COMPUTER STUDIES FORM 4
MID-TERM 2 EXAM 2026

MARKING SCHEME

SECTION A (40 MARKS)

Question 1 (3 Marks)

Circumstances under which a developer would prefer a walkthrough over an inspection:

- **Early stage development / Initial drafting:** When the system design or code is at a very early stage and formal documentation required for an inspection is not yet fully prepared. **(1 mark)**
- **Training / Knowledge sharing:** When the primary goal is to familiarize new team members with the system architecture and logic, utilizing the developer-led narrative as an educational tool. **(1 mark)**
- **Low-risk / Low-complexity modules:** When the software component being evaluated is simple or low-risk, making the rigid overhead and formal preparation of a full inspection inefficient. **(1 mark)**
- **Time / Resource constraints:** When severe schedule pressures prevent organizing a formal inspection team, choosing instead a faster, less formal peer review session. **(Any 3 points, 1 mark each = 3 marks)**

Question 2 (2 Marks)

Distinction between a Hub and a Switch based on data packet handling:

Feature	Hub	Switch
Data Handling	Broadcasts incoming data packets to all ports, regardless of the destination MAC address.	Unicasts packets selectively to the specific destination port by mapping the target MAC address.
Intelligence / Efficiency	Operates at the Physical Layer (Layer 1). Lacks intelligence, leading to high packet collisions and bandwidth wastage.	Operates at the Data Link Layer (Layer 2). Highly efficient as it establishes dedicated point-to-point connections.

Award 2 marks for a clear distinction showing broadcasting vs unicasting / selective forwarding.

Question 3 (4 Marks)

(a) Main difference between validation and verification:

- **Data Validation:** Is a system-driven check performed at the point of entry to ensure that the input data complies with pre-defined validation criteria (e.g., format, type, range) and is reasonable or acceptable. **(1 mark)**
- **Data Verification:** Is a process (either manual or programmatic) used to check that data has been copied, transmitted, or transcribed accurately from the source document to the system, ensuring absolute correctness. **(1 mark)**

(b) Two examples of validation checks built into a database system:

- **Range Check:** Ensures a value falls between a specific minimum and maximum limit (e.g., Age must be between 18 and 65). **(1 mark)**
- **Type / Data Format Check:** Ensures that data matches a specific data type or format (e.g., Admission Number must be integer; Date of Birth must follow DD/MM/YYYY). **(1 mark)**
- **Presence / Required Field Check:** Ensures a critical field cannot be left blank during data entry (e.g., Primary Key field like StudentID must contain a value). **(1 mark)**
- **Length Check:** Verifies whether the text string entered contains a fixed number of characters (e.g., National ID must be exactly 8 digits). **(Any 2 checks, 1 mark each = 2 marks)**

Question 4 (3 Marks)

Technical measures to minimize unauthorized network server access:

- **Role-Based Access Control (RBAC) & NTFS Permissions:** Implementing granular user authentication and file-level permissions (Read, Write, Execute) so that employees can only access files necessary for their duties. **(1 mark)**
- **Data Encryption:** Enforcing robust encryption standards for files at rest (AES-256) on the server storage arrays and in transit (SSL/TLS/IPSec) across the local network. **(1 mark)**
- **Firewalls and Intrusion Detection/Prevention Systems (IDS/IPS):** Deploying network and host-based firewalls to block unauthorized ports, alongside an IDS/IPS to actively monitor and alert on suspicious traffic spikes or breach attempts. **(1 mark)**
- **Multi-Factor Authentication (MFA):** Requiring users to supply secondary tokens or biometric identifiers alongside standard login credentials before accessing server storage layers. **(Any 3 measures, 1 mark each = 3 marks)**

Question 5 (3 Marks)

Binary Arithmetic Operation: $11011.01_2 + 101.11_2$

```
  11011.01
+   101.11
```

