

PHY422/820: Classical Mechanics

FS 2020

Exam Preparation

December 1, 2020

Problem P18 – Two Pendula on a Moving Cart

Two identical pendula of mass m and length l are attached to a cart of mass M that can move without friction in a straight line. They are constrained to swing in the plane that contains the line along which the cart moves. Denote the position of the cart by x , and the angles the pendula make with the vertical axis by θ_1, θ_2 .

1. How many degrees of freedom does the system have?
Try to guess what the normal modes would look like, considering the motion of the pendula *and* the cart.
2. Construct the Lagrangian and derive the equations of motion.
3. Apply the small-angle approximation to the equations of motion, and combine them to eliminate the coordinate x from the problem.
4. Find the remaining normal modes. Compare your answers with the initial guesses and results for systems that may exhibit similar physics. Check your answer by considering limiting cases!

