Welcome to Furman Engaged 2015

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Characteristics of the flexible Tsunami Barbell

INVENTORS: MR. GORDON BROWN AND MR. DAVID ABERNATHY.

RESEARCH SUPERVISORS: DR. RANDOLPH HUTCHISON, DR. RAYMOND MOSS AND DR. TONY CATERISANO,

What is a Tsunami Bar?

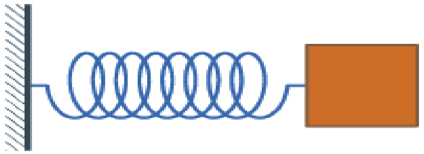
- FLEXIBLE, WEIGHT LIFTING BARBELL, Available in different SIZES and MATERIAL PROPERTIES
- Use: RESISTANCE TRAINING by ATHELETS and NON ATHELETS .

Goals

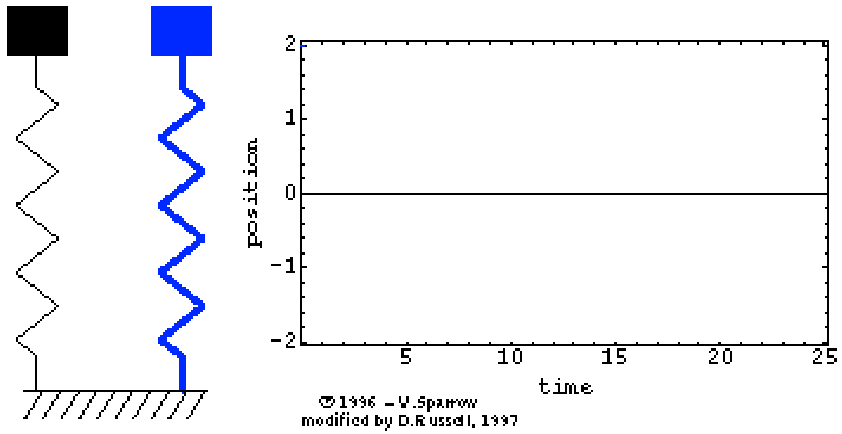
- 3D DATA COLLECTION AND ANALYSIS
- USE RESULTS TO CHARACTERIZE the TSUNAMI BAR WITH ***MASS-SPRING-DAMPER*** MODEL
  - CALCULATE SPRING CONSTANT
  - CALCULATE DAMPING COEFFICIENT

MATHEMATICAL MODEL

SPRING MASS SYSTEM



DAMPED OSCILLATION SYSTEM



2nd Order differential equation

$$\frac{d^2x}{dt^2} + 2\zeta\omega_0\frac{dx}{dt} + \omega_0^2 x = 0,$$

Spring constant

'k'

Natural Frequency

$$\omega_0 = \sqrt{\frac{k}{m}}$$

Damping coefficient

$$\zeta = \frac{c}{2\sqrt{mk}}.$$

Types of Bar used

- Black flex PVC, inner radius ¾” (Highly Damped)

- White rigid PVC, inner radius ¾”(Highly Damped)

- Beige CPVC, inner radius ½” (Highly Damped)

Cross-Section of the Bar.

