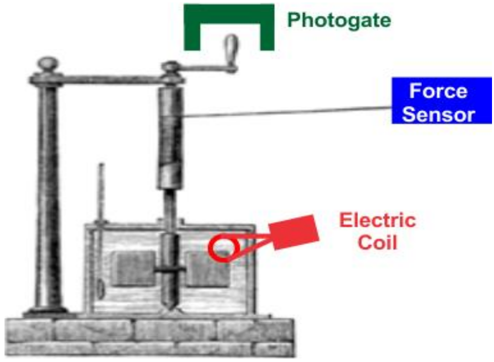
Labs Professors Fear



2. Amplifying the Joule Experiment: Impulse Per Volt?

Professor Du-Ane Du

www.Wacky1301SCI.com, *"Looking at serious science, sideways!"*

Joule's experiment can be amplified by adding an electric coil to compare electric heat to mechanical heat. This easily reproduced school lab shows that electric joules are a scaler multiple of impulse, 1 standard-linearized electric joule is always equivalent to 1.185 ρ of mechanical impulse, and 1 Volt = 1.185 ρ/C.
—By Du-Ane Du, Author of *Murdered Energy Mysteries*, (Amazon, Kindle, ebook 2018, paperback 2021).

This is the second of three experiments on the relationship between impulse (momentum-transfer), calories, and electric joules. Here, Experiment #2 is a sample mechanicalvs-electric heat experiment that can be repeated in a school or home lab. Experiment #1 is an analysis of Joule's original heat-is-work experiment, while electric-vs-magnetic force Experiment #3 can once again be duplicated and verified in a school or home lab. As one would expect, Labs Professors Fear produce results that are eye-opening, revolutionary, and controversial. *They are a must-perform for every aspiring engineer and physicist.*

Labs Professors Fear #2:

A detailed sample experiment amplifying Joule's heat-is-work experiment to include electric heat, was done by Mr. Du in Part 3, Chapter 4 of *Murdered Energy Mysteries*. This sample lab will begin with a lab-friendly excerpt of that dialogue, and will finish up with final observations and conclusions:

"How about this," Chip said. "One of the introductory questions on electricity asks, how much heat-impulse can be produced by 1.0 Cu-Zn volt."

“I take it we’re talking about a copper-zinc battery?” Tera hypothesized.

“Exactly,” Chip said. “Prior to 1885 scientists used electric measurements based on a system called CGS. Around 1836 a man named Daniell developed a copper-zinc battery that was inexpensive to make and very reliable. Joule’s proposals about electricity were based on Daniell’s battery. Finally, in the late 1880’s scientists used Daniell’s battery to standardize electric measurements, as Joule had suggested. The electric pressure, or inter-electron pressure, produced by the copper-zinc electrodes was called voltage, and was measured in a unit we can call Cu-Zn volts.”

“The current was still measured in amps?” Tera said. “You know, coulombs of electrons per second.”

“Yes.”

“What about heat? Is there a way to measure electric heat based on calories?”

“It’s fairly simple, the equation is,

$$(1\ volt)(1\ amp)(1\ sec) = 1\ J_{[1.2]} = 0.239\ cal,\text{”}$$

Chip said. “Or you can say that

$$1.0\ cal = 4.184\ J_{[1.2]}.\text{”}$$

"What equipment will I need?" Tera said. "Can I do the experiment in my room? I don't want the others to know about this."

"We can simulate the experiment here, and once you locate the equipment, you can perform the experiment in your bedroom."

"This is going to be a great secret," Tera gleefully whispered. "I'll work on it when Pico and Hectii are out of the apartment. Equipment?"

Equipment:

Loggerpro software or equivalent
Heat pulser
Heating coil
Electronic thermometer
Force sensor
Photogate
Large insulated cup/bowl
Smaller insulated cup, Water, Balance
Towel (for insulating)
Mineral oil
Hand mixer with wheel on its crank
Rubber bands, Tape, String
Clock or metronome

"I think I can find a lot of those at the kitchen store. What about a force sensor and electricity control devices?"

"I'll send a message and secure permission for you to borrow them from Ms. Ono, the Gravity Spa's science teacher," Chip said. "She may even let you use her lab after school."

"Let's do a simulation now, so I know how to do the experiment," Tera said.

