EXAM II

NAME: __Solutions_____

1. This is individual work.
2. **SHOW ALL WORK!**
3. Write legibly to receive credit.
4. Turn in your equation sheet.

ASCII Table for Printable Characters

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
32	20		43	2b	+	54	36	6	65	41	A	76	4c	L	87	57	W	98	62	b	109	6d	m	120	78	x
33	21	!	44	2c	,	55	37	7	66	42	B	77	4d	M	88	58	X	99	63	c	110	6e	n	121	79	y
34	22	"	45	2d	-	56	38	8	67	43	C	78	4e	N	89	59	Y	100	64	d	111	6f	o	122	7a	z
35	23	#	46	2e	.	57	39	9	68	44	D	79	4f	O	90	5a	Z	101	65	e	112	70	p	123	7b	{
36	24	$	47	2f	/	58	3a	:	69	45	E	80	50	P	91	5b	[	102	66	f	113	71	q	124	7c	|
37	25	%	48	30	0	59	3b	;	70	46	F	81	51	Q	92	5c	\	103	67	g	114	72	r	125	7d	}
38	26	&	49	31	1	60	3c	<	71	47	G	82	52	R	93	5d	]	104	68	h	115	73	s	126	7e	~
39	27	'	50	32	2	61	3d	=	72	48	H	83	53	S	94	5e	^	105	69	i	116	74	t			
40	28	(	51	33	3	62	3e	>	73	49	I	84	54	T	95	5f	_	106	6a	j	117	75	u			
41	29	)	52	34	4	63	3f	?	74	4a	J	85	55	U	96	60	`	107	6b	k	118	76	v			
42	2a	*	53	35	5	64	40	@	75	4b	K	86	56	V	97	61	a	108	6c	l	119	77	w			

hex digit	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
4-bit pattern	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111

1 mile = 1609 meters
c = 3×10^8 m/s

SCORE: _____/100	SCALE >89.5%: 31337 79.5 – 89.5%: H@XX0R 69.5 – 79.5%: G33K 59.5 – 69.5%: $€RiPt K1DD13 <59.5%: n00b

Wireless Exploitation

Lesson 11 – Intro to Communications Systems

1. **[4]** a) List or draw the three fundamental components of any communications system.

   Transmitter, Channel/Medium, Receiver

   b) What major challenge must these communications systems contend with?

   Noise

Lesson 12 – Intro to Modulation

2. **[9]** We wish to transmit the information signal $v_m = 5\sin(2\pi 6{,}000t)$ V.

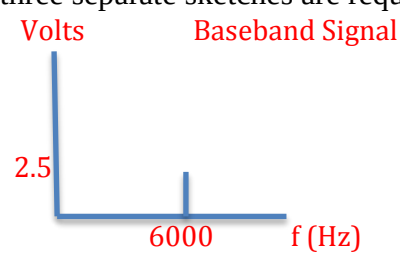
   a) Calculate the wavelength of the given signal.

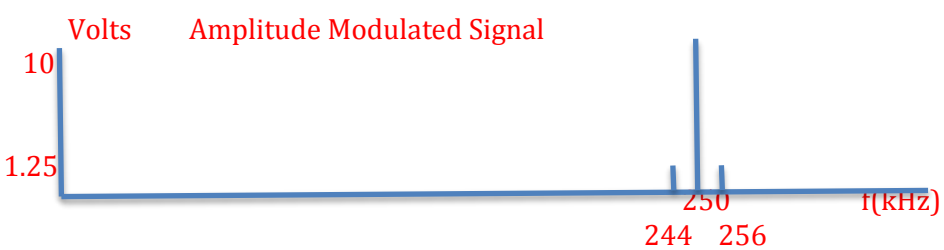
   $\lambda = c/f = (3\text{x}10^8 \text{ m/s})/ 6000 = 50$ km

b) Would it be practical to directly transmit this information signal using an antenna? Why/why not? No it would not be practical.

