**Problem 1** A bee with velocity vector \( \mathbf{r}'(t) \) starts out at the origin at \( t = 0 \) and flies around for \( T \) seconds. Where is the bee located at \( T \) seconds if \( \int_0^T \mathbf{r}'(u) du = 0 \)? What does the quantity \( \int_0^T ||\mathbf{r}'(u)|| du \) represent?

**Problem 2** In this question we will find the arclength parameterization of \( \mathbf{r}(t) = \langle e^t \sin(t), e^t \cos(t), e^t \rangle \).

(a) Find \( ||\mathbf{r}'(t)|| \).
(b) Find arclength \( s \) as a function of time \( t \) by using

\[
    s(t) = \int_0^t ||\mathbf{r}'(u)|| du.
\]

(c) Find time \( t \) as a function of arclength \( s \) by inverting the previous function.
(d) What is an arclength parameterization of \( \mathbf{r}(t) \)?

**Problem 3** Determine whether the following are true or false.

(a) A circle of radius 3 has more curvature than a circle of radius 4.
(b) Reparameterizing a curve can change it’s curvature at a point.
(c) A curve with constant curvature is a circle.

**Problem 4** For this question, consider the ellipse given by the equation

\[
    \frac{x^2}{9} + \frac{y^2}{4} = 1
\]

(a) Sketch this curve. When do you think the curvature maximal? When is it minimal?
(b) Consider the plane as the \( xy \)-plane in 3-space. The ellipse then has parameterisation given by

\[
    \mathbf{r}(t) = \langle 3 \cos(t), 2 \sin(t), 0 \rangle.
\]

Use the formula

\[
    \kappa(t) = \frac{||\mathbf{r}'(t) \times \mathbf{r}''(t)||}{||\mathbf{r}'(t)||^3}
\]

to calculate the curvature.
(c) Does your answer in the previous part agree with your guess form the first?