

~~If the beam is raised by tightening (and shortening the cable), explain whether the magnitude of force acting at the pivot,  $\vec{F}$ , increases, stays the same or decreases.~~

**Problem 4: Experiment 04 Analysis**

Fill in the table below with the numbers from your Experiment 04. Use at least 3 non-zero values of angular velocity  $\omega$ , 4 if you made that many measurements. It is acceptable to do this problem in collaboration with your lab partners in the experiment. You may either do it in class using *DataStudio* or you may export your table from *DataStudio* as a text file and save it, and do the fit later using software such as *Xess*.

**Data Table: experiment 04**

$\omega$					
$r_m$					

Fit these data to an expression of the form

$$r_m(\omega) = \frac{A}{1 - (\omega/\omega_c)^2}$$

Repeat the fit when  $A$  is not an adjustable parameter, but the value you measured for  $r_0 = r_m(\omega = 0)$ . When you do that, this is a fit with one adjustable parameter, and it is not necessary to include  $\omega = 0$  in the fit; it is automatically included by the choice  $r_0 = r_m(\omega = 0)$ .

- What value did your fit give for  $A$ , and how does it compare to your measured  $r_0$ ?
- Do you get a “better” fit when  $A$  is an adjustable parameter, or not? (Explain.)
- What did the one-parameter fit give for the critical frequency  $\omega_c$ ? Compare it to  $\sqrt{k/m}$  for the spring in your experiment.
- What root mean squared error did the fit give you? How does it compare with the accuracy you estimate for your measurements of  $r_m(\omega)$ ? (Remember, if you used a User-

Defined Fit in *DataStudio*, divide the program's Root MSE by the square root of the number of data points you used in your fit.)

~~Thus the magnitude of the force is~~

$$F = \sqrt{F_x^2 + F_y^2} = \frac{mg}{4} \sqrt{1 + \frac{4l^2}{h^2} + \frac{4l}{h} \sin \theta}$$

~~and is increased when  $\theta$  is increased.~~

#### Problem 4. Experiment 4 Data Analysis.

We use the following data:

$T$	$r_m$	$\omega$	$\Delta X$	$m_m r_m \omega^2$
$\infty$	4.8 cm	0 s <sup>-1</sup>	0 m	0 N
0.095 s	6.0 cm	66.1 s <sup>-1</sup>	0.012 m	2.44 N
0.074 s	7.2 cm	84.9 s <sup>-1</sup>	0.024 m	4.83 N
0.060 s	10.3 cm	105 s <sup>-1</sup>	0.055 m	10.5 N

a) Our fit gave  $A = 4.7$  cm, which is close (within the measurement error) to  $r_0 = 4.8$  cm.

b) We get a better fit when  $A$  is an adjustable parameter (root mean square error is  $\sigma = 0.07$  cm vs  $\sigma = 0.14$  cm when it is not adjustable — see Fig. 3).

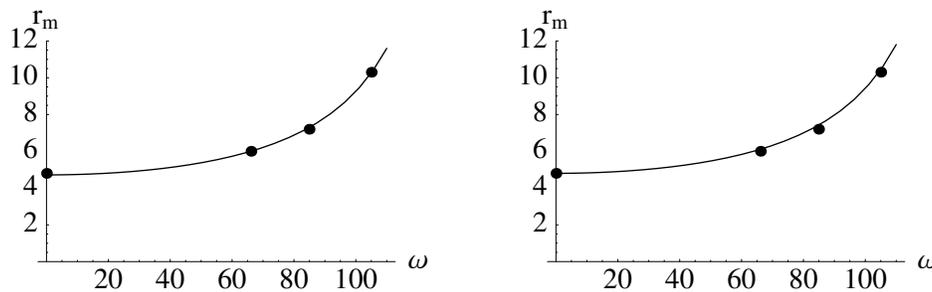


Figure 3: The one and two-parameter fits. Left: two-parameter fit.  $A = 4.7$  cm,  $\omega_c = 143$  s<sup>-1</sup>, RMSE is 0.07 cm. Right: one-parameter fit,  $\omega_c = 144$  s<sup>-1</sup>, RMSE is 0.14 cm.

c) The one-parameter fit gives  $\omega_c = 144$  s<sup>-1</sup>. On the other hand,  $\sqrt{k/m} = 142$  s<sup>-1</sup>.

d) The root mean square error of our fit,  $\sigma = 0.07 \text{ cm}$ , is of the order of the measurement error, which is about  $1 \text{ mm}$ .