Assignment 6: Rigid Body Dynamics

Robot Kinematics and Dynamics

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Contents

1 Overview

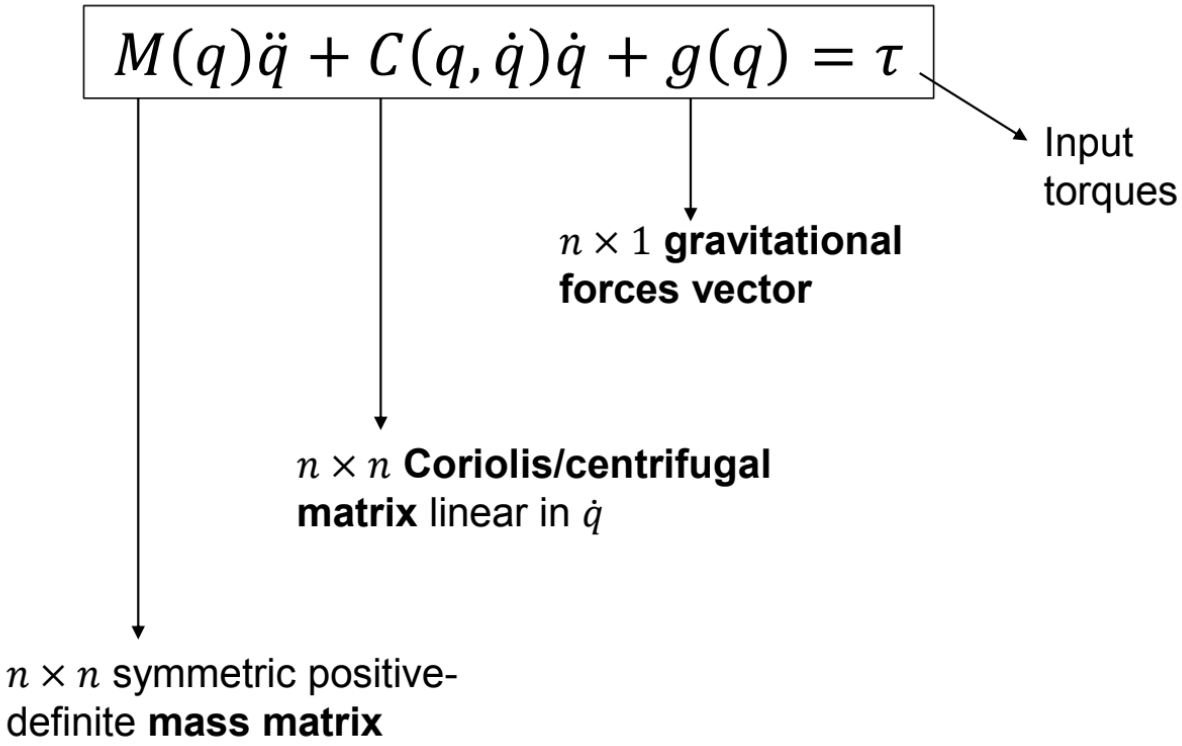
This assignment reinforces the following topics:

- Rigid Body Dynamics

2 Background

2.1 Standard Form

As a reminder, the standard form for writing equations of motion is as follows:



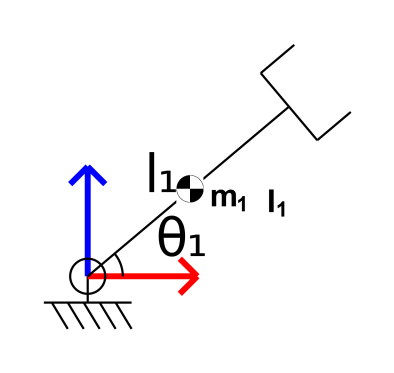
3 Instructions

- The deadline for this project is 26th September, 2024 09:00 P.M.
- Zip your code into a single file named `<AndrewId>.zip`. See the complete submission checklist at the end, to ensure you have everything. Submit your PDF file to Gradescope.
- Each question (for points) is marked with a **points** heading.
- **Start early!** This homework may take a long time to complete.
- **During submission indicate the answer/page correspondence carefully when submitting on Gradescope.** If you skip a written question, just submit a blank page for it. This makes our work much easier to grade.
- If you have any questions or need clarifications, please post in Piazza or visit the TAs during the office hours.
- Unless otherwise specified, **all units are in radians, meters, and seconds**, where appropriate.

