UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment & Information Technology

Department of Computer Science

COS326 - Database Systems

Semester Test

Total Marks: 100

28 September 2022

Time/Duration: 17:30pm - 20:00pm (2 Hours 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 **21** 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 **150** minutes to complete this semester test.

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.

Section A: Multiple Choice and Fill in the Blanks Questions (20 Marks)

Question 1 **(1 Mark)**

Which one of the following is **not** an RDBMS weakness?

a. Poor representation of "real-world" entities

b. Data independence

c. Semantic Overloading

d. Homogeneous data structure

Question 2 **(1 Mark)**

What is the purpose of the `@Entity` annotation in JPA?

a. Marks the class as an entity class

b. Specifies the primary key of the entity

c. Specifies the generation strategies for the class keys

d. It is used to sort the data in the database

Question 3 **(1 Mark)**

Which of the following JPQL clauses are compulsory in every query retrieval?

a. SELECT, UPDATE

b. ORDER BY, SET

c. FROM, SELECT

d. WHERE, UPDATE

Question 4 **(1 Mark)**

Study the query statement below and answer the question that follows:

```
CREATE TYPE StaffType UNDER PersonType AS (
          staffNo      StaffNoType,
          position    VARCHAR(10) DEFAULT 'Assistant',
          salary        DECIMAL(7, 2),
          branchNo  CHAR(4))
```

Which one of the following statements **best** describes StaffType?

a. StaffType is a type of a staff

b. StaffType is a subtype of PersonType

c. StaffType is a type of PersonType

d. PersonType is a subtype of StaffType

Question 5 **(1 Mark)**

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

```
CREATE SEQUENCE venueSeq START 101;
CREATE TYPE BuildingCodeType AS ENUM ('IT', 'LAW', 'CHM',
'PHY');
CREATE TYPE RoomCodeType AS (building BuildingCodeType, floor
int, room int);
CREATE TYPE EquipmentType AS ENUM ('projector', 'PAsystem',
'safe', 'PC', 'phone');
CREATE TABLE Venue (
      venueKey integer DEFAULT nextval('venSeq') PRIMARY KEY,
      venueCode    RoomCodeType,
      seats  int  );
CREATE TABLE LectureRoom  (
          equipmentList  text [ ] )
          INHERITS (VENUE);
```

Assuming that the above SQL statements have been executed in a PostgreSQL database, which one of the SQL statements below will insert the data shown below into the LectureRoom table?

venueKey:	auto-generated
venue code:	IT 4-2
seats:	120
equipment:	projector, PAsystem, safe

a.
```
INSERT INTO LectureRoom  ( venueCode, seats, equipmentList)
       VALUES ( ('IT', 4,2), 120,  ['projector', 'PAsystem',
'safe']);
```

b.
```
INSERT INTO LectureRoom  ( venueCode, seats, equipmentList)
       ( 'IT', 4,2, 120, ARRAY['projector', 'PAsystem',
'safe']);
```

c.
```
INSERT INTO LectureRoom  ( venueCode, seats, equipmentList)
       VALUES ( ('IT', 4,2), 120,  ARRAY['projector',
'PAsystem', 'safe'] );
```

d.
```
INSERT INTO LectureRoom  ( venueCode, seats, equipmentList)
       VALUES ( ('IT', 4,2, 120),  ARRAYS['projector',
'PAsystem', 'safe'] );
```

Question 6 **(1 Mark)**

Which one of the following PostgreSQL functions is used to return a text representation of array's dimensions?

a. array_agg()

b. arrays_dimensions()

c. arrays_aggdim()

d. array_dims()

Question 7 **(1 Mark)**

The PostgreSQL database table below has been created using the following query statement:

```
CREATE TABLE XMLStaff (docNo CHAR(4) staffData XML  );
```

The data shown below has then imported into the table.

docNo	staffData
1	<STAFF branchNo = "B001"> <STAFFNO>S010</STAFFNO> <NAME> <FNAME>Katlego</FNAME> <LNAME>Mashego</LNAME> </NAME> </STAFF>
2	<STAFF branchNo = "B002"> <STAFFNO>S011</STAFFNO> <NAME> <FNAME>Thabo</FNAME> <LNAME>Mdluli</LNAME> </NAME> </STAFF>
3	<STAFF branchNo = "B002"> <STAFFNO>S012</STAFFNO> <NAME> <FNAME>Johan</FNAME> <LNAME>van Wyk</LNAME> </NAME> </STAFF>

Which one of the following PostgreSQL statements will display the staff number and name of all staff, in the following format?

