Capacitors – Questions ①

A Physics Capacitors

1. (a) What is the definition and unit of capacitance? (2) [$e = -1.6 \times 10^{-19}$ C]

(b) A 2200 μF capacitor is connected to a 1.5 V cell. What charge is stored? How many electrons is this? Draw the circuit and show where the electrons are. (5)

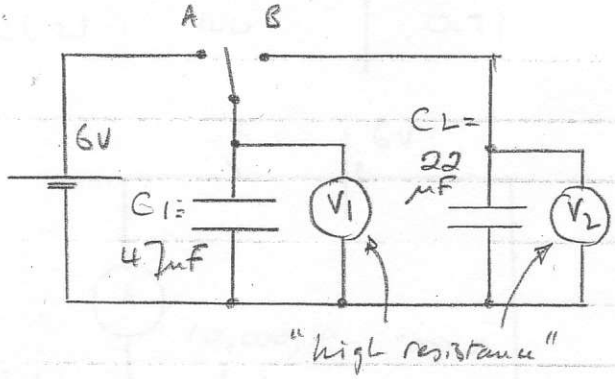
(c) How much energy is stored in the capacitor? (2)

(d) If you wanted to store 0.1 J energy at the same p.d., what capacitance would you need? (2) [9]

2. (a) You have three 12 μF capacitors. Draw the 4 ways of combining them and calculate the total capacitance of each. (8)

(b) If each capacitor can withstand 10 V, how can you arrange them to have a total capacitance of 8 μF, that can withstand 30 V? (You will need more than 3 capacitors, but less than 10!) (2) [10]

3. In the circuit shown, the switch is moved to A for a short time, then moved to B.



(a) What is the reading on V_1, with switch at A? (2)

(b) When the switch is moved to B, what happens to the charge, and the p.d. across each capacitor? (3)

(c) What are the new readings on each voltmeter? (4)

(d) What is the total energy delivered by the battery to charge C1? (2)

(e) What is the energy stored by C1 at 6 V? (2)

(f) What is the energy stored by C1 and C2 together, with the switch at B? (2)

(g) Can you explain the differences between answers (e), (f) and (g)? (2) [17]

C1 and C2 initially uncharged!!

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Capacitors — Questions – ②

A Physics

4. An 8.0 μF capacitor is charged to 50V
A 4 μF capacitor is charged to 200V.

(a) Calculate the charge and energy stored in each (2×3)

(b) They are then joined in parallel.
Calculate the new p.d. across each, the charge stored in each, and the energy stored by each. (3×2)

(c) Draw a diagram to show where the charge flows when they are connected. (2)

(d) Explain the change in energy stored (2) [16]

5. A capacitor is discharged through a 12 kΩ resistor, and the capacitor p.d. falls as shown →

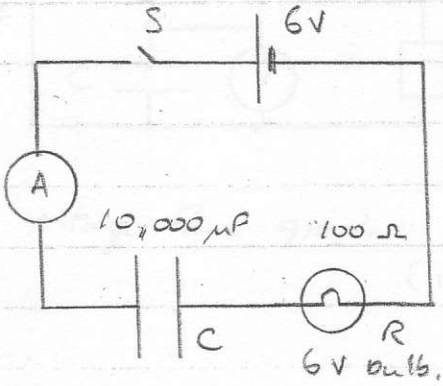
time (Secs)	p.d. (volts)
0	9.6
20	5.8
40	3.5
60	2.1
80	1.3
100	0.77

(a) Plot the p.d./time graph (4)

(b) Estimate the "half life" – the time for p.d. to halve (2) [8]

(c) Calculate the value of capacitance (2)

6. With C initially uncharged, switch S is closed.



(a) What is the initial current in the circuit? (2)

(b) What is the final p.d. across C? (1)

(c) What is the time constant? (2)

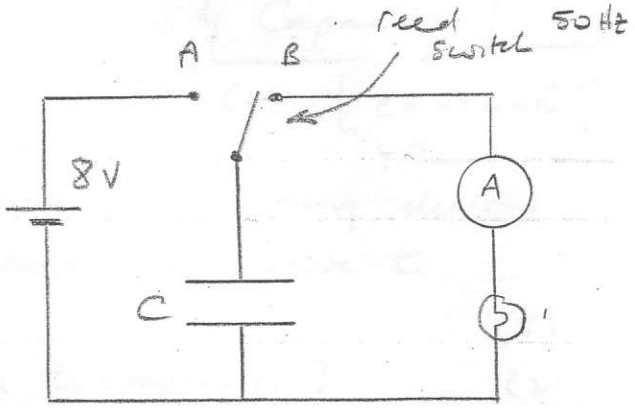
(d) What is the "half life" time $t_{\frac{1}{2}}$? (2)