4 Written Section

1) Rigid Body Dynamics

Please use the diagram of the arm below for the following questions:



The arm has a link length of l_1 where the center of mass is located in the center of the link at $\frac{l_1}{2}$. The link's mass is m_1 and it has moment of inertia I_1.

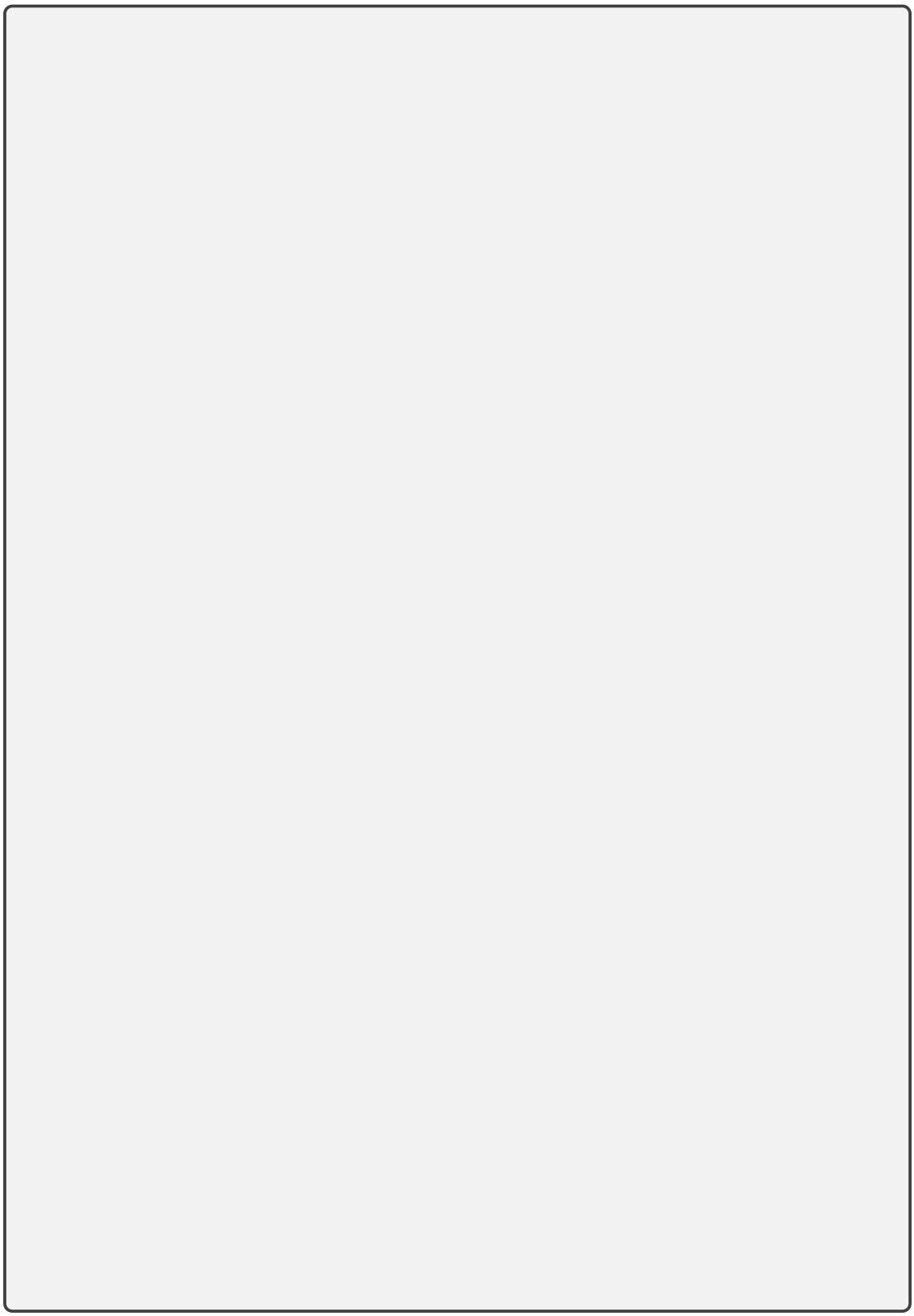
(1) [5 points] Determine the Kinetic Energy for the R arm shown above.

