**Howard University**

**College of Engineering and Architecture**

**Department of Electrical Engineering & Computer Science**

**Large Scale Programming**

**Fall 2025**

**Midterm Exam**

October 20, 2025

## **Instructions**

* **Exam Format:**  
  Your examination consists of both essay and programming problems.
* **Essay Questions:**  
  Complete all essay (rationale) questions inline in this document.  
  My preference is Microsoft Word (.docx), but .txt or .pdf are acceptable alternatives.  
  Upload your completed essay file to your repository under the package:

org.howard.edu.lsp.midterm.doc

You may use any file name.

* **Programming Problems:**  
  Each programming problem must be uploaded to your repository using the package specified in the question.  
  For example:

org.howard.edu.lsp.midterm.question1

* **Committing Your Work:**  
  If using a third-party IDE or tool to commit, commit early and often.  
  Do not wait until the end of the exam to push your code.  
  If you encounter problems committing, you may manually upload your code to your repository.  
  If you are unable to commit or upload, you may zip your project and email it to  
  bwoolfolk@whiteboardfederal.com.  
  ⚠️ This will result in a 20% deduction from your final exam score.
* **Citations and References:**  
  You must cite all references for any material obtained from the internet.  
  Any AI-generated content (e.g., ChatGPT conversations) must be included in full.  
  Each package you upload must include a references document corresponding to that package’s content.  
  ⚠️ Failure to provide references will result in a zero for that question.
* **Exam Policy:**  
  This is an OPEN BOOK, OPEN NOTES exam.  
  Collaboration of any kind is strictly prohibited. Any violations will be handled in accordance with **university academic integrity guidelines**.

**Question 1. (20 pts.)**

**Given the following, analyze the class below and answer the below questions. This question does NOT require you to write any code.**

package org.howard.edu.lsp.studentPortalHelper;

import java.io.\*;

import java.time.LocalDate;

import java.time.format.DateTimeFormatter;

import java.util.\*;

public class StudentPortalHelper {

// Data cache (in-memory)

private static final Map<String, String> cache = new HashMap<>();

// GPA calculation

public static double computeGPA(List<Integer> grades) {

if (grades == null || grades.isEmpty()) return 0.0;

int sum = 0;

int count = 0;

for (int g : grades) { sum += g; count++; }

double avg = (double) sum / count;

// simple mapping: 90–100=A=4, 80–89=B=3, etc.

if (avg >= 90) return 4.0;

if (avg >= 80) return 3.0;

if (avg >= 70) return 2.0;

if (avg >= 60) return 1.0;

return 0.0;

}

// CSV export to disk

public static void exportRosterToCsv(String filename, List<String> names) {

try (PrintWriter pw = new PrintWriter(new FileWriter(filename))) {

pw.println("name");

for (String n : names) {

pw.println(n);

}

} catch (IOException e) {

System.err.println("Failed to export roster: " + e.getMessage());

}

}

// Email formatting

public static String makeWelcomeEmail(String studentName) {

return "Welcome " + studentName + "! Please visit the portal to update your profile.";

}

// Date formatting (UI concern)

public static String formatDateForUi(LocalDate date) {

return date.format(DateTimeFormatter.ofPattern("MM/dd/yyyy"));

}

// Payment processing (stub)

public static boolean processTuitionPayment(String studentId, double amount) {

if (amount <= 0) return false;

// pretend to call external gateway...

return true;

}

// Password strength check (security)

public static boolean isStrongPassword(String pwd) {

if (pwd == null || pwd.length() < 8) return false;

boolean hasDigit = false, hasUpper = false;

for (char c : pwd.toCharArray()) {

if (Character.isDigit(c)) hasDigit = true;

if (Character.isUpperCase(c)) hasUpper = true;

}

return hasDigit && hasUpper;

}

// Ad-hoc caching

public static void putCache(String key, String value) {

cache.put(key, value);

}

public static String getCache(String key) {

return cache.get(key);

}

}

**Tasks:**

Using one or more **Arthur Riel heuristics**, analyze whether the StudentPortalHelper class demonstrates **high** or **low cohesion**.

a) Should a well-designed class have high or low cohesion? Explain and defend your answer. (5 pts.)

