



Welcome to Furman Engaged 2015

PRESENTER: MUHAMMAD MEHMOOD MALLICK

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?



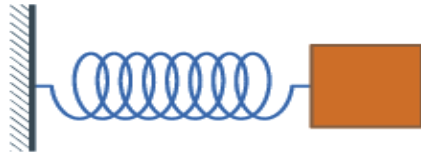
- ▶ FLEXIBLE, WEIGHT LIFTING BARBELL, Available in different SIZES and MATERIAL PROPERTIES
- ▶ Use: RESISTANCE TRAINING by ATHELETS and NON ATHELETS .

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



2nd Order differential equation

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

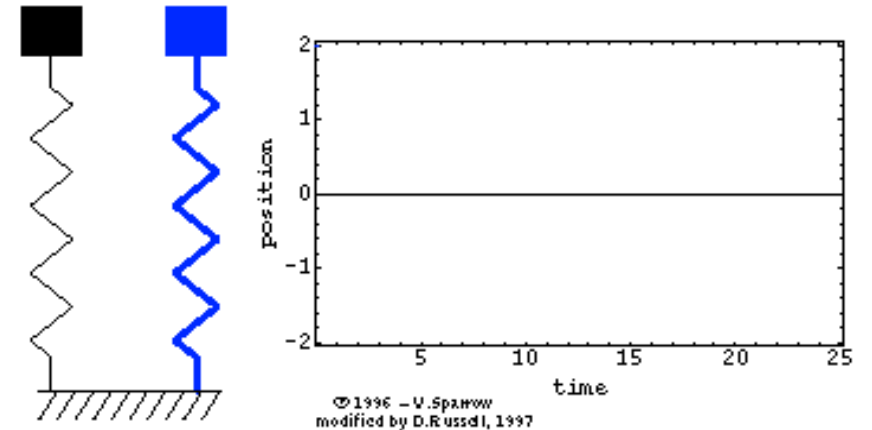
Spring constant

'k'

Natural Frequency

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

DAMPED OSCILLATION SYSTEM



Damping coefficient

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

Types of Bar used

- ▶ Black flex PVC, inner radius $\frac{3}{4}$ " (Highly Damped)



- ▶ White rigid PVC, inner radius $\frac{3}{4}$ " (Highly Damped)



- ▶ Beige CPVC, inner radius $\frac{1}{2}$ " (Highly Damped)



Cross-Section of the Bar.

