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Systematic Errors in Intro Lab Video Analysis

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Systematic Errors in Intro Lab Video Analysis

Abstract

In video analysis lab experiments, students frequently find large discrepancies between results based on self-filmed videos and expected values (e.g. for g determined by a fit to projectile motion data). These differences are frequently far larger than the uncertainty calculated from their fit. Using an inexpensive point-and-shoot camera with a 4x optical zoom to record video, we investigated two possible causes of this error: the effect of placing the reference meter stick at a different object-to-camera distance and the effect of the motion of interest being in a plane not perpendicular to the camera lens. When we observed these phenomena for wide angle, normal, and telephoto focal length settings we found systematic errors as large as 40%. Based on our findings, we make recommendations for minimizing these errors.

Keywords

laboratories, experiments, cameras, errors, measurement

Disciplines

Laboratory and Basic Science Research | Physics

Comments

Presented at the Iowa Section of the American Association of Physics Teachers Meeting held in Des Moines, Iowa, on November 7, 2015. Presented later by Dr. Zwart at the winter meeting of the American Association of Physics Teachers held in New Orleans on January 11, 2016.



Systematic Errors in Intro Lab Video Analysis

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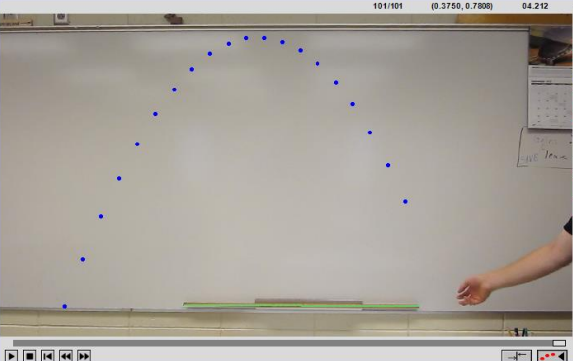
Logger Pro - twoDmotion.cmbl*

File Edit Experiment Data Analyze Insert Options Page Help

Page 1 Collect

No device connected.

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VideoAnalysis

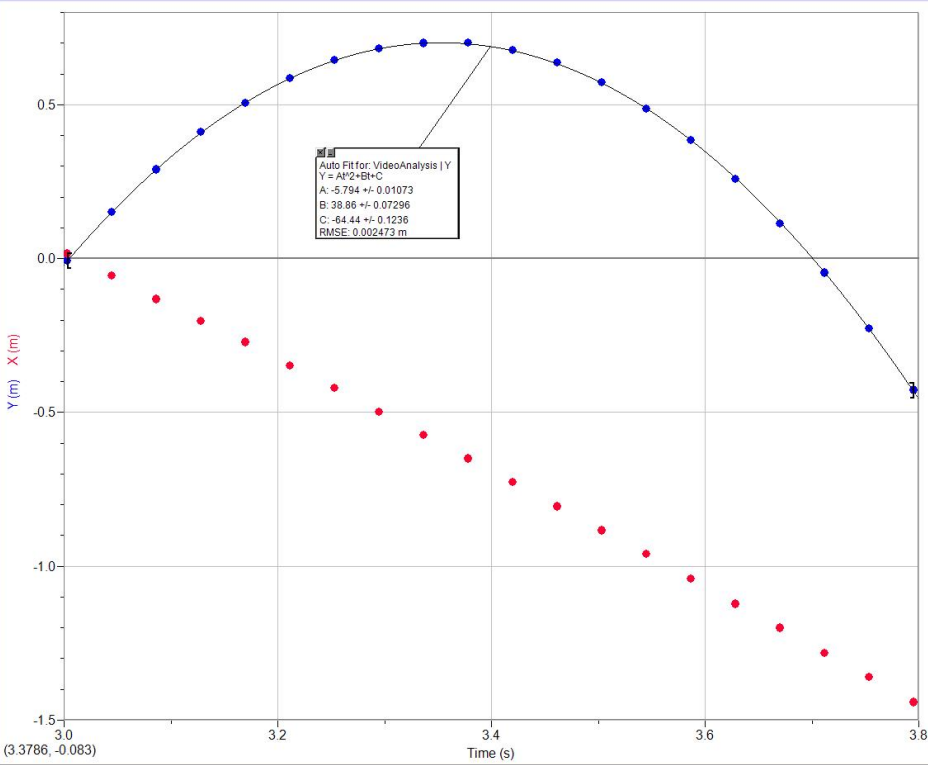
	Time (s)	X (m)	Y (m)	X Velocity (m/s)	Y Velocity (m/s)
1	3.003	0.01491	-0.007291	-1.728	3.830
2	3.045	-0.05579	0.1503	-1.752	3.401
3	3.086	-0.1325	0.2891	-1.751	3.059
4	3.128	-0.2038	0.4108	-1.713	2.596
5	3.170	-0.2718	0.5043	-1.747	2.118
6	3.212	-0.3495	0.5866	-1.782	1.654
7	3.253	-0.4219	0.6444	-1.794	1.153
8	3.295	-0.4985	0.6815	-1.813	0.676
9	3.337	-0.5735	0.6998	-1.825	0.217
10	3.378	-0.6507	0.7011	-1.840	-0.270
11	3.420	-0.7264	0.6780	-1.862	-0.776
12	3.462	-0.8063	0.6360	-1.881	-1.278
13	3.503	-0.8846	0.5715	-1.876	-1.781
14	3.545	-0.9614	0.4862	-1.896	-2.256
15	3.587	-1.042	0.3840	-1.923	-2.741
16	3.629	-1.124	0.2574	-1.915	-3.218
17	3.670	-1.201	0.1138	-1.916	-3.655
18	3.712	-1.283	-0.04678	-1.918	-4.068
19	3.754	-1.362	-0.2281	-1.915	-4.415
20	3.795	-1.443	-0.4282	-1.925	-4.645
21					

