LỘ TRÌNH CẤU TRÚC DỮ LIỆU & THUẬT TOÁN VỚI JAVA

DATA STRUCTURES & ALGORITHMS WITH JAVA

THÔNG TIN KHÓA HỌC

Thông tin	Chi tiết
Tên khóa học	Cấu Trúc Dữ Liệu & Thuật Toán với Java
Yêu cầu	Java Core Pro (OOP, Generics, Collections, Lambda/Stream)
Tổng số buổi	50 buổi (25 CTDL + 25 Thuật toán)
Thời lượng	2.5 giờ/buổi
Tổng thời gian	125 giờ
Lộ trình	17 tuần (3 buổi/tuần)

MỤC TIÊU

- Nắm vững Cấu Trúc Dữ Liệu & Thuật Toán
- Tư duy giải quyết vấn đề có hệ thống
- Sẵn sàng phỏng vấn FAANG/Big Tech
- Phân tích & tối ưu Time/Space Complexity
- Nhận diện 15+ coding patterns
- Viết code chất lượng production

PHẦN 1: CẤU TRÚC DỮ LIỆU - 25 BUỔI

Module	Tên Module	Buổi
1	Phân Tích Độ Phức Tạp - Complexity Analysis	2
2	Java Collections Framework	2
3	Mảng & ArrayList - Arrays & Dynamic Arrays	3
4	Chuỗi & StringBuilder - Strings	3
5	Danh Sách Liên Kết - Linked Lists	3
6	Ngăn Xếp & Hàng Đợi - Stacks & Queues	2
7	Cây Nhị Phân & BST - Binary Trees	3

Module	Tên Module	Buổi
8	Heap & Hàng Đợi Ưu Tiên - Heaps & PriorityQueue	2
9	Bảng Băm - Hash Tables & HashMap	2
10	Đồ Thị - Graphs	3

MODULE 1: PHÂN TÍCH ĐỘ PHỨC TẠP (2 BUỔI)

Buổi 1: Độ Phức Tạp Thời Gian

- Big O Notation: O(1), O(log n), O(n), O(n log n), O(n^2), O(2^n), O(n!)
- Quy tắc Big O: Drop constants, Drop lower terms, Different inputs
- Phân tích vòng lặp: Single, Nested, Sequential
- Phân tích đệ quy: Fibonacci, Factorial, Binary search
- Best/Average/Worst case, Amortized time
- Độ phức tạp Java Collections: ArrayList, LinkedList, HashMap, TreeMap, PriorityQueue

Buổi 2: Độ Phức Tạp Không Gian

- Space complexity basics
- Stack vs Heap memory trong Java
- Auxiliary space vs Input space
- Recursion call stack space
- Trade-offs: Time vs Space
- In-place algorithms
- Space optimization techniques
- Memory trong Java: Object overhead, Primitive vs Wrapper

MODULE 2: JAVA COLLECTIONS FRAMEWORK (2 BUỔI)

Buổi 3: Collections Hierarchy & Implementations

- Collection interfaces: Collection, List, Set, Queue, Deque
- Map interface hierarchy
- List: ArrayList, LinkedList, Vector, Stack
- Set: HashSet, LinkedHashSet, TreeSet
- Map: HashMap, LinkedHashMap, TreeMap, Hashtable
- Queue/Deque: PriorityQueue, ArrayDeque, LinkedList
- Collections utility methods
- Khi nào dùng implementation nào

Buổi 4: Generics & Comparators

- Generic classes, methods, bounded types
- Multiple type parameters, Wildcards
- Type erasure

- Comparable vs Comparator
- Lambda comparators, Comparator chaining
- Collections.sort(), Arrays.sort()
- Implement custom ArrayList

MODULE 3: MẢNG & ARRAYLIST (3 BUỔI)

Buổi 5: Array Basics & Two Pointers

- Arrays trong Java: Declaration, initialization, Arrays class utilities
- Two Pointers - Opposite direction: Reverse array, Palindrome
- Two Pointers - Same direction: Remove duplicates, Slow-fast
- Two Sum, Three Sum, Container with most water, Trapping rain water