- ▶ **FIBER GLASS RECTANGULAR BARS**



- ▶ **FIBER GLASS CIRCULAR BAR**



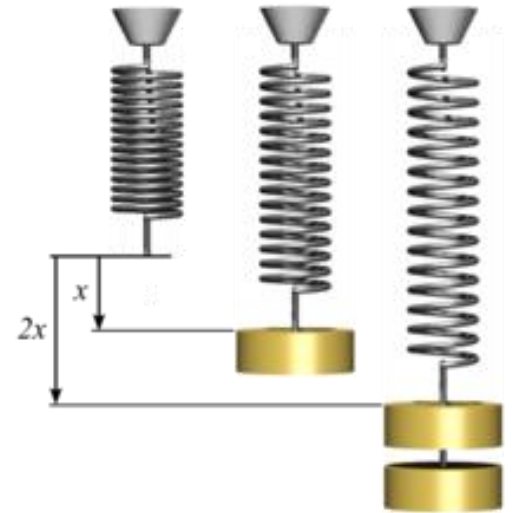
Properties

- ▶ **LIGHTLY DAMPED**

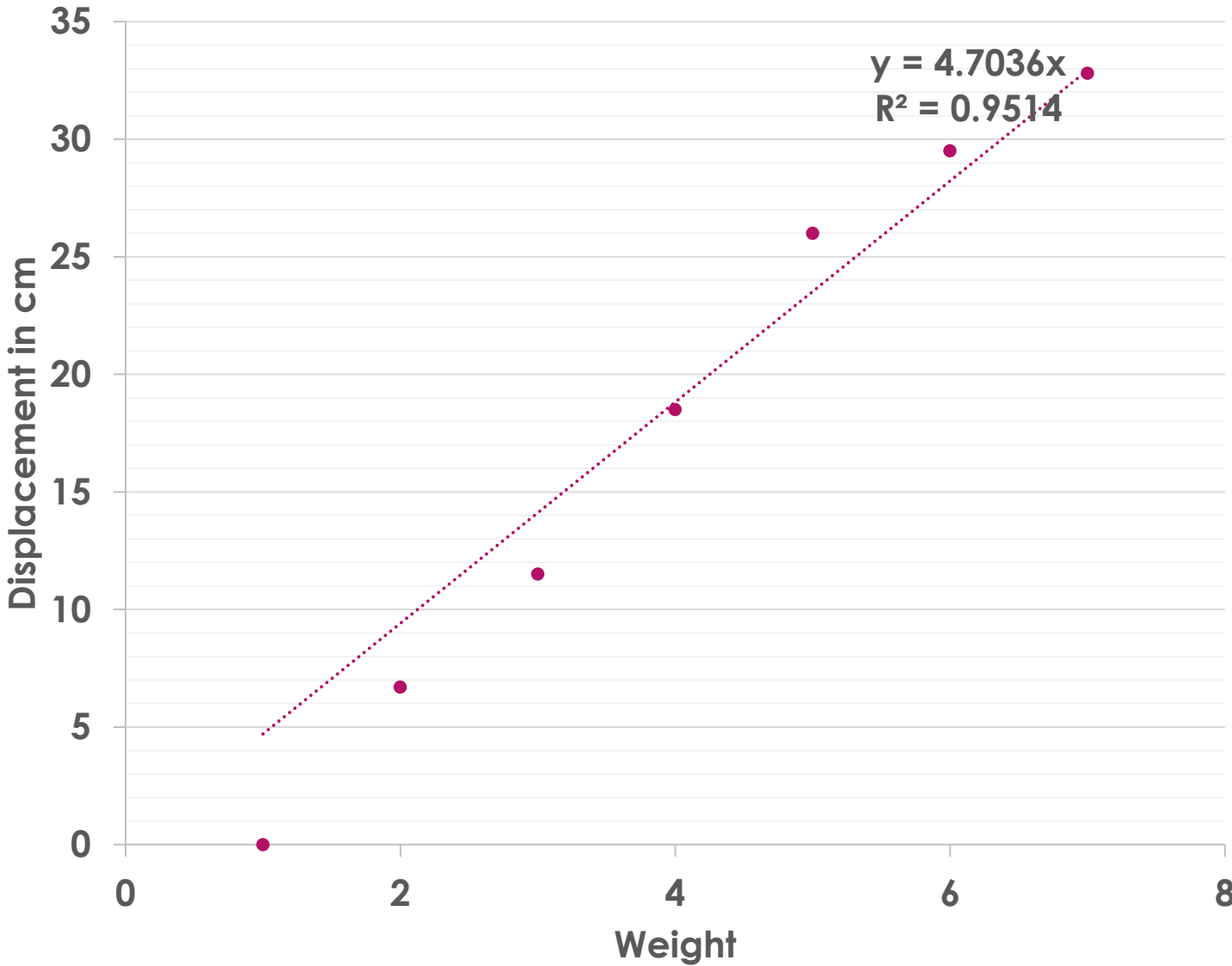