Replay

Data Set: VideoAnalysis Hide Data

Speed: 0.100 x Original Repeat

Help Pause Start Close



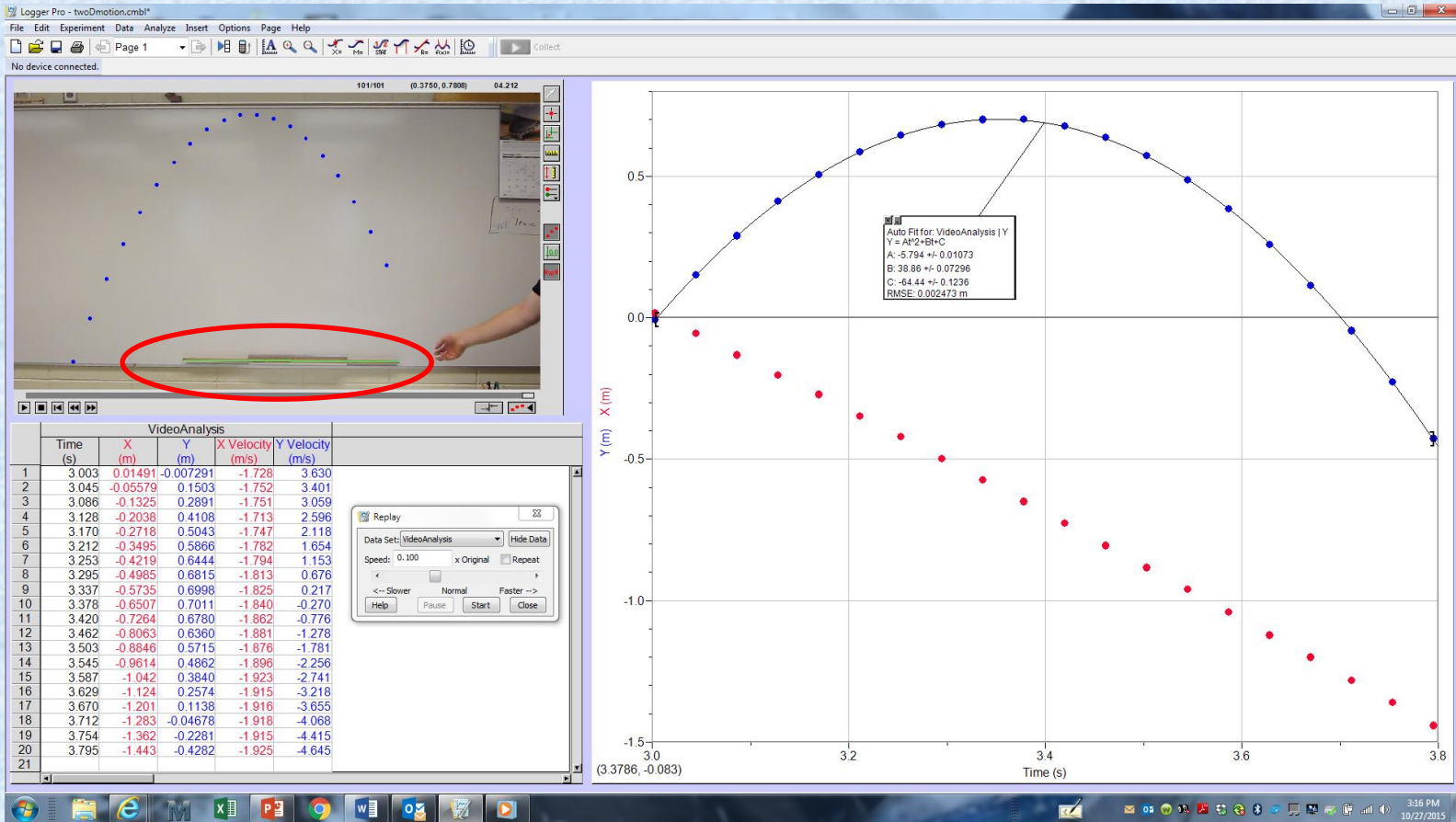
Auto Fit for: VideoAnalysis | Y
 $Y = A \cdot X^2 + B \cdot X + C$
 A: -5.794 +/- 0.01073
 B: 38.86 +/- 0.07296
 C: -64.44 +/- 0.1236
 RMSE: 0.002473 m

