Classical Mechanics

Do two of the following three problems, each on a separate sheet (or sheets). Staple together the sheets for each problem, if using multiple sheets, but do not staple all problems together. Write at the top of the first sheet of each problem your name, subject, and problem number.

Problem 1

Two masses m_1 and m_2 are on a string over a pulley of mass M, uniformly distributed over its radius R; the string is massless and is not slipping. Find the linear acceleration, as well as the tension on the string.
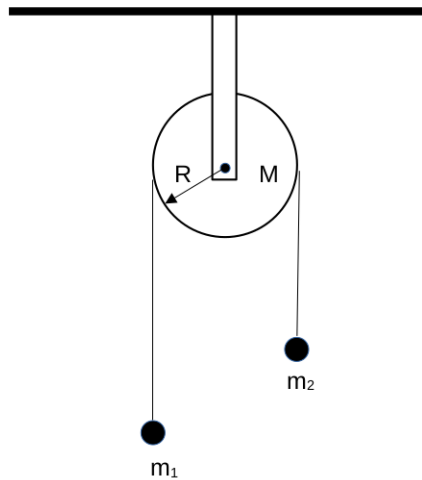

Figure 1: Masses on pulley

Problem 2

Neutrons are very penetrating in matter, because they have no electric charge. They cannot be easily stopped even by layers of lead, which is used as shielding for many other types of radiation. On the other hand, water, plastic, and other materials with high hydrogen content are very effective as neutron shields. Explain why, considering neutrons and atoms as classical, solid bodies, undergoing only elastic scattering and ignoring any quantum or nuclear effects. Note that a hydrogen atom has about the same mass as a neutron, but a lead atom is more than 200 times heavier. Show the relevant calculations, but you don't need to put in specific numbers.

Problem 3

A particle with mass m is moving in a one-dimensional potential

$$U(x) = A\,|x|^n\,,$$

where A is a constant and n is integer. Derive the period of oscillation T as a function of the energy E in terms of n. What is the energy dependence for the special case of a harmonic oscillator?