Hooke's law

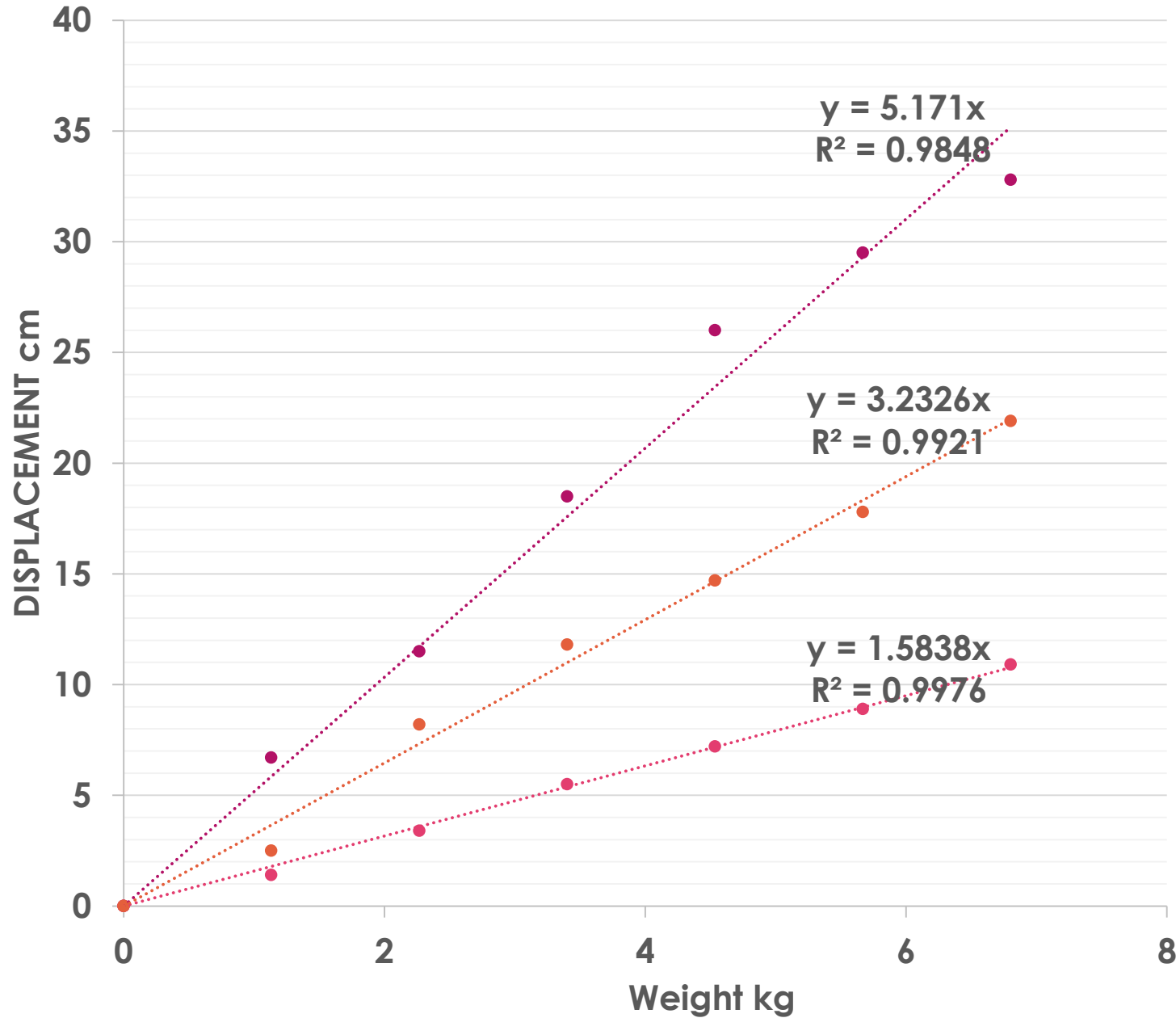
- ▶ **$F = -kx$, FORCE DIRECTLY PROPORTIONAL TO DISPLACEMENT**
- ▶ **F = FORCE APPLIED, x = DISPLACEMENT and**
- ▶ **k = SPRING CONSTANT.**



