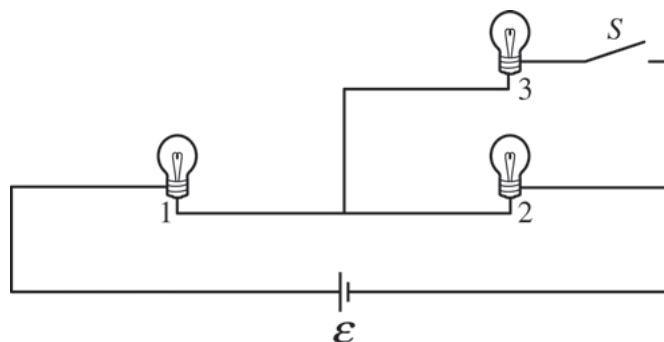




2. (12 points, suggested time 25 minutes)

A battery of emf $\mathcal{E}$ and negligible internal resistance, three identical incandescent lightbulbs, and a switch S that is initially open are connected in the circuit shown above. The bulbs each have resistance R . Students make predictions about what happens to the brightness of the bulbs after the switch is closed.

(a) A student makes the following prediction about bulb 1: “Bulb 1 will decrease in brightness when the switch is closed.”

- i. Do you agree or disagree with the student’s prediction about bulb 1 ? Qualitatively explain your reasoning.
- ii. Before the switch is closed, the power expended by bulb 1 is P_1 . Derive an expression for the power P_{new} expended by bulb 1 after the switch is closed in terms of P_1 .
- iii. How does the result of your derivation in part (a)ii relate to your explanation in part (a)i?

(b) A student makes the following prediction about bulb 2: “Bulb 2 will decrease in brightness after the switch is closed.”

- i. Do you agree or disagree with the student’s prediction about bulb 2 ? Explain your reasoning in words.
- ii. Justify your explanation with a calculation.

(c) While the switch is open, bulb 3 is replaced with an uncharged capacitor. The switch is then closed.

- i. How does the brightness of bulb 1 compare to the brightness of bulb 2 immediately after the switch is closed? Justify your answer.
- ii. How does the brightness of bulb 1 compare to the brightness of bulb 2 a long time after the switch is closed? Justify your answer.