The smallest practical antenna would have a size of one-tenth of this wavelength , which is 5000 meters (3.1 miles!).

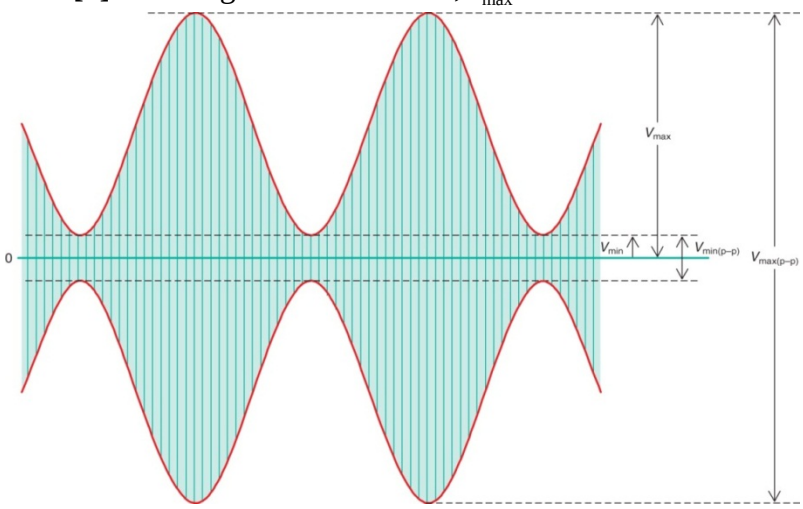
c) Suppose a carrier signal of $v_c = 10\sin(2\pi 250{,}000t)$ V is amplitude-modulated by the information signal given above. Sketch and label the frequency spectrum (i.e., the frequency domain representation) of the baseband signal, the carrier signal and the AM signal (three separate sketches are required).





d) What is the bandwidth of the AM signal? 256,000 – 244,000 = 12,000 Hz

3. **[8]** In the figure shown below, V_{max} is measured as 5.9 V and V_{min} measured as 1.2 V.



(a) Determine the value of V_c. V_c = (5.9+1.2)/2= 3.55V

(b) Determine the value of V_m. V_m = (5.9-1.2)/2= 2.35V

(c) Determine the modulation index. V_m/V_c = (5.9-1.2)/2= .662 → 66.2%= m

(d) Suppose we can change the value of V_m. What is the maximum value that we could use for V_m without causing overmodulation? $V_{m(max)}$= 3.55V

Lesson 13 – Signal Gain and dB

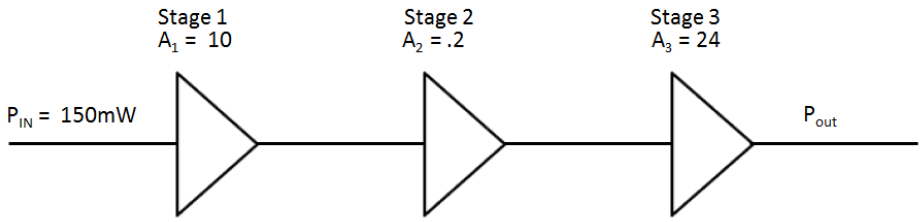
4. **[2]** Given $\mathbf{A_p = P_{out} / P_{in}}$
   a. If $\mathbf{A_p}$ < 1, this stage is an ___attenuator_____.
   b. If $\mathbf{A_p}$ > 1, this stage is an ___amplifier_____.

5. **[2]** Express the signal power of 20nW in dBm. (Circle correct answer).

   dBm = 10Log(20nW / 1mW)
   dBm = 10Log(20x10^-9 / 1x10^-3) = -46.9897 dBm

   a. [illegible]
   b. -67 dBm
   c. -77 dBm
   d. 154 dBm

6. **[6]** a) Using the arrangement of cascaded amplifiers below, compute $\mathbf{P_{OUT}}$.



P_{OUT} = 0.15W * 10 * 0.2 *24 =7.2W

b) What is the overall gain in dB?

