

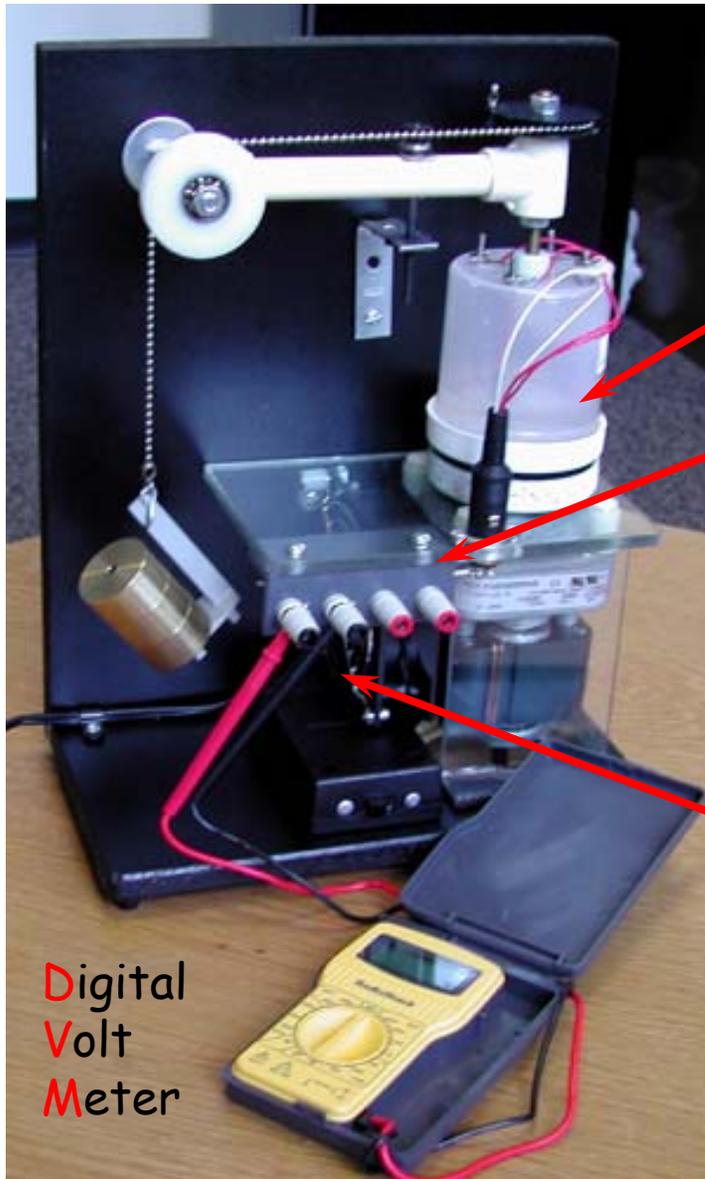
Experiment 10: Energy transformation



Goals

- Investigate the **transformation** of **non-conservative mechanical (friction)** and **electrical work** into **heat energy**:
⇒ Add heat to water in plastic jar and measure the resulting increase in temperature as a function of time!
- Determine the mechanical and electrical equivalents of heat.
- Observe that it is not easy to measure some important quantities accurately.

Equipment setup



- **Mechanical equivalent to heat:** A motor applies a known **friction torque** τ_f at a known ω to a plastic jar with a known mass of H_2O .

$$c = \frac{\tau_f \omega}{m(dT/dt)}$$

- **Electrical equivalent to heat:** Apply voltage (2.5V) across a resistor (2.5Ohms) and use resulting electrical heat: Resistor is connected to right pair of posts.

