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MTE 481 - Mechatronics Engineering Design Project
Capstone Group 52

October 20, 2025

1. Problem & Need Identification
2. Design Objectives & Specifications
3. Alternate Design Concepts
4. Patent Landscape Review
5. Technical Details & Components
6. Project Timeline

The Problem

Wheelchair sports players need BOTH hands for:

- **Wheelchair propulsion** - pushing wheels to move and steer
- **Equipment handling** - dribbling, passing, shooting, racquet sports

By the Numbers

- **73%** shoulder pain
- **60-80%** arm fatigue
- **15-20** interruptions/game
- **30-40%** lower scoring

User Story

"I have to stop dribbling just to reposition my chair — which interrupts gameplay and reduces my reaction speed."

- Adrit Batra
Laurier University

Sports Impact

Tennis, badminton, hockey currently limited for wheelchair users

Research Data

- **Biomechanical Impact**: 73% injury rate
- **Performance Gap**: 30-40% lower scoring
- **Accessibility**: 25-40% participation increase potential

The Vision

Revolutionize wheelchair sports through hands-free mobility technology

Core Innovation

- **Body-shift control** - natural, intuitive movement
- **Sports-optimized** - designed for competitive play
- **Equipment-friendly** - no interference with gear

Target Impact

- **25-40%** increase in sports participation
- **73%** reduction in shoulder injuries
- **New sports access** - tennis, badminton, hockey
- **Enhanced performance** - competitive advantage

Breaking Barriers

"I have to stop dribbling just to reposition my chair — which interrupts gameplay and reduces my reaction speed."

- Adrit Batra
Laurier University

The Solution

Hands-free wheelchair that responds to body weight shifts, enabling simultaneous movement and equipment handling

Performance

- Speed: **5 mph**
- Response: **¡100ms**
- Movement: **3 DOF**
- Battery: **2+ hours**

Safety & Physical

- Collision: **40N resistance**
- Load: **200 lbs**
- Emergency stop
- Stability factor: > 1.5

Control

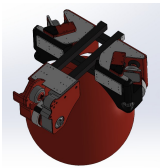
- Method: Body-shift
- 100% hands-free
- Intuitive operation

Constraints

- Budget: $< \$300$
- Timeline: **May 2026**
- Environmental: 5% contamination

Critical Requirements

- **C1:** Hands-Free Control - 100% movement without hand input
- **C2:** Safety - Withstand 30-50N collision forces
- **C3:** Equipment Compatibility - No interference with sports gear
- **C4:** Environmental - Handle 5% surface contamination
- **C5:** Response Time - $<$ 100ms system lag
- **C6:** Budget - $<$ \$300 total project cost
- **C7:** Timeline - Prototype by May 2026 symposium

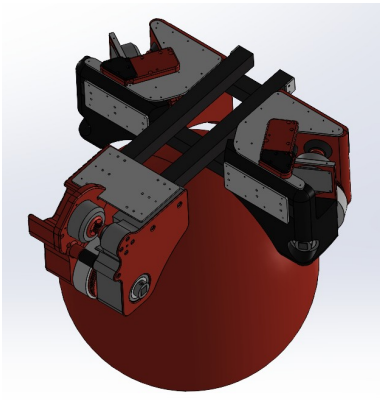


1. Ball Drive

2. Segway-Style

3. Mecanum Wheels

4. Track System

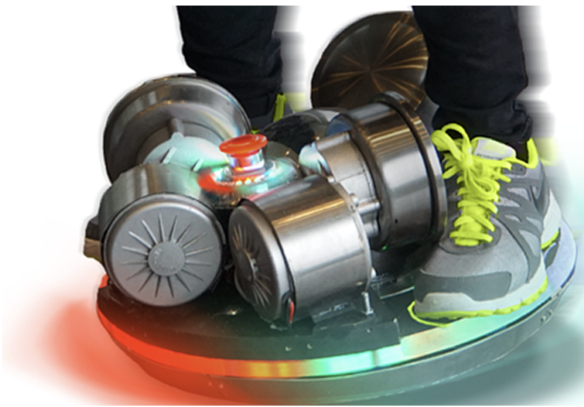


Strengths

- True 360° movement
- Intuitive control
- Minimal protrusions
- Equipment compatible

