Controls and Dynamical Systems

Student Reading Group

Indian Institute of Technology Bombay

Project Name

Author Names

Contents

List of Figures

List of Tables

Abstract

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Acknowledgements

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Chapter 1

Introduction

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This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

After this fourth paragraph, we start a new paragraph sequence. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look.

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Chapter 2

Theory

2.1 Key Pointers

There are few key points that everyone has to keep in mind while writing their respective sections, in order to prevent discrepancies when all the files are compiled in the end.

1. The name of the file should follow the specified format:
   (a) section_Your name's initials.tex

   Eg: **section_JD.tex**, if the name is John Doe
   This will help us keep track of your contributions!
   (b) In case more than one people are working on a given section (multiple people assigned to the same problem statement), then, do the following: section_Initials of name 1_Initials of name 2_.tex

   Eg: **section_JD_JRD_THJ.tex**
   If the people involved have names - Jon Doe, Jane R Doe, Tom Harry Jones
2. Have proper labels and captions for all the figures, tables, and equations involved. Ensure that the labels are unambiguous.
3. **Kindly adhere to the following nomenclature, when writing labels**:
   (a) Figures - \label{prefix_fig: description}
   (b) Tables - \label{prefix_tab: description}
   (c) Equations - \label{prefix_eq: number or description}

   The prefix is defined as **at-most** the first four characters of the suffix of the section_XXX.tex file. *Eg:*
   (a) **section_JD.tex → JD_fig**

(b) **section_JD_JRD_THJ.tex → JDJR_fig**

4. Do not modify the formatting of the report. Also do not add any \usepackage or similar macro commands to the main.tex file.
   All the primary packages you might need have already been imported using the Import_Packages.sty file.
   If there arises a situation where you require a new package or a command/macro, kindly contact us

5. Command for vectors with boldface: $ \vect{X} $ → $\boldsymbol{X}$
   Command for vectors with arrow-overhead: $ \Vec{X} $ → $\vec{X}$

6. Upload figures to the corresponding **Chapter/Figures** or the **Sections/Figures** folder, following the same convention as:
   prefix_FigName.jpg, prefix_FigName.png, etc

7. Citations to books, papers, online resources should be mentioned wheresoever it has been used appropriately - as is the standard practice.
   This is done by making adding the resource in the **reference.bib** file. Refer the website - Link.
   Once included in the **reference.bib** file, the source can be cited wherever required in the text, using the **\cite{}** command.
   Eg: Like this [1], this [2], and this [3]

2.2 First Section

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

For help on how to insert images and tables, refer this website: Link

Example of a figure:

Example of sub-figures:

- To refer the first figure - 2.1
- To refer the sub-figure - 2.2
  - To refer the individual sub-figures - 2.2b & 2.2c

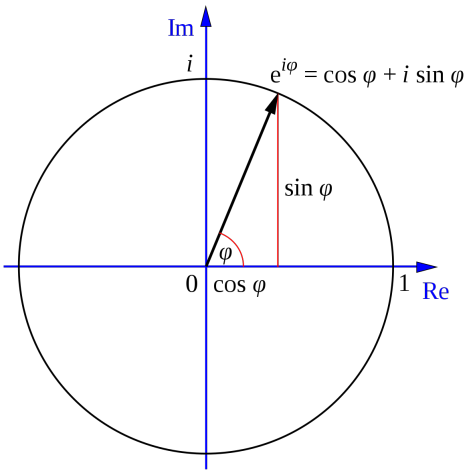
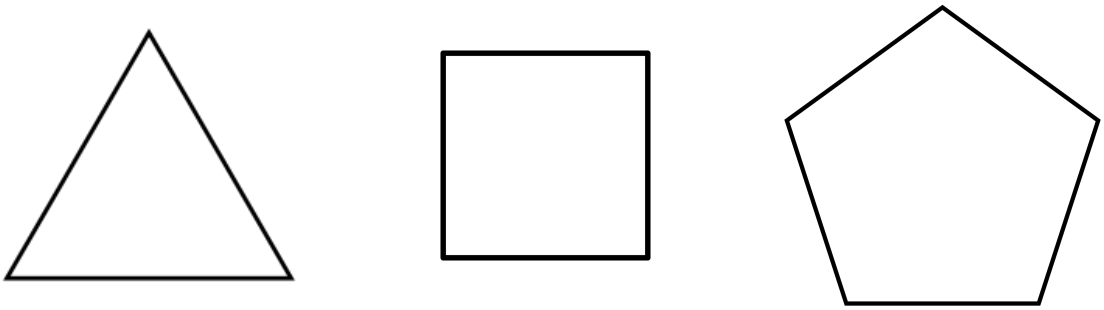


Figure 2.1: Euler's Formula



(a) Triangle (b) Square (c) Pentagon

Figure 2.2: Three Regular Polygons

Example of a basic table:

Example of an auto-generated table:

1. To refer the first table - 2.1
2. To refer the second table - 2.2
   (a) To auto-generate tables online - refer this website: Link

2.3 Second Section

Theorems, Corollaries, Lemmas, Remarks, Definitions, and Proofs can be defined easily.
All the information to do so can be found here - Link

