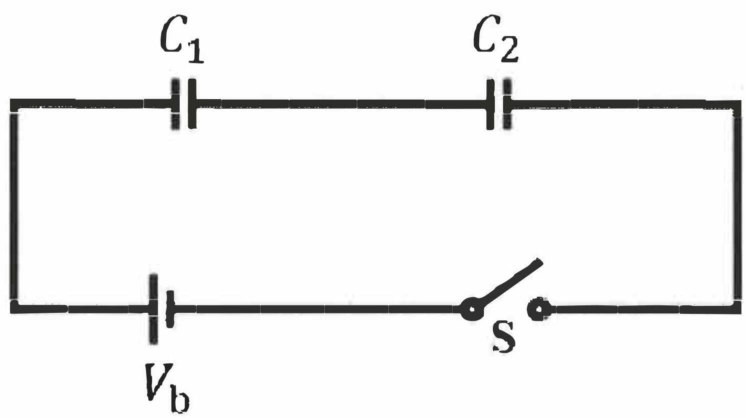
Series Capacitors

A pair of capacitors $C_1 = 38.0\ \mu$F and $C_2 = 28.0\ \mu$F are connected to a battery $V_b = 60.0$ V and a switch.

The capacitors are initially uncharged. After the switch has been closed and the capacitors are fully charged, what is the ratio Q_2/Q_1 of the charges on the capacitors, where Q_1 is the charge on C_1 and Q_2 is the charge on C_2?



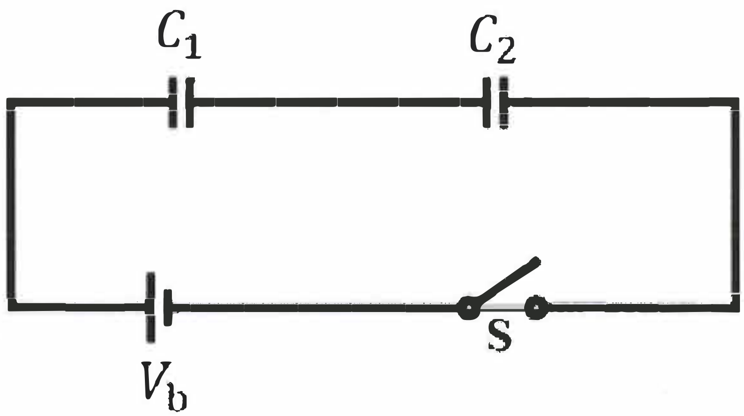
- (a) 0.543
- (b) 1.36
- (c) 0.737
- (d) 1.84
- (e) 1

For capacitors in series $Q_1 = Q_2$.

$$\boxed{\therefore \frac{Q_2}{Q_1} = 1}$$

Series Capacitors Voltage

A pair of capacitors $C_1 = 20.0\ \mu$F and $C_2 = 15.0\ \mu$F are connected to a battery $V_b = 60.0$ V and a switch. The capacitors are initially uncharged. After the switch has been closed and the capacitors are fully charged, what is the ratio V_2/V_1 of the voltages across the capacitors, where V_1 is the voltage across C_1 and V_2 is the voltage across C_2?



- (a) 1.33
- (b) 1
- (c) 0.562
- (d) 0.75
- (e) 1.78

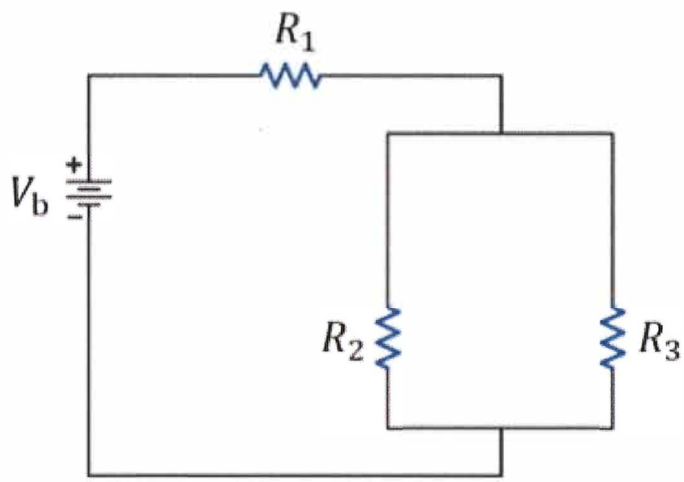
$$C = \frac{Q}{V} \quad \therefore \quad V = \frac{Q}{C}$$

$$\frac{V_2}{V_1} = \frac{Q_2/C_2}{Q_1/C_1} \quad \text{since } Q_2 = Q_1$$

$$\frac{V_2}{V_1} = \frac{C_1}{C_2} = \frac{20}{15} = \frac{4}{3} \Rightarrow \boxed{1.33}$$

