Positional Number Systems

Digital Data

Digital Data

- Data in the computer’s memory is represented using units that can each be in one of 2-states (0 or 1).

Digital Data

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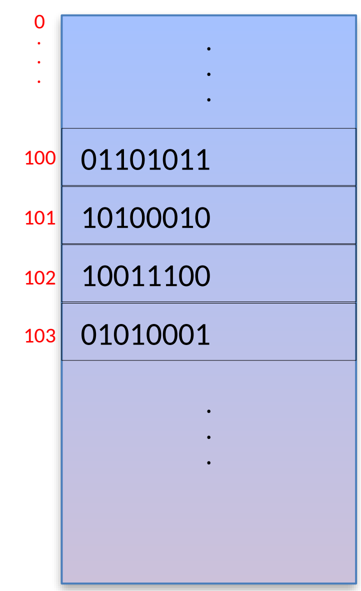

Digital Data

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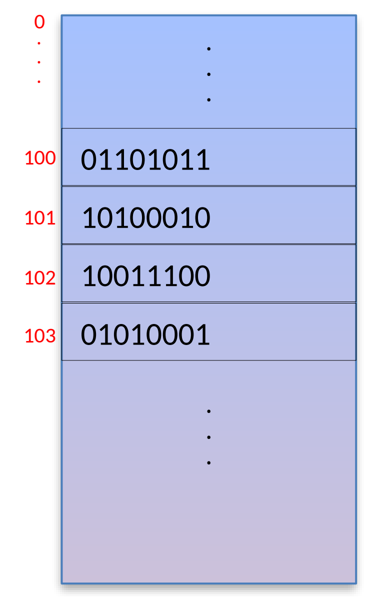
- Data is represented digitally, using binary numbers



Digital Data

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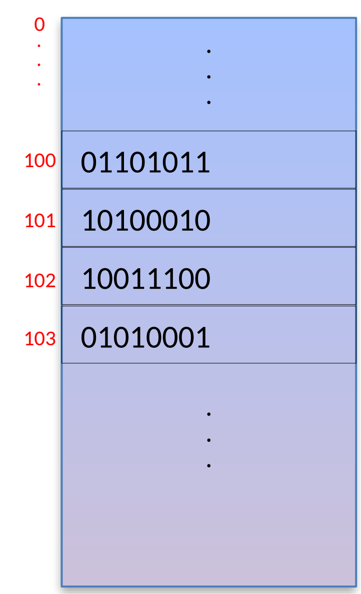
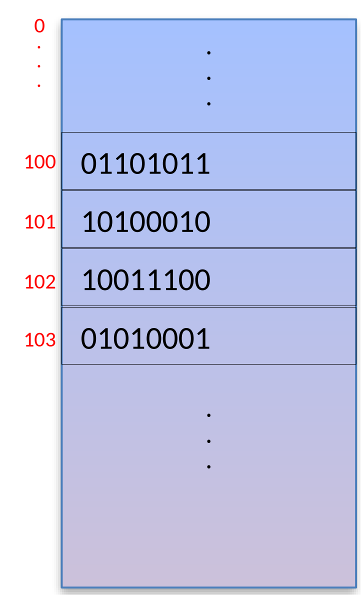
- Kinds of data:
  - Numbers



Digital Data

- Data in the computer's memory is represented using units that can each be in one of 2-states (0 or 1).
- Data is represented digitally, using binary numbers
- Kinds of data:
  - Numbers: Represented in binary



Digital Data

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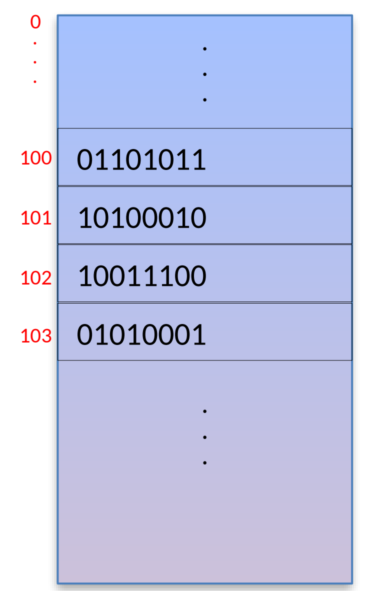
- Kinds of data:
  - Numbers: Represented in binary
  - Text



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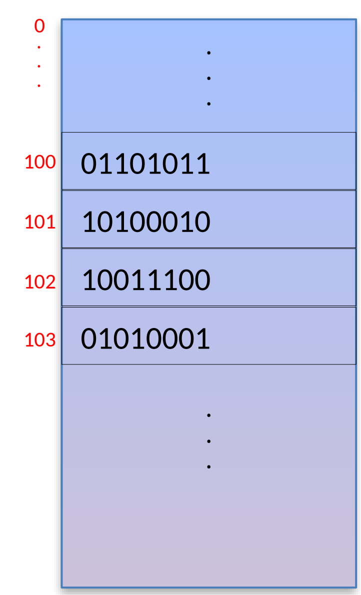
  - Text
  - Images



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- Kinds of data:
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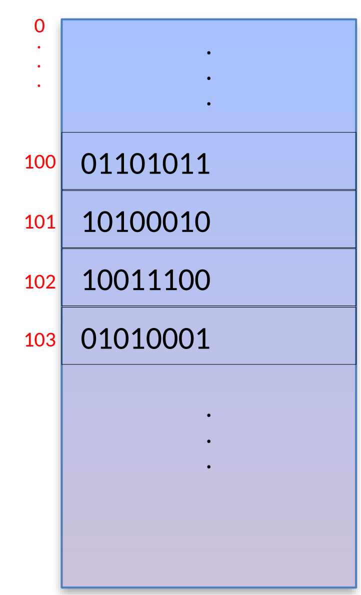
  - Text
  - Images
  - Video



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  - Text
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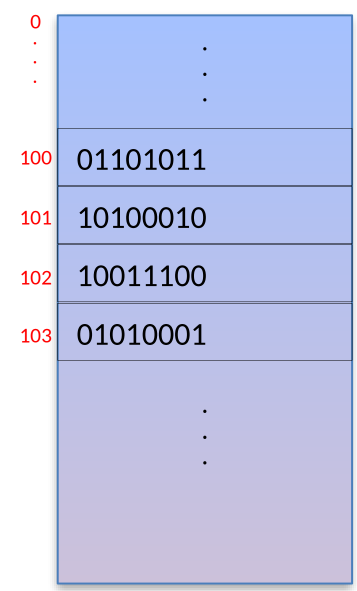
  - Video
  - Audio



Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

72

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

72

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

72 101

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

72 101

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

72 101 108 108

Digital Data

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
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36	$	52	4	68	D	84	T	100	d	116	t
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38	&	54	6	70	F	86	V	102	f	118	v
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43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

Hello World!

72 101 108 108 111 32 87 111 114 108 100 33

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- Kinds of data:
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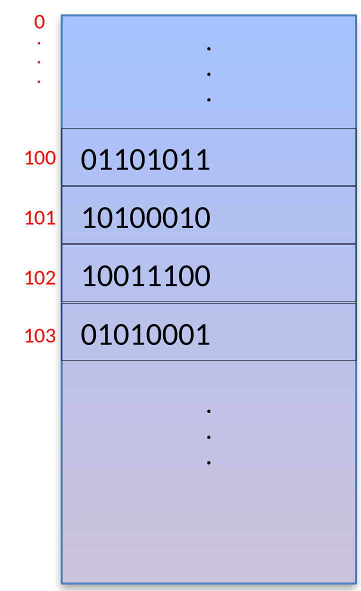
  - Text
  - Images

  - Video
  - Audio



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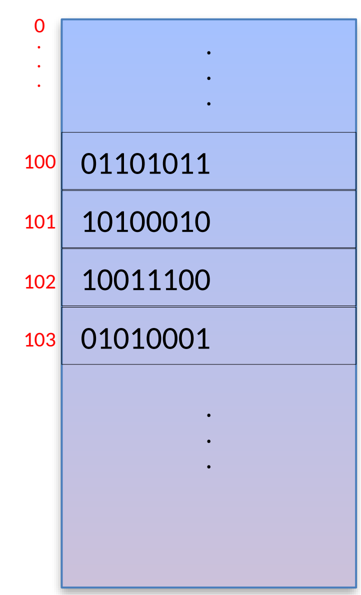
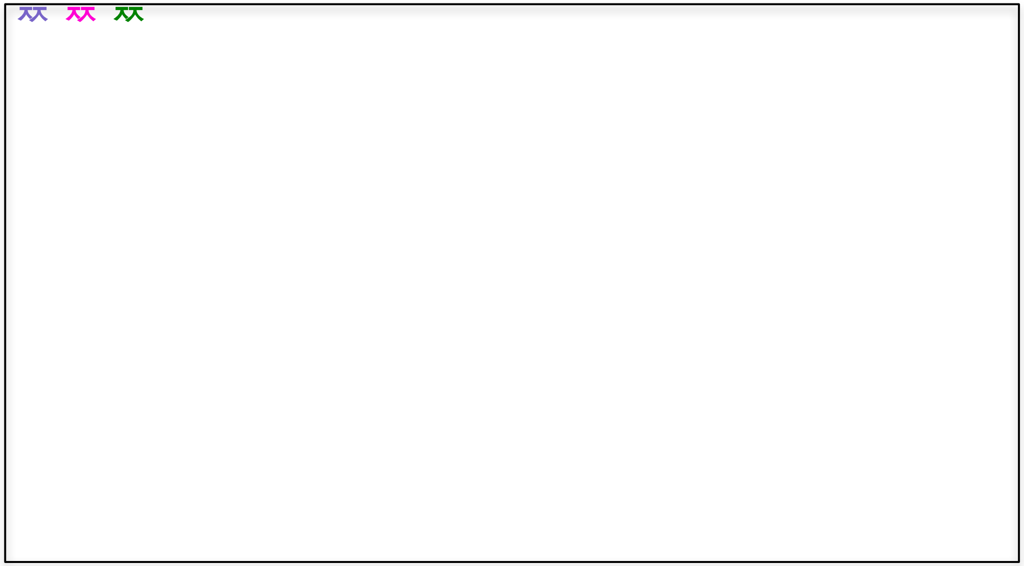


