Laboratory 1: Synch and Delay

To: R&D Team
From: James W. Bales
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Re: Synch and Delay
IM1a-JWB

This R&D lab pioneered the *synch and delay* method of analyzing high-speed phenomena (you have all seen the milkdrop photo that the old-timers studied for our food-products division). Our production division pointed out about a dozen different places in the plant where this analysis technique may be of use.

It appears that a difficult part of synch and delay is triggering the strobe. I've seen references to optical triggers (sometimes called "beam-break" or "reflective" triggers), switch closure (or "contact") triggers, and audio triggers. I've also read reports that claim that it is important that the event be reproducible, but they did not quantify what they meant by this term.

I'd like your team to investigate the three different kinds of triggers, and report to me your findings about the strengths and weaknesses of the synch and delay *technique*. In particular:

1. Describe in detail the procedure used for each trigger.
2. State the reproducibility you found for each triggering method.
3. Present a series of photographs illustrating the process by which a balloon pops.
4. For each trigger method, describe an application where it might be the best choice.

Assignment

Take photos of a balloon as it is popping using a sound trigger to initiate the strobe. Demonstrate that you can map out the entire process from initial contact of the pin onto the rubber to the point where the balloon is essentially gone. I would expect that at least 3 to 5 different time delays are required. For each delay, bracket your exposures by full stops.

Repeat taking photos of a balloon as it is popping using a beam-break trigger to initiate the strobe. Again, use 3 to 5 different time delays map out the entire process. For each delay, bracket your exposures by full stops.

Finally, take photos of a balloon as it is popping using the contact trigger. Again, use 3 to 5 different time delays to map out the entire process. For each delay, bracket your exposures by full stops.

Write up your results in a memo (a separate memo from each member of the team). Your memo should meet the four requirements listed above.

Laboratory 1: Synch and Delay -- Detailed Instructions

Pre-Laboratory Assignment

For the lab sessions you will need to bring yourself, a *pen* (not pencil), and your lab notebook. At least one of you should bring a calculator. As with all MIT subjects, labs start *5 minutes* after the appointed hour. Your team mates are counting on you being on time!

Before you come to your lab session, you must write down in your lab notebook:

1. *Your answers to all pre-lab questions*
2. *A list of the materials you will need to complete this lab.*
   In some cases you will not know exactly what you will be using – so a description will be fine (i.e. "something to pop the balloon", "something to measure the time between the trigger event and the strobe flash"). You should think carefully about this, as by mid-term your TA will only allow you to use what is on your list. If you forget something fundamental, like "camera" or "lens", this will be a problem.
3. *Project Plan*
   The object of this part of the pre-lab is to work out exactly what needs to be done and why during the lab session so you can be as efficient as possible. Think of it as a mental walkthrough of the lab.

   List out the major goals of the lab session (note that learning how to use the equipment is *not* a goal of this lab, just a convenient side benefit). The deliverables listed on the next page will help with this.

   Underneath each goal, list all measurements, drawings, and photos you will need to have before you leave lab to accomplish the goal. Note how many photos will you need, and describe how the balloon might look in each. Also under each goal, list anything that you will need to remember while setting up and any equations you may need to use.

Hand in the carbon-copy pages when you come to lab.

These items are required of you each week at the start of your lab session. We understand that there may be some confusion or misunderstanding as to our expectations in the first, but are confident that within a few weeks you will have these requirements mastered.

Pre-Lab Questions

Assume you have a strobe with a BCPS of 40, and that at a distance of two feet from the strobe, the hotspot is one foot in diameter. (The hot spot is the area of brightest light produced by the strobe.) Your 35-mm camera (negative size is 36 mm by 24 mm) has a 50-mm-focal-length lens and ASA 400 film. Your subject is a 12-inch-diameter balloon, and you want its image to almost fill the negative. **What do you select for:**

1. ***The camera-to-subject distance***
2. ***The strobe-to-subject distance***
3. ***The aperture?***

For each answer, explain why you selected that value.

Objectives

1. To determine the relative strengths and weaknesses of three methods for triggering strobes: optical beam-break, audio, and switch contact.
2. To map out the process by which a balloon pops

Deliverables

The deliverable for this effort is a report that will

1. Provide the background that the reader needs to understand
   a. What is meant by "synch and delay"
   b. How the three triggering methods work
2. Set forth a detailed procedure (with set up diagrams and/or photos and a list of equipment used) that would allow a reasonably skilled researcher to re-create your experiments
3. Present characteristic images of the events studied.
   a. For each of the three trigger methods, three images will be included, all taken with the same delay setting, intended to show the reproducibility (or lack thereof) for that process. The images will have different exposures, as different aperture settings will be used. Why is reproducibility important?
   b. Also, for each of the three trigger methods, a sequence of three to five images of the process of the phenomenon being studied, taken with different delays. Does your choice of triggering change the popping process? Why?
4. Discuss the relative merits of the three methods, with examples where each might be best.
5. Make recommendations as to when to chose one method over the other, and of ways to improve the results of the experiment if it were done again

Tips

Since you don't know *a priori* the right delay to use to map out a process, you might try this approach:

a) Start with a delay and take a photo.
b) Double the delay and take another photo.
c) If the process is complete, split the difference between the original delay and the most recent delay (e.g., started with 500 μs, but at 1 ms, the process is over so try 750 μs).
d) If the process is still going on, then double the time step (e.g., started with 500 μs, doubled to 1 ms, saw the process was still going on, so went to 2.0 ms).
e) Repeat c) or d) until you have a sequence of images of the event.

Don't forget to bracket your shots.

Document your work

Document your work carefully, include a table of photos taken, measurements of all distances for your set-up diagrams. We recommend that you take photos of the set-up for your report - use the FM-10 to take those images, log them in your notebook, and make the prints as you would any other images for your lab work.

Document the electrical connections between the various elements of your apparatus, noting *exactly* which connectors your group used on each item (e.g., a block diagram showing Channel 1 of the oscilloscope connected to the trigger input of the strobe).