7. [7 points]

Amira's friend Paul borrows her yo-yo and starts spinning it in a counterclockwise circle at a constant speed. His hand holds the string, at the center of the circle shown, 4 feet off the ground. The length of the string between his hand and the yo-yo is 3.5 feet.

In this problem, measure angles counterclockwise from the positive horizontal as usual. When the yo-yo is at point P, the angle ϕ as shown in the diagram to the right is $\frac{3\pi}{8}$ radians.
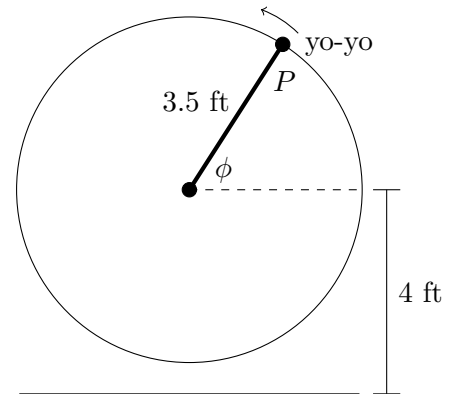
a. [3 points] How high off the ground is the yo-yo when it is at point P? *Give your answer in exact form or rounded to at least two decimals.*

Height: $\underline{\quad 3.5\sin\left(\frac{3\pi}{8}\right) + 4 \approx 7.23 \quad}$ feet

b. [2 points] After the yo-yo travels most of the way around the circle from its current position, there will be a moment at which it is directly underneath point P. Find the angle, in radians, between 0 and 2π, at which this occurs. *Give your answer in exact form or rounded to at least two decimals.*

Angle: $\underline{\quad 2\pi - \frac{3\pi}{8} \quad}$ radians

c. [2 points] It takes the yo-yo 1 second to make a complete circle. What angle, in radians, will the yo-yo make with the positive horizontal 1/3 of a second after it is at point P? *Give your answer in exact form or rounded to at least two decimals.*

Solution: If it takes 1 second to make a full rotation (2π radians), in 1/3 of a second it will make one third of a rotation, or $2\pi/3$ radians. Since we are starting at $\frac{3\pi}{8}$ radians, we need to find one third of a rotation later, or

$$\frac{3\pi}{8} + \frac{2\pi}{3} = \frac{25\pi}{24} \approx 3.27$$

Angle: $\underline{\quad \frac{3\pi}{8} + \frac{2\pi}{3} \approx 3.27 \quad}$ radians