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SOMBOR INDICES OF CERTAIN GRAPH OPERATORS

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ABSTRACT

Recently, Gutman considered a class of novel graph invariants of which the Sombor index was defined. In this paper, we study the certain Sombor indices and their exponentials of regular and complete bipartite graphs using some graph operators.

Keywords: Sombor index, Sombor exponential, reduced Sombor index, reduced Sombor exponential, line graph, subdivision graph.

Mathematics Subject Classification: 05C05, 05C07, 05C90.

I. INTRODUCTION

Let G be a finite, simple, connected graph with vertex set $V(G)$ and edge set $E(G)$. The degree of a vertex u is denoted by $d_G(u)$. The edge connecting the vertices u and v will be denoted by uv. We refer [1] for undefined notations and terminologies. SOMBOR INDICES OF CERTAIN GRAPH OPERATORS

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ABSTRACT

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 Sombor index, Sombor exponential, reduced Sombor index, reduced Sombor exponential, line
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is denoted by $d_G(u)$. The edge connecting the vertices u and v will be denoted by uv. We
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lex of a graph G was introduced by Gu

The Sombor index of a graph G was introduced by Gutman in [2] and defined it as

$$
SO(G) = \sum_{uv \in E(G)} \sqrt{\sigma_n(u)^2 + \sigma_n(v)^2}.
$$

In [3], Kulli introduced the first (a, b) -KA index of a graph G, defined it as $_{a,b}^{1}(G) = \sum d_{G}(u)^{a} + d_{G}(v)^{a}$. $_{a,b}^{1}(G) = \sum_{uv \in E(G)} \left[d_G(u)^{a} + d_G(v)^{a} \right].$ $uv\overline{\in E(G)}$ $K_{a,b}^{1}(G) = \sum |d_G(u)^{a} + d_G(v)^{a}|.$ Sombor index of a graph G was introduced by Gutman in [2] and defined it as
 $G) = \sum_{\substack{w \in E(G)}} \sqrt{a_n(u)^2 + \sigma_n(v)^2}$.

I, Kulli introduced the first (a, b) -KA index of a graph G, defined it as
 $(G) = \sum_{\substack{w \in E(G)}} \left(d_G(u)^u + d_G(v)^u \$

Clearly, the Sombor index is obtained as special case of the first (a, b) -KA index. If $a=2$ and $2,\frac{1}{2}$ $K_{-1}^{1}(G) = SO(G).$ $\sqrt{\sigma_n(u)^2 + \sigma_n(v)^2}$.

duced the first (a, b) -KA index of a graph G, defined it as
 $\left[d_G(u)^{\sigma} + d_G(v)^{\sigma}\right]$.

bor index is obtained as special case of the first (a, b) -KA index. If $a=2$ and
 $\sqrt{d_G(u)^3 + d_G(v)^3}$.

Sombor index,

Considering the Sombor index, we introduce the Sombor exponential of a graph G, defined as

$$
SO(G,x)=\sum_{uv\in E(G)}x^{\sqrt{d_G(u)^2+d_G(v)^2}}.
$$

In [2], Gutman defined the reduced Sombor index of a graph G as

$$
RSO(G) = \sum_{uv \in E(G)} \sqrt{(d_G(u) - 1)^2 + (d_G(v) - 1)^2}.
$$

Considering the reduced Sombor index, we propose the reduced Sombor exponential of a graph G and it is defined as

$$
RSO(G, x) = \sum_{uv \in E(G)} x^{\sqrt{(d_G(u) - 1)^2 + (d_G(v) - 1)^2}}.
$$

The average Sombor index was proposed by Gutman in [2] and it is defined as

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 2 2 2 2 . G G uv E G m m ASO G d u d v n n

where $|V(G)| = n$ and $|E(G)| = m$.

This index is equal to zero for regular graphs.

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(G) = m.

ual to zero for regular graphs.

average Sombor index, we introduce the average Sombor exponential of Considering the average Sombor index, we introduce the average Sombor exponential of a graph G, defined as

$$
ASO(G,x) = \sum_{uv \in E(G)} \sqrt{x} \left(d_G(u) - \frac{2m}{n} \right)^2 + \left(d_G(v) - \frac{2m}{n} \right)^2.
$$

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 $(t) - \frac{2m}{n}$
 $\left(\frac{2m}{a}\right)^2 + \left(d_G(v) - \frac{2m}{n}\right)^2$.

for regular graphs.

Sombor index, we introduce the average Sombor exponential of a
 $\frac{2m}{n}$, $\left(d_G(v) - \frac{2m}{n}\right)^$ **EXAMPLE 10**
 EXAMPLE 10 In Chemical Graph Theory, many graph indices were introduced and studied, see [4, 5]. The reduced first [6] and second [6] Zagreb indices were introduced and studied. where $|F(G)| = n$ and $|E(G)| = m$.

This index is equal to zero for regular graphs.

Considering the average Sombor index, we introduce the average Sombor exponential of a

graph G, defined as
 $ASO(G, x) = \sum_{ave E(G)} \sqrt{x^{\left(d_e(x) - \frac{2m}{x$ Considering the average Sombor index, we introduce the average Sombor exponential of a

graph G, defined as
 $ASO(G, x) = \sum_{\substack{w \in E(G) \\ \text{in}(G)}} \sqrt{x^{\left(d_x(n) - \frac{2m}{n}\right)^2} \left(d_x(v) - \frac{2m}{n} \right)^2}$.

