Regular Paper

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Abstract

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1 Introduction

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2 Methods

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2.2 Formalizations

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| Listing 1. GROUP\_17 - Th.16 | |
| 1  2  3  4  5  6  7  8  9  10  11  12  13 | **theorem** :: GROUP 17:16  **for** G **being** finite commutative Group,   h,k **be** Nat  **st** card G = h∗k **&** h,k are coprime **holds**  **ex** H,K **being** strict finite Subgroup **of** G **st**  **the** carrier **of** H = {x **where** x **is** Element **of** G: x|ˆh = 1 G} **&** :: 注釈を入れてもよい  **the** carrier **of** K = {x **where** x **is** Element **of** G: x|ˆk = 1 G} **&**   H **is** normal **&** K **is** normal  **&**    (**for** x **be** Element **of** G **holds**  **ex** a,b **be** Element **of** G **st** a in H **&** b in K **&** x = a ∗ b)  **&**    (**the** carrier **of** H) /\ (**th**e carrier **of** K) = {1\_G}; |

3 Results

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| Table 1. Table caption Nulla mi mi, venenatis sed ipsum varius, volutpat euismod diam. | | | | | | | | |
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3.3 Subsection 1

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3.4 Subsection 2

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4 Discussion

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5 Conclusions

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Acknowledgments

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Mizar article information

Works in Progress

GROUP\_17 Isomorphisms of Direct Products of Finite Commutative Groups  
by Hiroyuki Okazaki, Hiroshi Yamazaki and Yasunari Shidama

notations TARSKI, XBOOLE\_0, ZFMISC\_1, SUBSET\_1, RELAT\_1, FUNCT\_1, ORDINAL1,  
 RELSET\_1,PARTFUN1, FUNCT\_2, DOMAIN\_1, FUNCOP\_1, FUNCT\_4, FINSET\_1,  
 CARD\_1, PBOOLE, CARD\_3, NUMBERS, XCMPLX\_0, XXREAL\_0, XREAL\_0, NAT\_1  
 INT\_1, INT\_2, BINOP\_1, FINSEQ\_1, NEWTON, PRE\_POLY, NAT\_3, STRUCT\_0,  
 ALGSTR\_0, GROUP\_1, GROUP\_2, GROUP\_3, GROUP\_4, GROUP\_6, PRALG\_1, GROUP\_7,  
 INT\_7;