Weaknesses

- Complex mechanics
- Higher cost
- Maintenance needs



Strengths

- Proven technology
- Excellent stability
- Responsive control
- Established manufacturing

Weaknesses

- Only 2 DOF
- Poor sports compatibility
- Complex electronics

Strengths

- Precise control
- Proven in robotics
- Good load distribution
- Modular design

Weaknesses

- Complex wheels
- High maintenance
- Smooth surfaces only
- High cost

Strengths

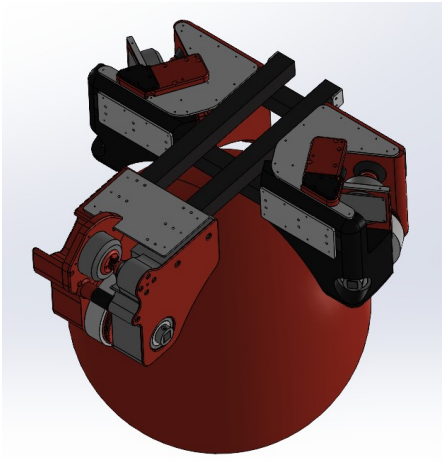
- Excellent traction
- Simple control
- Robust design
- Low maintenance

Weaknesses

- Only 2 DOF
- Limited turning
- High friction
- Poor surface compatibility

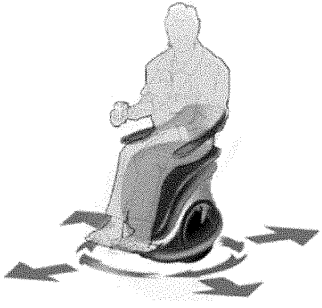
Criteria (Weight)	Ball	Segway	Mecanum	Track
Hands-Free (25%)	9	8	9	7
Non-Interfering (20%)	9	8	8	7
Responsive (20%)	9	7	9	6
Equipment Compat. (15%)	8	9	7	8
Safety (10%)	7	9	8	9
Intuitive (5%)	9	8	7	8
Full Mobility (5%)	10	6	10	6
WEIGHTED SCORE	**8.6**	**7.7**	**8.3**	**7.1**

Selected: Ball Drive System (8.6/10)

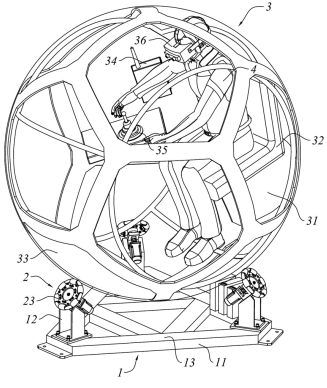


Omni-Directional Ball Drive System

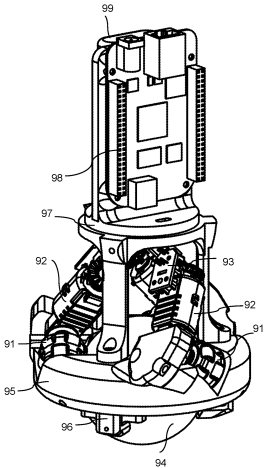
Score: 8.6/10



US20220062075A1
Omni-Dir Ball



CN112071160A
Single Wheel



US20180022197A1
Multi-Dir Device

Clear Path Forward

Our innovation:

Key Differentiators

- Multi-point ball contact system
- Sports-specific features
- Equipment compatibility focus
- Modular architecture
- Enhanced collision resistance

Assessment: Clear Path Forward

Control System

- Arduino Mega 2560
- **BNO085 IMU** (9-axis)
- **VESC-6 Controllers** (x2)
- I2C/SPI interfaces

Mechanical

- 8" Ball Drive (2-drive layout)
- Aluminum Frame
- **BLDC Motors** (149 KV)
- 3:1 gear reduction

Power & Safety

- **10S2P Li-ion** (36V, 6Ah)
- 216 Wh capacity
- Current limits: 25A cont, 60A peak
- Emergency stop
- Torque ramping

