Iraqi Journal of Science, 2020, Special Issue, pp: 238-242
DOI: 10.24996/ijs.2020.SI.1.32

ISSN: 0067-2904

On Soft bc-Open Sets in Soft Topological Spaces

Saif Z. Hameed*, Adiya K. Hussein
Department of Mathematics, College of Basic Education Mustansiriyah University, Baghdad, Iraq

Received: 5/1/ 2020 Accepted: 15/ 3/2020

Abstract

In this paper, we offer and study a novel type of generalized soft-open sets in soft topological spaces, named soft ƀc-open sets. Relationships of this set with other types of generalized soft-open sets are discussed, definitions of soft $ƀc-$ neighƀorhood, soft bc- closure and soft bc- interior are introduced, and its properties are investigated. Also, we introduce and explore several characterizations and properties of this type of sets.

Keywords: soft ƀ-open set, soft ƀc-open set, soft ƀc- nbd, soft ƀc-interior, soft ƀc-closure.

حول المجموعات المفتوحة الناعمة– bc في الفضاءات التبولوجية الناعمة

سيف زهير حميد* , عذية خليفة حسين

قسم الرياضيات، كلية التربيه الاساسيه، الجامعه المستنصريه، بغداد، العراق

الخلاصة

في هذا البحث قدمنا ودرسنا نوع جديد من المجموعات المفتوحة الناعمة اسميناها (المجموعات المفتوحة الناعمة نوع bc) وقد ناقشنا علاقاتها مع الانواع الاخرى المعروفة من المجموعات المفتوحة الناعمة, كذلك قدمنا تعريفا لكل من الجوارات من النمط bc, انغلاق مجموعة من النمط bc وداخل مجموعة من النمط bc ودرسنا خواصها.كما وجدنا العديد من الخواص والتمييزات للمجموعات الناعمة –bc.

1. Introduction and Preliminaries

The concept of soft set theory was instigated and applied by Molodtsov [1,2] as a mathematical device for dealing with uncertainties. In a previous work [3], Shaber and Naz defined soft topological spaces and soft open sets. Soft β- open sets were introduced and studied by several authors, including the soft α- open [4], soft preopen [5], soft semi open [4], and soft regular open sets [6]. . In another study [7], Akdag and Ozkan realized the soft b- open sets and soft continuity. The concept of bc- open sets was introduced by Ibrahim [8].

Let $(Z,\tau,$A) be a soft topological space, where A is any set of parameters. The soft closure (resp. soft interior) [9] of a soft set (P,A) is denoted by $(cl(P,A)$ (resp. $int(P,A)$). A subset (P,A) is said to be a β-open [4](resp. soft α-open[5], soft preopen[4], soft semi-open[6] and soft regular) set, if: $(P,A) \subset cl(int(cl((P,A)))$(resp.$(P,A) \subset int(cl(int((P,A))))$, $(P,A) \subset int(cl((P,A)))$, $(P,A) \subset cl(int((P,A)))$ and $(P,A) = int\left(cl((P,A))\right)$.

We denote the family of all soft sets over Ҳ by $SS(Z\,,A)$.

Definition 1.1[3]. Let τ be a collection of soft open sets over Z, then τ is said to be soft topological space if (1) $\widetilde{\emptyset}$and $\tilde{X}$ belong to τ, (2) The union of any subcollection

*Email: saif.zuhar.edbs@uomustansiriyah.edu.iq

of soft sets of τ belongs to τ, and (3) the intersection of any two soft sets in τ belongs to τ. We named the triple (Z,τ,A) by $\boldsymbol{STS}$.

Definition 1.2 [9]. The soft set $(P,A) \in SS(Z,A)$ is called a $soft\ point$ in Z, denoted by e_L, if for the element $e \in A$, $F(e) \neq \emptyset$ and $F(e') = \emptyset$ for all $e' \in A\setminus\{e\}$. The set of all soft points of Z is denoted by $SP(Z)$.

