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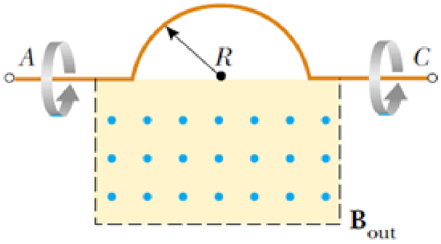
Problem 1 (5 points)

A semicircular conductor of radius R = 0.250 m is rotated about the axis AC at a constant rate of 120 rev/min as shown in next figure. A uniform magnetic field in all of the lower half of the figure is directed out of the plane of rotation and has a magnitude of 1.30 T. (a) Calculate the equation of the magnetic flux and emf induced in the conductor. (b) How would the answer to (a) change if B_{out} were allowed to extend a distance R above the axis of rotation?. Give the new equations for magnetic flux and emf. (c) Sketch the magnetic flux and emf versus time for (a). (d) Sketch the magnetic flux and emf versus time for (b).



Suppose that the conductor starts rotating when it is perpendicular to the magnetic field then:

$w = 4\pi$ rad/s, $T = \frac{1}{2}$ s

(a) $A_a = \frac{1}{2}\pi R^2 = \frac{1}{2} 3.14\cdot(0.25)^2 = 0.098\,m^2$, $k = 0,1,2,3,4\ldots$

For $\frac{1}{2}k\,s \le t \le \frac{1}{4}+\frac{1}{2}k\,s$

$\phi_a(t) = B\cdot A_a\cdot \sin(4\pi t) = 1.3\times 0.098 \sin(4\pi t) = 0.13\cdot \sin(4\pi t)$ Wb

$\mathcal{E}_a(t) = -\frac{d\phi_a(t)}{dt} = -1.63\cos(4\pi t)$ V.

For $\frac{1}{4}+\frac{1}{2}k\,s \le t \le \frac{1}{2}+\frac{1}{2}k\,s$

$\phi_a(t) = 0$ Wb, $\mathcal{E}_a(t) = 0$ V.

(b) $A_b = \frac{1}{2}\pi R^2 = \frac{1}{2} 3.14\cdot(0.25)^2 = 0.098\,m^2$

$\phi_b(t) = B\cdot A_b\cdot \sin(4\pi t) = 1.3\times 0.098 \sin(4\pi t) = 0.13\cdot \sin(4\pi t)$ Wb

$\mathcal{E}_b(t) = -\frac{d\phi_b}{dt} = -1.63\cos(4\pi t)$ V.

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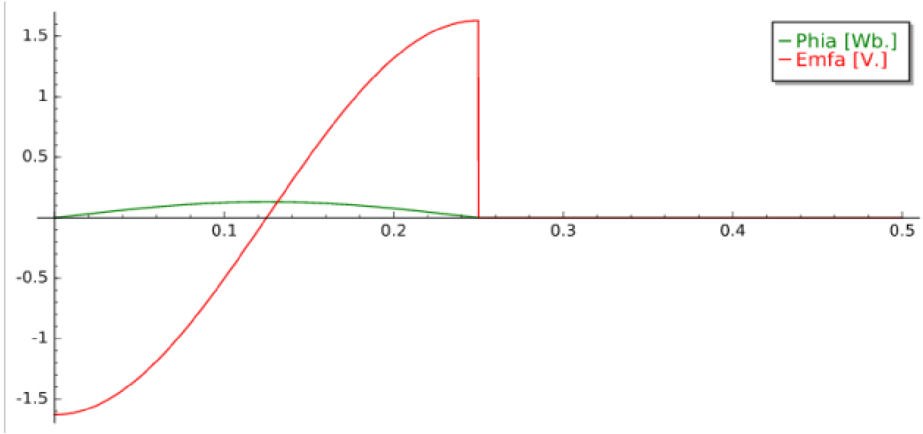
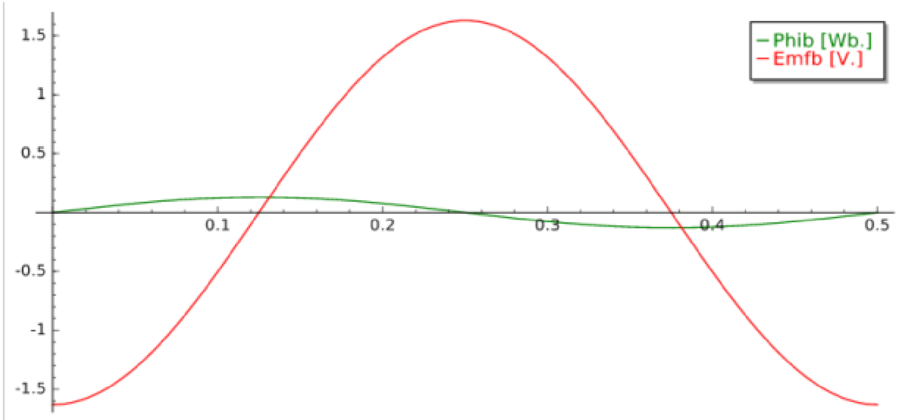
(c)



