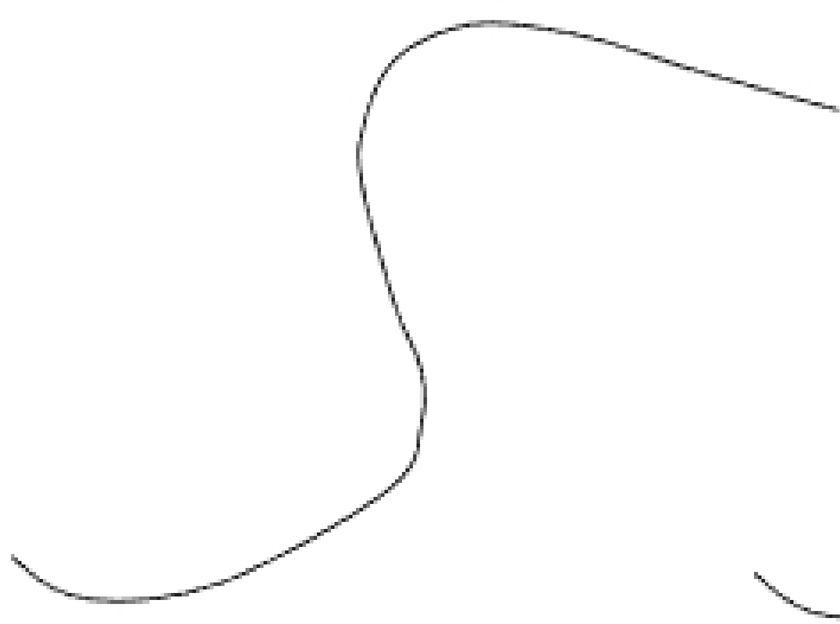
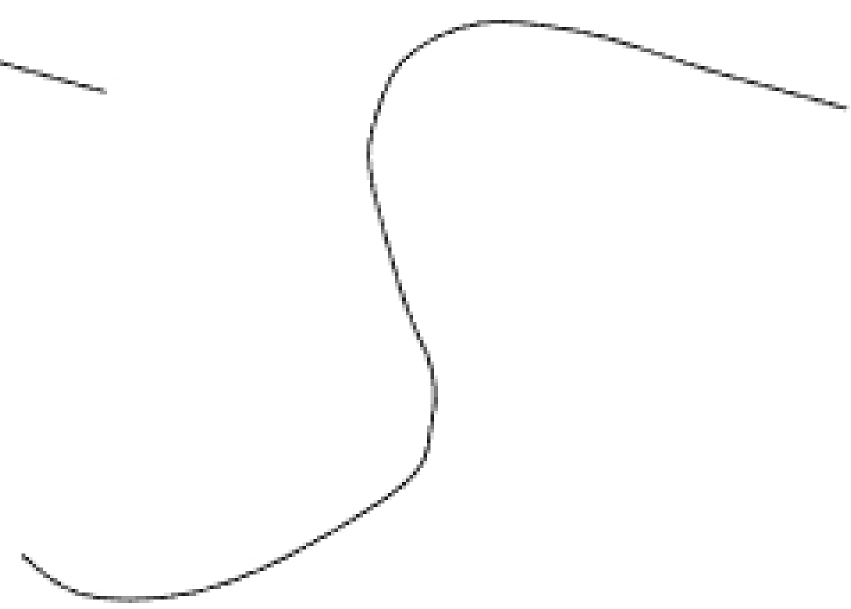
Learning Exercise 3:
Kinematics of Curved Path Translation

Objective: **To recognize the relationships between position, velocity, acceleration and time for motion along a given curved line.**
To be able to express kinematic quantities in terms of rectangular coordinates, normal-tangential coordinates and in terms of polar coordinates.

1. A body translates along a curved path. What can you say about the relationship of the paths made by any and all points on the body?

2. For the curved path shown, a point on the body moves from lower left to upper right. Let the speed be constant. Sketch a series of velocity vectors on the curve on the left. Sketch the acceleration vectors on the curve on the right. Using your knowledge of how it feels driving around different curves, show any changes that occur in the magnitude of the acceleration by making the vectors larger or smaller.





3. Look at the plots in Figure 3.2 of the notes corresponding to Example 3.1. How can it be true that the speed is not zero at the time when $dr/dt = 0$? Answer the same question regarding the acceleration and $dv/dt = 0$.

4. Consider Example 3.2 in the notes describing a case of "projectile motion". Are both solutions shown valid? Why or why not?

