KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS AND ASTRONOMY

ADVANCED CLASSICAL MECHANICS (508 PHYS)

PROBLEM SET 2

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PROBLEM (1)

Two points of mass m are joined by a rigid weightless rod of Length l , the centre of which is constraint to move on a circle of radius a . Write the kinetic energy of this system in generalised coordinates.

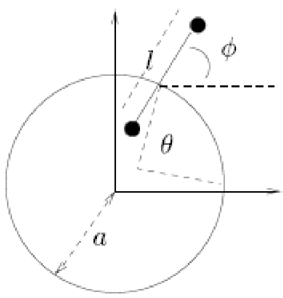

Figure 0.1: Sketch of problem 1

PROBLEM (2)

A particle moves in space under the influence of the potential

$$V(\vec{r},\vec{v}) = V(r) + \vec{\sigma}\cdot\vec{L}$$

where $\vec{r}$ is the radial position vector, $\vec{L}$ is the angular momentum of the particle and $\vec{\sigma}$ is a fixed vector in space.
Obtain the equations of motion for this particle in spherical coordinates.

PROBLEM (3)

A particle moves in a 2 dimensional plane under the influence of a force whose magnitude is given by,

$$F = \frac{1}{r^2}(1 - \frac{\dot{r}^2 - 2\ddot{r}r}{c^2})$$

Write the Lagrangian for this particle.

PROBLEM (4)

If we have L a Lagrangian for a system with n degrees of freedom, show that if we transformed the Lagrangian $L \to \tilde{L}$ such that ,

$$\tilde{L} = L + \frac{df(\vec{q})}{dt}$$

(i.e. added a total derivative)
The equations of motion do not change.

PROBLEM (5)

A Lagrangian for a system is given by,

$$L = \frac{m}{2}(a\dot{x}^2 + 2b\dot{x}\dot{y} + c\dot{y}^2) - \frac{K}{2}(ax^2 + 2bxy + cy^2)$$

We have a, b and c as constants, subject to the conditions $b^2 - ac \neq 0$.

1. Write the equations of motion for this system.
2. Discuss the physical system described by this Lagrangian.
3. What is the physical significance of the constraint on the constants?

PROBLEM (6)

We define the set of transformations to the electromagnetic scalar and vector potentials, respectively:

$$\phi \to \phi + \partial_t \Lambda$$
$$\vec{A} \to \vec{A} + \vec{\nabla}\Lambda$$

For some arbitrary function $\Lambda(x)$.
Show that these transformations do not affect the equations of motion for a (charged) particle in an Electromagnetic field.

PROBLEM (7)

Two mass points of masses m_1 and m_2 are connected by a string passing though a hole in a smooth table such that the mass m_1 rests on the table and m_2 hangs suspended, and can only move on the vertical direction.

1. What are the suitable generalised coordinates of this system ?
2. Write down the Lagrangian, then obtain the equations of motion for this system.
3. Reduce the problem to a single second order differential equation, then solve the equation.
4. Discuss the physical significance of the solution.