🎮 Lecture 17: Recursion & Testing in Gaming

RPG Mechanics Edition

📄 Files

- `GameRecursion.java` - Gaming recursion examples (fill in the blank)
- `GameTesting.java` - Gaming unit tests with JUnit (fill in the blank)

🎮 Gaming Scenarios

Recursion Examples

1. **Party XP Distribution** - Distribute XP to party recursively
2. **Damage Cascade** - Apply status effects that trigger more effects
3. **Dungeon Depth Counter** - Count levels of nested dungeons
4. **Skill Tree Navigation** - Find max skill damage through prerequisites
5. **Inventory Sorting** - Calculate total item value recursively
6. **Enemy Wave Spawning** - Spawn enemies in waves
7. **Combo Counter** - Build multiplier chains
8. **Loot Rarity Tree** - Check rarity through inheritance chain

Testing Examples (JUnit)

1. **Player Health Management** - Test damage/healing edge cases
2. **Mana System** - Test spell casting, mana overflow
3. **Inventory Limits** - Test item stacking and capacity
4. **XP to Level Conversion** - Test level thresholds
5. **Damage Calculation** - Test crit chance, bonuses
6. **Game Over Conditions** - Test death detection
7. **Buff/Debuff Stacking** - Test stat multipliers
8. **Gold Currency** - Test transaction edge cases

📚 Learning Goals

Recursion in Gaming

- ✅ Identify base cases (reached max dungeon level, no more combos, etc.)
- ✅ Build recursive logic (next wave, next skill, etc.)
- ✅ Trace through game recursion on paper
- ✅ Understand stack behavior in game systems
- ✅ Avoid infinite loops in game mechanics
- ✅ Implement realistic game algorithms

Testing Game Mechanics

- ✅ Test player damage calculations
- ✅ Test inventory edge cases
- ✅ Test game-over conditions
- ✅ Test stat overflow/underflow
- ✅ Test buff stacking
- ✅ Test resource management
- ✅ Catch game-breaking bugs before release

🔑 Key Concepts

Recursion Patterns in Games

Pattern	Gaming Example	Base Case
Linear Recursion	Walk down dungeon floors	Reached bottom level
Tree Recursion	Damage cascades on enemies	No more enemies affected
Tail Recursion	Spawn enemy waves	Wave count reached
Mutual Recursion	Team members call allies	No allies left to call

Game Testing Concepts

Test Type	Gaming Example	What We Check
Equality	Damage = 25	Exact damage values
Boolean	Is player dead?	True/false states
Null Check	Is inventory full?	Item doesn't exist
Exception	Cast spell with no mana	Exception thrown
Edge Case	Max health +1 damage	Overflow handling

💡 Real Gaming Examples

Recursion: Dungeon Traversal

```
Navigate dungeon with recursion:
- Base case: Reached bottom level (boss room)
- Recursive case: Move to next level, call recursively
- Perfect for: Procedurally generated dungeons
```

Testing: Health System

```
Test cases:
- Player has 100 HP
- Takes 50 damage → 50 HP
- Takes 60 damage → Game Over (caught by test!)
- Heal with overflow → Clamped to max
```

Real Bug Story: Integer Overflow in Damage

Many games have had bugs where:

- Damage calculated as: `damage = baseAtk * critMultiplier`
- With max attack (999) × 999 crit multiplier = overflow!
- Test catches: `testDamage_handlesMaxValues_givenCriticalHit()`
- Player gets one-shot instead of challenging combat

🎮 When to Use Recursion in Games (Some Use Cases)

Scenario	Use Recursion?	Gaming Example
Nested game menus	✓ YES	Menu → Submenu → Item
Dungeon levels	✓ YES	Level 1 → Level 2 → Boss
Skill prerequisites	✓ YES	Skill requires another skill
Equipment rarity tiers	✓ YES	Epic contains Rare contains Common
Simple loops	✗ NO	Spawn 10 enemies (use for loop!)
Time-critical updates	✗ NO	Game physics tick (use iteration!)
Deep nesting (20+)	✗ NO	Stack overflow risk

📊 Test Coverage for Games

Essential game tests:

```
✓ Health: 0 to MAX_VALUE
✓ Mana: 0 to MAX_VALUE
✓ Damage: Negative to MAX_VALUE
✓ Inventory: 0 items to max capacity
✓ Buffs: None to multiple stacking
✓ Level: 1 to 99
✓ XP: Overflow, underflow, exact thresholds
✓ Status Effects: None, single, multiple
✓ Equipment: Unequipped, equipped, broken
✓ Conditions: Alive, dead, stunned, frozen
```

❌ Common Game Programming Bugs (Caught by Tests!)

Bug	Test That Catches It	Example
Health > MAX_HEALTH	`testHeal_clamps_toMaxHealth()`	Heal overflow
Damage causes INT overflow	`testDamage_handles_maxDamage()`	999 * 999
Negative inventory	`testInventory_prevents_negativCount()`	Remove more than owned
Infinite combo	`testCombo_stops_atMaxChain()`	Base case missing
Mana becomes negative	`testMana_preventsNegative()`	Cast without checking
Level skip	`testLevelProgression_sequential()`	XP math wrong
Buff stacking crash	`testBuffs_multiple_stacking()`	Array index out of bounds

📋 Gaming Test Naming Convention

```
✅ GOOD:
testPlayerHealth_dies_whenHealthReachesZero()
testDamage_causesOverflow_givenMaxAttackAndCrit()
testInventory_rejectsItem_whenAtCapacity()
testCombo_multiplier_increases_withChainLength()
testBuff_stacking_caps_atMaximum()

❌ BAD:
test1()
testHealth()
testDamage()
```

When `testDamage_causesOverflow_givenMaxAttackAndCrit() FAILS`, you know exactly what's wrong!

🔧 Setup for Gaming Examples

RecursionExample Covers:

- Party member XP distribution
- Cascading damage effects
- Dungeon depth calculation
- Skill tree traversal
- Combo chain building
- Bonus: Loot rarity chains

TestingExample Covers:

- Player damage/healing
- Health boundaries
- Inventory limits
- Mana management
- Buff stacking
- Game-over detection
- Bonus: Critical hit overflow