The Chemical Graph Theory, many gra $ASO(G, x) = \sum_{w \in E(G)} \sqrt{x}^{\int_{Q(G)} (x - x)} \cdot \int_{\sqrt{G(G)}} (x - x) \cdot \int_{\sqrt{G(G)}} (x - x) \cdot \int_{\sqrt{G(G)}} f(x) \cdot \int_{\sqrt{G(G)}} f(x) \cdot \int_{\sqrt{G(G)}} f(x) \cdot \int_{\sqrt{G}} f(x) \cdot \int_{\sqrt{G}}$ In Chemical Graph Theory, many graph indices were introduced and studied, see [4, 5]. The

reduced first [6] and scenario (Figure binders were introduced and studied.

In this paper, we establish some results on the Sombo

 In this paper, we establish some results on the Sombor indices and their corresponding polynomials for line and subdivision graphs of some standard graphs.

2. RESULTS FOR LINE GRAPHS

The line graph $L(G)$ of a graph G is the graph whose vertex set corresponds to the edges of G such that two vertices of $L(G)$ are adjacent if and only if the corresponding edges of G are adjacent.

In the following theorem, we compute the Sombor indices and their exponentials of the line graphs of r-regular graphs.

Theorem 1. Let G be an *r*-regular graph with $n \ge 2$ vertices. Then

(i)
$$
SO(L(G)) = \sqrt{2}nr(r-1)^2
$$
.

(ii)
$$
RSO(L(G)) = \frac{1}{\sqrt{2}} nr(r-1)(2r-3).
$$

$$
(iii) \qquad ASO(L(G))=0.
$$

(iv)
$$
SO(L(G),x) = \frac{1}{2} nr(r-1)x^{2\sqrt{2}(r-1)}
$$

(v)
$$
RSO(L(G),x) = \frac{1}{2} nr(r-1)x^{\sqrt{2}(2r-3)}
$$

(vi)
$$
ASO(L(G),x) = \frac{1}{2}nr(r-1)x^{0}.
$$

polynomials for line and subdivision graphs of some standard graphs.

2. RESULTS FOR LINE GRAPHS

2. RESULTS FOR LINE GRAPHS

The line graph $L(G)$ of a graph G is the graph whose vertex set corresponds to the edges of **Proof:** Let G be an r-regular graph with $n \geq 2$ vertices. Then the line graph $L(G)$ of G is also an $(2r -$ 2)-regular graph with $\frac{1}{2}$ 2 (G) of a graph G is the graph whose vertex set corresponds to the edges of G
 $L(G)$ are adjacent if and only if the corresponding edges of G are adjacent.

theorem, we compute the Sombor indices and their exponentials of 1 $\frac{1}{2}$ nr (r-1) edges. Thus $d_{L(G)}(u) = 2r - 2$ for any vertex u of $L(G)$. In the following theorem, we compute the Sombor indices and their exponentials of the line
graphs of r-regular graphs.

Theorem 1. Let G be an r-regular graph with $n \ge 2$ vertices. Then

(i) $SO(L(G)) = \sqrt{2}nr(r-1)^2$.

(ii) RSO Theorem 1. Let G be an r-regular graph with $n \ge 2$ vertices. Then

(i) $SO(L(G)) = \sqrt{2}nr(r-1)^2$,

(ii) $RSO(L(G)) = \frac{1}{\sqrt{2}}nr(r-1)(2r-3)$.

(iii) $ASO(L(G)) = 0$.
 $SO(L(G), x) = \frac{1}{2}nr(r-1)x^{\sqrt{2}(x-1)}$.

(v) $RSO(L(G), x) = \frac{1}{2}nr(r-1)x^{\sqrt{2}(2r-3)}$.
 (i) $SO(L(G)) = \sqrt{2n(r-1)}$.
 $RSO(L(G)) = \frac{1}{\sqrt{2}}nr(r-1)(2r-3)$.

(ii) $ASO(L(G), x) = \frac{1}{2}nr(r-1)x^{\sqrt{2}(2r-3)}$.

(v) $RSO(L(G), x) = \frac{1}{2}nr(r-1)x^{\sqrt{2}(2r-3)}$.

(v) $ASO(L(G), x) = \frac{1}{2}nr(r-1)x^0$.

(vi) $ASO(L(G), x) = \frac{1}{2}nr(r-1)x^0$.
 Proof: Let G be an *r* (iii) $ASO(L(G)) = 0$.

(iv) $SO(L(G), x) = \frac{1}{2}nr(r-1)x^{2(2r-1)}$.

(v) $RSO(L(G), x) = \frac{1}{2}nr(r-1)x^{3(2r-2)}$.

(vi) $ASO(L(G), x) = \frac{1}{2}nr(r-1)x^{0}$.
 Proof: Let G be an r-regular graph with $n\geq 2$ vertices. Then the line graph $L(G)$ of G is

By using definitions, we deduce

(i)
$$
SO(L(G)) = \frac{1}{2}nr(r-1)\sqrt{(2r-2)^2 + (2r-2)^2}
$$

$$
\begin{aligned}\n\text{(ii)} \qquad & RSO(L(G)) = \frac{1}{2}nr(r-1)\sqrt{(2r-2-1)^2 + (2r-2-1)^2} \\
&= \frac{1}{\sqrt{2}}nr(r-1)(2r-3).\n\end{aligned}
$$

(iii)
$$
ASO(L(G)) = 0
$$
, since L(G) is regular.
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(iv) SO(L(G), x) = 2 2 ¹ 2 2 2 2 ¹ 2 r r nr r x ⁼ ¹ 2 2 1 1 . 2 ^r nr r x (v) RSO(L(G), x) = 2 2 ¹ 2 2 1 2 2 1 ¹ 2 r r nr r x ⁼ ¹ 2 2 3 1 . 2 ^r nr r x (vi) ASO(L(G), x) = ¹ ⁰ 1 .

