

Program Title CAR SIMULATOR

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Program Description, Equations, Variables

MAX. SPEED $V_{MAX} = 65 \text{ M/S}$

MAX. ACCELERATION $a_{MAX} = 8 \text{ M/S}^2$ (WHEN $V=0$)

MAX. FRICTION COEFFICIENT $\mu_{MAX} = 0.9$

MAX. POWER = ABOUT 420 HP (THEORETICALLY)

CAR WEIGHT = ABOUT 600 KG

$$10\mu = \begin{cases} V_1 \cdot \beta, & \text{IF } a \geq 0 \text{ (ACCELERATION)} \\ \sqrt{(V_1 \cdot \beta)^2 + (a \cdot \mu_{MAX})^2}, & \text{IF } a < 0 \text{ (BRAKING)} \end{cases}$$

WHERE $V_1 = \max\{V, V + a\}$. β IS IN RADIANS.

 $a_0 = a_{MAX} \cdot [a/10 - (V/V_{MAX})^2]$ THE CAR STARTS TO

SLIDE, IF $\mu_{MAX} < \mu$; IF $2\mu_{MAX} \leq \mu$, DISPLAY

SHOWS "CRD" (= IMPOSSIBLE TURN)

 β = TURNING ANGLE IN DECIMAL DEGREES (-LEFT, +RIGHT). INPUT: KEY C

 a = ACCELERATION OR BRAKING; $0 \leq a \leq 10$. INPUT: KEY E OR D

 X = THE DISTANCE FROM THE MIDDLE OF THE ROAD (-LEFT, +RIGHT)

 Y = POSITION ON A PLATE (PLATE LENGTH 50 METERS, WIDTH 10 METERS)

 n = PLATE NUMBER

 α = THE ANGLE (IN DEGREES) BETWEEN THE DIRECTION OF THE CAR AND THE ROAD

 V = PRESENT VELOCITY (M/S)

 β_{MAX} = THE GREATEST POSSIBLE β FOR THE NEXT MOVE (WITHOUT SLIDING), WHEN $a \geq 0$ AND $a_0 \leq 0$
 S = THE DISTANCE THE CAR HAS MOVED FROM THE BEGINNING

 t = TIME FROM THE START OF THE GAME

 V_A = AVERAGE VELOCITY (M/S)

 X, Y, n AND α, V, β_{MAX} ARE SHOWED IN A COMBINED DISPLAY (2 DIGITS EACH).

EXAMPLE: $\alpha = -3.81$ $V = 15.24$ $\beta_{MAX} = 33.84 \rightarrow \alpha \cdot V \beta_{MAX} = -4.1533$

Operating Limits and Warnings $|\beta|$ MUST BE $\leq 57^\circ \approx 1$ RADIAN

-IF $S_0 \leq 0$, IT WILL BE REPLACED BY 10^5 ($0 < 10^5 \leq 1$) ($S_0 = S$ DURING ONE SECOND)

-IF ACCELERATION $a > 10$, 10 WILL BE INPUT. IF BRAKING $a > 10$, THE CAR STARTS TO SLIDE

-WHEN THE CAR IS SLIDING, IT MOVES STRAIGHT FORWARD (BRAKING WITH $a=5$).

