

ENEE 204 Homework Set 1
February 1, 2005
Due February 8, 2005

Do the following problems from the book:

Chapter 1: 5,6,7,9,10,11,14,18,19,23,25,27,30

Challenge question: A 10V dc power supply is connected to a 1kohm resistor and a $10\mu\text{H}$ inductor in series to form a complete circuit. Find the current in the circuit as a function of time, and the voltage across the inductor as a function of time.

1.9 Problems

- Convert the following derived units to the four basic SI units (m, kg, s, A): (a) joules, (b) coulombs, (c) volts, (d) webers.
- Express the following quantities in terms of multiplying factors: (a) 2.54×10^{11} electrons, (b) -5.63×10^{-14} C, (c) 0.0035 Wb, (d) 0.00000915 A.
- Find the number of electrons required to generate a total charge of: (a) -1.6×10^{-7} C, (b) -1.17×10^{-17} C, (c) $12 \mu\text{C}$, (d) -3.73 pC.
- If a $-3 \mu\text{A}$ current flows through a surface S , how many electrons pass through S in (a) 1 s, (b) $3 \mu\text{s}$, (c) 53.4 fs?
- If the current flowing through a surface S has the time variation shown in Figure P1-5, plot the time dependence of net charge accumulating on the other side of S . Assume zero initial charge.

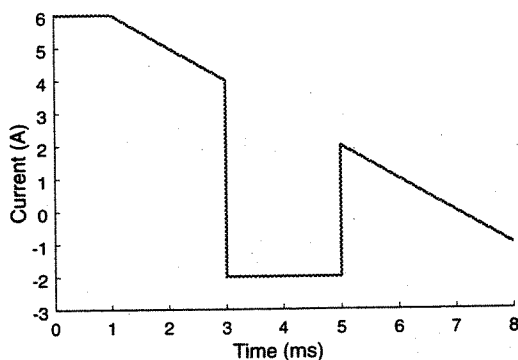


Figure P1-5

- The total charge in a volume V as a function of time is shown in Figure P1-6. Plot the time variation of electric current leaving V .

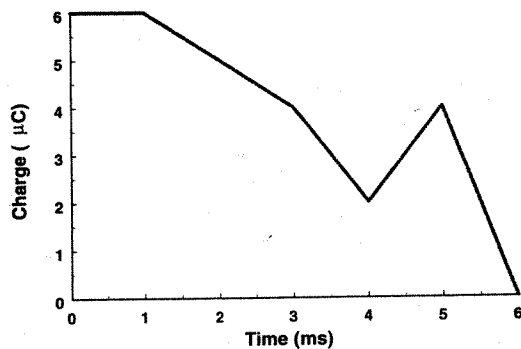


Figure P1-6

- The time dependences of the voltage across and the current through a two-terminal electric device are shown in Figure P1-7. Plot the power flowing into the device and the total stored energy as a function of time. Assume $w(0) = 0$.

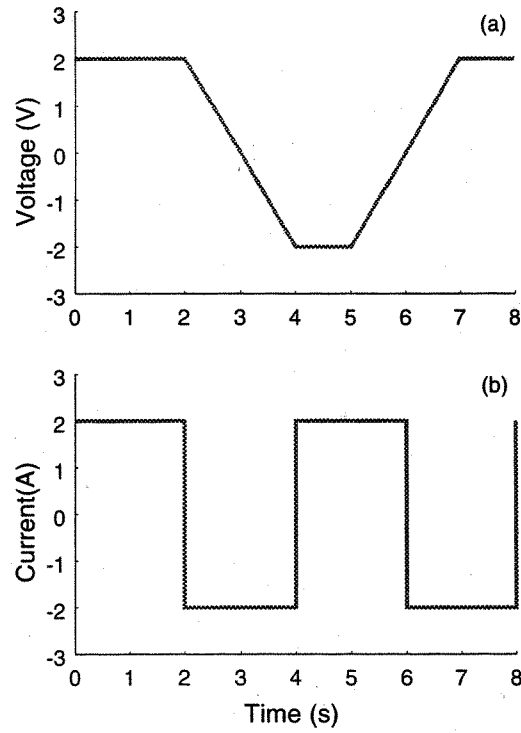


Figure P1-7

8. The voltage developed across a 12-turn coil of wire is shown in Figure P1-8. Plot the time variation of the magnetic flux linking one turn of the device. Assume zero initial flux.