(vi)
$$
ASO(L(G), x) = \frac{1}{2} nr(r-1)x^{0}.
$$

 From Theorem 1, we obtain the following results. **Corollary 1.1.** Let C_n be a cycle with $n \ge 3$ vertices. Then

(i)
$$
SO(L(C_n)) = 2\sqrt{2}n
$$

\n(ii)
$$
RSO(L(C_n)) = \sqrt{2}n
$$

\n(iii)
$$
ASO(L(C_n)) = 0.
$$

\n(iv)
$$
SO(L(C_n), x) = nx^{\sqrt{2}}
$$

\n(v)
$$
RSO(L(C_n), x) = nx^{\sqrt{2}}
$$

\n(vi)
$$
ASO(L(C_n), x) = nx^0
$$

Corollary 1.2. Let K_n be a complete graph with *n* vertices. Then

(i) SO(L(Kn)) = ² 2 1 2 . n n n (ii) RSO(L(Kn)) = ¹ 1 2 2 5 2 n n n n (iii) ASO(L(Kn)) = 0. (iv) SO(L(Kn), x) = ¹ 2 2 2 1 2 (v) RSO(L(Kn), x) = ¹ 2 2 5 1 2 (vi) ASO(L(Kn), x) = ¹ ⁰ 1 2 . (i) ² (ii) ,

(iv)
$$
SO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^{2\sqrt{2}(n-2)}
$$

(v)
$$
RSO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^{\sqrt{2}(2n-5)}
$$

(vi)
$$
ASO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^0.
$$

In the following theorem, we determine the Sombor indices and their exponentials of the line graphs of complete bipartite graphs. (ii) $RSO(L(K_n)) = \frac{1}{\sqrt{2}}n(n-1)(n-2)(2n-5)$

(iiv) $ASO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^{2\sqrt{2}(n-2)}$

(v) $BSO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^{2(2n-5)}$

(v) $RSO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^0$.

(vi) $ASO(L(K_n), x) = \frac{1}{2}n(n-1)(n-2)x^0$.

In the following theo

Theorem 2. Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices, pq edges and $1 \leq p \leq q$. Then

(i)
$$
SO(L(K_{p,q})) = \frac{1}{\sqrt{2}}pq(p+q-2)^2
$$
.

(ii)
$$
RSO(L(K_{p,q})) = \frac{1}{\sqrt{2}}pq(p+q-2)(p+q-3).
$$

$$
(iii) \qquad ASO(L(K_{p,q}))=0.
$$

(iv)
$$
SO(L(K_{p,q}),x) = \frac{1}{2}pq(p+q-2)x^{\sqrt{2}(p+q-2)}
$$
.

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(v)
$$
RSO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^{\sqrt{2}(p+q-3)}.
$$

(vi)
$$
ASO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^{0}.
$$

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(v) $RSO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^{\sqrt{2}(p+q-3)}$

(vi) $ASO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^0$

Proof: Let $K_{p,q}$ be a complete bipart RESEARCHERID

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(v) $RSO(L(K_{p,q}),x) = \frac{1}{2}pq(p+q-2)x^{\sqrt{2}(p+q-3)}$.

(vi) $ASO(L(K_{p,q}),x) = \frac{1}{2}pq(p+q-2)x^0$.
 Proof: Let $K_{p,q}$ be a **Proof:** Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices, pq edges and $1 \leq p \leq q$. Then the line RESEARCHERID

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(v) RSO($L(K_{p,q}), x$) = $\frac{1}{2}pq(p+q-2)x^{\sqrt{2}(p+q-3)}$.

(vi) ASO($L(K_{p,q}), x$) = $\frac{1}{2}pq(p+q-2)x^0$.
 Proof: Let $K_{p,q}$ be a complete bip 2 $\frac{1}{2}pq(p+q-2)$ edges. RESEARCHERID

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CO $d_{L(K_{p,q})}(u) = p + q - 2$ for any vertex u of $L(K_{p,q}).$ **RESEARCHERID**

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(v) RSO($L(K_{p,q})$,x) = $\frac{1}{2}pq(p+q-2)x^{\sqrt{2}(p+q-1)}$.

(vi) $ASO(L(K_{p,q}),x) = \frac{1}{2}pq(p+q-2)x^0$.
 Proof: Let K_{pq} be a complete bipartite graph **RESEARCHERID**

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By using definitions, we derive

,

2 pq p q p q p q 2 . 2 pq p q (ii) RSO(L(Kp,q)) = ¹ 2 2 2 2 1 2 1 2 pq p q p q p q ⁼ ¹ 2 3 . 2 pq p q p q (iv) SO(L(Kp,q), x) = 2 2 ¹ 2 2 ² ⁼ ¹ 2 2 2 .

(iii) $ASO(L(K_{p,q})) = 0$, since $L(K_{p,q})$ is regular.

graph
$$
L(K_{p,q})
$$
 of $K_{p,q}$ is an $(p+q-2)$ -regular graph with pq vertices and $\frac{1}{2}pq(p+q-2)$ edges.
\nTherefore $\Delta(L(K_{p,q})) = \delta(L(K_{p,q})) = p+q-2$ and $d_{L(K_{p,q})}(u) = p+q-2$ for any vertex u of $L(K_{p,q})$
\nBy using definitions, we derive
\n(i) $SO(L(K_{p,q})) = \frac{1}{2}pq(p+q-2)\sqrt{(p+q-2)^2 + (p+q-2)^2}$
\n $= \frac{1}{\sqrt{2}}pq(p+q-2)\sqrt{(p+q-2-1)^2 + (p+q-2-1)^2}$
\n $= \frac{1}{2}pq(p+q-2)(p+q-3)$.
\n(ii) $ASO(L(K_{p,q})) = 0$, since $L(K_{p,q})$ is regular.
\n(iv) $SO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^{x[(p+q-2)^2+(p+q-2)^2]}$
\n $= \frac{1}{2}pq(p+q-2)x^{x[(p+q-2)+y+q-2]^2}$
\n $= \frac{1}{2}pq(p+q-2)x^{x[(p+q-2)+y+q-2-1]^2}$
\n(v) $RSO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^{x[(p+q-2-1)^2]}$
\n $= \frac{1}{2}pq(p+q-2)x^{x[(p+q-2)-1]^2}$.
\n(vi) $ASO(L(K_{p,q}), x) = \frac{1}{2}pq(p+q-2)x^{x[(p+q-2-1)^2]}$
\n $= \frac{1}{2}pq(p+q-2)x^{x[(p+q-2)-1]^2}$.
\n(iii) $ASO(L(K_{p,q}), y) = \frac{1}{2}pq(p+q-2)x^{2}$.
\n(iii) $ASO(L(K_{p,q}), x) = p^2(p-1)^2$.
\n(ii) $BSO(L(K_{p,q}), x) = p^2(p-1)x^{x[(p-1)]}$
\n(iv) $SO(L(K_{p,q}), x) = p^2(p-1)x^{x[(p-1)]}$
\