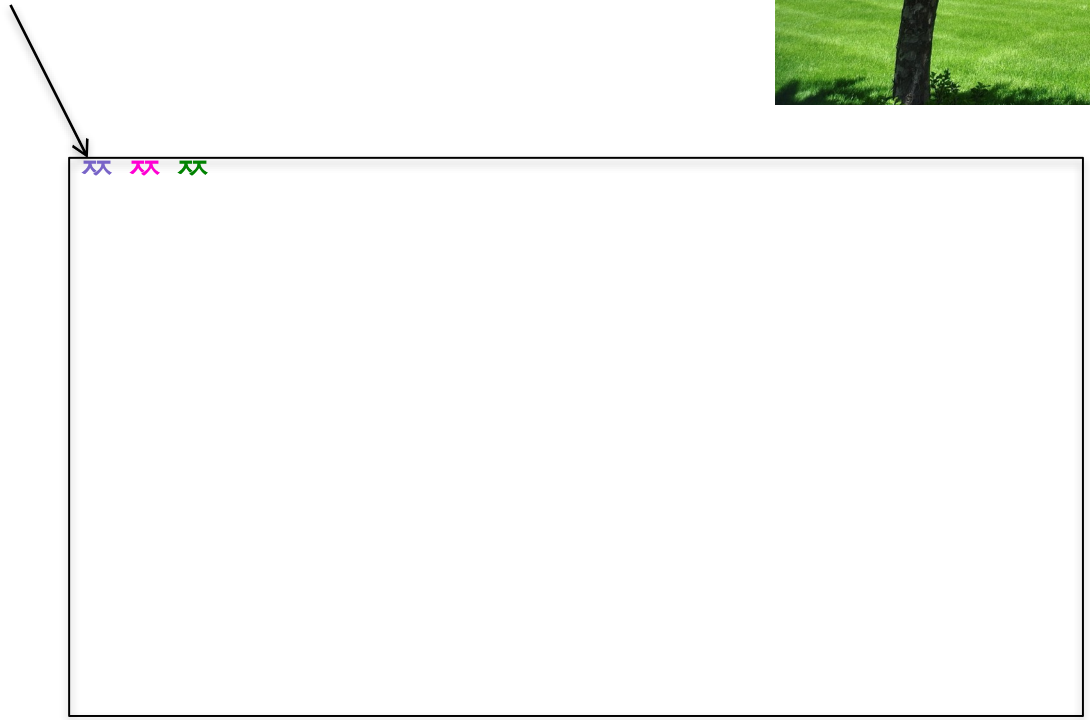
Digital Data

Digital Data



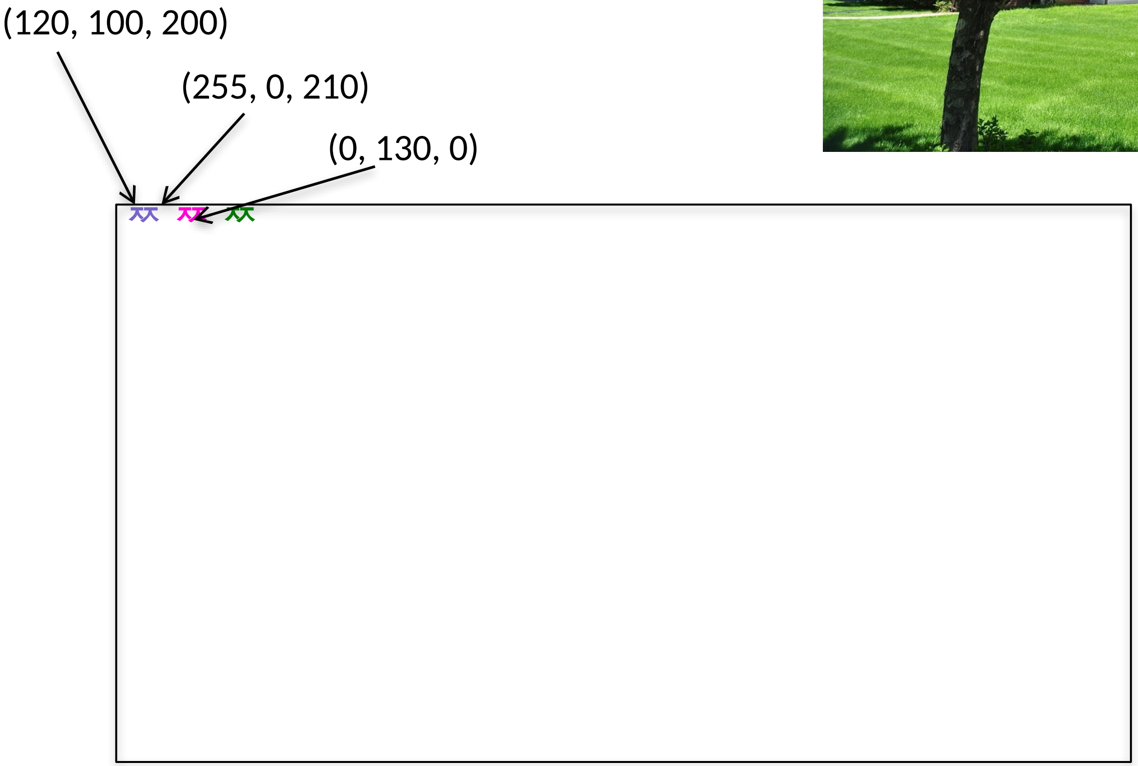
Digital Data

(120, 100, 200)



Digital Data

Digital Data



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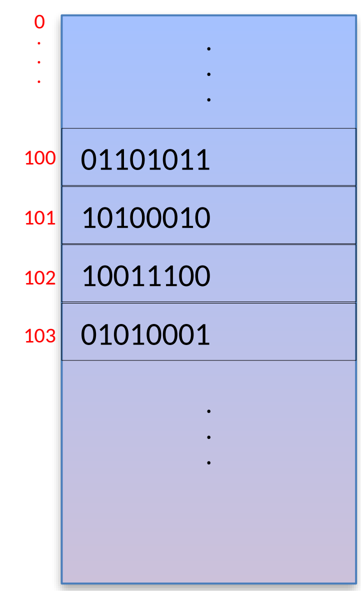

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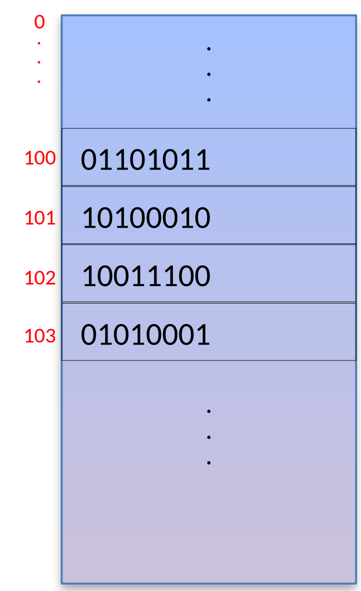
  - Text: Each character is mapped to a number
  - Images: Matrix of pixels' colors. Each color is represented as (R,G,B) levels
  - Video
  - Audio



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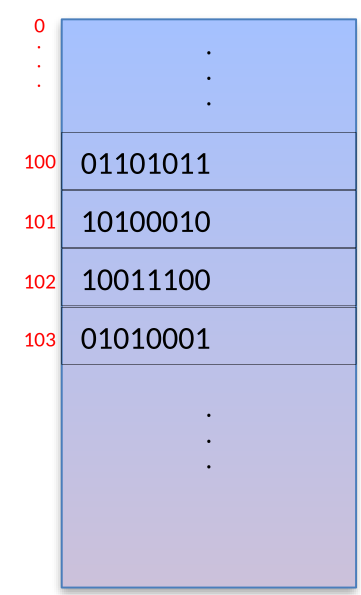
  - Text: Each character is mapped to a number
  - Images: Matrix of pixels' colors. Each color is represented as (R,G,B) levels
  - Video: Sequence of images
  - Audio



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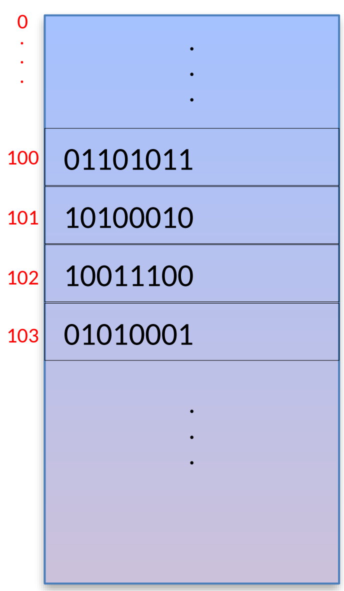
  - Numbers: Represented in binary
  - Text: Each character is mapped to a number
  - Images: Matrix of pixels' colors. Each color is represented as (R,G,B) levels
  - Video: Sequence of images
  - Audio: Sampled voltage levels



Lets Count

Lets Count

Decimal (base 10)

Lets Count

Decimal (base 10)

0

Lets Count

Decimal (base 10)

0

1

Lets Count

Decimal (base 10)

0

1

2

Lets Count

Decimal (base 10)

0

1

2

3

Lets Count

Decimal (base 10)

0

1

2

3

4

5

6

7

8

9

Lets Count

Decimal (base 10)

0

1

2

3

4

5

6

7

8

9

10

Lets Count

Decimal (base 10)

0	11
1	12
2	…
3	19
4	
5	
6	
7	
8	
9	
10	

Lets Count

Decimal (base 10)

0	11
1	12
2	…
3	19
4	20
5	
6	
7	
8	
9	
10	

Lets Count

Decimal (base 10)

0	11
1	12
2	…
3	19
4	20
5	21
6	…
7	
8	
9	
10	

Lets Count

Decimal (base 10)

0	11
1	12
2	…
3	19
4	20
5	21
6	…
7	99
8	
9	
10	

Lets Count

Decimal (base 10)

0	11
1	12
2	…
3	19
4	20
5	21
6	…
7	99
8	100
9	
10	

Lets Count

Decimal (base 10)

