Problem 1.17 Determine the net charge $\Delta Q$ that flowed through a certain device over the specified time intervals for each of the following currents:

(a) $i(t) = [3t + 6t^3] \text{ mA}$, from $t = 0$ to $t = 4 \text{ s}$

(b) $i(t) = 4 \sin(40\pi t) \cos(40\pi t) \mu \text{ A}$, from $t = 0$ to $t = 0.05 \text{ s}$

(c) $i(t) = [4e^{-t} - 3e^{-2t}] \text{ A}$, from $t = 0$ to $t = \infty$

(d) $i(t) = 12e^{-3t} \cos(40\pi t) \text{ nA}$, from $t = 0$ to $t = 0.05 \text{ s}$

Solution:

(a) 
\[ \Delta Q(0,4) = \int_0^4 i \, dt = \left[ \int_0^4 (3t + 6t^3) \, dt \times 10^{-3} \right] = \left( \frac{3t^2}{2} + \frac{6t^4}{4} \right)_0^4 \times 10^{-3} = 408 \text{ (mC)}. \]

(b) 
\[ \Delta Q(0,0.05) = \int_0^{0.05} i \, dt = \left[ \int_0^{0.05} 4 \sin 40\pi t \cos 40\pi t \, dt \right] \times 10^{-6} = \frac{4}{2 \times 40\pi} \sin^2 40\pi t|_0^{0.05} \times 10^{-6} = 0. \]

(c) 
\[ \Delta Q(0,\infty) = \int_0^{\infty} i \, dt = \int_0^{\infty} (4e^{-t} - 3e^{-2t}) \, dt = \left( -4e^{-t} + \frac{3}{2} e^{-2t} \right)|_0^{\infty} = 2.5 \text{ (C)}. \]

(d) 
\[ \Delta Q(0,0.05) = \int_0^{0.05} i \, dt = \left[ \int_0^{0.05} 12e^{-3t} \cos 40\pi t \, dt \right] \times 10^{-9}. \]

From Tables of Integrals,
\[ \int e^{ax} \cos bx \, dx = e^{ax} \frac{a \cos bx + b \sin bx}{a^2 + b^2}. \]

Hence,
\[ \Delta Q(0,0.05) = \left[ 12e^{-3t} \frac{(-3 \cos 40\pi t + 40\pi \sin 40\pi t)}{9 + (40\pi)^2} \right]|_0^{0.05} \times 10^{-9} = 0.32 \text{ (pC)}. \]
Problem 1.23  The plot in Fig. P1.23 displays the cumulative amount of charge \( q(t) \) that has exited a certain device up to time \( t \). What is the current at:

(a) \( t = 2 \) s  
(b) \( t = 6 \) s  
(c) \( t = 12 \) s

![Figure P1.23: \( q(t) \) for Problem 1.23.](image)

Solution:

(a) \( i = 0 \) @ \( t = 2 \) s (slope = 0 of first segment).

(b) \( i = \frac{4-2}{8-4} = \frac{2}{4} = 0.5 \) A (slope of second segment).

(c)

\[
i = \frac{dq}{dt} = \frac{d}{dt}(4e^{-0.2(t-8)}) = 4e^{1.6} \frac{d}{dt}e^{-0.2t} = -4 \times 0.2e^{1.6}e^{-0.2t} = -0.36 \text{ A @ } t = 12 \text{ s.}
\]
Problem 1.34  The voltage across a device and the current through it are shown graphically in Fig. P1.34. Sketch the corresponding power delivered to the device and calculate the energy absorbed by it.

Solution: For $0 \leq t \leq 1$ s,

$$p(t) = ui = (5t)(10t) = 50t^2$$

For $1 \leq t \leq 2$ s,

$$v = 5(2 - t)$$
$$i = 10(2 - t)$$
$$p(t) = 50(2 - t)^2$$

$$w = \int_0^2 p(t) \, dt$$
$$= \int_0^1 50t^2 \, dt + \int_1^2 50(2 - t)^2 \, dt$$
$$= 33.3 \, J.$$