Lab 3:
Centripetal Force and Centripetal Acceleration

Submitted to:	Mr. Lista
Submitted by:	David Ruggiero
	Patrick Gaglione
	Mark Klukowski
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Course:	SPH 4U

Purpose

To determine the relationships between centripetal force (centripetal acceleration) and radius, period, and frequency.

Hypothesis

We expect that the required centripetal force to maintain circular motion will increase as radius increases and as the frequency increases, and therefore decrease as the period decreases.[Note: our results should agree with the given equation: $F_c = 4m\pi^2 rf^2$]

Observations

Part A

# of washers	centripetal force (N)	# of rotations	time (s)	period (s)	frequency (Hz)
2	0.130	10	18.2	1.82	0.55
4	0.226	10	15.8	1.58	0.63
6	0.322	10	14.1	1.41	0.71
8	0.418	10	13.3	1.33	0.75
10	0.515	10	12.3	1.23	0.81
12	0.611	10	11.7	1.17	0.85
14	0.707	10	10.8	1.08	0.93
16	0.803	10	10.5	1.05	0.95

Part B

radius (m)	# of rotations	time (s)	frequency (Hz)	frequency^2 (Hz^2)
1.50	10	10.3	0.97	0.94
1.25	10	9.2	1.09	1.18
1.00	10	7.7	1.30	1.69
0.75	10	6.7	1.49	2.23
0.50	10	5.6	1.79	3.19
0.25	10	4.5	2.22	4.94

Analysis

1. See graph 1
2. Since the function appears to be polynomial, $\therefore$ *centripetal force* $\propto$ *period*^{n}.
To find '*n*' and the proportionality constant, '*k*,' plot the log of the centripetal force vs. the log of the period (see graph 2)

log period	log centripetal force
0.260	-0.885
0.199	-0.645
0.149	-0.492
0.124	-0.378
0.090	-0.289
0.068	-0.214
0.033	-0.151
0.021	-0.095

From the graph, we calculate that the slope (*n*) = -3.25. The y-intercept is -0.01, and $10^{-0.01}$ = k = 0.98
∴ from our data, we calculate:
$F_c = 0.98 \times T^{-3.25}$ (when r = 1.5 m)
3. See graph 3
4. Since the function appears to be polynomial, ∴ *centripetal force* ∝ *frequency*^{n}.
To find '*n*' and the proportionality constant, '*k*,' plot the log of the centripetal force vs. the log of the frequency (see graph 4)

log frequency	log centripetal force
-0.260	-0.885
-0.199	-0.645
-0.149	-0.492
-0.124	-0.378
-0.090	-0.289
-0.068	-0.214
-0.033	-0.151
-0.021	-0.095

From the graph, we calculate that the slope (*n*) = 3.25. The y-intercept is -0.01, and $10^{-0.01}$ = k = 0.98
∴ from our data, we calculate:
$F_c = 0.98 \times f^{3.25}$ (when r = 1.5 m)

1. See graph 5
2. (on graph 5)
3. for f^2 = 0.80 Hz^2:

radius (m)	force (N)
1.50	0.170
1.25	0.135
1.00	0.095
0.75	0.070
0.50	0.050
0.25	0.035

4. See graph 6

5. Since the function appears to be polynomial, ∴ *centripetal force* ∝ *radius*^{n}.
To find ‘n’ and the proportionality constant, ‘*k*,’ plot the log of the centripetal force vs. the log of the radius (see graph 6)

log radius	log centripetal force
0.176	-0.76955
0.097	-0.86967
0.000	-1.02228
-0.125	-1.1549
-0.301	-1.30103
-0.602	-1.45593

From the graph, we calculate that the slope (n) = 0.88. The y-intercept is -0.98, and $10^{-0.98}$ = k = 0.10
∴ from our data, we calculate:
$F_c = 0.10 \times r^{0.88}$ (when $f^2 = 0.80$ Hz^2)