**A well-designed class should have high cohesion in order for it to be as understandable as possible. It also can be easily reused in any other parts of an application and reduces the risk of bugs.**

b) Based on your analysis, discuss—**only if you believe changes are needed**—how you would reorganize or redesign the class to improve its structure. Your answer should (1) identify the class as having high, low or perfect cohesion and (2) describe a **general approach** to refactoring the class. If you believe the class already has good cohesion, justify why no changes are necessary. (15 pts)

*(If you believe the class already has good cohesion, justify why no changes are necessary.)*

**According to the Arthur Riel heuristics, the StudentPortalHelper class has low cohesion. A general approach to refactoring this class to make it more cohesive would be to group the methods into new dedicated classes. For example, an AcademicsService class can handle GPA calculations, a SecurityService class can handle password strength checks, etc.**

**Question 2. (20 pts.)**

Write a class AreaCalculator in the package org.howard.edu.lsp.midterm.question2 with the following **overloaded methods**: This should be uploaded to your repo.

// Circle area

public static double area(double radius)

// Rectangle area

public static double area(double width, double height)

// Triangle (base & height) area

public static double area(int base, int height)

// Square (side length) area

public static double area(int side)

**Requirements:**

Each method should compute and return the correct area.

* Circle area: π (use class Math.PI) × r²
* Rectangle area: width × height
* Triangle area: ½ × base × height
* Square area: side²
* For all methods: throw an IllegalArgumentException if any dimension is ≤ 0.

Create a class named Main that invokes each overloaded method **statically** to produce **exactly** the following output:

Circle radius 3.0 → area = 28.274333882308138

Rectangle 5.0 x 2.0 → area = 10.0

Triangle base 10, height 6 → area = 30.0

Square side 4 → area = 16.0

Finally, invoke **at least one** of the area methods with a value that causes an IllegalArgumentException to be thrown.

* Catch the exception using a try/catch block.
* Print an **error message** to System.out. (Any message is fine.)

Briefly (2–3 sentences as a comment in class Main) explain if **overloading** or simply use methods with different names, i.e., rectactangleArea, circleArea, etc..

| **Category** | **Description** | **Points** |
| --- | --- | --- |
| **1. Implementation** | Correct use of **method overloading** (same name, different signatures), correct formulas, and proper exception handling in each method. | **10** |
| **2. Program Behavior** | Main correctly invokes all methods statically, produces the required output exactly, and includes a working exception demonstration. | **6** |
| **3. Conceptual Understanding** | Brief explanation of why or why not overloading is the better design choice. | **4** |

**Question 3.**

**Given the following, answer the below questions.**

**(20 pts.)**

**Given:**

A car manufacturer uses Java software to track current vehicles being built. The UML diagram below shows an excerpt of the current software structure. You should assume the presence of other appropriate fields and methods



Each car can be built to one of three trim levels: Base, Luxury or Sport. They can also be configured with an electric or petrol engine. At various points in the manufacturing process the customer can choose to change the trim level.

**Task:**

1. Explain in detail why the current structure does or does not support this. (10 pts.)

**The current structure does not support allowing the dynamic changing of a car’s trim levels. The design is rigid and inflexible, which means once an object is created at one of the trim levels, it’s permanently set to that level and cannot be set to another one after.**

1. Describe how to refactor the structure to allow trim-level change for a car to dynamically change. Hint: How would you modify Car to use composition to solve the problem? (10 pts.)

**In order to allow dynamic trim-level changes to a car, refactor the structure to use composition over inheritance. You would have to separate Car from the trim levels and make Trim have its own interface and classes. After that, have that Car class contain a reference to a trim object and modify it to be configured with any Trim object.**

**Question 4. (30 pts.)**

Design and implement a small **smart-campus device** system showing both **class inheritance** (concrete classes extend a common abstract class) and **interface implementation**.

