MASENO UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

SECOND YEAR FIRST SEMESTER EXAMINATION FOR DEGREE OF BACHELOR OF SCIENCE IN PHYSICS WITH INFORMATION TECHNOLOGY

MAIN CAMPUS

SPH 201: DYNAMICS

Date: 8th December, 2016 Time: 3.30 - 6.30pm

INSTRUCTIONS:

- Answer All questions in Section A and any other TWO in Section B.

Useful Constants

Acceleration due to gravity, $9.8 m/s^2$

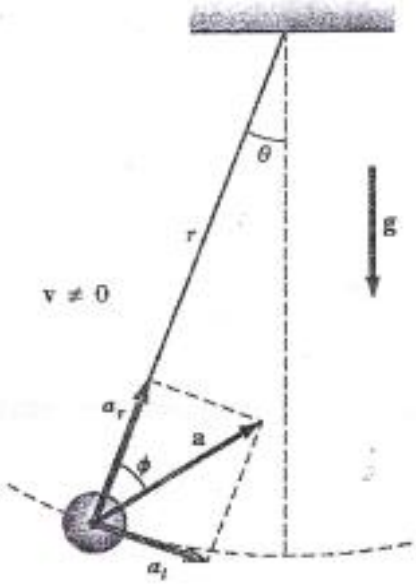
Moment of inertia of a solid sphere about the center of mass, $\frac{2}{5}MR^2$

Moment of inertia of a solid cylinder about an axis through its center, $\frac{1}{2}MR^2$

Section A

Question One [30 mks]

a) A ball tied to the end of a string is 0.50 m in length swings in a vertical circle under the influence of gravity as shown.



When the string makes an angle θ=20° with the vertical, the ball has a speed of 1.5 m/s.

i) Find the magnitude of the radial component of acceleration at this instant. **[3 mks]**

ii) Find the magnitude of the tangential acceleration at this instant. **[4 mks]**

iii) Find the magnitude and direction of the total acceleration at this instant. **[5 mks]**

b) A machine part has the shape of a solid uniform sphere of mass 225 g and diameter 3.00 cm. It is spinning about a frictionless axle through its center, but at one point on its equator it is scrapping against metal, resulting in a friction force of 0.0200 N at that point. How long will it take to decrease its angular speed by 22.5 rad/s? **[4 mks]**

c) The angular position, θ, of a wheel is given by $\theta = (2.0\ rad/s^3)t^3$. If the diameter of the wheel is 0.36 m,

i) Find the average angular velocity during the interval from t=2.0 s to t=5.0 s. **[4 mks]**

ii) Find the instantaneous angular velocity at time t=5.0 s. **[3 mks]**

iii) Find the average angular acceleration between t=2.0 s and t=5.0 s. **[4 mks]**

iv) Find the instantaneous angular acceleration at t=5.0s. **[3 mks]**

Section B

Question Two [20 mks]

a) Calculate the moment of inertia of a slender uniform rod of length L and mass M about an axis perpendicular to it and passing through its center of mass. **[12 mks]**

b) State the parallel axis theorem. **[4 mks]**

c) Using the parallel axis theorem, show that the moment of inertia of a slender uniform rod about an axis through one end is $I = \frac{1}{3}ML^2$. **[6 mks]**

Question Three [20 mks]

a) Show that the time rate of change of angular momentum of a body is equal to the net torque acting on the body. **[9 mks]**

b) Show that for a rigid body, the angular momentum magnitude is given by:

$$L = I\omega,$$

where I is the moment of inertia and ω is the angular velocity. **[7 mks]**

c) A turbine fan in a jet engine has a moment of inertia of 2.5 $kg \cdot m^2$ about its axis of rotation. As the turbine is starting up, its angular velocity as a function of time is

$$\omega_z = \left(40 rads/s^3\right)t^2.$$

Find the fan's angular momentum as a function of time. **[4 mks]**

Question Four [20 mks]

a) i)Define the term torque. **[2 mks]**

i) Show that the work done by a net external torque, τ, acting on a rotating body s equal to the change in rotational kinetic energy. **[7 mks]**

) i) Prove that the power, P, associated with work done by a torque, τ, acting on a otating body is given by:

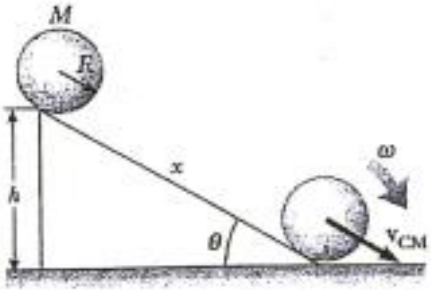
$$P = \tau\omega,$$

where ω is the angular velocity. **[5 mks]**

i) A 1.50 kg grinding wheel is in the form of a solid cylinder of radius 0.100 m. What constant toque will bring it from rest to an angular speed of 1200 rev/min in s? **[6 mks]**

Question Five [20 mks]

a) Consider a solid sphere rolling down an incline without slipping. As shown below. Show that the velocity of the center of mass is given by:



Show that:

$$V_{CM} = \left(\frac{2gh}{1 + I_{CM}/MR^2} \right)^{1/2}$$

g is the acceleration due to gravity. **[8 mks]**

b) For the solid sphere in (a) above, calculate:

(i) The linear speed of the center of mass at the bottom of the incline. **[6 mks]**

ii) The magnitude of the linear acceleration of the center of mass. **[6 mks]**