DESIGN & ANALYSIS OF SWIMMING POOL LIFT

ME6221: THEORY OF MECHANISMS

PROF. SUJATHA SRINIVASAN

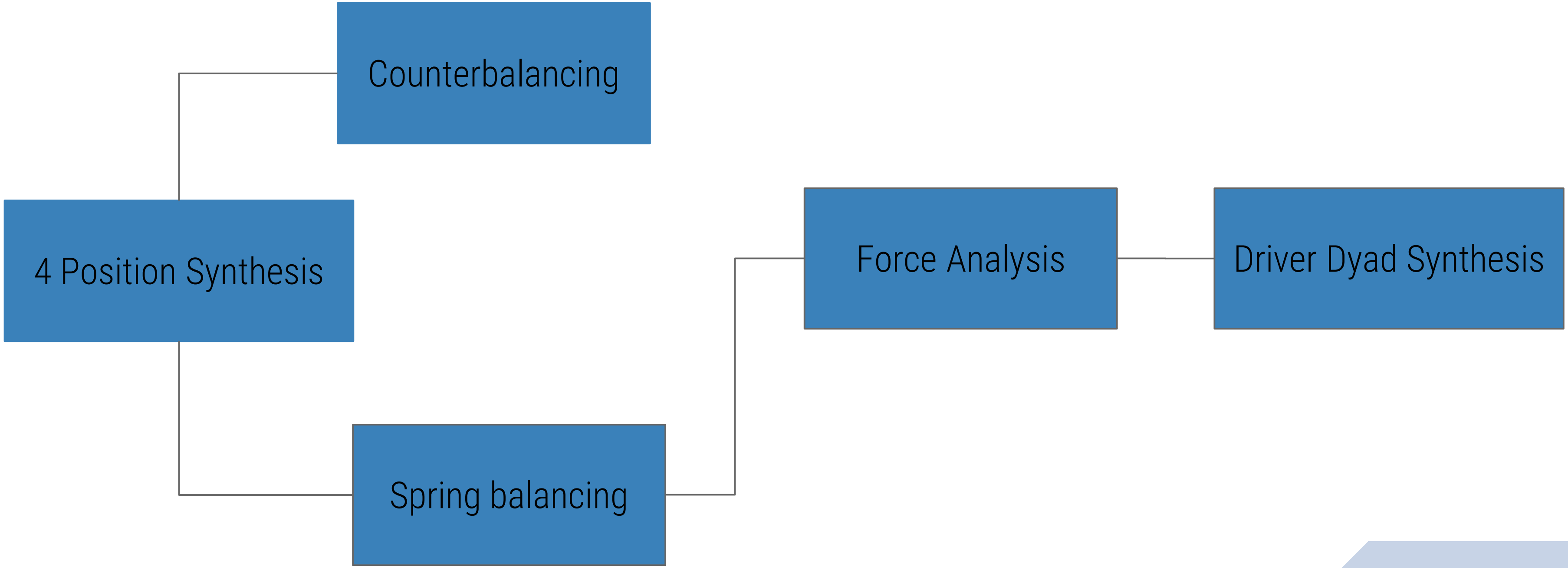
Group Members:

1. ED15B001 ADARSH S.
2. ME15B044 AKSHAY M.
3. ME15B048 NIKHIL S.
4. ME15B079 ABHIJEET V.

OBJECTIVES

- Design a swimming pool lift for a wheelchair user in accordance with American with Disability Act 2010
- Perform four position motion synthesis to develop a four bar mechanism
- Balance the mechanism against toppling
- Propose a driver dyad for actuation with high mechanical advantage with optimal link lengths for least force of actuation
- Incorporate spring balancing into the design to minimize torque requirements

METHODOLOGY

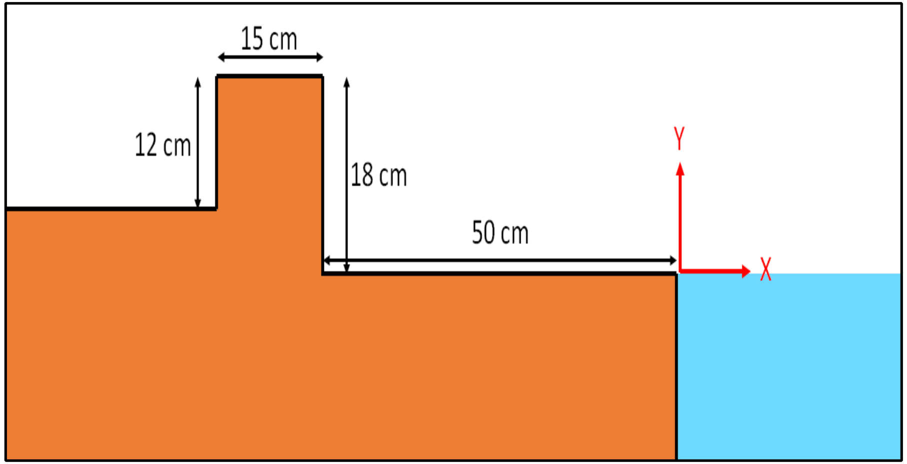


SITE SURVEY

- **Criteria:**
  - Wheelchair accessibility
  - Depth of the pool
  - Space availability for accommodating mechanism

