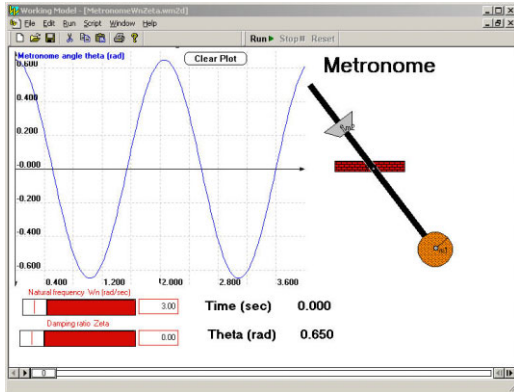


Lab 5 (associated with Hw 5): Dynamic response of rotational systems

The objective of this laboratory is to develop physical intuition for 2^{nd} -order ODEs and associated mathematical quantities, including decay ratio, period of vibration, natural frequency, and damping ratio.

Lab 5.1 Effect of damping ratio (ζ) and natural frequency (ω_n) on dynamic response.

In Lab 3.1, you varied ζ and ω_n and observed their effect on the vertical (translational) motions of a car with a spring-damper suspension system. In this experiment, you will vary ζ and ω_n and observe their effect on the rotational motions of a metronome. To begin this problem, double-click on the file MetronomeWnZeta.wm2d.



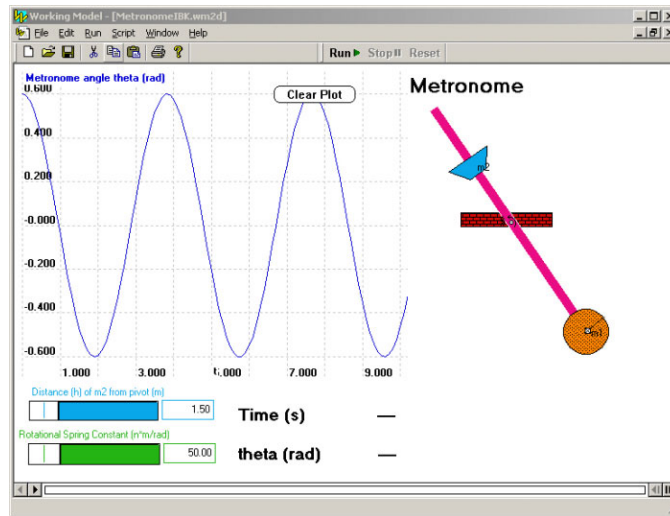
To answer each question with Working Model, click the **Reset** button (if necessary) and click and drag the sliders that control the numerical values for ω_n (measured in rad/sec) and ζ (dimensionless). To start the simulation, click the **Run** button, and to stop it, click the **Stop** button.

Decide which of the following statements are **true** or **false**. If a statement is **false**, provide a counter-example. If a statement involves ζ , assume ω_n is known, and vice-versa.

Statement	True/False	Counter-example if false
Increasing the damping ratio ζ always makes the metronome move slower	True/False	
For an <i>oscillating</i> metronome, increasing ζ always decreases the frequency of oscillation and makes the period longer	True/False	
For an <i>oscillating</i> metronome, increasing ζ always makes the decay ratio larger	True/False	
Increasing ζ always makes the metronome settle to equilibrium quicker	True/False	
For an <i>oscillating</i> metronome, increasing ω_n always increases the frequency of oscillation and makes the period shorter	True/False	
For an <i>oscillating</i> metronome, increasing ω_n always makes the decay ratio larger	True/False	
For a damped <i>oscillating</i> metronome, increasing ω_n decreases the settling time	True/False	
When $\zeta > 0$, increasing ω_n always makes the metronome settle to equilibrium quicker	True/False	

Lab 5.2 Effect of moment of inertia and spring stiffness on dynamic response.

For each simulation that follows, determine the effect of k (the rotational spring constant) and h (the distance between the particle of mass m_2 and the pivot point) on the rotational motions of the metronome. To begin this problem, double-click on the file `MetronomeIBK.wm2d`.



- (a) After running as many simulations as necessary, fill in the following table with -- (decreases), - (slightly decreases), 0 (no change), + (slightly increases), or ++ (increases).

	I (moment of inertia)	τ_{period}	ω_n
Effect of increasing k on:			
Effect of Increasing h on:			

- (b) Based on your observations, circle the appropriate answer in the following statements.
- A metronome with a higher natural frequency uses a **softer/stiffer** spring
 - A metronome with a lower natural frequency uses a **smaller/larger** value of h
- (c) In Homework 5.8, a small angle approximation $\sin(\theta) \approx \theta$ is used to convert a **nonlinear** ODE to a **linear** ODE. To see the difference between the actual value of $\theta(t)$ and the value of $\theta(t)$ predicted with the small angle approximation, double-click on the file `MetronomeNonlinearAngle.wm2d`.

Initial value of θ	Value of $\theta(t=10)$ predicted with small angle approximation	Actual value of $\theta(t=10)$	Difference
0.3 rad			
0.6 rad			
0.9 rad			
1.2 rad			

- (d) When is the small angle approximation most accurate?

Result: