Quiz 1

TRANSMISSION LINES

Name ________________________

Section ________________________

Short Answer Questions

1. (18 Pts) ____________
2. (12 Pts) ____________
3. (10 Pts) ____________
4. (5 Pts) ____________
5. (5 Pts) ____________

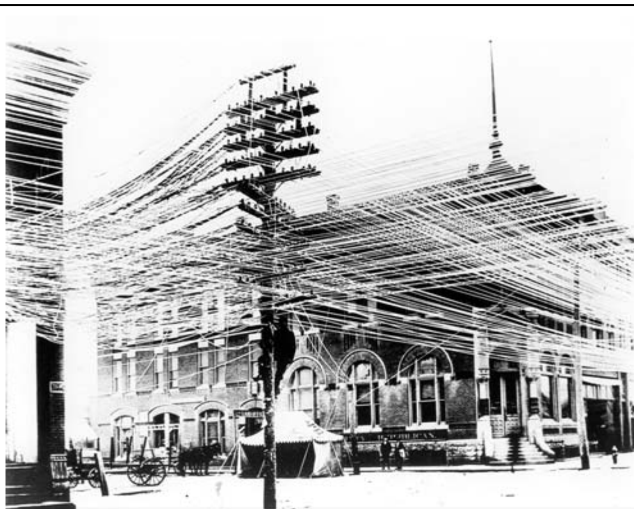
Regular Questions

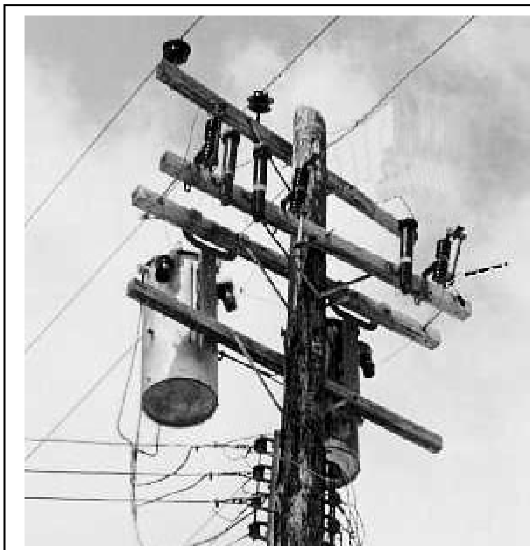
6. (20 Pts) ____________
7. (10 Pts) ____________
8. (20 Pts) ____________

Total

____

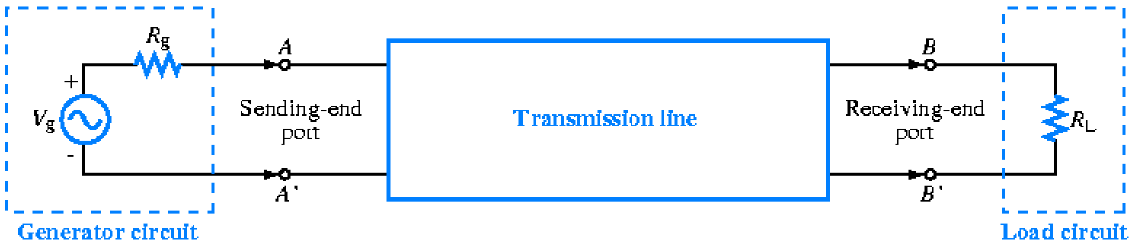
Notes:
1. **Please read over all questions before you begin your work. There may be some information in a later question that helps you with an earlier question.**
2. For short answer questions, you may add some comments to justify your answer.
3. Make sure your calculator is set to perform trigonometric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





MULTIPLE CHOICE AND SHORT ANSWER QUESTIONS

1. Input Impedance of Lossless Transmission Lines (18 points)



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

a. (8 pts) The transmission line load is a short circuit.

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

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

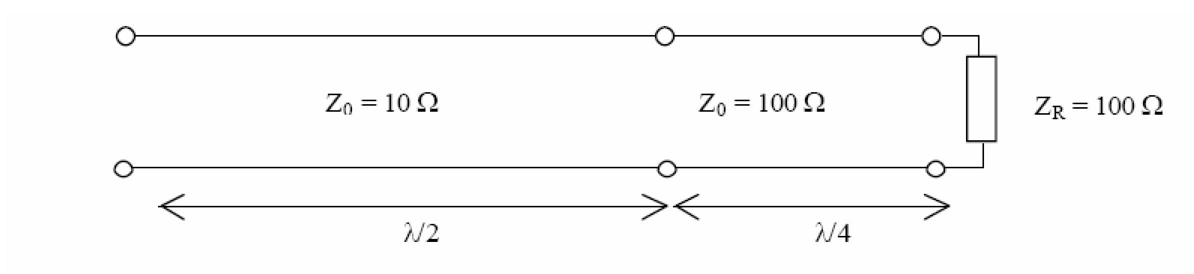
ii. For what line lengths will the input impedance observed at the sending point end be an open circuit? Circle all correct answers.

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

b. (5 pts) A transmission line has length $\lambda/2$, characteristic impedance $Z_o = 75\Omega$ and load $Z_L = 50\Omega + j75\Omega$. What is the input impedance?

$Z_{IN} = Z_L$

c. (5 pts) What is the input impedance of the network below? Z_{IN} = *100 Ohms since one first looks at the input impedance of the second line and then uses that for the load on the first line.*



2. Identifying Cable Properties (12 pts) *In 1949, entrepreneurs using simple antennas and Army-surplus coaxial cable created the country's first cable television system and revolutionized the way Americans watched TV. More than fifty years later, Time Warner Cable is the 2nd largest multiple service provider. (From the time Warner website.)* Assume that, like T-W, you find yourself in possession of several very large reels of coaxial cable, but you need to know something about them before you invest any time or effort into installing them in some kind of a system. You have been told that the cable is at least 1km long, has a characteristic impedance of $Z_o = 50\Omega$ and a propagation speed $u = 2.5x10^8\ {}^{m}\!/_{s}$. Which of the following experiments will tell you useful information? That is, which of these experiments shows the correct understanding of how the cable works? Remember that the cable will have finite loss. Assume also that you have access to only one end of the cable and that you have been told that the other end of the cable is open (not connected to anything). It will probably be helpful to draw some diagrams to go with these questions.