Y (m) X (m)

Time (s)

(3.3786, -0.083)

3:16 PM 10/27/2015



Fit to vertical motion shown yields $g = 11.74 \pm 0.02 \text{ m/s}^2$!!!

But data/graphs/fits are:

- sensitive to motion that varies in distance from camera
- sensitive to correct scaling factor

How can we measure the effects of these two factors?

Does camera focal length play a role?

Cannon PowerShot A1200



Camera has:

5.0 to 20.0 mm focal length zoom lens (4x optical zoom)
(35mm camera equivalent of 28 to 112 mm)

Video clip capability



Wide angle $f = 5\text{mm}$

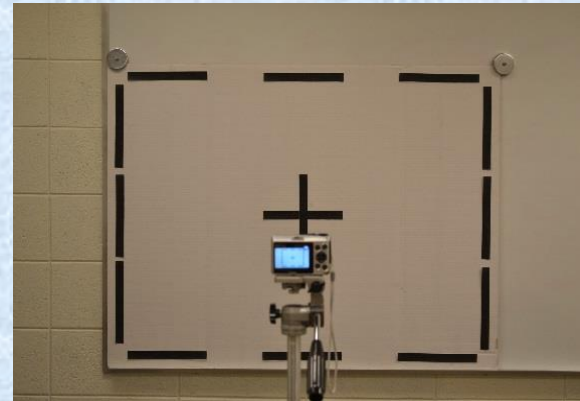


normal view

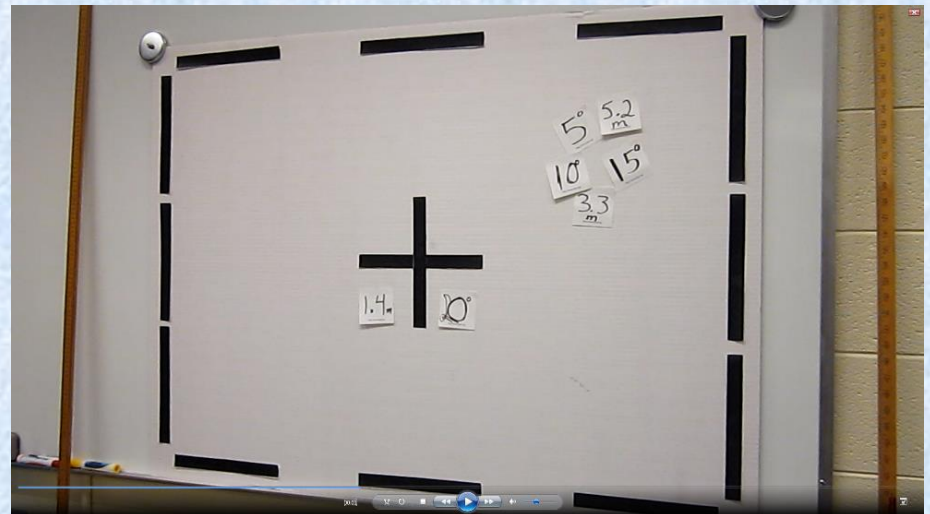
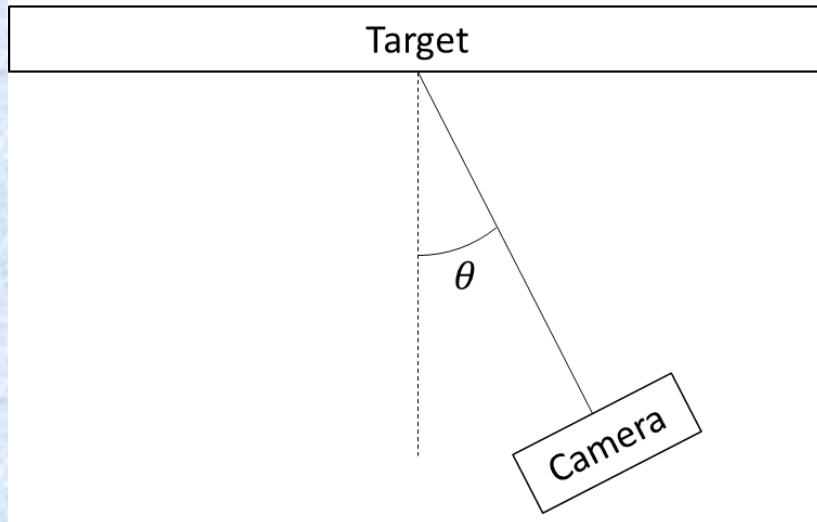


