THE PUBLISHING HOUSE
OF THE ROMANIAN ACADEMY

PROCEEDINGS OF THE ROMANIAN ACADEMY, Series A,
Volume 10, Number 2/2009, pp. 000-000

ON ZALMAI'S SEMIPARAMETRIC DUALITY MODEL FOR MULTIOBJECTIVE FRACTIONAL PROGRAMMING WITH n-SET FUNCTIONS

Ioan M. STANCU-MINASIAN*, Vasile PREDA**, Miruna BELDIMAN*, Andreea Mădălina STANCU*

* Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy,
Calea 13 Septembrie nr. 13, 050711, Bucharest 5, Romania, E-mail: stancum@csm.ro
** University of Bucharest, Faculty of Mathematics and Computer Sciences,
Str. Academiei 14, 010014, Bucharest, Romania

New duality results for a semiparametric duality model are given for a fractional programming problem involving n-set functions.

Key words: multiobjective programming, *n*-set function, duality, generalized convexity.

1. INTRODUCTION AND PRELIMINARIES

We consider the frame of optimization theory for *n*-set [2,5,8]. For formulating and proving various duality results, we use the class of generalized convex *n*-set functions called (F,b,φ,ρ, θ)-univex functions, which were defined in Zalmai [11]. Until now, F was assumed to be a sublinear function in the third argument. In our approach, we suppose that F is a convex function in the third argument, as in Preda *et al*. [7,8] and Bătătorescu *et al*. [1].

Let (X, A, μ) be a finite atomless measure space with $L_1(X, A, \mu)$ separable, and let d be the pseudometric on A^n defined by

$$d(R,S) := \left[\sum_{k=1}^{n} \mu^2 (R_k \Delta S_k)\right]^{1/2}$$

where $R = (R_1,\cdots,R_n)$, $S = (S_1,\cdots,S_n) \in A^n$ and Δ stands for symmetric difference. Thus, (A^n, d) is a pseudometric space.

For $h \in L_1(X, A, \mu)$ and $T \in A$ with indicator (characteristic) function $\chi_T \in L_\infty(X, A, \mu)$, the integral $\int h d\mu$ is denoted by $\langle h, \chi_T \rangle$.

Definition 1.1. [4] *A function* $f : A \to \mathbb{R}$ *is said to be differentiable at* $S^* \in A$ *if there exist* $Df(S^*) \in L_1(X, A, \mu)$, *called the derivative of f at* S^*, *and* $V_f : A \times A \to \mathbb{R}$ *such that*

$$f(S) = F(S^*) + \left\langle Df(S^*), \chi_S - \chi_{S^*} \right\rangle + V_f(S, S^*)$$

for each $S \in A$, *where* $V_f(S,S^*)$ *is* $o(d(S,S^*))$, *that is,*

$$\lim_{d(S,S^0)\to 0} \frac{V_f(S,S^*)}{d(S,S^*)} = 0.$$

Definition 1.2. [2] *A function* $g : A^n \to \mathbb{R}$ *is said to have a partial derivative at* $S^*=(S_1^*,\ldots, S_n^*) \in A^n$ *with respect to its i-th argument if the function* $f(S_i) = g(S_1^*,\ldots,S_{i-1}^*,S_i,S_{i+1}^*,\cdots,S_n^*)$ *has derivative* $Df(S_i^*)$, $i \in \underline{n} = \{1,2,\ldots,n\}$.

We define $\mathrm{D}_i g(S^*) = \mathrm{D}f(S_i^*)$ and write $\mathrm{D}g(S^*) = (\mathrm{D}_1 g(S^*),\ldots,\mathrm{D}_n g(S^*))$.

Definition 1.3. [2] *A function* g: $A^n \to \mathbb{R}$ *is said to be differentiable at* S^* *if there exist* $\mathrm{D}g(S^*)$ and $W_g : A^n \times A^n \to \mathbb{R}$ *such that*

$$G(S) = G(S^*) + \sum_{i=1}^{n} \left\langle \mathrm{D}_i G(S^*), \chi_{S_i} - \chi_{S_i^*} \right\rangle + W_G(S,S^*),$$

where $W_G(S,S^*)$ *is* $o(d(S,S^*))$ *for all* $S \in A^n$.

