BME 315 Biomechanics Experiment 2. Fall 2006.

Use of force platform to analyze dynamic force and moment

<u>Pre-lab assignment</u>

Review concepts as suggested in class. Also, you will need a 3.5" floppy disk or Zip disk. to record your data.

<u>Setup and Calibration</u>

Turn on the computer and prepare the force plate. Conduct a calibration as indicated at the bottom.

<u>Testing</u>

1. While standing on the force platform, perform a vertical jump as high as you can using both legs. Allow yourself to record a second or two before you jump to collect data on your weight.
2. Perform the same jump, this time using only one leg. Again record force and moment.
3. Try a horizontal (broad) jump. Measure the distance jumped, as well as force and moment.
4. Try a twisting jump. It will be helpful if the subject has played some basketball.
5. Now do some movement across the plate. For example, walk or run across or practice a phase of your triple jump. Alternatively, perform military push-ups, or kick in the air.
6. Take data with zero force, then place a small weight (50 grams if available) on the plate. How much noise is there? Can 50 grams be detected by the plate?

<u>Analysis</u>

1. We need to convert the output voltage to force values. Using the calibration, plot the force plate output and the applied force to verify that a linear relationship exists between the two. Determine the slope of the line and the y-intercept.
2. Calculate take-off velocity. Recall work $W = \int F dx$ gives rise to a change in kinetic energy, and impulse $J = \int F dt = mv$ gives rise to a change in momentum. Which concept is more useful here? For the high jump, use your z direction force data to prepare a graph of force vs. time.
3. What is the subject's kinetic energy at takeoff? Knowing that, how high did the person jump. Recall the expressions for kinetic and potential energy.
4. Jump height can also be measured using the airborne time. Calculate the height this way and compare it to previous method. What accounts for the difference?
5. For the broad jump, how does the distance jumped compare with your calculations? Discuss.
6. Compare the M_z values for the high jump, broad jump and twisting jump. Discuss.

<u>Questions</u>

1. When we calibrated the force platform, why was it important to use forces that were higher than we planned on using?
2. Based on your measurement of noise and of the response to the small weight, estimate the ratio of signal to noise for a standing person. What is the smallest force the platform can detect, based on the noise you measured?
3. What are some of the reasons one may measure forces in gait? What disease states might influence gait? How might gait force measurement be used in diagnosis or rehabilitation?

AMTI Force Platform
Calibration Guide

Equipment

The force platform that you will be using is an AMTI model OR6-6-1 biomechanics platform mounted to a flat, rigid surface (concrete floor). You can view the AMTI webpage for more information at: http://www.amtiweb.com

The force plate is a rigid plate sitting on four pedestals. Loads on the plate deform each pedestal. Foil strain gages are attached to each pedestal to measure the deformations. From these deformations, the forces and moments can be determined. Unless the force is applied in the exact center of the plate, the closest pedestal will deform more than the others. Thus, the resolution of the force requires some knowledge of how each pedestal reacts individually as well as in concert with one another.

The force plate has 6 degrees of freedom; it can measure the forces in the x-direction (F_x), in the y-direction (F_y) and in the z-direction (F_z) as well as the moments about each of these axis (M_x, M_y and M_z). For our purposes today, we will use 6 channels to record these 3 forces and 3 moments of data. However, we will calculate only 3 calibration constants: F_z(Force in the vertical direction), M_x(Moment about the x-axis), and M_y(Moment about the y-axis). *The data that will be recorded are voltages, proportional to a load or moment. That is why you are doing this first part of the experiment, to determine how the voltage readings obtained relate to the loads placed on the force plate.*

It is difficult to calculate the other calibration constants after the plate has been installed because the appropriate moments cannot be applied. How would one apply a pure shear load to the plate to compute the F_x calibration constant? It is important to record all 6 channels while loading in just one direction in order to verify that there is minimal crosstalk between channels.

To get calibration curves for the remaining channels (F_x, F_y, and M_z) you will estimate based on the following information: The Fx and Fy channels are four times more sensitive than F_z (recall sensitivity is measured in V/N). The M_z channel is 2.12 times more sensitive than Mx and My (measured in V/N*m). You should be able to use the slopes of your measured calibration curves and this information to obtain the predicted slopes of the remaining calibration curves. Using this slope and the data point you took with no load on the platform, construct theoretical calibration curves for the remaining channels.

For the calibration, known loads will be placed on the plate at known distances from the plate origin. It is important to apply a range of loads and moments rather than just one in order to insure that the force/volt or moment/volt conversion is linear throughout a wide range. Ideally, the range of the calibration should exceed the range of loads or moments recorded during the data collection.

The calibration of a six-channel sensor involves determination of the sensitivity of each channel to all applied load components. Loads are applied at various points in the three coordinate directions while the computer monitors the output from all six channels. For an instrument where the response is linear, the sensitivity information can be presented in a 6x6 matrix giving the basic channel sensitivities together with the crosstalk terms. The main diagonal of the matrix (upper left to lower right) represents the basic channel sensitivities. The off-diagonal terms, representing crosstalk, ideally would be zero: for most purposes they are small enough to be ignored. Under normal use, recalibration should not be necessary.

Set-up

Turn on the computer and monitor. On the desktop, there is a link to a LabView program called "Acquire Forces v2". Double click the icon to launch LabView, and click on the Run button -- a small arrow in the upper left corner -- to start execution of the LabView program.

On the left of the screen is a column of numbers representing the current voltages on the channels. From the top, the channels are F_x, F_y, F_z, M_x, M_y, M_z.

When you want to acquire data, select the appropriate length of recording and sampling frequency. Then click on "Acquire Data" to begin recording. When the recording is finished, it will prompt you to save the data file. You must save the dataset (the program will crash if you cancel the save). Once the dataset is saved, a graph of the forces and moments will be displayed.

When you are done using the software, close LabView. If it prompts you to save changes, say "No to All".

Record in the table below the applied load, the voltage output of each channel, and the distance between the point of load application and the origin (for channels 4-6). The convention for each channel is as follows:

Channel 1 F_x=anterior/posterior force(north = positive)
Channel 2 F_y=medial/lateral force(east = positive)
Channel 3 F_z=vertical force(downward=positive)
Channel 4 M_x=moment about the anterior/posterior axis
Channel 5 M_y=moment about the medial/lateral axis
Channel 6 M_z=moment about a superior/inferior axis

Record the calibration data below:

Load [kg_f]	X Position [m]	Y Position [m]	CH 1 [volts]	CH 2 [volts]	CH 3 [volts]	CH 4 [volts]	CH 5 [volts]	CH 6 [volts]

From the data above, calculate the slope and intercept for each channel.

Channel	Intercept	Slope
	[N] or [Nm]	N/volt or Nm/volt
1	______________	______________
2	______________	______________
3	______________	______________
4	______________	______________
5	______________	______________
6	______________	______________