$$c = \frac{\Delta VI}{m(dT/dt)}$$

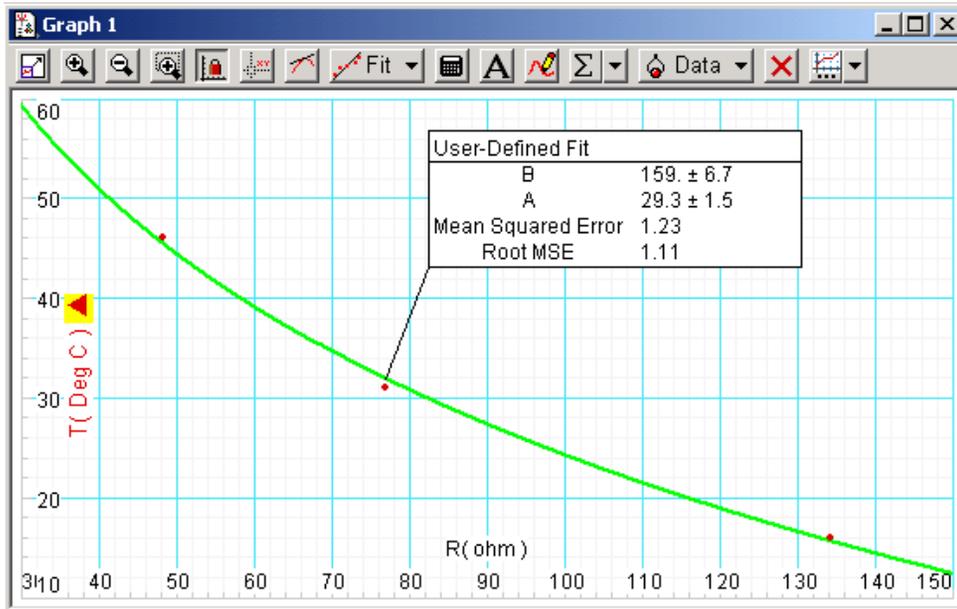
- **Temperature measurement:** Use a **thermistor** to measure the water temperature: Thermistor is a semi-conductor device with a temperature dependent internal resistance of

$$R(T) = R_0 e^{-\alpha T}$$

- **First task:** Calibrate thermistor and measure room temperature!

Calibrate thermistor

- Enter values R , T from jar into a DataStudio table. R is independent (X) value. T is dependent (Y) value.



Thermistor Calibration Data	
R (ohm)	T (Deg C)
134.40	16
77.00	31
48.40	46

- Fit to $B - A \cdot \ln(x)$, find A , B and then measure T_{room} with these parameters!

A	B	T_{room}

Setup of DataStudio

Sampling Options

Manual Sampling | Delayed Start | Automatic Stop

Keep data values only when commanded.
 Enter a keyboard value when data is kept.
 Prompt for a value.

Keyboard Data

Resistance (OHM)

Name: Resistance

Units: OHM Accuracy: 1.000E-3

Edit All Properties...

Include a list of prompt values for this keyboard data.

