6.163 Strobe Project Laboratory

Sample quiz with answers

1

The Marine Hydrodynamics Laboratory at MIT has a water tunnel in which researchers test propellers, hydrofoils and other sorts of submerged objects. For propeller experiments there is a strobe light that permits the motion of the blades to be 'stopped'. The strobe can be triggered by a magnetic pickup on the propeller shaft so that it fires once per revolution, and delay can be added so that the propeller can be viewed at any desired point in its rotation. There is a need to have photographs of the propeller blade for presentation at conferences. Someone else ran exposure tests a while back, so you know what f-stop to use for a single flash. You would like your photographs to be exposed by a single flash to get the clearest image. The camera has no control over the strobe firing rate or when the strobe fires. The 12Ó diameter propeller is rotating at 2400 rpm.

A - What shutter speed should you set on your camera? [Be sure to explain your reasoning.] The camera has a focal plane shutter that is completely open for the following times:

camera setting	full open time, ms
1/90	2
1/60	6
1/30	22
1/15	54
1/8	118
1/4	246
B	as long as you hold it

ANSWER:

The propeller is rotating at 2400 rpm and the strobe flashes once per revolution. This is 40 Hz, so there is one flash every 25 milliseconds. You would like your shutter to be full open when one and only one flash occurs. The logical choice of shutter speed is therefore

1/30, as the shutter will be open for 22 milliseconds. Odds are very high that the flash will occur during that 22 milliseconds. Any shorter shutter open time (1/60, 1/90) just makes it less likely that the shutter will be open when the flash fires. Any longer shutter open time and it is certain that the flash will fire more than once during that time.

B- Even with the best choice of shutter speed something can go wrong. What is it, and what would you do to ensure that you get good pictures?

ANSWER

The thing that can go wrong is that on occasion the 22 ms open time may just happen to fall between the once-every-25ms flashes. The solution is to take several exposures for each desired picture, pretty much guaranteeing that one or more will be exposed by one and only one flash.

In order to have good picture quality you want to minimize blurring. You decide that it is permissible for the propeller to rotate no more than 1 degree during the exposure.

C- What is the maximum permissible flash duration?

ANSWER

The propeller is rotating 40 times per second, or 40*360 = 14,400 degrees per second. To keep rotation to 1 degree the flash duration must be no more than 1/14400 sec = 69.4 microseconds.

2

A lab has a small centrifuge that is making a banging noise. They want you to image the problem so that it can be fixed. One of your first questions is "Does this just happen once in a while or does it seem to be regular (once per revolution)?" Why would you ask this,

and how would it influence what equipment you might take to tackle the job in either case? Which techniques that you learned in lab would be applicable (or not), and how?

ANSWER

If an event happens once in a while it is somewhat unpredictable, and you need some way to capture it when it occurs. If it is a once-per-rev sort of event the triggering and imaging are easier.

Happens once in a while

stroboscope - not very useful. Even if you 'stop' the motion a one-time event will be difficult to see and analyze.

microflash - a very special unit, with ultra-short flash. Not a general-purpose item. Good for bullets. Maybe applicable if centrifuge is fast enough (do calculations to support this).

synch/delay - good bet, if you can figure out something about the event that provides you with a reliable trigger.

multiflash - not good. Triggering problems as above, and you would get a superimposed multi-image that would be difficult to interpret.

high speed video - best bet. Especially useful is the capability you used in your lab session that lets the unit continually record over itself, and only stop when it has been triggered -- and it saves a user-specified number of frames that occured before the trigger. This makes the triggering requirements easy, as you can in effect see into the past.

Regularly periodic

stroboscope - good tool. Use the strobe to stop the motion or make it appear to move slowly forward or back. Since the event occurs each revolution you should be able to watch it in detail.

microflash - as above. Triggering is now straightforward, but use of this tool only justified if a super-short flash is really needed.

synch/delay - good tool. Synch on anything convenient and use delay to image the various stages of the event.

multiflash - as above. Triggering easy, but value of images questionable.

high speed video - useful as above, but no special triggering needed. Just record a segment into memory and play back at desired speed. Problem would only occur if rotation rate of centrifuge so fast that the 1000-frames-per-second capability is too low. (But there are faster units and even the one you used can operate at higher frame rates if part of the vertical image area is sacrificed.)

3

You are commissioned to take detailed photographs of a cobra's head in the process of striking, from a side-on view. Unless you actually want to be in the pit with the reptile you will have to stay behing a railing 10 feet away. The position at which the cobra will strike can be well controlled, so where to aim the camera is not an issue. The event is mostly horizontal, and you want to image an area 12" - 13" wide onto 35 mm film (24x36 mm).

A- What is the right focal length lens to use?

ANSWER

You are mapping 12 - 13" of real world onto 36 mm of film. This is a magnification of 1/9 (9*36mm = 324mm = 12.75"). You know that the object distance is 10'. Use the equation o=F(1+1/m). Then o=10*F, F=1'=304.8mm. Since the magnification does not have to be exact, choose a 300mm lens or a zoom lens that operates in the 300mm range. (An exact solution based on clearly stated numbers would be a perfectly acceptable answer.)

B- You would like the blur from movement during the strike to occupy no more than 0.2 mm on the film. What is the maximum flash duration that will allow you to achieve this? [If you do not know the value of any needed quantities, use variables and express the answer as an equation.]

ANSWER

You want the blur to be <=0.2mm on the film. Since the magnification is about 9, this corresponds to a motion of 9*0.2=1.8mm in the real world. We don't know the speed of the strike (check encyclopedia or call a herpetologist or measure with something like high speed video) so assign it to variable V. Then the time for the head to move 1.8mm is 1.8/V seconds (if V is in mm/sec). The flash duration must be t<=1.8/V