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$g(x)$-p-Clean Rings

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Abstract

Let R be a unital additive ring, $C(R)$ denote the center of the ring R and $g(x)$ be a polynomial in $C(R)[x]$. We explore a new ring structure called a $g(x)$-p-clean ring. An element r is said to be $g(x)$-p-clean if it can be decomposed into $r = p + s$, where p belongs to the set of pure elements $Pu(R)$, and s is a root of the polynomial $g(x)$. This study examines the core properties of such rings. We show, for instance, that if R admits the $g(x)$-p-clean property and I is an ideal of R, then the quotient ring R/I also inherits this property provided $\overline{g}(x) \in C(R/I)[x]$. We establish a number of structural results concerning these rings.

Keywords: Clean rings, p-Clean rings, $g(x)$-p-Clean rings.

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1. Introduction

Assume that R is a ring. An element $p \in R$ is labeled as pure if there exists some $q \in R$ such that $p = pq$ [1]. The symbol $Pu(R)$ represents the collection of all pure elements in R. Commonly used subsets in ring theory include $U(R)$, $Id(R)$, and $C(R)$, representing the units, idempotents, and central elements of a ring R, respectively. An element $r \in R$ is called clean if it admits a representation $r = u + e$, where $u \in U(R)$ and $e \in Id(R)$ [2, 3]. This notion has been generalized by incorporating polynomial roots. If $g(x)$ is a polynomial in $C(R)[x]$, then an element $r \in R$ is said to be $g(x)$-clean if it can be written as a sum of a unit and a root of $g(x)$. A ring R is said to be $g(x)$-clean if every element in R satisfies this property [4, 5]. A more relaxed version, called weakly $g(x)$-clean, allows r to

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be either the sum or the difference of a unit and a $g(x)$-root [6]. These ideas have been further extended in various studies [7–11]. An element $r \in R$ is called p-clean if there exist $e \in Id(R)$ and $p \in Pu(R)$ such that $r = p + e$ [1, 12]. In this paper, we introduce and explore a broader concept known as $g(x)$-p-clean rings. An element $r \in R$ is said to be $g(x)$-p-clean if there exist some $p \in Pu(R)$ and a root s of $g(x)$ such that $r = p + s$. The ring R itself is called $g(x)$-p-clean whenever every element of R admits such a decomposition.

2. Main results

In this section, we present a framework and establish the foundation for defining $g(x)$-p-clean rings and elements. The focus then shifts to analyzing the essential properties that characterize these rings. To support our findings, relevant examples are provided.

Definition 2.1. An element $p \in R$ is said to be pure provided there exists an element $q \in R$ with $p = pq$ [13]. The collection of pure elements in the ring R is represented by $Pu(R)$.

Definition 2.2. An element $r \in R$ is called p-clean if there exist $e \in Id(R)$ and $p \in Pu(R)$ such that $r = p + e$. When all of the elements in a ring R are p-clean, the ring is considered p-clean [1, 12].

Definition 2.3. Let $g(x) \in C(R)[x]$ and $p \in Pu(R)$. A $g(x)$-p-clean element of R is an element $r = s + p$ such that $g(s) = 0$. Every element in a ring R must be $g(x)$-p-clean for the ring to be considered $g(x)$-p-clean.

Given that all $g(x)$-clean rings are also $g(x)$-p-clean rings. Alternatively, p-clean rings are precisely $(x^2 - x)$-p-clean, to be precise. There exist rings that are $g(x)$-p-clean but not $g(x)$-clean, and vice versa:

Example 2.4. (1) $\mathbb{Z}$ is $(x^2 - x)$-p-clean but is not $(x^2 - x)$-clean.

(2) $\mathbb{Z}_{(3)} \cap \mathbb{Z}_{(5)} = \{\frac{a}{b} \mid a, b \in \mathbb{Z}, b \neq 0, \gcd(3, b) = 1, \gcd(5, b) = 1\}$ is $(x^2 - x)$-p-clean but is not $(x^2 - x)$-clean.

This establishes that p-cleanness and $g(x)$-p-cleanness are not equivalent in all cases, although for certain forms of $g(x)$, they may coincide.