Definition 1.3 [7]. If $(P,A) \in SS(Z,A)$ then it is called

(1) Soft $b - open\ set$ (briefly $sb - open\ set$), iff $(P,A) \subset int(cl((P,A))) \cup cl(int((P,A)))$.

(2) Sof t$b - closed$ (briefly, $sb - closed$)set, iff $(P,A) \supset int(cl((P,A))) \cap cl(int((P,A)))$.

Definition 1.4 [6,7]. Let (P,A) be a soft set of a $\boldsymbol{STS}$ (Z,τ,A), then

(1) Soft $semi - interior$ of a soft set (P,A) in Z is denoted by

$sSint((P,A)) = \cup\{(W,A) : (W,A)$ is a soft semi−open set and $(W,A) \subset (P,A)\}$.

(2) Soft $semi - closure$ of a soft set (P,A) in Z is denoted by

$sScl((P,A)) = \cap\{(L,A) : (L,A)$ is a soft semi−closed set and $(P,A) \subset (L,A)\}$.

(3) Soft $b - interior$ of a soft set (P,A) in Z is denoted by

$sbint((P,A)) = \cup\{(W,A) : (W,A)$ is a soft b−open set and $(W,A) \subset (P,A)\}$.

(4) Soft $b - closure$ of a soft set (P,A) in Z is denoted by

$sbcl((P,A)) = \cap\{(L,A) : (L,A)$ is a soft b−closed set and $(P,A) \subset (L,A)\}$.

Clearly, $sbcl\ (P,A)$ (resp. $sScl\ (P,A)$ is the smallest soft b-closed (resp. soft semi-closed) set over Z which contains (P,A), and $sbint\ ((P,A))$ (resp. $sSint\ ((P,A))$) is the largest soft b-open (resp. semi-open) set over Z which is contained in (P,A).

We will denote the family of all soft b-open (resp., soft semi-open) sets and soft b-closed ((resp., soft semi-closed) sets of a soft topological space by $bO(Z)$ (resp., $SSO(Z)$ $SbC(Z)$ (resp., $SSC(Z)$).

Definition 1.5 [10]. Let (Z,τ,A) be a $\boldsymbol{STS}$. and $x,y \in Z$, such that $x \neq y$. If there exist soft open sets (P,A) and (S,A), such that $x \in (P,A), y \notin (S,A)$, $y \in (S,A)$, and $x \notin (P,A)$, then (Z,τ,A) is called a soft T_1-space.

Theorem 1.6 [10]. Let (Z,τ,E) be $\boldsymbol{STS}$. Then each soft point is a soft closed if and only if (Z,τ,A) is a soft T_1-space.

Definition 1.7 [11]. An $\boldsymbol{STS}$ (Z,τ,A) is called a *soft locally indiscrete*, if every soft open set over Z is a soft closed set over Z.

2. Soft $bc -$ open sets

Now, we give a new family of $soft\ b - open$ sets named soft $bc - open$ sets in an $\boldsymbol{STS}$ and study some of its basic properties.

Definition 2.1 A subset (P,A) of $\boldsymbol{STS}$ (Z,τ,E) is named $soft\ bc - open$ $(sbc - open)$ if, for any $x \in (P,A) \in SbO(Z)$, there is a soft closed set (S,A), such that $x \in (S,A) \subset (P,A)$. The complement of (P,A) is named soft $bc - closed$ $(sbc - closed)$.

The collection of all soft $bc - open$ sets in Z is denoted by $SbcO(Z)$ and the collection of all soft $bc - closed$ sets in Z is named $SbcC(Z)$.

Theorem 2.2 A soft subset (P,A) of $\boldsymbol{STS}$ (Z,τ,A) is soft $bc - open$ iff (P,A) is $sb - open$ and it is a union of soft closed sets.