> ----------
> *100001.00*
>
> *Detailed Step-by-Step Working:*
> • *Fractional column 2^{-2} (rightmost): 1 + 1 = 0 carry 1*
> • *Fractional column 2^{-1}: 0 + 1 + 1 (carry) = 0 carry 1*
> • *Place the binary point aligned with the operands.*
> • *Units column 2^0: 1 + 1 + 1 (carry) = 1 carry 1*
> • *Twos column 2^1: 1 + 0 + 1 (carry) = 0 carry 1*
> • *Fours column 2^2: 0 + 1 + 1 (carry) = 0 carry 1*
> • *Eights column 2^3: 1 + 1 (carry) = 0 carry 1*
> • *Sixteens column 2^4: 1 + 1 (carry) = 0 carry 1*
> • *Thirty-twos column 2^5: brings down the 1 carry.*
> *Result = 100001.00_2 (or 100001_2)*

Marking Breakdown:

- **Alignment:** Proper vertical alignment of operands relative to the binary point. **(1 mark)**
- **Carries:** Correct processing of binary additions and structural carries. **(1 mark)**
- **Final Answer:** 100001.00_2 or 100001_2 clearly indicated. **(1 mark)**

Question 6 (2 Marks)

Role of a disk defragmenter utility program:

- **Consolidating scattered file fragments:** It rearranges non-contiguous clusters of files scattered across different mechanical sectors of the hard disk drive into contiguous storage sequences. **(1 mark)**
- **Optimizing file access speeds and free space:** By grouping related file data together and uniting free space fragments into a single continuous block, it minimizes physical drive read/write head movement, reducing disk latency and speeding up overall system performance. **(1 mark)**

Question 7 (2 Marks)

Definition of Bandwidth and its standard unit:

- **Definition:** Bandwidth is the maximum data transmission capacity of a network communication channel or medium, representing the volume of data that can be carried from one point to another within a fixed unit of time. **(1 mark)**
- **Standard Unit:** Bits per second (bps) — in modern high-speed contexts, commonly expressed as Megabits per second (Mbps) or Gigabits per second (Gbps). **(1 mark)**

Question 8 (3 Marks)

Standard functions of an operating system's kernel during memory management:

- **Memory Allocation & Deallocation:** Dynamically assigning specific blocks of primary memory (RAM) to active system processes and applications when they launch, and reclaiming those spaces when the processes terminate. **(1 mark)**
- **Memory Isolation & Protection:** Ensuring that executing programs do not overwrite or tamper with each other's allocated memory space or the memory space reserved for the kernel itself, preventing crashes and cross-process exploits. **(1 mark)**
- **Virtual Memory Management:** Overseeing paging and swapping operations when RAM capacity is exceeded, migrating inactive blocks between physical RAM and secondary disk-based swap space (virtual memory). **(1 mark)**
- **Tracking Memory Status:** Maintaining an updated internal map or allocation table detailing which bytes of physical memory are currently occupied by which processes and which bytes remain free. **(Any 3 functions, 1 mark each = 3 marks)**

Question 9 (2 Marks)

Disadvantages of adopting a Parallel Changeover strategy over a Direct Changeover approach:

- **High Operational Cost:** The organization incurs double expenditure because it must run and maintain two complete systems (hardware, software, power, and facilities) simultaneously. **(1 mark)**
- **Increased Employee Workload & Fatigue:** Data entry staff are required to input all transactions twice — once into the legacy system and once into the new automated inventory platform — causing duplication of effort and reduced productivity. **(1 mark)**
- **Data Duplication and Reconciliation Confusion:** Cross-checking discrepancies between outputs of both platforms requires complex, tedious audit procedures, which can lead to operational delays. **(Any 2 disadvantages, 1 mark each = 2 marks)**

Question 10 (3 Marks)

(a) Concept of a 'Foreign Key' in this context:

- **Explanation:** A foreign key is an attribute in the Employees table that matches the primary key of the Departments table. It acts as a relational bridge, enforcing referential integrity and linking each employee record to their respective department. **(1 mark)**

(b) Type of relationship and justification:

- **Relationship Type:** One-to-Many (1:M) **(1 mark)**
- **Justification:** A single Department can employ/contain many individual Employees, but each individual Employee belongs to only one specific Department at a given time. **(1 mark)**

Question 11 (2 Marks)

Reasons why an RDBMS is preferred over flat text files for dynamic websites:

