Building Strong Programming Skills with Weak Encryption

(A Nifty Assignment)

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WHAT IS THE PROBLEM?

Too many students
are not successfully completing
Introduction to Programming (Python)
at Augsburg
and many other institutions.

The average DFW rate nationally is 28% for introductory programming courses [*].

At Augsburg, it WAS 38% (in 2021).

[*] J. Bennedsen and M. E. Caspersen, "Failure rates in introductory programming: 12 years later," *ACM Inroads*, vol. 10, no. 2, pp. 30–36, Apr. 2019.

The Solution (or part of it, anyway – we think)

1. Overhauled assessment and adopted **equitable grading practices**,
2. Redesigned the curriculum to be **more engaging** and provide **more scaffolding**,
3. Increased academic support through **peer instructors**,
4. Fostered **community** through First-Year Experiences and peer tutoring.

Learning Objectives (Introduction to Programming)

It is later in the Semester ...

I am teaching about dictionaries and File I/O

Students will be able to:

1. define a new dictionary.
2. put and get elements into the dictionary.
3. read and parse a csv file.
4. write to a csv file.

But how I can I make this fun and engaging ...

Cybersecurity

Students are very interested and industry is interested (causal ??).

Learning Objectives (Introduction to Programming)

Students will be able to:

1. create and use **dictionaries** in Python.
2. (.csv) **file I/O.**
3. **number conversion** (decimal, binary, and hexadecimal)
4. convert between chars and **ASCII / UNICODE**.
5. describe the process of **hashing / encryption**.
6. list **vulnerabilities to hacking** of passwords.

Cybersecurity and Protecting Passwords

Individual Responsibility (as a consumer)

Corporate Responsibility

Resources:

- https://www.cisco.com/c/en/us/products/security/what-is-cybersecurity.html
- https://cloud.google.com/learn/what-is-encryption
- https://www.ssl2buy.com/wiki/difference-between-hashing-and-encryption
- https://www.techtarget.com/searchsecurity/definition/salt#:~:text=What%20is%20password%20salting%3F,stealing%20them%20from%20the%20database.
- https://auth0.com/blog/adding-salt-to-hashing-a-better-way-to-store-passwords/
- https://en.wikipedia.org/wiki/List_of_Unicode_characters
- https://ss64.com/ascii.html

A Simple Conversion (Caesar Cipher)

	M	**Y**	**P**	**A**	**S**	**S**	**W**	**O**	**R**	**D**	**!**
	77	89	80	41	83	83	87	79	82	68	33
+	2	5	1	0	3	2	5	2	2	3	4
	79	94	81	41	86	85	92	81	84	71	37
	O	**^**	**Q**	**A**	**V**	**U**	****	**Q**	**T**	**G**	**%**

KEY

What are other ways that computers interpret numbers or represent information?

Number Representation Practice (Worksheet)

Break decimal into components: 2,308 = 2*10^3 + 3*10^2 + 8*10^0 = 2000 + 300 + 8 71,030 = _____	Break binary into its components: 1011 = 2^3 + 2^1 + 2^0 = 8 + 2 + 1 = 11 10110 = _____
1 1 1 0 0 1 + 1 1 1 0 =========	Convert the binary into 2 hex digits, by first converting to decimal. 0110 1101 = _____

Hash Password – Base Level

1. **Salting the Password**
2. **Create a Bitstream**
3. **Convert a Bitstream to a Hexadecimal String**
4. **Convert a Hexadecimal String to an ASCII**

```
hex2deci = {
   '0':0,'1':1,'2':2,'3':3,'4':4,'5':5,'6':6,'7':7,'8':8,
   '9':9,'A':10,'B':11,'C':12,'D':13,'E':14,'F':15
   }
```

```
def create_bitstream(password,encodings):
   '''
   Convert each character of the password to its corresponding bitstream
   as defined in the encodings dictionary.
   For example, if password[0] = 'a' then add encodings['a'] to the bitstream.

   RETURN the bitstream (a string of 0s and 1s)
   '''
```

```
def hexify(bitstream):
   '''
   Convert the bitstream to a hex stream.
   Take every 4 bits and convert them to the corresponding hex value.
   For example, bitstream 001111110100 would be converted to '3F4'

   RETURN the hex string
   '''
```

Verify Password – Level Up (File I/O)

