UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
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Faculty of Engineering, Built Environment & Information Technology

Department of Computer Science

COS326 - Database Systems

Semester Test

Total Marks: 100

02 October 2023

Time/Duration: 17:30pm - 19:00pm (1 Hour 30 Minutes)

Examiner: Mr. S.M. Makura

External Moderator: Mr F. Elegbeleye (WSU)

Initials and Surname: _____

Student Number: _____

Degree: _____

Instructions

1. Fill in the semester test paper with your details above.
2. Read the question paper carefully and answer all the questions.
3. This paper comprises of 26 questions on 20 pages. It consists of three sections, namely Section A (Multiple Choice & Fill in the blank questions) - 20 marks, Section B (Application and Theory Based Questions) - 40 Marks, Section C (Scenario Based questions) - 40 Marks.
4. Answer **all** the questions in the answer book provided. After you are done, submit **both** the semester test paper together with your answer book.
5. You have 90 minutes to complete this semester test. Spend approximately the following minutes per each section:
   - Section A - 15 minutes
   - Section B - 30 minutes
   - Section C - 45 minutes
6. This is a closed book examination: you may therefore not have any study material with you.
7. Please switch off your smartphone/tablet and keep it off for the duration of the semester test.
8. All examination regulations and 'code of conduct' of the University of Pretoria are applicable during this semester test.

Integrity Statement:

The University of Pretoria commits itself to produce academic work of integrity. I affirm that I am aware of and have read the Rules and Policies of the University, more specifically the Disciplinary Procedure and the Tests and Examinations Rules, which prohibit any unethical, dishonest or improper conduct during tests, assignments, examinations and/or any other forms of assessment. I am aware that no student or any other person may assist or attempt to assist another student, or obtain help, or attempt to obtain help from another student or any other person during tests, assessments, assignments, examinations and/or any other forms of assessment.

Section A: Multiple Choice and Fill in the Blanks Questions (20 Marks)
(Spend approximately 15 minutes in this section)

Question 1

Which one of the following terms is used to describe the issue in RDBMSs where there is no mechanism to distinguish between relations and relationships or between different types of relationships?

a. Semantic Overloading.

b. Semantic Confusion.

c. Data Ambiguity.

d. Relation Overloading.

Question 2

Which one of the following statements best describes the purpose of an Object Identifier (OID) in an OODBMS like ObjectDB?

a. To manage transactions.

b. To represent database tables.

c. To maintain a direct correspondence between the real-world and database objects.

d. To define entity classes.

Question 3

To delete an object from the database in ObjectDB, what must be done within an active transaction?

a. Invoke the delete() method.

b. Use a DELETE SQL statement.

c. Invoke the remove() method.

d. Call the destroy() function.

Question 4

What is JPQL primarily used for in ObjectDB?

a. Managing database connections.

b. Defining database schema.

c. Writing object-oriented queries.

d. Handling transactions.

Question 5

In SQL:2011 standard, what does the keyword "INSTANTIABLE" signify when defining a User-Defined Type (UDT)?

a. It indicates that the UDT cannot be instantiated.

b. It specifies that instances of the UDT can be created.

c. It restricts the UDT from being used in any tables.

d. It allows the UDT to have multiple inheritance.

Question 6

What is the purpose of Enumerated types in PostgreSQL?

a. To store enumerated values as text.

b. To define complex data structures.

c. To create tables for storing enumerated values.

d. To optimize query performance.

Question 7

Study the following SQL statements and answer the question that follows:

```
CREATE TABLE Animal (
  animal_id serial PRIMARY KEY,
  name VARCHAR(50),
```

```
  species VARCHAR(50)
);

CREATE TABLE Bird (
  wingspan DECIMAL,
  beak_type VARCHAR(20)
) INHERITS (Animal);

INSERT INTO Bird (name, species, wingspan, beak_type)
VALUES ('Eagle', 'Bird of Prey', 2.2, 'Hooked');
```

In the given SQL statements above, what is the purpose of the "INHERITS" keyword?

a. It specifies a foreign key relationship between the "Animal" and "Bird" tables.

b. It creates a new table called "Bird" and copies all data from the "Animal" table into it.

c. It allows the "Bird" table to inherit the columns and constraints of the "Animal" table.

d. It defines a trigger that automatically inserts data into the "Bird" table when new data is added to the "Animal" table.

