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1. EXPERIMENT 5 - PRELIMINARY WORK

1.1 For the circuit given in *Fig. 1*, sketch roughly the waveforms of $V_C(t)$ and $V_R(t)$.

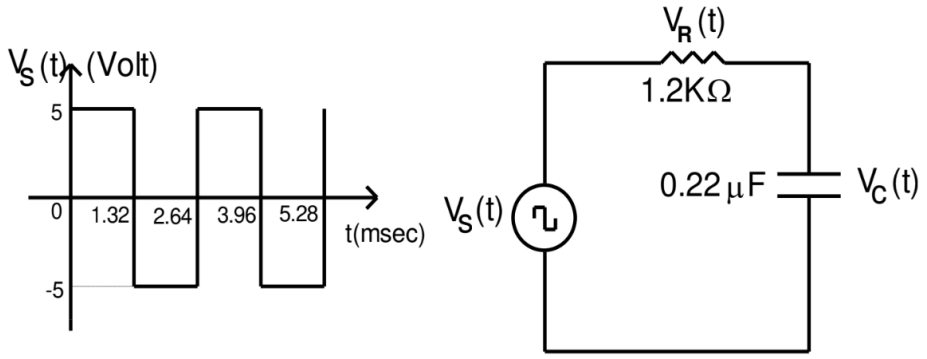

Figure 1

Answer: By a KCL equation for $0 < t < 1.32$ ms,

$$\frac{V_C - V_S}{R} = -C\frac{dV_C}{dt} \implies \frac{dV_C}{dt} = \frac{V_S - V_C}{RC} \implies \frac{dV_C}{V_S - V_C} = \frac{dt}{RC}$$

$$\implies \int_{V_C(0)}^{V_C(t)} \frac{dx}{V_S - x} = \int_0^t \frac{d\tau}{RC} \implies -\ln|V_S - x| \Big|_{x=V_C(0)}^{x=V_C(t)} = \frac{125000}{33}\tau \Big|_{\tau=0}^{\tau=t}$$

$$\implies \ln\left(\frac{V_S - V_C(t)}{V_S - V_C(0)}\right) = -\frac{125000t}{33} \implies V_C(t) = V_S + (V_C(0) - V_S)e^{-125000t/33}$$

The voltage across the resistor is then

$$V_R = V_S - V_C \implies V_R = (V_S - V_C(0))e^{-125000t/33}$$

One problem is that we need to know the value of $V_C(0)$, which is not given in the question. Assume that $V_C(0) = -5$ V. The voltages across the elements are

$$\left.\begin{array}{l} V_C(t) = 5 - 10e^{-125000t/33} \text{ V} \\ V_R(t) = 10e^{-125000t/33} \text{ V} \end{array}\right\} \; 0 < t < 1.32 \text{ ms}$$

For $1.32 \text{ ms} < t < 2.64$ ms, the polarity of the source changes. Assume that the final voltages are attained, i.e., the difference in the voltage at $t = 1.32$ ms and the final voltage is negligible. Therefore, the equations also change sign.

$$\left.\begin{aligned} V_C(t) &= -5 + 10e^{-125000(t-1.32\text{ ms})/33}\ \text{V} \\ V_R(t) &= -10e^{-125000(t-1.32\text{ ms})/33}\ \text{V} \end{aligned}\right\} 1.32\text{ ms} < t < 2.64\text{ ms}$$

Since $0 < t < 2.64$ ms comprises one square wave, we can sketch the entire graph.