a. Using a multimeter, you measure the DC resistance across the input of the cable. If you measure $R_{DC} = 50\Omega$, then the characteristic impedance of the cable is indeed $Z_o = 50\Omega$. *Not true since the measured resistance reflects only the resistance of the wire.*
b. Using a multimeter, you measure the DC resistance across the input of the cable. If you measure $R_{DC} = 50\Omega$, the other end of the cable is not open or the cable is shorted between its two conductors at some point in the reel of wire. *This is possible since the short can be near the far end of the wire and the resistance can be the order of .05 Ohms per meter.*
c. Using a pulsed voltage source with an internal impedance of $R_g = 50\Omega$, a *10V* pulse is launched on the cable. That is, the voltage source produces a *10V* pulse, as measured by an oscilloscope connected directly to the source. When the cable is connected, a *6V* pulse is observed at the input end of the cable (the only end we have access to). This tells us that the characteristic impedance of the cable is $Z_o = 75\Omega$ not $Z_o = 50\Omega$. *75/(75+50)=.6 so this is possible*
d. Using the same pulsed source, when the cable is connected, a *5V* pulse is observed at the input end of the cable (the only end we have access to). This tells us that the characteristic impedance of the cable is indeed $Z_o = 50\Omega$, as expected. *50/(50+50)=.5 so this is possible.*

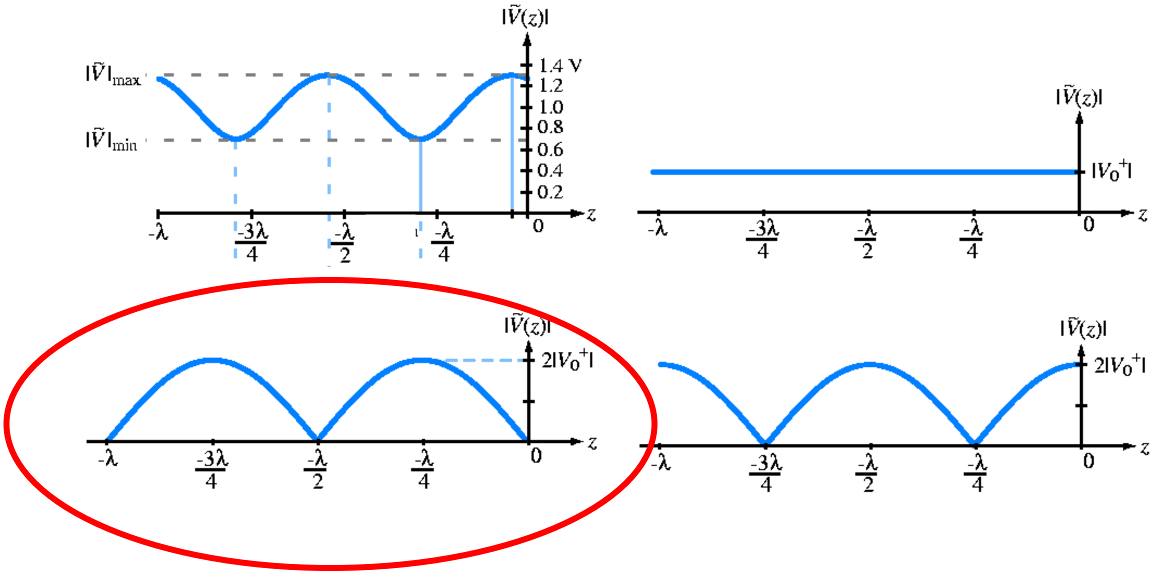
The only outcome that makes no sense is the first one.

3. Waves on Transmission Lines (10 points)

For all of the following questions, assume that a lossless transmission line has a characteristic impedance of $Z_o = 75\Omega$.

a. (3 pts) The load reflection coefficient for a given transmission line is $\Gamma_L = -0.5$. What is the load impedance? $Z_L =$ *25 Ohms*

b. (3 pts) A transmission line has a short circuit load ($Z_L = 0$). What does the Standing Wave Pattern look like? Circle the correct diagram below.

