**Title: B10 Upward Dripping**

[Subtitle]  
Sampling

[Subject symbol Mech]

Time  
15 minutes

Level  
Grade 4/5, High School 5

Concepts: Frequency, sampling

[Introductory box]

In movies and commercials, you see car wheels spinning backward while the car moves forward. How does that work exactly? And how many measurements do you need to sample an (analog) signal (digitally) so that you can reconstruct the signal?

[end box]

[FP05\_figure1; caption]

*The setup.*

[FP05\_figure2; caption]

*A view as the students will see it.*

**Required**

Dropper; stroboscope; collection tray; water; darkened room; pendulum

**Preparation**

Place a dropper, similar to the one used for pipetting, on the table. Position the collection tray underneath to catch the droplets. Place a stroboscope next to the setup. Also, prepare the pendulum setup, ensuring that the pendulum length is not too long (measure beforehand what the period is!).

**Execution**

Briefly explain that you are going to explain the effect of the backward spinning of wheels using a demonstration. The flash of the stroboscope corresponds to one frame of the film. You are sampling the motion.

Turn on the stroboscope and open the faucet slightly so that drops fall quickly in succession. By varying the flash frequency, you can freeze the drops; let them fall slowly or rise upward.

Replace the dropper with the pendulum. Set the flash frequency so that the pendulum is only visible in the extreme positions or at the equilibrium position. First, ask the students if they can tell whether the pendulum is moving back and forth or standing still. Then ask the students what they will see when you slightly increase the flash frequency and verify the answer by increasing the flash frequency.

**Physics Background**

To be able to construct an analog signal by taking samples (digitally), you need at least 2 measurements per period. This is called the Nyquist criterion. If the sampling frequency is lower than this frequency, aliasing occurs; the effect is seen in the backward spinning wheels of cars in movies.

**Tips**

There are videos available where the phenomenon is beautifully demonstrated, for example, with a helicopter. The link can be found with this demo B10 on the NVON website, www.nvon.nl/showdefysica2

Site

link https://www.youtube.com/watch?v=gkzKi-8cWxQ

Also, include a link to aliasing

Test results from Anita Tol to be incorporated