
Using Shared Data collection in large classes

— Physics introductory classes —
Jennifer Weinberg-Wolf
Duane Deardorff

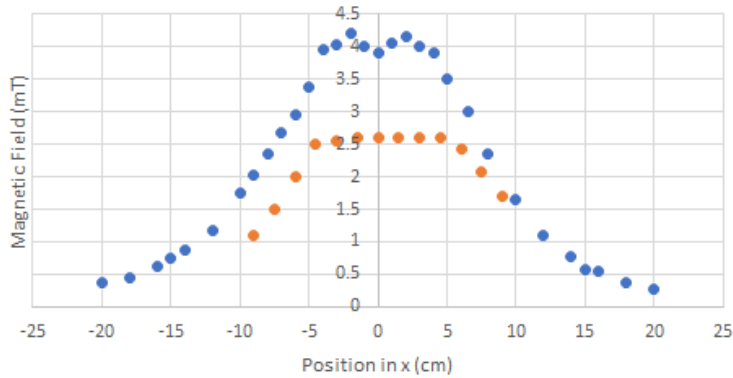
The problem - limited class time for high quality data collection of interesting problems

The solution - share data collection

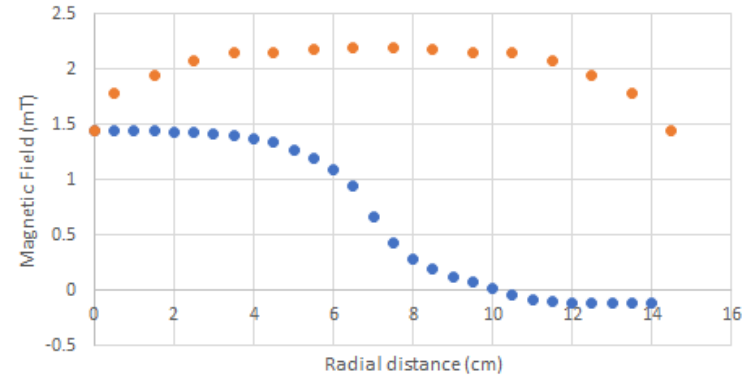
- Maintain high quality data
- Cover more (directions, situations, geometries, etc.)
- Collect more (larger N)
- Fix data on the spot (students learn in real time from each other)
- Efficient with limited time

Maintain High Quality Data (B-Field measurements)

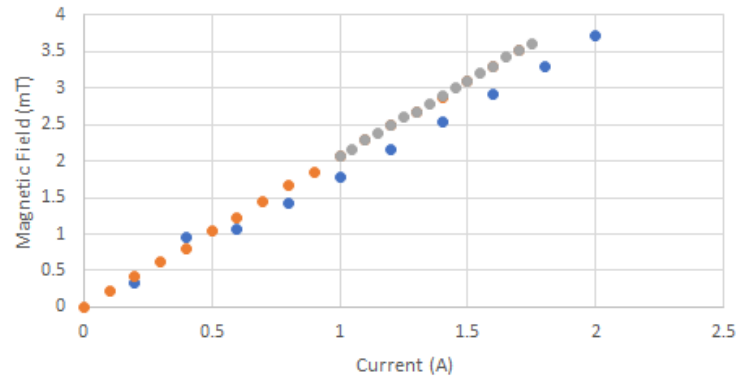
Axial Magnetic Field of a Helmholtz Coil



Radial Magnetic Field of a Helmholtz Coil



Current dependence of Magnetic Field

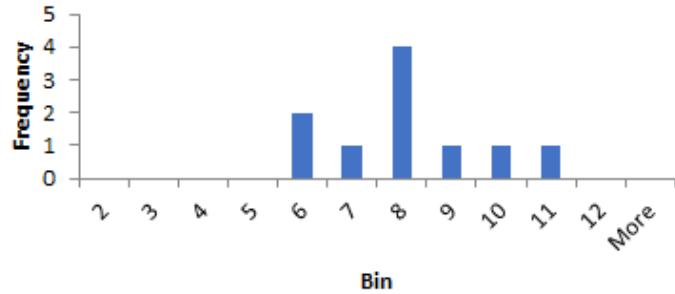


Cover more scenarios (Diffraction)

