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Communication Systems

TOPIC 1 Communication Systems

1. An amplitude modulated wave is represented by the expression $v_m = 5(1+0.6\cos 6280t)\ \sin(211\times10^4 t)$ volts The minimum and maximum amplitudes of the amplitude modulated wave are, respectively : **[Sep. 02, 2020 (I)]**

(a) $\frac{3}{2}$ V, 5 V (b) $\frac{5}{2}$ V, 8 V

(c) 5 V, 8 V (d) 3 V, 5 V

2. In an amplitude modulator circuit, the carrier wave is given by, $C(t) = 4\sin(20000\pi t)$ while modulating signal is given by, $m(t) = 2\sin(2000\pi t)$. The values of modulation index and lower side band frequency are : **[12 April 2019 II]**

(a) 0.5 and 10 kHz (b) 0.4 and 10 kHz

(c) 0.3 and 9 kHz (d) 0.5 and 9 kHz

3. A message signal of frequency 100 MHz and peak voltage100 V is used to execute amplitude modulation on a carrier wave of frequency 300 GHz and peak voltage 400 V. The modulation index and difference between the two side band frequencies are : **[10 April 2019 II]**

(a) 4 ; 1×10^8 Hz (b) 4 ; 2×10^8 Hz

(c) 0.25 ; 2×10^8 Hz (d) 0.25 ; 1×10^{-8}T

4. A signal $A\cos\omega t$ is transmitted using $v_0 \sin\omega_0 t$ as carrier wave. The correct amplitude modulated (AM) signal is: **[9 April 2019 I]**

(a) $v_0 \sin\omega_0 t + \frac{A}{2}\sin(\omega_0 - \omega)t + \frac{A}{2}\sin(\omega_0 + \omega)t$

(b) $v_0 \sin[\omega_0(1 + 0.01 A\sin\omega t)t]$

(c) $v_0 \sin\omega_0 t + A\cos\omega t$

(d) $(v_0 + A)\cos\omega t \sin\omega_0 t$

5. The physical sizes of the transmitter and receiver antenna in a communication system are: **[9 April 2019 II]**

(a) independent of both carrier and modulation frequency

(b) inversely proportional to carrier frequency

(c) inversely proportional to modulation frequency

(d) proportional to carrier frequency

6. The wavelength of the carrier waves in a modern optical fiber communication network is close to : **[8 April 2019 I]**

(a) 2400 nm (b) 1500 nm (c) 600 nm (d) 900 nm

7. In a line of sight ratio communication, a distance of about 50 km is kept between the transmitting and receiving antennas. If the height of the receiving antenna is 70m, then the minimum height of the transmitting antenna should be : **[8 April 2019 II]**

(Radius of the Earth = 6.4×10^6 m).

(a) 20 m (b) 51 m

(c) 32 m (d) 40 m

8. A 100 V carrier wave is made to vary between 160 V and 40 V by a modulating signal. What is the modulation index? **[12 Jan. 2019 I]**

(a) 0.3 (b) 0.5 (c) 0.6 (d) 0.4

9. To double the covering range of a TV transmittion tower, its height should be multiplied by: **[12 Jan 2019 II]**

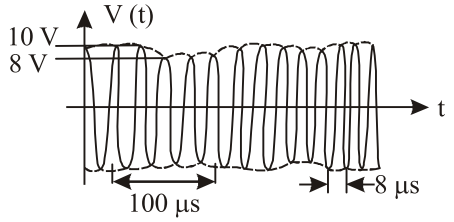
(a) $\frac{1}{\sqrt{2}}$ (b) 2 (c) 4 (d) $\sqrt{2}$

10. An amplitude modulated signal is given by $V(t) = 10[1 + 0.3\cos(2.2\times10^4 t)]\sin(5.5\times10^5 t)$. Here t is in seconds. The sideband frequencies (in kHz) are, [Given $\pi = 22/7$] **[11 Jan 2019 II]**

(a) 1785 and 1715 (b) 178.5 and 171.5

(c) 89.25 and 85.75 (d) 892.5 and 857.5

11. An amplitude modulated signal is plotted below :



Which one of the following best describes the above signal? **[11 Jan. 2019 II]**

