906528, ...}, AT\_EMPTY\_PATH) = 0  
21142 mmap(NULL, 181160, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7ff25ba73000  
21142 mmap(0x7ff25ba77000, 143360, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x4000) = 0x7ff25ba77000  
21142 mmap(0x7ff25ba9a000, 16384, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x27000) = 0x7ff25ba9a000  
21142 mmap(0x7ff25ba9e000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2b000) = 0x7ff25ba9e000  
21142 close(3) = 0****21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./tls/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "./libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******21142 openat(AT\_FDCWD, "/lib/x86\_64-linux-gnu/libc.so.6", O\_RDONLY|O\_CLOEXEC) = 3*** *21142 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\20t\2\0\0\0\0\0"..., 832) = 832  
21142 pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784  
21142 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=1922136, ...}, AT\_EMPTY\_PATH) = 0  
21142 mmap(NULL, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_ANONYMOUS, -1, 0) = 0x7ff25ba71000  
21142 pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784  
21142 mmap(NULL, 1970000, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7ff25b890000  
21142 mmap(0x7ff25b8b6000, 1396736, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x26000) = 0x7ff25b8b6000  
21142 mmap(0x7ff25ba0b000, 339968, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x17b000) = 0x7ff25ba0b000  
21142 mmap(0x7ff25ba5e000, 24576, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1ce000) = 0x7ff25ba5e000  
21142 mmap(0x7ff25ba64000, 53072, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_ANONYMOUS, -1, 0) = 0x7ff25ba64000  
21142 close(3) = 0  
21142 mmap(NULL, 12288, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_ANONYMOUS, -1, 0) = 0x7ff25b88d000  
21142 arch\_prctl(ARCH\_SET\_FS, 0x7ff25b88d740) = 0  
21142 set\_tid\_address(0x7ff25b88da10) = 21142  
21142 set\_robust\_list(0x7ff25b88da20, 24) = 0  
21142 rseq(0x7ff25b88e060, 0x20, 0, 0x53053053) = 0  
21142 mprotect(0x7ff25ba5e000, 16384, PROT\_READ) = 0  
21142 mprotect(0x7ff25ba9e000, 4096, PROT\_READ) = 0  
21142 mprotect(0x7ff25bb7d000, 4096, PROT\_READ) = 0  
21142 mprotect(0x7ff25bddb000, 45056, PROT\_READ) = 0  
21142 mprotect(0x7ff25bdf7000, 4096, PROT\_READ) = 0  
21142 mprotect(0x7ff25bdfc000, 4096, PROT\_READ) = 0  
21142 mprotect(0x404000, 4096, PROT\_READ) = 0  
21142 mprotect(0x7ff25be30000, 8192, PROT\_READ) = 0  
21142 prlimit64(0, RLIMIT\_STACK, NULL, {rlim\_cur=81921024, rlim\_max=RLIM64\_INFINITY}) = 0  
21142 munmap(0x7ff25bded000, 25258) = 0  
21142 futex(0x7ff25bde973c, FUTEX\_WAKE\_PRIVATE, 2147483647) = 0  
21142 getrandom("\x05\x7d\x50\x77\xed\x92\x55\x2a", 8, GRND\_NONBLOCK) = 8  
21142 brk(NULL) = 0x40323000  
21142 brk(0x40344000) = 0x40344000  
21142 newfstatat(1, "", {st\_mode=S\_IFCHR|0620, st\_rdev=makedev(0x88, 0), ...}, AT\_EMPTY\_PATH) = 0  
21142 write(1, "Program1 (Linked at compile time"..., 69) = 69  
21142 write(1, "> ", 2) = 2  
21142 newfstatat(0, "", {st\_mode=S\_IFCHR|0620, st\_rdev=makedev(0x88, 0), ...}, AT\_EMPTY\_PATH) = 0  
21142 read(0, "1 0.0 0.001\n", 1024) = 12  
21142 write(1, "Derivative(0, 0.001) = -0.000476"..., 36) = 36  
21142 write(1, "> ", 2) = 2  
21142 read(0, "2 3 4\n", 1024) = 6  
21142 write(1, "Square(3, 4) = 12\n", 18) = 18  
21142 write(1, "> ", 2) = 2  
21142 read(0, 0x403356c0, 1024) = ? ERESTARTSYS (To be restarted if SA\_RESTART is set)  
21142 --- SIGINT {si\_signo=SIGINT, si\_code=SI\_KERNEL} ---  
21142 +++ killed by SIGINT +++*

**Program 2**

*21142 execve("./program2", ["./program2"], 0x7ffc6da36878 /\* 27 vars /) = 0  
23380 brk(NULL) = 0xe715000  
23380 mmap(NULL, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_ANONYMOUS, -1, 0) = 0x7f70abe8a000  
23380 access("/etc/ld.so.preload", R\_OK) = -1 ENOENT (No such file or directory)****23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "/etc/ld.so.cache", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 newfstatat(3, "", {st\_mode=S\_IFREG|0644, st\_size=25258, ...}, AT\_EMPTY\_PATH) = 0  
23380 mmap(NULL, 25258, PROT\_READ, MAP\_PRIVATE, 3, 0) = 0x7f70abe83000  
23380 close(3) = 0****23380 openat(AT\_FDCWD, "/usr/local/lib64/libstdc++.so.6", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=2530008, ...}, AT\_EMPTY\_PATH) = 0  