 Using Theorem 2, we obtain the following results. **Corollary 2.1.** Let $K_{p,p}$ be a complete bipartite graph. Then

(i)
$$
SO(L(K_{p,p})) = 2\sqrt{2}p^2(p-1)^2
$$
.
\n(ii) $RSO(L(K_{p,p})) = \sqrt{2}p^2(p-1)(2p-3)$.
\n(iii) $ASO(L(K_{p,p})) = 0$.

(iv)
$$
SO(L(K_{p,p}), x) = p^2 (p-1) x^{2\sqrt{2}(p-1)}
$$

(v)
$$
RSO(L(K_{p,p}), x) = p^2 (p-1) x^{\sqrt{2}(2p-3)}
$$

(vi)
$$
ASO(L(K_{p,p}), x) = p^2 (p-1) x^0
$$
.

Corollary 2.2. Let $K_{1,p}$ be a star. Then

(i)
$$
SO(L(K_{1,p})) = \frac{1}{\sqrt{2}} p(p-1)^2.
$$

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 $1)(p-3)$. 2 $p(p-1)(p-3)$ (iii) $ASO(L(K_{1,p})) = 0.$

(iv)
$$
SO(L(K_{1,p}), x) = \frac{1}{2} p(p-1) x^{\sqrt{2}(p-1)}
$$

(v)
$$
RSO(L(K_{1,p}),x) = \frac{1}{2}p(p-1)x^{\sqrt{2}(p-2)}
$$

(vi)
$$
ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1) x^{0}.
$$

3. RESULTS FOR SUBDIVISION GRAPHS

The subdivision graph $S(G)$ of a graph G is the graph obtained from G by replacing each of its edges by a path of length two.

In the following theorem, we determine the Sombor indices and their exponentials of the subdivision graphs of *r*-regular graphs. [Kulli, 10(1): January, 2021]

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(ii) $RSO(L(K_{1,p})) = \frac{1}{\sqrt{2}} p(p-1)(p-3)$.

(iii) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-1)}$

(v) $SO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-2)}$

(v) $RSO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-2)}$

((ii) $RSO(L(K_{1,p})) = \frac{1}{\sqrt{2}} p(p-1)(p-3).$

(iii) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-1)}$

(iv) $SO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-2)}$

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-2)}$

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^0.$

3. RESULTS FOR SUBDIVIS (iii) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-1)}$

(v) $SO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-2)}$

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^{\sqrt{2}(p-2)}$

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2} p(p-1)x^0$.

3. RESULTS FOR SUBDIVISION GRAPHS

The subdivision graph $S(G)$ (iv) $SO(L(K_{1,p}), x) = \frac{1}{2}p(p-1)x^{\sqrt{2}(p-1)}$

(v) $RSO(L(K_{1,p}), x) = \frac{1}{2}p(p-1)x^{\sqrt{2}(p-2)}$

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2}p(p-1)x^0$.

3. RESULTS FOR SUBDIVISION GRAPHS

The subdivision graph $S(G)$ of a graph *G* is the graph obtained from (v) $RSO(L(K_{1,p}), x) = \frac{1}{2}p(p-1)x^{\sqrt{2}(p-2)}$

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2}p(p-1)x^0$.

3. RESULTS FOR SUBDIVISION GRAPHS

The subdivision graph $S(G)$ of a graph G is the graph obtained from G by replacing edges by a path of leng

Theorem 3. Let G be an *r*-regular graph with $n \ge 3$ vertices. Then

(i)
$$
SO(S(G)) = nr\sqrt{4+r^2}.
$$

(ii)
$$
RSO(S(G)) = nr\sqrt{2-2r+r^2}.
$$

(iii)
$$
ASO(S(G)) = \frac{r}{2+r} \sqrt{(4n-2nr)^2 + (nr^2 - 2nr)^2}
$$

(iv)
$$
SO(S(G),x) = nrx^{\sqrt{4+r^2}}
$$
.

(v)
$$
RSO(S(G), x) = nr x^{\sqrt{2-2r+r^2}}
$$
.
\n(vi) $ASO(S(G), x) = nr x^{\frac{\sqrt{(4n-2nr)^2 + (nr^2-2nr)^2}}{2n+nr}}$.

(vi) $ASO(L(K_{1,p}), x) = \frac{1}{2}p(p-1)x^{0}$.

3. RESULTS FOR SUBDIVISION GRAPHS

The subdivision graph $S(G)$ of a graph G is the graph obtained from G by replacing edges by a path of length two.

