NEPAL ENGINEERING COUNCIL (NEC)

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REGISTRATION EXAMINATION FOR COMPUTER ENGINEERING (BCT) — MODEL EXAM SET 01

Time Allowed:	Maximum Marks:	Pass Marks:	Negative Marking:
2 Hours (120 Mins)	**100 Marks**	**50 Marks**	**Nil (None)**

Candidate Name: ..... Roll No: ..... Center: .....

INSTRUCTIONS TO CANDIDATES

1. This Question Booklet contains **100 Multiple Choice Questions (MCQs)** divided equally across the 10 chapters of the official NEC Computer Engineering (ACtE) Syllabus (10 questions per section).
2. Each question carries **1 (one) mark**. All questions are compulsory. There is **no negative marking**.
3. Each question has four options marked (A), (B), (C), and (D). Select only **ONE** best answer for each question.
4. Darken the corresponding oval completely on the Optical Mark Recognition (OMR) Answer Sheet with a black or blue ballpoint pen.
5. Non-programmable scientific calculators are permitted. Electronic storage devices, smart watches, and mobile phones are strictly prohibited.

SECTION I: CONCEPT OF BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

Questions 01 – 10 (10 Marks)

Q.01 1.1 Basic Concept & Star-Delta Conversion

Three identical resistors, each having a resistance of 12 Ω, are connected in a Delta (Δ) network. What is the equivalent resistance of each branch when transformed into an equivalent Star (Y) network?

(A) 36 Ω
(B) 12 Ω
(C) 4 Ω
(D) 6 Ω

Q.02 1.2 Network Theorems: Thevenin's Theorem

When determining the Thevenin equivalent resistance (R_{th}) looking into the load terminals of a linear bilateral network, how must the independent sources inside the network be deactivated?

(A) Independent voltage sources are open-circuited; independent current sources are short-circuited
(B) Independent voltage sources are short-circuited; independent current sources are open-circuited
(C) Both independent voltage sources and independent current sources are short-circuited
(D) Both independent voltage sources and independent current sources are open-circuited

Q.03 1.2 Maximum Power Transfer Theorem

A DC source has an open-circuit voltage of $V_{th} = 24\ \text{V}$ and an internal Thevenin resistance of $R_{th} = 6\,\Omega$. What is the maximum power that can be delivered to a variable load resistor R_L, and what is the electrical transmission efficiency at this operating point?

(A) 96 W at 100% efficiency
(B) 48 W at 75% efficiency
(C) 24 W at 50% efficiency
(D) 12 W at 25% efficiency

Q.04 1.2 R-L-C Circuits & Resonance

In a series RLC AC circuit operating precisely at its resonant frequency (f_0), which of the following statements is strictly TRUE?

(A) Inductive reactance exceeds capacitive reactance, causing current to lag behind applied voltage

(B) Total circuit impedance is at its minimum and purely resistive ($Z = R$), resulting in a unity power factor

(C) Total circuit impedance is at its maximum and the current drops to zero

(D) The circuit exhibits net capacitive behavior with a phase angle of $\phi = -90^\circ$

Q.05 1.3 Alternating Current Fundamentals: 3-Phase Systems

In a balanced three-phase Star (Wye) connected AC electrical system, what is the exact mathematical relationship between the line parameters (V_L, I_L) and phase parameters (V_{ph}, I_{ph})?

(A) $V_L = V_{ph}$ and $I_L = \sqrt{3} I_{ph}$

(B) $V_L = \sqrt{3} V_{ph}$ and $I_L = I_{ph}$

(C) $V_L = \sqrt{3} V_{ph}$ and $I_L = \sqrt{3} I_{ph}$

(D) $V_L = \frac{V_{ph}}{\sqrt{3}}$ and $I_L = I_{ph}$

Q.06 1.4 Semiconductor Devices: Diodes

How does the reverse saturation current (I_0) of a standard silicon P-N junction diode change with an increase in junction operating temperature?

(A) It decreases by approximately 50% for every 10°C rise in temperature

(B) It remains completely independent of temperature because it depends solely on doping density

(C) It approximately doubles for every 10°C rise in temperature

(D) It increases linearly with absolute temperature T according to Ohm's law

Q.07 1.4 Semiconductor Devices: BJT Biasing

For a Bipolar Junction Transistor (BJT) to operate stably in its Active (linear amplification) region, what must be the respective biasing conditions of its two junctions?

(A) Both Emitter-Base and Collector-Base junctions must be forward biased

(B) Emitter-Base junction must be forward biased, and Collector-Base junction must be reverse biased

(C) Emitter-Base junction must be reverse biased, and Collector-Base junction must be forward biased

(D) Both Emitter-Base and Collector-Base junctions must be reverse biased

Q.08 1.4 Semiconductor Devices: MOSFET & CMOS

Why are MOSFETs overwhelmingly preferred over BJTs in high-density integrated circuits such as modern microprocessors and semiconductor memory?

(A) MOSFETs require higher base drive current and produce lower thermal dissipation

(B) MOSFETs have extremely high input impedance with negligible static gate current and occupy significantly smaller silicon chip area

(C) MOSFETs are minority carrier devices that exhibit zero carrier storage delay

(D) MOSFETs possess lower cut-off frequencies and higher flicker noise than BJTs

Q.09 1.5 Signal Generator: Oscillators

According to the Barkhausen criterion, what are the two essential conditions required for an electronic amplifier feedback circuit to sustain continuous sinusoidal oscillations?

(A) Loop gain magnitude $|A\beta| = 0$ and net phase shift around the feedback loop must be 90°

(B) Loop gain magnitude $|A\beta| = 1$ and net phase shift around the feedback loop must be 0° or an integer multiple of 360°

(C) Closed loop gain must be strictly negative with a phase shift of 180°

(D) Feedback fraction β must be zero and open loop gain $A \to \infty$

Q.10 1.6 Amplifiers: Operational Amplifiers

In an operational amplifier (Op-Amp), the Common-Mode Rejection Ratio (CMRR) is formally defined as the ratio of:

(A) Differential gain (A_d) to common-mode gain (A_{cm})
(B) Common-mode gain (A_{cm}) to differential gain (A_d)
(C) Output voltage to input offset current
(D) Slew rate to unity-gain bandwidth

SECTION II: DIGITAL LOGIC AND MICROPROCESSOR

Questions 11 – 20 (10 Marks)

Q.11 2.1 Digital Logic: Number Systems & 2's Complement

In an 8-bit signed two's complement binary number system, what is the valid numerical range of representable decimal values, and what decimal value does the bit pattern `1111 0110` represent?