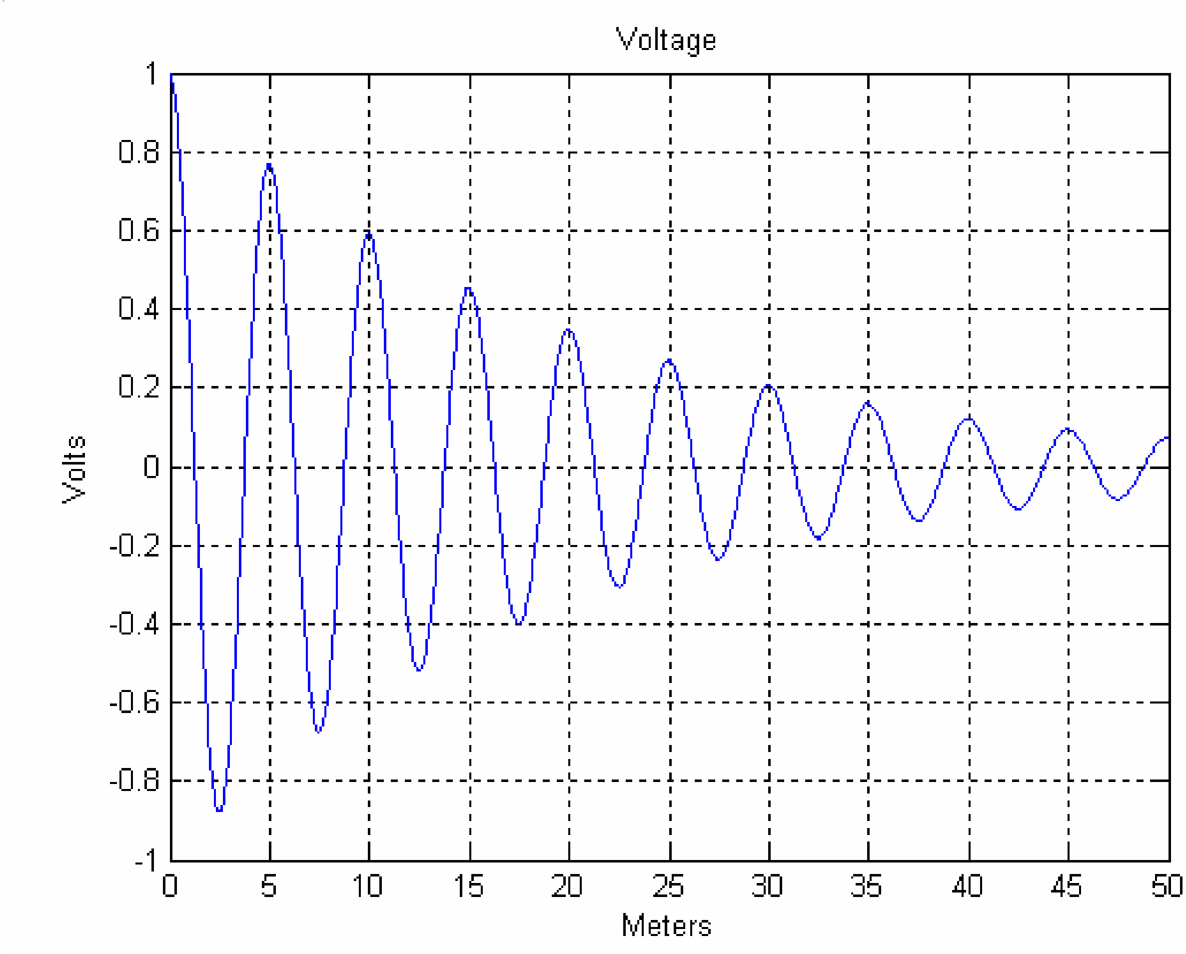


c. (4 pts) The voltage wave propagating on a transmission line is given in real space-time form as $v(z,t) = 10\cos(4\pi 10^8 t - 1.6\pi z) + 6\cos(4\pi 10^8 t + 1.6\pi z)$. Write this voltage expression in phasor form.

$$V = 10e^{-j1.6\pi z} + 6e^{+j1.6\pi z}$$

4. Lossy Transmission Line (5 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. $\alpha =$

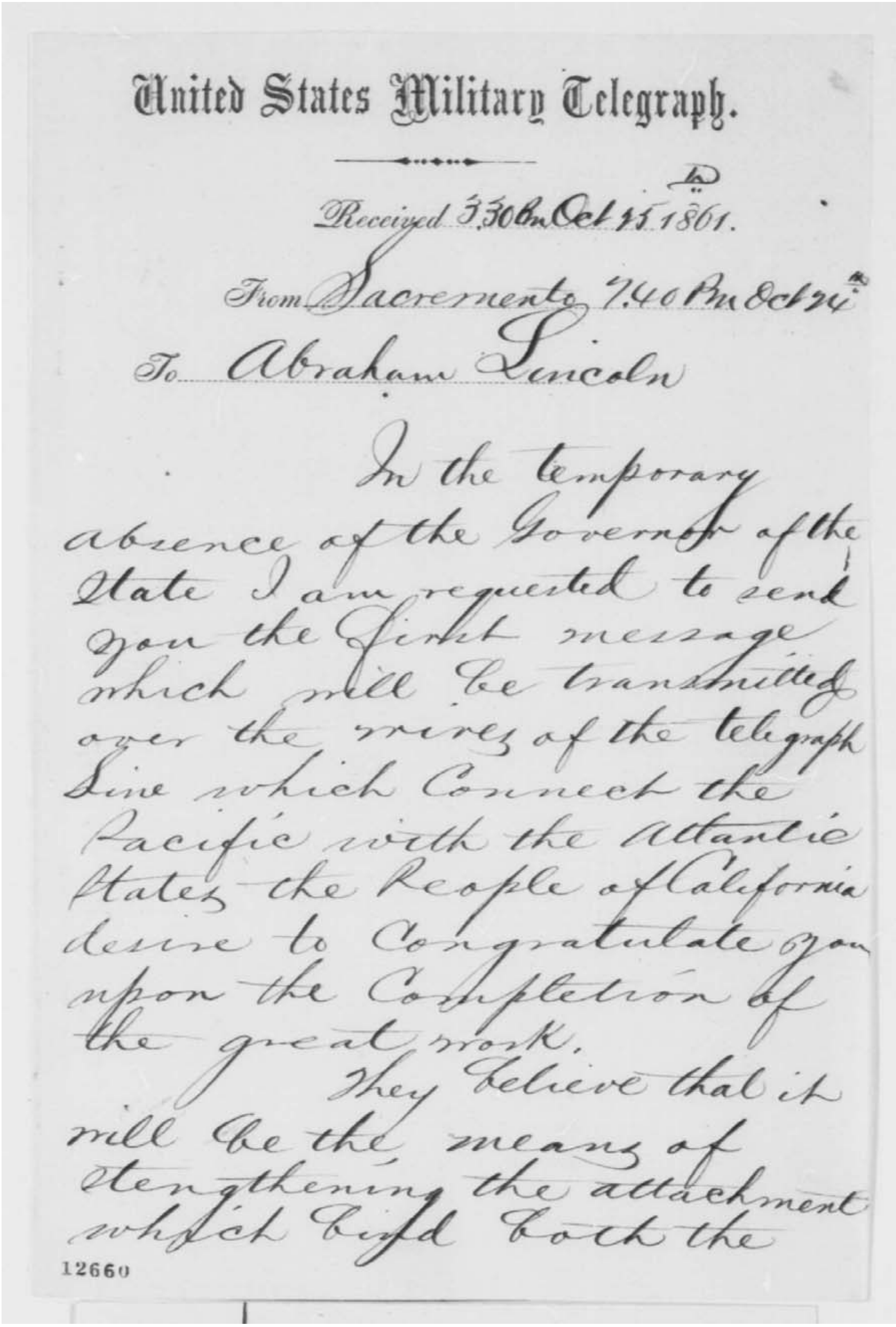


$\exp(-\alpha 30) = 0.2$ *and* $(-\alpha 30) = \ln(0.2) = -1.6094$ *and* $\alpha = 0.0536$

Answers around 0.05 are fine.

5. Cultural Question (5 points)

Who was president of the US when the first transcontinental telegraph line was completed? *I hope everyone knows it was Lincoln.*



United States Military Telegraph.

Received 3:30 Am Oct 25 1861.

