1. Mechanical Design PART A

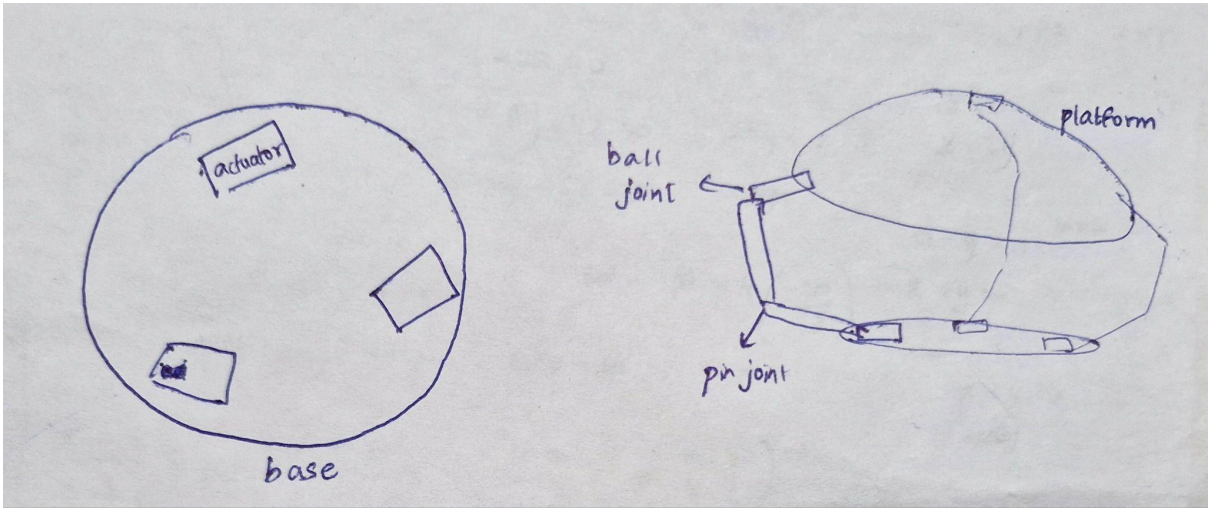
I will use a 3-DOF, 3-RPS parallel manipulator using three actuators.
The design includes:

Platform Structure: A circular platform made of lightweight material with less friction

Actuators: Three linear actuators arranged in an equilateral triangle form under the platform. Each actuator is placed on the base at 120 degree spacing, and is connected to the platform through 2 links using pin and ball joints. This allows vertical motion (prismatic), rotation at the base (revolute), and tilt freedom at the platform (spherical).

Camera: A camera is placed above to track the ball's position in real-time using OpenCV.

Improved Stability
The 3-RPS manipulator offers three controllable DOFs allowing precise platform adjustments. This is more stable than a 2-DOF system, which lacks vertical control. The addition of a DOF allows the platform to adjust its height, preventing vertical disturbances, which a 2-DOF system cannot do. PID tuning optimizes the system's response, balancing responsiveness and smoothness. This feedback loop ensures rapid stabilization, keeping the ball balanced during sudden movements.



Pros

1. The design uses only three linear actuators, compared to other 6 actuator models, lowering cost.

Cons

1. Compared to a 2-DOF servo system, the 3-RPS design is mechanically and computationally more complex. Inverse kinematics makes control more accurate but demands accurate tuning.
2. Joint wear over time may take place.
3. Noise due to moving arms and motor.

2. Alternative Camera Options Part B

Alternative 1: Touch Sensitive Platform

1. Sensor Selection
Type: Resistive touch panel (pressure-sensitive).
Key Specifications:

1. Resolution: capable of detecting a 5 cm diameter ball's contact point.
2. Sensitivity: Detects pressure from a ball with a force threshold of ~0.1 N.
3. Frequency: Reads the position of the ball every 20ms

2. Motion Tracking
The platform's surface consists of two conductive layers separated by spacers. When the ball rolls, its weight presses the layers together at the contact point, creating a measurable change in resistance. The system applies voltages across the X and Y axes, measuring the resulting voltage drops to determine the X, Y coordinates of the pressure point.

3. Pros and Cons
Pros:

1. Excellent accuracy due to the continuous nature of the resistive panel
2. Moderate cost, using widely available touchscreen technology.
3. Straightforward integration with a Raspberry Pi via ADC.

Cons:

1. Accuracy may degrade with very light balls.

Alternative 2: Infrared Sensor

1. Sensor Selection
Type: Infrared proximity sensors.
Key Specifications:

1. Range: 1 cm to 15 cm
2. Accuracy: ±5 mm for reflective surfaces (ball coated with reflective or matte material).

2. Motion Tracking
The sensors are placed between the actuators on the base. The 3 sensors emit IR light and measure the intensity of the reflected signal from the ball, with reflection strength indicating distance. The system triangulates the ball's X, Y coordinates using distance estimates from the three sensors, solving for the intersection point on the 2D plane.

3. Pros and Cons
Pros:

1. Good accuracy
2. Very low latency due to fast sensor responses and simultaneous sampling
3. Very cost effective

Cons:

1. Requires precise sensor alignment and calibration