PROBLEM 1:		9	The second second second second	0041@ Wall	
TROOGET 2.)	3		
			8 4	$\widehat{\mathcal{L}}$	
		. द		(4) ((h
480 18,007	i to	. 6	くwhide i*i<=i do i:=i+l,な入りの	الاحتاجا: الماسينا+ارعانا الماسينا+ارعانا الماسينا+ارعانا الماسيناء الماسي	A i * i * i <= 1 * then (i == 1 + 1; white - 1 <= 1 do i == 1 + 1) euse shup, * (4; 2)
	(3) (3)		ohite i:=i+	1. +1.	3
de la significant	1 = 2 × 20 1 × 1 0 0 0		۲	5 ol	(9)
10	41 67 (1)	(F) (3)	+1] =°2	<u> </u>	112
0] " }	, <u>k</u>	0
		5	(b'	white	
(voi	41,0-211,0-(1)=1	これはしている	;;; \ ;;	王 :	6
quest	Times Table 1		(14) Li:=i+1,0> (10-[1-1-2]	4: \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	1+1; white 1+1 <=1 od do i:=i+1, エンリック
the o	7.	(#) II	1 2		141.7 50 i:
<u>و</u>	至 是	-	(P) (P) (P) (P)		(1::
-6		1.7	€2		i *i <=1 then() <ur> /uhide [*i <=</ur>
6	るっても	41,9	45) \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	Azile
4		(40		⊢	7 \ A
P4 3	(1+(1-1)-1)-(1+) (1+(3x3-4) (1+(3x3-4) (1+(3x3-4) (1+(3x3-4)	・一会	=1)(t=	Y .	7
hat	(2)	山でからい	4141 (1×1=1)14)	(1=)) 上分して(1<=1)	
35	(£)		₹.	**	
भू ग्राह	मि चेत्रे	₹	7]	
Finally we see that $\sigma_2(i) = 2$, $(\sigma_2 = \sigma^1 + rom)$ the question)	4),0>11,00) = (14) = (14) = (14)	4,9	7		د آ

8	2			5.:
Spilosofition	100		<5Kip, 027 y 022 (5)	
1)=2 1)=2 - (4) (1:=141)=> (1:>5)	イ, の27リの2は)=2-(4)	イシュンリス こうい	((4)) ((4)) ((4)) ((4)) ((4)) ((4))	i*i<=i do i:=i+1)else skip, デスクリグシ
人),でま7世ででいうこ2	4),5 4),5 (17)		<i*i<=i, 0271jf(4<2)<="" td=""><td>حنا بنداً بله النائة المالا أنجاً ما المالا المالا</td></i*i<=i,>	حنا بنداً بله النائة المالا أنجاً ما المالا
くし,でまフリケュロ)=2 ((4)	LI, 027 U.Z	-(元) -(元) (元) (元) (元) (元) (元) (元) (元) (元) (元)	*!<=!,0</td <td>< i i * i then <= i</td>	< i i * i then <= i
الاقورا		D. J. Co.		02 =

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小USTAL while it is it ob insits which it is it

CINITAL STATE (IKED)

4 in Milain reprosings

PROBLEM 4

(a) large step operational semantics.

ARITHMETIC RULES:

BOOLEAN RULES:

(10) くり,のフリア,な くりょってりゅうの (2) large step operational semantice 10, phy (1 <0,2d 39 1d> ARITHMETIC RULES: (11) 2 (1 m) Kb1 11 b2,07 11 pvq,01 (m) (A) 11 a.(n) a (13) くり,のりりゅ - Profice for Einfles for (9) (b) small step operational semantics でから 17 mi と イロア こうしゅう (91) 1-0' TU-10 11 20 Fr-107 (Z+) ∠9, 05 -->1 ∠c', -17 (c,a), -> -> -> -> (c,a), -> + (c,a), -> -> (d) COLLABORATORS: CARLA VAZQUEZ (CPV150030) - 1 1 2 00 00 10 100000 かっし ひくっている SOURCES: -class lecture notes, handouts BOOLEAN RULES: (F) true, 00 4 50 (8) 5 love 2 12 62 10 80 11 (200) E in it (100) (B) TOTE 30 O CO 50 5107

