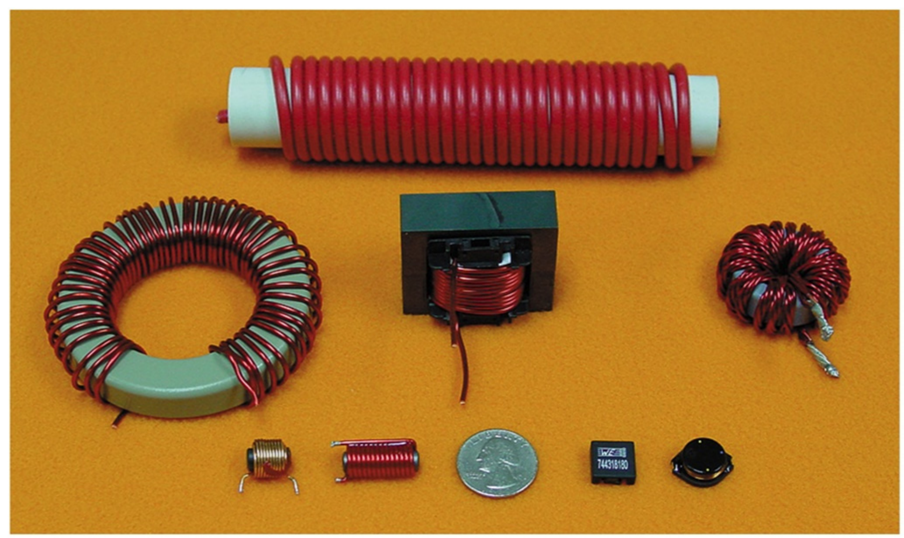
ECE212H1F – Circuit Analysis

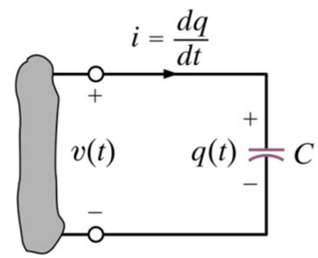
Lecture #9

Capacitors and Inductors

Individual Characteristics and Combinations



Key Points



1. A **capacitor** as a circuit element is characterized by:
   - The instantaneous current through the capacitor depends on the rate of change of the voltage across the capacitor: $i_C(t) = C\dfrac{dv_C(t)}{dt}$
   - The instantaneous power is: $p_C(t) = v_C(t)i_C(t)$
   - The instantaneous stored energy is: $w_C(t) = \int_{-\infty}^{t} p_L(t')dt' = \dfrac{1}{2}Cv_C^2(t)$
   - The voltage across a capacitor cannot change instantaneously, i.e., $i_C = C\dfrac{dv_C}{dt} \neq \infty$
   - After the initial charging up, a capacitor will look like an open-circuit $(i_C = 0)$ to a DC (direct current) source
   - Series capacitors have the same charges on their plates, thus the equivalent is:

$$C_{eqSeries} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}\right)^{-1}$$

   - Parallel capacitors have the same voltage across them, thus the equivalent is:

$$C_{eqParallel} = C_1 + C_2 + \ldots + C_n$$

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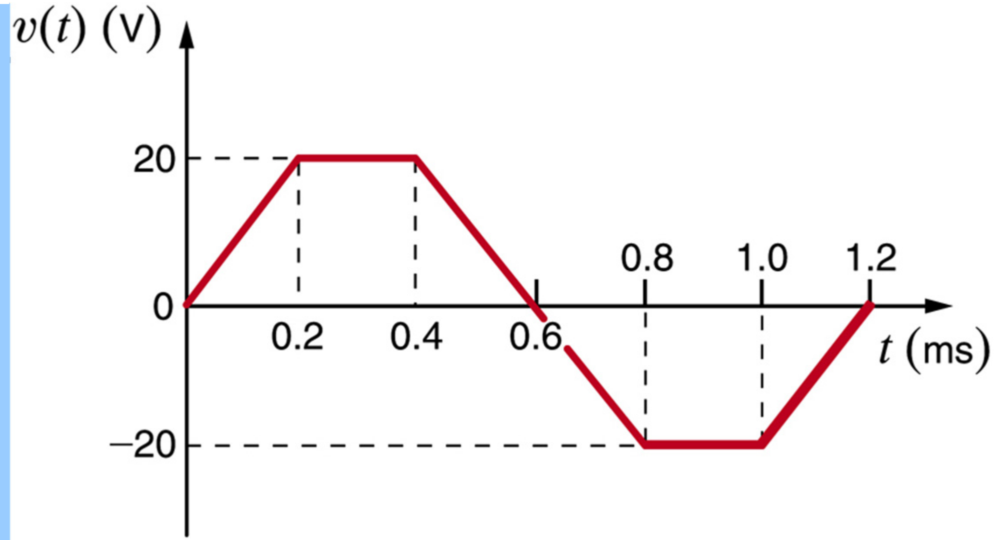
The voltage across a 1 μF capacitor is shown to the right. What is the current through the capacitor at t = 0.9 ms?



A. $i_C = 0$ A

B. $i_C = 0.022$ A

C. $i_C = -20$ A

D. $i_C = -0.022$ A

E. $i_C = 2.2$ mA

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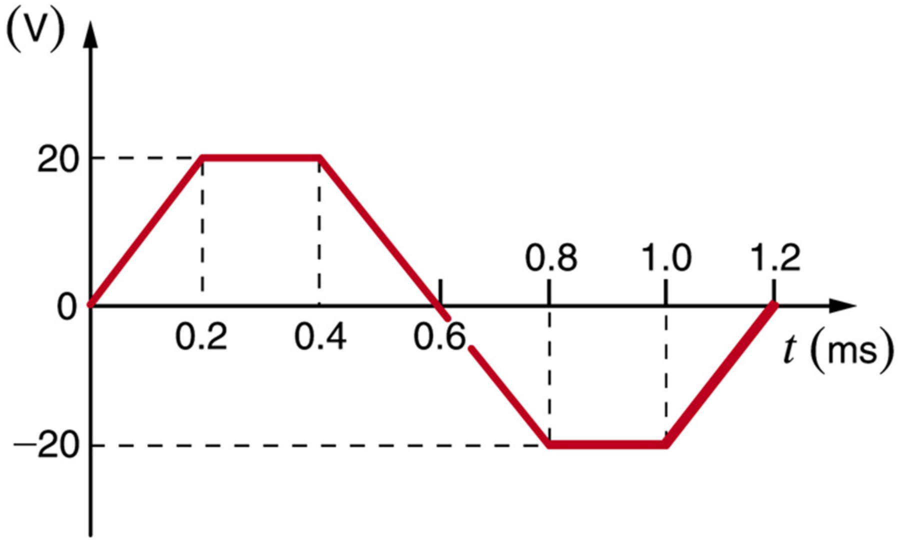
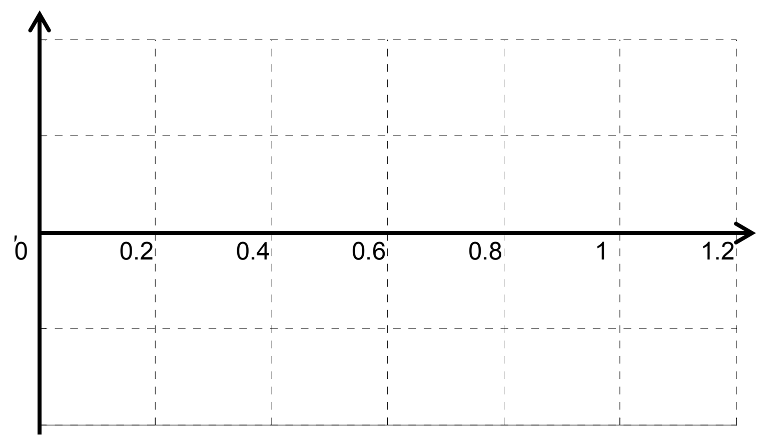
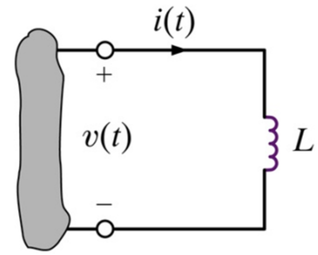
Example 1:
Current, Power, and Energy in a Capacitor

