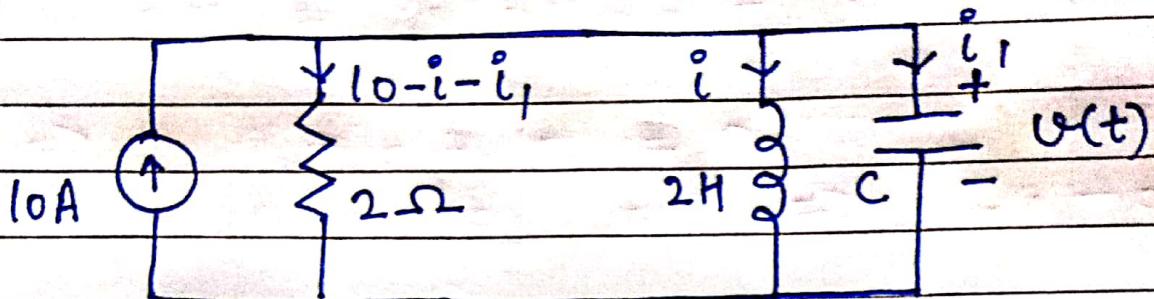


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## Answer 2

(A) When  $i(0^-) = 0$  and  $v(0^-) = 0$ .



$$(10 - i - i_1) \cdot 2 = 2i = v$$

$$\dot{v} = i_1 / C.$$

$$\Rightarrow (10 - i - C\dot{v}) \cdot 2 = v$$

$$20 - 2i - 2C \dot{i} = v$$

$$\star \dot{v} = 2\ddot{i}, v = 2i$$

$$\Rightarrow 2C \frac{d^2 i}{dt^2} + \frac{di}{dt} + i = 10. \quad \text{--- eq } 1$$

$$v = 2i - \text{eq } 2.$$

(i) for  $C = 1/9 \text{ F}$

Put  $C$  in eq 1.

$$\frac{d^2 i}{dt^2} + \frac{9}{2} \frac{di}{dt} + \frac{9}{2} i = 90/2.$$

roots of auxiliary eq :  $-3, -3/2$ .

$$i_c(t) = a e^{-3t} + b e^{-3t/2}$$

(complementary  
sol)

$$i_p(t) = 10.$$

(particular  
sol)

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$$i(t) = i_c(t) + i_p(t)$$

$$= ae^{-3t} + be^{-3t/2} + 10.$$

$$i(0^+) = i(0^-) = 0$$

$$i(0^+) = v(0^+)/2 = v(0^-)/2 = 0.$$

$$\Rightarrow a + b + 10 = 0$$

$$-3a - \frac{3b}{2} = 0 \Rightarrow 2a + b = 0.$$

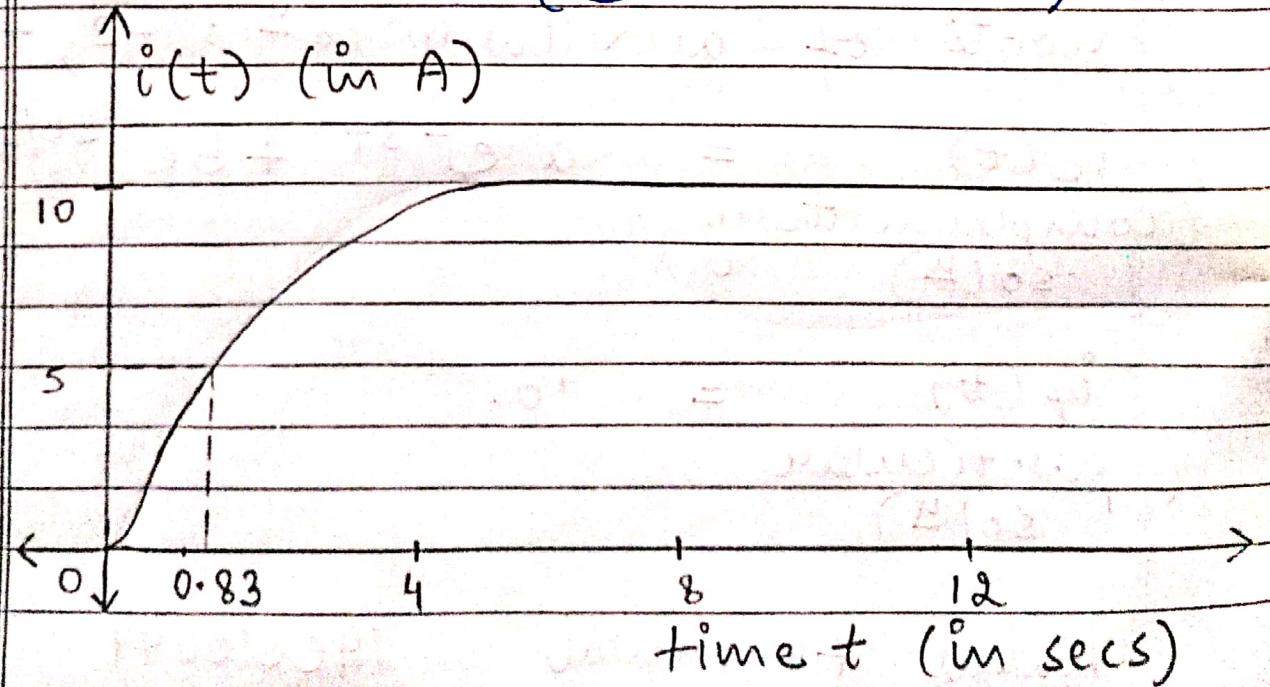
$$\Rightarrow a = 10, b = -20$$

$$\therefore i(t) = 10e^{-3t} - 20e^{-3t/2} + 10$$

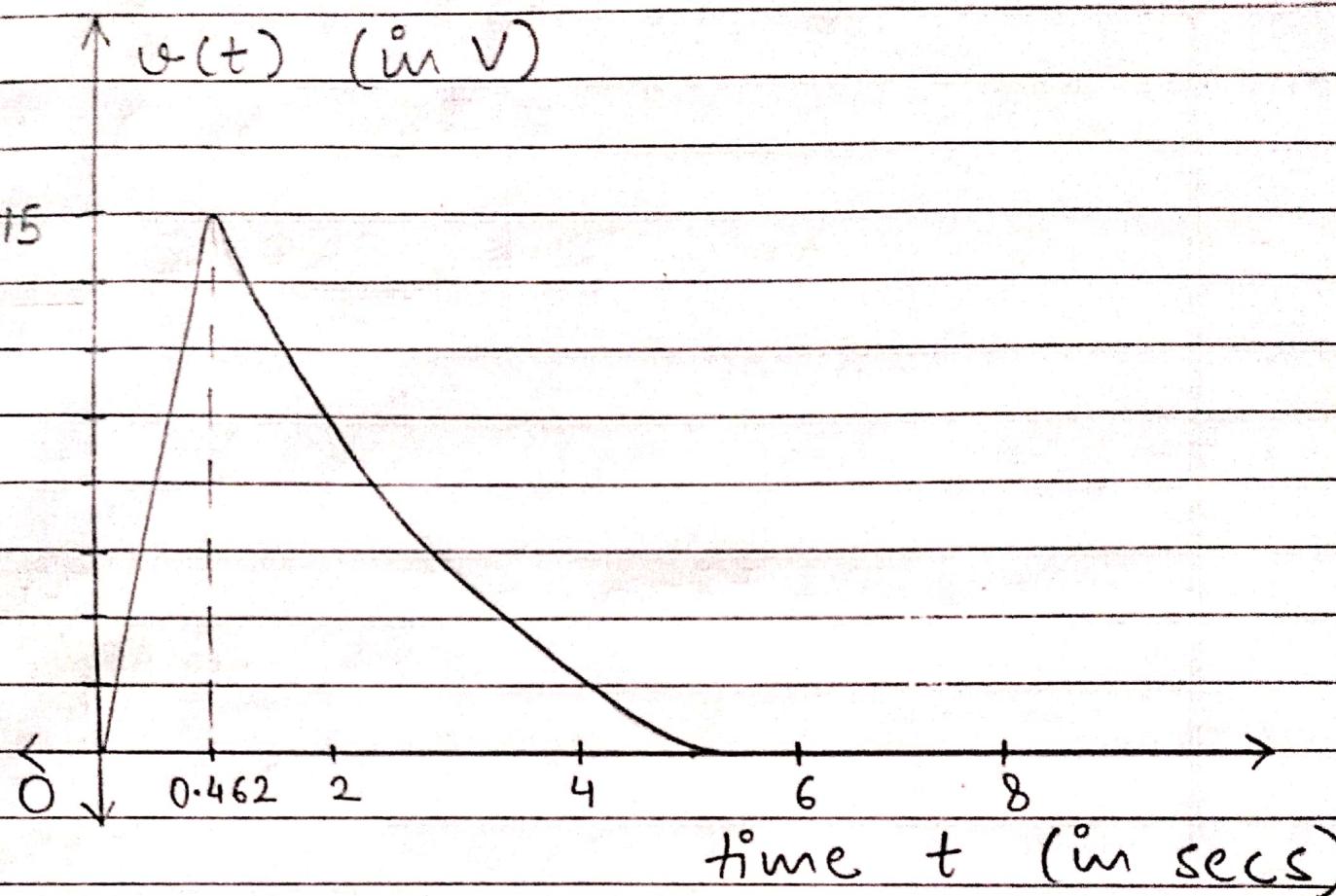
$$v(t) = 2 \frac{di}{dt} \quad (\text{from eq } 2)$$

$$v(t) = (-30e^{-3t} + 30e^{-3t/2}) \times 2$$

$$= -60(e^{-3t} - e^{-3t/2})$$



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(ii) for  $C = 1/4 F$ .Put C in eq  $\underline{u}$  1.

$$\frac{d^2 i}{dt^2} + 2 \frac{di}{dt} + 2i = 20.$$

roots of auxiliary eq  $\underline{u}$ :  $-1 \pm i$ 

$$i_c(t) = e^{-t} (a \sin t + b \cos t)$$

(complementary sol  $\underline{u}$ )

$$i_p(t) = 10.$$

(particular sol  $\underline{u}$ )

