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PHY 3221 : Intermediate Mechanics, Spring 2002

February 8^{th}, 2002

Midterm Exam # 1

Note. There are three problems. *All problems are marked out of 10, and are equally weighted.* Take a few minutes to read them and decide where you want to start from.

You may use any technique you like to solve the following problems. But always remember to write full work for what you do. This will help your grade in case of incomplete or wrong answers. Also, no credit will be given for an answer, even if correct, if you give no justification for it. I will take anything you write at face value, so be careful with vectors, equal signs, etc.

Write your final answers on the sheets provided. You may separate them as long as you put your name on each of them. We will staple them when you hand them in. Ask if you need extra sheets, they will be provided. Remember to put your name on each of them and add them after the problem they refer to.

Good luck!

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Problem 1

A particle of mass m moves along a path such that the position vector at all times is given by:

$$\mathbf{r}(t) = a\sin(\omega t)\,\mathbf{i} + b\cos(\omega t)\,\mathbf{j}$$

where a, b, and ω are real positive constants.

(1.a) Find the velocity vector $\mathbf{v}(t)$ and the acceleration vector $\mathbf{a}(t)$ at all times.

(1.b) Find the force acting on the particle and, by expressing it in terms of the position vector $\mathbf{r}(t)$, show that it is always directed toward the origin.

(1.c) Show that the particle trajectory is an ellipse.

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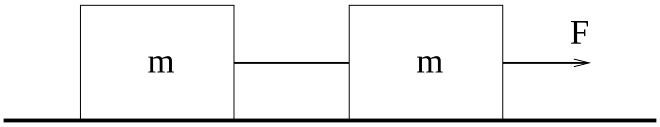
Problem 2

Two blocks of equal mass m are attached to each other by an inextensible string and placed on a horizontal table. A constant horizontal force $\mathbf{F}$ is applied to one of the two blocks (see figure). The coefficient of static and kinetic friction between the blocks and the table are μ_s and μ_k respectively.



(2.a) Find the minimum force necessary for the blocks to start moving.

(2.b) If a force of magnitude larger than the value you obtained in point **(2.a)** is applied to one of the two blocks, find the acceleration of the two blocks.

(2.c) Under the same assumptions as in point **(2.b)**, find the tension in the string linking the two blocks.

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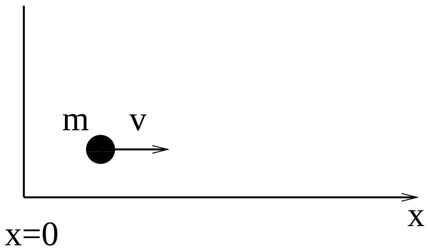
Problem 3

A particle of mass m moves along the x-axis, starting at $t=0$ from $x=0$ with velocity v_0. A retarding force proportional to the square of the velocity, i.e. $F_r = -mkv^2$, acts on the particle.



(3.a) Write the equation of motion of the particle and solve it to find the velocity of the particle at a generic time t, i.e. $v=v(t)$.

(3.b) Find the position of the particle at a generic time t, i.e. $x=x(t)$.

(3.c) Starting again from the equation of motion of the particle, determine the velocity of the particle as a function of the position, i.e. determine $v=v(x)$.

(3.d) Given the results in points **(3.a)**, **(3.b)**, and **(3.c)**, can you describe the asymptotic motion of the particle (i.e. how the particle motion looks like after you have waited a very long time)?

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