1. **Hash Password**
2. **Compare to Stored Password**
3. **New User Account**
4. **Write username + password to file of stored passwords.**

```
def write_users():
    '''
    Take the contents of the dictionary and write it to the file.
    Use 'w' when opening the file to overwrite the contents.
    Separate the username and encrypted password with a space character.
    '''

def add_account():
    '''
    Get a username from the user:
        Make sure it is 8 to 10 characters long.
        Make sure it is unique (i.e. not already in the dictionary)
        Continually ask until these criteria are met
    Get a password from the user:
        Make sure it is 6 to 15 characters long.
        Continually ask until these criteria are met
    Add the username and password to the dictionary.
    Write the dictionary to the file.
    '''
```

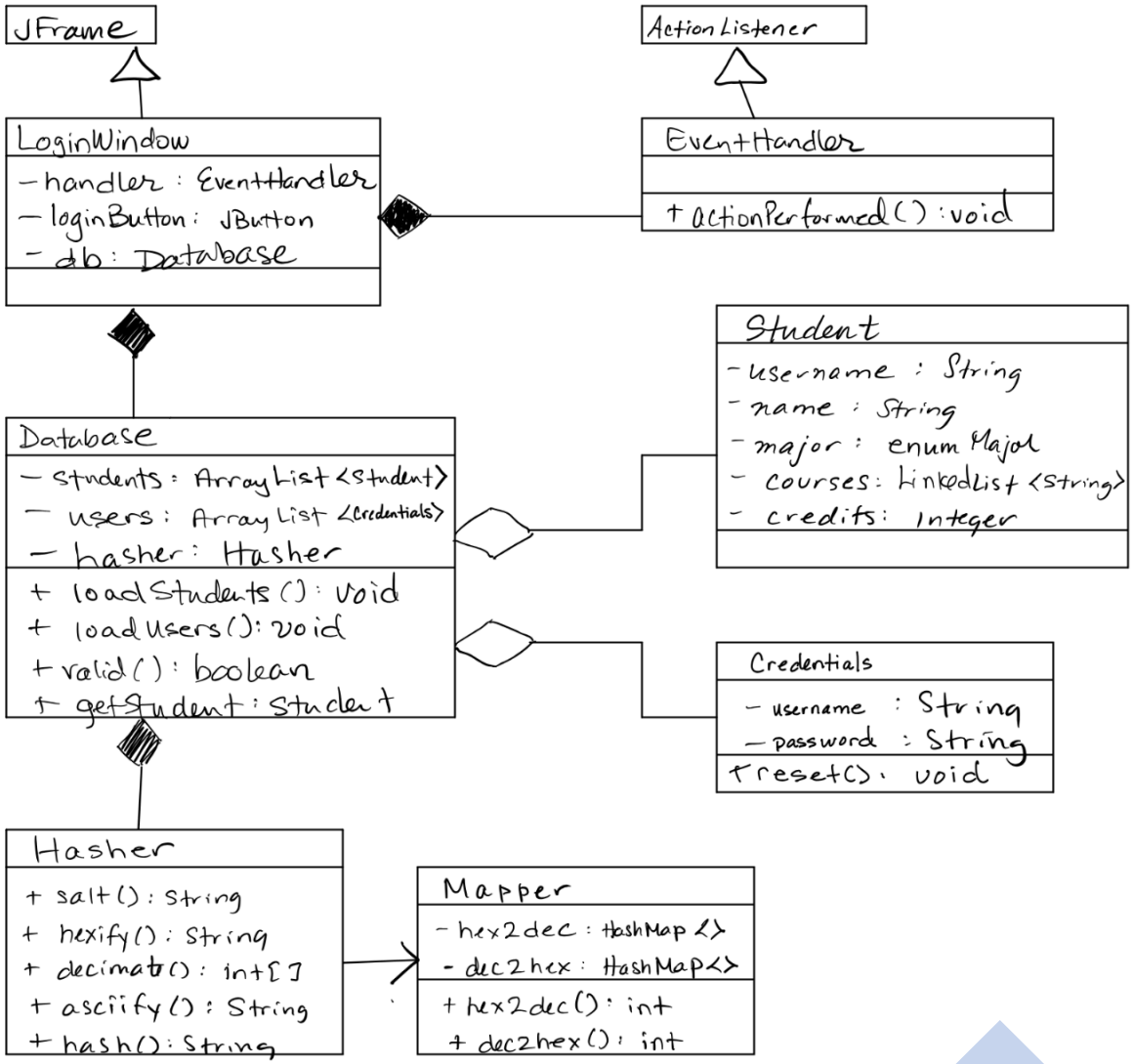
And Again ...