(a) $(9 + \sin(2.5\pi\times10^5 t))\sin(2\pi\times10^4 t)$V

(b) $(1 + 9\sin(2\pi\times10^4 t))\sin(2.5\pi\times10^5 t)$ V

(c) $(9 + \sin(2\pi \times 10^4 t))\sin(2.5\pi \times 10^5 t)$V
(d) $(9 + \sin(4\pi \times 10^4 t))\sin(5\pi \times 10^5 t)$ V

12. A TV transmission tower has a height of 140 m and the height of the receiving antenna is 40 m. What is the maximum distance upto which signals can be broadcasted from this tower in LOS (Line of Sight) mode? (Given : radius of earth = 6.4×10^6 m). **[10 Jan. 2019 I]**
(a) 65 km (b) 48 km (c) 80 km (d) 40 km

13. The modulation frequency of an AM radio station is 250 kHz, which is 10% of the carrier wave. If another AM station approaches you for license what broadcast frequency will you allot? **[10 Jan. 2019 I]**
(a) 2750 kHz (b) 2900 kHz
(c) 2250 kHz (d) 2000 kHz

14. In a communication system operating at wavelength 800 nm, only one percent of source frequency is available as signal bandwidth. The number of channels accomodated for transmitting TV signals of band width 6 MHz are (Take velocity of light $c = 3 \times 10^8$ m/s, $h = 6.6 \times 10^{-34}$ J-s) **[9 Jan. 2019 II]**
(a) 3.75×10^6 (b) 3.86×10^6
(c) 6.25×10^5 (d) 4.87×10^5

15. A telephonic communication service is working at carrier frequency of 10 GHz. Only10% of it is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a bandwidth of 5 kHz? **[2018]**
(a) 2×10^3 (b) 2×10^4 (c) 2×10^5 (d) 2×10^6

16. A carrier wave of peak voltage 14 V is used for transmitting a message signal. The peak voltage of modulating signal given to achieve a modulation index of 80% will be: **[2018]**
(a) 11.2 V (b) 7V (c) 22.4 V (d) 28 V

17. The number of amplitude modulated broadcast stations that can be accommodated in a 300 kHz band width for the highest modulating frequency 15 kHz will be: **[Online April 15, 2018]**
(a) 20 (b) 10 (c) 8 (d) 15

18. The carrier frequency of a transmitter is provided by a tank circuit of a coil of inductance 49μH and a capactiance of 2.5nF . It is modulated by an audio signal of 12kHz. The frequency range occupied by the side bands is: **[Online April 15, 2018]**
(a) 18kHz – 30kHz (b) 63kHz – 75kHz
(c) 442kHz – 466kHz (d) 13482kHz – 13494kHz

19. In amplitude modulation, sinusoidal carrier frequency used is denoted by ω_c and the signal frequency is denoted by ω_m. The bandwidth ($\Delta\omega_m$) of the signal is such that $\Delta\omega_m < \omega_c$. Which of the following frequencies is not contained in the modulated wave ? **[2017]**
(a) $\omega_m + \omega_c$ (b) $\omega_c - \omega_m$
(c) ω_m (d) ω_c

20. A signal is to be transmitted through a wave of wavelength λ, using a linear antenna. The length 1 of the antenna and effective power radiated P_{eff} will be given respectively as :
(K is a constant of proportionality) **[Online April 9, 2017]**
(a) $\lambda, P_{eff} = K\left(\frac{1}{\lambda}\right)^2$ (b) $\frac{\lambda}{8}, P_{eff} = K\left(\frac{1}{\lambda}\right)$
(c) $\frac{\lambda}{16}, P_{eff} = K\left(\frac{1}{\lambda}\right)^3$ (d) $\frac{\lambda}{5}, P_{eff} = K\left(\frac{1}{\lambda}\right)^{\frac{1}{2}}$

21. A signal of frequency 20 kHz and peak voltage of 5 Volt is used to modulate a carrier wave of frequency 1.2 MHz and peak voltage 25 Volts. Choose the correct statement. **[Online April 8, 2017]**
(a) Modulation index = 5, side frequency bands are at 1400 kHz and 1000 kHz
(b) Modulation index = 5, side frequency bands are at 21.2 kHz and 18.8 kHz
(c) Modulation index=0.8, side frequency bands are at 1180 kHz and 1220 kHz
(d) Modulation index=0.2, side frequency bands are at 1220 kHz and 1180 kHz

