Journal of Fractional Calculus and Applications
Vol. 16(2) July 2025, No. 6.
ISSN: 2090-5858.
ISSN 2090-584X (print)
http://jfca.journals.ekb.eg/

SUFFICIENT CONDITION FOR GEOMETRIC PROPERTIES Q-STARLIKENESS AND Q-CONVEXITY OF LAGUERRE POLYNOMIAL FUNCTION

DEEPA AMIT KARWA, SEEMA KABRA

Abstract. The geometric properties of q-starlikeness and q-convexity play a pivotal role in complex analysis, with significant implications in the theory of special functions and orthogonal polynomials. This paper explores sufficient conditions under which Laguerre polynomial functions exhibit q-starlikeness and q-convexity. It refers to some coefficient inequalities, by using this Legurerre polynomial satisfying these geometric properties. Normalized Legurere Polynomial over the unit disc behaves as a univalent function. Inequalities applying by Legurerre Polynomial, result in a form of Gauss hypergeometric function obtained. The geometric properties of q-starlikeness and q-convexity pertain to the nature of certain functions within the unit disk in the complex plane. For a function to be q-starlike or q-convex, it needs to satisfy specific conditions related to its argument and derivatives. The findings contribute to the broader understanding of geometric properties in special functions, offering a framework for further exploration and application.

1. Introduction

The study of q-calculus is fascinating the researchers and scholars. Fractional calculus operators and special function associated with geometric function theory has a vast role in physics, mathematics and in the field of engineering. q-calculus firstly defined by Jackson [10, 11]. Further some more work was done by Ismail et al. [9] for q-starlike function. Later a foundation work done by Shrivastava et al. [17, 19, 20]. He has published a series of paper related to Janowski function associated with q-calculus. q-calculus, q-starlike function and Fekete- Szego inequality is also discussed in [1, 3, 8]. Recently, Rehman et al. [16] searched some subclasses of q-starlike functions including some coefficient inequalities and sufficient condition.

2020 *Mathematics Subject Classification.* 30C45, 30C50, 30C80.
Key words and phrases. Univalent function, q-derivative operator, q-starlike function, q-convex function, Laguerre polynomial function.
Submitted May 18, 2024. Revised Feb. 19, 2025. Accepted May 31, 2025.

Gour et al. [14] has discovered some coefficient inequalities for q −starlikeness and convexity for Bessel function. Other recent research about q-calculus can be found in [2, 13].
Let Open unit disk is defined by $\mathbb{D} = \{ z \ : \ |z| < 1\}$ and $\mathcal{A}$ is the class of function $f(z)$, analytic in $\mathbb{D}$ where $f(z)$ is in the form

$$f(z) = z + \sum_{n=2}^{\infty} a_n z^n \tag{1}$$

Now, Let $\mathbb{S}$ denote the class of all functions in $\mathcal{A}$ and univalent in $\mathbb{D}$. Also Let $\mathcal{S}^*$ and $\mathcal{C}^*$ be the subclass of $\mathbb{S}$ consisting of all functions which map $\mathbb{D}$ onto a star shaped with respect to origin and convex domains, respectively [6, 14], where any $z \in \mathcal{S}^*$ meet the subsequent condition by subordination

$$\mathcal{R}\left\{\frac{zf'(z)}{f(z)}\right\} > 0 \ \ for\ all\ z \in \mathbb{D}\ and\ \frac{zf'(z)}{f(z)} < \frac{1+\mathrm{z}}{1-\mathrm{z}}, z \in \ \mathbb{D} \tag{2}$$

For $z \in \mathcal{C}^*$ fulfill the condition [14]

$$\mathcal{R}\left\{\frac{(zf'(z))}{f(z)}\right\} = \ \mathcal{R}\left\{1 + \ \frac{(zf''(z))}{f'(z)}\right\} > 0 \ \ for\ all\ z \in \ \mathbb{D} \tag{3}$$

Definition 1.1 If $\mathcal{H}$ be an analytic function through $\mathcal{H}(0) = 1$ fits the class $\mathcal{J}[P,Q]$ with $-1 \leq Q < P \leq 1$ if and only if

$$\mathcal{H}(\mathrm{z}) < \frac{1+\mathrm{Pz}}{1+\mathrm{Qz}}, z \in \ \mathbb{D}$$

