Assignment 1 - Security Patterns

(Group 2)

1. Introduction

This report documents the implementation and security aspects of a secure software design project. The application under review is designed to run exclusively over HTTPS, ensuring encrypted communication. It includes authentication, authorization, and logging mechanisms to maintain high security standards.

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2. Pre-requisites

Before running the application, the following steps must be completed:

2.1 SSL Certificate Requirement:

Since this application is designed to run exclusively over HTTPS, an SSL certificate must be associated with it. For this demo, a self-signed certificate is created using the following command:

```
openssl req -x509 -newkey rsa:4096 -keyout key.pem -out cert.pem
-days 365 -nodes
```

2.2 Dependency Installation:

Install the required dependencies by executing the command `pip install -r requirements.txt` in the root directory. This will install the following dependencies:

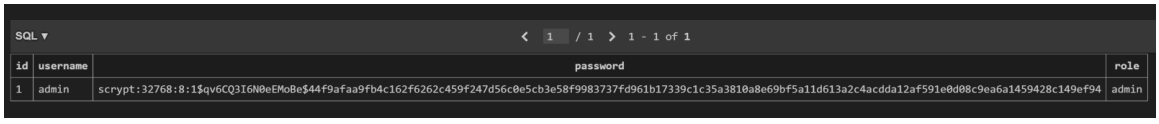
- python-dotenv
- werkzeug
- flask
- cryptography

2.3 Running the Application:

Start the application running `python app.py` in the root directory.

2.4 Admin User Initialization:

Upon the first run, an admin user is automatically created with credentials securely stored in an SQLite3 database.



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id	username	password	role
1	admin	scrypt:32768:8:1$qv6CQ3I6N0eEMoBe$44f9afaa9fb4c162f6262c459f247d56c0e5cb3e58f9983737fd961b17339c1c35a3810a8e69bf5a11d613a2c4acdda12af591e0d08c9ea6a1459428c149ef94	admin

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3. Implemented APIs and Security Tests

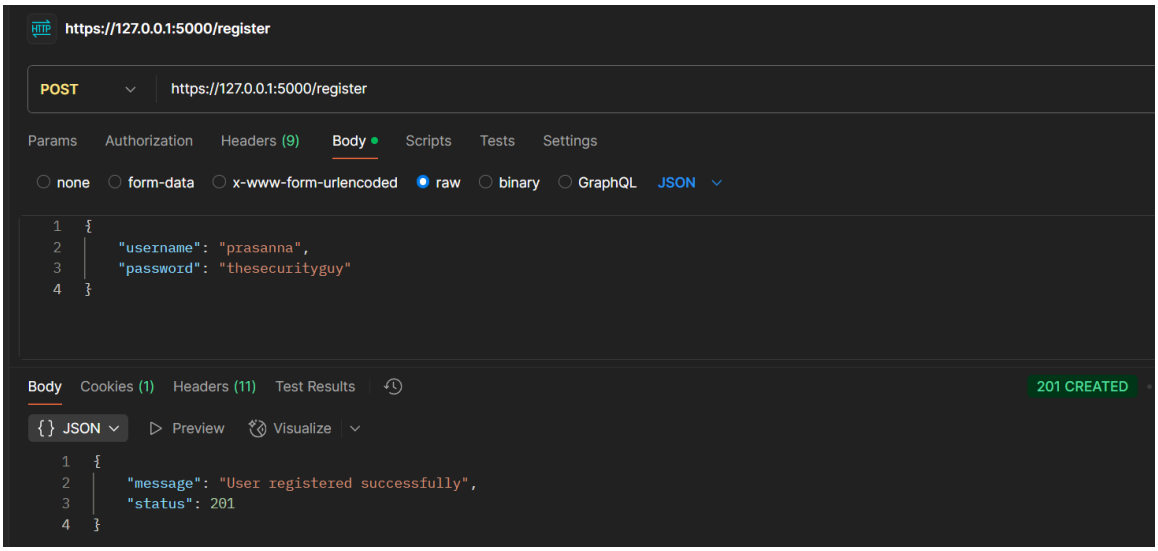
3.1 POST /register

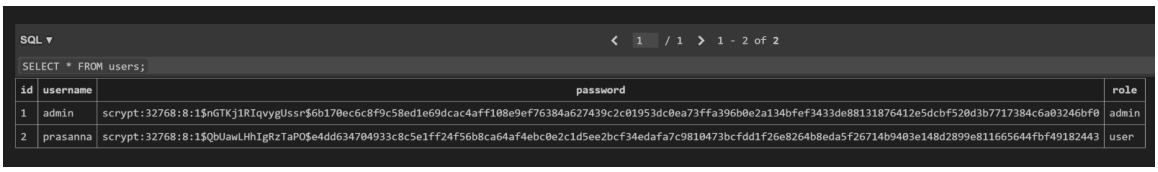
Requirements:

- Accepts a JSON request body containing username and password.
- Enforces unique usernames.
- Responses:
  - 201 Created if the user is registered successfully.
  - 400 Bad Request with an appropriate error message for invalid requests.

