IN3140 Seminar

Introduction

Today:

- Recap of some bits from the introduction lecture
- Expected knowledge – math & physics
- Administrative matters – assignments, deadlines, communication channels, learning material

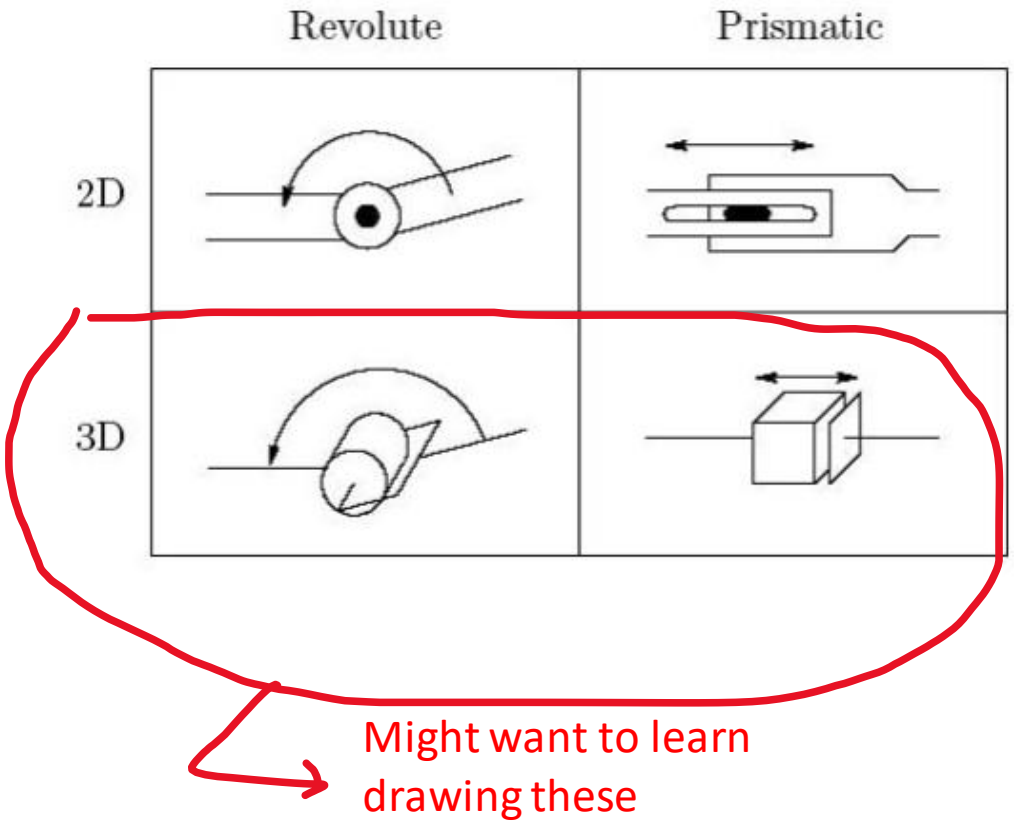
Focus of the course:

Robotic manipulators - "robot arms":

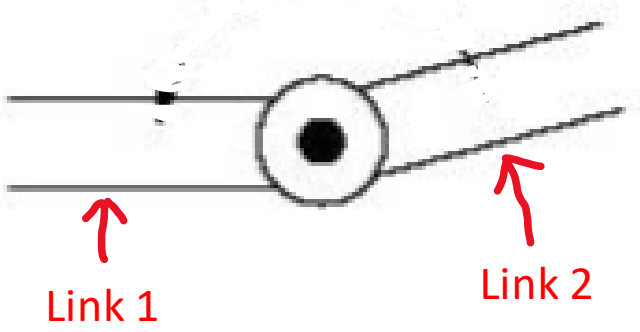
- how they work
- how they move
- how to calculate their movements
- how to program them

Manipulator structure: joints, links, end-effector

Joints: revolute (like your elbow) or prismatic (like telescope)