Question 8

Procedural language functions can be written in PL/pgSQL or _____

a. PL/JPQL

b. PL/pgTrigger

c. PL/TCL

d. PL/pgODI

Question 9

Which XML-related technology is commonly used for transforming XML data into formatted text documents?

a. XML Schema Definition (XSD)

b. Document Object Model (DOM)

c. Extensible Stylesheet Language (XSLT)

d. XML Namespaces

Question 10

Study the following XML file and answer **questions 10 and 11** that follow:

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <STAFFLIST>
3      <STAFF branchNo="B002">
4          <STAFFNO>SL20</STAFFNO>
5          <NAME>
6              <FNAME>Thando</FNAME>
7              <LNAME>Mandela</LNAME>
8          </NAME>
9          <POSITION>Manager</POSITION>
10         <DOB>1-Oct-98</DOB>
11         <SALARY>30000</SALARY>
12     </STAFF>
13     <STAFF branchNo="B003">
14         <STAFFNO>SL21</STAFFNO>
15         <NAME>
16             <FNAME>Marlize</FNAME>
17             <LNAME>Kruger</LNAME>
18         </NAME>
19         <POSITION>Accountant</POSITION>
20         <DOB>31-Nov-02</DOB>
21         <SALARY>27000</SALARY>
22     </STAFF>
```

Figure 1: Stafflist.xml file

To find the staff number of the first member of staff in an XML document with the root element STAFFLIST, which one of the following XQuery query statements would you use?

a. //STAFF/STAFFNO

b. //STAFFLIST/STAFF[1]/STAFFNO

c. /STAFFLIST/STAFF/STAFFNO[1]

d. /STAFFLIST/STAFF/STAFFNO

Question 11

Which of the following XQuery FLWOR expression retrieves the staff members' last names (LNAME) and dates of birth (DOB) for staff with a salary greater than 28000?

a. for $s in /STAFFLIST/STAFF

where $s/SALARY > 28000

return $s/NAME/LNAME, $s/DOB

b. for $s in /STAFFLIST/STAFF

where $s/DOB > 28000

return $s/NAME/LNAME, $s/SALARY

c. for $s in /STAFFLIST/STAFF

where $s/SALARY > 28000

return $s/DOB, $s/NAME/LNAME

d. for $s in /STAFFLIST/STAFF

where $s/LNAME > 28000

return $s/DOB, $s/SALARY

Question 12

What is the name of the new interface introduced in JPA 2 that extends the old Query interface?

Question 13

To store new entity objects in ObjectDB you use the _____ method.

Question 14

In ObjectDB, when you would like the primary key to be generated automatically in an Entity class you use the _____ annotation.

Question 15

According to the SQL:2011 standard, you can create unique object identifiers using the _____ type.

Question 16

ODMG stands for _____

Question 17

In PostgreSQL, the _____ is a delimiter you use to indicate where the function definition starts and ends.

Question 18

According to the XML hierarchical data model, we have data centric document types as well as _____ document types.

Question 19

What is the name of the XML component that identifies node type, e.g. element name or function text()?

Question 20

In XML, the _____ function generates XML value with a list of elements as children of a root item.

Section B Application and Theory - Based Questions (40 Marks)

(Spend approximately 30 minutes in this section)

Question 21 **(15 Marks)**

Object DBMS

Study the following code segments and answer the following questions:

Student.java

