قائمة الاسئلة

مبادئ الاتصالات - كلية الهندسة - قسم الكهرباء- المستوى الثالث - ...التخصصـ.اتصالات.- ..الزمن.ثلاث ساعات.. - درجة هذا الاختبار (50)

د. محمد الوادعي

1)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Amplitude modulation is

a) **Change in frequency of the carrier according to modulating signal**
b) **Change in amplitude of the modulating signal according to carrier signal**
c) **Change in amplitude of the carrier according to modulating signal**
d) **Change in amplitude of the carrier according to modulating signal frequency**

1)	-	a
2)	-	b
3)	+	c
4)	-	d

2)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Find the Fourier transform of the unit step function.

a) $\pi\delta(\omega) + \frac{1}{\omega}$

b) $\pi\delta(\omega) + \frac{1}{j\omega}$

c) $\pi\delta(\omega) - \frac{1}{j\omega}$

d) $2\pi\delta(\omega) + \frac{1}{j\omega}$

1)	-	a
2)	+	b
3)	-	c
4)	-	d

3)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) The AM spectrum consists of

a) Carrier frequency
b) Upper side band frequency
c) Lower side band frequency
d) All of the above

1)	-	a
2)	-	b
3)	-	c
4)	+	d

4)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Function of RF mixer is

a) Addition of two signals
b) Multiplication of two signals
c) Rejection of noise
d) All of the above

1)	-	a
2)	+	b
3)	-	c
4)	-	d

5)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) The modulation technique that uses the minimum channel bandwidth and transmitted power is

a) FM
b) DSB-SC
c) SSB
d) VSB

1)	-	a
2)	-	b
3)	+	c
4)	-	d

6)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Noise is added to a signal _________

a) At receiving antenna

b) At transmitting antenna

c) During regeneration of information

d) In the channel

1)	-	a
2)	-	b
3)	-	c
4)	+	d

7)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Calculate the bandwidth occupied by a DSB signal when the modulating frequency lies in the range from 100 Hz to 10KHz.

a) 28 kHz
b) 24.5 kHz
c) 20 kHz
d) 19.8 kHz

1)	-	a
2)	-	b
3)	-	c
4)	+	d

8)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) The function of multiplexing is

a) To reduce the bandwidth of the signal to be transmitted.
b) To combine multiple data streams over a single data channel.
c) To allow multiple data streams over multiple channels in a prescribed format.
d) To match the frequencies of the signal at the transmitter as well as the receiver.

1)	-	a
2)	+	b
3)	-	c
4)	-	d

9)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) What is the advantage of superheterodyning?

a) High selectivity and sensitivity
b) Low Bandwidth
c) Low adjacent channel rejection
d) Low fidelity

1)	+	a
2)	-	b
3)	-	c
4)	-	d

10)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Calculate the modulation index when a transmitter radiates a signal of 9.8 KW after modulation and 8 KW without modulation of the signal.