Buổi 6: Sliding Window & Prefix Sum

- Sliding Window - Fixed size: Maximum sum K elements
- Sliding Window - Variable size: Longest substring without repeating, Minimum window substring
- Prefix Sum: Range sum query, Subarray sum equals K
- Product of array except self

Buổi 7: Advanced Array Techniques

- Kadane's Algorithm: Maximum subarray sum
- Dutch National Flag: Sort 0s, 1s, 2s
- Moore's Voting Algorithm: Majority element
- Array rearrangement: Rotate, Next permutation
- Subarray problems: Maximum product subarray
- Matrix operations: Spiral traversal, Rotate matrix, Set zeroes

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MODULE 4: CHUỖI & STRINGBUILDER (3 BUỔI)

Buổi 8: String Fundamentals

- String vs StringBuilder vs StringBuffer
- String methods: charAt, substring, indexOf, replace, split, equals
- String pool & memory
- Character methods
- Palindrome check
- String reversal

Buổi 9: Anagram & String Manipulation

- Anagram detection: Sorting, Frequency count
- Group anagrams, Find all anagrams
- String transformation: Reverse words, String compression
- Subsequence & Substring problems
- Character frequency

Buổi 10: Pattern Matching

- Naive pattern matching
- KMP Algorithm: LPS array, Pattern matching O(m+n)
- Rabin-Karp Algorithm
- Applications: strStr(), Repeated substring pattern

MODULE 5: DANH SÁCH LIÊN KẾT (3 BUỔI)

Buổi 11: Singly Linked List

- Node structure, Basic operations: Insert, Delete, Search
- Two Pointers: Find middle, Detect cycle (Floyd's)
- Find cycle start, Remove Nth from end
- Check palindrome

Buổi 12: Reverse & Merge

- Reverse list: Iterative, Recursive
- Reverse between positions, Reverse in K groups
- Merge two sorted lists, Merge K sorted lists
- Add two numbers, Partition list

Buổi 13: Doubly Linked List & Design

- Doubly Linked List structure & operations
- LRU Cache: HashMap + Doubly linked list
- LFU Cache, Browser history
- Flatten multilevel list, Clone with random pointer

MODULE 6: NGĂN XẾP & HÀNG ĐỢI (2 BUỔI)

Buổi 14: Stack & Monotonic Stack

- Stack basics: LIFO, Operations
- Implementation: Array-based, Linked list-based, Use Deque
- Balanced parentheses, Expression evaluation
- Next greater/smaller element, Stock span
- Min stack, Max stack, Stack with increment
- Monotonic Stack: Increasing, Decreasing
- Daily temperatures, Largest rectangle in histogram
- Remove K digits, Decode string

Buổi 15: Queue & Deque

- Queue basics: FIFO, Operations
- Implementation: Array, Circular queue, Linked list
- Deque: ArrayDeque, Operations at both ends

- First non-repeating character, Sliding window maximum
- Implement queue using stacks, stack using queues

MODULE 7: CÂY NHỊ PHÂN & BST (3 BUỔI)

Buổi 16: Binary Tree Basics

- Tree terminology: Node, Root, Leaf, Height, Depth
- Node structure
- Traversals: Preorder, Inorder, Postorder, Level order
- Zigzag, Vertical order traversal
- Height, Count nodes, Diameter

Buổi 18: Binary Search Tree

- BST properties: Left < Root < Right
- Operations: Search, Insert, Delete
- Find min/max, Inorder successor/predecessor
- Validate BST
- Kth smallest, LCA, Convert sorted array to BST
- Two sum in BST

Buổi 19: Advanced Tree Problems

- Tree construction: From inorder+preorder, inorder+postorder
- Tree views: Left, Right, Top, Bottom, Boundary
- Vertical & Diagonal traversal
- Path problems: Root to leaf paths, Path sum
- Invert tree, Flatten to linked list, Connect nodes
- Maximum path sum, Serialize/Deserialize
- Trie: Insert, Search, StartsWith, Word search
- Segment Tree & Fenwick Tree (introduction)