Links: the "bones" of the manipulator

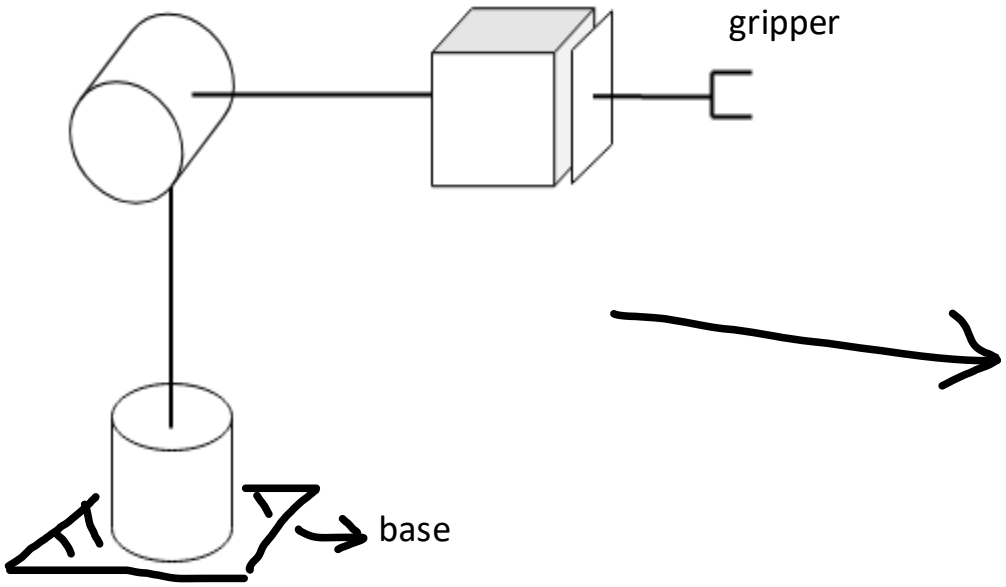


End-effector: a tool at the end (gripper, paint sprayer, welding torch, missile launcher, etc.)

<--- gripper

Manipulator Drawing Example

Manipulator with three joints – 3 DOF
(Degrees of Freedom)



IN3140/IN4140 is not an art or literature course. Poor presentation will not be directly punished for, **but no one is unbiased**.

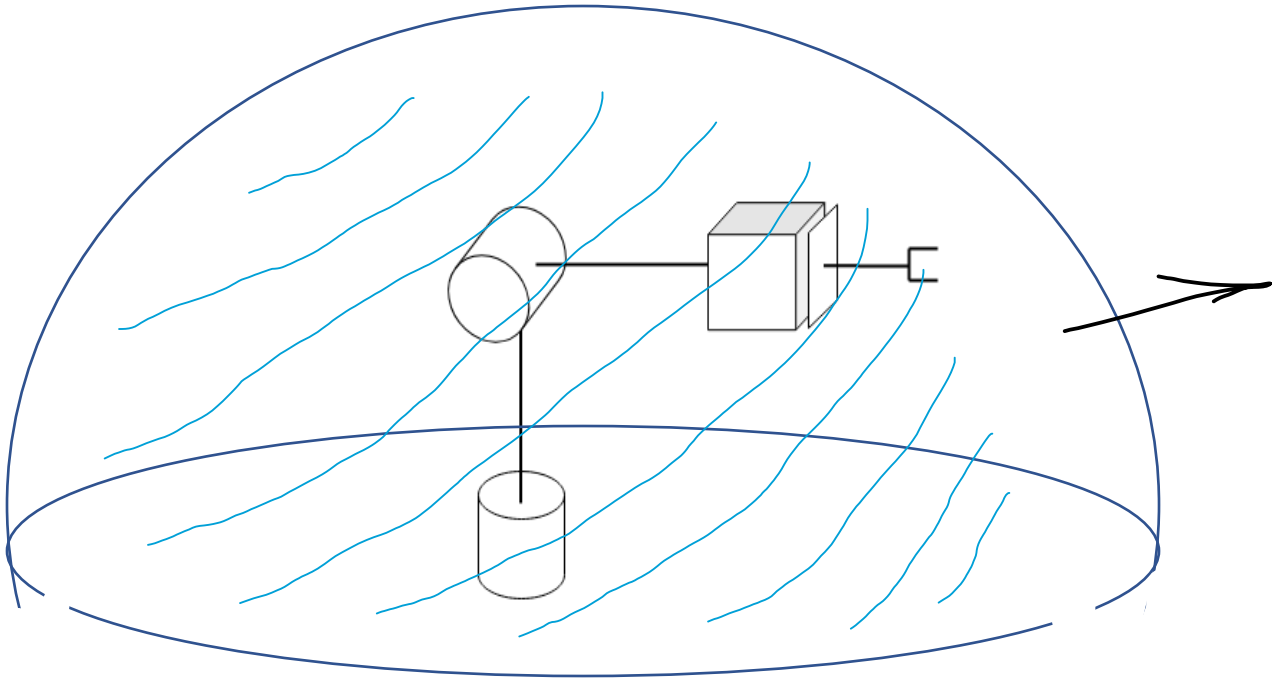
Manipulator classification:

- by joints (starting from the base): **R**evolute, **R**evolute, **P**rismatic – **RRP**
- by **workspace** – **spherical**

You will be expected to draw things like this

Workspace

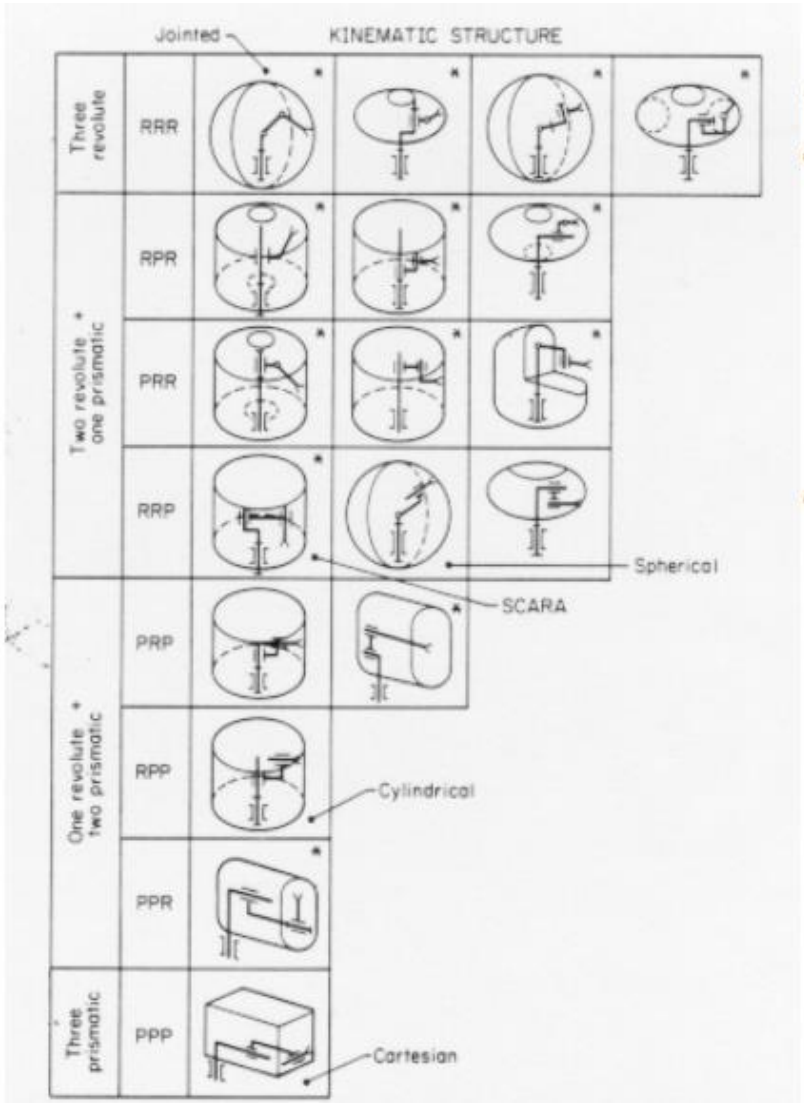
All points manipulator can reach. For the manipulator from last slide:



Workspace is a (half?)sphere, therefore a **spherical manipulator**

When asked to draw the workspace, draw the workspace AND the manipulator. Consider the joints and how they move - use your imagination and spatial intelligence.

Other Common Types (from lecture slides)



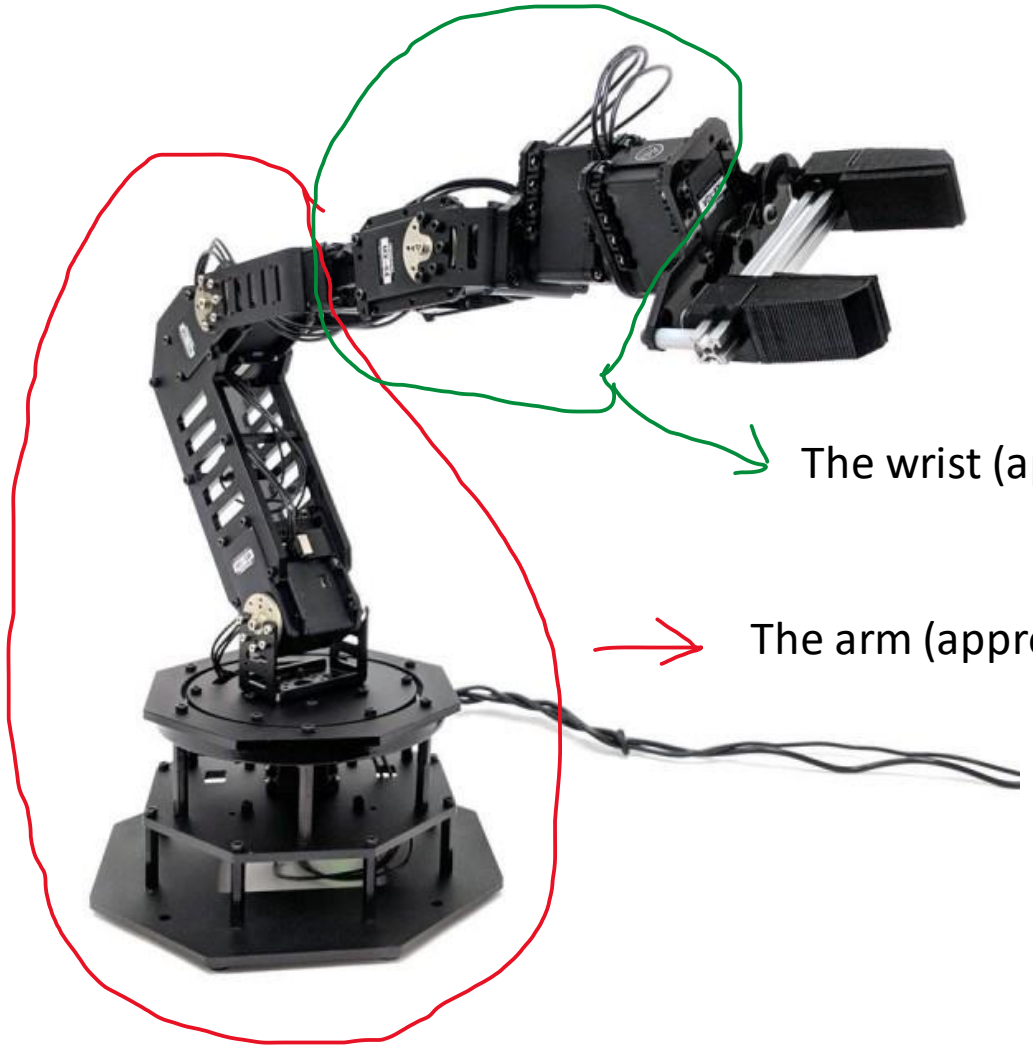
The most frequent arm configurations are :

