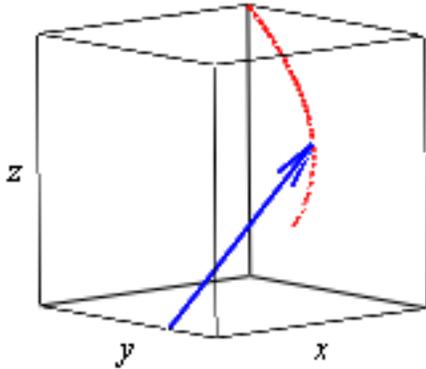


Show all work, including mental steps, in a clearly organized way that speaks for itself. Use proper mathematical notation, identifying expressions by their proper symbols (introducing them if necessary), and use arrows and equal signs when appropriate. Always simplify expressions. BOX final short answers. LABEL parts of problem. Keep answers EXACT (but give decimal approximations for interpretation). Indicate where technology is used and what type (Maple, GC). You are encouraged to use technology to check all of your hand results.



The parametrized curve segment

$$\vec{r}(t) = \langle e^t \cos(t), e^t \sin(t), e^t \rangle, -1/2 \leq t \leq 1/2$$

is shown in the figure together with  $\vec{r}(0)$ .

- Evaluate and simplify  $\vec{r}'(t)$ ,  $\vec{r}''(t)$ ,  $|\vec{r}'(t)| = \sqrt{3} e^t$ , (perfect square!),  $\vec{T}(t)$ ,  $|\vec{r}''(t)|$  and their values (including  $\vec{r}(t)$ ) at  $t=0$ .
- Evaluate the unit vector  $\vec{B}(t)$  in the direction of  $\vec{r}'(t) \times \vec{r}''(t)$ .
- Write the equation of the plane through  $\vec{r}(0)$  containing the tangent vector and the second derivative there.
- Write the parametrized equations of the tangent line through  $\vec{r}(0)$ .

e) Evaluate the curvature  $\kappa(t) = \frac{|\vec{r}'(t) \times \vec{r}''(t)|}{|\vec{r}'(t)|^3}$  and radius of curvature  $\rho(t)$ .

f) Evaluate the unit normal  $\vec{N}(t)$  directly by finding the unit vector direction of  $\vec{T}'(t)$  [no quotient rule needed!].

g) Write down an integral formula for the length of the curve  $\vec{r}(t)$  from  $t = -\frac{1}{2}$  to  $t = \frac{1}{2}$ . Evaluate it exactly and then numerically to 3 decimal places.

h) Evaluate the scalar tangential projection  $a_T(0)$  along  $\vec{T}(0)$  of the acceleration  $\vec{a}(0) = \vec{r}''(0)$  and its scalar normal projection  $a_N(0) = \vec{N}(0) \cdot \vec{a}(0)$  exactly. Does the sum of their squares equal the square of the magnitude of the acceleration as it should?

i) The center of the osculating circle has position vector:  $\vec{C}(t) = \vec{r}(t) + \rho(t) \vec{N}(t)$ . Show that

$$\vec{C}(0) = \left\langle -\frac{1}{2}, \frac{3}{2}, 1 \right\rangle.$$

j) **Optional**, only if you have time after checking everything thoroughly: what is the simple relation between  $a_T(t)$  and  $|\vec{r}'(t)|$  for this 3D logarithmic spiral?

## ► solution

## ▼ pledge

When you have completed the exam, please read and sign the dr bob integrity pledge and hand this test sheet on top of your answer sheets as a cover page, with the first test page facing up:  
 "During this examination, all work has been my own. I have not accessed any of the class web pages or any other sites during the exam. I give my word that I have not resorted to any ethically questionable means of improving my grade or anyone else's on this examination and that I have not discussed this exam with anyone other than my instructor, nor will I until after the exam period is terminated for all participants."

Signature: \_\_\_\_\_

Date: \_\_\_\_\_