22. Choose the correct statement : **[2016]**
(a) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(b) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.
(c) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(d) In amplitude modulation the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

23. A modulated signal $C_m(t)$ has the form $C_m(t) = 30 \sin 300\pi t + 10(\cos 200\pi t - \cos 400\pi t)$. The carrier frequency f_c, the modulating frequency (message frequency) f_ω and the modulation indix μ are respectively given by : **[Online April 10, 2016]**
(a) $f_c = 200$ Hz; $f_w = 50$ Hz; $\mu = \frac{1}{2}$
(b) $f_c = 150$ Hz; $f_w = 50$ Hz; $\mu = \frac{2}{3}$
(c) $f_c = 150$ Hz; $f_w = 30$ Hz; $\mu = \frac{1}{3}$
(d) $f_c = 200$ Hz; $f_w = 30$ Hz; $\mu = \frac{1}{2}$

24. An audio signal consists of two distinct sounds: one a human speech signal in the frequency band of 200 Hz to 2700 Hz, while the other is a high frequency music signal in the frequency band of 10200 Hz to 15200 Hz. The ratio of the AM signal bandwidth required to send both the signals together to the AM signal bandwidth requried to send just the human speech is : **[Online April 9, 2016]**

(a) 2 (b) 5 (c) 6 (d) 3

25. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. The frequencies of the resultant signal is/are : **[2015]**

(a) 2005 kHz, 2000 kHz and 1995 kHz
(b) 2000 kHz and 1995 kHz
(c) 2 MHz only
(d) 2005 kHz and 1995 kHz

26. Long range radio transmission is possible when the radio waves are reflected from the ionosphere. For this to happen the frequency of the radio waves must be in the range: **[Online April 19, 2014]**

(a) 80 - 150 MHz (b) 8 - 25 MHz
(c) 1 - 3 MHz (d) 150 - 1500 kHz

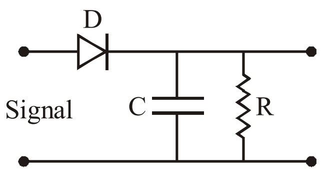
27. For sky wave propagation, the radio waves must have a frequency range in between: **[Online April 12, 2014]**

(a) 1 MHz to 2 MHz (b) 5 MHz to 25 MHz
(c) 35 MHz to 40 MHz (d) 45 MHz to 50 MHz

28. A transmitting antenna at the top of a tower has height 32 m and height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in line of sight (LOS) mode? **[Online April 9, 2014]**

(a) 55.4 km (b) 45.5 km (c) 54.5 km (d) 455 km

29. A diode detector is used to detect an amplitudemodulated wave of 60% modulation by using a condenser of capacity 250 picofarad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency which could be detected by it. **[2013]**



(a) 10.62 MHz (b) 10.62 kHz
(c) 5.31 MHz (d) 5.31 kHz

30. Which of the following modulated signal has the best noise-tolerance ? **[Online April 25, 2013]**

(a) Long-wave (b) Short-wave
(c) Medium-wave (d) Amplitude-modulated

31. Which of the following statement is NOT correct? **[Online April 23, 2013]**

(a) Ground wave signals are more stable than the sky wave signals.
(b) The critical frequency of an ionospheric layer is the highest frequency that will be reflected back by the layer when it is vertically incident.
(c) Electromagnetic waves of frequencies higher than about 30 MHz cannot penetrate the ionosphere.
(d) Sky wave signals in the broadcast frequency range are stronger at night than in the day time.

32. This question has Statement-1 and Statement-2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement-1: Short wave transmission is achieved due to the total internal reflection of the e-m wave from an appropriate height in the ionosphere.

Statement-2: Refractive index of a plasma is independent of the frequency of e-m waves. **[Online April 22, 2013]**

(a) Statement-1 is true, Statement-2 is false.
(b) Statement-1 is false, Statement-2 is true.
(c) Statement-1 is true, Statement-2 is true but Statement -2 is **not** the correct explanation of statement-1.
(d) Statement-1 is true, Statement-2 is true and Statement -2 is the correct explanation of Statement-1.