- Open kinematic chains :
  - Jointed articulated or anthropomorphic (human-like arms) (RRR)
  - Spherical (RRP)
  - Scara (RRP)
  - Cylindrical (RPP)
  - Cartesian (PPP)
  - Multi-joined (RRRRRR.....) , Redundant configurations
- Closed kinematic chains

See course book for a more detailed description.

About Wrists and Degrees of Freedom

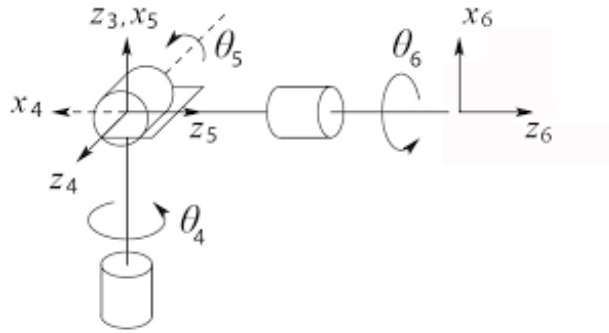
A human arm has a wrist, sometimes a manipulator also has one.



You will normally work with 2-4 DOF manipulators in the course. The wrist **by itself** is usually 3DOF. A "complete" manipulator is usually 3DOF of the arm + 3DOF of the wrist = 6DOF.

You will not be expected to do calculations for 6DOF – near impossible to handle without a computer. Rule of thumb: if more than 3 joints, run to your computer.

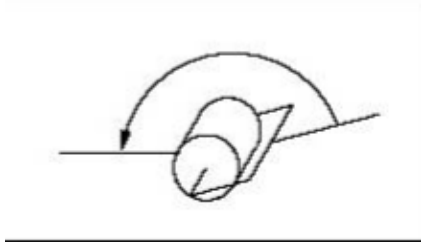
Very common type of wrist: spherical wrist



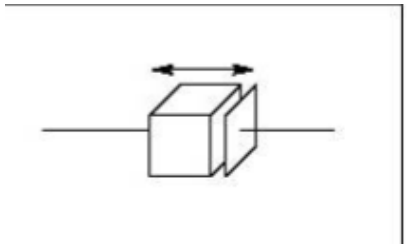
Course Topics

- Homogeneous Transformations: math for linear movement and rotations, written as 4x4 matrices
- Forward kinematics: given joint angles and extensions, find where the arm tip is
- Inverse kinematics: given position of the tip, find joint angles and extensions
- Velocity kinematics: given velocity of joints, find velocity of tip
- Dynamics: how to find force/torque equations (yes, physics)
- Robot Operating System (ROS): how to program real robots
- Control theory: how to control robot movement to make it smooth
- Evolutionary robotics: AI for robots (what and why, not how)
- Possible guest lectures from the industry or something else to pad out the remaining weeks

