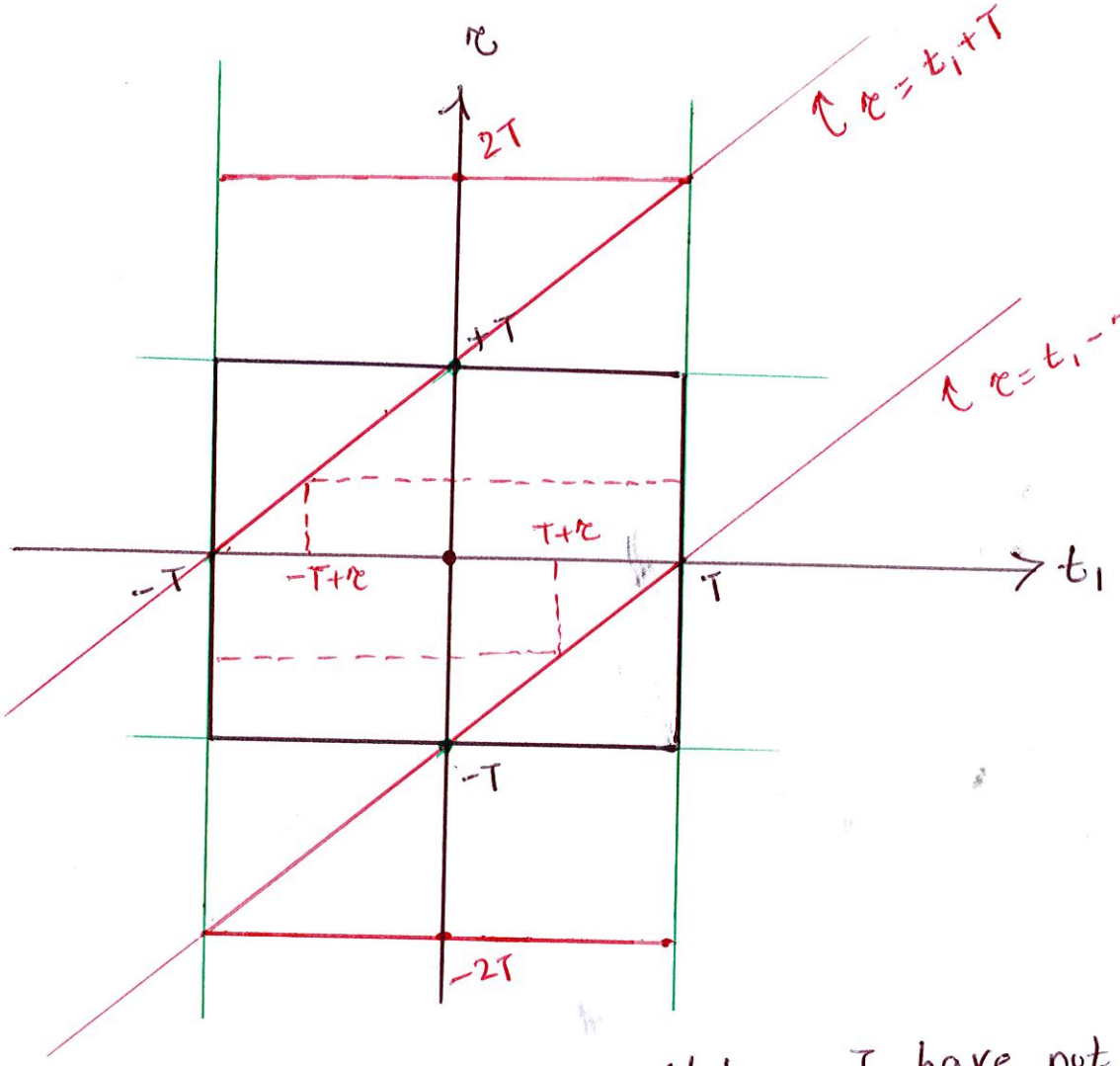
My sol:-



$\tau = t_1 - t_2$

where

$-T \le t_1 \le T$

$-T \le t_2 \le T$

$\Rightarrow \quad t_1 = t_2 + \tau$

for $t_2 = -T$

$t_1 = -T + \tau$ $\Rightarrow$ for $t_1 = -T \Rightarrow \tau = 0$

" $t_1 = T \Rightarrow \tau = 2T$

and for $t_2 = T$

$t_1 = T + \tau \Rightarrow$ for $t_1 = -T \Rightarrow \tau = -2T$

" $t_1 = T \Rightarrow \tau = 0$

as τ varies from 0 to 2T t_1 varies from $\tau - T$ to T

" " " " $-2T$ to -1 " " " $-T$ to $\tau + T$

↑ should it be $-2T$ to 0 or $-2T$ to -1 is correct?

Note :- I have not introduced a second variable, I have used τ and t_1 instead of τ and σ as you have proposed.

therefore the integral

$$\int_{-T}^{T}\int_{-T}^{T} c(t_1-t_2)\,dt_1\,dt_2 = \int_{0}^{2T}\int_{\tau-T}^{T} c(\tau)\,dt_1\,d\tau + \int_{-2T}^{-1}\int_{-T}^{\tau+T} c(\tau)\,dt_1\,d\tau$$

$$= \int_{0}^{2T} c(\tau)\underbrace{(2T-\tau)}_{\text{if } \tau>0}\,d\tau + \int_{-2T}^{-1} c(\tau)\underbrace{(2T+\tau)}_{\text{if } \tau<0}\,d\tau$$

then

$$= \int_{-2T}^{2T} c(\tau)\,[2T-|\tau|]\,d\tau$$