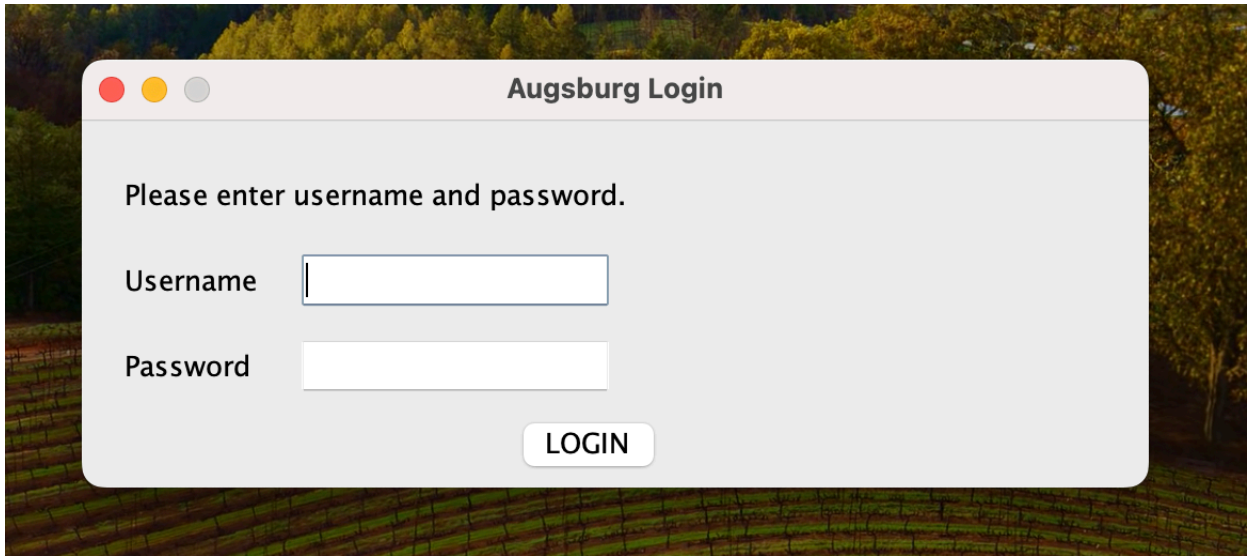
Data Structures

Learning Objectives (Data Structures)

Students will be able to:

1. (.csv) **file I/O.**
2. create **HashMap** and apply operations in Java.
3. create **ArrayList** and apply operations, including iteration.
4. create **LinkedList** and apply operations, including iteration.
5. modify text in **Graphics window**.
6. create an **event listener**.


JFrame
ActionListener
LoginWindow
- handler : EventHandler
- loginButton : JButton
- db : Database
EventHandler
+ actionPerformed() : void
Student
- username : String
- name : String
- major : enum Major
- courses : LinkedList <String>
- credits : Integer
Database
- students : ArrayList <Student>
- users : ArrayList <Credentials>
- hasher : Hasher
+ loadStudents() : void
+ loadUsers() : void
+ valid() : boolean
+ getStudent : Student
Credentials
- username : String
- password : String
+ reset() : void
Hasher
+ salt() : String
+ hexify() : String
+ decimate() : int[]
+ asciify() : String
+ hash() : String
Mapper
- hex2dec : HashMap <>
- dec2hex : HashMap<>
+ hex2dec() : int
+ dec2hex() : int


Augsburg Login
Please enter username and password.
Username
Password
LOGIN

```java
@Override
public void actionPerformed(ActionEvent ae) {

    // Retrieve entered text
    String username = userField.getText();
    String password = passwordField.getText();

    // validate credentials
    if (db.valid(username, password) == true){
       Student student = db.getStudent(username);
       message.setText("Hello " + student.name() + "!");
    }
    else{
       //invalid message
       message.setText("Username and/or password was invalid. Try
       again.");
    }
```

Event Handler in Pop-up

```java
// find the user and compare hashed passwords
for (int i = 0; i < users.size(); i++){

    if ( users.get(i).username().equals(username)) {
        if (hasher.hash(password).equals(users.get(i).password())) {
            return true;
        }
    }
}
```

Verifying Credentials

Part of Hashing Password

```java
public int[] decimate(String hexString) {
    // create an array to store corresponding values
    int[] key2dec = new int[hexString.length()];

    // map each hex to its decimal value using hash map in Converter
    for (int i=0; i<hexString.length(); i++) {
        key2dec[i] = Mapper.hex2dec(hexString.charAt(i));
```

Read .csv for User/Pwd

```java
String[] splitter = scan.nextLine().split(",");
Credentials newCred = new Credentials(splitter[0],splitter[1]);
users.add(newCred);
```

All on github

https://github.com/AugsburgCS/cybersecurity/