MODULE 8: HEAP & PRIORITY QUEUE (2 BUỔI)

Buổi 21: Heap Fundamentals

- Min heap vs Max heap, Complete binary tree
- Heap operations: Insert, Delete, Get min/max, Build heap
- PriorityQueue trong Java, Custom comparator
- Heap sort
- Top K problems: Kth largest/smallest, Top K frequent

Buổi 22: Heap Applications

- K-way merge: Merge K sorted arrays/lists
- Smallest range covering K lists
- Median from data stream (two heaps)

- Scheduling: Task scheduler, Meeting rooms II
- Reorganize string, Kth smallest in matrix

MODULE 9: BẢNG BĂM (2 BUỔI)

Buổi 23: Hashing Fundamentals

- Hash function, Collision resolution
- Load factor, Rehashing
- HashMap internals, HashSet internals
- Frequency counting, Two Sum
- Group anagrams, Word pattern
- HashCode & Equals contract

Buổi 24: Advanced Hashing

- LinkedHashMap: Insertion order, Access order
- TreeMap: Sorted keys, NavigableMap operations
- Design HashMap, Design HashSet
- LRU Cache, LFU Cache
- Longest consecutive sequence, Subarray sum equals K
- Rabin-Karp hashing

MODULE 10: ĐỒ THỊ (3 BUỔI)

Buổi 23: Graph Representation & DFS

- Graph basics: Vertices, Edges, Directed/Undirected, Weighted/Unweighted
- Representation: Adjacency matrix, Adjacency list, Edge list
- DFS: Recursive, Iterative, O(V+E)
- Connected components, Detect cycle
- Number of islands, Max area of island

Buổi 24: BFS & Shortest Path

- BFS: Queue-based, Level-order, O(V+E)
- Shortest path in unweighted graph
- Bipartite graph check
- Shortest path in binary matrix, 01 Matrix

Buổi 25: Graph Applications

- Multi-source BFS, Bidirectional BFS
- Word ladder, Rotten oranges
- Walls and gates
- Graph problem-solving strategies

PHẦN 2: THUẬT TOÁN - 25 BUỔI

Module	Tên Module	Buổi
11	Đệ Quy - Recursion	2
12	Quay Lui - Backtracking	3
13	Thuật Toán Đồ Thị Nâng Cao - Advanced Graph	4
14	Thuật Toán Sắp Xếp - Sorting	3
15	Tìm Kiếm Nhị Phân - Binary Search	3
16	Quy Hoạch Động - Dynamic Programming	6
17	Tham Lam - Greedy	2
18	Chia Để Trị - Divide & Conquer	2

MODULE 11: ĐỆ QUY (2 BUỔI)

Buổi 26: Recursion Fundamentals

- Base case & Recursive case
- Call stack visualization, Recursion vs Iteration
- Simple recursion: Factorial, Fibonacci, Power, GCD
- Tail recursion, Multiple recursion
- Recursion with arrays: Sum, Binary search, Check sorted

Buổi 27: Advanced Recursion

- Memoization, Tail call optimization
- Divide & Conquer recursion
- Tree recursion, String recursion
- Tower of Hanoi, Print subsets/permutations
- Generate binary strings

MODULE 12: QUAY LUI (3 BUỔI)

Buổi 28: Backtracking Fundamentals

- Backtracking concept: Brute force with pruning
- Decision tree, Template: Choose → Explore → Unchoose
- Subsets & Combinations: Power set, Combinations, Combination sum
- Permutations: All permutations, With duplicates

Buổi 29: String & Array Backtracking

- Letter combinations, Generate parentheses

- Palindrome partitioning, Restore IP addresses
- Word search, Word search II (with Trie)
- Partition to K equal sum subsets
- Remove invalid parentheses