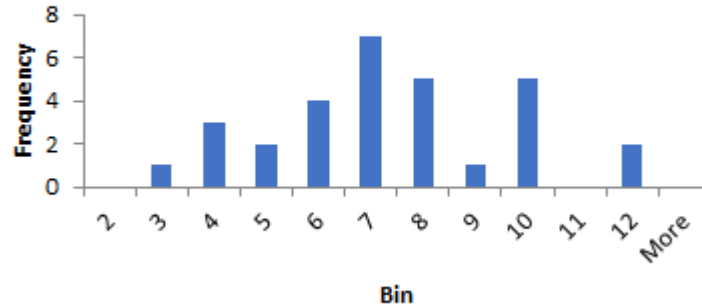
- Limited class time BUT many possible parameters to investigate
 - Number of slits
 - Slit spacing
 - Slit width
 - Wavelength of light
- Within 45 minutes of data collection, a class can generate data for 27 different experimental combinations - this would be impossible without sharing data!
- Reduce “busy work” of repeated, similar measurements
- Standardized spreadsheet ensures relevant data is collected

Collect more data (Probability)

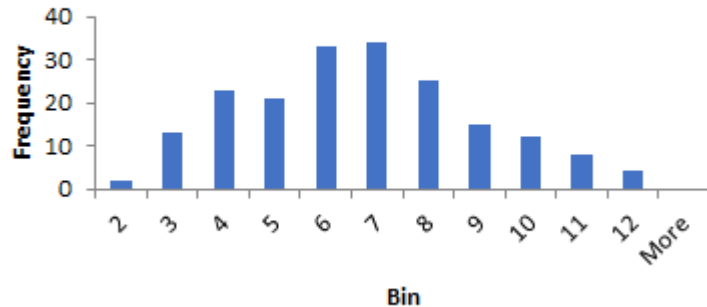
N=10 - One Student



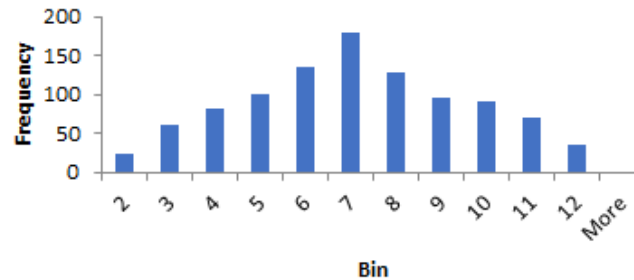
N=40 - Single Group



N=200 - One Class



N=1000 - Multiple Studios



Fix errors (work and energy lab activity)

Students and instructors can see collective results in real time, notice errors/outliers, and correct mistakes that might have been overlooked.

The following screen shots are from two different lab sections of Physics 104 on a single day - note time and date in lower right corner.

Notice in particular section 411 from 12:05 to 12:22 (last two slides), how the students in row 6 changed their numbers to reduce the relative energy loss from 70.5% to 27.2%, which made their results consistent with other groups.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1		Exploration 1												Exploration 2		Exploration 3	
2	Group Members	Mass of Cart (kg)	Hanging Mass (kg)	Initial Position (m)	Final Position (m)	Distance moved (m)	Average Force (N)	Initial Speed (m/s)	Final Speed (m/s)	Work Done (J)	Change in Kinetic Energy (J)	(W-K)/W	Time Finished	Have you discussed results with your group?	Time Finished	Video number	Mass of Bob (kg)
3	John, Sally, Harry	0.641	0.1	0.129	0.919	0.79	0.78	0	1.4	0.62	0.63	-1.94%					0.03
4	Nikita, Nandan, Ruchi, Aashni	0.612	0.0997	0.16	1.211	1.051				0.00	0.00	#DIV/0!					0.03
5	Melinda, Katherine, Dasol, Nicole, Mid	0.6	0.0998	0.247	0.692	0.445	0.621	0.038	0.968	0.28	0.28	-1.81%					0.03
6	Emily, James, Luke, Erin, Katherine	0.624	0.091	0.12	0.84	0.72				0.00	0.00	#DIV/0!					0.03
7	Will, Stephen, Caroline, Natalie	0.624	0.0906	0.274	0.372	0.098	0.845	0.376	0.606	0.08	0.07	14.90%					0.03
8	Rachel, Taylor, Morgan	0.599				0				0.00	0.00	#DIV/0!					0.03
9	Kallie, Kamaira, Ariel, Gary	0.632	0.115	0.177	0.637	0.46				0.00	0.00	#DIV/0!					0.03
10	Jared, Alex, Matt, Charlotte, Thomas	0.636	0.0995	0.207	0.836	0.629		0	1.16	0.00	0.43	#DIV/0!					0.03
11	Savannah, Farah, Joyah, Naveen	0.644	0.0989			0				0.00	0.00	#DIV/0!					0.03
12						0				0.00	0.00	#DIV/0!					0.03
13						0				0.00	0.00	#DIV/0!					0.03
14																	
15																	
16																	
17																	

