SI485H: Stack Based Binary Exploits and Defenses

06-Week Written Exam

Name ____________________________

Alpha____________________________

Question	Points
1	
2	
3	
4	
5	
Total	

1. Consider the following C program below for this question

```
int main(){

  char str[5];
  unsigned int i = 0xdeadbeef;

  memcpy(str,&i,4); // MARK 1

  str[4]=0x0; // MARK 2

  char *p;
  for(p=str;*p;p++){ //MARK 3
    printf("%p : 0x%02hhx\n", p , *p); //MARK 4
  }

  return 0;
}
```

a) (4 POINTS) At **MARK 1,** 4 bytes of the integer **i** are copied to **str.** Why is the **&** necessary with respect to its usage with **i**? What would happen if the **&** were not used?

b) (4 POINTS) At **MARK 2,** index 4 of **str** is set to 0x0. Why is this necessary with respect to the for loop at **MARK 3**? If this was not done, how would the output of the program be affected?

c) (4 POINTS) At **MARK 4,** the format strings **%02hhx** specifies what format for ***p**? Explain how this relates to the pointer type of **p** being **char *.**

d) (4 POINTS) Assuming that the value of **str** is 0xbfc39447, what is the output of this program? **BE PRECISE!**

e) (4 POINTS) Consider an alternate version of the program: Would the output change? **If so, describe how? If not, describe why not?**

```
#include <stdio.h>
#include <string.h>

int main(){

  unsigned short str[3];
  unsigned int i = 0xdeadbeef;

  memcpy(str,&i,4);

  str[2]= 0x0;

  char *p;
  for(p=str;*p;p++){
    printf("%p : 0x%02hhx\n", p , *p);
  }

  return 0;
}
```

2. Consider the disassembled program below for the function **foo**, **bar**, and **baz**, and the **main()** function in c.

```
(gdb) ds foo
Dump of assembler code for function foo:
   0x08048432 <+0>:     push   ebp
   0x08048433 <+1>:     mov    ebp,esp
   0x08048435 <+3>:     sub    esp,0x4
   0x08048438 <+6>:     mov    eax,DWORD PTR [ebp+0x8]
   0x0804843b <+9>:     mov    DWORD PTR [esp],eax
   0x0804843e <+12>:    call   0x8048428 <bar>
   0x08048443 <+17>:    mov    DWORD PTR [esp],eax
   0x08048446 <+20>:    call   0x804841d <baz>
   0x0804844b <+25>:    leave
   0x0804844c <+26>:    ret
End of assembler dump.
(gdb) ds bar
Dump of assembler code for function bar:
   0x08048428 <+0>:     push   ebp
   0x08048429 <+1>:     mov    ebp,esp
   0x0804842b <+3>:     mov    eax,DWORD PTR [ebp+0x8]
   0x0804842e <+6>:     not    eax
   0x08048430 <+8>:     pop    ebp
   0x08048431 <+9>:     ret
End of assembler dump.
(gdb) ds baz
Dump of assembler code for function baz:
   0x0804841d <+0>:     push   ebp
   0x0804841e <+1>:     mov    ebp,esp
   0x08048420 <+3>:     mov    eax,DWORD PTR [ebp+0x8]
   0x08048423 <+6>:     add    eax,0x1
   0x08048426 <+9>:     pop    ebp
   0x08048427 <+10>:    ret
End of assembler dump.
----------------------------------------------------
 int main(){
   unsigned int f = foo(0x11111111);
   printf("0x%08x\n",f);
 }
```

a) (3 POINTS) In the function **foo**, **CIRCLE** the line of assembly that indicates access to the argument to the function **foo.**

If **foo** had **two arguments** instead of one, at what address would the second argument be placed?

b) (4 POINTS) Write the source code for function **foo** below.

c) (3 POINTS) Consider the call stack when function **foo** is about to call function **bar.** Complete the **two missing** spots in the stack diagram to the right. Assume the indicated instruction just completed, and also refer to the source code for main.

0x0804843e <foo+9>

ebp+0x8 ->	
ebp+0x4 ->	0x08048462
ebp ->	0xbfff0408
esp ->	
	<- 4 bytes ->

d) (3 POINTS) Consider the call stack for the function **bar.** Complete the diagram to the right with the **two missing** spots filled in.

