











	USC Viterbi ⁽³²⁶⁾
Binary Representation Systems	Skill 4: Unique Combinations
 Integer Systems Unsigned Unsigned (Normal) binary Signed Signed Magnitude 2's complement 1's complement* Excess-N* Floating Point* For very large and small (fractional) numbers * = Not covered in this class 	 Given <i>n</i> digits of base <i>r</i>, how many unique numbers can be formed? What is the range? [] Use the examples below to generalize the relationship 2-digit, decimal numbers (r=10, n=2)
USC Viterbi School of Engineering	USCViterbi School of Engineering Approximating Large Powers of 2
 It helps to memorize the first 11 powers of 2 	 Often need to find decimal approximation of a large powers of 2 like 2¹⁶, 2³², etc. Use following approximations:
21 = 2	• Use following approximations:
$2^{1} = 2$ $2^{2} = 4$ $2^{3} = 8$ $2^{4} = 16$ $2^{5} = 32$ $2^{6} = 64$ $2^{7} = 128$ $1024 \overline{512} \overline{256} \overline{128} \overline{64} \overline{32} \overline{16} \overline{8} \overline{4} \overline{2} \overline{1}$	• Ose following approximations: $\begin{array}{c} -2^{10} \approx & 2^{24} = \\ -2^{20} \approx & \\ -2^{30} \approx & \\ -2^{40} \approx & 2^{28} = \end{array}$ • For other powers of 2, decompose

School of Engineering **Binary Codes ASCII Code** Used for representing text characters Using binary we can represent any kind of Originally 7-bits but usually stored as • information by coming up with a code in modern computer systems • Using *n* bits we can represent 2ⁿ distinct items • Example: - "Hello\n" Each character is converted to ASCII equivalent Colors of the rainbow: Letters: •Red = 000•'A' = 00000• 'H' = 0x48, 'e' = 0x65, ... •Orange = 001•'B' = 00001 •Yellow = 010• 'C' = 00010 \n = newline character is represented by either one or two ASCII •Green = 100character •Blue = 101- LF (0x0A) = line feed (moves cursor down a line) •Purple = 111•'Z' = 11001 - CR (0x0D) = carriage return character (moves cursor to start of current line) – Newline for Unix / Mac = LF only – Newline for Windows = CR + LF USC Viterbi USC School of Engineering UniCode **ASCII** Table 'M' = 0x4D = 0100 1101LSD/MSD Character Map 0 1 2 3 4 5 6 7 ASCII can represent only the English 0 NULL SPACE @ Ρ DLW 0 р Font: O Arial alphabet, decimal digits, and SOH 1 А Q 1 DC1 1 а q punctuation Ω e ⁴/₅ ± ¹/₃ ²/₃ ¹/₈ ³/₈ ⁵/₈ ⁷/₈ ⊃ ← STX u 2 В $\Pi \Sigma - /$ 2 DC2 R b r ∞ | | ∩ | | - 7-bit code => 2^7 = 128 characters С 3 ETX DC3 # 3 S с s It would be nice to have one code 4 EOT DC4 \$ 4 D Т d t that represented more % Е 5 U 5 ENQ NAK e u alphabets/characters for common F ACK 6 v a t H h K k Z z 6 SYN & f v languages used around the world וֹשׁ + ת ר ם ל כ ה ד א ע ײַ וֹ וּ fl 7 BEL ETB 1 7 G W w g Unicode זוהדגבא וס ר מ לי н 8 BS 8 Х CAN (h х א פֿ כֿ בֿ וֹ תּ ש Up to 32-bit Code => up to 4 billion 9 TAB ΕM) 9 Т Y i у combinations Characters to copy * LF J Ζ А SUB : j z 149,000 character defined for many abic Letter Beeh Isolated Form К В VT ESC k + ; ſ { languages FF L T С FS < Unicode hex value - Used by Java as standard character (i.e. FB52 => 1111101101010010) М CR GS D = m } code ~ Е SO RS > Ν ۸ n F SI US ? 0 DEL 0





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Skill 1: Converting Base r to Decimal

- 934.7₁₀ = $\frac{9}{10^2 = 100}$ $\frac{3}{10^1 = 10}$ $\frac{4}{10^0 = 1}$ $\frac{7}{10^{-1} = 0.1}$ = 934.7₁₀
- $1101.1_2 = 1$ $\frac{1}{2^3=8}$ $\frac{1}{2^2=4}$ $\frac{0}{2^1=2}$ $\frac{1}{2^0=1}$ $\frac{1}{2^{-1}=0.5}$ $8+4+1+0.5=13.5_{10}$
- $3B.4_{16} = \underline{3}_{16^{1}=16} \underline{B}_{16^{0}=1} \underline{.4} = 48 + 11 + 0.25 = 59.25_{10}$

Main Point: To convert any base to decimal (base 10), apply the implicit place values (weights) which are just the powers of the base and sum each digit times its place value.

General Conversion From Base r to Decimal

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- A number in base r has place values/weights that are the powers of the base
- Denote the coefficients as: a_i

Generalized approach:



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Examples	Binary Examples
$(746)_8 = 7^* 8^2 + 4^* 8^1 + 6^* 8^0$ = 448 + 32 + 6 = 486 ₁₀	$\frac{(1001.1)_2}{842.1} = 8 + 1 + 0.5 = 9.5_{10}$
$(1A5)_{16} = 1^* 16^2 + 10^* 16^1 + 5^* 16^0$ = 256 + 160 + 5 = 421 ₁₀	$(\underbrace{10110001}_{1\overline{28}}, \underbrace{10001}_{\overline{32}}, \underbrace{10001}_{\overline{10}}, \underbrace{100001}_{\overline{10}}, \underbrace{100000}_{\overline{10}}, \underbrace{1000000}_{\overline{10}}, \underbrace{1000000}_{\overline{10}}, \underbrace{1000000}_{\overline{10}}, \underbrace{100000}_{\overline{10}}, 1000$
$(AD2)_{16} = 10*16^2 + 13*16^1 + 2*16^0$ = 2560 + 208 + 2 = (2770)_{10}	
USC Viterbi School of Engineering	USC Viterbi Skill: Decimal to Base r
"Making change" BASE 10 TO BASE 2 OR BASE 16	 To convert a decimal number, x, to binary: Only coefficients of 1 or 0. So simply find place values that add up to the desired values, starting with larger place values and proceeding to smaller values and place a 1 in those place values and 0 in all others Similar to how one would make change 25₁₀ = 0/32 1/16 1/8 0/4 0/2 1/1 For 25₁₀ the place value 32 is too large to include so we include 16. Including 16 means we have to make 9 left over. Include 8 and 1.

USC Viterbi Stool of Engineering Decimal to Unsigned Binary	Decimal to Another Base
$73_{10} = \begin{array}{ccccccccccccccccccccccccccccccccccc$	 To convert a decimal number, x, to base r: Use the place values of base r (powers of r). Starting with largest place values, fill in coefficients that sum up to desired decimal value without going over.
$145_{10} = 1 0 0 1 0 1 1$	
$0.625_{10} = \frac{1}{.5} \frac{0}{.25} \frac{1}{.125} \frac{0}{.0625} \frac{0}{.03125}$	$75_{10} = 0$ 4 B hex 256 16 1