Problem Set #1

Question 1

A snowflake is caught up in a gust of wind and miraculously follows a trajectory described by

$$\vec{r}(t) = A\left(\mathrm{e}^{\alpha t}\hat{x} + \mathrm{e}^{-\alpha t}\hat{y}\right),$$

where A is some constant with dimensions of length.

(i) What is $\vec{v}(t)$?

(ii) What is the angle between $\vec{r}(t)$ and $\vec{v}(t)$ at some arbitrary time t?

(iii) Sketch the trajectory from $t = 0$ to $t = \infty$. Consider limiting cases to help make your sketch.

Question 2

(i) Consider a star of radius R, density ρ that oscillates with frequency ν. Using dimensional analysis, how does this oscillation frequency depend on R, ρ, and the gravitational constant G?

(ii) How does the speed of waves on a string depend on its mass M, length L, and tension, T?

Question 3

Taylor, Problem 1.10

Question 4

Taylor, Problem 1.18

Question 5

Taylor, Problem 1.39

Question 6

Taylor, Problem 1.45

Question 7 (Extra Credit)

A tube of mass M and length l is free to swing around a pivot at one end. a mass M is positioned inside the frictionless tube at this pivot end. The tube is held horizontal and released from rest. Let η be the fraction of the tube's length that the mass has traversed by the time the tube becomes vertical.
Does η depend on l?