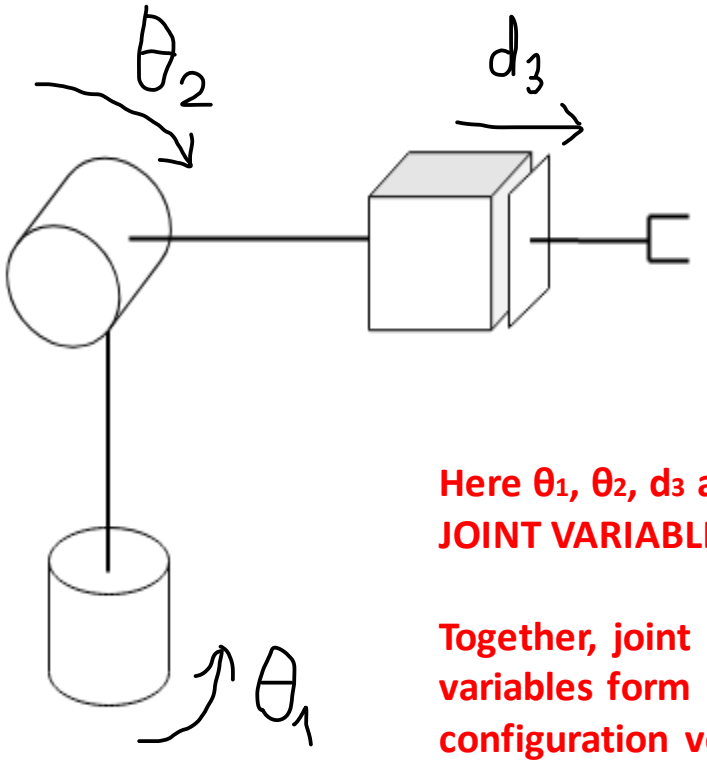
Joint Variables



Rotation angle of a revolute joint: ϑ *(measured in radians or degrees)*



Extension length of a prismatic joint: d (measured in meters or millimeters)



Subscript corresponds to joint number. There is only one *d*, but it is still d_3 – because third joint.

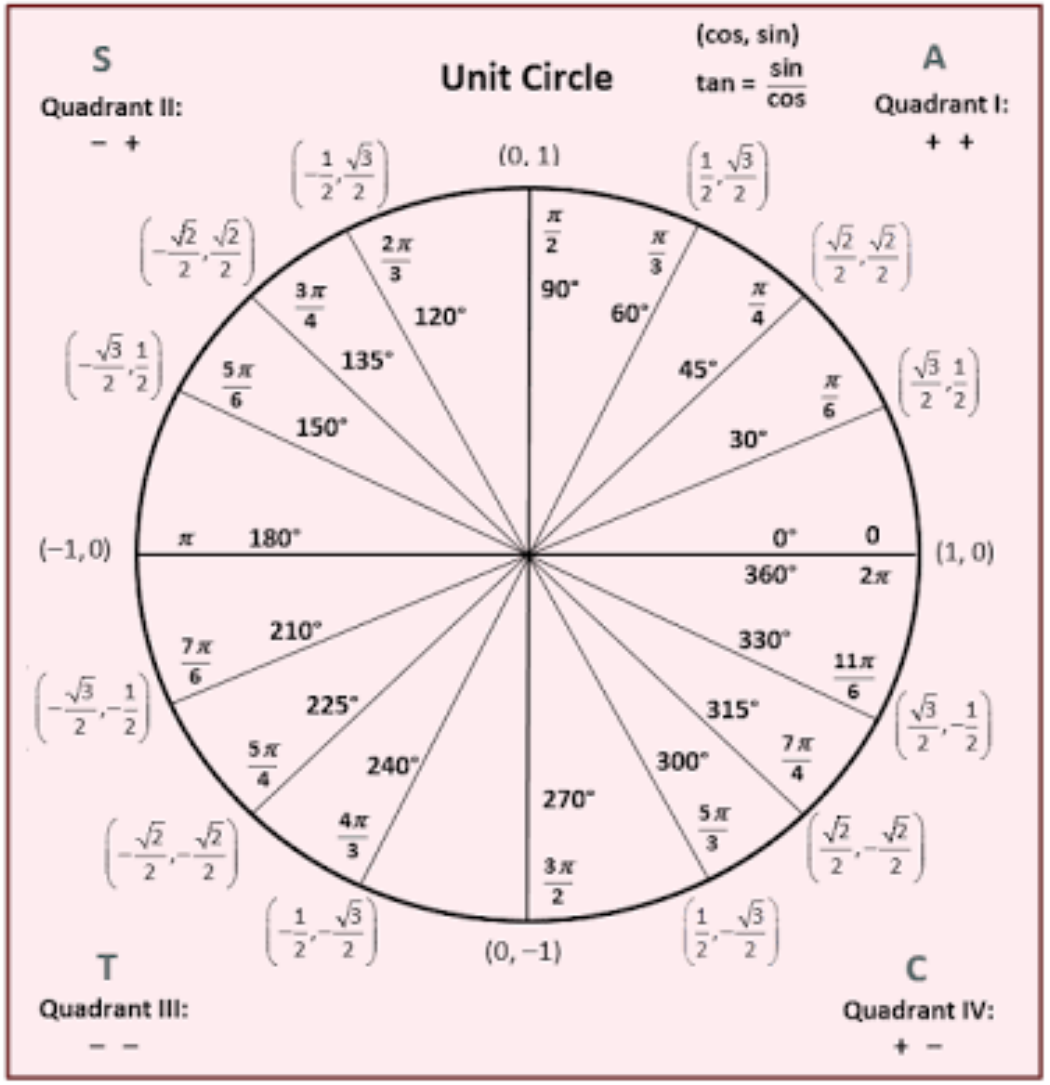
Here θ_1, θ_2, d_3 are JOINT VARIABLES.