Let $\mathbb{R}^q$ be the q-dimensional Euclidean space and $\mathbb{R}_+^q$ its positive orthant, i.e.

$$\mathbb{R}_+^q = \{x = (x_1,\ldots,x_q) \in \mathbb{R}^q : x_j \geq 0,\ j = 1,\ldots,q\}.$$

For any vectors $x = (x_1,\ldots,x_n)$ and $y = (y_1,\ldots,y_n) \in \mathbb{R}^n$, we put $x \leqq y$ iff $x_i \leqq y_i$, for each $i \in \underline{n}=\{1,2,\ldots,n\}$; $x \leq y$ iff $x \leqq y$, with $x \neq y$; $x < y$ iff $x_i < y_i$, for each $i \in n = \{1,2,\ldots n\}$; $x \nleq y$ means the negation of $x \leq y$. Clearly, $x \in \mathbb{R}_+^n$ iff $x \geqq 0$.

In this paper, we consider the multiobjective fractional subset programming problem

$$\text{(P)} \qquad \min \Phi(S) = \left(\frac{f_1(S)}{g_1(S)}, \frac{f_2(S)}{g_2(S)}, \cdots, \frac{f_p(S)}{g_p(S)} \right)$$

subject to

$$h_j(S) \leqq 0, \quad j \in \underline{q} = \{1,2,\ldots,q\}, \quad S \in A^n,$$

where A^n is the n-fold product of the σ-algebra A of subsets of a given set X, $f_i : A^n \to \mathbb{R}$, $g_i : A^n \to \mathbb{R}$, $i \in \underline{p} = \{1,2,\ldots,p\}$, and $h_j : A^n \to \mathbb{R}$, $j \in \underline{q}$, such that $g_i(S) > 0$ for each $i \in \underline{p}$ and all $S \in \mathcal{P}$. We denoted by $\mathcal{P} = \{S \in A^n : h_j(S) \leqq 0,\ j \in q\}$ the set of all feasible solutions to (P).

Definition 1.4. *A feasible solution* $S^0 \in \mathcal{P}$ *is said to be an efficient solution to (P) if there exists no other feasible solution* $S \in \mathcal{P}$ *such that*

$$\left(\frac{f_1(S)}{g_1(S)}, \frac{f_2(S)}{g_2(S)}, \cdots, \frac{f_p(S)}{g_p(S)} \right) \leq \left(\frac{f_1(S^0)}{g_1(S^0)}, \frac{f_2(S^0)}{g_2(S^0)}, \cdots, \frac{f_p(S^0)}{g_p(S^0)} \right)$$

In the following we consider F: $A^n \times A^n \times \mathbb{R} \to \mathbb{R}$ and a differentiable function $f : A^n \to \mathbb{R}$. The definitions below unify the concepts of $(F,\rho)-$convexity, $(F,\rho)-$pseudoconvexity, $(F,\rho)-$quasiconvexity from Preda [6] and univexity, pseudounivexity, quasiunivexity from Mishra [3].

Let $b : A^n \times A^n \to \mathbb{R}_+$, $\theta : A^n \times A^n \to A^n \times A^n$ such that $S \neq S^* \Rightarrow \theta(S, S^*) \neq (0,0)$, $\varphi : \mathbb{R} \to \mathbb{R}$, and a real number ρ.

Definition 1.5. [11] *A function f is said to be* (*strictly*) $(F,b,\varphi,\rho,\theta)-$*univex at* S^* *if*

$$\varphi(F(S) - F(S^*))(>) \geqq F(S,S^*;b(S,S^*)\mathrm{D}F(S^*)) + \rho d^2(\theta(S,S^*))$$

for each $S \in A^n$.

Definition 1.6. [11] *A function f is said to be (strictly) (F,b,φ,ρ,θ)-pseudounivex at* S^* *if*

$$F(S,S^*;\ b(S,S^*)\mathrm{D}f(S^*)) \geqq -\rho d^2(\theta(S,S^*)) \ \Rightarrow\ \varphi(f(S)-\mathrm{f}(S^*))\ (>)\ \geqq 0$$

for each $S \in A^n$, $S \neq S^*$.