0	11
1	12
2	…
3	19
4	20
5	21
6	…
7	99
8	100
9	101
10	…

Lets Count

Decimal (base 10)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

0	11
1	12
2	…
3	19
4	20
5	21
6	…
7	99
8	100
9	101
10	…

Lets Count

base 5

Lets Count

base 5

0

Lets Count

base 5

0

1

Lets Count

base 5

0

1

2

Lets Count

base 5

0

1

2

3

Lets Count

base 5

0

1

2

3

4

Lets Count

base 5

0

1

2

3

4

10

Lets Count

base 5

0
1
2
3
4
10
11
12
13
14

Lets Count

base 5

0
1
2
3
4
10
11
12
13
14
20

Lets Count

base 5

0	21
1	22
2	…
3	
4	
10	
11	
12	
13	
14	
20	

Lets Count

base 5

0	21
1	22
2	…
3	
4	100
10	
11	
12	
13	
14	
20	

Lets Count

base 5

0	21
1	22
2	...
3	44
4	100
10	
11	
12	
13	
14	
20	

Lets Count

base 5

0	21
1	22
2	…
3	44
4	100
10	101
11	…
12	
13	
14	
20	

Lets Count

base 5

Digits: 0, 1, 2, 3, 4

0	21
1	22
2	...
3	44
4	100
10	101
11	...
12	
13	
14	
20	

Lets Count

Octal (base 8)

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0

1

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0

1

2

3

4

5

6

7

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0

1

2

3

4

5

6

7

10

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0	13
1	14
2	15
3	16
4	17
5	
6	
7	
10	
11	
12	

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0	13
1	14
2	15
3	16
4	17
5	20
6	
7	
10	
11	
12	

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0	13
1	14
2	15
3	16
4	17
5	20
6	21
7	…
10	
11	
12	

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0	13
1	14
2	15
3	16
4	17
5	20
6	21
7	…
10	
11	100
12	

Lets Count

Octal (base 8)

Digits: 0, 1, 2, 3, 4, 5, 6, 7

0	13
1	14
2	15
3	16
4	17
5	20
6	21
7	…
10	77
11	100
12	…

Lets Count

Binary (base 2)

Lets Count

Binary (base 2)

Digits: 0, 1

Lets Count

Binary (base 2)

Digits: 0, 1

0

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

101

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

101

110

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

101

110

111

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

101

110

111

1000

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

101

110

111

1000

1001

Lets Count

Binary (base 2)

Digits: 0, 1

0

1

10

11

100

101

110

111

1000

1001

1010

…

Lets Count

Hexadecimal (base 16)

Lets Count

Hexadecimal (base 16)

0

Lets Count

Hexadecimal (base 16)

0

1

Lets Count

Hexadecimal (base 16)

0

1

2

Lets Count

Hexadecimal (base 16)

0
1
2
3
4
5
6
7
8

9

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9
1	
2	
3	
4	
5	
6	
7	
8	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9
1	a
2	
3	
4	
5	
6	
7	
8	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9
1	a
2	b
3	
4	
5	
6	
7	
8	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9
1	a
2	b
3	c
4	d
5	e
6	f
7	
8	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0
1
2
3
4
5
6
7
8

9
a
b
c
d
e
f
10

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12
1	a	13
2	b	…
3	c	19
4	d	
5	e	
6	f	
7	10	
8	11	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12
1	a	13
2	b	…
3	c	19
4	d	1a
5	e	
6	f	
7	10	
8	11	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12
1	a	13
2	b	…
3	c	19
4	d	1a
5	e	1b
6	f	…
7	10	1f
8	11	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12
1	a	13
2	b	…
3	c	19
4	d	1a
5	e	1b
6	f	…
7	10	1f
8	11	20

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12	21
1	a	13	22
2	b	…	…
3	c	19	2f
4	d	1a	
5	e	1b	
6	f	…	
7	10	1f	
8	11	20	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12	21
1	a	13	22
2	b	…	…
3	c	19	2f
4	d	1a	30
5	e	1b	
6	f	…	
7	10	1f	
8	11	20	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12	21
1	a	13	22
2	b	…	…
3	c	19	2f
4	d	1a	30
5	e	1b	…
6	f	…	
7	10	1f	100
8	11	20	

Lets Count

Hexadecimal (base 16)

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f

0	9	12	21
1	a	13	22
2	b	…	…
3	c	19	2f
4	d	1a	30
5	e	1b	…
6	f	…	ff
7	10	1f	100
8	11	20	…

Equivalent Representations

Equivalent Representations

13

Equivalent Representations

$(13)_{10}$

Equivalent Representations

$(13)_{10} = (\quad\quad)_8$

Equivalent Representations

$(13)_{10} = (15)_8$

Equivalent Representations

$(13)_{10} = (15)_8 = (\quad)_5$

Equivalent Representations

$(13)_{10} = (15)_8 = (23)_5$

Equivalent Representations

$$(13)_{10} = (15)_8 = (23)_5 = (\qquad\qquad)_2$$

Equivalent Representations

$$(13)_{10} = (15)_8 = (23)_5 = (1101)_2$$

Equivalent Representations

$$(13)_{10} = (15)_8 = (23)_5 = (1101)_2 = (\quad)_{16}$$

Equivalent Representations

$$(13)_{10} = (15)_8 = (23)_5 = (1101)_2 = (d)_{16}$$

Equivalent Representations

$$(13)_{10} = (15)_8 = (23)_5 = (1101)_2 = (d)_{16}$$

Representation of number N in base b_1 → Representation of number N in base b_2

Base Conversions

Base Conversions

(i) N in base b $\longrightarrow$ N in decimal

Base Conversions

(i) N in base b $\longrightarrow$ N in decimal

(ii) N in decimal $\longrightarrow$ N in base b

Base Conversions

(i) N in base b ⟶ N in decimal

(ii) N in decimal ⟶ N in base b

(i) base b □ decimal

(i) base b □ decimal

$(3\ 7\ 5)_{10}$

(i) base b → decimal

$(3\ 7\ \underbrace{5})_{10}$

(i) base b decimal

$$(3\ 7\ \underbrace{5}_{1})_{10}$$

(i) base b → decimal

$(3\ \underbrace{7}\ \underbrace{5}_{1})_{10}$

(i) base b → decimal

$$(3\,\underbrace{7}_{10}\,\underbrace{5}_{1})_{10}$$

(i) base b □ decimal

$$(\underbrace{3}\ \underbrace{7}_{10}\ \underbrace{5}_{1})_{10}$$

(i) base b □ decimal

$$(\underbrace{3}_{100}\,\underbrace{7}_{10}\,\underbrace{5}_{1})_{10}$$

(i) base b → decimal

$$(\underbrace{3}_{100}\,\underbrace{7}_{10}\,\underbrace{5}_{1})_{10}$$

||

10^2

(i) base b decimal

$$\left(\underbrace{3}_{\substack{100 \\ || \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ || \\ 10^1}}\ \underbrace{5}_{1}\right)_{10}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ ||\\ 10^2}}\;\underbrace{7}_{\substack{10\\ ||\\ 10^1}}\;\underbrace{5}_{\substack{1\\ ||\\ 10^0}})_{10}$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100 \\ || \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ || \\ 10^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 10^0}})_{10} = 5\cdot 10^0$$

(i) base b $\to$ decimal

$$(\underbrace{3}_{\substack{100 \\ || \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ || \\ 10^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100 \\ \| \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ \| \\ 10^1}}\ \underbrace{5}_{\substack{1 \\ \| \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100 \\ || \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ || \\ 10^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \| \\ 10^2}}\ \underbrace{7}_{\substack{10\\ \| \\ 10^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(1\ 2\ 5)_8$$

(i) base b □ decimal

$$(\underbrace{3}_{100 \,=\, 10^2}\ \underbrace{7}_{10 \,=\, 10^1}\ \underbrace{5}_{1 \,=\, 10^0})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(1\ 2\ \underbrace{5}_{})_8$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \parallel \\ 10^2}}\ \underbrace{7}_{\substack{10\\ \parallel \\ 10^1}}\ \underbrace{5}_{\substack{1\\ \parallel \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(1\ 2\ \underbrace{5}_{1})_8$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(1\ \underbrace{2}_{}\ \underbrace{5}_{1})_{8}$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(1\ \underbrace{2}_{8}\ \underbrace{5}_{1})_{8}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\;\underbrace{7}_{\substack{10\\ \|\\ 10^1}}\;\underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{}\;\underbrace{2}_{8}\;\underbrace{5}_{1})_{8}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{64}\ \underbrace{2}_{8}\ \underbrace{5}_{1})_{8}$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100 \\ \| \\ 10^2}}\,\underbrace{7}_{\substack{10 \\ \| \\ 10^1}}\,\underbrace{5}_{\substack{1 \\ \| \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64 \\ \| \\ 8^2}}\,\underbrace{2}_{8}\,\underbrace{5}_{1})_{8}$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8}$$