The voltage across a 1 μF capacitor is shown to the right. Draw the current waveform, $i(t)$





Key Points (cont'd)



2. An **inductor** as a circuit element is characterized by:
   - The instantaneous voltage across the inductor depends on the rate of change of the current through the inductor: $v_L(t) = L\frac{di_L(t)}{dt}$
   - The instantaneous power is: $p_L(t) = v_L(t)i_L(t)$
   - The instantaneous stored energy is: $w_L(t) = \int_{-\infty}^{t} p_L(t')dt' = \frac{1}{2}Li_L^2(t)$
   - The current through an inductor cannot change instantaneously, i.e., $v_L = L\frac{di_L}{dt} \neq \infty$
   - After the initial "charging up", an inductor will look like a short-circuit $(v_L = 0)$ to a DC (direct current) source
   - Series inductors have the same current through them, thus the equivalent is:

$$L_{eqSeries} = L_1 + L_2 + \ldots + L_n$$

   - Parallel inductors have the same voltage across them, thus the equivalent is:

$$L_{eqParallel} = \left(\frac{1}{L_1} + \frac{1}{L_2} + \ldots + \frac{1}{L_n}\right)^{-1}$$

R G B O

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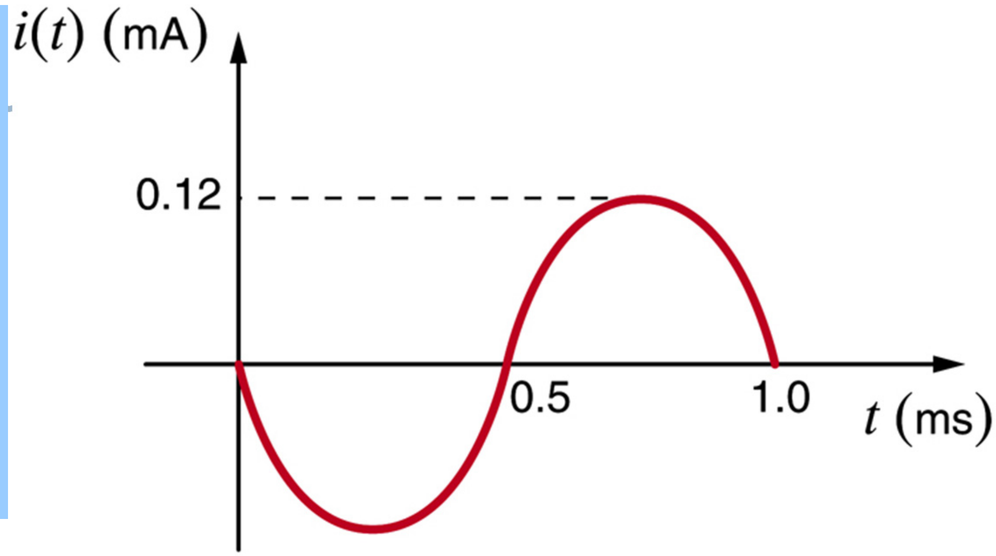
The current through a 1 mH inductor is shown to the right. A which of the following times does the inductor absorb power?



A. $t = 0.1$ ms

B. $t = 0.25$ ms

C. $t = 0.5$ ms

D. $t = 0.75$ ms

E. $t = 0.9$ ms