# Physics 105, Spring 2021, Reinsch

# Homework Assignment 3

# Due Thursday, February 11, 11:59 pm

**Problem 1**

Repeat Example 7.2 on pages 242 - 243 for the case of one particle in three dimensions, using spherical coordinates. For simplicity we will assume the potential $U$ is a function of $r$ and independent of $\theta$ and $\phi$. Your solution will have three subsections, "The $r$ Equation," "The $\theta$ Equation" and "The $\phi$ Equation."

**Problem 2**

A particle of mass $m$ moves in the first quadrant of the $xy$ plane (that is, the region with $x > 0$ and $y > 0$). We define generalized coordinates as follows. The coordinate $q_1$ is the distance from the particle to the origin, and the coordinate $q_2$ is the distance from the particle to the point $(a, 0)$, where $a$ is a positive constant.

(a) Write the kinetic energy of the particle in terms of the $q$ coordinates and their time derivatives.

(b) If the potential energy is $-mg$ times the Cartesian $y$ coordinate (where $g$ is a positive constant), what is $U(q_1, q_2)$?

**Problem 3**

Regarding the previous problem, we now define another choice of generalized coordinates. The new generalized coordinates are called $\mu$ and $\nu$. The relationship between the Cartesian coordinates and these new coordinates is

$$x = \frac{a}{2}(1 + \cosh\mu\,\cos\nu) \tag{1}$$

$$y = \frac{a}{2}\sinh\mu\,\sin\nu \tag{2}$$

(a) Write the kinetic energy in terms of $\mu$ and $\nu$ and their time derivatives. Simplify the expression for the kinetic energy by removing references to sinh and sin using identities such as $\sin^2 + \cos^2 = 1$.

(b) Find $q_1$ and $q_2$ as functions of $\mu$ and $\nu$. As in part (a) the formulas become very simple if we remove references to sinh and sin.

**Problem 4**

Taylor, Problem 7.8

**Problem 5**

Taylor, Problem 7.14

**Problem 6**

Taylor, Problem 7.33. Treat the bar as a point mass.