College Physics Homework 2

March 19, 2022

, Due: March 28 2022

This is an individual assignment; you must solve it by yourself.

Problem 1

(i) Suppose that a uniform rope of length L, resting on a frictionless horizontal surface, is accelerated along the direction of its length by means of a force F pulling it at one end. Derive an expression for the tension T in the rope as a function of position along its length. How is the expression for T changed if the rope is accelerated vertically in a constant gravitational field?

(ii) A mass M is accelerated by the rope in part (i). Assuming the mass of the rope to be m, calculate the tension for the horizontal and vertical cases.

Problem 2

A particle sliding down a frictionless ramp is to attain a given *horizontal* displacement Δx in a minimum amount of time. What is the best angle for the ramp? What is the minimum time (give your answer in terms of $\Delta x, g$)?

Problem 3

Two blocks of masses m_1 and m_2 are sliding down an inclined plane making an angle with the horizontal. The leading block (m_2) has a coefficient of kinetic friction μ_k; the trailing block (m_1) has a coefficient of kinetic friction $2\mu_k$. A string connects the two blocks; this string makes an angle ϕ with the ramp (Fig. 1). Find the tension in the string.

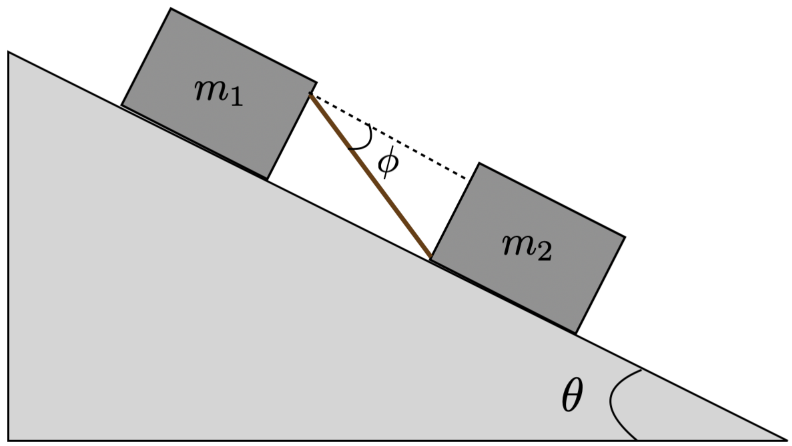

Figure 1: Figure for problem 3.

Problem 4

A large mass M hangs (stationary) at the end of a string that passes through a smooth tube to a small mass m that whirls around in a circular path of radius $l \sin\theta$, where l is the length of the string m to the top end of the tube (see Fig. 2). Write down the dynamical equations that apply to each mass and show that m must complete one orbit in a time of $2\pi(lm/gM)^{1/2}$. Consider whether there is any restriction on the value of the angle θ in this motion.

Problem 5

The speed of a body released from rest falling through viscous medium (for instance, an iron pellet falling in a jar full of oil) is given by the formula

$$v = -g\tau + g\tau e^{-t/\tau} \tag{1}$$

where τ is a constant that depends on the size and shape of the body and on the viscosity of the medium and $e = 2.718\cdots$ is the basis of the natural logarithms.

(i) Find the acceleration as a function of time.

(ii) Show that for $t \to \infty$, the speed approaches terminal value $-g\tau$.

(iii) By differentiation, verify that the equation for the position as a function of time consistent with the above expression for the speed is

$$x = -g\tau t - g\tau^2 e^{-t/\tau} + g\tau^2 + x_0 \tag{2}$$

(iv) Show that for small vales of t ($t \ll \tau$), the equation for x is approximately $x \approx \dfrac{-1}{2}gt^2 + x_0$.

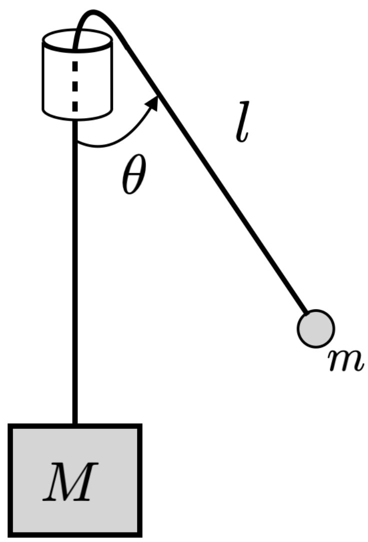

Figure 2: Figure for problem 4.