Massachusetts Institute of Technology
Physics Department

8.01x **Fall 1**

EXPERIMENT CF: CENTRIPETAL FORCE SOLUTIONS

1. Make measurements of the radius, r, of the circular orbit for the spinning nut for rotational frequencies, f, of 10 Hz, 12 Hz, 15 Hz; and 20 Hz. Record your results in Table 1.

2. Make measurements of the number of pennies, n_p, required to stretch the rubber band for the range of lengths corresponding to the radii of the circular orbits you measured in part 1. Record your results in Table 2.

3. Calculate the hanging weight, $F = n_p m_p g + m_{cup+clip} g$, due to the weight of the pennies, cup and paper clip you used in part 2. Add your results to Table 2.

4. Make a graph of the hanging weight vs. the length of the rubber band.

5. Using the results of your graph, determine the centripetal force necessary to keep the nut spinning for each of your rotational frequencies in part 1. Add your results to Table 1.

6. Calculate the centripetal acceleration $a_r = 4\pi^2 r f^2$ of the nut for each of the rotational frequencies and add these results to your Table 1.

7. Using your results from part 6, multiply the centripetal acceleration by the mass of the nut, 0.88×10^{-3} kg, and add these results to your Table 1.

8. How closely did you come to verifying Newton's Second Law for circular motion?

Table 1: Centripetal Force and Centripetal Acceleration for the Spinning Nut

Radius (mm)	Frequency (Hz)	$F_{centripetal}$ (N)	$a = 4\pi^2 r f^2$ (m/s^2)	ma ($kg\text{-}m/s^2$)
70	10	-	276	.24
80	12	0.14	455	.40
157	15	1.04	1.39×10^3	1.23
250	20	1.7	3×10^3	3

