Wednesday warm-up: Kinematics, II and III

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September 10, 2025

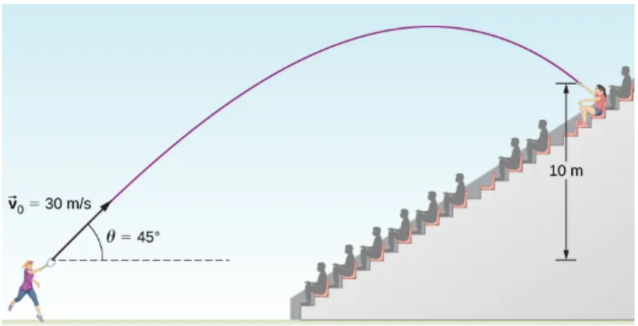

Figure 1: A tennis player hits a ball into the stands.

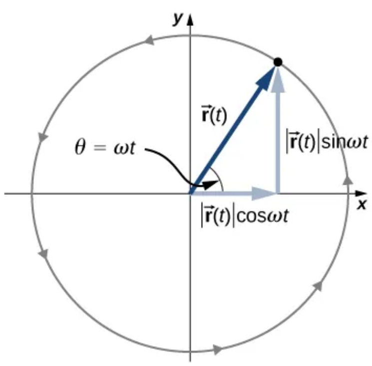

Figure 2: A diagram for uniform circular motion.

1 Memory Bank

1. $g = 9.81$ m s^{-2}
2. $v_x(t) = a_x t + v_{i,x}$
3. $v_y(t) = a_y t + v_{i,y}$
4. $x(t) = \frac{1}{2}a_x t^2 + v_{i,x}t + x_i$
5. $y(t) = \frac{1}{2}a_y t^2 + v_{i,y}t + x_i$
6. $v_f^2 = v_i^2 + 2a\Delta y$
7. $\vec{r}(t) = r\cos(\omega t)\hat{i} + r\sin(\omega t)\hat{j}$

2 Kinematics II

1. After winning a match, a tennis player hits the ball into the stands at 30 m/s and at an angle 45 degrees above the horizontal (Fig. 1). The ball is caught by a spectator 10 m above the point where the ball was hit. (a) What is the horizontal component of the initial velocity? (b) What is the vertical component of the initial velocity?

2. (a) Calculate the time it takes the tennis ball to reach the spectator. (b) What are the magnitude and direction of the ball's velocity at impact?

3. Consider Fig. 2. The angle $\theta(t) = \omega t$ describes the position of a system circling the origin at constant speed[1]. Show that

$$\vec{r}(t) = r\cos(\omega t)\hat{i} + r\sin(\omega t)\hat{j} \tag{1}$$

4. Show that the acceleration is $\vec{a} = -\omega^2\vec{r}$. Is the magnitude of the acceleration constant, or does it depend on time?

[1] The factor ω is the *angular velocity*, in radians per second.