33. If a carrier wave $c(t) = A \sin \omega_c t$ is amplitude modulated by a modulator signal $m(t) = A \sin \omega_m t$ then the equation of modulated signal $[C_m(t)]$ and its modulation index are respectively **[Online April 9, 2013]**

(a) $C_m(t) = A(1 + \sin \omega_m t) \sin \omega_c t$ and 2
(b) $C_m(t) = A(1 + \sin \omega_m t) \sin \omega_m t$ and 1
(c) $C_m(t) = A(1 + \sin \omega_m t) \sin \omega_c t$ and 1
(d) $C_m(t) = A(1 + \sin \omega_c t) \sin \omega_m t$ and 2

34. A radar has a power of 1kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500 m. The maximum distance upto which it can detect object located on the surface of the earth
(Radius of earth $= 6.4 \times 10^6$m) is : **[2012]**

(a) 80 km (b) 16 km (c) 40 km (d) 64 km

35. A radio transmitter transmits at 830 kHz. At a certain distance from the transmitter magnetic field has amplitude 4.82×10^{-11}T. The electric field and the wavelength are respectively **[Online May 26, 2012]**

(a) 0.014 N/C, 36 m (b) 0.14 N/C, 36 m
(c) 0.14 N/C, 360 m (d) 0.014 N/C, 360 m

36. Given the electric field of a complete amplitude modulated wave as

$$\vec{E} = \hat{i}E_c\left(1 + \frac{E_m}{E_c}\cos\omega_m t\right)\cos\omega_c t.$$

Where the subscript c stands for the carrier wave and m for the modulating signal. The frequencies present in the modulated wave are **[Online May 19, 2012]**

(a) ω_c and $\sqrt{\omega_c^2 + \omega_m^2}$
(b) $\omega_c, \omega_c + \omega_m$ and $\omega_c - \omega_m$

(c) ω_c and ω_m

(d) ω_c and $\sqrt{\omega_c \omega_m}$

37. A 10 kW transmitter emits radio waves of wavelength 500 m. The number of photons emitted per second by the transmitter is of the order of **[Online May 12, 2012]**

(a) 10^{37} (b) 10^{31} (c) 10^{25} (d) 10^{43}

38. This question has Statement – 1 and Statement – 2. Of the four choices given after the statements, choose the one that best describes the two statements. **[2011]**

Statement – 1 : Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.

Statement – 2 : The state of ionosphere varies from hour to hour, day to day and season to season.

(a) Statement–1 is true, Statement–2 is true, Statement–2 is the correct explanation of Statement–1.

(b) Statement–1 is true, Statement–2 is true, Statement–2 is not the correct explanation of Statement – 1.

(c) Statement – 1 is false, Statement – 2 is true.

(d) Statement – 1 is true, Statement – 2 is false.

39. Which of the following four alternatives is not correct ? We need modulation : **[2011 RS]**

(a) to reduce the time lag between transmission and reception of the information signal

(b) to reduce the size of antenna

(c) to reduce the fractional band width, that is the ratio of the signal band width to the centre frequency

(d) to increase the selectivity

Hints & Solutions

1. **(b)** From the given expression,
$V_m = 5\,(1 + 0.6\cos 6280t)\sin(211 \times 10^4 t)$
Modulation index, $\mu = 0.6$
$\because A_m = \mu A_c$
$$\frac{A_{max} + A_{min}}{2} = A_c = 5 \qquad ...(i)$$
$$\frac{A_{max} - A_{min}}{2} = A_m = 3 \qquad ...(ii)$$
From equation (i) + (ii),
Maximum amplitude, $A_{max} = 8$.
From equation (i) – (ii),
Minimum amplitude $A_{min} = 2$.

2. **(d)** Modulation index, $\mu = \frac{A_m}{A_c} = \frac{2}{4} = 0.5$
Given, $fe = \frac{20000\pi}{2\pi} = 10000$ Hz.
and $fm = \frac{2000\pi}{2\pi} = 1000$ Hz.
$\therefore$ LSB $= f_e - f_m = 10000 - 1000 = 9000$ Hz.

