Homework No. 10 (Spring 2025)

PHYS 205A-001: UNIVERSITY PHYSICS

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

Due date: Monday, 2025 Mar 31, Noon, 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.
- Variations of homework problems and additional problems with hyperlinks to old exams are available in Lecture Notes. These 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 as many times as you like, only the last file is graded. The deadline has an (undisclosed) buffer period, so do not hesitate to try submissions after the deadline.

Problems

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

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

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

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

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

   [**Solution**]

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

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

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

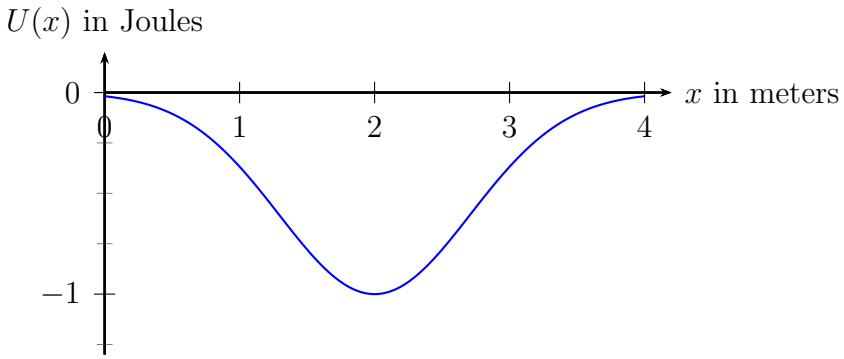

Figure 1: Problem 1.

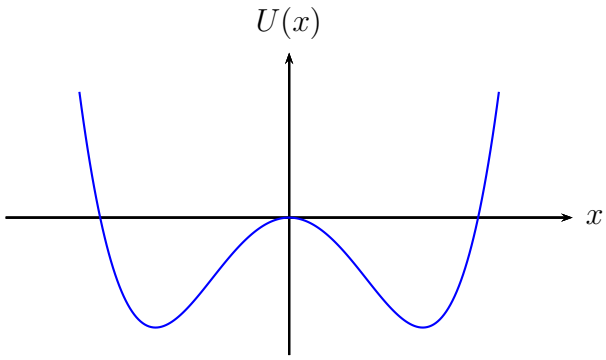

Figure 2: Problem 2.

(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**]

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

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

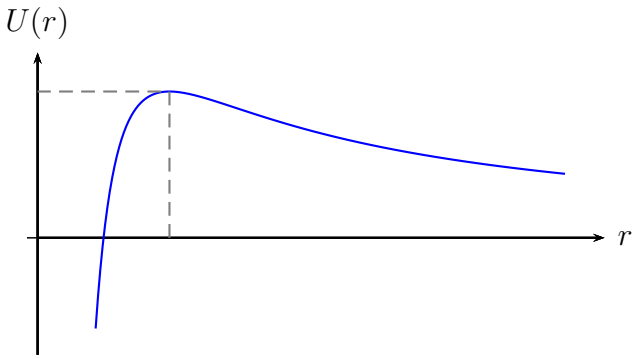

Figure 3: Problem 3.

(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**]