(A) -128 to +127; the pattern represents -10
(B) -127 to +128; the pattern represents -246
(C) -256 to +255; the pattern represents +246
(D) -128 to +127; the pattern represents -26

Q.12 2.1 Boolean Algebra & K-Maps

What is the minimal Sum-of-Products (SOP) Boolean expression for the function $F(A, B, C) = \sum m(1, 3, 5, 7)$?

(A) A
(B) B
(C) C
(D) A' + C

Q.13 2.2 Combinational Circuits: Multiplexers

How many 4-to-1 multiplexers are required to construct a single 16-to-1 multiplexer without using any additional external logic gates?

(A) 4
(B) 5
(C) 8
(D) 16

Q.14 2.2 Combinational Circuits: Encoders

In a 4-to-2 Priority Encoder where input D_3 has the highest priority and D_0 has the lowest priority, what is the output code (Y_1Y_0) when inputs D_2 and D_1 are simultaneously active HIGH (with $D_3 = 0$ and $D_0 = 1$)?

(A) 00
(B) 01
(C) 10
(D) 11

Q.15 2.3 Sequential Logic: Flip-Flops

Under what specific condition does the 'Race-Around Condition' occur in a level-triggered JK flip-flop?

(A) When $J = 0, K = 0$ and the clock pulse width is less than the propagation delay ($t_w < t_{pd}$)
(B) When $J = 1, K = 1$ and the clock pulse width exceeds the flip-flop propagation delay ($t_w > t_{pd}$)
(C) When $J = 1, K = 0$ and the clock signal is grounded
(D) When $J = 0, K = 1$ and the propagation delay is zero

Q.16 2.3 Sequential Logic: Counters

What is the total number of distinct operating states (modulus) for a 4-bit Johnson (twisted-ring) counter and a 4-bit standard Ring counter, respectively?

(A) 16 and 4
(B) 8 and 4
(C) 8 and 16
(D) 4 and 8

Q.17 2.4 Microprocessor: 8085 Architecture

In the Intel 8085 microprocessor, how is the lower-order multiplexed Address/Data bus ($AD_0 - AD_7$) demultiplexed to obtain separate address lines ($A_0 - A_7$) and data lines ($D_0 - D_7$)?

(A) By connecting the $\overline{RD}$ control signal to a bidirectional bus transceiver (74LS245)

(B) By using the Address Latch Enable (ALE) signal to latch the lower address byte into an external octal latch (74LS373)

(C) By connecting the $IO/\overline{M}$ control signal directly to a 3-to-8 line decoder (74LS138)

(D) By using the READY input signal to hold the CPU in wait states

Q.18 2.4 Microprocessor: Addressing Modes

The Intel 8085 assembly language instruction `LDAX B` loads the accumulator with data from the memory location specified by the BC register pair. Which addressing mode does this instruction employ?

(A) Direct addressing mode

(B) Immediate addressing mode

(C) Register Indirect addressing mode

(D) Implicit / Implied addressing mode

Q.19 2.5 Microprocessor System: Peripheral Interfacing (8255 PPI)

Which operating mode of the Intel 8255 Programmable Peripheral Interface (PPI) supports bidirectional 8-bit bus data transfer on Port A with handshake signals provided by Port C?

(A) Mode 0 (Basic Input/Output)

(B) Mode 1 (Strobed Input/Output)

(C) Mode 2 (Strobed Bidirectional Bus I/O)

(D) Bit Set/Reset (BSR) Mode

Q.20 2.6 Interrupt Operations: 8085 Interrupts

Which hardware interrupt in the Intel 8085 microprocessor is non-maskable, holds the highest priority, and automatically transfers execution to vector memory address `0024H`?

(A) INTR

(B) RST 7.5

(C) RST 6.5

(D) TRAP

SECTION III: PROGRAMMING LANGUAGE AND ITS APPLICATIONS

Questions 21 – 30 (10 Marks)

Q.21 3.1 C Programming: Operators & Short-Circuit Evaluation

What is the exact terminal output generated by the following C program segment?

```
int a = 0, b = 5;
if (a++ && ++b) {
    b += 2;
}
printf("%d %d", a, b);
```

(A) 1 5

(B) 1 6

(C) 0 5

(D) 1 8

Q.22 3.2 Pointers, Structures & Files in C

Given the C declarations:

```
int arr[] = {10, 20, 30, 40, 50};
int *p = arr;
```

What is the evaluated integer result of the expression `*p++ + *(++p)`?

(A) 30

(B) 40

(C) 50

(D) 60

Q.23 3.2 Structures vs Unions: Memory Allocation

In C on a standard 64-bit architecture with 8-byte boundary alignment, what is `sizeof(union Sample)` for the following definition?

```
union Sample {
    int i;        /* 4 bytes */
    char str[21]; /* 21 bytes */
    double d;     /* 8 bytes */
};
```

(A) 33 bytes
(B) 24 bytes
(C) 21 bytes
(D) 8 bytes

Q.24 3.2 Dynamic Memory Allocation & Pointers

What is a 'dangling pointer' in C and C++ programming?

(A) A pointer declared but never initialized to any memory address
(B) A pointer pointing to a memory location that has already been deallocated using `free()` or `delete`
(C) A pointer explicitly initialized to `NULL` to prevent invalid memory dereferencing
(D) A void pointer (`void*`) that cannot be dereferenced without an explicit type cast

Q.25 3.3 C++ Classes & Objects: this Pointer

Which of the following statements regarding the `this` pointer in C++ is strictly TRUE?

(A) The `this` pointer is implicitly available inside static member functions
(B) The `this` pointer is passed as a hidden constant pointer argument to all non-static member functions, pointing to the invoking object instance
(C) The `this` pointer can be explicitly reassigned to point to another object inside a member function
(D) The `this` pointer exists only when objects are created dynamically on the heap via `new`

Q.26 3.4 OOP Features: Inheritance & Constructors

In C++, when an instance of a derived class `Derived` that inherits from base class `Base` is instantiated and subsequently destroyed, what is the exact execution order of their constructors and destructors?

