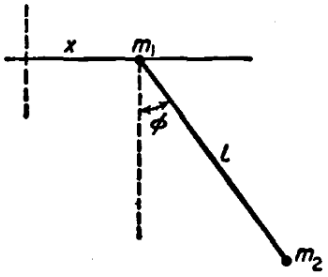
Exercises marked with (*) have extra difficulty, don't hesitate to ask for help.

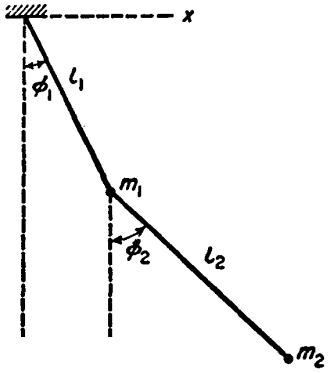
1. **Pendulum with free point of support** [Landau §5 ex. 2]
Particle of mass m_2 is hanging from a rigid bar of length ℓ and negligible mass. On the other end there is a device of mass m_1 linked to a horizontal bar, and it's free to move horizontally along the x axis. The device allows the hanging bar to span any angle φ respect to the vertical axis.



   (a) Write expressions for kinetic energy, T and potential, V, as functions of the generalized coordinates suggested by the figure.

   (b) Verify that if you fix the position of mass m_1 you recover the expressions of T and V of an ideal pendulum.

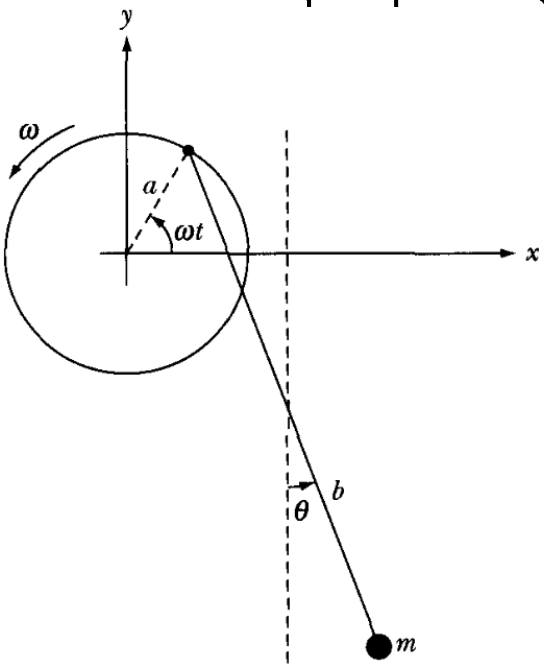
2. **Coplanar double pendulum** [Landau §5 ex. 1]
A ridig bar of lentgh ℓ_1 of negligible mass has a particle of mass m_1 attached to one end. There is a second bar of negligible mass hanging from the first one, of length ℓ_2, with a particle of mass m_2 attached to the other end too.



   (a) Write expressions for kinetic energy, T and potential, V, as functions of the generalized coordinates suggested by the figure.

   (b) Verify that you recover the expressions of T and V of an ideal pendulum if you set $m_1 = 0$, $\varphi_1 = \varphi_2 = \varphi$ and $\ell_1 = \ell_2 = \frac{\ell}{2}$.

3. (*) **Pendulum with rotating point of support** [Marion (e) ex. 7.5] [Landau §5 ex. 3]
A particle of mass m is attached to the end of a rigid bar of length b. The point of support is linked to a vertical circle of radius a and it rotates with constant frequency ω. It is assumed that all positions lie in the same plane and the mass of the bar is negligible. Calculate the kinetic energy, T, and potential V, of the particle of mass m.



4. (*) **Coupled weights rotating about a vertical axis** [Landau §5 ex. 4]
Particle with mass m_2 moves on a vertical axis and the whole system rotates about this axis with a constant angular velocity Ω. This particle is linked to two particles of mass m_1 through bars of length a and negligible mass, and at the same time these particles are linked to the fixed point A trough identical bars, forming the variable angle θ respect to the vertical axis. Calculate the kinetic energy of each of the three particles and find a compact expression of the kinetic energy of the whole system.