a) 100%
b) 80%
c) 67%
d) 50%

1)	-	a
2)	-	b
3)	+	c
4)	-	d

11)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	.01$^-$						
.4	.57	.54	.21	.05	.01$^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	.01$^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	-.10	.47	.46	.24	.08	.02	.01$^-$				
.8	-.19	.41	.48	.27	.11	.03	.01$^-$				
3.0	-.26	.34	.49	.31	.13	.04	.01				
.2	-.32	.26	.48	.34	.16	.06	.02				
.4	-.36	.18	.47	.37	.19	.07	.02	.01$^-$			
.6	-.39	.10	.44	.40	.22	.09	.03	.01$^-$			
.8	-.40	.01	.41	.42	.25	.11	.04	.01			
4.0	-.40	-.07	.36	.43	.28	.13	.05	.02			
.2	-.38	-.14	.31	.43	.31	.16	.06	.02	.01$^-$		
.4	-.34	-.20	.25	.43	.34	.18	.08	.03	.01$^-$		
.6	-.30	-.26	.18	.42	.36	.21	.09	.03	.01		
.8	-.24	-.30	.12	.40	.38	.23	.11	.04	.01		
5.0	-.18	-.33	.05	.36	.39	.26	.13	.05	.02	.01$^-$	
.2	-.11	-.34	-.02	.33	.40	.29	.15	.07	.02	.01$^-$	
.4	-.04	-.35	-.09	.28	.40	.31	.18	.08	.03	.01$^-$	
.6	.03	-.33	-.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	-.31	-.20	.17	.38	.35	.22	.11	.05	.02	.01$^-$
6.0	.15	-.28	-.24	.11	.36	.36	.25	.13	.06	.02	.01$^-$
.2	.20	-.23	-.28	.05	.33	.37	.27	.15	.07	.03	.01$^-$
.4	.24	-.18	-.30	-.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	-.12	-.31	-.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	-.07	-.31	-.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	-.00	-.30	-.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	-.28	-.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	-.25	-.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	-.21	-.27	-.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	-.16	-.29	-.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	-.11	-.29	-.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	-.06	-.29	-.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	-.00	-.27	-.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	-.25	-.22	.04	.27	.34	.28	.18	.10
.8	-.04	.26	.10	-.22	-.25	-.01	.24	.34	.29	.20	.11
9.0	-.09	.25	.14	-.18	-.27	-.06	.20	.33	.31	.21	.12
.2	-.14	.22	.18	-.14	-.27	-.10	.16	.31	.31	.23	.14
.4	-.18	.18	.22	-.09	-.27	-.14	.12	.30	.32	.25	.16
.6	-.21	.14	.24	-.04	-.26	-.18	.08	.27	.32	.27	.17
.8	-.23	.09	.25	.01	-.25	-.21	.03	.25	.32	.28	.19
10.0	-.25	.04	.25	.06	-.22	-.23	-.01	.22	.32	.29	.21

(1 Mark). What is the disadvantage of FM over AM?

a) High modulating power is needed
b) Requires high output power
c) High noise is produced
d) Large bandwidth required

1)	-	a
2)	-	b
3)	-	c
4)	+	d

12)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Find the convolution result of $[\delta(t) - \delta(t-1)] * -x[t+1]$, $\delta(t)$ being the delta function.

a) x(t+1) – x(t)
b) x(t) – x(t+1)
c) x(t) – x(t-1)
d) x(t-1) – x(t+1)

1)	-	a
2)	+	b
3)	-	c
4)	-	d

13)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). For 100% amplitude modulation, the power in upper sideband when carrier power is to be 100W?

a) 100 W
b) 75 W
c) 50 W
d) 25 W

1)	-	a
2)	-	b
3)	-	c
4)	+	d

14)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Any signal and its Hilbert transform have same energy density spectrum.

a) True

b) False

1)	+	a
2)	-	b

15)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	.01$^-$						
.4	.57	.54	.21	.05	.01$^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	.01$^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	.01$^-$				
.8	−.19	.41	.48	.27	.11	.03	.01$^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	.01$^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	.01$^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	.01$^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	.01$^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	.01$^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	.01$^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	.01$^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	.01$^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	.01$^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	.01$^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Envelope Detector is a/an --------------

a) Coherent detector

b) Asynchronous Detector

c) Synchronous Detector

d) Product Demodulator

1)	-	a
2)	+	b
3)	-	c
4)	-	d

16)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). The intermediate frequency of a superheterodyne receiver is 500 KHz. What is the image frequency at 1200 KHz?

a) 2200 KHz
b) 700 KHz
c) 200 KHz
d) Both (a) and (c).

1)	-	a
2)	-	b
3)	-	c
4)	+	d

17)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Calculate power in each sideband, if power of carrier wave is 176W and there is 60% modulation in amplitude modulated signal?

a) 13.36 W
b) 15.84 W
c) 52 W
d) 67 W

1)	-	a
2)	+	b
3)	-	c
4)	-	d

18)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) An AM broadcast station transmits modulating frequencies up to 6 kHz. If the AM station is transmitting on a frequency of 894 kHz, the values for upper and lower sidebands and the total bandwidth occupied by the AM station are:

a) 900 KHz, 888 KHz, 12 KHz
b) 894 KHz, 884 KHz, 12 KHz
c) 894 KHz, 888 KHz, 6 KHz
d) 900 KHz, 888 KHz, 6 KHz

1) + a
2) - b
3) - c
4) - d

19)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Consider a message signal *f(t)* with amplitude limited to the range from -2 to +2, i.e. $-2 < f(t) < +2$ for all t. The bandwidth of this message signal is much smaller than carrier frequency that is used to form the AM signal

$$\Phi_{AM}(t) = [0.5 + f(t)]cos(\omega_c t)$$

What kind of detector can be used to recover *f(t)* from $\Phi_{AM}(t)$?

a) Envelope detector.
b) Coherent detector with PLL.
c) Band-pass filter to extract the carrier from $\Phi_{AM}(t)$ then use it in a coherent detector.
d) b and c.
e) All of them.