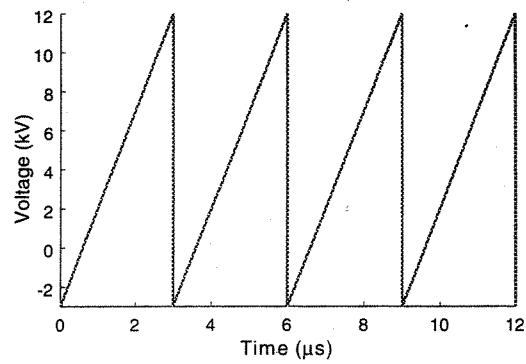


Figure P1-8

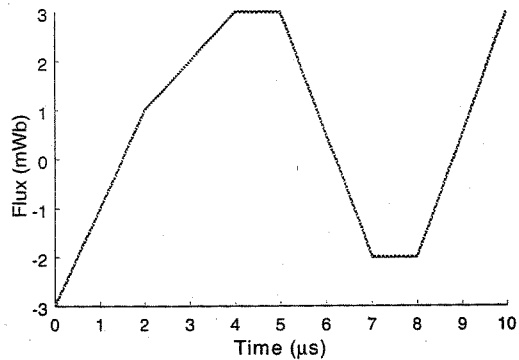


Figure P1-9

9. The total magnetic flux linking a circuit is shown in Figure P1-9 as a function of time. Plot the resulting voltage developed across the device.
10. The current through a circuit is given by $i(t) = (3 + t)$ A. Determine the flux (at time t) that must be linked through the device if the power consumed is a constant 1 W. Assume zero initial flux at $t = 0$.
11. If the current through a closed surface is given by $i(t) = 1 + 5t^2 + \cos(3t)$ A, what is the expression for the charge accumulating in the volume? Assume $q(0) = 0$.
12. If the voltage across a two-terminal device is $v(t) = te^{-t}$ V and the current through it is $i(t) = (1 - t)e^{-t}$ A, plot the energy stored in the device as a function of time (for $t > 0$). Assume $w(0) = 0$.
13. Calculate the nominal resistance of the following automotive hardware (which run off a 12 V battery): (a) a 12 W dome light, (b) a 50 W horn, and (c) a 300 W headlight.
14. To reach a new customer, the local electric company must transport five miles a current of $i(t) = 200 \cos(377t)$ amperes. What is the required diameter of a copper wire that would keep the average power transmission losses below 2 kW? The conductivity of copper is $\sigma = 5.8 \times 10^7 (\Omega\text{m})^{-1}$.
15. Assume you have a carbon composition resistor with a conductivity of $\sigma = 2.0 \times 10^3 (\Omega\text{m})^{-1}$. If you use this material to make 2 cm long resistors, what is the required diameter to produce a resistance of: (a) 4 m Ω , (b) 1 Ω , (c) 1 k Ω , and (d) 1 M Ω ? Which of these designs do you think are practical ones? How might you actually construct the impractical designs, if any?
16. Calculate the resistance value for each of the following cases of a circular-cross-section wire:

Resistor	Conductance $(\Omega\text{m})^{-1}$	Length (cm)	Radius (mm)
a	5	1	2
b	2×10^3	2	1
c	5.8×10^7	100	.003

17. Find the average power absorbed by a $20\ \Omega$ resistor when a current of $i(t) = 3/4 \sin(3t)$ A is applied.
18. A $10\ \mu\text{H}$ inductor is driven by a current $i(t) = 30 \cos(500t)$ mA. Calculate the power supplied to the inductor.
19. The voltage across a $2\ \text{mH}$ inductor is shown in Figure P1-19. Plot the current flowing through the inductor assuming an initial current of $10\ \text{mA}$.

