Homework No. 04B (Fall 2020)

PHYS 203A: COLLEGE PHYSICS

Department of Physics, Southern Illinois University–Carbondale

Due date: Thursday, 2020 Sep 24, 12:30pm, on D2L

Instructions

- Describe your thought process in detail and organize it clearly. Make sure your answer has the correct units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (Assessments → Assignments).

Questions

1. (**10 points.**) A $m = 20.0\,\mathrm{kg}$ ($mg = 196\,\mathrm{N}$) block is at rest on a horizontal floor. The coefficient of static friction between the floor and the block is 0.50, and the coefficient of kinetic friction between the floor and the block is 0.40.
   (a) What is the normal force N exerted on the block by the floor?
   (b) Calculate the maximum static frictional force, $F_{f,\max} = \mu_s N$, possible between the block and floor.
   (c) Calculate the kinetic frictional force, $F_f = \mu_k N$ between the block and floor if the block moves on the floor.
   (d) While the block is initially at rest you exert a horizontal force of $85\,\mathrm{N}$ on the block. Will the block move? If yes, what will be its acceleration?
   (e) While the block is initially at rest you exert a horizontal force of $105\,\mathrm{N}$ on the block. Will the block move? If yes, what will be its acceleration?
2. (**10 points.**) A trunk with a weight of $196\,\mathrm{N}$ rests on the floor. The coefficient of static friction between the trunk and the floor is 0.50, and the coefficient of kinetic friction is 0.40.
   (a) What is the magnitude of the minimum horizontal force with which a person must push on the trunk to start it moving?
   (b) Once the trunk is moving, what magnitude of horizontal force must the person apply to keep it moving with constant velocity?
   (c) If the person continued to push with the force used to start the motion, what would be the magnitude of the trunk's acceleration?

3. (**10 points.**) A car is traveling at 70.0 miles/hour ($= 31.3\,\mathrm{m/s}$) on a horizontal highway. It is brought to a stop by slamming on the brakes, which amounts to the tires skidding (without rolling) on the road.

   (a) What is the stopping distance when the surface is dry and the coefficient of kinetic friction μ_k between road and tires is 0.60?

   (b) If the coefficient of kinetic friction between road and tires on a rainy day is 0.20, what is the minimum distance in which the car will stop?

4. (**10 points.**) A mass $m = 20.0\,\mathrm{kg}$ is on an incline with coefficient of static friction $\mu_s = 0.80$ and coefficient of kinetic friction $\mu_k = 0.50$.

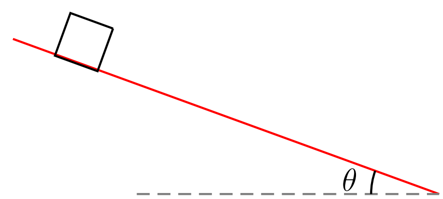

Figure 1: Problem 4.

   (a) Using Newton's law determine the equations of motion governing the motion of the mass.

   (b) Let $\theta = 30.0°$.

      i. Determine the normal force. (Answer: 170 N.)

      ii. Determine the maximum static frictional force, $F_{f,\mathrm{max}} = \mu_s N$, possible between the mass and the incline. (Answer: $F_{f,\mathrm{max}} = 136\,\mathrm{N}$.)

      iii. Find the net force in the lateral direction other than friction. (Answer: $mg\sin\theta = 98\,\mathrm{N}$.)

      iv. Determine the force of friction on the mass. (Answer: 98 N.)

      v. Will the mass move? (Answer: No.)

   (c) Let $\theta = 45.0°$.

      i. Determine the normal force.

      ii. Determine the maximum static frictional force, $F_{f,\mathrm{max}} = \mu_s N$, possible between the mass and the incline. (Answer: $F_{f,\mathrm{max}} = 110\,\mathrm{N}$.)

      iii. Find the net force in the lateral direction other than friction. (Answer: $mg\sin\theta = 139\,\mathrm{N}$.)

      iv. Determine the force of friction on the mass. (Answer: $F_f = \mu_k N = 70\,\mathrm{N}$.)

      v. Will the mass move? (Answer: Yes.)

      vi. Determine the acceleration of the resultant motion. (Answer: $3.5\,\mathrm{m/s^2}$.)

(d) Critical angle: As the angle of the incline is increased, there is a critical angle when the mass begins to move. For this case the force of friction is equal to the maximum static frictional force, $F_f = \mu_s N$, and the mass is at the verge of moving, $a_x = 0$. Show that the critical angle is given by

$$\theta_c = \tan^{-1} \mu_s, \tag{1}$$

which is independent of the mass m. Find the critical angle.