**1) Abstract Base Class — Device**

**The following Device class is partially implemented for you.  
You must not modify this code, but you will use it in your subclasses:**

package org.howard.edu.lsp.midterm.question4;

public abstract class Device {

private String id;

private String location;

private long lastHeartbeatEpochSeconds;

private boolean connected;

// PROVIDED CONSTRUCTOR

public Device(String id, String location) {

if (id == null || id.isEmpty() || location == null || location.isEmpty()) {

throw new IllegalArgumentException("Invalid id or location");

}

this.id = id;

this.location = location;

this.lastHeartbeatEpochSeconds = 0;

this.connected = false;

}

public String getId() {

return id;

}

public String getLocation() {

return location;

}

public long getLastHeartbeatEpochSeconds() {

return lastHeartbeatEpochSeconds;

}

public boolean isConnected() {

return connected;

}

protected void setConnected(boolean connected) {

this.connected = connected;

}

public void heartbeat() {

this.lastHeartbeatEpochSeconds = System.currentTimeMillis() / 1000;

}

public abstract String getStatus();

}

**You will extend this class** in your DoorLock, Thermostat, and Camera implementations.  
All subclasses must call super(id, location) in their constructors.

**2) Capability Interfaces (behaviors only)**

**Networked**

void connect();

void disconnect();

boolean isConnected();

Behavior:

* connect() brings the device online by setting connected = true.
* disconnect() sets connected = false.
* isConnected() reports the current connection state.  
  (Concrete classes may satisfy this using Device’s protected setter and public getter.)

**BatteryPowered**

int getBatteryPercent(); // 0..100

void setBatteryPercent(int percent);

Behavior:

* getBatteryPercent() returns current battery %.
* setBatteryPercent(int) updates it; throw IllegalArgumentException if outside 0..100 inclusive.

**3) Concrete Devices (must extend Device and implement interfaces)**

**All fields must be private. Implement methods exactly as specified.**

1. **DoorLock — extends Device, implements Networked, BatteryPowered**

**Private fields**

private int batteryPercent;

**Constructor**

public DoorLock(String id, String location, int initialBattery)

* Call super(id, location).
* Initialize battery by calling setBatteryPercent(initialBattery) (enforces 0..100).

**Implemented methods**

// Networked

@Override public void connect() { setConnected(true); }

@Override public void disconnect() { setConnected(false); }

@Override public boolean isConnected() { return super.isConnected(); }

// BatteryPowered

@Override public int getBatteryPercent() { return batteryPercent; }

@Override public void setBatteryPercent(int percent) {

if (percent < 0 || percent > 100) throw new IllegalArgumentException("battery 0..100");

this.batteryPercent = percent;

}

// Status

@Override public String getStatus() {

String connStatus = isConnected() ? "up" : "down";

return "DoorLock[id=" + getId() + ", loc=" + getLocation() +

", conn=" + connStatus + ", batt=" + batteryPercent + "%]";

}

**B) Thermostat — extends Device, implements Networked**

**Private fields**

private double temperatureC;

**Constructor**

public Thermostat(String id, String location, double initialTempC)

* Call super(id, location).
* Initialize temperatureC to initialTempC.

**Accessors**

public double getTemperatureC();

public void setTemperatureC(double temperatureC);

**Implemented methods**

// Networked

@Override public void connect() { setConnected(true); }

@Override public void disconnect() { setConnected(false); }

@Override public boolean isConnected() { return super.isConnected(); }

// Status

@Override public String getStatus() {

String connStatus = isConnected() ? "up" : "down";

return "Thermostat[id=" + getId() + ", loc=" + getLocation() +

", conn=" + connStatus + ", tempC=" + temperatureC + "]";

}

**C) Camera — extends Device, implements Networked, BatteryPowered**

**Private fields**

**private int batteryPercent;**

**Constructor**

public Camera(String id, String location, int initialBattery)

* Call super(id, location).
* Initialize battery by calling setBatteryPercent(initialBattery).

