	Number	Section
ic Electromagnetics Transmission Line Theory	ELEC 353	U
nation	Date	Time	# of pages
al	December 1997	3 Hours	3

ctor(s)

C.W. Trueman

erials allowed: [ ] No [X] Yes (Please specify)

ulators allowed: [ ] No [X] Yes

e student is permitted to have one 22 by 28 cm page of notes, written in ink on both sides. The notes mu an original copy in ink. Photocopies or notes in pencil are not permitted.

e page of notes must be handed in with the examination.

LY non-programmable calculators WITHOUT text display will be allowed.

al Instructions:

empt all questions. Show all steps clearly. Please begin each question on a new page.
dents are required to return question paper with exam booklet(s).

tal: 100 marks

1. (15 marks) A square plate is located in the xy plane with corners at (x=0,y=0), (a,0), (a,a), and (0,a). The plate carries charge density

$$\rho_s(x,y) = Axy \quad \text{Coul/meter}^2$$

Find the scalar potential at (x=0,y=0,z=h).

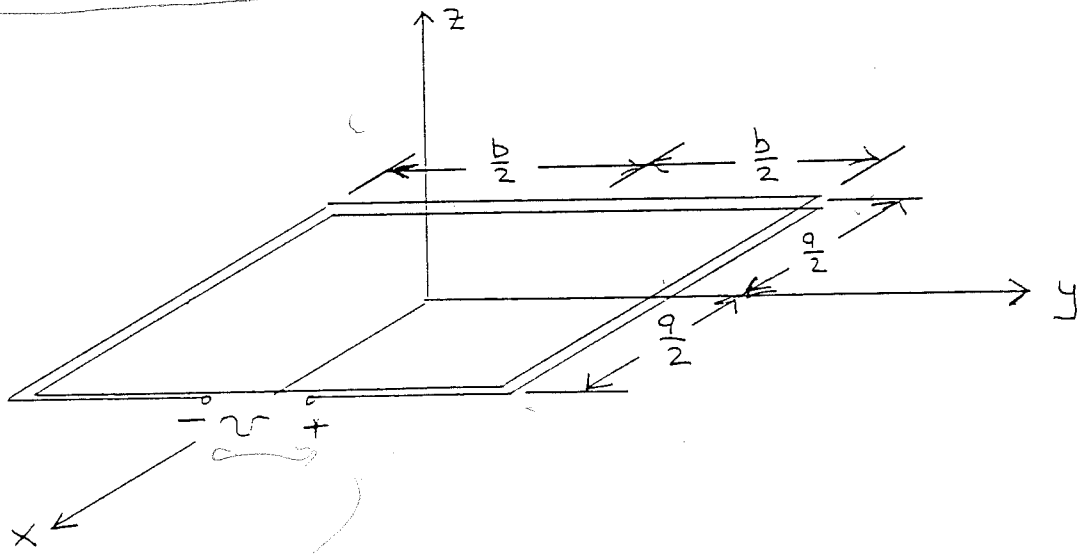
2. (20 marks) A coaxial cable has an inner conductor of radius $r=a$, and an outer conductor of radius $r=c$. The dielectric material between the conductors has two layers. From $r=a$ to $r=b$, the relative permittivity is ε_{r1}, and from $r=b$ to $r=c$ the relative permittivity is ε_{r2}. Both dielectrics are non-magnetic, with permeability μ_0.

(i) Find the capacitance per unit length.

(ii) Find the inductance per unit length.

(iii) Find the numerical value of the characteristic impedance if a=1 cm, b=1.1 cm, c=2 cm, and the dielectrics have $\varepsilon_{r1} = 2.25$ and $\varepsilon_{r2} = 1$.

(iv) Find the numerical value of the velocity of propagation of a wave on the cable.