Theorem 2.5. *Given a ring R with $g(x) = (x - d)(x - f) \in C(R)[x]$, where $d \neq f$ are central elements of R and $(d - f)$ is not a zero divisor element. Then, the following claims are true for a pure element p of R.*

(1) $(d - f) \in Pu(R)$ and R is p-clean if and only if R is $(x - d)(x - f)$-p-clean.

(2) Let R be p-clean and $(d - f) \in Pu(R)$. Then R is $g(x)$-p-clean.

Proof. (1) Suppose that r is an element of R. A $g(x)$ root s_1 and a pure p_1 exist such that $f = p_1 + s_1$ since R is $g(x)$-p-clean. As $h(s_1) = (s_1 - d)(s_1 - f) = 0$, we may conclude that $s_1 = d$. Accordingly, $f - d \in Pu(R)$. Assume once more that there exist a pure p_2 and a root s_2 of $g(x)$ such that, $(f-d)r+d = p_2+s_2$. We may start with $p = (f-d)(s_2-d)$, $s_2 = (f-d)e+d$. After that, we have $r = p+(f-d)p_2$. When $f-d \in C(R)$, then , $h(s_2) = (s_2-d)(s_2-f) = (f-d)p[(f-d)p+d-f] = (f-d)^2(p^2-p) = 0$. Since $(f-d) \neq 0$ is not an element of zero divisors and, $p^2 = p$, we get $p \in Id(R)$. Note that $(f-d)p_2 \in Pu(R)$ is evident. Conversely, suppose that $r \in R$. Hence $(f-d)(r-d) = p+e$, where $p \in Pu(R)$ and $e \in Id(R)$. So $r = [(f-d)e+d] + (f-d)p$. Since $(f-d), p \in Pu(R)$, $(f-d)p \in Pu(R)$. Because $h((f-d)e+d) = (f-d)e[(f-d)e+d-f] = (f-d)^2e(e-1) = 0$, $(f-d)e+f$ is a $g(x)$ root. Then R is $(x-d)(x-f)$-p-clean.
(2) Derives from (1). □

In fact, the requirement that both d and f belong to $C(R)$ in Theorem 2.5 may be substituted with the single condition that $(f-d)$ lies in $C(R)$.

Corollary 2.6. *Assume R is a ring. Then R is p-clean precisely when it is (x^2+x)-p-clean.*

Proof. It follows from Theorem 2.5, whit $d = 0$ and $f = -1$. □

Corollary 2.7. *Let R be a ring. Then R is p-clean and $2 \in Pu(R)$ if and only if every element in R can be expressed as the sum of a square root of 1 and a pure element.*

Proof. This is obtained from Theorem 2.5, whit $g(x) = x^2 - 1$. □

Theorem 2.8. *If R is a ring, $n \in \mathbb{N}$ and $r_1, r_2 \in R$, then R is $(r_1x^{2n} - r_2x)$-p-clean if and only if R is $(r_1x^{2n} + r_2x)$-p-clean.*

Proof. Let R be $(r_1x^{2n} - r_2x)$-p-clean and $r \in R$. Then, there exist $p \in Pu(R)$ and a root s of $(r_1x^{2n} - r_2x)$ such that $-r = p+s$. Hence, $r = (-p)+(-s)$, where $-p \in Pu(R)$ and $(r_1(-s)^{2n} + r_2s) = 0$. Therefore, R is $(r_1x^{2n} + r_2x)$-p-clean. The convrse is clear. □

As an illustration, it can be deduced that rings which are (x^2-x)-p-clean and those that are (x^2+x)-p-clean are essentially the same as p-clean rings.
The corner ring eRe is a p-clean ring if R is a p-clean ring and e is a central idempotent element, as demonstrated by [12, Proposition 2.16]. For rings that are $g(x)$-p-clean, the following can be proved:

Lemma 2.9. *Suppose R is a $(x-d)(x-f)$-p-clean ring, where $d \neq f$ are central elements of R and $(f-d)$ is not a zero divisor element. Then, for every central idempotent element e, eRe is $(x-ed)(x-ef)$-p-clean. Especially, if $g(x) = (x-ed)(x-ef) \in C(R)[x]$ and R is $(x-d)(x-f)$-p-clean where $d \neq f \in C(R)$ and $(f-d)$ is not a zero divisor element, then eRe is $g(x)$-p-clean.*

Proof. Just when R is p-clean and $(f-d) \in Pu(R)$, R is $(x-d)(x-f)$-p-clean. In [12, Proposition 2.16] it is proved that if the ring R is p-clean, the eRe is p-clean for every $e \in Id(R)$. Then, based on Theorem 2.5, eRe is $(x-ed)(x-ef)$-p-clean. □

A natural illustration of Lemma 2.9 can be given through the following simple example

Example 2.10. Let $R = \mathbb{Z}_6$ and take the polynomial $g(x) = (x-0)(x-1) = x(x-1)$. Since the roots of $g(x)$ in $\mathbb{Z}_6$ are $0, 1, 3, 4$, and $Pu(\mathbb{Z}_6) = \{0, 3\}$, it follows that every element of R may be written as the sum of a pure element and a root of $g(x)$. Thus R is $g(x)$-p-clean. Let $e = 3 \in \mathbb{Z}_6$, which is a central idempotent. Then the corner ring $eRe = 3\mathbb{Z}_6 = \{0, 3\}$ is a subring of R. The polynomial induced on eRe by Lemma 2.9 is $(x - e \cdot 0)(x - e \cdot 1) = x(x-3)$, whose roots in eRe are 0 and 3 and $Pu(eRe) = eRe$, every element of eRe is immediately the sum of a pure element and a root of this polynomial. Hence eRe is $(x - e \cdot 0)(x - e \cdot 1)$-$p$-clean, confirming Lemma 2.9 for this concrete case.

Assume that R and $R^{'}$ are rings, and that the identity element of R is mapped to that of $R^{'}$ by a ring homomorphism θ from $C(R)$ to $C(R^{'})$. This homomorphism gives rise to a corresponding map, denoted θ_0, from the polynomial ring $C(R)[x]$ into $C(R^{'})[x]$. For a polynomial $g(x) = \sum_{i=0}^{n} a_i x^i \in C(R)[x]$, the image under θ_0 is given by $\theta_0(g(x)) = \sum_{i=0}^{n} \theta(a_i)x^i \in C(R^{'})[x]$. Whenever $g(x) \in \mathbb{Z}$, it states that $\theta_0(g(x)) = g(x)$. We then go through several characteristics related to the class of rings that are $\theta_0(g(x))$-p-clean. We begin with a fundamental finding.

Proposition 2.11. *Consider two rings R and R', and let $\theta : R \longrightarrow R'$ be a surjective ring homomorphism. Suppose $g(x) = \sum_{i=0}^{n} a_i x^i \in C(R)[x]$. If the ring R is $g(x)$-p-clean, then the ring R' is also $\theta_0(g(x))$-p-clean.*

Proof. Let $g(x) = \sum_{i=0}^{n} r_i x^i \in C(R)[x]$, and define $\theta_0(g(x)) = \sum_{i=0}^{n} \theta(r_i)x^i$ as an element of $C(R')[x]$. Given any $\beta \in R'$, there exists some $r \in R$ such that $\theta(r) = \beta$. Because R is $g(x)$-p-clean, we can write $r = p + s$ for some $p \in Pu(R)$ and $s \in R$ satisfying $g(s) = 0$. Applying θ, we obtain $\beta = \theta(r) = \theta(p+s) = \theta(p) + \theta(s)$, where $\theta(p) \in Pu(S)$. Now, $\theta_0(\theta(s)) = \sum_{i=0}^{n} \theta(a_i)(\theta(s))^i = \sum_{i=0}^{n} \theta(a_i)\theta(s^i) = \sum_{i=0}^{n} \theta(r_i s^i) = \theta(\sum_{i=0}^{n} r_i s^i) = \theta(h(s)) = \theta(0) = 0$. Hence, R' is $\theta_0(g(x))$-p-clean. □

