IT 5 Digital Systems Design

Prelim Reviewer 2025-2026

The Design Philosophy

The transition from room-sized mainframes to a single laptop, or the 50 microprocessors in a modern car, is driven by the ability to manage complexity. The goal of this study is to move from physics (electrons) to logic (1s and 0s) to architecture (instructions).

The Three "-Y's" of Complexity Management

To build systems with billions of transistors, engineers use three systematic approaches:

1. **Hierarchy -** Dividing a system into smaller, easy-to-understand modules (e.g., a rifle is broken into a lock, stock, and barrel).
2. **Modularity -** Ensuring modules have well-defined functions and interfaces so they can connect without side effects.
3. **Regularity -** Seeking uniformity to reuse common modules (e.g., interchangeable parts), reducing the total number of distinct designs needed.

Abstraction

Abstraction is the act of hiding details when they are not important to the current task.

Level	Building Blocks
Application Software	Programs (Web browsers, games)
Operating Systems	Device drivers, memory management
Architecture	Instructions, Registers (The programmer's view)
Microarchitecture	Datapaths, Controllers
Logic	Adders, Memories, Gates
Digital Circuits	AND/NOT gates
Analog Circuits	Amplifiers, Filters

Devices	Transistors, Diodes
Physics	Electrons (Quantum mechanics)

Discipline

Discipline is the intentional restriction of design choices to work more productively.

The Digital Discipline - Restricting continuous voltages to discrete ranges (0 and 1). While analog circuits are "broader," digital circuits are simpler to design and combine into massive systems.

3. The Digital Abstraction

Most physical variables (voltage, frequency) are continuous. Digital systems use discrete variables.

Binary Representation - Electronic computers use "High" (1/TRUE) and "Low" (0/FALSE) voltages.

Information Measurement - The amount of information *D* in a variable with *N* states is: $D = \log_2 N$ bits

- A single bit carries $\log_2 2 = 1$ bit of information.
- One of Babbage's 10-position gears carried $\log_2 10$ approx 3.322 bits.

Number Systems & Data Units

Base Conversion Guide

Decimal (Base 10) - Uses digits 0–9. Weights are powers of 10.

Binary (Base 2) - Uses digits 0–1. Weights are powers of 2 (1, 2, 4, 8, 16...).

Hexadecimal (Base 16) - Uses 0–9 and A–F (A=10, F=15). One Hex digit represents exactly 4 bits (one nibble).

Terminology

Bit - single binary digit (0 or 1).

Nibble - 4 bits (1 Hex digit).

Byte - 8 bits (2 Hex digits).

Word - The "chunk" of data a processor handles (e.g., 32-bit or 64-bit).

LSB vs. MSB - The Least Significant Bit is the rightmost bit (1s column); the Most Significant Bit is the leftmost bit.

Prefixes (The Power of 2)

Kilo (K) - 2^{10} approx 1,000 (exactly 1,024).

Mega (M) - 2^{20} approx 1,000,000.

Giga (G - 2^{30} approx 1,000,000,000.

Quick Estimation - To estimate 2^{24}, split the exponent: $2^{20} \times 2^{4}$.

1 million x 16 = 16 million.

Would you like me to create another reviewer? Emeee Good luck po sa exam.

Hawak nyo ang bit!