$$i(t) = i_c(t) + i_p(t)$$

$$= e^{-t} (a \sin t + b \cos t) + 10.$$

$$i(0^+) = i(0^-) = 0$$

$$\dot{i}(0^+) = \dot{v}(0^+)/2 = v(0^-)/2 = 0$$

$$\Rightarrow b + 10 = 0 \Rightarrow b = -10$$

$$-b + a = 0 \Rightarrow b = a = -10.$$

$$\therefore i(t) = 10 - 10e^{-t} (\sin t + \cos t)$$

$$v(t) = 2 \frac{di}{dt} \quad (\text{from eq } \underline{u} 2)$$

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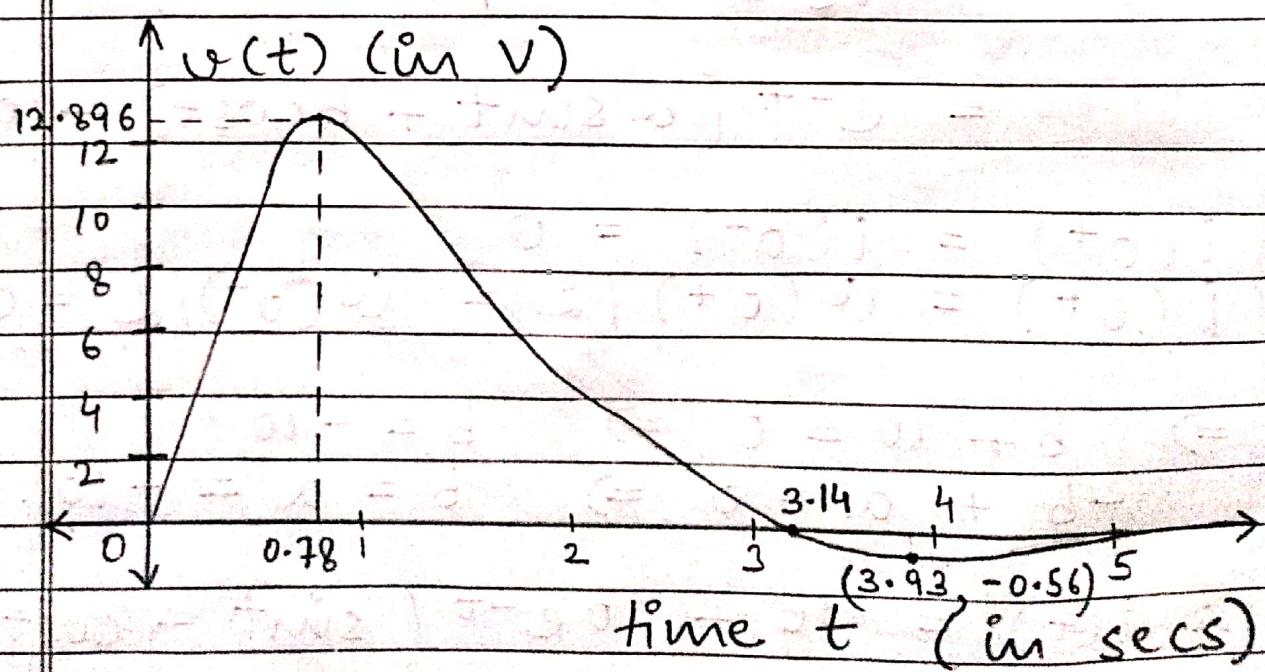
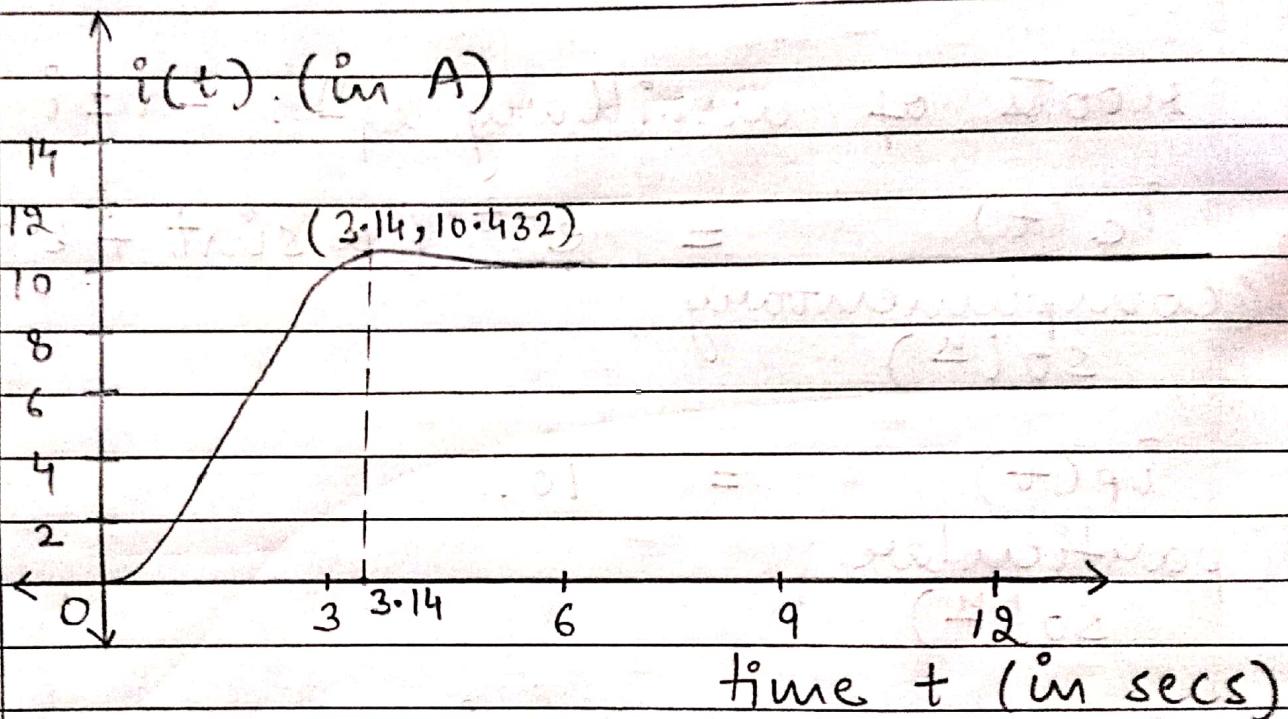
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$$v(t) = -10 \left[ -e^{-t} (\sin t + \cos t) + e^{-t} (\cos t - \sin t) \right] \times 2$$

$$v(t) = -20 e^{-t} (-2 \sin t)$$

$$v(t) = 40 e^{-t} \sin t.$$



(iii) for  $C = 1/8 F$ Put C in eq  $\underline{u}$  1.

$$\frac{d^2 i}{dt^2} + 4 \frac{di}{dt} + 4i = 40$$

roots of auxiliary eq  $\underline{u}$ : -2, -2

$$i_c(t) = e^{-2t} (a + bt)$$

(complementary  
sol  $\underline{u}$ )

$$i_p(t) = 10$$

(particular  
sol  $\underline{u}$ )

$$i(t) = i_c(t) + i_p(t)$$

$$= e^{-2t} (a + bt) + 10.$$

$$i(0+) = i(0-) = 0$$

$$i(0+) = v(0+)/2 = v(0-)/2 = 0.$$

$$\Rightarrow a + 10 = 0 \Rightarrow a = -10$$

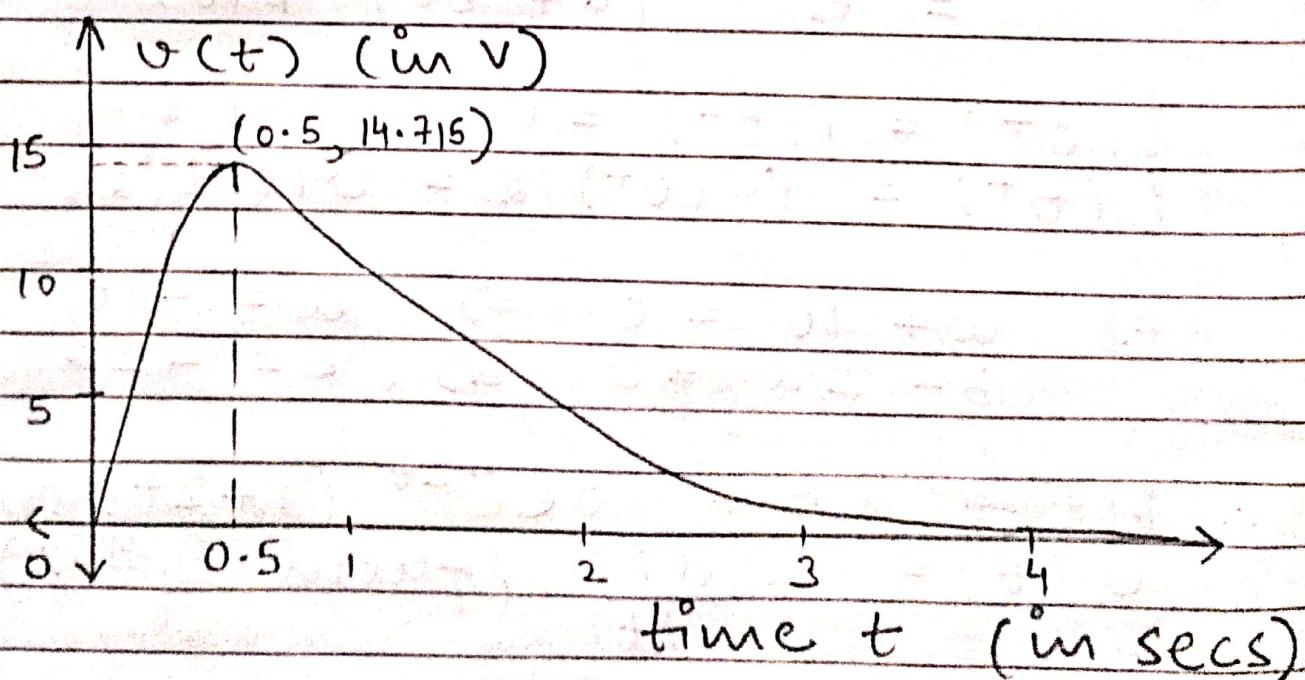
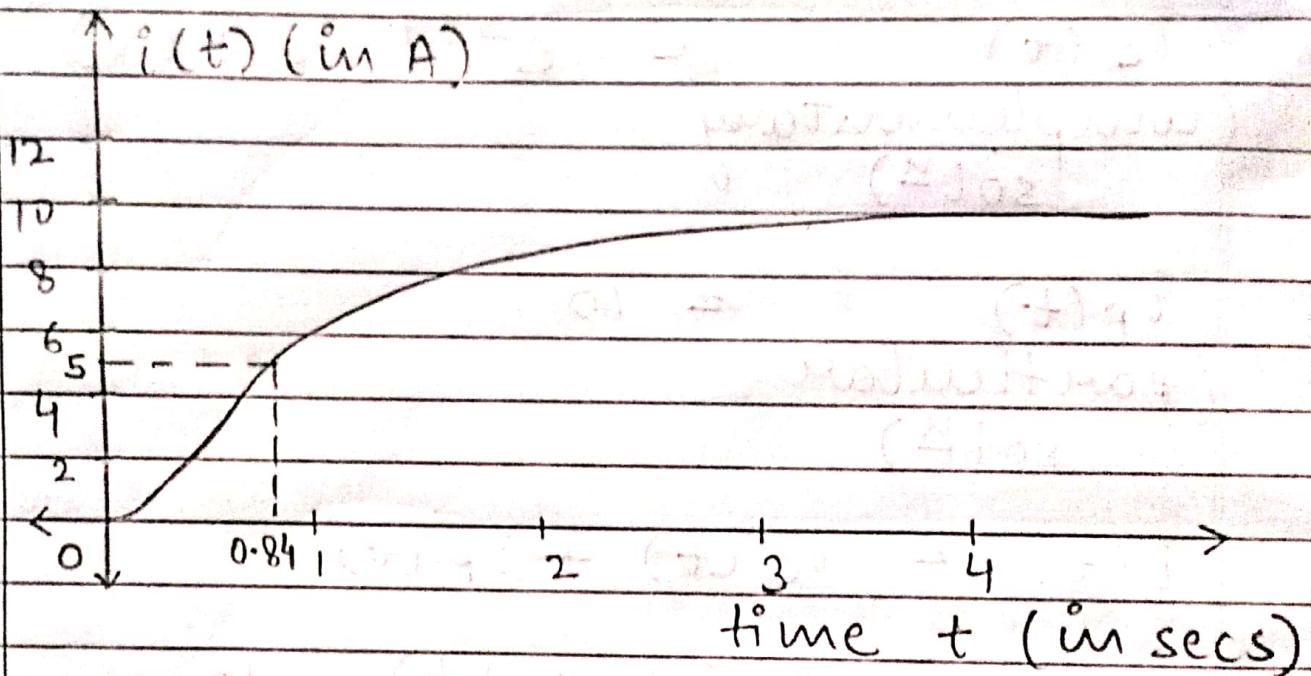
$$b - 2a = 0 \Rightarrow b = -20$$

$$\therefore i(t) = 10 - 10e^{-2t} (1+2t)$$

$$v(t) = 2 \frac{di}{dt} \quad (\text{from eq } \underline{u} 2)$$

$$v(t) = 10 \left( 2e^{-2t} (1+2t) - 2e^{-2t} \right) \times 2$$

$$v(t) = 80t e^{-2t}$$



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(B) When  $i(0^-) = 0$  and  $v(0^-) = 5V$ .

