Homework No. 11 (Spring 2023)

PHYS 205A-001: UNIVERSITY PHYSICS

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

Due date: Monday, 2023 May 1, 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.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments).

Problems

1. (**10 points.**) A solid sphere, (with $I = \frac{2}{5}MR^2$ when the axis of rotation passes through the center of sphere,) rolls perfectly (without sliding or slipping) on a horizontal surface. What fraction of the total kinetic energy of the sphere is in the form of rotational kinetic energy.

2. (**10 points.**) A solid cylinder, (with $I = \frac{1}{2}MR^2$ when the axis of rotation is along the axis of cylinder,) rolls perfectly (without sliding or slipping) on an inclined plane. If the cylinder started from rest at the top, vertical height of 1.20 m, what is the velocity of the cylinder when it reaches the bottom of the incline?

3. (**10 points.**) An object in the shape of a spherical shell, (with $I = \frac{2}{3}MR^2$ when the axis of rotation passes through the center of sphere,) rolls perfectly (without sliding or slipping) on the surface shown in Figure 1. It starts from rest at point A where the vertical height is $h_A = 40.0\,\text{m}$. Determine the velocity of the object at point E, where the vertical height is $h_E = 20.0\,\text{m}$.

4. (**10 points.**) An ice skater is spinning with both arms and a leg outstretched. Then, she pulls her arms and leg inward. As a result of this maneuver, her angular velocity ω increases by a factor of 2.0. What is the corresponding change in the moment of inertia.

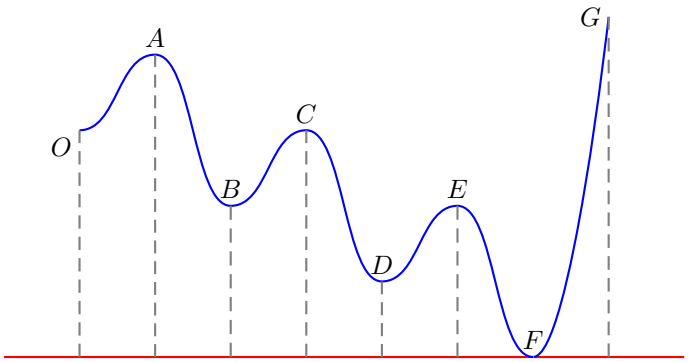

Figure 1: Problem 3.

5. (**10 points.**) [Gravitational slingshot] Earth's orbit around the Sun is an ellipse. At the aphelion the distance between Earth and Sun is 152.10×10^6 km and Earth's speed is 29.29 km/s. What will be Earth's speed at the perihelion when the distance between Earth and Sun is only 147.10×10^6 km. Hint: Angular momentum of Earth-Sun system is conserved. In orbital mechanics of spaceships this maneuver is used for gaining speed and is known as gravitational slingshot.

6. (**10 points.**) A solid sphere of radius $a = 0.20$ m, (with moment of inertia $I = \frac{2}{5}MR^2$ when the axis of rotation passes through the center of sphere,) rolls perfectly (without sliding and slipping) on a surface in the shape of a circle of radius $R = 2.0$ m shown in Figure 2. For what minimum velocity v_i at the bottom of the circle will the sphere be able to go all around?

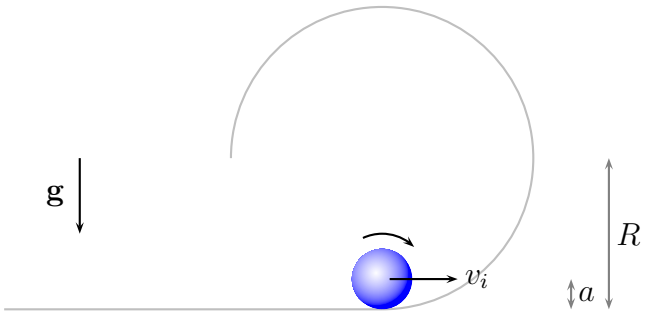

Figure 2: Problem 6.