(A) Derived constructor → Base constructor → Base destructor → Derived destructor
(B) Base constructor → Derived constructor → Derived destructor → Base destructor
(C) Base constructor → Derived constructor → Base destructor → Derived destructor
(D) Derived constructor → Base constructor → Derived destructor → Base destructor

Q.27 3.4 OOP Features: Operator Overloading

Which of the following groups of C++ operators CANNOT be overloaded under any circumstances according to the ISO C++ standard?

(A) +, -, *, /
(B) ==, !=, <, >
(C) ., .*, ::, ?:, sizeof
(D) [], (), ->, =

Q.28 3.5 Pure Virtual Function & Dynamic Binding

How is runtime (late) polymorphism and dynamic dispatch implemented under the hood by C++ compilers for classes containing virtual functions?

(A) Through compile-time inline substitution and template specialization
(B) Through a Virtual Method Table (VTABLE) of function pointers and a hidden virtual table pointer (`vptr`) embedded inside each object
(C) Exclusively through runtime type identification (RTTI) and dynamic memory casting
(D) By maintaining a global hash map of string method names checked on every call

Q.29 3.6 Generic Programming: Standard Template Library (STL)

In the C++ Standard Template Library (STL), which underlying data structure is typically used to implement `std::map`, and what is its guaranteed worst-case search time complexity for n elements?

(A) Hash Table with $O(1)$ search time

(B) Red-Black Tree (Self-balancing BST) with $O(\log n)$ search time

(C) Doubly Linked List with $O(n)$ search time

(D) Binary Min-Heap with $O(1)$ search time

Q.30 3.6 Exception Handling Constructs

In C++, what crucial safety mechanism occurs during exception propagation when an exception is thrown from a deeply nested function call?

(A) The operating system halts all other threads immediately

(B) Stack unwinding automatically invokes destructors in reverse order for all local automatic objects constructed within the exited scopes

(C) All dynamically allocated heap memory (`malloc` / `new`) is automatically garbage-collected

(D) Global variables are rolled back to their initial compile-time states

SECTION IV: COMPUTER ORGANIZATION AND EMBEDDED SYSTEM

Questions 31 – 40 (10 Marks)

Q.31 4.1 CPU Control Unit Design: Hardwired vs Microprogrammed

Compared to a microprogrammed control unit, a hardwired control unit:

(A) Is slower in execution speed and much more flexible to modify

(B) Stores control words in a dedicated internal Control Memory ROM

(C) Executes instructions faster because control signals are generated directly by combinational logic circuits, but is difficult to modify

(D) Requires higher microinstruction decode overhead and larger memory area

Q.32 4.1 Instruction Pipelining & Hazards

In an instruction pipeline, a Read-After-Write (RAW) data hazard occurs when:

(A) Two distinct instructions attempt to access the same physical hardware ALU functional unit simultaneously

(B) An instruction requires the result of an earlier instruction that has not yet completed its write-back stage to the register file

(C) A conditional branch instruction dynamically alters the Program Counter value

(D) An instruction attempts to write a register before a previous instruction has finished reading it

Q.33 4.2 Memory Hierarchy & Cache Design

A 32-bit byte-addressable computer system has a 64 KB 4-way set-associative cache with a block (line) size of 64 bytes. What are the bit widths of the Tag, Set Index, and Block Offset fields, respectively?

(A) Tag = 18 bits, Index = 8 bits, Offset = 6 bits

(B) Tag = 16 bits, Index = 10 bits, Offset = 6 bits

(C) Tag = 20 bits, Index = 6 bits, Offset = 6 bits

(D) Tag = 14 bits, Index = 12 bits, Offset = 6 bits

Q.34 4.2 Memory System: Cache Write Policies

In a cache memory subsystem employing a **Write-Back policy with a 'dirty bit':**

(A) Main memory is updated immediately on every CPU write cycle

(B) Write operations modify only the cache line, and main memory is updated only when that modified cache line is replaced (evicted)

(C) Data is written directly to secondary storage, bypassing main memory entirely

(D) Write misses always cause a system interrupt and flush the cache

Q.35 4.2 Virtual Memory & Address Translation

What is the primary architectural purpose of a Translation Lookaside Buffer (TLB) in a paged virtual memory system?

(A) To cache recently used disk blocks to speed up I/O transfers

(B) To act as a high-speed associative hardware cache for recently used virtual-to-physical page translation entries, avoiding slow main memory page table lookups

(C) To store dirty pages that are waiting to be swapped out to disk

(D) To provide cryptographic key validation for secure virtual machine isolation

Q.36 4.3 Input-Output Organization & DMA

During a **Cycle Stealing Direct Memory Access (DMA) transfer mode:**

(A) The DMA controller retains mastership of the system bus and transfers an entire block of data continuously without releasing the bus

(B) The DMA controller acquires the system bus to transfer exactly one data word/byte, then relinquishes bus control back to the CPU

(C) The CPU is put into a permanent reset state until the disk transfer completes

(D) All data words must pass through the CPU accumulator register before reaching memory

Q.37 4.3 Multiprocessor Architectures: Flynn's Taxonomy

According to Flynn's taxonomy of computer architectures, a modern Graphics Processing Unit (GPU) executing identical shader kernel instructions across thousands of independent data points simultaneously is categorized as:

(A) SISD (Single Instruction, Single Data)

(B) SIMD (Single Instruction, Multiple Data)

(C) MISD (Multiple Instruction, Single Data)

(D) MIMD (Multiple Instruction, Multiple Data)

Q.38 4.4 Embedded Systems: Hardware Architecture

Many embedded microcontrollers (such as AVR and PIC) are based on the **Harvard Architecture rather than the von Neumann architecture primarily because:**

(A) Harvard architecture shares a single memory bus for both code and data, minimizing chip packaging pin count

(B) Harvard architecture uses physically separate memories and buses for program instructions and data, enabling simultaneous instruction fetch and data read/write

(C) Harvard architecture eliminates the need for an Arithmetic Logic Unit (ALU)

(D) Harvard architecture requires no external oscillator or clock generator

Q.39 4.5 Real-Time Operating Systems: Task Scheduling

In a Real-Time Operating System (RTOS), 'Priority Inversion' occurs when a high-priority task is blocked waiting for a shared mutex held by a low-priority task, while a medium-priority task preempts the low-priority task. What standard protocol resolves this issue?

