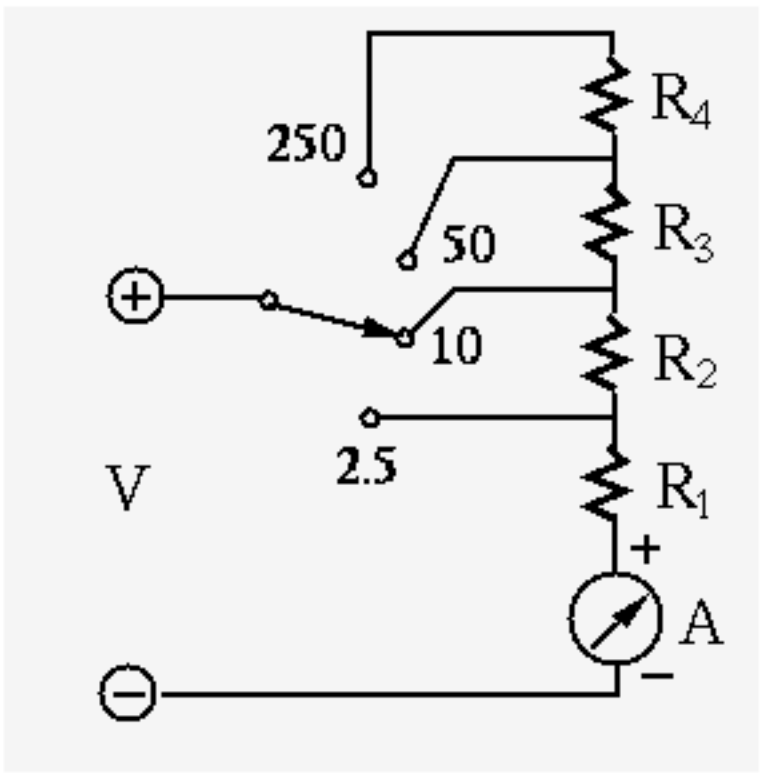
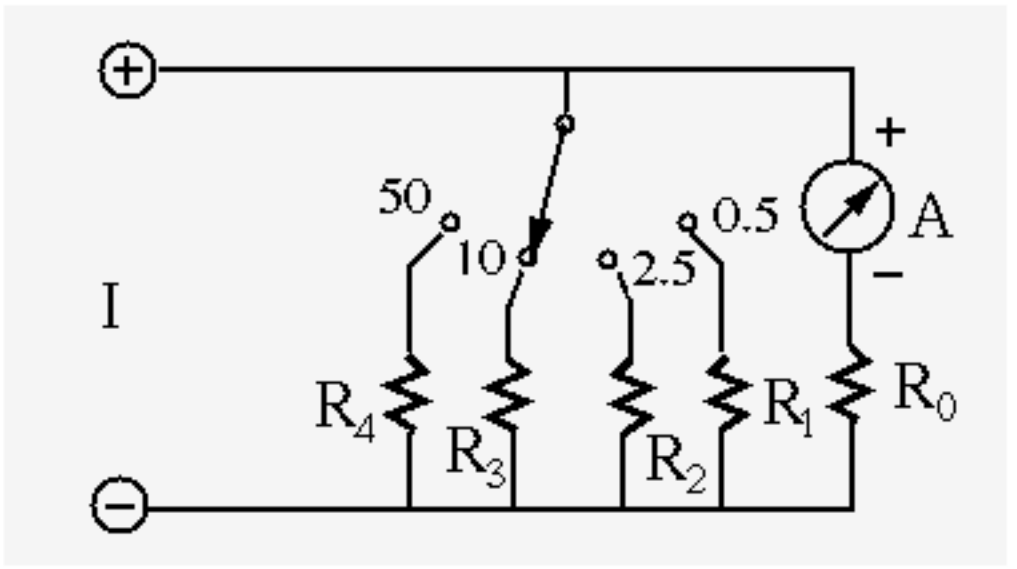
Design a multimeter that can measure DC voltage, current and resistance with different scales. Specifically, you are given an analog meter A with a needle display, which reaches full scale when a DC current of $I = 100\ \mu A = 10^{-4}\ A$ goes through it. The internal resistance of the meter is 10 Ohms. In addition, you need some multi-position rotary switches to select different scales for each of the three types of measurements, and resistors with any values needed in your design.

- Voltage measurement: measure voltages in these ranges (all in volts): 0-2.5, 0-10, 0-50, 0-250. Use a 4-position rotary switch to select one of the four ranges as shown in the figure below. For example, when the range of 0-10 is selected, the needle display will reach full scale when the voltage being measured is 10 V. The circuit is shown below. Determine all resistances labeled.



Solution: $R_1 = 25\ K\Omega,\ R_2 = 75\ K\Omega,\ R_3 = 400\ K\Omega$ and $R_4 = 2\ M\Omega$.

- Current measurement: measure currents in these ranges (all in mA): 0-0.5, 0-2.5, 0-10, 0-50. Use a 4-position rotary switch to select one of the four ranges as shown in the figure below. For example, when the range of 0-10 is selected, the needle display will reach full scale when a 10 mA current is measured. Determine all resistances labeled. Use $R_0 = 1\ K\Omega$.



Solution: Voltage across input is $V = 0.1\ mA \times 1\ K\Omega = 100\ mV$. Therefore

$$R_1 = 100/(0.5 - 0.1) = 250\ \Omega$$
$$R_2 = 100/(2.5 - 0.1) = 41.67\ \Omega$$
$$R_1 = 100/(10 - 0.1) = 10.1\ \Omega$$
$$R_1 = 100/(50 - 0.1) = 2\ \Omega$$