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Making High-Quality Videos on an Inexpensive DIY Lightboard (with Technical Tips Relevant to all Budgets)

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MERRIMACK COLLEGE

What is a Lightboard?

A lightboard [ref. 1] is a device for producing high-quality instructional videos, in which the presenter writes with neon markers on a pane of glass or plexiglass rimmed with LED lights while facing the camera; when done well, the presenter appears to be writing in the air (see, for example, Figure 2).

My low-budget lightboard

Following the outbreak of the pandemic I was concerned that I would not have -- and would not want to have! -- access to the 5-foot-wide lightboard I had built at Merrimack (with Merrimack colleague Chris Duston and a group of students, adapted from the Duke University design [ref. 2]), so in May-June 2020 I designed and built a home lightboard in my basement, shown below.

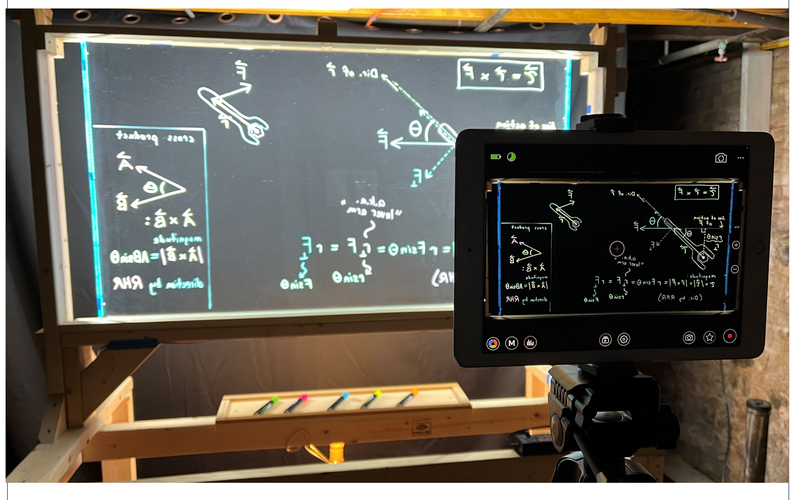

Figure 1. Low-budget DIY home lightboard, with camera (iPad with MoviePro app) shown in the foreground. This photo was taken with automatic settings; consequently the colors on the whiteboard are washed out. Careful attention to MANUAL SETTINGS allows the colors to stand out in the recorded video and also helps mask glass flaws and smudges etc.; see figure 2.

Cost breakdown:

- Low-iron glass 28”x48”x3/8” ……. was $360 (now $660)
  {28”x48”x1/4” plexiglass would be under $200 … talk to me about the pros and cons of glass vs. plexiglass}
- Wood/screws/casters ……$110
- LED lights, power, power adjustment…… $150
- Other* …… $170
- Camera: $0. Save money, use a smartphone (etc.)! But see “camera settings” in center column!

[*Other: markers $10, microfiber cloth for cleaning $10, clip-on-polarizer $10, black backdrop $30, wireless earpiece/mic $40, extension cord reel $30, MoviePro app (for manual settings control!) $10; phone/iPad tripod $30]

(my low-budget lightboard, continued …)

Structural/design features

- Glass dimensions were chosen to optimize 16:9 HD video format and to balance price, weight, usability
- 3 side glass perimeter access allows for easy replacement of perimeter LEDs without removing glass from frame.
- The glass frame/support is removeable from base with 4 screws (this will allow me to move the lightboard out of my basement if I ever move).

Lighting: I use type 2835 12-volt LED strips (6000-6500K) for glass rim lighting (taped directly to top and side edges of glass) and presenter lighting (taped to top and sides of frame). Following the Duke University design [ref. 2] I originally used PWM dimmers to control the light intensity, but I recently replaced these with **DC step-down converters** to eliminate “banding” effects (see 3rd column for more details).

Smartphone/tablet CAMERA SETTINGS

{camera settings acknowledgement: Steve Griffiths [ref. 3]}

Exposure: ISO and shutter speed should be set manually (using 3rd party app) to make the colors “pop” and to mask glass defects/smudges/etc. (Note: the presenter should be OVER-illuminated to compensate for the reduced exposure.)

“White balance” is less important but should also be set manually for best results.

The figure below illustrates what is possible (on a low-budget lightboard!) with careful attention to camera settings. For details, talk with me!

