VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

EXAMINATIONS – 2024

TRIMESTER 2

FRONT PAGE

CYBR 271

SECURE CODING
07/11/2024

Time Allowed: TWO HOURS (120 minutes)

Instructions:

- Attempt **ALL** questions in this booklet.
- Only silent non-programmable calculators or silent programmable calculators with their memories cleared are permitted in this examination.
- Printed foreign to English language dictionaries are permitted.
- Write answers in the spaces provided **in the examination booklet**.
- **Hand in the examination booklet.**

Questions	**Marks**
1. Security Principles	[5]
2. STRIDE Threat Modeling	[10]
3. Risk Assessment and Attack Trees	[10]
4. Security Reviews, Testing, and Supply Chain Attacks	[10]
5. Privilege Escalation	[10]
6. Buffer Overflow and Return-to-libc	[20]
7. Format String	[12]
8. Cross-site Scripting (XSS)	[10]
9. Cross-site Request Forgery (CSRF)	[8]
10. SQL-Injection	[5]

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

1. **Security Principles** **(5 marks)**

Consider a smart home system that allows users to remotely control their home's lighting, temperature, door locks, and security cameras via a mobile app.

(a) **(2 marks)** **Define** the security principle of "least privilege" and give an example of how this principle can be applied in the context of the smart home system.

(b) **(2 marks)** **Define** the security principle of "fail securely" and give an example of how this principle can be applied in the context of the smart home system.

(c) **(1 mark)** **Briefly** explain why applying these security principles is important in the context of smart home systems.

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2. **STRIDE Threat Modeling** **(10 marks)**

Consider an online voting system for a university student election. The system allows students to log in, view candidate information, and cast their votes securely.

(a) **(5 marks)** **Draw** a simple DFD representing the system. It must include at least one of each type of element e.g., data flow, data store, process, interactors and trust boundary.

(b) **(5 marks)** **Apply** the STRIDE model to the online voting system scenario. **Identify** five potential threats, each from a different STRIDE category, and **briefly** explain how they could impact the system.

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3. **Risk Assessment and Attack Trees** **(10 marks)**

Consider a cloud-based file storage service that allows users to upload, store, and share files.

(a) **(5 marks)** **Create** a simple attack tree for an attacker trying to gain unauthorized access to a user's files in the cloud storage service. Include at least **two levels** in your tree and **one** AND node.

(b) **(5 marks)** Pick a threat from your tree and apply **DREAD** to come up with an overall risk score (0-50). Make sure that you explain your reasoning and assumptions.

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4. **Security Reviews, Testing, and Supply Chain Attacks** **(10 marks)**

Consider a software company developing a new e-commerce platform integrating various third-party components for payment processing, inventory management, and customer analytics.

(a) **(5 marks)** **Briefly** explain why manual testing might be more effective than automatic testing for identifying vulnerabilities in the payment processing integration.

(b) **(3 marks)** **Briefly** explain what a supply chain attack is and why it's a significant concern for this e-commerce platform. Provide an example related to one of the platform's components.

(c) **(2 marks)** **Briefly** describe a measure the e-commerce platform developers could implement to mitigate the risks of supply chain attacks.

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5. **Privilege Escalation** **(10 marks)**

Consider a Unix-based system where multiple users have access to various applications and resources.

(a) **(2 marks)** **Briefly** explain what privilege escalation is and why it's a significant security concern.

(b) **(3 marks)** **Briefly** describe the concept of Set-UID programs in Unix systems. What is their purpose, and how do they work?

Consider the following C code snippet for a Set-UID program:

```c
#include <stdlib.h>
#include <stdio.h>
int main(int argc, char *argv[]) {
    char command[256];
    sprintf(command, sizeof(command), "/bin/echo %s", argv[1]);
    system(command);
    return 0;
}
```

(c) **(5 marks)** **Briefly** explain why the Set-UID program shown is vulnerable to privilege escalation, how an attacker might exploit it and how the risk can be mitigated.