This class of analytic functions was introduced by Janowski [12],by this $\exists$ a function $h \in \mathcal{J}[P,Q]$ iff

$$\mathcal{H}(\mathrm{z}) \quad < \quad \frac{(\mathrm{P}+1)\,\mathrm{h}(\mathrm{z}) - \ (\mathrm{P}-1)}{(\mathrm{Q}+1)\,\mathrm{h}(\mathrm{z}) - \ (\mathrm{Q}-1)}, \quad z \in \ \mathbb{D}$$

So, a function $z \ \in \mathcal{A}$ be in the class $\mathcal{S}^*[P,Q]$with $-1 \leq Q < P \leq 1$ if and only if

$$\frac{zf'(z)}{f(z)} < \frac{1+\mathrm{Pz}}{1+\mathrm{Qz}}, z \in \ \mathbb{D} \tag{4}$$

and a function $z \ \in \mathcal{A}$ be in the class $\mathcal{C}^*[P,Q]$with $-1 \leq Q < P \leq 1$ if and only if

$$1 + \ \frac{(zf''(z))}{f'(z)} < \frac{1+\mathrm{Pz}}{1+\mathrm{Qz}}, z \in \ \mathbb{D}$$

Definition 1.2 [19] The q-derivative of a function f will be

$$D_q f(z) = \begin{cases} \frac{f(z)-f(qz)}{(1-q)}, & if \quad z \ \in \mathbb{C}\ /\{0\} \\ f'(0), & if \qquad z \in 0 \end{cases}$$

and assuming that $f'(0)$ exists, if 0<q<1.
Now q-derivative defined [18] as

$$D_q f(z) \ = 1 + \ \sum_{n=2}^{\infty} [n]_q a_n z^{n-1} \qquad \text{for} \qquad z \in \mathbb{U}, z \in \ \mathcal{A}.$$

Where for $q \in (0,1)$ the number $[n]_q$ defined by

$$[n]_q = \begin{cases} \frac{1-q^n}{1-q}\ , & n \in \mathbb{C} \\ \sum_{r=0}^{n-1} q^r\ , & n \in \mathbb{N} \end{cases}$$

Definition 1.3 Ismail et al. [9] studied and discovered a q-extension of the class $\mathcal{S}^*$ of starlike functions in $\mathbb{D}$ is $\mathcal{S}_q^*$ and a function $z \in \mathcal{A}$ belongs to the class $\mathcal{S}_q^*$ iff

$$\left| \frac{z}{f(z)} D_q f(z) - \frac{1}{1-q} \right| < \frac{1}{1-q}\ ,\ z \in \mathbb{D} \tag{5}$$

Now by the definition of analytic function and subordination, the inequality (5) becomes

$$\frac{z}{f(z)} D_q f(z) < \frac{1+\mathrm{z}}{1-\mathrm{qz}}, z \in \mathbb{D} \tag{6}$$

and a function $z \in \mathcal{A}$ belongs to the class $\mathcal{S}_q^*[P,Q]$ iff

$$\frac{z}{f(z)} D_q f(z) < \frac{(\mathrm{P}+1)\,\mathrm{f}\,(\mathrm{z}) - (\mathrm{P}-1)}{(\mathrm{Q}+1)\,\mathrm{f}\,(\mathrm{z}) - (\mathrm{Q}-1)}, \quad z \in \mathbb{D} \tag{7}$$

where $f(z) = \frac{1+\mathrm{z}}{1-\mathrm{qz}}$, then by using $f(z)$ equation (7) becomes

$$\frac{z}{f(z)} D_q f(z) < \frac{(P+1)\,z + 2 + (P-1)\,qz}{(Q+1)\,z + 2 + (Q-1)\,qz} \tag{8}$$

(1) Clearly If $P = 1$, $Q = -1$ then $\mathcal{S}_q^*[P,Q] = \mathcal{S}_q^*$[1,-1]&
(2) If $q \to 1^-$ then $\mathcal{S}_q^* = \mathcal{S}^*$
(3) Duren also [4] described that $z \in \mathcal{C}_q^*[P,Q] \iff zD_q f(z) \in \mathcal{S}_q^*[P,Q]$

Let the differential equation for arbitrary real α, β *is*
$zf^{''}(z) + (\alpha + 1 - z) f^{'}(z) + \beta f(z) = 0$ then polynomial solution of this equation is generalized Laguerre polynomial,

$$L_\beta^\alpha(z) = \binom{\beta+\alpha}{\alpha} \sum_{n=0}^{\infty} \frac{(-\beta)_n}{(\alpha+1)_n} \frac{z^n}{n!}$$