In the following theorem, we determ $(p-1)x^0$.
 ISION GRAPHS
 $S(G)$ of a graph G is the graph obtained from G by replacing each of its

rem, we determine the Sombor indices and their exponentials of the

graphs.
 $\frac{2}{\sqrt{2}}$.
 $2r + r^2$.
 $(4n - 2nr)^2 + (nr$ **Proof:** Let G be an r-regular graph with $n\geq 3$ vertices. Then the subdivision graph $S(G)$ of G has 2 $n + \frac{nr}{r}$ vertices and *nr* edges. The edge partition of $S(G)$ is as follows. The subdivision graph $S(G)$ of a graph G is the graph obtained from G by replacing each of its

a path of length two.

in the following theorem, we determine the Sombor indices and their exponentials of the

in the fo Theorem 3. Let G be an r -regular graph with $n \ge 3$ vertices. Then

(i) $SO(S(G)) = nr\sqrt{4+r^2}$.

(iii) $RSO(S(G)) = nr\sqrt{2-2r+r^2}$.

(iv) $dSO(S(G)) = \frac{r}{2+r}\sqrt{(4n-2nr)^2 + (nr^2-2nr)^2}$.

(v) $SO(S(G), x) = nrx^{\frac{2(n+2n+r^2)}{2(n+2n+r)}}$.

(v) $RSO(S(G), x) = nrx^$ (ii) $RSO(S(G)) = m\sqrt{2-2r+r^2}$.

(iii) $ASO(S(G)) = \frac{r\sqrt{2-2r+r^2}}{\sqrt{(4n-2nr)^2 + (nr^2-2nr)^2}}$.

(iv) $SO(S(G), x) = nrx^{\sqrt{4+r^2}}$.

(v) $SO(S(G), x) = nrx^{\sqrt{4-2nr^2 + n^2}}$.

(v) $ASO(S(G), x) = nrx^{\sqrt{4-2nr^2 + (4n^2-2nr)^2}}$

(vi) $ASO(S(G), x) = nrx^{\sqrt{4-2n^2 + (4n^2-2n)^2}}$ (ii) $SO(S(G)/S) = \frac{2}{2+r} \sqrt{4+r^2}$

(v) $SO(S(G), x) = mx \frac{\sqrt{4x-r^2}}{4+r^2}$

(vi) $ASO(S(G), x) = mx \frac{\sqrt{4x^2 - 2x r^2}}{4 + ar}$

(vi) $ASO(S(G), x) = mx \frac{\sqrt{4x^2 - 2x r^2}}{2 + ar}$

(vi) $ASO(S(G), x) = mx \frac{\sqrt{4x^2 - 2x r^2}}{2 + ar}$

(vi) $SO(S(G), x) = mx \frac{\sqrt{4x^2 - 2x r^2}}{2 + ar}$ $\frac{2-2r+r^2}{(4n-2nr)^2+(nr^2-2nr)^2}$

graph with $n\geq 3$ vertices. Then the subdivision graph $S(G)$ of G has

The edge partition of $S(G)$ is as follows.
 $S(G) (u) = 2, d_{S(G)}(v) = r^3$, $|E| = nr$.

we obtain
 $\frac{2+r^2}{2r^2} = nr\sqrt{4+r^2}$

$$
E = \{uv \in E(S(G)) | d_{S(G)}(u) = 2, d_{S(G)}(v) = r\}, \qquad |E| = nr.
$$

By using definitions, we obtain

(i)
$$
SO(S(G)) = nr\sqrt{2^2 + r^2} = nr\sqrt{4 + r^2}
$$

\n(ii) $RSO(S(G)) = nr\sqrt{(2-1)^2(r-1)^2} = nr\sqrt{2-2r+r^2}$

$$
\text{(ii)} \quad\n\text{RSO(S(G))} \quad = \frac{nr\sqrt{(2-1)}(r-1)}{r-1} = \frac{nr\sqrt{2-2r+r^2}}{4nr} \quad \text{(iii)} \quad \text{ASO(S(G))} \quad = \frac{nr}{2} \left(\frac{4nr}{r} \right)^2 \left(\frac{4nr}{r} \right)^2 \quad r
$$

(iii)
$$
ASO(S(G)) = nr \sqrt{\left(2 - \frac{4nr}{2n + nr}\right)^2 \left(r - \frac{4nr}{2n + nr}\right)^2} = \frac{r}{2+r} \sqrt{(4n - 2nr)^2 + (nr^2 - 2nr)^2}
$$

(iv)
$$
SO(S(G), x) = nr x^{\sqrt{2^2+r^2}} = nr x^{\sqrt{4+r^2}}
$$

(v)
$$
RSO(S(G), x) = nr x^{\sqrt{(2-1)^2 + (r-1)^2}} = nr x^{\sqrt{2-2r+r^2}}
$$

(vi)
$$
ASO(S(G), x) = nrx^{\sqrt{\left(2-\frac{4nr}{2n+nr}\right)^2 + \left(r-\frac{4nr}{2n+nr}\right)^2}} = nrx^{\sqrt{\frac{(4n-2nr)^2 + (nr^2-2nr)^2}{2n+nr}}}
$$

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 From Theorem 3, we obtain the following results. **Corollary 3.1.** Let C_n be a cycle with $n \ge 3$ vertices. Then

(i)
$$
SO(S(C_n)) = 4\sqrt{2}n
$$

\n(ii) $RSO(S(C_n)) = 2\sqrt{2}n$
\n(iii) $ASO(S(C_n)) = 0$.

(iv) $SO(S(C_n), x) = 2nx^{2\sqrt{2}}$

$$
(v) \qquad RSO(S(C_n),x)=2nx^{\sqrt{2}}
$$

(vi) $ASO(S(C_n), x) = 2nx^0$

Corollary 3.2. Let K_n be a complete graph.

(i)
$$
SO(S(K_n)) = n(n-1)\sqrt{5-2n+n^2}
$$
.
(ii) $RSO(S(K_n)) = n(n-1)\sqrt{5-4n+n^2}$.