(i) for  $C = 1/9 F$ .

Put  $C$  in eq  $\underline{u}$  1.

$$\frac{d^2 i}{dt^2} + \frac{9}{2} \frac{di}{dt} + \frac{9i}{2} = 45$$

roots of auxiliary eq  $\underline{u}$  :  $-3, -3/2$

$$i_c(t) = ae^{-3t} + be^{-3t/2}$$

(complementary  
sol  $\underline{u}$ )

$$i_p(t) = 10.$$

(particular  
sol  $\underline{u}$ )

$$i(t) = i_c(t) + i_p(t)$$

$$= ae^{-3t} + be^{-3t/2} + 10.$$

$$i(0^+) = i(0^-) = 0$$

$$i(0^+) = v(0^+)/2 = v(0^-)/2 = 5/2.$$

$$\Rightarrow a + b + 10 = 0$$

$$-3a - \frac{3b}{2} = \frac{5}{2} \Rightarrow 6a + 3b + 5 = 0$$

$$\Rightarrow a = 8.33, b = -18.33$$

$$\therefore i(t) = 8.33 e^{-3t} - 18.33 e^{-3t/2} + 10.$$

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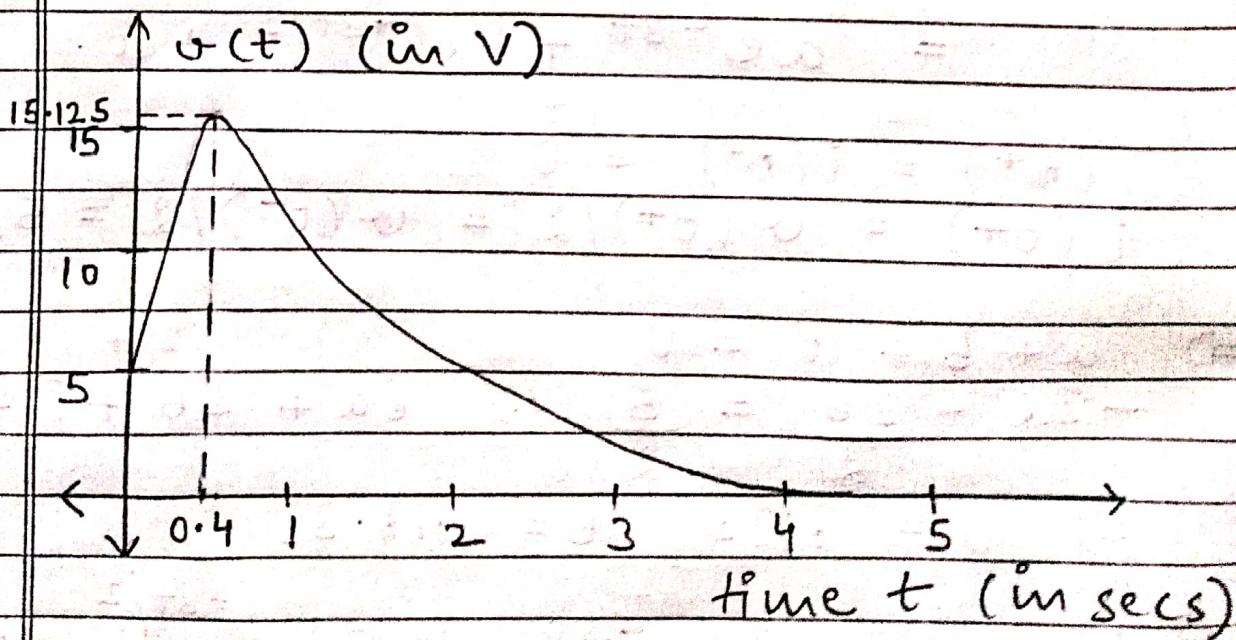
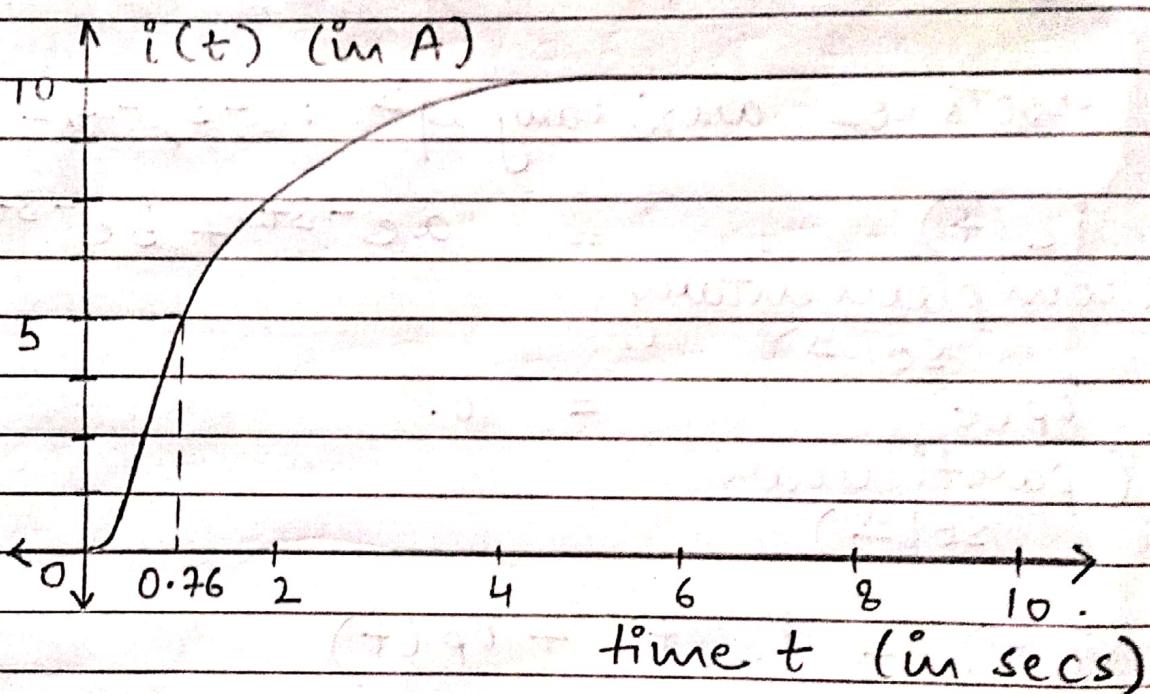
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$$v(t) = 2 \frac{di}{dt} \quad (\text{from eqn 2})$$

$$= 2(-25e^{-3t} + 27.5e^{-3t/2})$$

$$= 55e^{-3t/2} - 50e^{-3t}$$

$$v(t) = 5(11e^{-3t/2} - 10e^{-3t})$$



(ii) for  $c = 1/4 F$ .Put  $c$  in eq  $\underline{u}$  1.

$$\frac{d^2 i}{dt^2} + 2 \frac{di}{dt} + 2i = 20.$$

roots of auxiliary eq  $\underline{u}$ :  $-1 \pm i$ 

$$i_c(t) = -e^{-t} (a \sin t + b \cos t)$$

(complementary  
sol  $\underline{u}$ )

$$i_p(t) = 10. \quad (\text{particular sol } \underline{u})$$

$$\begin{aligned} i(t) &= i_c(t) + i_p(t) \\ &= e^{-t} (a \sin t + b \cos t) + 10. \end{aligned}$$

$$i(0^+) = i(0^-) = 0$$

$$i(0^+) = v(0^+)/2 = v(0^-)/2 = 5/2$$

$$\Rightarrow b + 10 = 0 \Rightarrow b = -10.$$

$$a - b = 5/2 \Rightarrow a = 12.5 - 7.5$$

$$i(t) = e^{-t} (12.5 \sin t - 10 \cos t) + 10.$$

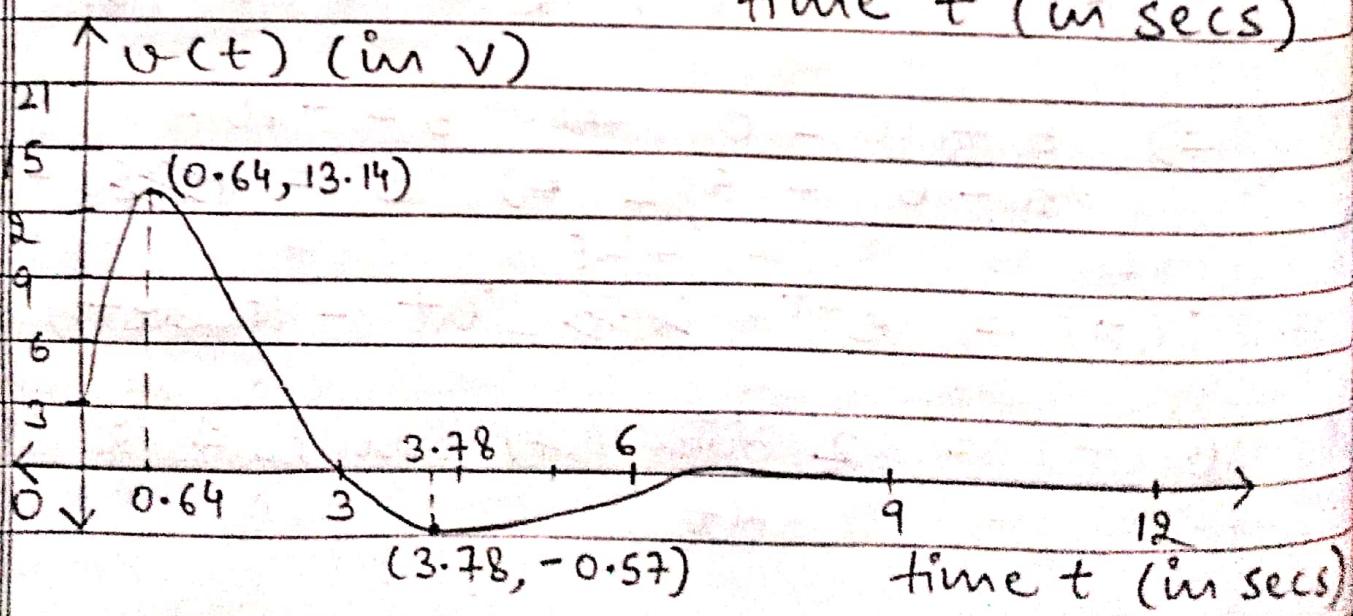
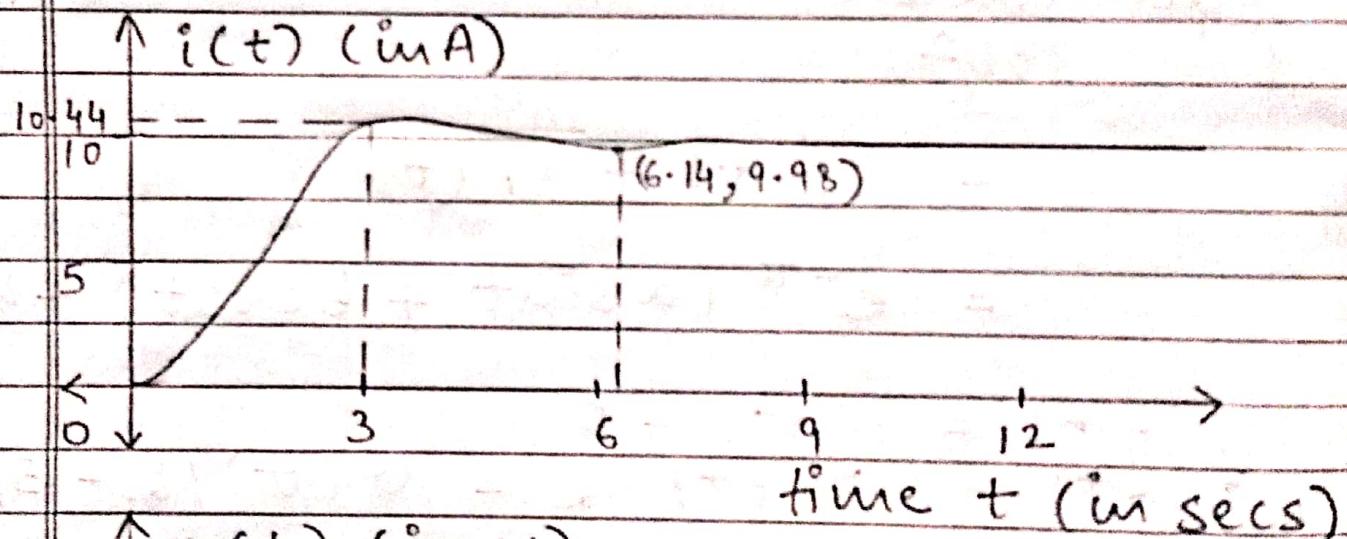
$$v(t) = 2 \frac{di}{dt} \quad (\text{from eq } \underline{u} 2)$$