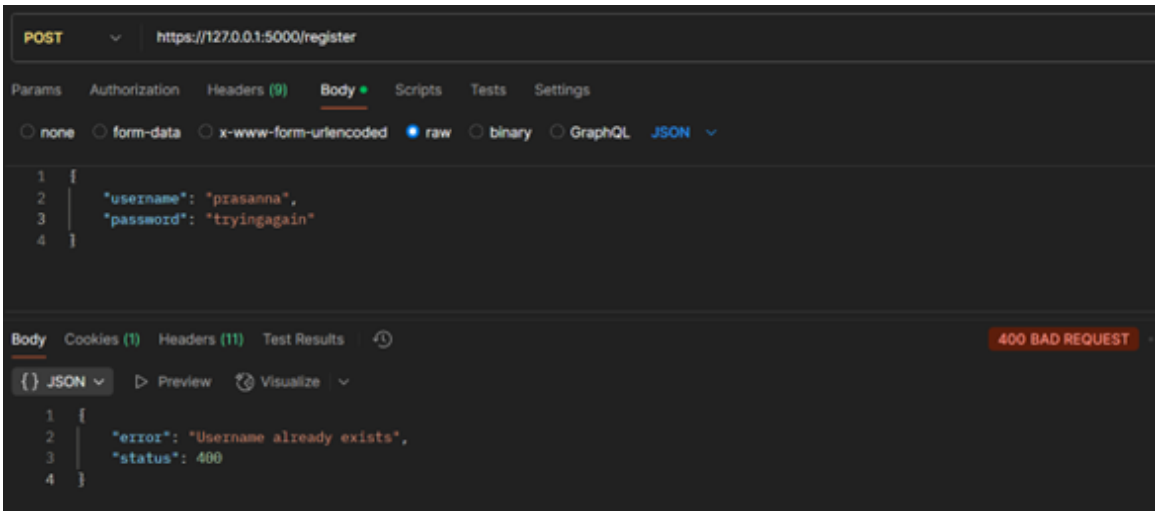
Test Results:

- Successful Registration: A new user can register successfully; the credentials are securely stored in SQLite3, and a 201 response is sent.

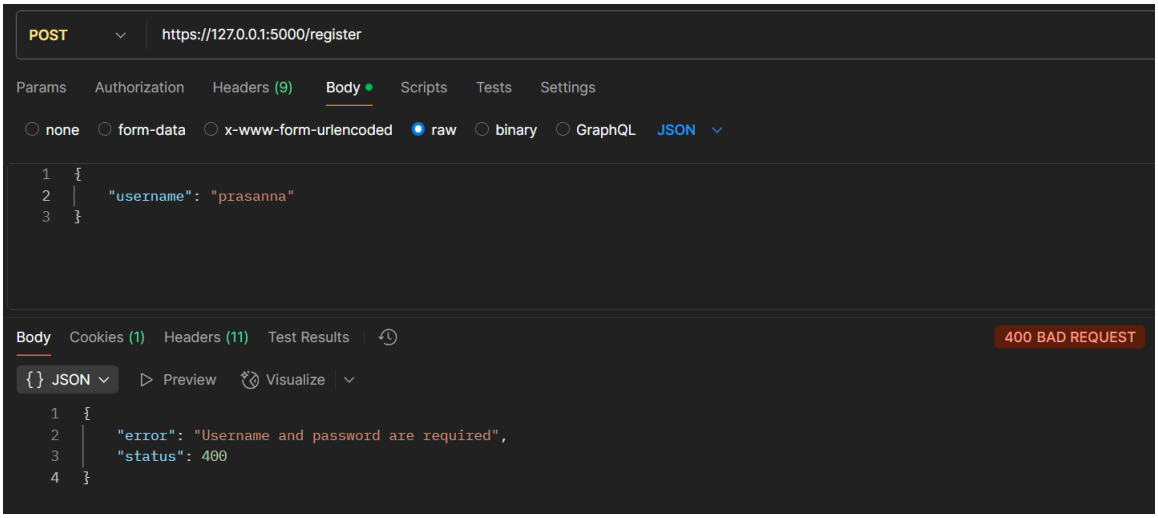




- Duplicate Registration: Registering with an existing username returns a 400 Bad Request error.