(2) [5 points] Determine the Potential Energy for the R arm shown above.

(3) [5 points] Write the Lagrangian for the R arm shown above.

(4) [5 points] Determine the Equations of Motion for the R arm shown above using the

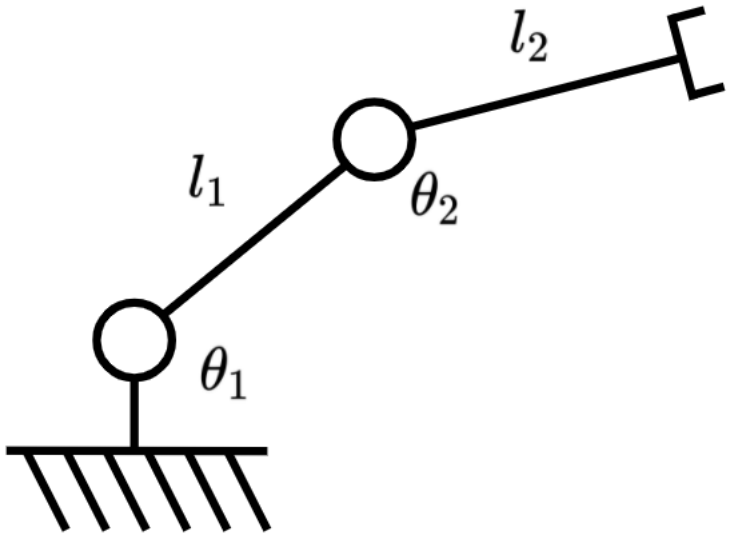
Lagrangian.



(5) [5 points] Rewrite the equations of motion into standard form.

1) RR robot

Consider the following robot



Given the above RR arm, each with a mass of m_i located at $l_i/2$ and a moment of intertia of I_i about their com

(1) [5 points] Determine the Kinetic Energy for the RR arm shown above.

(2) [5 points] Determine the Potential Energy for the RR arm shown above.

(3) [2 points] Write the Lagrangian for the RR arm shown above.

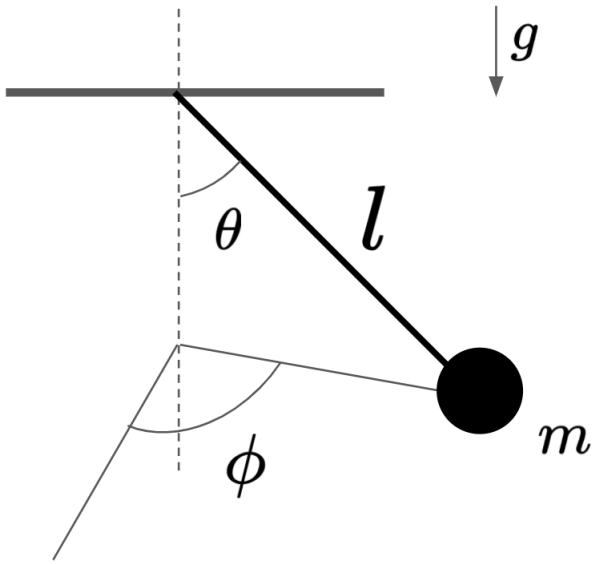
(4) [10 points] Determine the Equations of Motion with respect to θ_1 for the RR arm shown above using the Lagrangian.

(5) [10 points] Determine the Equations of Motion with respect to θ_2 for the RR arm shown above using the Lagrangian.

(6) [5 points] Rewrite the equations of motion into standard form.

2) 3D Pendulum

Consider the following robot



Given a pendulum that can move anywhere in 3D space, with a fixed length l and a mass m, solve for its equations of motion. Hint: use spherical coordinates.

(1) [5 points] Determine the Kinetic Energy for 3D pendulum.

(2) [5 points] Determine the Potential Energy for the 3D pendulum.

(3) [2 points] Write the Lagrangian for the 3D pendulum.

(4) [10 points] Determine the Equations of Motion with respect to θ for the 3D pendulum.

(5) [10 points] Determine the Equations of Motion with respect to ϕ for the 3D pendulum.

(6) [5 points] If ϕ is kept constant, what do the equations above reduce to? What system that we've studied in class has similar EOMs?

5 Code Questions

There is no coding portion in this homework.

6 Submission Checklist

- ☐ Upload `<andrew_id>.pdf` to Gradescope.