## J02M.3—Stretching Cable

## Problem

Consider a cable of mass m with its upper end fixed and with mass M suspended from its lower end. When the cable is unstretched (and NOT hanging vertically) it has length l and spring constant k.

- a) What is the spring constant of a segment of the cable with length  $L \ll l$ ? You may assume that the cable has a fixed cross section, and is made from a material with a constant Young modulus.
- b) Determine the amount  $s_0$  by which the cable is stretched in the static situation when the suspended mass M is at rest. Make sure to take in to account the effect of the mass of the cable.
- c) Deduce an expression for the possible angular frequencies of vertical oscillations of the mass M.
- d) What is the lowest frequency of oscillation for the special cases that (i) M = 0, (ii) m = 0, and (iii)  $m/M \ll 1$ ?