1. Define what an Equivalent Circuit Model is and explain its significance in battery technology. Discuss the components typically used in an ECM for lithium-ion batteries, including:
   - Voltage source (representing open-circuit voltage)
   - Resistors (representing internal resistance)
   - Capacitors (representing dynamic response)
2. Draw the basic equivalent circuit for a lithium-ion battery, including all relevant components. Label each component and provide a brief description of its function in the circuit.
3. Write down the fundamental equations that govern the behavior of the ECM. Include:
   - The relationship between terminal voltage (U), open-circuit voltage (OCV), and internal resistance (R).
   - The equations governing current (I) flow through the circuit.
4. Equivalent circuit modeling simplifies the complex electrochemical behavior of batteries into an electrical network composed of resistors, capacitors, and voltage sources. A more complete method for the equivalent circuit model (ECM) for lithium-ion batteries can be obtained by incorporation of Warburg impedance. The Warburg impedance represents the diffusion of ions within the battery, particularly at low frequencies. It is crucial for understanding how batteries respond to varying loads and charging cycles. In this model the components of the Equivalent Circuit are:
   - **Open-Circuit Voltage (OCV)**: Represents the voltage of the battery when no current flows.
   - **Resistor (R)**: Models internal resistance.
   - **Capacitor (C)**: Represents charge storage dynamics.
   - **Warburg Impedance (Z_W)**: Accounts for ion diffusion effects in the electrolyte.

   - Draw a typical Equivalent Circuit for a lithium-ion battery, including all relevant components. Label each component and provide a brief description of its function in the circuit.
   - Given a lithium-ion battery with the following parameters:
     - Open-Circuit Voltage (OCV): 4.2 V
     - Internal Resistance (R): 0.1 Ω
     - Charge Transfer Resistance (R_{ct}): 0.05 Ω
     - Capacitance (C): 1000 μF
     - Warburg Impedance (Z_W): $0.5 + j0.5$ Ω (where j is the imaginary unit)

     Calculate the terminal voltage (V_{out}) when a current of 2 A is drawn from the battery.

     Using Ohm's Law and considering the resistances in series:

     $$V_{out} = OCV - I(R + R_{ct}) - V_{ZW}$$

     Where V_{ZW} can be approximated using:

     $$V_{ZW} = I \cdot Z_W = I \cdot (0.5 + j0.5)$$