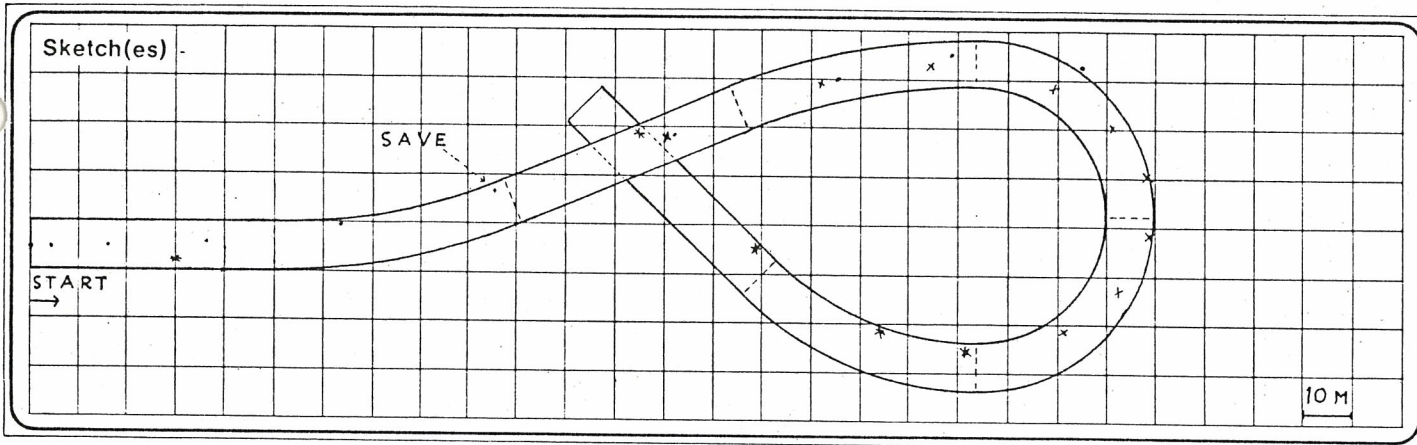
HOWEVER, HALF OF β WILL BE INCLUDED AFTER ONE SECOND INTERVAL

-ALTHOUGH THE PROGRAM SIMULATES REAL WORLD, DON'T TAKE IT TOO

SERIOUSLY; IT'S STILL FAR FROM REALITY.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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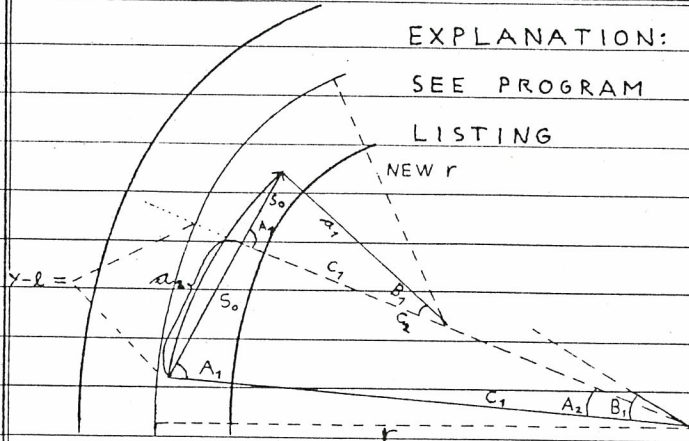


Sample Problem(s) START: f CL REG f P > 5 f CL REG 50 STO 2 STO 6

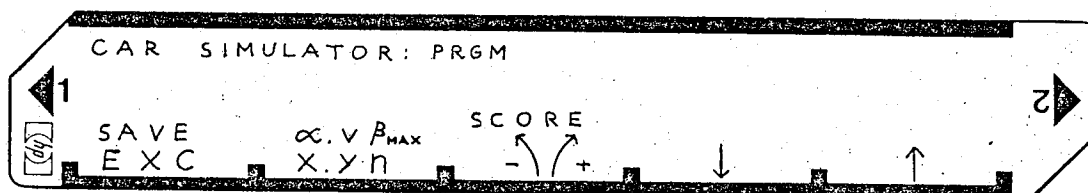
ROADCODES: .54569975 STO A (OPTIONAL: f W/DATA, ENTER DATA CARD)

