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

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

(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 \([\text{Problem } 2.\text{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 \( \mathbf{r}(0) = 0 \)). If \( \mathbf{r}'(t) \cdot (1, 0, 0) > 0 \), is it possible for the point \( P \) to collide with the point \((-2, 0, 3)\)?

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 \( \mathbf{r}_1'(0) \times \mathbf{r}_2'(0) \)?