Buổi 30: Grid Backtracking & Game Solving

- Rat in maze, Unique paths III
- Sudoku solver, N-Queens
- Knight's tour, Hamiltonian path
- Graph coloring

MODULE 13: THUẬT TOÁN ĐỒ THỊ NÂNG CAO (4 BUỔI)

Buổi 31: Topological Sort & Union Find

- Topological Sort: DAG, Kahn's algorithm, DFS-based
- Detect cycle in directed graph
- Course schedule, Alien dictionary
- Union Find: Structure, Find with path compression, Union by rank
- Connected components, Redundant connection, Accounts merge

Buổi 32: Shortest Path Algorithms

- Dijkstra's Algorithm: Single-source, PriorityQueue, O((V+E) log V)
- Network delay time, Path with minimum effort
- Bellman-Ford: Handles negative weights, Detect negative cycles
- Floyd-Warshall: All-pairs shortest paths

Buổi 33: Minimum Spanning Tree

- MST concept, Properties, Applications
- Kruskal's Algorithm: Sort edges, Union-Find
- Prim's Algorithm: PriorityQueue
- Min cost to connect all points

Buổi 34: Advanced Graph Algorithms

- Strongly Connected Components: Kosaraju's, Tarjan's
- Articulation Points & Bridges
- Eulerian Path & Circuit: Hierholzer's algorithm
- Bipartite matching, Graph coloring
- Critical connections, Reconstruct itinerary

MODULE 14: THUẬT TOÁN SẮP XẾP (3 BUỔI)

Buổi 35: Comparison-based Sorting

- Simple sorts: Bubble, Selection, Insertion
- Merge Sort: Divide & conquer, Stable, O(n log n)
- Quick Sort: Partition, Pivot selection, 3-way partitioning
- Heap Sort: In-place, O(n log n)
- Stability, Best/Average/Worst cases

Buổi 36: Non-comparison Sorting

- Counting Sort: O(n+k)
- Radix Sort: Digit-by-digit
- Bucket Sort: Uniform distribution
- TimSort, IntroSort
- Sort colors, Sort by parity

Buổi 37: Partial Sorting & Custom

- Quick Select: Kth element, O(n) average
- Top K elements using heap/quick select
- Custom sorting: Comparator, Lambda, Multi-criteria
- Largest number, Sort by frequency
- External sorting (concept)

MODULE 15: TÌM KIẾM NHỊ PHÂN (3 BUỔI)

Buổi 38: Binary Search Basics

- Prerequisites: Sorted array
- Iterative vs Recursive, O(log n)
- Variations: First occurrence, Last occurrence, Count, Floor, Ceiling
- Rotated sorted array: Find element, Find minimum
- Binary search templates

Buổi 39: Binary Search on Answer

- Search space concept: Range of values
- Monotonic function
- Sqrt(x), Capacity to ship packages
- Koko eating bananas, Split array largest sum
- Minimize maximum, Maximize minimum

Buổi 40: Matrix & Advanced Binary Search

- Search in 2D matrix, Search 2D matrix II
- Kth smallest in matrix
- Median of two sorted arrays
- Find K-th smallest pair distance
- Binary search + Greedy/DP

MODULE 16: QUY HOẠCH ĐỘNG (6 BUỔI)

Buổi 41: DP Fundamentals

- Overlapping subproblems, Optimal substructure
- Memoization (top-down), Tabulation (bottom-up)
- 1D DP: Fibonacci, Climbing stairs, House robber, Decode ways
- DP template: States, Recurrence, Base cases
- Space optimization

Buổi 42: DP on Strings

- Longest Common Subsequence (LCS)
- Longest palindromic subsequence
- Edit distance (Levenshtein)
- Distinct subsequences, Shortest common supersequence
- Wildcard matching, Regular expression matching
- Palindrome problems: Substrings, Min insertion, Partitioning

Buổi 43: 2D DP & Grid Problems

- Grid DP: Unique paths, Minimum path sum
- Maximal square, Maximal rectangle
- Longest increasing path in matrix
- Space optimization: 2D → 1D, Rolling array

