Lecture - 1
Chapter - 1

Basic Electric Circuit : একটা source থাকে (Battery), ~~এবং~~ Load থাকে (light, fan etc), এবং current flow থাকে (e^- এর flow) যার ফলে আমরা output পাই।

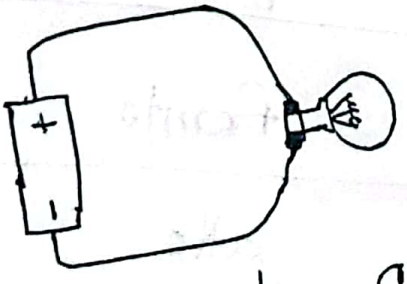
Note: আমাদের simple circuit নিয়েই কাজ করতে হবে। complex সুযোগ নাও থাকতে পারে।

What we will do in EC?

→ এই course আমাদের circuit দেয়া থাকবে। তা আমাদের solv করতে হবে। এবং solv ~~করে~~ →

Current determine → i
Voltage ও → V
resistance ও → R
Power ও → P

} determine করতে হবে



Simple Circuit

⊛ System of Units:

⊛ SI এককঃ

multiplier	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	K
10^{2}	hekto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	C
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Charge (Q): Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).

1ft
(*) ~~ইলেকট্রন~~ (e^-) এর charge 1.69×10^{-19} C

(*) 1 C charge এ electron আছে 6.24×10^{18} ft।

Q: 5 C এর charge কত?

1 ft e^- এর charge হলো 1.69×10^{-19} C

So,

1.69×10^{-19} C ——— 1 e^-

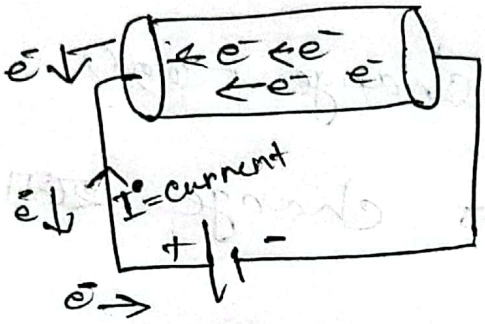
1 C ——— $\frac{1}{1.6 \times 10^{-19}}$

5 C ——— $\frac{5 \times 1}{1.6 \times 10^{-19}}$

$= 3.125 \times 10^{19}$ e^-

Current flow: (I)

e^- এর flow হলো Current flow. অর্থাৎ, rate of change of charge, which is measured in amperes (A).



→ Current ~~always~~ positive to negative flow বলে।

→ But in reality electrons হলো negative to positive এ flow হয়।

→ Charge এর flow হলো current flow (I) হয়। এটি time এর respect এ flow হয়।

Mathematical equation for current :

$$i = \frac{\Delta q}{\Delta t} = \frac{q_2 - q_1}{t_2 - t_1} = \frac{dq}{dt}$$

$\frac{dq}{dt}$ → অনেক ছোট Δq এর ক্ষেত্রে ।এর Continous হবে

$\frac{q_2 - q_1}{t_2 - t_1}$ → discrete বা linear এর জন্য

Current Flow. = i

Charge = q

⇒ অর্থাৎ, যদি current flow কোথায় interval এর-মধ্যে হয় বা linear equation বা graph linear হয় সেক্ষেত্রে,

$\therefore$ Current, $i = \frac{q_2 - q_1}{t_2 - t_1}$

Here,
i = current
q_1 = Charge 1
q_2 = Charge 2
t_1 = Charg 1's time
t_2 = Charge 2's time

(*) Current কোনো নির্দিষ্ট time (t) এর, continous ~~non linear~~ eqn হলে তাকে:

$$i = \frac{dq}{dt}$$

Here,
Q = Charge এর equation based on (t).

Q, Charge এর Unit হলো Coulomb (C)

I, Current ,, ,, ,, Ampere (A).
$= (Cs^{-1})$

$1\ A = 1\ C/s$

$mA = 10^{-3} A$ = mili Ampere

$\mu A = 10^{-6} A$ = micro Ampere

$nA = 10^{-9} A$ = nano Ampere

$kA = 10^{3} A$ = kilo Ampere

$MA = 10^{6} A$ = Mega Ampere

Mathmetical equation for charge (Q):

we know,

$$i(t) = \frac{dQ}{dt}$$

$$\Rightarrow i\,dt = dQ$$

$$\Rightarrow \int i\,dt = \int dQ$$

$$\therefore Q = \int i\,dt$$

$$\boxed{\therefore Q = \int_{t_0}^{t} i\,dt}$$

Here,

Q = charge

t_0 = lower limit time

t = upper limit time

$\pi = 3.1416$ or $\pi = 180°$

for radian for degree

Example 1.2 (i) The total charge entering a terminal is given by $q = 5t \sin 4\pi t$ mC. Calculate the current at $t = 0.5$ s.