telephoto $f = 20\text{mm}$

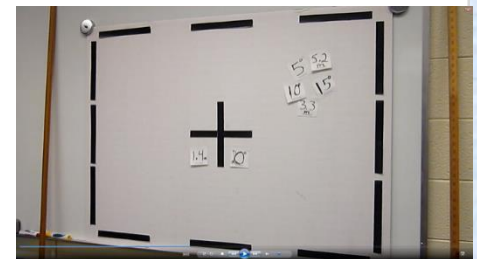
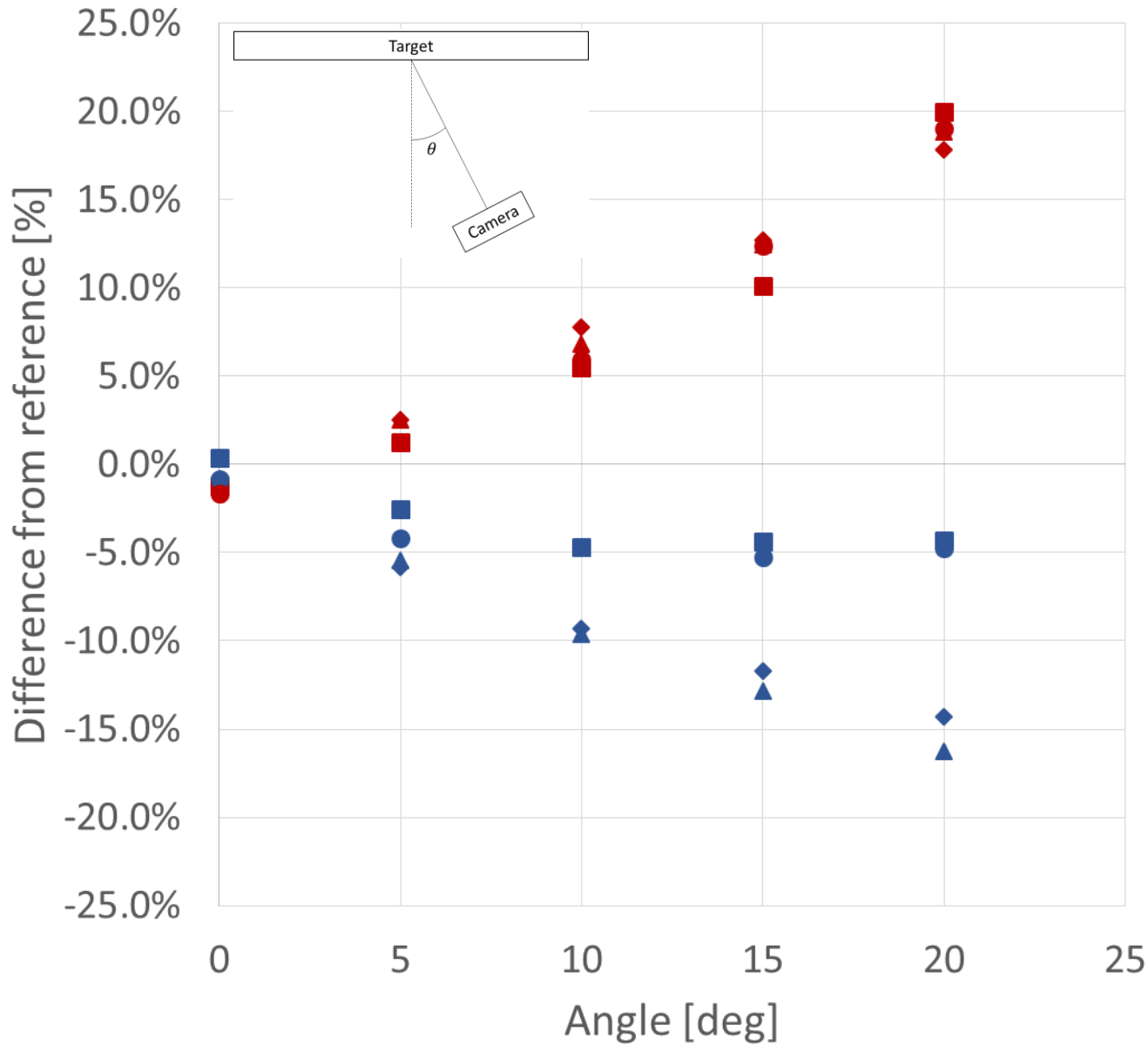
Experiment 1:



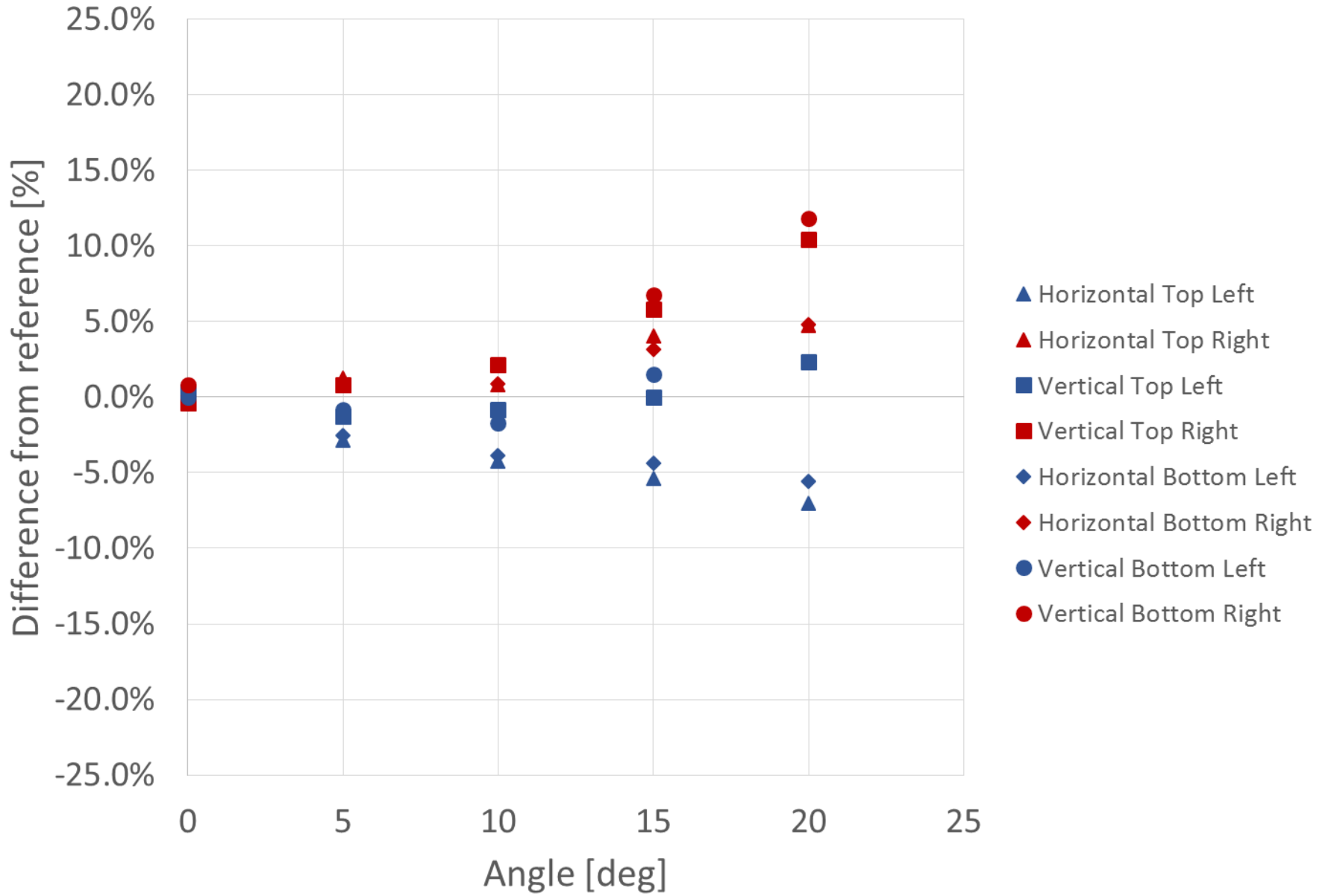
- Set zoom at wide angle and moved to fill frame with target
- Shot video clips with camera at normal incidence and then changed angle
- Repeated with zoom at telephoto and 'normal' settings
- Used center horizontal segment and found apparent length of other segments



