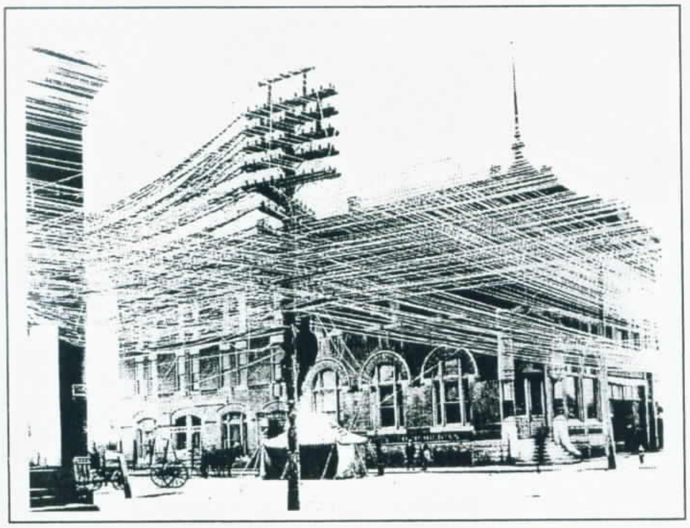
Name Solution

Section ______



Notes:
1. **Please read over all questions before you begin your work. There may be some information in a later question that helps you with an earlier question.**
2. For short answer questions, you may add some comments to justify your answer.
3. Make sure your calculator is set to perform trigonometric functions in radians & not degrees & use 4 significant digits.

Short Answer Questions

1. (20 Pts) ______
2. (10 Pts) ______
3. (5 Pts) ______
4. (10 Pts) ______
5. (10 Pts) ______

Regular Questions

6. (25 Pts) ______
7. (20 Pts) ______

Total

______

MULTIPLE CHOICE AND SHORT ANSWER QUESTIONS

1. Input Impedance of Lossless Transmission Lines (20 points)

Assume a sinusoidal source is connected to a lossless transmission line, as shown.

a. (8 pts) The transmission line load is an open circuit. Multiples of $\lambda/2$

i. For what line lengths will the input impedance observed at the sending point end also be an open circuit? Circle all correct answers.

$0 \quad \lambda/8 \quad \lambda/4 \quad 3\lambda/8 \quad \lambda/2 \quad 5\lambda/8 \quad 3\lambda/4 \quad 7\lambda/8 \quad \lambda \quad 9\lambda/8 \quad 5\lambda/4 \quad 11\lambda/8 \quad 3\lambda/2$

No Line

ii. For what line lengths will the input impedance observed at the sending point end be a short circuit? Circle all correct answers. Odd Mult of $\lambda/4$

$0 \quad \lambda/8 \quad \lambda/4 \quad 3\lambda/8 \quad \lambda/2 \quad 5\lambda/8 \quad 3\lambda/4 \quad 7\lambda/8 \quad \lambda \quad 9\lambda/8 \quad 5\lambda/4 \quad 11\lambda/8 \quad 3\lambda/2$

b. (5 pts) A transmission line has length $\lambda/2$, characteristic impedance $Z_o = 100\Omega$ and load $Z_L = 100\Omega + j100\Omega$. What is the input impedance?

$Z_{IN} =$ Z_L for length of $\lambda/2$ (always)

