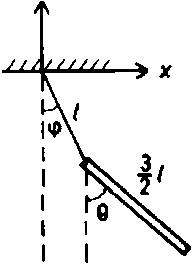
**Final exam Date:27/5/2021 Time:2.30 hours**

**Instructor: Dr. E. Badran**

Q1:A thin uniform bar of mass m and length is suspended by a string of length and negligible mass.

1. Show that the kinetic and potential energy are for small oscillations are:
2. Write the secular equation.
3. Find the normal frequencies.
4. Find normal modes for small oscillations in a plane and discuss the physical meaning of the normal modes.

Q2: Orbits around a black hole be described in terms of the effective potential

Where *L* is the orbit angular momentum. With respect to be classical Keplerian case, the only modification is the last 1/r3 term (for simplicity we are setting GN =1 and the reduced mass µ =1.) The above potential should be interested and used in the standard way, I,e,. the radial equation of motion for a point particle orbiting a black hole is that associated with the Lagrangian

1. Show that for L2 < 12 there are no circular orbits, whereas for L2 >12 there are *two*.
2. Shetch a plot of *V*eff (r) for L2 < 12 and for L2 > 12.
3. Describe the possible orbits for L2 > 12 and L2 < 12.

Q3: : Show that the moment of inertia of a uniform rectangular sheet of sides ***a, 2a*** and mass ***m*** in the xy- plane and one corner at the origin along the diagonal is

I =

1. Find the angular momentum and kinetic energy, when it is rotating with angular velocity about the diagonal through the origin.
2. Find the angular momentum and kinetic energy, when it is rotating with angular velocity about the z – axis.
3. Find the principal moment of inertia of the rectangular sheet about the corner.
4. Find the direction of the principal axis of the largest principal moment.

Q4: **A** merry-go-round (carousel) starts from rest and accelerates with a

constant **angular** acceleration of **0.02** revolution per second **per** second. **A**

woman sitting on a chair 6 meters from the axis of revolution holds a **2** kg

ball. Calculate the magnitude and direction of the force

she must exert to hold the ball ***5*** seconds after the merry-go-round begins

to rotate. Specify the direction with respect to the radius of the chair on

which she is sitting.