- Invalid Request: Missing a required field (e.g., no password) results in a 400 Bad Request error.



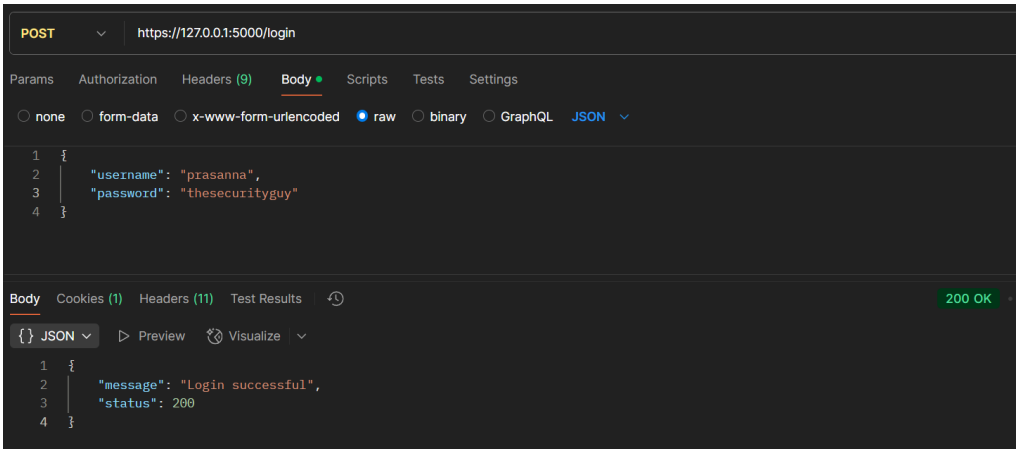
3.2 POST /login

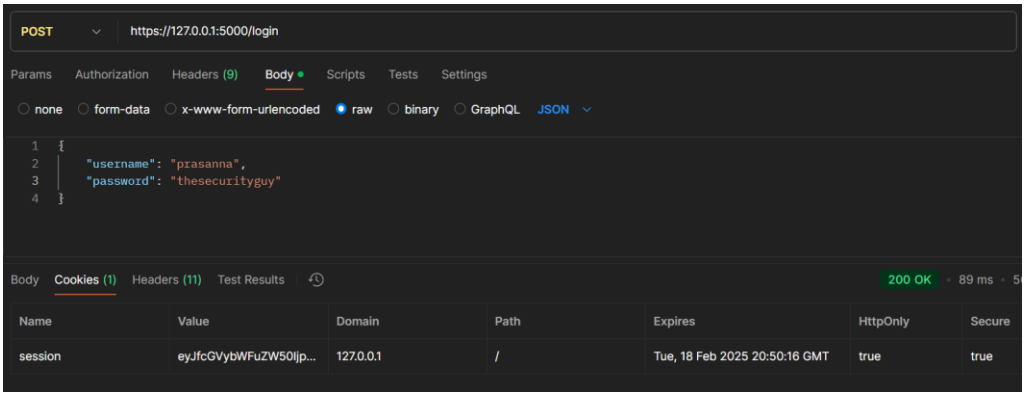
Requirements:

- Accepts a JSON request body containing username and password.
- Responses:
  - 200 OK with a valid session cookie if authentication is successful.
  - 401 Unauthorized for incorrect credentials.

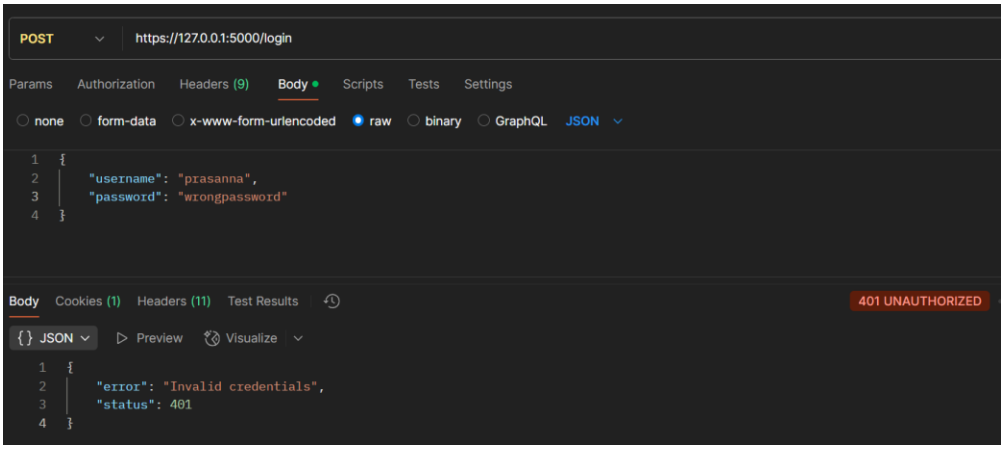
Test Results:

- Valid Credentials: Logging in with correct credentials returns 200 OK with a session cookie.





