Chapter 1 Time-Lapse Introduction and theory

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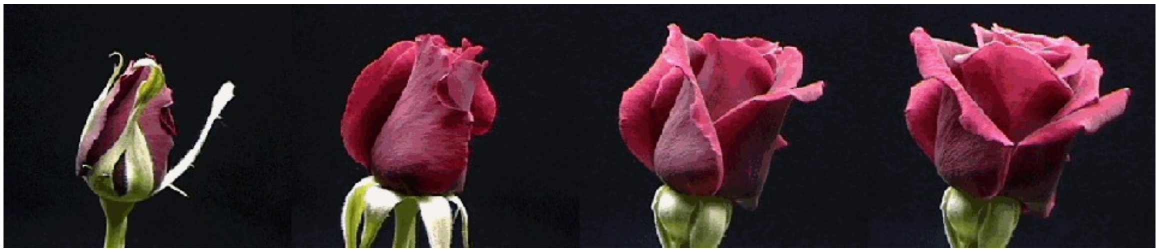


First a few words about terminology and spelling.

Time-Lapse is the correct spelling, although other spellings are seen with equal frequency. These spellings include Timelapse and Time Lapse. Several texts refer to time-lapse photography as chronophotography where chrono comes from Latin for time. Time-lapse systems can also be referred to as intervalometers.

This document was created in response to questions from a number of friends and acquaintances on the Internet. Although this document is not in the standard form of an FAQ, it does answer many questions and shows the way to solve common problems.

The science and art of time-lapse photography involves the manipulation of time to speed up processes. There are a number of related processes which are very much open to experimentation. Hopefully, I will be able to explain some of these techniques.

Time-lapse photography is defined as taking moving pictures at any rate slower than the standard 24 frames per second currently used in the movie industry. Even old footage that was filmed at 16 frames per second when shown at 24 fps can be said to be time-lapse because the observed action is speeded up. Time-lapse photography is often portrayed as a novelty shot to add comic relief, but the true nature of time-lapse photography shines when motion studies are involved. Objects such as clouds, plants, and chemical reactions that take days or months to run to completion can be filmed and speeded up by factors of millions. An acorn will sprout and appear to grow into a small tree in the matter of a few seconds. These films then become the jewels of the scientific world, new processes and observations are often discovered. The time-lapse photographer enters new territory with each assignment. Few people have the patience, or dedicated equipment to enter this field.

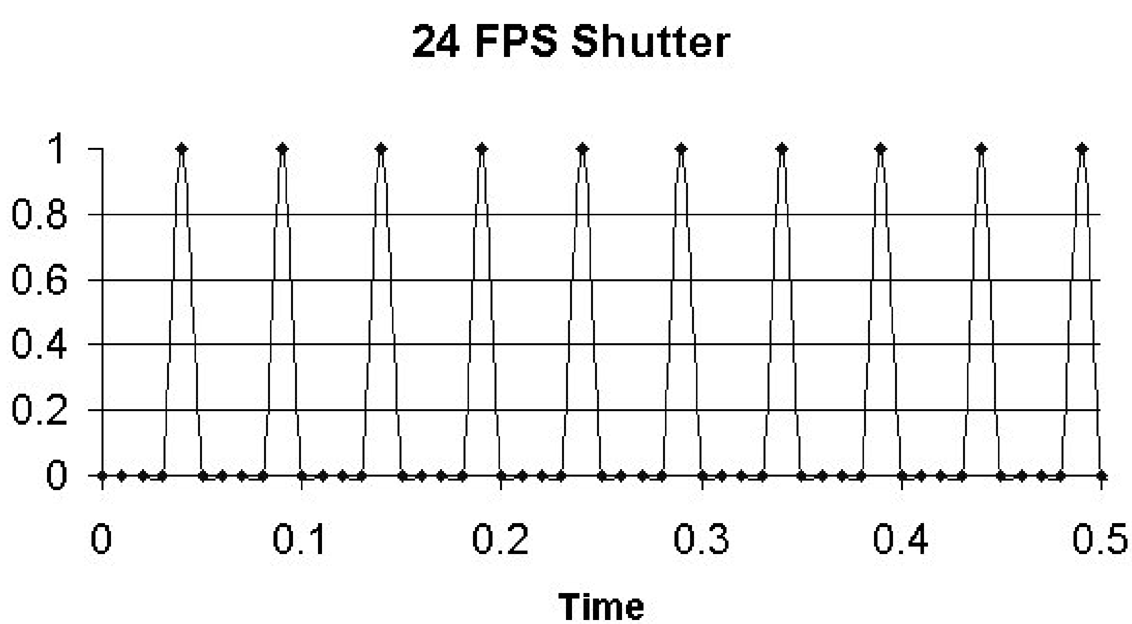
As an active scientific photographer specializing in time-lapse I am always interested in hearing from others in the field.

