EPFL

Mock exam 1
PHYS-101(en)
29 October 2024

Problem booklet

Problems

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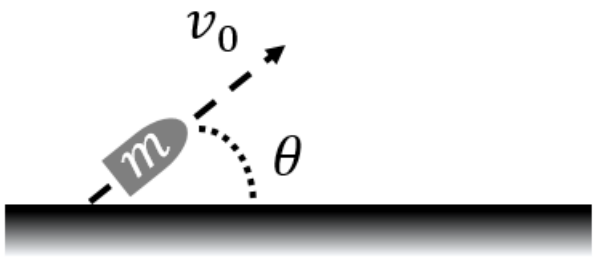
1. Projectile motion (5 points)



A projectile of mass m is launched with an initial speed v_0 at an angle θ with respect to the ground, as depicted above. You can neglect air resistance and assume that the ground is flat and completely horizontal. The magnitude of the acceleration due to gravity is g.

a. What are the *velocity* and *position* of the airborne projectile as a function of time? Give the answers in terms of v_0, θ, g and any initial position consistent with your reference frame.

b. Find the total duration of the flight of the projectile in terms of v_0, θ and g.

c. Find the range of the projectile. (The range is the distance from the launch site to the place where the projectile hits the ground). What is its total displacement?

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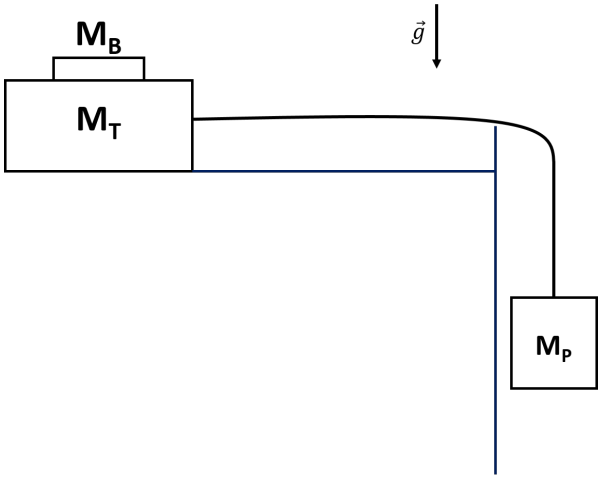
2. Escape through a window (10 points)



The building is on fire, so you and your flatmate (colocataire) attach one end of a rope to a table (whose mass is M_T), and throw the other end out of the window to escape. Your physics textbook (mass M_B) is also resting on the table. Coefficients of static and kinetic friction between the table and the floor are μ_s and μ_k. Neglect friction between the window frame and the rope.

a. You (mass M_P) are the first to climb out of the window. The mass of the table + book is sufficient to prevent it from sliding when you are suspended from the rope. We approximate the system with the schema shown in the figure (where the rope is massless and inextensible). Draw free-body diagrams for you (M_P) and the combined table + book ($M_T + M_B$). Find the minimum mass of the table + book needed to prevent it from sliding towards the window.

b. Realizing that your physics textbook (mass M_B) could be consumed by the flames, your flatmate grabs it to save it from the fire. With the reduced mass, the table suddenly starts sliding towards the window! Solve for your acceleration.

c. Alarmed, your flatmate hastily throws the book back on the table. However, since $\mu_k < \mu_s$ for the table, the table continues to slide towards the window! Fortunately, the added mass of the book has slowed the acceleration of your decent enough that you can land safely on the ground. The coefficient of static friction between the book and the table is β_s. What is the value of β_s required such that the book does not slide with respect to the table, ensuring a soft landing for you?