StaffNumber	FirstName	Surname
S010	Katlego	Mashego
S011	Thabo	Mdluli
S012	Johan	van Wyk

a.
```
SELECT xpath('/STAFF/STAFFNO/text()', staffData)  AS StaffNumber,
  xpath ('/STAFF/NAME/FNAME/text()', staffData)  AS FirstName,
   xpath('/STAFF/NAME/LNAME/text()', staffData)  AS Surname
   FROM XMLStaff;
```

b. SELECT unnest (xpath('/STAFF/STAFFNO/text()', staffData)) AS StaffNumber,

unnest (xpath('/STAFF/NAME/FNAME/text()', staffData)) AS FirstName,

unnest (xpath('/STAFF/NAME/LNAME/text()', staffData)) AS Surname,

FROM XMLStaff

c. SELECT xpath('/STAFF/STAFFNO', staffData) AS StaffNumber,

xpath('/STAFF/NAME/FNAME', staffData) AS FirstName,

xpath('/STAFF/NAME/LNAME', staffData) AS Surname,

FROM XMLStaff

d. SELECT unnest (xpath('/STAFF/STAFFNO/StaffNumber.text()', staffData)) AS StaffNumber,

unnest (xpath('/STAFF/NAME/FNAME/FirstName.text()', staffData)) AS FirstName,

unnest (xpath('/STAFF/NAME/LNAME/Surname.text()', staffData)) AS Surname,

FROM XMLStaff

Question 8 **(1 Mark)**

Which one of the following is **not** a PostgreSQL user defined function category?

a. query language

b. procedural language

c. internal

d. composite

Question 9 **(1 Mark)**

Study the following query statement and answer the question that follows:

```
CREATE FUNCTION functionName(pmt1Type, pmt2Type,   .... )
RETURNS returntype AS
     $$
                SQL statement
      $$ LANGUAGE SQL;
```

The above is an example of a _____ function:

a. SQL

b. pgsql

c. composite

d. internal

Question 10 **(1 Mark)**

Study the following XML document called **staff_list.xml** and answer the question that follows:

```
<STAFFLIST>
<STAFF branchNo = "B005">
      <STAFFNO>SL21</STAFFNO>
      <NAME>
            <FNAME>John</FNAME><LNAME>Green</LNAME>
      </NAME>
      <SALARY>30000</SALARY>
</STAFF>
<STAFF branchNo = "B003">
      <STAFFNO>SG37</STAFFNO>
      <NAME>
            <FNAME>Ann</FNAME><LNAME>Brown</LNAME>
      </NAME>
      <SALARY>12000</SALARY>
</STAFF>
</STAFFLIST>
```

Which one of the following FLWOR queries will list the staff numbers of all staff at branch B005 with salary greater than R15,000?

a.
```
for $S in //STAFF
where $S/SALARY > 15000 and
$S/@branchNo = "B005"
```

```
return $S/STAFFNO
```

b.
```
for $S in STAFF
where $S/SALARY > 15000 and
 $S/@branchNo = "B005"
 return $S/STAFFNO
```

c.
```
for $S in //STAFF
where $S.SALARY > 15000 and
$S.@branchNo = "B005"
return $S.STAFFNO
```

d.
```
for $S in $/STAFF
where $S/SALARY > 15000 and
$S/STAFF/@branchNo = "B005"
return $S/STAFFNO
```

Question 11 **(1 Mark)**

A _____ defines an action that the DBMS should take when some event occurs.

a. variable

b. trigger

c. parameter

d. query

Question 12 **(1 Mark)**

Study the following query statement and answer the question that follows:

```
CREATE TRIGGER valid_area
     _______ INSERT ON Cities
     FOR EACH ROW
          EXECUTE PROCEDURE check_valid_area();
```

Assuming that a trigger function called `check_valid_area()` has already been executed in PostgreSQL, select the appropriate syntax to use in the blank space to ensure that the trigger happens before the insert operation.

a. PREVIOUS

b. AFTER

c. BEFORE

d. AFORE

Question 13 **(1 Mark)**

Study the following query statement and answer the question that follows:

```
/child::STAFF[position()=1
```

Which one of the following components is the node test of the above query statement?

a. child

b. STAFF

c. position

d. 1

Question 14 **(1 Mark)**

XQuery uses path expressions as well as _____ expressions.

Question 15 **(1 Mark)**

Study the following query statement and answer the question that follows:

```
let $mymath := function($x, $y, $z)
{$x * $y +$z}
return $mymath(4,3,10)
```

When the above query statement is executed in BaseX, what will be the output?