So Normalized Laguerre polynomial

$$\mathcal{U}(z) = z \binom{\alpha}{\beta+\alpha} L_\beta^\alpha(z) = \sum_{n=0}^{\infty} \frac{(-\beta)_n}{(\alpha+1)_n} \frac{z^{n+1}}{n!}\ or$$

$$\mathcal{U}(z) = z \binom{\alpha}{\beta+\alpha} L_\beta^\alpha(z) = z + \sum_{n=2}^{\infty} \frac{(-\beta)_{n-1}}{(\alpha+1)_{n-1}} \frac{z^n}{n-1!}$$

satisfy the condition of normalizations of any function$\{ F(z) = z + \sum_{n=2}^{\infty} a_n z^n$, F(0) =0 & $F^{'}(0) = 1\}$ so by comparing

$$a_n = \frac{(-\beta)_{n-1}}{(\alpha+1)_{n-1}(n-1!)}$$

In this paper now we investigate some sufficient conditions of q - starlikeness and q-convexity for Laguerre polynomial function by using sufficient conditions defined

by Shrivastava [19]. Some similar work has also done by Gour et al.[5, 16] and sufficient condition of starlike function for multivalent function by Goyal et al. [7].
Lemma 1.1[19] Suppose $z \in \ \mathcal{S}_q^* [P, Q]$ if it is achieving below condition

$$\sum_{n=2}^{\infty} \left(2q[n-1]_q + \left|(Q+1)[n]_q - (P+1)\right|\right)|a_n| < |Q-P| \tag{9}$$

Lemma 1.2 [19] Suppose $z \in \ \mathcal{C}_q^* [P, Q]$ if it is achieving below condition

$$\sum_{n=2}^{\infty} [n]_q \left(2q[n-1]_q + \left|(Q+1)[n]_q - (P+1)\right|\right)|a_n| < |Q-P| \tag{10}$$

2. Main Results

Theorem 2.1 Let $L(\alpha, \beta; q)$ be defined as follows
$L(\alpha, \beta; q) = \left(\frac{2q+(Q+1)}{1-q} + \ (\ P+1)\right)\left(-; k\ ;\ \frac{c}{4}\right) - \frac{(Q+3)q}{1-q} {}_0F_1\left(-\ ; k\ ;\ \frac{cq}{4}\right) + (\mathrm{P{+}Q{+}2})$
If the inequality $L(\alpha, \beta; q) < |Q-P|$
Holds, then function $\mathcal{U}(z) = zL(z) \in \mathcal{S}_q^* [P, Q]$
Proof: Here

$$\mathcal{U}(z) = z \binom{\alpha}{\beta+\alpha} L_\beta^\alpha(z) = z + \sum_{n=2}^{\infty} \frac{(-\beta)_{n-1}}{(\alpha+1)_{n-1}} \frac{z^n}{n-1!}$$

$$= z + \sum_{n=2}^{\infty} a_n z^n \quad , \ z \in \mathfrak{D}$$

From Lemma 1.1, any function $z \in \mathcal{S}_q^* [P, Q]$
fulfils (9). Then, for $\mathcal{U}(z)$ it is sufficient to show that (9) holds, for

$$a_n = \frac{(-\beta)_{n-1}}{(\alpha+1)_{n-1}(n-1!)} \ or = \frac{(-1)^n(\beta)_{n-1}}{(\alpha+1)_{n-1}(n-1!)} \ \& \ [n]_q = \ \frac{1-q^n}{1-q}$$

Now, by using triangle's inequality we get

$$\sum_{n=2}^{\infty} \left(2q[n-1]_q + \left|(Q+1)[n]_q - (P+1)\right|\right)|a_n| \le \sum_{n=2}^{\infty} 2q\frac{1-q^{n-1}}{1-q}|a_n| + \sum_{n=2}^{\infty}(Q+1)\frac{1-q^n}{1-q}|a_n| +$$

$$+ \sum_{n=2}^{\infty}(P+1)|a_n|$$

$$= \sum_{n=2}^{\infty}\left(\frac{2q+(Q+1)}{1-q} + \ (P+1)\right)|a_n| - \sum_{n=2}^{\infty}\frac{(Q+3)q^n}{1-q}|a_n|$$

$$= \left(\frac{2q+(Q+1)}{1-q} + \ (P+1)\right)\sum_{n=2}^{\infty}\frac{(\beta)_{n-1}}{(\alpha+1)_{n-1}}\frac{1}{n-1!} - \frac{(Q+3)q}{1-q}\sum_{n=2}^{\infty}\frac{(\beta)_{n-1}}{(\alpha+1)_{n-1}}$$

