Homework #5

School ID: 202355517 Name: 권민규

이번 Homework는 20점입니다.

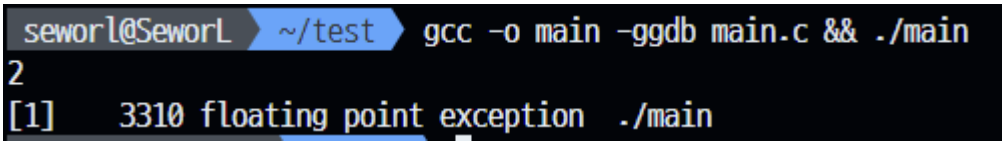
1

```c
#include <stdio.h>

int mydivide(int, int);

int main() {
  int x = 5, y = 2;
  printf("%d\n", mydivide(x, y));

  x = 3; y = 0;
  printf("%d\n", mydivide(x, y));

  return 0;
}

int mydivide(int a, int b) {
  return a / b;
}
```

1. 코드를 수행하여 발생된 에러가 무엇인지를 설명하라

코드를 컴파일한 뒤 그대로 실행했다.

```
gcc -o main -ggdb main.c && ./main
```



부동소수점 예외를 내뱉는다. 특히 주로 0으로 나누기 연산을 할 때 주로 발생하는 오류다.

2. gdb를 실행시켜 run 및 where의 결과를 기술하라.

```
gdb ./main
run
where
```

pwndbg 플러그인이 설치되어있어 약간의 CUI에 차이가 발생한다. 전체 결과는 아래와 같다.

```
pwndbg> run
Starting program: /home/seworl/test/main
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
2

Program received signal SIGFPE, Arithmetic exception.
0x00005555555551d4 in mydivide (a=3, b=0) at main.c:16
16      int mydivide(int a, int b) { return a / b; }
```

```
LEGEND: STACK | HEAP | CODE | DATA | RWX | RODATA
──────────────────────────[ REGISTERS / show-flags off / show-compact-regs off
]──────────────────────────
*RAX  0x3
 RBX  0x0
*RCX  0x1
 RDX  0x0
*RDI  0x3
 RSI  0x0
 R8   0x0
*R9   0x5555555592a0 ◂— 0xa32 /* '2\n' */
*R10  0x77
*R11  0x246
*R12  0x7fffffffd848 —▸ 0x7fffffffdb46 ◂— '/home/seworl/test/main'
*R13  0x555555555149 (main) ◂— endbr64
*R14  0x555555557dc0 (__do_global_dtors_aux_fini_array_entry) —▸ 0x555555555100
(__do_global_dtors_aux) ◂— endbr64
*R15  0x7ffff7ffd040 (_rtld_global) —▸ 0x7ffff7ffe2e0 —▸ 0x555555554000 ◂—
0x10102464c457f
*RBP  0x7fffffffd710 —▸ 0x7fffffffd730 ◂— 0x1
*RSP  0x7fffffffd710 —▸ 0x7fffffffd730 ◂— 0x1
*RIP  0x5555555551d4 (mydivide+18) ◂— idiv dword ptr [rbp - 8]
─────────────────────────────────[ DISASM / x86-64 / set emulate on
]─────────────────────────────────
 ► 0x5555555551d4 <mydivide+18>    idiv   dword ptr [rbp - 8]
    ↓
   0x5555555551d4 <mydivide+18>    idiv   dword ptr [rbp - 8]









──────────────────────────────────────────────[ SOURCE (CODE)
]──────────────────────────────────────────────
In file: /home/seworl/test/main.c:16
   11   printf("%d\n", mydivide(x, y));
   12
   13   return 0;
   14 }
   15
 ► 16 int mydivide(int a, int b) { return a / b; }
──────────────────────────────────────────────────[ STACK
]──────────────────────────────────────────────────
00:0000│ rbp rsp 0x7fffffffd710 —▸ 0x7fffffffd730 ◂— 0x1
01:0008│+008     0x7fffffffd718 —▸ 0x5555555551a5 (main+92) ◂— mov esi, eax
02:0010│+010     0x7fffffffd720 ◂— 0x0
03:0018│+018     0x7fffffffd728 ◂— 0x3
04:0020│+020     0x7fffffffd730 ◂— 0x1
05:0028│+028     0x7fffffffd738 —▸ 0x7ffff7db1d90 (__libc_start_call_main+128) ◂—
mov edi, eax
06:0030│+030     0x7fffffffd740 ◂— 0x0
```

```
07:0038|+038     0x7fffffffd748 —▸ 0x555555555149 (main) ◂— endbr64
──────────────────────────────────────────────[ BACKTRACE
]──────────────────────────────────────────────
 ► 0   0x5555555551d4 mydivide+18
   1   0x5555555551a5 main+92
   2   0x7ffff7db1d90 __libc_start_call_main+128
   3   0x7ffff7db1e40 __libc_start_main+128
   4   0x555555555085 _start+37
──────────────────────────────────────────────────────────────────────────────────
──────────────────────────
pwndbg> where
#0  0x00005555555551d4 in mydivide (a=3, b=0) at main.c:16
#1  0x00005555555551a5 in main () at main.c:11
#2  0x00007ffff7db1d90 in __libc_start_call_main (main=main@entry=0x555555555149
<main>, argc=argc@entry=1, argv=argv@entry=0x7fffffffd848) at
../sysdeps/nptl/libc_start_call_main.h:58
#3  0x00007ffff7db1e40 in __libc_start_main_impl (main=0x555555555149 <main>,
argc=1, argv=0x7fffffffd848, init=<optimized out>, fini=<optimized out>,
rtld_fini=<optimized out>, stack_end=0x7fffffffd838) at ../csu/libc-start.c:392
#4  0x0000555555555085 in _start ()
```