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| Listing 2. GROUP\_17 - abstract | |
|  | :: Isomorphisms of Direct Products of Finite Commutative Groups  :: by Hiroyuki Okazaki , Hiroshi Yamazaki and Yasunari Shidama  environ  vocabularies FINSEQ\_1, FUNCT\_1, RELAT\_1, RLVECT\_2, CARD\_3, TARSKI, BINOP\_1,  GROUP\_1, XXREAL\_0, GROUP\_2, CARD\_1, FUNCT\_4, GROUP\_6, GROUP\_7, FUNCOP\_1,  ALGSTR\_0, PARTFUN1, FUNCT\_2, SUBSET\_1, XBOOLE\_0, STRUCT\_0, NAT\_1,  ORDINAL4, PRE\_TOPC, ARYTM\_1, ARYTM\_3, FINSET\_1, INT\_2, ZFMISC\_1, PBOOLE,  NEWTON, INT\_1, NAT\_3, REAL\_1, PRE\_POLY, XCMPLX\_0, UPROOTS, INT\_7;  notations TARSKI, XBOOLE\_0, ZFMISC\_1, SUBSET\_1, RELAT\_1, FUNCT\_1, ORDINAL1,  RELSET\_1, PARTFUN1, FUNCT\_2, DOMAIN\_1, FUNCOP\_1, FUNCT\_4, FINSET\_1,  CARD\_1, PBOOLE, CARD\_3, NUMBERS, XCMPLX\_0, XXREAL\_0, XREAL\_0, NAT\_1,  INT\_1, INT\_2, BINOP\_1, FINSEQ\_1, NEWTON, PRE\_POLY, NAT\_3, STRUCT\_0,  ALGSTR\_0, GROUP\_1, GROUP\_2, GROUP\_3, GROUP\_4, GROUP\_6, PRALG\_1, GROUP\_7,  INT\_7;  constructors BINOP\_1, REALSET1, GROUP\_6, MONOID\_0, PRALG\_1, GROUP\_4, CARD\_2,  GROUP\_7, RELSET\_1, WELLORD2, NAT\_D, INT\_7, RECDEF\_1, NAT\_3, FINSOP\_1;  registrations XBOOLE\_0, XREAL\_0, STRUCT\_0, GROUP\_2, MONOID\_0, FUNCT\_2, CARD\_1,  CARD\_3, GROUP\_7, GROUP\_3, RELSET\_1, FINSEQ\_1, INT\_1, AOFA\_000, GR\_CY\_1,  FINSET\_1, NAT\_3, RELAT\_1, FUNCT\_1, MEMBERED, FUNCOP\_1, NEWTON, VALUED\_0,  PRE\_POLY, PBOOLE, INT\_7, GROUP\_6, ORDINAL1;  requirements NUMERALS, SUBSET, ARITHM, BOOLE;  begin :: Preliminaries  theorem :: GROUP\_17:1  for A,B,A1,B1 be set st A misses B  & A1 c= A & B1 c= B & A1 \/ B1 = A \/ B holds  A1 = A & B1 = B;  theorem :: GROUP\_17:2  for H,K be non empty finite set holds  card product (<\* H, K \*>) = card(H)\*card(K);  theorem :: GROUP\_17:3  for ps,pt,f be bag of SetPrimes,  q being Nat  st (support ps) misses (support pt) & f = ps + pt & q in (support ps) holds  ps.q = f.q;  theorem :: GROUP\_17:4  for ps,pt,f be bag of SetPrimes,  q being Nat  st (support ps) misses (support pt) & f = ps + pt & q in (support pt) holds  pt.q = f.q;  theorem :: GROUP\_17:5  for h be non zero Nat, q being Prime  st not q,h are\_coprime holds  q divides h;  theorem :: GROUP\_17:6  for h,s be non zero Nat  st for q being Prime st q in support (prime\_factorization s)  holds not q,h are\_coprime holds  support (prime\_factorization s) c= support (prime\_factorization h);  theorem :: GROUP\_17:7  for h,k,s,t be non zero Nat  st h,k are\_coprime & s \* t = h \* k  & (for q being Prime st q in support prime\_factorization s  holds not q,h are\_coprime)  & (for q being Prime st q in support prime\_factorization t  holds not q,k are\_coprime)  holds  s = h & t = k;  definition  let G be non empty multMagma,  I be finite set,  b be (the carrier of G)-valued total I -defined Function;  func Product b -> Element of G means  :: GROUP\_17:def 1  ex f being FinSequence of G st it = Product f & f = b\*canFS(I);  end;  theorem :: GROUP\_17:8  for G being commutative Group,  A,B being non empty finite set,  FA be (the carrier of G)-valued total A -defined Function,  FB be (the carrier of G)-valued total B -defined Function,  FAB be (the carrier of G)-valued total A \/ B -defined Function  st A misses B & FAB = FA +\* FB holds  Product (FAB) = (Product FA) \* (Product FB);  theorem :: GROUP\_17:9  for G being non empty multMagma,  q be set,  z be Element of G,  f be (the carrier of G)-valued total {q}-defined Function  st f = q .--> z  holds Product f = z;  begin :: Direct Product of Finite Commutative Groups  theorem :: GROUP\_17:10  for X,Y being non empty multMagma holds  the carrier of product <\*X,Y\*>  = product <\* the carrier of X,the carrier of Y \*>;  theorem :: GROUP\_17:11  for G being Group, A,B being normal Subgroup of G st  (the carrier of A) /\ (the carrier of B) = {1\_G} holds  for a,b be Element of G st a in A & b in B holds a\*b = b\*a;  theorem :: GROUP\_17:12  for G being Group, A,B being normal Subgroup of G st  (for x be Element of G holds  ex a,b be Element of G st a in A & b in B & x = a\*b)  & (the carrier of A) /\ (the carrier of B) = {1\_G} holds  ex h being Homomorphism of product <\*A,B\*>,G st h is bijective  & for a,b be Element of G st a in A & b in B  holds h.