Together, joint variables form configuration vector q:

$$q = \begin{bmatrix} \theta_1 \\ \theta_2 \\ d_3 \end{bmatrix}$$

Math Knowledge: Trigonometry

- Remember what sine, cosine, and tangent mean
- Memorize sin and cos for 0, 30, 60, 90, 180 degrees by heart
- Use the unit circle and imagination if can't remember
- Remember trigonometric identities: http://www.sosmath.com/trig/Trig5/trig5/trig5.html
- **Abbreviated notations:**
  - **$\sin(\theta_1) = s_1$, $\cos(\theta_1) = c_1$**
  - **$\sin(\theta_1)*\cos(\theta_2) = s_1c_2$**
  - Remember how to read them, they will be used often to conserve space



Other Math and Physics Knowledge

- Remember matrix multiplication rules
- Multiplication order is important
- Typical forward kinematics task: multiplication of three 4x4 matrices (full of abbreviated notations from last slide)

- Starting from velocity kinematics there will be derivatives
- Remember ALL differentiation rules

- Some experience with physics will help in dynamics: Newton's laws, force formulas, etc.

Administrative matters: Mandatory Assignments

- There will be 5 assignments, and you MUST pass them all to take the final exam
- Assignment 1 will be posted soon, but don't rush it.
- Assignments DO NOT count towards the final grade, only the exam does
- Platform for submission: https://devilry.ifi.uio.no/
- Typically need 40-50% to pass an assignment
- You can get an extension for 3 CALENDAR days, if you ask for it BEFORE the deadline (via e-mail or Devilry comments)
- You may get a second attempt – additional 3 WORK days
- Longer extensions or third attempts will involve the IFI administration

Administrative matters: Communication Channels

- Only e-mail and lectures/seminars for now
  - Artem: artemch@uio.no
  - Kristian: krisrgra@uio.no
- We will decorate the course page with links to the learning materials, assignments, and the lecture/assignment plan
  - Last year's page can be useful: https://www.uio.no/studier/emner/matnat/ifi/IN3140/v20/
- Will try to set up a Mattermost (https://mattermost.uio.no/) channel for quick communication

Administrative Matters: Learning Materials

- The course book: Mark W. Spong, Seth Hutchinson, M. Vidyasagar: *Robot Modeling and Control*, 2005. Wiley. ISBN: 978-0-471-64990-8.

- Additional Material from the past years on GitHub:
  - Old seminar notes: https://github.uio.no/INF3480/Groupsessions
  - Old lecture slides and exams also in the repository – will be added to course page later
  - INF3480 because that is the old course code