Definition 1.7. [11] *A function f is said to be* (*prestrictly*) (*F,b,φ,ρ,θ*)*-quasiunivex at* S^* *if*

$$\varphi(f(S)-f(S^*))\ (<)\leqq 0 \Rightarrow F(S,S^*;b(S,S^*)\mathrm{D}f(S^*))\leqq -\rho d^2(\theta(S,S^*))$$

for each $S \in A^n$.

For problem (P), Zalmai [10] gave the necessary conditions for efficiency below.

Theorem 1.1. *Assume that* f_i, g_i, $i \in \underline{p}$, *and* h_j, $j \in \underline{q}$, *are differentiable at* $S^* \in A^n$, *and that for each* $i \in \underline{p}$ *there exists* $\hat{S}_i \in A^n$, *such that*

$$h_j(S^*) + \sum_{k=1}^{n}\left\langle \mathrm{D}_k h_j(S^*), \chi_{\hat{S}_k} - \chi_{S_k^*}\right\rangle < 0, j \in \underline{q},$$

and for each $l \in \underline{p}\setminus\{i\}$ we have

$$\sum_{k=1}^{n}\left\langle g_i(S^*)\mathrm{D}_k f_l(S^*) - f_i(S^*)\mathrm{D}_k g_l(S^*), \chi_{\hat{S}_k} - \chi_{S_k^*}\right\rangle < 0.$$

If S^* *is an efficient solution to* (P), *then there exists* $u^* \in U = \{u \in \mathbb{R}^p : u > 0, \sum_{i=1}^{p} u_i = 1\}$ and $v^* \in \mathbb{R}_+^q$ *such that*

$$\sum_{k=1}^{n}\left\langle \sum_{i=1}^{p} u_i^*[g_i(S^*)\mathrm{D}_k f_i(S^*) - f_i(S^*)\mathrm{D}_k g_i(S^*)] + \sum_{j=1}^{q} v_j^*\mathrm{D}_k h_j(S^*), \chi_{S_k} - \chi_{S_k^*}\right\rangle \geqq 0, \tag{1}$$

for all $S \in A^n$, $v_j^* h_j(S^*) = 0, j \in \underline{q}$.

We shall refer to an efficient solution S^* to (P) satisfying the first two conditions in Theorem 1.1 for some $\hat{S}_i$, $i \in \underline{p}$, as a *normal* efficient solution.

2.THE DUALITY MODEL AND DUALITY RESULTS

In this section we present a general duality model for (P). Here we use two partitions of the index sets $\underline{q}$ and $\underline{p}$, respectively.

Let $\{\mathrm{I}_0, \mathrm{I}_1, ..., \mathrm{I}_k\}$ be a partition of the index set $\underline{p}$ and $\{\mathrm{J}_0, \mathrm{J}_1, ..., \mathrm{J}_m\}$ a partition of the index set $\underline{q}$ such that K={0,1,...,*k*} ⊂ M={0,1,...,*m*}, and, for fixed *S, u* and *v*, and $t \in \mathrm{K}$ let the function $\Omega_t(S;\cdot,u,v): A^n \to \mathbb{R}$ be defined by

$$\Omega_t(S,T,u,v) = \sum_{i\in \mathrm{I}_t} u_i\left[f_i(S)g_i(T) - f_i(T)g_i(S)\right] + \Sigma v_j h_i(T)$$

We associate with problem (P) the dual problem

$$(\mathrm{D}) \qquad \max \delta(T,u,v) = \left(\frac{f_1(T)}{g_1(T)}, \frac{f_2(T)}{g_2(T)}, \cdots, \frac{f_p(T)}{g_p(T)} \right)$$

subject to

$$F\left(S,T; b(S,T)\sum_{i=1}^{p} u_i \left[G_i(T)\mathrm{D}F_i(T) - F_i(T)\mathrm{D}G_i(T) \right] + \sum_{j=1}^{q} v_j \mathrm{D}h_j(T) \right) x \geqq 0 \ \forall S \in A^n$$

$$\sum_{j\in \mathrm{J}_t} v_j h_j(T) \geqq 0,\ t \in M$$

$$T \in A^n,\ \ u \in U,\ \ v \in \mathbb{R}_+^q.$$

In the following we consider a convex function $F(S,T;\cdot): L_1(X,A,\mu) \to \mathbb{R}$ and $\Lambda_t(\cdot, v^*): A^n \to \mathbb{R}$, $\Lambda_t(T, v^*) = \sum_{j\in \mathrm{J}_t} v_j^* h_j(T), t \in \mathrm{M}$.