Resistor Circuit

Consider the circuit below with $V_b = 5.40\ \mathrm{V}$, $R_1 = 150\ \Omega$, $R_2 = 185\ \Omega$ and $R_3 = 230\ \Omega$. Find the voltage across R_2.



- (a) 3.96 V
- (b) 4.92 V
- (c) 3.21 V
- (d) 2.19 V
- (e) 5.4 V

$$R_p = \frac{R_2 R_3}{R_2 + R_3} = 102.5\,\Omega$$

$$I = \frac{V_b}{R_1 + R_p} = \frac{5.4\ \mathrm{V}}{150\,\Omega + 102.5\,\Omega} = 0.0214\ \mathrm{A}$$

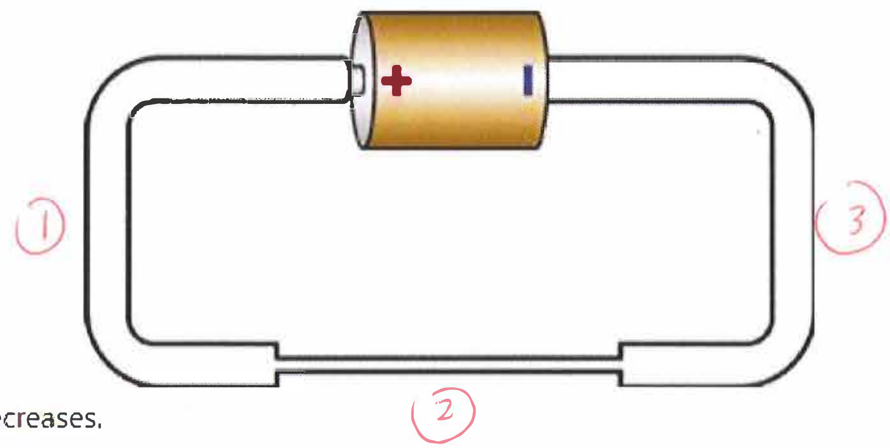
$$V_2 = V_b - I R_1 = \boxed{2.19\ \mathrm{V}}$$

or

$$V_2 = I R_p = \boxed{2.19\ \mathrm{V}}$$

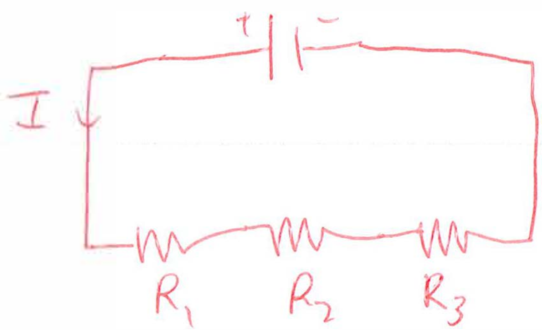
Wire Loop

The circuit below consists of a battery and a tungsten wire. As shown in the figure, the tungsten wire has a thin (small radius) section in the middle. What happens to the current as it moves from the thick section of the wire to the thin section?



- (a) The current decreases.
- (b) The current is zero.
- (c) The current increases.
- (d) The current is unchanged.
- (e) More information is needed.