Black flex PVC

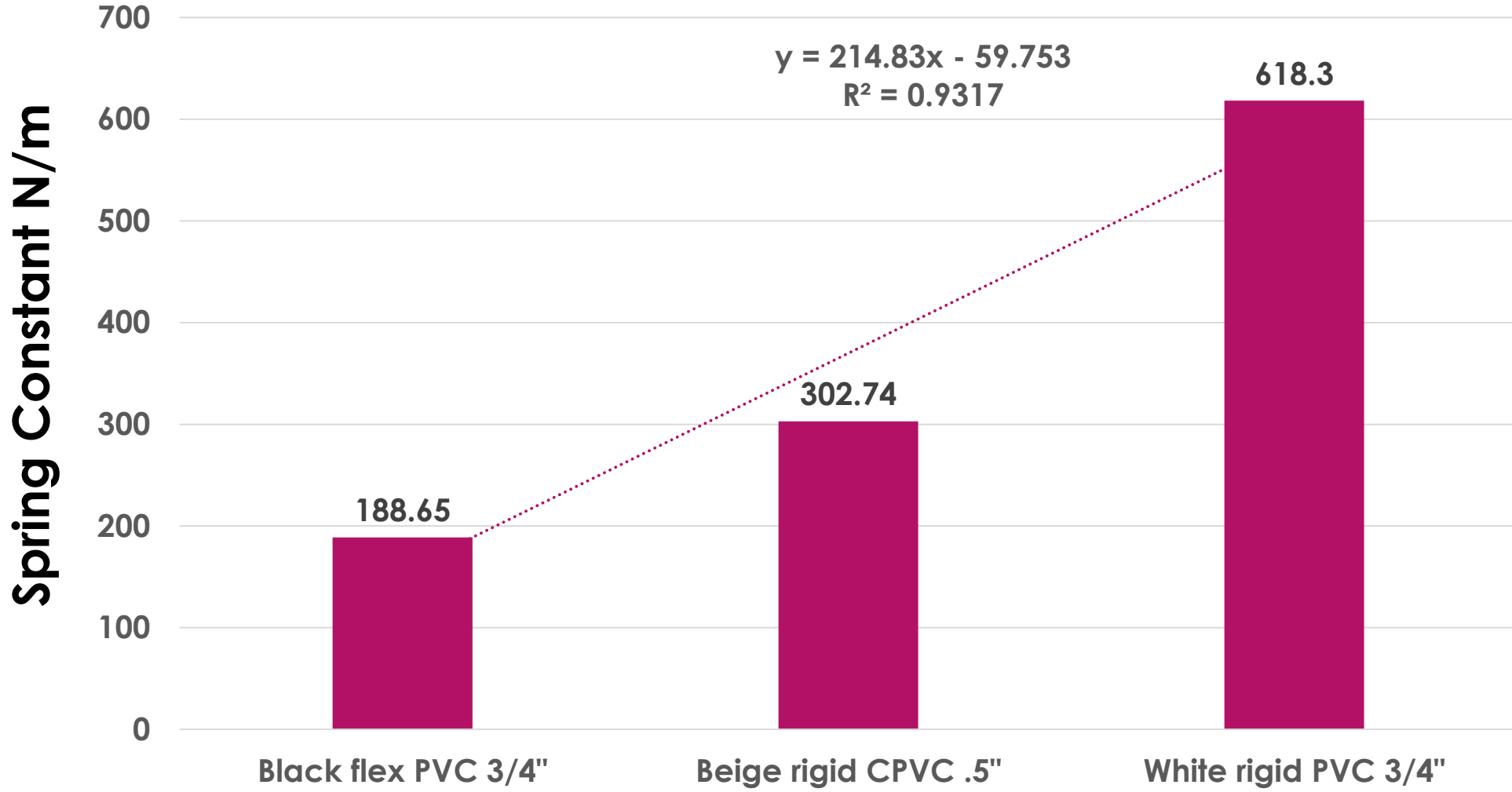


SPRING CONSTANTS



- Black Flex PVC
- White Rigid PVC
- Beig rigid CPVC
- Linear (Black Flex PVC)
- Linear (White Rigid PVC)
- Linear (Beig rigid CPVC)

