**Physics 8.01T**                                                    **Fall Term 2004**

**Problem Set 4: Uniform Circular Motion**

**Available on-line September 24; Due: October 5 at 4:00 p.m.**

Please write your name, subject, lecture section, table, and the name of the recitation instructor on the top right corner of the first page of your homework solutions. Please place your solutions in your lecture section table box.

**Problem Set 4: Due Wed Oct 1 at 4:00 pm.**

## Sept 24
Hour One: Problem Solving Session 4: Newton's Laws of Motion; Spring Forces, Tension.
Reading: YF 5.1-5.3, 5.5

**Problem Set 3: Due Tues Sept 28 at 4:00 pm.**

## Sept 27
Hour One: Circular Motion Kinematics: Uniform Circular Motion.
Reading: YF 3.4, 5.4

Hour Two: Problem Solving Session 5: Uniform Circular Motion
**Reading: YF 5.4**

## Sept 29
Hour One: Experiment 4: Circular Motion
Reading: Experiment 4

Hour Two: Test Review

## Sept 30 QUIZ ONE: Fundamental Concepts; Kinematics; Newton's Laws.
**7:30-9:30 pm**
**Oct 1** No class

**Problem Set 4: Due Tues Oct 5 at 4:00 pm.**

## Oct 4
Hour One: Universal Law of Gravitation; Circular Planetary Orbits
Reading: YF 5.4, 12.1-12.2

Hour Two: Problem Solving Session 5: Uniform Circular Motion, Universal Law of Gravitation; Circular Planetary Orbits
Reading: YF 5.4, 12.1-12.2

## Oct 6

Hour One: The Lever Principle: Static Equilibrium and Torque with Experiment 5: Static Equilibrium
Reading: YF 11.1-11.3, Experiment 5

Hour Two: Problem Solving Session 6: Static Equilibrium and Torque
Reading: YF 11.3

## Oct 8

Hour One: Problem Solving Session 7: Static Equilibrium and Torque

**Problem Set 5: Due Tues Oct 12 at 4:00 pm.**

**Problem 1: (*Rotational kinematics*)**

The earth is spinning about its axis with a period of 23 hours 56 min and 4 sec. The equatorial radius of the earth is $6.38 \times 10^6$ m. The latitude of Cambridge, Mass is $42^o \ 22'$.

    a) Find the velocity and centripetal acceleration of a person at MIT as they undergo circular motion about the earth's axis of rotation.

    b) The rotation of the Earth is slowing down. In 2004, the Earth took $1.01\,\text{s}$ longer to complete $365$ rotations than in 1924. What was the average angular deceleration of the Earth in the time interval from 1924 to 2004?

**Problem 2: *Second Law Applications: uniform circular motion***

A mass $m$ is connected to a vertical revolving axle by two massless inextensible strings of length $l$, each making an angle of $45^0$ with the axle. Both the axle and the mass are revolving with angular velocity $\omega$. Gravity is directed downwards.

    a) Draw a clear force diagram for $m$.

    b) Find the tension in the upper string, $T_{upper}$, and lower string, $T_{lower}$.
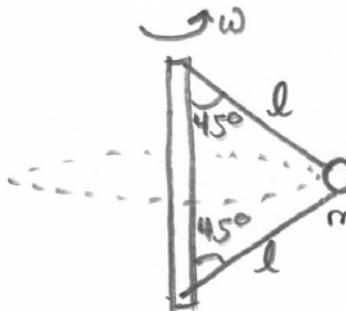


**Problem 3: *Experiment 5: Static Equilibrium Pre-Class Question***

A pivoted beam is supported by a cable that is attached to the beam a distance $2/3$ of the way along the beam from the pivot. The center of mass of the beam is $1/2$ the distance from the pivot. The beam makes an angle $\theta$ with respect to the horizontal. There is a unknown force, $\vec{F}$, acting at the pivot.
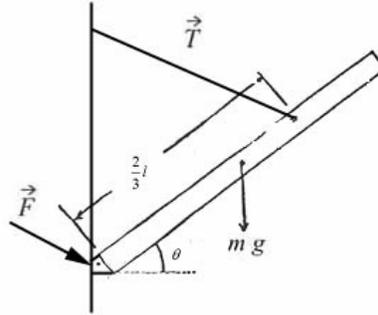
If the beam is raised by tightening (and shortening the cable), explain whether the magnitude of force acting at the pivot, $\vec{F}$, increases, stays the same or decreases.

## 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 $r_0 = r_m(\omega = 0)$.

a) What value did your fit give for A, and how does it compare to your measured $r_0$?

b) Do you get a "better" fit when $A$ is an adjustable parameter, or not? (Explain.)

c) 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.

d) 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.)