Final Exam (Spring, 2020)

Student ID:_____ Name:_____

[1] For each description below, find all the answers from the list: [1 pt each, No partial pt]

① Find all the data communication channels in your smartphone [C, L, W, X (E can be included)]
② What are the three angular motions of a gyro sensor? [N, Q, Y]
③ Find all the proprioceptive sensors in your smartphone [A, E, F]
④ Find all the actuators in your smartphone [(B, H, R) or (B, R) or (H, R)]
⑤ Find all the proximity sensors from the list [G, I, O, V]
⑥ What are the two components consisting of active sensors? [P, U]
⑦ [M] sensor produces an electric voltage when there is a pressure difference between the two sides.
⑧ [A] measures a change in velocity of a linear motion in 3D space.

A) Accelerometer	F) Gyroscope	K) Microphone	P) Receiver	U) Transmitter
B) AMOLED	G) Infrared sensor	L) NFC	Q) Roll	V) Ultrasonic
C) Bluetooth	H) LCD	M) Piezoelectric	R) Speaker	W) USB
D) CMOS sensor	I) LIDAR	N) Pitch	S) Thermal	X) WLAN
E) GPS	J) Mechanical switch	O) RADAR	T) Touch screen	Y) Yaw

[2] For each description below, choose either **True** or **False**: [1 pt each, -1 pt for Wrong answer]

① The decimal number 219 corresponds to 11011101 in 8-bit binary number [F]
② **Huffman coding** is a lossless compression, but **Run-length coding** is a lossy compression. [F]
③ In **analog-to-digital conversion**, the only technique to avoid **aliasing** is to satisfy the **Nyquist sampling rate**. [F]
④ The only method to reduce the errors in data transmission is to increase the **signal duration** because the increase in signal duration increases the **signal energy** while decreasing the **noise variance**. [F]
⑤ A pair of **complementary** signals never become **orthogonal**. [T]
⑥ The two binary signals {1, 1, 1, -1, -1, -1} and {1, -1, 1, -1, 1, -1} are **orthogonal**. [F]
⑦ **Channel capacity** of wireless transmission is proportional to both the **bandwidth** and the **transmission range**. [F]

[3] Fill in the blank. [2 pts each, No partial pt]

① [Signal-to-Noise Ratio or SNR] describes both the quality of the received signal and the probability of detecting the correct data value.
② [Central Limit] theorem says that the sum of *n* independent random variables approaches to a Gaussian distribution as n becomes large, no matter what the distributions of the random variables have.
③ [Delay], [Multiplier], and [Adder] are the three components of a linear filter.
④ The matched processor computes [correlation] between the target signal and the received signal.
⑤ [Harmonic] frequencies are integer-multiple of the fundamental frequency.
⑥ [Source entropy] represents the average number of bits that are required to represent the symbols from a source as a binary code.
⑦ When comparing two binary strings of equal length, [Hamming] distance is the number of bit positions where the two bits are different.

[4] List five advantages of digital systems compared to analog systems. [5 pts] (Order does not matter)

(1) Robust to noise (잡음에 강인함)
(2) Easy to store, transmit, record (저장, 전송, 기록이 용이)
(3) Programmable (프로그래밍 처리 가능)
(4) Low power consumption (저 소비전력)
(5) Small size, mass production (소형화 대량생산 가능)

[5] Given a logic equation $Y = \bar{A} \cdot B + \bar{B} \cdot C$, (a) find the **Truth table**, (b) Draw the circuit diagram with the minimum number of gates, and (c) Draw another circuit diagram using **NAND gate only**.

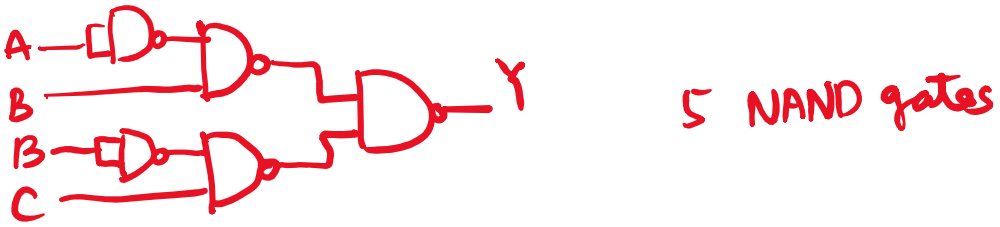
(a) Truth Table [2 pts]

A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

(b) Circuit Diagram with the minimum number of gates [3 pts]

