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COMPUTER SCIENCE
STANDARD LEVEL
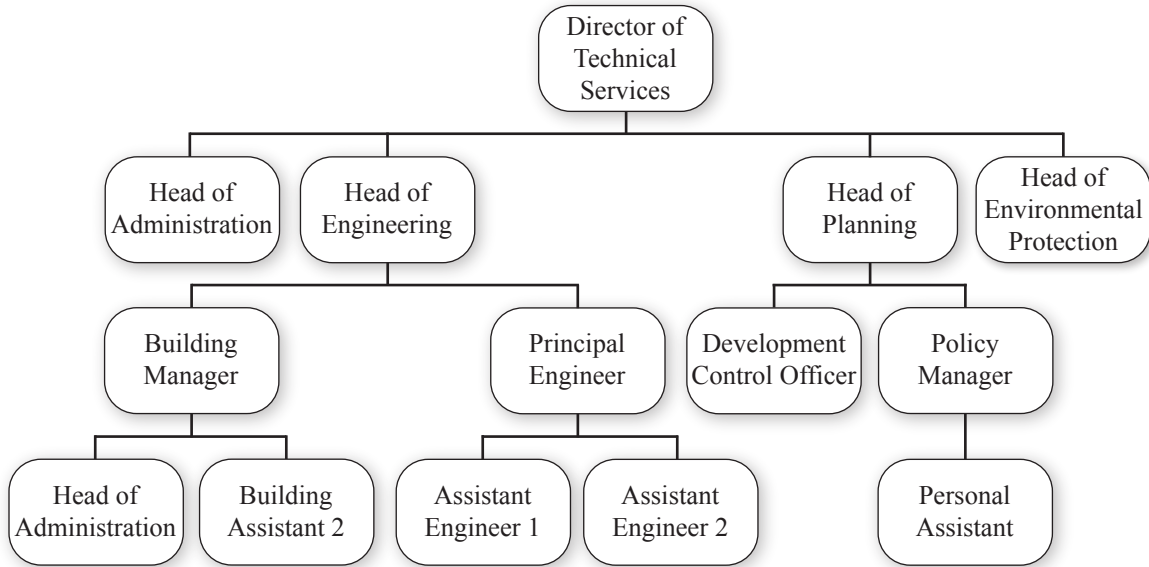**PAPER 2**

SPECIMEN PAPER

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all of the questions from one of the Options.

Option A — Databases

A1. A company has a division called Technical Services. This division is organized into departments. The following chart shows how the various staff are organized.

The Human Resources Department maintains a flat file database to store information about all the staff members for salary, holiday and promotion purposes. A sample of the stored information is shown below.

Staff Number	Surname	Forename	Job Title	Line Manager	Salary
948	Kent	McKenzie	Head of Planning	Adrienne Mathis	90875
156	Barker	Rae	Head of Administration	Adrienne Mathis	30465
815	Riddle	Kevyn	Development Control Officer	Kent McKenzie	34768
580	Figueroa	Rina	Policy Manager	Kent McKenzie	45078
871	Mathis	Adrienne	Director of Technical Services	Russell Z. Harrell	45800
457	Neal	Paul	Head of Environmental Protection	Adrienne Mathis	80670
297	Oliver	Ralph	Principal Engineer	Daria Gilmore	50796
51	Gilmore	Daria	Head of Engineering	Adrienne Mathis	90655

(This question continues on the following page)

(Question A1 continued)

The Human Resources Department is experiencing many errors when compiling reports of personnel and has been advised that it should change to a relational database.

(a) (i)   Define the term *database*.   *[1]*

     (ii) Describe the difference between a *flat file database* and a *relational database*.   *[2]*

(b) (i)   Identify **two** problems caused by data redundancy.   *[2]*

     (ii) Outline using examples how data redundancy in this database could lead to errors.   *[2]*

(c) The departments usually have many ongoing projects that occupy their team members. The Human Resources Department needs to produce lists showing who is involved in current projects.

     The following information has been provided:

     Project: Project_Ref, Project_Name, Budget
     Department: Dept_Ref, Dept_Name
     Staff: Staff_Number, Forename, Surname, Job_Title, Salary
     The projects are owned by a department.
     Each member of staff is a member of a department.

     (i)   Construct an Entity Relationship Diagram to show how a relational database could be designed to make this possible with the least chance of producing errors caused by data redundancy.   *[4]*

     (ii) Identify the steps to create a query that could be constructed to produce a list of staff members whose salary is greater than $50 000 who are involved in a project called "Relocation_2012".   *[4]*

Turn over

A2. A bank wants to transfer money from one account to another. Both accounts are held in the bank's database management system (DBMS). The account DBMS carries out a series of separate operations in order to achieve this transaction. These include removing of money from one account and adding it to the other. An error may occur if this process is interrupted, for example due to a power failure. This could compromise the integrity of the account database.