Performance

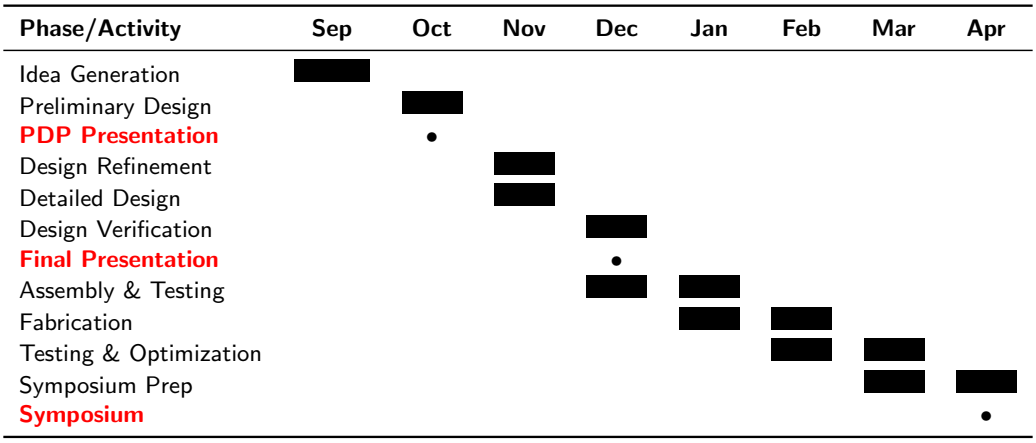
- **5 N·m torque** per motor
- **100W average** power
- Max speed: 1 m/s
- Real-time balance control

Engineering Specifications Summary

Parameter	Target
Maximum Speed	1 m/s (2.2 mph)
Response Time	$<$ 100ms
Battery Life	$>$ 2 hours (216 Wh)
Load Capacity	80 kg (176 lbs)
Motor Torque	5 N·m per motor
Motor Power	100W average
Degrees of Freedom	3 DOF (omni-dir)
Tipping Resistance	40N
Operating Temperature	0-40°C

Quantified targets based on user needs and engineering analysis

8-Month Development Schedule



Project Highlights

- Addresses critical need in wheelchair sports
- Research-backed problem identification (73% injury rate)
- Comprehensive design evaluation (4 concepts)
- Clear technical specifications (30+ parameters)
- Within budget ($230-320 vs $300 limit)
- Feasible 8-month timeline

Expected Impact: 25-40% increase in wheelchair sports participation

Thank you very much!

Open for Questions!!

Capstone Group 52
MTE 481 - Fall 2025

Samuel — Ameen — Joseph — Chanuth — Adesh

Category	Specification	Value	Justification
Mobility	Max Speed	5 mph	Safe for indoor sports
	Acceleration	0-5mph in 2s	Natural feel
	DOF	3 DOF	Full mobility
Control	Response	¡100ms	Real-time control
	IMU Rate	100 Hz	Body tracking
Stability	CoG Height	¡18 in	Tipping prevention
	Wheelbase	24" x 24"	Stability polygon
Power	Battery	7Ah @ 12V	2+ hour runtime
	Motors	25W each	Sufficient torque

Control System

- Arduino Mega 2560 ($25-30)
- MPU-6050 IMU ($5-8)
- L298N Driver ($8-12)

Mechanical

- 12V Motors x2 ($15-20 ea)
- 8" Ball Mech ($50-80)
- Al Frame ($30-50)

Power & Safety

- 12V 7Ah Battery ($25-35)
- Protection Board ($8-12)
- E-Stop Button ($10-15)
- Speed Control ($3-5)

Total: $230-320

- **C1: Hands-Free** - 100% movement without hand contact
- **C2: Safety** - 30-50N collision resistance, no tipping
- **C3: Equipment** - No interference with sports gear
- **C4: Environmental** - 5% surface contamination tolerance
- **C5: Response** - ¡100ms sensor-to-motor lag
- **C6: Budget** - $<$ \$300 total cost
- **C7: Timeline** - May 2026 deadline