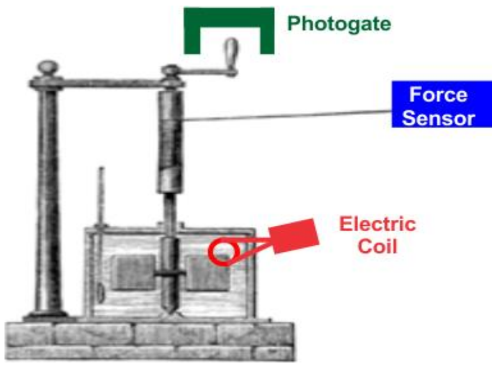
Chip drew illustrations on Tera's phone as he spoke, "This experiment will be done in three parts. We begin with an insulated bowl or large cup that'll hold the hand-mixer, an electric heating coil, electric thermometer, and mineral oil or cooking oil at the same time.

"The hand mixer has a hand-crank that's shaped like a wheel with a knob on the edge—a lot like the mixer Joule used! You place enough oil in the insulated cup, so it covers the mixing blades—and you don't want bubbles to form when you mix the oil."

"All this seems simple enough." Tera appraised.

Part 1A: Calibrating Hand Mixer

(Need: mixer, bowl, oil, force sensor, photogate, string.)



"In the first part," Chip said, "you attach a force sensor to a string, and wrap the string around the circular part of the mixer's hand crank."

"I see," Tera said. "That means, when I pull on the force sensor, it'll tell me the force-rate required to turn the mixer. I time the number of turns per second, and then I can calculate the impulse used per turn."

"Yes, and I can do the calculations for you."

"Do you have an example data-sheet that we can look at?" Tera said.

"First let's talk about the setup," Chip said. "A hand mixer is designed to mix liquids. You want to transfer momentum from your hand to the mixer, and the mixer blades will transfer the momentum to the molecules in the oil."

Symbols

$im\Delta\rho$ – impulse

$10\ \rho = 10$ kgm/s

$10\ \rho = 10$ N*s

5 N = 5 ρ/s

"Which means, I need the blades to have as much interaction with the liquid as possible," Tera said. "Instead of open blades, I'll crisscross rubber bands or put tape on the blades. That way the blades will mix more intensely, and the experiment will progress faster."

"Wonderful."

"Oh, and I'll need to test for friction," Tera said. "To do that I'll wrap a string around the hand-crank wheel, attach the string to the force sensor, and then pull the string with the mixer in the air. By mixing air only, when I pull on the string the force sensor will tell me how much impulse I'm giving to the mixer, and losing to friction."

"Here's an example data table of the friction caused by a mixer with its blades crisscrossed with tape," Chip said. "They measured a starting time, ending time, and the number of revolutions used to turn the hand crank.

"Then they calculated the revolutions per minute (rpm). The computerized force sensor multiplied the force and time to find the impulse, and the impulse was divided by the number of revolutions to determine the impulse for each revolution—that's located in the red column on the far right," Chip said as he displayed the following:

	FRICTION	No Oil			A
Start	End				ρ
Time	Time	# REV	RPM	Imp	Imp/rev
3.08	4.76	3	107.1429	0.4643	0.154767
2.36	3.5	2	105.2632	0.3001	0.15005
1.74	3.66	3	93.75	0.452	0.150667
2.02	3.96	3	92.78351	0.4858	0.161933
2	3.94	3	92.78351	0.4491	0.1497
1.58	3.76	3	82.56881	0.4874	0.162467
1.96	4.18	3	81.08108	0.4628	0.154267
1.78	3.28	2	80	0.2994	0.1497
2.96	5.32	3	76.27119	0.4496	0.149867
2.06	3.64	2	75.94937	0.3384	0.1692
2.22	3.84	2	74.07407	0.3168	0.1584
2.22	4.66	3	73.77049	0.4441	0.148033
2.48	4.92	3	73.77049	0.5077	0.169233
2.4	5.16	3	65.21739	0.4718	0.157267
2.44	5.54	3	58.06452	0.5003	0.166767
2.28	5.54	3	55.21472	0.5148	0.1716
2.64	6.3	3	49.18033	0.5782	0.192733
			friction	average	0.16258

"How'd they find the numbers for start and end times?" Tera asked.

