

# A Guide To Lithium-Ion Batteries

## Overnight Charging

**The answer is no, you cannot harm a device by leaving it plugged in overnight.**

Lithium Ion battery charging follows a very strict profile, and the final phase of the process is to cease all charging - there is no trickle charge or anything going on once the battery hits 100% charge, because lithium ion batteries have no tolerance for being even slightly over-charged.

## Discharge

**Lithium ion batteries do not tolerate deep discharges well.** Although it's possible to run a battery down to 0% on the meter, what is really happening at this stage is the device is shutting down above the terminal (lowest) voltage of the battery in order to save it - if lithium ion cells fall below a certain voltage, they can be irreparably damaged and won't be capable of accepting a re-charge.

The best thing to do, on the low end of the charge spectrum, is to **avoid discharging below 30% whenever possible**. The bottom 30% of the charge profile is taxing on the batteries from an electro-chemical/physical perspective, and using them in that range causes more wear on the batteries.

## Charging and Charging Frequency

It's important to note that lithium ion cells do not suffer from "memory", which is a loss of capacity from partial charging.

**A couple small charges throughout the day, to keep the battery above that 30% threshold is better, overall, for a lithium ion battery, than letting it go below 30% and receiving one big charge at the end of the day.**

Another interesting facet of lithium ion battery technology is just as the bottom of the charge profile is hardest on the cells (eg. discharging them down to the very bottom of their capacity), charging to 100% is actually stressful for the cells as well - putting that last 10% of charge into a device is the roughest phase of the charge on the cells. So you're actually best off to always have the device above 30%, but below 100%.

In practical terms, this is hard to do and requires too much monitoring - so **the best compromise is to aim for a 100% charge once a day at most** - this is the overnight charge originally asked about. You don't want to keep stuffing the battery with that last 10% charge over and over throughout the day, because that's where a lot of the harm and degradation of the battery occurs.

Batteries should be charged when the phone is at room temperature - charging below room

temperature doesn't damage the battery (to my knowledge), but charging at an elevated temperature (eg. after an epic gaming session) is an extremely good way to damage the battery. A few full recharges at an internal battery temperature of 40 Celsius is a good way to permanently knock 10-20% capacity off the battery.

## **Calibration**

**The capacity shown on your devices is an estimate of available capacity, not the gospel truth.** The charging circuitry knows what a full charge voltage is, and what a terminal voltage is, as well as the approximate voltage discharge curve of a lithium ion battery. It also knows how much current it put into the device and how much current has been taken out of the cells.

We've already said that its harmful to discharge a lithium ion battery all the way to zero, but sometimes you will want to. If you notice that the indicated battery capacity is grossly wrong, you'll want to run the device until it shuts down, and then allow it to fully recharge in one go. This will allow the monitoring hardware to reset it's knowledge about how much charge can be stuffed into the battery at its current health state.

**Don't do this weekly. Don't do this monthly. Do this if you feel there are significant misrepresentations about battery capacity.** Every time you do this, you are inflicting a fair degree of wear on the battery.

## **Battery Service Life**

**Lithium Ion batteries are rated for a finite number of cycles. A cycle is defined as taking the rated amount of power out of the battery, and putting 100% of that power back in (so a full discharge to a full recharge). What most people don't understand is that this is a cumulative number.** If you drain 20% of the battery down, and recharge it, you've just completed 20% of a cycle. If you subsequently take 40% out, and put 40% back in, you're now up to 60% of a cycle. Take another 40% out, and put 40% back in (so your third charge of the day), and you've finally hit 1 cycle.

This supports and reinforces the notion that many smaller recharges are better overall than a deep discharge followed by a full recharge - you aren't burning up charge cycles and shortening the life of the battery by plugging it in frequently for small top-ups (unless you are doing a top-up from in the 90-100% range over and over)

**Lithium ion batteries also have a finite shelf life** Lithium is a highly reactive chemical, and the high power density of lithium ion cells means they are under a lot of electrochemical stress. This means that lithium ion batteries are degrading the minute they leave the factory. No matter how much you baby your cells, once you start to get up to the 3 year mark, you've permanently lost capacity due to old age. Some cells last longer, some last shorter, but fundamentally, you are fighting a losing battle against time.

## **Leaving Your Laptop Plugged In**

This doesn't apply much to mobile devices, but we should address the effect of leaving your laptop plugged in all the time.

**Just as charging to 100% capacity is stressful on a battery, so is sitting at 100% charge all the time.** It's literally stressful to the battery's construction - you've got a huge reserve of electrons being held in electrochemical stasis, and they want to flow and move and balance out the charge in the battery. Leaving a battery in this state of imbalance (100% charge) full time will begin to wear down the battery's ability to hold a charge.

But a lot of laptop users are plugged in a lot of the time. So what to do? My suggestion, if you put less than one cycle a week on your battery presently (see how to calculate a charge cycle above) is to artificially perform one once a week. Every Friday, unplugging until you hit 30% and then recharging will go a long way to keeping the battery healthy over its normal 3 year lifespan.

## **Summary**

Well, having posted all of that information, I'd say the main thing is to just enjoy using your device.

If you follow these three rules you'll be OK:

- avoid draining to zero or very low charge levels as often as possible
- don't recharge while hot
- don't leave in hot places (in a car is the worst)

Realistically, if you don't hammer the battery with deep discharges, and don't let it cook to death in a car in the summer, the battery will probably perform well for the lifespan of the device (which is, coincidentally, about the service life of a Lion battery, 3-4 years)

Source: <http://tinyurl.com/a656np8>

Thanks to sclitheroe from CalgaryPuck for the information!