For Project 1, you are to perform kinematics and inverse dynamics analyses and write a report. Max 8 pages and ~4000 words. **Project Deadline Nov 18 at 12.00.**

Special thanks to Minh for being an excellent test subject!

General information
The assignment can be completed in any programming language you like (e.g., Matlab). Time derivatives can be computed numerically (an example script has been provided in the m file). Analyze only in 2D/sagittal plane. This will correspond to the *y-z* plane. See figures describing the coordinate systems during the motions.

Coordinates and forces for each motion are saved in one text file each – for example, the data for normal walking is saved in coordinated: walking.txt and the force plate data is saved in walking_FP.txt. I have uploaded a basic .m file that imports the data from the text files into Matlab and assigns variable names to the data points. It also does a simple animation with the data points. You are free to use this .m file, but do not have to if you do not want to. You should compute kinematics first, then kinetics when the kinematics are correct.

Data information
- Camera sampling frequency was 100 Hz. The experimental data is a text file, and each column is labeled. The first column in the text file corresponds to the frame number (it's called 'Field') and time is in the second column (s).
- More recorded frames are included than you actually need. I've indicated below which are the relevant frames for each motion. You only really need to analyze data within the interval given, plus a few frames before and after for numerical derivative computations. (You should not include these extra frames in any plots).
- The coordinate data is already filtered. You do not need to filter or smooth the data in any other way.
- Coordinates are converted from millimeters into meters in the .m file.
- Force data was collected at 1000 Hz in units *N*. It is down-sampled to 100 Hz in the .m file.
- The foot contact is illustrated on the figure. The right foot contacted force plate 2 and the left foot contacted force plate 1 in all trials.
- The unit of force is *N* and the Center of Pressure (COP) coordinates are converted from *mm* into *m* in the .m file

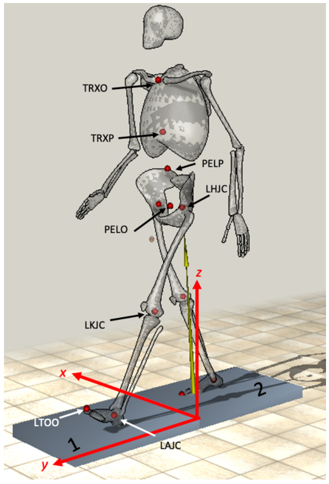
Motion files
All groups:
- **Normal walking**, gait cycle (foot strike to foot strike Left: Foot strike frame 288, toe-off frame 347, foot strike frame 386. Right: foot strike frame 237, toe-off frame 295, foot strike frame 336). Analyze **both** sides, normalize to each gait cycle.

Furthermore:
Groups with even numbers:
- **Normal walking vs. Jogging** (**one right cycle** each): Jogging cycle right: foot strike frame 163, toe-off frame 188, foot strike frame 229.

Groups with odd numbers:
- **Normal walking vs. crouch walking** (**one right cycle** each) Crouch gait cycle: foot strike frame 222, toe-off frame 287, foot strike frame 328.

Coordinate explanations (see figure to right):

RHJC	Right hip joint center output
RKJC	Right knee joint center output
RAJC	Right ankle joint center
RTOO	Right foot marker
LHJC	Left hip joint center output
LKJC	Left knee joint center output
LAJC	Left ankle joint center output
LTOO	Right foot marker
PELO	Pelvis origin
PELP	Pelvis proximal (superior) point
TRXO	Thorax (Chest) origin
TRXP	Thorax (Chest) proximal (inferior) point



Computation of angles and sign conventions

Compute sagittal plane kinematics during the relevant time interval, in *degrees*

- Trunk Angle (absolute angle, use the line between THORAXO and THORAXP to define the angle, 0 (vertical line), >0 for anterior tilt, and <0 for posterior tilt)
- Pelvis Angle (absolute angle, use the line between PELO and PELP to define the angle, 0 (vertical line), >0 for anterior tilt, and <0 for posterior tilt)
- Hip Angle (relative angle between thigh segment and pelvis, 0=extended hip, >0 for flexion, and <0 for extension)
- Knee Angle (relative angle between shank and thigh segments, 0=extended knee, >0 for flexion, and <0 for hyperextension)
- Ankle angle (relative angle between foot segment and shank segment, 0 (neutral)=right angle between foot and shank, >0 for dorsiflexion, and <= for plantarflexion). Please add an offset of + 5 degrees of dorsiflexion to the ankle angle. This better represents the anatomical position of the foot segment (e.g., + 5 deg represents that foot segment is 0 deg when is parallel to the ground. This offset is due to a limitation in which points I can export)

Kinetics/Inverse Dynamics computations:

Anthropometry: Choose (and cite) which anthropometry definitions to use. The subject's height is 1705 mm and weight is 65.3 kg. You can assume that the PELP denotes the joint between the pelvis and trunk segments, and that the PELP and PELO indicate the segment length of the pelvis. Assume the pelvis mass is 14.2% body mass, and that the pelvis COM is 0.25 of the segment length from the PELO coordinate (i.e., closer to PELO than to PELP).