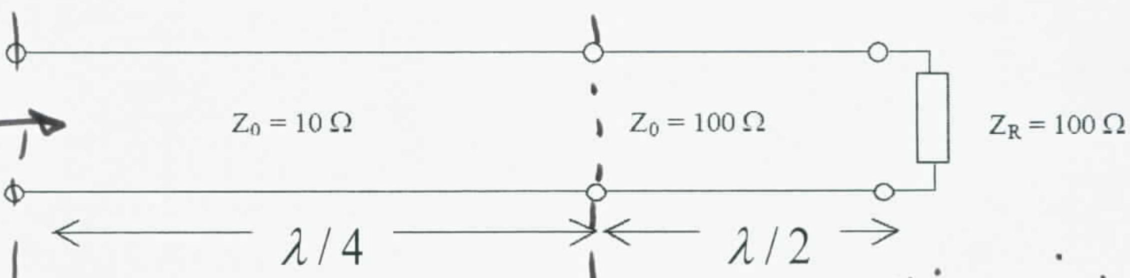
$= 100 + j100$

c. (7 pts) What is the input impedance of the network below? $Z_{IN} =$

$Z_{in} = \frac{Z_0^2}{Z_L}$

$= \frac{10^2}{100}$

$= 1$



Z_{in} at this point is 100Ω because the line is matched

2. Lossy Transmission Line (10 points)

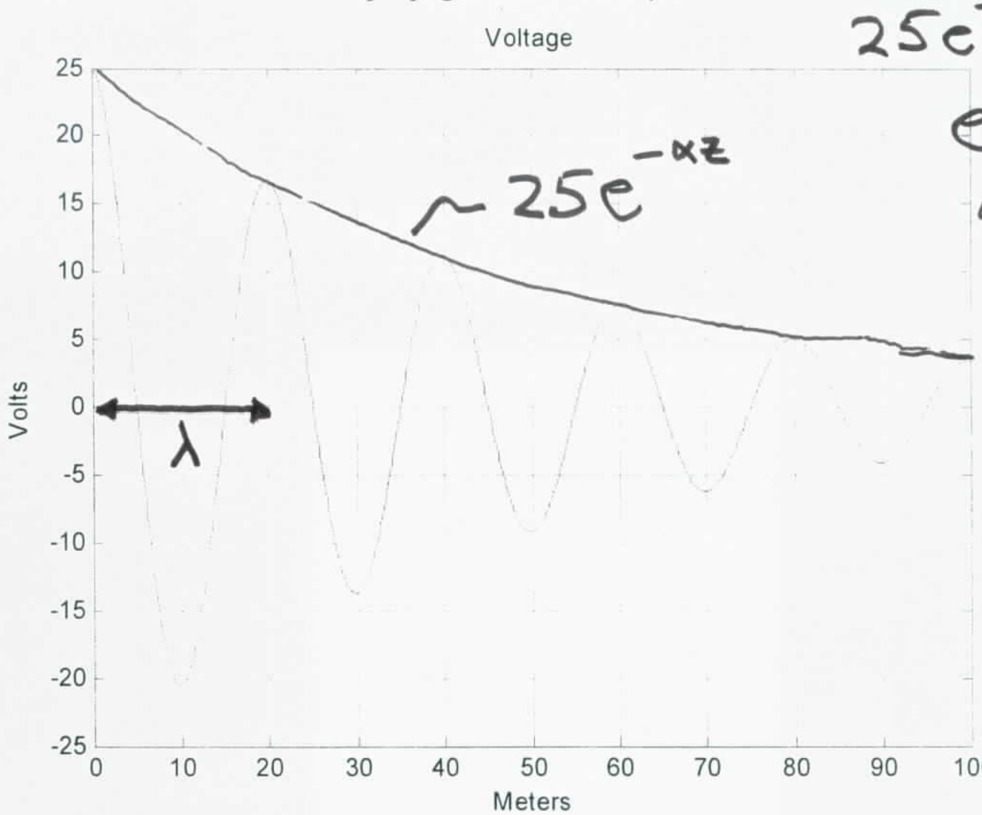
A sinusoidal voltage wave is propagating on a low loss transmission line. The voltage as a function of position appears as shown below. From this plot, determine the damping coefficient $\alpha =$ and the propagation constant $\beta =$

$25e^{-\alpha 80} = 5$

$e^{-\alpha 80} = .2$

$\alpha 80 = \ln(.2)$

$\alpha = .02$



$\lambda = 20 \quad \beta = \frac{2\pi}{\lambda} = \frac{2\pi}{20} = \frac{\pi}{10} = .314$