Solution:

Here,

$$q = 5t \sin 4\pi t \text{ mC}$$

$\therefore$ Current,

$$i = \frac{dq}{dt} = \frac{d(5t \sin 4\pi t)}{dt}$$

($5t$ → u, $\sin 4\pi t$ → v)

$$= 5t \times \frac{d}{dt}(\sin 4\pi t) + \sin 4\pi t \times \frac{d(5t)}{dt}$$

$$= 5t \times \cos 4\pi t \times 4\pi + \sin 4\pi t \times 5$$

$$= 20\pi t \cos 4\pi t + 5 \sin 4\pi t$$

$$\therefore i(t) = 20\pi t \cos 4\pi t + 5 \sin 4\pi t$$

So, at $t = 0.5$ s, Current is;

~~$i(0.5) = 20\pi \times \cos$~~

$$i(0.5) = 20 \times \pi \times (0.5) \times \cos(4\pi(0.5)) + 5 \sin 4\pi (0.5)$$

$$= 31.42 \text{ mA}$$

(Ans)

$$\frac{d(u.v)}{dx} = u \cdot \frac{dv}{dx} + v \cdot \frac{du}{dx}$$

(ii) If in example 1.2 $q = (10 - 10e^{-2t})$ mC, find the current at $t = 1.0$ s

Soln:

Here,

$$q = 10 - 10e^{-2t}$$

So,

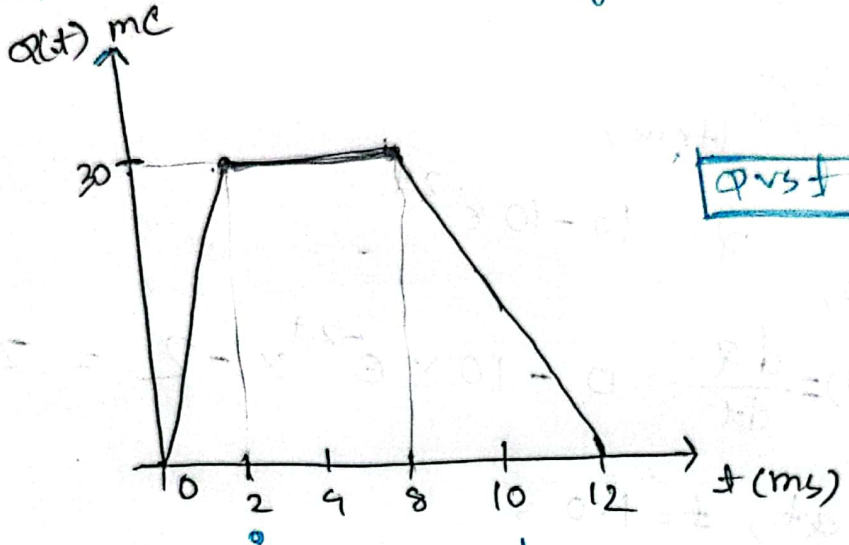
$$i(t) = \frac{dq}{dt} = 0 - 10 \times e^{-2t} \times -2 = 20e^{-2t}$$

at, $t = 1.0$ s

$$i(1.0) = 20 \times e^{-2 \times 1.0}$$

$$= 2.707 \text{ mA} \quad \text{(Ans)}$$

Question: The charge entering a certain element is shown in figure below:



q vs t graph

Find the current at:

(a) $t = 1$ ms (b) $t = 6$ ms (c) $t = 10$ ms

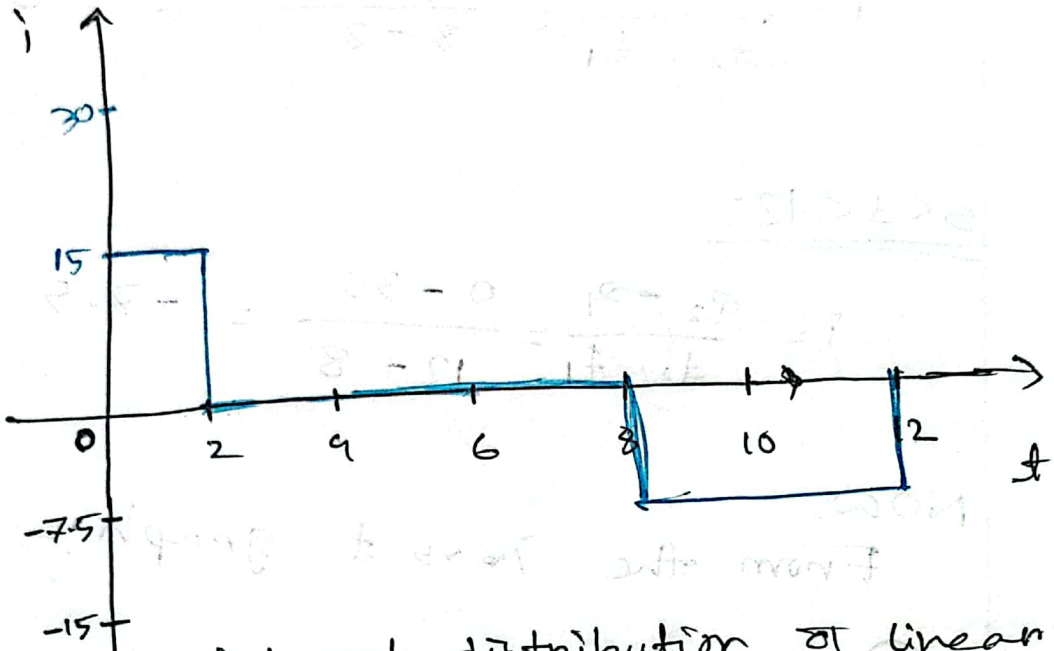
Solution: ১ type question ১ দেয়া আছে q vs t graph. ১ ~~current~~ প্রত্যেকটি point ১ current (i) বের করতে হবে।