(i) base b → decimal

$$(\underbrace{3}_{100 = 10^2}\,\underbrace{7}_{10 = 10^1}\,\underbrace{5}_{1 = 10^0})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{64 = 8^2}\,\underbrace{2}_{8 = 8^1}\,\underbrace{5}_{1 = 8^0})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100\\ \| \\ 10^2}}\ \underbrace{7}_{\substack{10\\ \| \\ 10^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 10^0}})_{10} = 5\cdot10^0 + 7\cdot10^1 + 3\cdot10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \| \\ 8^2}}\ \underbrace{2}_{\substack{8\\ \| \\ 8^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 8^0}})_{8} = 5\cdot8^0 + 2\cdot8^1 + 1\cdot8^2 = 85$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \| \\ 10^2}}\ \underbrace{7}_{\substack{10\\ \| \\ 10^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \| \\ 8^2}}\ \underbrace{2}_{\substack{8\\ \| \\ 8^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(1\ 0\ 1\ 1)_2$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100 \\ || \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ || \\ 10^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64 \\ || \\ 8^2}}\ \underbrace{2}_{\substack{8 \\ || \\ 8^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 8^0}})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2 = 85$$

$$(\underbrace{1}\ \underbrace{0}\ \underbrace{1}\ \underbrace{1})_2$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2 = 85$$

$$(\underbrace{1}\ \underbrace{0}\ \underbrace{1}\ \underbrace{1}_{1})_{2}$$

(i) base b □ decimal

$$(\underbrace{3}_{100 = 10^2}\ \underbrace{7}_{10 = 10^1}\ \underbrace{5}_{1 = 10^0})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{64 = 8^2}\ \underbrace{2}_{8 = 8^1}\ \underbrace{5}_{1 = 8^0})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2 = 85$$

$$(\underbrace{1}_{}\ \underbrace{0}_{}\ \underbrace{1}_{2}\ \underbrace{1}_{1})_{2}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \| \\ 10^2}}\;\underbrace{7}_{\substack{10\\ \| \\ 10^1}}\;\underbrace{5}_{\substack{1\\ \| \\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \| \\ 8^2}}\;\underbrace{2}_{\substack{8\\ \| \\ 8^1}}\;\underbrace{5}_{\substack{1\\ \| \\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}\;\underbrace{0}_{4}\;\underbrace{1}_{2}\;\underbrace{1}_{1})_{2}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100 \\ || \\ 10^2}}\ \underbrace{7}_{\substack{10 \\ || \\ 10^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64 \\ || \\ 8^2}}\ \underbrace{2}_{\substack{8 \\ || \\ 8^1}}\ \underbrace{5}_{\substack{1 \\ || \\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{8}\ \underbrace{0}_{4}\ \underbrace{1}_{2}\ \underbrace{1}_{1})_{2}$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\ \underbrace{0}_{\substack{4\\ \|\\ 2^2}}\ \underbrace{1}_{\substack{2\\ \|\\ 2^1}}\ \underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \| \\ 10^2}}\ \underbrace{7}_{\substack{10\\ \| \\ 10^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \| \\ 8^2}}\ \underbrace{2}_{\substack{8\\ \| \\ 8^1}}\ \underbrace{5}_{\substack{1\\ \| \\ 8^0}})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \| \\ 2^3}}\ \underbrace{0}_{\substack{4\\ \| \\ 2^2}}\ \underbrace{1}_{\substack{2\\ \| \\ 2^1}}\ \underbrace{1}_{\substack{1\\ \| \\ 2^0}})_{2} = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 1 \cdot 2^3$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ ||\\ 10^2}}\ \underbrace{7}_{\substack{10\\ ||\\ 10^1}}\ \underbrace{5}_{\substack{1\\ ||\\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ ||\\ 8^2}}\ \underbrace{2}_{\substack{8\\ ||\\ 8^1}}\ \underbrace{5}_{\substack{1\\ ||\\ 8^0}})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ ||\\ 2^3}}\ \underbrace{0}_{\substack{4\\ ||\\ 2^2}}\ \underbrace{1}_{\substack{2\\ ||\\ 2^1}}\ \underbrace{1}_{\substack{1\\ ||\\ 2^0}})_{2} = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 1 \cdot 2^3 = 11$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5 \cdot 10^0 + 7 \cdot 10^1 + 3 \cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5 \cdot 8^0 + 2 \cdot 8^1 + 1 \cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\ \underbrace{0}_{\substack{4\\ \|\\ 2^2}}\ \underbrace{1}_{\substack{2\\ \|\\ 2^1}}\ \underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2} = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 1 \cdot 2^3 = 11$$

$$(3\ b\ 2)_{16}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\ \underbrace{0}_{\substack{4\\ \|\\ 2^2}}\ \underbrace{1}_{\substack{2\\ \|\\ 2^1}}\ \underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2} = 1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 1\cdot 2^3 = 11$$

$$(\underbrace{3}_{}\ \underbrace{b}_{}\ \underbrace{2}_{})_{16}$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\ \underbrace{0}_{\substack{4\\ \|\\ 2^2}}\ \underbrace{1}_{\substack{2\\ \|\\ 2^1}}\ \underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2} = 1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 1\cdot 2^3 = 11$$

$$(\underbrace{3}_{16^2}\ \underbrace{b}_{16^1}\ \underbrace{2}_{16^0})_{16}$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\ \underbrace{0}_{\substack{4\\ \|\\ 2^2}}\ \underbrace{1}_{\substack{2\\ \|\\ 2^1}}\ \underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2} = 1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 1\cdot 2^3 = 11$$

$$(\underbrace{3}_{16^2}\ \underbrace{b}_{16^1}\ \underbrace{2}_{16^0})_{16} = 2\cdot 16^0 + 11\cdot 16^1 + 3\cdot 16^2$$

(i) base b → decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\ \underbrace{7}_{\substack{10\\ \|\\ 10^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\ \underbrace{2}_{\substack{8\\ \|\\ 8^1}}\ \underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\ \underbrace{0}_{\substack{4\\ \|\\ 2^2}}\ \underbrace{1}_{\substack{2\\ \|\\ 2^1}}\ \underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2} = 1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 1\cdot 2^3 = 11$$

$$(\underbrace{3}_{16^2}\ \underbrace{b}_{16^1}\ \underbrace{2}_{16^0})_{16} = 2\cdot 16^0 + 11\cdot 16^1 + 3\cdot 16^2 = 946$$

(i) base b □ decimal

$$(\underbrace{3}_{\substack{100\\ \|\\ 10^2}}\;\underbrace{7}_{\substack{10\\ \|\\ 10^1}}\;\underbrace{5}_{\substack{1\\ \|\\ 10^0}})_{10} = 5\cdot 10^0 + 7\cdot 10^1 + 3\cdot 10^2 = 375$$

$$(\underbrace{1}_{\substack{64\\ \|\\ 8^2}}\;\underbrace{2}_{\substack{8\\ \|\\ 8^1}}\;\underbrace{5}_{\substack{1\\ \|\\ 8^0}})_{8} = 5\cdot 8^0 + 2\cdot 8^1 + 1\cdot 8^2 = 85$$

$$(\underbrace{1}_{\substack{8\\ \|\\ 2^3}}\;\underbrace{0}_{\substack{4\\ \|\\ 2^2}}\;\underbrace{1}_{\substack{2\\ \|\\ 2^1}}\;\underbrace{1}_{\substack{1\\ \|\\ 2^0}})_{2} = 1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 1\cdot 2^3 = 11$$

$$(\underbrace{3}_{16^2}\;\underbrace{b}_{16^1}\;\underbrace{2}_{16^0})_{16} = 2\cdot 16^0 + 11\cdot 16^1 + 3\cdot 16^2 = 946$$

$$(a_n \ldots a_2 a_1 a_0)_b = a_0\cdot b^0 + a_1\cdot b^1 + a_2\cdot b^2 + \ldots + a_n\cdot b^n$$

Base Conversions

(i) N in base b → N in decimal

(ii) N in decimal → N in base b

Base Conversions

(i) N in base b → N in decimal

(ii) N in decimal → N in base b

(ii) decimal → base b (demonstrated on b=2)

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

$$\ldots \;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}\;\;\underline{\quad\quad}$$

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

$$\ldots \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \_\_\_ \quad \underset{2^0}{\_\_\_}$$

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

$$\ldots\ \underline{\qquad}\ \ \underline{\qquad}\ \ \underline{\qquad}\ \ \underline{\qquad}\ \ \underline{\qquad}\ \ \underline{\qquad}\ \ \underline{\qquad}\ \ \underline{\qquad}\ \ \underset{2^1}{\underline{\qquad}}\ \ \underset{2^0}{\underline{\qquad}}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

$$\ldots \;\_\_\_\; \_\_\_\; \_\_\_\; \_\_\_\; \_\_\_\; \_\_\_\; \_\_\_\; \underset{2^2}{\_\_\_}\; \underset{2^1}{\_\_\_}\; \underset{2^0}{\_\_\_}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

...	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
										||
										1

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
									$\parallel$	$\parallel$
									2	1

(ii) decimal ▭ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
								$\parallel$	$\parallel$	$\parallel$
								4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
							$\|\|$	$\|\|$	$\|\|$	$\|\|$
							8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
						$\|\|$	$\|\|$	$\|\|$	$\|\|$	$\|\|$
						16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

...	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
					||	||	||	||	||	||
					32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
				$\vert\vert$	$\vert\vert$	$\vert\vert$	$\vert\vert$	$\vert\vert$	$\vert\vert$	$\vert\vert$
				64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
			||	||	||	||	||	||	||	||
			128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
		||	||	||	||	||	||	||	||	||
		256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

		?								
…	___	___	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…										
	___	1	___	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	?								
2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
||	||	||	||	||	||	||	||	||	||
512	256	128	64	32	16	8	4	2	1

(ii) decimal ⎵ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

...	0								
2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
||	||	||	||	||	||	||	||	||	||
512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

...	0	0	0	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	___	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	?	__	__	__	__	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	0	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…										
	0	0	0	0	1	1	1	1	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad\qquad)_2$$

…	0	0	0	0	1	1	1	1	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

75

$1 + 2 + 4 + 8 + 16 + 32 = 63$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

...	0	0	0	0	1	1	1	1	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

$1 + 2 + 4 + 8 + 16 + 32 = 63$

$1 + 2 + 4 + 8 + \ldots + 2^k =$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad)_2$$

…	0	0	0	0	1	1	1	1	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	?	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	___	___	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	__	__	__	__	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{75}$$

$1 + 2 + 4 + 8 + 16 + 32 = 63$

$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	__	__	__	__	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{11}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\ \underline{64} \\ 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	__	__	__	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{11}$$

$1 + 2 + 4 + 8 + 16 + 32 = 63$

$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$

$$\begin{array}{r} 75 \\ -\underline{64} \\ 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	___	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

11

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	?	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{11}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad)_2$$

…	0	0	0	1	0	0	0	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{11}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$$

$$\begin{array}{r} 75 \\ -\underline{64} \\ 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	0	1	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

11

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\ \underline{64} \\ 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad)_2$$

…	0	0	0	1	0	0	?			
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

11

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	1	__	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1}_{11}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad)_2$$

…	0	0	0	1	0	0	1	__	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

11

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array} \qquad \begin{array}{r} 11 \\ -\ 8 \\ \hline 3 \end{array}$$