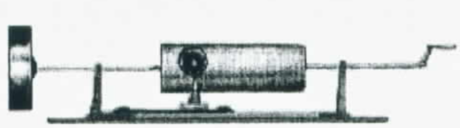
3. Cultural Question (5 points)

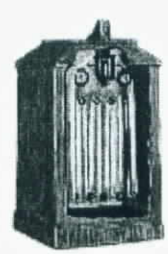
Who was the most famous American inventor of the 19th century? When is his birthday?

Edison

11 Feb (1847)


electric light bulb


phonograph


kineoscope

4. Cable Properties (10 points)

The following five sets of cable parameters are provided to you by a technician. Since you do not trust the work of this particular tech, you need to check each set to see if they at least are consistent. In other words, determine which of the following sets of parameters are consistent.

a. Total capacitance is 2nF, time delay is 100ns, characteristic impedance is 50Ohms, velocity of propagation is $2\text{x}10^8$m/s

$$\frac{2\times10^{-9}}{100\times10^{-9}} = \frac{1}{50} \checkmark$$

b. Total capacitance is 1nF, time delay is 100ns, characteristic impedance is 100Ohms, velocity of propagation is $2\text{x}10^8$m/s

$$\frac{10^{-9}}{10^{-7}} = \frac{1}{100} \checkmark$$

c. Total capacitance is 2nF, time delay is 100ns, characteristic impedance is 100Ohms, velocity of propagation is $2\text{x}10^8$m/s

$$\frac{2\times10^{-9}}{100\times10^{-9}} = \frac{1}{50} \times$$

d. Total capacitance is 1.07nF, time delay is 80ns, characteristic impedance is 75Ohms, velocity of propagation is $2.5\text{x}10^8$m/s

$$\frac{1.07\times10^{-9}}{80\times10^{-9}} = \frac{1}{75} \checkmark$$

e. Total capacitance is 2.14nF, time delay is 80ns, characteristic impedance is 75Ohms, velocity of propagation is $2.5\text{x}10^8$m/s

$$\frac{2.14\times10^{-9}}{80\times10^{-9}} = \frac{1}{37.5} \times$$

Use the following to check:

d = length

$C = c'd$ total cap

↑ per unit length

$$\text{delay} = t_d = \frac{d}{v}$$

$$\frac{C}{t_d} = \frac{c'\cancel{d}}{\cancel{d}}v = c'v = \frac{c'}{\sqrt{c'L'}} = \sqrt{\frac{c'}{L'}} = \frac{1}{Z_0}$$

5. Standing Waves (10 points)

For all of the following questions, assume that a lossless transmission line has a characteristic impedance of $Z_o = 100\Omega$.

a. (4 pts) The load reflection coefficient for a given transmission line is $\Gamma_L = 0.5$. What is the load impedance? $Z_L =$
What is the Standing Wave Ratio? $SWR =$