Discussion

1. According to our experimental data, the following proportions describe centripetal force:

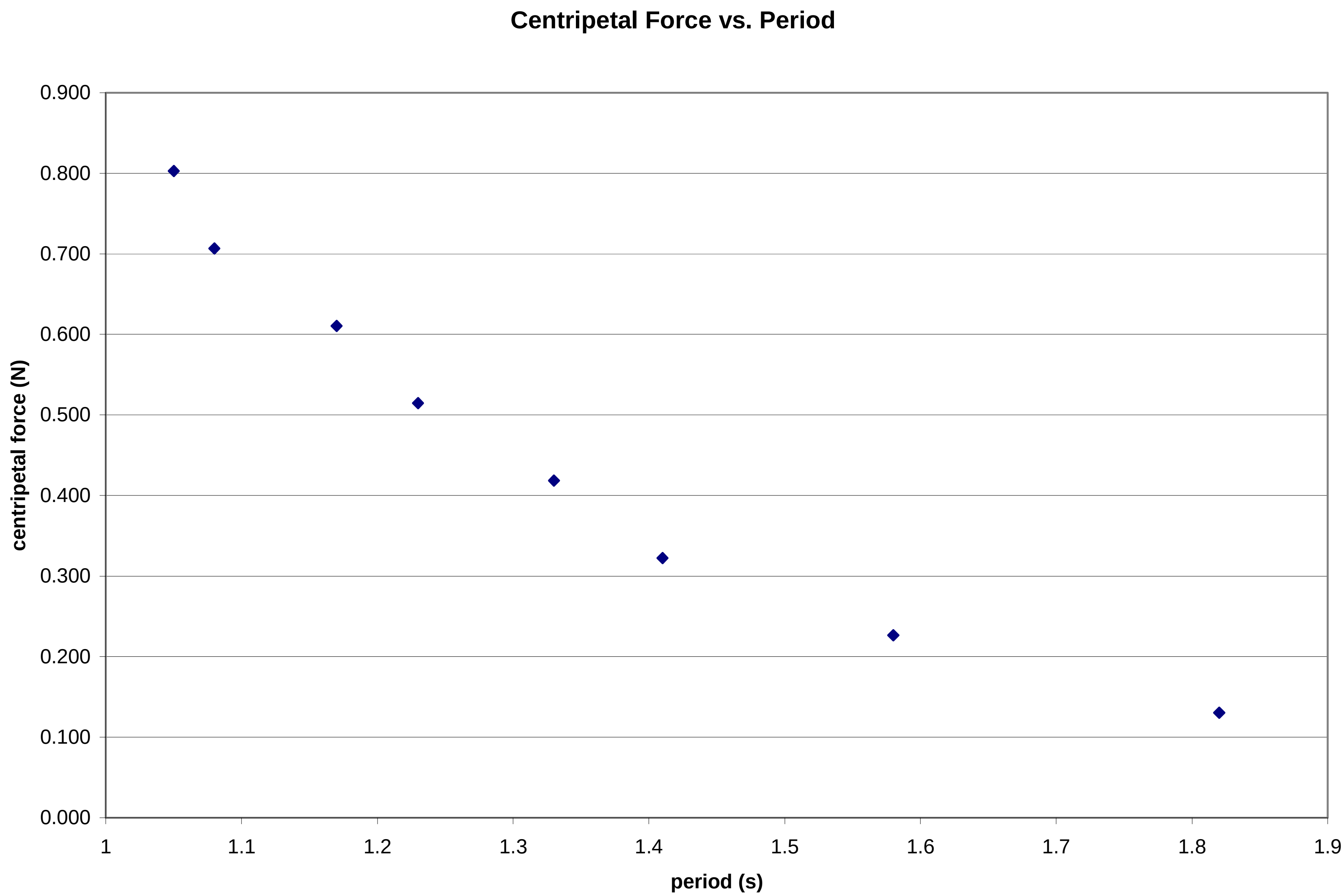
a) $F_c \propto f^{3.25}$ $F_c = 0.98 \times f^{3.25}$ (when $r = 1.5$ m)
b) $F_c \propto T^{-3.25}$ $F_c = 0.98 \times T^{-3.25}$ (when $r = 1.5$ m)
c) $F_c \propto r^{0.88}$ $F_c = 0.10 \times r^{0.88}$ (when $f^2 = 0.80$ Hz^2)

2. These results contradict our hypothesis by a surprising amount. In theory, F_c should be directly proportional to the radius and the square of the frequency, and inversely proportional to the square of the period; however, the exponents in our results differ from the expected results considerably. The coefficients also differ somewhat from our expectations. In a) and b), the expected coefficient is $4\pi^2 rm = 0.83$ (note that ‘m’ = 0.014 kg) and in c) it is $4\pi^2 mf^2 = 0.44$.