(A) Round-Robin Time Slicing

(B) Priority Inheritance Protocol (PIP)

(C) First-Come First-Served (FCFS) Scheduling

(D) Shortest Job First (SJF) Scheduling

Q.40 4.6 Hardware Description Languages: VHDL

In VHDL digital hardware design, which construct defines the external input/output interface ports of a module, and which construct describes its internal logic behavior or structural interconnection?

(A) `ARCHITECTURE` defines external ports; `ENTITY` defines internal logic

(B) `ENTITY` defines external ports; `ARCHITECTURE` defines internal logic

(C) `PACKAGE` defines external ports; `CONFIGURATION` defines internal logic

(D) `PROCESS` defines external ports; `SIGNAL` defines internal logic

SECTION V: CONCEPT OF COMPUTER NETWORK AND NETWORK SECURITY SYSTEM

Questions 41 – 50 (10 Marks)

Q.41 5.1 Networking Models: Protocol Data Units (PDUs)

What are the standard Protocol Data Unit (PDU) designations at the Transport, Network, and Data Link layers of the OSI model?

(A) Packet, Segment, Frame
(B) Segment, Packet, Frame
(C) Frame, Packet, Datagram
(D) Message, Bit, Byte

Q.42 5.2 Data Link Layer: Error Detection (CRC)

In Cyclic Redundancy Check (CRC) error detection, if the generator polynomial is $G(x) = x^4 + x + 1$, how many bits of Frame Check Sequence (FCS / CRC remainder) will be appended to the transmitted data frame?

(A) 5 bits
(B) 4 bits
(C) 3 bits
(D) 1 bit

Q.43 5.2 MAC Protocols: CSMA/CD Minimum Frame Size

In a 100 Mbps CSMA/CD Ethernet network with a maximum one-way propagation delay of $t_p = 25.6\ \mu s$, what is the theoretical minimum frame size required to guarantee that collisions are reliably detected?

(A) 64 bytes
(B) 128 bytes
(C) 512 bytes
(D) 640 bytes

Q.44 5.3 Network Layer: IPv4 Subnetting & CIDR

An enterprise network is allocated the IPv4 CIDR block `192.168.10.0/26`. What is its subnet mask, the number of assignable host IP addresses, and its directed broadcast address?

(A) Subnet Mask: 255.255.255.192; Usable Hosts: 62; Broadcast: 192.168.10.63
(B) Subnet Mask: 255.255.255.128; Usable Hosts: 126; Broadcast: 192.168.10.127
(C) Subnet Mask: 255.255.255.224; Usable Hosts: 30; Broadcast: 192.168.10.31
(D) Subnet Mask: 255.255.255.240; Usable Hosts: 14; Broadcast: 192.168.10.15

Q.45 5.3 Network Layer: Routing Protocols

What primary problem causes the 'Count-to-Infinity' phenomenon in Distance Vector routing protocols (e.g., RIP), and which technique is used to combat it?

(A) Flooding overhead in link-state packets; solved by Dijkstra's shortest path algorithm
(B) Slow propagation of link failure information leading to routing loops; mitigated by Split Horizon with Poison Reverse
(C) Exhaustion of autonomous system numbers; mitigated by BGP path attributes
(D) Excessive ARP broadcast storms; mitigated by Spanning Tree Protocol (STP)

Q.46 5.4 Transport Layer: TCP Connection Establishment

During the standard TCP Three-Way Handshake used to establish a reliable transport connection, what is the exact sequence of control flag packets exchanged between client and server?

(A) Client sends `ACK` → Server sends `SYN` → Client sends `SYN+ACK`
(B) Client sends `SYN` → Server sends `SYN+ACK` → Client sends `ACK`
(C) Client sends `FIN` → Server sends `ACK` → Client sends `FIN+ACK`
(D) Client sends `RST` → Server sends `SYN` → Client sends `ACK`

Q.47 5.4 Transport Layer: TCP Congestion Control

In TCP Reno congestion control, how does the congestion window size (`cwnd`) grow during the **Slow Start phase upon receiving acknowledgments?**

(A) It increases linearly by 1 Maximum Segment Size (MSS) per Round Trip Time (RTT)

(B) It doubles every Round Trip Time (RTT), exhibiting exponential growth until reaching `ssthresh`

(C) It remains fixed at 64 KB until packet loss occurs

(D) It decreases by half for every unacknowledged packet

Q.48 5.5 Application Layer: DNS Resolution

What is the key functional difference between a **recursive DNS query and an **iterative** DNS query?**

(A) In recursive queries, the client contacts each nameserver directly; in iterative queries, the local server handles all communication

(B) In a recursive query, the queried DNS server assumes full responsibility to resolve the domain and return the final IP address; in an iterative query, the server returns the best referral IP address to the next authoritative server

(C) Recursive queries use TCP port 53 exclusively; iterative queries use UDP port 53 exclusively

(D) Recursive queries are used only for reverse IP lookups, while iterative queries are for forward lookups

Q.49 5.6 Network Security: Cryptography (RSA)

In the RSA public-key cryptographic algorithm, given two prime numbers $p = 7$ and $q = 11$, and a public encryption exponent $e = 13$, what is the modulus n and the private decryption key d?

(A) $n = 77, d = 37$

(B) $n = 77, d = 13$

(C) $n = 70, d = 23$

(D) $n = 60, d = 17$

Q.50 5.6 Network Security: IPsec Modes

In IPsec (IP Security), how does **Tunnel Mode fundamentally differ from **Transport Mode**?**

(A) Transport Mode encrypts the entire original IP packet including the original IP header

(B) Tunnel Mode encrypts the entire original IP packet (header and payload) and encapsulates it inside a completely new outer IP header, typically used for site-to-site VPN gateways

(C) Transport Mode operates at the Data Link layer, whereas Tunnel Mode operates at the Application layer

(D) Tunnel Mode provides data compression only without encryption or authentication

SECTION VI: THEORY OF COMPUTATION AND COMPUTER GRAPHICS

Questions 51 – 60 (10 Marks)

Q.51 6.1 Finite Automata: DFA State Minimization

What is the minimum number of states in a Deterministic Finite Automaton (DFA) that accepts the language over alphabet $\Sigma = \{0, 1\}$ consisting of all strings ending with the substring `01` ?