3. **(c)** Range of frequency $= (f_c - f_m)$ to $(f_c + f_m)$
$\therefore$ Band width $= 2f_m = 2 \times 100 \times 10^6$ Hz
$= 2 \times 10^8$ Hz
and Modulation index $= \frac{A_m}{A_c} = \frac{100}{400} = 0.25$

4. **(a)**

5. **(b)** Size of antenna,
$l = \frac{\lambda}{4}$. As $\lambda = \frac{C}{f}$ $\therefore l \propto \frac{1}{f}$

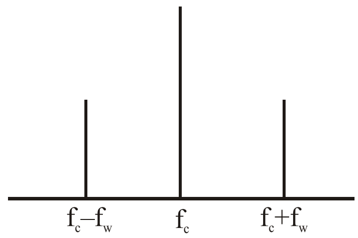
6. **(b)** Carrier waves of wavelength 1500 nm is used in modern optical fiber communication.

7. **(c)** LOS $= \sqrt{2h_T R} + \sqrt{2h_R R}$
or $50 \times 103 = \sqrt{2h_T \times 6.4 \times 10^6} + \sqrt{2 \times 70 \times 6.4 \times 40^6}$
On solving, $h_T = 32$ m

8. **(c)** Maximum amplitude $= E_m + E_c = 160$
$E_m + 100 = 160$
$E_m = 160 - 100 = 60$
Modulation index,
$$\mu = \frac{E_m}{E_c} = \frac{60}{100}$$
$\mu = 0.6$

9. **(c)** As we know, Range $= \sqrt{2hR}$
therefore to double the range height 'h' should be 4 times.

10. **(c)** Equation given
$V(t) = 10\,[1 + 0.3\cos(2.2 \times 10^4)]$
$\sin(5.5 \times 10^5 t)$
$= 10 + 1.5\,[\sin(57.2 \times 10^4 t) + \sin(52.8 \times 10^4 t)]$
$\omega_c + \omega_w = 57.2 \times 10^4 = 2\pi f_1$
$$f_1 = \frac{57.2 \times 10^4}{2 \times \left(\frac{22}{7}\right)} = 9.1 \times 10^4 \simeq 91\,\text{KHz}$$
$\omega_c - \omega_w = 52.8 \times 10^4$
$$f_2 = \frac{52.8 \times 10^4}{2 \times \left(\frac{22}{7}\right)} \simeq 84\,\text{KHz}$$



Upper side band frequency (f_1) is
$$f_1 = f_c - f_w = \frac{52.8 \times 10^4}{2\pi} \approx 85.00\,\text{kHz}$$
Lower side band frequency (f_2) is
$$f_2 = f_c + f_w = \frac{57.2 \times 10^4}{2\pi} \approx 90.00\,\text{kHz}$$

11. **(c)** After analysing the graph we may conclude that
(i) Amplitude varies as 8–10 V or 9 ± 1
(ii) Two time period as
100 μs (signal wave) & 8 μs (carrier wave)
So, equation of AM signal is
$$\left[9 \pm 1\sin\left(\frac{2\pi t}{T_1}\right)\sin\left(\frac{2\pi t}{T_2}\right)\right]$$
$= [9 \pm \sin(2\pi \times 10^4 t)]\sin(2.5\pi \times 10^5 t)\text{V}]$

12. **(a)** Maximum distance upto which signal can be broadcasted
$$d_{max} = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$
where h_T and h_R are heights of transmission tower and receiving antenna respectively.

Putting values R, hT and hR

$$d_{max} = \sqrt{2\times6.4\times106}\left[\sqrt{140}+\sqrt{40}\right]$$

or, $d_{max} \simeq 65$ km

13. **(d)** According to question, modulation frequency, 250 Hz is 10% of carrier wave

$$f_{carrier} = \frac{250}{0.1} = 2500\,\text{KHZ}$$

$\therefore$ Range of signal 2500 ± 250 KHz = 2250 Hz to 2750 Hz For 2000 KHZ

$f_{mod} = 200$ Hz

$\therefore$ Range = 1800 KHZ to 2200 KHZ

14. **(c)** Frequency, $f = \frac{V}{\lambda} = \frac{3\times10^8}{8\times10^{-7}} = \frac{30}{8}\times10^{14}$ Hz