3. Using the above equation a), we calculate:
$F_c = 0.98 \times f^{3.25}$
$F_c = 0.98 \times 8^{3.25}$
$F_c = 844$ N

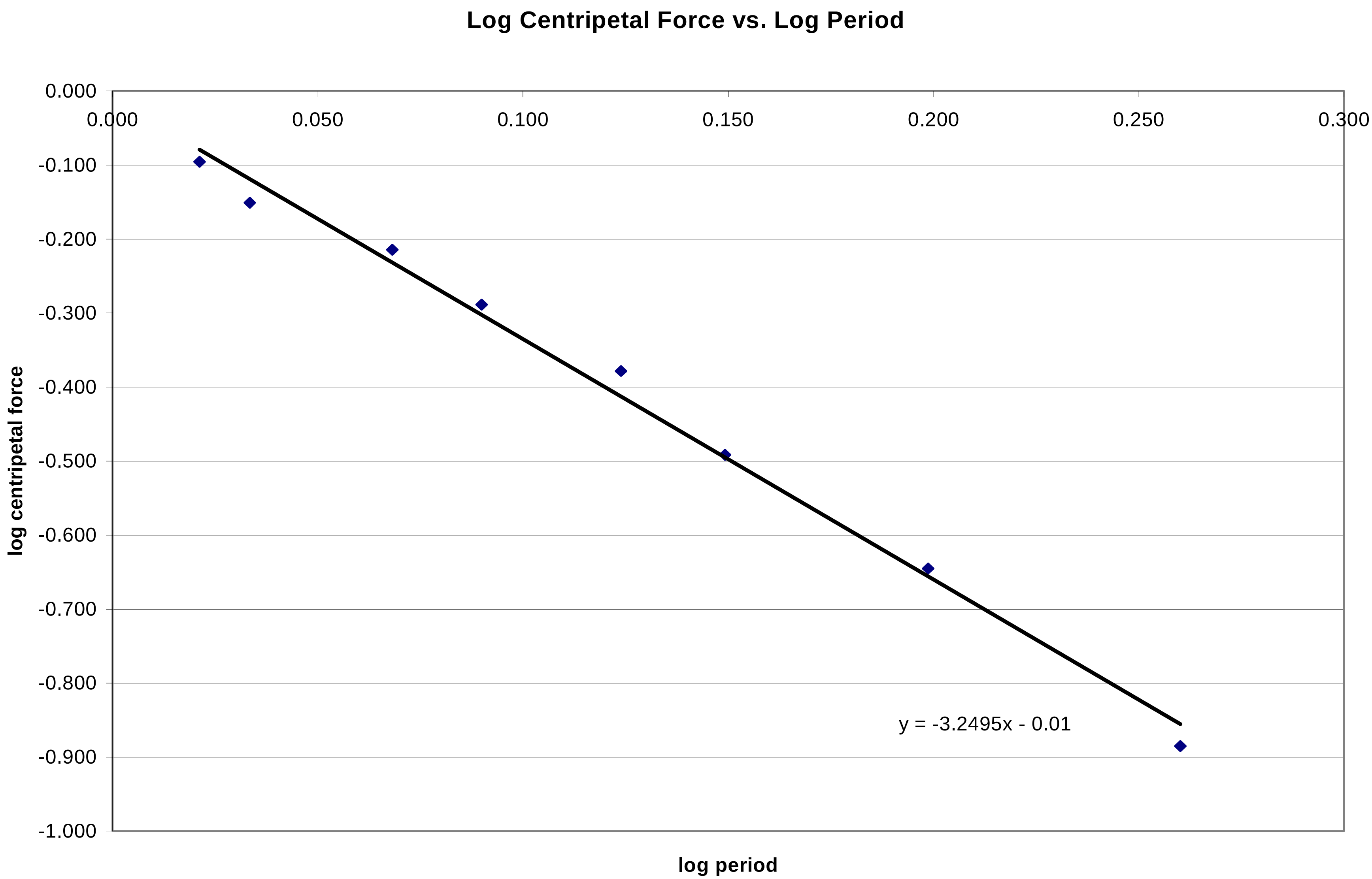
[However, using the equation $F_c = 4\pi^2 mf^2 r$, the answer we get is 53.1 N]

