Chapter 15: Radio-Wave Propagation

MULTIPLE CHOICE

1. Radio waves were first predicted mathematically by:
   a. Armstrong
   b. Hertz
   c. Maxwell
   d. Marconi
   ANS: C

2. Radio waves were first demonstrated experimentally by:
   a. Armstrong
   b. Hertz
   c. Maxwell
   d. Marconi
   ANS: B

3. The technology that made cell phones practical was:
   a. the microprocessor chip
   b. the miniature cell-site
   c. high-power microwave transmitters
   d. all of the above
   ANS: A

4. Cell phones reduce much of the problems of mobile communications with:
   a. high power levels
   b. high antennas
   c. reuse of frequencies
   d. all of the above
   ANS: C

5. Which of the following are electromagnetic:
   a. radio waves
   b. light
   c. gamma waves
   d. all of the above
   ANS: D

6. The electric and magnetic fields of a radio wave are:
   a. perpendicular to each other
   b. perpendicular to the direction of travel
   c. both a and b
   d. none of the above
   ANS: C

7. TEM stands for:
   a. Transverse Electromagnetic
   b. Transmitted Electromagnetic
   c. True Electromagnetic
   d. none of the above
   ANS: A

8. In free space, radio waves travel at a speed of:
   a. $3 \times 10^6$ meters per second
   b. $300 \times 10^6$ meters per second
   c. $3 \times 10^6$ miles per second
   d. $300 \times 10^6$ miles per second
   ANS: B
9. Which is a possible polarization for an electromagnetic wave:
   a. vertical  c. circular
   b. horizontal d. all of the above

   ANS: D

10. Which polarization can be reasonably well received by a circularly polarized antenna:
    a. vertical  c. circular
    b. horizontal d. all of the above

    ANS: D

11. The number of circular polarization modes (directions) is:
    a. 1  c. 3
    b. 2  d. many

    ANS: B

12. An antenna has "gain" as compared to:
    a. an isotropic radiator  c. a ground-wave antenna
    b. a vertically polarized radiator  d. none of the above

    ANS: A

13. EIRP stands for:
    a. the E and I fields of the Radiated Power
    b. the Effective Isotropic Radiated Power
    c. the Effective Internal Reflected Power
    d. the Electric-field Intensity of the Radiated Power

    ANS: B

14. The "attenuation of free space" is due to:
    a. losses in the characteristic impedance of free space
    b. losses due to absorption in the upper atmosphere
    c. the decrease in energy per square meter due to expansion of the wavefront
    d. the decrease in energy per square meter due to absorption of the wavefront

    ANS: C

15. Ground waves are most effective:
    a. below about 2 MHz  c. at microwave frequencies
    b. above about 20 MHz  d. when using horizontally polarized waves

    ANS: A

16. Radio waves would most strongly reflect off:
    a. a flat insulating surface of the right size  c. a flat metallic surface of the right size
    b. a flat dielectric surface of the right size  d. a flat body of water

    ANS: C

17. Radio waves sometimes "bend" around a corner because of:
    a. reflection  c. refraction
b. diffusion
d. diffraction
ANS: D

18. Space waves are:
   a. line-of-sight
   b. reflected off the ionosphere
   c. same as sky waves
   d. radio waves used for satellite communications
ANS: A

19. Sky waves:
   a. are line-of-sight
   b. "bounce" off the ionosphere
   c. are same as space waves
   d. are radio waves used for satellite communications
ANS: B

20. Sky waves cannot be "heard":
   a. close to the transmitter
   b. far from the transmitter
   c. in the "silent" zone
   d. in the "skip" zone
ANS: D

21. A 20-dB reduction in the strength of a radio wave due to reflection is called:
   a. fading
   b. diffraction
   c. frequency diversity
   d. spatial diversity
ANS: A

22. "Ghosts" on a TV screen are an example of:
   a. fading
   b. diffraction
   c. multipath distortion
   d. cancellation due to reflection
ANS: C

23. A "repeater" is used to:
   a. send a message multiple times over a channel
   b. send a message over multiple channels at the same time
   c. extend the range of a radio communications system
   d. cancel the effects of fading
ANS: C

24. Cellular phone systems rely on:
   a. high power
   b. repeaters
   c. the radio horizon
   d. the reuse of frequencies
ANS: D

25. If the number of cell-phone users within a cell increases above some limit:
   a. the cell area is increased
   b. the power levels are increased
b. the cell area is split
d. the number of channels is reduced
ANS: B