(A) 2

(B) 3

(C) 4

(D) 5

Q.52 6.1 Regular Expressions & Closure Properties

Regular languages are closed under which of the following complete sets of formal operations?

(A) Union, Concatenation, and Kleene Star only

(B) Union, Intersection, Complement, Concatenation, and Difference

(C) Union and Intersection, but NOT Complement

(D) Context-free substitution and Homomorphic reversal only

Q.53 6.1 Pumping Lemma for Regular Languages

Which of the following formal languages over $\Sigma = \{a, b\}$ is NON-REGULAR and cannot be recognized by any finite automaton?

(A) $L_1 = \{w \mid w \text{ contains an even number of } a\text{'s}\}$

(B) $L_2 = \{a^m b^n \mid m \geq 1, n \geq 1\}$

(C) $L_3 = \{a^n b^n \mid n \geq 0\}$

(D) $L_4 = \{w \mid w \text{ starts and ends with the symbol } a\}$

Q.54 6.2 Context-Free Languages & Pushdown Automata

Which of the following statements regarding Pushdown Automata (PDA) is strictly TRUE?

(A) Deterministic Pushdown Automata (DPDA) and Non-Deterministic Pushdown Automata (NPDA) have identical language recognition power

(B) NPDAs are strictly more powerful than DPDAs, because languages like even-length palindromes $\{ww^R\}$ cannot be accepted by any DPDA

(C) A standard single-stack PDA can recognize context-sensitive languages such as $\{a^n b^n c^n\}$

(D) Adding a second independent pushdown stack to a PDA leaves its computational power unchanged

Q.55 6.2 Context-Free Grammars: Normal Forms

In formal language theory, a context-free grammar is in Chomsky Normal Form (CNF) if all its production rules strictly follow which syntactic structure?

(A) $A \to BC$ or $A \to a$ (where A, B, C are non-terminals and a is a single terminal)

(B) $A \to aB$ or $A \to a$ (where A, B are non-terminals and a is a terminal)

(C) $A \to \alpha$ where α is any combination of terminals and non-terminals of length ≤ 2

(D) $A \to BCD$ or $A \to \epsilon$

Q.56 6.3 Turing Machines & Computability

Alan Turing's seminal 1936 proof concerning the Halting Problem demonstrated that determining whether an arbitrary computer program will eventually halt or run forever is:

(A) Decidable in polynomial time $O(n^2)$ using deterministic algorithms

(B) Decidable in exponential time $O(2^n)$

(C) Undecidable (uncomputable), because no general algorithm can exist that solves the halting problem for all possible program-input pairs

(D) Solvable by converting the program into a Non-Deterministic Turing Machine

Q.57 6.4 Computer Graphics: Frame Buffer Architecture

A raster graphics display system has a resolution of 1280×1024 pixels and operates in 24-bit True Color mode. What is the minimum frame buffer memory required to store a single full-screen image?

(A) 1.25 MB

(B) 3.75 MB

(C) 15.00 MB

(D) 31.45 MB

Q.58 6.4 Line Drawing Algorithms: Bresenham's vs DDA

What is the primary computational advantage of Bresenham's line drawing algorithm over the Digital Differential Analyzer (DDA) algorithm?

(A) Bresenham's algorithm utilizes floating-point divisions for superior anti-aliased edge smoothing

(B) Bresenham's algorithm uses only incremental integer additions, subtractions, and bit shifts, completely avoiding floating-point arithmetic and rounding operations

(C) Bresenham's algorithm requires no coordinate initialization step

(D) Bresenham's algorithm works exclusively on polar trigonometric coordinate curves

Q.59 6.5 2D Transformations: Homogeneous Coordinates

In 2D computer graphics using homogeneous coordinates, what is the 3×3 transformation matrix for a counterclockwise rotation by an angle θ about the coordinate origin?

(A) $\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(B) $\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(C) $\begin{bmatrix} 1 & 0 & \cos\theta \\ 0 & 1 & \sin\theta \\ 0 & 0 & 1 \end{bmatrix}$

(D) $\begin{bmatrix} \sin\theta & \cos\theta & 0 \\ \cos\theta & -\sin\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Q.60 6.5 2D Line Clipping: Cohen-Sutherland Algorithm

In the Cohen-Sutherland line clipping algorithm, a 4-bit region outcode (TBRL: Top, Bottom, Right, Left) is assigned to endpoints P_1 and P_2. A line segment is trivially REJECTED (guaranteed to lie entirely outside the clip window) if:

(A) $\text{Code}(P_1) = 0000$ and $\text{Code}(P_2) = 0000$

(B) $\text{Code}(P_1)$ OR $\text{Code}(P_2) = 0000$

(C) $\text{Code}(P_1)$ AND $\text{Code}(P_2) \neq 0000$

(D) $\text{Code}(P_1)$ XOR $\text{Code}(P_2) = 1111$

SECTION VII: DATA STRUCTURES, DATABASE SYSTEM AND OPERATING SYSTEM

Questions 61 – 70 (10 Marks)

Q.61 7.1 Data Structures: Postfix Evaluation Using Stack

What is the evaluated numerical result of the postfix (Reverse Polish) expression `6 3 2 + * 10 - 4 /` ?

(A) 2

(B) 5

(C) 8

(D) 10

Q.62 7.1 Balanced Trees: AVL Tree Rotations

In an AVL tree, what is the permissible range of the Balance Factor ($BF = h_{left} - h_{right}$) for every node, and which tree rotation is required when an insertion causes an imbalance in the left subtree of the right child of a node?

(A) $BF \in \{-1, 0, +1\}$; Right-Left (RL) Double Rotation

(B) $BF \in \{-2, 0, +2\}$; Left-Left (LL) Single Rotation

(C) $BF \in \{-1, 0, +1\}$; Left-Right (LR) Double Rotation

(D) $BF \in \{0, +1\}$; Right-Right (RR) Single Rotation

Q.63 7.2 Sorting & Computational Complexity: QuickSort

What are the average-case and worst-case time complexities of standard QuickSort on an array of n elements, and under what condition does the worst-case time complexity occur when using the first element as the pivot?