Graph 1

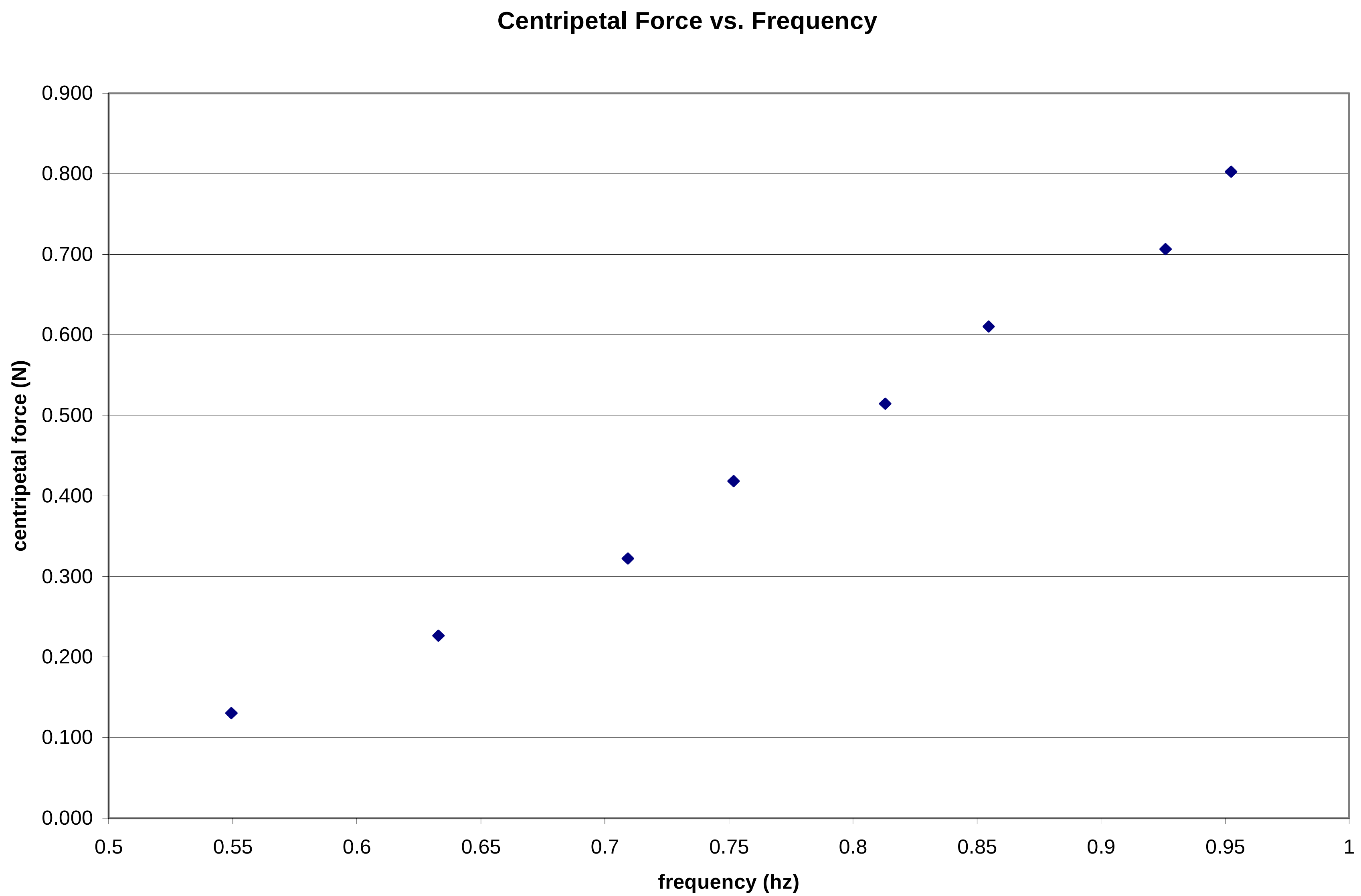


Centripetal Force vs. Period
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
centripetal force (N)
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
period (s)