(a) (i) Identify **two** characteristics of a *transaction* in terms of a database. *[2]*

(ii) Distinguish between a database *schema* and a database *state*. *[2]*

(iii) Explain why the interruption described above could compromise the integrity of the account database. *[2]*

(b) Identify the steps that should be taken by the software in order to maintain the integrity of the account database. *[4]*

(c) The bank account data is shared between various applications, such as the bank's internal accounting systems and the online transaction system. Explain how problems of concurrency can arise and how they can be avoided. *[6]*

A3. (a) (i) Identify **two** functions of a *database management system* (DBMS). *[2]*

(ii) List **two** tools usually provided with a DBMS. *[2]*

(b) Database management systems allow data sharing and multiple views. Explain why these features are important to an organization that uses databases. *[4]*

(c) Explain why it is important for data to be independent of the application software that manipulates it. *[6]*

Option B — Modelling and Simulation

B1. Mathematical models are used to provide information to building designers.

(a) Identify **two** characteristics of a mathematical model.   *[2]*

Any new building must be constructed to resist the force of a possible earthquake. The force (V) that the building must resist in order to prevent collapse varies according to the following variables:

Variable	
Z	The Earthquake zone (1–3) in which the building is constructed
I	Importance of the building according to its intended use (*e.g.* school, hospital, *etc.*)
C	Structure index based on the dimensions, the weight and the shape of the building
R	Flexibility of the building

A simplified version of V can be calculated by the formula:

$$V = (Z * I * C) / R,$$

where Z and I are given and the values of C and R are obtained from published tables.

A building designer needs to be able to calculate the value of V for any one of a large number of buildings that is being designed. Z is fixed for all buildings; I, C and R can vary from building to building.

(b) Outline why the use of a spreadsheet is appropriate for this modelling task.   *[2]*

(c) Construct a diagram to show the way in which data and calculations would be implemented in a spreadsheet.   *[4]*

(d) Outline how data from the look up tables could be input into the spreadsheet.   *[4]*

Within a city in an earthquake zone there are many different designs of buildings. It is decided to test all buildings for their resistance to a possible earthquake in that zone.

(e) Describe the data collection and data input needed to use the spreadsheet to test all buildings.   *[6]*

Turn over

B2. Despite many attempts, the simulation of an earthquake by computer has proved inaccurate and planned buildings are tested by making a physical model and applying the relevant forces to see if it can withstand an earthquake in the given zone.

(a)   Explain the relationship between a *simulation* and *mathematical modelling*.   *[2]*

(b)   With reference to a simulation with which you are familiar, explain the importance of accurate rules and data in a simulation.   *[4]*

Simulation has proved successful in predicting weather patterns.

(c)   Describe **one** advantage and **one** social consequence of using simulations for weather forecasting.   *[4]*

B3. Cyclone Yasi hit Northern Australia in February 2011. There were many after effects such as flooding and landslides.

Cyclone Yasi
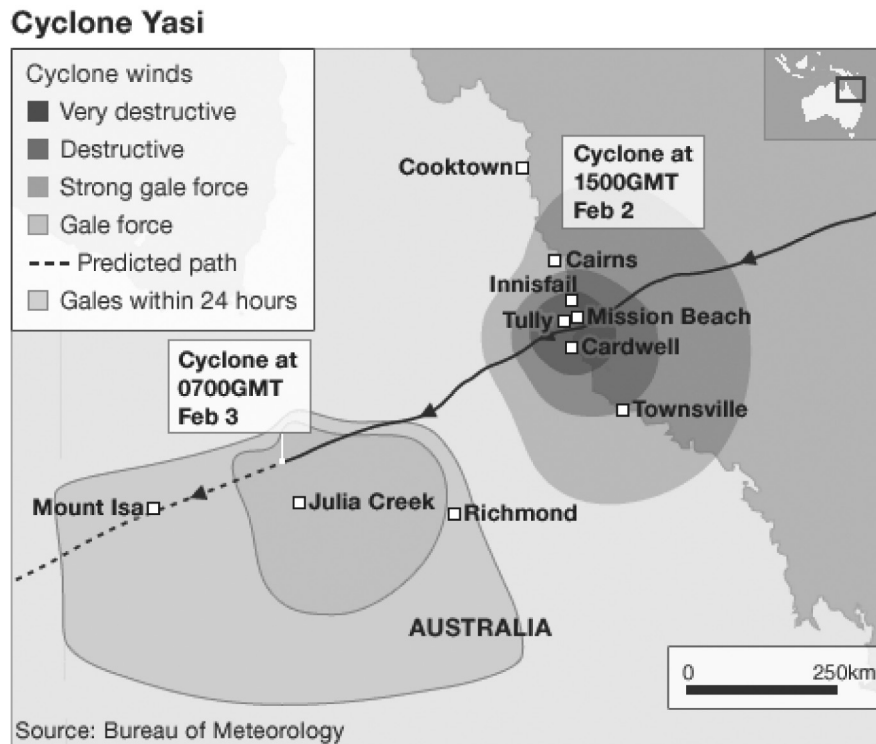
[Source: Australian Government Bureau of Meteorology (accessed 07 February 2011)]