3. 문제를 일으키는 변수의 값과 주소, 그리고 그것이 어떤 문제를 일으키는지를 기술하라.

위에서 main 함수에서 두 번쨰로 mydivide를 호출하는 부분에서 오류가 발생했으므로, breakpoint를 설정하고 변수를 확인해준다.

```
b main.c:11
run
info locals
```

```
pwndbg> info locals
x = 3
y = 0
```

y값이 0이기 때문에 `mydivide` 함수에서 0으로 나누기 연산을 수행하며 오류를 뱉게 된다. y값의 주소를 확인해준다.

```
print &y
```

```
pwndbg> print &y
$1 = (int *) 0x7fffffffd72c
```

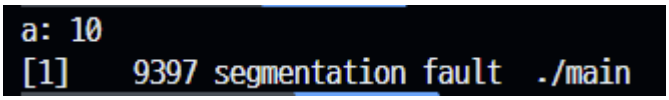
2

```c
#include <stdio.h>
void myInt(int*, int);

int main() {
  int a;
  myInt(&a, 10);
  printf("a: %d\n", a);

  int* b;
  myInt(b, 10);
  printf("b: %d\n", *b);

  return 0;
}

void myInt(int* ip, int i) {
  *ip = i;
}
```

1. 코드를 수행하여 발생된 에러가 무엇인지를 설명하라.

코드를 컴파일한 뒤 그대로 실행했다.

```
gcc -o main -ggdb main.c && ./main
```



segmentation fault가 뜬다.

2. gdb를 실행시켜 run 및 where의 결과를 기술하라.

