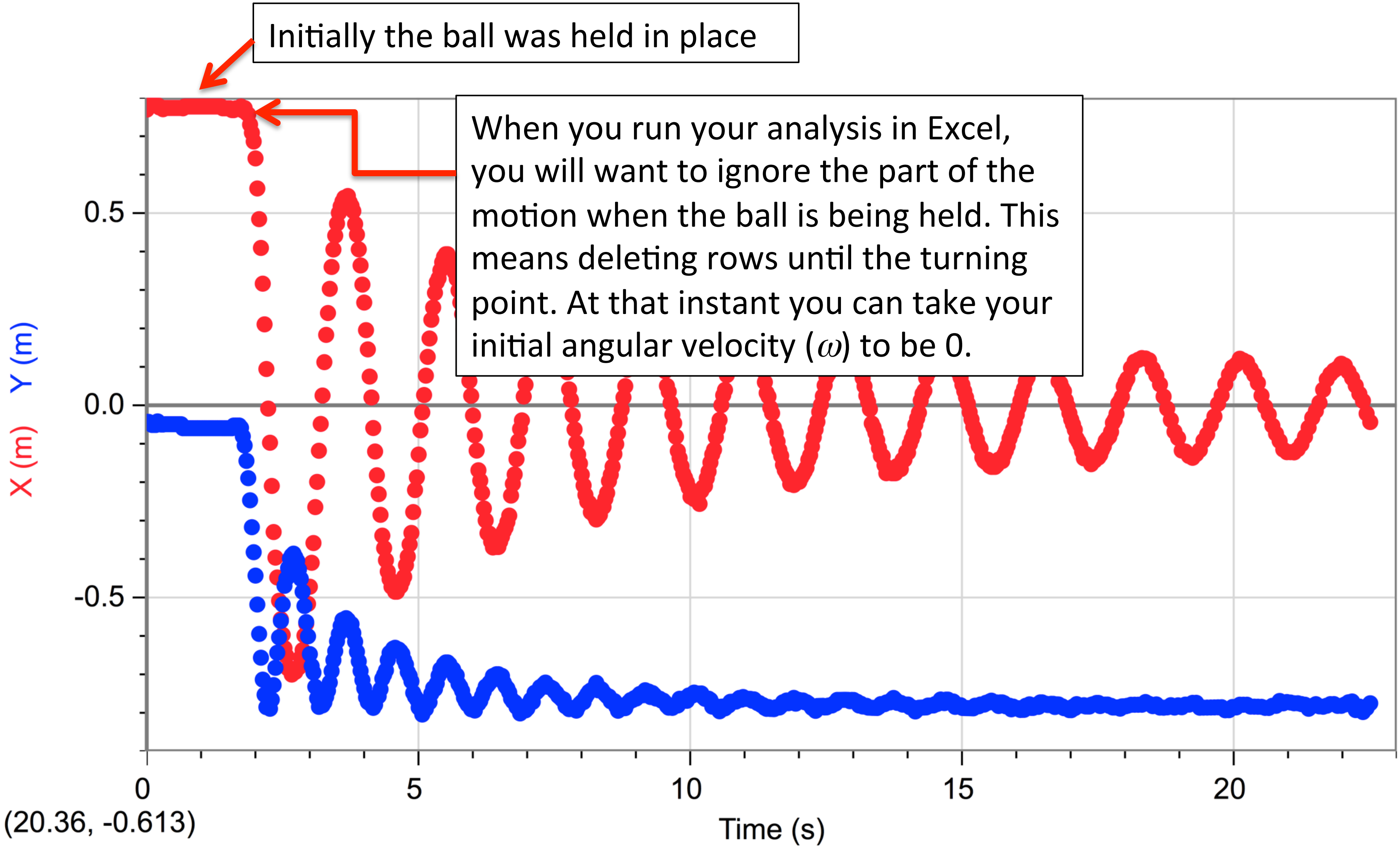
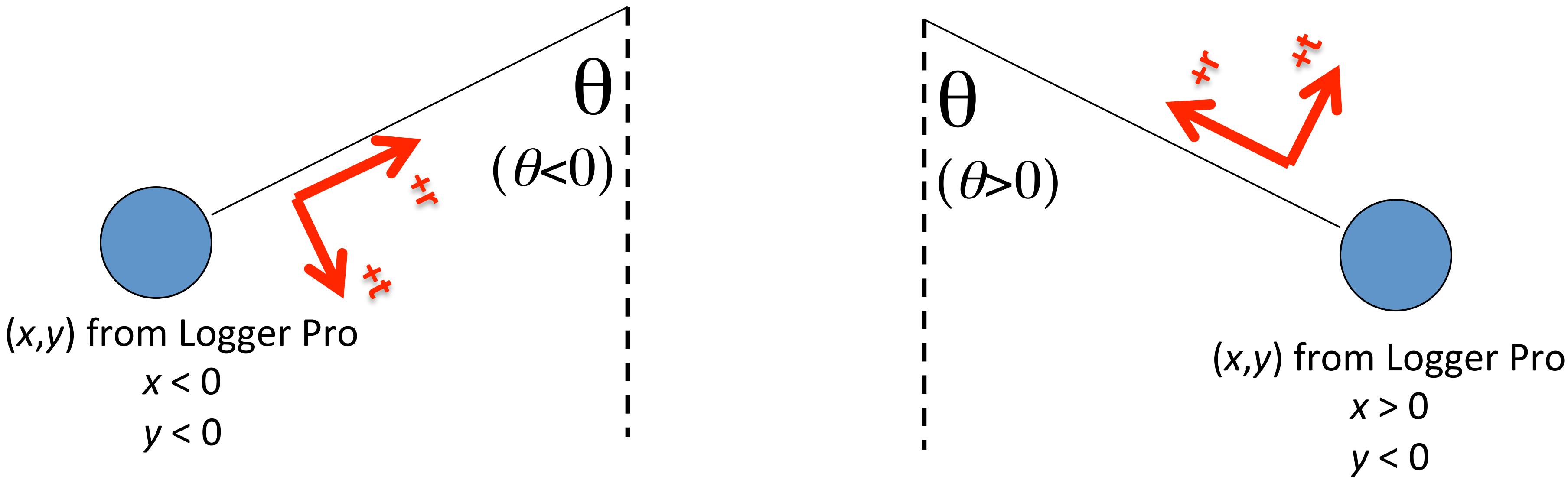
LoggerPro Data