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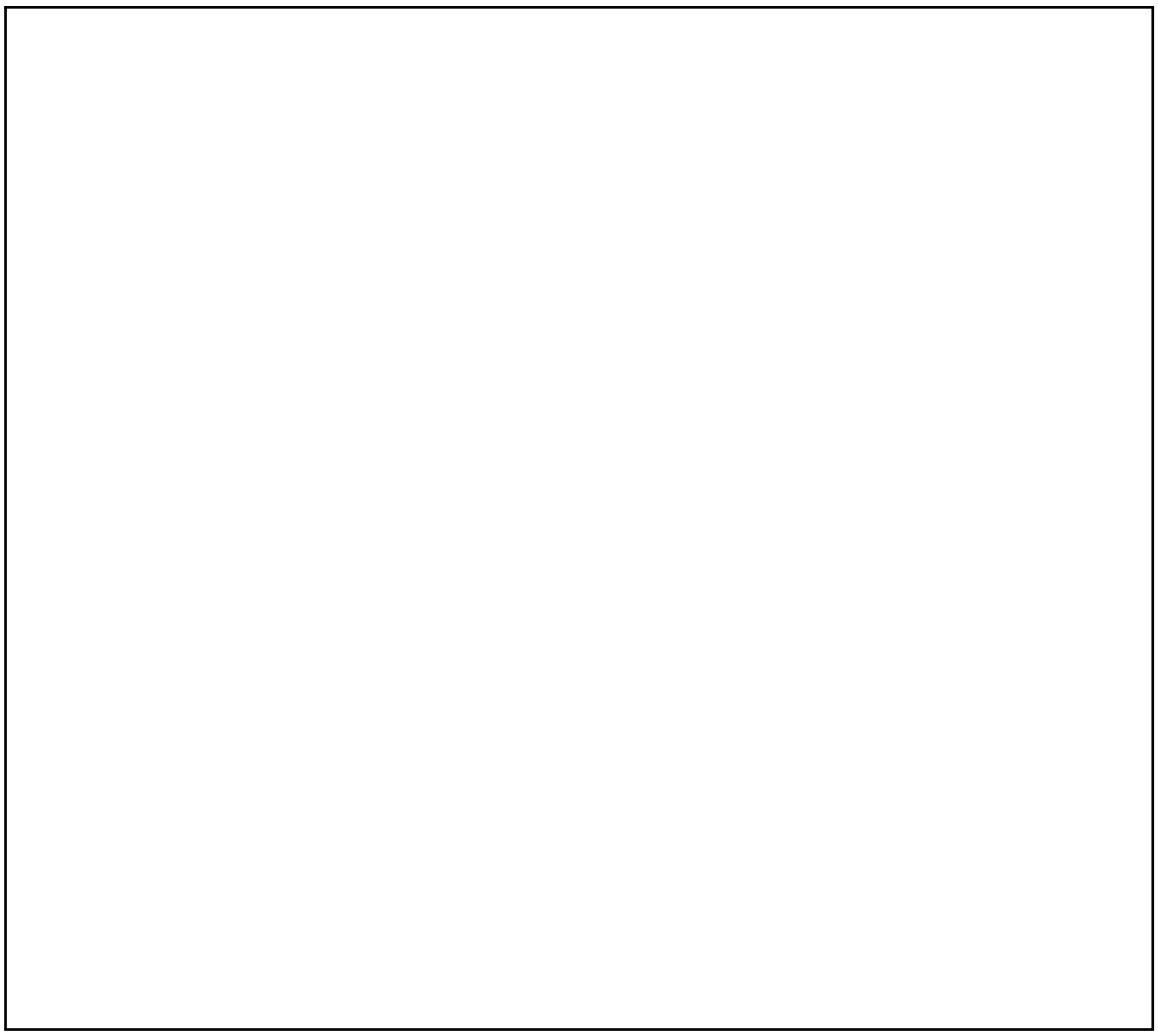
6. **Buffer Overflow and Return-to-libc** **(20 marks)**

***Note**: Unless stated otherwise, assume an Intel x86 32-bit computer system is being used.*

(a) **(6 marks)** Draw the **stack frame** of the `foo()` function assuming line number 5 is being executed and **cdecl** calling convention is used.

```
1  int foo(int a, int b, int c, int d)
2  {
3      static char buffer;
4      int i, j;
5      i = a - d;
6      j = b + i;
7      return j;
8  }
9
10 int bar(char arg)
11 {
12     int result;
13     int str = 5;
14     static int k=5;
15     result = foo(arg, 3, 2, str);
16     return result+k;
17 }
```



(b) **(4 marks)** How many bytes is the stack frame of the function `bar()`? **Briefly** justify your answer by providing a breakdown of the stack frame contents and their respective sizes. You can ignore any alignment requirements in your answer.