Corollary 2.12. *Let I be an ideal of a $g(x)$-p-clean ring R. Then R/I is $\overline{g}(x)$-p-clean, where $\overline{g}(x) \in C(R/I)[x]$.*

Proof. Assume that $\theta : R \longrightarrow R/I$ is the canonical epimorphism. Note that if $r \in C(R)$, then $\overline{r} \in C(R/I)$, and therefore the outcome is derived from Proposition 2.11. □

Lemma 2.13. *Let $g(x) \in \mathbb{Z}[x]$ and $R_1, R_2, \cdots, R_n$ be rings. Then $R = \prod_{i=1}^{n} R_i$ is $g(x)$-p-clean if and only if for every $1 \leq i \leq n$, R_i is $g(x)$-p-clean.*

Proof. Suppose that R is $g(x)$-p-clean. Define $\theta_j : R = \prod_{i=1}^{n} R_i \longrightarrow R_j$ by $\theta_j((r_i)) = r_j$. Since θ_j is a ring epimorphism for every $1 \leq j \leq n$, R_j is $g(x)$-p-clean, by Corollary 2.12. Conversely, assume taht $(r_1, r_2, \cdots, r_n) \in \prod_{i=1}^{n} R_i$ and $r_i = p_i + s_i$, $1 \leq i \leq n$, where $p_i \in Pu(R_i)$ and $h(s_i) = 0$. Let $p = (p_1, p_2, \cdots, p_n)$ and $s = (s_1, s_2, \cdots, s_n)$. Then $p \in Pu(R)$ and $g(s) = 0$. Thus, R is $g(x)$-p-clean. □

The following example illustrates the statement of Lemma 2.13 that the direct product ring is $g(x)$-p-clean precisely when each component ring admits this property.

Example 2.14. Let $R = \mathbb{Z}_4 \times \mathbb{Z}_2$ and consider the polynomial $g(x) = x^2 - 1$. In $\mathbb{Z}_4$, the elements $1, 3$ satisfy $x^2 - 1 = 0$, and $Pu(\mathbb{Z}_4) = \mathbb{Z}_4$. In $\mathbb{Z}_2$, the element 1 is a root of $x^2 - 1 = 0$, and $Pu(\mathbb{Z}_2) = \mathbb{Z}_2$. Let $(r, s) \in R$. Since in each component r and s may be written as $r = p_1 + s_1$ and $s = p_2 + s_2$, where $p_1 \in Pu(\mathbb{Z}_4)$ and $p_2 \in Pu(\mathbb{Z}_2)$, and $g(s_1) = g(s_2) = 0$, we obtain $(r, s) = (p_1, p_2) + (s_1, s_2)$, where $(p_1, p_2) \in Pu(R)$ and $g(s_1, s_2) = 0$. Thus every element of R is $g(x)$-p-clean. Consequently, $R = \mathbb{Z}_4 \times \mathbb{Z}_2$ is $g(x)$-p-clean.

Suppose R is a ring with unity, and R' is a (possibly non-unital) ring equipped with a bimodule structure such that, for any $r \in R$ and $s_1, s_2 \in R'$, $(s_1 s_2)r = s_1(s_2 r)$, $r(s_1 s_2) = (r s_1)s_2$ and $(s_1 r)s_2 = s_1(r s_2)$. Multiplying $(r_1, s_1)(r_2, s_2) = (r_1 r_2, r_1 s_2 + s_1 r_2 + s_1 s_2)$ yields the additive abelian group $I(R, R') = R \oplus R'$, which is the ring constructed by extending R through the ideal R', denoted by $I(R, R')$. $g_R(x) = r_0 + r_1 x + \cdots + r_n x^n \in C(R)[x]$ is obviously true if $g(x) = (r_0, s_0) + (r_1, s_1)x + \cdots + (r_n, s_n)x^n \in C(I(R, R'))[x]$.