(A) Average $O(n \log n)$, Worst $O(n \log n)$; when array elements are uniformly random

(B) Average $O(n \log n)$, Worst $O(n^2)$; when the array is already sorted or reverse-sorted

(C) Average $O(n^2)$, Worst $O(n^3)$; when array contains duplicate keys

(D) Average $O(n)$, Worst $O(n \log n)$; when pivot is chosen randomly

Q.64 7.2 Graph Algorithms: Minimum Spanning Trees

Which design paradigm do both Prim's and Kruskal's Minimum Spanning Tree (MST) algorithms follow, and which auxiliary data structure allows Kruskal's algorithm to achieve an efficient $O(E \log E)$ time complexity?

(A) Dynamic Programming; Double-ended Queue

(B) Divide and Conquer; Adjacency Matrix

(C) Greedy Method; Disjoint Set Union (Union-Find) with path compression

(D) Backtracking; Red-Black Balanced Binary Search Tree

Q.65 7.3 Database Normalization: Normal Forms

A relational database schema $R(A, B, C, D)$ is in **Third Normal Form (3NF) if for every non-trivial functional dependency $X \to Y$:**

(A) X is a superkey only

(B) Either X is a superkey, or Y is a prime attribute (a member of a candidate key)

(C) Every non-prime attribute is partially dependent on a proper subset of a candidate key

(D) All attributes are non-numeric and no multi-valued dependencies exist

Q.66 7.3 SQL & Query Processing

In an SQL query containing `SELECT`, `FROM`, `WHERE`, `GROUP BY`, and `HAVING` clauses, what is the exact logical execution order of the filtering and grouping clauses?

(A) `HAVING` → `WHERE` → `GROUP BY`

(B) `WHERE` → `GROUP BY` → `HAVING`

(C) `GROUP BY` → `HAVING` → `WHERE`

(D) `WHERE` → `HAVING` → `GROUP BY`

Q.67 7.4 Concurrency Control: Two-Phase Locking (2PL)

What formal theoretical guarantee is provided by the **Two-Phase Locking (2PL) protocol in relational database transaction management?**

(A) It guarantees complete freedom from system deadlocks

(B) It guarantees conflict serializability of concurrent transaction execution schedules

(C) It guarantees zero disk I/O latency for read operations

(D) It guarantees that transactions will never experience aborts or rollbacks

Q.68 7.5 Operating Systems: Process Scheduling

Three processes P_1, P_2, P_3 arrive simultaneously at time $t = 0$ ms with CPU burst times of 8 ms, 4 ms, and 2 ms, respectively. Using non-preemptive **Shortest Job First (SJF) scheduling, what is the average waiting time across all three processes?**

(A) 2.67 ms

(B) 3.33 ms

(C) 4.67 ms

(D) 6.00 ms

Q.69 7.5 Operating Systems: Deadlock Conditions

Which of the following is NOT one of the four necessary and sufficient Coffman conditions required for an operating system deadlock to occur?

(A) Mutual Exclusion

(B) Hold and Wait

(C) Preemption of resources by the operating system

(D) Circular Wait

Q.70 7.6 Memory Management: Belady's Anomaly

Which page replacement algorithm is susceptible to **Belady's Anomaly (where increasing the number of allocated physical page frames paradoxically results in an increased number of page faults)?**

(A) Least Recently Used (LRU)

(B) Optimal Page Replacement (OPT)

(C) First-In, First-Out (FIFO)

(D) Least Frequently Used with Aging (LFU)

SECTION VIII: SOFTWARE ENGINEERING AND OOAD

Questions 71 – 80 (10 Marks)

Q.71 8.1 Software Process Models: The Spiral Model

What is the primary distinguishing feature and fundamental advantage of Barry Boehm's **Spiral Model of software development compared to the classic Waterfall model?**

(A) Strict linear progression that completely prohibits customer feedback until post-delivery

(B) Explicit, systematic risk analysis and mitigation performed at each iterative cycle

(C) Total elimination of formal documentation and testing phases

(D) Exclusive suitability for small, low-budget software utilities

Q.72 8.1 Requirements Engineering: Functional vs Non-Functional

Which of the following requirements in a Software Requirements Specification (SRS) is classified as a **Non-Functional Requirement (NFR)?**

(A) "The system shall allow users to register an account using an email address and password."

(B) "The system shall generate a monthly payroll report in PDF format for all employees."

(C) "The system shall process and return 95% of database search queries within 200 milliseconds under a concurrent load of 1,000 active users."

(D) "The system shall allow administrators to assign role-based access permissions to staff members."

Q.73 8.2 Software Design: Coupling and Cohesion

In modular software architectural design, high-quality, maintainable, and reusable systems should strive for:

(A) High coupling and high cohesion

(B) Low coupling and low cohesion

(C) High coupling and low cohesion

(D) Low coupling and high cohesion

Q.74 8.3 Software Testing: Cyclomatic Complexity

For a software program whose control flow graph G contains $E = 14$ edges, $N = 10$ nodes, and $P = 1$ connected component, what is McCabe's Cyclomatic Complexity $V(G)$, representing the number of linearly independent execution paths?

(A) 4

(B) 6

(C) 14

(D) 24

Q.75 8.3 Software Testing: Boundary Value Analysis

If an online admission form input field accepts student age as an integer between 18 and 60 (inclusive), which set of test input values represents rigorous **Boundary Value Analysis (BVA)?**

(A) {25, 35, 45, 55}

(B) {17, 18, 19, 59, 60, 61}

(C) {0, 50, 100}

(D) {-18, 0, 18, 60}

Q.76 8.3 Software Cost Estimation: COCOMO Model

In the Constructive Cost Model (COCOMO), a software project undertaken by a small, experienced in-house team with flexible requirements in a familiar hardware environment is categorized under which project mode?

(A) Embedded mode

(B) Semidetached mode

(C) Organic mode

(D) Dynamic mode

Q.77 8.3 Quality Management: CMMI Levels

In the Capability Maturity Model Integration (CMMI), at which maturity level are software engineering and management processes standardized, documented, and established across the entire organization?

