Robotics 311 : How to build robots and make them move

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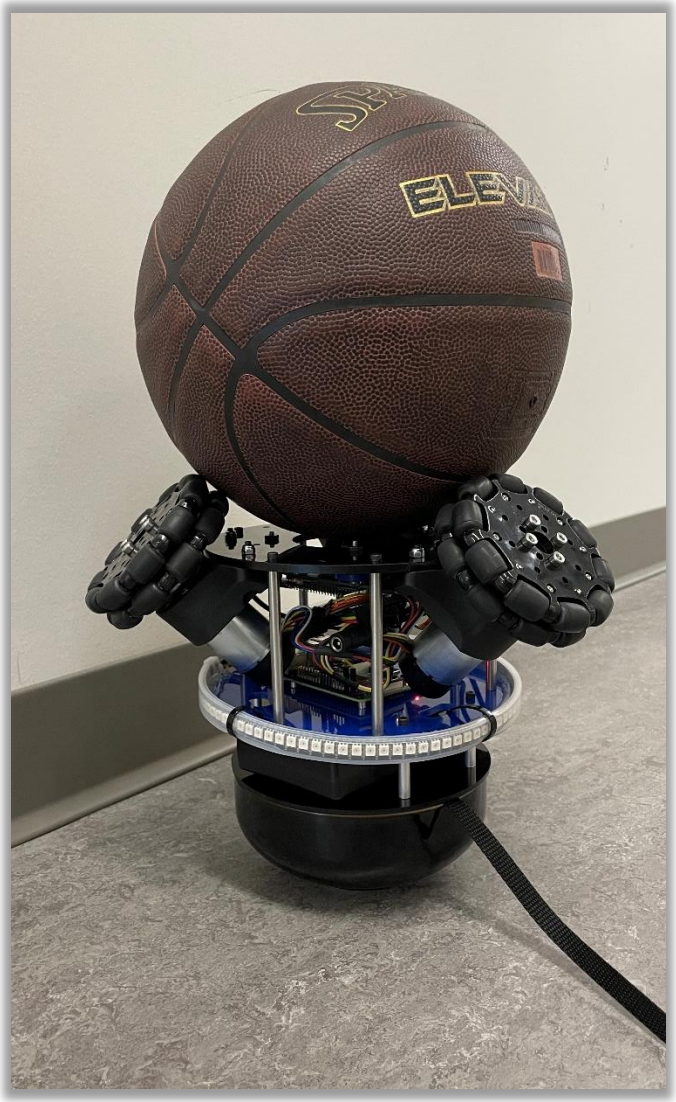
Photo credit: Brenda Ahearn / U-M CoE

ROB 311 – Lab 9

- Today we will
  - Modify Python program for ball rolling
  - Collect data of ball rolling with upside down ball-bot
  - Confirm kinematics relationships

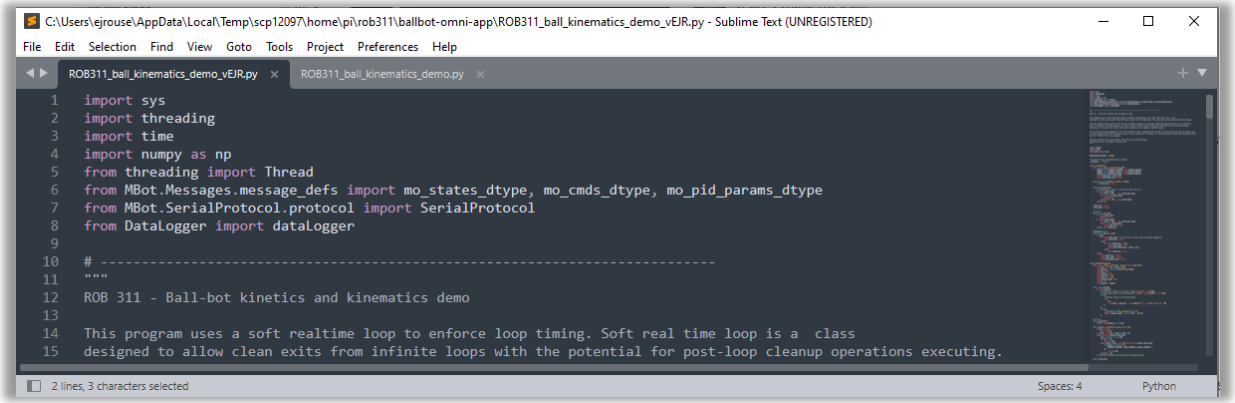
Kinematics

- One thing that is important is understanding the motion of your ball-bot
- To facilitate this understanding, today we will verify our ability to roll the basketball in a desired direction
- You will edit a provided Python script
- Collect data of the ball-bot rolling the ball (upside down)
- Analyze the data in MATLAB to investigate kinematics
- Confirm your layout and wiring are done correctly