Buổi 44: Knapsack Problems

- 0/1 Knapsack: Include/exclude decision
- Unbounded Knapsack: Unlimited items
- Variations: Subset sum, Partition equal subset sum, Target sum
- Coin change: Count ways, Minimum coins
- Space optimization

Buổi 45: DP on Subsequences & LIS

- Longest Increasing Subsequence: DP $O(n^2)$, Binary search O(n log n)
- Number of LIS, Russian doll envelopes
- Longest arithmetic subsequence
- Stock problems (I-VI): State machine DP

Buổi 46: Advanced DP

- DP on intervals: Matrix chain multiplication, Burst balloons
- Bitmask DP: Traveling salesman, Assignment problem
- DP optimization: Divide & conquer, Convex hull trick
- Hard DP: Distinct subsequences, Scramble string

MODULE 17: THAM LAM (2 BUỔI)

Buổi 47: Greedy Fundamentals

- Locally optimal → Globally optimal
- No backtracking, Proof of correctness
- Interval problems: Activity selection, Non-overlapping intervals, Meeting rooms
- Arrays: Jump game, Gas station, Candy distribution
- Strings: Remove K digits, Largest number

Buổi 48: Advanced Greedy

- Greedy with sorting: Connect sticks, Queue reconstruction
- Huffman coding, Fractional knapsack
- Remove duplicate letters, Partition labels
- Hand of straights, Maximum swap

MODULE 18: CHIA ĐỂ TRỊ (2 BUỔI)

Buổi 49: Divide & Conquer Fundamentals

- Divide, Conquer, Combine
- Classic algorithms review: Merge sort, Quick sort, Binary search
- Maximum subarray (Kadane vs D&C comparison)
- Count inversions
- Closest pair of points
- Median of two sorted arrays
- Master Theorem: T(n) = aT(n/b) + f(n)

Buổi 50: Advanced Divide & Conquer

- Advanced multiplication: Karatsuba
- Matrix multiplication: Strassen's algorithm (concept)
- Fast Fourier Transform - FFT (concept)
- D&C on trees: Construct from traversals
- Merge K sorted lists (D&C approach)
- Complex problems: Expression add operators, Reverse pairs

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15 CODING PATTERNS

Pattern	**Áp Dụng**
Two Pointers - Hai Con Trỏ	Arrays, Linked Lists
Sliding Window - Cửa Sổ Trượt	Subarrays, Substrings
Fast & Slow Pointers	Cycle detection
Merge Intervals - Trộn Khoảng	Intervals
Prefix Sum - Mảng Tiền Tố	Range queries

Pattern	Áp Dụng
DFS - Depth-First Search	Trees, Graphs
BFS - Breadth-First Search	Shortest path
Backtracking - Quay Lui	Combinations, Permutations
Binary Search - Tìm Kiếm Nhị Phân	Sorted arrays
Top K Elements	Heaps
K-way Merge - Trộn K Chiều	Multiple sorted arrays
Dynamic Programming - Quy Hoạch Động	Optimization
Greedy - Tham Lam	Local optimal
Union Find - Tập Rời Rạc	Connected components
Topological Sort - Sắp Xếp Topo	Dependencies

LỘ TRÌNH HỌC TẬP 17 TUẦN

Tuần 1-2: Complexity (2), Collections (2), Arrays (2)
Tuần 3-4: Arrays (1), Strings (3), Linked Lists (2)
Tuần 5-6: Linked Lists (1), Stacks & Queues (2), Trees (3)
Tuần 7-8: Heaps (2), Hash Tables (2), Graphs (2)
Tuần 9: Graphs (1), Recursion (2)
Tuần 10-11: Backtracking (3), Advanced Graph (3)
Tuần 12-13: Advanced Graph (1), Sorting (3), Binary Search (2)
Tuần 14: Binary Search (1), DP (2)
Tuần 15-16: DP (4), Greedy (2)
Tuần 17: Divide & Conquer (2), Review (1)