"In the experiment, a photo-gate was used to detect when the crank-handle passed its start position," Chip said. "It turned one revolution before they started taking data, and they stopped taking data before the final revolution."

"Clever, I'll do the same thing," Tera said. "After I mix air to test for friction, I'll add cooking oil, or mineral oil to the insulated cup, and I'll crank the mixer to see how much impulse it takes to mix the oil at different speeds. Do you have a sample of how that might be done?"

"The red column in the next table tells us the impulse per revolution when oil is mixed, and the mixer is cranked at different speeds. In addition, the corresponding friction value was subtracted to find the impulse that was actually transferred to the oil," Chip said as he displayed the following:

Impulse Required By Mineral Oil **B**

Trial #	Start time	End time	#REV	RPM	Imp	ρ Imp/rev	FRICT-ION	ρ imp/rev
18	1.48	6.42	3	36.437	4.746	1.582	0.16258	1.4194
23	3	4.64	1	36.585	1.572	1.572	0.16258	1.4094
24	4.66	7.66	2	40.000	3.192	1.596	0.16258	1.4334
19	3.54	7.54	3	45.000	5.267	1.756	0.16258	1.5931
22	3.58	7.52	3	45.685	5.239	1.746	0.16258	1.5838
20	4.94	7.54	2	46.154	3.539	1.770	0.16258	1.6069
27	6.58	7.86	1	46.875	1.761	1.761	0.16258	1.5984
21	4.96	7.52	2	46.875	3.489	1.745	0.16258	1.5819
25	2.94	7.86	4	48.780	7.220	1.805	0.16258	1.6424
9	2.58	6.14	3	50.562	5.534	1.845	0.16258	1.6821
26	4.22	6.56	2	51.282	3.677	1.839	0.16258	1.6759
33	2.72	7.4	4	51.282	7.325	1.831	0.16258	1.6687
35	2.72	6.16	3	52.326	5.556	1.852	0.16258	1.6894
36	2.6	6.02	3	52.632	5.558	1.853	0.16258	1.6901
4	2.9	6.28	3	53.254	5.441	1.814	0.16258	1.6511
28	2.58	5.96	3	53.254	5.673	1.891	0.16258	1.7284
42	4.44	7.82	3	53.254	5.767	1.922	0.16258	1.7598
11	3.12	6.48	3	53.571	5.648	1.883	0.16258	1.7201

34	3.92	6.16	2	53.571	3.740	1.870	0.16258	1.7074	
29	2.82	5.06	2	53.571	3.751	1.876	0.16258	1.7129	
14	3.18	6.48	3	54.545	5.695	1.898	0.16258	1.7358	
2	1.88	5.12	3	55.556	5.446	1.815	0.16258	1.6528	
30	4.26	7.5	3	55.556	5.626	1.875	0.16258	1.7128	
32	2.42	5.66	3	55.556	5.708	1.903	0.16258	1.7401	
3	3.4	6.64	3	55.556	5.478	1.826	0.16258	1.6634	
7	3.04	6.26	3	55.901	5.741	1.914	0.16258	1.7511	
1	3.04	6.24	3	56.250	5.436	1.812	0.16258	1.6494	
10	3	6.2	3	56.250	5.734	1.911	0.16258	1.7488	
31	4.26	6.38	2	56.604	3.794	1.897	0.16258	1.7344	**about**
43	4.44	5.5	1	56.604	1.957	1.957	0.16258	1.7944	**60**
5	2.4	6.62	4	56.872	7.474	1.869	0.16258	1.7059	**RPM**
38	4.36	7.5	3	57.325	5.766	1.922	0.16258	1.7594	**1.759**
16	4.16	6.24	2	57.692	3.805	1.903	0.16258	1.7399	**1.740**
37	4.36	5.4	1	57.692	1.971	1.971	0.16258	1.8084	**1.808**
8	4.18	7.26	3	58.442	5.856	1.952	0.16258	1.7894	**1.789**
15	4.34	5.36	1	58.824	1.955	1.955	0.16258	1.7924	**1.792**
6	3.54	5.56	2	59.406	3.812	1.906	0.16258	1.7434	**1.743**
39	2.38	6.4	4	59.701	7.752	1.938	0.16258	1.7754	**1.775**
40	3.4	6.4	3	60.000	5.839	1.946	0.16258	1.7838	**1.784**
41	3.4	5.38	2	60.606	3.956	1.978	0.16258	1.8154	**1.815**
12	2.62	5.58	3	60.811	5.935	1.978	0.16258	1.8158	**1.816**
13	3.68	5.58	2	63.158	3.965	1.983	0.16258	1.8199	**1.820**
17	2.8	5.52	3	66.176	6.128	2.043	0.16258	1.8801	**1.880**
							Average around 60:		**1.794**
	Best fit line = 0.0071693844X				+	**1.441865573**			**Best fit line says =**
				0.013550519		**0.983326629**		**At 60**	**1.796**