```
1   package semtestqn21;
2
3   import java.io.Serializable;
4   import javax.persistence.Entity;
5   import javax.persistence.GeneratedValue;
6   import javax.persistence.Id;
7
8   @Entity
9   public class Student implements Serializable {
10     private static final long serialVersionUID = 1L;
11     @Id
12     @GeneratedValue private long id;
13      private String name;
14      private int age;
15
16      // Default constructor (required by JPA)
17      public Student() {
18      }
19
20      // Parameterized constructor
21      public Student(String name, int age) {
22          this.name = name;
23          this.age = age;
24      }
25
26      // Getter for id
27      public Long getId() {
28          return id;
29      }
30
30
31      // Getter for name
32      public String getName() {
33          return name;
34      }
```

```
35
36      // Setter for name
37      public void setName(String name) {
38          this.name = name;
39      }
40
41      // Getter for age
42      public int getAge() {
43          return age;
44      }
45
46      // Setter for age
47      public void setAge(int age) {
48          this.age = age;
49      }
50  }
```

SemesterTest.java

```
1   package semtestqn21;
2
3   import java.util.List;
4   import javax.persistence.EntityManager;
5   import javax.persistence.EntityManagerFactory;
6   import javax.persistence.EntityTransaction;
7   import javax.persistence.Persistence;
8   import javax.persistence.TypedQuery;
9
10  public class SemesterTest{
11      public static void main(String[] args) {
12
13
14          EntityManagerFactory emf =
15  Persistence.createEntityManagerFactory("objectdb/db/students.
16  odb");
17
18
19          EntityManager em = emf.createEntityManager();
20
21
22          Student student = new Student();
23          student.setName("Nelson Mandela");
24          student.setAge(30);
25
26          EntityTransaction transaction = em.getTransaction();
```

```
27          transaction.begin();
28          em.persist(student);
29          transaction.commit();
30
31
32          Student retrievedStudent = em.find(Student.class,
33  student.getId());
34          System.out.println("Retrieved Student: " +
35  retrievedStudent.getName() + ", Age: " +
36  retrievedStudent.getAge());
37
38
39          transaction.begin();
40          retrievedStudent.setAge(31);
41          transaction.commit();
42
43          // Retrieve all Students
44
45
46
47          // Delete a Student
48
49
50
51          // Close the EntityManager and EntityManagerFactory
52          em.close();
53          emf.close();
54      }
55  }
```

Student.java file

(a) What does the "@Entity" annotation indicate when used before a Java class like "Student" in JPA? (2 Marks)

(b) Explain the purpose of getter and setter methods for class properties like "name" and "age" in the Student class. Why are these methods important in JPA entities? (2 Marks)

SemesterTest.java file

(c) What is the purpose of the EntityTransaction interface used in line 12? (1 Mark)

(d) Write the Java code snippet you can insert in lines 44-46 that can be used

to retrieve all student details in the ObjectDB database. **Note**, write the code in the answer book provided not in this question paper.

(3 Marks)

(e) Write the Java code snippet that you can insert in lines 48-50 that can be used to delete a student. **Note**, write the code in the answer book provided not in this question paper.

(3 Marks)

(f) Describe in your own words, at least **three** disadvantages of using relational databases which prompt the need to have object-oriented databases. No one word answers.

(4 Marks)

Question 22 **(15 Marks)**

ORDBMS

Study the following SQL statements and answer the following questions:

```
CREATE TABLE my_table (
    id serial PRIMARY KEY,
    data_array numeric[]
);

INSERT INTO my_table (data_array) VALUES
    (ARRAY[10, 20, 30, 40, 50]),
    (ARRAY[5, 15, 25]),
    (ARRAY[100, 200, 300, 400]);
```

You have executed the above statements in PostgreSQL and they ran successfully.

(a) Complete the following function such that it calculates the average for each array column and displays the following result:

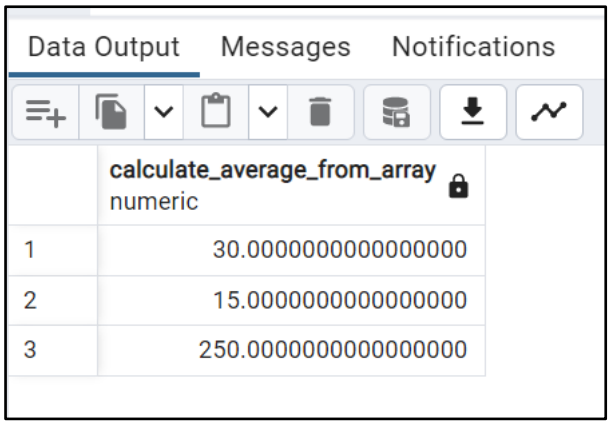


Figure 2 - Query output

(10 Marks)

(Write your answers in the answer book. One answer per each line)

