Physics 24A – Problem Set 2

Name _____

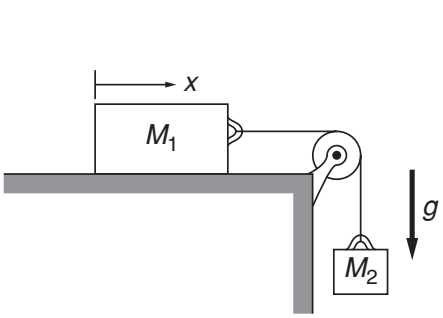
Due: Monday, 29 January 2024

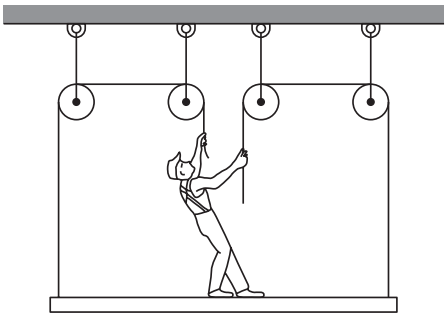
For full credit, include words explaining your reasoning, diagrams, as well as calculations. You must provide the full problem statement with your solution.

Problem 1 – Blocks and elevators* (KK 2.2 and 2.12)

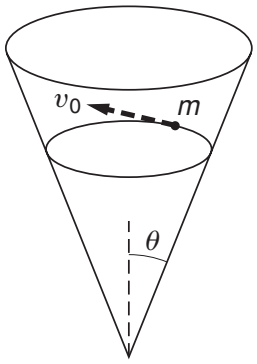
(a) The two blocks M_1 and M_2 shown in the sketch are connected by a string of negligible mass. If the system is released from rest, find how far block M_1 slides in time t. Neglect friction.

(b) A painter of mass M stands on a scaffold of mass m and pulls himself up by two ropes which hang over pulleys, as shown. He pulls each rope with force F and accelerates upward with a uniform acceleration a. Find a—neglecting the fact that no one could do this for long.

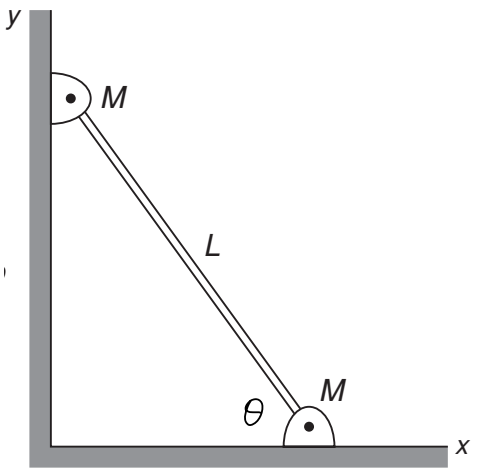




Problem 2 – Mass in cone (KK 2.6) A particle of mass m slides without friction on the inside of a cone. The axis of the cone is vertical, and gravity is directed downward. The apex half-angle of the cone is θ, as shown. The path of the particle happens to be a circle in a horizontal plane. The speed of the particle is v_0. Draw a force diagram and find the radius of the circular path in terms of v_0, g, and θ.



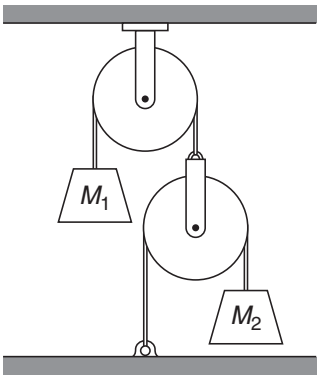
Problem 3 – Leaning pole (KK 2.7) A pole of negligible mass leans against a wall, at angle θ with the horizontal. Gravity is directed down and the pole is momentarily at rest.



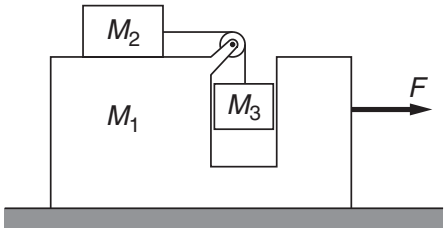
(a) Find the constraint relating the **initial** vertical acceleration of one end to the **initial** horizontal acceleration of the other.

(b) Now suppose that each end carries a pivoted mass M. Find the **initial** vertical and horizontal components of acceleration for these masses as the pole just begins to slide on the frictionless wall and floor. Assume that at the beginning of the motion the forces exerted by the rod are along the line of the rod. (As the motion progresses, the system rotates and the rod exerts sideways forces. You do not want to solve *that* problem!)

Problem 4 – Two masses and two pulleys* (KK 2.8) Masses M_1 and M_2 are connected to a system of strings and pulleys, as shown. The strings are massless and inextensible, and the pulleys are massless and frictionless. Find the acceleration of M_1.



Problem 5 – Pedagogical machine* (KK 2.13) A "pedagogical machine" is illustrated in the sketch. All surfaces are frictionless. What force F must be applied to M_1 to keep M_3 from rising or falling?



Problem 6 – Disk with catch (KK 2.15) A disk rotates with constant angular velocity ω, as shown. Two masses, m_A and m_B, slide without friction in a groove passing through the center of the disk. They are connected by a light string of length l, and are initially held in position by a catch, with mass m_A at distance r_A from the center. Neglect gravity. At $t = 0$ the catch is removed and the masses are free to slide. Find $\ddot{r}_A$ immediately after the catch is removed, in terms of m_A, m_B, l, r_A, and ω.