



**Mock exam 1
PHYS-101(en)
28 October 2025**

Problem booklet

Problems

Problem 1 – 20 points – page 3

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1. Blocks, pulleys, and a rope (20 points)

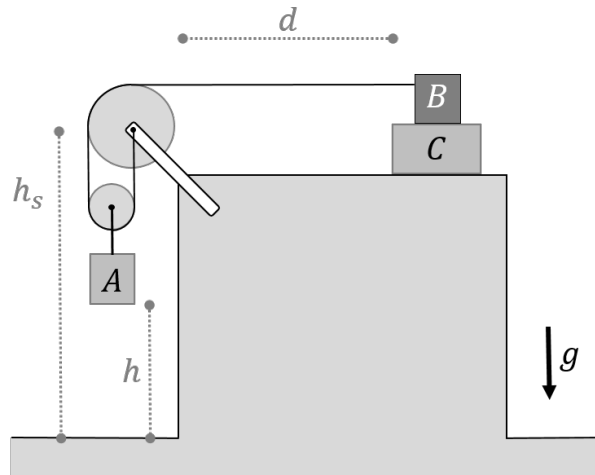


Figure 1: The system of blocks, pulleys, and a rope for problem 1.

Consider the system shown in Fig. 1.

Block C , of mass m_C , lies on a flat, level, surface. This surface is solidly anchored to the floor. The coefficient of static friction between the surface and block C is μ_{CS}^s , and for kinetic friction it is μ_{CS}^k . As is typically the case, $\mu_{CS}^k < \mu_{CS}^s$.

On top of block C lies block B (mass m_B). The coefficient of static friction between these two objects is μ_{BC}^s , and the coefficient of kinetic friction is μ_{BC}^k .

A massless and inextensible rope is attached to block B , goes around a large pulley of radius R_L , then a small one of radius R_S , and is finally anchored at the location shown. Both pulleys are massless and frictionless.

Hanging from the small pulley (with a massless string) is block A , of mass m_A .

Initially, blocks A , B , and C are all at rest. The lower face of block A is separated from the floor by a distance h . The left face of block C is separated from the large pulley and its support by a distance d . Use this information to answer the following questions.

- a) Make a drawing of the system where you clearly indicate your choice of reference frame.

Then, draw free-body diagrams for blocks A , B , and C , including all the forces acting on each object. You can consider block A and the small pulley to be a single object.

- b) If T is the tension of the rope, show that the condition for blocks B and C to start moving together as a single object (with a sufficiently large T) is:

$$\mu_{BC}^s > \left(1 + \frac{m_C}{m_B}\right) \mu_{CS}^s$$

Hint: Consider how the magnitude of friction between blocks B and C compares to the magnitude of friction between block C and the surface when blocks B and C are not moving.

Then, argue that this condition is sufficient to guarantee that blocks B and C will continue moving as a single object once in motion.

- c) Assuming that the condition above is met (i.e., blocks B and C move together as a single object BC), find the maximum value of m_A (call it m_A^{sta}) for which BC stays static.
- d) Assume now that $m_A > m_A^{\text{sta}}$, so that BC starts moving. Show that the acceleration of BC , \vec{a}_{BC} , and the acceleration of block A , \vec{a}_A , are related by $|\vec{a}_{BC}| = 2|\vec{a}_A|$.
Then, find the acceleration of block A in terms of the parameters of the problem.
Hint: The final expression for \vec{a}_A will only contain the terms g , m_A , m_B , m_C , and μ_{CS}^k .
- e) Find a condition on d and h for block A to hit the floor before BC touches the large pulley.
If that condition is met, how long does it take A to hit the floor?
- f) Imagine now that the whole system is placed in an elevator (see Fig. 2) and the elevator accelerates downward with a constant acceleration of magnitude a , as seen from a fixed reference frame outside the elevator. Assume that $a < g$, and $m_A > m_A^{\text{sta}}$.
Find \vec{a}_A as seen from the fixed reference frame.

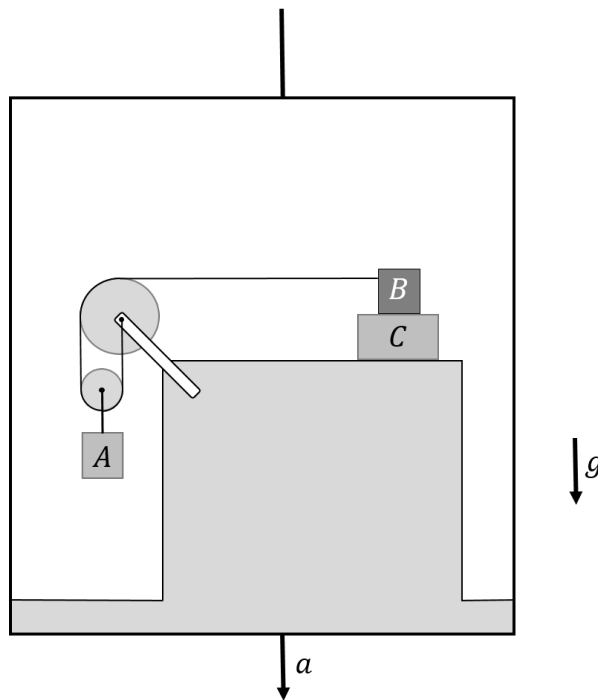


Figure 2: System in an elevator.