β	a	MESSAGE	X. Y n	$\alpha. V \beta_{MAX}$	β	a	MESSAGE	X. Y n	$\alpha. V \beta_{MAX}$
START: B			0.5000	0.0057	30 C	1 D		-5.4205	-7.1435
	10 E		0.0401	0.0857	EXACT X: RCL 1 = -4.8818				
	10 E		0.1601	0.1632	35 C	0 D		-5.0406	6.1436
3 CHS C	10 E		-1.3601	-3.2322	32 C	2 E		-2.1706	15.1533
10 CHS C	10 E		-4.1302	-7.3016	22 C	4 E		1.3306	8.1828
	10 E		-3.4702	8.3714	28 C	0 E		3.0207	4.1729
SAVE SITUATION: f a			-3.4702	8.3714	20 C	10 E		4.2407	4.2520
8 CHS C	5 E		0.3403	1.3813	16 C	10 E		4.0408	-3.3216
10 C	7 D	(5)	0.1904	-2.3116	3 C	10 E		3.3908	0.3813
11 C	7 D		-2.4604	-3.2421		10 E		3.3001	0.4311
12 C	8 D	ERROR			f C $\rightarrow$ (s = 429.6096) $\rightarrow$ t = 19 ; $\div \rightarrow V_A = 22.6110$				

Solution(s) CLX B		-5.1505	-19.1631
EXACT X: RCL 1 = -5.1458			
EXCHANGE: A		-3.4702	8.3714
SAVE SITUATION: f a		-3.4702	8.3714
8 CHS C	0 E	0.3203	1.3415
5 C	2 D	1.1504	0.3017
12 C	7 D	1.4104	0.2322
18 C	5 D	1.1305	-9.1828
25 C	2 D	-2.2905	-13.1632



Reference(s)



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	ENTER PROGRAM CARD (SIDE 1 AND 2)			
2.	STEPS 3-11 CAN BE SKIPPED, IF A PRE-RECORDED DATA CARD IS USED			
3.	CLEAR ALL REGISTERS		f CL REG f P > S f CL REG	
4.	STORE STARTING VALUES	50	STO 2 STO 6	
5.	PRESS DECIMAL POINT		.	
6.	ENTER ROAD CODES (UP TO TEN PIECES)	CCC...		
	CODE: 1 2 3 4 5 6 7 8 9 0 PLATE FORM -90° -67,5° -45° -22,5° 0° 22,5° 45° 67,5° 90° NEW LAP			
7.	STORE CODES		STO A	
8.	REPEAT STEPS 5-7 FOR REGISTERS R _B - R _E UNTIL ALL CODES HAVE BEEN STORED. THE LAST CODE IN R _E MUST BE 0			
9.	OPTIONAL:		f W/DATA	
10.	OPTIONAL: ENTER BLANK MAGNETIC CARD (ONLY 1 SIDE)			
11.	GO TO STEP 13.			
12.	ENTER DATA CARD (ONLY 1 SIDE)			
13.	OPTIONAL: TURN β DEGREES TO THE RIGHT OR TURN β DEGREES TO THE LEFT	β β	C CHS C	β $-\beta$
14.	ACCELERATION, $0 \leq a \leq 10$ OR BRAKING, $0 \leq a \leq 10$	a a	E D	X.YN, $\propto V \beta_{MAX}$ X.YN, $\propto V \beta_{MAX}$
15.	OPTIONAL: X.YN AND $\propto V \beta_{MAX}$		B	X.YN, $\propto V \beta_{MAX}$
16.	OPTIONAL: $\propto V \beta_{MAX}$ ONLY		f b	$\propto V \beta_{MAX}$
17.	OPTIONAL: SCORE; S AND t AND $V_A (= s/t)$		f c ÷	s, t V_A
18.	OPTIONAL: SAVE PRESENT SITUATION		f a	X.YN, $\propto V \beta_{MAX}$
19.	OPTIONAL: EXCHANGE PRESENT WITH OLD SITUATION FOR A NEW MOVE GO TO STEP 13 FOR A NEW GAME GO TO STEP 2		A	X.YN, $\propto V \beta_{MAX}$
	MESSAGES: 'ERROR' AFTER C KEY: $ \beta > 57^\circ$; TRY WITH SMALLER β			
	'ERROR' AFTER D OR E KEY: YOU ARE OUT OF THE ROAD ($ X > 5$). GAME IS LOST, GO TO STEP 2 OR 19			
	'CRD': IMPOSSIBLE TURN; TRY WITH SMALLER β AND/OR a			
	DIGIT 5 PAUSING: YOUR CAR STARTS TO SLIDE			

