

PHYSICS 110A : CLASSICAL MECHANICS
PROBLEM SET #4

[1] Consider the mechanical thingy in Fig. 1. Two masses m are connected to the central axis and to a third mass M by massless rigid rods of length ℓ , as shown. The mass M slides frictionlessly along the axis. There is one degree of freedom, which is the angle θ , also shown. The thingy is rotated about its symmetry axis with angular velocity ω .

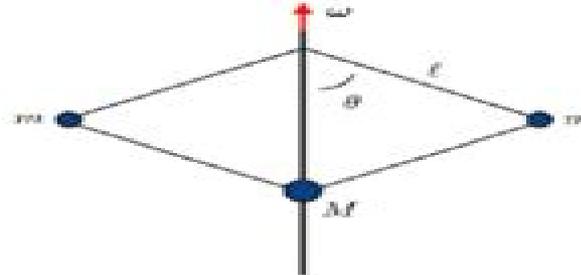


Figure 1: The thingy.

- (a) Find the Lagrangian for the thingy.
- (b) Find the equation of motion.
- (c) Show that there is one stable equilibrium when ω is small. Find the equilibrium point and find the frequency of small oscillations about this equilibrium.
- (d) Show that for $\omega > \omega_c$, the stable equilibrium shifts to a nonzero value of θ . Find the location of the new equilibrium and compute the corresponding frequency of small oscillations.
- (e) Identify any and all conserved quantities.

[2] A mechanical system is described by the Lagrangian

$$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) + \frac{1}{2}m(\dot{\rho}^2 + \rho^2\dot{\phi}^2) - V(x + ky + lz, y + a\phi), \quad (1)$$

where k , l , and a are constants.

- (a) How many independent one-parameter families of transformations leave L invariant?
- (b) For each continuous symmetry, identify the associated conserved quantity.
- (c) Are there any other conserved quantities? Find an expression for any other conserved quantities which may exist.

Classical Mechanics Problem Solutions

RS Peters



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