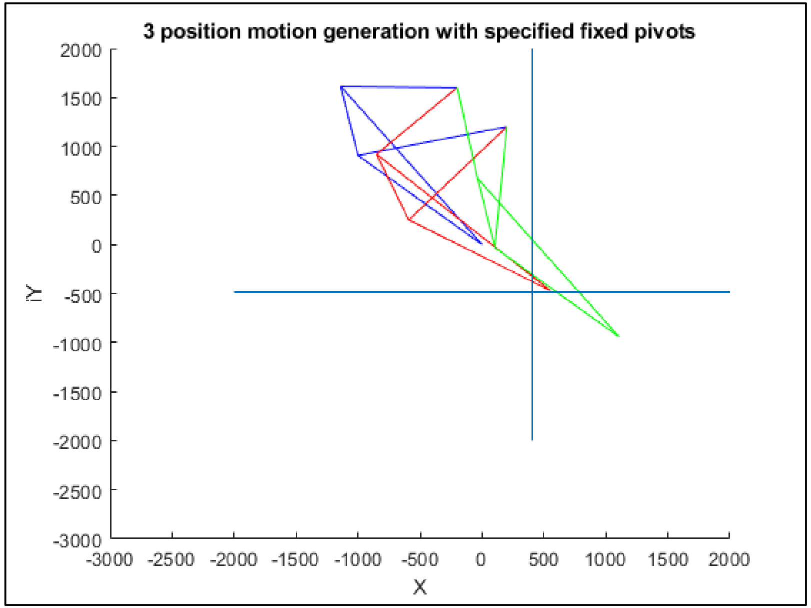
KINEMATIC SYNTHESIS

- Initial & final positions chosen based on ADA requirements
  - **$(x0,y0) = (-405\text{ mm}, 485\text{ mm})$**
  - **$(xf,yf) = (700\text{mm}, -455\text{mm})$**



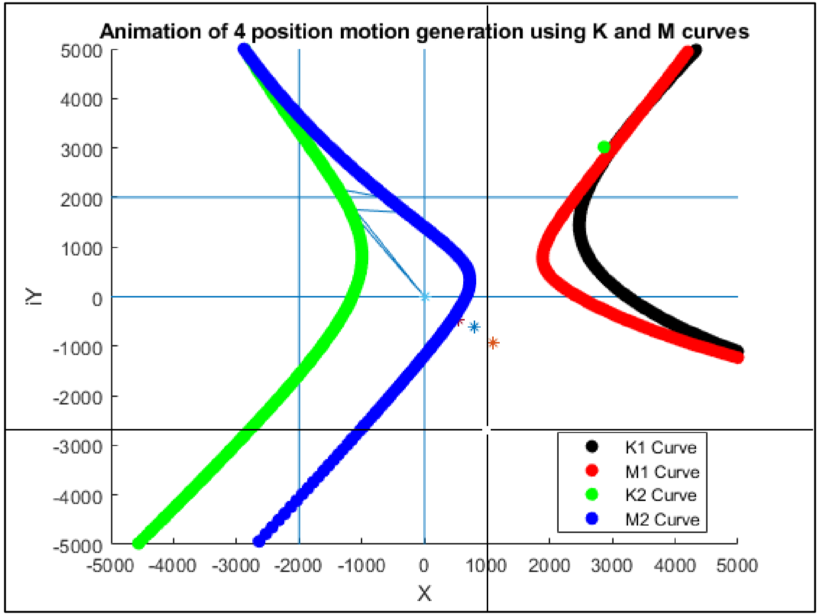
KINEMATIC SYNTHESIS

- 3 Position synthesis was initially performed to find approximate location of fixed pivots



KINEMATIC SYNTHESIS

- 4 position synthesis performed afterward to generate best locations for fixed pivots