- **Concurrent Multi-User Access & Locking:** An RDBMS safely handles hundreds of simultaneous customer connections using transaction controls and row-level locking mechanisms, whereas flat text files face file locking conflicts, causing corruption when multiple users write data concurrently. **(1 mark)**
- **Optimized Search Queries and Speed:** Utilizes advanced database index models and structured query tools (SQL) to fetch specific data records rapidly out of millions of lines, unlike flat files which require slow sequential reading from top to bottom. **(1 mark)**
- **Data Integrity & Relationship Support:** Enforces strict data types, field constraints, and relational rules (primary/foreign keys) natively, ensuring that orphaned records and corrupted forms are blocked automatically. **(Any 2 reasons, 1 mark each = 2 marks)**

Question 12 (2 Marks)

Physical indicators that a desktop computer's Power Supply Unit (PSU) is failing or overloaded:

- **Abnormal Fan Noise or Seizure:** The internal cooling fan emits excessive grinding noises due to bearing failure or stops spinning entirely, causing immediate heat accumulation. **(1 mark)**
- **Excessive Thermal Output or Burning Odor:** The PSU exhaust air feels extremely hot to the touch, or components emit a distinct electrical burning smell due to failing capacitors or overheating transformer coils. **(1 mark)**
- **Frequent Spontaneous System Reboots/Shutdowns:** The PC randomly switches off or reboots without warning, particularly during high-load processing phases, because the PSU voltage rails fluctuate or trip built-in over-current protections. **(Any 2 indicators, 1 mark each = 2 marks)**

Question 13 (2 Marks)

Function of an Analog-to-Digital Converter (ADC) within an automated greenhouse system:

- **Step 1: Sampling Continuous Physical Signals:** The soil moisture sensor measures physical characteristics continuously and outputs an analog electrical signal (varying voltage or current) corresponding to the dampness level. **(1 mark)**
- **Step 2: Conversion to Discrete Digital Binary:** The ADC processes this continuous voltage, converting it into discrete digital binary data strings (0s and 1s) that the digital greenhouse microcontroller can interpret, compare against thresholds, and act upon (e.g., triggering water pumps). **(1 mark)**

Question 14 (4 Marks)

Health risks associated with poor ergonomic setups and their mitigations:

- **Risk 1: Repetitive Strain Injury (RSI) / Carpal Tunnel Syndrome:** Inflammation of wrist tendons due to repetitive typing or awkward wrist positioning on non-ergonomic peripherals. **(1 mark)**
- **Mitigation 1:** Use contoured ergonomic keyboards, split layouts, wrist rests, and maintain an elbow angle of roughly 90 degrees while typing. **(1 mark)**
- **Risk 2: Computer Vision Syndrome (CVS) / Severe Eye Strain:** Eye fatigue, blurred vision, and dryness caused by prolonged focusing on low-refresh displays, harsh glare, or improper monitor distance. **(1 mark)**
- **Mitigation 2:** Position the screen about 50-70 cm from the eyes, apply anti-glare filters, adjust contrast, and practice the 20-20-20 rule (look 20 feet away for 20 seconds every 20 minutes). **(1 mark)**

Question 15 (3 Marks)

Characteristics of fifth-generation computer languages (5GL):

- **Constraint-Driven Programming:** Programs are designed around constraints and declarative conditions rather than specifying the exact step-by-step procedural algorithm or code logic. **(1 mark)**
- **Artificial Intelligence & Natural Language Integration:** They are extensively utilized in AI development, expert systems, and neural network research, heavily incorporating natural language syntax processing. **(1 mark)**
- **Intelligent Problem Solving:** The system utilizes rule-based logic processors to infer conclusions from a set of facts, rather than executing standard pre-compiled functions. **(1 mark)**

SECTION B (60 MARKS)

Question 16 (Compulsory) — 15 Marks

(a) Pseudocode Representation for the Discount Processing System (5 Marks):

```
START
   PRINT "Enter Customer Type (W for Wholesale, R for Retail):"
   READ Customer_Type
   PRINT "Enter Total Order Amount:"
   READ Amount

   IF Customer_Type == "W" THEN
      IF Amount >= 50000 THEN
         Discount_Rate = 0.15
      ELSEIF Amount >= 20000 AND Amount < 50000 THEN
         Discount_Rate = 0.10
      ELSE
         Discount_Rate = 0.05
      ENDIF

   ELSEIF Customer_Type == "R" THEN
      IF Amount >= 30000 THEN
         Discount_Rate = 0.08
      ELSE
         Discount_Rate = 0.02
      ENDIF

   ELSE
      PRINT "ERROR: Invalid Customer Type Code!"
      Discount_Rate = 0.00
   ENDIF

   Discount_Amount = Amount * Discount_Rate
   Net_Payable = Amount - Discount_Amount

   PRINT "Discount Amount: Sh. ", Discount_Amount
   PRINT "Final Net Payable Amount: Sh. ", Net_Payable
END
```

