🌪️ Spiral Model in Software Engineering

📌 Introduction

The Spiral Model is a software development life cycle (SDLC) model that was proposed by Barry Boehm in 1986. It combines the features of both:

- The Waterfall Model (step-by-step approach) and
- The Prototyping Model (building a working version early).

It is especially designed for large, complex, and high-risk projects.
The model is called “spiral” because the development process is represented as a spiral curve that starts at the center and expands outward.

👉 Each loop of the spiral represents a phase of development.

🔄 Phases of Spiral Model

Everyloop(cycle)ofthespiralhas four stages:

1. Planning Phase

- Objectives are set for the current phase.
- Requirements are collected from the customer.
- Constraints (time, cost, resources) are identified.
- A plan is prepared for the next activities.
  📌 Example: Collecting features the customer wants in the first version.

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2. Risk Analysis Phase

- This is the most important part of the Spiral Model.
- Possible risks are identified and studied:
  - Technical risks (new technology may fail).
  - Schedule risks (time may not be enough).
  - Cost risks (budget may not fit).
  - Operational risks (system may not be user-friendly).
- To reduce risks, prototypes or simulations are developed and tested.
  📌 Example: Building a prototype of the payment gateway to check if it works securely.

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3. Engineering (Development and Testing) Phase

- After planning and risk analysis, the actual work is done here.
- Activities include:
  - Designing the software
  - Coding/programming

- Unit testing, integration testing, and system testing
- Each loop produces a working version (increment) of the software.
  📌 Example: In the first loop → a basic system with login. In the next loop → add database features.

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4. Evaluation Phase

- The software increment is shown to the customer/stakeholders.
- Customer provides feedback. If satisfied → move to the next loop.
- If not → changes are made.
- 📌 Example: Customer reviews the login system and asks to add "forgot password" before the next loop.

🌀 How Spiral Model Works (Step-by-Step)

1. Start from the center of the spiral with very small objectives.
2. Perform planning, risk analysis, engineering, and evaluation in the first loop.
3. Each loop ends with a prototype or working system.
4. The spiral moves outward → adding more features with each loop.
5. The process repeats until the final full system is completed and delivered.

📌 Example Progression:

- Loop 1: Requirement gathering and feasibility study.
- Loop 2: High-level design and architecture prototype.
- Loop 3: Detailed design and partial coding.
- Loop 4: Full coding, testing, and deployment.

✅ Advantages of Spiral Model

1. Strong focus on risk management – problems are identified early.
2. Customer involvement – feedback is taken at the end of each loop.
3. Flexibility – changes can be made anytime.
4. Early working software – prototypes are delivered frequently.
5. Suitable for large, complex, and expensive projects.
6. Combines the best of waterfall (structured) and prototyping (iterative).

❌ Disadvantages of Spiral Model

1. Very costly – risk analysis and prototyping increase expenses.
2. Needs experienced risk analysts.
3. May take a long time for final product delivery.

4. Not suitable for small or low-risk projects.
5. Too complex compared to simple models like Waterfall or Agile.

📌 Applications of Spiral Model

The Spiral Model is used in:

- Banking software (ATM systems, online banking)
- Aerospace systems (satellite control software)
- Military/defense projects
- Medical systems (life-critical software) Any large system with high
- risk and frequent customer interaction

✨ Summary

- The Spiral Model is a risk-driven SDLC model. Software is
- developed in loops (cycles), and each loop has:
  Planning → Risk Analysis → Engineering → Evaluation.
- Each loop produces a better version of the software.
- Best suited for large, costly, and high-risk projects.
- Focuses on continuous customer feedback and risk reduction.