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$$v(t) = 2e^{-t} (7.5 \sin t + 10 \cos t - 7.5 \cos t + 10 \sin t)$$

$$= 2e^{-t} (2.5 \cos t + 17.5 \sin t)$$

$$v(t) = e^{-t} (5 \cos t + 35 \sin t)$$



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(iii) for  $C = 1/8 F$

Put C in eq<sup>n</sup> 1.

$$\frac{d^2 i}{dt^2} + \frac{4 di}{dt} + 4i = 40$$

roots of auxiliary eq<sup>n</sup> : -2, -2.

$$i_c(t) = e^{-2t} (a + bt)$$

(complementary  
sol<sup>n</sup>)

$$i_p(t) = 10.$$

(particular  
sol<sup>n</sup>)

$$i(t) = i_c(t) + i_p(t)$$

$$= e^{-2t} (a + bt) + 10.$$

$$i(0^+) = i(0^-) = 0$$

$$i'(0^+) = v(0^+)/2 = v(0^-)/2 = 5/2.$$

$$\Rightarrow a + 10 = 0 \Rightarrow a = -10$$

$$b - 2a = 5/2 \Rightarrow b = -17.5.$$

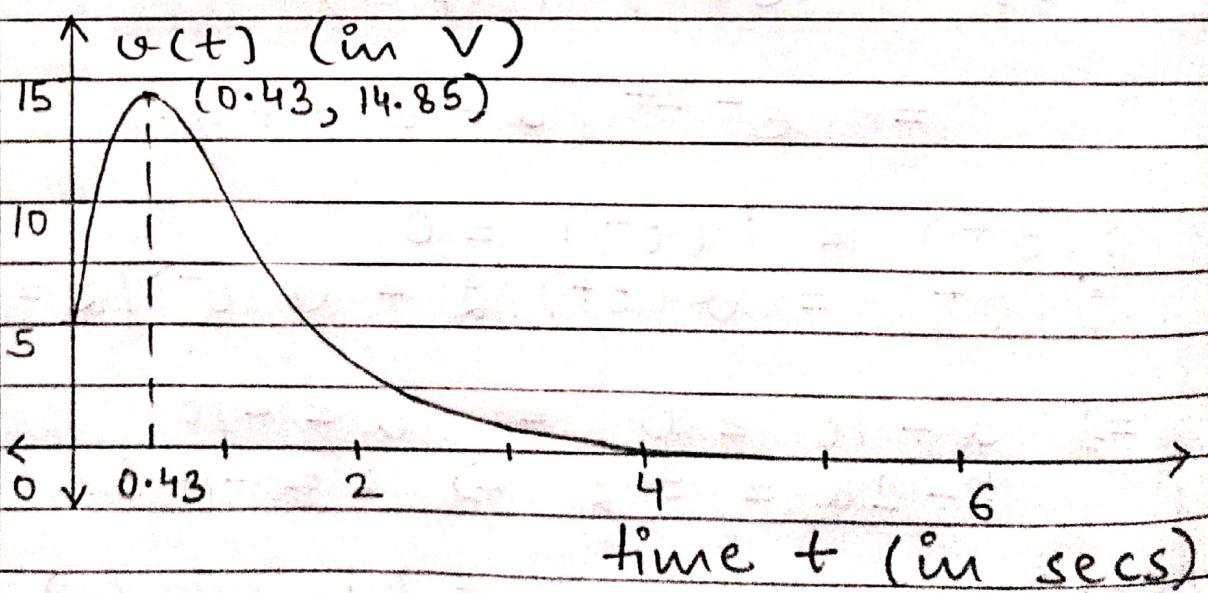
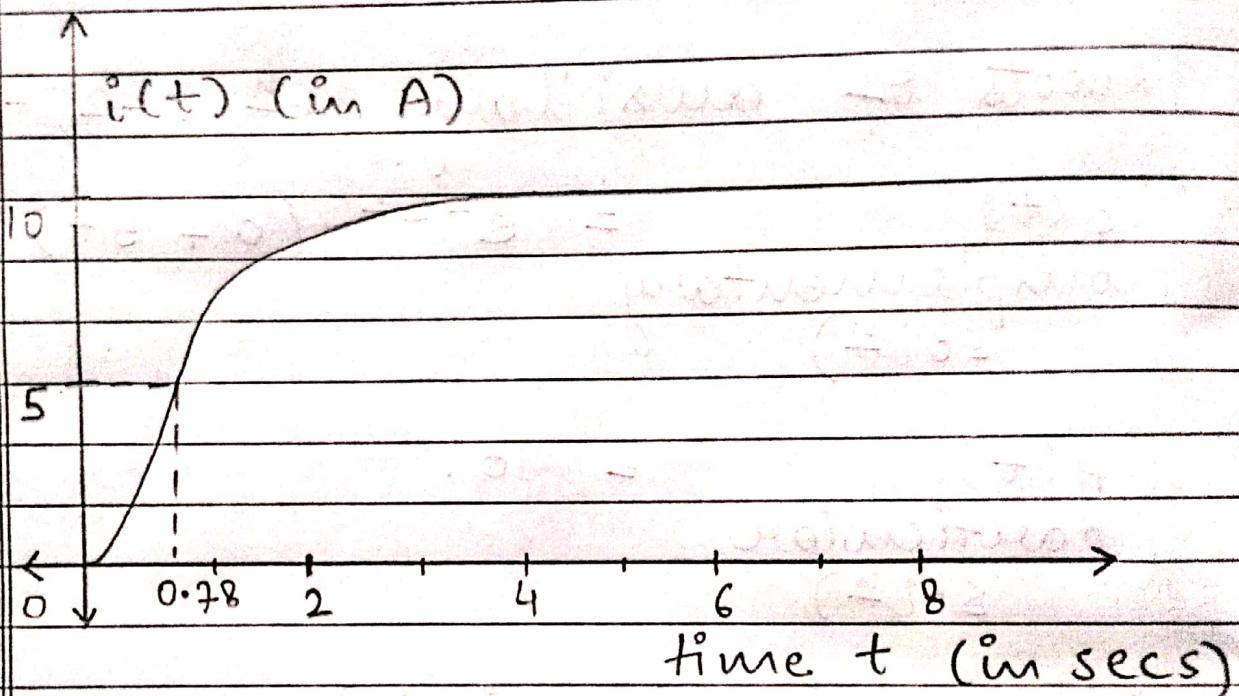
$$\therefore i(t) = 10 - e^{-2t} (10 + 17.5t)$$

$$v(t) = 2 \frac{di}{dt} \text{ (from eq<sup>n</sup> 2)}$$

$$v(t) = 2e^{-2t} [-17.5 + 20 + 35t]$$

$$v(t) = 2e^{-2t} (35t + 2.5)$$

$$v(t) = e^{-2t} (5 + 70t).$$



## (c) LTspice Simulation

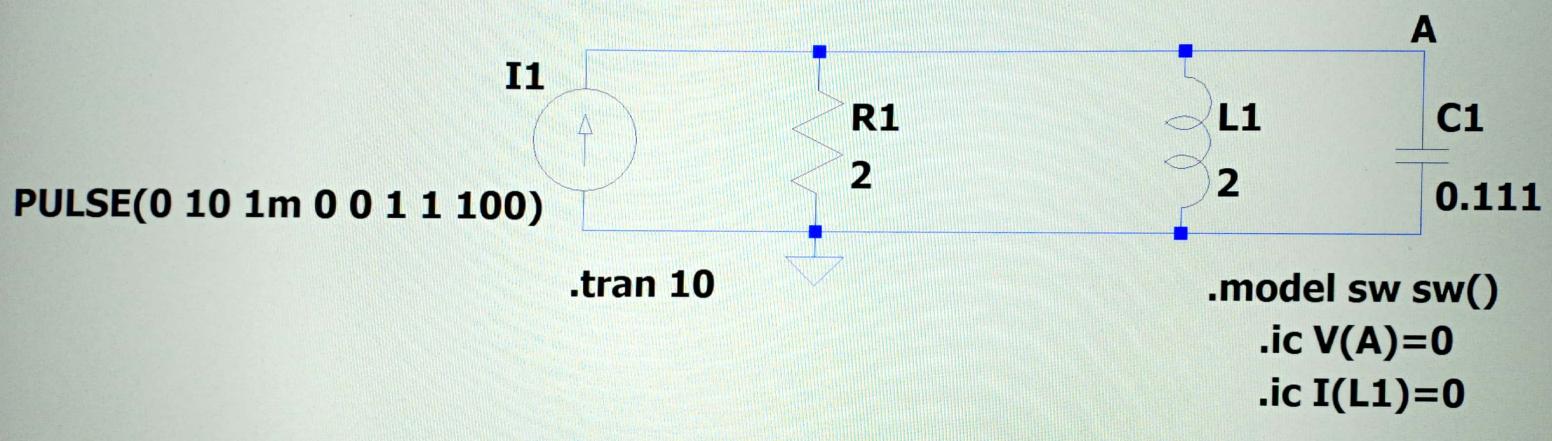
From the next page follow the circuits simulated on LTspice for each part of this question.