(d)



x axis t in seconds

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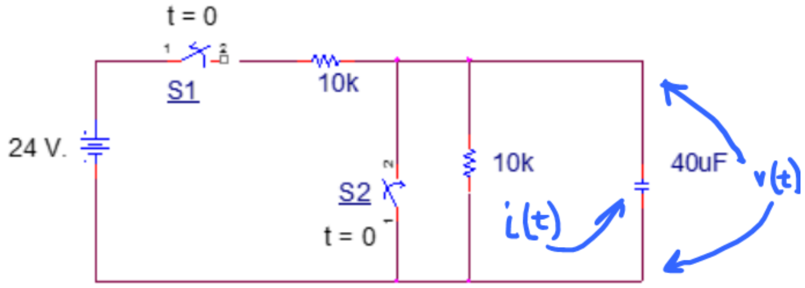
Problem 2 (5 points)

Given the circuit in next figure where for t < 0 s the switch S1 has been closed during a long time and the switch S2 has been opened during a long time. At t = 0 s the switch S1 opens and the switch S2 closes. (a) Find the equation of v(t) for t >= 0 s, and (b) Find the equation of i(t) for t >= 0 s. (c) Draw a graph of v(t). (d) Draw a graph of i(t). (Note: The resistance of the closed S2 switch is 10^{-9} Ohm). (All resistances in Kohm, capacitances in microfarad).



$$v_0 = 24V.\ \frac{10K}{10K+10K} = 12\ V.$$

$$\tau = 40\mu F \cdot \frac{10K\cdot 10^{-9}}{10K+10^{-9}} \simeq 40\cdot 10^{-15}\ s = 4\cdot 10^{-14}\ s$$

(a) $$v(t) = 12 \cdot e^{-\frac{(t-t_0^{=0})}{\tau}} = 12\cdot e^{-\frac{t}{4\cdot 10^{-14}}}\ V$$

(b) $$i(t) = \frac{v(t)}{R} = \frac{12}{\frac{10K\cdot 10^{-9}}{10K+10^{-9}}}\ v(t)\ A \simeq 12\cdot 10^{9}\cdot e^{-\frac{t}{4\cdot 10^{-14}}}\ A$$

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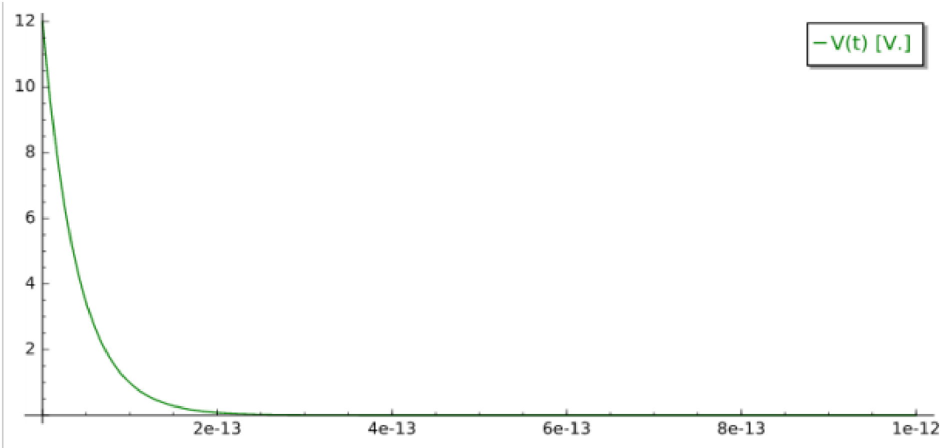
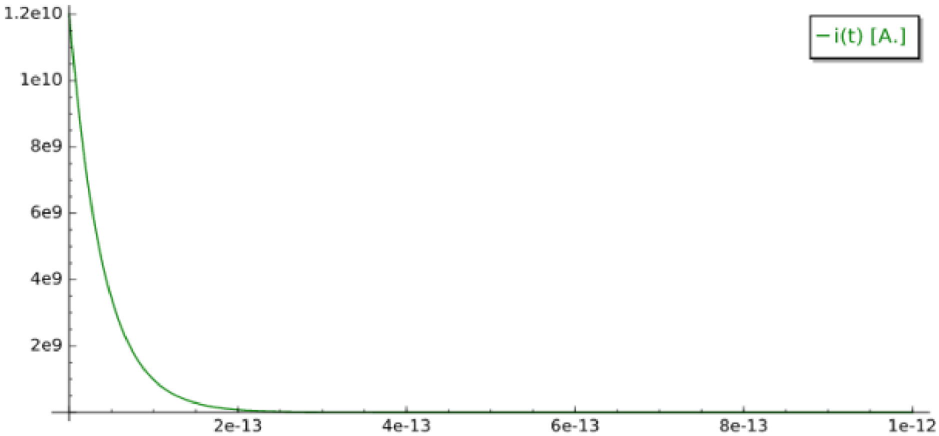
(c)



(d)



x axis t in seconds