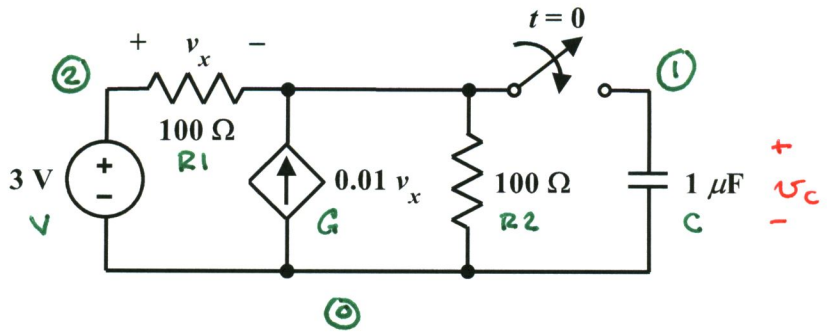
EE 2240

Problem #08

The capacitor is initially uncharged when the switch is closed at $t = 0$. Find an analytical expression for the energy stored in the capacitor for $t \geq 0$. Also use PSpice and Probe to plot the energy stored in the capacitor for $0 \leq t \leq 5\tau$, where τ is the circuit time constant for $t > 0$.



$v_c(0) = 0$

For $t > 0$:

$$10^{-6}\dot{v}_c + \frac{1}{100}v_c - 0.01(3 - v_c) + \frac{1}{100}(v_c - 3) = 0$$

or $\quad 10^{-6}\dot{v}_c + 0.03 v_c = 0.06$

$$\Rightarrow \quad \dot{v}_c + 30000\, v_c = 60000$$

$\Downarrow$ $\qquad$ $\Downarrow$ $\quad 30000\, v_c(\infty) = 60000$

$\therefore v_c(\infty) = 2\text{ V}$

$$\tau = \frac{1}{30000} = 33\tfrac{1}{3}\ \mu\text{s}$$

$$\therefore \quad v_c(t) = \left(-2e^{-30000t} + 2\right)\ \text{V},\ t \geq 0$$

$$w_c(t) = \tfrac{1}{2}(1\mu\text{F})\, v_c^2(t)$$

$$= \tfrac{1}{2} \times 10^{-6} \times \left(4e^{-60000t} - 8e^{-30000t} + 4\right)$$

$$= \left(2e^{-60000t} - 4e^{-30000t} + 2\right)\ \mu\text{J},\ t \geq 0$$

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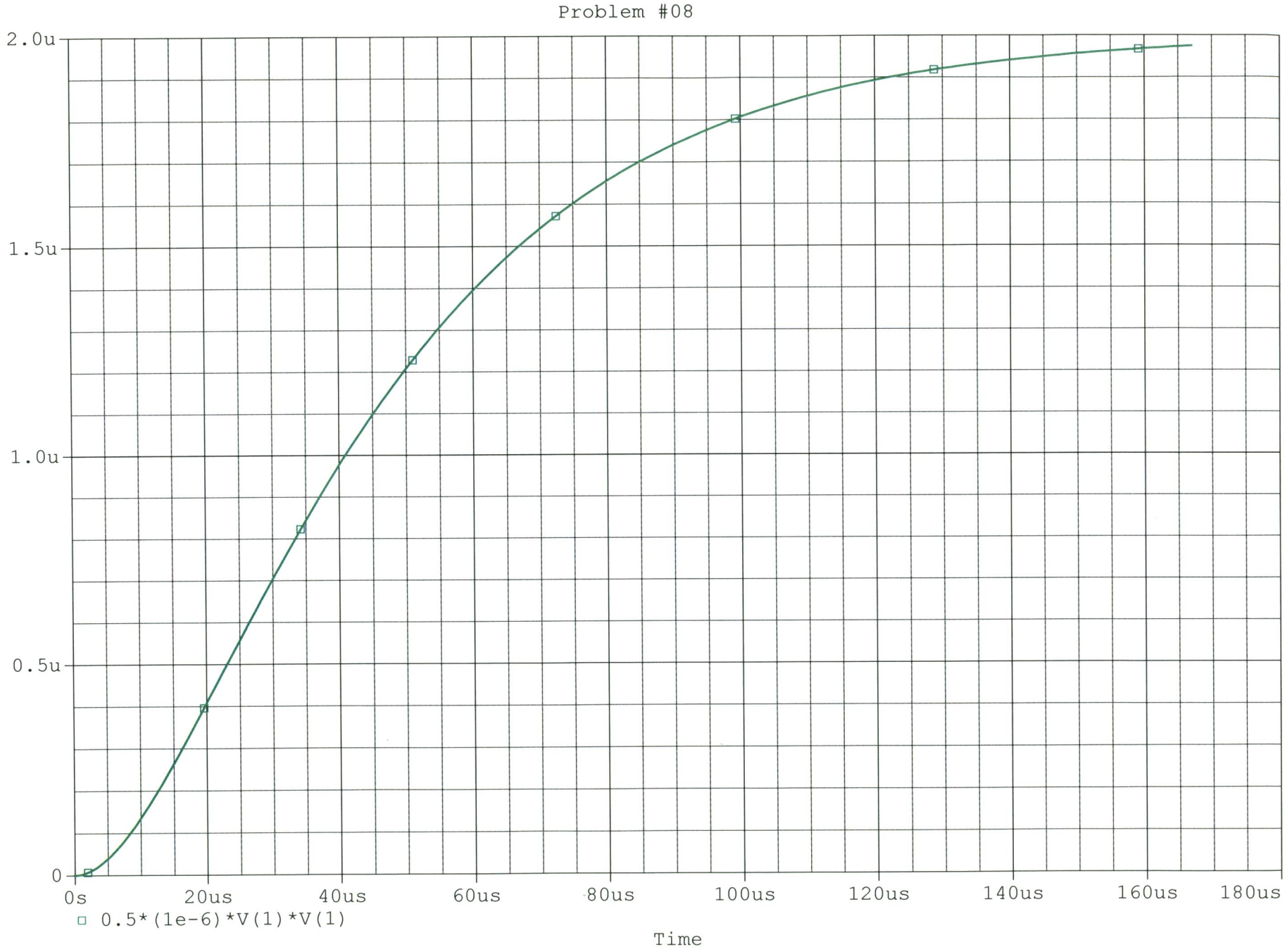
```
V  2  0  DC  3
R1  2  1  100
G  0  1  2  1  0.01
R2  1  0  100
C  1  0  1u  IC=0
.TRAN  1u  167u  0  1u  UIC
.PROBE
.END
```

$5\tau \approx 167\mu s$

See the next page for the output.


Problem #08
2.0u
1.5u
1.0u
0.5u
0
0s
20us
40us
60us
80us
100us
120us
140us
160us
180us
0.5*(1e-6)*V(1)*V(1)
Time