### 🎯 Objective:

Dive into emerging fields where Generative AI is converging with reinforcement learning, multimodal perception, and robotics. This phase enables exploration of next-gen systems with real-world interactivity, perception, and reasoning.

## 🔍 Curriculum Breakdown

### 1. Reinforcement Learning (RL)

#### 📌 1.1 Core Concepts

* Agent: the learner or decision-maker
* Environment: where the agent interacts
* Policy: strategy to choose actions
* Reward signal: feedback loop to learn optimal behaviors

#### 📌 1.2 Algorithms

* Q-Learning: value-based decision making
* DQN (Deep Q Networks): neural networks for RL
* PPO (Proximal Policy Optimization): policy-based RL used in modern LLM training

#### 📌 1.3 GenAI Applications

* RLHF: fine-tuning LLMs with human preference scores
* Policy optimization in dialog generation
* Reward shaping for safer, aligned outputs

📌 Lab: Train a simple Q-learning agent in OpenAI Gym (e.g., CartPole)

### 2. Vision-Language Integration

#### 📌 2.1 Multimodal Learning

* Input/output across text + image + audio modalities
* Cross-modal embeddings & alignment
* Challenges: data representation, fusion, scaling

#### 📌 2.2 Notable Models

* GPT-4V: input images + text, generates multimodal outputs
* BLIP-2: bootstrapping language-image pretraining
* Flamingo (DeepMind): interleaved text-image reasoning
* Gemini (Google): vision, text, code, audio understanding

#### 📌 2.3 Use-Cases

* Visual question answering (VQA)
* Document parsing and image captioning
* Grounded image-based conversations

📌 Demo: Try a Hugging Face demo for BLIP-2 or use GPT-4V with image input

### 3. Robotics & Embodied AI

#### 📌 3.1 What is Embodied AI?

* Combine GenAI with real-world sensors and actuators
* Merge perception, planning, and control in dynamic environments

#### 📌 3.2 Key Concepts

* Sensor fusion: integrating visual, spatial, and tactile inputs
* Spatial reasoning and path planning
* Feedback loops for action refinement

#### 📌 3.3 Use-Cases

* AI-powered warehouse or delivery robots
* Home assistants with speech + navigation
* Robotics + LLMs: explainable or interactive agents

📌 Experiment: Use Unity ML-Agents to simulate a GenAI-controlled agent following instructions

### 4. Research Exploration

#### 📌 4.1 Keeping Up with Research

* Follow trends via:  
  + arXiv
  + Papers with Code
  + ML Conference Tracks (NeurIPS, ICLR, CVPR, ACL)

#### 📌 4.2 Explore & Prototype

* Replicate SOTA models using pre-trained weights
* Run ablation studies or visualize architecture behavior
* Evaluate papers with open datasets and leaderboard tracking

#### 📌 4.3 Build Low-Code Experiments

* Use 🤗 Transformers, Gradio, or Google Colab
* Plug in open weights and pretrained pipelines to test ideas quickly

📌 Mini Project: Reproduce a recent model’s behavior using HF models + public datasets

### 5. Tools & Platforms

#### ✅ Reinforcement Learning

* OpenAI Gym: classic environments (CartPole, Lunar Lander)
* RLlib (Ray): scalable RL for production
* DeepMind Control Suite: continuous control environments

#### ✅ Multimodal GenAI

* Hugging Face Transformers, Diffusers, BLIP
* Gemini API, CLIP, GPT-4V

#### ✅ Robotics & Embodied AI

* Unity ML-Agents: 3D simulation + RL agents
* ROS (Robot Operating System): real-world robot control
* Habitat AI (Facebook AI): photo-realistic navigation environments

### 🧪 Capstone Exploration Project

Project Idea: *Build a GenAI-enabled virtual or simulated agent*

* Use an RL-trained policy to navigate or act
* Add LLM for planning or instruction interpretation
* Use vision-language grounding (BLIP, GPT-4V)
* Demonstrate control loop via Unity or Habitat
* Document results + lessons learned