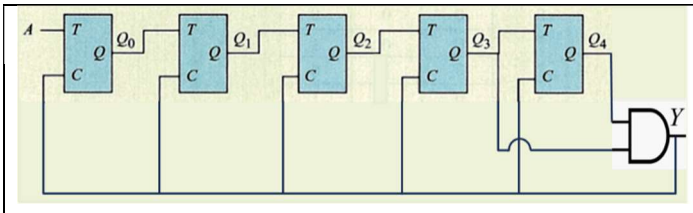
(c) Circuit diagram with NAND gate only (You cannot use even NOT gates) [3 pts]

$$\overline{Y} = \overline{\bar{A} \cdot B + \bar{B} \cdot C} = \overline{\bar{A} \cdot B} \cdot \overline{\bar{B} \cdot C}$$



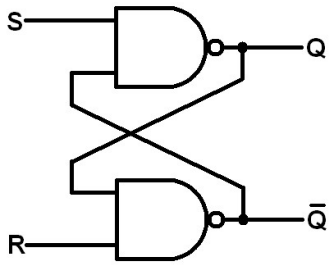
[Grading] DeMorgan's law 를 이용

[6] The following is a **Modulo-K counter** using the Toggle Flip-Flop logic circuit. (a) Find the value **K**, (b) Verify your answer (i.e., how do you come up with the value of **K**?).



(a) **K** [3 pts]	24
(b) **Validation** [4 pts]	$Y=Q_4 \bullet Q_3$ 즉 Count=24 가 되면 Y=1 이 되어 모두 Clear 시킴

[7] The following is an **SR-FF circuit** using **NAND** gate. Complete the **State transition table**. [8 pts]
*If the state is invalid, write '**Invalid state**'.*



Set	Reset	Q (Current)	Q (Next)
0	0	0	Invalid
0	0	1	Invalid
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

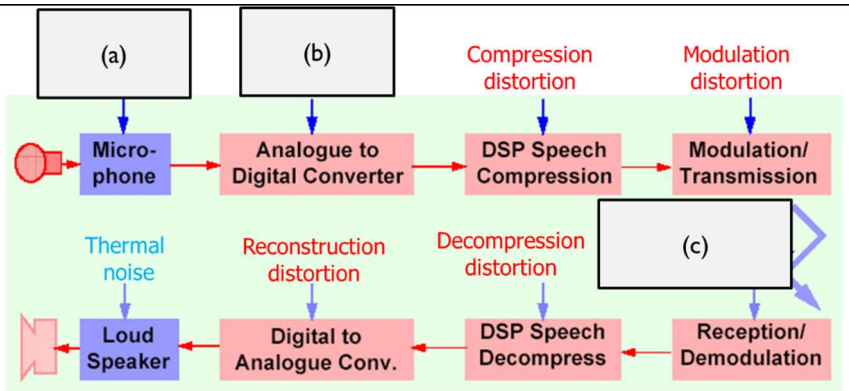
[Grading] 각 state 별 1 점씩

[8] An audio CD stores 650 MB(MegaBytes) of data. The sampling rate of 44 kHz is used with 16-bit quantization. What duration of **stereo** music (**two separate waveforms**) can be stored on a CD? Give the answer in **minutes**. You must show your calculation process. [5 pt]

$$\frac{650 \times 10^6 \text{ (Bytes)}}{2 \times 44 \times 10^3 \times 2 \text{ (Bytes/sec)}} = 3,693 \text{ sec} = 61.55 \text{ min} \approx 62 \text{ min (or 61 min)}$$

[Grading] 계산 과정에 따라 부분점수: 5/3/1/0

[9] The following figure depicts the noise/distortion chain in digital communication. Specify possible types of noise or distortion (a) in sensors acquiring an analog signal, (b) in the analog-to-digital conversion process, (c) in wireless data transmission. [6 pts] [Grading] 각 2 점 – No partial pt



(a)Environmental noise

(b) Quantization error and aliasing (2 개 모두)

(c) Interference, Multi-path, Doppler effect (2 개 이상)

[10] Today, 1,000 students came to the campus and only 50 students are sampled to check the body temperature. The following table shows the number of students with temperatures in 0.2° interval.

(a) Find the **sample mean** and the **sample variance** of body temperature (Note: calculate the sample mean with *one digit below the decimal point* and the sample variance with *two digits below the decimal point*). [6 pts]

Temp(℃)	35.5	35.7	35.9	36.1	36.3	36.5	36.7	36.9	37.1	37.3	37.5	37.7
# of Students	1	2	7	5	7	11	9	4	2	0	1	1
Calculation space												

[Grading] 각 3 점 – 계산과정에서 오류로 인해 결과값이 소수점 아래에서 다른 경우 부분점수 1.5

(a)-1 Sample mean = 36.4	(a)-2 Sample variance = 0.20

(b) Estimate the total number of students among 1,000 students whose temperature can be above 37°C. (Note: You MUST use the z-Table) [3 pts]

(b)

Standard Dev. $\sigma = \sqrt{0.2} = 0.447 \approx 0.45$ $\quad z = \frac{37 - 36.4}{0.45} = 1.333$

From z-Table, $P(z \geq 1.333) = 1 - P(z \leq 1.333) = 0.0918$

∴ # of students whose temp is above 37°C

$= 0.0918 \times 1{,}000 = 91.8 \approx 92$ (명)

[11] A data packet contains a 4-digit password 2045. Each code word contains a single character encoded using **ASCII codes** that form octabit (8-bit) data plus an even-parity bit.