```
CREATE _________ calculate_average_from_array(numbers
numeric[])

RETURNS NUMERIC AS $$

_________
    total numeric := 0;
    count numeric := 0;
    average numeric;
     num int;
BEGIN
        FOREACH _____ IN ARRAY numbers
    LOOP
        total := total + num;
        count := count + 1;
    END _______;


    IF count > 0 THEN
        average := ____________;
    ELSE
        average := NULL;
```

```
    END IF;


    RETURN __________;
END;
$$ _______________;
```

(b) Write the Select statement query that will output the result shown in Figure 2. (3 Marks)

(c) Apart from the FOREACH used in the above function, mention **two** other programming constructs for looping you can use in PostgreSQL? (2 Marks)

Question 23 **(15 Marks)**

Semi structured and XML

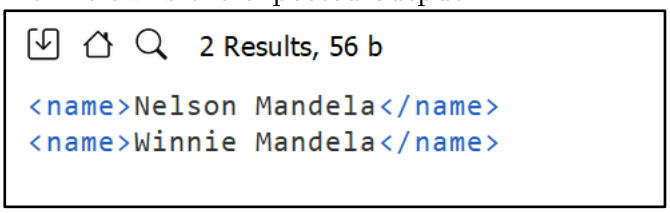
Study the following XML file and answer the questions that follow:

Students.xml

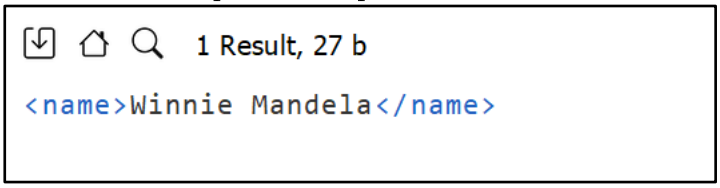
```
<students>
    <student>
        <id>1</id>
        <name>Nelson Mandela</name>
        <age>30</age>
        <gender>Male</gender>
        <degree>Computer Science</degree>
        <grade>A</grade>
    </student>
    <student>
        <id>2</id>
        <name>Winnie Mandela</name>
        <age>22</age>
        <gender>Female</gender>
        <degree>Mathematics</degreee>
        <grade>B</grade>
    </student>
    <!-- More student records here -->
</students>
```

(a) Write an XPath query to print out all the names of students from the XML

file. Below is the expected output. (2 Marks)



(b) Write an XPath Query to retrieve the names of all the female students. Below is the expected output. (3 Marks)



(c) Complete the following FLWR query such that it retrieves the names and ages of students older than 21, sorted by age in descending order (5 Marks).

```
for $student _______________
where ____________________
order by _________________
return (__________________)
```

Note: Write your answer in the answer book provided and not in the question paper.

(d) Describe your understanding of the ODMG Object Model and the Object Definition Language (ODL). (5 Marks)

Section C: Scenario Based Questions (40 Marks)

(Spend approximately 45 minutes in this section)

Question 24 **(15 Marks)**

OODBMS

Study the following scenario and answer the following questions:

> You are working as a freelance software developer. The University of Pretoria ITS division have called for your services. They would like to migrate from their relational database to an object-oriented database for use in the university. At the University of Pretoria, a lecturer works for one department. However, a department can have multiple lecturers associated with it.
> You suggest the use of ObjectDB to ITS. They have asked you to come and show some of the capabilities of ObjectDB.
>
> Source: Makura S.M (2023)

(a) Mention the relationship annotations that would be appropriate to use in the above-mentioned scenario, specifically the one you would use in the Lecturer entity class and one you would use in the Department entity class. Support your answer by providing a motivation why you chose those relationship annotations. (4 Marks)

(b) Mention the appropriate annotation to use to make the Lecturer and Department classes entities. Why is it necessary to use this annotation in JPA entities? (3 Marks)

(c) Describe with the aid of Java code examples, the usage of the Query and the TypedQuery interfaces in JPA. Your examples must be related to the entity classes mentioned in this scenario. (8 Marks)

Question 25 **(15 Marks)**

ORDBMS

Study the following scenario and answer the following questions:

> You have a friend called Jacob who is busy with a PostgreSQL assignment. He has asked for your assistance is the assignment. Jacob has managed to create a table called orders using the below SQL query statement.