To ensure that the emergency services could be located where they will be most needed a 2D visual model of likely danger areas, shown above, was created and distributed to surrounding areas in real time.

(a) Outline the ways in which visualization can be used to display the possible effects of the cyclone in real time. *[4]*

(b) Explain the technical difficulties that could arise in data collection and processing when attempting to predict in real time. *[4]*

(c) Explain the advantages of using visualization in this case. *[6]*

(d) Compare the use of 2D visualization with 3D visualization in this situation. *[3]*

Turn over

Option C — Web Science

C1. A publishing company, ABC Publications, based in London has a large IT department. This department is responsible for:

- providing IT services to the company
- maintaining the company's web site
- creating and maintaining web based learning resources that are sold to schools and colleges.

The company is finding it difficult to recruit and retain sufficient high quality IT staff to keep these functions operating at an optimal level. It is investigating transferring at least part of its IT operations to a cloud computing solution. At the moment it has not been decided how much of this should be implemented by a private cloud and how much by a public cloud.

(a) Define the term *private cloud*. *[1]*

(b) Distinguish between a cloud computing model and a conventional client server model in providing computing services. *[4]*

(c) Explain why ABC Publications might benefit from changing part of its IT provision to a cloud based model. *[4]*

(d) Comment on the privacy **and** security issues relating to ABC's use of cloud computing. *[4]*

C2. A theatre box office maintains a web site that can display what productions are coming up and which seats are available for a particular production. It can then take orders online. The interface consists of dynamic web pages such as the one below, in which the underlying HTML interacts with client-side and server-side scripts.

Part of the source code for this page is:

```
<script type="text/javascript" src="http://assets.ophse.org/_inc/popdt/init_live.js"></script>
<script type="text/javascript" src="http://assets.ophse.org/_inc/popdt/src/flash.js"></script>
```

(a) Identify **one** characteristic of Hypertext Markup Language (HTML). *[1]*

(b) Identify the steps that the server would carry out so that the information in the events' calendar can be displayed on the client's computer. *[4]*

(c) (i) Identify **two** ways that a client-side script may be made available to a web browser. *[2]*

   (ii) Describe **one** reason why a client-side script may be used in preference to a server-side script. *[2]*

(This question continues on the following page)

Turn over

(Question C2 continued)

(d) The organizers of the theatre want to ensure their web pages appear higher up the ranking of search engines.

Suggest whether the use of meta-tags can help achieve this aim. *[4]*

(e) It is common for dynamic web pages to make use of a mixture of client-side and server-side scripting. Explain how the interaction of HTML, client-side and server-side scripting have allowed the production of a web page such as the one shown here. *[6]*

C3. As the web has developed, data formats, communication protocols and standards such as XML or SQL have proven crucial to progress. Two fundamental concerns that have been central to this development are the issues of interoperability and that of open standards.

(a) (i) Identify **one** characteristic of XML. *[1]*

(ii) Define the term *protocol*. *[1]*

(b) Describe, with the use of examples, how the use of open standards allows interoperability to occur. *[3]*

Music is distributed across the web in a variety of different ways such as peer-2-peer (P2P) networks.

(c) Discuss **two** factors that would affect the decision to use either lossless or lossy compression when transferring files across the Internet. *[6]*

(d) Explain **one** advantage of the use of a peer-2-peer (P2P) network for obtaining and downloading music and movie files. *[2]*

Option D — Object-oriented programming

A bus company operates in a local city. The bus company operates along fixed routes where there are marked stops and sometimes bus shelters for people to wait in out of the weather. People (passengers) pay the driver a specified fare for travel when they enter a bus.

There are many objects in this company, here are some of them:

Object	Description
Bus	A physical vehicle that carries *passengers* on a specific *route* and has a *driver*.
Passenger	A person that travels on a *bus*.
Route	A series of roads/streets the *bus* travels over from its start to its destination.
Bus Stop	A **named** place on a *route* where people wait for a *bus*. May be a simple marker or may have a shelter and seats.
Driver	A person qualified to drive a *bus* and trained to drive it over a given *route*.