For the first of the two solutions, $t_1 = 13.92$ sec with $\theta_1 = 26.11^{\circ}$, and using the results shown for the velocity and position vectors, find the following:

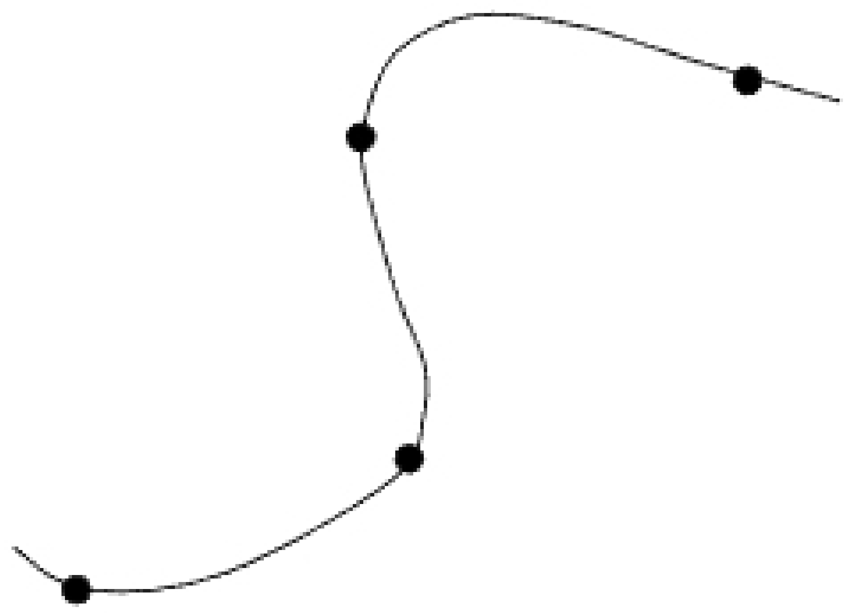
1. The maximum height reached by the projectile.

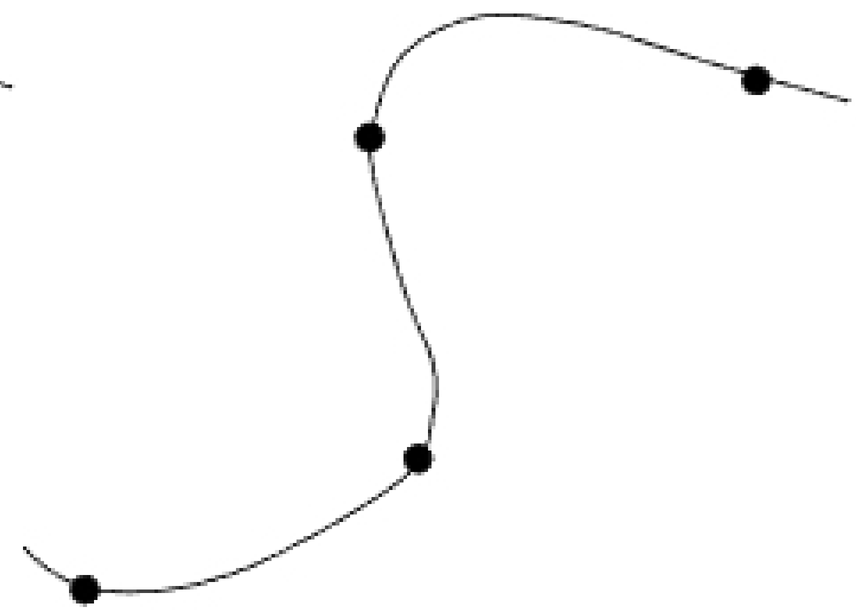
2. The total horizontal distance the projectile has traveled when it hits the ground.

3. The total time it takes to hit the ground.

4. The speed it is traveling just before it hits the ground.

5. For the curve on the left, consider that a point on a translating body is increasing its speed as it moves from lower left to upper right. Draw a feasible direction for the total acceleration vector at each of the four points. Do the same for the curve on the right, but now consider that the speed is decreasing as the point moves along the path.





6. **Some Kinetics**: In Example 3.3 in the notes, the train has a constant speed and a maximum acceleration (in the horizontal plane of motion) equal to 2.830 ft.sec^2 at the point where the radius of curvature is the smallest. If the engineer weighs 250 lb, what magnitude of horizontal force does his seat provide to keep him from sliding? If the speed were to be doubled, what would the required force equal?

7. For the curve on the left, show unit normal and unit tangential vectors at the four points identified. For the curve on the right, show unit radial and transverse vectors at the points identified using the origin shown and show the angle θ for each point.