Solution steps:

① প্রথমে (q vs t) graph টিকে (i vs t) graph ১ convert করব।

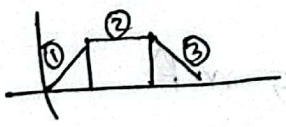
② then t point ১ i বের করব।

⁂ Changing q vs t to i vs t graph



→ এখানে graph interval distribution টা linear তাই আমরা, $i = \frac{Q_2 - Q_1}{t_2 - t_1}$ equation use করতে পারি।

→ এখানে 3 time zone (0-2, 2-8, 8-12) এ 3টি different ধরনের current আছে। So:-



Here,

So, t_1 → ① $t < ②$: t_2 → $t_2 = 2$; $t_1 = 0$; $Q_2 = 30$; $Q_1 = 0$

$$i = \frac{Q_2 - Q_1}{t_2 - t_1} = \frac{30 - 0}{2 - 0} = 15 \text{ mA}$$

এখানে যেহেতু 0 to 2 interval এ $i = 15$ constant তাই graph টি 3 constant এ graph হবে।

$2 < t < 8$:

$$I = \frac{q_2 - q_1}{t_2 - t_1} = \frac{30 - 30}{8 - 2} = \frac{0}{6} = 0$$

$8 < t < 12$:

$$I = \frac{q_2 - q_1}{t_2 - t_1} = \frac{0 - 30}{12 - 8} = -7.5$$

NOW,
From the i vs t graph:-

(1) at, $t = 1$ ms:

$I = 15$ mA

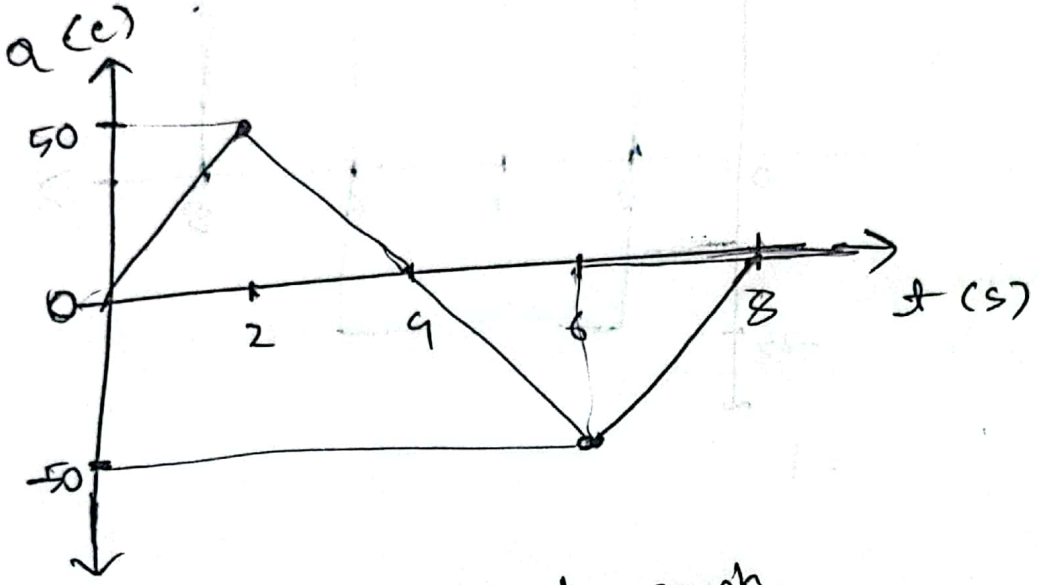
(4) $t = 6$ ms:

$I = 0$ mA

(4) $t = 10$ ms:

$I = -7.5$ mA

(*) The charge flowing in a wire is plotted in the given fig:



q vs t graph

convert to i vs t graph

Here, $Q_2 = 50 \mid Q_1 = 0 \mid t_2 = 2 \mid t_1 = 0$

$0 < t < 2$:

$$i = \frac{Q_2 - Q_1}{t_2 - t_1} = \frac{50 - 0}{2 - 0} = 25 \text{ A}$$

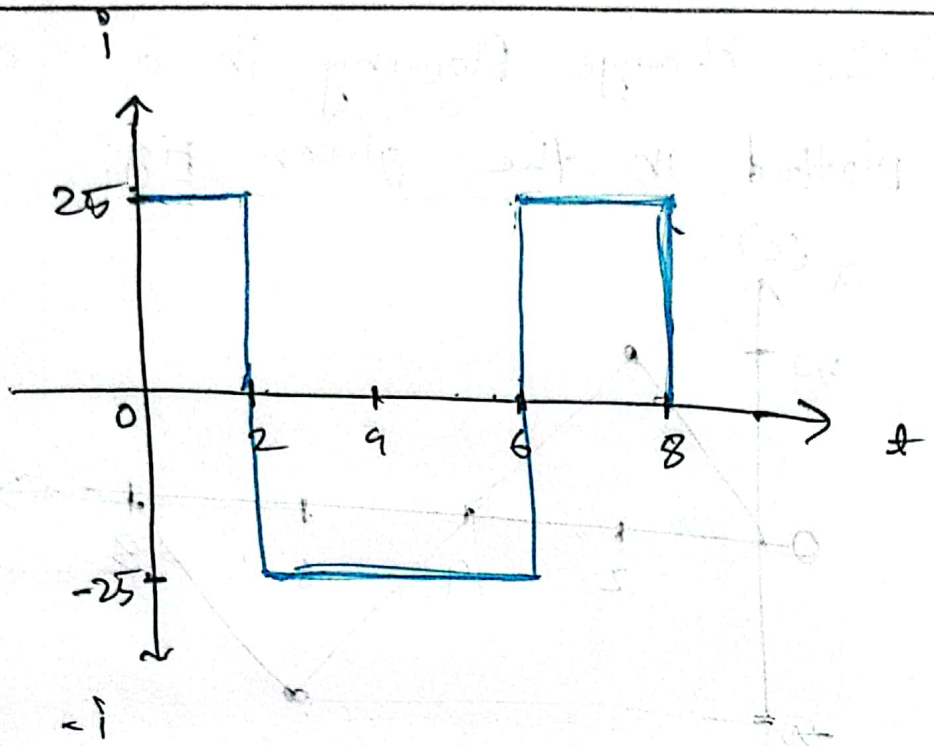
$2 < t < 6$:

$Q_2 = -50 \mid Q_1 = 50 \mid t_2 = 6 \mid t_1 = 2$

$$i = \frac{-50 - 50}{6 - 2} = -25 \text{ A}$$

$6 < t < 8$: $Q_1 = -50 \mid Q_2 = 0 \mid t_1 = 6 \mid t_2 = 8$

$$i = \frac{0 - (-50)}{8 - 6} = 25 \text{ A}$$



learn All diff and
Integrations equation

Lecture - 2

✱ Integration 2 type এর হয় :-

① With Limit: Charge value বের করা হয়.
[নির্দিষ্ট interval এর ক্ষেত্রে i.e. Limit থাকলে]

② Without limit: Charge এর equation বের বের করতে হবে. equation এর variable হবে time (t) হবে।

With limit:

$$\text{Charge, } Q(t) = \int_{t_1}^{t_2} i \, dt$$

[নির্দিষ্ট interval এর ক্ষেত্রে with limit এ করব।]

Without limit:

$$\text{Charge, } Q(t) = \int i \, dt$$

[একটা particular time-এ charge বের করতে বলবে, সেখানে without limit এ equation বের করব then সেই particular t এর মান বসিয়ে Q বের করব।]

Example: Determine the total charge entering a terminal between $t = 1$ s and $t = 2$ s if the current passing the terminal is

$i = (3t^2 - t)$ A.

Soln: Here,

$i = (3t^2 - t)$ A | $Q = ?$

~~Gate~~ ~~Specific times~~.

time limit, $t_1 = 1$ and $t_2 = 2$

$$\therefore Q = \int_{t_1}^{t_2} i\,dt = \int_1^2 (3t^2 - t)\,dt$$

$$= \left[\frac{3}{3} \times t^3 - \frac{t^2}{2}\right]_1^2$$

$$= \left[t^3 - \frac{t^2}{2}\right]_1^2$$

$$= 5.5 \text{ C}$$ Ans

(*) The current flowing through an element is:

$$i = \begin{cases} 9\ A\ ; & 0 < t < 1 \\ 9t^2\ A; & t > 1 \end{cases}$$

Calculate the charge entering the element from $t = 0$ to $t = 2$ s

Solution:

Charg from $t = 0$ to $t = 2$ s. is

$$Q = \int_0^2 i\ dt = Q_1 + Q_2$$

$0 < t < 1$:

$$Q_1 = \int_0^1 9\ dt = [9t]_0^1 = 9$$

$2 > t > 1$:

$$Q_2 = \int_1^2 9t^2\ dt = \left[\frac{9t^3}{3}\right]_1^2 = \left(\frac{9 \times 2^3}{3}\right) - \left(\frac{9 \times 1^3}{3}\right)$$

$$= 9.33$$

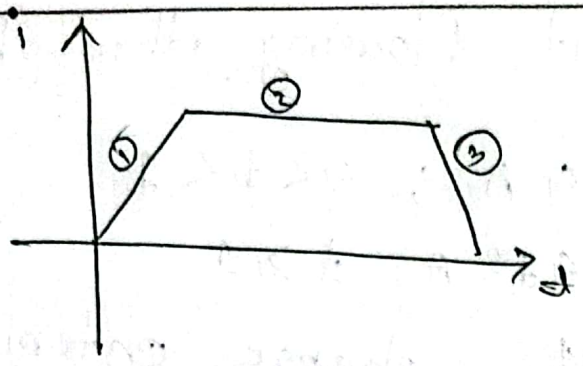
$$\therefore Q = \int_0^2 i\ dt = \int_0^1 9\ dt + \int_1^2 9t^2\ dt$$