26. As a cell-phone user passes from one cell to another:
a. a "handoff" process occurs
c. both cells will handle the call
b. a "sectoring" process occurs
d. nothing occurs
ANS: A

27. To receive several data streams at once, a CDMA spread-spectrum system uses:
a. a "funnel" receiver
c. multiple receivers
b. a "rake" receiver
d. none of the above
ANS: B

28. The troposphere is the:
a. highest layer of the atmosphere
c. lowest layer of the atmosphere
b. middle layer of the atmosphere
d. the most ionized layer of the atmosphere
ANS: C

29. Meteor-trail propagation is:
a. used for radio telephony
c. also called "ducting"
b. used to send data by radio
d. not possible
ANS: B

COMPLETION

1. Radio waves were mathematically predicted by ____________________.
ANS: Maxwell

2. Radio waves were first demonstrated by ____________________.
ANS: Hertz

3. Radio waves are ____________________ electromagnetic waves.
ANS: transverse

4. The propagation speed of radio waves in free space is ____________________ m/sec.
ANS: $300 \times 10^6$

5. Electromagnetic radiation can be thought of as a stream of particles called ____________________.
ANS: photons

6. Unlike sound or water waves, radio waves do not need a ____________________ to travel through.
ANS: medium

7. The dielectric strength of clean dry air is about ____________________ volts per meter.
   ANS: $3 \times 10^6$

8. Waves from an ____________________ source radiate equally in all directions.
   ANS: isotropic

9. The wavefront of a point source would have the shape of a _________________.
   ANS: sphere

10. At a far distance from the source, a radio wavefront looks like a flat ________________-wave.
    ANS: plane

11. The polarization of a radio wave is the direction of its ________________ field.
    ANS: electric

12. The electric field of a radio wave is ________________ to its magnetic field.
    ANS: perpendicular

13. Both the electric and magnetic fields of a radio wave are ________________ to its propagation
direction.
    ANS: perpendicular

14. With ________________ polarization, the direction of a radio wave's electric field rotates as it
    travels through space.
    ANS: circular

15. An antenna is said to have ________________ in a certain direction if it radiates more power in that
direction than in other directions.
    ANS: gain

16. The watts per square meter of a radio wave ________________ as the wave-front moves through
    space.
    ANS: decrease

17. Reflection of plane-waves from a smooth surface is called ________________ reflection.
    ANS: specular
18. ____________________ is the "bending" of radio waves as they travel across the boundary between two different dielectrics.

ANS: Refraction

19. The process of ____________________ makes radio waves appear to "bend around a corner".

ANS: diffraction

20. ____________________ waves travel from transmitter to receiver in a "line-of-sight" fashion.

ANS: Space

21. ____________________ waves are vertically polarized radio waves that travel along the earth's surface.

ANS: Ground

22. ____________________ waves are radio waves that "bounce off" the ionosphere due to refraction.

ANS: Sky

23. The ____________________ zone is a region where sky waves cannot be received.

ANS: skip

24. "Ghosts" on a TV screen are an example of ____________________ distortion.

ANS: multipath

25. The "fast fading" seen in mobile communications is caused by ____________________ waves interfering with direct waves.

ANS: reflected

26. Cell phones typically operate at a ____________________ power level.

ANS: low

27. The ____________________ of frequencies allows many cell-phone users to share a geographical area.

ANS: reuse

28. ____________________ is when a cell-site uses three directional antennas, each covering a third of the cell area, to reduce interference.

ANS: Sectoring

29. The use of ____________________ chips makes cell phones a practical technology.

ANS: microprocessor
1. A certain dielectric has permittivity of $6.3 \times 10^{-10}$ F/m and the same permeability as free space. What is the characteristic impedance of that dielectric?

ANS:
45 ohms

2. If a point source of radio waves transmits 1 watt, what is the power density 10,000 meters from the source?

ANS:
796 pW/m²

3. What power must a point-source of radio waves transmit so that the power density at 3000 meters from the source is 1 μW/m²?

ANS:
113 watts

4. If a radio receiver needs 1 nW/m² of power density to function, how far away from a 1-watt point source will it continue to work?

ANS:
8.9 km

5. A line-of-sight radio link over flat terrain needs to use antenna towers 50 km apart. What, approximately, is the minimum height for the towers assuming all the towers are the same?

ANS:
37 meters

6. A mobile radio is being used at 1 GHz in an urban environment with lots of reflecting structures. If the car is traveling 36 km/hour, what is the expected time between fades?

ANS:
15 msec