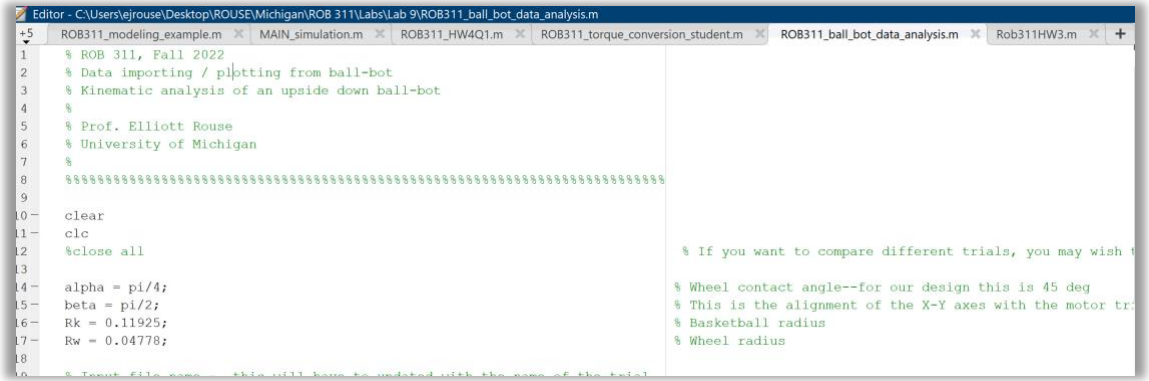


Files Provided

- You will need two software files from Canvas under Lab 9
- Python script to run your ball-bot / collect data
  - `ROB311_ball-bot_kinematics_demo.py`



- MATLAB script to process data



Ball-Bot Code Overview

- The Python file applies a specified torque and sends power to the motors
- It also records many relevant variables for analysis
- There are pre-written functions in the top of the script
- These function can be used for the code you write
  - Computation of motor torques from x, y, and z torques (`compute_motor_torques`)
  - Computation of ball rotation from wheel rotation (`compute_phi`)
- Overview of script

Ball-Bot Code Overview

- In this exercise, we will do some conversions of motor rotation (psi) from radians to counts
- This isn't necessary, but gives you a feel for doing the conversions—future versions of our code will stay in radians
- You need to make three changes to the Python script
- 1. add your code convert psi into encoder counts
    - You will need to know the encoder conversion

```
273  # ------------------------------------------------------------------------
274
275  def rad_2_counts(psi_rad):
276      '''
277      Parameters:
278      ----------
279      psi_rad: Wheel rotation in radians
280
281      Returns:
282      --------
283      psi_counts: Wheel rotation in counts
284      '''
285      # YOUR
286      # CODE
287      # GOES
288      # HERE
289
290      psi_counts = psi_rad
291
292      return psi_counts
293
```

- 2. Change torque components to change ball rolling direction

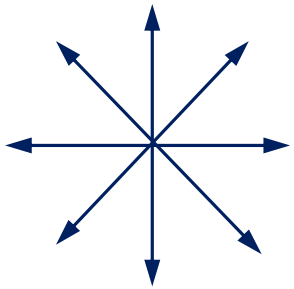
```
360          # ------------------------------------------------------------
361          # Compute motor torques (T1, T2, and T3) with Tx, Ty, and Tz
362
363          # Beginning with torque rolling toward positive y-axis
364          # CHANGE THESE TO ADJUST THE ROLLING DIRECTION OF YOUR BALL-BOT
365
366          Tx = 2
367          Ty = 0
368          Tz = 0
369
370          # ------------------------------------------------------------
371
```

