

1. (10 points) Two blocks with masses m_1 and m_2 are connected by a rope that passes over a pulley of radius R and mass M ; see Fig. 1. The moment of inertia of the pulley about its center is I . Assume that there is no friction, and the center of mass of the block with mass m_2 is at a distance R above the center of the pulley. (a) Calculate I in terms of M and R . (b) Find the linear acceleration of the blocks due to the gravity. (The gravitational acceleration is g).

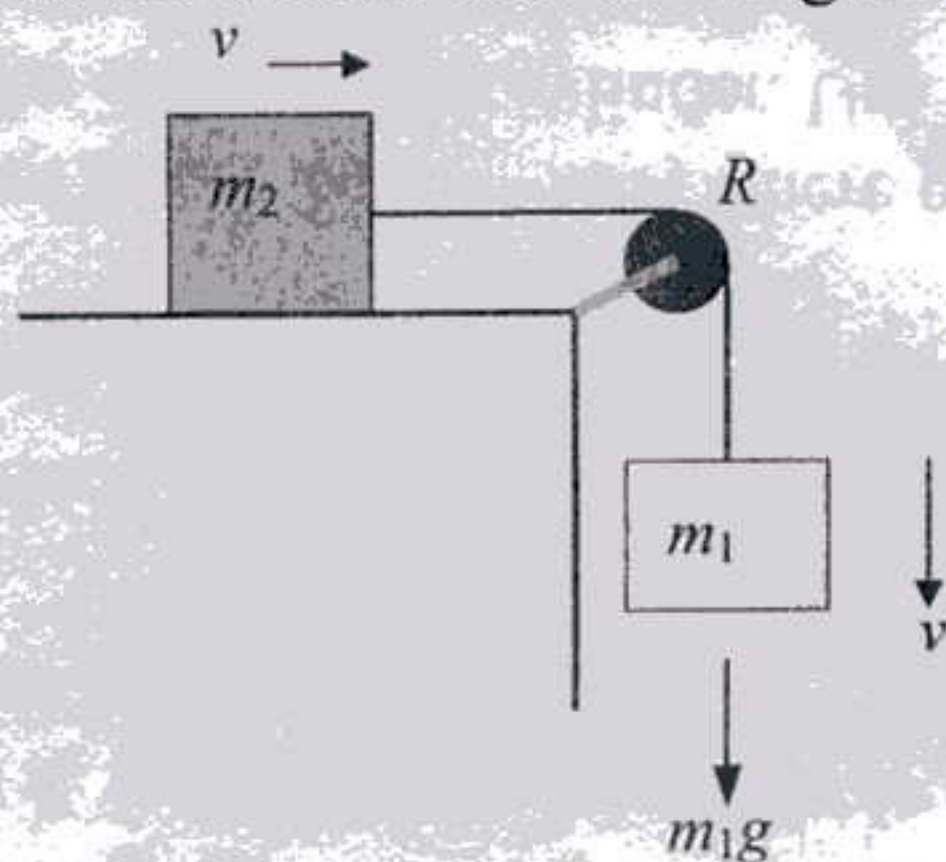


Fig. 1

2. (15 points) A uniform solid cylindrical disk of mass M and radius R rolls across a horizontal table at a speed v . (a) What is the speed of the top of the rolling disk? (Write down the answer in terms of v). (b) What is the angular speed ω of the rolling disk? (c) What is the kinetic energy K of the rolling disk? (d) What fraction of the kinetic energy is associated with the motion of rotation about an axis through the center of mass?
3. (10 points) A block of mass M , at rest on a horizontal frictionless table, is attached to a rigid support by a spring of constant k . A bullet of mass m and velocity v strikes the block as shown in Fig. 2. The bullet remains embedded in the block. Determine (a) the velocity of the block immediately after the collision, and (b) the amplitude of the resulting simple harmonic motion.