PHYS104: Work and Energy Activity ☆

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
1		Exploration 1												Exploration 2		Exploration 3		
2	<u>Group Members</u>	<u>Mass of Cart (kg)</u>	<u>Hanging Mass (kg)</u>	<u>Initial Position (m)</u>	<u>Final Position (m)</u>	<u>Distance moved (m)</u>	<u>Average Force (N)</u>	<u>Initial Speed (m/s)</u>	<u>Final Speed (m/s)</u>	<u>Work Done (J)</u>	<u>Change in Kinetic Energy (J)</u>	<u>(W-K)/W</u>	<u>Time Finished</u>	<u>Have you discussed results with your group?</u>	<u>Time Finished</u>	<u>Video number</u>	<u>Mass of Bob (kg)</u>	<u>Height (m)</u>
3	John, Sally, Harry	0.641	0.1	0.129	0.919	0.79	0.78	0	1.4	0.62	0.63	-1.94%					0.03	
4	Nikita, Nandan, Ruchi, Aashni	0.612	0.0997	0.23	0.74	0.51	0.817	0	1.057	0.42	0.34	17.95%					0.03	
5	Melinda, Katherine, Dasol, Nicole, Mid	0.6	0.0998	0.247	0.692	0.445	0.621	0.038	0.968	0.28	0.28	0.00%					0.03	
6	Emily, James, Luke, Erin, Katherine	0.624	0.091	0.12	0.84	0.72	0.65	0.5	1.21	0.47	0.38	19.06%					0.03	
7	Will, Stephen, Caroline, Natalie	0.624	0.0906	0.328	0.454	0.126	0.847	0.517	0.751	0.11	0.09	13.26%					0.03	
8	Rachel, Taylor, Morgan	0.599				0				0.00	0.00	#DIV/0!					0.03	
9	Kallie, Kamaira, Ariel, Gary	0.632	0.115	0.194	0.824	0.63	0.782			0.49	0.47	4.60%					0.03	
10	Jared, Alex, Matt, Charlotte, Thomas	0.636	0.0995	0.207	0.836	0.629	0.83	0	1.16	0.52	0.43	17.70%					0.03	
11	Savannah, Farah, Joyah, Naveen	0.644	0.0989	0.326	0.362	0.056	0.90	0.507	0.622	0.05	0.04	17.05%					0.03	
12						0				0.00	0.00	#DIV/0!					0.03	
13						0				0.00	0.00	#DIV/0!					0.03	
14	Jenna, Amanda, John, Shayna	0.647	0.0996	0.47	1.05	0.58	0.82	0.45										
15																		
16																		
17																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
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5	Melinda, Katherine, Dasol, Nicole, Mid	0.6	0.0998	0.247	0.692	0.445	0.621	0.038	0.968	0.28	0.28	0.00%					0.03	
6	Emily, James, Luke, Erin, Katherine	0.624	0.091	0.12	0.84	0.72	0.65	0.5	1.21	0.47	0.38	19.06%					0.03	
7	Will, Stephen, Caroline, Natalie	1.1	0.0906	0.328	0.454	0.126	0.847	0.517	0.751	0.11	0.16	-52.91%					0.03	
8	Rachel, Taylor, Morgan	0.599				0				0.00	0.00	#DIV/0!					0.03	
9	Kallie, Kamaira, Ariel, Gary	0.632	0.115	0.194	0.824	0.63	0.782	0.241	1.242	0.49	0.47	5.01%					0.03	
10	Jared, Alex, Matt, Charlotte, Thomas	0.636	0.0995	0.207	0.836	0.629	0.83	0	1.16	0.52	0.43	17.70%					0.03	
11	Savannah, Farah, Joyah, Naveen	0.644	0.0989	0.326	0.382	0.056	0.90	0.507	0.622	0.05	0.04	17.05%					0.03	
12						0					0.00	#DIV/0!					0.03	
13	good job everybody!					0				0.00	0.00	#DIV/0!					0.03	
14	Jenna, Amanda, John, Shayna	0.647	0.0996	0.458	0.536	0.078	0.82	0.45	0.83	0.06	0.16	-1.45%						
15	any other groups?																	
16																		
17																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
1		Exploration 1												Exploration 2		Exploration 3		