(ii) decimal → base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	1	___	___	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{4 \quad 2 \quad 1}_{3}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\underline{64} \\ 11 \end{array} \qquad \begin{array}{r} 11 \\ -\underline{\ 8} \\ 3 \end{array}$$

(ii) decimal $\rightarrow$ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	1	0	__	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

3

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1}-1$$

$$\begin{array}{r} 75 \\ -\underline{64} \\ 11 \end{array} \qquad \begin{array}{r} 11 \\ -\underline{\ 8} \\ 3 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad)_2$$

…	0	0	0	1	0	0	1	0	1	
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{4 \quad 2 \quad 1}_{3}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\ 64 \\ \hline 11 \end{array} \qquad \begin{array}{r} 11 \\ -\ 8 \\ \hline 3 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…	0	0	0	1	0	0	1	0	1	__
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

$$\underbrace{4 \quad 2 \quad 1}_{3}$$

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\underline{64} \\ 11 \end{array} \qquad \begin{array}{r} 11 \\ -\underline{\ 8} \\ 3 \end{array} \qquad \begin{array}{r} 3 \\ -\underline{\ 2} \\ 1 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

…										
	0	0	0	1	0	0	1	0	1	___
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1
										1

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\underline{\;64} \\ 11 \end{array} \qquad \begin{array}{r} 11 \\ -\underline{\;\;8} \\ 3 \end{array} \qquad \begin{array}{r} 3 \\ -\underline{\;\;2} \\ 1 \end{array}$$

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad)_2$$

...	0	0	0	1	0	0	1	0	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1
										1

$$1 + 2 + 4 + 8 + 16 + 32 = 63$$

$$1 + 2 + 4 + 8 + \ldots + 2^k = 2^{k+1} - 1$$

$$\begin{array}{r} 75 \\ -\underline{64} \\ 11 \end{array} \qquad \begin{array}{r} 11 \\ -\underline{\ \ 8} \\ 3 \end{array} \qquad \begin{array}{r} 3 \\ -\underline{\ \ 2} \\ 1 \end{array}$$

(ii) decimal $\sqcup$ base b (demonstrated on b=2)

$$(75)_{10} = (\qquad\qquad\qquad)_2$$

...	0	0	0	1	0	0	1	0	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (1001011)_2$$

…	0	0	0	1	0	0	1	0	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

(ii) decimal □ base b (demonstrated on b=2)

$$(75)_{10} = (1001011)_2$$

…	0	0	0	1	0	0	1	0	1	1
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	||	||	||	||	||	||	||	||	||	||
	512	256	128	64	32	16	8	4	2	1

Base Conversions

(i) N in base b $\longrightarrow$ N in decimal

(ii) N in decimal $\longrightarrow$ N in base b

Base Conversions

(i) N in base b $\longrightarrow$ N in decimal

(ii) N in decimal $\longrightarrow$ N in base b

(iii) N in binary $\longleftrightarrow$ N in hexadecimal

(iii) binary $\longleftrightarrow$ hexadecimal

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad\qquad\qquad)_2$$

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$$

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
a	
b	
c	
d	
e	
f	

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$$

(iii) binary ⟷ hexadecimal

Hex Digit	4 bit binary
0	0000
1	
2	
3	
4	
5	
6	
7	
8	
9	
a	
b	
c	
d	
e	
f	

$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$

(iii) binary ⟷ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	
3	
4	
5	
6	
7	
8	
9	
a	
b	
c	
d	
e	
f	

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$$

(iii) binary ⟷ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	
4	
5	
6	
7	
8	
9	
a	
b	
c	
d	
e	
f	

$$(3b9)_{16} = (\qquad\qquad\qquad)_2$$

(iii) binary ⟷ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	0011
4	
5	
6	
7	
8	
9	
a	
b	
c	
d	
e	
f	

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$$

(iii) binary ⟷ hexadecimal

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

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\qquad\qquad\qquad\qquad)_2$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\quad \underbrace{1001}_{9})_2$$

(iii) binary ⟷ hexadecimal

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

$$(3b9)_{16} = (\qquad \underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

(iii) binary ⟷ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\ 11011010011)_2 = (\qquad\qquad)_{16}$$

(iii) binary ⟷ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\ 1101101\underbrace{0011})_2 = (\qquad\qquad)_{16}$$

(iii) binary ⟷ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\ 110\underbrace{1101}\underbrace{0011})_2 = (\qquad)_{16}$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\underbrace{110}\underbrace{1110}\underbrace{1001}\underbrace{1}\,)_2 = (\qquad\qquad)_{16}$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\underbrace{0110}\underbrace{1101}\underbrace{0011})_2 = (\qquad\qquad)_{16}$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\underbrace{{\color{red}0}110}\underbrace{1101}\underbrace{0011}_{3})_2 = (\qquad\qquad)_{16}$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\underbrace{0110}\underbrace{1101}_{d}\underbrace{0011}_{3})_2 = (\qquad)_{16}$$

(iii) binary ⟷ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\underbrace{0110}_{6}\underbrace{1101}_{d}\underbrace{0011}_{3})_2 = (\qquad)_{16}$$

(iii) binary $\longleftrightarrow$ hexadecimal

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

$$(3b9)_{16} = (\underbrace{0011}_{3}\underbrace{1011}_{b}\underbrace{1001}_{9})_2$$

$$(\underbrace{{\color{red}0}110}_{6}\underbrace{1101}_{d}\underbrace{0011}_{3})_2 = (6d3)_{16}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1 \cdot 2^0$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1 \cdot 2^0 + 1 \cdot 2^1$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1{\cdot}2^0+1{\cdot}2^1+0{\cdot}2^2+0{\cdot}2^3+1{\cdot}2^4+0{\cdot}2^5+1{\cdot}2^6+1{\cdot}2^7+0{\cdot}2^8+1{\cdot}2^9+1{\cdot}2^{10}+0{\cdot}2^{11}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$=$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3\qquad}$$

(iii) binary ⟷ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 1}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 0\cdot 2^3} + 1\cdot 2^4 + 0\cdot 2^5 + 1\cdot 2^6 + 1\cdot 2^7 + 0\cdot 2^8 + 1\cdot 2^9 + 1\cdot 2^{10} + 0\cdot 2^{11}$

$= \underbrace{(1\cdot 2^0 + 1\cdot 2^1 + 0\cdot 2^2 + 0\cdot 2^3)\cdot 2^0}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3} + \underbrace{1 \cdot 2^4 + 0 \cdot 2^5 + 1 \cdot 2^6 + 1 \cdot 2^7} + 0 \cdot 2^8 + 1 \cdot 2^9 + 1 \cdot 2^{10} + 0 \cdot 2^{11}$

$= \underbrace{(1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3) \cdot 2^0 +} \qquad \underbrace{\qquad\qquad\qquad\qquad}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(\qquad\qquad\qquad\qquad\qquad)\cdot 2^4}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3}_{} + \underbrace{1 \cdot 2^4 + 0 \cdot 2^5 + 1 \cdot 2^6 + 1 \cdot 2^7}_{} + 0 \cdot 2^8 + 1 \cdot 2^9 + 1 \cdot 2^{10} + 0 \cdot 2^{11}$

$= \underbrace{(1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3) \cdot 2^0}_{} + \underbrace{(1 \cdot 2^0 \qquad\qquad\qquad\qquad) \cdot 2^4}_{}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1 \qquad\qquad)\cdot 2^4}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2 \qquad)\cdot 2^4}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$

$= (1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0+(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4+$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3}_{} + \underbrace{1 \cdot 2^4 + 0 \cdot 2^5 + 1 \cdot 2^6 + 1 \cdot 2^7}_{} + \underbrace{0 \cdot 2^8 + 1 \cdot 2^9 + 1 \cdot 2^{10} + 0 \cdot 2^{11}}_{}$

$= \underbrace{(1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3) \cdot 2^0}_{} + \underbrace{(1 \cdot 2^0 + 0 \cdot 2^1 + 1 \cdot 2^2 + 1 \cdot 2^3) \cdot 2^4}_{} + \underbrace{(\qquad\qquad\qquad) \cdot 2^8}_{}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3}+\underbrace{1\cdot2^4+0\cdot2^5+1\cdot2^6+1\cdot2^7}+\underbrace{0\cdot2^8+1\cdot2^9+1\cdot2^{10}+0\cdot2^{11}}$$

$$= \underbrace{(1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3)\cdot2^0}+\underbrace{(1\cdot2^0+0\cdot2^1+1\cdot2^2+1\cdot2^3)\cdot2^4}+\underbrace{(0\cdot2^0+\qquad\qquad)\cdot2^8}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2$ =

$$= 1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$= (1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0+(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4+(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3}+\underbrace{1\cdot2^4+0\cdot2^5+1\cdot2^6+1\cdot2^7}+\underbrace{0\cdot2^8+1\cdot2^9+1\cdot2^{10}+0\cdot2^{11}}$$

$$= \underbrace{(1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3)\cdot2^0}+\underbrace{(1\cdot2^0+0\cdot2^1+1\cdot2^2+1\cdot2^3)\cdot2^4}+\underbrace{(0\cdot2^0+1\cdot2^1+1\cdot2^2+0\cdot2^3)\cdot2^8}$$

(iii) binary ⟷ hexadecimal

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

(iii) binary ⟷ hexadecimal

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

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	0011 = $1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	1101
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	1101
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{\underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)}_{3}\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

(iii) binary ⟷ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}_{}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}_{}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}_{}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}_{}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}_{}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}_{}$

$= \underbrace{(3)\cdot 2^0}_{}$

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= 1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$= (1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0+(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4+(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8$$

$$= (3)\cdot 2^0$$

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	1101
e	1110
f	1111

(iii) binary ⟷ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	1101
e	1110
f	1111

(iii) binary $\leftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	0011 = $1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	1101= $1 \cdot 2^0 + 0 \cdot 2^1 + 1 \cdot 2^2 + 1 \cdot 2^3$
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1{\cdot}2^0 + 1{\cdot}2^1 + 0{\cdot}2^2 + 0{\cdot}2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	$1101 = 1{\cdot}2^0 + 0{\cdot}2^1 + 1{\cdot}2^2 + 1{\cdot}2^3 = 13$
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0}$$