- Invalid Credentials: Logging in with incorrect credentials results in a 401 Unauthorized error.



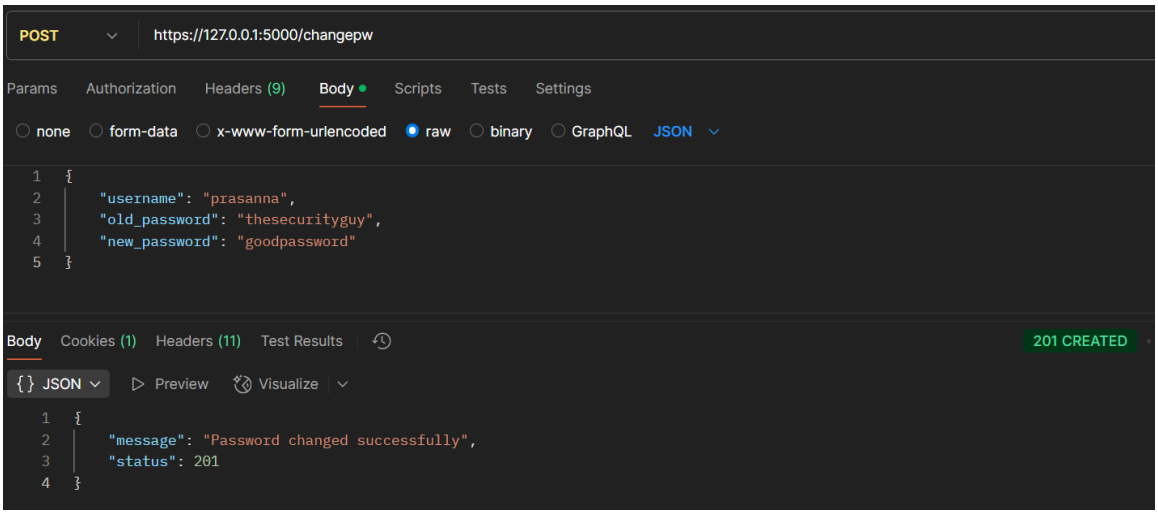
3.3 POST /changepw

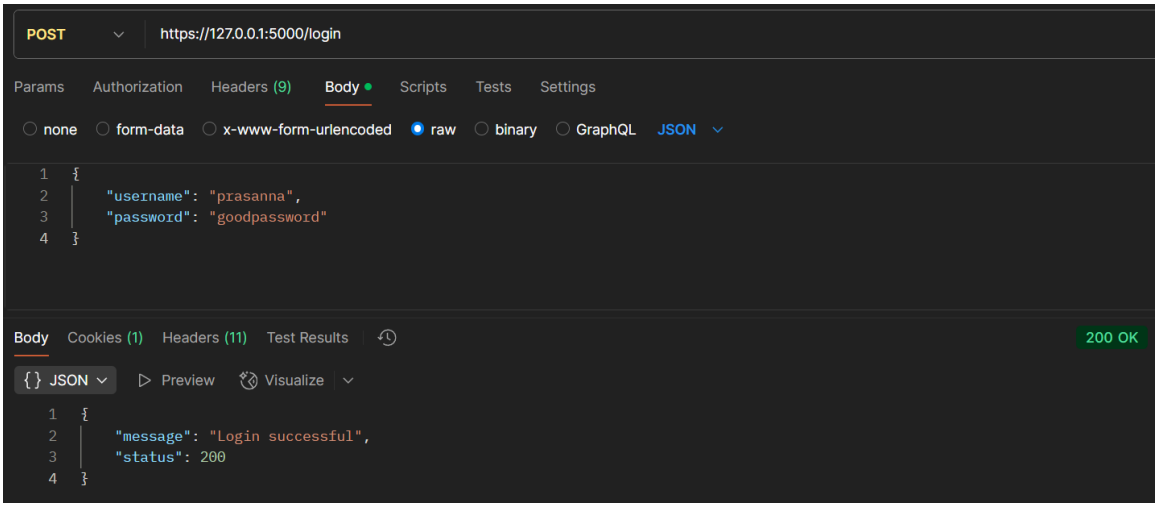
Requirements:

- Accepts a JSON request body containing username, old_password, and new_password.
- Responses:
  - 201 Created if the password is changed successfully.
  - 400 Bad Request for invalid requests.