(e) Sketch graphs of voltage across C, and current through bulb against time (2 × 4)

(f) Describe and explain what happens in the circuit as C charges up. (3) [18]

Capacitors - Questions - (3) A Physics

7. The reed switch operates at 50 Hz to charge C from the battery, and discharge it through the bulb. The ammeter shows a current of 32 mA flows



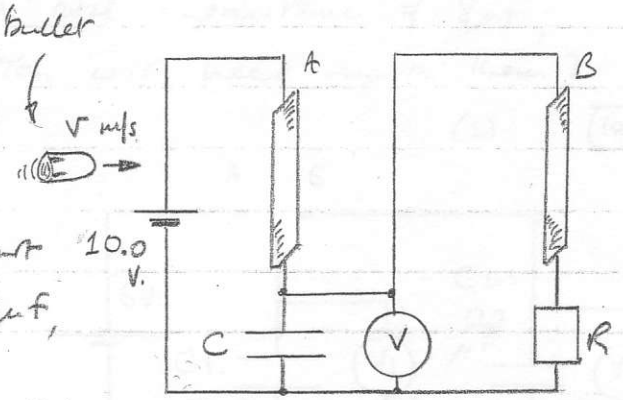
(a) What is the charge flowing each second? (1)

(b) Calculate the value of C (2)

(c) Sketch a graph to show how the capacitor p.d. varies over 1 cycle of charge and discharge (5)

(d) Will the capacitor be fully charged in the time available? Explain your answer. (3) [11]

8. This arrangement is used to measure the speed of a bullet. A and B are thin strips of aluminium foil, 0.2 m apart. The cell has a p.d. of 10 V, C = 2.0 μF, and R = 800 Ω



(a) Calculate CR, and $t_{\frac{1}{2}}$. (2)

(b) Use these figures to plot (not sketch) the voltage time graph. (for times up to $3 \times t_{\frac{1}{2}}$). (4)

(c) Data from measurements of bullet speed...
p.d. before bullet is fired. — 10.0 V.
p.d. after bullet has broken strips A and B — 4.1 V
Use your graph to find the time delay between A and B, (2)

(d) What is the speed of the bullet? (2)

(e) Explain briefly how this arrangement is used to measure the speed of a bullet (4) [14]

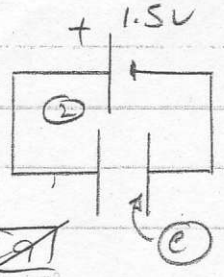
Capacitors – Answers – Q 1-4 (A Physics Classic)

1. (a) charge stored / volt of p.d. Farad (2)

(b) $Q = CV$ (1) $= 3.3 \times 10^{-3}$ (1) C $= 2.1 \times 10^{16}$ electrons /5

(c) Energy $= \frac{1}{2}QV = \frac{1}{2}CV^2 = 2.5 \times 10^{-3}$ J /2

(d) $C = 2 \times \text{energy} / V^2 = 2 \times 0.1 / 1.5^2 = 0.089$ farad



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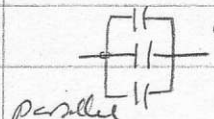
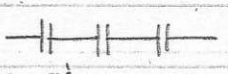
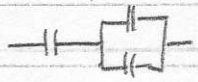
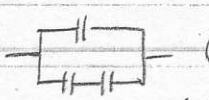
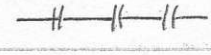
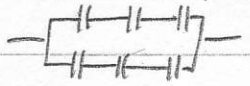
2. (a)  parallel $C_t =$ 36μf  series $C_t = 12/3 =$ 4μf  $C_t = \frac{12 \times 24}{12+24} =$ 8μf  $C_t = 12 + 6 =$ 18μf (8)