As $\left|(-\beta)_{n-1}\right| = \ (\beta)_{n-1}$
By applying Gauss hypergeometric function property above condition convert in
$=\left(\frac{2q+(Q+1)}{1-q} + \ (\ P+1)\right) {}_1F_1(\beta; \alpha+1\ ;\ 1) - \frac{(Q+3)q}{1-q} {}_1F_1(\beta\ ; \alpha+1\ ;\ q) + (\mathrm{P{+}Q{+}2})$
$=L(\alpha, \beta; q)$& conclude that the function $\mathcal{U}(z) = zL(z) \in \mathcal{S}_q^* [P, Q]$

Corollary 2.1 Let P= z ,Q = 1 then above condition become

$$L^*(\alpha,\beta:q)=\left(\frac{2q+1}{1-q}+z+1\right){}_1F_1(\beta;\alpha+1\ ;\ 1)-\frac{4q}{1-q}{}_1F_1(\beta;\alpha+1\ ;\ q)+(z+3) \tag{11}$$

If the inequality $L(\alpha,\beta;q)=1-z$ holds, then the function $\mathcal{U}(z)=zL(z)\in\mathcal{S}_q^*[z]$

(1) If $z=0$ then from (11)

$$L_1{}^*[\alpha,\beta;q]=\left(\frac{2q+1}{1-q}+1\right){}_1F_1(\beta;\alpha+1\ ;\ 1)-\frac{4q}{1-q}{}_1F_1(\beta;\alpha+1\ ;\ q)+3$$

If the inequality $L_1{}^*[\alpha,\beta;q]<1$ holds , then the function $\mathcal{U}(z)=zL(z)\in\mathcal{S}_q^*[0]$.

Theorem 2.2. Let $M(\alpha,\beta;q)$, be defined as follows

$$M(\alpha,\beta;q)=\frac{1}{(1-q)^2}\left[(q+Q+2+P(1-q))\,{}_1F_1(\beta;\alpha+1\ ;\ 1)\right]$$
$$-\frac{1}{(1-q)^2}\left[\left(Pq(1-q)+2Qq+q^2+5q\right){}_1F_1(\beta;\alpha+1\ ;\ q)\right]+$$
$$+\frac{1}{(1-q)^2}\left[(Q+3)\,q^2{}_1F_1\left(\beta;\alpha+1\ ;\ q^2\right)\right]+(\mathrm{P}+\mathrm{Q}+2)$$

If the inequality $M(\alpha,\beta;q)<|Q-P|$

Holds, then function $\mathcal{U}(z)=zL(z)\in\mathcal{C}_q^*[P,Q]$

Proofs: Here

$$\mathcal{U}(z)=z+\sum_{n=2}^{\infty}\frac{(-\beta)_{n-1}}{(\alpha+1)_{n-1}}\frac{z^n}{n-1!}=z+\sum_{n=2}^{\infty}a_nz^n \quad ,\ z\in\mathfrak{D}$$

From Lemma 1.1, any function $z\in\ \mathcal{C}_q^*[P,Q]$ fulfils (9) .Then, for $\mathcal{U}(z)$ it is sufficient to show that (10) holds, for

$$a_n=\frac{(-\beta)_{n-1}}{(\alpha+1)_{n-1}(n-1!)}\ or =\frac{(-1)^n(\beta)_{n-1}}{(\alpha+1)_{n-1}(n-1!)}\&[n]_q=\frac{1-q^n}{1-q}$$

Now, by using triangle's inequality we get

$$\sum_{n=2}^{\infty}[n]_q\left(2q[n-1]_q+\left|(Q+1)[n]_q-(P+1)\right|\right)|a_n|$$
$$\leq\sum_{n=2}^{\infty}2q[n]_q\frac{1-q^{n-1}}{1-q}|a_n|+\sum_{n=2}^{\infty}(Q+1)[n]_q\frac{1-q^n}{1-q}|a_n|+\sum_{n=2}^{\infty}(P+1)[q]_n|a_n|$$
$$=\sum_{n=2}^{\infty}2q\frac{1-q^n}{1-q}\frac{1-q^{n-1}}{1-q}|a_n|+\sum_{n=2}^{\infty}(Q+1)\frac{1-q^n}{1-q}\frac{1-q^n}{1-q}|a_n|+\sum_{n=2}^{\infty}(P+1)\frac{1-q^n}{1-q}|a_n|$$
$$=\sum_{n=2}^{\infty}\frac{2q+(Q+1)+\ (P+1)(1-q)}{(1-q)^2}|a_n|+\sum_{n=2}^{\infty}\frac{2+(Q+1)}{(1-q)^2}q^{2n}|a_n|$$
$$-\sum_{n=2}^{\infty}\frac{(P+1)(1-q)+2(Q+1)+\ 2q+2}{(1-q)^2}q^n|a_n|$$