From Sacramento 7.40 Pm Oct 24th

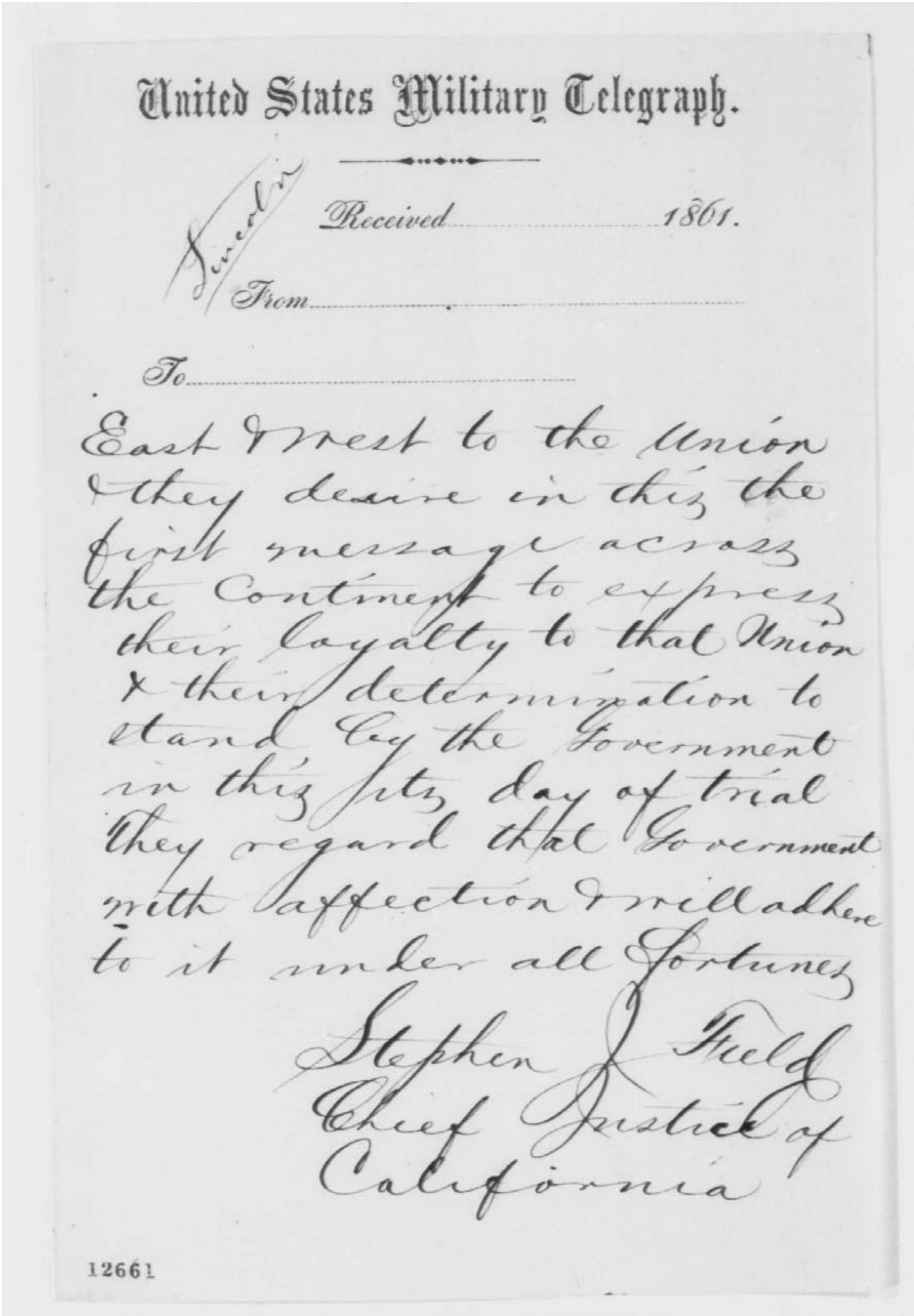
To Abraham Lincoln

In the temporary absence of the Governor of the State I am requested to send you the first message which will be transmitted over the wires of the telegraph Line which connect the Pacific with the Atlantic States the People of California desire to congratulate you upon the Completion of the great work.

They believe that it will be the means of stengthening the attachment which bind both the

12660

Quiz 1


United States Military Telegraph.

Lincoln

Received .... 1861.

From ....

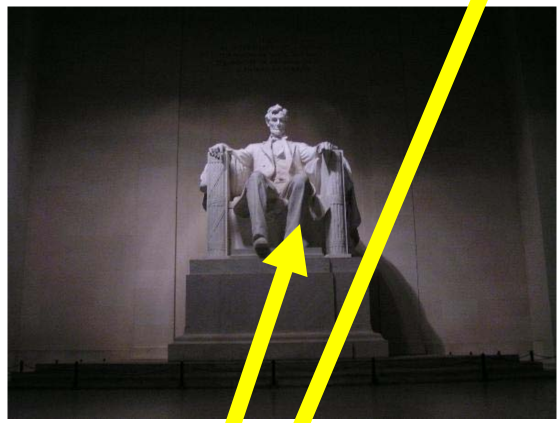
To ....

East & West to the Union & they desire in this the first message across the Continent to express their loyalty to that Union & their determination to stand by the Government in this its day of trial They regard that Government with affection & will adhere to it under all fortunes

Stephen J Field
Chief Justice of California

12661

Can you identify the locations of the following statues?



Label Each Figure with the Correct Location Selected from the Following:

Lincoln Park, Chicago

The University of Wisconsin – Madison

Portland, Oregon

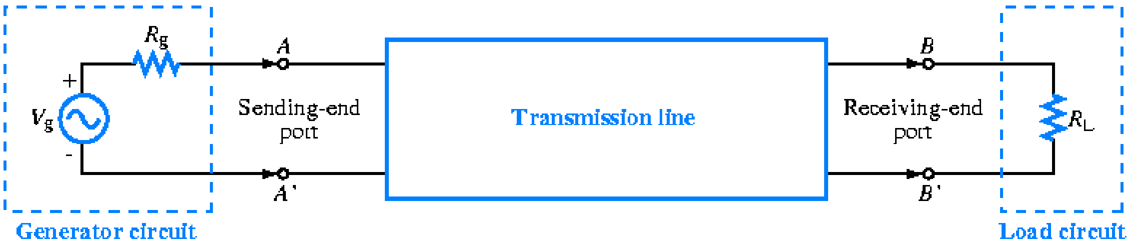
The Lincoln Memorial, Washington, DC

Oklahoma City, Oklahoma

REGULAR QUESTIONS

6. Sinusoidal Voltages on a Lossless Transmission Line (20 points)

A lossless transmission line has a characteristic impedance of Z_o = 50 Ohms. The propagation velocity on the line is $u = 1.5x10^8 \, {}^{m}\!/_{s}$. The load impedance Z_L is purely resistive.