(b) You need 3 Caps in series →  $C_t = 4\mu f$ $V_{max} = 30V$

So you need ...  $C_t = 4 + 4 =$ 8μf (2) 10

3. (a) $V_1 = 6$ V (2)

(b) Charge flows (1) $C_1 \rightarrow C_2$ (1) until p.d.s equal (1) /3

(c) use $Q = CV$ Q constant at $Q = C_1V = 47 \times 10^{-6} \times 6 =$ 2.82 × 10⁻⁴ C (1)

New $C_t = 47 + 22 =$ 69μf (1)

So p.d. across both $V = Q/C_t = 2.82 \times 10^{-4} / 69 \times 10^{-6} =$ 4.1 V (1) /4

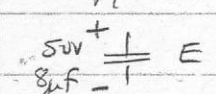
(d) energy from battery $E_{batt} = Q \times V_{batt} = 2.8 \times 10^{-4} \times 6 =$ 1.69 × 10⁻³ J (2)

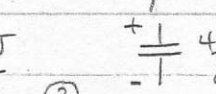
(e) E stored by C_1, $E_{C1} = \frac{1}{2}CV^2 =$ 8.5 × 10⁻⁴ J (2)

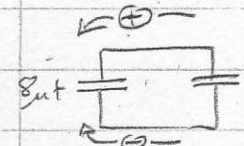
(f) E on $C_1 + C_2$, $E_{final} = \frac{1}{2}C_tV^2 = \frac{1}{2}QV_{final} =$ 5.8 × 10⁻⁴ J (2)

(g) Each time charge flows, energy is lost in overcoming resistance of wires, and heating them up.

Energy lost (1) flow of charge battery → C_1 (2) charge flow $C_1 \rightarrow C_2$ (2) 17

4. (a)  $E = \frac{1}{2}CV^2 =$ 0.01 J $Q = CV =$ 4 × 10⁻⁴ C (3)

 $E = \frac{1}{2}CV^2 =$ 0.08 J $Q = CV =$ 8 × 10⁻⁴ C (3) (6)

(b)  $Q_t =$ 12 × 10⁻⁴ C $C_t =$ 12 × 10⁻⁶ F so new pd $V = \frac{Q_t}{C_t} =$ 100 V

$Q_{8\mu f} = CV = 8 \times 10^{-6} \times 100 = 8 \times 10^{-4}$ C $Q_{4\mu f} = CV =$ 4 × 10⁻⁴ C 16

$E_{8\mu F} = \frac{1}{2}QV =$ 4 × 10⁻² J $E_{4\mu f} = \frac{1}{2}QV =$ 2 × 10⁻² J $E_t =$ 6 × 10⁻² J

(c) charge flows 4μf → 8μf (d) Initially $E_t =$ 0.09 J; Finally $E_t =$ 0.06 J } lost as heat when charge flows in wires

TLN 3.98 (phew!)

Capacitors - Q 5-8 Answers /12 A Physics

5.... (a) graph..... /4

(b) $t_{\frac{1}{2}} = 27$ s /2

(c) $t_{\frac{1}{2}} = 0.69CR$

$\hookrightarrow C = 3.3 \times 10^{-3}$ f

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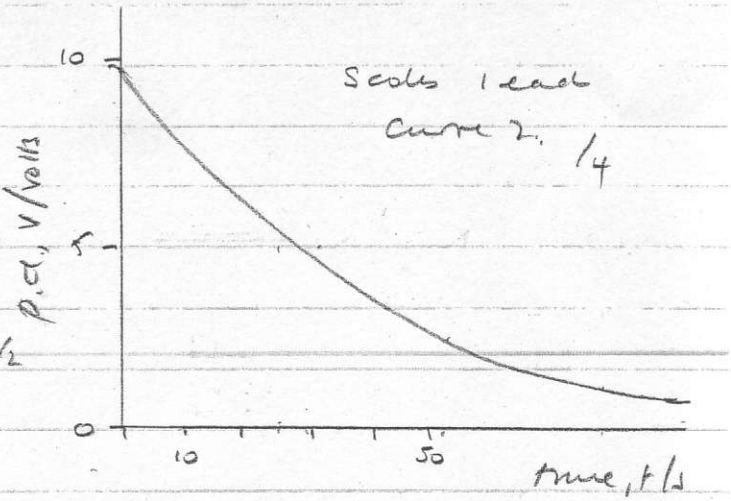