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\n**EXAMPLE 3.00**
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\n**INOM SON EUNS**
\n**Corollary 3.1.** Let
$$
C_n
$$
 be a cycle with $n \ge 3$ vertices. Then
\n(i) $SO(S(C_n)) = 4\sqrt{2n}$
\n(ii) $BSO(S(C_n)) = 2\sqrt{2n}$
\n(iii) $ASO(S(C_n), x) = 2nx^{\sqrt{2}}$
\n(iv) $SO(S(C_n), x) = 2nx^{\sqrt{2}}$
\n(v) $BSO(S(C_n), x) = 2nx^{\sqrt{2}}$
\n(vi) $ASO(S(C_n), x) = 2nx^{\sqrt{2}}$
\n**Corollary 3.2.** Let K_n be a complete graph.
\n**Corollary 3.2.** Let K_n be a complete graph.
\n(ii) $BSO(S(K_n)) = n(n-1)\sqrt{5-2n+n^2}$.
\n(iii) $ASO(S(K_n)) = n(n-1)\sqrt{5-4n+n^2}$.
\n(ii) $ASO(S(K_n)) = n(n-1)\sqrt{5-4n+n^2}$.
\n(iv) $SO(S(K_n), x) = n(n-1)x^{\sqrt{5-2n+n^2}}$.
\n(v) $BSO(S(K_n), x) = n(n-1)x^{\sqrt{5-4n+n^2}}$.
\n(vi) $ASO(S(K_n), x) = n(n-1)x^{\sqrt{5-4n+n^2}}$.
\nIn the following theorem, we compute the Sombor indices and their exponentials of the

(iv)
$$
SO(S(K_n), x) = n(n-1)x^{\sqrt{5-2n+n^2}}
$$
.

(v)
$$
RSO(S(K_n), x) = n(n-1)x^{\sqrt{5-4n+n^2}}
$$

(vi)
$$
ASO(S(K_n), x) = n(n-1)x^{\frac{\sqrt{(6n-2n^2)^2 + (n^3-4n^2+3n)^2}}{n(n+1)}}.
$$

(i) $SO(S(C_n)) = 4\sqrt{2n}$

(iii) $ASO(S(C_0)) = 2\sqrt{2n}$

(iv) $SO(S(C_0), x) = 2n x^{\sqrt{2}}$

(v) $SO(S(C_0), x) = 2n x^{\sqrt{2}}$

(v) $RSO(S(C_0), x) = 2n x^0$

(v) $ASO(S(C_0), x) = 2n x^0$
 Corollary 3.2. Let K_n be a complete graph.

(i) $SO(S(K_n)) = n(n-1)\sqrt{5-2n$ e graph.
 $\frac{1}{1-2n+n^2}$.
 $\frac{1}{1-4n+n^2}$.
 $\frac{1}{1-4n+n^2}$.
 $\frac{1}{2n^2+n^2}$.
 $\frac{5-2n+n^2}{2n^2+n^2}$.
 $\frac{5-2n+n^2}{n(n+1)^2}$.

We compute the Sombor indices and their exponentials of the trititie graphs. $\frac{n^2}{n^2}$.
 $+(n^3 - 4n^2 + 3n)^2$.
 $\frac{+(n^3 - 4n^2 + 3n)^2}{(n+1)}$.

($\frac{n+1}{(n+1)}$.)

($\frac{n+1}{(n+1)}$.)

apphs.
 $\frac{n}{2}$ explores, pq edges and $1 \leq p \leq q$. Then In the following theorem, we compute the Sombor indices and their exponentials of the subdivision graphs of complete bipartite graphs. (vi) $ASO(S(C_n), x) = 2nx^0$
 Corollary 3.2. Let K_n be a complete graph.

(i) $SO(S(K_n)) = n(n-1)\sqrt{5-2n+n^2}$.

(ii) $RSO(S(K_n)) = n(n-1)\sqrt{5-4n+n^2}$.

(iii) $ASO(S(K_n)) = \frac{n-1}{n+1}\sqrt{(6n-2n^2)^2 + (n^3-4n^2+3n)^2}$.

(iv) $SO(S(K_n), x) = n(n-1)x^{\sqrt{5-2n+n^2}}$.

Theorem 4. Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices, pq edges and $1 \le p \le q$. Then

(i)
$$
SO(S(K_{p,q})) = pq\sqrt{p^2 + 4} + pq\sqrt{q^2 + 4}
$$
.

(ii)
$$
RSO(S(K_{p,q})) = pq\sqrt{p^2 + q - 2} + pq\sqrt{q^2 - 2q + 4}.
$$

Corollary 3.2. Let
$$
K_n
$$
 be a complete graph.
\n(i) $SO(S(K_n)) = n(n-1)\sqrt{5-2n+n^2}$.
\n(ii) $RSO(S(K_n)) = n(n-1)\sqrt{5-4n+n^2}$.
\n(iii) $ASO(S(K_n)) = \frac{n-1}{n+1}\sqrt{(6n-2n^2)^2 + (n^3-4n^2+3n)^2}$.
\n(iv) $SO(S(K_n), x) = n(n-1)x^{\sqrt{5-4n+n^2}}$.
\n(v) $RSO(S(K_n), x) = n(n-1)x^{\sqrt{5-4n+n^2}}$.
\n(vi) $ASO(S(K_n), x) = n(n-1)x^{\frac{\sqrt{(6n-2n^2)^2 + (n^3-4n^2+3n)^2}}{n(n+1)}}}$.
\nIn the following theorem, we compute the Sombor indices and their exponentials of the subdivision graphs of complete bipartite graphs.
\n**Theorem 4.** Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices, pq edges and $1 \le p \le q$. Then
\n(i) $SO(S(K_{p,q})) = pq\sqrt{p^2+4+pq\sqrt{q^2+4}}$.
\n(ii) $RSO(S(K_{p,q})) = pq\sqrt{p^2+q-2+pq\sqrt{q^2-2q+4}}$.
\n(iii) $ASO(S(K_{p,q})) = \frac{pq}{p+q+pq}[(p^2+p^2q-3pq)^2 + (2p+2q-2pq)^2]^{\frac{1}{2}}$
\n $+ \frac{pq}{p+q+pq}[(q^2+pq^2-3pq)^2 + (2p+2q-2pq)^2]^{\frac{1}{2}}$
\n(iv) $SO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+4}} + pqx^{\sqrt{q^2+4}}$.
\n(v) $RSO(S(K_{p,q}), x) = pqx^{\sqrt{p^2-2p+2}} + pqx^{\sqrt{q^2-2q+2}}$.
\n $[(p^2+p^2q-3pq)^2+(2p+2q-2pq)^2]^{\frac{1}{2}}$ $[(q^2+pq^2-3pq)^2+(2p+2q-2pq)^2]^{\frac{1}{2}}$