(iii) binary $\leftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3}+\underbrace{1\cdot2^4+0\cdot2^5+1\cdot2^6+1\cdot2^7}+\underbrace{0\cdot2^8+1\cdot2^9+1\cdot2^{10}+0\cdot2^{11}}$$

$$= \underbrace{(1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3)\cdot2^0}+\underbrace{(\underbrace{1\cdot2^0+0\cdot2^1+1\cdot2^2+1\cdot2^3}_{13})\cdot2^4}+\underbrace{(0\cdot2^0+1\cdot2^1+1\cdot2^2+0\cdot2^3)\cdot2^8}$$

$$= \underbrace{(3)\cdot2^0}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= 1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$$

$$= (1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0+(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4+(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8$$

$$= (3)\cdot 2^0 + (13)\cdot 2^4$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4}$$

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1{\cdot}2^0 + 1{\cdot}2^1 + 0{\cdot}2^2 + 0{\cdot}2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	$1101 = 1{\cdot}2^0 + 0{\cdot}2^1 + 1{\cdot}2^2 + 1{\cdot}2^3 = 13$
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	0011 = $1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3 = 3$
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	1101 = $1 \cdot 2^0 + 0 \cdot 2^1 + 1 \cdot 2^2 + 1 \cdot 2^3 = 13$
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3 = 3$
4	0100
5	0101
6	$0110 = 0 \cdot 2^0 + 1 \cdot 2^1 + 1 \cdot 2^2 + 0 \cdot 2^3$
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	$1101 = 1 \cdot 2^0 + 0 \cdot 2^1 + 1 \cdot 2^2 + 1 \cdot 2^3 = 13$
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

Hex Digit	4 bit binary
0	0000
1	0001
2	0010
3	$0011 = 1{\cdot}2^0 + 1{\cdot}2^1 + 0{\cdot}2^2 + 0{\cdot}2^3 = 3$
4	0100
5	0101
6	$0110 = 0{\cdot}2^0 + 1{\cdot}2^1 + 1{\cdot}2^2 + 0{\cdot}2^3 = 6$
7	0111
8	1000
9	1001
a	1010
b	1011
c	1100
d	$1101 = 1{\cdot}2^0 + 0{\cdot}2^1 + 1{\cdot}2^2 + 1{\cdot}2^3 = 13$
e	1110
f	1111

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)}_{6}\cdot 2^8$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3+1\cdot2^4+0\cdot2^5+1\cdot2^6+1\cdot2^7+0\cdot2^8+1\cdot2^9+1\cdot2^{10}+0\cdot2^{11}$

$= (1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3)\cdot2^0+(1\cdot2^0+0\cdot2^1+1\cdot2^2+1\cdot2^3)\cdot2^4+(0\cdot2^0+1\cdot2^1+1\cdot2^2+0\cdot2^3)\cdot2^8$

$= (3)\cdot2^0 \quad + \quad (13)\cdot2^4 \quad + \quad (6)\cdot2^8$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$

$= \underbrace{(3)\cdot 2^0}_{2^0} + (13)\cdot 2^4 + (6)\cdot 2^8$

$=$

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$$

$2^0 = 1$

$$=$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3+1\cdot2^4+0\cdot2^5+1\cdot2^6+1\cdot2^7+0\cdot2^8+1\cdot2^9+1\cdot2^{10}+0\cdot2^{11}$

$= (1\cdot2^0+1\cdot2^1+0\cdot2^2+0\cdot2^3)\cdot2^0+(1\cdot2^0+0\cdot2^1+1\cdot2^2+1\cdot2^3)\cdot2^4+(0\cdot2^0+1\cdot2^1+1\cdot2^2+0\cdot2^3)\cdot2^8$

$= (3)\cdot2^0 + (13)\cdot2^4 + (6)\cdot2^8$

$2^0 = 1 = 16^0$

$=$

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 16^0}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= 1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3+1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7+0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}$

$= (1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0+(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4+(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8$

$= \quad (3)\cdot 2^0 \quad + \quad (13)\cdot 2^4 \quad + \quad (6)\cdot 2^8$

2^4

$= \quad (3)\cdot 16^0$

(iii) binary $\leftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4}_{2^4 = 16} + \underbrace{(6)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 16^0}$$

(iii) binary $\leftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$

$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$

$2^4 = 16 = 16^1$

$= \underbrace{(3)\cdot 16^0}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$

$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$

$= \underbrace{(3)\cdot 16^0} + \underbrace{(13)\cdot 16^1}$

(iii) binary $\longleftrightarrow$ hexadecimal

$$(011011010011)_2 =$$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8 \quad}_{2^8}$$

$$= \underbrace{(3)\cdot 16^0} + \underbrace{(13)\cdot 16^1}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$$

$$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$$

$$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$$

$2^8 = (2^4)^2$

$$= \underbrace{(3)\cdot 16^0} + \underbrace{(13)\cdot 16^1}$$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$

$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$

$2^8 = (2^4)^2 = (16)^2$

$= \underbrace{(3)\cdot 16^0} + \underbrace{(13)\cdot 16^1}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$= \underbrace{1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3}+\underbrace{1\cdot 2^4+0\cdot 2^5+1\cdot 2^6+1\cdot 2^7}+\underbrace{0\cdot 2^8+1\cdot 2^9+1\cdot 2^{10}+0\cdot 2^{11}}$

$= \underbrace{(1\cdot 2^0+1\cdot 2^1+0\cdot 2^2+0\cdot 2^3)\cdot 2^0}+\underbrace{(1\cdot 2^0+0\cdot 2^1+1\cdot 2^2+1\cdot 2^3)\cdot 2^4}+\underbrace{(0\cdot 2^0+1\cdot 2^1+1\cdot 2^2+0\cdot 2^3)\cdot 2^8}$

$= \underbrace{(3)\cdot 2^0} + \underbrace{(13)\cdot 2^4} + \underbrace{(6)\cdot 2^8}$

$= \underbrace{(3)\cdot 16^0} + \underbrace{(13)\cdot 16^1} + \underbrace{(6)\cdot 16^2}$

(iii) binary $\longleftrightarrow$ hexadecimal

$(011011010011)_2 =$

$$= \underbrace{1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3}_{} + \underbrace{1 \cdot 2^4 + 0 \cdot 2^5 + 1 \cdot 2^6 + 1 \cdot 2^7}_{} + \underbrace{0 \cdot 2^8 + 1 \cdot 2^9 + 1 \cdot 2^{10} + 0 \cdot 2^{11}}_{}$$

$$= \underbrace{(1 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 0 \cdot 2^3) \cdot 2^0}_{} + \underbrace{(1 \cdot 2^0 + 0 \cdot 2^1 + 1 \cdot 2^2 + 1 \cdot 2^3) \cdot 2^4}_{} + \underbrace{(0 \cdot 2^0 + 1 \cdot 2^1 + 1 \cdot 2^2 + 0 \cdot 2^3) \cdot 2^8}_{}$$

$$= \underbrace{(3) \cdot 2^0}_{} + \underbrace{(13) \cdot 2^4}_{} + \underbrace{(6) \cdot 2^8}_{}$$

$$= \underbrace{(3) \cdot 16^0}_{} + \underbrace{(13) \cdot 16^1}_{} + \underbrace{(6) \cdot 16^2}_{}$$

$= (6d3)_{16}$

Addition

Addition

$$
\begin{array}{r}
325_{10} \\
+\ 692_{10} \\
\hline
\end{array}
$$

Addition

$$
\begin{array}{r}
325_{10} \\
+\ 692_{10} \\
\hline
{}_{10}
\end{array}
$$

Addition

$$
\begin{array}{r}
325_{10} \\
+\ 692_{10} \\
\hline
7_{10}
\end{array}
$$

Addition

$$
\begin{array}{r}
\,^{1} \\
325_{10} \\
+\ 692_{10} \\
\hline
17_{10}
\end{array}
$$

Addition

$$
\begin{array}{r}
{}^{1}\;{}^{1}\;\;\;\; \\
325_{10} \\
+\ 692_{10} \\
\hline
017_{10}
\end{array}
$$

Addition

$$
\begin{array}{r}
{}^{1}\,{}^{1} \\
325_{10} \\
+\ 692_{10} \\
\hline
1017_{10}
\end{array}
$$

Addition

$$\begin{array}{r} {}^{1\,1} \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array}$$

$$\begin{array}{r} 365_{8} \\ +\ 243_{8} \\ \hline \end{array}$$

Addition

$$\begin{array}{r} {}^{1\,1} \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array}$$

$$\begin{array}{r} 365_{8} \\ +\ 243_{8} \\ \hline _{8} \end{array}$$

Addition

$$
\begin{array}{r}
{}^{1\,1}\\
325_{10}\\
+\ 692_{10}\\
\hline
1017_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
{}^{1}\\
365_{8}\\
+\ 243_{8}\\
\hline
0_{8}
\end{array}
$$

Addition

$$\begin{array}{r} {}^{1\,1} \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array} \qquad \begin{array}{r} {}^{1\,1} \\ 365_{8} \\ +\ 243_{8} \\ \hline 30_{8} \end{array}$$

Addition

$$
\begin{array}{r}
{}^{1}\,{}^{1} \\
325_{10} \\
+\;692_{10} \\
\hline
1017_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
{}^{1}\;{}^{1} \\
365_{8} \\
+\;243_{8} \\
\hline
630_{8}
\end{array}
$$

Addition

$$
\begin{array}{r}
{\scriptstyle 1\;1\;\;} \\
325_{10} \\
+\ 692_{10} \\
\hline
1017_{10}
\end{array}
\qquad
\begin{array}{r}
{\scriptstyle 1\;\;1\;\;} \\
365_{8} \\
+\ 243_{8} \\
\hline
630_{8}
\end{array}
\qquad
\begin{array}{r}
10011100_{2} \\
+\ 11011001_{2} \\
\hline
\end{array}
$$

Addition

$$\begin{array}{r} {\scriptstyle 1\ 1\ \ } \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array} \qquad \begin{array}{r} {\scriptstyle 1\ \ 1\ \ } \\ 365_{8} \\ +\ 243_{8} \\ \hline 630_{8} \end{array} \qquad \begin{array}{r} 10011100_{2} \\ +\ 11011001_{2} \\ \hline {}_{2} \end{array}$$

