JOINT INSTITUTE
交大密西根学院

PHYSICS I (Summer 2021)

Problem Set 3

Due: 3 June 2021, 2.30 p.m.

Problem 1. A particle moves along a circle with radius R, so that the tangential component of its acceleration is constant. At $t = 0$ the velocity of the particle was equal to zero. Find

(a) the magnitude of the normal component a_n of the acceleration,

(b) the magnitude of the acceleration vector $\mathbf{a}$ as well as the angle the vector $\mathbf{a}$ forms with the position vector $\mathbf{r}$,

as functions of time.

(2 + 2 points)

Problem 2. A small metal ball is suspended on a string attached to the roof of a car. Find the angle that the string forms with the vertical direction, if the car:

(a) moves with constant speed along a straight line,

(b) moves with constant acceleration along a straight line,

(c) slides without friction down a plane inclined at an angle α to the horizontal.

Solve the problem in an inertial frame of reference (clearly indicate the frame of reference you are solving the problem in). Sketch relevant free body diagrams.

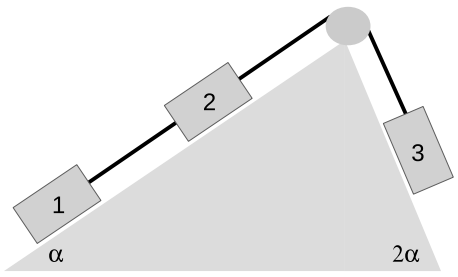
(1 + 2 + 2 points)

Problem 3. Three blocks with masses m_1, m_2, and m_3 are connected by massless strings and placed on planes inclined at the angles α and 2α, as shown in the figure below. The pulley is frictionless, and the coefficients of kinetic friction between blocks 1 and 2 and the surface are equal to μ_1 and μ_2, respectively. There is no friction between block 3 and the incline.

(a) Assuming that the system moves so that block 3 slides downwards accelerating, find the acceleration of the blocks and the tensions in all strings.

(b) What condition (relating the masses and the coefficients of friction) needs to be satisfied, if the blocks are to move as assumed in part (a)?

(4 + 1 points)

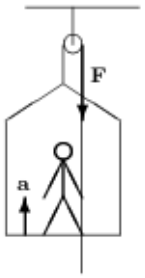


Problem 4. A student of weight 320 N stands on a wooden bar of weight 160 N (see the figure), and pulls the rope downwards with force 250 N. Find

(a) the acceleration of the student as he moves upwards,

(b) the force he exerts on the bar.

(3 + 1 points)



Problem 5. Suppose that a uniform rope with mass m and length d, placed on a horizontal table, is attached to a block with mass M resting on the same table. The rope is pulled from the side opposite the block with an applied horizontal force of magnitude F, and the system moves with acceleration. The coefficient of kinetic friction between the block and the surface is μ_{k}, and there is no friction between the rope and the surface. Find the tension in the rope as a function of the distance from the block.

(5 points)

Problem 6. A particle with mass $m = 2$ kg is acted upon by force $\mathbf{F} = (4\sin 2t, 6t - 12, -6e^{-3t})$ N (the numbers here are assumed to have correct units). Assuming initial conditions $\mathbf{r}(0) = (5, 2, -3)$ m and $\mathbf{v}(0) = (2, 0, 1)$ m/s find the velocity and position of the particle at any instant of time t.

(3/2 + 3/2 points)

Problem 7. A ball with mass m is thrown vertically upwards with initial speed v_0. Assuming linear air drag write down and solve the equation of motion for the ball, i.e. find the time dependence of its position. Find the position of the highest point of the trajectory as well the time needed to reach it.

(3 + 1 points)

Problem 8. A particle, moving along a straight line in the positive x–axis direction, slows down so that its acceleration $a_x = -kv_x$, where k is a positive constant and v_x is the particle's velocity. At the initial instant of time $t = 0$, the is v_0.

(a) What is the total distance traveled by the particle (i.e. how far does it travel until it stops)?

(b) How long does it take for the particle to travel a distance s?

(3 + 1 points)