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	FLBL C	31 25 13	TURNING β DEGREES		$\div$	81	
	ENTER $\uparrow$	41			STO $\div$ 0	33 61 00	$R_0 := V + \frac{1}{2} a_0 = s_0'$
	$\rightarrow R$	32 73	CONVERT TO RADIANS		RCL 9	34 09	$\beta/2$
	STO 9	33 09		060	AF? 1	35 71 01	SLIDING?
	$\sin^{-1}$	32 62	$ \beta > 1 \text{ RAD?}$		$fX = 0$	31 51	NO: $\beta = 0?$
	$hX > Y$	35 52			GTO 1	22 01	YES: JUMP, $s_0 = s_0'$
	hRTN	35 22			STO $\div$ 3	33 61 03	$R_1 := \alpha + \beta/2 = \pi/2 - A_1$
	FLBL 3	31 25 03	SLIDING		STO $\div$ 0	33 81 00	
	hLST X	35 82			f SIN	31 62	
010	$\alpha \leq Y$	32 71	$2\mu_{\max} \leq \mu?$		STO $\times$ 0	33 71 00	$R_0 = s_0 = \frac{2 s_0' \cdot \sin(\beta/2)}{\beta}$
	f W/DATA	31 41	YES: DISPLAY "CRD"		FLBL 1	31 25 01	
	5	05			ASF 1	35 51 01	CLEAR SLIDING
	$f - x -$	31 84	PAUSE a (BRAKING)		RCL 6	34 06	RADIUS r
	hCF 1	35 61 01	SET SLIDING	070	STO -1	33 51 01	$R_1 := X - r = -C_1$
	FLBL D	31 25 14	BRAKING		RCL 2	34 02	Y
	CHS	42			5	05	
	FLBLE	31 25 15	ACCELERATION		0	00	PLATE LENGTH ℓ
	EEX	43			$-$	51	$Y - \ell$
	1	01			RCL 3	34 03	$\pi/2 - A_1$
020	$\alpha \leq Y$	32 71	$a \geq 10?$		RCL 0	34 00	s_0
	ENTER $\uparrow$	41	YES: $a = 10$		$fX \neq 0$	31 61	$s_0 \leq 0?$
	$\div$	81			$fX < 0$	31 71	YES: $0 < s_0 \leq 1$
	hST I	35 33	$a/10$		$\rightarrow 10^x$	32 53	
	RCL 4	34 04	V	080	fR $\leftarrow$	31 72	$R_1 := s_0 \cdot \sin A_1$
	STO 0	33 00	$R_0 := V$		hST I	35 33	$s_0 \cdot \cos A_1$
	6	06			$hX > Y$	35 52	$-C_1$
	5	05	$V_{\max}$		RCL 1	34 01	
	$\div$	81			$+$	61	
	α^2	32 54	$(V/V_{\max})^2$		$\div$	81	ARC TAN $\frac{s_0 \cdot \sin A_1}{s_0 \cdot \cos A_1 - C_1} = -B_1$
	$-$	51			$\rightarrow \tan^{-1}$	32 64	r
	8	08	$a_{\max}$		RCL 6	34 06	
	X	71	a_0		$hX > Y$	35 52	
	ENTER $\uparrow$	41			X	71	
	$fX < 0$	31 71	$a_0 < 0?$	090	$\alpha \leq Y$	32 71	$-r \cdot B_1 \leq Y - \ell?$
	0	00	YES: ENTER ZERO		GTO 0	22 00	YES: GO TO NEW PLATE
	RCL 4	34 04	V		STO -2	33 51 02	$Y := Y + r \cdot B_1$
	$+$	61	$V_1 = \max\{V, V + a_0\}$		STO -7	33 51 07	$S := S + r \cdot B_1$
	RCL 9	34 09			RCL 9	34 09	$\beta/2$
	X	71	$V_1 \cdot \beta$		STO -9	33 51 09	$R_0 := 0$
040	hRC I	35 34	$a/10$		STO $\div$ 3	33 61 03	$R_2 := \alpha := \alpha + \beta/2 + \beta/2$
	9	09	$10\mu_{\max}$		RCL 6	34 06	r
	X	71	$a \cdot \mu_{\max}$		ARC I	35 34	$s_0 \cdot \sin A_1$
	$fX > 0$	31 81	$a > 0?$		hLST X	35 82	$-B_1$
	CLX	44	YES: $a \cdot \mu_{\max} = 0$	100	STO $\div$ 3	33 61 03	$R_3 := \alpha + \beta - B_1$
	hF? 1	35 71 01	SLIDING?		f SIN	31 62	$-a_1 = \frac{s_0 \cdot \sin A_1}{\sin -B_1}$
	$\rightarrow P$	32 72	NO: 10μ		$\div$	81	
	9	09			$+$	61	
	$-$	51			STO 1	33 01	$X := r - a_1$
	$fX > 0$	31 81	$\mu_{\max} < \mu?$		5	05	$X_{\max}$
050	GTO 3	22 03	YES: GO TO SLIDE		$\div$	81	$ X > X_{\max}?$
	1	01			$\sin^{-1}$	32 62	YES: DISPLAY "ERROR"
	STO $\div$ 5	33 61 05	$t := t + 1$		FLBL B	31 25 12	X, Y, n ; OUTPUT
	hRA	35 54	a_0		RCL 8	34 08	$n/10$
	STO $\div$ 4	33 61 04	$V := V + a_0$	110	EEX	43	
	2	02			1	01	
	STO $\div$ 9	33 81 09	$R_0 := \beta/2$		$\div$	81	$n/100$

