

PHYSICS C: MECHANICS

SECTION II

Time—45 minutes

3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.

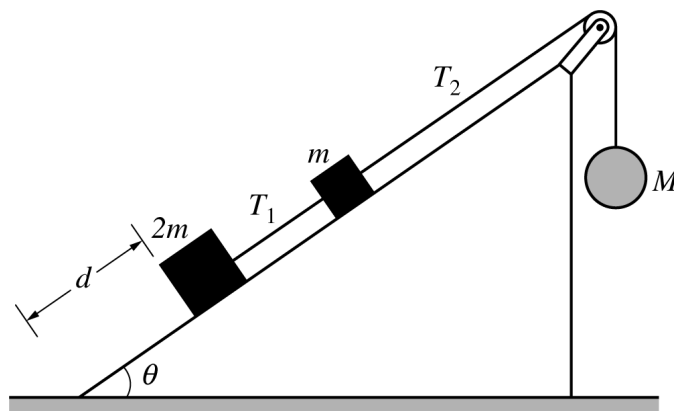


Figure 1

1. Blocks of mass m and $2m$ are connected by a light string and placed on a frictionless inclined plane that makes an angle θ with the horizontal, as shown in Figure 1 above. Another light string connecting the block of mass m to a hanging sphere of mass M passes over a pulley of negligible mass and negligible friction. The entire system is initially at rest and in equilibrium.

- (a) On the dots below that represent the block of mass m and the sphere of mass M , draw and label the forces (not components) that act on each of the objects shown. Each force must be represented by a distinct arrow starting on and pointing away from the dot.



- (b) Derive expressions for the magnitude of each of the following. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figures in part (a).

- i. The force T_2 exerted on the block of mass m by the string. Express your answers in terms of m , θ , and physical constants, as appropriate.
- ii. The mass M for which the system can remain in equilibrium. Express your answers in terms of m , θ , and physical constants, as appropriate.

- (c) Now suppose that mass M is large enough to descend and that the sphere reaches the floor before the blocks reach the pulley. Answer the following for the moment immediately after the sphere reaches the floor.

- i. Does the tension T_1 increase, decrease to a nonzero value, decrease to zero, or stay the same?

☐ Increase
 ☐ Decrease to a nonzero value
☐ Decrease to zero
 ☐ Stay the same

- ii. Is the velocity of the block of mass m up the ramp, down the ramp, or zero?

☐ Up the ramp
 ☐ Down the ramp
 ☐ Zero

- iii. Is the acceleration of the block of mass m up the ramp, down the ramp, or zero?

☐ Up the ramp
 ☐ Down the ramp
 ☐ Zero

- (d) Consider the initial setup in Figure 1. Now suppose the surface of the incline is rough and the coefficient of static friction between the blocks and the inclined plane is μ_s . Derive an expression for the minimum possible value of M that will keep the blocks from moving down the incline. Express your answer in terms of m , μ_s , θ , and fundamental constants, as appropriate.

- (e) The string connecting block m and the sphere of mass M then breaks, and the blocks begin to move from rest down the incline. The lower block starts a distance d from the bottom of the incline, as shown in Figure 1. The coefficient of kinetic friction between the blocks and the inclined plane is μ_k . Derive an expression for the speed of the blocks when the lower block reaches the bottom of the incline. Express your answer in terms of m , d , μ_k , θ , and fundamental constants, as appropriate.