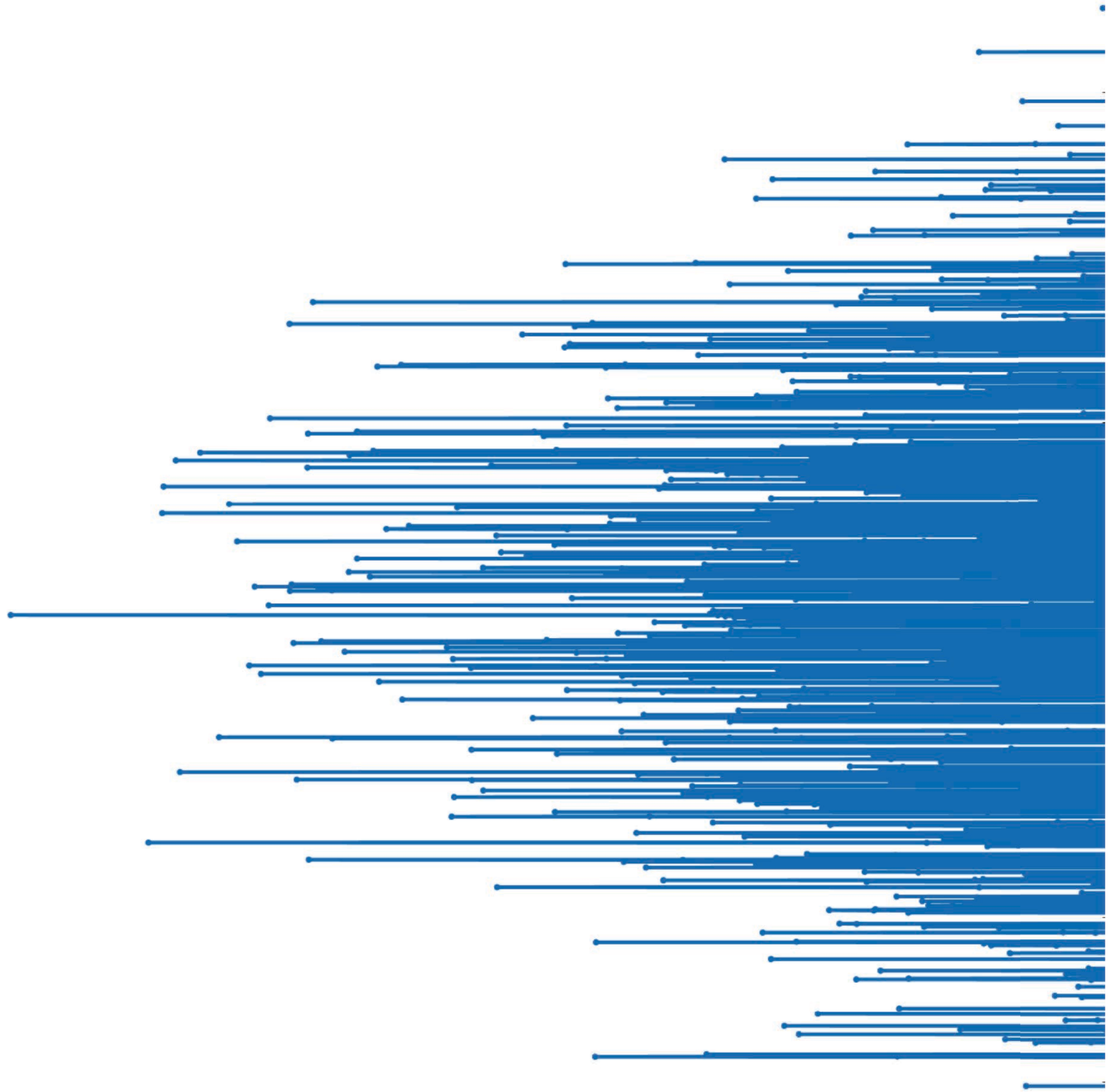
PHYS 2010 (W20)
Classical Mechanics



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Tutorial IV

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Ref. (re images):
Knudsen & Hjorth (2000), Kesten & Tauck (2012)

