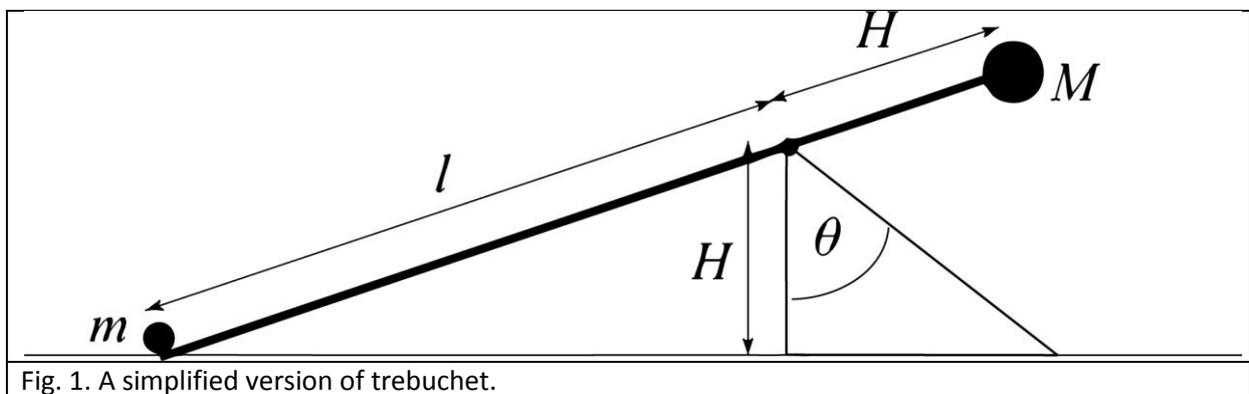


A simplified version of trebuchet

Introduction

Trebuchet is a siege engine that was employed in the Middle Ages to smash castle walls or to lob projectiles over them. A simplified version of a trebuchet is shown in Fig. 1. A heavy weight of mass M falls under gravity, and thereby lifts a lighter weight of mass m . The motion of the mass M is blocked as shown in the figure, which launches the lighter mass m ; the blockade forms angle θ with the vertical. The mass of the blockade is much larger than all other masses. The shorter arm of the trebuchet is of length H , whereas the longer arm is of length l ; the whole beam (both arms) are of mass μ .



Task 1

Calculate the angular velocity ω at which the projectile is launched. Express the range R of the projectile in terms of ω and other quantities with respect to the turning point. (3.0 points)

Task 2

By assuming that the range R is much larger than the size of the trebuchet, would the range be larger on the Moon or on Earth? (0.5 points)

Task 3

Express the range in terms of masses and parameters of the trebuchet, by assuming that $ml \ll MH$, and that R is much larger than the size of the device. If we further neglect the mass of the beam μ , and if $l/H \gg 1$, calculate the angle θ which yields the maximal range. What is the maximal range in this approximation? (2.5 points)

Task 4

Calculate the maximal length l of the longer arm above which the trebuchet will not move. The beam mass is proportional to its length. (1.5 points)

Task 5

We wish to throw the projectile over a thick wall of length $2L$ and height L . Calculate the optimal angle θ , which will cost the least amount of energy, in order to throw successfully the projectile over the wall. Calculate the distance from the wall where the trebuchet should be placed. Neglect the size of the device. (2.5 points)