- **FIBER GLASS RECTANGULAR BARS**

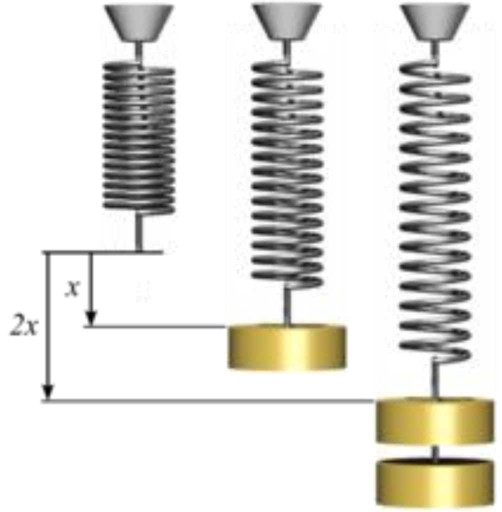
- **FIBER GLASS CIRCULAR BAR**

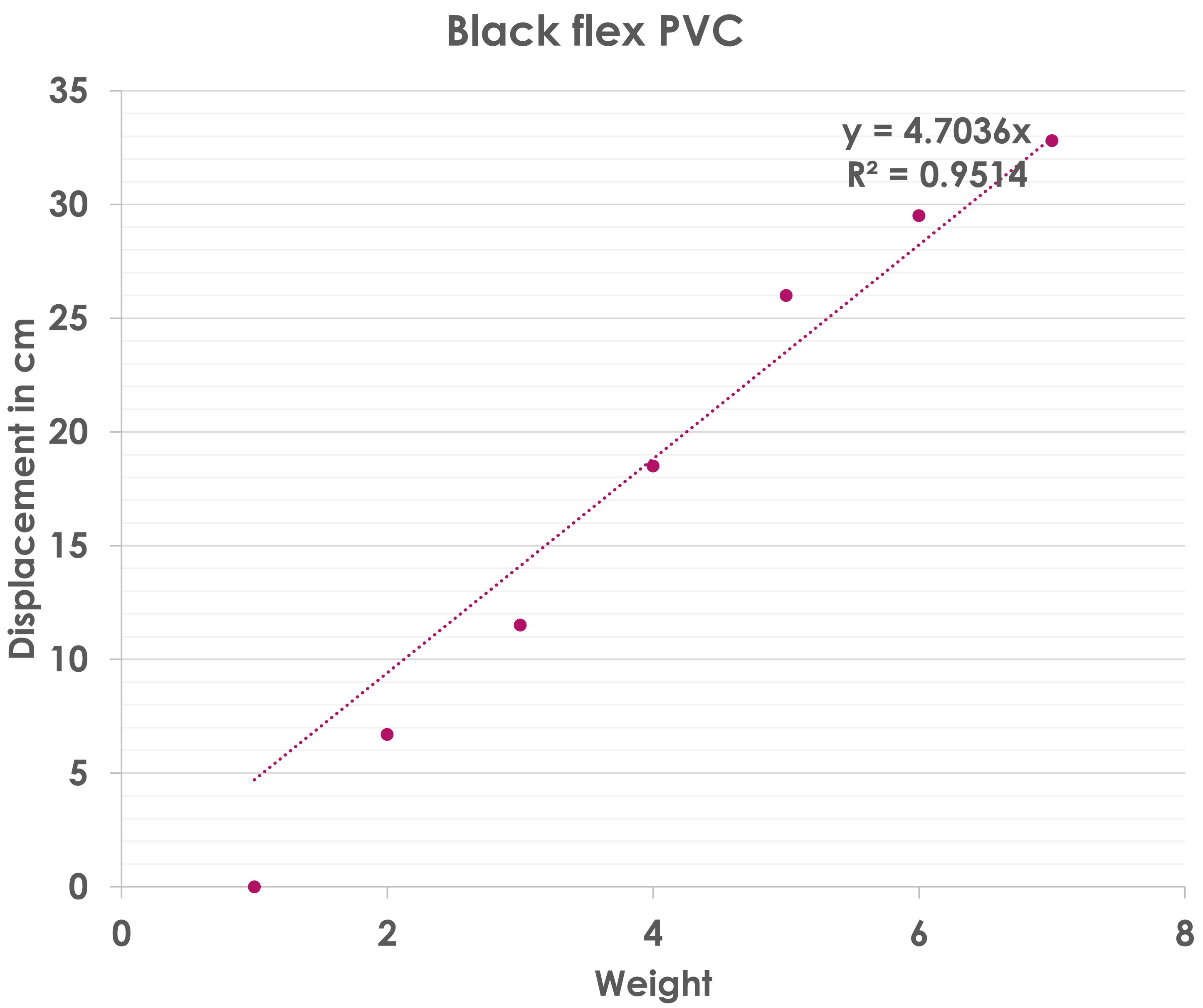
<u>Properties</u>

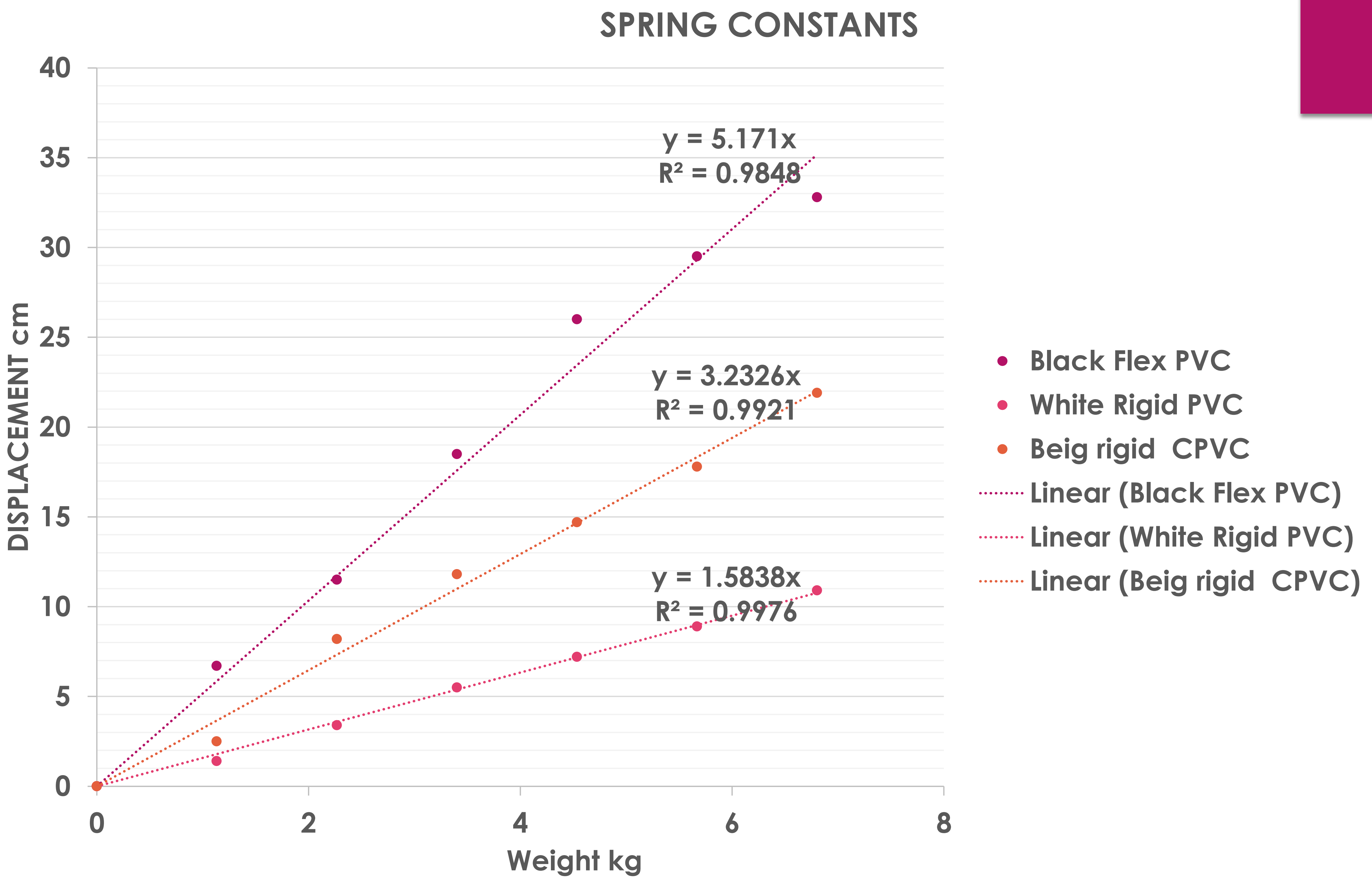
- LIGHTLY DAMPED

Hooke's law

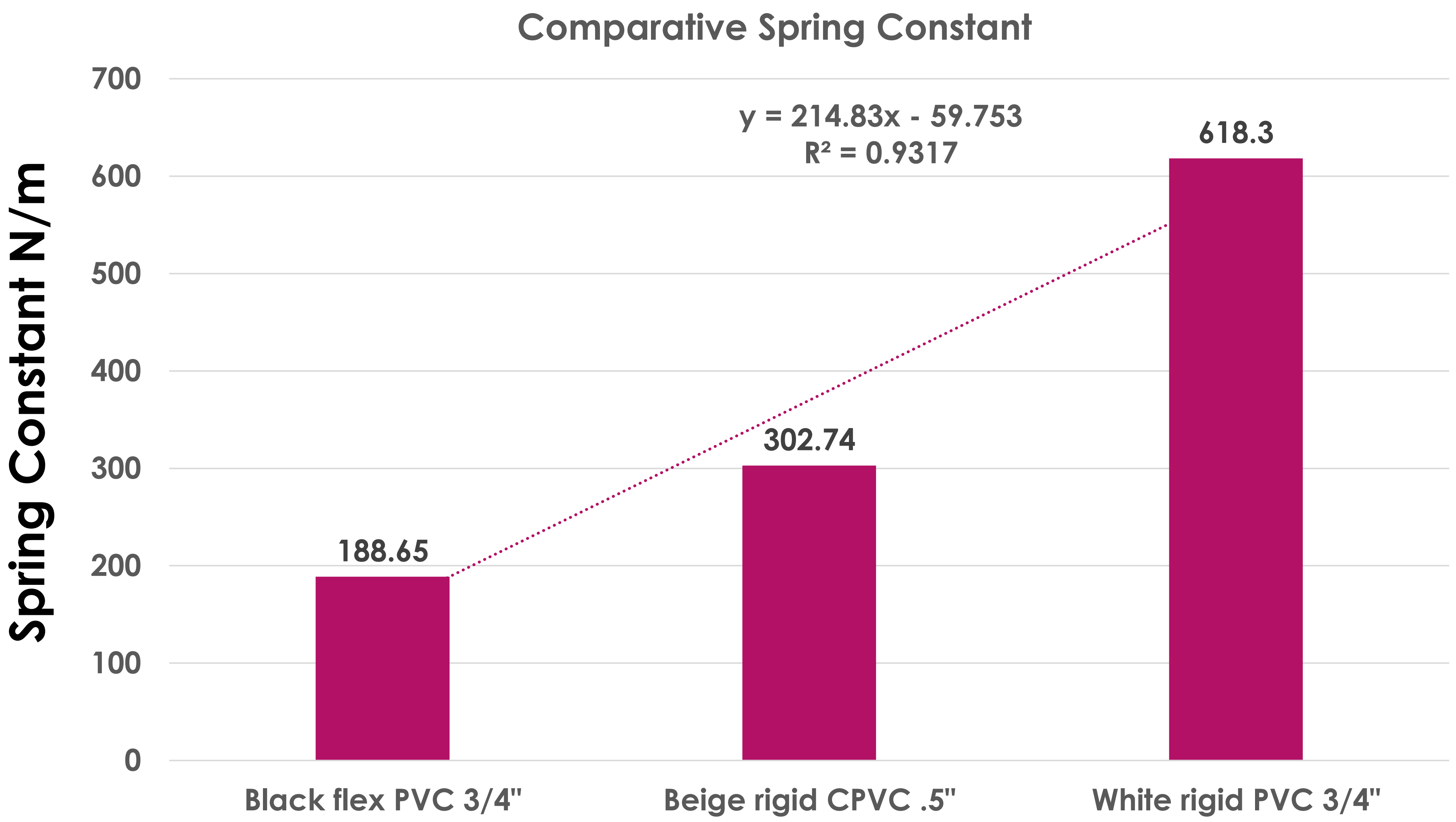