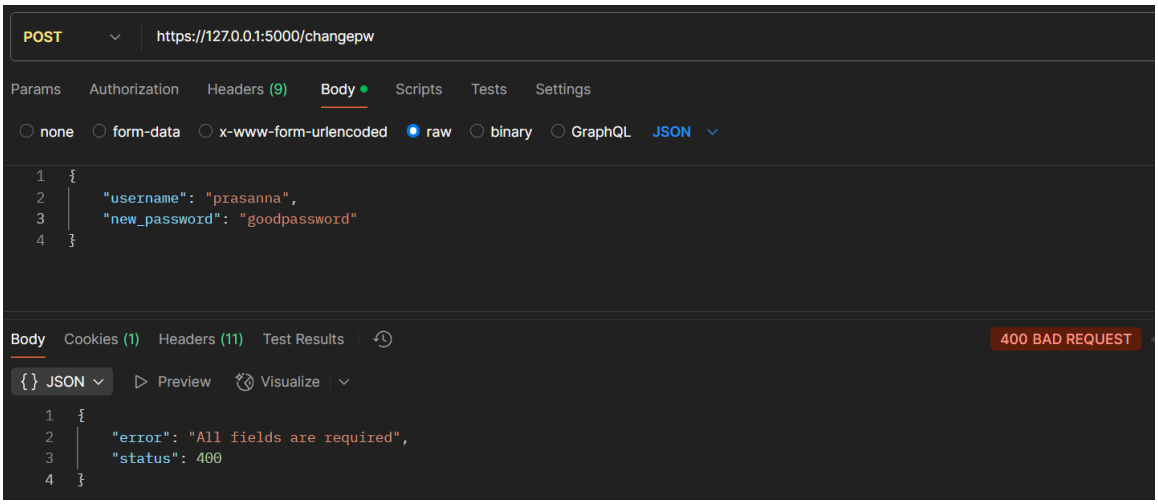
Test Results:

- Successful Password Change: Authorized users can change their passwords and log in with the new credentials.





- Invalid Requests: Malformed or incorrect password change requests return 400 Bad Request.