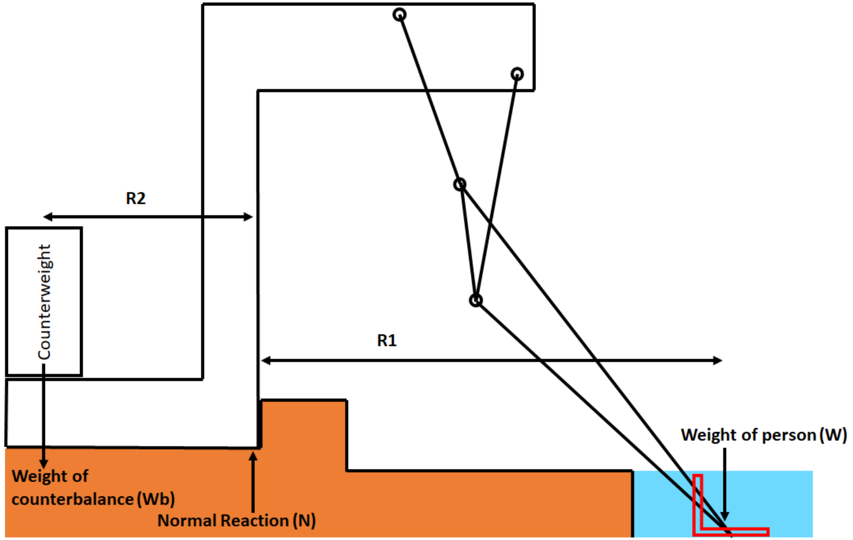


KINEMATIC SYNTHESIS

Link	Length(m)	Direction(deg) at initial pose
Crank length l1	0.941	179.18
Dyad 1 length l2	1.976	-54.73
Follower length l3	1.235	-166.32
Dyad 2 length l4	1.351	-42.21
Coupler length l5	0.719	-78.77
Base length l6	0.565	-45.00

COUNTERBALANCING

- 2 extreme scenarios:
  - The person is seated & the mechanism is at its extreme position into the water
  - There is no one sitting on the mechanism & the mechanism is at its initial position
- If we are counterbalancing purely by a mass, then required mass = 150 kgs

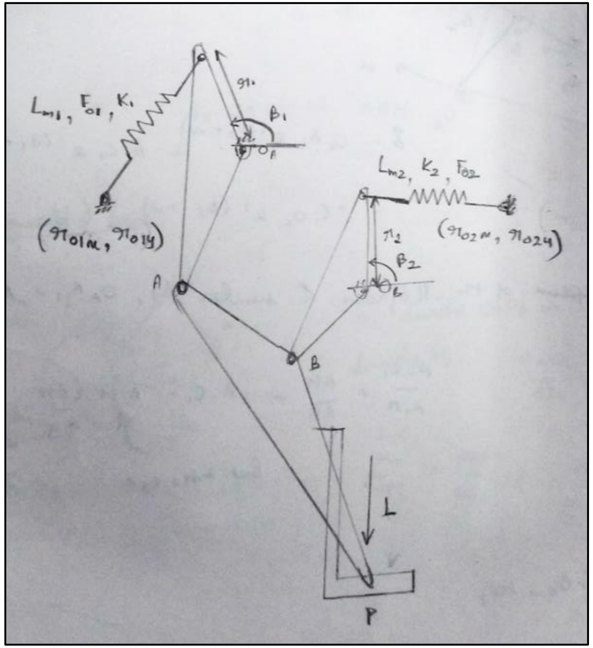


COUNTERBALANCING

- **Alternate proposal:** Attach buoys to the frame/mechanism through rigid links
- Buoys can be lowered into the water only when necessary & then removed
- With a counterbalance of 20 kgs, the buoys need to displace a volume of water equal to around 65 litres at a distance 1.5 m into the pool to provide sufficient counter-moment
- As we have control over how the buoys are lowered into the pool, we can ensure the system doesn't topple in the other direction
- Buoys can be actuated by the same linkage

