Physics 121 – Review for Midterm Exam #4

Equations to remember (in addition to those from the previous reviews):

- Impulse: \( I = \Delta p = \int_{t_1}^{t_2} F \, dt \)
- Gravity: \( \vec{F} = \frac{GMm}{r^2} \hat{r} \)
- Springs: \( F = -kx, \ U = -\frac{1}{2}kx^2 \)
- Harmonic Oscillators: \( \omega = \sqrt{\frac{k}{m}} \quad f = \frac{\omega}{2\pi} \quad T = \frac{1}{f} \quad x(t) = A \cos(\omega t + \varphi) \)
- Simple Pendulum: \( \theta(t) = A \cos(\omega t + \varphi) \quad \omega = \sqrt{\frac{gL}{I}} \)
- Physical Pendulum: \( \theta(t) = A \cos(\omega t + \varphi) \quad \omega = \sqrt{\frac{mgd}{I}} \)
- Damped oscillator: \( \frac{d^2x}{dt^2} = -\omega_0^2x - 2\beta \frac{dx}{dt} \quad \omega_0 = \sqrt{\frac{k}{m}} \quad \beta = \frac{b}{2m} \quad b \) is the damping factor. Overdamped: \( \beta > \omega_0 \) Critically damped: \( \beta = \omega_0 \) Underdamped: \( \beta < \omega_0 \)

Concepts to know:

- The direction of angular momentum, how torques affect the motion of bicycle tires, gyroscopes, etc.
- Statics: Sum of torques=0, sum of forces = 0. It is often convenient to take ccw rotations and torques as positive and cw rotations and torques as negative.
- Orbits are conical sections: circles, ellipses, parabolas, and hyperbolas. It is difficult for an orbit to be circular or parabolic.
- Understand amplitude, phase angle, angular frequency, frequency, and period for linear harmonic oscillators. Know how to determine amplitude and phase angle from initial conditions or conditions at another time.
- Given \( x(t) \), be able to find the velocity and acceleration, and also the maximum velocity and maximum acceleration.
- Given \( \theta(t) \), be able to find the angular velocity and angular acceleration.
- Find the cm and moment of inertia of a simple physical pendulum to determine its frequency.
- Know the behavior of underdamped, overdamped, and critically damped oscillators.
- Know what is meant by transient vs steady state behavior of an oscillator.
- Know that an oscillator driven near its natural frequency of oscillation has a large steady-state amplitude. This is called resonance.

Problems to review:

- Atwood machine with massive pulley
- Pushed box
- Object rolling down an incline
- See-saw
- Ladder
- Platform