

### WPE Dynamics 2007

A particle of mass  $m$  may slide on the surface of a frictionless flat plate of mass  $M$  and centroidal moment of inertia  $I_G$  as shown. The particle is attached to the plate by a spring of constant  $k$  and unstretched length  $l_0$ . The plate is attached to a fixed point  $P$  by stiff wires and may swing about  $P$  in the vertical plane. (a) Using the distance  $x$  and the angle  $\phi$  as generalized coordinates, derive the Lagrangian equations of motion for the system. (b) Assuming small oscillations, show that there is a possible motion of the system that satisfies  $x=A\phi$ , where  $A$  is a constant, and determine  $A$ . (c) Express in terms of  $A$  the frequency of the oscillation in part (b). (d) What is the sign of  $A$  if  $k=0$  (i.e. the spring is removed)?