Question 16 **(1 Mark)**

The _____ function generates XML value with a single element as a child of its root item.

Question 17 **(1 Mark)**

The 3 Vs of Big Data are Volume, Velocity and _____.

Question 18 **(1 Mark)**

In order to list all collections in MongoDB, you use the _____ command in MongoDB shell.

Question 19 **(1 Mark)**

Apart from ObjectDB, mention one OODMS you know of _____.

Question 20 **(1 Mark)**

Procedural language functions are functions written in _____.

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

Question 21 (15 Marks)

Object ODBMS

Study the following code segments and answer the following questions:

Point.java

```
1   package semestertest;
2   import java.io.Serializable;
3   import javax.persistence.*;
4
5   @Entity
6   public class Point implements Serializable {
7
8       private static final long serialVersionUID = 1L;
9       @Id
10      @GeneratedValue
11      private long id;
12
13      private int x;
14      private int y;
15
16      public Point() {}
17
18      Point(int x, int y) {
19          this.x = x;
20          this.y = y;
21      }
22
23      public Long getId() {
24          return id;
25      }
26
27      public int getX() {
28          return x;
29      }
30
31      public int getY() {
32          return y;
33      }
34
35      @Override
36      public String toString() {
37          return String.format("(%d, %d)", this.x,
38  this.y);
```

```
39      }
40  }
41
42
43
44
```

SemesterTest.java

```
1   package semestertest;
2
3   import javax.persistence.*;
4   import java.util.*;
5
6   public class SemesterTest {
7       public static void main(String[] args) {
8           EntityManagerFactory emf =
9
10  Persistence.createEntityManagerFactory("$objectdb/db/poin
11  ts1.odb");
12          EntityManager em = emf.createEntityManager();
13
14          em.getTransaction().begin();
15          for (int i = 0; i < 10; i++) {
16              Point p = new Point(i, i);
17              em.persist(p);
18          }
19          em.getTransaction().commit();
20
21          Query q1 = em.createQuery("SELECT COUNT(p) FROM
22  Point p");
23          System.out.println("Total Points: " +
24  q1.getSingleResult());
25
26          Query q2 = em.createQuery("SELECT AVG(p.x) FROM
27  Point p");
28          System.out.println("Average X: " +
29  q2.getSingleResult());
30
31          TypedQuery < Point > query =
32              em.createQuery("SELECT p FROM Point p",
33  Point.class);
34          List < Point > results = query.getResultList();
35          for (Point p: results) {
36              System.out.println(p);
37          }
38
39          em.close();
```

```
40          emf.close();
41      }
42
43  }
44
```

Based on the above SemesterTest.java code, explain the purpose of the following:

(a) EntityManagerFactory (line 8) (1 Mark)

(b) createEntityManagerFactory (line 10) (1 Mark)

(c) EntityManager (line 12) (1 Mark)

(d) getTransaction().commit() (line 19) (2 Marks)

(e) Query (lines 21 and 26) (2 Marks)

(f) Assuming that objectdb.jar file has already been added to the Java IDE project and the above code is run. What will be the output of line 36? (3 Marks)

(e) Describe the advantages of using an object-oriented database over using the traditional relational databases. **No** one word answers (5 Marks)

Question 22 **(15 Marks)**

Object Relational DBMS

Study the following query statement and answer the questions that follow:

```
1  CREATE FUNCTION popDensity(real, int ) RETURNS int  AS
2  $$
3       DECLARE density int;
4       BEGIN
5            density = CAST ( (($1 * 1000000) / $2 ) AS int );
6            RETURN density;
7       END;
8  $$ LANGUAGE plpgsql;
9  SELECT name, population, area, popDensity( population, area )
```

(a) Describe what each line of the above code does (lines 1 to 9). **No** one word answers (10 Marks)

(b) Briefly describe in your own words, your understanding of the third-generation database manifesto. (5 Marks)

Question 23 (10 Marks)

