ECET 3410 – Comprehensive Theory Questions

High *f* Systems **Print Name (Last Name First):_ Samples w/ Answers__ ___**

Multiple Choice – Choose the best response to complete each statement

______ With respect to waveguides, the **Cutoff Frequency** for a given mode of operation:

A) is the minimum frequency for which that mode is able to setup
B) will change depending on whether the waveguide is mounted vertically or horizontally
C) will decrease with decreasing size of the waveguide
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ Given the **traveling wave equation** $E(x) = E_0^+ \cdot e^{-\gamma \cdot x} + \Gamma_R \cdot E_0^+ \cdot e^{-2 \cdot \gamma \cdot L} \cdot e^{+\gamma \cdot x}$ for an AC transmission-line, the term "$\Gamma_R \cdot E_0^+ \cdot e^{-2 \cdot \gamma \cdot L} \cdot e^{+\gamma \cdot x}$" is best described as:

A) the attenuation coefficient relating to the traveling waveform
B) the reflected wave in the system
C) the wave traveling from the sending to the receiving end
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ **Time Domain Reflectometry**:

A) can be used to determine the position of a fault on a cable provided the cable type is known
B) can be used to determine a cable's length even if the cable type is unknown
C) utilizes steady-state AC waveforms to determine the characteristic impedance of a cable
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ An **incident waveform** is:

A) any waveform that hits a boundary in a transmission-line system
B) a waveform traveling from the receiving end to the sending end of a transmission-line
C) a waveform that increases in magnitude as it travels in a transmission-line
D) all of the above (a-c) are correct
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A) the portion of the voltage that results from a reflection off the source connected to the sending end
B) the portion of the voltage that results from a reflection off the load connected to the receiving end
C) the value of the incident wave applied to the sending end of the line
D) all of the above (a-c) are correct
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______ Given the **traveling wave equation** $E(x) = E_0^+ \cdot e^{-\gamma \cdot x} + \Gamma_R \cdot E_0^+ \cdot e^{-2 \cdot \gamma \cdot L} \cdot e^{+\gamma \cdot x}$ for an AC transmission-line, the term "Γ_R" is best described as:

A) the reflection coefficient for a traveling wave that is incident upon the voltage source
B) the reflection coefficient for a traveling wave that is incident upon the load connected to the receiving end
C) the value of the reflected voltage
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______ The **propagation constant** in the traveling wave equation:

A) defines how fast the traveling wave will decay in magnitude
B) will be purely imaginary for a lossless transmission-line
C) defines the length of a wavelength on a transmission-line
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ The **standing wave pattern** on a transmission-line:

A) repeats every two wavelengths of the traveling waveforms
B) will have a minimum at the receiving end of the line for an un-terminated line
C) is a repetitive pattern that always varies from 0 → max → 0 → max → …
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ With respect to transmission-lines, the **characteristic impedance** of a line:

A) provides a ratio of incident voltage to incident current that will travel on the line
B) may be defined as the input impedance of the line if the line is assumed to be of infinite length
C) is not affected by the value of the load impedance terminating the line
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ The **standing wave pattern** on a transmission-line:

A) repeats every ½-wavelength of the traveling waveforms
B) will have a maximum at the receiving end of the line for a short-circuited line
C) is a repetitive pattern that always varies from 0 → max → 0 → max → …
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ A **matched load** on a lossless transmission-line:

A) will result in no reflected waveform
B) will receive 100% of the power sent down the line by a source connected to the sending-end of the line
C) will result in a VSWR on the line of one (1)
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ With respect to waveguides, the **Cutoff Frequency**:

A) will increase with increasing size of the waveguide
B) varies with the frequency of the source
C) is the minimum frequency for which the waveguide may theoretically function (for a given mode)
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ An **incident waveform** is:

A) a waveform traveling from the receiving end to the sending end of a transmission-line
B) a waveform that decreases in magnitude as it travels down a practical transmission-line
C) a waveform that increases in magnitude as it travels down a practical transmission-line
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ The **VSWR** on a lossless transmission-line:

A) will be 0 for a perfectly matched load
B) is defined to be the ratio of the maximum RMS voltage in the standing-wave pattern on the line compared to the minimum RMS voltage in the standing-wave pattern on the line
C) is not affected by the value of the load impedance terminating the line
D) all of the above (a-c) are correct
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______ **Time Domain Reflectometry** may be used to determine the length of a transmission-line provided that:

A) the velocity of propagation on the line is known
B) the characteristic impedance of the line is known
C) the load impedance terminating the line is known
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ The **propagation constant** for a wave traveling on a transmission-line:

A) defines how fast the traveling wave will decay in magnitude
B) will be purely real for a lossless transmission-line
C) will be purely real for a practical (lossy) transmission-line
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ **Skin Depth**:

A) provides a measure of how far an electro-magnetic wave will penetrate into a good conductor
B) decreases with increasing frequency
C) can cause the effective resistance of a conductor to increase in high-frequency systems
D) all of the above (a-c) are correct
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______ A **¼-wavelength tuner**:

A) is a simple device used to cancel the reactive part of a load's impedance value
B) often requires use of a transmission-line with a "non-standard" characteristic impedance
C) can be used to match either purely real or purely imaginary loads to a source
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ Given a wave traveling on a lossless transmission-line terminated with a **short-circuit**:

A) there will be no reflected waveform on the line
B) the standing wave pattern will have a maximum at the location of the short-circuit
C) will resultant VSWR on the line will be zero (0)
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ When using a **Smith Chart** to determine the input impedance of a transmission-line terminated with a known load:

A) the solution will require a rotation around the Smith Chart in the clock-wise direction
B) the input impedance will be closer to the center of the chart than the load impedance if the line is lossy
C) the plotted impedances must be normalized if the impedance of the point in the center of the chart is not equal to the line's characteristic impedance
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ Given the **traveling wave equation** $E(x) = E_0^+ \cdot e^{-\gamma \cdot x} + \Gamma_R \cdot E_0^+ \cdot e^{-2\cdot\gamma\cdot L} \cdot e^{+\gamma\cdot x}$ for an AC transmission-line, the term "E_0^+" is best described as:

A) the actual voltage at the sending end of the line
B) the voltage applied to the sending end at time t=0
C) the value of the incident voltage applied to the sending end of the line
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

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A) the actual voltage on the line as a function of position "x"
B) the actual voltage at the sending end of the line for a transmission line having length "x"
C) the actual voltage at the sending end of the line at time "x"
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ With respect to waveguides, the **Cutoff Frequency** for a given mode of operation:

A) is the minimum frequency for which that mode is able to setup
B) will change depending on the source frequency
C) will decrease with decreasing size of the waveguide
D) all of the above (a-c) are correct
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______ An **incident waveform** is:

A) a waveform traveling from the sending-end to the receiving-end of a transmission-line
B) a waveform traveling from the receiving-end to the sending-end of a transmission-line
C) any waveform that hits a boundary in a transmission-line system
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

______ With respect to a traveling AC electro-magnetic field, **skin depth**:

A) defines how far the wave will penetrate into a good conductor
B) will always increase with increasing frequency
C) allows for the creation of more efficient and less lossy conductors at high frequencies
D) all of the above (a-c) are correct
F) none of the above (a-d) are correct

______ The **propagation constant** for a wave traveling on a transmission-line:

A) defines how fast the traveling wave will decay in magnitude
B) will be purely real for a lossless transmission-line
C) will be purely imaginary for a practical (lossy) transmission-line
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______ On a **Smith Chart**:

A) the magnitude of the reflection coefficient resulting from a load impedance may be determined by the distance of the normalized load impedance from the origin on the chart
B) one complete rotation around the chart relates to a distance of 2 wavelengths on a transmission-line
C) purely reactive (non-resistive) impedances occur only on the horizontal axis
D) all of the above (a-c) are correct
E) none of the above (a-d) are correct

True / False For each of the following, specify whether or not each of the responses is true or false by **PRINTING** either **TRUE** or **FALSE** in the blank preceding each response.

___________ The magnitude of a ***reflection coefficient*** due to a load can never be greater than one.

___________ The ***characteristic impedance*** of a transmission-line defines the ratio of voltage to current of an incident or a reflected waveform.

___________ For normal transmission-lines, the ***permeability*** of the material surrounding the line is assumed to be one.

___________ Given a source connected to a coaxial line; if the source frequency is increased, the ***wavelength*** on the line will also increase.

___________ The ***nominal velocity*** (as given in table 1-3 of the text) defines the velocity of a wave on a coaxial-cable as a percent (%) if the speed of light in "air" (free-space).

___________ When expressed in decibels, ***attenuation*** on a coaxial-cable is linearly proportional to length.

___________ Both the ***attenuation constant*** (α) and the ***phase delay*** (β) may be assumed to be zero on a lossless transmission-line.

___________ A ***single-stub tuner*** is a matching network that is used to match only purely real load impedances.

___________ Given a source connected to a coaxial line; if the ***source frequency is decreased***, the wavelength on the line will also decrease.

___________ The ***magnitude of a reflected wave*** on a transmission-line cannot be greater than the magnitude of the incident wave from which it came (assuming a passive load impedance).

___________ The ***reflection coefficient magnitude*** for a short-circuit load is equal to that for an open-circuit.

___________ Decreasing the ***permittivity (ε)*** of the insulation filling a coaxial cable will cause the propagation velocity on the line to increase.

___________ If two different loads connected to the receiving-end of a similar transmission-lines result in the same reflection coefficient magnitude then they will also result in the same VSWR on the lines.

___________ ***Waveguides*** are typically used in systems operating at much higher frequencies than that using coaxial lines.

___________ The ***nominal velocity*** (as given in table 1-3 of the text) defines the velocity of a wave on a coaxial-cable as a percent (%) of the speed of light in "air" (free-space).

___________ The ***phase constant*** (β) may be assumed to be zero on a lossless transmission-line.

___________ The ***phase constant*** (β) on a transmission-line will typically increase with increasing source frequency.

____________ The ***attenuation constant*** (α) on a transmission-line will typically increase with increasing source frequency.

____________ The ***sending-end*** of a transmission-line is the side to which the "incident wave" is applied.

____________ A ***single-stub tuner*** is a matching network that is used to match any real or complex load impedances.

____________ Given a source connected to a coaxial line; if the ***source frequency is increased***, the wavelength on the line will also increase.

____________ The ***magnitude of the reflection coefficient*** on a transmission-line cannot be greater than one (assuming a passive load impedance).

____________ The ***reflection coefficient*** for a short-circuit load is equal to that for an open-circuit.

____________ A ***uniform plane wave*** is a wave for which the instantaneous electric and magnetic fields are constant in a plane that is orthogonal to the direction of propagation.

____________ A ***matched transmission line*** will have neither a voltage nor a power reflection due to the load.

____________ ***Waveguides*** cannot operate properly at frequencies below their cutoff frequency.

____________ The ***nominal velocity*** (as given in table 1-3 of the text) defines the velocity of a wave on a coaxial-cable as a percent (%) of the speed of light in "air" (free-space).

____________ The ***attenuation constant*** (α) may be assumed to be zero on a lossless transmission-line.

____________ The ***phase constant*** (β) may never be zero on a practical (lossy) transmission-line.

____________ Given two different characteristic impedance coaxial cables having the same applied incident voltage, the cable with the ***larger characteristic impedance*** will have the ***incident current with a larger magnitude***.

____________ The ***receiving-end*** of a transmission-line is typically terminated by a load impedance.

____________ The time difference between the application of an incident wave and the arrival of a reflected wave measured by a ***TDR*** is equal to the time it takes a traveling wave to travel twice the length of the transmission-line.

Question #A) If a waveguide system is designed to operate in the TE_{10} mode, why is it **undesirable** for higher order modes to develop within the guide?

Question #B) Briefly describe the relevance of **skin depth** or **depth of penetration** for high frequency waves.

Question #C) Explain the meaning and/or importance of **cutoff frequencies** with respect to waveguides.

ECET 3410 – Comprehensive Theory Questions
High *f* Systems **Print Name (Last Name First):_** **Samples w/ Answers__ ___**

Multiple Choice – Choose the best response to complete each statement

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F) is the minimum frequency for which that mode is able to setup
G) will change depending on whether the waveguide is mounted vertically or horizontally
H) will decrease with decreasing size of the waveguide
I) all of the above (a-c) are correct
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__B___ Given the **traveling wave equation** $E(x) = E_0^+ \cdot e^{-\gamma \cdot x} + \Gamma_R \cdot E_0^+ \cdot e^{-2\cdot\gamma\cdot L} \cdot e^{+\gamma \cdot x}$ for an AC transmission-line, the term "$\Gamma_R \cdot E_0^+ \cdot e^{-2\cdot\gamma\cdot L} \cdot e^{+\gamma \cdot x}$" is best described as:

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__A___ **Time Domain Reflectometry**:

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F) the portion of the voltage that results from a reflection off the source connected to the sending end
G) the portion of the voltage that results from a reflection off the load connected to the receiving end
H) the value of the incident wave applied to the sending end of the line
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__D___ The **propagation constant** in the traveling wave equation:

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__E___ The **standing wave pattern** on a transmission-line:

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__C___ With respect to waveguides, the **Cutoff Frequency**:

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__B___ The **VSWR** on a lossless transmission-line:

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__E___ Given a wave traveling on a lossless transmission-line terminated with a **short-circuit**:

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__D___ When using a **Smith Chart** to determine the input impedance of a transmission-line terminated with a known load:

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G) the input impedance will be closer to the center of the chart than the load impedance if the line is lossy
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__C__ Given the **traveling wave equation** $E(x) = E_0^+ \cdot e^{-\gamma \cdot x} + \Gamma_R \cdot E_0^+ \cdot e^{-2\cdot\gamma\cdot L} \cdot e^{+\gamma \cdot x}$ for an AC transmission-line, the term "E_0^+" is best described as:

F) the actual voltage at the sending end of the line
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__A___ Given the **traveling wave equation** $E(x) = E_0^+ \cdot e^{-\gamma \cdot x} + \Gamma_R \cdot E_0^+ \cdot e^{-2\cdot\gamma\cdot L} \cdot e^{+\gamma \cdot x}$ for an AC transmission-line, the term "$E(x)$" is best described as:

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__**A**___ With respect to a traveling AC electro-magnetic field, **skin depth**:

E) defines how far the wave will penetrate into a good conductor
F) will always increase with increasing frequency
G) allows for the creation of more efficient and less lossy conductors at high frequencies
H) all of the above (a-c) are correct
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__**A**___ The **propagation constant** for a wave traveling on a transmission-line:

F) defines how fast the traveling wave will decay in magnitude
G) will be purely real for a lossless transmission-line
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I) all of the above (a-c) are correct
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__**A**___ On a **Smith Chart**:

F) the magnitude of the reflection coefficient resulting from a load impedance may be determined by the distance of the normalized load impedance from the origin on the chart
G) one complete rotation around the chart relates to a distance of 2 wavelengths on a transmission-line
H) purely reactive (non-resistive) impedances occur only on the horizontal axis
I) all of the above (a-c) are correct
J) none of the above (a-d) are correct

True / False For each of the following, specify whether or not each of the responses is true or false by **PRINTING** either **TRUE** or **FALSE** in the blank preceding each response.

___**_True_**__ The magnitude of a ***reflection coefficient*** due to a load can never be greater than one.

___**_True_**__ The ***characteristic impedance*** of a transmission-line defines the ratio of voltage to current of an incident or a reflected waveform.

___**_True_**__ For normal transmission-lines, the ***permeability*** of the material surrounding the line is assumed to be one.

___**_False**___ Given a source connected to a coaxial line; if the source frequency is increased, the ***wavelength*** on the line will also increase.

___**_True_**__ The ***nominal velocity*** (as given in table 1-3 of the text) defines the velocity of a wave on a coaxial-cable as a percent (%) if the speed of light in "air" (free-space).

___**_True_**__ When expressed in decibels, ***attenuation*** on a coaxial-cable is linearly proportional to length.

___**_False**___ Both the ***attenuation constant*** (α) and the ***phase delay*** (β) may be assumed to be zero on a lossless transmission-line.

___**_False**___ A ***single-stub tuner*** is a matching network that is used to match only purely real load impedances.

___**_False**___ Given a source connected to a coaxial line; if the ***source frequency is decreased***, the wavelength on the line will also decrease.

___**_True_**__ The ***magnitude of a reflected wave*** on a transmission-line cannot be greater than the magnitude of the incident wave from which it came (assuming a passive load impedance).

___**_True_**__ The ***reflection coefficient magnitude*** for a short-circuit load is equal to that for an open-circuit.

___**_True_**__ Decreasing the ***permittivity (ε)*** of the insulation filling a coaxial cable will cause the propagation velocity on the line to increase.

___**_True_**__ If two different loads connected to the receiving-end of a similar transmission-lines result in the same reflection coefficient magnitude then they will also result in the same VSWR on the lines.

___**_True_**__ ***Waveguides*** are typically used in systems operating at much higher frequencies than that using coaxial lines.

___**_True_**__ The ***nominal velocity*** (as given in table 1-3 of the text) defines the velocity of a wave on a coaxial-cable as a percent (%) of the speed of light in "air" (free-space).

___**_False**___ The ***phase constant*** (β) may be assumed to be zero on a lossless transmission-line.

___**_False**___ The ***phase constant*** (β) on a transmission-line will typically increase with increasing source frequency.

___**_True_**__ The ***attenuation constant*** (α) on a transmission-line will typically increase with increasing source frequency.

___**_True_**__ The ***sending-end*** of a transmission-line is the side to which the "incident wave" is applied.

___**_True_**__ A ***single-stub tuner*** is a matching network that is used to match any real or complex load impedances.

___**_False**___ Given a source connected to a coaxial line; if the ***source frequency is increased***, the wavelength on the line will also increase.

___**_True_**__ The ***magnitude of the reflection coefficient*** on a transmission-line cannot be greater than one (assuming a passive load impedance).

___**_False**___ The ***reflection coefficient*** for a short-circuit load is equal to that for an open-circuit.

___**_True_**__ A ***uniform plane wave*** is a wave for which the instantaneous electric and magnetic fields are constant in a plane that is orthogonal to the direction of propagation.

___**_True_**__ A ***matched transmission line*** will have neither a voltage nor a power reflection due to the load.

___**_True_**__ ***Waveguides*** cannot operate properly at frequencies below their cutoff frequency.

___**_True_**__ The ***nominal velocity*** (as given in table 1-3 of the text) defines the velocity of a wave on a coaxial-cable as a percent (%) of the speed of light in "air" (free-space).

___**_True_**__ The ***attenuation constant*** (α) may be assumed to be zero on a lossless transmission-line.

___**_True_**__ The ***phase constant*** (β) may never be zero on a practical (lossy) transmission-line.

___**_False**___ Given two different characteristic impedance coaxial cables having the same applied incident voltage, the cable with the ***larger characteristic impedance*** will have the ***incident current with a larger magnitude***.

___**_True_**__ The ***receiving-end*** of a transmission-line is typically terminated by a load impedance.

___**_True_**__ The time difference between the application of an incident wave and the arrival of a reflected wave measured by a ***TDR*** is equal to the time it takes a traveling wave to travel twice the length of the transmission-line.

Question #A) If a waveguide system is designed to operate in the TE_{10} mode, why is it **undesirable** for higher order modes to develop within the guide?

Higher order modes will couple inefficiently to the load

Question #B) Briefly describe the relevance of **skin depth** or **depth of penetration** for high frequency waves.

As a wave penetrates a good conductor, it is attenuated quickly, such that after $3\delta_s$ (three skin-depths) of penetration it is almost fully absorbed.

Question #C) Explain the meaning and/or importance of **cutoff frequencies** with respect to waveguides.

A cutoff frequency is the lowest frequency that a specific mode can operate in a waveguide – thus a specific mode cannot exist below its cutoff freq.