11.7: Statics

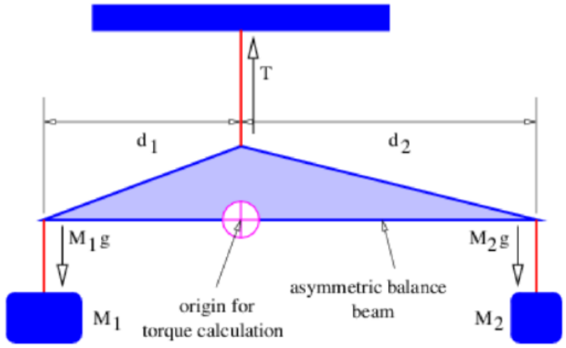

Figure 11.7.7:: Asymmetric mass balance. We assume that the balance beam is massless.

If a rigid body is initially at rest, it will remain at rest if and only if the sum of all the forces and the sum of all the torques acting on the body are zero. As an example, a mass balance with arms of differing length is shown in Figure 11.7.7:. The balance beam is subject to three forces pointing upward or downward, the tension T in the string from which the beam is suspended and the weights M_1 g and M_2 g exerted on the beam by the two suspended masses. The parameter g is the local gravitational field and the balance beam itself is assumed to have negligible mass. Taking upward as positive, the force condition for static equilibrium is

$$T-M_1 g-M_2 g=0 \quad \text{(zero net force)} \tag{11.7.1}$$

Defining a counterclockwise torque to be positive, the torque balance computed about the pivot point in Figure 11.7.7: is

$$\tau=M_1 g d_1-M_2 g d_2=0 \quad \text{(zero torque)} \tag{11.7.2}$$

where d_1 and d_2 are the lengths of the beam arms.

The first of the above equations shows that the tension in the string must be

$$T=\left(M_1+M_2\right) g \tag{11.7.3}$$

while the second shows that

$$\frac{M_1}{M_2}=\frac{d_2}{d_1} \tag{11.7.4}$$

Thus, the tension in the string is just equal to the weight of the masses attached to the balance beam, while the ratio of the two masses equals the inverse ratio of the associated beam arm lengths.