Addition

$$
\begin{array}{r}
{\scriptstyle 1\ 1\ \ \ \ \ \ } \\
325_{10} \\
+\ 692_{10} \\
\hline
1017_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
{\scriptstyle 1\ \ 1\ \ \ \ \ \ } \\
365_{8} \\
+\ 243_{8} \\
\hline
630_{8}
\end{array}
\qquad\qquad
\begin{array}{r}
10011100_{2} \\
+\ 11011001_{2} \\
\hline
1_{2}
\end{array}
$$

Addition

$$\begin{array}{r} {}^{1\ 1} \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array}$$

$$\begin{array}{r} {}^{1\ \ 1} \\ 365_{8} \\ +\ 243_{8} \\ \hline 630_{8} \end{array}$$

$$\begin{array}{r} 10011100_{2} \\ +\ 11011001_{2} \\ \hline 01_{2} \end{array}$$

Addition

$$
\begin{array}{r}
{\scriptstyle 1\ 1} \\
325_{10} \\
+\ 692_{10} \\
\hline
1017_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
{\scriptstyle 1\ \ 1} \\
365_{8} \\
+\ 243_{8} \\
\hline
630_{8}
\end{array}
\qquad\qquad
\begin{array}{r}
10011100_{2} \\
+\ 11011001_{2} \\
\hline
101_{2}
\end{array}
$$

Addition

$$\begin{array}{r} {}^{1\ 1} \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array} \qquad \begin{array}{r} {}^{1\ \ 1} \\ 365_{8} \\ +\ 243_{8} \\ \hline 630_{8} \end{array} \qquad \begin{array}{r} {}^{1} \\ 10011100_{2} \\ +\ 11011001_{2} \\ \hline 0101_{2} \end{array}$$

Addition

$$\begin{array}{r} {}^{1\,1} \\ 325_{10} \\ +\;692_{10} \\ \hline 1017_{10} \end{array} \qquad \begin{array}{r} {}^{1\;\;1} \\ 365_{8} \\ +\;243_{8} \\ \hline 630_{8} \end{array} \qquad \begin{array}{r} {}^{1\;\;1} \\ 10011100_{2} \\ +\;11011001_{2} \\ \hline 10101_{2} \end{array}$$

Addition

$$
\begin{array}{r}
{}^{1\ 1} \\
325_{10} \\
+\ 692_{10} \\
\hline
1017_{10}
\end{array}
\qquad
\begin{array}{r}
{}^{1\ \ 1} \\
365_{8} \\
+\ 243_{8} \\
\hline
630_{8}
\end{array}
\qquad
\begin{array}{r}
{}^{1\ \ 1} \\
10011100_{2} \\
+\ 11011001_{2} \\
\hline
110101_{2}
\end{array}
$$

Addition

$$\begin{array}{r} 1\ \ 1\ \\ 325_{10} \\ +\ \ 692_{10} \\ \hline 1017_{10} \end{array} \qquad \begin{array}{r} 1\ \ 1\ \ \\ 365_{8} \\ +\ \ 243_{8} \\ \hline 630_{8} \end{array} \qquad \begin{array}{r} 1\ \ 1\ \\ 10011100_{2} \\ +\ \ 11011001_{2} \\ \hline 1110101_{2} \end{array}$$

Addition

$$
\begin{array}{cccccc}
 & ^{1} & ^{1} & & & \\
 & & 3 & 2 & 5 & _{10} \\
+ & & 6 & 9 & 2 & _{10} \\
\hline
 & 1 & 0 & 1 & 7 & _{10}
\end{array}
\qquad\qquad
\begin{array}{ccccc}
 & ^{1} & ^{1} & & \\
 & 3 & 6 & 5 & _{8} \\
+ & 2 & 4 & 3 & _{8} \\
\hline
 & 6 & 3 & 0 & _{8}
\end{array}
\qquad\qquad
\begin{array}{ccccccccccc}
 & ^{1} & & & ^{1} & ^{1} & & & & & \\
 & & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & _{2} \\
+ & & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & _{2} \\
\hline
 & & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & _{2}
\end{array}
$$

Addition

$$\begin{array}{r} {}^{1\,1} \\ 325_{10} \\ +\ 692_{10} \\ \hline 1017_{10} \end{array} \qquad \begin{array}{r} {}^{1\;1} \\ 365_{8} \\ +\ 243_{8} \\ \hline 630_{8} \end{array} \qquad \begin{array}{r} {}^{1\qquad\;\; 1\;\;1} \\ 10011100_{2} \\ +\ 11011001_{2} \\ \hline 101110101_{2} \end{array}$$

Subtraction

Subtraction

$$\begin{array}{r} 427_{10} \\ -\ 192_{10} \\ \hline \end{array}$$

Subtraction

$$
\begin{array}{r}
427_{10} \\
-\ 192_{10} \\
\hline
\end{array}
$$

$_{10}$

Subtraction

$$
\begin{array}{r}
427_{10} \\
-\ 192_{10} \\
\hline
5_{10}
\end{array}
$$

Subtraction

$$
\begin{array}{r}
^{12} \\
\cancel{4}\cancel{2}7_{10} \\
-\ 192_{10} \\
\hline
5_{10}
\end{array}
$$

Subtraction

$$
\begin{array}{r}
\overset{3}{\cancel{4}}\,\overset{12}{\cancel{2}}\,7_{10} \\
-\ \ 1\,9\,2_{10} \\
\hline
5_{10}
\end{array}
$$

Subtraction

$$
\begin{array}{r}
\overset{3}{\cancel{4}}\,\overset{12}{\cancel{2}}\,7_{10} \\
-\;\;192_{10} \\
\hline
35_{10}
\end{array}
$$

Subtraction

$$
\begin{array}{r}
\overset{3}{\cancel{4}}\,\overset{12}{\cancel{2}}\,7_{10} \\
-\ \ 192_{10} \\
\hline
235_{10}
\end{array}
$$

Subtraction

$$
\begin{array}{r}
\overset{3}{\cancel{4}}\overset{12}{\cancel{2}}7_{10} \\
- \quad 192_{10} \\
\hline
235_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
536_{8} \\
- \quad 351_{8} \\
\hline
\end{array}
$$

Subtraction

$$
\begin{array}{r}
\overset{3}{\cancel{4}}\overset{12}{\cancel{2}}7_{10} \\
-\ 192_{10} \\
\hline
235_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
536_{8} \\
-\ 351_{8} \\
\hline
_{8}
\end{array}
$$

Subtraction

$$
\begin{array}{r}
\overset{3}{\cancel{4}}\overset{12}{\cancel{2}}7_{10} \\
-\ \ 192_{10} \\
\hline
235_{10}
\end{array}
\qquad\qquad
\begin{array}{r}
536_{8} \\
-\ \ 351_{8} \\
\hline
5_{8}
\end{array}
$$

Subtraction

$$\begin{array}{r} \scriptstyle 3\ \ 12 \\ \cancel{4}\cancel{2}7_{10} \\ -\ \ 192_{10} \\ \hline 235_{10} \end{array} \qquad \begin{array}{r} \scriptstyle 13_8 \\ \cancel{5}\cancel{3}6_{8} \\ -\ \ 351_{8} \\ \hline 5_{8} \end{array}$$

Subtraction

$$\begin{array}{r} {\scriptstyle 3\ \ 12} \\ \cancel{4}\cancel{2}7_{10} \\ -\ \ 192_{10} \\ \hline 235_{10} \end{array} \qquad \begin{array}{r} {\scriptstyle 4\ \ 13_8} \\ \cancel{5}\cancel{3}6_{8} \\ -\ \ 351_{8} \\ \hline 5_{8} \end{array}$$

Subtraction

$$\begin{array}{r} {\scriptstyle 3\ 12} \\ \cancel{4}\cancel{2}7_{10} \\ -\ 192_{10} \\ \hline 235_{10} \end{array} \qquad \begin{array}{r} {\scriptstyle 4\ 13_8} \\ \cancel{5}\cancel{3}6_{8} \\ -\ 351_{8} \\ \hline 65_{8} \end{array}$$

Subtraction

$$\begin{array}{r} {\scriptstyle 3\ 12} \\ \cancel{4}\cancel{2}7_{10} \\ -\ 192_{10} \\ \hline 235_{10} \end{array} \qquad \begin{array}{r} {\scriptstyle 4\ 13_{8}} \\ \cancel{5}\cancel{3}6_{8} \\ -\ 351_{8} \\ \hline 165_{8} \end{array}$$

Signed Numbers

Signed Numbers

$(26)_{10} = (11010)_2$

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10}$$

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Approaches to represent signed numbers using only 0s and 1s:

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Approaches to represent signed numbers using only 0s and 1s:

- Sign and Magnitude

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Approaches to represent signed numbers using only 0s and 1s:

- Sign and Magnitude

sign magnitude

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Approaches to represent signed numbers using only 0s and 1s:

- Sign and Magnitude

1

sign magnitude

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Approaches to represent signed numbers using only 0s and 1s:

- Sign and Magnitude

1000…011010

sign magnitude

Signed Numbers

$$(26)_{10} = (\underbrace{1}_{16}\underbrace{1}_{8}\underbrace{0}_{4}\underbrace{1}_{2}\underbrace{0}_{1})_2$$

$$(-26)_{10} = (-11010)_2$$

Approaches to represent signed numbers using only 0s and 1s:

- Sign and Magnitude

  $$\underbrace{1}_{\text{sign}}\underbrace{000\ldots011010}_{\text{magnitude}}$$

- Two's Complement

Two’s Complement

Two’s Complement

In a k-bit two’s complement representation of a number:

Two’s Complement

In a k-bit two’s complement representation of a number:

- A positive integer is represented in its (k-1)-bit unsigned binary representation, padded with a 0 to its left

Two's Complement

In a k-bit two's complement representation of a number:

- A positive integer is represented in its (k-1)-bit unsigned binary representation, padded with a 0 to its left
- The sum of a number and its additive inverse is 2^k

Two's Complement

$(26)_{10}$

Two’s Complement

$(26)_{10} = (\qquad\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$

Two's Complement

$$(26)_{10} = (\underbrace{\qquad\qquad\qquad}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