$= 3.75 \times 10^{14}$ Hz

1% of f = 0.0375×10^{14} Hz

$= 3.75 \times 10^{12}$ Hz $= 3.75 \times 10^6$ MHz

As we know, number of channels accomodated for transmission =

$$\frac{\text{total bandwidth of Channel}}{\text{bandwidth needed per channel}} = \frac{3.75\times10^6}{6} = 6.25\times10^5$$

15. **(c)** If n = no. of channels

10% of 10 GHz = n × 5 KHz or,

$\Rightarrow n = 2 \times 10^5$

16. **(a)** Given : modulation index m = 80% = 0.8

$E_c = 14$ V, $E_m = ?$

using, $m = \frac{E_m}{E_c} \Rightarrow E_m = m \times E_c = 0.8\times14 = 11.2$V

17. **(b)** Given, modulating frequency $f_m = 15$ KHz

$\therefore$ Bandwidth of one channel = $2f_m = 30$ kHz

$\therefore$ No of channels accommodate $= \frac{300\text{kHz}}{30\text{kHz}} = 10$

18. **(c)** Given : Inductance, $L = 49\ \mu\text{H} = 49 \times 10^{-6}$ H, capacitance $C = 2.5$ nF $= 2.5 \times 10^{-9}$ F

Using $\omega = \frac{1}{\sqrt{LC}}$

$$= \frac{1}{\sqrt{49\times10^{-6}\times\frac{2.5}{10}\times10^{-9}}} = \frac{1}{7\times5\times10^{-8}} = \frac{10^8}{7\times5}$$

or, $\frac{10^8}{7\times5} = 2\pi\times f = 2\times\frac{22}{7}\times f \quad (\because\ \omega = 2\pi f)$

or, $f = \frac{10^7}{22} = \frac{10^4}{22}$ kHz = 454.54 kHz

Therefore frequency range 454.54 ± 12kHz

i.e., 442 kHz – 466 kHz

19. **(c)** Modulated carrier wave contains frequency ω_c and $\omega_c \pm \omega_m$

20. **(a)** Length of antenna = comparable to λ

Power radiated by linear antenna inversely depends on the square of wavelength and directly on the length of the antenna. Hence,

Power $P = \mu\left(\frac{1}{\lambda}\right)^2$

here $\mu = K$

21. **(d)** Modulation index (m) $= \frac{V_m}{V_0} = \frac{5}{25} = 0.2$

Given, frequency of carrier wave $(f_c) = 1.2 \times 10^6$ Hz

$= 1200$ kHz.

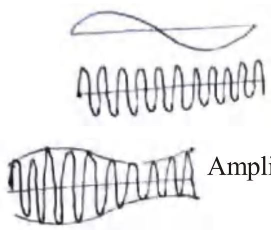
Frequency of signal $(f_0) = 20$ kHz.

Side frequency bands $= f_c \pm f_0$

$f_1 = 1200 - 20 = 1180$ kHz

$f_2 = 1200 + 20 = 1220$ kHz

22. **(c)** In amplitude modulation, the amplitude of the high frequency carrier wave made to vary in proportional to the amplitude of audio signal.



23. **(b)** Comparing the given equation with standard modulated signal wave equation, $m = A_c \sin \omega_c t + \frac{\mu A_c}{2}$ $\cos(\omega_c - \omega_s)t - \frac{\mu A_c}{2}\cos(\omega_c + \omega_s)t$

$\mu\frac{A_c}{2} = 10 \Rightarrow \mu = \frac{2}{3}$ (modulation index)

$A_c = 30$

$\omega_c - \omega_s = 200\pi$

$\omega_c + \omega_s = 400\pi$

$\Rightarrow f_c = 150,\ f_s = 50$ Hz.

24. **(c)** Ratio of AM signal Bandwidths

$$= \frac{15200-200}{2700-200} = \frac{15000}{2500} = 6.$$

25. **(a)** Amplitude modulated wave consists of three frequencies are $\omega_c + \omega_m$, ω, $\omega_c - \omega_m$

i.e. 2005 kHz, 2000kHz, 1995 kHz

26. **(b)** Frequency of radio waves for sky wave propagation is 2 MHZ to 30 MHZ.