구체적인 실행 방법은 1번 문제와 동일하므로 생략한다.


```
pwndbg> run
Starting program: /home/seworl/test/main
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
a: 10

Program received signal SIGSEGV, Segmentation fault.
0x000055555555520c in myInt (ip=0x0, i=10) at main.c:16
16      void myInt(int* ip, int i) { *ip = i; }
LEGEND: STACK | HEAP | CODE | DATA | RWX | RODATA
──────────────────────────[ REGISTERS / show-flags off / show-compact-regs off
```

```
]──────────────────────────
 RAX  0x0
 RBX  0x0
*RCX  0x1
*RDX  0xa
 RDI  0x0
*RSI  0xa
 R8   0x0
*R9   0x7fffffffd5e6 ◂— 0xe0b4181cce003031 /* '10' */
 R10  0x0
*R11  0x246
*R12  0x7fffffffd848 —▸ 0x7fffffffdb46 ◂— '/home/seworl/test/main'
*R13  0x555555555169 (main) ◂— endbr64
*R14  0x555555557db8 (__do_global_dtors_aux_fini_array_entry) —▸ 0x555555555120
(__do_global_dtors_aux) ◂— endbr64
*R15  0x7ffff7ffd040 (_rtld_global) —▸ 0x7ffff7ffe2e0 —▸ 0x555555554000 ◂—
0x10102464c457f
*RBP  0x7fffffffd700 —▸ 0x7fffffffd730 ◂— 0x1
*RSP  0x7fffffffd700 —▸ 0x7fffffffd730 ◂— 0x1
*RIP  0x55555555520c (myInt+22) ◂— mov dword ptr [rax], edx
─────────────────────────────────[ DISASM / x86-64 / set emulate on
]──────────────────────────────────
 ► 0x55555555520c <myInt+22>    mov    dword ptr [rax], edx
   0x55555555520e <myInt+24>    nop
   0x55555555520f <myInt+25>    pop    rbp
   0x555555555210 <myInt+26>    ret

   0x555555555211               add    byte ptr [rax], al
   0x555555555213               add    bl, dh




──────────────────────────────────────────────[ SOURCE (CODE)
]──────────────────────────────────────────────
In file: /home/seworl/test/main.c:16
   11   printf("b: %d\n", *b);
   12
   13   return 0;
   14 }
   15
 ► 16 void myInt(int* ip, int i) { *ip = i; }
──────────────────────────────────────────────────[ STACK
]──────────────────────────────────────────────────
00:0000│ rbp rsp 0x7fffffffd700 —▸ 0x7fffffffd730 ◂— 0x1
01:0008│+008     0x7fffffffd708 —▸ 0x5555555551bf (main+86) ◂— mov rax, qword ptr
[rbp - 0x10]
02:0010│+010     0x7fffffffd710 ◂— 0x0
03:0018│+018     0x7fffffffd718 ◂— 0xa00000000
04:0020│+020     0x7fffffffd720 ◂— 0x0
05:0028│+028     0x7fffffffd728 ◂— 0x1f5de0b4181cce00
06:0030│+030     0x7fffffffd730 ◂— 0x1
07:0038│+038     0x7fffffffd738 —▸ 0x7ffff7db1d90 (__libc_start_call_main+128) ◂—
mov edi, eax
```

```
──────────────────────────────────────────────[ BACKTRACE
]──────────────────────────────────────────────
 ► 0   0x55555555520c myInt+22
   1   0x5555555551bf main+86
   2   0x7ffff7db1d90 __libc_start_call_main+128
   3   0x7ffff7db1e40 __libc_start_main+128
   4   0x5555555550a5 _start+37
──────────────────────────────────────────────────────────────────────────────────────────────
──────────────────────
pwndbg> where
#0  0x00005555555552c in myInt (ip=0x0, i=10) at main.c:16
#1  0x00005555555551bf in main () at main.c:10
#2  0x00007ffff7db1d90 in __libc_start_call_main (main=main@entry=0x555555555169
<main>, argc=argc@entry=1, argv=argv@entry=0x7fffffffd848) at
../sysdeps/nptl/libc_start_call_main.h:58
#3  0x00007ffff7db1e40 in __libc_start_main_impl (main=0x555555555169 <main>,
argc=1, argv=0x7fffffffd848, init=<optimized out>, fini=<optimized out>,
rtld_fini=<optimized out>, stack_end=0x7fffffffd838) at ../csu/libc-start.c:392
#4  0x00005555555550a5 in _start ()
```

3. 문제를 일으키는 변수의 값과 주소, 그리고 그것이 어떤 문제를 일으키는지를 기술하라.

```
pwndbg> info locals
a = 10
b = 0x0
pwndbg> print *b
Cannot access memory at address 0x0
```

포인터 변수로 선언된 b의 주솟값이 정해지지 않았고, 그 상태에서 값을 저장하려 시도해서 발생한 오류이다.