The result below establishes several versions of weak duality related to problems (P) and (D).

Theorem 2.1 (Weak duality). *Let S and (T,u,v) be arbitrary feasible solutions to* (P) *and* (D), *respectively, and assume that any one of the following sets of hypotheses is satisfied:*

(a) (i) $2k\Omega_t(\cdot,T,u,v)$ *is strictly* $(F,b,\varphi_t,\rho_t,\theta)-$*pseudounivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{K}$;

(ii) $2(m-k)\Lambda_t(\cdot,v)$ *is* $(F,b,\varphi_t,\rho_t,\theta)-$*quasiunivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{M}\setminus\mathrm{K}$;

(iii) $\frac{1}{k}\sum_{t\in \mathrm{K}} \rho_t + \sum_{t\in \mathrm{M}\setminus\mathrm{K}} \frac{\rho_t}{m-k} \geqq 0;$

(b) (i) $2k\Omega_t(\cdot,T,u,v)$ *is prestrictly* $(F,b,\varphi_t,\rho_t,\theta)-$*quasiunivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{K}$;

(ii) $2(m-k)\Lambda_t(\cdot,v)$ *is strictly* $(F,b,\varphi_t,\rho_t,\theta)-$ *pseudounivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{M}\setminus\mathrm{K}$;

(iii*)* $\frac{1}{k}\sum_{t\in \mathrm{K}} \rho_t + \sum_{t\in \mathrm{M}\setminus\mathrm{K}} \frac{\rho_t}{m-k} \geqq 0;$

(c) (i) $2k\Omega_t(\cdot,T,u,v)$ *is prestrictly* $(F,b,\varphi_t,\rho_t,\theta)-$*quasiunivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{K}$;

(ii) $2(m-k)\Lambda_t(\cdot,v)$ is $(F,b,\varphi_t,\rho_t,\theta)-$*quasiunivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{M}\setminus\mathrm{K}$;

(iii) $\frac{1}{k}\sum_{t\in \mathrm{K}} \rho_t + \sum_{t\in \mathrm{M}\setminus\mathrm{K}} \frac{\rho_t}{m-k} \geqq 0;$

(d) (i) $3k_1\Omega_t(\cdot,T,u,v)$ *is strictly* $(F,b,\bar{\varphi}_t,\bar{\rho}_t,\theta)-$*pseudounivex at T for each* $t \in \mathrm{K}_1$, $\bar{\varphi}_t$ *is increasing, and* $\bar{\varphi}_t(0)=0$ *for each* $t \in \mathrm{K}_1$, $3k_2\Omega_t(\cdot,T,u,v)$ *is prestrictly* $(F,b,\bar{\varphi}_t,\bar{\rho}_t,\theta)-$*quasiunivex at T for each* $t \in \mathrm{K}_2$, $\bar{\varphi}_t$ *is increasing, and* $\bar{\varphi}_t(0)=0$ *for each* $t \in \mathrm{K}_2$, *where* $\{\mathrm{K}_1,\mathrm{K}_2\}$ *is a partition of* K*, with* $\mathrm{K}_1 \neq \varnothing$, $\mathrm{K}_2 \neq \varnothing$, $k_1 = |\mathrm{K}_1|$, $k_2 = |\mathrm{K}_2|$;

(ii) $3(m-k)\Lambda_t(\cdot,v)$ is $(F,b,\varphi_t,\rho_t,\theta)-$ *quasiunivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t \in \mathrm{M}\setminus\mathrm{K}$;

(iii) $\frac{1}{k_1}\sum_{t\in K_1}\rho_t+\frac{1}{k_2}\sum_{t\in K_2}\rho_t+\sum_{t\in M\setminus K}\frac{\rho_t}{m-k}\geqq 0$;

