# Definitions of Physical Quantities Worksheet—Solutions Provided After Lab

To be discussed in class after the first few measurements. Students complete columns 2 and 4 during lab discussion.

The definitions and importance of these quantities were identified in the first semester of the course. The worksheet was developed and used for subsequent semesters.

Note: Integral notation was introduced and discussed by the instructor. No calculus background was assumed.

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| **Physical Quantity** | **Unit** | **Meaning** | **How it is determined** |
| Emf E |  | Potential difference created by chemical reactions on anode and cathode; drives current through external circuit **if** a closed loop exists. |  |
| External resistance *Rexternal* |  | Our load is a pure resistor (ohmic element); its resistance is constant and independent of the applied voltage |  |
| Time *t1* |  | Time stamp for 1st measurement (= highest value of external potential) |  |
| Time *t2* |  | Time stamp for last measurement used (= time  2 hours after *t1*) |  |
| **Physical Quantity** | **Unit** | **Meaning** | **How it is determined** |
| External voltage *V1* |  | Highest potential difference applied to load (at time *t1*) |  |
| External voltage *V2* |  | Potential difference remaining across load after  2 hours (at time *t2*) |  |
| Current *I1* |  | Current through load at start of experiment (at time *t1*) |  |
| Current *I2* |  | Current through load after  2 hours (at time *t2*) |  |
| Percentage of external voltage remaining  (% *Vremaining*) |  | Compares performance of battery after 2 hours to initial output. |  |
| Percentage of current remaining  (% *Iremaining*) |  | Compares performance of battery after 2 hours to initial output. |  |
| **Physical Quantity** | **Unit** | **Meaning** | **How it is determined** |
| Power delivered *Presistor* |  | Energy per second delivered to the load resistor. |  |
| Power converted *Ptotal* |  | Energy per second converted by the battery from chemical energy. |  |
| Battery capacity = charge capacity |  | How much charge the battery was able to move through the circuit due to its chemical reactions (during the 2 hour time interval that we are evaluating). |  |
| Battery capacity = charge capacity given in units commonly used |  | In order to compare the value for the battery capacity that we determined to published data, we will convert our value to the units used on the published data sheets. |  |

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| **Physical Quantity** | **Unit** | **Meaning** | **How it is determined** |
| Energy delivered *Eresistor* |  | Total amount of energy delivered to the resistor in the 2 hour time interval that we are evaluating. |  |
| Energy converted *Etotal* |  | Total amount of energy converted by the battery from chemical energy in the  2 hour time interval that we are evaluating. |  |
| Percentage of energy delivered to resistor  (% Edelivered) |  | Some of the converted energy is delivered to the battery itself, while some is delivered to the resistor: How much (percentage-wise) reaches the resistor? [Ideal: 100%] |  |

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| **Physical Quantity** | **Unit** | **Meaning** | **How it is determined** |
| Internal voltage drop *Vinternal* |  | Voltage drop over the internal resistance of the battery, explaining the difference between *Vexternal* and the emf E. |  |
| Internal resistance *rinternal* |  | The internal resistance of the battery accounts for the decrease in external voltage as the chemical reactions on the electrodes slow down. |  |
| Factor of increase for *Vinternal*  [Factor(*Vinternal*)] |  | Describes by how much (as a multiplicative factor) the internal voltage drop *Vinterna*l has changed over the course of the 2-hour experiment. |  |
| Factor of increase for *rinternal*  [Factor(*rinternal*)] |  | Describes by how much the internal resistance of the battery *rinternal* has changed over the course of the 2-hour experiment. |  |