2	<u>Group Members</u>	<u>Mass of Cart (kg)</u>	<u>Hanging Mass (kg)</u>	<u>Initial Position (m)</u>	<u>Final Position (m)</u>	<u>Distance moved (m)</u>	<u>Average Force (N)</u>	<u>Initial Speed (m/s)</u>	<u>Final Speed (m/s)</u>	<u>Work Done (J)</u>	<u>Change in Kinetic Energy (J)</u>	<u>(W-K)/W</u>	<u>Time Finished</u>	<u>Have you discussed results with your group?</u>	<u>Time Finished</u>	<u>Video number</u>	<u>Mass of Bob (kg)</u>	<u>Height (m)</u>
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6	Emily, James, Luke, Erin, Katherine	0.624	0.091	0.12	0.84	0.72	0.65	0.5	1.21	0.47	0.38	19.06%					0.03	
7	Will, Stephen, Caroline, Natalie	1.1	0.0906	0.346	0.474	0.128	0.907	0.363	0.554	0.12	0.10	17.02%					0.03	
8	Rachel, Taylor, Morgan	0.599				0				0.00	0.00	#DIV/0!					0.03	
9	Kallie, Kamaira, Ariel, Gary	0.632	0.115	0.194	0.824	0.63	0.782	0.241	1.242	0.49	0.47	5.01%					0.03	
10	Jared, Alex, Matt, Charlotte, Thomas	0.636	0.0995	0.207	0.836	0.629	0.83	0	1.16	0.52	0.43	17.70%					0.03	
11	Savannah, Farah, Joyah, Naveen	0.644	0.0989	0.326	0.382	0.056	0.90	0.507	0.622	0.05	0.04	17.05%	10:36 AM				0.03	
12						0					0.00	#DIV/0!					0.03	
13	good job everybody!					0				0.00	0.00	#DIV/0!					0.03	
14	Jenna, Amanda, John, Shayna	0.647	0.0996	0.458	0.536	0.078	0.82	0.45	0.83	0.06	0.16	-1.45%						
15	any other groups?																	
16																		
17																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
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5	Melinda, Katherine, Dasol, Nicole, Mia	0.6	0.0998	0.247	0.692	0.445	0.621	0.038	0.968	0.28	0.28	0.00%	yes				0.03	
6	Emily, James, Luke, Erin, Katherine	0.624	0.091	0.12	0.84	0.72	0.65	0.5	1.21	0.47	0.38	19.06%					0.03	
7	Will, Stephen, Caroline, Natalie	1.1	0.0906	0.346	0.474	0.128	0.907	0.363	0.554	0.12	0.10	17.02%					0.03	
8	Rachel, Taylor, Morgan	0.599				0				0.00	0.00	#DIV/0!					0.03	
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11	Savannah, Farah, Joyah, Naveen	0.644	0.0989	0.326	0.382	0.056	0.90	0.507	0.622	0.05	0.04	17.05%	10:36 AM				0.03	
12	Jenna, Amanda, John, Shayna	0.647	0.0996	0.458	0.536	0.078	0.82	0.45	0.83	0.06	0.16	-1.45%						
13																		
14	Hansen, Shannon, Aimee, Patrick	0.672	0.0997	Note: students in the 11:00 section should use the second worksheet in this Google doc.														
15	Troy, Brenda, Henry, Katharine, Sarah	0.635	0.0987	Note: students in the 11:00 section should use the second worksheet in this Google doc.														
16	Marc, Carlos Rosa, Michelle, Micheal	0.6062	0.0999	Note: students in the 11:00 section should use the second worksheet in this Google doc.														
17																		
18																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
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5	Melinda, Katherine, Dasol, Nicole, Mid	0.6	0.0998	0.247	0.692	0.445	0.621	0.038	0.968	0.28	0.28	0.00%	yes				0.03	
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8	Rachel, Taylor, Morgan	0.599				0				0.00	0.00	#DIV/0!					0.03	