$$= 9 + 9.33$$

$$= 13.33\ C$$

Ans

⇒



এখানে, i vs t এর graph আছে সেটা

charge বের করার equation হলো:

$$q = \int_{t_1}^{t_2} i\,dt$$ এখানে i এর equation

এ (i) এর equation বসাতে হবে।

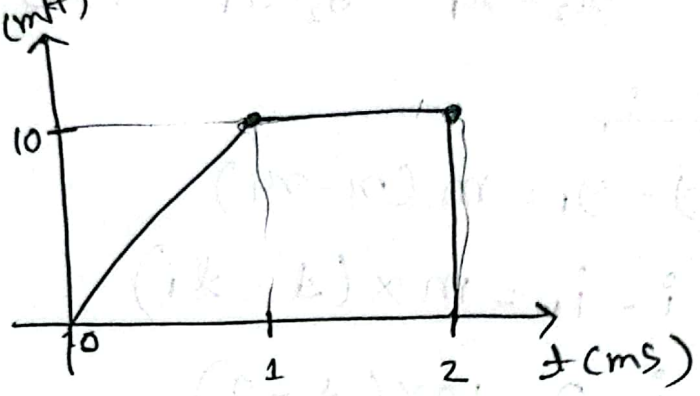
But graph এ তো equation নাই value দেয়া আছে। তাই graph এ value i এর value থেকে (i) এর equation বের করার জন্য সরল রেখার 2ft equation use করব।

$$y - y_1 = m(x - x_1)$$

এখানে,
y হচ্ছে : i (current)
x হচ্ছে : t (time)
m হলো ঢাল

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

1.8: The current flowing past a point in a device is shown in Figure below. Calculate the total charge through the point. i(mA)

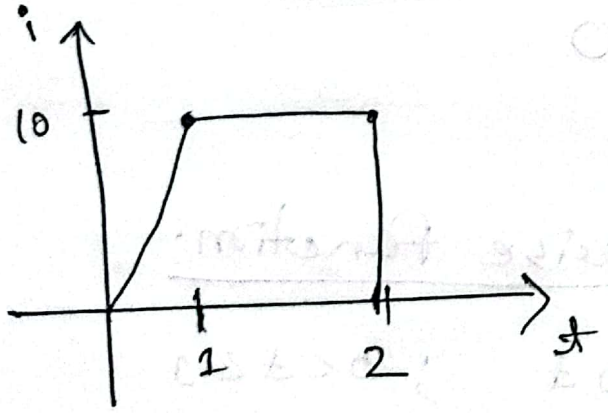


Soln:

2 type ची Math ची solution Steps असतात

उदा:- 1 Current ची Graph → 2 Current ची Piecewise equation → 3 With Limit Integration → 4 Total Charge

Steps 1:



Step 2:

for $0 < t < 1$:

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{i_2 - i_1}{t_2 - t_1} = \frac{10 - 0}{1 - 0} = 10$$

Here,
$i_1 = 0$
$i_2 = 10$
$t_1 = 0$
$t_2 = 1$

$\therefore$ ~~i i~~
~~t t~~

$$y - y_1 = m(x - x_1)$$

$$\Rightarrow i - i_1 = m \times (t - t_1)$$

$$\Rightarrow i - 0 = 10 \times (t - 0)$$

$$\Rightarrow \therefore i = 10t$$

$1 < t < 2$:

$$m = \frac{10 - 10}{2 - 1} = 0$$

$$i - i_1 = 0 \times (2 - 1)$$

$$\Rightarrow i - 10 = 0$$

$$\therefore i = 10$$

$\therefore$ Piece wise function:

$$i = \begin{cases} 10t & ; 0 < t < 1 \\ 10 & ; 1 < t < 2 \\ 0 & ; t > 2 \end{cases}$$

Step 3:

Total charge:

$$Q = \int_0^{\infty} i \, dt$$

$$= \int_0^1 i \, dt + \int_1^2 i \, dt + \int_2^{\infty} i \, dt$$

$$= \int_0^1 10t \, dt + \int_1^2 10 \, dt + \int_2^{\infty} 0 \, dt$$

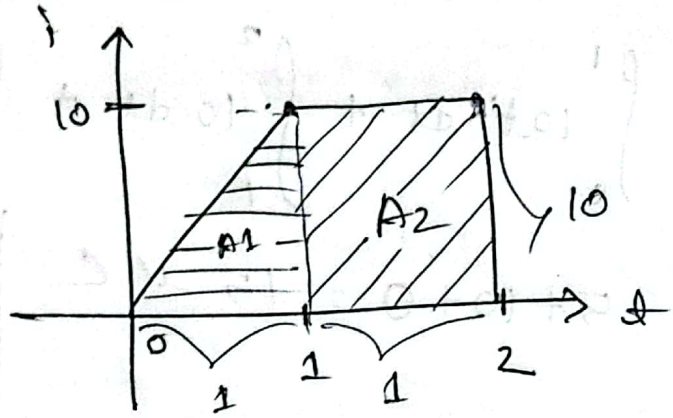
$$= 5 + 10 + 0 = 15 \, \mu C$$

এখানে, integration হওয়ায় ms × mA = mC হবে। তা μC হবে।

Alternative:

অন্য Integration Method এ না করে Area under the curve method এ করতে পারি। (Fundamental এর Integration topic):

এই ক্ষেত্রে:-



Area of

A_1 = triangle from 0 to 1

$= \frac{1}{2} \times$ height $\times$ weight

$= \frac{1}{2} \times$ ভূমি $\times$ উচ্চতা $= \frac{1}{2} \times 1 \times 10 = 5$

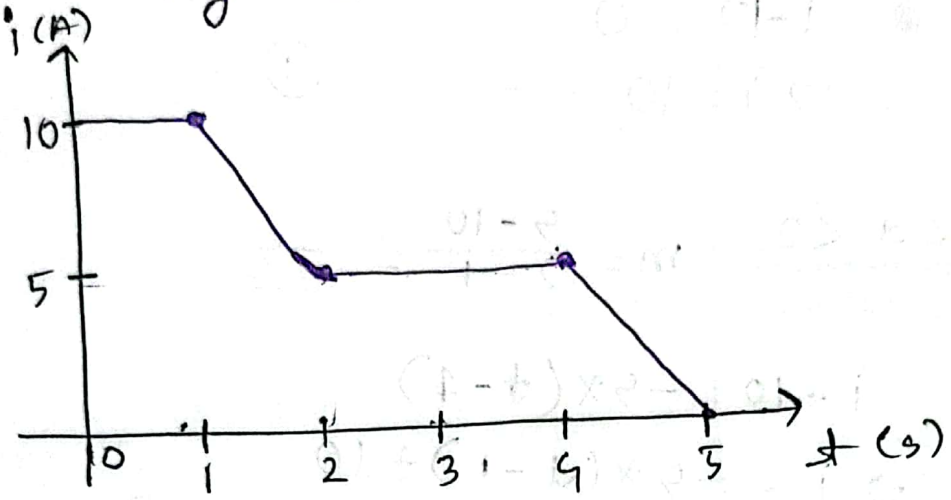
A_2 = Area of rectangle from 1 to 2

$=$ ভূমি $\times$ উচ্চতা $= 1 \times 10 = 10$

$\therefore A = A_1 + A_2 = 10 + 5 = 15$

total charge $Q = 15\ \mu C$

1.9: The current through an element is shown in fig below:

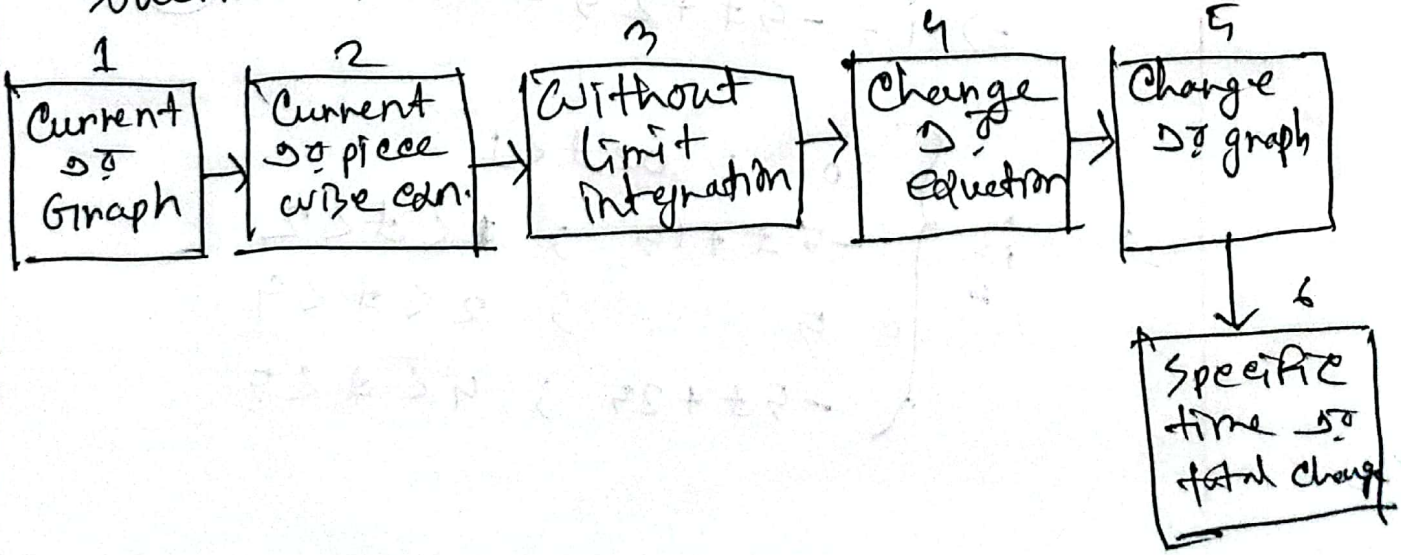


~~Solution Step~~

Determine the total charge that passed through the element at:

(a) $t = 1$ s (b) $t = 3$ s (c) $t = 5$ s

Soln: ৩২ type ৩৫ meth ৩ specific time ৩ value ৮৮২৮২ ৩৮২ Area under the curve method ৩ apply ২৮০ ৰা। ৩খানে solution ৩৫ steps গুলা হলো:-



~~$y + 10 = 0 \times (t - 0)$~~
~~$\Rightarrow y = 10$~~

$\frac{10 - 10}{1 - 0} = 0$

$0 < t < 1$: $m = \frac{0}{1} = 0$

$\therefore \quad i - 10 = 0$

$\Rightarrow i = 10$ ——— (1)

$1 < t < 2$: $m = \frac{5 - 10}{2 - 1} = -5$

$i - 10 = -5 \times (t - 1)$

$\Rightarrow i = -5 \times (t - 1) + 10$

$\Rightarrow i = -5t + 15$ ——— (4)

$2 < t < 4$: $m = 0$

$i - 5 = 0 \times (t - t_1)$

$\Rightarrow i = 5$ ——— (11)

$4 < t < 5$: $m = \frac{0 - 5}{5 - 4} = -5$

$i - 5 = -5 \times (t - 4)$

$\Rightarrow i - 5 = -5t + 20$

$\Rightarrow i = -5t + 25$ ——— (iv)

$$\therefore \quad i = \begin{cases} 10 & ; \quad 0 < t < 1 \\ -5t + 15 & ; \quad 1 < t < 2 \\ 5 & ; \quad 2 < t < 4 \\ -5t + 25 & ; \quad 4 < t < 5 \end{cases}$$

এখন প্রত্যেক event এর জন্য Charge এর equation বের করব।

initially, এর value বের করার জন্য
$Q(t_1) = 0$
$\Rightarrow Q(0) = 0$ ধরব
আর যদি question এ $Q(t_1) = n$ value দেয়া থাকে তাহলে তা ধরব।

$0 < t < 1$:

$i = 10$

$\therefore Q = \int 10\, dt = 10t + c$

$\Rightarrow Q(0) = 10 \times 0 + c$ | let, $Q(0) = 0$

$\Rightarrow 0 = 0 + c$

$\therefore c = 0$

So, $Q(t) = 10t + 0 = 10t$ ——— (1)

$\rightarrow Q(1) = 10 \times 1 = 10$

$1 < t < 2$:

$i = -5t + 15$

$\therefore Q = \int -5t + 15\, dt = -\frac{5}{2}t^2 + 15t + c$

$\rightarrow Q(1) = -\frac{5}{2} \times 1^2 + 15 \times 1 + c$

$\Rightarrow 10 = -\frac{5}{2} + 15 + c$

$\therefore c = -2.5$

$\therefore Q(t) = -\frac{5}{2}t^2 + 15t - 2.5$ ——— (ii)

$\therefore Q(2) = -\frac{5}{2} \times 2^2 + 15 \times 2 - 2.5 = 17.5$

$\therefore Q(1) = 17.5$

$2 < t < 4$

$i = 5$

$q = \int 5\,dt = 5t + c$

from previous equation $q(2) = 17.5$

$q(2) = 5 \times 2 + c$

$\Rightarrow 17.5 = 5 \times 2 + c$

$\therefore c = 7.5$

$\therefore q(t) = 5t + 7.5$ ——— (iii)

$\Rightarrow q(4) = 5 \times 4 + 7.5 = 27.5$

$\therefore q(4) = 27.5$

$4 < t < 5$

$i = -5t + 25$

$q = \int -5t + 25\,dt$

$= -\frac{5}{2}t^2 + 25t + c$

$q(4) = -\frac{5}{2} \times 4^2 + 25 + c$

$\Rightarrow 27.5 = -\frac{5}{2} \times 4^2 + 25 + c$

$\therefore c = -32.5$

$q(t) = -\frac{5}{2}t^2 + 25t - 32.5$ ——— (iv)

So for:

$t = 1$

$Q(t) = 10t$

$\therefore Q(1) = 10 \times 1 = 10\ C$

$t = 3$

$Q(t) = 5t + 7.5 = 5 \times 3 + 7.5 = 22.5$

$t = 5$:

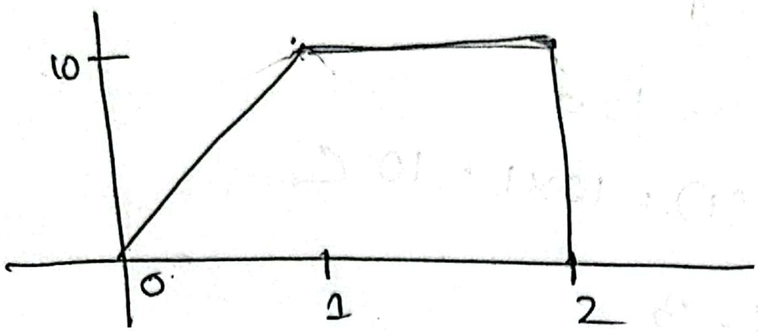
$Q(t) = -\frac{5}{2}t^2 + 25t - 32.2$

$\therefore Q(5) = -\frac{5}{2} \times 5^2 + 25 \times 5 - 32.5$

$= 30$

Ans

(8) Draw the Q vs t Graph for:



Steps:

Current vs graph → Current vs piecewise eqn → Without limit integration → Change vs eqn → Change vs graph

From Graph: (1.8 vs current question cover)

$$i = \begin{cases} 10t & ; 0<t<1 \\ 10 & ; 1<t<2 \\ 0 & ; 2<t \end{cases}$$

$0<t<1$

$$Q = \int 10t \, dt = \frac{10t^2}{2} + c = 5t^2 + c$$

Let, $Q(0) = 0$

$\therefore Q(0) = 5\times 0^2 + c$

$0 = 5\times 0^2 + c$

$\therefore c = 0$

So,

$Q(t) = 5t^2 + 0$ —— (1)

$Q(1) = 5\times 1^2 = 5$

$1 < t < 2$

$q = \int 10\, dt = 10t + c$

$q(1) = 10 \times 1 + c$

$\Rightarrow 5 = 10 + c$

$\therefore c = -5$

$\therefore q(t) = 10t - 5$ ——— (ii)

$q(2) = 10 \times 2 - 5 = 15$

from previous equation

$q(t) = 5t^n$

$q(1) = 5 \times 1^n = 5$

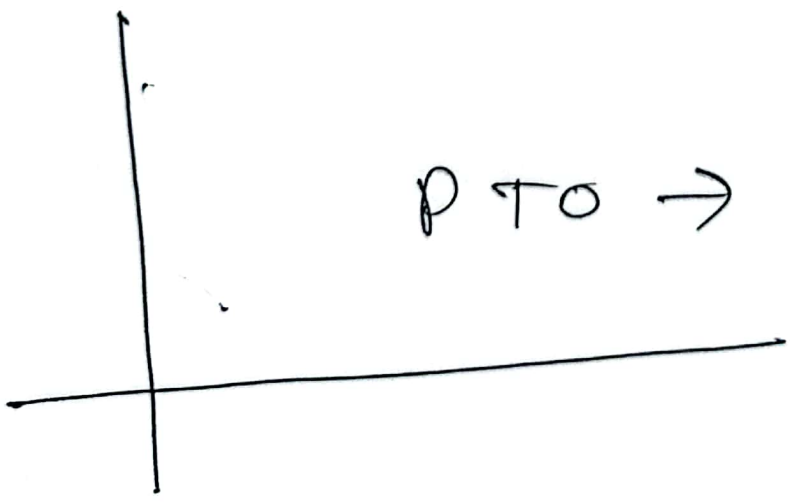
$2 < t < \infty$:

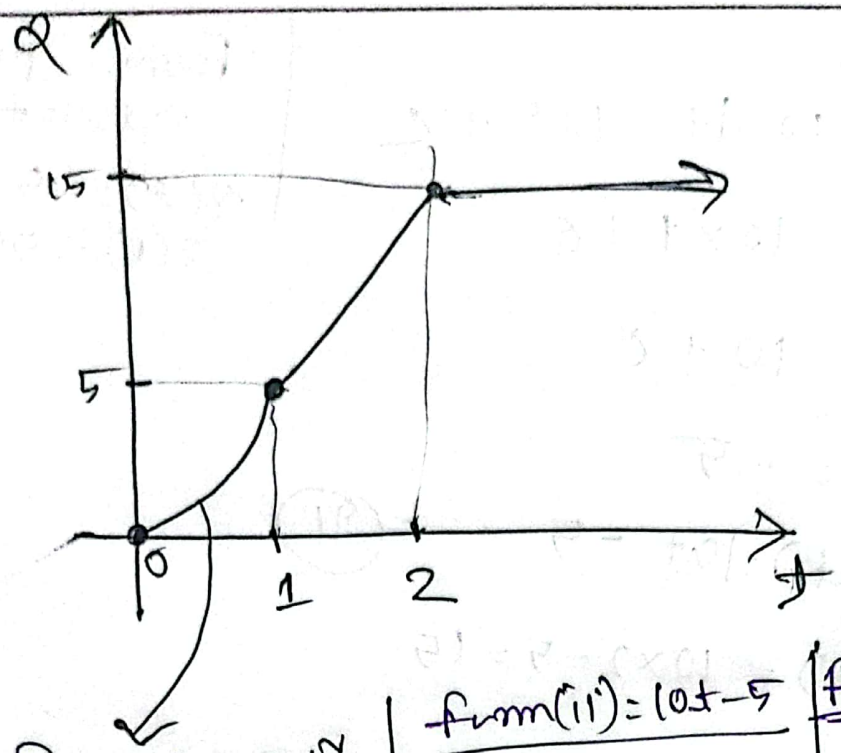
$q = \int 0\, dt = 0 + c$

$q(2) = c$

$\Rightarrow 15 = c$

$\therefore q(t) = 15$ ——— (iii)





From (i): $q = 5t^2$

$t=0$:
$q = 5\times0^2 = 0$

$t=2$:
$q = 5\times1^2 = 5$

From (ii): $q = 10t - 5$

$t=1$:
$q = 10\times1 - 5 = 5$

$t=2$
$q = 20 - 5 = 15$

From (iii): $q = 15$

$t > 2$
$q = 15$