Physics 248 **CAVENDISH LAB** **Spring, 2010**

The goal of this lab is to measure the gravitational constant G. We will use a commercially built apparatus that makes it possible to observe the very small gravitational forces between some balls made of lead. The apparatus consists of two small masses, m_1, attached to either end of an aluminum rod. The rod is suspended from it's center by a very thin wire. Two larger masses, m_2, can be positioned to exert either a clockwise or a counterclockwise gravitational torque on the rod. The torque causes the rod to begin to rotate which twists the wire. The angle through which the rod has rotated is measured by shining a laser beam onto a mirror attached to the rod and observing the position of resulting spot on a screen far away.

Before lab, your instructor will set up the apparatus and leave the masses in one position (position A). This will be done early enough so that any oscillations have time to damp out. This means that the net torque on the rod is initially zero, with the gravitational torque just balanced by the torque from the wire.

To start the experiment we move the large masses to the opposite position (B). This changes the torque and the result is that the rod begins the turn. We will measure the initial angular acceleration of the rod and relate this to the gravitational torque,

$$\tau = I\alpha \qquad \text{where} \qquad \tau = |\vec{r} \times \vec{F}|.$$

PROCEDURE:

- Tape together a few sheets of paper and then tape the paper to the white board. We will use the paper to record the position of the laser spot.
- With $t = 0$ defined as the time the masses were moved, mark the position of the laser spot at regular time intervals – e.g. every 10 or 15 seconds.
- Continue marking the position until the rod has undergone at least two full oscillations.
- Remove the paper from the wall and use a ruler to measure the spot positions relative to any convenient origin.
- Enter the data, $y(t)$, into a spread sheet.

- Fit the data with a curve of the form

$$y(t) = A \cos \omega t \, e^{-\beta t} + B.$$

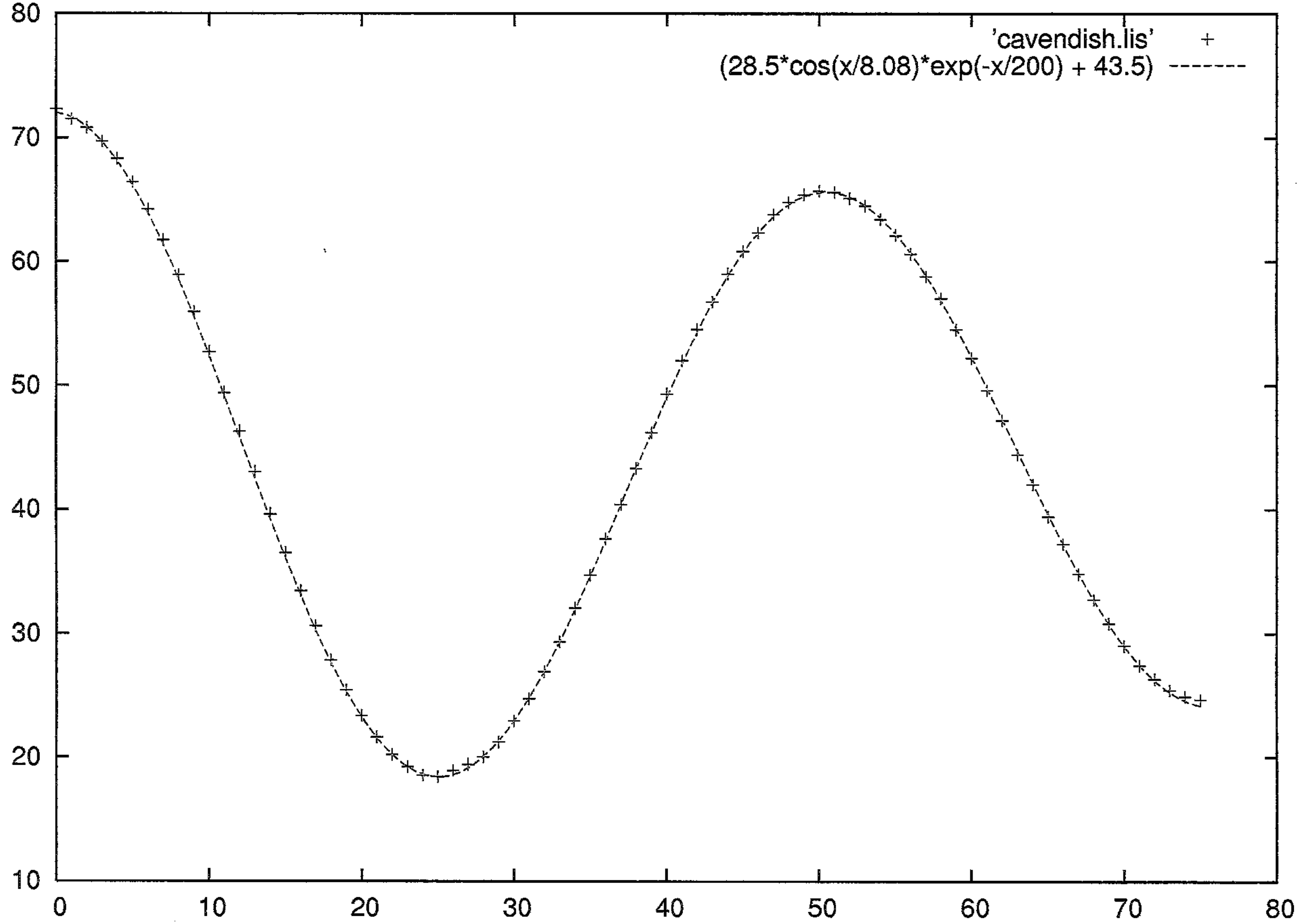
  Vary the constants A, B, ω and β until the fit looks good. Once you have determined the "best" parameter values you can use the equation in place of the individual measurements.

- Find a formula to convert the values of y into values of θ, the angle of the rod. There is a factor of 2 from the mirror reflection that you could easily miss.

- Once you have $\theta(t)$, take the second derivative to find the angular acceleration α and obtain a numerical value for α at $t = 0$.

- Write down equations for the moment of inertia of the rod (assume the rod itself is massless and treat the masses m_1 as point masses) and for the gravitational torque. Remember that the torque was zero for $t < 0$, and so the initial torque on the rod is equal to the amount by which we **changed** the gravitational torque when we moved the balls from position A to position B.

- Find G.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