OK Cancel Help

Data Properties

General | Numeric | Appearance

Measurement Name: Resistance

Description: Thermistor Resistance

Variable Name: R

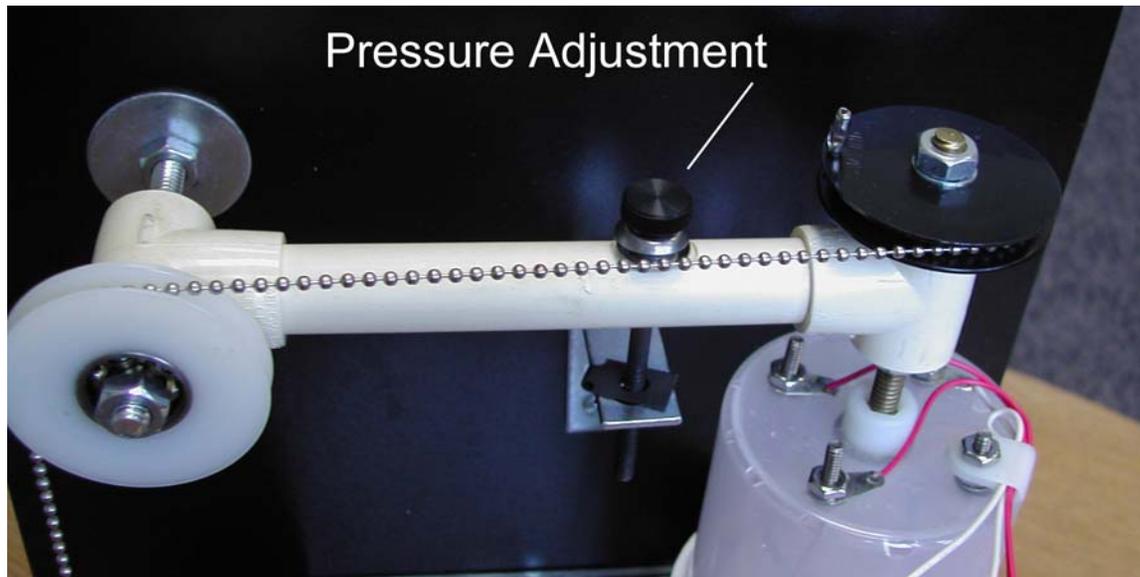
Units: OHM Type: Other

Display Minimum: 0.00 Display Maximum: 0.00

Accuracy: 1.00E-3 Precision: 2

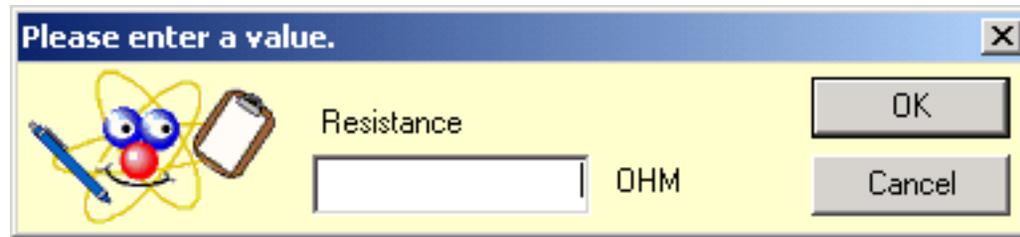
OK Cancel

Friction heating



- Hang 305 g from chain.
- Turn on motor, adjust pressure for balance.

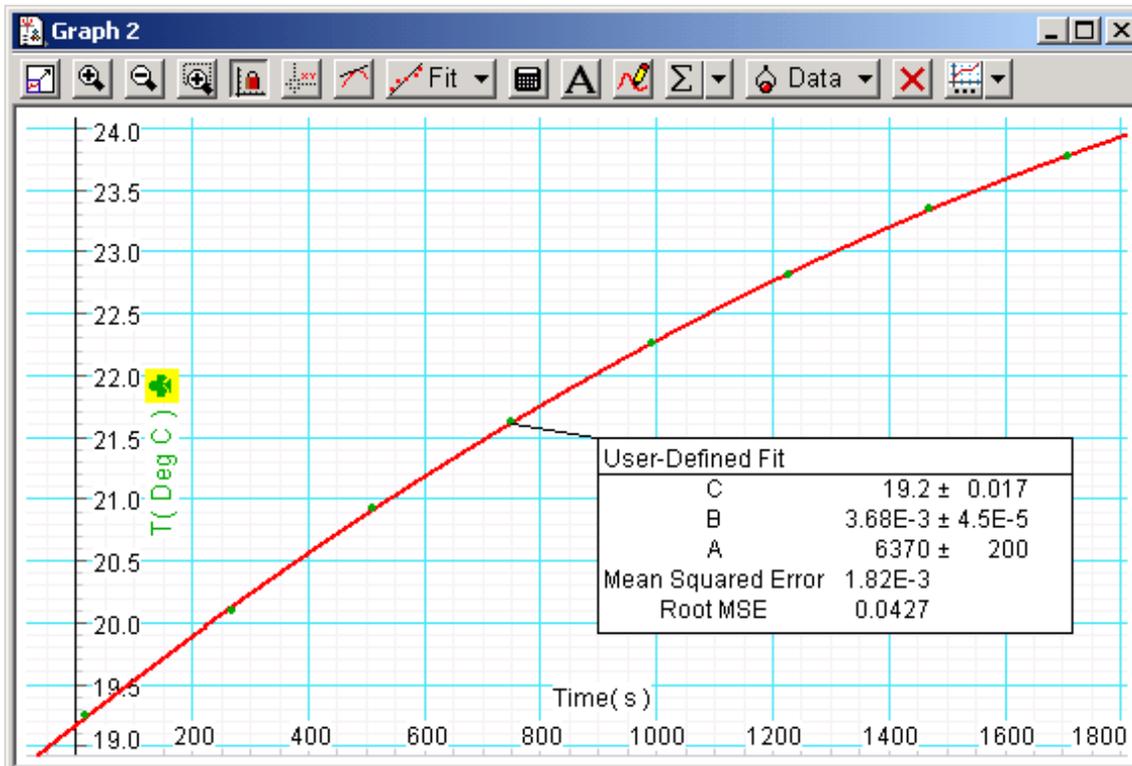
Click Start. Each time you click Keep: Keep you get:



Do this every 3 min. for 24min. Then click red stop button.