Comparative Spring Constant

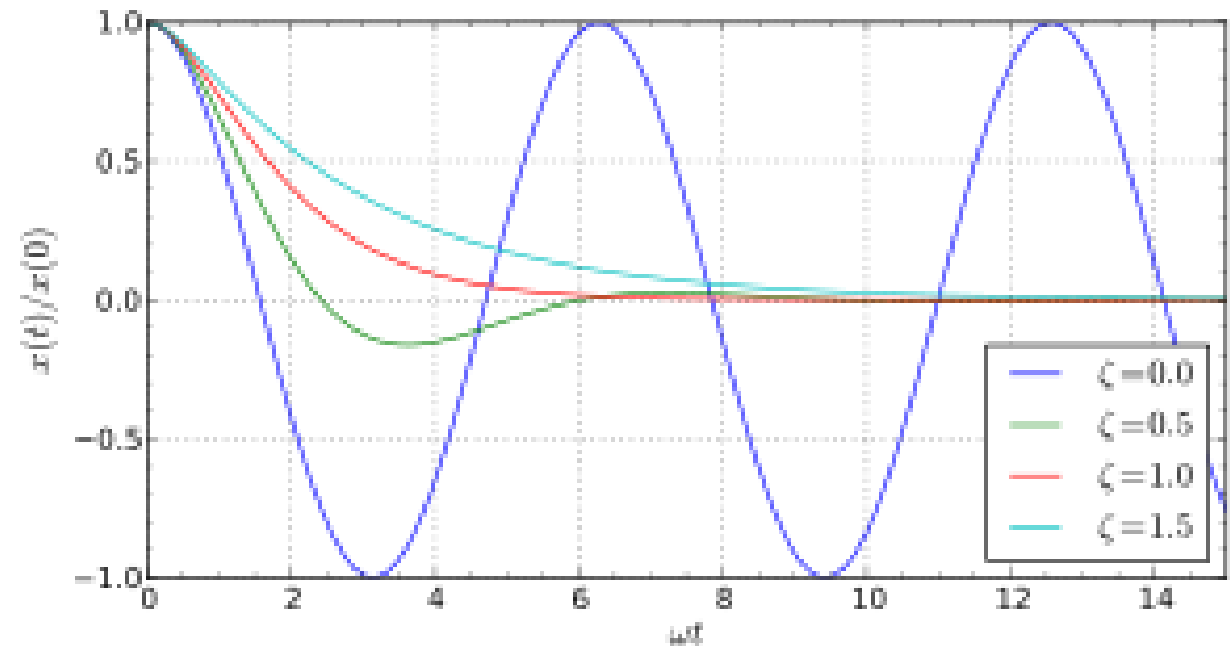
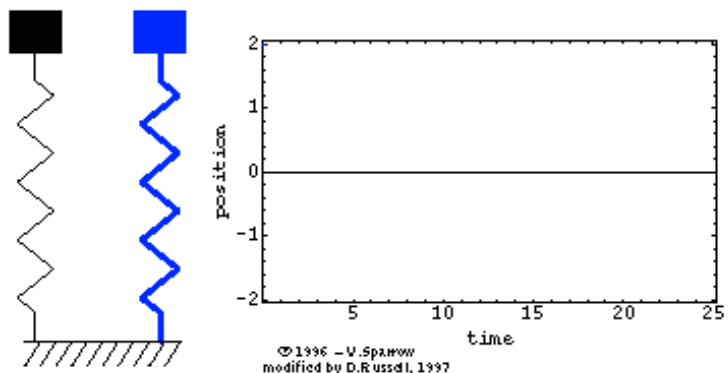