Proof. (⇒) Let (P,A) be a soft $bc - open$ set. Then (P,A) is $sb - open$ set and for each $x \in (P,A)$ there is a soft closed set (L,A), such that $x \in (L,A) \subseteq (P,A)$. Then we get $\cup\{x\}_{x\in(P,A)} = (P,A) \subseteq (L,A) \subseteq (P,A)$. Thus, $(P,A) = \cup(L,A)$, where (P,A) is a soft closed set for each $x \in (P,A)$.

(⇐) Direct form the definition of soft $bc - open$.

Corollary 2.3 For a $\boldsymbol{STS}$ (Z,τ,A), if (L,A) is $sb - open$ set over X, then (L,A) is an $sbc - open$ if (L,A) is a soft closed set.

Proposition 2.4 A soft subset (H,A) of an $\boldsymbol{STS}$ (Z,τ,A) is $sbc - closed$ if and only if (H,A) is a soft $b - closed$ set and it is an intersection of soft open sets.

Proof. It is obvious.

Remark 2.5 Every $sbc - open$ set of a space Z is soft $b - open$, but the converse is not true in general, as shown by the following example.

Example 2.6 Let $Z = \{v_1,v_2,v_3\}, A = \{e_1,e_2,e_3\}$ and

$\tau = \{\widetilde{\emptyset}, \widetilde{Z}, (P_1,A), (P_2,A), (P_3,A), (P_4,A)\}$

where $(P_1,A), (P_2,A), (P_3,A), (P_4,A)$ are soft sets over Z, defined as follows:

$(P_1, A) = \{(e_1, \widetilde{Z}), (e_2, \{v_2, v_3\}), (e_3, \{v_1, v_2\})\}$,
$(P_2, A) = \{(e_1, \widetilde{\emptyset}), (e_2, \{v_1\}), (e_3, \{v_3\})\}$,
$(P_3, A) = \{(e_1, \{v_2\}), (e_2, \{v_1, v_3\}), (e_3, \{v_3\})\}$,
$(P_4, A) = \{(e_1, \{v_2\}), (e_2, \{v_3\}), (e_3, \widetilde{\emptyset})\}$.
Then, τ defines a soft topology on Z .
The soft closed sets are $\widetilde{Z}, \widetilde{\emptyset}, (P_1, A)^c, (P_2, A)^c, (P_3, A)^c, (P_4, A)^c$,
where $(P_1, A)^c = \{(e_1, \widetilde{\emptyset}), (e_2, \{v_1\}), (e_3, \{v_3\})\} = (P_2, A)$
$(P_2, A)^c = \{(e_1, \widetilde{Z}), (e_2, \{v_2, v_3\}), (e_3, \{v_1, v_2\})\} = (P_1, A)$
$(P_3, A)^c = \{(e_1, \{v_1, v_3\}), (e_2, \{v_2\}), (e_3, \{v_1, v_2\})\}$,
$(P_4, A)^c\{(e_1, \{v_1, v_3\}), (e_2, \{v_2, v_3\}), (e_3, \widetilde{Z})\}$.
The family of $SƀOS(Z) = \{(P_1, A), (P_2, A), (P_3, A), (P_4, A)\}$.
The family of $SƀcOS(Z) = \{(P_1, A), (P_2, A), (P_3, A)\}$.
Then $(P_4, A) \in SƀOS(Z)$, but $(P_4, A) \notin SƀcOS(Z)$.
By Remark (2) [8] and the above Remark (2.5), we have the following implications:

Soft regular set ⇒ Soft -open set⇒ Soft α −open set⇒ Soft $semi$ −open set

⇓ ⇓

Soft pre −open set ⇒ Soft ƀ −open set ⇒Soft β −open set

⇑

Soft ƀc −open set

Proposition 2.7 An arbitrary union of $sƀc - open$ sets is $sƀc - open$ set.
Proof. Suppose that $\{(P, A)_\lambda : \lambda \in \Delta\}$ is a family of soft $ƀc - open$ sets in(Z, τ, A). Then $(P, A)_\lambda$ is soft $ƀ - open$ set for each $\lambda \in \Delta$. So, $\cup(P, A)_\lambda$ is soft $ƀ - open$. Let $x \in \cup\{(P, A)_\lambda : \lambda \in \Delta\}$, so $x \in (L, A)_\lambda$ for some $\lambda \in \Delta$. Since $(P, A)_\lambda$ is soft $ƀ - open$ for each λ, then there is a soft closed set (L, A) such that
$x \in (L, A) \subset (P, A)_\lambda \subset \cup\{(P, A)_\lambda : \lambda \in \Delta\}$, so $x \in (L, A) \subset \cup\{(P, A)_\lambda : \lambda \in \Delta\}$. Therefore, $\cup\{(P, A)_\lambda : \lambda \in \Delta\}$ is soft $ƀc - open$ set.
Now we show that the intersection of two $sƀ$c- open sets is not necessarily sƀc- open.
Example 2.8. Let the ***STS*** $(Z, \tau,$ A) as in Example 2.6, then $(P_1, A) \in SƀcO(Z)$ and $(P_3, A) \in SƀcO(Z)$, but $(P_1, A) \cap (P_3, A) = (P_4, A) \notin SƀcO(Z)$.
Remark 2.9. From the above example we notice that the family of all s$ƀc - open$ subset of a space Z is a supra topology and thus it is not a topology in general.
The following result gives a condition under which the family of all s$ƀc - open$ sets became a topology on Z.
Proposition 2.10. If the collection $SƀO(Z)$ is a topology on Z, then $SƀcO(Z)$ is also a topology on Z.
Proof. It is clear that $\widetilde{\emptyset}, \widetilde{Z} \in SƀcO(Z)$ and, by Proposition 2.7, the union of any subset of $SƀcO(Z)$ is $sƀc - open$. Now, let (P, A) and (S, A) be two $sƀc - open$ sets, then (P, A) and (P, A) are soft $ƀ - open$ sets. Since $SƀO(Z)$ is a topology on Z, so $(P, A) \cap (S, A)$ is soft $ƀ - open$. If $x \in (S, A) \cap (P, A)$, then $x \in (P, A)$ and $x \in (S, A)$. So there exist two soft closed sets (L, A) and (K, A), such that $x \in (L, A) \subset (S, A)$ and $x \in (K, A) \subset (P, A)$. This implies that $x \in (L, A) \cap (K, A) \subset (S, A) \cap (P, A)$. Since any intersection of soft closed sets is soft closed, then $(L, E) \cap (K, A)$ is a closed set. Thus, $(P, A) \cap (S, A)$ is $sƀc - open$ set.
Theorem 2.11 A soft set (P, A) of a ***STS*** (Z, τ, A) is a soft $ƀc - open$ set iff, for each $x \in (P, A)$, there is a soft $sƀc - open$ set (S, A) such that $x \in (S, A) \subseteq (P, A)$.
Proof. Suppose that (P, A) is soft $ƀc - open$ in the space Z, then for each $x \in (P, A)$, put $(P, A) = (S, A)$ is $sƀc - open$ set containing x such that $x \in (P, A) \subseteq (S, A)$.
Conversely, assume that for any $x \in (P, A)$, there is a $sƀc - open$ set (S, A) such that $x \in (S, A) \subseteq (P, A)$. Thus, $(P, A) = \cup(S, A)_x$ where $(S, A)_x \in SƀcO(Z)$ for each x. Hence, (P, A) is $sƀc - open$ set.

Theorem 2.12 Let (Z,τ,A) be soft $T_1-space$, then (P,A) is $sƄ-open$ set iff (P,A) is a soft $Ƅc-open$.

Proof Suppose that (Z,τ,A) is soft $T_1-space$ and (P,A) is $sƄ-open$ set. If $(P,A)=\widetilde{\emptyset}$, then $(P,A)\in sƄc(Z)$. If $(P,A)\neq\widetilde{\emptyset}$, let $x\in(P,A)$. Since (Z,τ,A) is soft $T_1-space$, then by Theorem 1.6, each soft point is a closed set and, hence, $x\in\{x\}\subset(P,A)$. Therefore, (P,A) is an $sƄc-open$, thus $SƄO(Z)\subset SƄcO(Z)$. But $SƄcO(Z)\subset SƄO(Z)$. Hence, $SƄO(Z)=SƄcO(Z)$.