포인터 변수인 b의 주소가 이번 오류의 분석에 필요한 건 아니라 b와 *b를 탐색하였다.

3

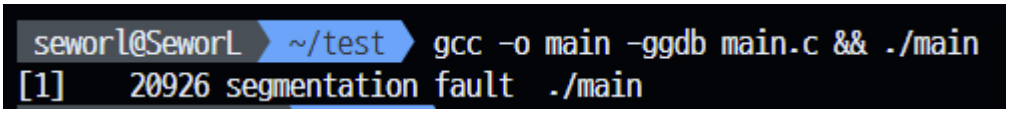
```c
#include <stdio.h>
#include <stdlib.h>

void sort(int myData[], size_t len);
void swap(int *pa, int *pb);

enum { LEN = 5 };

int main() {
  int myData[LEN] = {2, 1, 5, 3, 6};

  sort(myData, LEN);

  printf("sorted myData:\n");

  for (int i = 0; i < LEN; ++i) {
```

```
    printf("%d\n", myData[i]);
  }

  return 0;
}

void sort(int myData[], size_t len) {
  for (int i = 0; i < (len - 1); ++i) {
    for (int j = i + 1; j < len; ++j) {
      if (myData[i] > myData[j]) {
        swap(&myData[i], &myData[j]);
      }
    }
  }
}

void swap(int *a, int *b) {
  int *temp;
  *temp = *a;
  a = b;
  b = temp;
}
```

1. 코드를 수행하여 발생된 에러가 무엇인지를 설명하라.

코드를 컴파일한 뒤 그대로 실행했다.

```
gcc -o main -ggdb main.c && ./main
```



segmentation fault 오류이다.

2. gdb를 실행시켜 run 및 where의 결과를 기술하라.

구체적인 실행 방법은 1번 문제와 동일하므로 생략한다.


```
pwndbg> run
Starting program: /home/seworl/test/main
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".

Program received signal SIGSEGV, Segmentation fault.
0x0000555555555309 in swap (a=0x7fffffffd710, b=0x7fffffffd714) at main.c:35
35          *temp = *a;
LEGEND: STACK | HEAP | CODE | DATA | RWX | RODATA
──────────────────────────[ REGISTERS / show-flags off / show-compact-regs off
]──────────────────────────
```