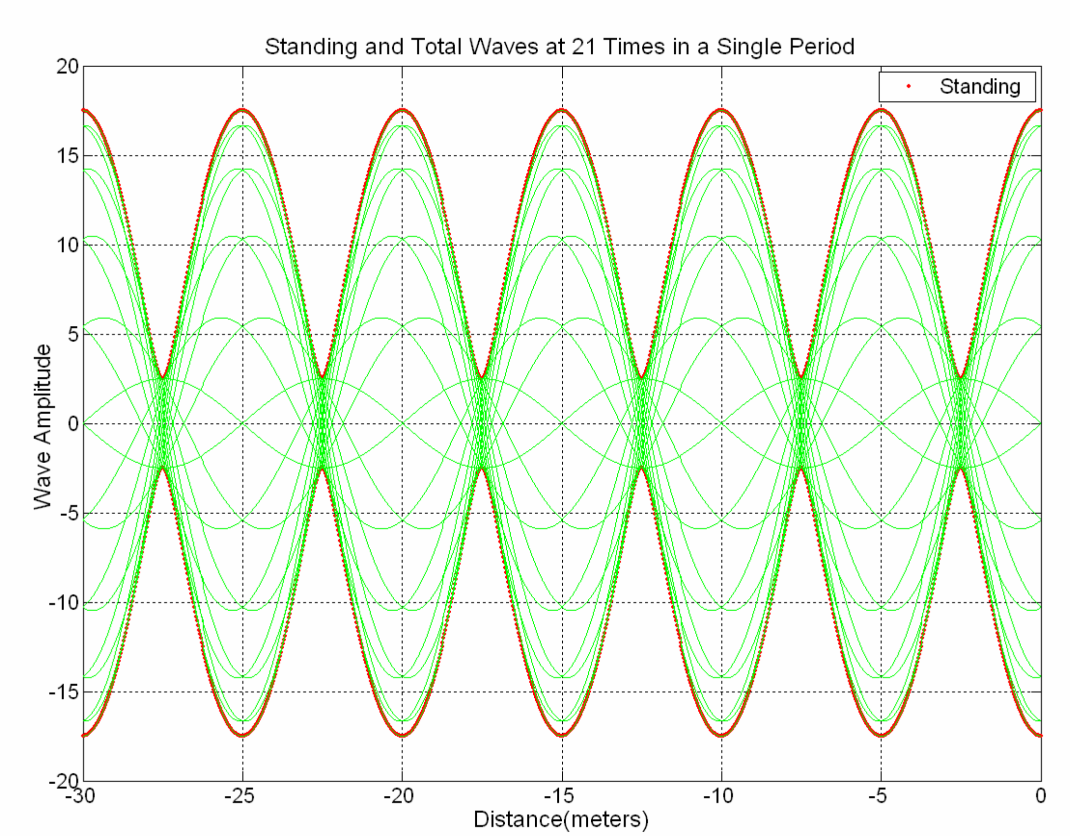


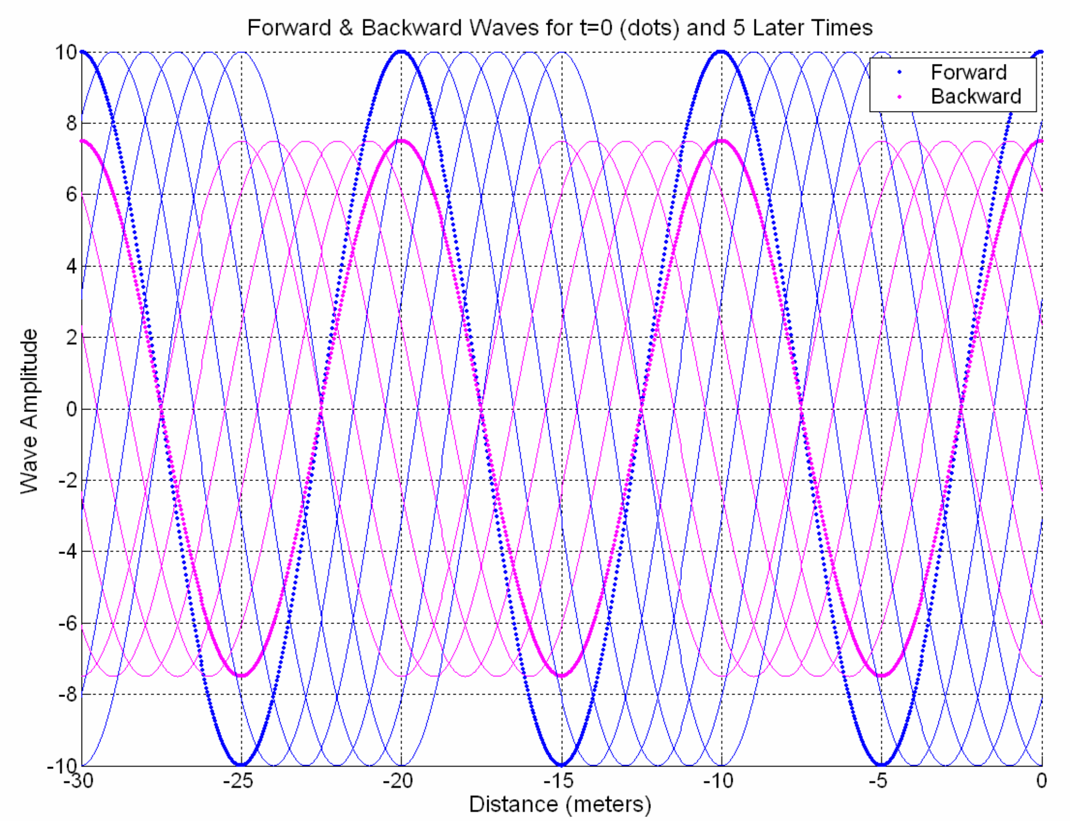
a. (3 pts) Consider the voltage Standing Wave Pattern shown on the following page. What is the Voltage Standing Wave Ratio? *VSWR =17.5/2.5=7*

b. (2 pts) Is the load impedance larger or smaller than the characteristic impedance Z_o? *Larger because the standing wave pattern is a max at the load*

c. (3 pts) What is the load reflection coefficient? Γ_L *=7.5/10=.75 Note that this can be determined from the lower plot which shows both the forward and backward waves.*

d. (3 pts) What is the value of the load impedance? Z_L *=350 Ohms. Can check the reflection coefficient to see this.*


Standing and Total Waves at 21 Times in a Single Period
Standing
Wave Amplitude
Distance(meters)
20
15
10
5
0
-5
-10
-15
-20
-30
-25
-20
-15
-10
-5
0


Forward & Backward Waves for t=0 (dots) and 5 Later Times
Forward
Backward
Wave Amplitude
Distance (meters)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-30
-25
-20
-15
-10
-5
0

e. (3 pts) What is the amplitude of the injected voltage wave? $V^+ = 10V$ *from the lower plot.*

f. (2 pts) What percentage of power is reflected by the load? *The reflection coefficient is 0.75. The reflected power goes with the square of the reflection coefficient so that the percentage of the power is (.75)(.75)=56.25% Answers around 56% are acceptable.*

g. (2 pts) What is the wavelength? $\lambda = 10m$ *The features of the standing wave pattern are separated by 5m and this must be a half wavelength. The waves in the lower figure clearly show a wavelength of 10m.*

h. (2 pts) What is the frequency of the source? $f =$

The frequency is given by the ratio of the velocity to the wavelength. In this case this is 1.5e8 over 10 or 1.5 e 7 or 15MHz

