

BATTERIES 101

What mAh, Wh, nominal voltage, and C-rate actually mean, the common chemistries at a glance, and a rough runtime from capacity and draw. With a live calculator.

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A battery stores energy chemically and hands it back as current. Three numbers tell you almost everything about one: how much charge it holds, its voltage, and the current it can safely deliver. Learn those and a datasheet full of cells stops being a mystery.

CAPACITY: MAH AND WH

Capacity in milliamp-hours (mAh) is how much charge a cell holds: a 2000 mAh cell can deliver 2000 mA for one hour, or 200 mA for ten. Energy in watt-hours (Wh) folds in the voltage, so it compares cells of different voltages fairly. Multiply charge by voltage to get energy.

$$\text{Wh} = (\text{mAh} / 1000) \times \text{Vnom}$$

CALCULATOR · BATTERY WATT-HOURS CALCULATOR (MAH TO WH, PACK SIZING)

Convert cell capacity and voltage to watt-hours and size a series/parallel pack's energy, voltage, and capacity. mAh to Wh done right.

Interactive calculator: academy.onethousanddrones.com/tools/battery-watt-hours

CONVERT A CELL'S MAH AND VOLTAGE TO WATT-HOURS AND SIZE A PACK.

NOMINAL, FULL, AND EMPTY VOLTAGE

A cell's voltage drifts as it drains. A single Li-ion cell reads about 4.2 V full, sits near its 3.7 V nominal for most of the discharge, and is empty around 3.0 V. The nominal figure is the one printed on the cell and the one used for the energy math.

C-RATE: HOW HARD YOU CAN PUSH IT

C-rate expresses a current as a multiple of the capacity. 1 C is the current that drains the whole cell in one hour, so 1 C of a 2000 mAh cell is 2000 mA. A cell rated for a 2 C discharge can safely deliver twice that. Exceed the rating and the cell overheats.

$$I = \text{C-rate} \times Q$$

THE COMMON CHEMISTRIES

CHEMISTRY	NOMINAL CELL	AT A GLANCE
LiPo / Li-ion	3.7 V	High energy density, needs a protection circuit
NiMH	1.2 V	Robust, self-discharges, no protection needed
Alkaline	1.5 V	Cheap, single-use, high internal resistance

- [Battery University. BU-107: Comparison Table of Secondary Batteries \(chemistries, nominal voltage\).](#) [batteryuniversity.com](#)

A LI-ION CELL HOLDS NEAR ITS NOMINAL VOLTAGE FOR MOST OF THE DISCHARGE, THEN FALLS OFF A CLIFF NEAR EMPTY.

A rough runtime is capacity divided by average draw. A 2000 mAh cell feeding a board that averages 100 mA lasts about twenty hours before the safe voltage window runs out. Lesson eleven does this honestly, with the usable fraction and the regulator loss folded in.

DEEP DIVE · WHY YOU NEVER GET THE WHOLE PRINTED CAPACITY

A cell's printed capacity is measured all the way down to its empty voltage under gentle conditions, but a real board cannot use all of it. The regulator stops working once the cell falls below its dropout, and a lithium cell is called empty at 3.0 V, not 0 V, with useful charge still chemically inside it that you must not touch. Draw harder than the test current and internal resistance costs you more still. So a real design reaches only part of the label, and honest runtime math starts by discounting the capacity to the fraction you can actually reach. (Battery University)

- [Battery University. BU-402: What Is C-rate? \(current as a multiple of capacity\).](#) [batteryuniversity.com](#)

CHECKPOINT

1. A 2000 mAh capacity tells you roughly what?

- The cell's physical size
- How much charge it holds, so its runtime at a given draw
- The cell's maximum voltage

ANSWER · B

mAh is charge: a 2000 mAh cell gives 2000 mA for an hour, or 200 mA for ten.

2. What does a watt-hours figure add over milliamp-hours?

- The voltage, so cells of different voltages compare fairly
- The cell's self-discharge rate
- The number of charge cycles

ANSWER · A

Wh = charge x voltage, an energy figure that is fair across different voltages.

3.1 C of a 2000 mAh cell is what current?

- a. 200 mA
- b. 20 mA
- c. 2000 mA

ANSWER · C

1 C drains the capacity in one hour, so 2000 mAh at 1 C is 2000 mA.

- Prerequisite: voltage, current, and resistance
- Calculate it: the battery watt-hours calculator
- Next: LiPo and Li-ion safety