1. THE RETURNING EXPLORER

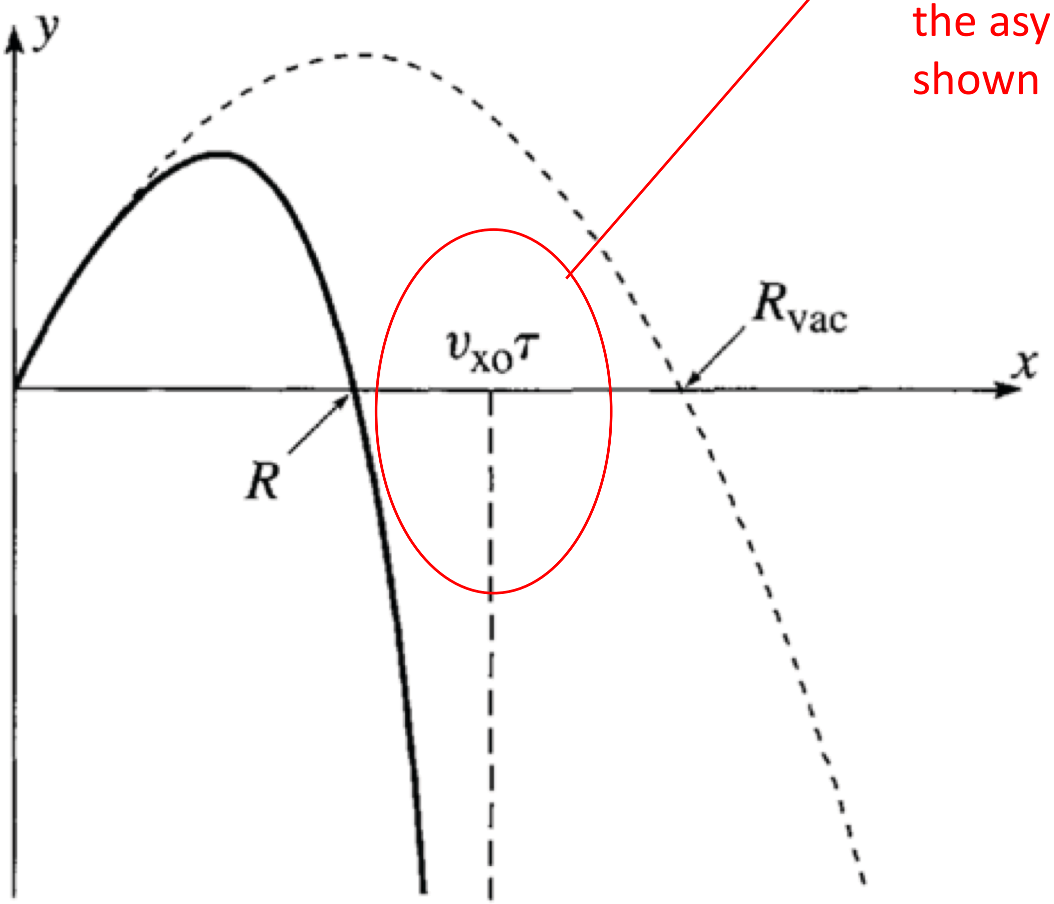
AN OLD RIDDLE runs as follows. An explorer walks one mile due south, turns and walks one mile due east, turns again and walks one mile due north. He finds himself back where he started. He shoots a bear. What color is the bear? The time-honored answer is: "White," because the explorer must have started at the North Pole. But not long ago someone made the discovery that the North Pole is not the only starting point that satisfies the given conditions! Can you think of any other spot on the globe from which one could walk a mile south, a mile east, a mile north and find himself back at his original location?

Problem

Calculate $\nabla \cdot \mathbf{r}$:

Here $\mathbf{r}$ is just the "coordinate vector" (i.e., $\mathbf{r} = \mathbf{i}x + \mathbf{j}y + \mathbf{k}z$)

Problem



For a projectile experiencing linear drag, determine an expression for the asymptotic horizontal limit as shown here.

Problem

A particle moving in 1-D experiencing quadratic drag only can be described by the following ODE. Solve this via separation of variables to determine $v(t)$ and $x(t)$. Sketch them as well, noting any relevant time constants.

$$m\frac{dv}{dt} = -cv^2.$$

Problem

Find the scalar potential for the gravitational force on a unit mass m_1,

$$\mathbf{F}_G = -\frac{G m_1 m_2 \hat{\mathbf{r}}}{r^2} = -\frac{k\hat{\mathbf{r}}}{r^2},$$

Problem

A baseball is dropped from a tall tower. Assume only gravity and air resistance proportional to the balls velocity squared (i.e., quadratic drag) act on the ball. Provide a numerical estimate of the associated terminal velocity and make a rough time sketch of the associated timecourse of the speed.

Problem

Calculate the scalar potential for the **centrifugal** force per unit mass, $\mathbf{F}_C = \omega^2 r \hat{\mathbf{r}}$, radially **outward**. Physically, you might feel this on a large horizontal spinning disk at an amusement park.