(A) Level 1 (Initial)

(B) Level 2 (Managed)

(C) Level 3 (Defined)

(D) Level 5 (Optimizing)

Q.78 8.4 OOAD & UML: Class Relationships

In a UML Class Diagram, what is the semantic difference between **Composition (filled black diamond) and **Aggregation** (hollow/white diamond)?**

(A) Composition represents a weak relationship where part objects can outlive the whole; Aggregation represents exclusive ownership

(B) Composition represents strong ownership where the lifetime of the part is tied to the whole (if the whole is destroyed, parts are destroyed); Aggregation represents a weaker 'has-a' relationship where parts can exist independently

(C) Composition is used exclusively for multiple inheritance; Aggregation is used only for interface implementation

(D) There is no semantic difference; they are interchangeable cosmetic drawing symbols

Q.79 8.4 OOAD & UML: Use Case Diagrams

In UML Use Case diagrams, what is the key distinction between the `<<include>>` and `<<extend>>` relationships between two use cases?

(A) `<<include>>` represents optional conditional behavior; `<<extend>>` represents mandatory common behavior

(B) `<<include>>` indicates that the base use case unconditionally incorporates the behavior of the included use case; `<<extend>>` indicates that an extending use case conditionally adds behavior at a defined extension point

(C) `<<include>>` connects actors to use cases; `<<extend>>` connects classes to objects

(D) Both relationships are completely synonymous and may be used interchangeably

Q.80 8.3 Software Configuration Management (SCM)

In Software Configuration Management (SCM), a **Baseline is formally defined as:**

(A) The initial unstructured brainstorming notes written before project kickoff

(B) A formally reviewed and agreed-upon version of a software configuration item that serves as the basis for further development and can only be modified through formal change control procedures

(C) A temporary local backup copy of source code stored on a developer's personal workstation

(D) The minimum hardware CPU clock frequency required to execute compiled application binaries

SECTION IX: ARTIFICIAL INTELLIGENCE AND NEURAL NETWORKS

Questions 81 – 90 (10 Marks)

Q.81 9.1 AI Foundations & Intelligent Agents

In Artificial Intelligence, an environment that is fully observable, deterministic, sequential, static, discrete, and single-agent is best exemplified by which of the following task domains?

(A) Autonomous vehicle driving in urban street traffic

(B) Playing a competitive game of speed Chess with a chess clock against a human opponent

(C) Solving an 8-Puzzle sliding tile problem

(D) Medical diagnosis of patients in an emergency trauma center

Q.82 9.2 Uninformed Search: Iterative Deepening Search

Why is **Iterative Deepening Search (IDS) widely regarded as the preferred uninformed search strategy for large state spaces with unknown solution depth?**

(A) It combines the completeness and optimality of Breadth-First Search with the low linear memory complexity $O(bd)$ of Depth-First Search

(B) It executes substantially faster than DFS by permanently caching all explored nodes in RAM

(C) It uses a heuristic evaluation function to prune suboptimal search paths

(D) It searches backwards from goal states to the initial state

Q.83 9.2 Informed Search: A* Algorithm & Heuristics

In A* search, an evaluation function is defined as $f(n) = g(n) + h(n)$. To guarantee that A* tree search finds an optimal (shortest-cost) path to the goal, the heuristic function $h(n)$ must be **admissible, meaning:**

(A) $h(n)$ must never underestimate the true minimal cost to reach the goal ($h(n) \geq h^*(n)$)

(B) $h(n)$ must never overestimate the true minimal cost to reach the goal ($0 \leq h(n) \leq h^*(n)$)

(C) $h(n)$ must be strictly equal to the path cost from the start node ($h(n) = g(n)$)

(D) $h(n)$ must approach negative infinity as the goal node is reached

Q.84 9.2 Adversarial Search: Alpha-Beta Pruning

In the Minimax game-playing search algorithm with Alpha-Beta pruning, an **Alpha Cut-off occurs at a MIN node when:**

(A) $\beta \leq \alpha$, where α is the best (highest) value found so far by MAX, and β is the best (lowest) value found so far by MIN

(B) $\alpha > 0$ and $\beta = 0$

(C) Both players achieve identical evaluation scores

(D) The search depth reaches an odd number

Q.85 9.3 Knowledge Representation: First-Order Logic & Unification

In First-Order Predicate Logic (FOPL) automated theorem proving, what is the Most General Unifier (MGU) that unifies the two atomic literals $P(x, f(y))$ and $P(a, f(g(z)))$?

(A) $\{x/a, y/z\}$

(B) $\{x/a, y/g(z)\}$

(C) $\{x/f(a), y/g(z)\}$

(D) They cannot be unified because f is a function symbol

Q.86 9.3 Probabilistic Reasoning: Bayes' Rule

A network diagnostic AI monitors server hardware failures. The prior probability of a rare hardware fault is $P(\text{Fault}) = 0.01$. An automated diagnostic test has a True Positive rate of $P(\text{Test}^+ \mid \text{Fault}) = 0.90$ and a False Positive rate of $P(\text{Test}^+ \mid \neg\text{Fault}) = 0.05$. If a server tests positive (Test^+), what is the posterior probability $P(\text{Fault} \mid \text{Test}^+)$ that the server actually has the fault?

(A) 90.0%

(B) 50.0%

(C) 15.4%

(D) 1.8%

Q.87 9.5 Machine Learning: Decision Trees (ID3)

In inductive decision tree learning algorithms (such as ID3), the attribute chosen to split the dataset at each decision node is the one that achieves:

(A) The minimum Information Gain

(B) The highest Information Gain (maximum reduction in Entropy)

(C) The largest number of distinct split branches

(D) Zero variance among continuous numerical features

Q.88 9.5 Machine Learning: Naive Bayes Classifier

Why is the Naive Bayes classification algorithm termed 'naive'?

(A) It assumes all data attributes follow a standard Gaussian distribution with zero mean

(B) It makes the simplifying assumption that all feature attributes are conditionally independent of each other given the class label

(C) It cannot be applied to multi-class classification problems

(D) It requires zero training data and relies purely on random weights

Q.89 9.6 Neural Networks: The Perceptron

In their landmark 1969 book, Marvin Minsky and Seymour Papert mathematically proved that a single-layer perceptron with a threshold activation function cannot solve which classic logical problem?