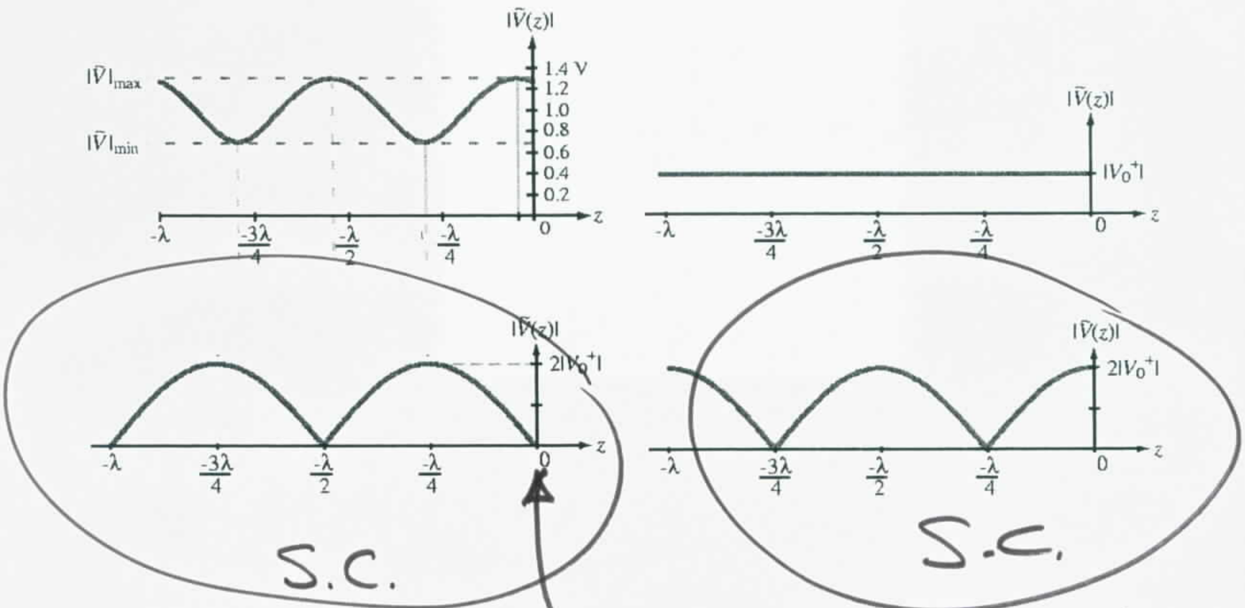
$$0.5 = \frac{Z_L - 100}{Z_L + 100}$$

$$\Rightarrow Z_L = 300$$

$$SWR = \frac{1+.5}{1-.5} = 3$$

checking $0.5 = \frac{300-100}{300+100} = \frac{200}{400}$ ✓

b. (6 pts) A transmission line has a short circuit load ($Z_L = 0$). What does the Voltage Standing Wave Pattern look like? Circle and label the correct diagram below. Also circle and label the Current Standing Wave Pattern if the vertical scale was Amps instead of Volts and all the voltage labels were changed to current.



Voltage

V=0 at load

current
i is max value at load.

REGULAR QUESTIONS

6. Sinusoidal Voltages on a Lossless Transmission Line (25 points)

A lossless transmission line has a capacitance per unit length of 64pF/m and an inductance per unit length of 1 μ H/m. The load impedance Z_L is purely resistive. Both the load impedance and the generator impedance are 50 Ohms. The source voltage amplitude is unknown at this point.

a. (3 pts) Find the characteristic impedance and the propagation velocity for this transmission line.

$$Z_0 = \sqrt{\frac{L'}{C'}} = \sqrt{\frac{10^{-6}}{64\times10^{-12}}} = \sqrt{\frac{10^6}{64}} = \frac{1000}{8} = 125\,\Omega$$

$$v = \frac{1}{\sqrt{L'C'}} = \frac{1}{\sqrt{64\times10^{-18}}} = \frac{10^9}{8} = \frac{10}{8}\times10^8 = 1.25\times10^8 \text{ m/s}$$

b. (3 pts) Determine the reflection coefficient at the load. $\Gamma_L =$ and the Voltage Standing Wave Ration (VSWR) on the line.

