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[PRACTICAL] Misconceptions about CoM and Motors

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The **Task 3B-Questionnaire** was given ***in order to provide a hint and make you think on the fundamental concepts which you will surely need to use*** - if you want to succeed at controlling/balancing the robot.

That is the reason behind asking questions like **“Center of Mass opinion”**, **“Parallel/perpendicular axis theorems”**, **“Motor torque requirement calculation”** etc.

Misconceptions

We found that many of you teams are having either confusion or wrong information on these very important points.
For instance,

- The aerodynamic factors or drag play no role in this bike! (negligible)
  But few others require detail discussion - so please read the sections below & ask if you still are not clear. 🚨

1. Center of Mass (Low or HIGH) - What is better?

What most people answered, (some inspired from internet & GPT model responses)
→ ***" a pendulum with longer length needs higher corrective torque.***

Ok, that’s a true statement. But that’s half the truth.

See a simple pendulum, and it’s period of oscillations under gravity(g).

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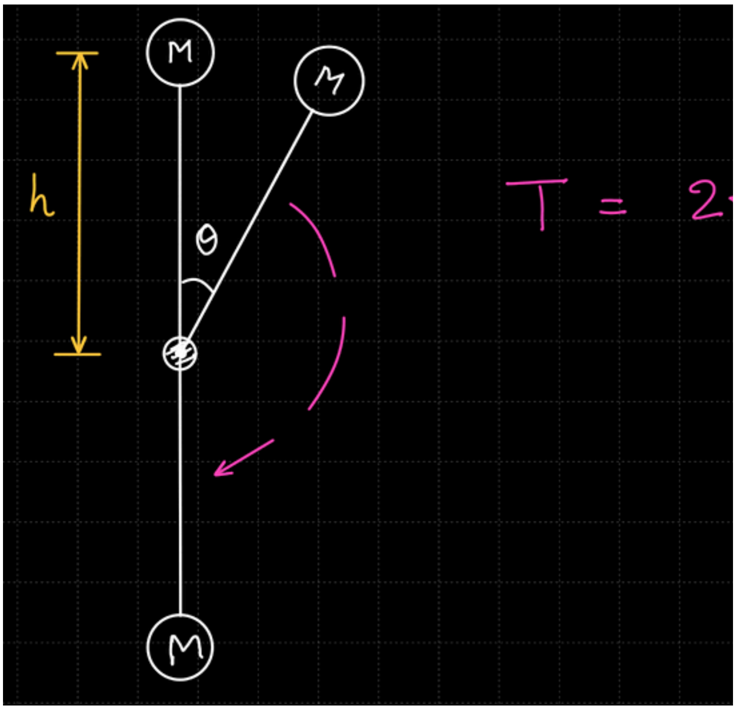

Figure 1: Simple Pendulum Time Period

The time it takes to cover some theta angle during it's fall → is also a small part of the total time period. ***"Notice the relation between length of the pendulum and time period."***

> - **A pendulum with longer length, falls slower !!**
>   It gives your controller more time for corrective action.
>   So, Do not hesitate to keep the Center of Mass higher, as it will give benefit.

2. Distance of Center of Mass from the "Rear Wheel" - why should you care?

It's a **Rotary Inverted Pendulum** and the **ease(how much force effort) and precision(how little you can act) of corrective action** hugely depends on the **"base arm length"**.

(CoM = Center of Mass)

Lunar Scout Bike	Rotary Inverted Pendulum
Distance of CoM from rear wheel(i.e. drive wheel)	The base arm length (from hinge to elbow joint)

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Lunar Scout Bike	Rotary Inverted Pendulum
Height or distance of center of mass from wheel axis	Distance of vertical rod's CoM from elbow joint

> ***Torque = LEVER ARM x Force***
> ***Angular Velocity = Tangential Velocity / LEVER ARM***
> And for Lunar Scout Bike,
> **Distance of CoM from rear wheel(i.e. drive wheel) = LEVER ARM**

The corrective input i.e. force and velocity is given at the end of lever arm in this bike so,

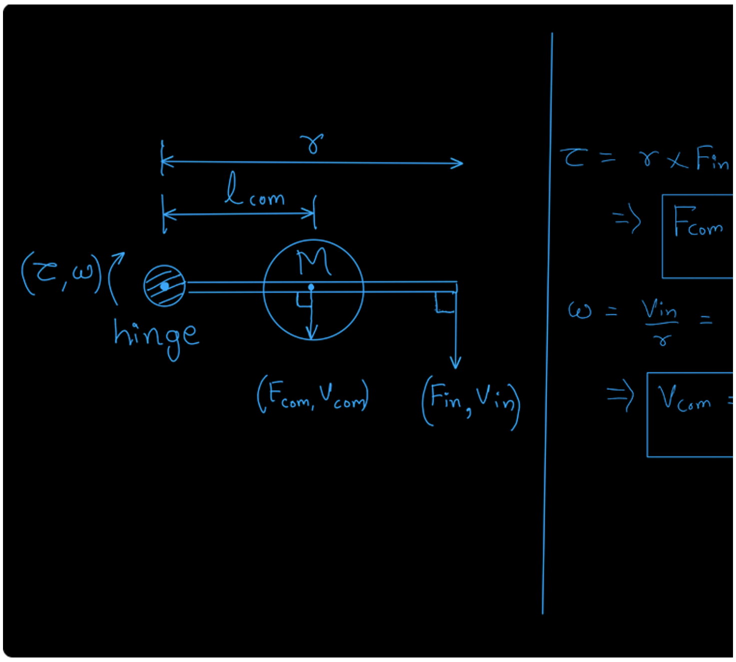

Figure 2: Input (Force,Velocity) relation with values at CoM, due to LEVER ARM

M = total mass of bike at CoM location
Fcom, Vcom, lcom = Force, Velocity and distance of CoM w.r.t given hinge(drive wheel)
Fin, Vin, r = Force, Velocity and distance for corrective input (omniwheel motor)