$$
+\frac{pq}{p+q+pq}\left[\left(q^2+pq^2-3pq\right)^2+\left(2p+2q-2pq\right)^2\right]^{\frac{1}{2}}
$$

(iv)
$$
SO(S(K_{p,q}),x) = pqx^{\sqrt{p^2+4}} + pqx^{\sqrt{q^2+4}}.
$$

(v)
$$
RSO(S(K_{p,q}),x) = pqx^{\sqrt{p^2-2p+2}} + pqx^{\sqrt{q^2-2q+2}}.
$$

(v)
$$
RSO(S(K_n), x) = n(n-1)x^{\sqrt{3-4n+4}}
$$

\n(vi) $ASO(S(K_n), x) = n(n-1)x^{\frac{\sqrt{(6n-2n^2)^2 + (n^2-4n^2+3n)^2}}{n(n+1)}}.$
\nIn the following theorem, we compute the Sombor indices and their exponentials
\nsubdivision graphs of complete bipartite graph with $p+q$ vertices, pq edges and $1 \le p \le q$. Th
\n(i) $SO(S(K_{p,q})) = pq\sqrt{p^2+4} + pq\sqrt{q^2+4}.$
\n(ii) $RSO(S(K_{p,q})) = pq\sqrt{p^2+q-2} + pq\sqrt{q^2-2q+4}.$
\n(iii) $ASO(S(K_{p,q})) = \frac{pq}{p+q+pq} \left[(p^2+p^2q-3pq)^2 + (2p+2q-2pq)^2 \right]^{\frac{1}{2}}$
\n $+ \frac{pq}{p+q+pq} \left[(q^2+pq^2-3pq)^2 + (2p+2q-2pq)^2 \right]^{\frac{1}{2}}$
\n(iv) $SO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+4}} + pqx^{\sqrt{q^2+4}}.$
\n(v) $RSO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+4}} + pqx^{\sqrt{q^2+4}}.$
\n(v) $RSO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+2p+2}} + pqx^{\sqrt{q^2-2q+2}}.$
\n(vi) $ASO(S(K_{p,q}), x) = pqx^{\sqrt{p^2-2p+2}} + pqx^{\sqrt{q^2-2q+2}} + pqx^{\sqrt{q^2-2p+2}} + pqx^{\sqrt{p^2-2p+2}} + pqx^$

In the following theorem, we compute the Sombor indices and their exponentials
subdivision graphs of complete bipartite graphs.
 Theorem 4. Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices, pq edges and 1 w

w compute the Sombor indices and their exponentials of the

partite graphs.

Le bipartite graph with $p+q$ vertices, pq edges and $1 \le p \le q$. Then
 $\frac{4 + pq\sqrt{q^2 + 4}}{4 + q - 2 + pq\sqrt{q^2 - 2q + 4}}$.
 $\frac{1}{pq} \left[(p^2 + p^2q - 3pq)^$ **Proof:** Let $K_{p,q}$ be a complete bipartite graph with $p+q$ vertices, pq edges and $1 \leq p \leq q$. The vertex set of $K_{p,q}$ can be partitioned into two independent sets V_1 and V_2 such that $u \in V_1$ and $u \in V_2$ for every edge uv of $K_{p,q}$. Let $K=K_{p,q}$. We have $d_K(u)=q$ and $d_K(v)=p$. Then subdivision graph $S(K_{p,q})$ has $p+q+pq$ vertices and 2pq edges. The edge partition of $S(K_{p,q})$ is as follows:

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ICIN Yaliue: 3.00	Image Factor: 5.164	
ICIN Yaliue: 3.00	10019. $E_1 = \{w \in E(K) d_K(u) = p, d_K(v) = 2\}$	IC1 = pq.
IC2D (d) $d_K(u) = p, d_K(v) = 2\}$	IC3 = p, q.	
ES = { $w \in E(K) d_K(u) = q, d_K(v) = 2\}$	IC4 = pq.	
(i) $SO(S(K_{p,q})) = pq\sqrt{p^2 + 2^2} + pq\sqrt{q^2 + 2^2}$		
(ii) $RSO(S(K_{p,q})) = pq\sqrt{p-1^2 + (2-1)^2} + pq\sqrt{(q-1)^2 + (2-1)^2}$		
$= pq\sqrt{p^2 - 2p + 2} + pq\sqrt{q^2 - 2q + 2}$		
(iii) $ASO(S(K_{p,q})) = pq\left[\left(p - \frac{4pq}{p+q+pq}\right)^2 + \left(2 - \frac{4pq}{p+q+pq}\right)^2\right]^{\frac{1}{2}}$		
$+ pq\left[\left(q - \frac{4pq}{p+q+pq}\right)^2 + \left(2 - \frac{4pq}{p+q+pq}\right)^2\right]^{\frac{1}{2}}$		
$= \frac{pq\left[\left(p^2 + p^2 + pq\right)^2 + (2q + 2q - 2pq)^2\right]^{\frac{1}{2}}}{p+q+pq}$		
(iv) $SO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+q} + pqx^{\sqrt{q^2-2q+2}}$		
(v) $RSO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+q} + pqx^{\sqrt{q^2-2q+2}}$ </td		