9	Kallie, Kamaira, Ariel, Gary	0.632	0.115	0.194	0.824	0.63	0.782	0.241	1.242	0.49	0.47	5.01%					0.03	
10	Jared, Alex, Matt, Charlotte, Thomas	0.636	0.0995	0.207	0.836	0.629	0.83	0	1.16	0.52	0.43	17.70%					0.03	
11	Savannah, Farah, Joyah, Naveen	0.644	0.0989	0.326	0.382	0.056	0.90	0.507	0.622	0.05	0.04	17.05%	10:36 AM				0.03	
12	Jenna, Amanda, John, Shayna	0.647	0.0996	0.458	0.536	0.078	0.82	0.45	0.83	0.06	0.16	-1.45%						
13																		
14																		
15	Troy, Brenda, Henry, Katharine, Sarah	0.635	0.0987	Note: students in the 11:00 section should use the second worksheet in this Google doc.														
16	Martine, Tyler, Sarah, Ariana																	
17																		
18																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		Exploration 1												Exploration 2		Exploration 3		
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4	Hansen, Patrick, Aimee, Shannon	0.672	0.0997	0.16	0.949	0.789	0.875	0	1.166	0.69	0.46	33.8%					0.03	
5	Marc, Carlos Rosa, Michelle, Mich	0.6062	0.0999	1	0.2	0.8												0.03
6	Troy, Brenda, Henry, Katharine, Sa	0.635	0.0987			0				0.00	0.00	#DIV/0!						0.03
7	Olivia, Alexandra, Salma, Ahmad, I	0.608	0.0995			0				0.00	0.00	#DIV/0!						0.03
8						0				0.00	0.00	#DIV/0!						0.03
9						0				0.00	0.00	#DIV/0!						0.03
10						0				0.00	0.00	#DIV/0!						0.03
11						0				0.00	0.00	#DIV/0!						0.03
12						0				0.00	0.00	#DIV/0!						0.03
13	Britton, Rowena, Donna	0.653	0.0999			0				0.00	0.00	#DIV/0!						0.03
14																		
15																		
16																		
17																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		Exploration 1											Exploration 2		Exploration 3			
2	<u>Group Members</u>	<u>Mass of Cart (kg)</u>	<u>Hanging Mass (kg)</u>	<u>Initial Position (m)</u>	<u>Final Position (m)</u>	<u>Distance moved (m)</u>	<u>Average Force (N)</u>	<u>Initial Speed (m/s)</u>	<u>Final Speed (m/s)</u>	<u>Work Done (J)</u>	<u>Change in Kinetic Energy (J)</u>	<u>(W-K)/W</u>	<u>Time Finished</u>	<u>Have you discussed results with your group?</u>	<u>Time Finished</u>	<u>Video number</u>	<u>Mass of Bob (kg)</u>	<u>Height Change (m)</u>
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4	Hansen, Patrick, Aimee, Shannon	0.672	0.0997	0.16	0.949	0.789	0.855	0	1.166	0.67	0.46	32.3%					0.03	
5	Marc, Carlos Rosa, Michelle, Mich	0.6062	0.0999	1	0.2	0.817	0.792	0	1.259	0.65								
6	Troy, Brenda, Henry, Katharine, Sa	0.635	0.0987	0.962	0.2	0.762	0.8104	0	0.733	0.62	0.17	72.4%					0.03	
7	Olivia, Alexandra, Salma, Ahmad, I	0.608	0.0995			0				0.00	0.00	#DIV/0!					0.03	
8						0				0.00	0.00	#DIV/0!					0.03	
9						0				0.00	0.00	#DIV/0!					0.03	
10						0				0.00	0.00	#DIV/0!					0.03	
11						0				0.00	0.00	#DIV/0!					0.03	
12						0				0.00	0.00	#DIV/0!					0.03	
13	Britton, Rowena, Donna	0.653	0.0999			0				0.00	0.00	#DIV/0!					0.03	
14																		
15																		
16																		
17																		