Friction heating: T vs. time

- First plot R vs. t, then Calculate $T=A-B*\ln(x)$, where A, B are your thermistor calibration parameters. Plot result to get T vs. t.



- Fit to $C+B*T*(1-t/A)$ to find A, B, and C.
- Initial guesses: C=20, B=0.004, A=5000.

C	B	A

Electric heating

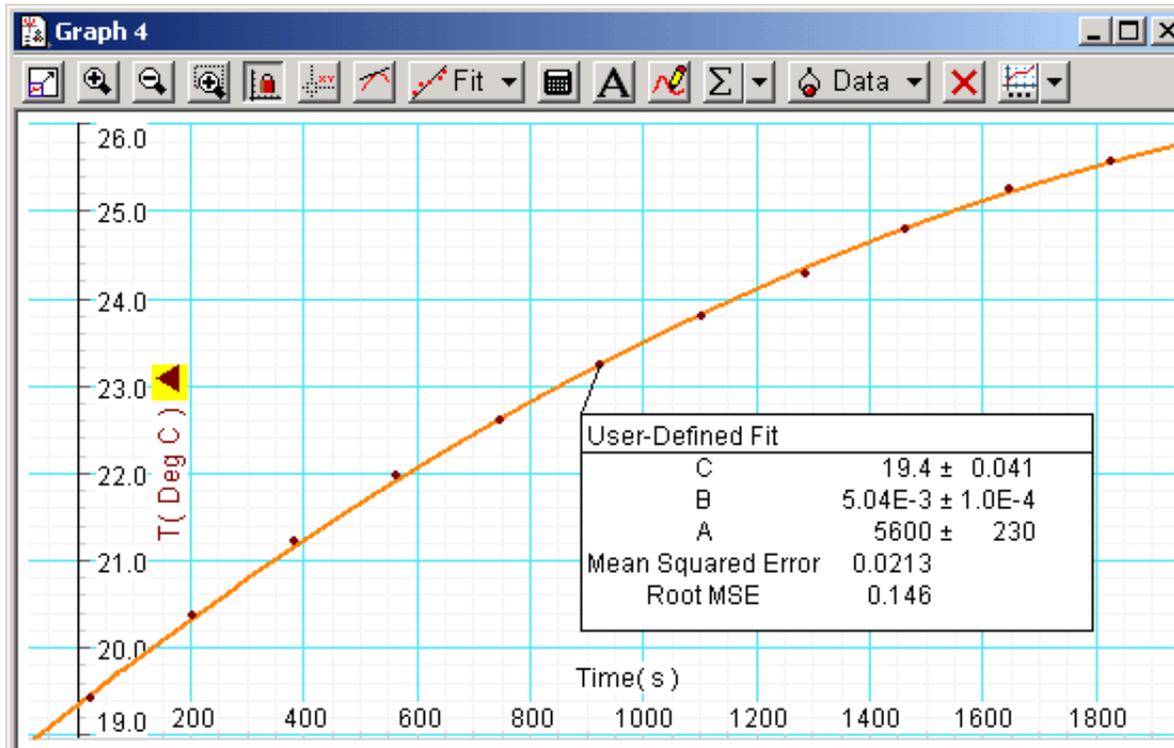
- ❑ Release jar, place on platform above binding posts.
- ❑ Connect power supply to right binding posts, set to $\sim 2.50\text{V}$. Use DVM to measure more accurately.

$R_{\text{heater}} (\Omega)$	$V_{\text{heater}} (\text{V})$

- ❑ Agitate water by rocking apparatus: (i) about 10 s each minute, (ii) for 30 s prior to measuring thermistor.
- ❑ Measure thermistor about every 3 min. for 24 min.
- ❑ Make a graph of T vs. t as for friction heating.

Electric hearing: T vs. time

- First plot R vs. t, then Calculate $T=A-B*\ln(x)$, where A, B are your parameters. Plot result to get T vs. t.



