

Char	Code	Name	Description
	32	-	Normal space
!	33	-	Exclamation
"	34	quot	Double quote
#	35	-	Hash or pound
\$	36	-	Dollar
%	37	-	Percent
&	38	-	Ampersand
'	39	-	Apostrophe
(40	-	Open bracket
)	41	-	Close bracket
*	42	-	Asterisk
+	43	-	Plus sign
,	44	-	Comma
-	45	-	Minus sign
.	46	-	Period
/	47	-	Forward slash

Char	Code	Name	Description
0	48	-	Digit 0
1	49	-	Digit 1
2	50	-	Digit 2
3	51	-	Digit 3
4	52	-	Digit 4
5	53	-	Digit 5
6	54	-	Digit 6
7	55	-	Digit 7
8	56	-	Digit 8
9	57	-	Digit 9
:	58	-	Colon
;	59	-	Semicolon
<	60	lt	Less than
=	61	-	Equals
>	62	gt	Greater than
?	63	-	Question mark

Char	Code	Name	Description
@	64	-	At sign
A	65	-	A
B	66	-	B
C	67	-	C
D	68	-	D
E	69	-	E
F	70	-	F
G	71	-	G
H	72	-	H
I	73	-	I
J	74	-	J
K	75	-	K
L	76	-	L
M	77	-	M
N	78	-	N
O	79	-	O

Char	Code	Name	Description
P	80	-	P
Q	81	-	Q
R	82	-	R
S	83	-	S
T	84	-	T
U	85	-	U
V	86	-	V
W	87	-	W
X	88	-	X
Y	89	-	Y
Z	90	-	Z
[91	-	Open square bracket
\	92	-	Backslash
]	93	-	Close square bracket
^	94	-	Pointer
_	95	-	Underscore

Char	Code	Name	Description
`	96	-	Grave accent
a	97	-	a
b	98	-	b
c	99	-	c
d	100	-	d
e	101	-	e
f	102	-	f
g	103	-	g
h	104	-	h
i	105	-	i
j	106	-	j
k	107	-	k
l	108	-	l
m	109	-	m
n	110	-	n
o	111	-	o

Char	Code	Name	Description
p	112	-	p
q	113	-	q
r	114	-	r
s	115	-	s
t	116	-	t
u	117	-	u
v	118	-	v
w	119	-	w
x	120	-	x
y	121	-	y
z	122	-	z
{	123	-	Left brace
	124	-	Vertical bar
}	125	-	Right brace
~	126	-	Tilde
ⓧ	127	-	(Unused)

Char	Code	Name	Description
	160	nbspc	Non-breaking space
!	161	lexcl	Inverted exclamation
¢	162	cent	Cent sign
£	163	pound	Pound sign
¤	164	curren	Currency sign
¥	165	yen	Yen sign
¦	166	brvbar	Broken bar
§	167	sect	Section sign
¨	168	uml	Umlaut or diaeresis
©	169	copy	Copyright sign
ª	170	ordf	Feminine ordinal
«	171	lequo	Left angle quotes
¬	172	not	Logical not sign
¸	173	shy	Soft hyphen
®	174	reg	Registered trademark
ˆ	175	macr	Spacing macron

Char	Code	Name	Description
°	176	deg	Degree sign
±	177	plussmn	Plus-minus sign
²	178	sup2	Superscript 2
³	179	sup3	Superscript 3
´	180	acute	Spacing acute
µ	181	micro	Micro sign
¶	182	para	Paragraph sign
·	183	middot	Middle dot
¸	184	cedil	Spacing cedilla
¹	185	sup1	Superscript 1
²	186	ordm	Masculine ordinal
»	187	raquo	Right angle quotes
¼	188	frac14	One quarter
½	189	frac12	One half
¾	190	frac34	Three quarters
¿	191	quest	Inverted question mark

Char	Code	Name	Description
À	192	Agrave	A grave
Á	193	Aacute	A acute
Â	194	Acirc	A circumflex
Ã	195	Atilde	A tilde
Ä	196	Auml	A umlaut
Å	197	Aring	A ring
Æ	198	AElig	AE ligature
Ç	199	Ccedil	C cedilla
È	200	Egrave	E grave
É	201	Eacute	E acute
Ê	202	Ecirc	E circumflex
Ë	203	Euml	E umlaut
Ì	204	Igrave	I grave
Í	205	Iacute	I acute
Î	206	Icirc	I circumflex
Ï	207	Iuml	I umlaut