Graph 2

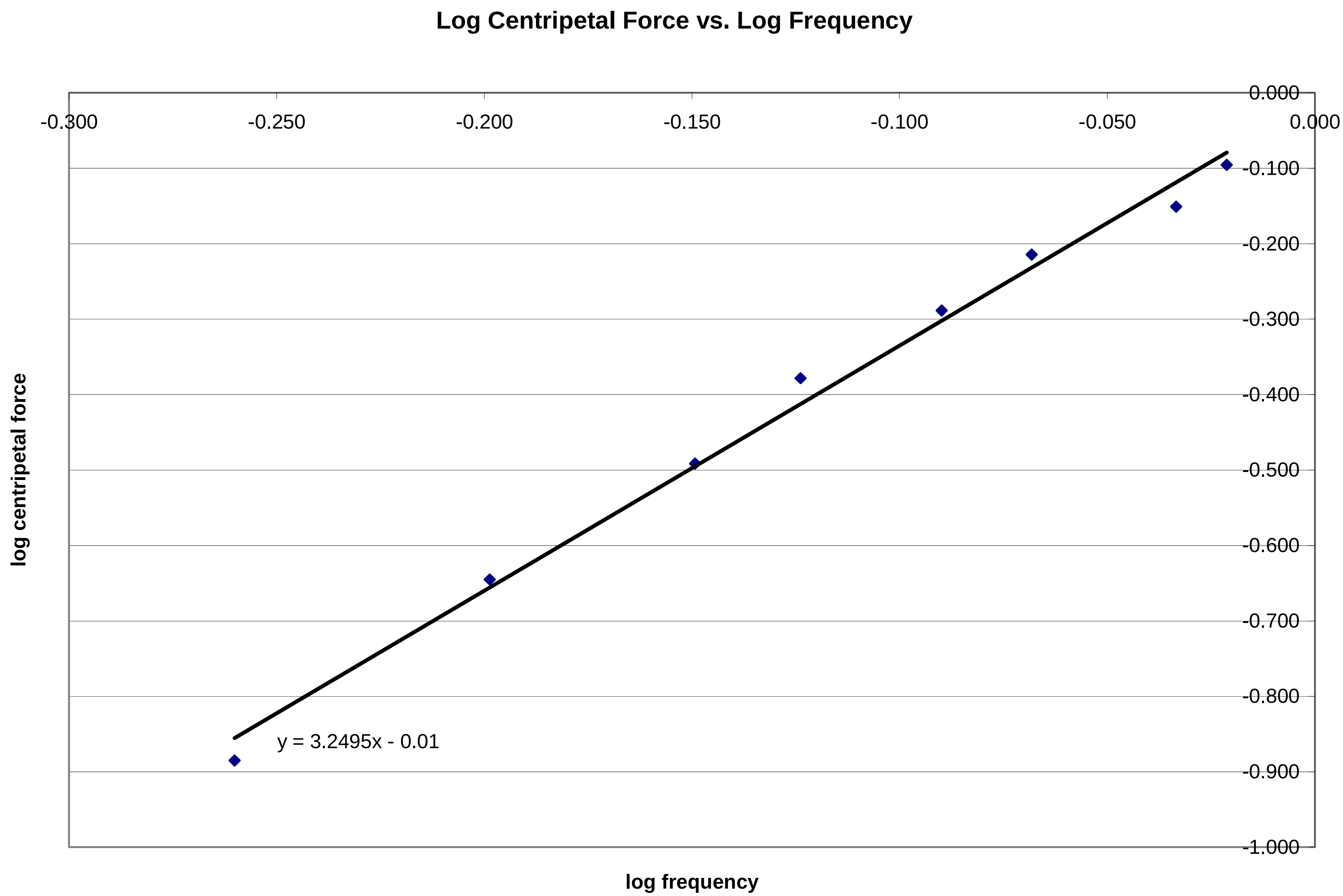

Log Centripetal Force vs. Log Period
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
-0.700
-0.800
-0.900
-1.000
0.000
0.050
0.100
0.150
0.200
0.250
0.300
log centripetal force
log period
y = -3.2495x - 0.01