```
CREATE TABLE orders (
    order_id SERIAL PRIMARY KEY,
    order_date DATE NOT NULL,
    total_amount NUMERIC(10, 2) NOT NULL,
    order_status VARCHAR(20)
);
```

Source: Makura S.M (2023)

(a) Using the information provided in the scenario above, complete the following trigger function such that it calculates the "order_status" based on the "total_amount" of the order. If the total amount is greater than 1000, it sets the status to "BigOrder"; otherwise, it sets it to "StandardOrder". (5 Marks)

(Write your answers in the answer book. One answer per each line)

```
CREATE FUNCTION update_order_status() RETURNS ______AS _____
BEGIN
    IF _________________ > 1000 THEN
        _________________ = 'BigOrder';
    ELSE
        ___________ = 'StandardOrder';
    END IF;
    RETURN NEW;
END;
$$ LANGUAGE plpgsql;
```

(b) Briefly explain to Jacob the uses of triggers in ORDBMS. (2 Marks)

(c) Complete the following trigger such that it calls the trigger function update_order_status before a new order is inserted. (4 Marks)

(Write your answers in the answer book. One answer per each line)

```
CREATE _________ update_order_status_trigger
_____________ ON orders
FOR _____________
EXECUTE ___________ update_order_status();
```

(d) Write the SQL statements to insert orders into the orders table with the following information:

Order Date	Amount
02 October 2023	550
02 October 2023	1050

(4 Marks)

Question 26 **(15 Marks)**

Semi-structured Data and XML

Study the following scenario and answer the following questions:

You are provided with the following XML file which shows details of staff who work for XYZ Company.

```
<?xml version="1.0" encoding="UTF-8"?>
<STAFFLIST>
    <STAFF branchNo="B002">
        <STAFFNO>SL20</STAFFNO>
        <NAME>
            <FNAME>Thando</FNAME>
            <LNAME>Mandela</LNAME>
        </NAME>
        <POSITION>Manager</POSITION>
        <DOB>1-Oct-98</DOB>
        <SALARY>30000</SALARY>
    </STAFF>
    <STAFF branchNo="B003">
        <STAFFNO>SL21</STAFFNO>
        <NAME>
            <FNAME>Marlize</FNAME>
            <LNAME>Kruger</LNAME>
        </NAME>
        <POSITION>Accountant</POSITION>
        <DOB>31-Nov-02</DOB>
        <SALARY>27000</SALARY>
    </STAFF>
```

Source: Makura S.M (2023)

(a) Write the SQL query statements do the following:

(i) Create a table called StaffData using the XML data type. (3 Marks)

(ii) Insert the above XML records into the StaffData table. (5 Marks)

(b) What is the purpose of an XMLElement function? (2 Marks)

(c) You create another table called **staff** and insert the following values:

```
CREATE TABLE staff (
      staffNo CHAR(4), fName CHAR(10),
       lName CHAR(10), branchNo CHAR(4) );

INSERT INTO staff VALUES ('SL20', 'Thando', 'Mandela',
'B002');
INSERT INTO staff VALUES ('SL21', 'Marlize', 'Kruger',
'B003');
```

Write the SQL query statement to list all staff as XML elements with name and branch number as an attribute. (**Hint:** Use the XMLElement and XMLattributes clause). (5 Marks)