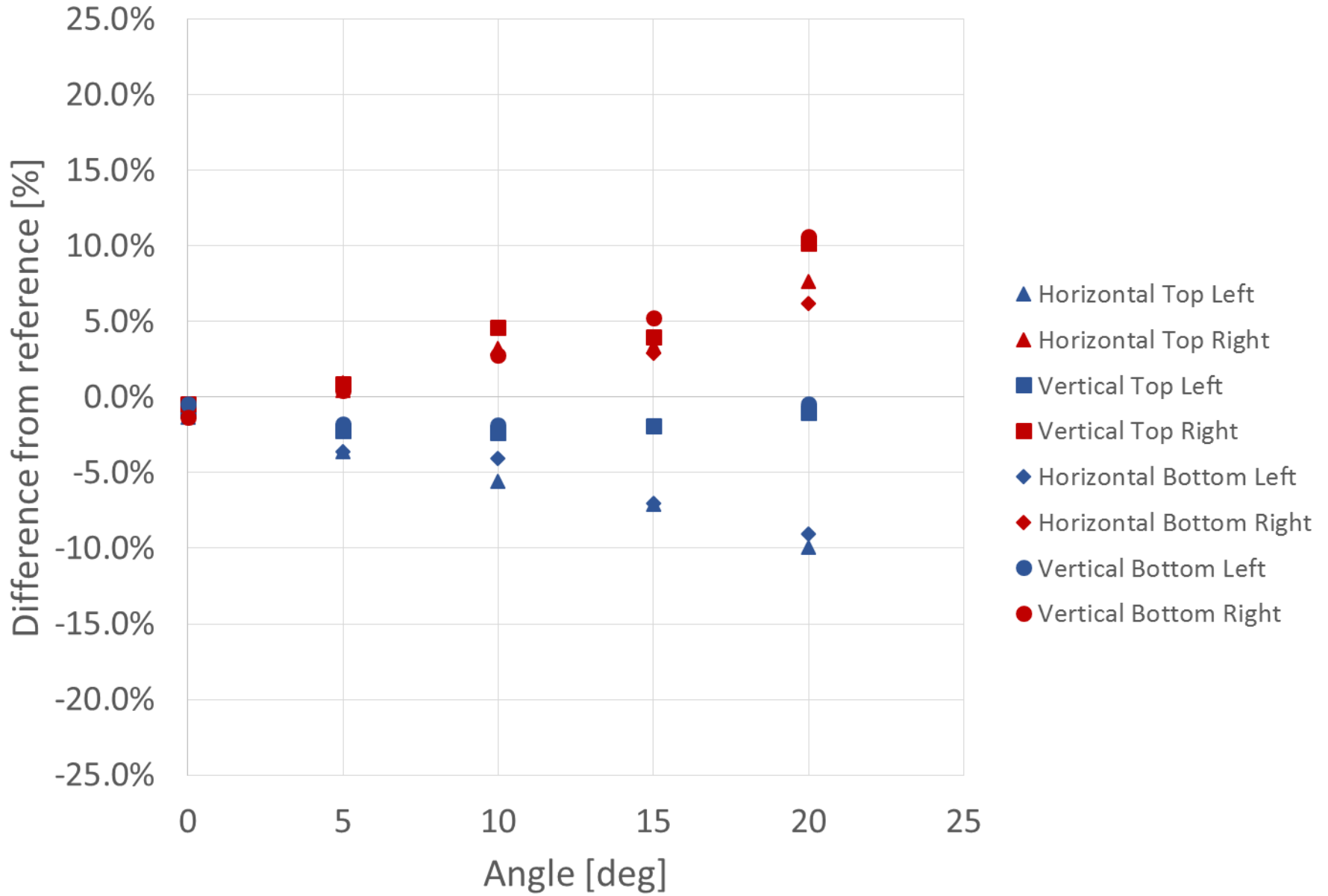
Wideangle



Telephoto



Normal



Results summary of apparent length change:

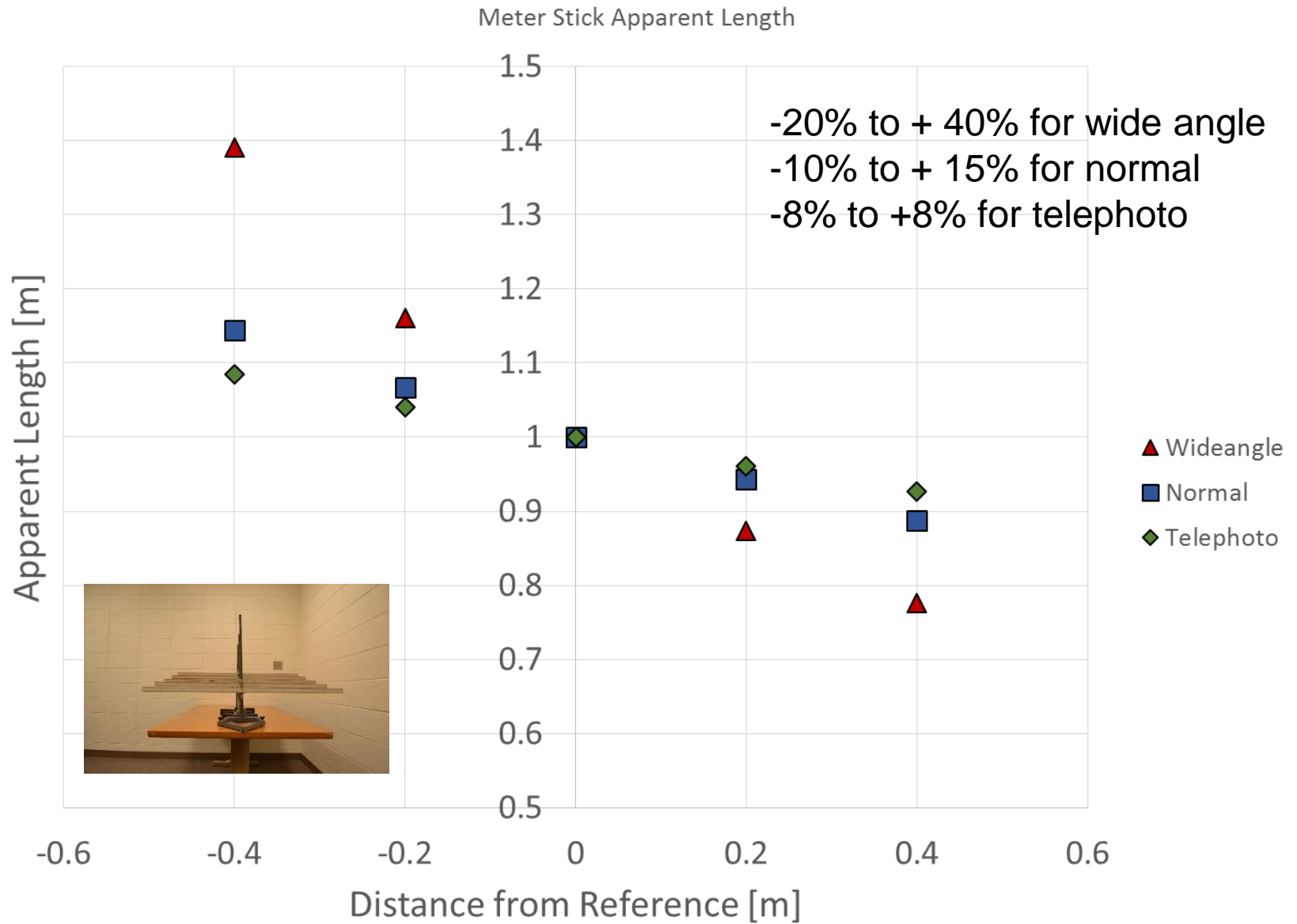
- – 16% to + 20% variation for wide angle ($f = 5.0$ mm)
- – 7% to + 11% variation for telephoto ($f = 20.0$ mm)
- --10% to + 10% variation for normal ($f \sim 13$ mm)

