FPGA Ball and Plate - Project Checklist
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COMMITMENT: Open-loop control of platform.

1. **Joystick interface**
    - Samples normalized joystick potentiometer voltages into 12-bit values.
    - Can be demonstrated with XADC demo.
2. **SPI interface**
    - SPI master and state machine for communicating with STMPE610 touch screen controller module.
    - Can be demonstrated with Lab 5c-like display.
3. **Servo interface**
    - Outputs periodic PWM signal, pulse width determined by commanded angle.
    - Can be demonstrated live by controlling a servo.
4. **Control FSM**
    - Main state machine. Passes inputs and outputs between modules as necessary. Toggles between manual and feedback control. Keeps track of the setpoint. Also demonstrable via Lab 5c-like display.
5. **Plate Pose Controller**
    - Locked to 2-DOF (pitch and roll, other values set/assumed to be zero)
      Uses inverse kinematics to calculate rod lengths given translations and rotations relative to initial orientation.
    - Calculates servo angles from the rod lengths.
    - Demonstrated live.

GOAL: Closed-loop control of ball position on top plate.

In addition to the above modules...

1. **Ball Position Controller**
    - PID-type feedback controllers convert dx and dy into roll and pitch values for pose ctrl.
    - Joystick offsets setpoint (centered by default).
    - Demonstrated live and with Lab 5c-like display.
2. **IMU interface (as a sensor)**
    - Measures IMU output to determine servo step response and plate tilt.
    - Incorporates sensor fusion.
    - Demonstrated with figures.

STRETCH:

1. **IMU interface (as a user input device)**

- Uses IMU movement as input for pose controller.
- Demonstrated live.

2. **Motion profile module**
    - Gets ball to follow a trajectory (square, ellipse, figure-8, etc.)
        i. Sequence of setpoints.
        ii. Change to sp[i+1] automatically when ball close enough to sp[i].
    - Demonstrated live and with Lab 5c-like display.
3. **Improved controller module (state-space with state/observer feedback or ADRC)**
    - Demonstrated live (by comparison to PID), supplemented by MATLAB simulations.