By using Gauss hypergeometric function above equation becomes

$=\frac{q+Q+2+P(1-q)}{(1-q)^2}\left[{}_1F_1(\beta;\alpha+1\ ;\ 1)-1\right]$- $\frac{Pq(1-q)+\ 2Qq+\ q^2+\ 5q}{(1-q)^2}\left[{}_1F_1(\beta;\alpha+1\ ;\ q)-1\right]$
$+$
$\frac{(Q+1)q^2}{(1-q)^2}\left[{}_1F_1\left(\beta;\alpha+1\ ;\ q^2\right)-1\right]$

$= \frac{1}{(1-q)^2}[(q+Q+2+P(1-q)[{}_1F_1(\beta;\alpha+1\ ;\ 1)]$

$$-\frac{1}{(1-q)^2}\left(Pq(1-q)+2Qq+q^2+5q\right)[{}_1F_1(\beta;\alpha+1\ ;\ q)]$$

$+\frac{(Q+3)q^2}{(1-q)^2}\left[{}_1F_1\left(\beta;\alpha+1\ ;\ q^2\right)\right]+$ (P+Q+2) $= M(\alpha,\beta;q) < |Q-P|$

Therefore, the theorem's assumption implies (10), hence function $\mathcal{U}(z) = zL(z) \in \mathcal{C}_q^*[P,Q]$

Corollary 2.2 Let P= z , Q = 1 then above condition become

$$M^*(\alpha,\beta;q) = \frac{1}{(1-q)^2}(q+3+z(1-q))\,{}_1F_1(\beta;\alpha+1\ ;\ 1)$$

$$-\frac{1}{(1-q)^2}\left(zq(1-q)+7q+q^2\right)({}_1F_1(\beta;\alpha+1\ ;\ q))+$$

$$+\frac{4q^2}{(1-q)^2}\left({}_1F_1\left(\beta;\alpha+1\ ;\ q^2\right)\right)+(z+3) \tag{12}$$

If the inequality$M^*(\alpha,\beta : q) < 1-z$ holds, then the function $\mathcal{U}(z) = zL(z) \in \mathcal{C}_q^*[1,-1]$

(1) If $z = 0$ then from (11)

$M_1^*(\alpha,\beta:q) = \frac{1}{(1-q)^2}[(q{+}3{+}z)[{}_1F_1(\beta;\alpha+1\ ;\ 1)] - \frac{1}{(1-q)^2}\left(2q+q^2+5q\right)[{}_1F_1(\beta;\alpha+1\ ;\ q)] + \frac{1}{(1-q)^2}\,4q^2\left[{}_1F_1\left(\beta;\alpha+1\ ;\ q^2\right)\right]+3$

If the inequality $M_1{}^*(\alpha,\beta;q) < 1$ holds, then the function $\mathcal{U}(z) = zL(z) \in \mathcal{C}_q^*[0]$

3. Conclusion

In this paper, we get the sufficient condition for a function associated with normalized Laguerre Polynomial function to be q- starlikeness and q-convexity as [14, 15]. In conclusion, this paper provides a detailed examination of the conditions under which Laguerre polynomials exhibit q-starlikeness and q-convexity, enriching the theoretical landscape of geometric function theory and expanding the utility of Laguerre polynomials in complex analysis.

4. Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Alsoboh, A., Cağlar, M. and Buyankara, M.;"Fekete-Szegö Inequality for a Subclass of Bi-Univalent Functions Linked to q-Ultraspherical Polynomials," Contemporary Mathematics, vol. 5(2), pp. 2366–2380, May 2024.

[2] Arif, M., Barkub, O., Srivastava, H. M., Abdullah, S., & Khan, S. A.; Some Janowski type harmonic q-starlike functions associated with symmetrical points. *Mathematics*, *8*(4), 629, 2020.