Two's Complement

$$(26)_{10} = (\ \underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

Two's Complement

$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10}$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$\begin{array}{r l} & 0\ 0\ 0\ 1\ 1\ 0\ 1\ 0 \quad \leftarrow 26 \\ + & \qquad\qquad\qquad\quad\ \ \leftarrow -26 \\ \hline & \qquad\qquad\qquad\quad\ \ \leftarrow 2^8 \end{array}$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$\begin{array}{rrl} & 0\;0\;0\;1\;1\;0\;1\;0 & 26 \\ + & & -26 \\ \hline & 1\;0\;0\;0\;0\;0\;0\;0\;0 & 2^8 \end{array}$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$\begin{array}{r} 0\,0\,0\,1\,1\,0\,1\,0 \\ +\qquad\qquad\qquad\qquad\;\, 0 \\ \hline 1\,0\,0\,0\,0\,0\,0\,0\,0 \end{array}$$

26

-26

2^8

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$\begin{array}{rl}
1 & \\
0\,0\,0\,1\,1\,0\,1\,0 & \quad 26 \\
+\qquad\qquad\quad 1\,0 & \quad -26 \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0 & \quad 2^8
\end{array}$$

Two's Complement

$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$

$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$

$$\begin{array}{r l}
\;{}^{}0\,0\,0\,1\,\overset{1}{1}\,\overset{1}{0}\,1\,0 & \leftarrow 26 \\
+\qquad\qquad\quad 1\,1\,0 & \leftarrow -26 \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0 & \leftarrow 2^8
\end{array}$$

Two's Complement

$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$

$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$

$$
\begin{array}{r l}
\;\; {}^{}0\,0\,0\,\overset{1}{1}\,\overset{1}{1}\,0\,\overset{1}{1}\,0 & \leftarrow 26 \\
+ \qquad\qquad\;\; 0\,1\,1\,0 & \leftarrow -26 \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0 & \leftarrow 2^8
\end{array}
$$

Two's Complement

$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$

$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$

$$
\begin{array}{r}
\scriptstyle 1\;\;\;1\;\;\;1\;\;\;\;1\;\;\;\;\; \\
0\,0\,0\,1\,1\,0\,1\,0 \\
+\qquad\quad 0\,0\,1\,1\,0 \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0
\end{array}
\begin{array}{l}
\leftarrow 26 \\
\leftarrow -26 \\
\leftarrow 2^8
\end{array}
$$

Two’s Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$\begin{array}{ccccccccccl}
 & & & ^1 & ^1 & ^1 & ^1 & ^1 & & & \\
 & & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & \leftarrow 26 \\
 & + & & & & & & & & & \\
 & & & & 1 & 0 & 0 & 1 & 1 & 0 & \leftarrow -26 \\
\hline
 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \leftarrow 2^8
\end{array}$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$
\begin{array}{r l}
 & {\scriptstyle 1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1} \\
 & 0\,0\,0\,1\,1\,0\,1\,0 \quad \leftarrow 26 \\
+ & 1\,1\,0\,0\,1\,1\,0 \quad \leftarrow -26 \\
\hline
 & 1\,0\,0\,0\,0\,0\,0\,0\,0 \quad \leftarrow 2^8
\end{array}
$$

Two's Complement

$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$

$(-26)_{10} = (\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$

$$
\begin{array}{rl}
{}^{1\,1\,1\,1\,1\,1\,1} & \\
0\,0\,0\,1\,1\,0\,1\,0 & \leftarrow 26 \\
+\;1\,1\,1\,0\,0\,1\,1\,0 & \leftarrow -26 \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0 & \leftarrow 2^8
\end{array}
$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (\qquad\qquad\qquad\qquad)_{\text{8 bit 2's complement}}$$

$$\begin{array}{r} ^{1\ 1\ 1\ 1\ 1\ 1\ 1} \\ 0\,0\,0\,1\,1\,0\,1\,0 \\ +\ 1\,1\,1\,0\,0\,1\,1\,0 \\ \hline 1\,0\,0\,0\,0\,0\,0\,0\,0 \end{array} \qquad \begin{array}{l} \leftarrow 26 \\ \leftarrow -26 \\ \leftarrow 2^8 \end{array}$$

Two's Complement

$$(26)_{10} = (0\underbrace{0011010}_{\text{7 bits}})_{\text{8 bit 2's complement}}$$

$$(-26)_{10} = (11100110)_{\text{8 bit 2's complement}}$$

$$
\begin{array}{rl}
1\;1\;1\;1\;1\;1\;1 & \\
0\;0\;0\;1\;1\;0\;1\;0 & \leftarrow 26 \\
+\;\;1\;1\;1\;0\;0\;1\;1\;0 & \leftarrow -26 \\
\hline
1\;0\;0\;0\;0\;0\;0\;0\;0 & \leftarrow 2^8
\end{array}
$$

Two’s Complement

Two's Complement

$(00101101)_{8\text{ bit 2's complement}}$

Two's Complement

$(00101101)_{8\text{ bit 2's complement}} = (\quad\quad)_{10}$

Two’s Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (\quad\quad)_{10}$$

Two's Complement

$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (45)_{10}$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (45)_{10}$$

$$(11101010)_{\text{8 bit 2's complement}}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\qquad)_{10}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8 \text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8 \text{ bit 2's complement}} = (\qquad)_{10}$$

-x

$+$

+x

$$1\,0\,0\,0\,0\,0\,0\,0\,0$$

2^8

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (45)_{10}$$

$$(11101010)_{\text{8 bit 2's complement}} = (\qquad)_{10}$$

$$\begin{array}{r l}
\;1\,1\,1\,0\,1\,0\,1\,0 & \leftarrow -x \\
+ & \leftarrow +x \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0 & \leftarrow 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\qquad)_{10}$$

$$\begin{array}{r@{\quad}l} 1\,1\,1\,0\,1\,0\,1\,0 & \leftarrow -x \\ +\qquad\qquad\quad 0 & \leftarrow +x \\ \hline 1\,0\,0\,0\,0\,0\,0\,0\,0 & \leftarrow 2^{8} \end{array}$$

Two's Complement

$$(\underbrace{0}_{}\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\quad\quad)_{10}$$

$$\begin{array}{rl}
1\;1\;1\;0\;1\;\overset{1}{0}\;1\;0 & \text{-x} \\
+ \qquad\qquad\qquad 1\;0 & \text{+x} \\
\hline
1\;0\;0\;0\;0\;0\;0\;0\;0 & 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (45)_{10}$$

$$(11101010)_{\text{8 bit 2's complement}} = (\qquad)_{10}$$

$$\begin{array}{cccccccccc}
 & & & & & 1 & 1 & & & \\
 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & \quad -x \\
+ & & & & & & & 1 & 1 & 0 \quad +x \\
\hline
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \quad 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\quad\quad)_{10}$$

$$\begin{array}{rccccccccl}
 & & & & 1 & 1 & 1 & & & \\
 & & 1 & 1 & 1\,0 & 1 & 0 & 1 & 0 & \leftarrow -x \\
+ & & & & & 0 & 1 & 1 & 0 & \leftarrow +x \\
\hline
 & 1 & 0 & 0 & 0\,0 & 0 & 0 & 0 & 0 & \leftarrow 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\quad\quad)_{10}$$

$$\begin{array}{cccccccccc l}
 & & & 1 & 1 & 1 & 1 & & & & \\
 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & & \leftarrow -x \\
+ & & & & 1 & 0 & 1 & 1 & 0 & & \leftarrow +x \\
\hline
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & & \leftarrow 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\qquad)_{10}$$

$$\begin{array}{cccccccccl}
 & & 1 & 1 & 1 & 1 & 1 & & & \\
 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & \leftarrow -x \\
+ & & & 0 & 1 & 0 & 1 & 1 & 0 & \leftarrow +x \\
\hline
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \leftarrow 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\qquad)_{10}$$

$$\begin{array}{rccccccccl}
 & & 1 & 1 & 1 & 1 & 1 & 1 & & \\
 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & \leftarrow -x \\
+ & & 0 & 0 & 1 & 0 & 1 & 1 & 0 & \leftarrow +x \\
\hline
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \leftarrow 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\qquad)_{10}$$

$$\begin{array}{rl}
{}^{1\;1\;1\;1\;1\;1\;1} & \\
11101010 & \leftarrow -x \\
+\;00010110 & \leftarrow +x \\
\hline
100000000 & \leftarrow 2^8
\end{array}$$

Two's Complement

$(\underbrace{0}\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (45)_{10}$

$(11101010)_{\text{8 bit 2's complement}} = (\qquad)_{10}$

$$
\begin{array}{r l}
{\scriptstyle 1\;1\;1\;1\;1\;1\;1} & \\
\,11101010 & \leftarrow -x \\
+\,00010110 & \leftarrow 22 \\
\hline
100000000 & \leftarrow 2^8
\end{array}
$$

Two's Complement

$$(\underbrace{0}\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{8\text{ bit 2's complement}} = (45)_{10}$$

$$(11101010)_{8\text{ bit 2's complement}} = (\quad\quad)_{10}$$

$$\begin{array}{r}
{\scriptstyle 1\;1\;1\;1\;1\;1\;1\;\;} \\
1\,1\,1\,0\,1\,0\,1\,0 \\
+\;0\,0\,0\,1\,0\,1\,1\,0 \\
\hline
1\,0\,0\,0\,0\,0\,0\,0\,0
\end{array}
\begin{array}{l}
\\
\leftarrow -22 \\
\leftarrow 22 \\
\\
\leftarrow 2^8
\end{array}$$

Two's Complement

$$(0\underbrace{0}_{64}\underbrace{1}_{32}\underbrace{0}_{16}\underbrace{1}_{8}\underbrace{1}_{4}\underbrace{0}_{2}\underbrace{1}_{1})_{\text{8 bit 2's complement}} = (45)_{10}$$

$$(11101010)_{\text{8 bit 2's complement}} = (-22)_{10}$$

$$\begin{array}{ccccccccccl}
 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & & & \\
 & & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & \leftarrow -22 \\
+ & & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & \leftarrow 22 \\
\hline
 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \leftarrow 2^8
\end{array}$$