Combine kinematics computations with the force plate data and anthropometric data. You are to calculate joint reaction forces (*N*) and *internal* moments (*Nm*) using inverse dynamics, as well as joint power (*W*) at the ankle, knee and hip. Note that I will upload moments and powers normalized to body weight (i.e. moments as *Nm/kg* and powers as *W/kg*). You can choose which to illustrate - not normalized or normalized, either is fine. You need to compute reaction forces at the joint in order to compute the joint moments, but do not plot these. Please use the following conventions for moment: **Hip extensor** moment, **knee extensor** moment and ankle **plantarflexor** moment are defined as **positive** (this may require a sign change of your data depending on your calculations). For power, **positive** is power **generation**, **negative** is power **absorption**. NOTE: this sign convention may differ from those used in the course book; your plots should look similar to those in the book but possibly upside-down.

Report structure:

Begin with a brief intro. Briefly describe the context of the contents in the report.

Short "Methods" section. Generally describe the experimental protocol of the motion capture. Show an example or two of your angle computations. Describe the inverse dynamics, both with text and with free body diagrams of the body segments (you can just draw these on paper and scan them if you wish), and all equations. You must also provide details of the anthropometry assumptions you've used (e.g. *cite your source*).

Results. These must include both plots and interpretations of these plots. Specific points to interpret in the text are listed below, as open-ended questions.

All groups:

- ***Normal walking:*** **Plot** all sagittal plane angles, as well as ankle, knee, and hip joint moments and powers for the left and the right gait cycle. **Describe** the motion qualitatively. **Discuss** which muscle groups are active and whether their activity is concentric, isometric or eccentric during the different phases in the gait cycle. **Describe** whether his kinematics and kinetics are symmetric. Try to **conclude** which muscle groups are most important for normal walking.

Furthermore:

- **Groups with even numbers: *Normal walking vs. jogging:* Plot** all sagittal plane angles, as well as ankle, knee and hip joint sagittal plane moments, and joint powers, for the right side. **Compare** and **contrast** this data between the two related but different motions. **Describe** the moments and powers in terms of demands on the muscle groups. **Discuss** which muscle groups are active, when, and whether their activity is concentric, isometric or eccentric. Are the same muscle groups that are most responsible for power generation and absorption in walking also most responsible in jogging? **Discuss**.
- ***Groups with odd numbers: Normal walking vs. crouch walking:*** **Plot** all sagittal plane angles, as well as ankle, knee and hip joint sagittal plane moments, and joint powers, for the right side in both movements. **Compare** and **contrast** this data between the two related but different motions. **Describe** the moments and powers in terms of demands on the muscle groups. **Discuss** which muscle groups are active, when, and whether their activity is concentric, isometric or eccentric. Are the same muscle groups that are most responsible for power generation and absorption in normal walking also most responsible in crouch walking? **Discuss**.

Describe the contribution of each team member.

General note about plots:

- ***Include plot labels, axis labels and units.*** By "axis labels", I mean you are to write the sign convention in the *y*-axes labels; write, for instance "Flex" and "Extens", etc., next to the y-axis as appropriate.
- Plots must be clear and well-scaled; select a reasonable *y*-axis range that illustrates clearly but does not exaggerate small motions.
- All text in the figures must be legible when printed on A4 paper, i.e. *not too small*.
- When comparing 2 similar motions in adjacent plots, it is most effective if they are on the same scale or at least have the same range.

General note about text in report:

- ***Use anatomically accurate and specific terminology***. You are to interpret the plots as the movements, torques and powers that they represent. A phrase like "the angle increases" is vague, but "knee flexion increases" or "the knee flexes" is specific and clear.

Project Deadline Nov 18 at 12.00:
- Report of max ~8 pages and ~4000 words, according to structure above
- **Attach** your matlab code as an .m file as an appendix.
- **Upload** to your group's project page in Canvas.

Grading will be based on:
- Completeness
- Accuracy
- Quality and clarity of data presentation in plots
- Quality and clarity of descriptions/observations /written comments

Each assignment will be graded between 0-10 points, depending on the ambition achieved and the assignment quality A grade of 6 is standard, indicating a passing grade. Higher grades can be achieved with excellent / outstanding analyses and interpretations.

NOTE:
In a few days, I will upload some of my solutions for walking, to help you in troubleshooting. It is crucial that your kinematics computations are correct, otherwise your kinetics will also be incorrect.