Time-Lapse Theory

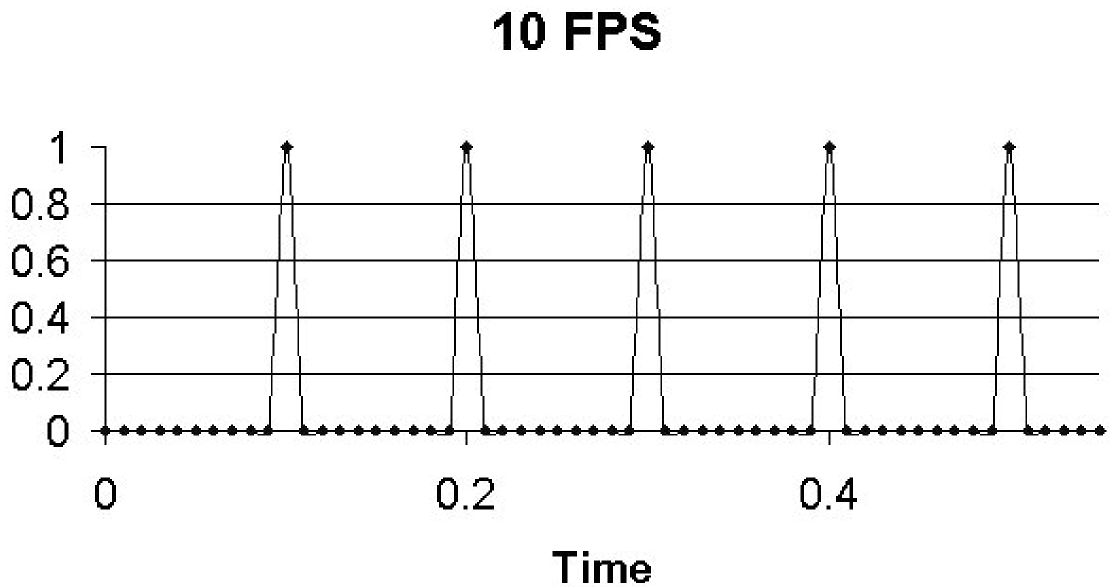
One of the most difficult aspects about time-lapse photography is choosing how long to turn the camera off between frames. This period when the camera is not exposing frames is called the wait time. The wait time can range from .25 seconds for a sped-up sequence of clouds, to one frame every 15 minute for an acorn growing into a small tree. Each subject has a specific wait time that gives the best results. The techniques shown in this chapter should act as general guidelines to help time-lapse photographers narrow down their choices of a wait time.

In the diagrams below, a high line represents an open shutter, while a low line represents a closed shutter.

A normal camera would have an exposure-time graph as shown below.
The film camera takes an images every 24^{th} of a second.



Time-lapse work can be represented by the following diagram: The above diagram would be for a film camera. If a video camera were used it would have 29.97 exposures per second. The video camera exposes 29.97 exposures in each second as compared to a film camera which would only expose 24 frames. The vertical axis of the graph represents a shutter opening and then closing. The shutter would be fully open when the vertical axis reads a value of 1. This graph represents an ideal shutter and not any specific camera.



This graph shows that there is a greater time between exposures than is shown in normal filming. The longer the duration between exposures, the more time is speed up when the final film is shown. Also the longer the time between exposures, the more difficult the filming.

To determine the time between exposures in a normal time-lapse, you will need to know how long the action you want to record takes. You will also need to know how long the finished sequence on film is to last.

Total time for the filming divided by the total number of frames is equal to the wait time between each exposure.

The following calculation will show how to compress two days into five seconds of film:

Two days = 48 hours = 2880 min. =172800 seconds.

$$\frac{172800 \text{ sec.}}{5 \text{ sec} \times 24} =$$

$$\frac{172800 \text{ sec.}}{120} = \text{1440 sec wait between exposures}$$

The above equation is a bit ideal. When filming a sequence, always try to over shoot. That is, expose 20% more frames than required. The extra exposures insure that you still have the shot if the subject moves more quickly than expected and will allow an editor to adjust the speed of the finished shot by dropping frames out during digital editing.

