1. Prove that following curves are parametrised by arclength:
   
   (A) \( \mathbf{r}(t) = \left( \frac{5 \cos t}{13}, \frac{28}{193} - \sin t, -\frac{12 \cos t}{13} \right) \)
   
   (B) \( \mathbf{r}(t) = \left( \frac{(1 + t)^{3/2}}{3}, \frac{(1 - t)^{3/2}}{3}, \frac{t}{\sqrt{2}} \right) \)

2. Prove that following curves are of constant speed:
   
   (A) \( \mathbf{r}(t) = \left( \frac{\arcsin t + t\sqrt{1-t^2}}{2}, \frac{t^2}{2} \right) \)
   
   (B) \( \mathbf{r}(t) = \left( \sqrt{1+t^2}, 2t, \ln \left( t + \sqrt{1+t^2} \right) \right) \)

3. Parametrise the curve defined by \( \mathbf{r}(t) = \left( t - \tanh t, \text{sech} t \right) \) by arclength.

   \( \diamond \text{Tractrix} \diamond \)

4. Prove that the arclength function of \( r = r(\theta) \) is of the form
   
   \[ s(t) = \int_a^t \left( r(t)^2 + (r'(t))^2 \right)^{1/2} \, dt \]

   for some \( \alpha \in \mathbb{R} \).

5. Prove that the tractrix is an involute of the catenary. Employ this fact to sketch the tractrix.

6. Compute the arclength of a segment of an involute of the circle.

7. Compute the arclength of a segment of an involute of the circular helix.

8. Consider an involute of the regular curve \( \mathbf{r} : J \to \mathbb{R}^n \) with arclength \( s : J \to \mathbb{R} \) written in the form
   
   \[ \mathbf{q}(t) = \mathbf{r}(t) - s(t) \mathbf{T}(t) \]

   for all \( t \in J \), where \( \mathbf{T} \) is the unit tangent field of \( \mathbf{r} \). Let \( \hat{J} = J - s^{-1}(0) \).

   (A) Prove that \( \mathbf{q} \) is regular on \( \hat{J} \) iff \( \mathbf{r}'' \) vanishes nowhere on \( \hat{J} \).

   (B) Prove that for each \( t \in \hat{J} \), the tangent line to \( \mathbf{r} \) at \( \mathbf{r}(t) \) is perpendicular to the tangent line to \( \mathbf{q} \) at \( \mathbf{q}(t) \).