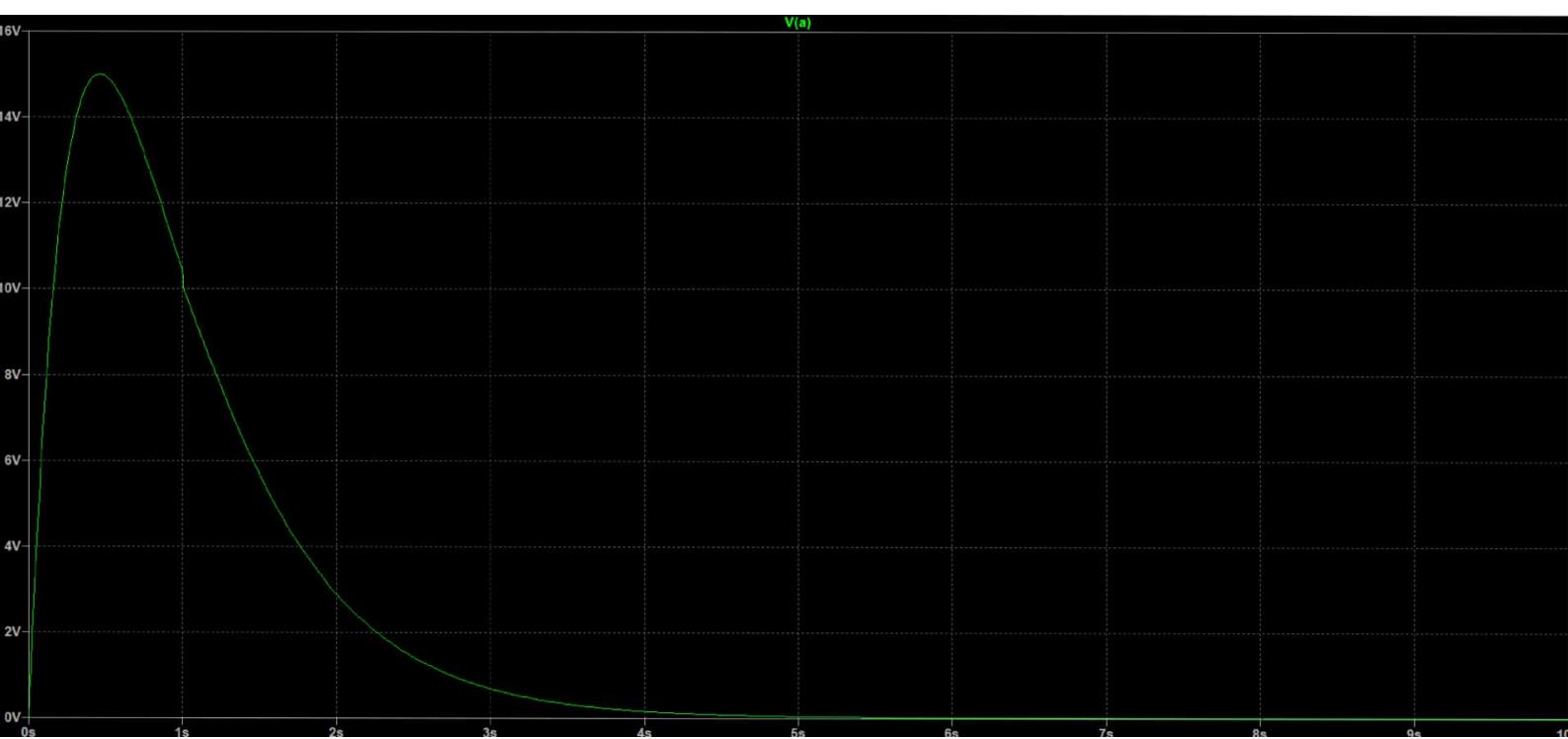
Two graph one for  $v_c(t)$  and other for  $i_L(t)$  follow their corresponding circuit on the top of which the part of this question is clearly mentioned.

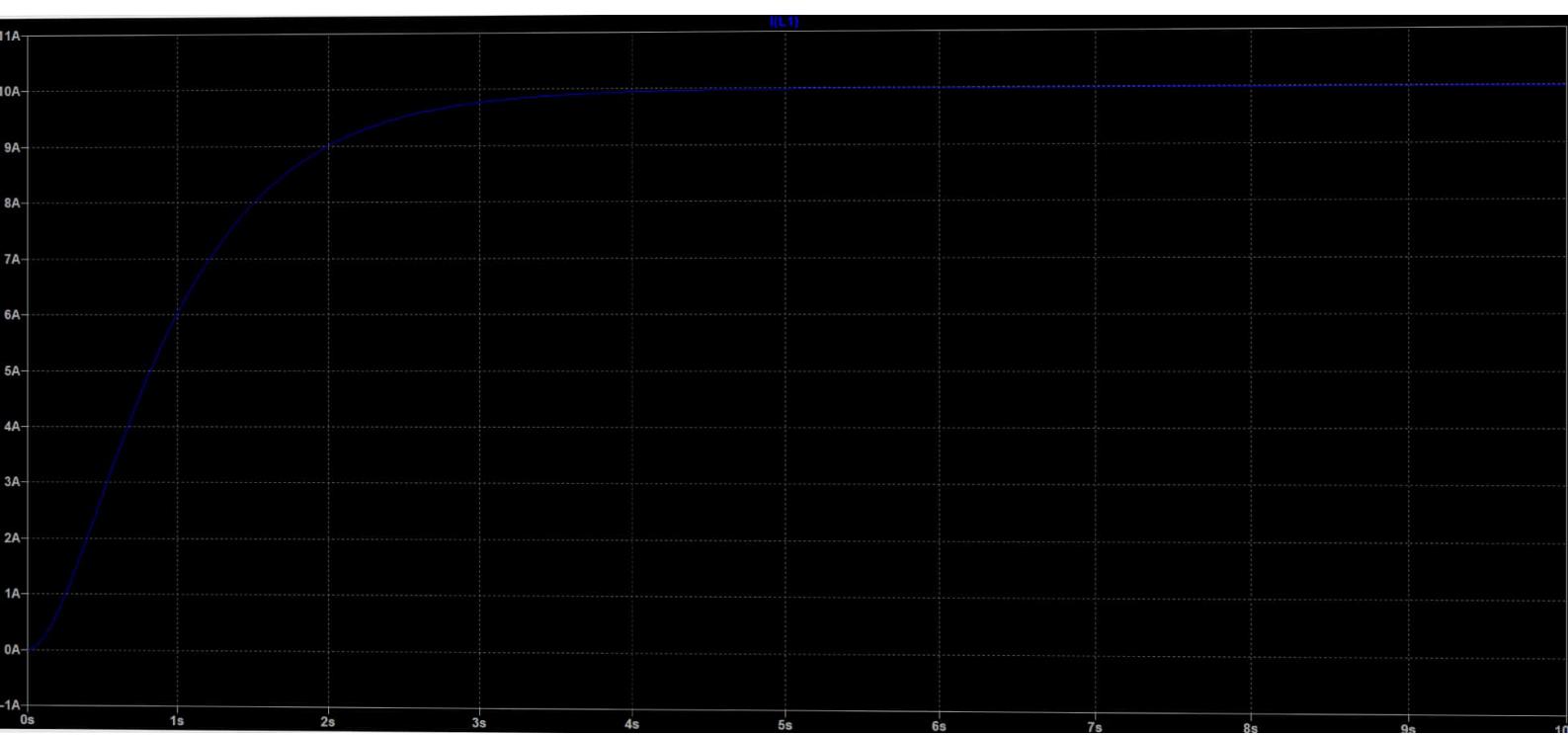
Note that  $i_L(t)$  is the blue-colour plot and  $v_c(t)$  is the green colour plot.

- \* The plots and results obtained theoretically were matched with those obtained from the simulation. Values like maxima, minima, zeros and overshoot matched exactly with those predicted theoretically.