(a) Generate a data packet that includes a LRC code word. [3 pts]

(b) Find the **data increase factor** for your data packet. [2 pts]

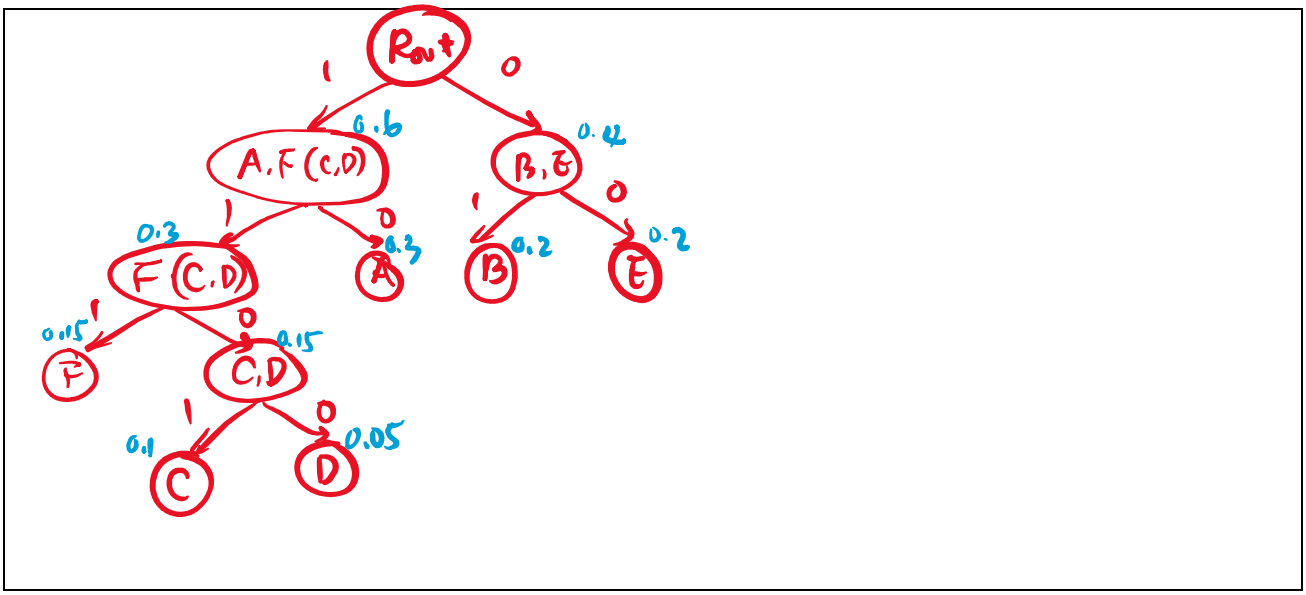
(a) No partial pt	(b) No partial pt
'2' = 50 = 00110010 1 '0' = 48 = 00110000 0 '4' = 52 = 00110100 1 '5' = 53 = 00110101 0 LRC = 00000011 0	DIF = $\frac{(8+1)\times(4+1)}{4\times8}$=1.406

[12] Consider the data file consisting of 6 symbols A ~ F: AAFBECCAFFEBAADEBABE

(a) Find the 1st ordering of the symbols in the **decreasing order of the effective probabilities**. [2 pts]

Symbol	A - 6	B - 4	E - 4	F - 3	C - 2	D - 1
Effective probability	0.3	0.2	0.2	0.15	0.1	0.05

(b) Find the **binary tree for Huffman coding** to compress this file. [4 pts]



(c) Find the code words of the symbols. [2 pts]

(d) Compute the **effective source entropy** and the **average number of bits** per symbol. [4 pts]

(c) Table of Codewords [2 pts]

[Grading] Partial pt – 2/1/0

Symbol	Codeword
A	10 (2 bits)
B	01 (2 bits)
C	1101 (4 bits)
D	1100 (4 bits)
E	00 (2 bits)
F	111 (3 bits)

(d)-1 Effective source entropy

[2 pts] – no partial pt

$$\hat{H}_s = -\sum_{i}^{6} P_e(x_i) \cdot \log_2 P_e(x_i) = 2.41$$

(d)-2 Average number of bits

[2 pts] – no partial pt

Total # of bits = 49 bits

Average # of bits = 49/20 = 2.5 bits/symbol

[13] Consider the binary (two state = +1 or -1) sequence: $\{s_i,\ 0 \le i \le 5\} = \{+1, +1,\ +1, -1, -1, -1\}$.