Pseudocode Marking Criteria:

- **Initial Inputs:** Correct initialization and reading of inputs (Customer_Type and Amount). **(1 mark)**
- **Wholesale Branch Structure:** Accurate nested IF-ELSE logic matching the three tiered brackets for Wholesale ('W'). **(1 mark)**
- **Retail Branch Structure:** Accurate nested IF-ELSE logic matching the two tiered brackets for Retail ('R'). **(1 mark)**
- **Error Fallback Branch:** Handling invalid inputs by printing an error message and setting discount to 0. **(1 mark)**
- **Calculations & Output:** Correct expression of Discount_Amount, Net_Payable formula, and clear final outputs. **(1 mark)**

(b) Detailed Program Flowchart (6 Marks):

Since standard graphical shapes cannot be dynamically drawn inside text bodies, the standard logic text layout below maps the full flow schema required for full grading evaluation:

```
[Terminator: Oval] -> Start
      |
[Input/Output: Parallelogram] -> Read Customer_Type, Amount
      |
[Decision: Diamond] -> Is Customer_Type == 'W'?
      |
      |---> YES: [Decision: Diamond] -> Is Amount >= 50,000?
      |            |---> YES: [Process: Rect] -> Discount_Rate = 0.15
      |            |---> NO:  [Decision: Diamond] -> Is Amount >= 20,000?
      |                         |---> YES: [Process: Rect] -> Discount_Rate = 0.10
      |                         |---> NO:  [Process: Rect] -> Discount_Rate = 0.05
      |
      |---> NO:  [Decision: Diamond] -> Is Customer_Type == 'R'?
                  |---> YES: [Decision: Diamond] -> Is Amount >= 30,000?
                  |            |---> YES: [Process: Rect] -> Discount_Rate = 0.08
                  |            |---> NO:  [Process: Rect] -> Discount_Rate = 0.02
                  |
                  |---> NO:  [Input/Output: Parallelogram] -> Print "ERROR"
                               |
                          [Process: Rect] -> Discount_Rate = 0.00
      |
      +---> (All structural logical paths merge here)
      |
[Process: Rectangle] -> Discount_Amount = Amount * Discount_Rate
                        Net_Payable = Amount - Discount_Amount
```

```
      |
[Input/Output: Parallelogram] -> Print Discount_Amount, Net_Payable
      |
[Terminator: Oval] -> End
```

Flowchart Marking Criteria:

- **Correct ANSI Standard Symbols:** Ovals for Start/End, Parallelograms for Input/Output, Rectangles for Processing, Diamonds for Decisions. **(2 marks)**
- **Logical Path Integrity:** All directional flowlines have clear arrow heads; decision splits are clearly labeled with YES/NO. **(2 marks)**
- **Accurate Branch Merging:** All conditional logic branches cleanly re-converge before execution of the final calculation blocks and termination. **(2 marks)**

(c) Three programmatic logic testing strategies (4 Marks):

- **Normal / Valid Testing:** Supplying values that fall directly within standard operational constraints (e.g., Customer_Type = 'W', Amount = Sh. 35,000) to confirm the module executes accurate percentage outputs under typical conditions. **(1 mark)**
- **Boundary Value Testing:** Testing data points directly on the limits of the conditional brackets (e.g., exactly Sh. 50,000, Sh. 49,999, or Sh. 20,000) to guarantee inequality expressions (>= vs >) trigger correctly without off-by-one errors. **(1 mark)**
- **Erroneous / Invalid Testing:** Inputting completely illegal data arguments (e.g., Customer_Type = 'X', or negative amount figures) to verify that the error trapping paths respond gracefully. **(1 mark)**
- **Dry Running / Desk Checking:** Manually tracing the variables step-by-step through the code structure on paper using sample data tables before actual execution to map code path accuracy. **(Award 1 mark per strategy described + 1 mark for structured technical clarity across the response, Max 4 marks)**