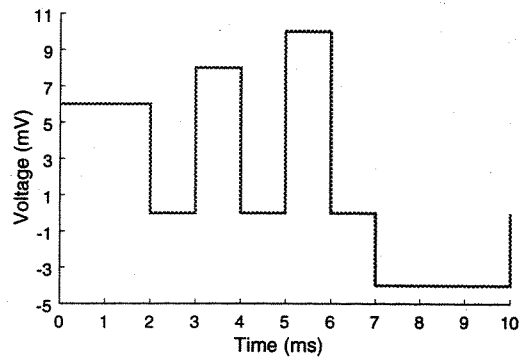


Figure P1-19

20. The current flowing through a $39\ \mu\text{H}$ inductor is shown in Figure P1-20. Plot the power in the inductor as a function of time.

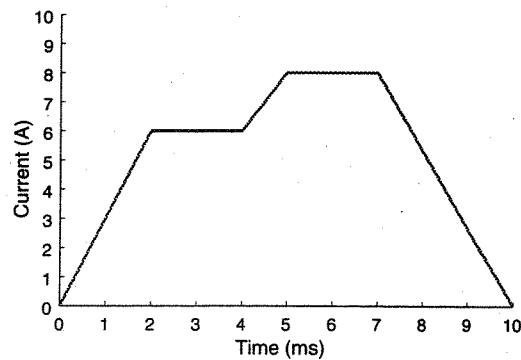


Figure P1-20

21. The current through a $91\ \mu\text{H}$ inductor is given by $i(t) = 7e^{-t/20}$ A. Find expressions for the flux linked by the inductor and the voltage across the inductor. What is the total charge that passes through the inductor from $t = 0$ to $t = \infty$? Assume $q(0) = 0$.

22. Calculate the capacitance for each of the following cases of a parallel plate capacitor:

Capacitor	Relative dielectric constant ϵ_r	Plate gap (mm)	Radius (cm)
a	1	2	1
b	2.3	.1	4
c	32.4	.003	10

23. The voltage across a $10 \mu\text{F}$ capacitor is shown in Figure P1-23. Plot the power supplied to the capacitor as a function of time.

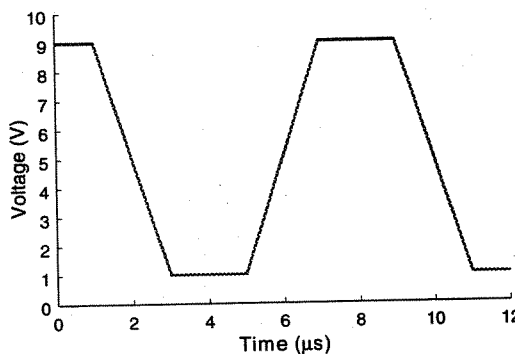


Figure P1-23

24. A 47 pF capacitor is driven by a voltage $v(t) = 1 + 6e^{-2t}$ V. Calculate the power supplied to the capacitor.
25. The current through a $20 \mu\text{F}$ capacitor is given by $i(t) = 2e^{-3t}$ A for $t > 0$. Find expressions for the voltage, accumulated charge, instantaneous power, and electric energy stored in the capacitor. Assume zero initial charge.
26. The voltage across a 5 nF capacitor is given by $v(t) = 1 + t + 3t^2$ V for $t > 0$. Find expressions for the current, accumulated charge, instantaneous power, and electric energy stored in the capacitor.
27. The voltage across a 5 mH inductor is given by $v(t) = 3t^2 + 5t^4$ V for $t > 0$. Find expressions for the current, magnetic flux, instantaneous power, and electric energy stored in the inductor. Let $i(0) = 0$.
28. The current through a $33 \mu\text{H}$ inductor is given by $i(t) = 20t \cos(30t)$ mA for $t > 0$. Find expressions for the voltage, magnetic flux, instantaneous power, and electric energy stored in the inductor.
29. The current through a $1 \text{ k}\Omega$ resistor is given by $i(t) = 2e^{-t} \sin(10t)$ mA for $t > 0$. Find expressions for the voltage across the resistor and the instantaneous power dissipated by the resistor. What is the maximum power dissipated in the resistor?
30. The voltage across a 1.4Ω resistor is given by $v(t) = e^{-t/10} - e^{-t/100}$ V for $t > 0$. Find expressions for the current through the resistor and the instantaneous power dissipated by the resistor. Plot the power dissipated in the resistor.