“That’s a lot of data,” Tera said. “It looks like they did the experiment over 40 times, and then they arranged it by…”

"Increasing rpm (revolutions per minute)," Chip said. "The computer identified the starting and ending times, and it calculated the rpm involved in each experiment. The computer multiplied force by the time to determine how much impulse was used. Then the impulse was divided by the rpm to determine how much momentum the impulse transferred to the oil during each revolution."

"And the friction column uses the data from the first experiment to subtract the amount of impulse that was wasted in the friction of the mixer," Tera noted. "What's the line at the bottom for?"

"To keep things simple, the main experiment will be done at 1 revolution per second, or 60 rpm."

Tera nodded her approval, "Making it easier to count and turn the crank at a steady speed—all you do is watch the seconds-window of a clock!"

"Or listen to a metronome," Chip said. "The data was graphed, and a best-fit line was used to predict how much impulse would be needed to turn the crank."

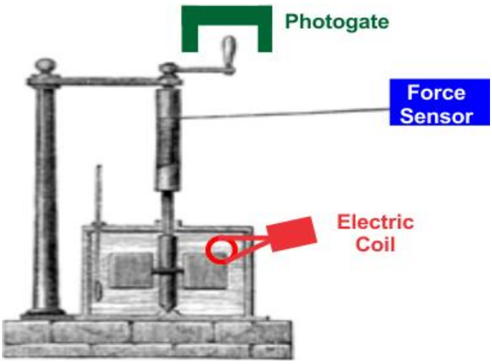
"Why not just average the values around 60?" Tera said. "That produced a value of 1.794 momentums per turn of the crank."

"When the data fluctuates in a nice linear fashion, scientists prefer to use a best-fit line to make predictions. The best-fit line showed 1.796 momentums per turn of the crank at an rpm of 60."

"Which is why they used that value," Tera said.

Part 1B: Impulse to Heat Oil

(Mixer, bowl, oil, heating coil, thermometer, clock.)



"Now," Tera said, "the next thing to do is put a thermometer and the heating coil in the oil and turn the crank for… how long would it take, Chip?" [Note, the heating coil isn't used at this time, but it is included in the container of oil so the experimental apparatus is the same in both versions of the experiment.]

"This sample experiment was done at a rate of 60 turns per minute for 40 minutes. The electronic thermometer registered a slow rise in temperature."

"If the computer recorded the time and the temperature, can it develop a best-fit line of how fast the temperature rose?"

"Yes," Chip said. "The temperature rose at a rate of 0.0326°C per minute."

"Ok, how long did it take for the temperature to rise 1°C?"

"To find that, we invert the number, producing a result of 30.67485 minutes per degree Celsius."

"Perfect," Tera said agreeably. "Multiply by 60 rpm and we produce 1840.491 revolutions per degree Celsius. And the first experiment showed that it took 1.796 ρ of impulse to turn the crank at 60 rpm. So, what was the total amount of impulse per degree?"

"3305.521 momentums per degree Celsius," Chip said. "Of course, I'm including a lot more digits than the experiment warrants. 3300 ρ per degree is probably as accurate as this experiment would have been good for."

"3305 ρ per degree Celsius," Tera said. "Now for the electric-calories… Is there a shortcut for calculating electric-calories?"

"This experiment involved several shortcuts that actually improve accuracy," Chip said. "For example, notice that you never recorded the volume or mass of the oil."

"You're right, why?"

"Because the experiment involves an enclosed system that includes oil, the metal of the mixer blades, the metal of the electric heating coil, the thermometer, the insulating material of the cup, etc. The measurement of 3305.521 momentums per degree Celsius is the total amount of impulse required to heat the entire system."