Graph 3

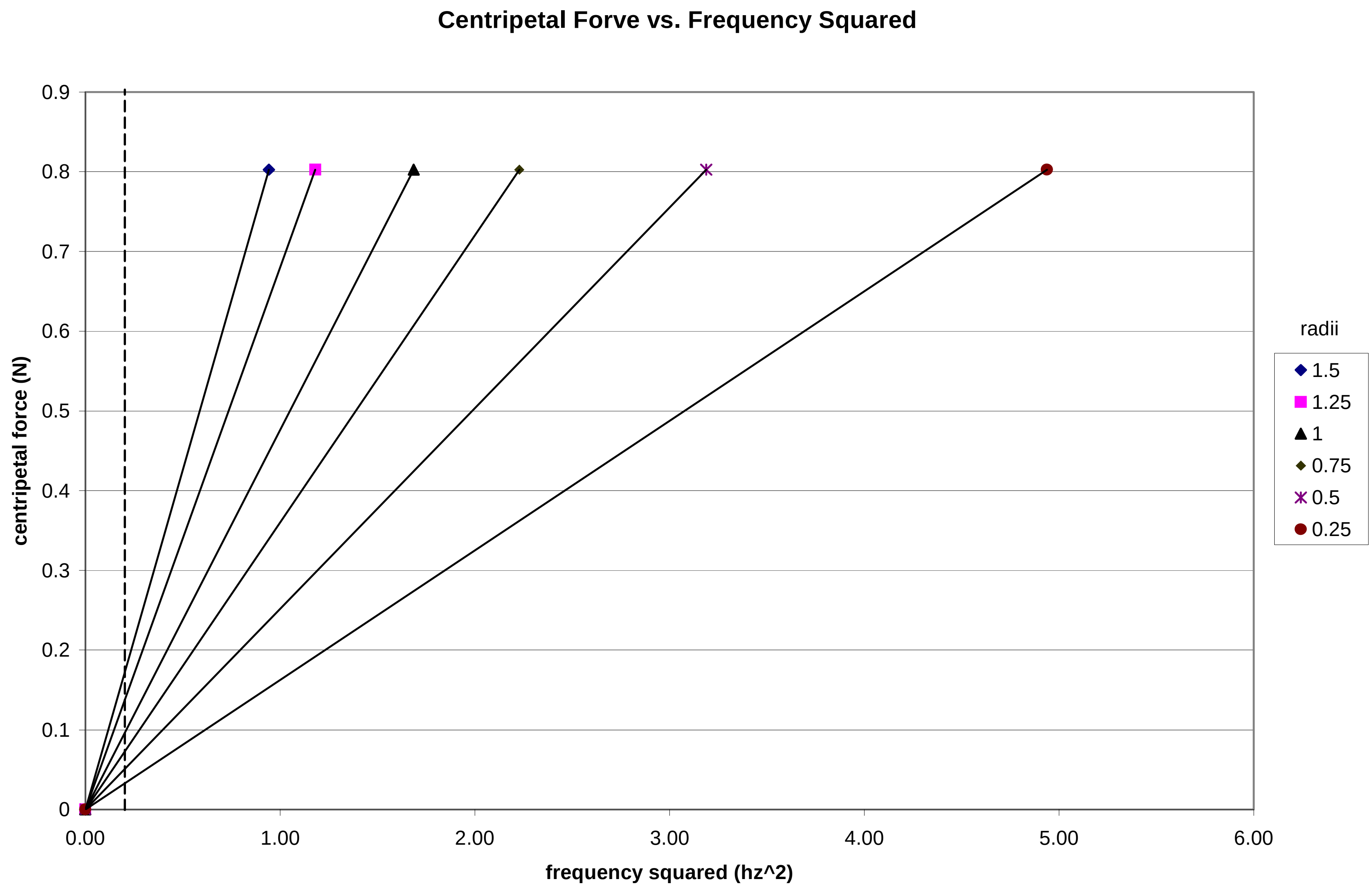


Centripetal Force vs. Frequency
centripetal force (N)
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
frequency (hz)