[3] Cağlar, M., Orhan, H. and Srivastava, H. M.; "Coefficient Bounds For q-Starlike Functions Associated With Q-Bernoulli Numbers," Journal of Applied Analysis and Computation, vol. 15(4), pp. 2354–2364, Aug. 2023.

[4] Duren, P. L.; *Univalent functions* (Vol. 259). Springer Science & Business Media, 2001.

[5] Gour, M. M., Joshi, S., & Goswami, P.; Sufficient condition for q-starlike and q-convex functions associated with generalized confluent hypergeometric functions. *Adv Theory Nonlinear Anal Appl (ATNAA)*, *4*(4), 421-431, 2020.

[6] Gour, M. M., Joshi, S., & Purohit, S. D.; Certain coefficient inequalities for the classes of q-starlike and q-convex functions. *South East Asian Journal of Mathematics and Mathematical Sciences*, *18*(3), 43-54, 2022.

[7] Goyal, S. P., & Goyal, R.; Sufficient conditions for starlikeness of multivalent functions of order δ. *J Indian Acad Math*, *29*(1), 115-124, 2007.

[8] Hua, Q., Shaba, T. G., Younis, B. Khan, B., Mashwani, W. K. and Cağlar, M.;"Applications of q-derivative operator to subclasses of bi-univalent functions involving Gegenbauer polynomials," Applied Mathematics in Science and Engineering, vol. 30(1), pp. 501–520, Jun. 2022.

[9] Ismail, M. E. H., Merkes, E., & Styer, D.; A generalization of starlike functions. *Complex Variables, Theory and Application: An International Journal*, *14*(1-4), pp.77-84, 1990.

[10] Jackson, F. H. XI; On q-functions and a certain difference operator. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, *46*(2), pp. 253-281, 1909.

[11] Jackson, F. H.; On q-definite integrals. *Quart. J. Pure Appl. Math*, *41*(15), pp. 193-203, 1910.

[12] Janowski, W.; Some extremal problems for certain families of analytic functions I. In *Annales Polonici Mathematici* ,Vol. 3(28), pp. 297-326, 1973.

[13] Mahmood, S., Ahmad, Q. Z., Srivastava, H. M., Khan, N., Khan, B., & Tahir, M.; A certain subclass of meromorphically q-starlike functions associated with the Janowski functions. *Journal of Inequalities and Applications*,pp. 1-11, 2019.

[14] Mahmood, S., Jabeen, M., Malik, S. N., Srivastava, H. M., Manzoor, R., & Riaz, S. M.; Some coefficient inequalities of q-starlike functions associated with conic domain defined by q-derivative. *Journal of Function Spaces*, 2018.

[15] Noor, K. I., & Malik, S. N.; On coefficient inequalities of functions associated with conic domains. *Computers & Mathematics with Applications*, *62*(5), pp. 2209-2217, 2011.

[16] Seoudy, T. M., & Aouf, M. K.; Coefficient estimates of new classes of q-starlike and q-convex functions of complex order. *J. Math. Inequal*, *10*(1), pp. 135-145, 2016.

[17] Shafiq, M., Khan, N., Srivastava, H. M., Khan, B., Ahmad, Q. Z., & Tahir, M.; Generalisation of close-to-convex functions associated with Janowski functions. *Maejo International Journal of Science & Technology*, *14*(3), 2020.

[18] Srivastava, H. M., & Bansal, D.; Close-to-convexity of a certain family of q-Mittag-Leffler functions. *J. Nonlinear Var. Anal*, *1*(1), pp. 61-69, 2017.

[19] Srivastava, H. M., Khan, B., Khan, N., & Ahmad, Q. Z.; Coefficient inequalities for $ q $-starlike functions associated with the Janowski functions. *Hokkaido Mathematical Journal*, *48*(2), pp. 407-425, 2019.

[20] Srivastava, H. M., Tahir, M., Khan, B., Ahmad, Q. Z., & Khan, N. Some general classes of q-starlike functions associated with the Janowski functions. *Symmetry*, *11*(2), 292, 2019.

Deepa Amit Karwa

Department of Mathematics, Sangam University, Bhilwara, Rajasthan, India, Sharad Institute of Technology College of Engineering,Yadrav, Kolhapur,Maharashtra, India

Email address: deepaamitkarwa@gmail.com

Seema Kabra

Department of Mathematics, Sangam University, Bhilwara, Rajasthan, India

Email address: kabraseema@rediffmail.com