- F = -kX, FORCE DIRECTLY PROPOTIONAL TO DISPLACEMENT
- **F= FORCE APPLIED, x = DISPLACEMENT and**
- **K=SPRING CONSTANT.**



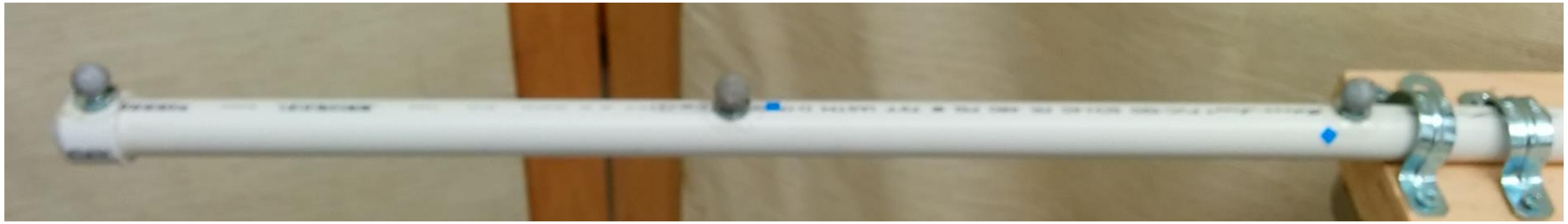

Black flex PVC
y = 4.7036x
R² = 0.9514
Displacement in cm
Weight
0
5
10
15
20
25
30
35
0
2
4
6
8



SPRING CONSTANTS
y = 5.171x
R² = 0.9848
y = 3.2326x
R² = 0.9921
y = 1.5838x
R² = 0.9976
DISPLACEMENT cm
Weight kg
40
35
30
25
20
15
10
5
0
0
2
4
6
8
Black Flex PVC
White Rigid PVC
Beig rigid CPVC
Linear (Black Flex PVC)
Linear (White Rigid PVC)
Linear (Beig rigid CPVC)