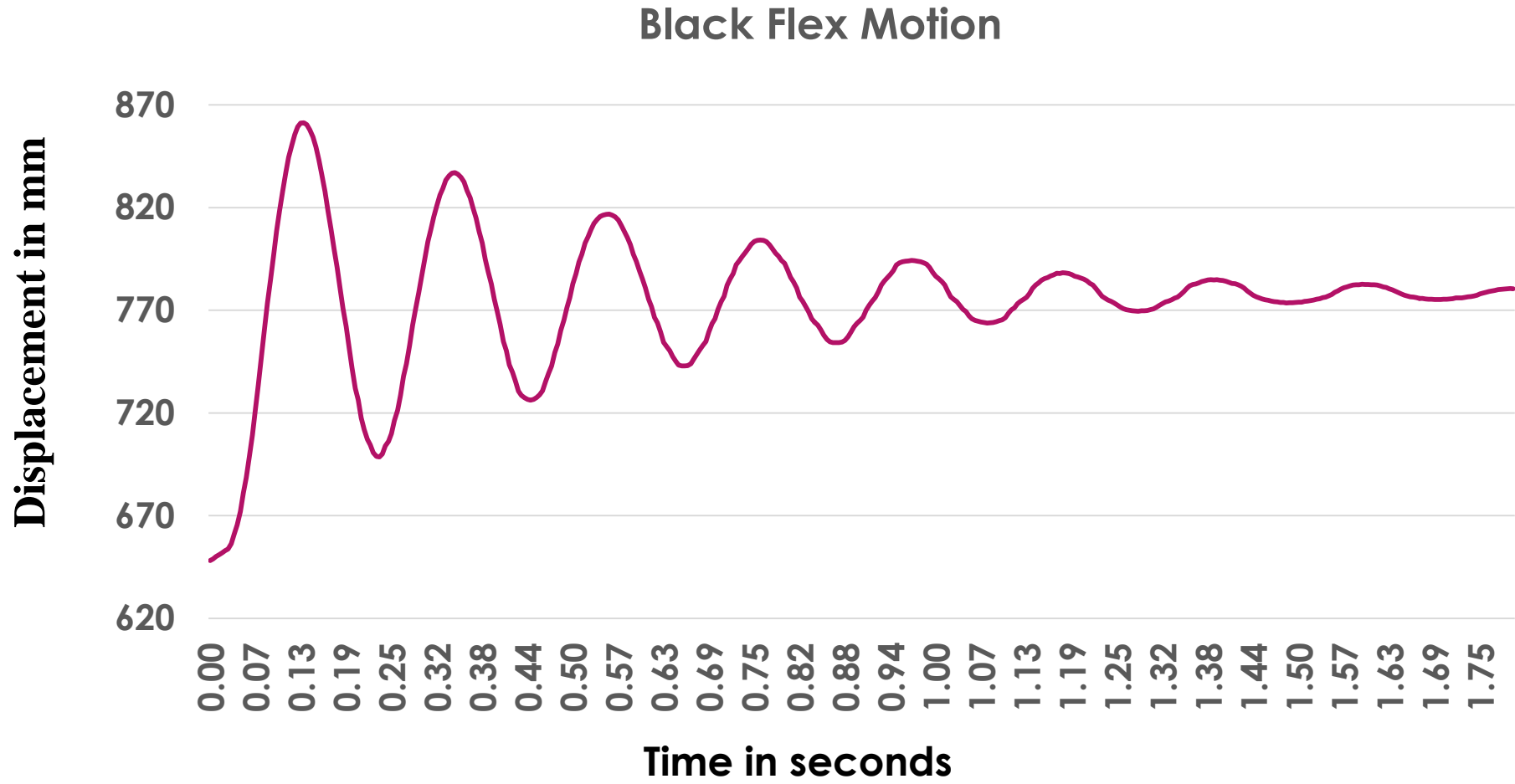
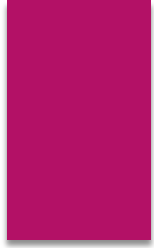
MOTION CAPTURE DEMONSTRATION