Char	Code	Name	Description
Ð	208	ETH	ETH
Ñ	209	Ntilde	N tilde
Ò	210	Ograve	O grave
Ó	211	Oacute	O acute
Ô	212	Ocirc	O circumflex
Õ	213	Otilde	O tilde
Ö	214	Ouml	O umlaut
×	215	times	Multiplication sign
Ø	216	Oslash	O slash
Ù	217	Ugrave	U grave
Ú	218	Uacute	U acute
Û	219	Ucirc	U circumflex
Ü	220	Uuml	U umlaut
Ý	221	Yacute	Y acute
Þ	222	THORN	THORN
Š	223	szig	sharp s

Char	Code	Name	Description
à	224	agrave	a grave
á	225	aacute	a acute
â	226	acirc	a circumflex
ã	227	atilde	a tilde
ä	228	auml	a umlaut
å	229	aring	a ring
æ	230	aelig	ae ligature
ç	231	ccedil	c cedilla
è	232	egrave	e grave
é	233	eacute	e acute
ê	234	ecirc	e circumflex
ë	235	euml	e umlaut
ì	236	igrave	i grave
í	237	iacute	i acute
î	238	icirc	i circumflex
ï	239	iuml	i umlaut

Char	Code	Name	Description
ð	240	eth	eth
ñ	241	ntilde	n tilde
ò	242	ograve	o grave
ó	243	oacute	o acute
ô	244	ocirc	o circumflex
õ	245	otilde	o tilde
ö	246	ouml	o umlaut
+	247	divide	division sign
ø	248	oslash	o slash
ù	249	ugrave	u grave
ú	250	uacute	u acute
û	251	ucirc	u circumflex
ü	252	uuml	u umlaut
ý	253	yacute	y acute
þ	254	thorn	thorn
ÿ	255	yuml	y umlaut



2.2 Consider three languages L_1 , L_2 , and L_3 , and assume that L_1 does not contain the empty string. Show that if $L_2 = L_1 L_2 \cup L_3$, then $L_2 = L_1^* L_3$.

[FROM Intro. to Discrete Event Systems by Cassandras & LaFortune]

PROOF SHOW L_2 DEFINED BY $L_2 = L_1 L_2 \cup L_3$ (*)
IS EQUAL TO $L_1^* L_3$:

$$L_2 = L_1^* L_3$$

PART 1 ($L_2 \supseteq L_1^* L_3$)

FROM (*),
HENCE
AND

$$L_2 \supseteq L_3$$

$$L_1 L_2 \supseteq L_1 L_3$$

$$L_1 L_2 \cup L_3 = L_2 \supseteq L_1 L_3$$

$$L_2 \supseteq L_1^i L_3$$

$$L_1 L_2 \supseteq L_1^{i+1} L_3$$

$$L_1 L_2 \cup L_3 = L_2 \supseteq L_1^{i+1} L_3$$

THUS
SO

$$L_2 \supseteq L_1^n L_3 \quad \text{FOR ALL } n \geq 0$$

$$L_2 \supseteq \bigcup_{n \geq 0} L_1^n L_3 = L_1^* L_3 \quad \#$$

PART 2 ($L_2 \subseteq L_1^* L_3$)

CHOOSE x IN L_2 WHERE $L_2 = L_1 L_2 \cup L_3$

THEN $x \in L_3$ AND WE ARE DONE SINCE $L_3 \subseteq L_1^* L_3$

OR

$x = x_1 y_1$ WHERE $x_1 \in L_1$ AND $y_1 \in L_2$
 $|x_1| \geq 1$

CONTINUING

$$x = x_1 x_2 \cdots x_n y_n \quad \text{WHERE}$$

$$x_i \in L_1, |x_i| \geq 1$$

$$\text{AND } y_n \in L_3$$

(SPECIFICALLY, $y_i = x_{i+1} y_{i+1}$
WHERE $x_{i+1} \in L_1, y_{i+1} \in L_2$)

$$\text{THEN } x \in L_1^n L_3 \subseteq L_1^* L_3$$

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