1)	-	a
2)	-	b
3)	-	c
4)	+	d
5)	-	e

20)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) What is the modulation index value if $V_{max} = 7.5\ V$ and $V_{min} = 1.5\ V$?

a) 0.8
b) 0.667
c) 0.425
d) 0.5

1)	-	a
2)	+	b
3)	-	c
4)	-	d

21)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) If an AM signal is represented by
$\phi(t) = [10 + 2sin(1.6\pi \times 10^3 t)]sin(3.2\pi \times 10^6 t)$ ***Volts*. Calculate the value of modulation index and the value of bandwidth of this signal.**

a) 2, 16 MHz
b) 0.2, 8 kHz
c) 0.6, 16 kHz
d) 0.2, 16 kHz

1)	-	a
2)	-	b
3)	-	c
4)	+	d

22)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) A system uses a deviation of 100 kHz and a modulating frequency of 15 kHz. What is the approximate bandwidth?

a) 115 kHz
b) 230 kHz
c) 170 kHz
d) 340 kHz

1)	-	a
2)	+	b
3)	-	c
4)	-	d

23)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(2 Marks) Determine the instantaneous frequency of the signal

$$\varphi(t) = cos(200\pi t)cos(5sin2\pi t) + sin(200\pi t)sin(5sin2\pi t)$$

a) $100 + 5cos(2\pi t) \quad Hz$
b) $200\pi + 10\pi cos(2\pi t) \quad Hz$
c) $100 + 5cos(2\pi t) \quad Hz$
d) $100 - 5cos(2\pi t) \quad Hz$

1)	-	a
2)	-	b
3)	-	c
4)	+	d

24)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Consider a message signal $f(t) = cos(800\pi t)$ that is used to modulate to produce the FM signal, $\Phi_{FM}(t) = cos[2\pi 10^8 t + 10sin(800\pi t)]$. What is the frequency deviation Δf, in hertz?

a) 80 Hz
b) 400 Hz
c) 4000 Hz
d) 800 Hz

1)	-	a
2)	-	b
3)	+	c
4)	-	d

25)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Consider a message signal $f(t) = cos(800\pi t)$ that is used to modulate to produce the FM signal, $\Phi_{FM}(t) = cos[2\pi 10^8 t + 5sin(200\pi t)]$ with frequency deviation, Δf = 500 Hz. What is the approximate bandwidth?

a) 1200 Hz
b) 1600 Hz
c) 1000 Hz
d) 600 Hz

1)	+	a
2)	-	b
3)	-	c
4)	-	d

26)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Consider an angle-modulated signal

$$\Phi(t) = 10cos(\omega_c t + 3sin2\pi(10^3)t$$

Assuming PM system, find the peak frequency deviation?

a) 3 Hz.
b) 30 Hz.
c) 300 Hz.
d) 3000 Hz.

1)	-	a
2)	-	b
3)	-	c
4)	+	d

27)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Consider an angle-modulated signal

$$\Phi(t) = 10cos(\omega_c t + 3sin2\pi(10^3)t$$

Assuming PM system, find the bandwidth when f_m is decreased by one-half.

(hent for $\beta = 3 \implies n = 5$)

a) 1 kHz.
b) 4 kHz.
c) 6 kHz.
d) 8 kHz.

