**Preliminary Exam**
Open Response Questions

1. A tennis ball launcher is placed on the floor at the front end of a train that has a uniform forward acceleration of 2.00 m/s^2. The launcher projects a ball at an initial speed of 25.0 m/s with respect to the train toward its rear. The ball achieves a maximum height of 10.0 m. Ignore air resistance.
(10) a. Find θ_O, the angle of launch with respect to the floor.
(15) b. Find how far from the front end of the train the ball lands.

(contributed by Leaf Turner)

2. A cube of mass *M* starts at rest at point *A* at a height of *4R*, where *R* is the radius of the circular part of the track. The cube slides down the track and around the loop. The cube is very small compared to the size of the track.
(15) a. Assuming the track is frictionless, find the force the track exerts on the cube at point *B*. Express your answer as a function of *Mg*.
(10) b. The cube is replaced by a sphere with mass *M* and radius *r* ($r << R$). Assuming that the sphere starts at the same height 4R and rolls without slipping, find the force the track exerts on the sphere at point *B*. Express your answer as a function of *Mg*.
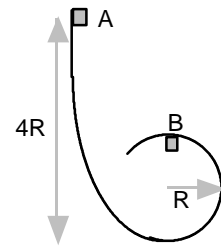
(contributed by Mary Mogge)

3. Two masses, m_1 and m_2, attached to equal length massless strings, are hanging side-by-side just in contact with each other. Mass m_1 is swung out to the side to a point having a vertical displacement 0.20 m above mass m_2. It is then released from rest and collides elastically with the stationary hanging mass m_2. Each of the masses is observed to rise to the same height following the collision.
(20) a. Find the numerical value of this height.
(5)   b. The masses swing back down and undergo a second elastic collision. Describe what happens following the second collision. (A proof is not required.)

(contributed by Leaf Turner)

(25) 4. A car accelerates uniformly from rest. Initially, its door is slightly ajar. Calculate how far the car travels before the door slams shut. Assume the door has a frictionless hinge, a uniform mass distribution, and a length *L* from front to back.

(contributed by Leaf Turner)

The 1999 Preliminary Examination open response questions were written by the coaches of the United States Physics Team. The coaches are: Academic Director, Dr. Mary Mogge – Professor of Physics at California State Polytechnic University, Pomona, CA; Senior Coach, Dr. Leaf Turner – Physicist in the Theoretical Division of Los Alamos National Laboratory, Los Alamos, NM; Dr. Warren Turner – Physics Teacher at St. Paul's School, Concord, NH. The coaches would also like to thank former academic director, Dr. Larry Kirkpatrick for his many helpful comments.