A_T = 10*0.2*24 = 48 → 10log(48) = 16.8 dB

7. **[4]** True/False

T **F** FM is a constant-amplitude signal in the time domain.

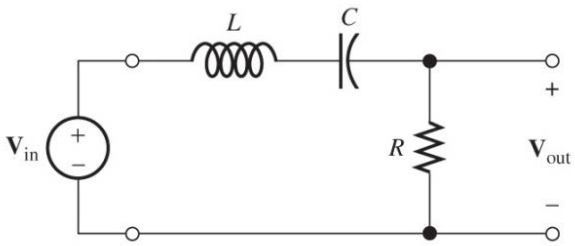
T **F** If the decibel gain of a component is negative, then the component inverted the signal.

T **F** Modulation is the process of taking a high frequency carrier signal down to baseband for more efficient transmission.

T **F** Noise only impacts semiconductor components

Lesson 14 – Fourier and Filters

8. [**8**] Given the following LRC circuit below:



The circuit shown has a resonant frequency, ***fr*** = 100 kHz. The circuit has a resistance value, R = 100Ω , capacitance value, C = 1.33**nF.** and an inductance value of L=1.904mH.

a. Determine the quality factor, Q, for the circuit.
Q= X_L/R
Q= 2π(100k)(1.9x10^-3)/100
Q=11.9665

Q = 11.9665____

b. What is the BW of this circuit?
BW= fr/Q
BW= 100x10^3/ 11.96665
BW=8.356 x 10^3

BW = _8.356kHz___

c. Calculate the upper and lower cut-off frequencies.

Q>10 ,so we can use the assumption that the BW splits the resonant frequency evenly on both sides.
$\mathbf{f_H}$ = fr + BW/2= 100kHz + 8.356kHz/2 = 104.18kHz
$\mathbf{f_L}$= fr – 4.18kHz = 95.82kHz

$\mathbf{f_H}$ = __104.18kHz____

$\mathbf{f_L}$ = __95.82kHz_____

d. If the following triangle wave with a fundamental frequency, f, of 20kHz is put through this filter, determine the output.

$$v_t(t) = 2 + \frac{8}{\pi^2}\cos(2\pi ft) + \frac{8}{(3\pi)^2}\cos(6\pi ft) + \frac{8}{(5\pi)^2}\cos(10\pi ft) + \frac{8}{(7\pi)^2}\cos(14\pi ft)$$

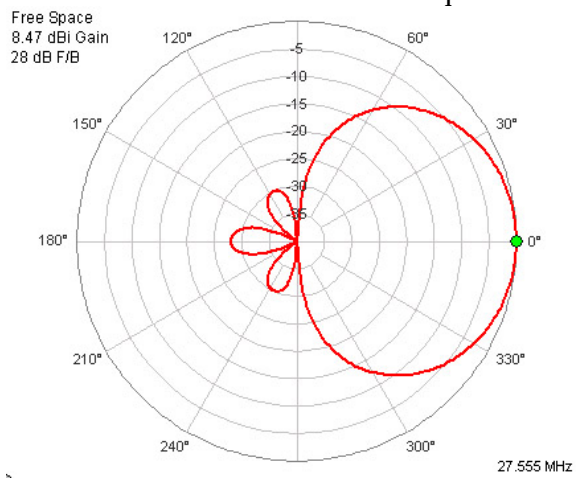
0Hz 40kHz 120kHz 200kHz 280kHz

The ideal bandpass filter passes frequencies around 100kHz with cutoff frequencies only a little more than 4kHz on either side. Thare no components of this signal in that frequency range.

$V_t(t)$=_____~0V_____

Lesson 15 –Antennas

9. **[6]** Use the information below to answer follow-on questions about this antenna:



a. What is the beamwidth of this antenna?

30° to 330°, so approximately 60° . Any answer between 55° and 65° should be good.

b. What is the Side Lobe Level with respect to the side lobe positioned at 240°?