Question 17 (15 Marks)

(a) Convert denary fraction 23.625_{10} into binary notation (3 Marks):

1. Integer Part Conversion (Divide by 2 repeatedly):

- *23 ÷ 2 = 11 remainder 1 (LSB)*
- *11 ÷ 2 = 5 remainder 1*
- *5 ÷ 2 = 2 remainder 1*
- *2 ÷ 2 = 1 remainder 0*
- *1 ÷ 2 = 0 remainder 1 (MSB)*

Reading bottom to top: $23_{10} = 10111_2$

2. Fractional Part Conversion (Multiply by 2 repeatedly):
- *$0.625 \times 2 = 1.250$ -> Extract 1*
- *$0.250 \times 2 = 0.500$ -> Extract 0*
- *$0.500 \times 2 = 1.000$ -> Extract 1 (Stop when fractional part is 0)*

Reading top to bottom: $0.625_{10} = .101_2$

3. Combine both segments:
Final Binary Result = 10111.101_2

Marking Breakdown:

- **Integer steps:** Showing correct sequential division for 23 resulting in 10111. **(1 mark)**
- **Fractional steps:** Showing correct sequential multiplication for 0.625 resulting in .101. **(1 mark)**
- **Final result:** Accurate fusion showing 10111.101_2 with correct base notation. **(1 mark)**

(b) Subtraction arithmetic using 8-bit Two's Complement: $28_{10} - 43_{10}$ (5 Marks):

The operation is treated as: $28_{10} + (-43_{10})$

Step 1: Convert positive 28_{10} to an 8-bit binary string:
- *$28 = 16 + 8 + 4$ -> 11100_2*
- *Pad to 8 bits -> 00011100_2*

Step 2: Convert positive 43_{10} to an 8-bit binary string:
- *$43 = 32 + 8 + 2 + 1$ -> 101011_2*
- *Pad to 8 bits -> 00101011_2*

Step 3: Derive Two's Complement representation for -43_{10}:
- *Invert all bits of positive 43 (One's Complement): 11010100_2*
- *Add 1 to the LSB: $11010100 + 1 = 11010101_2$*
- *Therefore, $-43_{10} = 11010101_2$*

Step 4: Perform binary addition of the two 8-bit strings:

```
  00011100  ( 28₁₀)
+ 11010101  (-43₁₀)
----------
  11110001  (Final binary result)
```

> *Step 5: Verify the result by converting back to Decimal:*
> • *Since the MSB is 1, the result is negative.*
> • *To find magnitude, invert bits of 11110001 -> 00001110*
> • *Add 1 -> 00001111_2*
> • *$00001111_2 = 8 + 4 + 2 + 1 = 15_{10}$*
> • *Applying the negative sign gives -15_{10}.*
> • *Check: 28 - 43 = -15. (Matches perfectly)*

Marking Breakdown:

- **Operand 1:** Correct 8-bit binary representation of +28 (00011100). **(1 mark)**
- **Operand 2 conversion:** Correct inversion and addition of 1 to find -43 (11010101). **(2 marks)**
- **Addition stage:** Accurate binary addition showing all intermediate carries. **(1 mark)**
- **Verification:** Correct conversion to final binary string 11110001 and confirmation of decimal value -15. **(1 mark)**

(c) 24-bit True Color display panels calculations:

- **(i) Unique colors calculation:** The total number of unique colors is determined by evaluating 2 raised to the power of the bit depth. Index form = 2^{24}. Fully evaluated = 16,777,216 colors. **(2 marks)**
- **(ii) Theoretical minimum storage capacity for a single frame buffer:** Total pixels = 1920 × 1080 = 2,073,600 pixels.
  Each pixel requires 24 bits = 3 Bytes.
  Total Bytes = 2,073,600 × 3 = 6,220,800 Bytes.
  Convert to KB = 6,220,800 ÷ 1024 = 6,075 KB.
  Convert to MB = 6,075 ÷ 1024 = 5.9326 MB (Accept 5.93 MB). **(2 marks)**

(d) Distinction between ASCII and Unicode character definitions:

- **ASCII framework:** Utilizes a restricted 7-bit or 8-bit character mapping framework, topping out at a maximum of 128 or 256 unique character slots. It is exclusively suited for basic English alphanumeric text. **(1 mark)**
- **Unicode Framework:** Utilizes an expanded variable-width framework (ranging from 16-bit up to 32-bit blocks, such as UTF-16/UTF-8), establishing over 140,000 unique entry positions. **(1 mark)**
- **Global Baseline Strategy:** Unicode can simultaneously represent character structures from nearly all active global languages making it an absolute baseline requirement for localized enterprise application design. **(1 mark)**

Question 18 (15 Marks)

(a) Structural benefits of selecting a Mesh topology over a Star topology for a backbone network:

- **High Fault Tolerance & Redundancy:** In a mesh layout, multiple redundant point-to-point physical transmission paths link every core switch node. If an inter-building trunk cable or fiber link fails, routing algorithms instantly redirect data across alternative paths. In contrast, if a central hub switch in a star layout fails, the entire network drops. **(2 marks)**
- **Elimination of Central Processing Bottlenecks:** Data routing loads are distributed across all active nodes rather than being pushed entirely through a single central star node, reducing routing congestion during peak business traffic hours. **(2 marks)**

(b) Transmission principles and media options selection justifications:

- **(i) Physical transmission principle of Fiber Optic:** Fiber optic lines rely on the principle of Total Internal Reflection. Light pulses generated by laser diodes travel down a pure silica glass core. Because the surrounding cladding layer has a lower refractive index, the light rays are constantly reflected back into the core, preventing loss and maintaining low signal attenuation over very long distances. **(2 marks)**
- **(ii) Reasons Cat6 UTP is preferred over Coaxial cable for desktop client nodes:** Cat6 UTP provides substantially higher data bandwidth rates (up to 10 Gbps over shorter runs) compared to legacy coaxial designs. Additionally, UTP Cat6 is highly flexible, thinner, easier to terminate with standard RJ-45 clips, and far more cost-effective to install. **(2 marks)**

(c) Definition of IP Address and assignment methodology comparison:

- **IP Address Definition:** An Internet Protocol (IP) address is a unique numerical identifier assigned to each node or device connected to a network, serving to locate and route data to that device. **(1 mark)**
- **Static IP Assignment:** The network administrator manually configures a fixed IP address within the operating settings of the target device. This address never changes automatically, making it ideal for servers and shared network printers. **(1 mark)**
- **Dynamic IP Assignment:** A Dynamic Host Configuration Protocol (DHCP) server automatically assigns a temporary IP address to a client machine from an available pool when it boots up. This address is leased and may change over time. **(2 marks)**

(d) Function of a Domain Name System (DNS) server on an intranet browser terminal:

- **Step 1: Intercepting Human-Readable URLs:** When a user inputs a text-based domain name like 'www.knec.ac.ke', the internal computer terminal sends a resolution query to the DNS server because routers cannot process plain text strings. **(1 mark)**
- **Step 2: Looking up IP Mappings:** The DNS server searches its internal database tables or queries authoritative root directory systems to match the text domain name against its corresponding numeric IP address (e.g., 192.0.2.50). **(1 mark)**

- **Step 3: Returning the IP Address:** The DNS server sends the resolved IP address back to the user's browser, allowing it to establish a direct HTTP/HTTPS connection with the target web server. **(1 mark)**

Question 19 (15 Marks)

(a) Dimensions evaluated during a baseline feasibility study phase:

- **(i) Economic Feasibility Audit:** An evaluation of the financial viability of the project. It involves conducting a Cost-Benefit Analysis (CBA) to compare total development costs (hardware, development time, licensing) against anticipated long-term savings and financial returns, ensuring the project fits within budget. **(2 marks)**
- **(ii) Operational Feasibility Audit:** An assessment of how well the proposed system will fit into the existing organizational culture and workflows. It evaluates user acceptance levels, required training, and whether employees will support or resist the new system. **(2 marks)**

(b) Three factual investigation methodologies to collect detailed system requirements:

- **Direct Observation:** The analyst stands alongside operational staff during regular working hours to watch their actual day-to-day routines, identifying process bottlenecks that staff might fail to describe in text forms. **(1 mark)**
- **Interviews:** Conducting face-to-face, structured or unstructured conversations with key stakeholders and staff members to gather deep qualitative insights and perspectives about current system failures. **(1 mark)**
- **Questionnaires:** Distributing standardized forms with open or closed-ended questions to a large number of geographically scattered staff members to efficiently gather statistical data. **(1 mark)**
- **Document Review / Artifact Analysis:** Examining existing user manuals, data logs, paper forms, files, and balance sheets to understand the current system's data structures. **(Any 3 methodologies, 1 mark each = 3 marks)**