1)	-	a
2)	+	b
3)	-	c
4)	-	d

28)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). In a FM receiver, amplitude limiter ----------------

a) eliminates any change in amplitude of received FM signals
b) eliminates any change in frequency of received FM signals
c) reduce the amplitude of received signals
d) amplifies low frequency signals

1)	+	a
2)	-	b
3)	-	c
4)	-	d

29)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(2 Marks). A given FM transmitter is modulated with the sinusoidal input, $f(t) = 10cos(200\pi t)$, and a modulation index of 3. The unmodulated carrier power is 10 watts across a 50-Ω resistive load. Determine the peak amplitude of the first-order lower sideband. (Hint: use the herewith Bessel function table)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7
2.0	.22	.58	.35	.13	.03	.01⁻		
.2	.11	.56	.40	.16	.05	.01		
.4	.00	.52	.43	.20	.06	.02		
.6	−.10	.47	.46	.24	.08	.02	.01⁻	
.8	−.19	.41	.48	.27	.11	.03	.01⁻	
3.0	−.26	.34	.49	.31	.13	.04	.01	
.2	−.32	.26	.48	.34	.16	.06	.02	
.4	−.36	.18	.47	.37	.19	.07	.02	.01⁻

a) **2.178 V.**
b) **1.089 V**
c) **10.75 V.**
d) **6.24 V**

1)	-	a
2)	-	b
3)	+	c
4)	-	d

30)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) A given FM transmitter is modulated with the sinusoidal input, $f(t) = 10cos(200\pi t)$, and a modulation index of 3. The unmodulated carrier power is 10 watts across a 50-Ω resistive load. Determine the average power of the third-order sideband. (Hint: use the herewith Bessel function table of Bessel functions).

a) 1.296 W
b) 1.922 W
c) 3.844 W
d) 6 W

1)	-	a
2)	+	b
3)	-	c
4)	-	d

31)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	-.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	-.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	-.26	.34	.49	.31	.13	.04	.01				
.2	-.32	.26	.48	.34	.16	.06	.02				
.4	-.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	-.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	-.40	.01	.41	.42	.25	.11	.04	.01			
4.0	-.40	-.07	.36	.43	.28	.13	.05	.02			
.2	-.38	-.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	-.34	-.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	-.30	-.26	.18	.42	.36	.21	.09	.03	.01		
.8	-.24	-.30	.12	.40	.38	.23	.11	.04	.01		
5.0	-.18	-.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	-.11	-.34	-.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	-.04	-.35	-.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	-.33	-.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	-.31	-.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	-.28	-.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	-.23	-.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	-.18	-.30	-.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	-.12	-.31	-.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	-.07	-.31	-.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	-.00	-.30	-.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	-.28	-.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	-.25	-.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	-.21	-.27	-.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	-.16	-.29	-.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	-.11	-.29	-.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	-.06	-.29	-.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	-.00	-.27	-.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	-.25	-.22	.04	.27	.34	.28	.18	.10
.8	-.04	.26	.10	-.22	-.25	-.01	.24	.34	.29	.20	.11
9.0	-.09	.25	.14	-.18	-.27	-.06	.20	.33	.31	.21	.12
.2	-.14	.22	.18	-.14	-.27	-.10	.16	.31	.31	.23	.14
.4	-.18	.18	.22	-.09	-.27	-.14	.12	.30	.32	.25	.16
.6	-.21	.14	.24	-.04	-.26	-.18	.08	.27	.32	.27	.17
.8	-.23	.09	.25	.01	-.25	-.21	.03	.25	.32	.28	.19
10.0	-.25	.04	.25	.06	-.22	-.23	-.01	.22	.32	.29	.21

(2 Marks) A given FM transmitter is modulated with the sinusoidal input, $f(t) = 10cos(200\pi t)$, and a modulation index of 3. The unmodulated carrier power is 10 watts across a 50-Ω resistive load. Find the bandwidth if the input sinusoid peak amplitude is reduced to two volts.

a) 1200 Hz
b) 600 Hz
c) 200 Hz
d) 320 Hz

1)	-	a
2)	-	b
3)	-	c
4)	+	d

32)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(2 Marks) A given PM- modulated signal has a peak frequency deviation of 30 Hz for an input sinusoid of a unit amplitude and a frequency of 90 Hz. Determine the required frequency multiplication factor, n, to produce a peak frequency deviation of 30 kHz when the input sinusoid has unit amplitude and a frequency of 300 Hz.

a) 100
b) 300
c) 500
d) 1000

1)	-	a
2)	+	b
3)	-	c
4)	-	d

33)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

Q33 (2 Marks) The bandwidths of the following angle-modulated system are compared, using the sinusoidal test signal, $f(t) = acos(2\pi f_m t)$. The resulting approximate bandwidths are tabulated below:

System	a	f_m	a	f_m	a	f_m
	1 V	3 kHz	2 V	3 kHz	1 V	6 kHz
Bandwidth	6 kHz		6 kHz		12 kHz	

Identify the type of angle modulation used (FM or PM: Narrowband or Wideband).

a) **FM Wideband**
b) **PM Narrowband**
c) **Could be FM or PM Wideband**
d) **Could be FM or PM Narrowband**

1) - a
2) - b
3) - c
4) + d

34)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(2 Marks) The bandwidths of the following angle-modulated system are compared, using the sinusoidal test signal, $f(t) = a\cos(2\pi f_m t)$. The resulting approximate bandwidths are tabulated below:

System	a	f_m	a	f_m	a	f_m
	1 V	3 kHz	2 V	3 kHz	1 V	6 kHz
Bandwidth	100 kHz		200 kHz		100 kHz	

Identify the type of angle modulation used (FM or PM: Narrowband or Wideband).

a) **FM Wideband**
b) **PM Wideband**
c) **Could be FM or PM Wideband**
d) **Could be FM or PM Narrowband**

1)	+	a
2)	-	b
3)	-	c
4)	-	d

35)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark) Balanced modulator is used to produce balanced modulation of a carrier wave.

a) True

b) False

1) - a

2) + b

36)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

Q36 (1 Mark). Varacter diode modulator is an indirect way of generating FM.

a) True
b) False

1)	-	a
2)	+	b

37)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Which of the following is an indirect way of generating FM?

a) By reactance modulator
b) By bipolar transistor
c) By varacter diode
d) By armstrong modulator

1)	-	a
2)	-	b
3)	-	c
4)	+	d

38)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). The sinusoidal signal $f(t) = sin\omega_m t$ is applied to the input of angle system. The corresponding modulated signal output is:

$$\phi(t) = 100\ cos(\omega_c t + 4sin\omega_m t)$$

What is the system type?

a) FM system.
b) PM system.
c) It could be FM or PM system.
d) AM system.

1)	-	a
2)	+	b
3)	-	c
4)	-	d

39)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(2 Marks). A carrier waveform is frequency-modulated by the sum of two sinusoids:

$$\phi(t) = 100\, cos(\omega_c t + sin\omega_m t + 2\, sin2\omega_m t)$$

$where\ f_c = 100\ kHz\ and\ f_m = 1\ kHz$.

What is the peak frequency deviation from carrier?

a. **10 kHz**
b. **7 kHz**
c. **5 kHz**
d. **3.5 kHz**

1)	-	e
2)	-	f
3)	+	g
4)	-	h

40)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). A FM carrier is sinusoidally modulated. For what value of β is all of the power in the sidebands (i.e. zero average power at the carrier frequency? (Hint: You can use the herewith Bessel function table).

a) 1.4
b) 2.4
c) 3.4
d) 5

1)	-	a
2)	+	b
3)	-	c
4)	-	d

41)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). Why AM is used for broadcasting?

a) More immune to noise

b) Less transmitting power is required

c) It has high fidelity

d) Avoids Receivers Complexity

1)	-	a
2)	-	b
3)	-	c
4)	+	d

42)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^{-}$						
.4	.57	.54	.21	.05	$.01^{-}$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^{-}$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^{-}$				
.8	−.19	.41	.48	.27	.11	.03	$.01^{-}$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^{-}$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^{-}$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^{-}$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^{-}$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^{-}$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^{-}$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^{-}$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^{-}$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^{-}$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^{-}$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). If the modulating frequency of a carrier wave varies between 700 Hz and 7 KHz, find it's bandwidth?

a) 10 KHz
b) 12.6 KHz
c) 23 KHz
d) 17.3 KHz

1)	-	a
2)	+	b
3)	-	c
4)	-	d

43)

