Q1  Indirection  (0 points)

Consider the following vulnerable C code:

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

struct log_entry {
    char title[8];
    char *msg;
};

void log_event(char *title, char *msg) {
    size_t len = strlen(msg, 256);
    if (len == 256) return; /* Message too long. */
    struct log_entry *entry = malloc(sizeof(struct log_entry));
    entry->msg = malloc(256);
    strcpy(entry->title, title);
    strncpy(entry->msg, msg, len + 1);
    add_to_log(entry); /* Implementation not shown. */
}
```

Assume you are on a little-endian 32-bit x86 system and no memory safety defenses are enabled.

Q1.1 (3 points) Which of the following lines contains a memory safety vulnerability?

- (A) Line 10
- (B) Line 13
- (C) Line 14
- (D) Line 15
- (E) —
- (F) —
Q1.2 (3 points) Fill in the numbered blanks on the following stack and heap diagram for log_event.
Assume that lower-numbered addresses start at the bottom of both diagrams.

Stack

```
<table>
<thead>
<tr>
<th>Stack</th>
<th>Heap</th>
</tr>
</thead>
<tbody>
<tr>
<td>msg</td>
<td>3</td>
</tr>
<tr>
<td>l</td>
<td>2</td>
</tr>
<tr>
<td>rip</td>
<td></td>
</tr>
<tr>
<td>sfp</td>
<td></td>
</tr>
<tr>
<td>len</td>
<td></td>
</tr>
<tr>
<td>entry</td>
<td></td>
</tr>
</tbody>
</table>
```

○ (G) 1 = entry->title 2 = entry->title 3 = msg
○ (H) 1 = entry->title 2 = msg 3 = entry->title
○ (I) 1 = title 2 = entry->title 3 = entry->msg
○ (J) 1 = title 2 = entry->msg 3 = entry->title

○ (K) —-
○ (L) —-

Using GDB, you find that the address of the rip of log_event is 0xbfffe0f0.
Let SHELLCODE be a 40-byte shellcode. Construct an input that would cause this program to execute shellcode. Write all your answers in Python 2 syntax (just like Project 1).

Q1.4 (6 points) Give the input for the title argument.

Q1.5 (6 points) Give the input for the msg argument.
Consider the following vulnerable C code:

```c
#include <byteswap.h>
#include <inttypes.h>
#include <stdio.h>

void prepare_input(void) {
  char buffer[64];
  int64_t *ptr;

  printf("What is the buffer?\n");
  fread(buffer, 1, 68, stdin);

  printf("What is the pointer?\n");
  fread(&ptr, 1, sizeof(uint64_t *), stdin);

  if (ptr < buffer || ptr >= buffer + 68) {
    printf("Pointer is outside buffer!\n");
    return;
  }

  /* Reverse 8 bytes of memory at the address ptr */
  *ptr = bswap_64(*ptr);
}

int main(void) {
  prepare_input();
  return 0;
}
```

The `bswap_64` function takes in 8 bytes and returns the 8 bytes in reverse order.

Assume that the code is run on a 32-bit system, no memory safety defenses are enabled, and there are no exception handlers, saved registers, or compiler padding.

Q2.1 (3 points) Fill in the numbered blanks on the following stack diagram for `prepare_input`.

```

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0xbffff494)</td>
<td>(0xbffff490)</td>
<td>(0xbffff450)</td>
<td>(0xbffff44c)</td>
</tr>
</tbody>
</table>
```

- (A) 1 = sfp, 2 = rip, 3 = buffer, 4 = ptr
- (B) 1 = sfp, 2 = rip, 3 = ptr, 4 = buffer
- (C) 1 = rip, 2 = sfp, 3 = buffer, 4 = ptr
- (D) 1 = rip, 2 = sfp, 3 = ptr, 4 = buffer
- (E) __________
- (F) __________
Q2.2 (4 points) Which of these values on the stack can the attacker write to at lines 10 and 13? Select all that apply.

- [ ] (G) buffer
- [ ] (H) ptr
- [ ] (I) sfp
- [ ] (J) rip
- [ ] (K) None of the above
- [ ] (L) ___

Q2.3 (3 points) Give an input that would cause this program to execute shellcode. At line 10, first input these bytes:

- [ ] (A) 64-byte shellcode
- [ ] (B) \xbf\xff\xf4\x4c
- [ ] (C) \x4c\xf4\xff\xbf
- [ ] (D) \xbf\xff\xf4\x50
- [ ] (E) \x50\xf4\xff\xbf
- [ ] (F) ___

Q2.4 (3 points) Then input these bytes:

- [ ] (G) 64-byte shellcode
- [ ] (H) \xbf\xff\xf4\x4c
- [ ] (I) \x4c\xf4\xff\xbf
- [ ] (J) \xbf\xff\xf4\x50
- [ ] (K) \x50\xf4\xff\xbf
- [ ] (L) ___

Q2.5 (3 points) At line 13, input these bytes:

- [ ] (A) \xbf\xff\xf4\x50
- [ ] (B) \x50\xf4\xff\xbf
- [ ] (C) \xbf\xff\xf4\x90
- [ ] (D) \x90\xf4\xff\xbf
- [ ] (E) \xbf\xff\xf4\x94
- [ ] (F) \x94\xf4\xff\xbf

Q2.6 (3 points) Suppose you replace 68 with 64 at line 10 and line 15. Is this modified code memory-safe?

- [ ] (G) Yes
- [ ] (H) No
- [ ] (I) ___
- [ ] (J) ___
- [ ] (K) ___
- [ ] (L) ___

This is the end of Q2. Leave the remaining subparts of Q2 blank on Gradescope, if there are any. You have reached the end of the exam.