Scales 1 each

Curve 2. /4

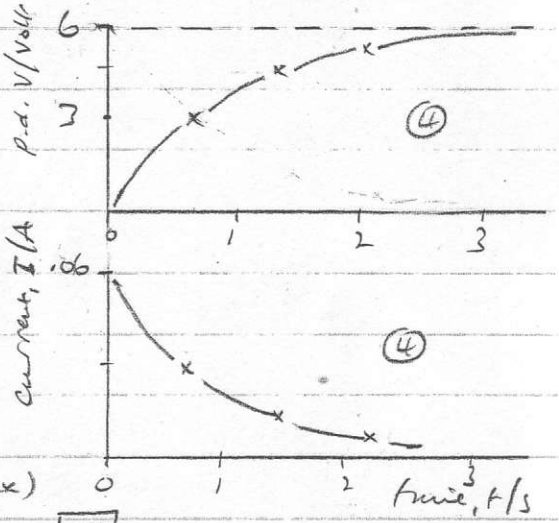
6. (a) $I_0 = V_0/R = 6/100 = 0.06$ A $= 60$ mA /2

(b) $V_{final} = 6$ V.!! /1

(c) $\frac{1}{2}$ = 1 sec /2

(d) $t_{\frac{1}{2}} = 0.69CR = 0.69$ s /2

(e) graph ... labels (1), Scales (2), plot (1)



(f) as C charges up .....

Electrons flow (1) round circuit (clockwise), large initial current, as p.d. builds up (1) across C, opposing cell p.d., current falls (1) exponentially, approaching zero (3max)

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7. (a) charge/sec, $Q = I = 32 \times 10^{-3}$ A = C/s. /1

(b) Current = Q/sec = CVf $\Rightarrow C = I/Vf = 32 \times 10^{-3}/8 \times 50 = 80\ \mu$f /2

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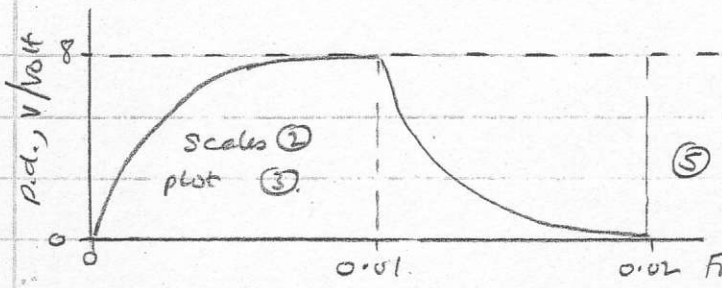
(c)



Scales (2)

plot (3).

(5)

You need R-value for this!

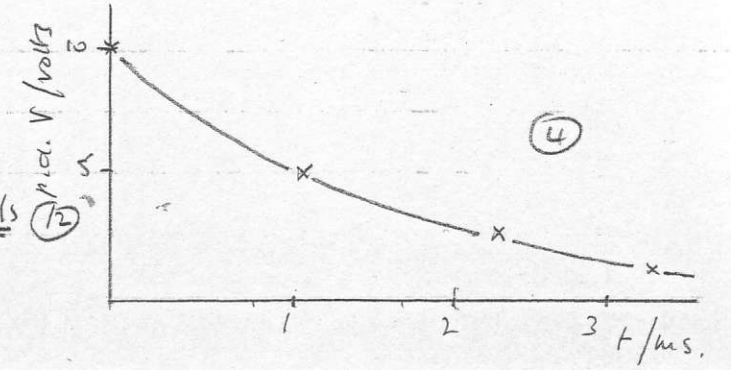
$t_{\frac{1}{2}} = 0.69CR$ should be

$\ll 0.01$ sec for C to fully charge/discharge. /3.

8. (a) $CR = 1.6 \times 10^{-3}$ s $t_{\frac{1}{2}} = 1.1 \times 10^{-3}$ s. /2

(b) From graph, t delay should be 1.43×10^{-3} sec (2)

(c) $V = d/t = 0.2/1.43 \times 10^{-3} = 140$ m/s /2



(d) Bullet breaks strip A, C starts discharging as bullet travels to B.

Bullet breaks B, stops C discharging.

Time for travel A - B found from V drop.

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TW 3.98