These two objects have already been defined for the bus company:

```
BusRoute

Integer: route
String: start

setRoute(Integer: route)
setStart(String: start)
Integer getRoute()
String getStart()
String toString()
```

```
Bus

Integer: id
String: driver
BusRoute: busRoute

setId(Integer: id)
setDriver(String: driver)
setBusRoute(BusRoute: route)
Integer getId()
String getDriver()
BusRoute getBusRoute()
String toString()
```

Turn over

The `toString()` method returns a String implementation of an object.

These are implemented in code as follows:

```java
public class BusRoute
{
  private int route;
  private String start;
  public BusRoute(int r, String s)
  {
    setRoute(r);
    setStart(s);
  }
  public void setRoute(int r){ route = r; }
  public void setStart(String s){ start = s; }
  public int getRoute(){ return route; }
  public String getStart(){ return start; }
  public String toString()
  {
    return "Route: " + route + " start: " + start;
  }
}


public class Bus
{
  private int id;
  private String driver;
  private BusRoute busRoute;
  public Bus(int i, String d, BusRoute r)
  {
    setId(i);
    setDriver(d);
    setBusRoute(r);
  }
  public void setId(int i){ id = i; }
  public void setDriver(String d){ driver = d; }
  public void setBusRoute(BusRoute r){ busRoute = r; }
  public int getId(){ return id; }
  public String getDriver(){ return driver; }
  public BusRoute getBusRoute(){ return busRoute; }
  public String toString()
  {
    return "Bus id:" + id + " - " + driver + ": " + busRoute.toString();
  }
}
```

D1. (a)　Explain the term *parameter variable*, using an example from the code. 　　　*[2]*

(b)　Describe **one** additional field that might have been included in the `BusRoute` object/class. Include data types and sample data. 　　　*[2]*

(c)　Identify the output produced by the following code fragment.

```
Bus bus = new Bus(1001, "N Prakesh", new BusRoute(431, "Klang"));
System.out.println(bus.toString());
```
　　　[2]

Consider the code fragment below.

```
private static final int MAX_BUSES = 12;
private Bus[] buses = new Bus[MAX_BUSES];
buses[0] = new Bus(1001, "N Prakesh", new BusRoute(431, "Klang"));
buses[1] = new Bus(1010, "J Carey", new BusRoute(342, "Tanglin"));
buses[2] = new Bus(1014, "H Lee", new BusRoute(411, "Queenstown"));
buses[3] = new Bus(1015, "K Peters", new BusRoute(319, "Jamaica Street"));

showBusDrivers(buses, 1010);
```

(d)　Construct the method `showBusDrivers(Bus[] b, int n)` which lists the drivers for all buses with a route number less than or equal to the parameter variable (`n`). 　　　*[6]*

The company wishes to keep track of its drivers in more detail, including first and last name and employee number – this is a 4-digit whole number.

(e)　Construct a suitable diagram for this `Driver` object. 　　　*[3]*

Turn over

D2. In relation to the Bus example:

    (a)   Outline how encapsulation is used. *[2]*

    (b)   Outline a disadvantage of using Object Oriented Design. *[2]*

    (c)   Explain how a programming team could benefit from an Object Oriented Design approach. *[4]*

Recall that a *Bus Stop* is one of many **named** places on a *route* where *buses* stop to pick up or drop off *passengers*. It may or may not have a **shelter** to protect *passengers* from the weather. The **distance** in km from the start point of the *Bus Route* is important information for planning.

    (d)   Design the Bus Stop Object using a simple object diagram. *[3]*

    (e)   Suggest how Bus Stop information for a given Bus Route instance could be stored, giving both sample data and sample code fragments to show how it could be implemented. *[4]*

D3. The company grows, offers more routes of different types and decides to use three different types of bus:

- A bus that operates on busy city routes – the Urban Bus – has only a driver.
- A smaller bus that operates on longer country routes – it carries an additional person to collect the fares.
- A van that can be used for heavy equipment deliveries rather than passengers – the Delivery Van – it carries a co-driver and a helper.

These vehicles will have some things in common, such as a *driver*, and other elements that are different, for example both Urban and Rural buses will operate on a fixed *route* whereas the Delivery Van will take equipment to specified *destinations* (such as factories or other businesses).

    (a)   Construct diagrams to show how you would re-design the `Bus` class to implement inheritance. *[8]*

    (b)   Explain the advantage of inheritance for this situation. *[4]*

A method is required in the subclasses that returns the number of employees per vehicle.

    (c)   Outline how polymorphism might apply in this design. *[3]*