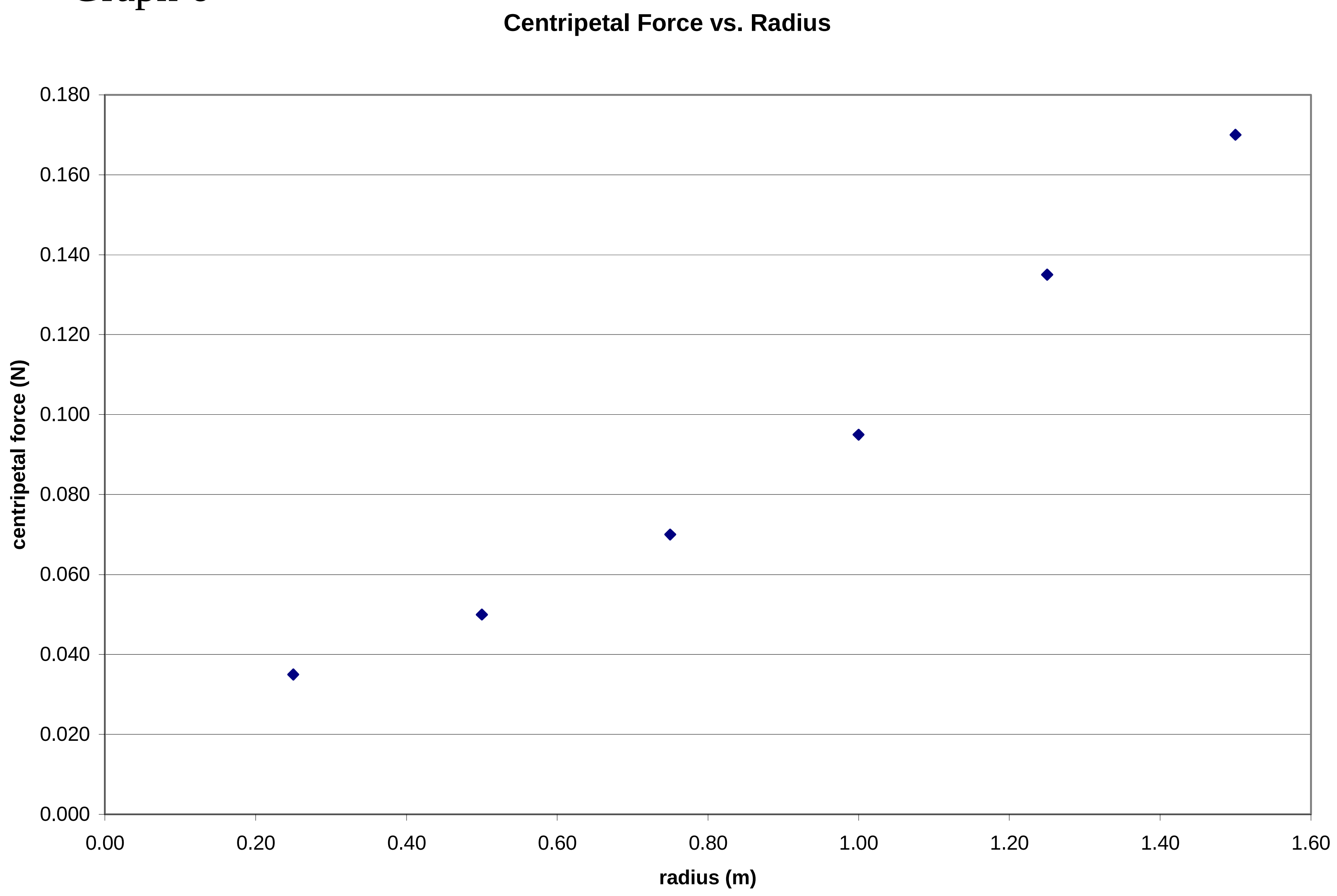
Graph 4


Log Centripetal Force vs. Log Frequency
-0.300
-0.250
-0.200
-0.150
-0.100
-0.050
0.000
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
-0.700
-0.800
-0.900
-1.000
y = 3.2495x - 0.01
log centripetal force
log frequency