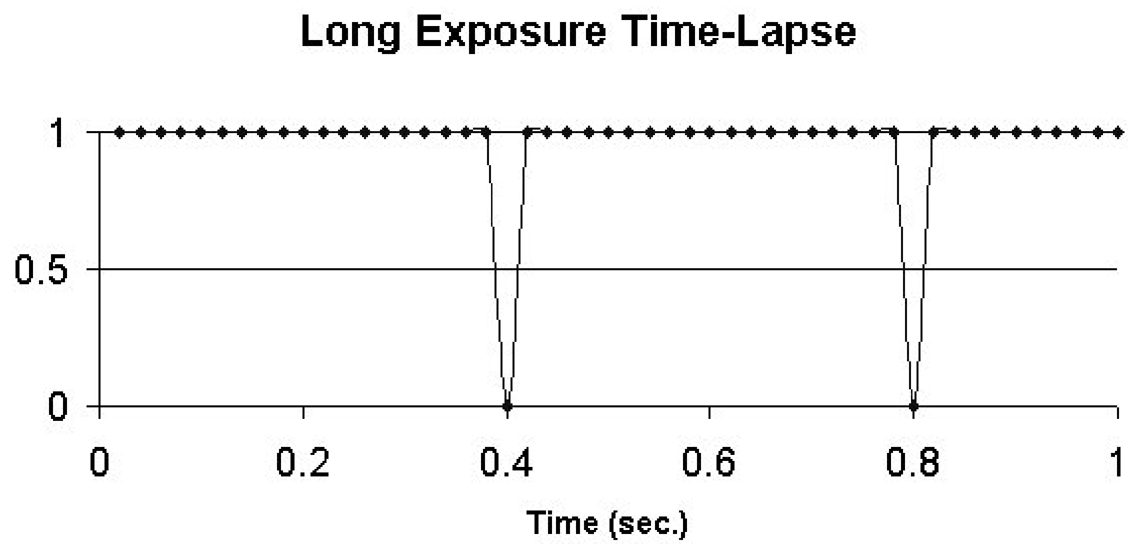
For 16-mm film, there are 40 frames per foot, and with 35-mm film there are 18 frames per foot. These values are useful when calculating how much shooting time is left on a roll or magazine. It is a good idea to leave at least ten feet of film a the end of the load. Never cut a shot too close. It is always easier to load a new magazine than to run the risk of a sequence taking longer than expected and running out of film.

It is still difficult to determine the correct wait time when the duration of the event is unknown. Take the example of filming a city from day to night. It is difficult to know exactly how the shadows will fall and the amount of light that will be available once clouds start moving in or evaporating near sunset. There are some variables that can never be accounted for and some scenes just need to be filmed for more than one day.

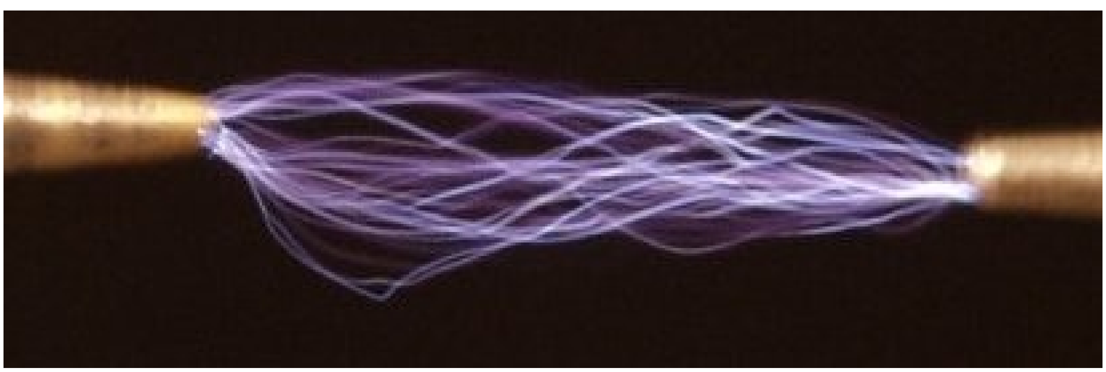
For fluid motion to be created from the individual frames of a time-lapse sequence, the subject only needs to move a small amount between each frame. How small a change between frames is a bit of a judgment call. If you can detect just a small change of position between individual frames, than your timing is right. The resulting shot can always be speeded up on a digital edit station. When filming long duration events, remember that it is quite common for scenes to change at variable rates. An example would be a construction site where cement might be poured in a day, steel goes up in a week, and then the finished brick work takes a month. All of these processes will require their own rate on the finished movie, although they might be all filmed at the rate of the fastest event. For more on timing a construction time-lapse, see chapter 12.