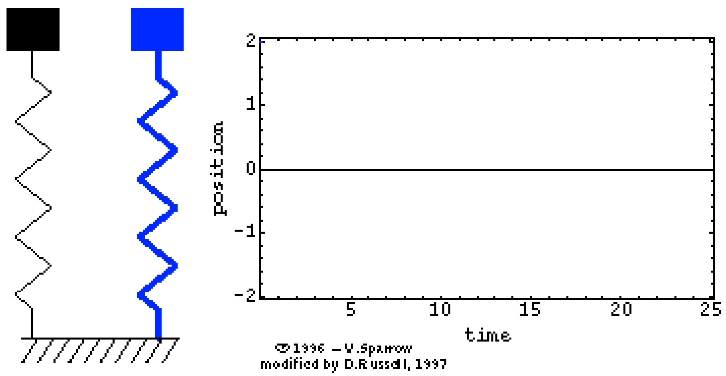

Comparative Spring Constant
Spring Constant N/m
700
600
500
400
300
200
100
0
y = 214.83x - 59.753
R² = 0.9317
188.65
302.74
618.3
Black flex PVC 3/4"
Beige rigid CPVC .5"
White rigid PVC 3/4"

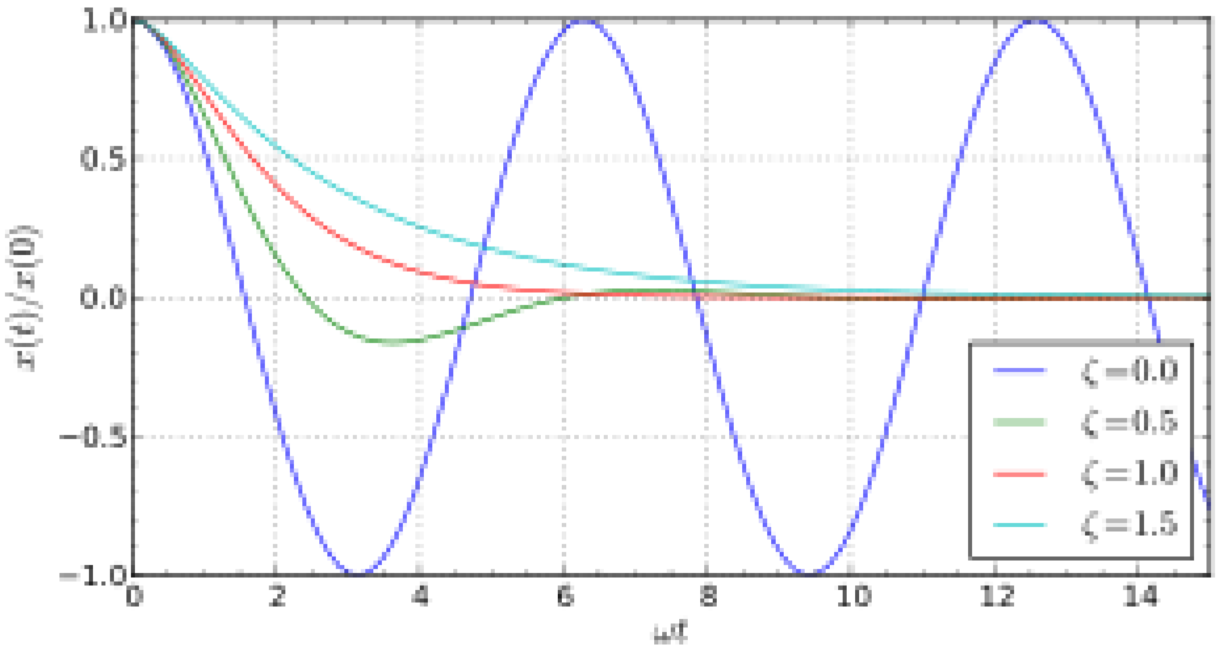
MOTION CAPTURE DEMONSTRATION

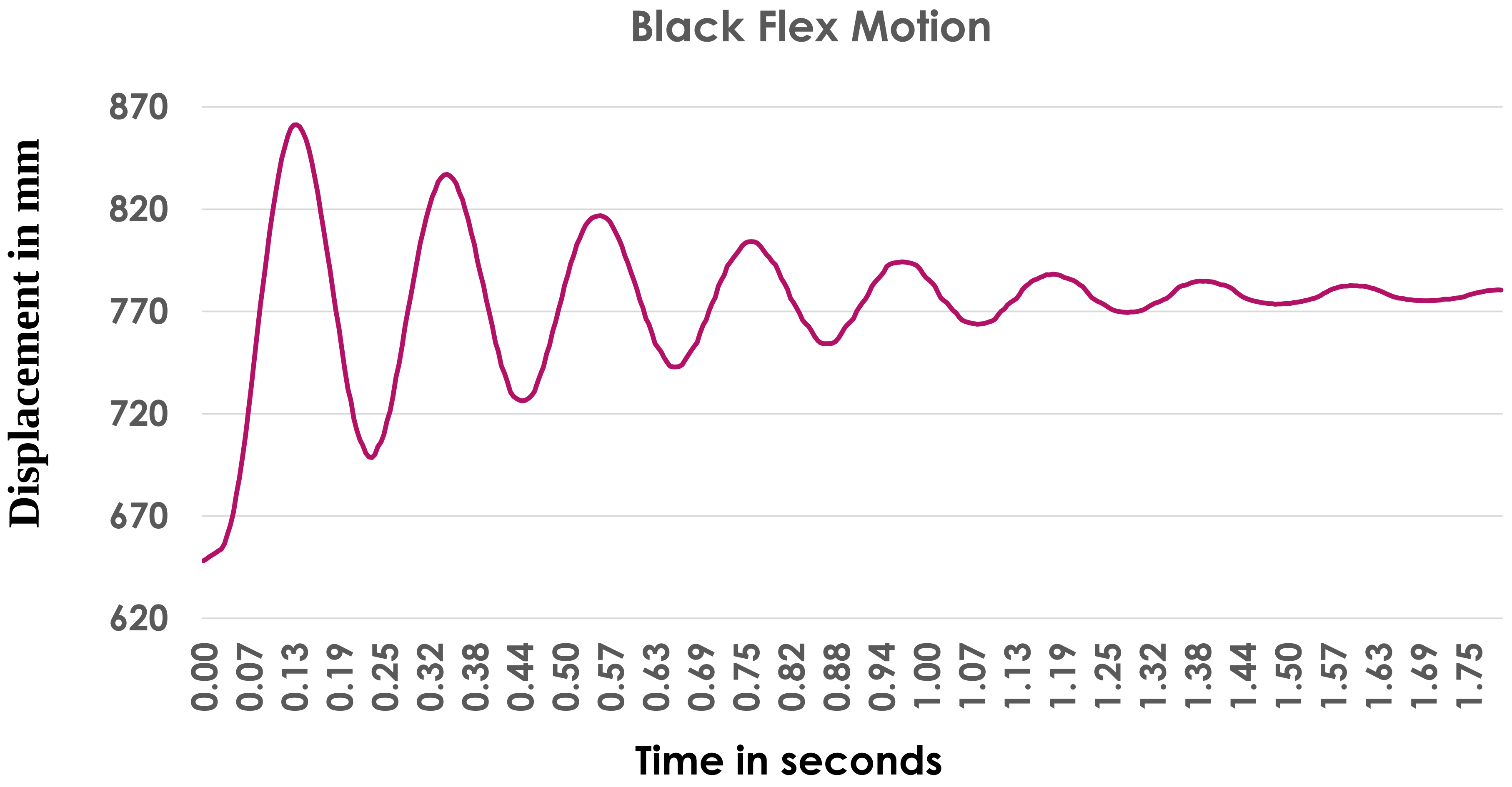


DAMPING COEFFCIENTS

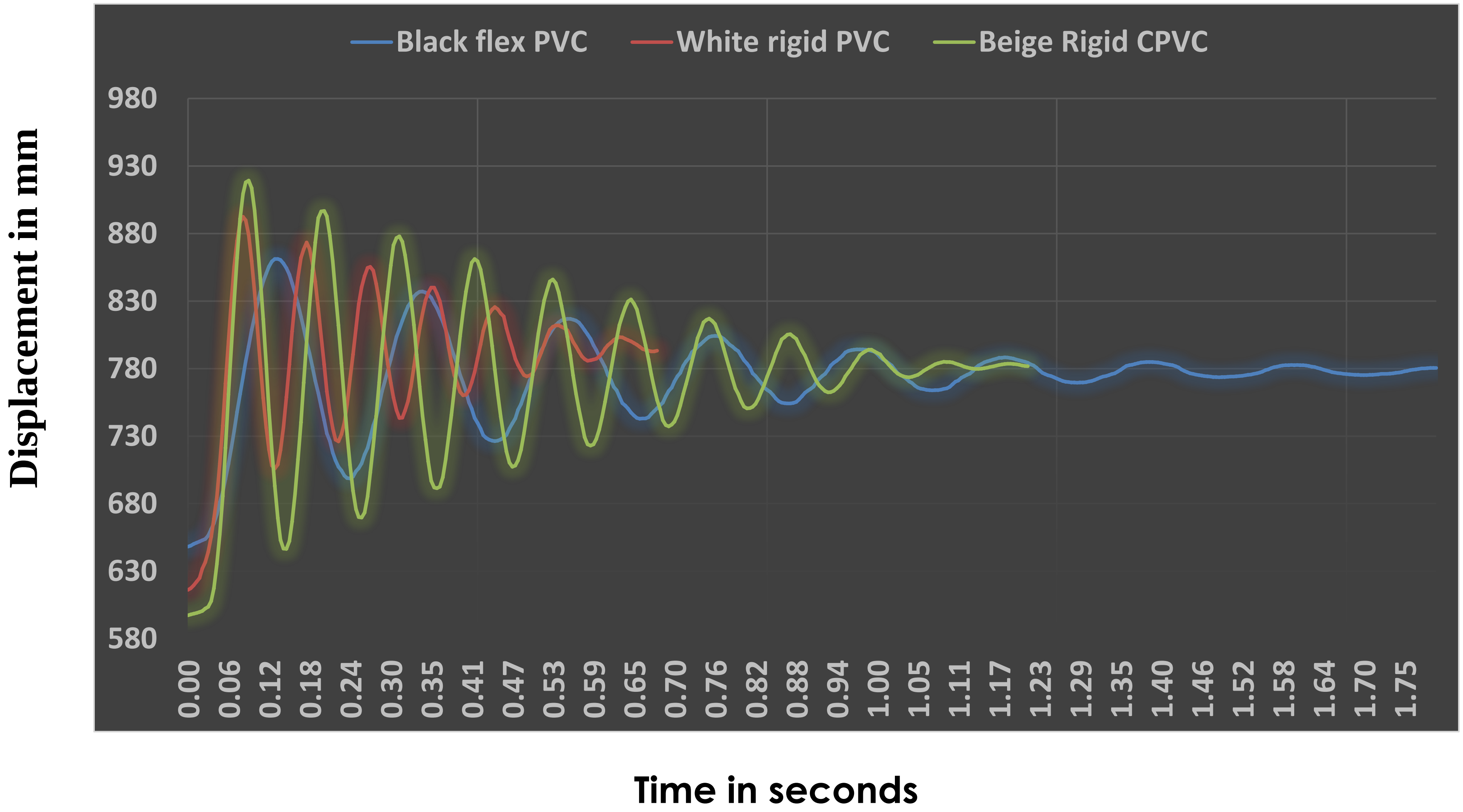
- **Critical damping ($\zeta = 1$)**
- **Over-damping ($\zeta > 1$)**
- **Under-damping ($0 \le \zeta < 1$)**






Black Flex Motion
870
820
770
720
670
620
Displacement in mm
0.00
0.07
0.13
0.19
0.25
0.32
0.38
0.44
0.50
0.57
0.63
0.69
0.75
0.82
0.88
0.94
1.00
1.07
1.13
1.19
1.25
1.32
1.38
1.44
1.50
1.57
1.63
1.69
1.75
Time in seconds