(c) **(2 marks)** Calculate the memory address of the "Return Address" field for the `qux()` function given below. Assume the offset between the start of the `buffer` variable and `ebp` is 64 bytes, and `ebp` is pointing to the address `0xbffea190`. Justify your answer by providing a working of the solution.

```
1 int buf(char *str)
2 {
3     int x;
4     char buffer[8];
5     strcpy(buffer, str);
6
7     return 1;
8 }
```

(d) **(2 marks)** **Briefly** describe the role of **canary** as a buffer overflow countermeasure.

(e) **(2 marks)** Which countermeasure does return-to-libc aim to defeat? **Briefly** explain how return-to-libc is able to overcome the said countermeasure.

(f) **(3 marks)** **Briefly** explain the three main tasks in a return-to-libc attack.

(g) **(1 mark)** **Briefly** explain how an attacker can pass a custom string to a program which can then be used in the return-to-libc attack.

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7. **Format String** **(12 marks)**

***Note**: Unless stated otherwise, assume an Intel x86 32-bit computer system is being used.*

(a) **(8 marks)** Consider the following program:

```
#include <stdio.h>

void fmtstr()
{
    char input[100];
    int var = 0xbeefbeef;
    int secret = 0x11223344;
    int i = 0;

    printf("Please enter a string: ");
    fgets(input, sizeof(input) , stdin);
    printf(input);
}

void main ()
{
    fmtstr ();
}
```

Assume that the distance between the variable `i` and `va_list` is `20` bytes.

i. **(2 marks)** **Construct** an input that is guaranteed to crash the program. **Justify** your answer.

ii. **(3 marks)** **Construct** an input that will print out the variable `secret`. **Justify** your answer.

iii. **(3 marks)** **Construct** an input that will change the value of the variable `var` to any value. Assume that `var` is at address `0x41424344`. **Justify** your answer.

Hint: You may use the fact that `0x41` is the ASCII character `'A'`.

(b) **(4 marks)** **Briefly** describe **two** countermeasures that can prevent format string attacks.

8. **Cross-site Scripting (XSS)** **(10 marks)**

(a) **(2 marks)** **Briefly** explain **one** particular *website behavior* that can make it vulnerable to non-persistent XSS attack.

(b) **(2 marks)** **Briefly** explain the **two** approaches that a Javascript code can use to self-propagate.

(c) **(4 marks)** A website (`cybr271.org`) utilises the Content Security Policy (CSP) mechanism to prevent XSS attacks and allows script to be executed based on the following CSP.

Explain the meaning of this CSP.

```
Content-Security-Policy: default-src 'self';
   script-src 'self' 'nonce-3efsdfsdff' victoria.ac.nz';
```

(d) **(2 marks)** The *nonce* and *hashing* mechanisms can be used to allow inline script code to run on a page. **Briefly** discuss **one** advantage of nonce over hashing.

9. **Cross-site Request Forgery (CSRF)** **(8 marks)**

(a) **(2 marks)** A CSRF attack involves three parties: a *victim user*, a *targeted website*, and a *malicious website* that is controlled by an attacker. What important requirement regarding the user session with respect to the targeted website should be satisfied for the attack to be successful? **Briefly** explain what will happen if this condition is not satisfied.

(b) **(3 marks)** **Briefly explain** what the `referer` header is, **how** it can prevent a CSRF attack, and **one** of its drawbacks.

(c) **(3 marks)** **Briefly** explain how same-site cookies can enhance CSRF protection. **Briefly** discuss **one** disadvantage of `SameSite=Strict` attribute value.

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10. **SQL-Injection** **(5 marks)**

(a) **(2 marks)** **Briefly** explain what "prepared statements" are, and the underlying principle that it uses to mitigate SQL-injection attacks.

(b) **(3 marks)** The following SQL statement is sent to the database to add a new user to the database, where the content of the `$name` and `$passwd` variables are provided by the user, but the `EID` and `Balance` field are set by the system.

Assume the malicious user has the following credentials:

- username is "`malice`"
- password is "`abc123`"

The SQL query in the web page is:

```
1  $sql = "INSERT INTO account (Name, EID, Password, Balance)
2          VALUES ('$name', 'EID6000', '$passwd', 0)";
```

Suppose in the new user creation page, it asks for the username and password. What values should a malicious user use to set his/her balance to a particular value, say 1000000?

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