

INKPHYSICS FLASHCARDS

Capacitance

Year 13 · 8 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/flashcards.

DEFINITION

Define: Capacitance.

CAPACITORS AND ENERGY STORED

CHECK YOURSELF

A capacitor has plates of area 0.020 m^2 separated by 1.0 mm , with a dielectric of relative permittivity 2.5 . Find its capacitance, and the charge and energy it stores at 12 V .

Hint: Geometry first, then $Q = CV$, then the energy form that uses what you now hold.

CAPACITORS AND ENERGY STORED

SPOT THE ERROR

Say what is wrong with this claim:

A capacitor is a small battery.

CAPACITORS AND ENERGY STORED

CHECK YOURSELF

A 12 V supply charges a capacitor through a $10 \text{ k}\Omega$ resistor. State the current the moment the switch closes, and the current and capacitor pd after a long time, explaining each value.

Hint: At the first instant the capacitor opposes nothing; after a long time it opposes everything.

CHARGING AND DISCHARGING

SPOT THE ERROR

Say what is wrong with this claim:

A capacitor charges at a steady rate until it is full.

CHARGING AND DISCHARGING

DEFINITION

Define: Time constant.

THE TIME CONSTANT AND EXPONENTIAL DECAY

CHECK YOURSELF

A $470 \mu\text{F}$ capacitor discharges through a $10 \text{ k}\Omega$ resistor. Find the time constant, the half-life, and the fraction of the charge remaining after 9.4 s .

Hint: Base units first; then notice what 9.4 s is in time constants.

THE TIME CONSTANT AND EXPONENTIAL DECAY

SPOT THE ERROR

Say what is wrong with this claim:

After one time constant the capacitor is empty.

THE TIME CONSTANT AND EXPONENTIAL DECAY

CHECK YOURSELF

$C = A\epsilon_0\epsilon_r/d = (0.020 \times 8.85 \times 10^{-12} \times 2.5) / 1.0 \times 10^{-3} = 4.4 \times 10^{-10} \text{ F}$, about 0.44 nF.

$Q = CV = 4.4 \times 10^{-10} \times 12 = 5.3 \times 10^{-9} \text{ C}$.

$E = 1/2 CV^2 = 0.5 \times 4.4 \times 10^{-10} \times 144 = 3.2 \times 10^{-8} \text{ J}$: tiny numbers, so the farad rarely appears without a prefix.

CAPACITORS AND ENERGY STORED

DEFINITION

The charge stored per unit potential difference: $C = Q/V$, in farads.

CAPACITORS AND ENERGY STORED

CHECK YOURSELF

At $t = 0$ the uncharged capacitor has no pd, so the whole 12 V sits across the resistor: $I_0 = V/R = 12 / 10\,000 = 1.2 \text{ mA}$.

After a long time the capacitor pd has climbed to 12 V, matching the supply.

With no pd left across the resistor the current is zero: the capacitor is fully charged and the circuit rests.

CHARGING AND DISCHARGING

SPOT THE ERROR

A battery converts chemical energy and holds its voltage steady for hours; a capacitor merely stores separated charge, and its voltage falls the moment charge leaves. Capacitors deliver small energy fast; batteries deliver large energy slowly.

CAPACITORS AND ENERGY STORED

DEFINITION

The time RC for the charge on a discharging capacitor to fall to $1/e$, about 37%, of its initial value.

THE TIME CONSTANT AND EXPONENTIAL DECAY

SPOT THE ERROR

The flow is never steady: the fuller the capacitor, the smaller the pd left to push charge, so the current – and the rate of charging – dies away exponentially. Fast at first, then ever slower, and never strictly full.

CHARGING AND DISCHARGING

SPOT THE ERROR

After one time constant RC , about 37% of the charge remains – not zero. Exponential decay loses the same fraction in each interval, so the capacitor approaches empty without ever arriving.

THE TIME CONSTANT AND EXPONENTIAL DECAY

CHECK YOURSELF

$RC = 10\,000 \times 470 \times 10^{-6} = 4.7 \text{ s}$.

$T_{1/2} = 0.69RC = 0.69 \times 4.7 = 3.2 \text{ s}$.

9.4 s is two time constants, so the fraction left is $e^{-2} = 0.135$, about 13.5%: two rounds of keeping 37%.

THE TIME CONSTANT AND EXPONENTIAL DECAY