$$\Gamma_L = \frac{50-125}{50+125} = \frac{-75}{175} = -0.429$$

for $Z_0 > Z_L$

$$VSWR = \frac{1+.429}{1-.429} = 2.5$$

$$\left\{ \text{Note also } VSWR = \frac{1+\frac{Z_0-Z_L}{Z_0+Z_L}}{1-\frac{Z_0-Z_L}{Z_0+Z_L}} = \frac{Z_0}{Z_L} \right.$$

c. (3 pts) The generator frequency is 12.5MHz. Find the propagation constant β and wavelength λ

$$\omega = 2\pi f$$

$$\beta = \frac{\omega}{v} = \frac{2\pi\, 12.5\times10^6}{1.25\times10^8} = \frac{\pi}{5} = \frac{2\pi}{\lambda} \Rightarrow \lambda = 10$$

d. (4 pts) If the length of the line is 7.5 meters, find the input impedance Z_{in}

$$\beta d = \frac{2\pi}{10}7.5 = \frac{3}{4}2\pi = \frac{3\pi}{2} \quad \tan\beta d \to \infty$$

$$Z_{in} = \frac{Z_0^2}{Z_L} = \frac{(125)^2}{50} = 312.5\,\Omega$$

e. (5 pts) If we wish to deliver 10mW on average to the load, what is the amplitude of the injected voltage wave? $V^+ =$

$$V_{in} = \frac{Z_{in}}{Z_{in}+R_g} V_s = 0.862\, V_s$$

$$P_{in} = P_{out} = \frac{1}{2}\frac{V_{in}^2}{Z_{in}} = 0.0016\, V_{in}^2 = .01$$

$\Rightarrow V_{in} = 2.5\,V \Rightarrow V_s = 2.9\,V$

Input is at Vmax

$V_{in} = V_{max} = V^+(1+|\Gamma|)$

$2.5 = V^+(1.429)$

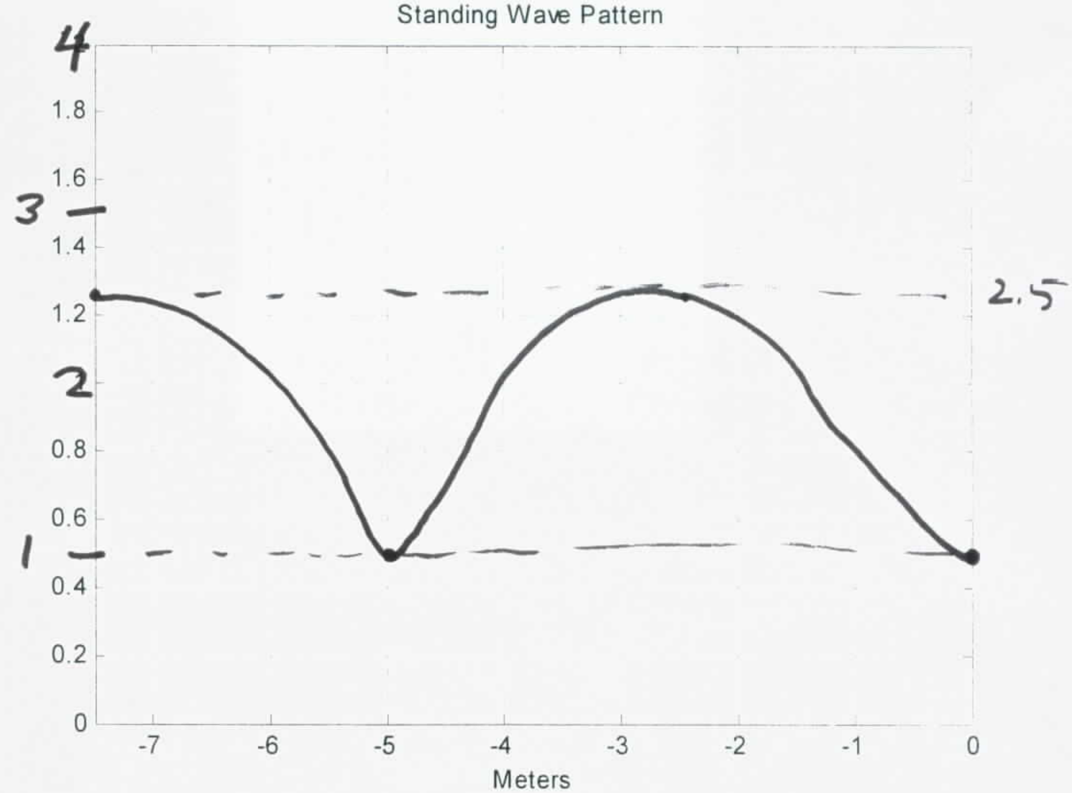
$\Rightarrow V^+ = 1.75$

f. (3 pts) What percentage of power is reflected by the load?