(e) (i) $3k\Omega_t(\cdot,T,u,v)$ *is prestrictly* $(F,b,\varphi_t,\rho_t,\theta)-$ *quasiunivex at T,* φ_t *is increasing, and* $\varphi_t(0)=0$ *for each* $t\in K$;

(ii) $3(m_1-k_1)\Lambda_t(\cdot,v)$ *is strictly* $(F,b,\tilde{\varphi}_t,\tilde{\rho}_t,\theta)-$ *pseudounivex at T for each* $t\in(M\setminus K)_1$, $\tilde{\varphi}_t$ *is increasing, and* $\tilde{\varphi}_t(0)=0$ *for each* $t\in(M\setminus K)_1$, $3(m_2-k_2)\Lambda_t(\cdot,v)$ *is* $(F,b,\tilde{\varphi}_t,\tilde{\rho}_t,\theta)-$ *quasiunivex at T for each* $t\in(M\setminus K)_2$, $\tilde{\varphi}_t$ *is increasing, and* $\tilde{\varphi}_t(0)=0$ *for each* $t\in(M\setminus K)_2$, *where* $\{(M\setminus K)_1,(M\setminus K)_2\}$ *is a partition of* $M\setminus K$, *with* $(M\setminus K)_1\neq\varnothing$, $m_1=|(M\setminus K)_1|$, $(M\setminus K)_2\neq\varnothing$, $m_2=|(M\setminus K)_2|$;

(iii) $\frac{1}{k}\sum_{t\in K}\rho_t+\sum_{t\in(M\setminus K)_1}\frac{\rho_t}{m_1-k_1}+\sum_{t\in(M\setminus K)_2}\frac{\rho_t}{m_2-k_2}\geqq 0$;

(f) (i) $4k_1\Omega_t(\cdot,T,u,v)$ *is strictly* $(F,b,\bar{\varphi}_t,\bar{\rho}_t,\theta)-$ *pseudounivex at T,* $\bar{\varphi}_t$ *is increasing, and* $\bar{\varphi}_t(0)=0$ *for each* $t\in K_1$, $4k_2\Omega_t(\cdot,T,u,v)$ *is prestrictly* $(F,b,\bar{\varphi}_t,\bar{\rho}_t,\theta)-$ *quasiunivex at T,* $\bar{\varphi}_t$ *is increasing and,* $\bar{\varphi}_t(0)=0$ *for each* $t\in K_2$, *where* $\{K_1,K_2\}$ *is a partition of* K, *with* $K_1\neq\varnothing$, $K_2\neq\varnothing$, $k_1=|K_1|$, $k_2=|K_2|$;

(ii) $4(m_1-k_1)\Lambda_t(\cdot,v)$ *is strictly* $(F,b,\tilde{\varphi}_t,\tilde{\rho}_t,\theta)-$ *pseudounivex at T,* $\tilde{\varphi}_t$ *is increasing, and* $\tilde{\varphi}_t(0)=0$ *for each* $t\in(M\setminus K)_1$, $4(m_2-k_2)\Lambda_t(\cdot,v)$ *is* $(F,b,\tilde{\varphi}_t,\tilde{\rho}_t,\theta)-$ *quasiunivex at T,* $\tilde{\varphi}_t$ *is increasing, and* $\tilde{\varphi}_t(0)=0$ *for each* $t\in(M\setminus K)_2$, *where* $\{(M\setminus K)_1,(M\setminus K)_2\}$ *is a partition of* $M\setminus K$, *with* $(M\setminus K)_1\neq\varnothing$, $m_1=|(M\setminus K)_1|$, $(M\setminus K)_2\neq\varnothing$, $m_2=|(M\setminus K)_2|$;

(iii) $\frac{1}{k_1}\sum_{t\in K_1}\rho_t+\frac{1}{k_2}\sum_{t\in K_2}\rho_t+\sum_{t\in(M\setminus K)_1}\frac{\rho_t}{m_1-k_1}+\sum_{t\in(M\setminus K)_2}\frac{\rho_t}{m_2-k_2}\geqq 0$;

(iv) $K_1\neq\varnothing$ *or* $(M\setminus K)_1\neq\varnothing$ *or*

$$\frac{1}{k_1}\sum_{t\in K_1}\rho_t+\frac{1}{k_2}\sum_{t\in K_2}\rho_t+\sum_{t\in(M\setminus K)_1}\frac{\rho_t}{m_1-k_1}+\sum_{t\in(M\setminus K)_2}\frac{\rho_t}{m_2-k_2}>0;$$

Then $\Phi(S)\not\leq\delta(T,u,v)$.