4. (15 points) One mole of an ideal monatomic gas is taken through the cycle in Fig. 3. (a) How much work is done by the gas in going from state a to state c along path abc ? (b) What are the changes in internal energy and entropy in going from b to c ? Express all answers in terms of the pressure p_0 , volume V_0 , and temperature T_0 of state a .

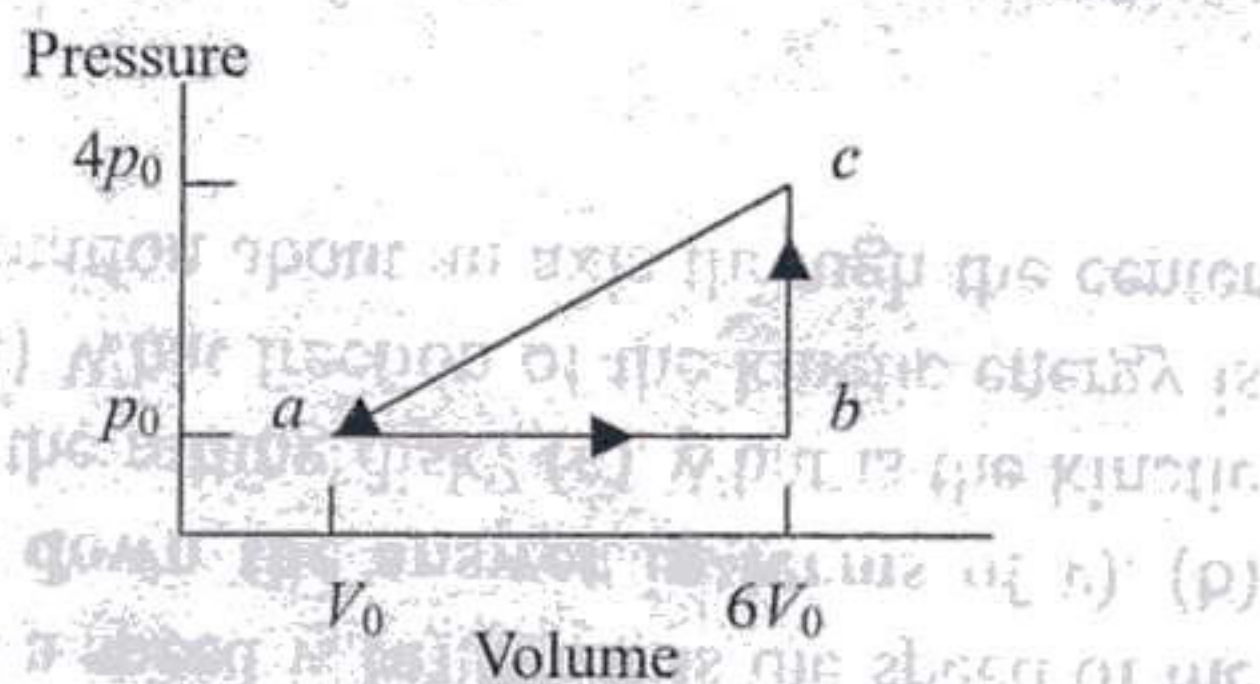


Fig. 3

5. (15 points) (a) Describe Gauss's law, which relates the electric flux Φ through a closed surface S to the charge Q enclosed by the surface.
 (b) Use Gauss's law to verify that a charge Q , uniformly distributed over the surface of a sphere with radius R , is equivalent externally to a point charge Q at the center of the sphere.
6. (15 points) (a) State Ampere's law, which relates a path integral of the magnetic field B around a closed loop to the net steady current I passing through the area of the loop.
 (b) The current density in a cylinder of radius R is $J = \alpha r$, where α is the constant and r is the distance to the center of the cylinder. Use Ampere's law to determine the magnetic field within the cylinder.
7. (10 points) (a) What is the speed of light in fused quartz (refractive index 1.5)? (b) Could the refractive index n of a material medium be smaller than 1? Why?
8. (10 points) Describe briefly the concept of the **photon**, including expressions for the energy E and momentum p of a photon. What is the momentum-energy relation for photons?