23380 mmap(NULL, 2543808, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70abc15000  
23380 mmap(0x7f70abcba000, 1216512, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0xa5000) = 0x7f70abcba000  
23380 mmap(0x7f70abde3000, 581632, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1ce000) = 0x7f70abde3000  
23380 mmap(0x7f70abe71000, 57344, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x25c000) = 0x7f70abe71000  
23380 mmap(0x7f70abe7f000, 12480, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_ANONYMOUS, -1, 0) = 0x7f70abe7f000  
23380 close(3) = 0****23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./libm.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "/lib/x86\_64-linux-gnu/libm.so.6", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0644, st\_size=907784, ...}, AT\_EMPTY\_PATH) = 0  
23380 mmap(NULL, 909560, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70abb36000  
23380 mmap(0x7f70abb46000, 471040, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x10000) = 0x7f70abb46000  
23380 mmap(0x7f70abbb9000, 368640, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x83000) = 0x7f70abbb9000  
23380 mmap(0x7f70abc13000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0xdc000) = 0x7f70abc13000  
23380 close(3) = 0****23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "/usr/local/lib64/libgcc\_s.so.1", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0644, st\_size=906528, ...}, AT\_EMPTY\_PATH) = 0  
23380 mmap(NULL, 181160, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70abb09000  
23380 mmap(0x7f70abb0d000, 143360, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x4000) = 0x7f70abb0d000  
23380 mmap(0x7f70abb30000, 16384, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x27000) = 0x7f70abb30000  
23380 mmap(0x7f70abb34000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2b000) = 0x7f70abb34000  
23380 close(3) = 0****23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v3/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./glibc-hwcaps/x86-64-v2/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./tls/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./x86\_64/libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "./libc.so.6", O\_RDONLY|O\_CLOEXEC) = -1 ENOENT (No such file or directory)******23380 openat(AT\_FDCWD, "/lib/x86\_64-linux-gnu/libc.so.6", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\20t\2\0\0\0\0\0"..., 832) = 832  
23380 pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=1922136, ...}, AT\_EMPTY\_PATH) = 0  
23380 pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784  
23380 mmap(NULL, 1970000, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70ab928000  
23380 mmap(0x7f70ab94e000, 1396736, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x26000) = 0x7f70ab94e000  
23380 mmap(0x7f70abaa3000, 339968, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x17b000) = 0x7f70abaa3000  
23380 mmap(0x7f70abaf6000, 24576, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1ce000) = 0x7f70abaf6000  
23380 mmap(0x7f70abafc000, 53072, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_ANONYMOUS, -1, 0) = 0x7f70abafc000  
23380 close(3) = 0  
23380 mmap(NULL, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_ANONYMOUS, -1, 0) = 0x7f70ab926000  
23380 mmap(NULL, 12288, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_ANONYMOUS, -1, 0) = 0x7f70ab923000  
23380 arch\_prctl(ARCH\_SET\_FS, 0x7f70ab923740) = 0  
23380 set\_tid\_address(0x7f70ab923a10) = 23380  
23380 set\_robust\_list(0x7f70ab923a20, 24) = 0  
23380 rseq(0x7f70ab924060, 0x20, 0, 0x53053053) = 0  
23380 mprotect(0x7f70abaf6000, 16384, PROT\_READ) = 0  
23380 mprotect(0x7f70abb34000, 4096, PROT\_READ) = 0  
23380 mprotect(0x7f70abc13000, 4096, PROT\_READ) = 0  
23380 mprotect(0x7f70abe71000, 45056, PROT\_READ) = 0  
23380 mprotect(0x404000, 4096, PROT\_READ) = 0  
23380 mprotect(0x7f70abebc000, 8192, PROT\_READ) = 0  
23380 prlimit64(0, RLIMIT\_STACK, NULL, {rlim\_cur=81921024, rlim\_max=RLIM64\_INFINITY}) = 0  
23380 munmap(0x7f70abe83000, 25258) = 0  
23380 futex(0x7f70abe7f73c, FUTEX\_WAKE\_PRIVATE, 2147483647) = 0  
23380 getrandom("\x30\xfc\x4a\x97\x0e\x39\x87\x00", 8, GRND\_NONBLOCK) = 8  
23380 brk(NULL) = 0xe715000  
23380 brk(0xe736000) = 0xe736000  
23380 newfstatat(1, "", {st\_mode=S\_IFCHR|0620, st\_rdev=makedev(0x88, 0), ...}, AT\_EMPTY\_PATH) = 0  