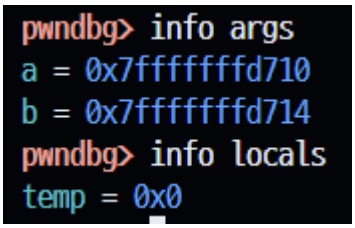
```
 RAX  0x0
 RBX  0x0
 RCX  0x0
*RDX  0x2
*RDI  0x7fffffffd710 ◂— 0x100000002
*RSI  0x7fffffffd714 ◂— 0x500000001
*R8   0x7ffff7fa3f10 (initial+16) ◂— 0x4
*R9   0x7ffff7fc9040 (_dl_fini) ◂— endbr64
*R10  0x7ffff7fc3908 ◂— 0xd00120000000e
*R11  0x7ffff7fde660 (_dl_audit_preinit) ◂— endbr64
*R12  0x7fffffffd848 —▸ 0x7fffffffdb46 ◂— '/home/seworl/test/main'
*R13  0x555555555189 (main) ◂— endbr64
*R14  0x555555557db0 (__do_global_dtors_aux_fini_array_entry) —▸ 0x555555555140
(__do_global_dtors_aux) ◂— endbr64
*R15  0x7ffff7ffd040 (_rtld_global) —▸ 0x7ffff7ffe2e0 —▸ 0x555555554000 ◂—
0x10102464c457f
*RBP  0x7fffffffd6c0 —▸ 0x7fffffffd6f0 —▸ 0x7fffffffd730 ◂— 0x1
*RSP  0x7fffffffd6c0 —▸ 0x7fffffffd6f0 —▸ 0x7fffffffd730 ◂— 0x1
*RIP  0x555555555309 (swap+26) ◂— mov dword ptr [rax], edx
─────────────────────────────────[ DISASM / x86-64 / set emulate on
]──────────────────────────────────
 ► 0x555555555309 <swap+26>    mov    dword ptr [rax], edx
   0x55555555530b <swap+28>    mov    rax, qword ptr [rbp - 0x20]
   0x55555555530f <swap+32>    mov    qword ptr [rbp - 0x18], rax
   0x555555555313 <swap+36>    mov    rax, qword ptr [rbp - 8]
   0x555555555317 <swap+40>    mov    qword ptr [rbp - 0x20], rax
   0x55555555531b <swap+44>    nop
   0x55555555531c <swap+45>    pop    rbp
   0x55555555531d <swap+46>    ret

   0x55555555531e              add    byte ptr [rax], al
   0x555555555320 <_fini>      endbr64
   0x555555555324 <_fini+4>    sub    rsp, 8
──────────────────────────────────────────────[ SOURCE (CODE)
]──────────────────────────────────────────────
In file: /home/seworl/test/main.c:35
   30   }
   31 }
   32
   33 void swap(int *a, int *b) {
   34   int *temp;
 ► 35   *temp = *a;
   36   a = b;
   37   b = temp;
   38 }
──────────────────────────────────────────────────[ STACK
]──────────────────────────────────────────────────
00:0000| rbp rsp 0x7fffffffd6c0 —▸ 0x7fffffffd6f0 —▸ 0x7fffffffd730 ◂— 0x1
01:0008|+008     0x7fffffffd6c8 —▸ 0x5555555552c2 (sort+142) ◂— add dword ptr [rbp
- 4], 1
02:0010|+010     0x7fffffffd6d0 ◂— 0x5
03:0018|+018     0x7fffffffd6d8 —▸ 0x7fffffffd710 ◂— 0x100000002
04:0020|+020     0x7fffffffd6e0 ◂— 0x0
05:0028|+028     0x7fffffffd6e8 ◂— 0x100000000
```

```
06:0030|+030     0x7fffffffd6f0 —▸ 0x7fffffffd730 ◂— 0x1
07:0038|+038     0x7fffffffd6f8 —▸ 0x5555555551d8 (main+79) ◂— lea rax, [rip +
0xe25]
──────────────────────────────────────────────────[ BACKTRACE
]──────────────────────────────────────────────────
 ► 0   0x555555555309 swap+26
   1   0x5555555552c2 sort+142
   2   0x5555555551d8 main+79
   3   0x7ffff7db1d90 __libc_start_call_main+128
   4   0x7ffff7db1e40 __libc_start_main+128
   5   0x5555555550c5 _start+37
──────────────────────────────────────────────────────────────────────────────
──────────────────────────
pwndbg> where
#0  0x0000555555555309 in swap (a=0x7fffffffd710, b=0x7fffffffd714) at main.c:35
#1  0x00005555555552c2 in sort (myData=0x7fffffffd710, len=5) at main.c:27
#2  0x00005555555551d8 in main () at main.c:12
#3  0x00007ffff7db1d90 in __libc_start_call_main (main=main@entry=0x555555555189
<main>, argc=argc@entry=1, argv=argv@entry=0x7fffffffd848) at
../sysdeps/nptl/libc_start_call_main.h:58
#4  0x00007ffff7db1e40 in __libc_start_main_impl (main=0x555555555189 <main>,
argc=1, argv=0x7fffffffd848, init=<optimized out>, fini=<optimized out>,
rtld_fini=<optimized out>, stack_end=0x7fffffffd838) at ../csu/libc-start.c:392
#5  0x00005555555550c5 in _start ()
```

3. 문제를 일으키는 변수의 값과 주소, 그리고 그것이 어떤 문제를 일으키는지를 기술하라.

swap 함수의 내부에 breakpoint를 걸어주고 변수를 확인해준다.

```
b main.c:35
run
info args
info locals
```



포인터 변수 temp가 초기화되지 않은 상태에서 값을 저장하려 시도해서 발생한 오류이다.

4. 에러를 수정하여 이 코드가 의도하는 결과를 기술하라.

`swap` 함수를 다음과 같이 수정한다.

```
void swap(int *a, int *b) {
  int temp;
```

```
    temp = *a;
    *a = *b;
    *b = temp;
}
```