(v)
$$
RSO(S(K_{p,q}), x) = pqx^{\sqrt{p^2-2p+2}} + pqx^{\sqrt{q^2-2q+2}}
$$

$$
(vi) \quad ASO(S(K_{p,q}), x) = pqx \frac{\left[(p^2+p^2q-3pq)^2 + (2q+2q-2pq)^2 \right]^{\frac{1}{2}}}{p+q+pq} + pqx + pqx + pqx
$$

 From Theorem 4, we get the following results. **Corollary 4.1.** Let $K_{p,p}$ be a complete bipartite graph. Then

(iv)
$$
SO(S(K_{p,q}), x) = pqx^{\sqrt{p^2+4}} + pqx^{\sqrt{q^2+4}}
$$

\n(v) $RSO(S(K_{p,q}), x) = pqx^{\sqrt{p^2-2p+2}} + pqx^{\sqrt{q^2-2q+2}}$
\n(vi) $ASO(S(K_{p,q}), x) = pqx \frac{\left[(p^2 + p^2q - 3pq)^2 + (2q + 2q - 2pq)^2 \right]^{\frac{1}{2}}}{p+q+pq} + pqx \frac{\left[(q^2 + pq^2 - 3pq)^2 + (2p + 2q - 2pq)^2 \right]^{\frac{1}{2}}}{p+q+pq}$
\nFrom Theorem 4, we get the following results.
\nCorollary 4.1. Let $K_{p,p}$ be a complete bipartite graph. Then
\n(i) $SO(S(K_{p,p})) = 2p^2\sqrt{p^2 + 4}$.
\n(ii) $RSO(S(K_{p,p})) = 2p^2\sqrt{p^2 - 2p + 2}$.
\n(iii) $ASO(S(K_{p,p})) = \frac{4p^2}{2+p}(p^4 - p^3 + 2p^2 - 4p + 4)^{\frac{1}{2}}$.
\n(iv) $SO(S(K_{p,p}), x) = 2p^2x^{\sqrt{p^2+4}}$
\n(v) $RSO(S(K_{p,p}), x) = 2p^2x^{\sqrt{p^2-2p+2}}$.
\n(vi) $ASO(S(K_{p,p}), x) = \frac{2p}{2+p}x^{2p(p^4-p^2+2p^2-4p+4)^{\frac{1}{2}}}$.
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(iv)
$$
SO(S(K_{p,p}), x) = 2p^2x^{\sqrt{p^2+4}}
$$
.

(v)
$$
RSO(S(K_{p,p}), x) = 2p^2x^{\sqrt{p^2-2p+2}}
$$
.

(vi)
$$
ASO(S(K_{p,p}), x) = \frac{2p}{2+p} x^{2p(p^4-p^3+2p^2-4p+4)^{\frac{1}{2}}}.
$$

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[Kulli, 10(1): January, 2021] Impact Factor: 5.164 IC™ Value: 3.00 CODEN: IJESS7 **Corollary 4.2.** Let K_{1n} be a star. Then

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\n**THEOREARCHERID**
\n[Kull, 10(1): January, 2021]
\n**LCIM Value**: 3.00
\n**Corollary 4.2.** Let
$$
K_{1,p}
$$
 be a star. Then
\n(i) $SO(S(K_{1,p})) = p(\sqrt{5} + \sqrt{p^2 + 1}).$
\n(ii) $RSO(S(K_{1,p})) = p(1 + \sqrt{p^2 - 2p + 2}).$
\n(iii) $ASO(S(K_{1,p})) = \frac{p}{1 + 2p} \Big[(4p^2 - 4p + 5)^{\frac{1}{2}} + (4p^4 - 12p^3 + 9p^2 + 4)^{\frac{1}{2}} \Big].$
\n(iv) $SO(S(K_{1,p}), x) = px^{\sqrt{5}} + px^{\sqrt{p^2 + 4}}$
\n(v) $RSO(S(K_{1,p}), x) = px^1 + px^{\sqrt{p^2 - 2p + 2}}.$
\n(vi) $ASO(S(K_{1,p}), x) = px^1 + px^{\sqrt{p^2 - 2p + 2}} + \frac{p}{1 + 2p}x^{(4p^4 - 12p^3 + 9p^2 + 4)^{\frac{1}{2}}}.$
\n**CONCLUSION**

(iii)
$$
ASO(S(K_{1,p})) = \frac{p}{1+2p} \Big[\Big(4p^2 - 4p + 5\Big)^{\frac{1}{2}} + \Big(4p^4 - 12p^3 + 9p^2 + 4\Big)^{\frac{1}{2}} \Big].
$$

(iv)
$$
SO(S(K_{1,p}), x) = px^{\sqrt{5}} + px^{\sqrt{p^2+4}}
$$

(v)
$$
RSO(S(K_{1,p}),x) = px^1 + px^{\sqrt{p^2-2p+2}}
$$
.

(vi)
$$
ASO(S(K_{1,p}), x) = \frac{p}{1+2p} x^{(4p^2-4p+5)^{\frac{1}{2}}} + \frac{p}{1+2p} x^{(4p^4-12p^3+9p^2+4)^{\frac{1}{2}}}.
$$

CONCLUSION

 Gutman considered a class of novel graph invariants of which the Sombor index was introduced. In this paper, we have determined the certain Sombor indices and their corresponding exponentials of regular and complete bipartite graphs using graph operators such as line graph and subdivision graph.

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