> **NOTE:** Your motors have just enough torque and speed.
> That's why this calculation is necessary - ***to know if bike is asking more(torque or speed) than what motor can provide***, and… **what to change in both cases.**

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CONCLUSION :

Center of mass is too important, so do not ignore. Whether you are using PID or LQR, you should calculate location of center of mass for your robot.

How to calculate?

- Choose a reference point *(origin)* and reference coordinate axes on your robot.
- For each item present on your robot, list out masses, dimensions & coordinates(x,y,z) w.r.t. your reference point and axes.
- Apply **the formula from definition**

```
Xcom = (m1*x1 + m2*x2 + ..... + mn*xn) / (
Ycom = (m1*y1 + m2*y2 + ..... + mn*yn) / (
Zcom = (m1*z1 + m2*z2 + ..... + mn*zn) / (
```

```
(Xcom, Ycom, Zcom) = coordinates of center of mass
(xi, yi, zi) = coordinates or i'th object
mi = the mass of i'th object
i = 1, 2, ....., n (for n objects in the system)
```

Selecting a good location for CoM

CoM Location	Effect
Too Low (close to base)	Control need to be very fast *(refer to pendulum time period)*. Only benefits if you have low motor torque limit.
Too high (far from base)	More time for corrective action, but make sure max. corrective torque is within motor rating.
Too close to rear wheel	Motor needs to run at much higher speed, so it’s not useful if it needs more than max. RPM of motor. But you can have smaller corrective movements.
Too close to omniwheel	Motor doesn’t need to run much to balance, so lower speed also does

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CoM Location	Effect
	the job. Since Lcom = R makes, Vcom = Vin(see figure-2)

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(The description given above is about
omniwheel motor.)
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[URGENT] New POST in PRACTICAL guide ser…

[Announcement] Open Door Session

Listed on Feb 1

Closed on Feb 1

Pinned globally on Feb 4

JerishSingh e-Yantra Staff Feb 19

Simple Pendulum vs Physical pendulum:

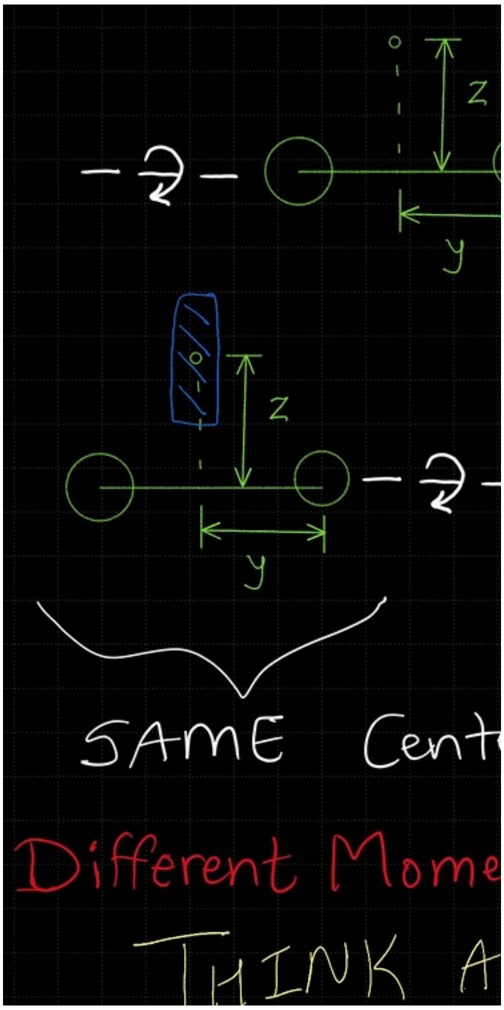

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Image 1

[HINT] Design & Dynamics & Tuning sequence

Pinned on Feb 19

Krutarth e-Yantra Staff Feb 20

Now… if we THINK ABOUT IT

24.2: Physical Pendulum

Our bike's not a simple pendulum right away. So the time period doesn't only depend on the height of center of mass… since ***"there can be multiple possible moment of inertia for same location of center of mass."***

Hence for physical pendulum, such as our bike… **height of CoM** and **moment of inertia about the pivot axis** … both are the deciding factors for falling time !!!

So think about different ways of placement of an object → for effective moment of inertia selection & better dynamic response.

Related Topics

Topic	Replies	Views	Activity
Doubt in task3B question 2	1	65	Nov 2023
Doubt in Task 2A LS_3083 task-2	1	76	Oct 2023

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Topic	Replies	Views	Activity
Lunar Scout: Task 2	3	3.8k	Sep 2023
Lunar Scout: Task 1	3	9.6k	Sep 2023
Lunar Scout: Task-4	1	970	Nov 2023