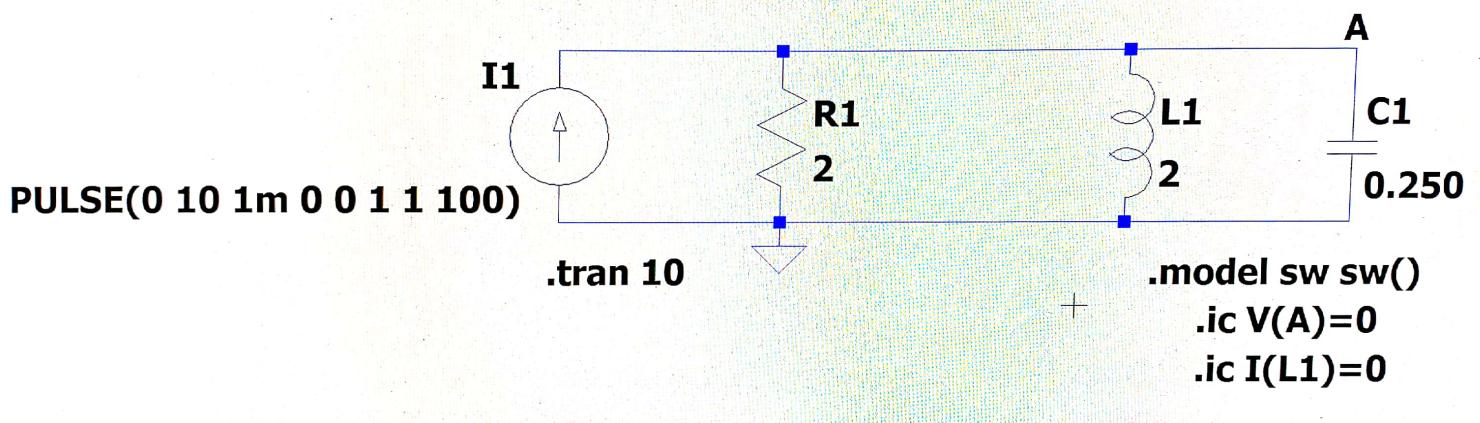
### ANSWER O2 - PART A1

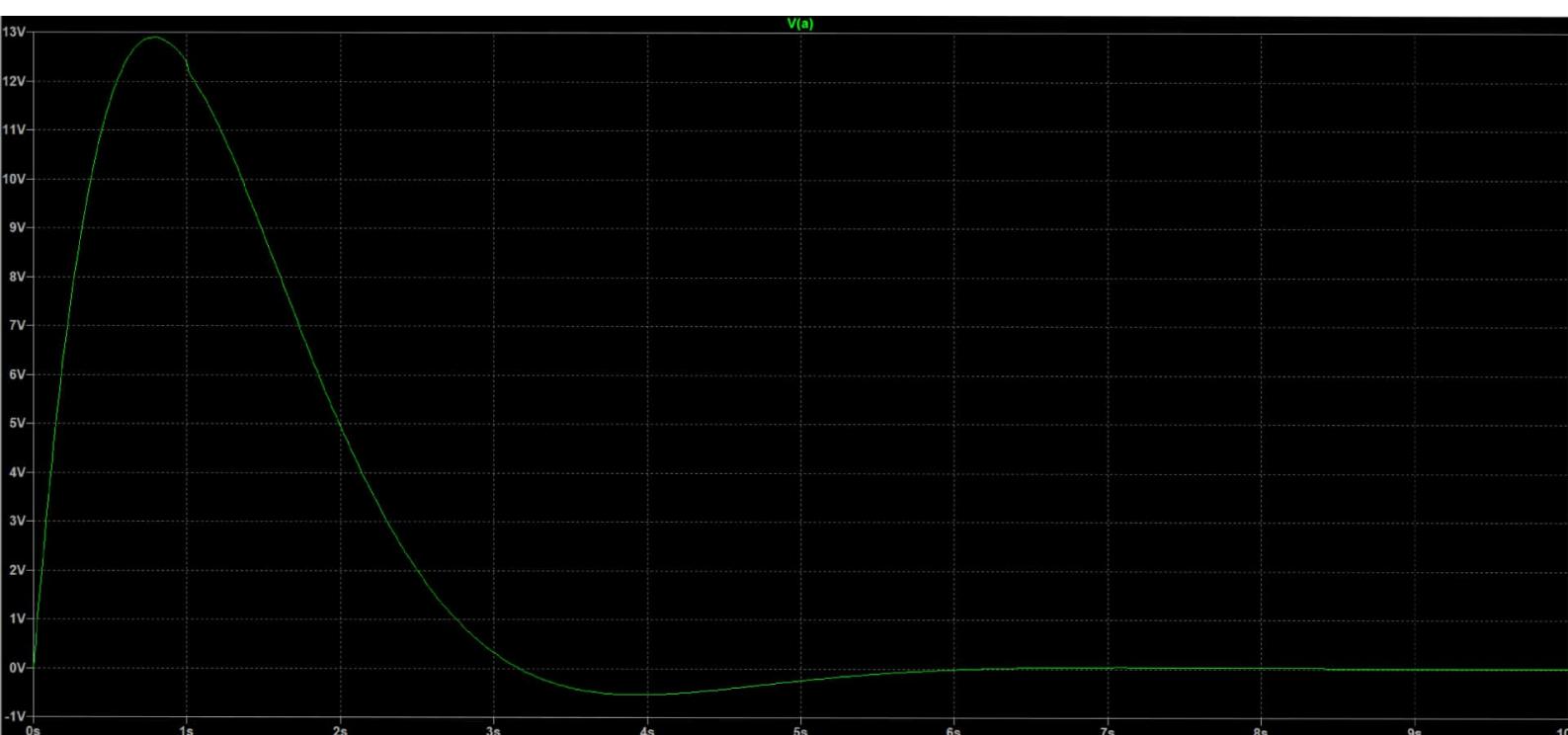


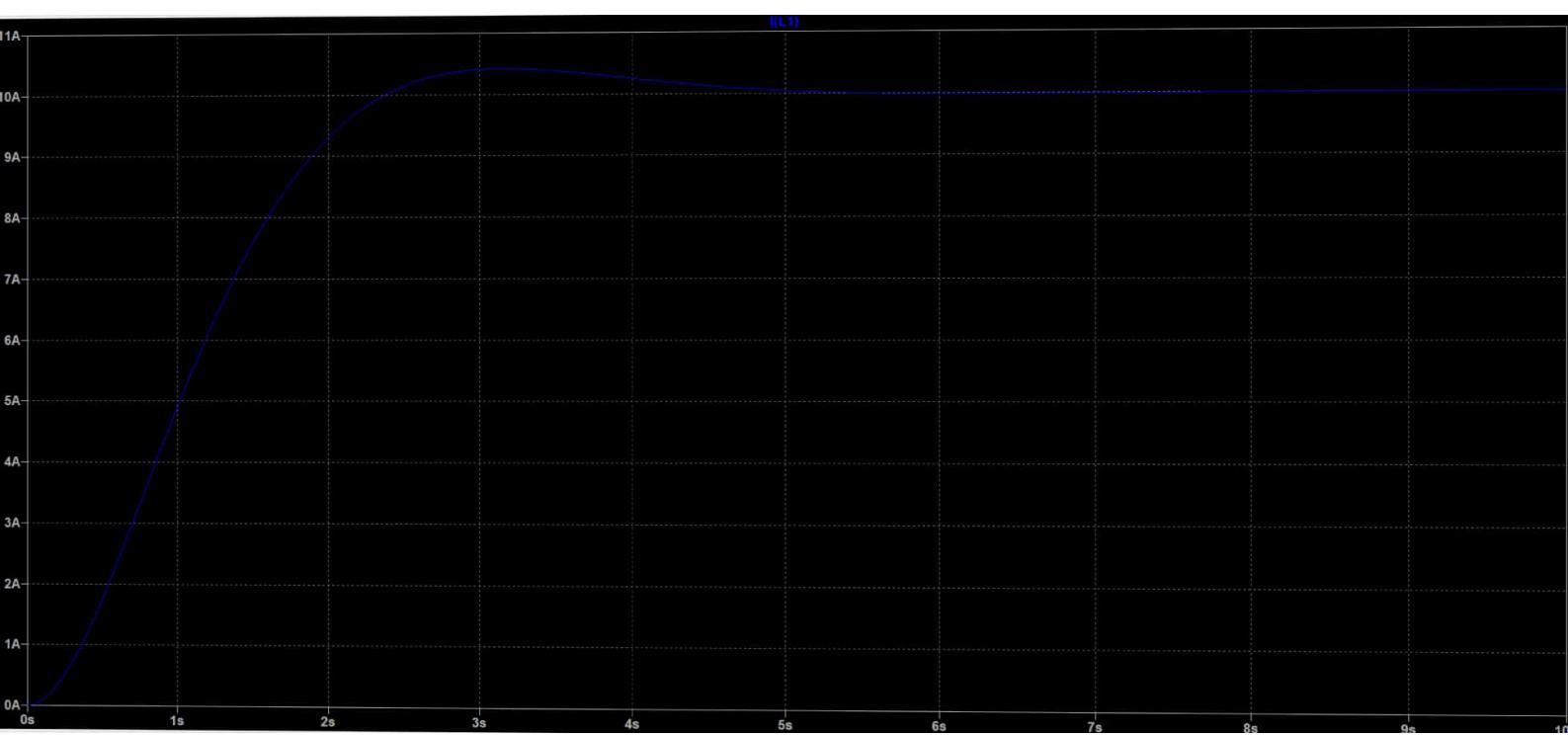




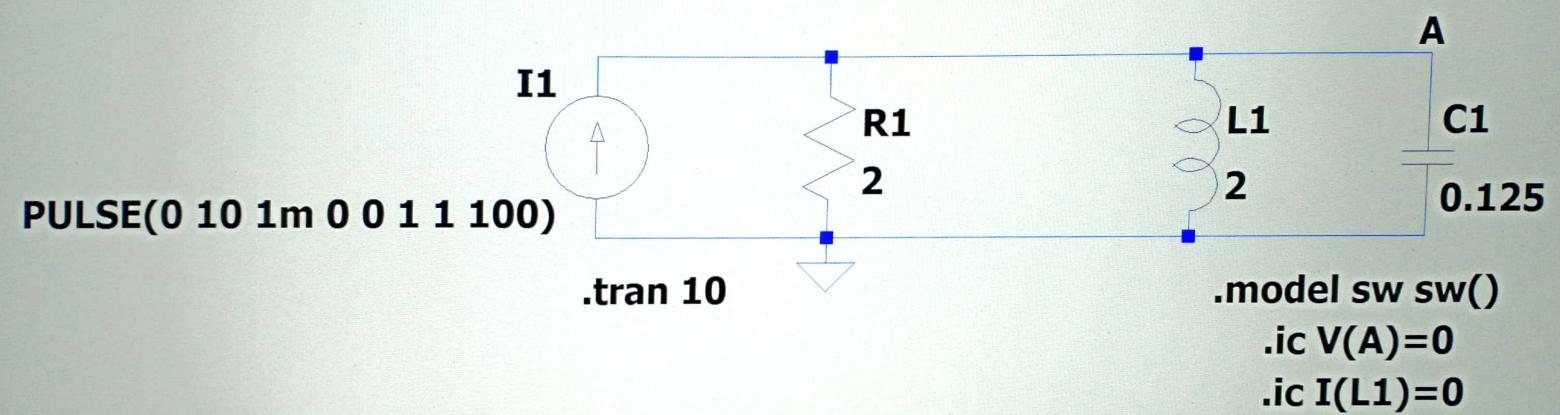