SLL (dB) = Gboresight (dB) – Gsidelobe(dB) = 0dB - ~-30dB = ~30dB.

c. If this antenna is transmitting at a power of 15W, what is the EIRP?

From the specs for the radiation pattern- you can find all sorts of data- Especially the gain in dBi

$G_t = 10^{\frac{8.47}{10}} = 7.03$ EIRP = G_tP_t = (7.03)(15W) = 105.46W

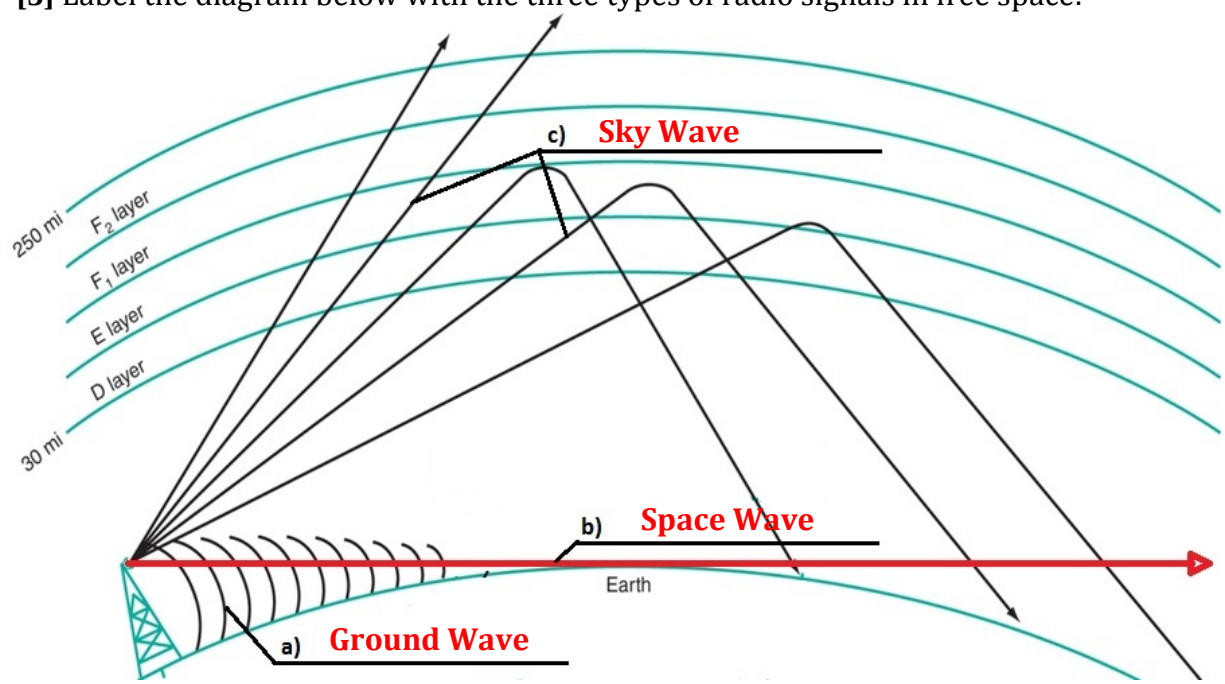
10. **[2]** Initially you start off with a dipole antenna. You add a reflector and director to the dipole antenna. What happens to the gain and beamwidth of the of the radiated energy? Circle your answer.

a. The gain increases and the beamwidth increases.
b. The gain increases and the beamwidth decreases.
c. The gain decreases and the beamwidth increases.
d. The gain decreases and the beamwidth decreases.