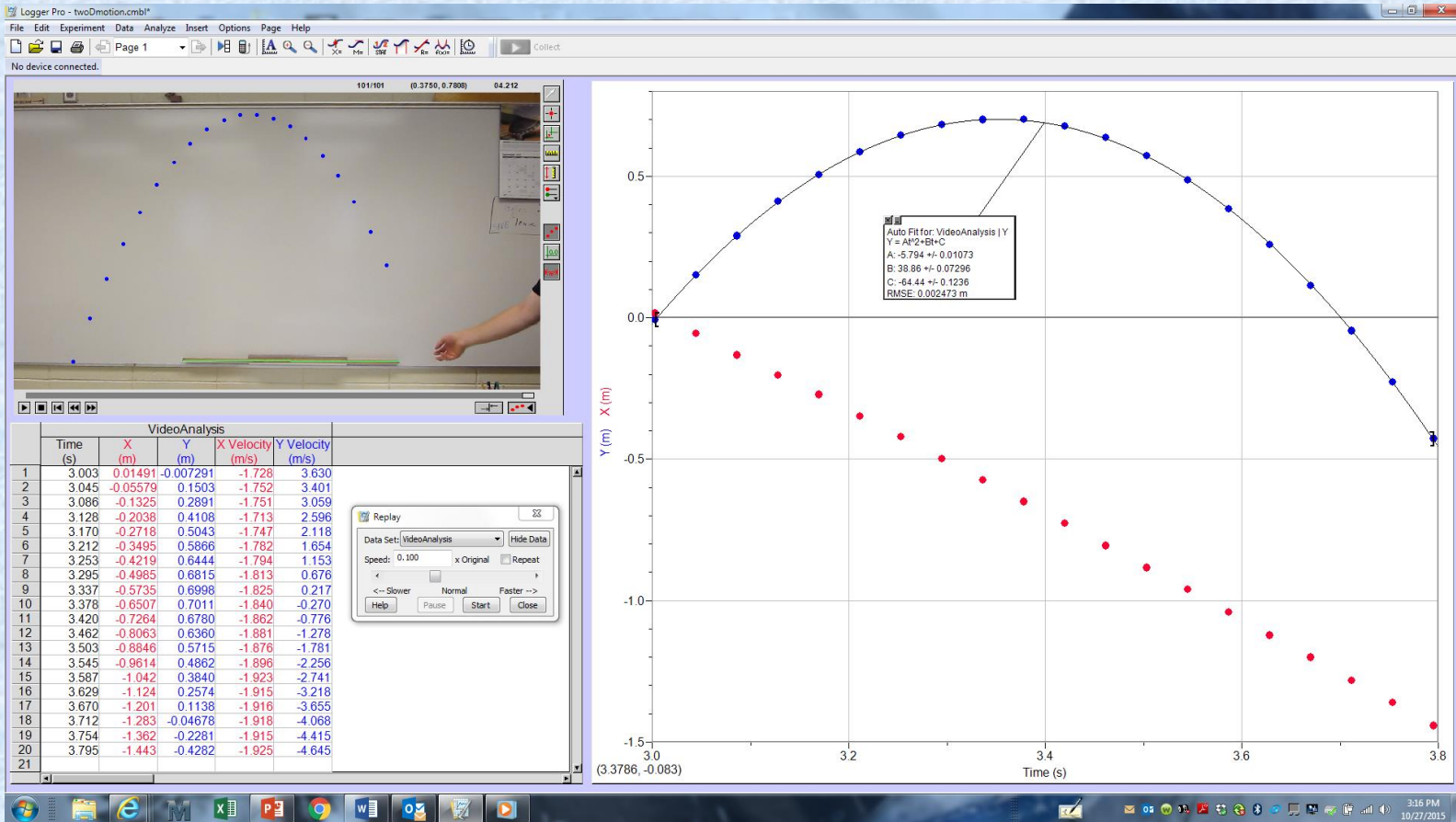
Experiment 2:



- Set up array of 5 meter sticks varying 20 cm apart horizontally
- Made measurements at wide angle, normal, and telephoto settings
- Set camera at same distances as Experiment 1
- Used center to set scale and measured apparent length of other sticks

Experiment 2:





Fit to vertical motion shown yields $g = 11.74 \pm 0.02 \text{ m/s}^2$!!!

Moral of the story:

Try to keep motion plane perpendicular to camera

Try to have reference length same distance from camera
as motion

Stay away from frame corners

Stay away from the wide angle setting for the camera lens

Questions?

See <http://homepages.dordt.edu/zwart/> for detailed information on the material presented

Feel free to e-mail me with any questions john.zwart@dordt.edu