27. **(b)** Sky wave propagation is suitable for frequency range 5 MHz to 25 MHz.

28. **(b)** Given : $h_R = 32$ m
$h_T = 50$ m
Maximum distance, $d_M = ?$
Applying, $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$
$= \sqrt{2\times6.4\times10^6\times50} + \sqrt{2\times6.4\times10^6\times32} = 45.5$ km

29. **(b)** **Given :** Resistance R = 100 kilo ohm
$= 100 \times 10^3 \Omega$
Capacitance C = 250 picofarad
$= 250 \times 10^{-12}$F
$\tau = RC = 100 \times 10^3 \times 250 \times 10^{-12}$ sec
$= 2.5 \times 10^7 \times 10^{-12}$ sec
$= 2.5 \times 10^{-5}$ sec
The higher frequency whcih can be detected with tolerable distortion is

$$f = \frac{1}{2\pi m_a RC} = \frac{1}{2\pi\times0.6\times2.5\times10^{-5}} Hz$$

$$= \frac{100\times10^4}{25\times1.2\pi} Hz = \frac{4}{1.2\pi}\times10^4 Hz$$

= 10.61 KHz

This condition is obtained by applying the condition that rate of decay of capacitor voltage must be equal or less than the rate of decay modulated singnal voltage for proper detection of mdoulated signal.

30. **(b)** Short-wave has the best noise tolerance.

31. **(c)** Above critical frequency (f_c), an electromagnetic wave penetrates the ionosphere and is not reflected by it.

32. **(a)** Effective refractive index of the ionosphere

$$n_{eff} = n_0\left[1 - \frac{80.5N}{f^2}\right]^{1/2}$$

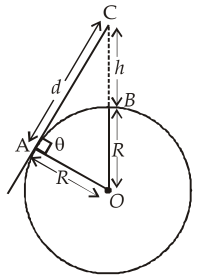
where f is the frequency of em waves

33. **(c)** Modulation index

$$m_a = \frac{E_m}{E_c} = \frac{A}{A} = 1$$

Equation of modulated signal [$C_m(t)$]
$= E_{(C)} + m_a E_{(C)} \sin \omega_m t$
$= A(1+ \sin w_C t) \sin \omega_m t$
(As $E_{(C)} = A \sin\omega_C t$)

34. **(a)** Let d is the maximum distance, upto which it can detect the objects



From ΔAOC

$$OC^2 = AC^2 + AO^2$$

$$(h+R)^2 = d^2 + R^2$$

$$\Rightarrow \quad d^2 = (h+R)^2 - R^2$$

$$d = \sqrt{(h+R)^2 - R^2}\ ;\ d = \sqrt{h^2 + 2hR}$$

$$d = \sqrt{500^2 + 2\times6.4\times10^6} = 80\,\text{km}$$

35. **(d)** Frequency of EM wave υ = 830 KHz
$= 830 \times 10^3$ Hz.
Magnetic field, $B = 4.82 \times 10^{-11}$ T
As we know, frequency, $\upsilon = \frac{c}{\lambda}$
or $\lambda = \frac{c}{v} = \frac{3\times10^8}{830\times10^3}$
$\lambda \simeq 360$ m
And, $E = BC = 4.82 \times 10^{-11} \times 3 \times 10^8$
$= 0.014$ N/C

36. **(b)** The frequencies present in amplitude modulated wave are :
Carrier frequency = ω_c
Upper side band frequency = $\omega_c + \omega_m$
Lower side band frequency = $\omega_c - \omega_m$.

37. **(b)** Power = $\frac{nhc}{\lambda}$
(where, n = no. of photons per second)

$$\Rightarrow \quad n = \frac{10\times10^3\times500}{6.6\times10^{-34}\times3\times10^8} \simeq 10^{31}$$

38. **(b)** For long distance communication, sky wave signals are used.
Also, the state of ionosphere varies every time.
So, both statements are correct.

39. **(a)** Low frequencies cannot be transmitted to long distances. Therefore, they are super imposed on a high frequency carrier signal by a process known as modulation. Speed of electro-magnetic waves will not change due to modulation. So there will be time lag between transmission and reception of the information signal.