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## PHYS 1210 Worksheet.: Simple Harmonic Motion

1. A rotor with rotational inertia  $I$  rotates on a fixed axis. It shares an axle with a pulley of radius  $r$ . A massless, inextensible cable wrapped around the pulley is withdrawn by a hanging weight of mass  $m$ .

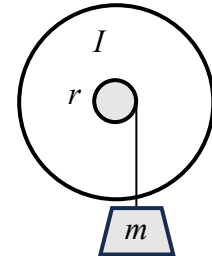
A. How does the torque on the rotor depend on  $r$ ?

B. How does the torque on the rotor depend on the tension in the cable?

C. How does the angular acceleration of the rotor depend on  $I$ ?

D. What forces determine the acceleration of the hanging mass?

E. Find the acceleration of the rotor in terms of  $I$ ,  $m$ ,  $r$ , and any necessary physical constants.



## Simple Harmonic Motion

Hooke's law (ideal spring):  $F = -kx$ ;

Work to stretch or compress an ideal spring from rest to displacement  $x$ :  $W = \frac{1}{2} kx^2$

Governing relationship:  $-kx = m \frac{d^2x}{dt^2}$

## Problems

2. Consider a mass  $m$  oscillating subject to the force of a Hooke's law spring with spring constant  $k$ .

A. How should the oscillation frequency depend on  $m$ ?

B. How should the oscillation frequency depend on  $k$ ?

Let us speculate that the position of the mass follows a formula  $x = A \sin(\omega t + \varphi)$ , where  $A$ ,  $\omega$ , and  $\varphi$  are constants.

- C. If  $x(t = 0) = A$ , what is  $\varphi$ ?
- D. If  $x(t = 0) = -A$ , what is  $\varphi$ ?
- E. If  $x(t = 0) = 0$ , what is  $\varphi$ ?
- F. What is the velocity of the mass,  $v = dx/dt$ ?
- G. What is the acceleration of the mass,  $a = d^2x/dt^2$ ?
- H. Can that expression for  $x$  as a function of  $t$  satisfy the governing equation  $m d^2x/dt^2 = -kx$ ? If so, under what conditions?
- I. What is the formula for the net force at time  $t$ ?
- J. What is the formula for the kinetic energy at time  $t$ ?
- K. What is the formula for the elastic potential energy at time  $t$ ?
- L. What is the formula for the total mechanical energy at time  $t$ ?