Sample questions and reading material

Note: In the end, the references are provided from where the following questions have been taken. Besides, a few other topics pertinent to the requirement of the project have also been mentioned.

Questions

1. A solid sphere is released from rest at a rough inclined plane. Draw a free body diagram of the sphere and determine the condition for its motion in the state of pure rolling.

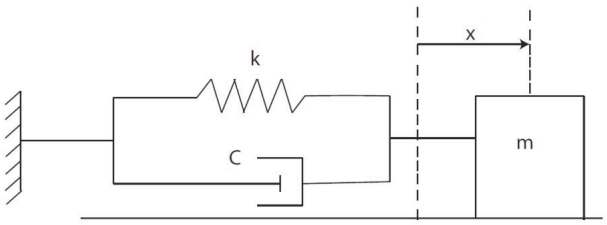
2. A solid sphere of mass 0.50 kg is kept on a horizontal surface. The coefficient of static friction between the surfaces in contact is $\frac{2}{7}$. What maximum force can be applied at the highest point in the horizontal direction so that the sphere does not slip on the surface? See chapter 10, question 84 [1].

3. A 2 kg block is placed over a 4 kg block and both are placed on a smooth horizontal surface. The coefficient of friction between the blocks is 0.20. Draw a free body diagram of each block. Find the acceleration of the two blocks if a horizontal force of 12 N is applied to (a) the upper block, (b) the lower block. Take $g = 10m/s^2$. See chapter 6, question 22 [1].

4. A small object is released from rest at A and slides with friction down the circular path. If the coefficient of friction is 0.2, determine the velocity of the object as it passes B. See chapter 3, question 3/99 [2].

5. When a sphere is rolled on a horizontal surface, it slows down and eventually stops. Why? See chapter 10 [1].

6. A block of mass m slides on a frictionless surface and is connected to a fixed support by a spring and a dashpot acting in parallel (see Figure below). Here k is the spring constant, c is the damping coefficient associated with the dashpot, and x is the displacement of the center of mass of the block from its equilibrium or rest position. The forces exerted by the spring and the dashpot are proportional to x and the velocity of the block, respectively. Formulate the equation of motion for the block, and solve it for *over-damped*, *under-damped*, and *critically damped* conditions. What is the natural frequency of this system? [3]



Algorithm

1. Write an algorithm for finding roots of a quadratic equation.

2. There are a few balls in a box which interact with each other in one or some other way. Write an algorithm to calculate distance between every pair of the balls.

3. Write an algorithm to find inverse of a square matrix.

4. Write an algorithm to calculate gravitational force between two bodies of mass m_1 and m_2 located at positions $\overrightarrow{r_1}$ and $\overrightarrow{r_2}$, respectively.

Topics

- Vectors, Kinematics and dynamics of rigid bodies (Two-dimensional).
- First and second order ordinary differential equations.
- Numerical schemes for ordinary differential equations, e.g., Runge-Kutta, etc.
- Concept of mean, median, mode, average, standard deviation, etc. Normal, Poisson and Gaussian distribution.

References

[1] Concepts of Physics, H. C. Verma, Bharati Bhawan Publishers & Distributors.

[2] Engineering Mechanics (Vol. II), Fifth Edition, Merian & Kraige.

[3] Theory of Vibration with Applications, W. T. Thomson.