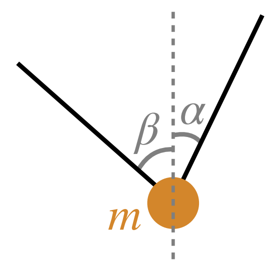
Problem Set 3

Free body diagrams

PHYS-101(en)

1. Balancing forces

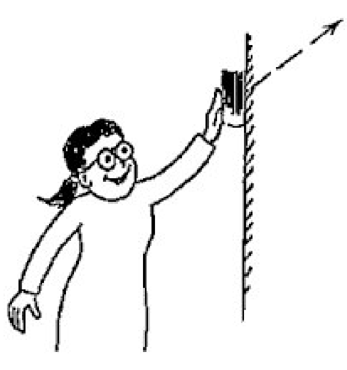
A ball of mass m is suspended in the air by two cables as shown below.



1. List the forces exerted on the ball.
2. Project these forces into a Cartesian coordinate system.
3. The ball is static and does not undergo any acceleration. Determine the magnitude of each force as a function of m, the gravitational acceleration g, α, and β. What happens when $\alpha = \beta$?

2. Pushing a book against a wall

You are holding a book against a vertical wall by pushing it upwards with your hand. The angle between your force and the vertical is α (which is $< 90°$). The mass of the book is m and the coefficient of static friction is μ_s. There are two cases: if you push too hard the book will start to slide up and if you don't push hard enough the book will slide down.

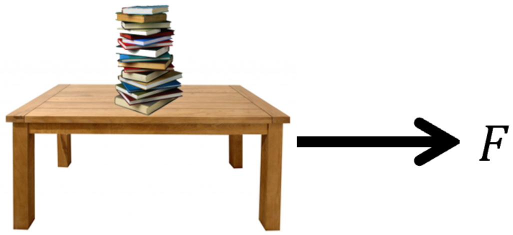


1. Draw free body diagrams for both cases, when the book is just about to start sliding.
2. For both cases, calculate the magnitude of your force (as a function of α) to just prevent slipping.

3. Calculate the force (as a function of α) for which the friction becomes zero. Evaluate your result for $\alpha = 0°$ and $\alpha = 90°$.

3. Force with friction

Carl tries to move a table of mass M, which has a pile of books sitting on it of total mass m. The coefficient of kinetic friction (between the table and floor) is μ_d and the coefficient of static friction (between the table and books) is μ_s. Determine the maximum force that Carl can apply to the table for which the books do not slide. Assume the books do not slide with respect to each other. Examine your result using the values $\mu_s = 0.75$, $\mu_d = 0.5$, $m = 3$ kg, and $M = 10$ kg.



4. Triangular trolley

A triangular trolley of mass M has a hypotenuse which makes an angle θ with the horizon (see diagram below). A second smaller trolley of mass m can move freely on the hypotenuse of the triangular trolley. We assume there is no friction/air drag and that the two trolleys can move freely. An external force is applied **on the triangular trolley**, which keeps the smaller trolley at a constant height (i.e. immobile relative to the triangular trolley).

1. Draw the free body diagram for each trolley.
2. Determine the magnitude of the force F required to keep the small trolley immobile on the triangular trolley.