PART A: Mechanical Design

Actuator Configuration

To balance a ball on a flat platform in two dimensions (X and Y), I propose a **2-DOF gimbal-style tilting platform** actuated by **two servo motors** placed orthogonally beneath the platform. Each motor controls the tilt along one axis—X or Y.

To make it more innovative and explore alternatives to typical rotary servos, I also considered **linear actuators** or even **pneumatic air bladders** that inflate/deflate to tilt the platform. However, rotary motors offer more precise and reliable control.

Design Summary:

- **2 Servo Motors** (standard or high-torque)
- **Tiltable Platform** mounted on a dual-axis gimbal mechanism
- **Ball** rests freely on the platform
- **Microcontroller** (like Arduino) to control motor angles based on sensor inputs

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Degrees of Freedom

The 2-DOF design allows independent tilt in both X and Y directions:

- **DOF 1 (X-axis)** → Controls forward/backward tilt
- **DOF 2 (Y-axis)** → Controls left/right tilt

These two degrees of freedom are essential for full planar motion control and allow smooth and continuous correction of the ball's position using PID control or other feedback methods.

Aspect	Advantages	Drawbacks
Simplicity	Compact design with only 2 motors	Requires calibration for smooth motion
Control Precision	Accurate tilt via servos; easier PID implementation	Rotary actuators might need encoders for feedback
Cost	Affordable using basic servo motors	More advanced motors/feedback sensors will increase cost
Scalability	Design can be scaled for different platform sizes	Weight of larger platforms may require stronger actuators
Reliability	Rotary servos are robust and widely available	Mechanical wear over time; limited to motor torque and speed
Performance	Good for real-time corrections with low latency	Vibrations or backlash in the mechanism can reduce precision

PART B: Non-Vision Sensing Approaches

We avoid using cameras. Here are two alternative sensor systems for detecting the ball's position:

Infrared (IR) Emitter-Receiver Array (Break-Beam Sensors)

Working Principle:

- An array of IR emitter-receiver pairs is placed along X and Y edges of the platform.
- As the ball moves, it breaks the IR beams at specific points.
- The pattern of broken beams gives a 2D estimate of the ball's position.

Tracking:

- IR sensors placed along the sides continuously monitor beam status.
- The blocked beams correspond to approximate X and Y positions of the ball.

Pros and Cons:

Pros	Cons
Works even if the ball doesn't touch the surface	Limited resolution unless many beams used
Fast and reliable in well-lit conditions	Can be affected by ambient light interference
Non-contact sensing	Slightly complex alignment and calibration