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PROBLEM 2: d'abuson (cor oran) (-,(x) -> - (+x)
                                                             (12)
 given W= (while true do 2:=2+2) and == {(7,0)}
 Step 1: < while brue do 2:= 2+3, 0> -> 1 (4 true then
                                             (2:=2+2; 118081
 (8)
             solo maril about alle of while brue do 7:=2+2)
                                            else skip,
 how there exists some derivation of justiment capaign - we will
 Step 2: < i brue then (x:=x+2; while true do x:=x+2) else skip, ->
 (6) \(\frac{1}{2} \) \(\frac{2}{2} = \frac{1}{2}; \text{ while true do 2: = 2+2,0=} \)
                                              So here Kin and nie
                                       unu Inisakti ie kka
Step 3:
 (1).
(2):=2+2,0) (2:=2+2),017 issentaguri solubol
     ⟨2:=x+2; while true do x:=x+2,0> 1 < (2:=x+2),
while true do 2 = 2 there and than 0, then Inol ; 2 where there at
 exactly to + symbols. to waymbols, xo '+' symbols and all unlega
   100 m 2 2+2,07 -1/(2+2),0/2
 Step4:
 (3)
 Inductive case: Superfection of Jodinstrages: seep orionality

(2:=12,07 — 7 L2:=(2+2),07

Drawst and with one of the 3 desti abon rules for with mediciness, 16, 14.
                               lde literatore must consider the factors
Step 5
               くぬ,のラーショ く2,01>
                                                  FI Sule 17
  (23)
               く2+7,07 -1 く2+21,017
                                                   Carle 2: Rule 16.
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(21) (21) (Carifer low (Ctreek ob surt still) = 12 miles

Liety: < my por do or: = 4+5 as The they

PROBLEM 3: STATE : (1)

Theorem 1 of judgement La, 0-711, n holds then In1 < 2

Proof There exists some derivation ool judgement 20,0711 n. We will

prove the theorem by structural induction on D

Base case: suppose Dionly consists of 1 rule. Then, D= < n, -74, n, (3)

so here K=0 and n=2

Thus In1 < 2 x +1 ie 2 < 2

Inductive hypothesis, Assume that the theorem holds for all the derivations

that are shicky smaller than D. that is, assume that if < ao, 0074, no

has a derivation stricky smaller than 0, then Inol < 2 where there are

ezactly ko't' symbols, ko 'symbols, ko '* symbols and all integer

constants are 2 in ao

Inductive case: Suppose that 0 consists of more than one rule. In that case,

D must end with one of the 3 derivation rules for arithmetic ie 15, 16, 17.

ble therefore must consider the 3 cases

case 1: Rule 17 case 3: Rule 15

case 2: Rule 16.

Sep 3:

5 00/0

Thewise me mon that De is shouly sensing to 250 # 120 Los on the

the know that Di is strictly smaller than derivation D. Of there are ki binary operators in the expression at, then we conclude by I.H that Inil & 3Ki+1

likewise, we know that Dz is strictly smaller than derivation D. If there are Kz bunary operators in the expression az then we conclude by I.H that Inzl < 3k2+1

Theis, the total operators in D would be it k= K|+ K2+ Holes and

: (ninzl & 2 (Kitk2+1)+1 7) show the of second is sho

$$\Rightarrow \left| \begin{array}{c} (3k_1+1) \\ 2 \end{array} \right| \left| \begin{array}{c} (3k_2+1) \\ 2 \end{array} \right| \leq 2$$

Thus; the relation holds ie |n1 n2 | < 2 K+1

case 2: Suppose of nends with Rule 16 some put in in that warry approxima in the englate by I. It in the

D= <a>1,0711 n1 <a>2,0711 n2 1+116 <a>1,0711 n2 1+116

of g. of nich control ment colling wholds is so soon wind our services in the property of the

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kle know that DI is strictly smaller than derivation D. I there are 'ki' binary operators in the expression as, then we conclude by I.H that 105 25 A Ur. Inil & 2 skitl likewise, we know that Dz is strictly smaller than derivation D. 91 there are k2 binary operators in the expression az then we conclude by 1.4 that triary exercition in the expression of then we conclude by the support Thus, the total operators in D would be K=K1+K2+1 thewise, we know that De is shidly small + (1703+18) conon D. of their My private above in the expression as then we conduct by It I this $\Rightarrow \begin{vmatrix} (3k_1+1) & (3k_2+1) \\ 2 & -2 \end{vmatrix} \le 2^{3k_1+3k_2+4}$ Inal & a Thus, the relation holds ie initials 21 in volonge loss and with case 3: Suppose D ends with Rule 15 1+ (1+ ext 12) = | Latin | : = (Shiti) (3K2+1) & 2KQ13K2+17 DI D= Layor UM 202,07 11, N2 Trus; the relation holds ic ∠a1+a2, ~7 y n1+n2 We know that Di is snicky smaller than derivation D. A there are ki binary operators in the expression as, then we conclude by 1.4 that J. (Inil & 23Kitl LOS OF HE 10 115 - 10-

Likewise, we know that Dz is strictly smaller than derivation D. of there

are $`t_2'$ binary operators in the expression as, then we conclude by 1.11 that $10.21 \le 2^{3k_2+1}$

Thus, the total operators in D would be K=K1+K2+1

Thus, the retation holds is Inital < 2 ktl