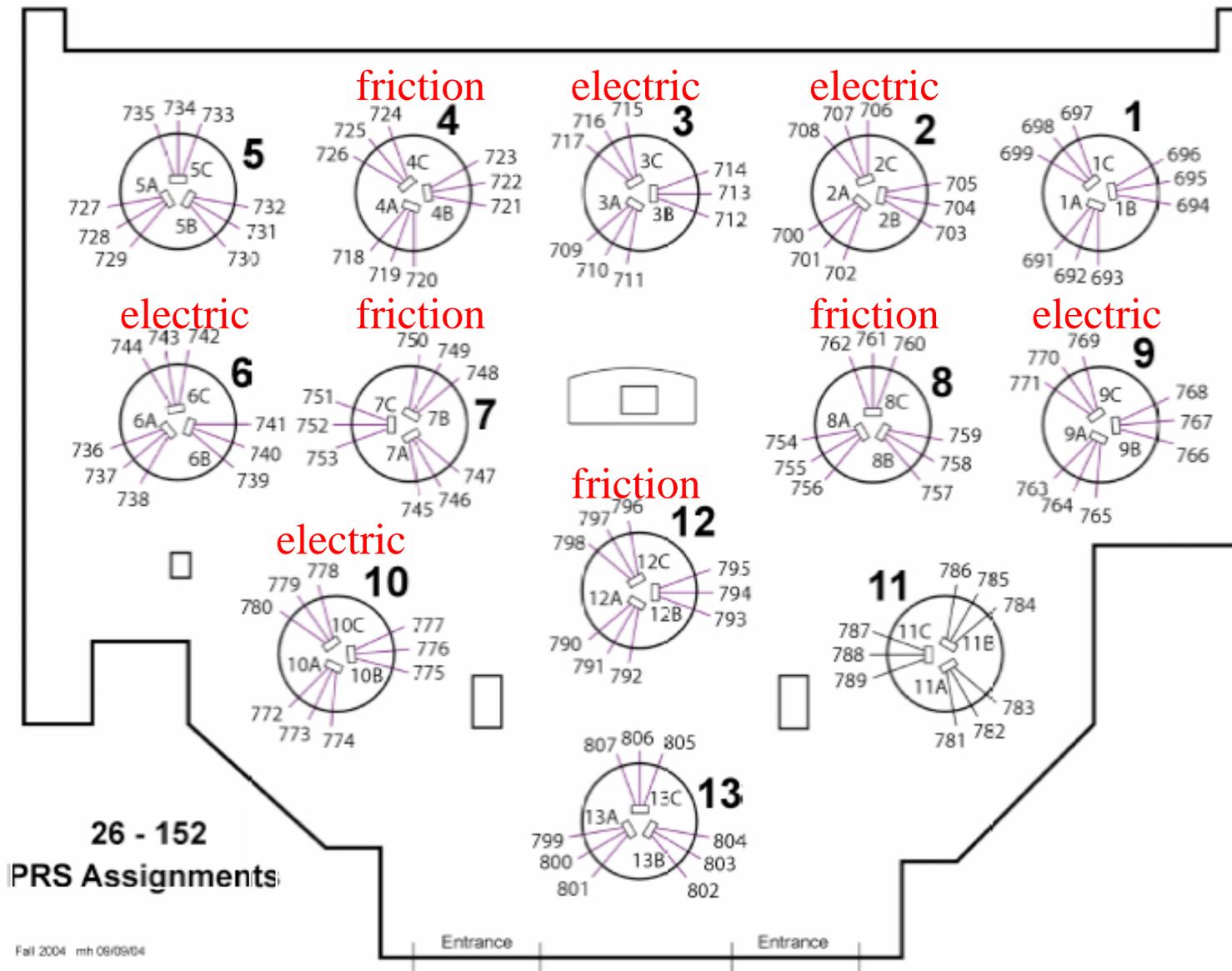
- Fit to $C+B*T*(1-t/A)$ to find A, B, and C.
- Initial guesses: C=20, B=0.004, A=5000.

C	B	A

Analysis

- Analyze your results in a problem on Problem Set 12, following the discussion/example in the experiment write up.
- The “Special” link on the web page has an historical discussion of the mechanical equivalent of heat, Count Rumford, James Joule, and others.

Assignment: Friction or electric heating



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