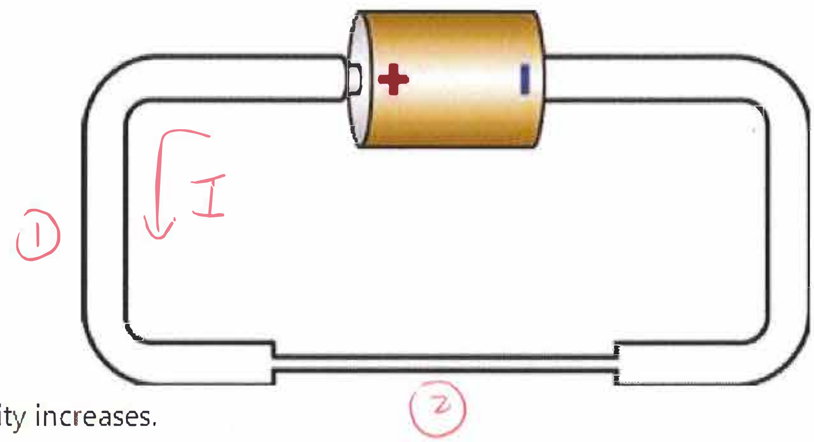
like series resistors



current I is same
in all resistors.

Drift velocity

The circuit below consists of a battery and a tungsten wire. As shown in the figure, the tungsten wire has a thin (small radius) section in the middle. As charges move from the thick section of wire to the thin section, what happens to the drift velocity?



- ○ (a) The drift velocity increases.
- ○ (b) The drift velocity decreases.
- ○ (c) The drfit velocity is unchanged.
- ○ (d) The drfit velocity is zero.
- ○ (e) More information is needed.

know $I_{①} = I_{②}$

$I = qnv_d A$

$\therefore \frac{I_{①}}{I_{②}} = \frac{\cancel{qn} V_{d①} A_{①}}{\cancel{qn} V_{d②} A_{②}}$ but $I_{①} = I_{②}$

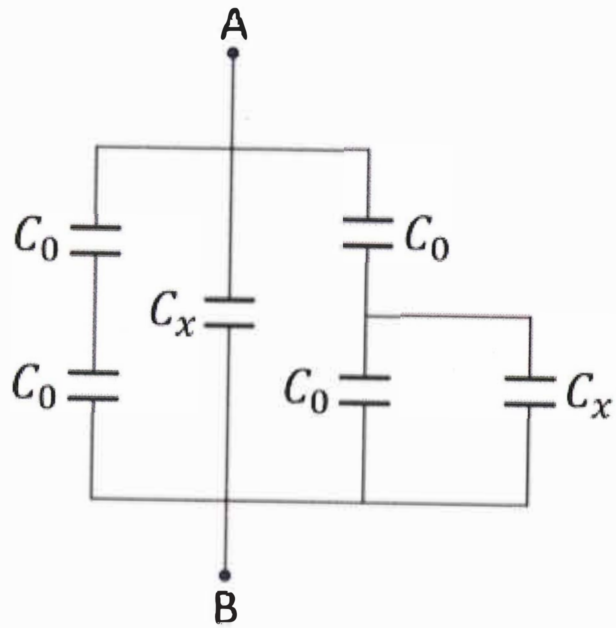
$\therefore \frac{V_{d②}}{V_{d①}} = \frac{A_{①}}{A_{②}}$ $A_{②} < A_{①}$

$\boxed{\therefore V_{d②} > V_{d①}}$

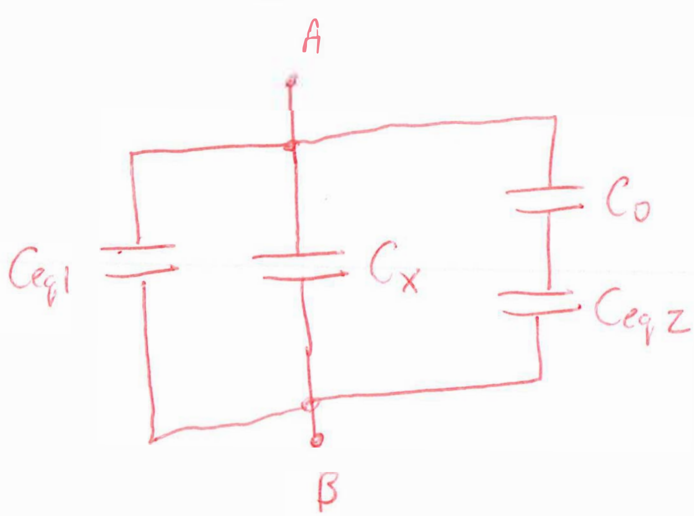
The drift speed increases as I goes from thick to thin section of wire.