(c) Distinguish between Adaptive and Corrective Maintenance frameworks with case scenarios:

- **Adaptive Maintenance:** Modifying a software system after delivery to keep it operational and compatible with changes in its business or technical environment (such as a new operating system or legal regulation), without changing its core functions. **(1 mark)**
- **Adaptive Scenario:** Updating the payroll module's tax calculation tables to comply with new statutory tax changes introduced by the government. **(1 mark)**
- **Corrective Maintenance:** Diagnosing and fixing errors, bugs, or logical processing faults discovered by users after the system goes live into production. **(1 mark)**
- **Corrective Scenario:** Fixing a runtime error that crashes the inventory system whenever a user tries to process an order containing more than 1,000 unique items. **(1 mark)**

(d) Role and value of a Data Flow Diagram (DFD) during logical system design:

- **Graphic Modeling Asset:** A Data Flow Diagram (DFD) provides a clear graphical representation of how data moves through an information system. It maps inputs, operational processes, data storage repositories, and destination outputs using standard symbols. **(2 marks)**
- **Analytical Value in System Design:** It helps systems engineers identify logical errors, data bottlenecks, missing inputs, or redundant data paths before any physical coding begins. Additionally, it serves as a clear blueprint for communication between technical developers and non-technical business clients. **(2 marks)**

Question 20 (15 Marks)

(a) Define 'Referential Integrity' and outline its database enforcement mechanics:

- **Definition:** Referential integrity is a data validation rule which guarantees that relationships between database tables remain synchronized and consistent, ensuring that no foreign key pointing to a non-existent primary key can ever be created. **(1 mark)**
- **Enforcement Mechanism:** The database engine enforces this rule by preventing users from adding a record to a child table if its foreign key does not match an existing primary key in the parent table. It also blocks users from deleting or changing a parent record if corresponding child records exist. **(2 marks)**

(b) Analysis of the raw un-normalized student course bookings relation:

- **(i) Explanation of First Normal Form (1NF) violation:** The table violates the rules of 1NF because it contains non-atomic (repeating or multi-valued) data attributes within single row entries. Specifically, fields like CourseID, CourseTitle, and InstructorName contain lists of multiple values separated by commas (e.g., 'C401, C405') within a single row cell, which breaks relational database design principles. **(2 marks)**

(ii) Normalized 1NF State Representation (2 Marks):

StudentID	StudentName	CourseID	CourseTitle	InstructorName
S101	Alice Mwangi	C401	Computer Studies	Mr. Omwamba
S101	Alice Mwangi	C405	Mathematics	Mrs. Cheruiyot
S102	John Kiprop	C401	Computer Studies	Mr. Omwamba
S103	Mary Atieno	C405	Mathematics	Mrs. Cheruiyot
S103	Mary Atieno	C409	Physics	Mr. Njoroge

(c) Distinguish between 'Data Redundancy' and 'Data Independence' inside enterprise databases:

- **Data Redundancy:** The unnecessary duplication of the same data fields across multiple tables or files within a database ecosystem. This causes wasted storage space and leads to data anomalies and inconsistencies when a value is updated in one place but left unchanged elsewhere. **(2 marks)**
- **Data Independence:** The structural separation of data descriptions from the application programs that use it. It ensures that changes made to the database's physical storage layout or logical schema do not require rewriting the application software code. **(2 marks)**

(d) Benefit of creating an 'Index' configuration path on non-primary fields:

- **Accelerated Query Search Speeds:** An index creates an optimized pointer lookup path (typically using balanced trees or hash maps) that allows the database engine to find records instantly based on indexed fields, without having to scan through every row in the table from top to bottom. **(2 marks)**
- **Performance Optimization for Sorting and Joins:** It significantly speeds up the execution of complex query commands involving 'WHERE' filters, 'ORDER BY' sorting clauses, and table 'JOIN' fields, reducing server CPU utilization and disk read overhead during peak application traffic hours. **(2 marks)**