STATIC BALANCING

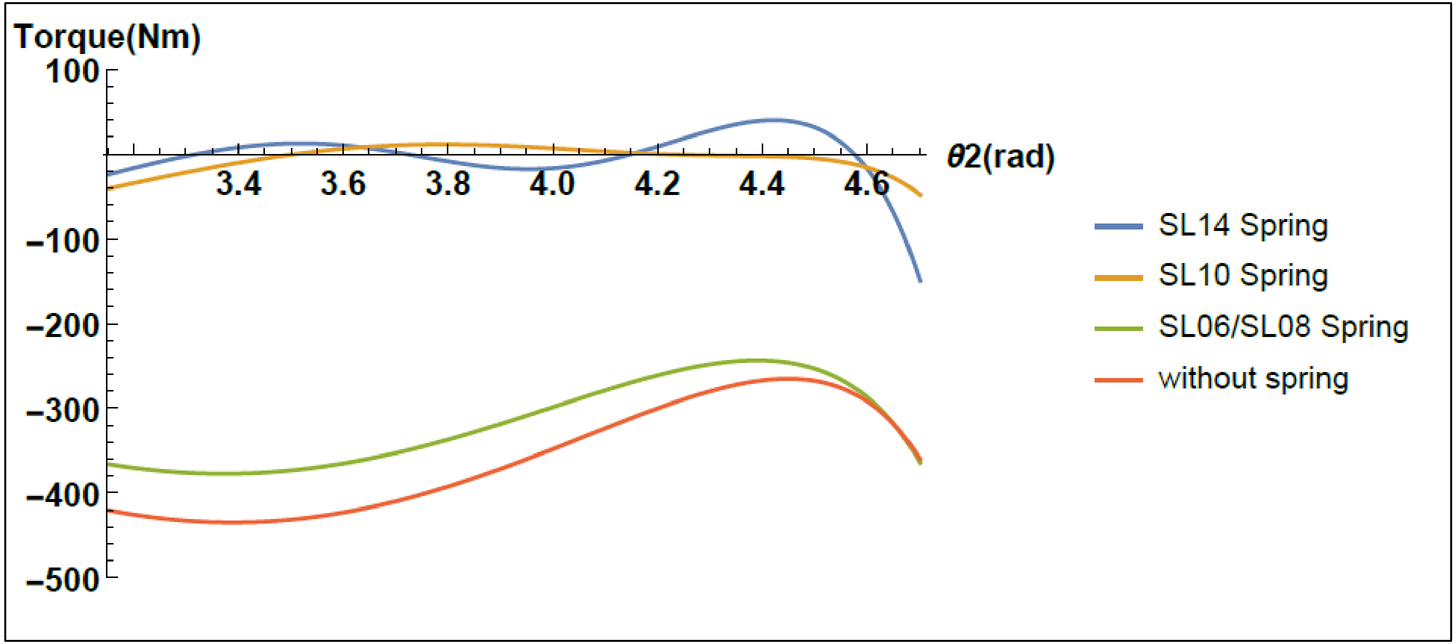
- Potential energy $P = f(\theta 2)$, $\theta min < \theta 2 < \theta max$
- Torque $T = -f'(\theta 2) \sim (P(\theta 2) - P(\theta 2 - d\theta))/d\theta$
- Mean square torque $G = \Sigma T^2/N$
- Minimize G, subject to:
  - Variable bounds for spring parameters as per catalogue & practical considerations
  - Spring compression at any point should be within the specified range



STATIC BALANCING

Case	RMS Value of Input Torque(Nm)
Without balancing	364.92
With SL06 & SL08 gas spring series	319.97
With SL10 gas spring series	14.93
With SL14 gas spring series	28.60

STATIC BALANCING



FORCE ANALYSIS

- Quasi-static assumption
- Linear mass density : 1 Kg/m
- Initial configuration is found & operational range of angle is given as input
- Iterate over input angles for force and moment calculations
- A*F=B

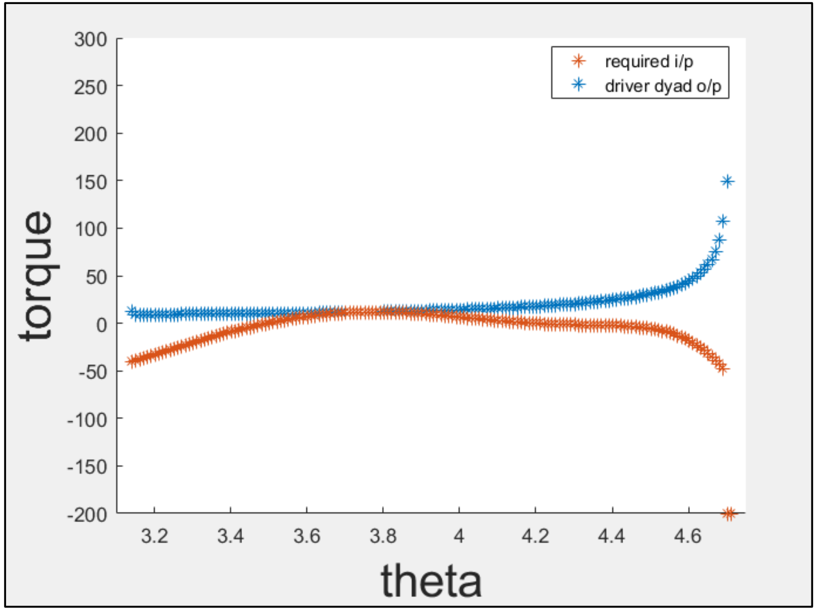
B= input matrix (accelerations of links)

F= force matrix [τ Fox Foy F1x F1y F2x F2y F3x F3y]

A= coefficient matrix

METHOD OF ACTUATION

- The driver dyad synthesis is done by optimizing the link lengths for maximum mechanical advantage
- The algorithm compares input torque required with the driver dyad output torque
- The output of the synthesis is a Grashof-neutral mechanism



THANK YOU

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