(a) Compute the signal energy $\mathcal{E}_S$. [1 pt]

(b) Design the matched processor (*Find only the coefficients of the linear processor*). [1 pt]

(c) Compute the matched processor output V_1 when the received signal is $\{s_i\}$. [1 pt]

(d) Compute the matched processor output V_2 when the received signal is the complementary signal of $\{s_i\}$. [1 pts]

(e) Design an orthogonal signal of $\{s_i\}$, and compute the matched processor output V_3 when the received signal is the orthogonal signal. [2 pts]

(a) $\mathcal{E}_S = 1^2+1^2+1^2+(-1)^2+(-1)^2+(-1)^2 = 6$

(b) $c_i = s_i\ (0 \le i \le 5)$ or $c_0 = c_1 = c_2 = +1,\ c_3 = c_4 = c_5 = -1$

(c) $V_1 = 1^2+1^2+1^2+(-1)^2+(-1)^2+(-1)^2 = 6 = \mathcal{E}_S$

(d) Complementary signal $= -s_i = \{-1, -1, -1, +1, +1, +1\}$

$V_2 = -1-1-1-1-1-1 = -6 = -\mathcal{E}_S$

(e) Orthogonal signal $= (\neg s_i) = \{+1\ -1\ +1\ +1\ -1\ +1\}$ or $\{-1\ +1\ -1\ -1\ +1\ -1\}$

$V_3 = 0$ ($\because$ orthogonal)

[Bonus Problem] Cloud Computing 의 개념과 장점을 아는대로 쓰시오. [4 pts]

[개념] (200 자 이내)

- Internet 이 제공하는 inter-connectivity 와 communication speed 의 장점을 활용하기 위해 hardware (CPSs, memories)와 software (운영체제 및 응용프로그램)를 인터넷 환경에서 모은 것
- 언제 어디서나 컴퓨터가 필요할 때 필요한 만큼 충분히 사용할 수 있음

[장점] (250 자 이내)

1. 리소스가 적게 필요한 경우 적은 비용으로 처리 가능하고, 필요에 따라 컴퓨터 성능을 쉽게 확장할 수 있음
2. 필요한 만큼의 server sections 만을 가동하여 사용 전력을 효율적으로 관리
3. 냉각 비용을 줄이기 위해 multi-core CPU 처럼 server sections 은 순환될 수 있음
4. 동일한 servers 를 운영하므로 유지 보수가 쉽고 교체 용이

[Bonus Problem] COVID-19 Pandemic 사태가 장기화되면서 우리 사회의 여러 분야에서 큰 변화가 발생하면서 정보통신 기술분야에서도 악영향을 받는 기업이 있는 방면에, 오히려 크게 성장하는 기업도 생기고 있다. 만일 COVID-19 Pandemic 이 앞으로 1 년간 더 지속된다는 가정 하에, (a) 인간사회에 발생할 변화 가운데 가장 중요하다고 생각하는 변화를 작성하고, (b) 그 변화가 정보통신기술이나 공학분야에 어떤 영향을 미칠 수 있을지 예측하고, (c) 그 변화에 대응하기 위하여 정보통신 공학자로서 준비할 것이 무엇인지 서술하시오. [6 pts]

(a) 가장 중요한 인간사회 변화 (200 자 이내)

- 적절한 사례와 함께 변화 상황을 "구체적"으로 작성할 것
- 중요성의 근거를 제시할 것
- 이미 일어난 변화보다는 새롭고 독창적인 변화일수록 높은 점수

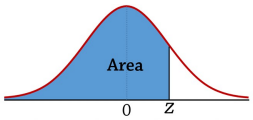
(b) 정보통신기술이나 공학분야에 미치는 영향 예측 (200 자 이내)

- (a)와 연결될 것
- 그 변화에 대응하여, 공학과 기술 분야에서 어떤 변화, 발전이 일어날 지 예측
- 구체적인 기술을 언급할수록 높은 점수
- 이미 일어난 기술변화 보다는 새롭고 독창적인 변화일수록 높은 점수

(c) 정보통신공학자로서의 준비 사항 (200 자 이내)

- (b)와 연결되고, 공학자로서의 구체적인 필요 역량 및 준비자세를 언급할 것
- 구체적인 준비 방안을 제시
- 공학자로서의 비전 언급

z-Table



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

ASCII Code Table

ASCII printable characters

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