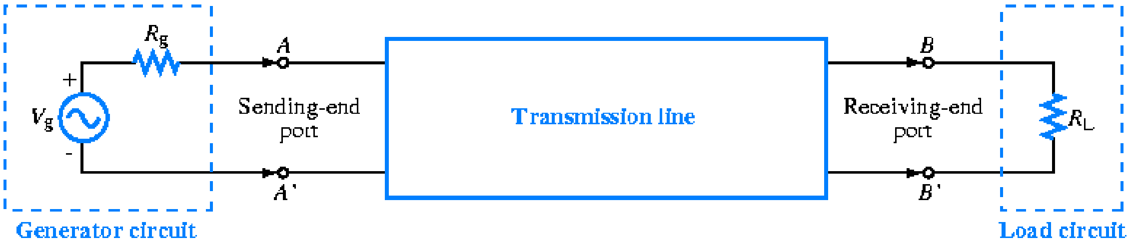
From Dave Barry

"Electricity originates inside clouds. There, it forms into lightning, which is attracted to the Earth by golfers. After entering the ground, the electricity hardens into coal, which, when dug up by power companies and burned in big ovens called 'generators,' turns back into electricity, where it is transformed by TV sets into commercials for beer, which passes through the consumers and back into the ground, thus completing what is known as a 'circuit.'"

The m-file used to generate the plots

```
% Standing and Traveling Waves
% K. A. Connor 11 February 2007

% Wave Parameters
lam=10;beta=2*pi/lam;u=1.5e8;w=beta*u;
V1=10;V2=7.5;f=w/(2*pi);TT=1/f;

% Setting up the Range of z for the plots
z=[-1:.001:0].*3*lam;

% The Phasor Form of the total Waves
v=V1.*exp(-i.*beta.*z)+V2.*exp(i.*beta.*z);
vf=V1.*exp(-i.*beta.*z);
vb=V2.*exp(i.*beta.*z);

% Plotting Standing and Total Waves at Different Times
plot(z,abs(v),'r.',z,-abs(v),'r.');legend('Standing');
hold on;
for n=0:20;
   plot(z,real(v.*exp(i.*w.*n.*TT/20)),'g');
end;
grid;
title('Standing and Total Waves at 21 Times in a Single Period');
xlabel('Distance(meters)');
ylabel('Wave Amplitude');


% Plotting Forward and Backward Waves at the Same Times
figure;hold on;
plot(z,real(vf),'b.',z,real(vb),'m.');
for n=1:5;
   plot(z,real(vf.*exp(i.*w.*n.*TT/10)),'b',z,real(vb.*exp(i.*w.*n.*TT/10)),'m');
end;
grid;
title('Forward & Backward Waves for t=0 (dots) and 5 Later Times');
xlabel('Distance (meters)');
ylabel('Wave Amplitude');
legend('Forward','Backward');
```

7. Sinusoidal Voltages on a Lossless Transmission Line (10 points)



A lossless transmission line has a characteristic impedance of Z_o = 100 Ohms. The propagation velocity on the line is $u = 2x10^8\ m/s$ and the length of the line is *125 m*. The load impedance Z_L is 50 Ohms. The generator voltage is v_g = *10V* at a frequency of *2MHz* and the generator internal impedance R_g = *50 Ohms.*

a. Determine the input impedance of the line

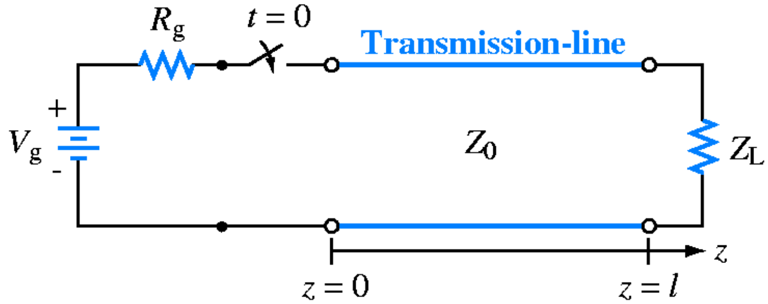
$\beta = (2\pi f)/u = (2\pi 2e6)/(2e8) = 0.02\pi$ *so that*
$\tan(\beta d) = \tan(0.02\pi 125) = \tan(2.5\pi) \to \infty$ *since the line is a multiple of half wavelengths. Thus,* $Z_{IN} = \frac{Z_o^{\ 2}}{Z_L} = \frac{100^2}{50} = 200$

b. Determine the average power delivered to the load

This will be the same as the power to the input impedance. Thus, $V_{IN} = \frac{200}{200+50}10 = 8$

