Homework No. 08 (Spring 2025)

PHYS 205A-001: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Due date: Wednesday, 2025 Mar 05, Noon, on D2L

Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Links to solutions are provided.
- Variations of homework problems and additional problems with hyperlinks to old exams are available in Lecture Notes. These serve as practice problems.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments). You can replace your PDF file as many times as you like, only the last file is graded. The deadline has an (undisclosed) buffer period, so do not hesitate to try submissions after the deadline.

Problems

1. (**10 points.**) A trunk with a weight of 196 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?

   [**Solution**]

2. (**10 points.**) A car is traveling at 70.0 miles/hour (= 31.3 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?

   [**Solution**]

3. (**10 points.**) A 5.0 kg block is sent sliding up a plane inclined at $\theta = 37°$ while a horizontal force $\vec{F}$ of magnitude 50 N acts on it. The coefficient of kinetic friction between the block and plane is 0.30. See Figure 1.

   (a) What are the magnitude and direction of the block's acceleration?

   (b) The block's initial speed is 4.0 m/s. How far up the plane does the block go?

   (c) When it reaches the highest point, does it remain at rest or slide back down the plane?

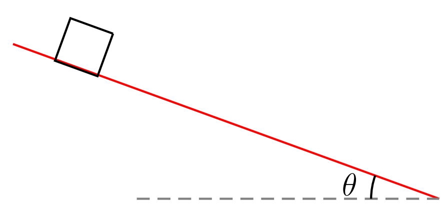

Figure 1: Problem 3.

   [**Solution**]

4. (**10 points.**) A 10.0 kg mass is held to a vertical wall by pushing on it by a force $\vec{\mathbf{F}}$ exerted horizontally. See Figure 2. Determine the magnitude of the minimal force F that needs to be applied for the mass to be held up. The coefficient of static friction between the mass and the wall is 0.50, and the coefficient of kinetic friction is 0.40.

   [**Solution**]

5. (**10 points.**) A stuntman drives a car over the top of a hill, the cross section of which can be approximated by a circle of radius $R = 150$ m. See Figure 3. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill?

   [**Solution**]

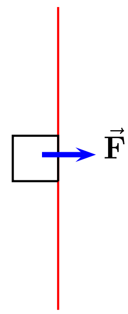

Figure 2: Problem 4

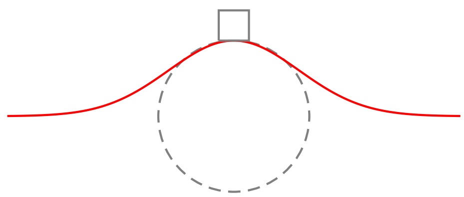

Figure 3: Problem 5

6. (**10 points.**) In the Globe of Death stunt motorcycle stunt riders ride motorcycles inside a mesh globe. In particular, they can loop vertically. Consider a motorcycle going around a vertical circle of 20.0 m radius, inside the globe, with uniform velocity. Refer Figure 4. Determine the minimum speed necessary for the motorcycle to stay in contact with the globe during the complete vertical circle.

Figure 4: Problem 6.

[**Solution**]

7. (**20 points.**) Consider the case when the friction force is quadratically proportional to

velocity,

$$F_f = \frac{1}{2} D\rho A v^2, \tag{1}$$

where A is the area of crosssection of the object, ρ is the density of the medium, and D is a dimensionless drag coefficient. This should be contrasted with the case when the drag is linear in velocity. Typically, for small speeds, or when the size of the object is small, the drag force is linear in velocity. This is the case for motion in a highly viscous fluid, or for micron sized organisms in water. On the other hand, a sky diver, or a car on an interstate, experience quadratic drag forces. For a mass m falling under uniform gravity we have the equation of motion

$$m\frac{dv}{dt} = mg - F_f. \tag{2}$$

Show that the terminal velocity, when $dv/dt = 0$, is given by

$$v_T = \sqrt{\frac{2mg}{D\rho A}}. \tag{3}$$

What is the terminal speed of a 6.00 kg spherical ball that has a radius of 3.00 cm and a drag coefficient of 1.60? The density of the air through which the ball falls is 1.20 kg/m^3

[**Solution**]