Comparative motion of the Bars



SOLUTION

For successive amplitudes m = 1

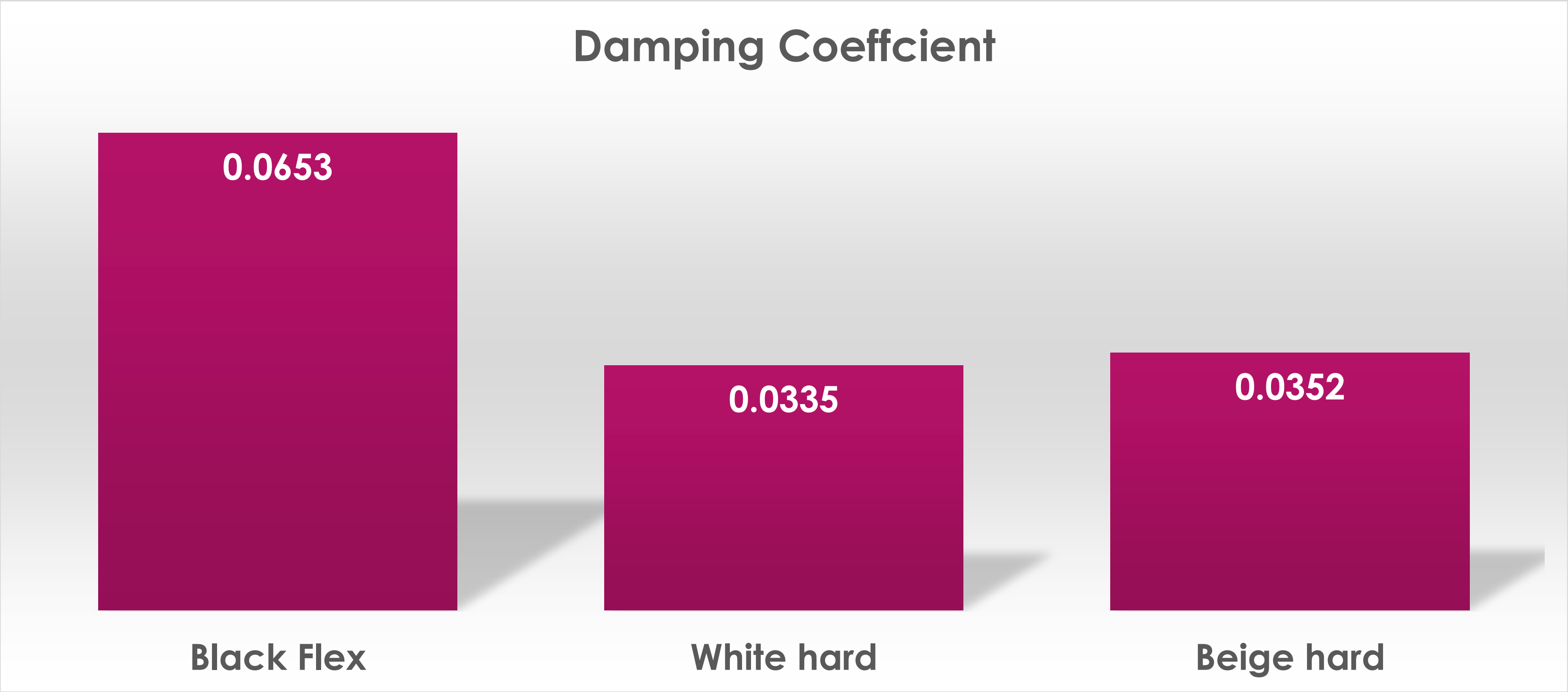
$$\ln\left(\frac{x_1}{x_2}\right) = \ln\left(\frac{3}{0.5}\right) = \ln 6 = 1.792 = \text{amplitude reduction factor}$$

$$1.792 = \frac{2\pi\ \delta}{\sqrt{1-\delta^2}} \quad \text{square both sides}$$

$$3.21 = \frac{39.478\delta^2}{1-\delta^2} \quad \text{so} \quad 1-\delta^2 = 12.298\delta^2$$

$$13.298\delta^2 = 1 \text{ and } \delta^2 = \frac{1}{13.298} = 0.075 \text{ and } \delta = \sqrt{0.075} = 0.274$$

DAMPING COEFFICIENT



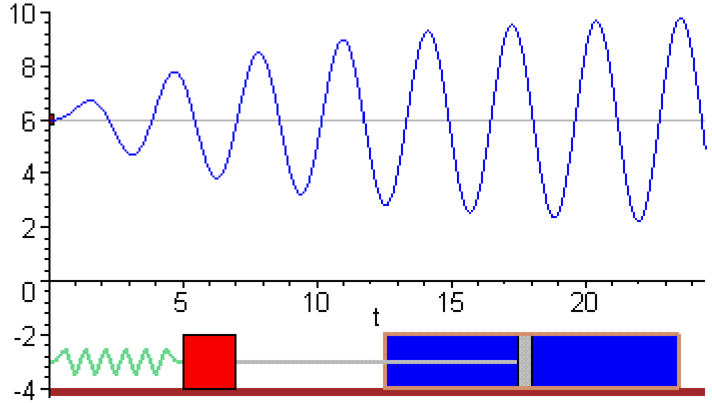
FUTURE RESEARCH AND GOALS

Forced Oscillations

Newton's 2nd Law terms

Sinusoidal driving force

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = F_0\cos(\omega t + \varphi_d)$$



- OPTIMUM VELOCITY, RANGE OF MOTION
- DISTANCE OF WEIGHT FROM THE BAR
- COMPREHENSIVE MODEL

QUESTIONS OR COMMENTS.