REGISTERS

0	1	2	3	4	5	6	7	8	9
s_0	X	Y	α IN RADIANS	V	t	r	S	n/10	β IN RADIANS
S0 USED	S1 SAVE X	S2 SAVE Y	S3 SAVE α	S4 SAVE V	S5 SAVE t	S6 SAVE r	S7 SAVE S	S8 SAVE n/10	S9 SAVE β
A ROAD, 10 PLATES	B ROAD, 10 PLATES	C ROAD, 10 PLATES	D ROAD, 10 PLATES	E ROAD, 9 PLATES	I USED				



50029

Program Listing II

Page 5 of 5

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 2	34 02	Y		X	71	$-C_1 \cdot \sin A_2 = a_2$
	RCL 1	34 01	X	170	STO - 0	33 51 00	$S_0 := S_0 - a_2$
	fGSB 2	31 22 02	COMBINED DISPLAY		4	04	
	f-X-	31 84	SUBROUTINE		0	00	
	gLBL fb	32 25 12	PAUSE X.YN		0	00	8.l
	RCL 4	34 04	$\alpha \cdot V \beta_{MAX}$; OUTPUT		RCL 8	34 08	n/10
	fX<0	31 71	V		fLBL 9	31 25 09	
120	STO - 4	33 51 04	V<0?		STO 8	33 08	
	9	09	YES: V:=0		2	02	
	gX>Y	32 81	10 μ_{MAX}		0	00	
	ENTER ↑	41	10 $\mu_{MAX} > V$?		+	61	
	AX>X	35 52	YES: V = $\mu_{MAX} \cdot 10$	180	AST I	35 33	$R_I := 20 + n/10$
	÷	81	$\beta_{MAX} = \frac{10 \mu_{MAX}}{V} \leq 1$		gFRAC	32 83	
	fD←	31 73	CONVERT β_{MAX} TO DEGREES		.	83	
	fINT	31 83			I	01	
	1	01			STO + 8	33 61 08	$R_g := (n+1)/10$
	f%	31 82	$\beta_{MAX}/100$		÷	81	
130	RCL 4	34 04	V		g10 ^x	32 53	
	RCL 3	34 03	α		RCL (X)	34 24	
	fD←	31 73	CONVERT α TO DEGREES		X	71	
	fLBL 2	31 25 02	COMBINED DISPLAY		gFRAC	32 83	
	DSP 0	23 00		190	EEX	43	
	fRND	31 24	ROUND X OR α		I	01	
	ARV	35 53			X	71	
	fRND	31 24	ROUND Y OR V		fINT	31 83	ROAD CODE C
	+	61	Y.N OR V. β_{MAX}		fX=0	31 51	C=0?
	/	01			GTO 9	22 09	YES: GO TO NEW LAP
140	f%	31 82	O.YN OR O.V β_{MAX}		5	05	
	ARA	35 54	X OR α		-	51	
	fX≠0	31 61	COMBINATION		AST π	35 73	
