PHY2105 Spring 2025 Exercise Sheet

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Simple & Damped Harmonic Motion

Consider the units.

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1 Damped Oscillation

(a) Find what type of damped oscillation is the system and if found oscillatory determine its frequency and plot a schematic graph

(a) $\omega_0 = 2$ and $\gamma = 7$

(b) $\omega_0 = 3$ and $\gamma = 6$

(c) $\omega_0 = 4$ and $\gamma = 5$

(d) $\omega_0 = 5$ and $\gamma = 4$

(e) $\omega_0 = 6$ and $\gamma = 3$

(f) $\omega_0 = 7$ and $\gamma = 2$

(g) $\omega_0 = 8$ and $\gamma = 1$

(b) A capacitor $1.0\mu F$, an inductor 0.2h and a resistance 800Ω are joined in series. Is the circuit oscillatory?

(c) For a damping spring, the spring constant is 196 N/m and the angular frequency is 5 rad/sec. if the constant b = 0.5 kg/sec. What will be the lifetime for this wave?Also, determine the time required for the amplitude to become half of its initial value.

(d) A damped harmonic oscillator has a mass of 2 kg, a damping coefficient of 3 kg/s, and a spring constant of 50 N/m. Determine whether the system is underdamped, overdamped, or critically damped.

(e) A damped oscillator starts with an initial amplitude of $A_0 = 10$ cm. If the damping coefficient $\gamma = 0.1$ s^{-1}, how long will it take for the amplitude to drop to 2.5 cm?

(f) A simple harmonic oscillator with mass 0.5 kg and spring constant 200 N/m experiences damping such that its energy is reduced to half in 10 s. Determine the damping coefficient γ.

(g) A resistor of 500Ω, an inductor of 0.1 H, and a capacitor of 2.0μF are connected in series. Find whether the circuit is oscillatory or not. If it is oscillatory, determine the frequency of oscillations.

(h) A system has a natural angular frequency $\omega_0 = 6$ rad/s and a damping coefficient $\gamma = 4$ rad/s. Find the damped angular frequency ω_d.

(i) A 1 kg mass attached to a spring undergoes damped oscillations with a damping coefficient $b = 0.4$ kg/s. The system's initial amplitude is 5 cm. How long does it take for the amplitude to reduce to $\frac{1}{e}$ of its initial value?

(j) A damped harmonic oscillator has a damping coefficient $b = 3$ kg/s, a mass of 1 kg, and a spring constant of 20 N/m. Classify the type of damping.

(k) The total energy of a damped oscillator follows the relation $E(t) = E_0 e^{-\gamma t}$. If the initial energy is $E_0 = 100$ J and the damping coefficient is $\gamma = 0.2$ s^{-1}, determine the energy after 5 seconds.

(l) A damped system has a spring constant of 150 N/m, a mass of 2 kg, and a damping coefficient $b = 0.6$ kg/s. Calculate the characteristic lifetime τ of the oscillation.

(m) A damped harmonic oscillator loses energy exponentially according to $E(t) = E_0 e^{-\gamma t}$. If the system initially has 20 J of energy and its damping coefficient is $\gamma = 0.3$ s^{-1}, how long will it take for the energy to drop to 10 J?

2 Derivation

(a) Derive the Equation of Motion and Solution for the following damped harmonic system

  (a) Spring in a Medium

  (b) LRC Circuit

Best of Luck!!!