Proposition 2.13 If (Z,τ,A) is $soft\ locally\ indiscrete$, then $SSO(Z)\subset SƄcO(Z)$.

Proof. Let (P,A) be any soft subset of $\boldsymbol{STS}(Z,\tau,A)$ and $(P,A)\in SSO(Z)$, if $(P,A)=\widetilde{\emptyset}$, then $(P,A)\in SƄcO(Z)$. If $(P,A)\neq\widetilde{\emptyset}$, then $(P,A)\subset cl(int((P,A)))$. Since (Z,τ,A) is soft $locally\ indiscrete$, then $int(P,A)$ is soft closed, so $int(P,A)\subset(P,A)$. This implies that for each $x\in(P,A)$, $x\in(int(P,A))\subset(P,A)$. Therefore, (P,A) is $sƄc-open$ set. Hence $SSO(Z)\subset SƄcO(Z)$.

Theorem 2.14 Let $\{(P,A)_\alpha : \alpha\in\Delta\}$ be a collection of s$Ƅc-closed$ sets in a soft topological space (Z,τ,A). Then $\bigcap\{(P,A)_\alpha : \alpha\in\Delta\}$ is soft $Ƅc-closed$.

Proof. The proof follows from Proposition 2.7.

3. Some Properties of Soft $Ƅc-Open$ Sets

In this section, we provide some soft topological operations on oft sets and discuss its properties.

Definition 3.1 Let (Z,τ,A) be an $\boldsymbol{STS}$ and $x\in\widetilde{Z}$.Then, a soft set (P,A) is said to be soft $Ƅc-neighƄorhood$ (briefly, soft $Ƅc-nƄh$) of x, if there exists a soft $Ƅc-open$ set (K,A) over Z such that $x\in(K.A)\subset(P,A)$.

Proposition 3.2 For an $\boldsymbol{STS}$ (Z,τ,A), a soft set (P,A) is $sƄc-open$ iff it is a soft $Ƅc-neighƄorhood$ of each of its points.

Proof. Let $(P,A)\subset\widetilde{Z}$ be a soft $sƄc-open$ set, since for every $x\in(P,A), x\in(P,A)\subset(P,A)$ and (P,A) is $sƄc-open$, this shows that(P,A) is a soft $Ƅc-neighƄorhood$ of each of its points.

Conversely, suppose that (P,A) is a soft $Ƅc-neighƄorhood$ of each of its points. Then for each $x\in(P,A)$, there exists $(S,A)_x\in SƄcO(Z)$ such that $(S,A)_x\subset(P,A)$. Then $(P,A)=\bigcup\{(S,A)_x : x\in(P,A)\}$. Since each $(S,A)_x$ is $sƄc-open$. It follows that (P,A) is $sƄc-open$.

Proposition 3.3 Every soft $Ƅc-neighƄorhood$ of a point is soft $Ƅ-neighƄorhood$.

Proof. It is obvious from the fact that every $sƄc-open$ set is $sƄ-open$.

Definition 3.4 Let (P,A) be soft set of a $\boldsymbol{STS}$ (Z,τ,A), then a point $x\in Z$ is called soft $Ƅc-interior$ point of (P,A), if there exists an $sƄc-open$ set (U,A) such that $x\in(U,A)\subset(P,A)$. The set of all $sƄc-interior$ points of (P,A) is denoted by $sƄcInt(P,A)$.

Proposition 3.5 Let (P,A) be a soft set of Z , then $sƄcInt(P,A)\subset sƄint(P,A)$.

Proof. Since $sƄc-open$ set is$sƄ-open$, so the proof holds.