PHYS104: Work and Energy Activity ☆

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		Exploration 1												Exploration 2		Exploration 3		
2	<u>Group Members</u>	<u>Mass of Cart (kg)</u>	<u>Hanging Mass (kg)</u>	<u>Initial Position (m)</u>	<u>Final Position (m)</u>	<u>Distance moved (m)</u>	<u>Average Force (N)</u>	<u>Initial Speed (m/s)</u>	<u>Final Speed (m/s)</u>	<u>Work Done (J)</u>	<u>Change in Kinetic Energy (J)</u>	<u>(W-K)/W</u>	<u>Time Finished</u>	<u>Have you discussed results with your group?</u>	<u>Time Finished</u>	<u>Video number</u>	<u>Mass of Bob (kg)</u>	<u>Height Change (m)</u>
3	John, Sally, Harry	0.641	0.1	0.129	0.919	0.79	0.78	0	1.4	0.62	0.63	-1.9%					0.03	
4	Hansen, Patrick, Aimee, Shannon	0.672	0.0997	0.16	0.949	0.789	0.855	0	1.166	0.67	0.46	32.3%					0.03	
5	Marc, Carlos Rosa, Michelle, Mich	0.6062	0.0999	1	0.2	-0.8	0.792	0	1.259	0.65	0.48	26.00%						
6	Troy, Brenda, Henry, Katharine, Sa	0.635	0.0987	0.962	0.2	0.762	0.8104	0	0.757	0.62	0.18	70.5%					0.03	
7	Olivia, Alexandra, Salma, Ahmad, I	0.608	0.0995			0				0.00	0.00	#DIV/0!					0.03	
8						0				0.00	0.00	#DIV/0!					0.03	
9						0				0.00	0.00	#DIV/0!					0.03	
10						0				0.00	0.00	#DIV/0!					0.03	
11						0				0.00	0.00	#DIV/0!					0.03	
12						0				0.00	0.00	#DIV/0!					0.03	
13	Britton, Rowena, Donna	0.653	0.0999	4.17	4.32	0.15	0.85	0		0.13	0.00	100.0%					0.03	
14																		
15																		
16																		
17																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1		Exploration 1												Exploration 2			Exploration 3		
2	<u>Group Members</u>	<u>Mass of Cart (kg)</u>	<u>Hanging Mass (kg)</u>	<u>Initial Position (m)</u>	<u>Final Position (m)</u>	<u>Distance moved (m)</u>	<u>Average Force (N)</u>	<u>Initial Speed (m/s)</u>	<u>Final Speed (m/s)</u>	<u>Work Done (J)</u>	<u>Change in Kinetic Energy (J)</u>	<u>(W-K)/W</u>	<u>Time Finished</u>	<u>Have you discussed results with your group?</u>	<u>Time Finished</u>	<u>Video number</u>	<u>Mass of Bob (kg)</u>	<u>Height Change (m)</u>	
3	John, Sally, Harry	0.641	0.1	0.129	0.919	0.79	0.78	0	1.4	0.62	0.63	-1.9%					0.03		
4	Hansen, Patrick, Aimee, Shannon	0.672	0.0997	0.16	0.949	0.789	0.855	0	1.166	0.67	0.46	32.3%					0.03		
5	Marc, Carlos Rosa, Michelle, Mich	0.6062	0.0999	0.181	0.799	0.618	0.792	0	1.259	0.49	0.48	1.84%	12:10 PM						
6	Troy, Brenda, Henry, Katharine, Sa	0.635	0.0987	0.97	0.1	0.87	0.7579	0	1.23	0.66	0.48	27.2%					0.03		
7	Olivia, Alexandra, Salma, Ahmad, I	0.608	0.0995			0				0.00	0.00	#DIV/0!					0.03		
8	Rachel, Callie, Matt, Zach, Zach	0.612	0.0996	-0.013	0.118	0.131	0.833	0.0057	0.596	0.11	0.11	0.4%					0.03		
9						0				0.00	0.00	#DIV/0!					0.03		
10						0				0.00	0.00	#DIV/0!					0.03		
11						0				0.00	0.00	#DIV/0!					0.03		
12						0				0.00	0.00	#DIV/0!					0.03		
13	Britton, Rowena, Donna	0.653	0.0999	4.17	4.32	0.15	0.85	0.56	1.29	0.13	0.44	-246.6%					0.03		
14																			
15	Martine, Tyler, Sarah, Ariana	0.6	0.0996	0.184	0.394	0.21	0.791	0.024	0.812	0.17	0.23								
16	Anna, Dana, Deepu, Thurston	0.6423	0.099	0.181	0.442	0.261	0.754	0	0.685	0.20	0.15	23.40%							
17																			