

**Problem 1** Find the parametric equation to the tangent line to the helix  $\mathbf{r}(t) = \langle 2 \cos(t), \sin(t), t \rangle$  at  $(0, 1, \pi/2)$ .

**Problem 2** Consider a particle with a path parameterization given by  $\mathbf{r}(t) = \langle t^3, t^6 \rangle$ .

- (a) Sketch the curve of this particle's trajectory.
- (b) Show that the velocity of the particle at  $t = 0$  is zero.
- (c) One might think as the velocity vector is zero at  $t = 0$ , it isn't possible for there to be a tangent line at  $t = 0$ . Why does this not make sense considering your sketch in Problem (2.a)? Based on your sketch, what do you think the tangent line should be?
- (d) This apparent contradiction can be fixed by reparameterising the curve. Do so such that the new path parameterisation has non-zero vector when the particle is at the origin. Then show that the tangent line is as expected in the previous part.

**Problem 3** Describe physically what happens to a point particle if it's path parameterization  $\mathbf{r}(t)$  is such that:

- (a)  $\|\mathbf{r}(t)\|' = 0$
- (b)  $\|\mathbf{r}'(t)\| = 0$

**Problem 4** Suppose we have a point  $P$  with trajectory given by  $\mathbf{r}(t)$  in  $\mathbb{R}^3$  such that it starts at the origin (that is  $\mathbf{r}(0) = \mathbf{0}$ ). If  $\mathbf{r}'(t) \cdot \langle 1, 0, 0 \rangle > 0$ , is it possible for the point  $P$  to collide with the point  $\langle -2, 0, 3 \rangle$ ?

**Problem 5** Suppose we have a curve that has two different parameterisations given by  $\mathbf{r}_1(t)$  and  $\mathbf{r}_2(s)$  such that  $\mathbf{r}_1(0) = \mathbf{r}_2(0)$ . What is  $\mathbf{r}'_1(0) \times \mathbf{r}'_2(0)$ ?