(A) Logical AND
(B) Logical OR
(C) Logical NOT
(D) Logical XOR (Exclusive-OR)

Q.90 9.6 Neural Networks: Backpropagation Algorithm

When training a Multi-Layer Perceptron (MLP) using the Backpropagation algorithm, why must the activation functions used in hidden layer neurons be continuous and differentiable?

(A) Because the algorithm uses the mathematical chain rule of calculus to compute partial derivatives (gradients) of the loss function with respect to network weights
(B) Because non-continuous step functions consume excessive GPU RAM
(C) Because non-differentiable functions always force the learning rate to zero
(D) To guarantee that the sum of all network synaptic weights equals zero

SECTION X: PROJECT PLANNING, DESIGN AND IMPLEMENTATION

Questions 91 – 100 (10 Marks)

Q.91 10.1 Engineering Drawings: Standard Sheet Sizes

According to ISO 216 and standard engineering drafting specifications, what is the exact surface area and trimmed dimensions of an **A0 drawing sheet, and what constant aspect ratio is preserved across all A-series sheets?**

(A) Area = 0.50 m², Dimensions: 594 × 841 mm, Aspect Ratio: 1:2
(B) Area = 1.00 m², Dimensions: 841 × 1189 mm, Aspect Ratio: $1:\sqrt{2}$
(C) Area = 2.00 m², Dimensions: 1000 × 2000 mm, Aspect Ratio: 1:1.5
(D) Area = 1.00 m², Dimensions: 800 × 1250 mm, Aspect Ratio: $1:\sqrt{3}$

Q.92 10.2 Engineering Economics: Time Value of Money

An IT engineering enterprise invests NPR 1,000,000 today in enterprise cloud infrastructure. If the annual market interest rate is 10% compounded annually, what is the future worth (F) of this capital investment at the end of 3 years?

(A) NPR 1,300,000
(B) NPR 1,331,000
(C) NPR 1,210,000
(D) NPR 1,400,000

Q.93 10.2 Engineering Economics: Project Evaluation

In engineering economic feasibility appraisal, an independent commercial project is financially acceptable and viable if:

(A) Net Present Value (NPV) < 0 and Benefit-Cost Ratio (B/C) < 1.0
(B) Net Present Value (NPV) > 0 and Internal Rate of Return (IRR) is greater than the Minimum Attractive Rate of Return (MARR)
(C) The discounted payback period exceeds the project's physical operational life
(D) Depreciation charges exceed annual net revenues

Q.94 10.2 Depreciation Methods: Straight Line

A data center server cluster is procured for NPR 600,000. It has an estimated useful service life of 5 years and a salvage (scrap) value of NPR 100,000. Using the **Straight-Line Depreciation method, what is the annual depreciation charge and the book value of the cluster at the end of Year 2?**

(A) Annual Depreciation: NPR 100,000; Book Value: NPR 400,000

(B) Annual Depreciation: NPR 120,000; Book Value: NPR 360,000

(C) Annual Depreciation: NPR 80,000; Book Value: NPR 440,000

(D) Annual Depreciation: NPR 100,000; Book Value: NPR 500,000

Q.95 10.3 Project Planning & Scheduling: CPM

In Critical Path Method (CPM) project network scheduling, what does the **Total Float (TF) of an activity represent?**

(A) The duration by which an activity can be delayed without affecting the earliest start of any immediate successor activity

(B) The maximum amount of time an activity can be delayed beyond its earliest start time without delaying the overall project completion date

(C) The negative slack time occurring on the critical path

(D) The total working calendar time needed to crash the project

Q.96 10.3 Project Planning & Scheduling: PERT

In Project Evaluation and Review Technique (PERT), given an optimistic time estimate of $a = 4$ days, a most likely time estimate of $m = 7$ days, and a pessimistic time estimate of $b = 16$ days, what are the expected activity duration (t_e) and its variance (σ^2)?

(A) $t_e = 8 \text{ days}, \sigma^2 = 4$

(B) $t_e = 9 \text{ days}, \sigma^2 = 2$

(C) $t_e = 7 \text{ days}, \sigma^2 = 1.44$

(D) $t_e = 10 \text{ days}, \sigma^2 = 6$

Q.97 10.4 Project Management: Procurement & Tendering in Nepal

Under Nepal's Public Procurement Act (PPA 2063) and Public Procurement Regulations (PPR 2064), what percentage of the estimated bid amount is typically required to be furnished by bidders as **Bid Security (Earnest Money)?**

(A) 0.5% to 1.0% of the estimated amount

(B) 2.0% to 3.0% of the estimated bid amount

(C) 10.0% to 15.0% of the total contract price

(D) Exactly 50% of the initial mobilization advance

Q.98 10.4 Project Management: Contract Administration

In engineering contract administration, what is the primary purpose of a **Liquidated Damages (LD) clause?**

(A) To impose punitive criminal fines on contractors for minor material deviations

(B) To provide pre-agreed, legally enforceable compensatory damages to the employer for financial losses caused by contractor delays in completing the project beyond the contracted completion date

(C) To compensate the contractor for unexpected inflation and exchange rate fluctuations

(D) To relieve the client of all project quality assurance responsibilities

Q.99 10.5 Engineering Professional Practice: Ethics

In international professional codes of ethics and the Nepal Engineering Council (NEC) Code of Conduct, what is universally established as the **paramount duty of a professional engineer?**

(A) Maximizing commercial profit and shareholder returns for the client organization

(B) Holding paramount the safety, health, and welfare of the public and environmental sustainability in the execution of engineering work

(C) Completing assigned design projects before the scheduled deadline regardless of inspection protocols

(D) Protecting proprietary company software code from governmental statutory oversight

Q.100 10.6 Engineering Regulatory Body: Nepal Engineering Council (NEC)

Under the Nepal Engineering Council (NEC) Act 2055 and its amendments, which of the following statements regarding the licensure and registration of engineers in Nepal is strictly TRUE?

(A) An engineering graduate holding a recognized Bachelor's degree in engineering who passes the council examination is registered under the 'General Registered Engineer' category

(B) Professional Engineer registration is automatically granted to all graduates immediately upon university graduation without any work experience requirement

(C) Foreign engineers are completely barred from practicing or registering in Nepal under any project

(D) Registration in the Nepal Engineering Council is entirely optional for signing government building or IT infrastructure drawings