0x0804842e <bar+3>

ebp+0x8 ->	
ebp+0x4 ->	
ebp,esp ->	0xbfff0430
	<- 4 bytes ->

e) (4 POINTS) Why is it the case that function **bar** and **baz** does not subtract from the stack pointer like the function **foo**?

f) (3 POINTS) What is the output of executing this program, assuming all types are unsigned? ***(Hint: not inverts bytes, so 0x1 in bits is 0001 thus its inverse is 1110)***

3. Consider the disassembled program below:

```
$ gdb -q q3
Reading symbols from q3...(no debugging symbols found)...done.
(gdb) br foo
Breakpoint 1 at 0x8048453
(gdb) r 5 1
Starting program: ./q3 5 1

Breakpoint 1, 0x08048453 in foo ()
(gdb) ds
Dump of assembler code for function foo:
   0x0804844d <+0>:    push   ebp
   0x0804844e <+1>:    mov    ebp,esp
   0x08048450 <+3>:    sub    esp,0x10
=> 0x08048453 <+6>:    mov    DWORD PTR [ebp-0x4],0x0
   0x0804845a <+13>:   mov    DWORD PTR [ebp-0x8],0x0
   0x08048461 <+20>:   jmp    0x8048476 <foo+41>
   0x08048463 <+22>:   mov    eax,DWORD PTR [ebp-0x8]
   0x08048466 <+25>:   mov    edx,DWORD PTR [ebp+0xc]
   0x08048469 <+28>:   mov    ecx,eax
   0x0804846b <+30>:   shl    edx,cl
   0x0804846d <+32>:   mov    eax,edx
   0x0804846f <+34>:   add    DWORD PTR [ebp-0x4],eax
   0x08048472 <+37>:   add    DWORD PTR [ebp-0x8],0x1
   0x08048476 <+41>:   mov    eax,DWORD PTR [ebp-0x8]
   0x08048479 <+44>:   cmp    eax,DWORD PTR [ebp+0x8]
   0x0804847c <+47>:   jl     0x8048463 <foo+22>
   0x0804847e <+49>:   mov    eax,DWORD PTR [ebp-0x4]
   0x08048481 <+52>:   leave
   0x08048482 <+53>:   ret
End of assembler dump.
```

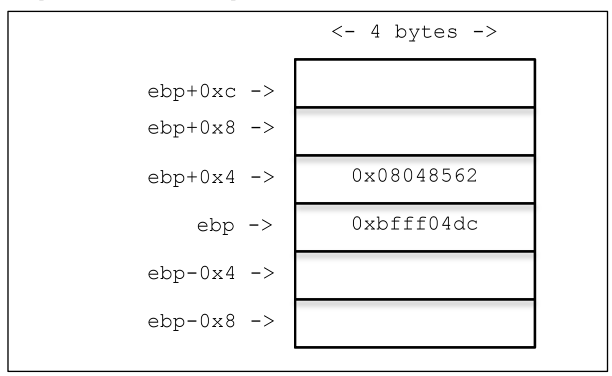
a) (2 POINTS) Provide the proper **gcc** compilation command such that **q3** will be compiled to not have the **no debugging symbols found** message removed when run under **gdb**?

b) (2 POINTS) Currently the there is a break point at **foo.** If the user wished to place a break point to occur *after* the **cmp** instruction, produce the gdb command below?

c) (4 POINTS) After next break point, occurring after the **cmp** command, Provide two gdb commands that show the value of the register **eax** and the value at the address **ebp+0x8** as hex words.

d) (2 POINTS) How come the conditional jump **jl** instruction has only one operand, which is the next instruction to jump to, and not anything about the condition? What and where is the condition actually tested and how is **jl** receiving that information?

e) (4 POINTS) Assume the user issues the command **c 3** since adding the break from part (c). Fill in the stack diagram with the correct values at this point in the program assuming **foo(5,1)** was called:



f) (3 Point) Write the source code for the function **foo.**

g) (2 POINT) What is the return value of the function when called with **foo(5,1)**