Ball-Bot Code Overview

- Finally, you need to convert wheel rotation into ball motion
- The function `compute_phi` is expecting psi in counts (not rad)
- Add a line to compute phi, adding any conversions to psi as needed

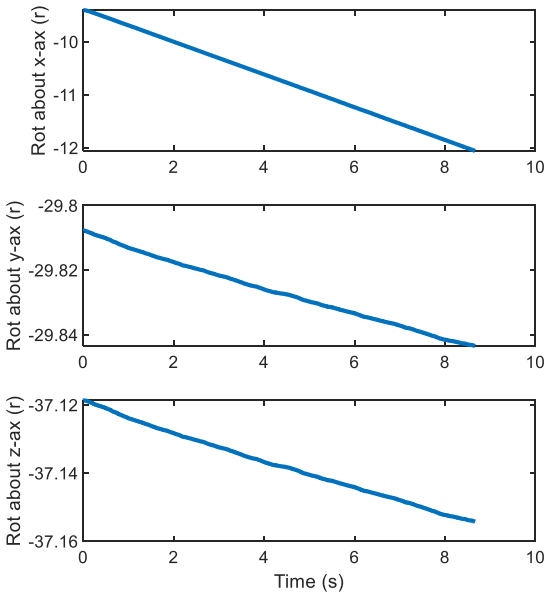
```
377         # ------------------------------------------------------------
378         # Compute ball rotation (phi) with psi_1, psi_2, and psi_3
379
380         # YOUR
381         # CODE
382         # GOES
383         # HERE
384
385         # ----------------------------------------
386
```

- Once this is completed, you should collect data with many torque directions around a circle

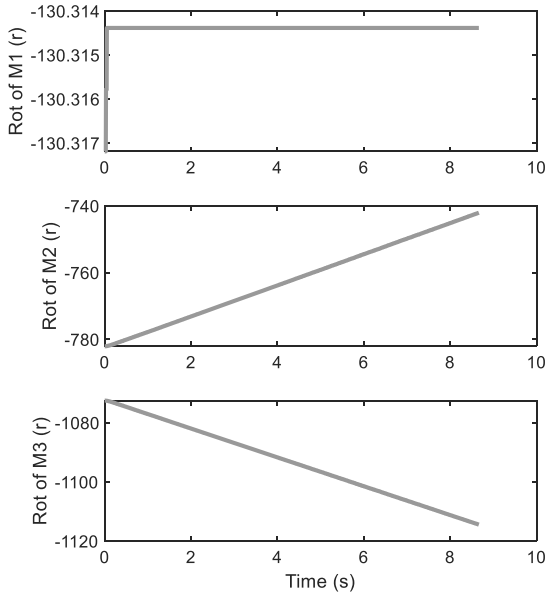


MATLAB Analysis Overview

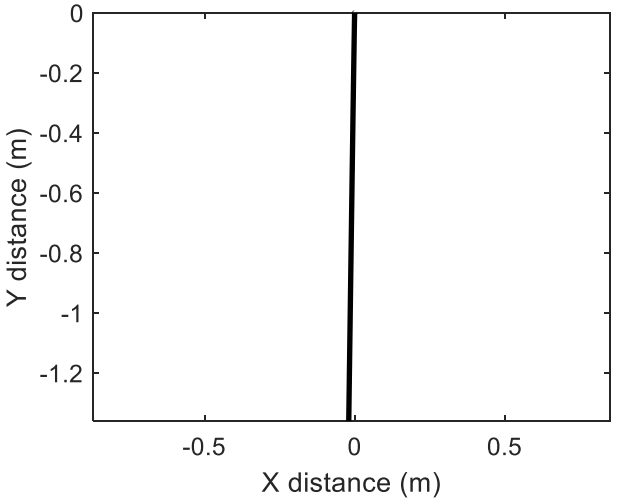
- The MATLAB file provided is similar to last week
- It reads in the saved data and plots it for you
- It creates three plots



Phi / ball rotation shown across all planes



Psi / wheel rotation shown across all planes



x-y planar motion of the ball

Your Goal

- Your goal is to collect trials for torque around a circle
- Plot the x-y motion of the ball on a single plot
- On the same plot, show vectors that describe the torque directions (components of T_x and T_y)
- How similar / different are the torque directions and motion directions?