**Implemented methods**

// Networked

@Override public void connect() { setConnected(true); }

@Override public void disconnect() { setConnected(false); }

@Override public boolean isConnected() { return super.isConnected(); }

// BatteryPowered

@Override public int getBatteryPercent() { return batteryPercent; }

@Override public void setBatteryPercent(int percent) {

if (percent < 0 || percent > 100) throw new IllegalArgumentException("battery 0..100");

this.batteryPercent = percent;

}

// Status

@Override public String getStatus() {

String connStatus = isConnected() ? "up" : "down";

return "Camera[id=" + getId() + ", loc=" + getLocation() +

", conn=" + connStatus + ", batt=" + batteryPercent + "%]";

}

**4) Provided Driver**

**Do not modify this file. Your classes must compile and run with it unchanged.**

package org.howard.edu.lsp.midterm.question4;

import java.util.\*;

public class Main {

public static void main(String[] args) {

Device lock = new DoorLock("DL-101", "DormA-1F", 85);

Device thermo = new Thermostat("TH-202", "Library-2F", 21.5);

Device cam = new Camera("CA-303", "Quad-North", 72);

// === Invalid battery test ===

System.out.println("\n== Exception test ==");

try {

Device badCam = new Camera("CA-404", "Test-Lab", -5);

System.out.println("ERROR: Exception was not thrown for invalid battery!");

} catch (IllegalArgumentException e) {

System.out.println("Caught expected exception: " + e.getMessage());

}

// === Heartbeat demonstration ===

System.out.println("\n== Heartbeat timestamps BEFORE ==");

for (Device d : Arrays.asList(lock, thermo, cam)) {

System.out.println(d.getId() + " lastHeartbeat=" + d.getLastHeartbeatEpochSeconds());

}

lock.heartbeat();

thermo.heartbeat();

cam.heartbeat();

System.out.println("\n== Heartbeat timestamps AFTER ==");

for (Device d : Arrays.asList(lock, thermo, cam)) {

System.out.println(d.getId() + " lastHeartbeat=" + d.getLastHeartbeatEpochSeconds());

}

// === Base-class polymorphism ===

List<Device> devices = Arrays.asList(lock, thermo, cam);

System.out.println("\n== Initial status via Device ==");

for (Device d : devices) {

System.out.println(d.getStatus());

}

// === Interface polymorphism: Networked ===

System.out.println("\n== Connect all Networked ==");

for (Device d : devices) {

if (d instanceof Networked) {

((Networked) d).connect();

}

}

// === Interface polymorphism: BatteryPowered ===

System.out.println("\n== Battery report (BatteryPowered) ==");

for (Device d : devices) {

if (d instanceof BatteryPowered) {

BatteryPowered bp = (BatteryPowered) d;

System.out.println(d.getClass().getSimpleName() + " battery = " + bp.getBatteryPercent() + "%");

}

}

// === Final status check ===

System.out.println("\n== Updated status via Device ==");

for (Device d : devices) {

System.out.println(d.getStatus());

}

}

}

**5) Brief Rationale (2–4 sentences)**

* Why is Device defined as an abstract class?
* How do the Networked and BatteryPowered interfaces add behavior to your concrete classes?
* Is this design an example of *multiple inheritance* in Java? Explain why or why not.

**Grading (30 pts)**

| **Category** | **Description** | **Points** |
| --- | --- | --- |
| **Implementation** | Correct use of inheritance and interfaces; meets all required method signatures and behaviors; uses the provided Device constructor; correctly implements Networked and BatteryPowered; uses setConnected(boolean) properly; validates inputs. | **15** |
| **Program Behavior** | Code compiles and runs with the provided Main.java unchanged; heartbeat behavior works; base-class and interface polymorphism demonstrated; exception thrown for invalid battery input; getStatus() output matches required formats. | **9** |
| **Rationale** | Clear, thoughtful, and specific answers to the four questions above. References to the student's own code are present. Shows conceptual understanding of abstraction, interface-based behavior, and multiple inheritance in Java. | **6** |

**Question 5 (10 pts)**  
**Reflection on AI Use in Learning and Problem Solving**

Discuss your personal experience using **AI tools** (such as ChatGPT, GitHub Copilot, or others) before and during this course.  
In your response, address the following points:

1. How have you used AI to support your learning or programming in this course?
2. What benefits or limitations did you encounter?
3. Looking ahead, how do you expect AI to influence the way you solve problems **academically or professionally**?

Your answer should be **1–2 well-developed paragraphs.**