Table 2: Calibrating the Rubber Band

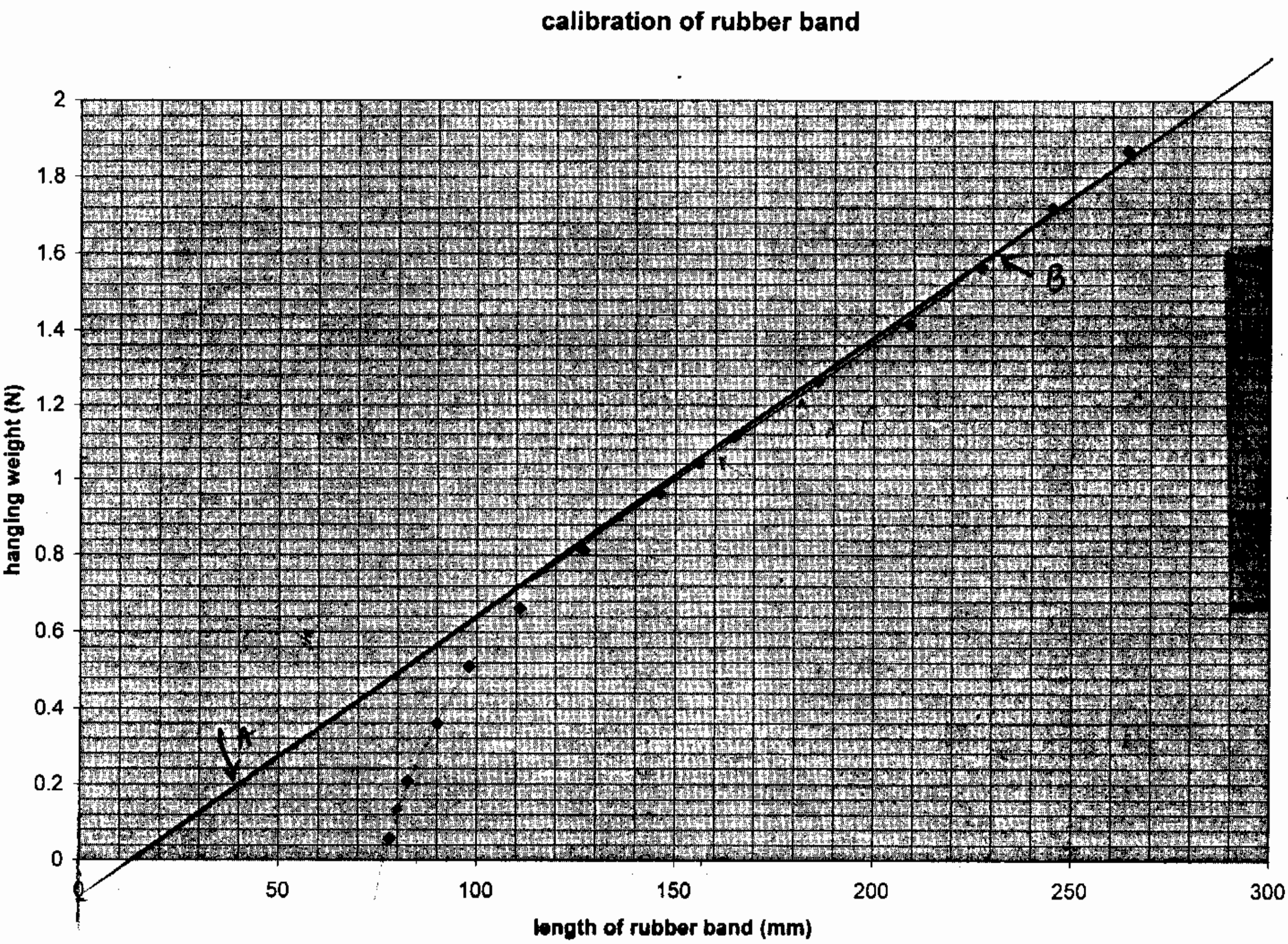
I calculated the hanging weight

$m^{total} g = (n_p)(m_p) g + m_{cup+clip} g$

$m_p = 3.08$ g (pre-82)

$m_{cup+clip} = 5.9$ g

# of pennies n_p	Length of rubber band (mm)	Hanging weight (N)
0	78	0.06
5	82.5	0.21
10	90	0.36
15	98	0.51
20	111	0.66
25	127	0.81
30	146	0.96
35	165	1.11
40	186	1.27
45	209	1.42
50	227	1.57
55	245	1.72
60	264	1.87



5) Notice that my estimation of the radius for the circular orbit is only accurate to ± 1.0 cm due to the difficulty in setting the frequency and holding it and reading the radius of the orbit.

a) thus a measurement of 70 mm is less than the stretch of the rubber band due to just the cup and clip

b) a stretch of 80 mm corresponds to a force of 0.14 N. If in fact my stretch was 80 mm + 10 mm = 90 mm (the range of my error), the force corresponds to .36 N.

c) for a stretch of 157 mm, the force is 1.04 N with an error rang ± .1 N

d) my motor could not hold a frequency of 20 rpm very well, so I estimated the length at 250 mm ± 20 mm, if I assume the linear behavior of the rubber band extends, the best fit straight line has

$$F = a\ell + b$$

$$a = \frac{y_B - y_A}{x_B - x_A} = \frac{(1.6\,N) - (.2\,N)}{(.23\,m) - (.4\,m)} = 7.37\,\frac{N}{m}, \quad b = -.1\,N$$

so $F = (7.37 \frac{N}{m})(.25m) - .1N = 1.74\ N$. Thus measurement is not dependable.

8. From my data analysis, only the $f = 15Hz$ measurement is reliable. The fractional error is

$$f = \frac{ma - F_{cent}}{ma} = \frac{1.23N - 1.04N}{1.23\ N} = .15$$

This experiment cannot verify or disprove the 2nd law due to the large uncertainties in the experimental values for the length of the rubber band and the frequency of rotation for the nut.