$\Gamma = -.429$

$\Gamma^2 = .184 \Rightarrow 18\%$

g. (4 pts) Sketch the standing wave pattern for this transmission line with the load end at the right and the source end at the left.



Also Checks with PSPice

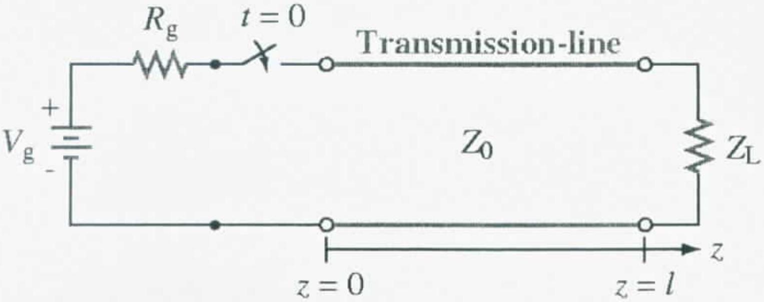
$V_{in} = 2.5$

$V_{out} = 1$

Amplitudes

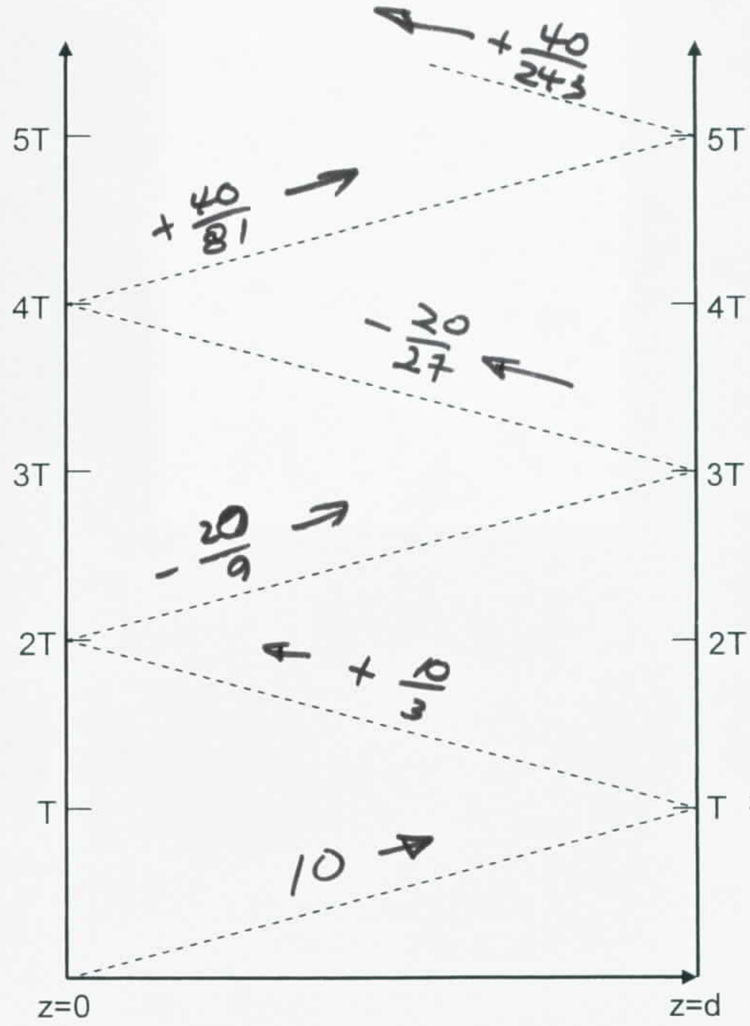
$\frac{3\lambda}{4}$

7. Pulses on Transmission Lines (20 points)



A 12V DC power supply with a 10 Ohm internal impedance is connected to a 50 Ohm transmission line with a 100 Ohm load. The length of the line is 10 meters and the propagation speed is 2×10^8 m/s.

