Student ID Number: _____

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part A, 7 January 2002, 09:00 - 12:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.

2. All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.

3. For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.

4. Your assigned student **ID Number**, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.

5. All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.

6. Each problem is worth 10 points.

7. Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part A, 7 January 2002, 09:00 - 12:00

A1. An one-wheeled vehicle of mass M is moving on a straight track (in the x-direction) as shown in the figure. The shock absorber connecting the the wheel to the body of the vehicle consists of a spring (with a spring constant k) in parallel with a damping mechanism (with damping coefficient γ), as shown. The surface of the track can be described by the function

$$y = A\cos\left(\frac{2\pi x}{\lambda}\right) \quad ,$$

where y is the height of the surface and λ is the period of the sinusoidal variation. The vehicle maintains its vertical position while moving and the wheel is always in contact with the road surface. Assume the masses of the wheel and the shock absorber system are negligible.

(a) (4 points) The vehicle is moving with a constant speed v. Show that the vertical displacement of the vehicle, given by $Y(t)$, can be written as a sum of two components, namely

$$Y(t) = C_1\sin(\omega t) + C_2\cos(\omega t) \quad ,$$

where $\omega = \frac{2\pi v}{\lambda}$.

(b) (3 points) Sketch the behaviors of C_1 and $(C_2 - A)$ as a function of ω or v, and briefly discuss the physical meaning of each component.

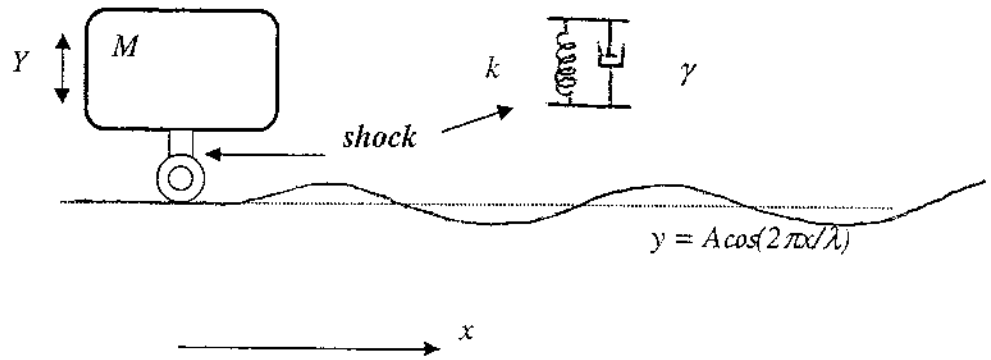
(c) (3 points) Show

$$T = \frac{Y_{max}}{A} = \frac{\sqrt{\gamma^2 + \left(\frac{k}{\omega}\right)^2}}{Z_m} \quad ,$$

where

$$Z_m = \left\{\gamma^2 + \left(M\omega - \frac{k}{\omega}\right)^2\right\}^{1/2} \quad .$$

T is called the transmissibility of the system.



PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS

UNIVERSITY OF FLORIDA

Part A, 17 August 2001, 09:00 - 12:00

A2. Consider quantum mechanical vectors of the form

$$|z\rangle \equiv e^{-|z|^2/2} \sum_{n=0}^{\infty} (z^n/\sqrt{n!})\,|n\rangle\ ,$$

for all complex z, where $\{|n\rangle\}_{n=0}^{\infty}$ are the usual orthonormalized harmonic oscillator eigenstates. The states $\{|n\rangle\}$ satisfy $a|n\rangle = \sqrt{n}|n-1\rangle$ and $a^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$, where the annihilation and creation operators a and $a^\dagger$ satify $aa^\dagger - a^\dagger a = 1$.

(a) (3 points) Evaluate $\langle z|z'\rangle$, where z and z' label two possibly distinct states.

(b) (4 points) Evaluate $\langle z|\, a^{\dagger\,3} a^5\, |z'\rangle$.

(c) (3 points) Evaluate, in terms of $a^\dagger$ and a, the following integral:

$$\int\int [1 + z^* z^2]\,|z\rangle\langle z|\, d(\mathrm{Re}\, z)\, d(\mathrm{Im}\, z)/\pi\ ,$$

where the integral runs over the entire complex plane.

A3. (a) (5 points) Calculate the self-inductance of a solenoid of length ℓ, radius $r \ll \ell$, and total number of turns N.

(b) (5 points) An inductor L is connected in series with a resistor R and a battery of voltage V. If the battery is connected at time $t = 0$, what is the current through the inductor as a function of time?