Lesson 16 – Propagation

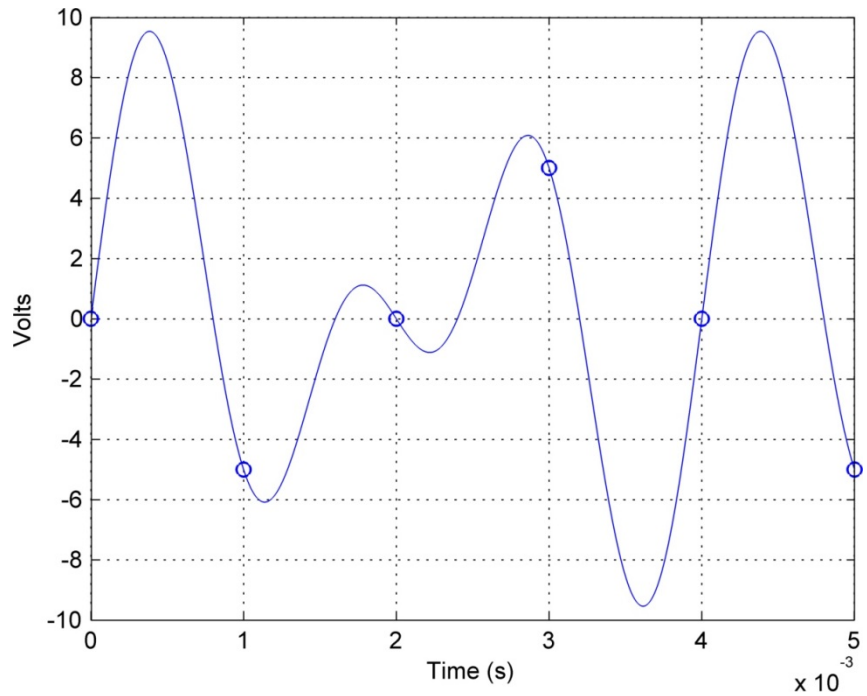
11. **[3]** a) Electromagnetic waves behave like optical waves. They can be __reflected__, where the direction of the wave changes at an interface. Or they can be bent around objects (__diffracted__). __Scattering__ describes a wave that is reflected off a rough surface and re-radiated in many directions.

b) **[3]** Label the diagram below with the three types of radio signals in free space:



Lesson 17 – Analog to Digital Conversion

12. **[8]** The signal given by the formula $v(t) = 5\sin(2\pi 500t) + 5\sin(2\pi 750t)$ is sampled as shown below.



a. What is the Nyquist rate?

The Nyquist Rate is 1.5 kHz = (2 x 750Hz); because 750Hz is the highest message frequency

b. Is this signal sampled optimally? Why or why not?

The signal is sampled at 1 kHz, which is below the Nyquist Rate of 1.5 kHz, therefore it is not sampled correctly

c. Given the upper and lower bounds depicted on this graph, and that your application requires 1 volt of resolution or better, what is the minimum number of bits you need for each sample in your A/D converter?

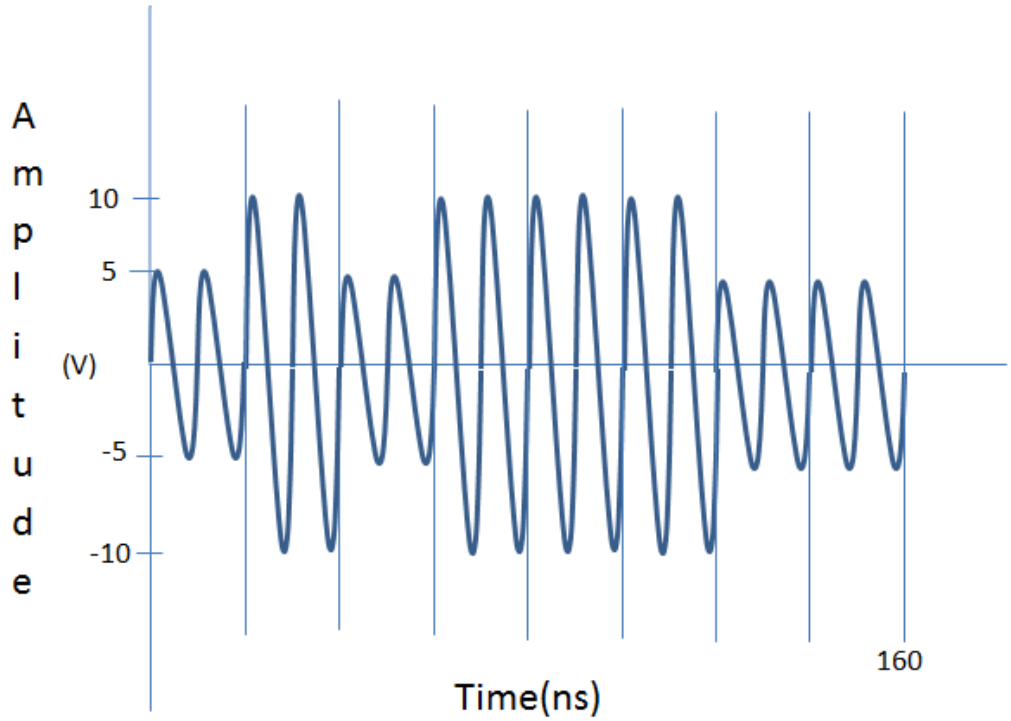
q= [10-(-10)]/2^n; q=1V; so
$\log_2(20)$=4.32. Because this application needs at least 20 levels, a <u>five bit</u> quantizer is the minimum number of bits you can use to satisfy the requirement.