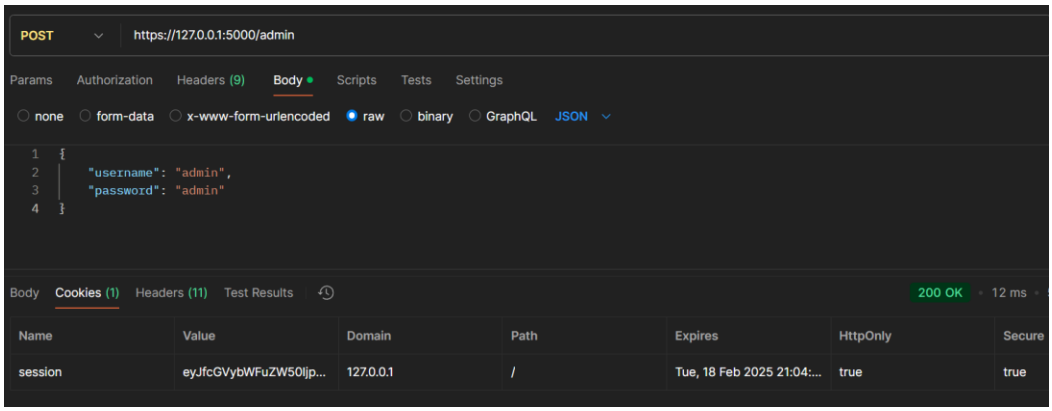
3.4 GET /admin

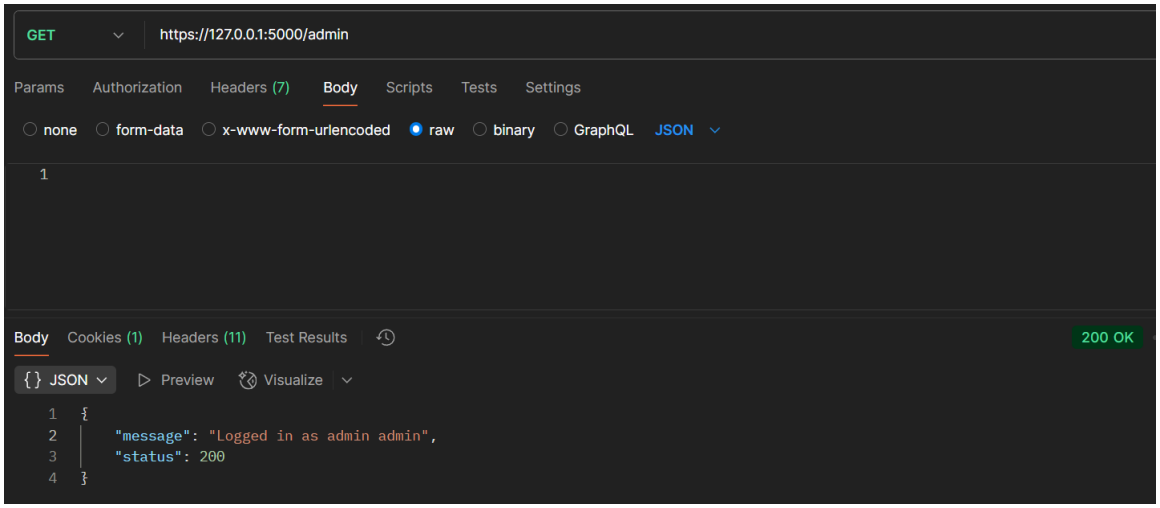
Requirements:

- Requires a valid session cookie set during login, received from API endpoint: `/login`
- Admin users can access the endpoint and see: `Logged in as admin <username>`
- Non-admin users are denied access.

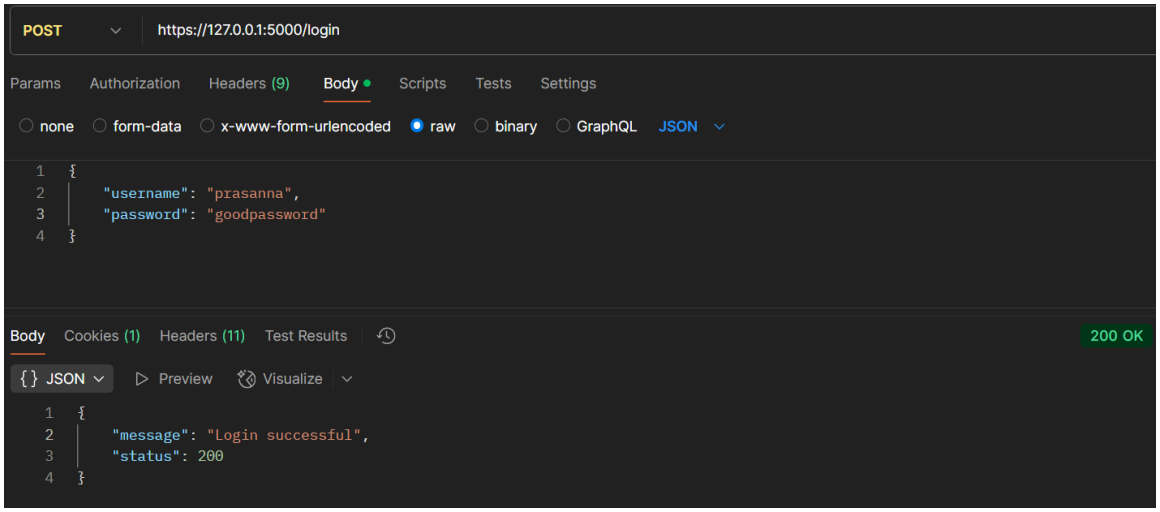
Test Results:

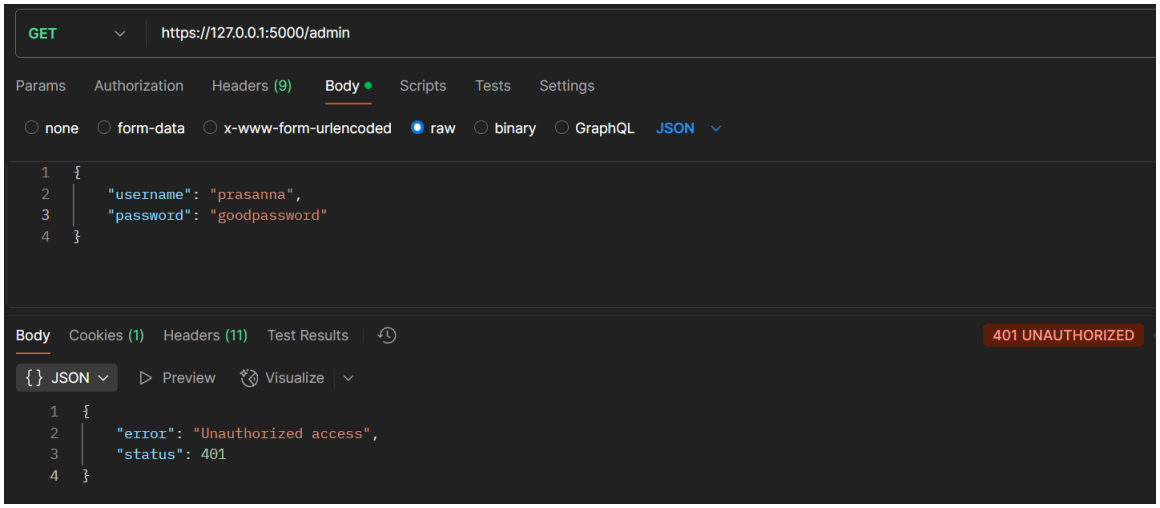
- Admin Access: Admin users successfully access `/admin` with a valid session cookie.