## ANSWER O2 - PART A2

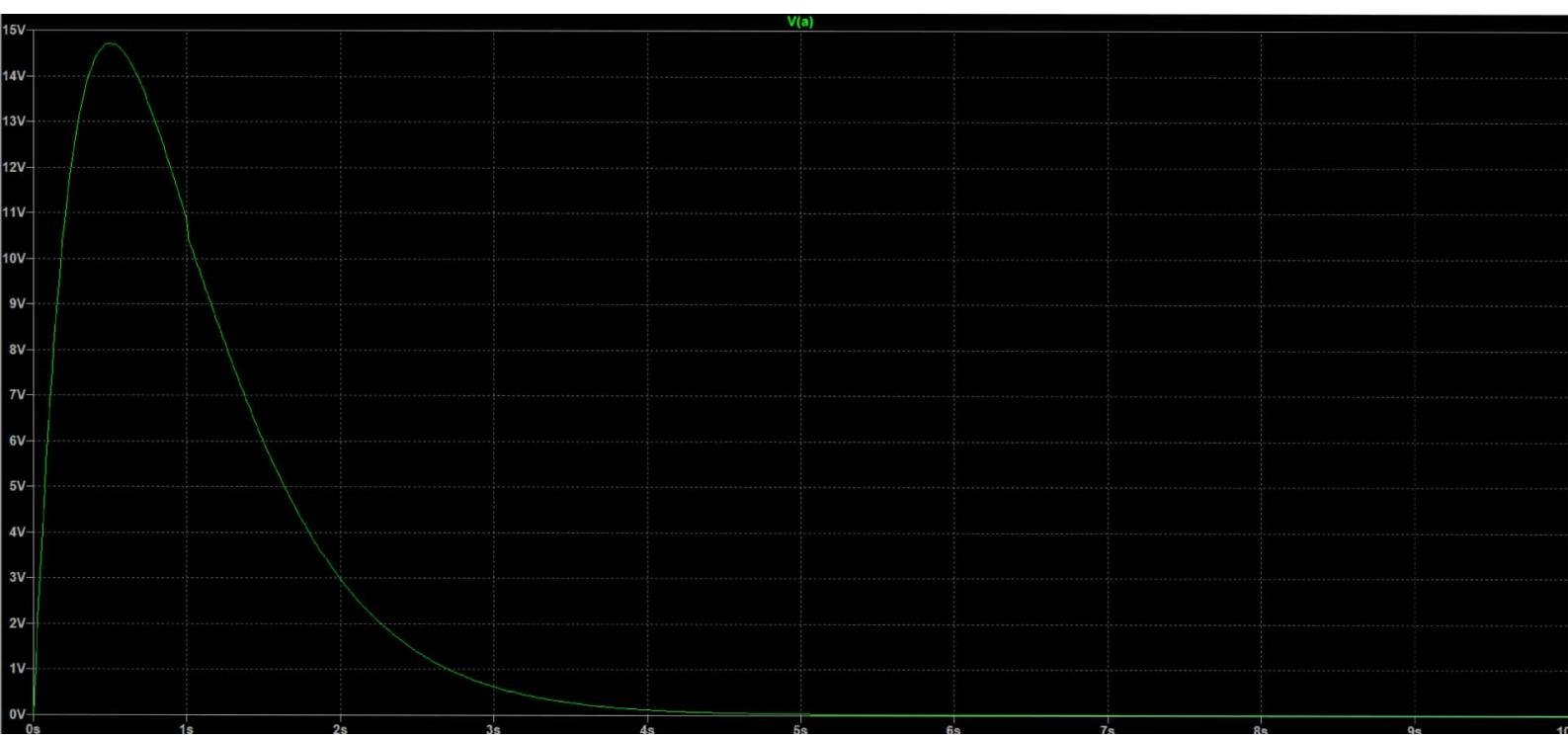


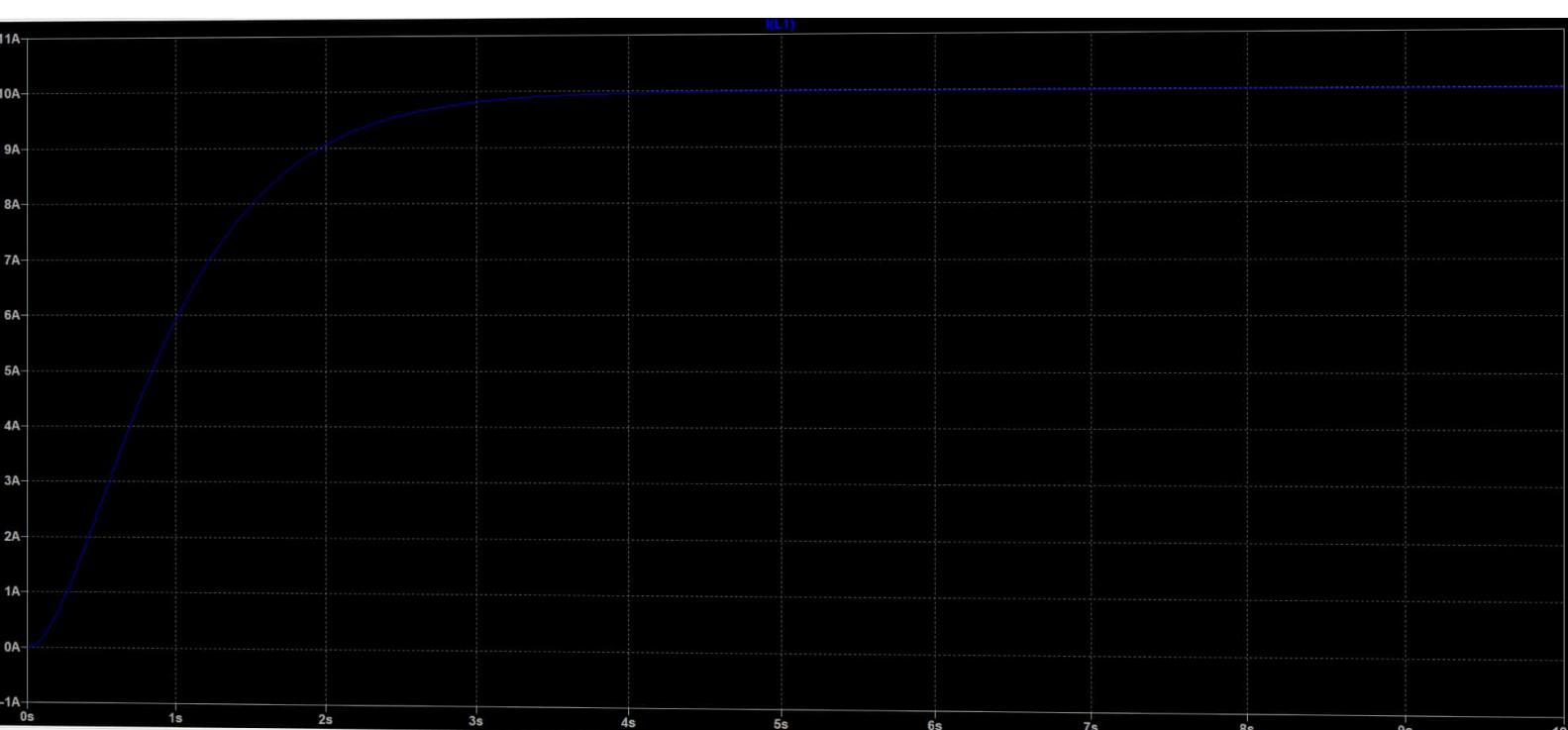




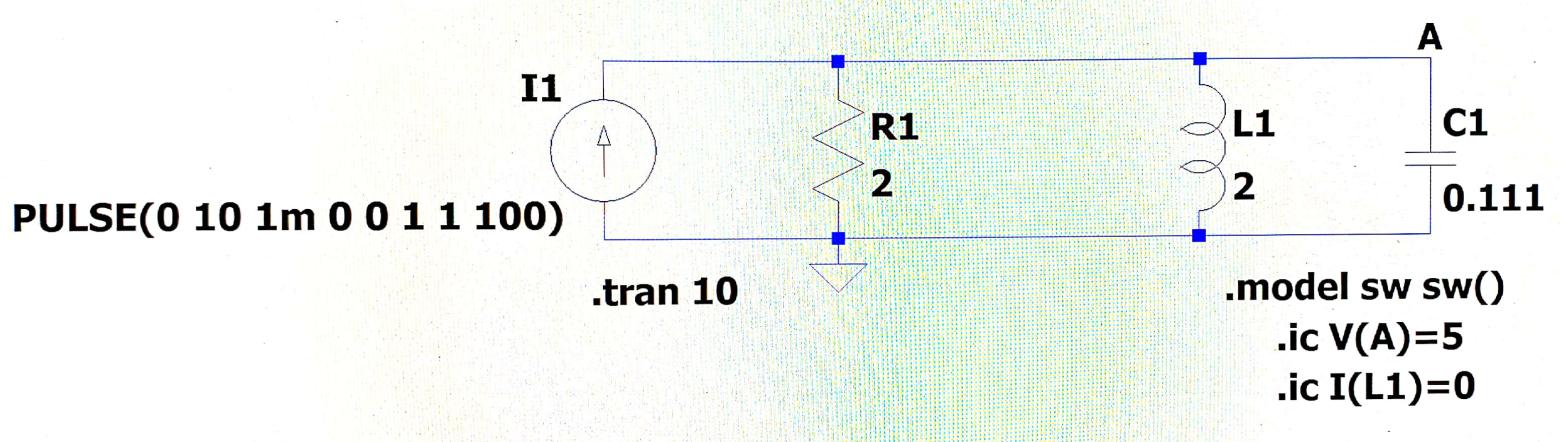
### ANSWER O2 - PART A3

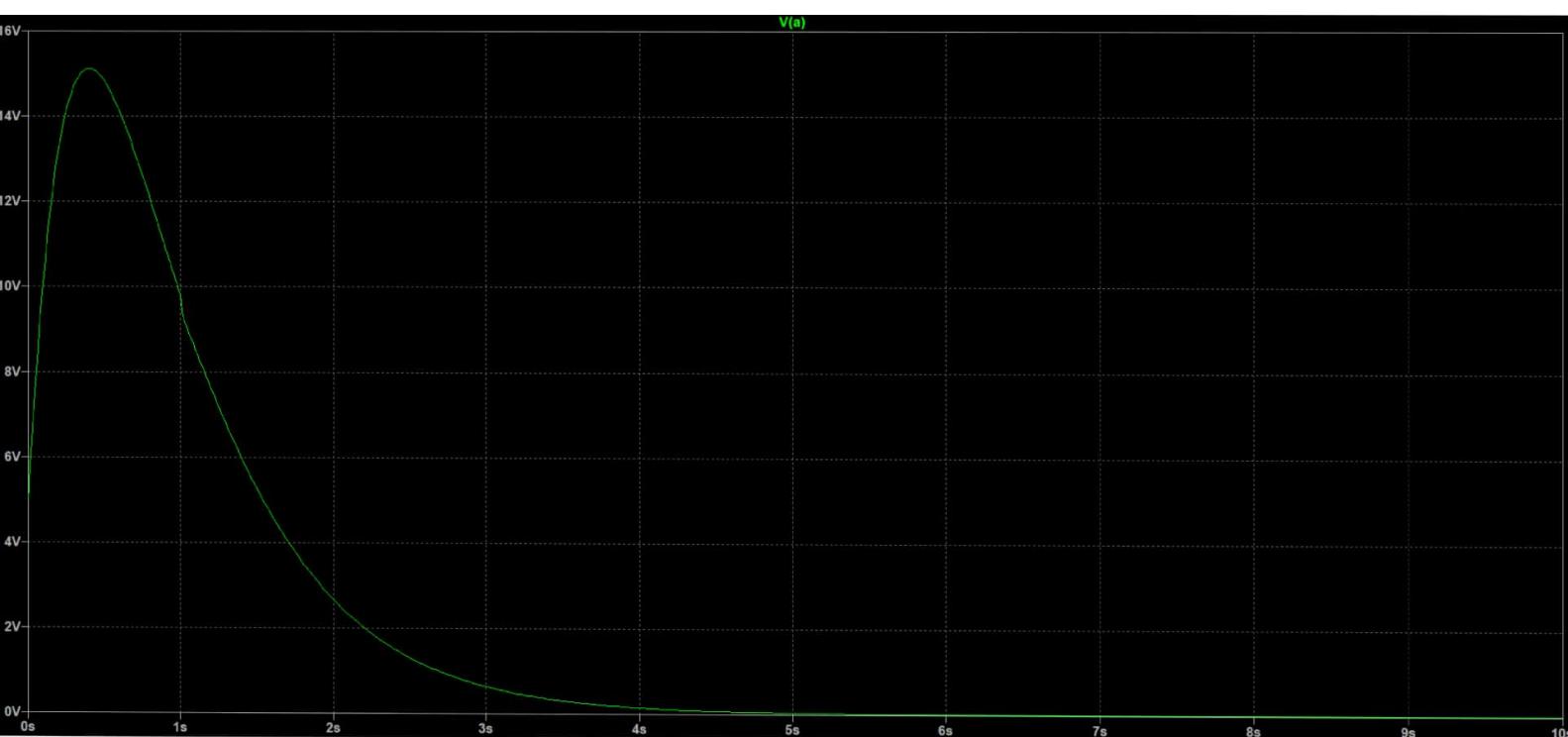


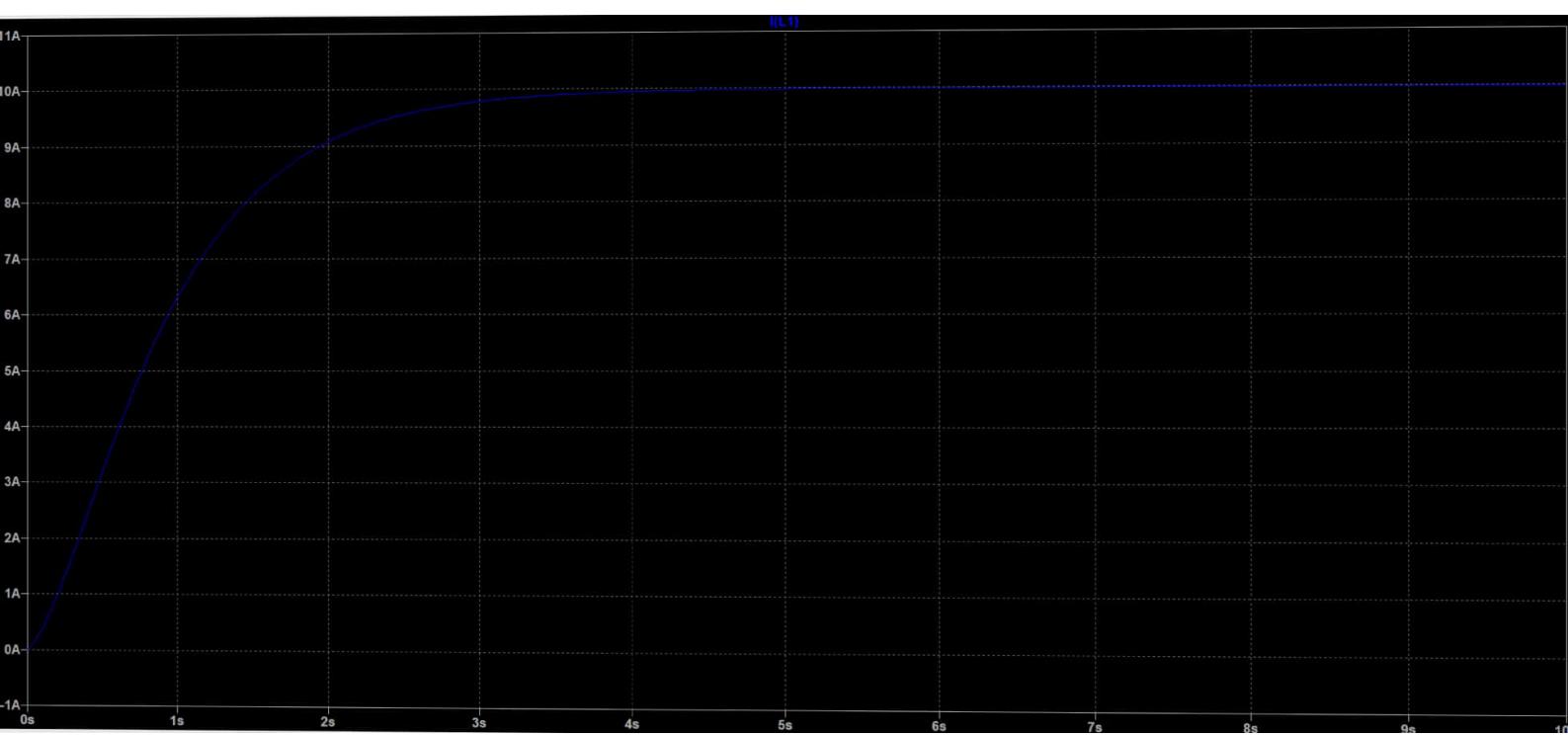