23380 write(1, "Program2 (Runtime loading)\n", 27) = 27****23380 openat(AT\_FDCWD, "./libderivative1.so", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=15288, ...}, AT\_EMPTY\_PATH) = 0  
23380 getcwd("/workspaces/MAI\_OS\_Labs/Lab4/src", 128) = 33  
23380 mmap(NULL, 16408, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70abe85000  
23380 mmap(0x7f70abe86000, 4096, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1000) = 0x7f70abe86000  
23380 mmap(0x7f70abe87000, 4096, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70abe87000  
23380 mmap(0x7f70abe88000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70abe88000  
23380 close(3) = 0  
23380 mprotect(0x7f70abe88000, 4096, PROT\_READ) = 0****23380 openat(AT\_FDCWD, "./libsquare1.so", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=15160, ...}, AT\_EMPTY\_PATH) = 0  
23380 getcwd("/workspaces/MAI\_OS\_Labs/Lab4/src", 128) = 33  
23380 mmap(NULL, 16400, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70ab91e000  
23380 mmap(0x7f70ab91f000, 4096, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1000) = 0x7f70ab91f000  
23380 mmap(0x7f70ab920000, 4096, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70ab920000  
23380 mmap(0x7f70ab921000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70ab921000  
23380 close(3) = 0  
23380 mprotect(0x7f70ab921000, 4096, PROT\_READ) = 0  
23380 write(1, "> ", 2) = 2  
23380 newfstatat(0, "", {st\_mode=S\_IFCHR|0620, st\_rdev=makedev(0x88, 0), ...}, AT\_EMPTY\_PATH) = 0  
23380 read(0, "1 0.0 0.01\n", 1024) = 11  
23380 write(1, "Derivative(0, 0.01) = -0.0050008"..., 34) = 34  
23380 write(1, "> ", 2) = 2  
23380 read(0, "2 3 4\n", 1024) = 6  
23380 write(1, "Square(3, 4) = 12\n", 18) = 18  
23380 write(1, "> ", 2) = 2  
23380 read(0, "0\n", 1024) = 2  
23380 munmap(0x7f70abe85000, 16408) = 0  
23380 munmap(0x7f70ab91e000, 16400) = 0  
23380 write(1, "Switched to second set of librar"..., 37) = 37****23380 openat(AT\_FDCWD, "./libderivative2.so", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=15288, ...}, AT\_EMPTY\_PATH) = 0  
23380 getcwd("/workspaces/MAI\_OS\_Labs/Lab4/src", 128) = 33  
23380 mmap(NULL, 16408, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70abe85000  
23380 mmap(0x7f70abe86000, 4096, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1000) = 0x7f70abe86000  
23380 mmap(0x7f70abe87000, 4096, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70abe87000  
23380 mmap(0x7f70abe88000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70abe88000  
23380 close(3) = 0  
23380 mprotect(0x7f70abe88000, 4096, PROT\_READ) = 0****23380 openat(AT\_FDCWD, "./libsquare2.so", O\_RDONLY|O\_CLOEXEC) = 3*** *23380 read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\0\0\0\0\0\0\0\0"..., 832) = 832  
23380 newfstatat(3, "", {st\_mode=S\_IFREG|0755, st\_size=15232, ...}, AT\_EMPTY\_PATH) = 0  
23380 getcwd("/workspaces/MAI\_OS\_Labs/Lab4/src", 128) = 33  
23380 mmap(NULL, 16400, PROT\_READ, MAP\_PRIVATE|MAP\_DENYWRITE, 3, 0) = 0x7f70ab91e000  
23380 mmap(0x7f70ab91f000, 4096, PROT\_READ|PROT\_EXEC, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x1000) = 0x7f70ab91f000  
23380 mmap(0x7f70ab920000, 4096, PROT\_READ, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70ab920000  
23380 mmap(0x7f70ab921000, 8192, PROT\_READ|PROT\_WRITE, MAP\_PRIVATE|MAP\_FIXED|MAP\_DENYWRITE, 3, 0x2000) = 0x7f70ab921000  
23380 close(3) = 0  
23380 mprotect(0x7f70ab921000, 4096, PROT\_READ) = 0  
23380 write(1, "> ", 2) = 2  
23380 read(0, "1 0.0 0.01\n", 1024) = 11  
23380 write(1, "Derivative(0, 0.01) = 0\n", 24) = 24  
23380 write(1, "> ", 2) = 2  
23380 read(0, "2 3 4\n", 1024) = 6  
23380 write(1, "Square(3, 4) = 6\n", 17) = 17  
23380 write(1, "> ", 2) = 2  
23380 read(0, 0xe729610, 1024) = ? ERESTARTSYS (To be restarted if SA\_RESTART is set)  
23380 --- SIGINT {si\_signo=SIGINT, si\_code=SI\_KERNEL} ---  
23380 +++ killed by SIGINT +++*

**Вывод**

Данная лабораторная работа включает в себя два варианта загрузки библиотек. Динамическую загрузку в процессе выполнения программы и статическую при компиляции и линковки. Программа с линковкой во время компиляции работает быстрее, так как ей не требуется загружать необходимые библиотеки в процессе. Динамическая загрузка позволяет самому принимать решение о том, какие конкретно библиотеки требуются и загружать нужную, это сильно экономит память. Выполнение лабораторной работы помогло понять разницу между статическими и динамическими библиотеками.