For details on using equations, refer this website - Link

A	B	C
1	2	3
4	5	6

Table 2.1: Basic Table

Sl No	Name	Roll No	Age	Department
1	ABC	18xxxxxx	20	abcdef
2	XYZ	17xxxxxx	21	wxyz
3	EFG	16Dxxxxxx	22	efghi
4	LMN	19xxxxxx	19	lmnop

Table 2.2: Auto-generated table

Example:

$$\begin{aligned} A &= \frac{\pi r^2}{2} \\ &= \frac{1}{2}\pi r^2 \end{aligned} \tag{2.1}$$

$$\boldsymbol{A} \times \boldsymbol{X} = [x_1, x_2, \ldots, x_n]^T \tag{2.2}$$

To refer to the first equation - 2.1

To refer to the second equation - 2.2

Chapter 3

Assignment Problems

3.1 Question 1

Consider a simple robotic arm below to which a bob of ***mass m*** is attached at its end and it is fixed on a cylindrical base which rotates with ***constant angular speed*** $\dot{\alpha}$ about a fixed verticle axis as shown in the figure below. A constant ***torque*** τ acts on the massless rod to change its position. Derive the dynamics of the motion of the bob using a Lagrangian approach and suitably generalised coordinates. (Assume cylindrical base and the arm to be massless). Simulate the behaviour of the system in MATLAB / Python i.e. plot the variables θ and α as a function of time which describe the states of the system at any time instant

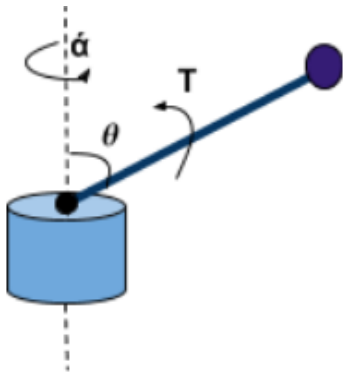


Figure 3.1: Scheatic representation of question

Authors

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(iii) Shivansh Bharadwaj

Solution

First we find the Lagrangian $\boldsymbol{L}(q,\dot{q})$ of the system.In order to do that the we have to fix a coordinate system known as generalized-coordinates.In this case we fix angle from vertical θ and the angle in plane of rotation α as our generalized coordinate.The Lagrangian can be calculated by using the relation

$$\boldsymbol{L}(q,\dot{q})=\boldsymbol{T}(q,\dot{q})-\boldsymbol{U}(q,\dot{q})$$

where $\boldsymbol{T}(q,\dot{q})$ is the Kinetic energy of the system in generalized coordinates and $\boldsymbol{U}(q,\dot{q})$ is the potential energy of the system in generalized coordinates.Here q and $\dot{q}$ represent generalized coordinates and generalized velocity.

In our case $\boldsymbol{U}$ and $\boldsymbol{T}$ in generalized coordinates are:

$$\boldsymbol{U}= -\tau\theta+mgl\cos(\theta)$$
$$\boldsymbol{T}= \tfrac{1}{2}ml^2[\sin^2(\theta)\dot{\alpha}^2+\dot{\theta}^2]$$

Using ***Lagrange's Equation*** described above which is derived using ***Hamilton's Principle of Least Action*** we get the ***Equation of Motion*** as described

$$\ddot{\alpha}=0$$
$$ml^2\ddot{\theta}=mgl\sin(\theta)+\tau-ml^2\dot{\alpha}^2\cos(\theta)\sin(\theta)$$

Now these equations are solved using ***Rk-4 Solver*** implemented in ***Python***.Some solutioins obtained with different initial conditions are shown below.These solutions were obtained for $\boldsymbol{m}$=1, $\boldsymbol{l}$=1 and $\dot{\alpha}$=1.In all these cases ***Torque*** τ=10 N-m.

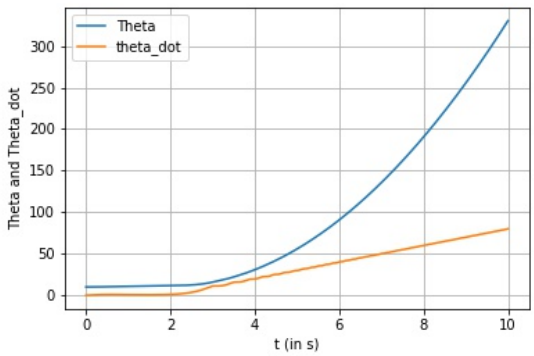

Figure 3.2: $\theta(0)$=10 rad , $\dot{\theta}$=0 rad/s

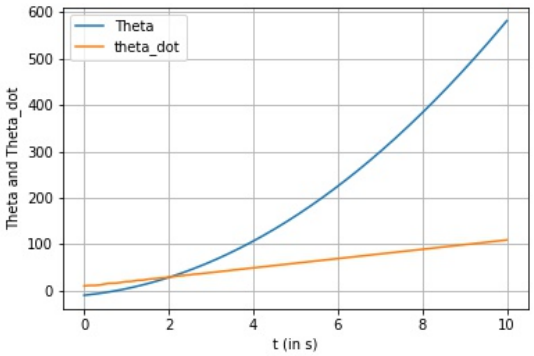

Figure 3.3: $\theta(0)$=–10 rad , $\dot{\theta}$=10 rad/s

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Bibliography

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