Suggested Theta Coordinate System



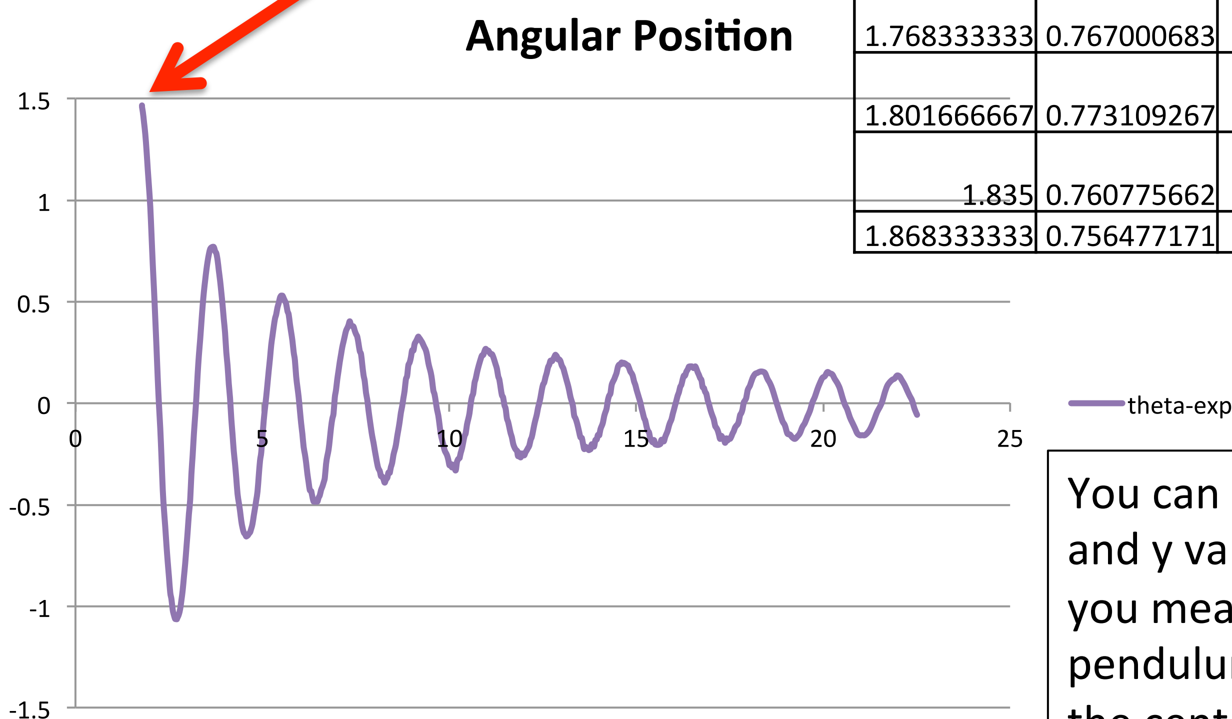
To get the usual θ (defined from the positive x-axis counterclockwise) use the function atan2(x, *y*) in Excel.