4. Consider the following disassembled code for function foo:

```
(gdb) ds foo
Dump of assembler code for function foo:
 0x0804844d <+0>: push ebp
 0x0804844e <+1>: mov ebp,esp
 0x08048450 <+3>: sub esp,0x48
 0x08048453 <+6>: mov DWORD PTR [ebp-0xc],0x0
 0x0804845a <+13>: mov eax,DWORD PTR [ebp+0x8]
 0x0804845d <+16>: mov DWORD PTR [esp+0x4],eax
 0x08048461 <+20>: lea eax,[ebp-0x2c]
 0x08048464 <+23>: mov DWORD PTR [esp],eax
 0x08048467 <+26>: call 0x8048320 <strcpy@plt>
 0x0804846c <+31>: jmp 0x804848c <foo+63>
 0x0804846e <+33>: lea eax,[ebp-0x2c]
 0x08048471 <+36>: mov DWORD PTR [esp+0x8],eax
 0x08048475 <+40>: mov eax,DWORD PTR [ebp-0xc]
 0x08048478 <+43>: mov DWORD PTR [esp+0x4],eax
 0x0804847c <+47>: mov DWORD PTR [esp],0x8048540
 0x08048483 <+54>: call 0x8048310 <printf@plt>
 0x08048488 <+59>: add DWORD PTR [ebp-0xc],0x1
 0x0804848c <+63>: cmp DWORD PTR [ebp-0xc],0x2
 0x08048490 <+67>: jle 0x804846e <foo+33>
 0x08048492 <+69>: leave
 0x08048493 <+70>: ret
End of assembler dump.
(gdb) r "Go Navy"
Starting program: ./main "Go Navy"
0: Go Navy
1: Go Navy
2: Go Navy
[Inferior 1 (process 3044) exited with code 013
```

a) (4 POINTS) Write the source code for function **foo**:

b) (2 POINTS) Consider executing the program **main** which calls **foo** using the command line argument like **foo(argv[1])**.

./main `python –c "print 'A'***x**"`

At what value of **x** does the functionality of the loop change?

c) (3 Points) **Explain** your previous answer:

d) (4 POINTS) Complete the command line arguments below such that the loop will execute exactly **5 times** as opposed to the 3 times it is currently executing:

./main `python –c " "`

e) (4 POINTS) Consider the fact the function **bar** is at address **0x0804844d** and the function **baz** is at address **0x0804892c**. Write a command line argument below such that upon return from **foo**, first the function **bar** would execute *followed* by the function **baz**:

./main `python –c " "`

f) (3 POINTS) If the function **bar** was at address **0x08048a00** instead of the one described above, would the exploit still work? If so, explain why. If not, explain why not.

5. Consider the following shell code dissably from objdump:

```
08048060 <_start>:
 8048060:   eb 20                   jmp    8048082 <callback>

08048062 <dowork>:
 8048062:   5e                       pop    esi      ;MARK 1
 8048063:   6a 00                    push   0x0
 8048065:   56                       push   esi
 8048066:   ba 00 00 00 00           mov    edx,0x0
 804806b:   89 e1                    mov    ecx,esp  ;MARK 2
 804806d:   89 f3                    mov    ebx,esi
 804806f:   b8 0b 00 00 00           mov    eax,0xb
 8048074:   cd 80                    int    0x80     ;MARK 3
 8048076:   bb 00 00 00 00           mov    ebx,0x0
 804807b:   b8 01 00 00 00           mov    eax,0x1
 8048080:   cd 80                    int    0x80     ;MARK 4

08048082 <callback>:
 8048082:   e8 db ff ff ff           call   8048062 <dowork> ; MARK 5
 8048087:   2f 62 69 6e 2f 73 68 00 db    /bin/sh\0
```

a) (3 POINTS) The following code using a **jump-callback** to avoid a fixed reference. Explain why this is necessary for shell code as compared to using the named reference to the shell code, e.g., **shell**, like in the instruction below:

shell: db "/bin/sh/",0x0

b) (3 POINTS) After the instruction at **MARK 5** completes, what value is pushed onto the top of the stack and is popped into the **esi** register? Explain why and how this value was pushed onto the stack.

c) (4 POINTS) At **MARK 2** the current stack pointer value (as stored in the **esp** register) is stored in register **ecx.** What part of the **execve()** call does this pointer value represent? **DRAW a diagram to support your explanation.**

d) (3 POINTS) If we were to use this shell code in an exploit like so:

./vulnerable_program $(printf `./hexify.sh shellcode`)

where **vulnerable_program** used a **strcpy()**, would this be an successful exploit or will it fail? **Explain why or why not.**

e) (5 POINTS) Write the corrected version of the shell code that would produce a successful exploit.

f) (2 POINTS) What system call is associated with the interrupt instruction at **MARK 4**?