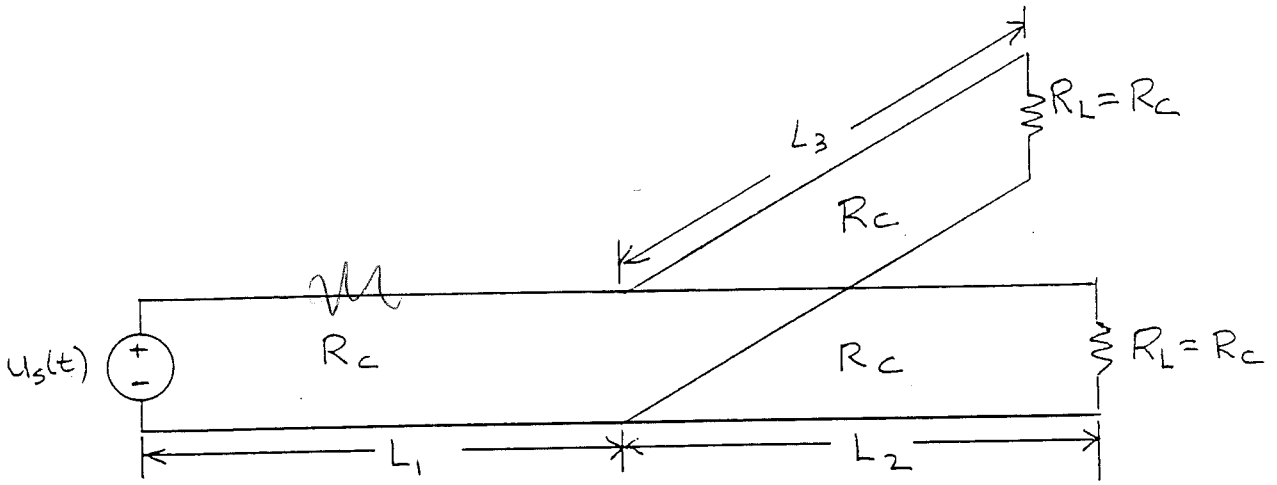


3. (15 marks) A rectangular loop of wire has two turns, as shown in the figure. The flux density in the loop is given by

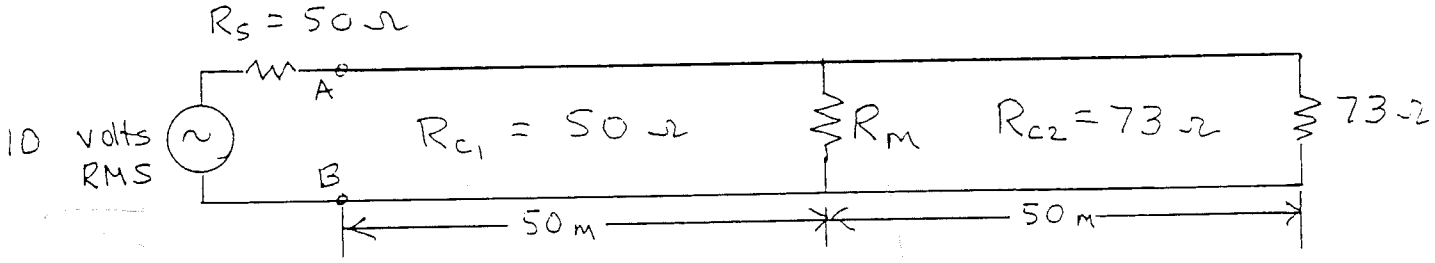
$$\overline{B} = \hat{a}_x B_0 \cos(\omega t) + \hat{a}_z B_0 \sin(\omega t) \quad \text{Tesla}$$

Find the flux through the loop. Find the voltage induced at the terminals of the loop.

4. (20 marks) A plane wave in air at 850 MHz is normally incident on the surface of a lossy dielectric with relative permittivity $\varepsilon_r = 41.2$, conductivity σ =1.2 S/m, and $\mu = \mu_0$. If the power density in the incident wave is 1 Watt/metre^2, then find the electric field strength at a depth of 2 cm in the dielectric.



