What might be a benefit of wiring a collection of identical batteries in series? What might be a benefit of wiring a collection of identical batteries in parallel? Discuss.

Series increases total potential rise, does parallel increase total current?

If you were to connect a collection of identical batteries **in series, the overall potential drop in the series would continue to increase as the emf of each subsequent battery raises the potential drop more than the last one**. This means that a series of batteries could be particularly useful for increasing the voltage supplied to a device. **If a collection of identical batteries were connected in parallel, the emf of each battery would increase the potential of the current by the same amount**. However, because there are more batteries for the current to flow through, **the resistance would decrease, and the current would increase. This means that a collection of batteries in parallel can supply more current**, meaning they will last a longer period of time.

Parallel connection increases the capacity for providing current

Connecting the batteries in a series would allow **the current to be equal for the overall series between the batteries. The potential difference would also be equal because the batteries are identical. This allows the voltage to increase per number of batteries**. Eventually, the wiring would get acquire too much heat for the wiring to be safe, but it would work for a time.

Connecting the batteries in parallel would increase the total current capacity by decreasing the total resistance because the current would simultaneous use each battery. The total resistance would decrease because it would not compound as it would in a series setup. **Each added battery would not increase the overall current, just the current's capacity if the current stayed the same**. Lets say each battery produced 2 Volts. Each successive addition would not mean the overall voltage to be 2 * the total number of batteries, but it would stay at 2 Volts.

What would happen if you connected a pair of unequal batteries in parallel, say, a 12 Volt and a 9 Volt battery? Explain your reasoning.

Voltages are inconsistent

If you were to do this, **the voltage would drop in the 12 Volt and the voltage would increase in the 9 Volt battery**. This is because current would flow from the higher potential to the lower potential. The 9 Volt battery would increase because they are in parallel, so the **Voltages would eventually be the same.**

Currents must be flowing between the batteries

If they were connected in parallel, then the resistors would be seen as internal resistances with the two batteries acting as EMF's. **In parallel, the positive ends of each resistor and the negative ends are connected. Therefore, the current will flow out of the positive terminal of the larger EMF battery, and into the positive terminal of the other resistor.**

Terminal voltage is key

If the part of the circuit in parallel is made of only the two batteries, then the batteries would short out. **If the internal resistance of the 12 V battery is larger than the internal resistance of the 9 V battery by an amount that would make the potential drop across both equal**, then they would not short out. However, I must say **I am slightly confused as to how that is not the same as connecting the terminals of a one battery**.

Good, thoughtful analysis

Two unequal batteries (9V and 12V, here) connected in parallel seems at first like a paradox. Devices connected in parallel are meant to share the same potential drop (by definition of parallel configuration). Meanwhile, **these batteries appear to provide unequal potential drops** across them. However, more thought reveals that **these batteries do not necessarily have to have unequal terminal voltages.** This is because those labels (9V and 12V) refer to the electromotive force of the battery. The batteries also contain some internal resistance, r, and as a result, **the terminal voltage of any battery is actually the emf minus the potential drop resulting from the current moving through that internal resistance.** In other words, the terminal voltage $V = emf - Ir$.

So, the solution is simple. Assuming that these two batteries are being used to power some unknown circuit, the current will simply be unequal between the two batteries. The circuit itself will experience the total current, but **the batteries will have current running through them such that the decrease in terminal voltage in the 12V battery is 3V more than the decrease in the 9V battery. If the internal resistances of the two are the same, the 12V battery will have to have much more current running through it so that its terminal voltage is much smaller than the 12V printed on it**. The 9V will have comparatively less current, enough so that the 12V battery can have the same terminal voltage as it.