Bessel Functions of the First Kind, $J_n(x)$

x	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00										
.2	.99	.10									
.4	.96	.20	.02								
.6	.91	.29	.04								
.8	.85	.37	.08	.01							
1.0	.77	.44	.11	.02							
.2	.67	.50	.16	.03	$.01^-$						
.4	.57	.54	.21	.05	$.01^-$						
.6	.46	.57	.26	.07	.01						
.8	.34	.58	.31	.10	.02						
2.0	.22	.58	.35	.13	.03	$.01^-$					
.2	.11	.56	.40	.16	.05	.01					
.4	.00	.52	.43	.20	.06	.02					
.6	−.10	.47	.46	.24	.08	.02	$.01^-$				
.8	−.19	.41	.48	.27	.11	.03	$.01^-$				
3.0	−.26	.34	.49	.31	.13	.04	.01				
.2	−.32	.26	.48	.34	.16	.06	.02				
.4	−.36	.18	.47	.37	.19	.07	.02	$.01^-$			
.6	−.39	.10	.44	.40	.22	.09	.03	$.01^-$			
.8	−.40	.01	.41	.42	.25	.11	.04	.01			
4.0	−.40	−.07	.36	.43	.28	.13	.05	.02			
.2	−.38	−.14	.31	.43	.31	.16	.06	.02	$.01^-$		
.4	−.34	−.20	.25	.43	.34	.18	.08	.03	$.01^-$		
.6	−.30	−.26	.18	.42	.36	.21	.09	.03	.01		
.8	−.24	−.30	.12	.40	.38	.23	.11	.04	.01		
5.0	−.18	−.33	.05	.36	.39	.26	.13	.05	.02	$.01^-$	
.2	−.11	−.34	−.02	.33	.40	.29	.15	.07	.02	$.01^-$	
.4	−.04	−.35	−.09	.28	.40	.31	.18	.08	.03	$.01^-$	
.6	.03	−.33	−.15	.23	.39	.33	.20	.09	.04	.01	
.8	.09	−.31	−.20	.17	.38	.35	.22	.11	.05	.02	$.01^-$
6.0	.15	−.28	−.24	.11	.36	.36	.25	.13	.06	.02	$.01^-$
.2	.20	−.23	−.28	.05	.33	.37	.27	.15	.07	.03	$.01^-$
.4	.24	−.18	−.30	−.01	.29	.37	.29	.17	.08	.03	.01
.6	.27	−.12	−.31	−.06	.25	.37	.31	.19	.10	.04	.01
.8	.29	−.07	−.31	−.12	.21	.36	.33	.21	.11	.05	.02
7.0	.30	−.00	−.30	−.17	.16	.35	.34	.23	.13	.06	.02
.2	.30	.05	−.28	−.21	.11	.33	.35	.25	.15	.07	.03
.4	.28	.11	−.25	−.24	.05	.30	.35	.27	.16	.08	.04
.6	.25	.16	−.21	−.27	−.00	.27	.35	.29	.18	.10	.04
.8	.22	.20	−.16	−.29	−.06	.23	.35	.31	.20	.11	.05
8.0	.17	.23	−.11	−.29	−.11	.19	.34	.32	.22	.13	.06
.2	.12	.26	−.06	−.29	−.15	.14	.32	.33	.24	.14	.07
.4	.07	.27	−.00	−.27	−.19	.09	.30	.34	.26	.16	.08
.6	.01	.27	.05	−.25	−.22	.04	.27	.34	.28	.18	.10
.8	−.04	.26	.10	−.22	−.25	−.01	.24	.34	.29	.20	.11
9.0	−.09	.25	.14	−.18	−.27	−.06	.20	.33	.31	.21	.12
.2	−.14	.22	.18	−.14	−.27	−.10	.16	.31	.31	.23	.14
.4	−.18	.18	.22	−.09	−.27	−.14	.12	.30	.32	.25	.16
.6	−.21	.14	.24	−.04	−.26	−.18	.08	.27	.32	.27	.17
.8	−.23	.09	.25	.01	−.25	−.21	.03	.25	.32	.28	.19
10.0	−.25	.04	.25	.06	−.22	−.23	−.01	.22	.32	.29	.21

(1 Mark). After passing the FM signal through mixer, what is the change in the frequency deviation Δf when the modulating frequency is doubled?

a) Becomes 2Δf
b) Becomes Δf/2
c) Becomes Δf^2
d) Remains unchanged

1)	-	a
2)	-	b
3)	-	c
4)	+	d