a. Generate the bounce diagram for this configuration. (10 pts)



$$\Gamma_g = \frac{10-50}{10+50} = -\frac{40}{60} = -\frac{2}{3}$$

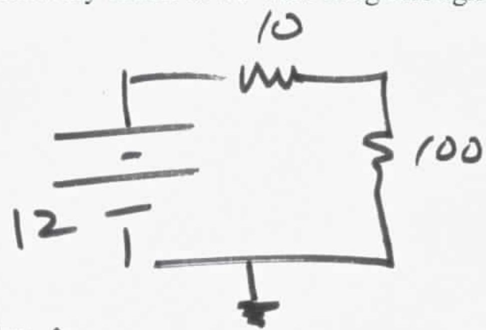
$$V_{in} = 12 \frac{50}{50+10} = \frac{12}{60} 50 = 10V$$

$$T = \frac{10}{2 \times 10^8} = 50ns$$

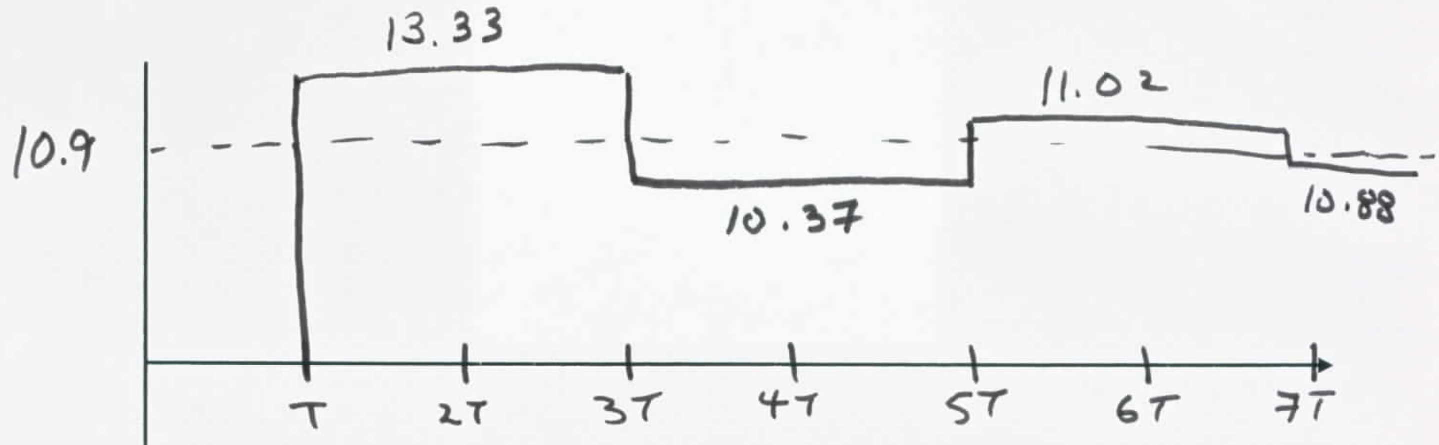
$$\Gamma_L = \frac{100-50}{100+50} = \frac{1}{3}$$

b. Determine and plot the voltage observed at the load as a function of time. Indicate the value the voltage will eventually reach if we wait long enough (time goes to infinity). (10 pts)

For large times



$$V = \frac{100}{100+10} 12 = 10.9$$



Also checks with PSpice