d. Given your answer in part (c), what is the exact resolution?

$20V/2^5$ levels = 0.625 V

Lesson 19 –Digital Modulation

13. **[6]** Given the following ASK signal (Note: vertical lines denote bit divisions): (single bit)) (Lower Voltage '0', Higher Voltage '1') (MSB on the left)

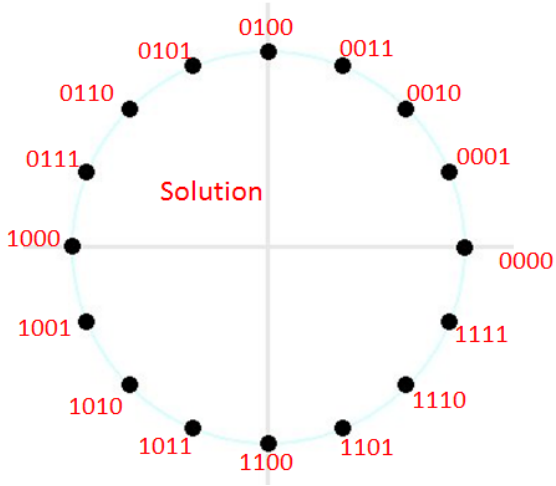


a) What is the resulting bit stream?
0101 1100

b) What is the bit rate?
T_b = 20ns => R_b = 1/20E-9 = 50 Mbps

c) What ASCII character was transmitted?
'\'

14. **[6]** Given the following constellation diagram:



a) Which modulation scheme is shown? (circle one)

16-ASK 16-PSK 16-FSK 16-QAM

b) How many bits are represented by each symbol (N)?
$\log_2(16) = 4$ bits

c) How many degrees of separation are between each symbol?
$360 / 16 = 22.5^o$

Lesson 20 – Electronic Warfare

15. **[3]** You are located 9500 meters from the omnidirectional receiver you are jamming. The transmitted signal you are jamming originates 4500 meters from the receiver. The signal transmitter's EIRP is 15 W. Assuming both the transmitter and jammer have line of sight, what EIRP (dBW) must you transmit to jam the receiver with a J/S of 3 dB?

$$10\log(15W) = 11.76\ dBW$$

$$\frac{J}{S}_{dB} = EIRP_J - EIRP_S + 20\log d_s - 20\log d_j$$

$$3\ dB = EIRP_J - 11.76\ dBW + 20\log 4500 - 20\log 9500$$

$$EIRP_J = 21.25\ dBW$$

16. **[3]** Write the appropriate subdivision of Electronic Warfare next to the matching application.

Electronic Attack (EA)	Jamming
Electronic Protection (EP)	Stealth technology
Electronic Support (ES)	Locating a transmitter