- Unauthorized Access: Non-admin users attempting to access /admin receive an "*Unauthorized access*" error.





4. Security Implementation Details

4.1 Role-Based Authorization

- The system enforces role-based access control (RBAC), ensuring only users with an admin role can access privileged endpoints.

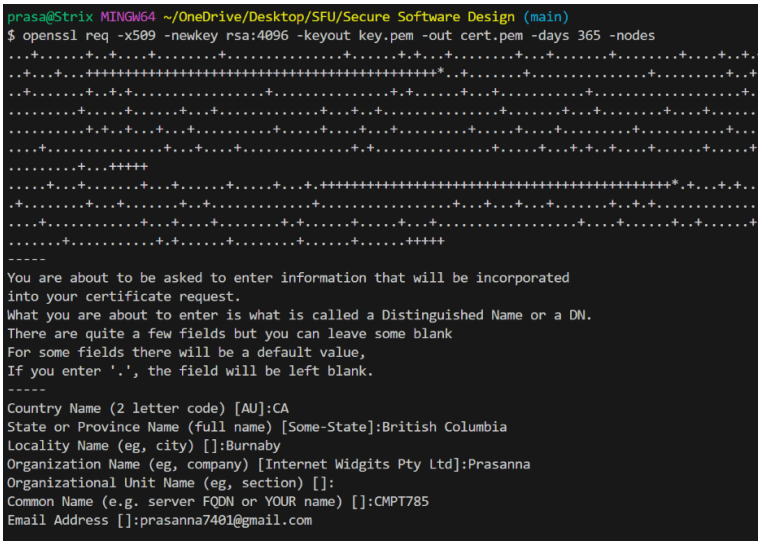
```python
@app.before_request
def before_request():
    g.user = None
    if 'username' in session:
        g.user = session['username']
        g.role = session['role']
```

```python
@auth_bp.route('/admin', methods=['GET'])
def admin():
    if g.user and g.role == 'admin':
        return jsonify({'message': f'Logged in as admin {g.user}', 'status': 200}), 200
    return jsonify({'error': 'Unauthorized access', 'status': 401}), 401
```

4.2 Secure Communication

- All communications occur over `HTTPS` using a self-signed SSL certificate (adhoc).
- Enforces `HTTPS` using `TLS` to prevent credential sniffing in MITM attacks.

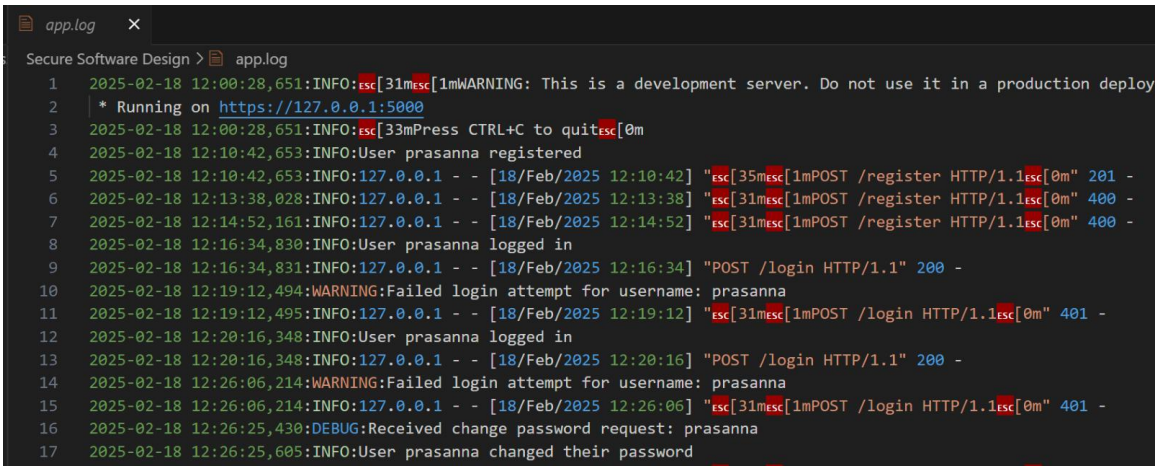
```python
if __name__ == '__main__':
    app.run(ssl_context='adhoc', port=5000)
```



