PHY115: Final Project

Spring 2023

Due: Friday the 28th

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1 Theory Questions (20 points)

Please read the following questions carefully and provide your answers.

1. **Newton's Laws (7 points)**
   (a) When are Newton's Laws considered valid?
   (b) Can the second Law of Newton be used to explain the first one? If yes, how?
   (c) Is the normal force the reaction pair of the weight? If not, why? If yes, why?
2. **Linear Momentum (7 points)**
   (a) Define linear momentum.
   (b) Write the second Law of Newton in terms of linear momentum.
   (c) When is linear momentum conserved?
   (d) When is a component of linear momentum conserved?
   (e) Give an example in which linear momentum is not conserved, but one of its coordinates is.
   (f) **EXTRA CREDIT (5 points):** Find a scene in a movie or animation short that illustrates the previous point and provide a link to the scene.
3. **Angular Momentum (6 points)**
   (a) Define torque and angular momentum.
   (b) Write the equation that relates angular momentum and torque.
   (c) Write the equation for angular momentum that is equivalent to the definition of linear momentum.
   (d) Write the equation for the torque that is equivalent to the second Law of Newton.
   (e) When is angular momentum conserved? Give an example.
   (f) **EXTRA CREDIT (5 points):** Find a scene in a movie or animation short that illustrates the previous point and provide a link to the scene.

2 Test Your Understanding (20 points)

Please read the following questions carefully and provide your answers.

1. Imagine that you have to create an animation of a large explosion. How would you convey the impression that the explosion is big, assuming that there are no nearby objects for scale comparison? **(6 points)**

2. A client brings a treasured ball to your engineering firm, seeking to determine whether the ball is solid or hollow. Design a simple and inexpensive experiment that you can conduct quickly, without damaging the precious ball, to ascertain whether it is solid or hollow. **(7 points)**

3. Watch the following scenes from the movie "2001 space odyssey"

   - https://www.youtube.com/watch?v=0ZoSYsNADtY
   - https://www.youtube.com/watch?v=vG6CjOFlo7A

   and obtain an estimation of the radius of the space station[1]. **(7 points)**

3 Octave Project (60 points)

Simulate the motion of several objects as they roll down an inclined plane. For this simulation, consider a cylinder, a hollow cylinder, and a sphere as the objects. Choose two materials, one for the objects and another for the surface of the inclined plane, such that the friction coefficient allows all three objects to roll down without slipping. The dimensions of the objects and the angle of inclination for the plane are open for you to choose.

To solve the problem, please follow these guidelines:

3.1 Theory Part (30 points)

1. Create a diagram of the problem and indicate the coordinate axes that you have chosen. Write the set of equations for translation and rotation that you will use to solve the problem.

2. Explain the meaning of each equation.

3. Write the expressions for acceleration, angular acceleration, and the coefficient of friction.

[1] **Hint:** Utilize the principles of rotational physics to solve the problem. First, calculate the angular velocity of the space station. From there, you can determine the centripetal acceleration experienced by objects on the station, and consider that people inside the station experience an acceleration equivalent to that of gravity.

4. Which coefficient of friction should be used and why?

5. Consider a sphere, a hollow cylinder, and a solid cylinder rolling down an inclined plane. Choose a value for the angle of inclination, theta, and a value for the radius of the objects. Calculate the required coefficient of friction for each object to roll without slipping.

6. What is the value of the coefficient of friction that is necessary for all three objects to roll without slipping?

7. Derive the equations of motion for the objects. This should include the expressions for the X, Y, and Z coordinates that control the translation of the body and the expression for the angle, θ, that controls rotation.

Note: Please ensure that your answers are clear and concise and that you provide all necessary steps and calculations.

3.2 3ds Max Animation (30 points)

Using the equations of motion obtained in the previous section, create an animation of the three objects rolling down the inclined plane. Ensure that the materials used in the animation are consistent with the required friction coefficient for each object to roll down the plane without slipping.

When submitting your work, please include both the rendered animation and the mathematical expressions used to create it. You must submit the theory development of the problem as well.