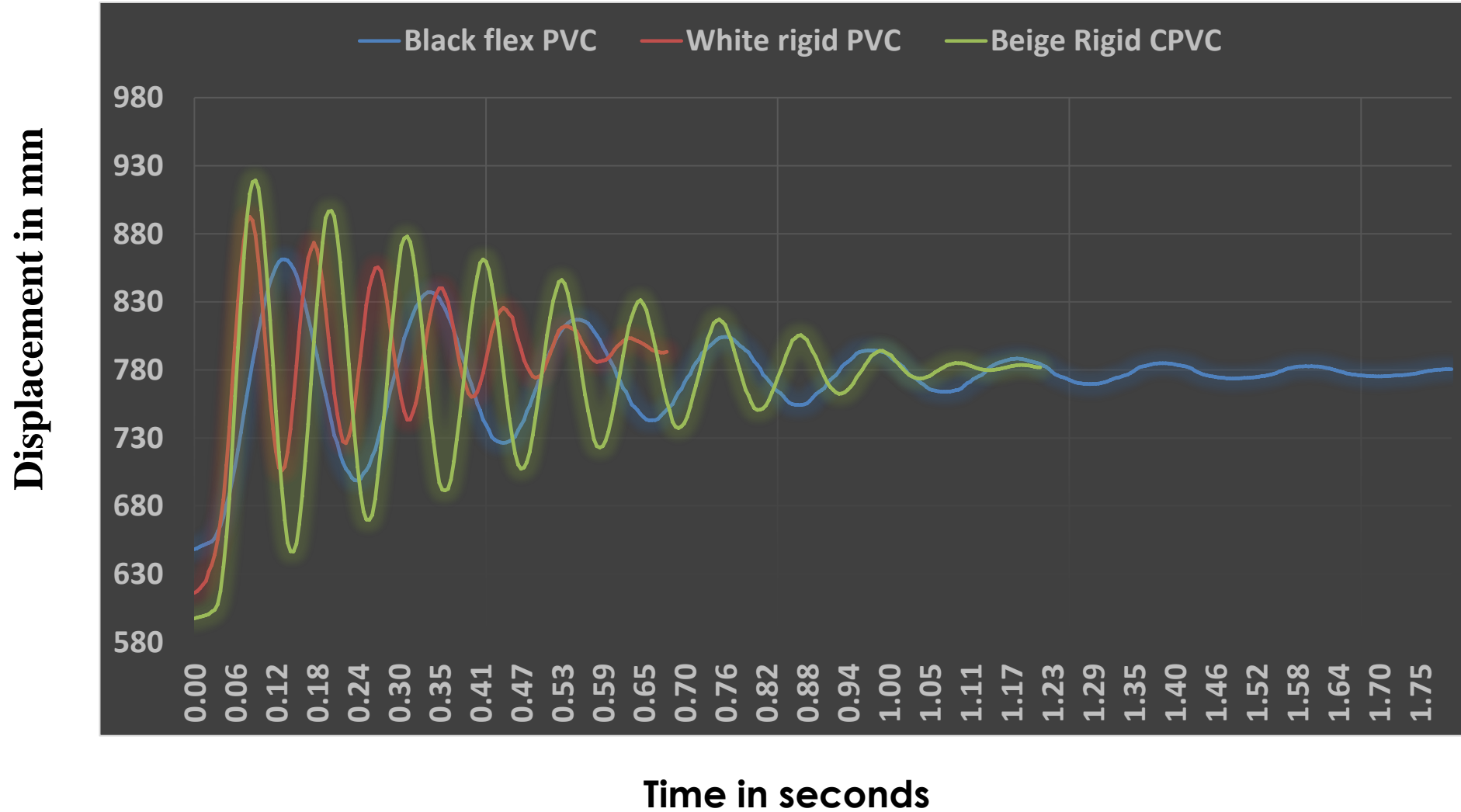
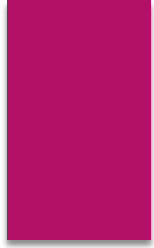
DAMPING COEFFICIENTS

- ▶ Critical damping ($\zeta = 1$)
- ▶ Over-damping ($\zeta > 1$)
- ▶ Under-damping ($0 \leq \zeta < 1$)