4.3 Audit and Logging

- Key activities such as user registration, login attempts, password changes, and failed logins are logged in `app.log` in the application repository.

```
logging.info(f'User {username} registered')
logging.info(f'User {username} logged in')
logging.info(f'User {username} changed their password')
```



4.4 Secure Session Management

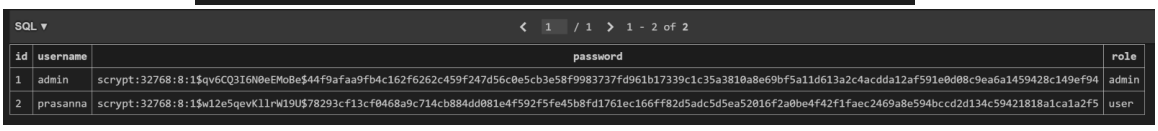
- User sessions timeout after 30 minutes of inactivity.
- Session cookies:
  - Are stored securely.
  - Use the `HttpOnly` flag to prevent JavaScript access (mitigates XSS attacks).
  - Have the `SameSite` attribute set to prevent CSRF attacks.

```
app.config['PERMANENT_SESSION_LIFETIME'] = timedelta(minutes=30)
app.config['SESSION_COOKIE_SECURE'] = True
app.config['SESSION_COOKIE_HTTPONLY'] = True
app.config['SESSION_COOKIE_SAMESITE'] = 'Lax'
```

4.5 Password Management

- Passwords are hashed using `werkzeug.security.generate_password_hash` before being stored in the database.

```
hashed_password = generate_password_hash(password)
```



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id	username	password	role
1	admin	scrypt:32768:8:1$qv6CQ3I6N0eEMoBe$44f9afaa9fb4c162f6262c459f247d56c0e5cb3e58f9983737fd961b17339c1c35a3810a8e69bf5a11d613a2c4acdda12af591e0d08c9ea6a1459428c149ef94	admin
2	prasanna	scrypt:32768:8:1$w12e5qevKllrW19U$78293cf13cf0468a9c714cb884dd081e4f592f5fe45b8fd1761ec166ff82d5adc5d5ea52016f2a0be4f42f1faec2469a8e594bccd2d134c59421818a1ca1a2f5	user

4.6 Input Validation and Sanitization

- A dedicated function, `validate_input`(), checks all user inputs using regex.
- Helps mitigate injection attacks (SQL Injection, XSS, etc.).

```python
def validate_input(data):
    if not data or not isinstance(data, dict):
        logging.debug('Invalid input: data is not a dictionary or is empty')
        return False, 'Invalid input: data is not a dictionary or is empty'
    for key, value in data.items():
        if not isinstance(value, str) or not re.match(r'^[a-zA-Z0-9_]+$', value):
            logging.debug(f'Invalid input: {key}={value} does not match required pattern')
            return False, f'Invalid input: {key} does not match required pattern'
    return True, ''
```

4.7 Security Headers

- Additional security headers are enforced through the `add_security_headers` function to protect against:
  - XSS attacks
  - Clickjacking
  - MIME-sniffing vulnerabilities

```python
def add_security_headers(response):
    response.headers['Content-Security-Policy'] = "default-src 'self'"
    response.headers['X-Content-Type-Options'] = 'nosniff'
    response.headers['X-Frame-Options'] = 'DENY'
    response.headers['X-XSS-Protection'] = '1; mode=block'
    return response
```

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5. Environment and Deployment Security

- Environment Variables:
  - `SECRET_KEY` is stored in a `.env` file to sign session cookies.
  - In a CI/CD pipeline, these values should be stored securely in a `secrets management provider` in production deployments.
- Development Assistance:
  - GitHub Copilot was utilized to assist with code development.

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6. Conclusion

This report outlines the implementation and security mechanisms of the secure application described in Assignment 1.

The system incorporates best practices in the industry, including SSL encryption, role-based access control, session management, and input validation. Besides this, we added rate limiting (10req/min) for more security. Further enhancements could include:

- Integration with an OAuth provider for more robust authentication.
- Implementation of multi-factor authentication (MFA) to enhance security.
- More distinct input validation for each type of data.

By following these security practices, the application ensures confidentiality, integrity, and availability for its users.