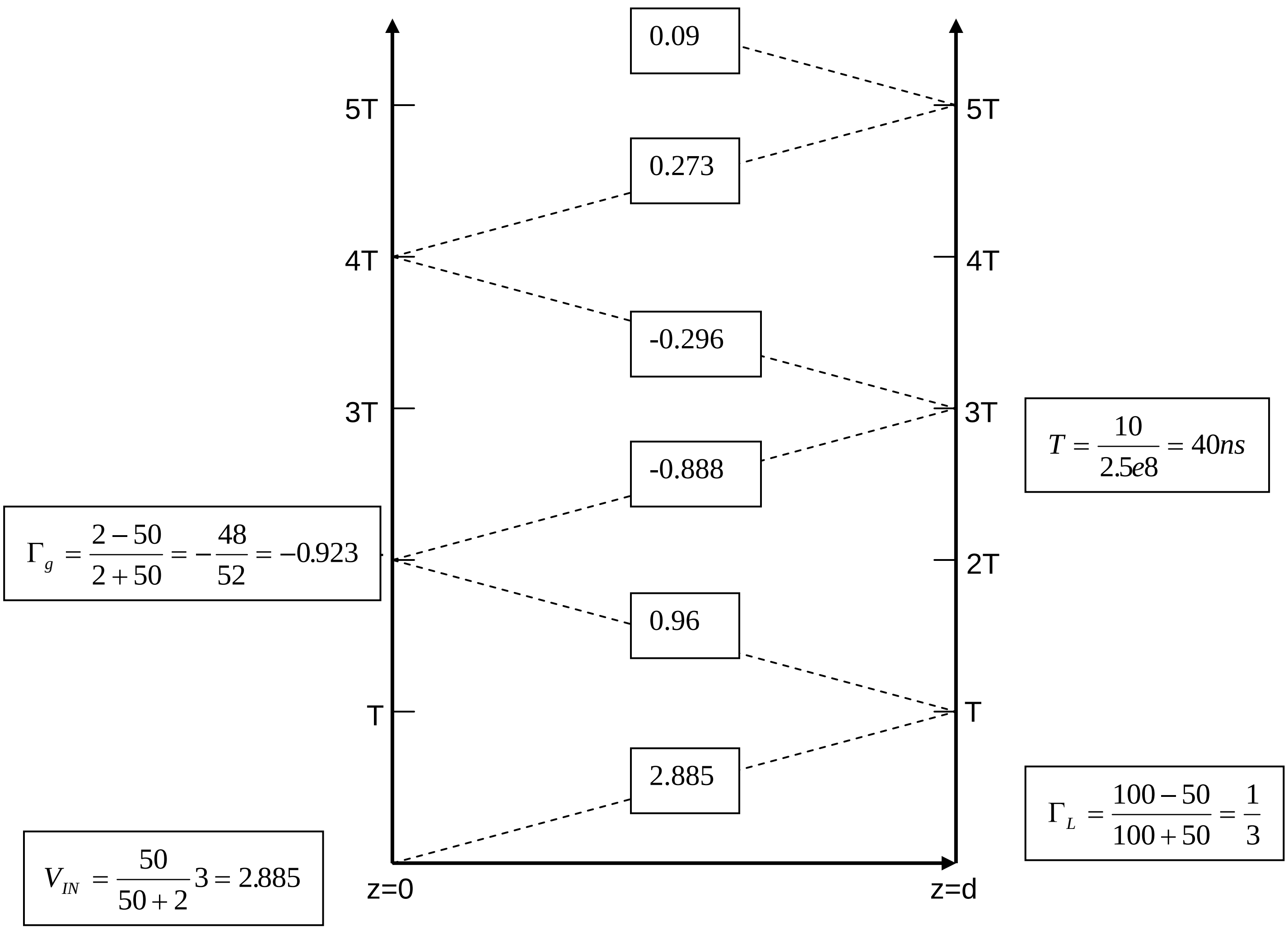
and the power in will be $P_{IN} = \frac{1}{2}\frac{64}{200} = 160mW$

Transient Voltages on a Lossless Transmission Line (20 points)
Version 1 – using 2 Ohms for the internal impedance of the source.



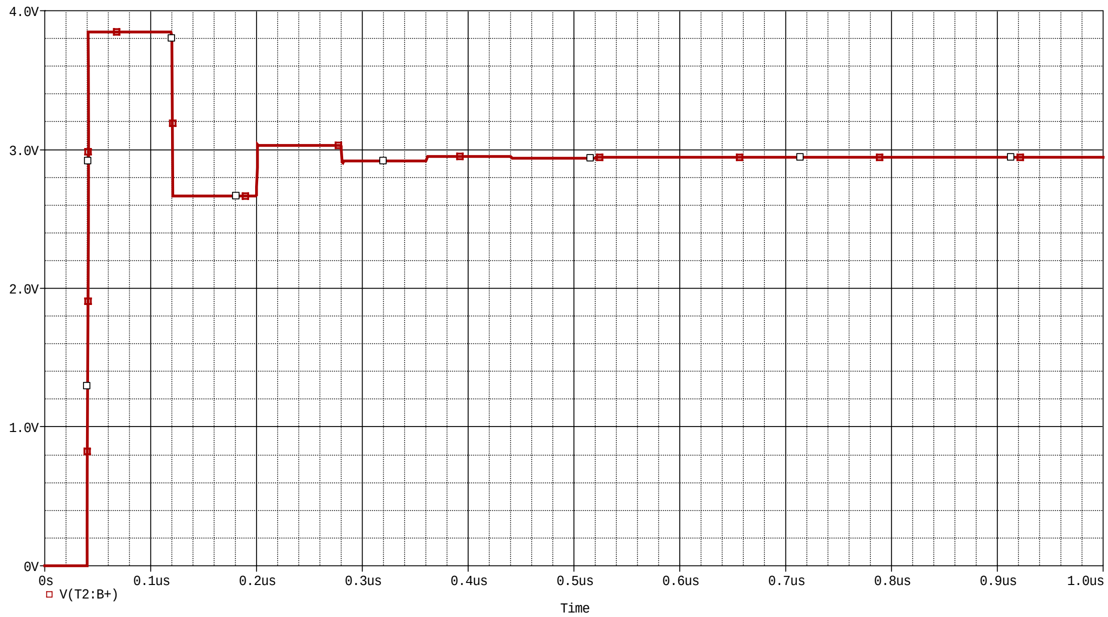
A 3V battery with a 2 Ohm internal impedance is connected to a 50 Ohm transmission line with a 100 Ohm load. The length of the line is 10 meters and the propagation speed is $2.5x10^8$ m/s.

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

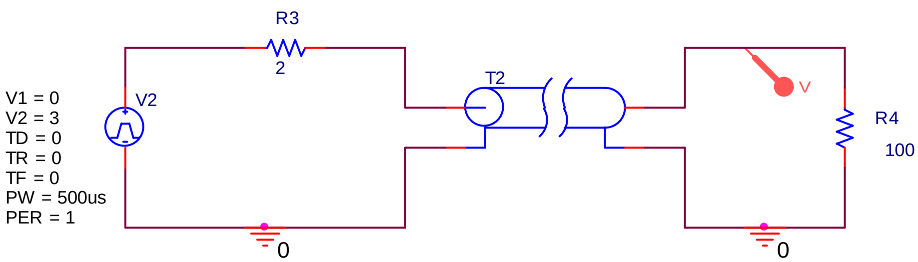


b. Determine and plot the voltage observed at the load as a function of time. Indicate the value the voltage will eventually reach if we wait long enough (time goes to infinity). (10 pts)

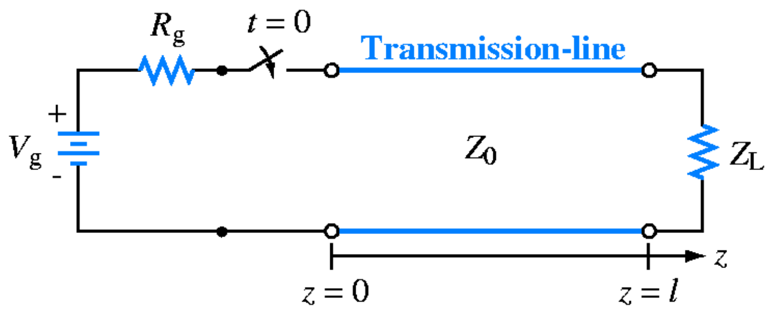
Done with PSpice to be sure the plot is clear.