Semi-structured data & XML

Study the following XML files and query statement and answer the questions that follow:

stafflist.xml

```
<?xml version="1.0"
encoding="UTF-8"?>
<STAFFLIST>
   <STAFF branchNo="B005">
      <STAFFNO>SL21</STAFFNO>
      <NAME>
         <FNAME>John</FNAME>
         <LNAME>White</LNAME>
      </NAME>

<POSITION>Manager</POSITION>
      <DOB>1-Oct-45</DOB>
      <SALARY>30000</SALARY>
   </STAFF>
   <STAFF branchNo="B003">
      <STAFFNO>SG37</STAFFNO>
      <NAME>
         <FNAME>Ann</FNAME>
         <LNAME>Beech</LNAME>
      </NAME>

<POSITION>Assistant</POSITION>
      <SALARY>I2000</SALARY>
   </STAFF>
</STAFFLIST>
```

nok.xml

```
<?xml version="1.0"
encoding="UTF-8"?>
<NOKLIST>
     <NOK>

     <STAFFNO>SL21</STAFFNO>
          <NAME>Mary
White</NAME>
     </NOK>
</NOKLIST>
```

Query Expression:

```
1  for $S in doc("staff_list.xml")//STAFF,
2       $NOK in doc("nok.xml")//NOK
3  where $S/STAFFNO = $NOK/STAFFNO
4  return <STAFFNOK> {$S, $NOK/NAME } </STAFFNOK>
```

You are told that the **staff_list.xml** file contains staff details and the **nok.xml** contains details of the next of kin of each staff.

(a) What type of query expression is this? (1 Mark)

(b) What is the purpose of the $S in line 1? (2 Marks)

(c) Explain what is happening at line 3. (2 Marks)

(d) Explain what is happening at line 4. (2 Marks)

(e) Assuming that the above XML files have already been imported into BaseX, and the above query statement is executed, what will be the output? (3 Marks)

Section C: Scenario-Based Questions (40 Marks)

Question 24 (15 Marks)

Object ODBMS

Study the following scenario and answer the following questions:

You have been called for an interview at Emerald Tech Logistics for a Database developer intern position. Emerald Tech utilises ObjectDB in their business operations. You had mentioned in your CV that you learnt ObjectDB during your studies. As part of the interview requirements, they would like to test your proficiency in using ObjectDB. They have provided you with the following Java Files:

AdressBook.java

```
1   import java.io.Serializable;
2   import javax.persistence.Entity;
3   import javax.persistence.GeneratedValue;
4   import javax.persistence.Id;
5
6   @Entity
7   public class AddressBook implements Serializable {
8       private static final long serialVersionUID = 1L;
9       @Id
10      @GeneratedValue
11      private long id;
12      private String name;
13      private String address;
14
15      public AddressBook() {
16
17      }
18      public AddressBook(String n, String a) {
19          this.name = n;
20          this.address = a;
21      }
22      public Long getId() {
23          return id;
24      }
25      public void setId(Long id) {
26          this.id = id;
27      }
28      public String getName() {
29          return name;
30      }
31      public void setName(String n) {
```

```
32          this.name = n;
33      }
34      public String getAddress() {
35          return address;
36      }
37      public void setAddress(String a) {
38          this.address = a;
39      }
40
41      @Override
42      public String toString() {
43          return String.format("(%s, %s)",
44              this.name, this.address);
45      }
46  }
```

SemesterTest2.java

```
1   import java.util.List;
2   import javax.persistence.EntityManager;
3   import javax.persistence.EntityManagerFactory;
4   import javax.persistence.Persistence;
5   import javax.persistence.TypedQuery;
6
7   public class SemesterTest2 {
8       public static void main(String[] args) {
9           EntityManagerFactory emf =
10  Persistence.createEntityManagerFactory("$objectdb/db/ad
11  dressbook.odb");
12          EntityManager em = emf.createEntityManager();
13          em.getTransaction().begin();
14
15          AddressBook b1 = new AddressBook("Cyril
16  Ramaphosa", "Pretoria");
17          AddressBook b2 = new AddressBook("Jacob Zuma",
18  "Johannesburg");
19          AddressBook b3 = new AddressBook("Kgalema
20  Motlanthe", "Polokwane");
21          AddressBook b4 = new AddressBook("Thabo Mbeki",
22  "Durban");
23          AddressBook b5 = new AddressBook("Nelson
24  Mandela", "Eastern Cape");
25          em.persist(b1);
26          em.persist(b2);
27          em.persist(b3);
28          em.persist(b4);
29          em.persist(b5);
```

```
30
31          em.getTransaction().commit();
32
33          TypedQuery < AddressBook > query =
34  em.createQuery("SELECT b FROM AddressBook b",
35  AddressBook.class);
36          List < AddressBook > results =
37  query.getResultList();
38
39          for (AddressBook bb: results) {
40              System.out.println(bb);
41          }
42
43          em.close();
44          emf.close();
45      }
46  }
47
```

Use this information to answer the following questions.

