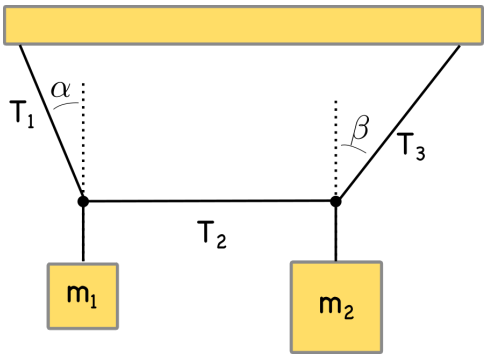
Homework set 10. Physics 141, Fall 2021

Due date: Friday Nov. 18, 2022 at noon.

Total of 8 points. On Force balance and equilibrium states (statics).

1. (2 points) The system shown in the Figure is in equilibrium. The mass of block 1 is $m_1 = 1.4$ kg and the mass of block 2 is $m_2 = 3.7$ kg. String 1 makes an angle $\alpha = 19°$ with the vertical and string 2 is exactly horizontal.



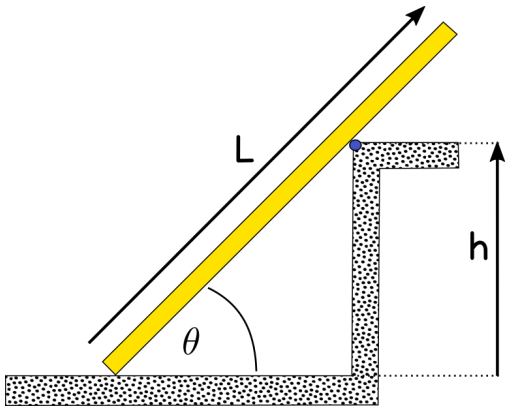
a) What is the tension T_1?

b) What is the tension T_2?

c) Find the angle β between string 3 and the vertical.

d) What is the tension T_3?

2. (2 points) A plank, of length L and mass M, rests on the ground and on a frictionless roller at the top of a wall of height h (see Figure). The center of gravity of the plank is at its center. The plank remains in equilibrium for any value of $\theta < \theta^*$ but slips if $\theta = \theta^*$. Here θ^* is a critical angle.



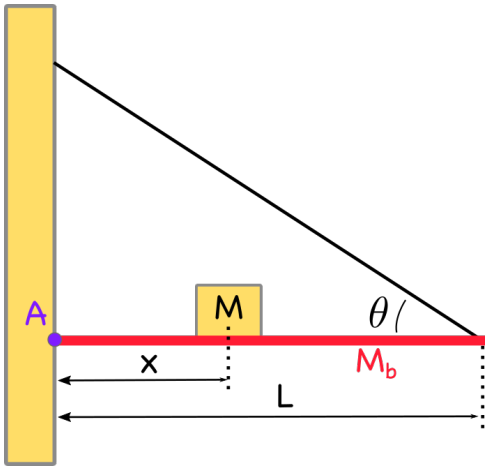
a) Calculate the magnitude of the force exerted by the roller on the plank when $\theta = \theta^*$.

b) Calculate the magnitude of the normal force exerted by the ground on the plank for $\theta = \theta^*$.

c) Calculate the magnitude of the friction force between the ground and the plank when $\theta = \theta^*$.

d) What is the coefficient of static friction μ?

3. (2 points) A uniform horizontal bar of length L =4 m and weight $M_b g = 223$ N is pinned to a vertical wall and supported by a thin wire that makes an angle of $\theta = 33°$ with the horizontal. A mass M, with a weight of 347 N, can be moved anywhere along the bar. The wire can withstand a maximum tension of $T_{max} = 576$ N.

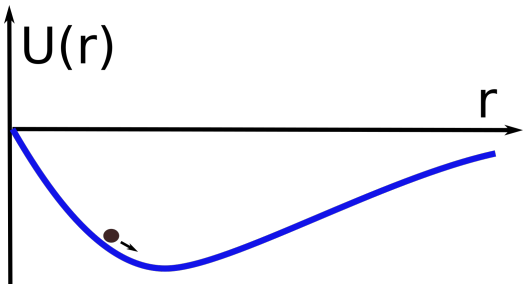


a) What is the maximum possible distance x from the wall at which mass M can be placed before the wire breaks?

b) With M placed at this maximum distance, what is the horizontal component of the force exerted on the bar by the pin at A?

c) With M placed at this maximum distance, what is the vertical component of the force exerted on the bar by the pin at A?

4. (2 points)



A particle of mass m is in a potential energy well with potential energy as a function of radius

$$U(r) = -Are^{-\alpha r}$$

We consider only radial motions. Here A, α are positive constants.

a) What radius r_* is an equilibrium point?

b) Give the Taylor expansion of $U(r)$ about this equilibrium point. In other words find $U(r_*), U'(r_*)$ and $U''(r_*)$ so that you can approximate

$$U(r) \approx U(r_*) + U'(r_*)(r - r_*) + \frac{1}{2}U''(r_*)(r - r_*)^2 \ldots$$

c) What is the period of small radial oscillations about the bottom of the potential well and near this equilibrium point?