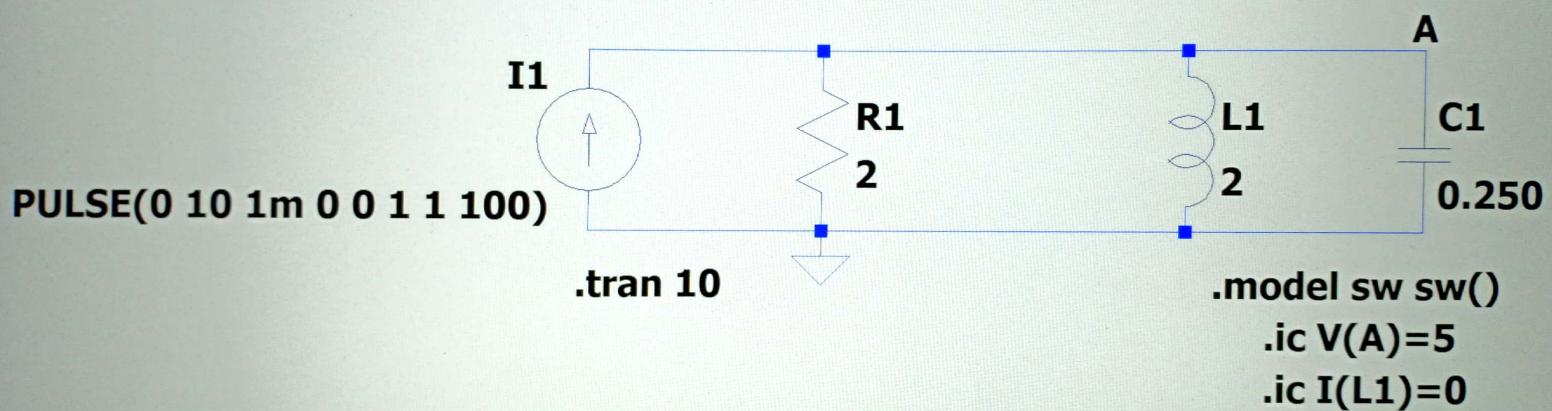
### ANSWER O2 - PART B1

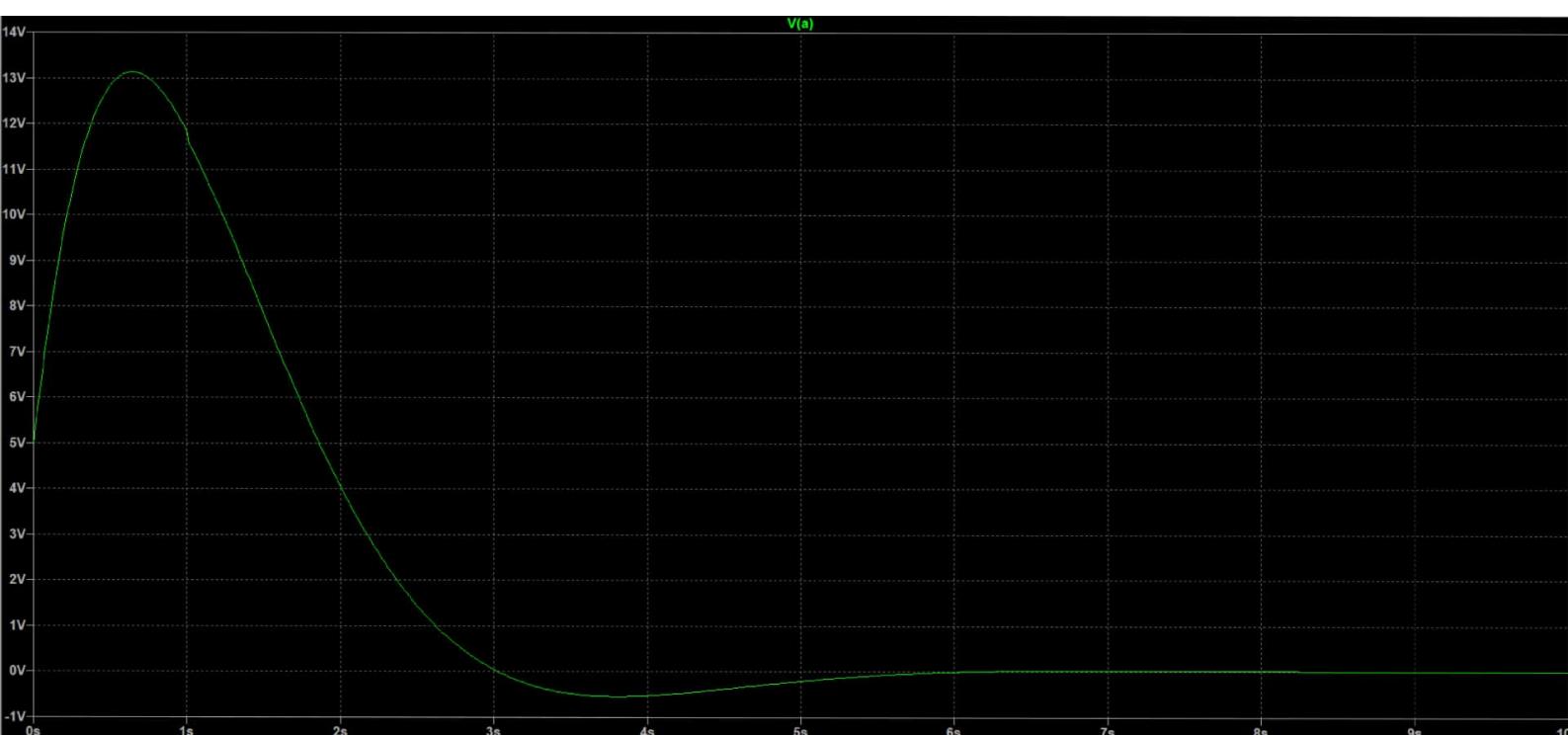


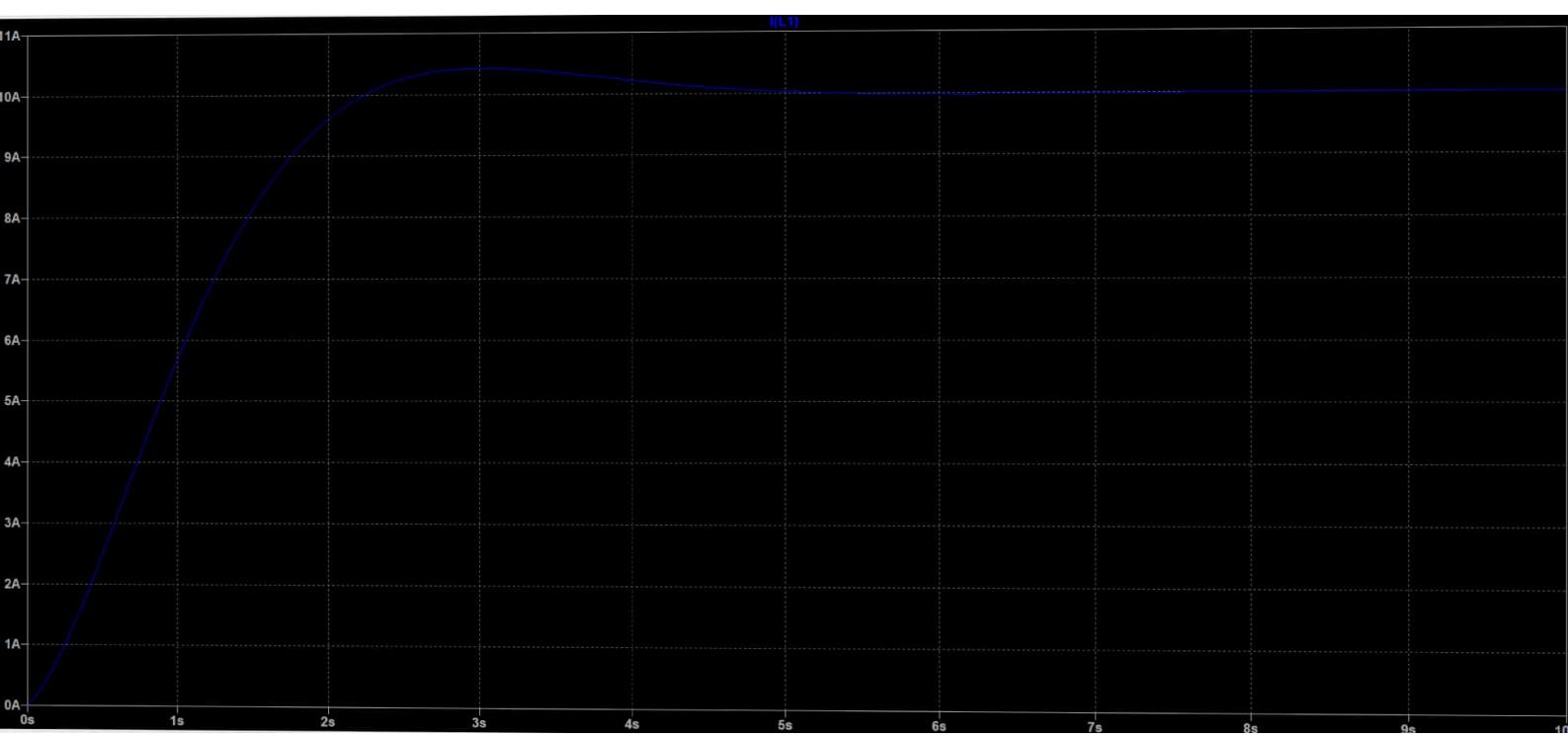




## ANSWER O2 - PART B2







### ANSWER O2 - PART B3