Now our θ as defined above (negative on left, positive on right) is shifted from the usual definition by $-\pi/2$ (-90^{o}) rotation. This means that the angle 0 in the usual definition corresponds to $\pi/2$ for our θ. So we should use atan2(x, *y*) + $\pi/2$ in Excel to get the correct angle.

The data copied from Logger Pro to Excel

The modeling works better when you begin at a location with zero velocity, by deleting rows until the first turning point.

t	x-exp	y-exp	r-exp	theta-exp
1.768333333	0.767000683	-0.080911414	0.771256575	1.464898051
1.801666667	0.773109267	-0.104675351	0.78016336	1.435423081
1.835	0.760775662	-0.144606739	0.774397002	1.382162743
1.868333333	0.756477171	-0.18965683	0.779889366	1.324352669



You can use your experimental x and y values to determine r, or if you measured the length of the pendulum (attachment point to the center of the ball) then you can use that constant value here.

Parameters

parameter	value	units
m	0.0103	kg
g	9.81	m/s^2
rho	?	kg/m^3
r-ball	0.05	m
r-pendulum	?	m
Cd	?	

You can define parameters that you will use in the analysis on the far right side of the spreadsheet

Look up density of air

You can get this by calculating the experimental radius from *x* and *y* at each data point, and then averaging the column. Alternately, you may have measured the length of the pendulum in lab so you can put that value here

This is the parameter you'll change to fit the model to the experimental data. Start with Cd = 0 (where should should not see any decrease in amplitude).

Initial Conditions (row 2)

t	x-exp	y-exp	r-exp	theta-exp	Fg-t	FD-t	a-t	alpha	omega	theta-calc
1.768333333	0.767000683	-0.080911414	0.771256575	1.464898051					0	1.464898051

Tangential component of the gravitational force

Tangential component of the air drag force

Tangential component of acceleration

Angular acceleration

Initial angular velocity is set to zero, if we start at a turning point

Set the initial angle to match the experimental value

Calculations

Calculations (row 3)

t_i

	A	B	C	D	E	F	G	H	I	J	K
1	t	x-exp	y-exp	r-exp	theta-exp	Fg-t	FD-t	a-t	alpha	omega	theta-calc
2	1.76833	0.767	-0.0809	0.77126	1.4649					0	1.4649
3	1.80167	0.77311	-0.1047	0.78016	1.43542	-0.1005	0	-9.755	-12.385	-0.4128	1.45114
4	1.835	0.76078	-0.1446	0.7744	1.38216	-0.1003	0.00028	-9.7124	-12.331	-0.8239	1.42367

t_f

Determine the tangential components of the forces (make sure your signs are consistent)