(<\*a,b\*>) = a\*b;  theorem :: GROUP\_17:13  for G being finite commutative Group,  m be Nat,  A be Subset of G  st A ={x where x is Element of G: x|^m = 1\_G}  holds  A <> {}  &  (for g1,g2 be Element of G  st g1 in A & g2 in A holds g1 \* g2 in A) &  for g be Element of G st g in A holds g" in A;  theorem :: GROUP\_17:14  for G being finite commutative Group,  m be Nat,  A be Subset of G  st A ={x where x is Element of G: x|^m = 1\_G} holds  ex H being strict finite Subgroup of G  st the carrier of H = A & H is commutative normal;  theorem :: GROUP\_17:15  for G being finite commutative Group,  m be Nat,  H being finite Subgroup of G  st the carrier of H = {x where x is Element of G: x|^m = 1\_G} holds  for q being Prime st q in support prime\_factorization card H  holds not q,m are\_coprime;  theorem :: GROUP\_17:16  for G being finite commutative Group,  h,k be Nat  st card G = h\*k & h,k are\_coprime holds  ex H,K being strict finite Subgroup of G st  the carrier of H = {x where x is Element of G: x|^h = 1\_G} &  the carrier of K = {x where x is Element of G: x|^k = 1\_G} &  H is normal & K is normal  &  (for x be Element of G holds  ex a,b be Element of G st a in H & b in K & x = a\*b)  &  (the carrier of H) /\ (the carrier of K) = {1\_G};  theorem :: GROUP\_17:17  for H,K be finite Group holds  card product (<\* H, K \*>) = card(H)\*card(K);  theorem :: GROUP\_17:18  for G being finite commutative Group,  h,k be non zero Nat  st card G = h\*k & h,k are\_coprime  ex H,K being strict finite Subgroup of G st  card H = h & card K = k &  (the carrier of H) /\ (the carrier of K) = {1\_G} &  ex F being Homomorphism of product <\*H,K\*>,G  st F is bijective  & for a,b be Element of G st a in H & b in K  holds F.(<\*a,b\*>) = a\*b;  begin :: Finite Direct Products of Finite Commutative Groups  theorem :: GROUP\_17:19  for G be Group,  q be set,  F be associative Group-like multMagma-Family of {q},  f being Function of G,product F st F = q .--> G &  for x being Element of G holds f . x = q .--> x holds  f is Homomorphism of G,(product F);  theorem :: GROUP\_17:20  for G be Group,  q be set,  F be associative Group-like multMagma-Family of {q},  f being Function of G,product F st F = q .--> G &  for x being Element of G holds f . x = q .--> x holds  f is bijective;  theorem :: GROUP\_17:21  for q be set,  F be associative Group-like multMagma-Family of {q},  G be Group st F = q .--> G holds  ex I be Homomorphism of G,product F st  I is bijective &  for x being Element of G holds I . x = q .--> x;  theorem :: GROUP\_17:22  for I0,I be non empty finite set,  F0 be associative Group-like multMagma-Family of I0,  F be associative Group-like multMagma-Family of I,  H,K be Group,  q be Element of I,  k be Element of K,  g be Function st  g in the carrier of product F0 &  not q in I0 & I = I0 \/ {q} & F = F0 +\* (q .--> K) holds  g +\* (q .--> k) in the carrier of product F;  theorem :: GROUP\_17:23  for I0,I be non empty finite set,  F0 be associative Group-like multMagma-Family of I0,  F be associative Group-like multMagma-Family of I,  H,K be Group,  q be Element of I,  G0 be Function of H,product F0 st  G0 is Homomorphism of H,product F0  & G0 is bijective & not q in I0 & I = I0 \/ {q} & F = F0 +\* (q .--> K) holds  for G be Function of product <\*H,K\*>,(product F) st  for h be Element of H,k be Element of K  holds ex g be Function  st g=G0.h & G.(<\*h,k\*>) = g +\* (q .--> k) holds  G is Homomorphism of product <\*H,K\*>,product F;  theorem :: GROUP\_17:24  for I0,I be non empty finite set,  F0 be associative Group-like multMagma-Family of I0,  F be associative Group-like multMagma-Family of I,  H,K be Group,  q be Element of I,  G0 be Function of H, product F0 st  G0 is Homomorphism of H, product F0  & G0 is bijective  & not q in I0 & I = I0 \/ {q} & F = F0 +\* (q .--> K) holds  for G be Function of product <\*H,K\*>, product F st  for h be Element of H,k be Element of K  holds ex g be Function  st g=G0.h & G.(<\*h,k\*>) = g +\* (q .--> k)  holds G is bijective;  theorem :: GROUP\_17:25  for q be set,  F be multMagma-Family of {q},  G be non empty multMagma st  F = q .