Definition 3.6 Let (P,A) be asoft set of a $\boldsymbol{STS}(Z,\tau,A)$, then the soft $Ƅc-closure$ of (P,A), denoted by $sƄcCl\,(P,A)$, is the intersection of all $sƄc-closed$ sets containing (P,A).

In the following theorem we provide some properties of $sƄc-interior$ of a soft set.

Theorem 3.7 Let (Z,τ,A) be $\boldsymbol{STS}$ and let (P,A) and (M,A) be soft sets over Z . Then

1) $sƄcInt(P,A)$ is the union of all $sƄc-open$ sets which are contained in (P,A).
2) $sƄcInt(P,A)$ is $sƄc-open$ set in Z .
3) (P,A) is $sƄc-open$ iff$(P,A)=sƄcInt(P,A)$.
4) $sƄcInt(sƄcInt(P,A))=sƄcInt(P,A)$.
5) $sƄcInt(\widetilde{\emptyset})=\widetilde{\emptyset}$ and $sƄcInt(\widetilde{Z})=\widetilde{Z}$.
6) $sƄcInt(P,A)\subset(P,A)$.
7) If $(P,A)\subset(M,A)$, then $sƄcInt(P,A)\subset sƄcInt(M,A)$.
8) If $(P,A)\bigcap(M,A)=\widetilde{\emptyset}$, then $sƄcInt(P,A)\subset sƄcInt(M,A)$.
9) $sƄcInt(P,A)\bigcup sƄcInt(M,A)\subset sƄcInt((P,A)\bigcup(M,A))$.
10) $sƄcInt((P,A)\bigcap(M,A))\subset sƄcInt(P,A)\bigcap sƄcInt(M,A)$.

Proof. The proofs of these facts are easy, so we will only prove the point number 7:

Suppose that $x\in Z$, $x\in sƄcInt(P,A)$, then by Definition 3.4, there is a set (U,A) such that $x\in(U,A)\subset(P,A)\subset(P,A)$, thus $x\in sƄcInt(P,A)$.

Theorem 3.8 Let (P,A) be any soft set in a $\boldsymbol{STS}\,(Z\,,\tau,A)$, then $x\in sbcCl(Z\,)$ if and only if $(P,A)\cap(U,A)=\emptyset$ for any $sbc-open$ set (U,A) containing x.

Proof.(⇒) let $x\in sbcCl(P,A)$. Suppose that $(P,A)\cap(U,A)_x=\emptyset$, where $(U,A)_x\in sbcO(Z\,)$ containing x. Hence, $(P,A)\subset(U,A)_x^c$, where $(U,A)_x^c\in\ sbcC(P,A)$. Hence, $x\notin sbcCl(P,A)$, which is a contradiction.

(⇐) Let $x\notin sbcCl(P,A)$, then $x\notin\bigcap(L,A)$, where $(L,A)\ \in sbcC(Z\,)$ and $(P,A)\subset(L,A)$ for each (L,A). Hence, $x\in\big(\bigcap(L,A)\big)^c$, where $\big(\bigcap(L,A)\big)^c\in sbcO(Z\,)$ containing x. Now, we have $(P,A)\cap\big(\bigcap(L,A)\big)^c\subset\big(\bigcap(L,A)\big)\cap\big(\bigcap(L,A)\big)^c=\emptyset.$

Theorem 3.9 Let (P,A) be any soft subset of an $\boldsymbol{STS}\,(Z\,,\tau,A)$ if $(P,A)\cap(L,A)\neq\emptyset$ for any soft closed set$(\,L,A)$ containing x, then $x\in sbcCl(P,A)$.

Proof. Suppose that $(\mathrm{U},A)_x\in sbcO(Z\,)$ containing x, then by definition (2.1), there is (L,A) soft closed set such that $x\in(L,A)\subset(U,A)$. So, by the hypothesis, $(P,A)\cap(L,A)\neq\emptyset$. Hence, $(P,A)\cap(U,A)\neq\emptyset$ for any $sbc-open$ set $(U,A)_x$. Therefore, $x\in sbcCl(P,A)$.