Relate tangential acceleration to the net force and mass

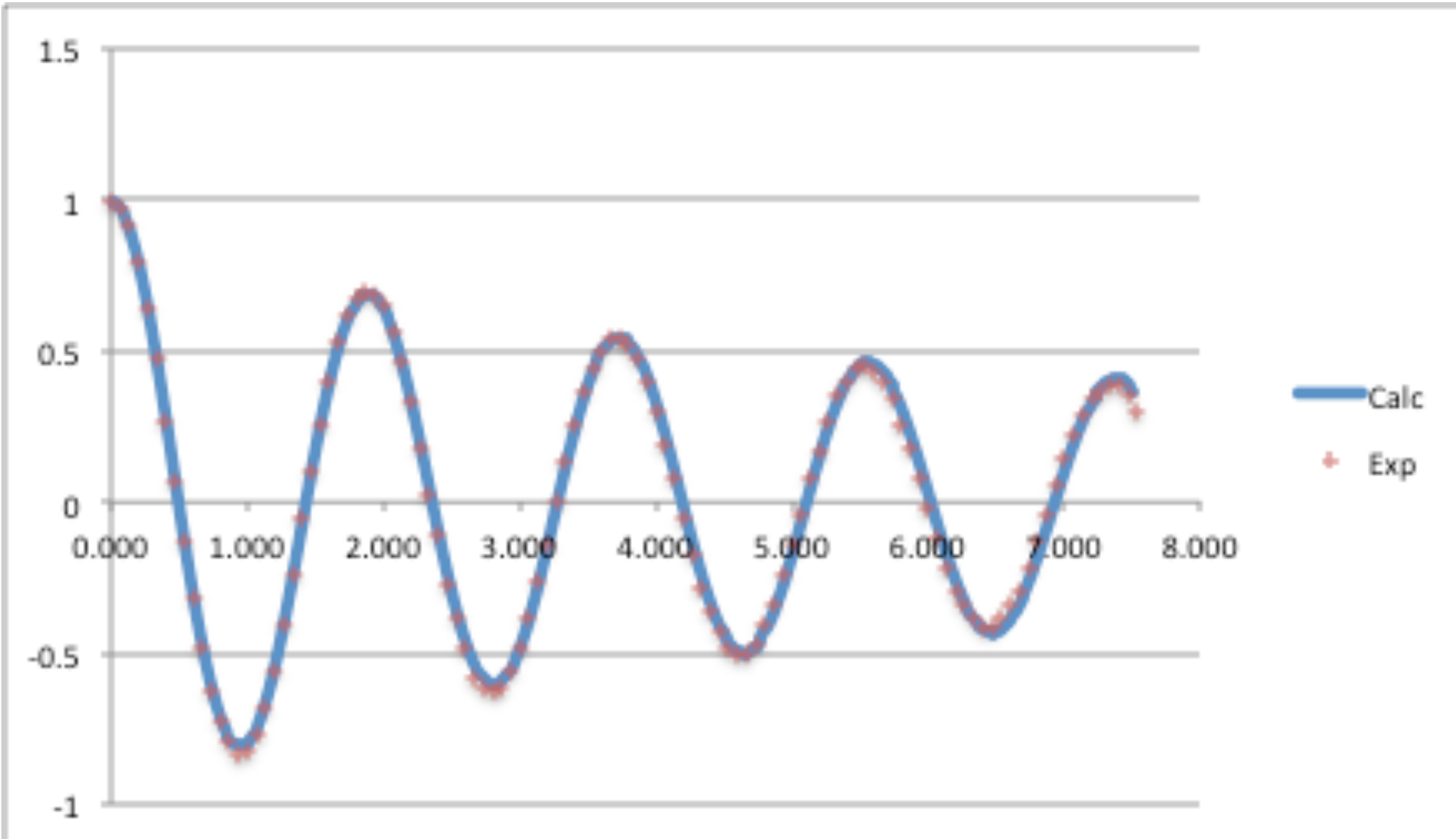
$\alpha = a_t / r_{pendulum}$

$\omega_f = \omega_i + \alpha \left(t_f - t_i\right)$

$\theta_f = \theta_i + \omega \left(t_f - t_i\right)$

Calculations

Display of Model



Plot the experimental data and the calculated data versus time (as XY Scatter) and compare as you change the drag parameter.

Lab report

You should include a description of the main aspects of your model.
Make sure to include a free body diagram and carefully extract r- and t-equations.

You should be able to determine a drag parameter for the model. Can you look it up for a sphere and compare to what you obtain?

You should also be able to obtain tension throughout the motion (and explain how you'd do this in your lab report). Plot it and interpret physically what's going on.