3.85 2.66 3.02 2.94

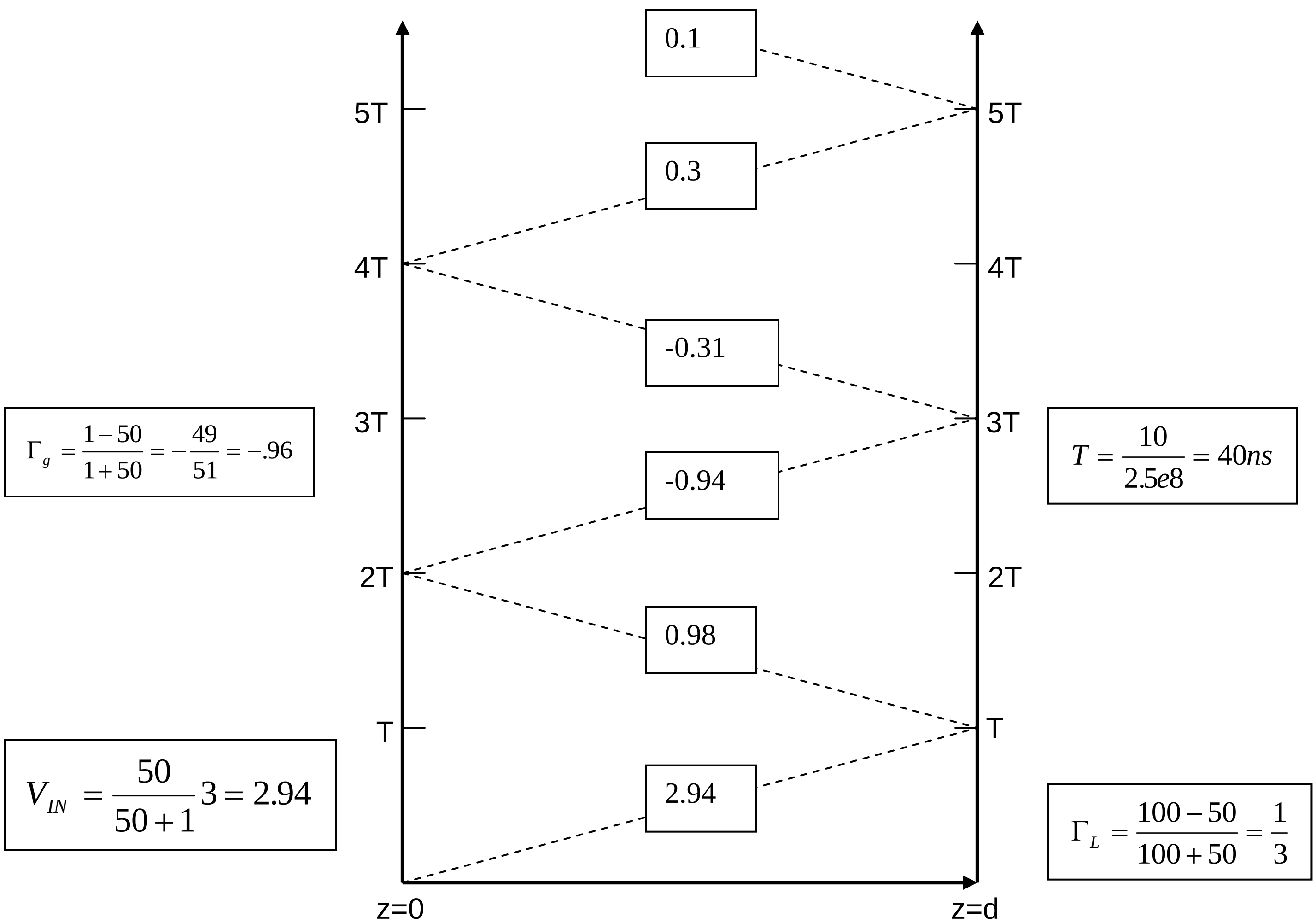


Version 2 – using 1 Ohm for the internal impedance of the source.



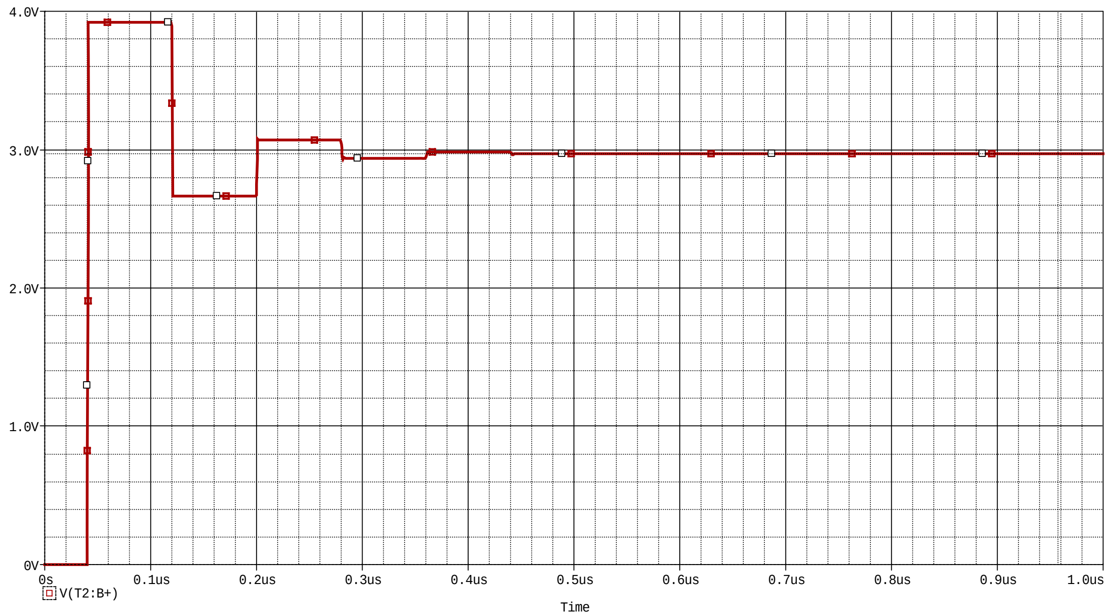
A 3V battery with a 1 Ohm internal impedance is connected to a 50 Ohm transmission line with a 100 Ohm load. The length of the line is 10 meters and the propagation speed is 2.5x10^8 m/s.

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



d. 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)

Done with PSpice to be sure the plot is clear.



3.92 2.67 3.07 2.97