Comparative motion of the Bars



SOLUTION

For successive amplitudes $m = 1$

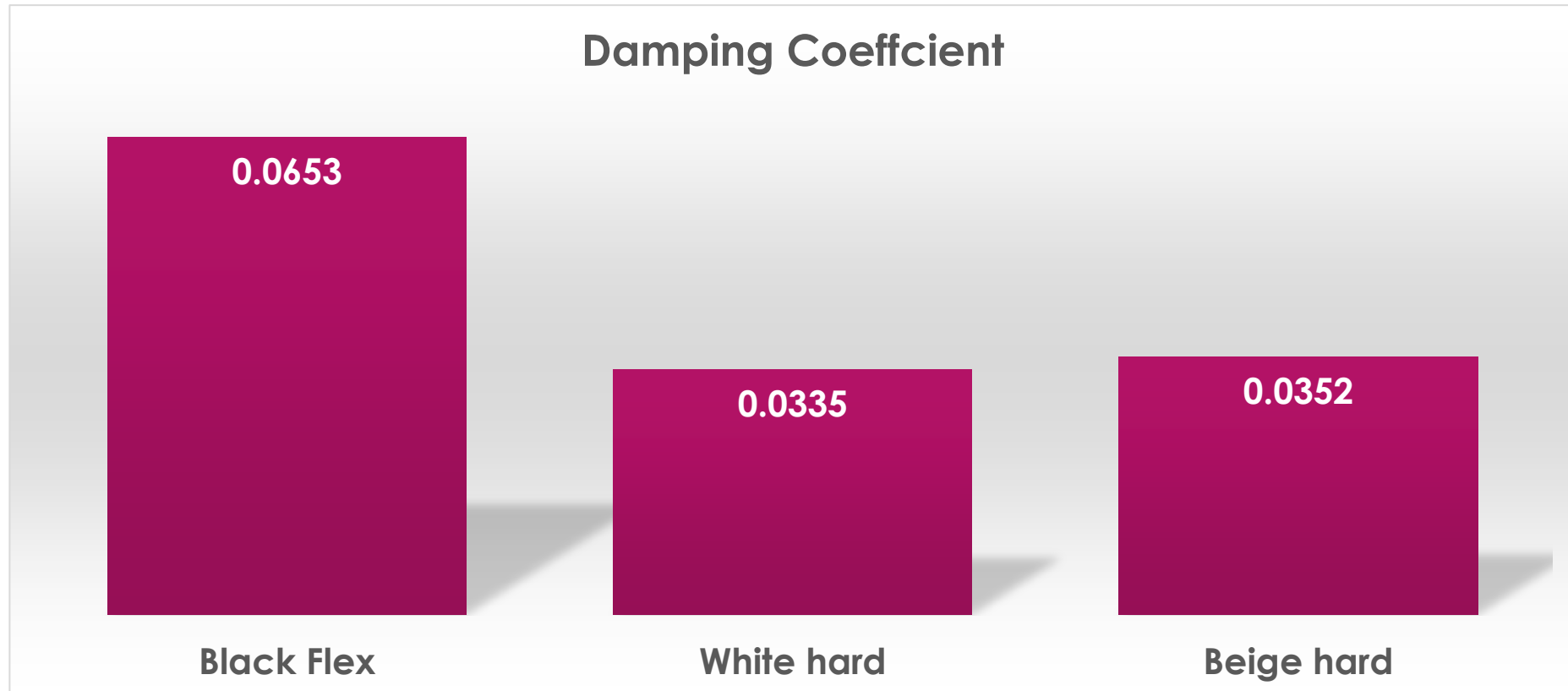
$$\ln\left(\frac{x_1}{x_2}\right) = \ln\left(\frac{3}{0.5}\right) = \ln 6 = 1.792 = \text{amplitude reduction factor}$$

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

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

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

DAMPING COEFFICIENT



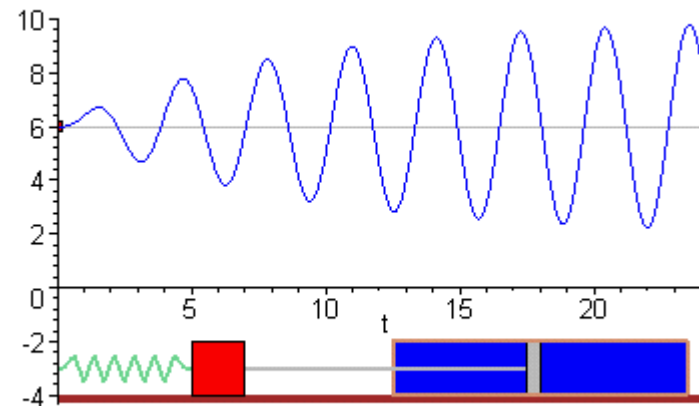
FUTURE RESEARCH AND GOALS

Forced Oscillations

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

Newton's 2nd Law terms Sinusoidal driving force

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





QUESTIONS OR
COMMENTS.