"And we'll use the electric heating coil to heat the entire system," Tera said knowingly. "Then we'll compare the heating rates… this experiment is ingenious!"

Part 2A: Calibrating Heating Coil

(Insulated cup, water, balance, heating coil, heat pulser, thermometer.)

"The electric heating coil will be turned on and off by a computer, and a device called a heat pulser. In the experiment sample we're looking at, the pulser turned the electricity on for 5.0 seconds each pulse."

"Did they use electricity data to calculate the number of calories per pulse?"

"No, they calibrated with water," Chip said. "There're a lot of variables involved—the electric voltage, amperage, length of pulse, etc. The simplest, and most accurate, approach is to use distilled water to calibrate the number of calories per pulse."

"We did something like that in school last year," Tera recalled. "We found the mass of an insulated foam cup, added a specific number of grams of distilled water, and then added heat. What did their numbers look like?"

"Here:"

C: 5 second pulses	
empty cup	3.27 g
cup & water	189.8 g
water only	186.53 g
start temp	25.97° C
end temp	45.79° C
temp change	19.82° C
calories	3697
#pulses	13
calories/pulse	**284.4**

"Their electric heating element produced 284 cal for each five-second pulse," Tera said. "I like that method—it means I won't have to do all of those electricity calculations."

"Precisely," Chip said.

Part 2B: Heating Coil to Heat Oil

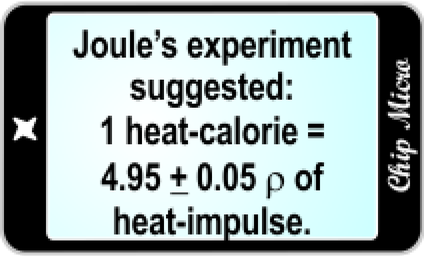
(Bowl, oil, mixer, heating coil, thermometer.)

"Now, put the electric heating coil into the oil, next to the hand mixer," Chip said.

"Got it," Tera stipulated. "The first oil experiment determined that it takes 3305 ρ of mechanical impulse to raise the temperature of the entire system by 1°C."

"That took a long time, and this electric heating coil adds a lot of heat per pulse."

"Right, so I would add electric heat very slowly… say 1 pulse every 30 or 40 minutes for several hours. Too bad I don't have a heat pulser that works in 1 second increments, then I could pulse once every 10 minutes!"



"Yes, but our sample experiment is in 5 second increments, so we'll stick with that for now," Chip said. "They used the same computerized thermometer as in Part 1, put the heating coil into the same oil, along with the hand mixer. They started the timer and added 1 pulse of electric heat every 30 minutes for several hours."

"Several hours," Tera said. "To minimize heat loss, I'll cover the entire thing with a towel."

"This approach would have produced a nice long, gentle rise in temperature—very similar to the rise in temperature caused by turning the hand mixer," Chip said.

"Show me the initial data."

"Here:"

Calories	284	cal/pulse
#pulses	6	
total heat:	1704	Calories
time	180	Minutes
heating rate	9.466667	cal/min
slope	**0.01421**	**°C/min**

"The graph was a linear set of data points, and they calculated the best-fit line," Tera said. "Chip, what happens when we invert the slope?"

"We produce 70.37298 minutes per degree Celsius," Chip said. "Then we multiply by 9.46667 cal per minute to find that it takes 666.1975 cal to raise the temperature of the entire enclosed system by 1°C."

Final Calculations

"Fantastic," Tera confidently professed. "In the hand-mixer experiment, it took 3305 ρ of impulse to raise the temperature of the system by 1°C. Can we compare these rates?"

"Certainly, the comparison looks like:"

$$1\ cal = \frac{3305.521\ \rho/℃}{666.1975\ cal/℃}$$

1 cal = 4.96 ρ of mechanical impulse

1 cal = 4.96 ρ of Voltage Trapped Impulse

was written on her phone.

"Explo! Hectii's estimate was nearly perfect," Tera admired. "This needs to be our **calorie fact #3 of mechanical heat-impulse.** We'll say that experiments with hand mixers and electric heaters show that 4.96 ρ of mechanical impulse produce the same amount of temperature change as 1.0 calorie of electric heat.