5. (15 marks) A unit-step function generator drives a load with the circuit shown above, with $L_1 = L_2 = 10$ m, and $L_3 = 1$ m. The cables have characteristic impedance $R_c = 50\Omega$ and speed-of-propagation 200 meters per microsecond. Find the voltage across the load, $v(t)$, for $0 \le t \le 0.35$ microseconds.



6. (15 marks) A sinusoidal generator of RMS value 10 volts at 50 MHz drives a 73 ohm load with the transmission line circuit shown above. The speed of propagation on the transmission lines is 300 meters per microsecond.

   (i) Find the power delivered to the 73 ohm load if the resistor R_m is removed from the circuit.

   (ii) What value of R_m is needed to make the input impedance at terminals AB equal to 50 ohms? With this value of R_m, how much power is delivered to the 73 ohm load?

Concordia UNIVERSITY

COURSE	NUMBER	SECTION
Basic Electromagnetics and Transmission Line Theory	ELEC353	U
EXAMINATION Final Examination	**DATE** Dec. 22, 1999	**TIME** afternoon
INSTRUCTOR Dr. Christopher W. Trueman		

MATERIALS ALLOWED: ☐ No ☒ Yes (specify)

The student is permitted to have one page of notes of size 22 by 28 cm, written in ink on both sides. The notes must be an original copy in ink. Photocopies or notes in pencil are not permitted.

The page of notes must be handed in with the examination.

CALCULATORS ALLOWED: : ☐ No ☒ Yes

ONLY non-programmable calculators WITHOUT text display will be allowed.

SPECIAL INSTRUCTIONS:

Answer All Questions. Total 100 marks

1. (15 marks) A circular ring of radius a lies in the xy plane, centered at the origin. The ring carries charge density

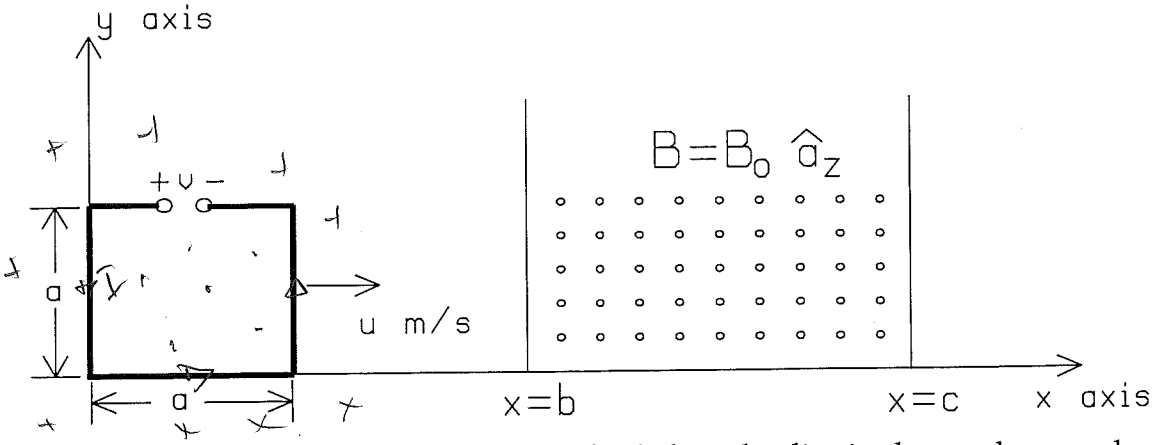
$$\rho_l = P\cos(\phi) \quad \text{Coul/meter}$$

Find the electric field at an observer on the z axis at height h above the center of the ring.

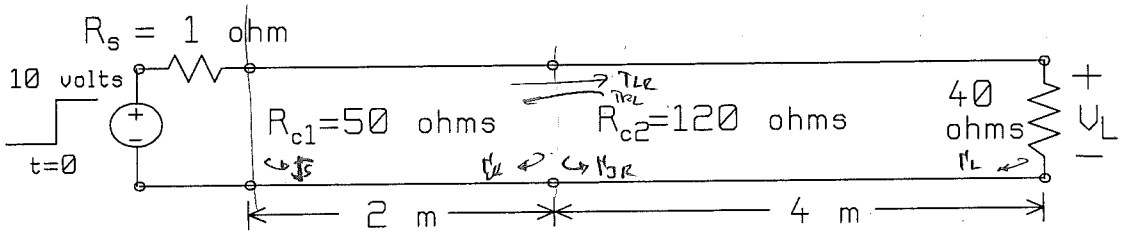
2. (10 marks) A parallel-plate capacitor has plates of area A m^2 and separated by distance $3d$. There are three layers of dielectric. Adjacent to each plate there is a dielectric layer of relative permittivity ε_r and thickness d. The center of the capacitor is an air layer of thickness d.

(i) Find the capacitance.

(ii) If the voltage between the plates is V_o volts, then find the electric field in each layer.



3. (15 marks) A small square loop of wire of side length a lies in the xy plane as shown in the figure. At t=0, the left-hand side of the loop coincides with the y axis. The loop moves at constant velocity u m/s, in the $+\hat{a}_x$ direction, into a region of magnetic flux density $\overline{B} = B_0 \hat{a}_z$ starting at $x = b$ m and ending at $x = c$ m. Find the voltage $v(t)$ induced at the terminals of the loop. Draw a large, clear, well-labelled graph of the voltage $v(t)$ as a function of time.



4. (20 marks) A step function generator drives two transmission lines in series, as shown in the figure. The first line has characteristic resistance 50 ohms and the second has characteristic resistance 120 ohms. Both lines have speed of propagation u=200 meters per microsecond. Find the voltage across the load $v_L(t)$ for $0 < t < 80$ microseconds.

5. (20 marks) A transmission line circuit operates at 1900 MHz. The source generates an open-circuit voltage of 10 volts amplitude and has internal resistance 50 ohms. It drives a transmission line of length 2.7 cm, characteristic resistance 50 ohms and speed of propagation 300 meters per microsecond. The line is terminated by a load resistor of value 73 ohms. Find the power delivered to the load resistor.

6. (20 marks) A plane wave in air at 850 MHz is normally incident on the surface of a dielectric half space with relative permittivity 4.1 and conductivity 10 mS/m. If the amplitude of the incident plane wave is 5 volts/meter, then find the amplitude of the field in the air at a distance of 10 cm from the surface of the dielectric.

Course	Number	Section
Basic Electromagnetics and Transmission Line Theory	ELEC 353	U

Examination	Date	Time	# of pages
Final	December 1998	3 Hours	3

Instructor(s)

Dr. C.W. Trueman

Materials allowed: [ ] No [X] Yes (Please specify)

Calculators allowed: [ ] No [X] Yes

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The page of notes must be handed in with the examination.

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Special Instructions:

Attempt all questions. Show all steps clearly. Please begin each question on a new page.
Students are required to return question paper with exam booklet(s).

Total: 100 marks

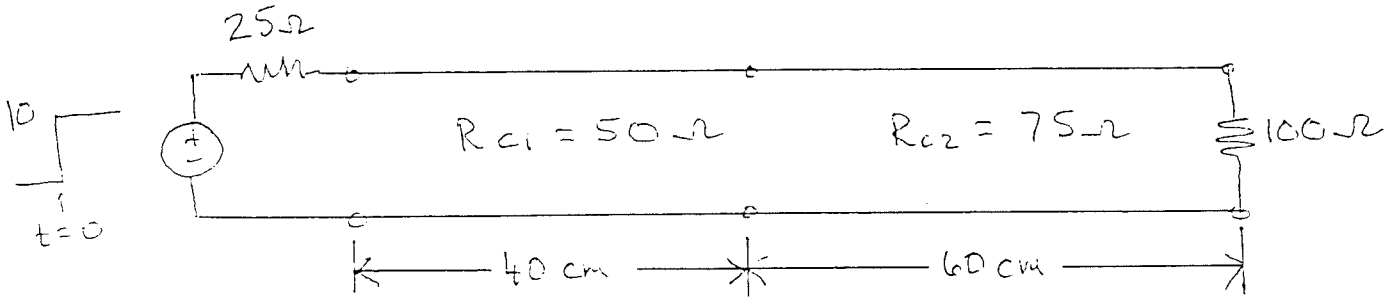
1. (15 marks) An infinitely-long cylinder of radius a is centered on the z axis and contains volume charge density ρ_1 C/m^3. It is surrounded by an infinitely-long cylindrical shell, also centered on the z axis. The shell has inner radius b and outer radius c, and contains charge density $\rho_2(r) = -Kr$ C/m^3.

   (i) Find the electric flux density for $0 < r < \infty$.

   (ii) If ρ_1=10 C/m^3, then find the value of K needed to make the flux density equal to zero for $r>c$.

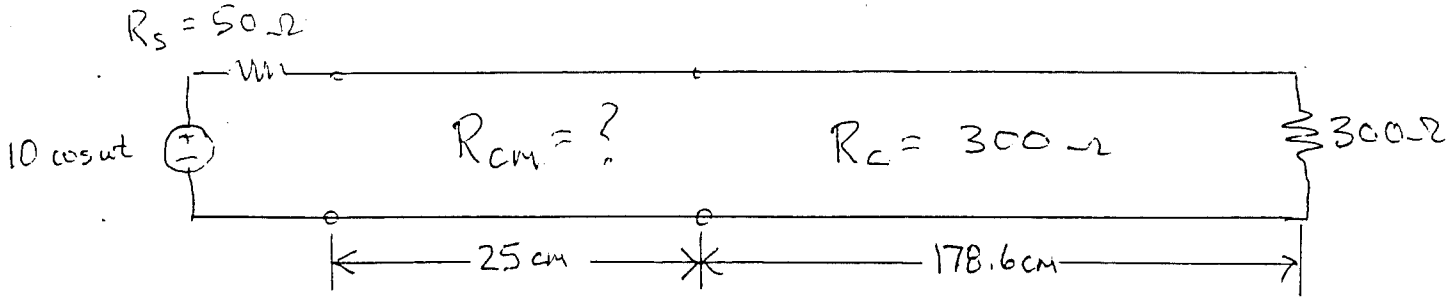
2. (10 marks) A circular wire of radius a lies in the xy plane centered at the origin. The wire carries current I Amps in the $+\hat{a}_\phi$ direction. Find the magnetic field at a point $z=h$ on the z axis above the center of the ring. Show all steps in the derivation clearly.

3. (15 marks) A parallel-plate capacitor has a bottom plate of area A located at $z=0$ and a top plate of the same area located at z=d. The space between the plates is filled with a dielectric material which has relative permittivity $\varepsilon_r = (1 + z/d)$. The voltage at the top plate is V_0 volts relative to the bottom plate.
   (i) Find the electric field in the dielectric in terms of voltage V_0.
   (ii) Find the capacitance.
   (iii) Find the stored energy in the capacitor.



4. (15 marks) A step function generator of internal resistance 25 ohms produces a step voltage of amplitude 10 volts at t=0 sec. The generator drives the circuit shown above. The velocity of propagation on both transmission lines is 200 meters per microsecond.
   (i) Draw a bounce diagram for $0<t<9$ ns.
   (ii) Draw a neat, well-labeled graph of $v_m(t)$ for $0<t<9$ ns.

5. (15 marks) A plane wave in air at 850 MHz is normally incident upon the surface of a lossy dielectric having relative permittivity ε_r=28 and conductivity σ=10 milliSiemens/meter. If the amplitude of the incident wave is 10 volts/meter, then find the amplitude of the field in the dielectric at a depth of 1 cm below the surface.



6. (15 marks) A sinusoidal generator at 300 MHz drives a 300 ohm load with the transmission line circuit shown above. The speed of propagation on the transmission lines is 300 meters per microsecond.
   (i) Find the input impedance Z_{in} of the transmission line circuit at the generator terminals in terms of the characteristic resistance R_{cm} of the first transmission line.
   (ii) What value of R_{cm} is needed to make the input impedance match the generator impedance of 50 ohms?

7. (15 marks) A current element antenna of length 10 cm lies along the z axis centered at the origin. It carries a current of 10 mA. A second current element antenna also has length 10 cm and is parallel to the z axis. It centered on the x axis at the point $x=h$, and carries current I_2. The frequency is 50 MHz.
   (i) Find the far field at a distant point $x=r$ on the positive x axis, with $r>>h$.
   (ii) Find the far field at a distant point $x=-r$ on the negative x axis.
   (iii) Find the magnitude and phase of the current I_2 required to make the far field at $x=-r$ equal to zero. What is the numerical value of the far field at $x=10$ kilometers? Use $h = \lambda/4$.

ELEC 353 – Basic Electromagnetics and Transmission Line Theory

Class Test

October 20, 1998.

Closed book- no books or notes allowed!

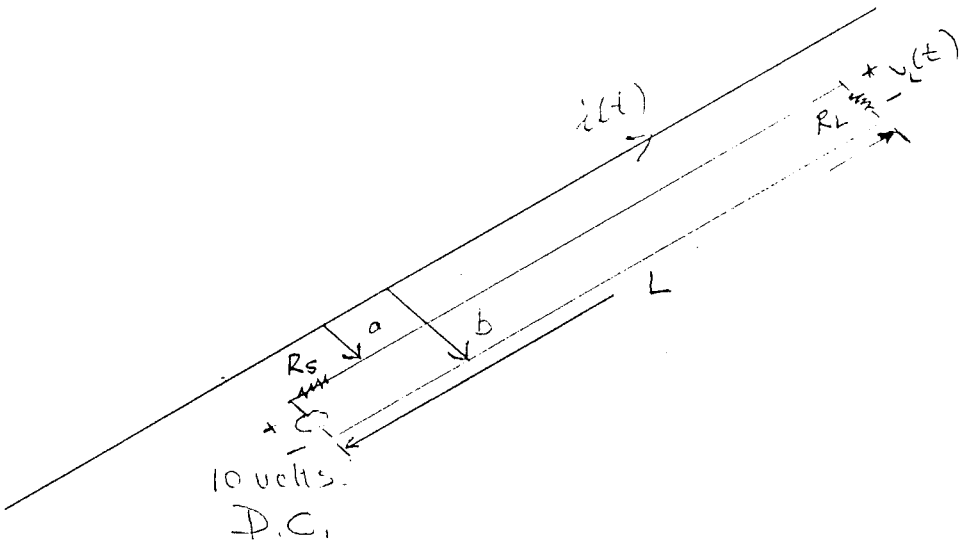
Each question is worth 10 marks.

1. A circular ring of radius a lies in the xy plane, centered at the origin. The ring carries charge density

   $\rho_l = P\cos(\phi)$ Coul/meter

   Find the electric field at an observer on the z axis at height h above the center of the ring.

2. A coaxial cable has an inner conductor of radius a and an outer conductor of radius b. The dielectric is air.
   (i) If the voltage at the inner conductor relative to the outer conductor is V volts, then find the maximum value of the electric field in the cable, expressed in terms of voltage V.
   (ii) If the dielectric strength of air is E_{max} =3 megavolts/meter, and if the diameter of the inner conductor is 1 mm, then design the cable so that it can sustain a maximum voltage of 5000 volts. (Answer: a numerical value for radius b.)



3. An infinitely-long straight wire carries current $i(t) = I_0\cos(\omega t)$ Amps. A circuit of length L is parallel to the wire, as shown in the figure. Find the voltage $v_L(t)$ across the resistor. This is an example of "crosstalk" between adjacent circuits.