--> G holds  for y be (the carrier of G)-valued total {q} -defined Function holds  y in the carrier of product F & y.q in the carrier of G &  y= q .--> y.q;  theorem :: GROUP\_17:26  for q be set,  F be associative Group-like multMagma-Family of {q},  G be Group st F = q .--> G holds  ex HFG be Homomorphism of product F,G st  HFG is bijective &  for x be (the carrier of G)-valued total {q} -defined Function  holds HFG.x = Product x;  theorem :: GROUP\_17:27  for I0,I be non empty finite set,  F0 be associative Group-like multMagma-Family of I0,  F be associative Group-like multMagma-Family of I,  H,K be Group,  q be Element of I,  G0 be Homomorphism of H,(product F0) st  not q in I0 & I = I0 \/ {q} & F = F0 +\* (q .--> K) & G0 is bijective  ex G be Homomorphism of product <\*H,K\*>,(product F) st  G is bijective &  for h be Element of H,k be Element of K  ex g be Function st g=G0.h & G.(<\*h,k\*>) = g +\* (q .--> k);  theorem :: GROUP\_17:28  for I0,I be non empty finite set,  F0 be associative Group-like multMagma-Family of I0,  F be associative Group-like multMagma-Family of I,  H,K be Group,  q be Element of I,  G0 be Homomorphism of product F0, H st not q in I0 &  I = I0 \/ {q} & F = F0 +\* (q .--> K) & G0 is bijective holds  ex G be Homomorphism of product F, product <\*H,K\*> st G is bijective &  for x0 be Function,  k be Element of K,  h be Element of H  st h = G0.x0 & x0 in product F0 holds  G.(x0 +\* (q .-->k)) = <\* h, k \*>;  theorem :: GROUP\_17:29  for I be non empty finite set,  F be associative Group-like multMagma-Family of I,  x be total I -defined Function  st for p be Element of I holds x.p in F.p  holds x in the carrier of product F;  theorem :: GROUP\_17:30  for I0,I be non empty finite set,  F0 be associative Group-like multMagma-Family of I0,  F be associative Group-like multMagma-Family of I,  K be Group,  q be Element of I,  x be Element of product F st  not q in I0 & I = I0 \/ {q} & F = F0 +\* (q .--> K) holds  ex x0 be total I0 -defined Function,  k be Element of K st x0 in product F0  & x = x0 +\* (q .--> k) & for p be Element of I0 holds x0.p in F0.p;  theorem :: GROUP\_17:31  for G be Group,  H be Subgroup of G,  f being FinSequence of G,  g being FinSequence of H  st f=g  holds Product f = Product g;  theorem :: GROUP\_17:32  for I be non empty finite set,  G be Group,  H be Subgroup of G,  x be (the carrier of G)-valued total I -defined Function,  x0 be (the carrier of H)-valued total I -defined Function  st x=x0  holds Product x = Product x0;  theorem :: GROUP\_17:33  for G being commutative Group,  I0,I be non empty finite set,  q be Element of I,  x be (the carrier of G)-valued total I -defined Function,  x0 be (the carrier of G)-valued total I0 -defined Function,  k be Element of G st  not q in I0 & I = I0 \/ {q} & x = x0 +\* (q .--> k)  holds  Product x = (Product x0)\*k;  theorem :: GROUP\_17:34  for G being strict finite commutative Group  st card G > 1 holds  ex I be non empty finite set,  F be associative Group-like commutative multMagma-Family of I,  HFG be Homomorphism of product F,G st  I = support (prime\_factorization card G)  & (for p be Element of I holds F.p is strict Subgroup of G &  card (F.p) = (prime\_factorization card G).p) &  (for p,q be Element of I st p <> q holds  (the carrier of (F.p)) /\ (the carrier of (F.q)) = {1\_G}) &  HFG is bijective &  for x be (the carrier of G)-valued total I -defined Function  st for p be Element of I holds x.p in F.p  holds x in product F & HFG.x = Product x;  theorem :: GROUP\_17:35  for G being strict finite commutative Group st card G > 1 holds  ex I be non empty finite set,  F be associative Group-like commutative multMagma-Family of I st  I = support (prime\_factorization card G)  & (for p be Element of I holds F.p is strict Subgroup of G &  card (F.p) = (prime\_factorization card G).p) &  (for p,q be Element of I st p <> q holds  (the carrier of (F.p)) /\ (the carrier of (F.q)) = {1\_G})  &  (for y be Element of G  ex x be (the carrier of G)-valued total I -defined Function  st (for p be Element of I holds x.p in F.p) & y = Product x)  &  for x1,x2 be (the carrier of G)-valued total I -defined Function st  (for p be Element of I holds x1.p in F.p) &  (for p be Element of I holds x2.p in F.p) &  Product x1 = Product x2 holds x1=x2; |