"Things that can be measured, exist in the natural world," Tera continued, "therefore mechanical heat-impulse exists, and ρ of impulse is a valid measure of how much heat has been transferred from one object to another."

"Wonderful conclusion," Chip said. "And to finish off the experiment's original question, we divide by 4.184 VoltAmpSec to find that:"

(1 volt)(1 amp)(1 sec) = 1 J[1.2] *= 1.185 ρ of impulse*
1 Volt = 1.185 ρ/coulomb
was written on her phone.

"You know I don't care about that electricity stuff," Tera said. "But just imagine, James Prescott Joule was so close! If he had focused on the time it took to raise the temperature instead of the work he thought he was doing… He would have come up with 4.958 $\pm$0.04 momentums per degree Celsius, just like Hectii calculated!"

OBSERVATIONS & CONCLUSIONS:

As seen above, Joule's experiment can be amplified by adding an electric coil to compare electric heat to mechanical heat. This easily reproduced school lab shows that electric joules are a scaler multiple of impulse, 1 standard-linearized electric joule is always equivalent to 1.185 ρ of mechanical impulse, and 1 Volt = 1.185 ρ/C. [ρ/C is a type of pressure not unlike N/m^2 or ρ/mol].

Remember, this is a reproducible lab. Students and teachers are encouraged to gather the equipment and reproduce this experiment themselves.

Labs Professor's Fear #2 can be further enhanced by altering the crank speed. Have one lab group design their experiments to be performed at 60 cranks per minute. Have another group design their experiments to be performed at 40 cranks per minute, have a third group design their experiments to be performed at 80 cranks per second, etc.

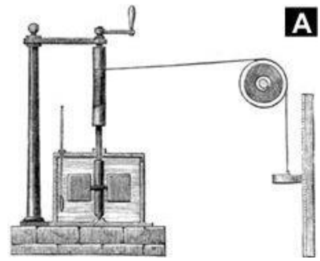
The Energy Paradox: Energy and work are always impulse times average speed. A good estimate of energy involved can be made by assuming that:

1 crank/second = 0.84 m/s
0.5 cranks/second = 0.42 m/s
2 cranks per second = 1.68 m/s

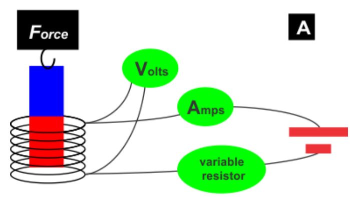
If different groups use different crank speeds, then the class as a whole can compare the different values for joules compared to the values for impulse. Which is more reliable?

To discover more, explore:

Labs Professors Fear #1: a detailed analysis of James Prescott Joule's Heat-is-Work experiment. Using Joule's data, it can be shown that 1 cal of heat is equivalent to 4.95 ρ of mechanical impulse. *This lab should be reviewed by all students prior to doing Experiment #2*. (www.Wacky1301Sci.com)



Labs Professors Fear #3: a repeatable school/home experiment that uses the interaction of permanent magnet and a solenoid's electromagnetic field to calibrate voltage. (www.Wacky1301Sci.com)



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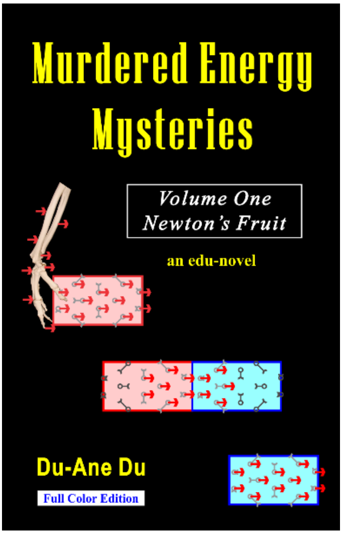

[Examine or purchase at Amazon.com]

Murdered Energy Mysteries seeks to increase understanding of the various forms of momentum and momentum transfer, as well as the various forms of energy and energy transfer. The lack of understanding on the part of the scientific community is substantial, and more research needs to be done.

—Du-Ane Du, author of the edu-novel *Murdered Energy Mysteries* (Amazon, Kindle, e-book 2018, paperback 2021.)

More information, visit www.Wacky1301SCI.com