**Task 2.3**

Since we have a Li-Po battery, so its nominal voltage is=11.1V,

And we will better work with nominal voltage because of the discharging curve, also the given says that battery’s capacity=5200mAh, but we would work with 80% of the battery to have a safe factor=20%, so the capacity would be=4160mAh.

Also our batteries would have a max c-rating=60C, but the resistor would determine its c-rate according to the discharged current.

Assuming the following:

1. All used batteries are ideal (no internal resistance)
2. LED is ideal
3. Resistor’s power=7W.

Needed current==

So, in concept of C-rate, we need to supply this current for 5 hrs..

, current =c-rate

Since we need to connect n batteries in parallel, so capacity will be multiplied by n.

**Bonus:**

Battery management system (BMP):

Relating to this problem, we could not actually connect batteries in parallel in real life, as no two batteries (even if they have the voltage) will discharge with the same rate.

Solving this problem is BMS which stands for Battery Management System. It’s a crucial modern component in battery-powered devices, electric vehicles (EVs), and renewable energy systems.

The main function is to monitor and control the performance, efficiency, and safety of a battery.

If we harp on about the problem of connecting those batteries in parallel, that if any cell runs out of charge though other cells may be still hold charge and vice versa, obviously if any cell is fully charged, then charging process must stop.

Hence, cell balancing is needed to be not vulnerable to any of the catastrophic failures that may occur such as:

Reduced Battery Performance:

* Safety Hazards: Batteries can be potentially dangerous if not managed properly.
* Limited Battery Life: Batteries are subject to degradation over time.
* Inaccurate State of Charge (SOC) Estimation: Knowing the battery's SOC is crucial for managing its energy and predicting its remaining capacity accurately.
* Lack of Fault Diagnosis and Reporting
* Inefficient Energy Utilization
* Integration Challenges: In many applications, such as electric vehicles or renewable energy systems, the BMS interfaces with other components and systems to ensure seamless operation. Without a BMS, integrating and coordinating these systems becomes more complex, potentially leading to compatibility issues and suboptimal performance.

A BMS performs several key tasks to ensure the optimal operation of a battery:

* Battery Monitoring: The BMS continuously monitors various parameters of the battery, such as voltage, current, temperature, and state of charge (SOC). This information helps in assessing the battery's health and performance.
* State of Charge (SOC) Estimation: The BMS estimates the SOC, which indicates the remaining capacity of the battery as a percentage of its total capacity. SOC estimation allows users to know how much energy is available in the battery and helps prevent overcharging or deep discharging.
* Cell Balancing: In a multi-cell battery pack, the BMS ensures that each individual cell is balanced in terms of voltage. Cell balancing helps equalize the charge across cells, maximizing the overall capacity and extending the battery's lifespan, but the drawback here is that the system is limited by the least capacity’s cell, pack’s energy spent as heat-inherently wasteful, also due to heat, additional coolant techniques are required.
* Overvoltage and Undervoltage Protection: The BMS protects the battery by monitoring the voltage levels. It prevents overcharging (which can damage the battery) and deep discharging (which can reduce the battery's capacity). If the voltage exceeds safe limits, the BMS may disconnect the battery or initiate corrective measures.
* Overcurrent Protection: The BMS monitors the current flow into and out of the battery. It safeguards against excessive currents that can damage the battery or other connected components. In case of a fault or short circuit, the BMS can disconnect the battery to prevent further damage.
* Temperature Management: The BMS monitors and controls the temperature of the battery. High temperatures can degrade the battery and reduce its lifespan. The BMS may activate cooling systems or limit charging/discharging rates to maintain safe operating temperatures.
* Communication and Data Logging: Many BMS systems provide communication interfaces (such as CAN, LIN, or Ethernet) to exchange data with external devices, such as vehicle controllers or energy management systems. BMS also logs important battery-related data, including historical performance, faults, and events
* Active cell balancing: the cell which is fully charged, then transfers energy to other cells until equilibrium, so SOC of pack is equal to the average of all individual cell SOC.But its drawbacks are complex architecture, additional cost of electronics.