Homework No. 05 (Fall 2020)

PHYS 203A: COLLEGE PHYSICS

Department of Physics, Southern Illinois University–Carbondale

Due date: Tuesday, 2020 Sep 29, 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 $\rightarrow$ Assignments).

Questions

1. (**10 points.**) The wheel of a car has a radius of $0.30\,\text{m}$ and is being rotated at 720 revolutions per minute (rpm) on a tire-balancing machine. Determine the speed (in m/s) at which the outer edge of the wheel is moving.

2. (**10 points.**) A typical ramp in a cloverleaf interchange design on the interstate has a radius of $60.0\,\text{m}$. What is the centripetal acceleration of a car exiting an interstate at a speed of $20.0\,\text{m/s}$ ($\sim 45\,\text{miles/hour}$). Compare this to the acceleration due to gravity $g = 9.8\,\text{m/s}^2$.

3. (**10 points.**) When a small $2.0\,\text{g}$ coin is placed at a radius of $5.0\,\text{cm}$ on a horizontal turntable that makes three full revolutions in $3.14\,\text{s}$, the coin does not slip.

   (a) What is the coin's speed?

   (b) What is the magnitude and direction of the coin's acceleration?

   (c) What is the magnitude and direction of the frictional force on the coin?

   (d) If you learn that the coin is on the verge of slipping when it is placed at a radius of $10\,\text{cm}$. What is the coefficient of static friction between coin and turntable?

4. (**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 $R = 150\,\text{m}$. See Figure 1. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill?

5. (**10 points.**) At what maximum speed can a car safely negotiate a horizontal unbanked turn (of radius $50.0\,\text{m}$)

   (a) in dry weather (when coefficient of static friction is 0.95).

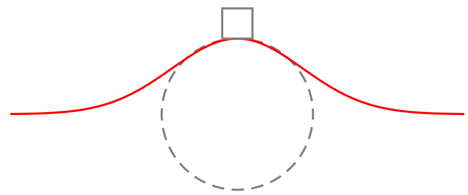

Figure 1: Problem 4

(b) in icy weather (when coefficient of static friction is 0.10).

6. (**10 points.**) The Daytona 500 is the major event of the NASCAR season. It is held at the Daytona International Speedway in Daytona, Florida. The turns in the oval track have a maximum radius (at the top) of 316 m and are banked steeply, with banking angle $\theta = 31^\circ$ with respect to the horizontal. Suppose these maximum-radius turns are frictionless, say in extreme icy conditions.

   (a) Is it possible to drive on this turn without slipping? If not, why not?

   (b) If yes, at what speeds would the cars have to travel around to negotiate the turn safely.

7. (**10 points.**) Determine the orbital speed of the International Space Station (ISS) orbiting at a height of 409 km above the Earth's surface. Determine the orbital period of ISS in minutes.

8. (**10 points.**) Determine the height H above the Earth's surface at which all synchronous satellites (regardless of mass) must be placed in orbit?

9. (**10 points.**) An astronomical object is spotted farther than Pluto. Based on observations it is estimated that the object goes around the Sun once in 343 years. Using Kepler's third law determine the distance of the object from Sun in terms of R_E. That is, how many R_E away from Sun is the object. For insight it is given that the distance between Earth and Sun is $R_E = 1.5 \times 10^{11}$ m even though this is not needed in the problem.