Source: Makura S.M (2022)

AdressBook.java file

(a) What does line 7 mean when it says the class implements Serializable? (2 Marks)

(b) What is the meaning of the `@Id` annotation in line 9? (2 Marks)

(c) What is the meaning of the `@GeneratedValue` annotation in line 10? (2 Marks)

SemesterTest2.java

(d) Describe the purpose of the import statement in line 5? (2 Marks)

(e) Give a description of what is happening in lines 25 - 29? (2 Marks)

(f) What is the name of the database utilised in this code? (1 Mark)

(g) State the clause you would use to change the details of b2 in line 17? (2 Marks)

(h) Give a description of what will happen if we run the code without lines 43 and 44? (2 Marks)

Question 25 **(15 Marks)**

Object RDBMS

Study the following scenario and answer the following questions:

The Department of Computer Science at the University of Pretoria has asked for your assistance. You have been provided with the following table called students contained in a PostgreSQL database with a list of student marks:

Students Table

	name text	mark integer
1	Sheunesu Makura	33
2	Karabo Tshabalala	75
3	Angelique Potgieter	65
4	Thandiwe Simelane	39

You have also been provided with the following function:

```
CREATE FUNCTION has_excelled(integer ) RETURNS text AS
$$
     DECLARE   pass text;
     BEGIN
          IF   $1   >=   40   THEN
                pass   :=   'YES';
          ELSE
                pass   :=   'NO';
          END IF;
          RETURN   pass;
     END;
$$ LANGUAGE plpgsql
```

Source: Makura S.M (2022)

(a) Describe what the function in the above scenario is trying to achieve? (2 Marks)

(b) Complete the following query such that when it is executed in PostgreSQL, it will utilise the function mentioned in the scenario and output the details we see below.

	name text	mark integer	has_excelled text
1	Sheunesu Makura	33	NO
2	Karabo Tshabalala	75	YES
3	Angelique Potgieter	65	YES
4	Thandiwe Simelane	39	NO

```
_______ name, mark, _____________ FROM STUDENTS;
```

(2 Marks)

(b) Complete the trigger function and trigger below so that it executes before any insert or update operation on the students table:

```
CREATE FUNCTION check_valid_mark() RETURNS _______ AS
$$
   BEGIN
     IF (_____________) THEN
         RAISE EXCEPTION 'Invalid mark, please try again!';
     END IF;
          RETURN _________;
     END;
$$ LANGUAGE plpgsql;

CREATE TRIGGER valid_mark
     _________ INSERT OR _________ ON STUDENTS
     FOR EACH ROW
          EXECUTE PROCEDURE _____________ ;
```

Note: Write your answers in the answer book and not on this paper.

(6 Marks)

(c) How does an ORDBMS like PostgreSQL overcome the limitations (weaknesses) of a RDBMS? (5 Marks)

Question 26 **(10 Marks)**

Semi structured Data & XML

Study the following scenario and answer the following questions:

You have been invited by Siyabonga High School to provide a presentation to pupils studying Computer Applications and Technology on how you would use BaseX to run queries. You have been provided the following XML file called **staff_list.xml**.

staff_list.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<STAFFLIST>
   <STAFF branchNo="B005">
      <STAFFNO>SL21</STAFFNO>
      <NAME>
         <FNAME>John</FNAME>
         <LNAME>White</LNAME>
      </NAME>
      <POSITION>Manager</POSITION>
      <DOB>1-Oct-45</DOB>
      <SALARY>30000</SALARY>
   </STAFF>
   <STAFF branchNo="B003">
      <STAFFNO>SG37</STAFFNO>
      <NAME>
         <FNAME>Ann</FNAME>
         <LNAME>Beech</LNAME>
      </NAME>
      <POSITION>Assistant</POSITION>
      <SALARY>I2000</SALARY>
   </STAFF>
</STAFFLIST>
```

Source: Makura S.M (2022)

(a) Explain to the pupils, how would you import the above XML file into BaseX? Explain step by step. (3 Marks)

(b) You execute the following query in BaseX.

```
//STAFFLIST/STAFF[2]/STAFFNO
```

(b.1) Explain to the pupils, what the above query is supposed to do? (2 Marks)

(b.2) What will be the output when you execute the above query? (1 Mark)

(c) You execute another query in BaseX.

```
for $N in   //STAFF/NAME/FNAME/text()   return   $N
```

(c.1) Explain to the pupils what the above query is supposed to do? (2 Marks)

(c.2) What will be the output when you execute the above query? (1 Mark)

d. Describe to the pupils, what is semi structured data? (1 Mark)

End of semester test paper