Long Exposure Time-Lapse

Another way to record information is with a long exposure time technique. In this technique the shutter is kept open and only closed to advance the film. Since the shutter is open much more than it is closed, there is a high probability that a random event will be photographed. This technique requires the camera shutter to be held open for a specific time before advancing to the next frame. A characteristic on-off pattern would be shown below.



The vertical axis is a high value of 1 when the shutter is open and low when the shutter is closed. The graph above shows a camera advancing the film twice during each of the low points. Since the shutter is open more than it is closed, this is a way to capture some unique images. This technique will turn a stormy sea into a magical mist and cars moving in traffic at night into tracers of red light. This is also useful for capturing meteor displays, the Aurora Borealis, car traffic, and lightning.



In this image a Tesla coil spark is filmed with a ½ second exposure to actually capture many discharges

One aspect of long exposure time-lapse filming is the duty cycle of the sequence. The duty cycle is important for capturing random events on film (for example lightning).

In normal time-lapse, a frame is exposed for a short duration and the camera waits a while before the next frame is exposed. The duty cycle of this shutter is defined as:

$$\text{Duty Cycle} = \frac{\text{Time Shutter is Open}}{[\text{wait time} + \text{shutter open time}]} \times 100$$

An Example: A camera has an exposure of 1/30 of a sec and waits 400 seconds between exposures. First the exposure fraction is converted to decimal form 1/30 = .0333 sec.

$$\text{Duty Cycle} = \frac{.03333}{400 + .03333} \times 100$$

$$= \frac{.03333 \times 100}{400.03333}$$

$$= \frac{3.333}{400.03333} = .832\ \%$$

In this case, the shutter is open less than 1% of the time.

To capture sporadic events like lightning, a duty cycle of 90% or greater is desired. This is also important in working with solenoids that might trigger a camera. In specific cases the solenoid will get too hot and fail if used above the rated duty cycle.

The Use of Time Reversal

Time-lapse photography can take advantage of human perception. In many situations the average viewer can not tell the direction time is moving. Below are two sequences to show this effect. On one the direction of time is from the left to the right (normal), and on the other the direction of time is from right to left (reversed.) Can you tell which sequence is running forward, and which one is run in reverse?

Forward or Reverse?

If you are having trouble telling which of the sequences is reversed, you are not alone. This principle is of great value to time-lapse photographers. If you need to film a flower opening, and the only flower you have is already open, then film the flower closing and run the resulting film in reverse. This is a fine procedure as long as you can get away with the time reversal trick. If processes are filmed where there is a clear direction to time, the trick will not work. For instances with plants, if the flower wilts before closing or wilts as it closes, the film can not be run in reverse. Spend some time observing the processes to see if filming in reverse has any advantage. Some flowers will pop open in a few minutes, and you will waste a lot of film waiting for the event to happen. The same flower closes quite slow and is a candidate for the time reversal process. Have you decided which of the above shots is in reverse? It is the one on the bottom.

All time-lapse photographers suffer from the second guess syndrome. That is, when a camera is set up and taking picture, the photographer wonders if the correct wait time has been chosen. It is very tempting to change the wait time, but doing so will wreck the sequence. A sudden change in motion of any more than 20 percent is quickly noticed. If you are filming at a one second wait time and then jump to a 1.2 second wait time, this will be noticed on the final film. It is better to go in 10% steps, and then only if you are absolutely positive you know the desired wait time. Remember, it is always better to expose more frames than you need. You can always speed up a shot, but it is much harder to slow down a shot.

This chapter (and the ones that follow) will help in the selection of a wait time for a specific topic, but there is no substitute for a real subject timing test. A subject timing test allows the photographer to observe or measure how long the duration of an event will last. The test might use a video camera set off a few hours apart, or even a still camera or a low resolution digital camera to get a basic idea how fast a particular scene or event will change. If at all possible, a digital test should be done to create a movie. This timing test insures that the director of photography, or the art editor is satisfied with the timing sequences and does not want the photographer to shoot more film or digital stills.