Theorem 2.2. (Strong duality). *Let* $S^*\in\mathcal{P}$ *be a normal efficient solution to* (P), *let* $F(S,S^*;Df(S^*))=\sum_{k=1}^{n}\left\langle D_k f(S^*),\chi_{S_k}-\chi_{S_k^*}\right\rangle$ *for any differentiable function* $f:A^n\to\mathbb{R}$ *and* $S\in A^n$, *and assume that any one of the sets of hypotheses specified in* Theorem 2.1. *holds for all feasible solutions to* (D). *Then there exist* $u^*\in U$ *and* $v^*\in\mathbb{R}_+^q$ *such that* (S^*,u^*,v^*) *is an efficient solution of* (D) *and* $\Phi(S^*)=\delta(S^*,u^*,v^*)$.

Remark 2.1. *Using* Theorems 2.1 *and* 2.2, *and tehniques from* [5] *and* [10], *we can also obtain a strict converse duality result.*

For a detalied presentation of these results, the reader is referred to [9].

3. CONCLUSIONS

We have obtained duality results for a dual model of Zalmai [10], replacing the assumption of sublinearity by that of convexity. Similar results can be obtained for the other dual models from [10]. Also, almost all results of this type present in the literature can be extended to the case where F is not necessarily sublinear.

ACKNOWLEDGEMENTS

This work was partially supported by Grant PN II IDEI no. 112/2007.

REFERENCES

1. BĂTĂTORESCU, A., PREDA, V., BELDIMAN, M., *On higher order duality for multiobjective programming involving generalized* (F,ρ,γ,b)-*convexity*, Math. Rep. (Bucur.) **9(59)** (2007)2, 161-174.
2. CORLEY, H. W., *Optimization theory for n-set functions*, J. Math. Anal. Appl. **127** (1987)1, 193-205.
3. MISHRA, S.K., *Duality for multiple objective fractional subset programming with generalized* (F,ρ,σ,θ)-V-*type*-I *functions*, J. Global Optim. **36** (2006)4, 499-516.
4. MORRIS, R. J. T., *Optimal constrained selection of a measurable subset*, J. Math. Anal. Appl. **70**(1979)2, 546-562.
5. PREDA, V., *On minmax programming problems containing n-set functions*, Optimization **22** (1991)4, 527-537.
6. PREDA, V., *On efficiency and duality for multiobjective programms*, J. Math. Anal. Appl. **166** (1992)2, 365-377.
7. PREDA, V., STANCU-MINASIAN, I.M., BELDIMAN, M., STANCU, A., *Optimality and duality for multiobjective programming with generalized V-type I univexity and related n-set functions*, Proc. Rom. Acad. Ser. A Math. Phys. Tech. Sci. Inf. Sci. **6**(2005)3, 183-191.
8. PREDA, V., STANCU-MINASIAN, I.M., BELDIMAN, M., STANCU, A., *Generalized* V-*univexity type*-I *for multiobjective programming problems with n- set function*, to appear in J. Global Optim., 2009.
9. PREDA, V., STANCU-MINASIAN, I.M., BELDIMAN, M., STANCU, A., *Duality for multiobjective fractional programming with generalized* (F,b,φ,ρ,θ)-*univex n-set functions*, submitted.
10. ZALMAI, G. J., *Efficiency conditions and duality models for multiobjective fractional subset programming problems with generalized* (F,α,ρ,θ)-V-*convex functions*, Comp. Math. Appl. **43** (2002)12, 1489-1520.
11. ZALMAI, G. J., *Generalized* (F,b,φ,ρ,θ)-*univex n-set functions and global semiparametric sufficient efficiency conditions in multiobjective fractional subset programming*, Int. J. Math. Math. Sci. **6**(2005), 949-973.

Received February 3, 2009