Homework No. 10 (Spring 2024)

PHYS 205A-001: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Due date: Monday, 2024 Apr 1, 12:00 PM, on D2L

Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Links to solutions are provided. Further, links to few variations of the problem are provided that serve as practice problems.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments). You can replace your PDF file, only the last file is graded.

Problems

1. (**10 points.**) Consider the potential energy curve shown in Figure 1.

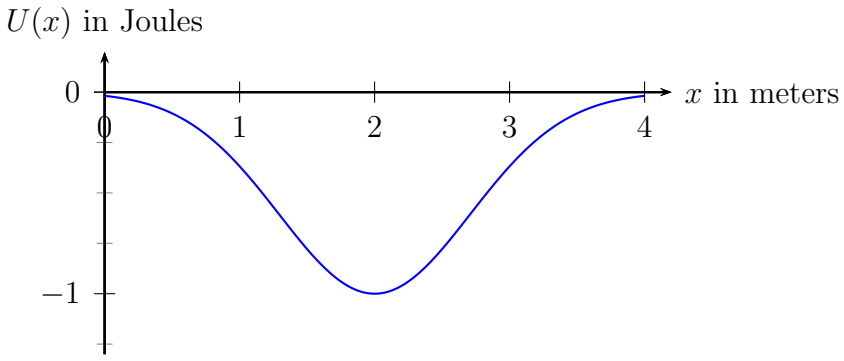

Figure 1: Problem 1.

(a) What is the potential energy in Joules when the associated force is zero?

(b) Sketch the curve of force versus x from $x = 0\,\text{m}$ to $x = 4\,\text{m}$.

(c) For what range of x is the force repulsive (positive)?

(d) For what range of x is the force attractive (negative)?

[**Solution**, see 2023S MT-03 P02, 2017F-001 MT-03 P03, 2017F-002 MT-03 P03]

2. (**10 points.**) The potential energy of a particle moving along the x axis is given by

$$U(x) = ax^2 - bx^4, \qquad a = -4.0\,\frac{\text{J}}{\text{m}^2}, \quad b = -1.0\,\frac{\text{J}}{\text{m}^4}. \tag{1}$$

Plot of $U(x)$ with respect to x is shown in Figure 2.

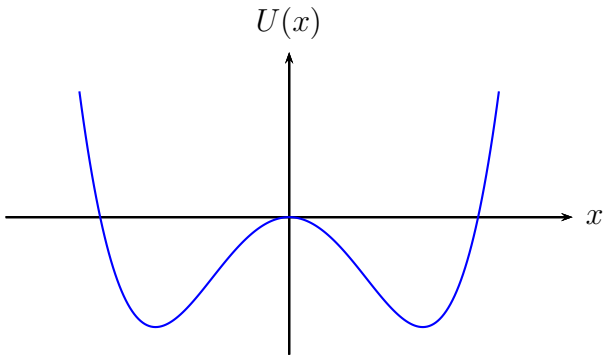

Figure 2: Problem 2.

(a) Determine the points on the x axis where the potential energy is zero.

(b) Determine the points on the x axis where the force on the particle is zero.

(c) Evaluate

$$\frac{d^2U}{dx^2} \tag{2}$$

at each of the points where the force is zero. What can you conclude about the stability of the particle at the points where the force is zero? That is, is it a stable point or an unstable point?

(d) For what range of x is the force repulsive (positive)?

(e) For what range of x is the force attractive (negative)?

[**Solution**, see 2022F MT-03 P02, 2022S MT-03 P05, 2015F MT-03 P05, 2014F MT-03 P03]

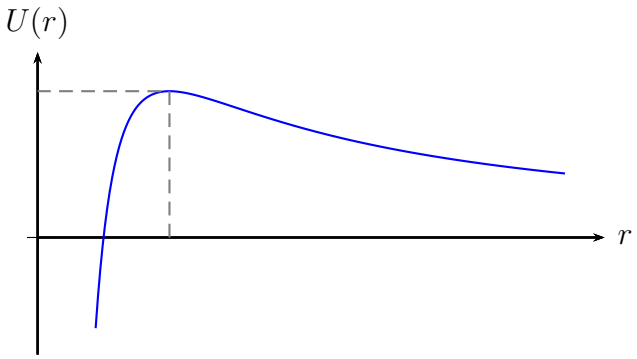

Figure 3: Problem 3.

3. (**10 points.**) Consider the potential energy curve shown in Figure 3, which is given by the expression ($r > 0$)

$$U(r) = \frac{\beta}{2r^2} - \frac{\alpha}{r}, \qquad \alpha = -1.0\,\mathrm{J\,m}, \quad \beta = -2.0\,\mathrm{J\,m^2}. \tag{3}$$

(a) Determine the points on the x axis where the potential energy is zero.

(b) Determine the points on the x axis where the force on the particle is zero.

(c) Evaluate

$$\frac{d^2U}{dx^2} \tag{4}$$

at each of the points where the force is zero. What can you conclude about the stability of the particle at the points where the force is zero? That is, is it a stable point or an unstable point?

(d) For what range of x is the force repulsive (positive)?

(e) For what range of x is the force attractive (negative)?

[**Solution**, see 2021S MT-03 P02, 2018S MT-03 P07]