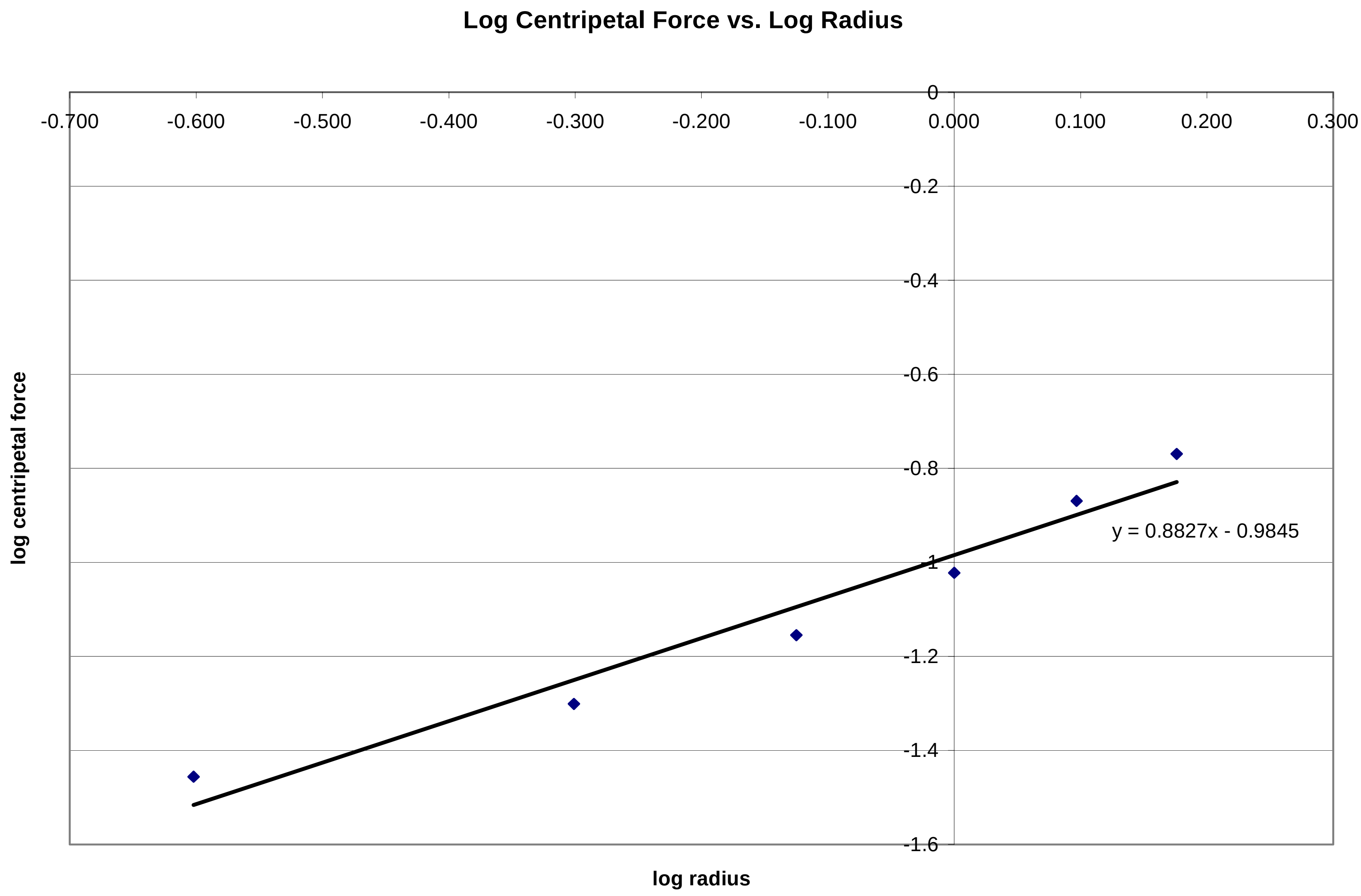
Graph 5


Centripetal Forve vs. Frequency Squared
centripetal force (N)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
frequency squared (hz^2)
radii
1.5
1.25
1
0.75
0.5
0.25

Graph 6


Centripetal Force vs. Radius
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
centripetal force (N)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
radius (m)

Graph 7



Log Centripetal Force vs. Log Radius
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-0.700
-0.600
-0.500
-0.400
-0.300
-0.200
-0.100
0.000
0.100
0.200
0.300
y = 0.8827x - 0.9845
log centripetal force
log radius