Theorem 3.10. Let $(Z\,,\tau,A)$ be an $\boldsymbol{STS}$ and let (P,A) and (M,A) be soft sets over Z . Then

1) $sbcCl(P,A)$ is the intersection of all $sbc-closed$ sets which are containing (P,A).
2) $(P,A)\subset sbcCl(P,A)$.
3) $sbcCl(P,A)$ is $sbc-closed$ set in Z .
4) (P,A) is $sbc-closed$ iff $(P,A)=sbcCl(P,A)$.
5) $sbcCl\big(sbcCl(P,A)\big)=sbcCl(P,A)$.
6) $sbcICl(\widetilde{\emptyset})=\widetilde{\emptyset}$ and $sbcCl(\widetilde{Z}\,)=\widetilde{Z}$.
7) If $(P,A)\subset(\mathrm{M},A)$, then $sbcCl(P,A)\subset sbcCl(\mathrm{M},A)$.
8) If $sbcCl(P,A)\cap sbcCl(\mathrm{M},A)=\widetilde{\emptyset}$, then $(P,A)\cap(\mathrm{M},A)=\widetilde{\emptyset}$.
9) $sbcCl(P,A)\cup sbcCl(\mathrm{M},A)\subset sbcCl\big((P,A)\cup(\mathrm{M},A)\big)$.
10) $sbcCl\big((P,A)\cap(\mathrm{M},A)\big)\subset sbcCl(P,A)\cap sbcCl(\mathrm{M},A)$.

Proof. It is obvious.

Acknowledgment

The authors would like to thank Mustansiriyah University (www.uomustansiriyah.edu.iP), Baghdad, Iraq for its support in the present work.

References

1. Molodtsov, D. **1999**. ”Soft set theory-first results,” *Computers and Mathematics with Applications*, **37**(4-5): 19-31.
2. Molodtsov, D., Leonov, V.Y. and Kovkov, D.V**. 2006**. "Soft sets technique and its application",*Nechetkie Sistemyi Myagkie Vychisleniya*, **1**(1): 8-39.
3. Shabir, M. and Naz, M. **2011**. "On soft topological spaces". *Computers and Mathematics with Applications*, **61**(7): 1786-1799.
4. Arockiarani and Arokialancy, **A. 2013**. ”Generalized soft gβ-closed sets and soft gsβ-closed sets in soft topological space”, *International Journal of Mathemat- ical Archive*, **4**(2): 1-7.
5. Akdag, M. and Ozkan, A. **2014**. "Soft α -Open Sets and Soft α -Continuous Functions". *Abstr. Appl. Anal*. 2014, Article ID 891341, 7 pages. doi:10.1155/2014/891341. https://projecteuclid.org/euclid.aaa/1412273201.
6. Chen, B**. 2013**. ”Soft Semi-open sets and related properties in soft topological spaces,” *Applied Mathematics and Information Sciences*, **7**(1): 287-294.
7. Akdag, M. and Ozkan, A. **2014**. “Soft b-open sets and soft b-continuous functions”. *Math Sci*, **8**: 124, doi: 10.1007/s40096-014-0124-7.
8. Ibrahim, H. **2013**. "Bc-Open Sets in Topological Spaces", *Advances in Pure Mathematics*, **3**(1): 34-40. doi: 10.4236/apm.2013.31007.
9. Zorlutuna, M., Akdag, W. K. and Atmaca, S. **2012**."Remarks on soft topological spaces," *Annals of Fuzzy Mathematics and Informatics*, **3**(2): 171-185.
10. Hussain, S. and Ahmad, B. **2015**. “Soft separation axioms in soft topological spaces”, *Hacettepe Journal of Mathematics and Statistics*, **44**(3): 559 – 568.
11. Selvi, A. and Arockiarani, I. **2015**. "On Soft slightly πg-continuous functions", *Journal of Progressive Research in Mathematics*, **3**(2): 168-174.