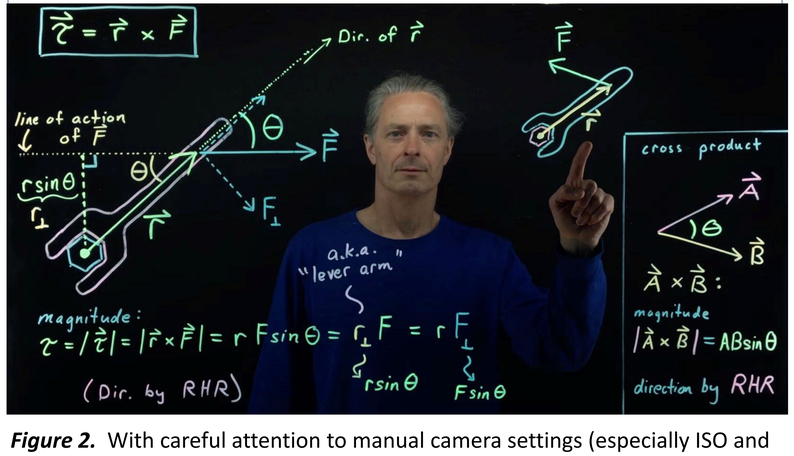

Figure 2. With careful attention to manual camera settings (especially ISO and shutter speed), the glass itself appears invisible, glass defects and smudges are masked, and pen colors clearly stand out. This video was taken using my (6+ year old) 2017 iPad Pro; camera SETTINGS are far more important than the camera itself, as long as the camera is “good enough” for 1920x1080 HD.

[Advanced, but low cost!] BANDING, and how to eliminate it!

LED lighting strips normally operate with an applied voltage of 12 Volts. Low-cost PWM (Pulse Wave Modulation) dimmers “dim” the lights by periodically turning on and off (or reducing) the applied voltage. For example, in the oscilloscope scans shown in the figure below, the period is approximately 800 microseconds, which corresponds to a frequency of about 1250 Hz.

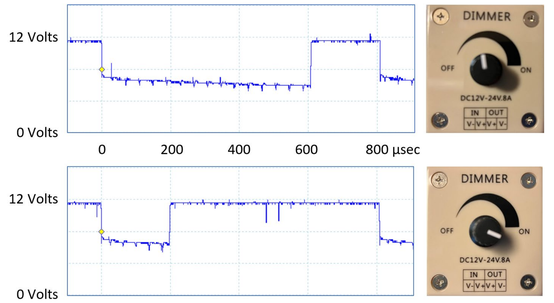

Figure 3. The top and bottom dial positions shown correspond respectively to having the lights “fully on” for ¼ or ¾ of the full 800 microsecond period.

The 1250 Hz “dimming frequency” cannot be detected by the naked eye, but can interact with other frequencies in the filming process to produce noticeable banding effects in video recorded with high shutter speeds (see figure 4, below). This is particularly important when filming with ***phones*** (etc.), which – unlike DSLR cameras – have no aperture adjustment and hence must rely solely on ISO and shutter speed to reduce exposure (in order to make the colors “pop” and to mask glass flaws/smudges/etc. as previously discussed).

Fortunately, there is an easy (and inexpensive) fix*: instead of using PWM dimmers, use adjustable DC step-down converters or variable DC power supplies to deliver a steady but adjustable DC voltage to the LED lights.* Since suitable DC step-down converters range from $2 to $20 (vs. $10 for a PWM dimmer) and suitable variable DC power supplies are available for $20, there is no reason to use PWM dimmers to control lightboard LEDs.

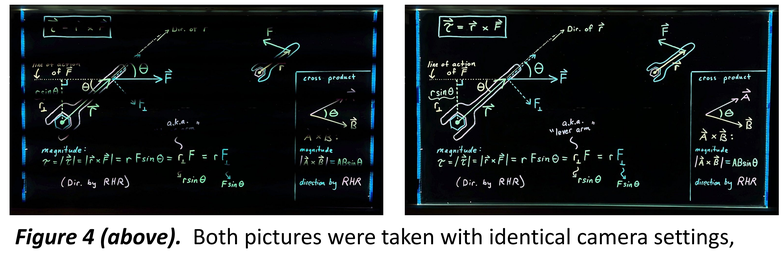

Figure 4 (above). Both pictures were taken with identical camera settings, including identical high shutter speeds chosen to magnify potential banding effects. The use of a DC step down converter (right) completely eliminates the banding resulting from use of a PWM dimmer (left).

References:

[1] See www.lightboard.info, maintained by Michael Peshkin, (independent) co-developer of the open-source lightboard.
[2] Overview: https://sites.duke.edu/ddmc/2014/06/04/the-lightboard-is-done/
Build details: https://duke.atlassian.net/wiki/spaces/LIG/pages/22085707/Lightboard
[3] I learned about the importance of camera settings from Steve Griffiths (or, rather, from his videos). See, for example: https://youtu.be/i68rwDF8ipA