	AX>Y	35 52			X	71	
	gX>Y	32 81		200	EEX	43	
	CHS	42			4	04	
	+	61	X.YN OR $\alpha \cdot V \beta_{MAX}$		CHS	42	8.l
	DSP 4	23 04	RESET DISPLAY		+	61	$(C-5) \cdot \pi + 10^{-4} = R$
	ARTN	35 22	RETURN OR HALT		÷	81	
	fLBL 0	31 25 00	NEW PLATE		STO 6	33 06	$R_g := \text{NEW } R$
150	RCL 3	34 03	$\pi/2 - A_1$		GTO 1	22 01	
	RCL 1	34 01	$-C_1$		gLBL fc	32 25 13	SCORE; OUTPUT
	ARA	35 54	Y-l		RCL 7	34 07	
	STO - 7	33 51 07	$S := S + l - Y$		AST PAUSE	35 72	PAUSE S
	RCL 6	34 06	$R_1 := r$	210	RCL 5	34 05	
	STO 1	33 01	$\frac{Y-l}{r} = -A_2$		ARTN	35 22	DISPLAY t
	÷	81			gLBL fa	32 25 11	SAVE X,Y, $\alpha \dots \beta$
	STO 2	33 02			9	09	
	RCL 3	34 03	$\pi/2 - A_1$		AST I	35 33	$R_I := 9$
	+	61	$\pi/2 - A_1 - A_2$		fLBL 8	31 25 08	LOOP
160	fCOS	31 63	$-C_1 \cdot \sin A_1$		RCL (X)	34 24	
	÷	81	$\frac{-C_1 \cdot \sin A_1}{\sin(A_1+A_2)} = -C_2$		fP>S	31 42	STORER _g - R ₁
	fR←	31 72			STO (X)	33 24	IN R ₅₉ - R ₅₇
	STO + 1	33 61 01	$R_1 := r - C_2$		fP>S	31 42	
	ALSTX	35 82		220	fDSZ	31 33	SKIP?
	RCL 2	34 02	$-A_2$		GTO 8	22 08	NO: GO BACK
	STO - 2	33 51 02	Y:=0		fLBL A	31 25 11	EXCHANGE
	STO + 3	33 61 03	$\alpha := \alpha - A_2$		fP>S	31 42	PRIMARY-SECONDARY
	fSIN	31 62	$\sin A_2$		GTO B	22 12	GO TO X.YN

LABELS

FLAGS

SET STATUS

EXCHANGE	B X.YN	C LEFT-RIGHT	D BRAKING	E ACCELERAT.	0	1 SLIDING?	ON OFF	TRIG	DISP
a SAVE	b $\alpha \cdot V \beta_{MAX}$	c SCORE	d SLIDING	e	1	2	0 ☐ ☒	DEG ☐	FIX ☒
0 NEW PLATE	1 USED	2 COMBINED DSP	3 SLIDING	4	2	3	1 ☒ ☐	GRAD ☐	SCI ☐
5 1	6	7	8 LOOP	9 NEW LAP	3	4	2 ☐ ☒	RAD ☒	ENG ☐
							3 ☐ ☒		n 4