Equivalent capacitance

If $C_x = 1.6C_0$, find the equivalent capacitance between the circuit nodes A and B.



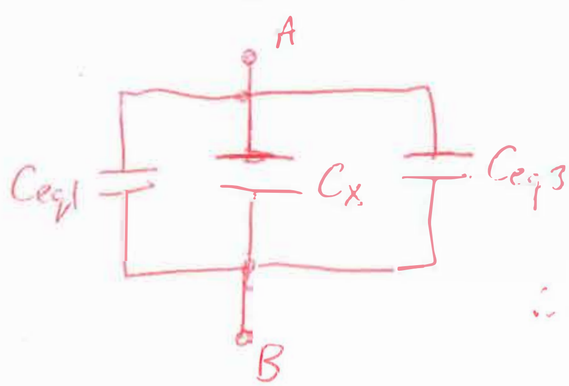
- (a) $1.6C_0$
- (b) $2.6C_0$
- (c) $0.5C_0$
- (d) $2.82C_0$
- (e) $0.722C_0$



$$\frac{1}{C_{eq1}} = \frac{1}{C_0} + \frac{1}{C_0} = \frac{2}{C_0}$$

$$\therefore C_{eq1} = \frac{C_0}{2}$$

$$C_{eq2} = C_0 + C_x$$



$$\frac{1}{C_{eq3}} = \frac{1}{C_0 + C_x} + \frac{1}{C_0} = \frac{C_0 + C_0 + C_x}{C_0(C_0 + C_x)}$$

$$\therefore C_{eq3} = \frac{C_0(C_0 + C_x)}{2C_0 + C_x}$$

$$\therefore C_{eq} = C_{eq1} + C_x + C_{eq3} = \frac{C_0}{2} + C_x + \frac{C_0(C_0 + C_x)}{2C_0 + C_x} = \boxed{2.82C_0}$$

Stored energy

A parallel plate capacitor with plate separation d_0 is charged by connecting it to a battery. The energy stored by the capacitor is U_0. The battery is then disconnected and the plate separation is changed to $d_1 = 2.4d_0$. If U_1 is the energy stored by the capacitor when the plate separation is d_1, what is the ratio U_1/U_0?

- (a) 0.645
- (b) 0.417
- (c) 5.76
- (d) 1.55
- (e) 2.4
- (f) 0.174

$$U_0 = \frac{Q^2}{2C_0} \qquad U_1 = \frac{Q^2}{2C_1}$$

after battery disconnected, charge on plates cannot change.

$$\therefore \frac{U_1}{U_0} = \frac{Q^2/2C_1}{Q^2/2C_0} = \frac{C_0}{C_1}$$

$$C = \varepsilon_0 \frac{A}{d}$$

$$\therefore \frac{U_1}{U_0} = \frac{\varepsilon_0 A/d_0}{\varepsilon_0 A/d_1} = \frac{d_1}{d_0} = \boxed{2.4}$$

Dissipated power

The power rating of a $2.20\ \mathrm{k\Omega}$ resistor is $1.00\ \mathrm{W}$. What is the maximum voltage that can be applied across this resistor?

- (a) 2.2e+03 V
- (b) 1.48 V
- (c) 0.0213 V
- (d) 2.2 V
- (e) 46.9 V

$$P = \frac{V^2}{R}$$

$$\therefore V_{max} = \sqrt{PR} = \sqrt{(2200\,W)(1\,W)}$$

$$= 46.9\ V$$

Kirchhoff laws

The Kirchhoff loop rule is a statement of which conservation princple?

- (a) conservation of charge
- (b) conservation of entropy
- (c) conservation of momentum
- (d) conservation of energy
- (e) conservation of angular momentum

Net Change in P.E. of a charge around a closed loop in a circuit is zero.

Instantaneous current

A charge crossing a surface due to a proton beam is given by $Q = 5.0t^3 + 4.0t^2 + 6.0$ where Q is measured in Coulombs and the time t is measured in seconds. What is the current due to the proton beam when $t = 1.0$ s.

- (a) 23 A
- (b) 14 A
- (c) 23 A
- (d) 14 A
- (e) 15 A

$$I = \frac{dQ}{dt} = (3)(5)t^2 + (2)(4)t$$

$$= 23 \text{ A}$$