Theorem 2.15. *Let R and R' be as above. Then if $I(R, R')$ is $g(x)$-p-clean, then R is $g_R(x)$-p-clean.*

Proof. Suppose that $\theta_R : I(R, R') \longrightarrow R$ is defined by $\theta_R(r, s) = r$. Hence θ_R is a ring epimorphism. If $I(R, R')$ is $g(x)$-p-clean, then R is $g_R(x)$-p-clean, according to Corollary 2.12. □

Suppose that $\phi \in End(R)$ and that R is arbitrary. The symbol $R[[x, \phi]]$ represents the ring of skew formal power series whose coefficients lie in R, where $xr = \phi(r)x$ for any $r \in R$. Notably, when ϕ is the identity map on R, this construction reduces to the standard ring of formal power series $R[[x]]$. The skew polynomial ring $R[x, \phi]$ can be defined in an analogous way. It can be demonstrated that the idealization $I(R, \langle x \rangle)$, where $\langle x \rangle$ indicates the ideal produced by x, is isomorphic to $R[[x, \phi]]$. Next, the following can be stated.

Theorem 2.16. *Consider a ring homomorphism ϕ from R to itself. If $R[[x, \phi]]$ is $g(x)$-p-clean, then R is $g_\alpha(x)$-p-clean, where $\alpha : R[[x, \phi]] \longrightarrow R$ is definde by $\alpha(f) = f(0)$.*

Proof. Follows from Corollary 2.12. □

Corollary 2.17. *Take R to be a ring such that $R[[x]]$ be a $g(x)$-p-clean ring. Then R is $g(x)$-p-clean.*

Proof. Follows from Theorem 2.16. □

A Morita context $\mathcal{M}(R, R', M, K, f, h)$ consists of two rings R and R, two bimodules ${}_RM'_R$, ${}'_RK_R$ and a pair of bimodule homomorphisms $f : M \otimes_{R'} K \longrightarrow R$ and $h : K \otimes_R M \longrightarrow R'$ such that $f(m \otimes k)m' = mh(k \otimes m')$ and $h(k \otimes m)k' = kf(m \otimes k')$ [14]. These data give rise to a ring $T(\mathcal{M}) = \begin{pmatrix} R & M \\ K & R' \end{pmatrix}$ with multiplication defined in the natural matrix-like fashion, making $T(\mathcal{M})$ an associative ring. This construction is known as the Morita context ring determined by M. For additional information regarding these rings, see [14–17]. If $g(x) = \begin{pmatrix} r_0 & m_0 \\ k_0 & s_0 \end{pmatrix} + \begin{pmatrix} r_1 & m_1 \\ k_1 & s_1 \end{pmatrix} x + \cdots + \begin{pmatrix} r_n & m_n \\ k_n & s_n \end{pmatrix} x^n \in C(T(\mathcal{M}))[x]$, then $g_R(x) = r_0 + r_1x + \cdots + r_nx^n \in C(R)[x]$ and $g_{R'}(x) = s_0 + s_1x + \cdots + s_nx^n \in C(R')[x]$.

Lemma 2.18. *Let the ring $T(\mathcal{M}) = \begin{pmatrix} R & M \\ K & R' \end{pmatrix}$ be $g(x)$-p-clean. Then R is $g_R(x)$-p-clean and R' is $g_{R'}(x)$-p-clean.*

Proof. It is easy to see that $I = \begin{pmatrix} 0 & M \\ K & R' \end{pmatrix}$ and $J = \begin{pmatrix} R & M \\ K & 0 \end{pmatrix}$ are two ideals of $T(\mathcal{M})$. Since $T(\mathcal{M})/I \cong R$ and $T(\mathcal{M})/J \cong R'$, the claim holds by Corollary 2.12. □

Corollary 2.19. *Let R and R' be two rings, and assume M be a bimodule over them with left R-action and right R'-action. Define the upper triangular matrix ring $T = \begin{pmatrix} R & M \\ 0 & R' \end{pmatrix}$. If T possesses the $g(x)$-p-clean property, then both R and R' individually satisfy $g_R(x)$-p-cleaness and $g_{R'}(x)$-p-cleaness, respectively.*

Proof. Follows from Lemma 2.18. □

Corollary 2.20. *Take R is a commutative ring such that every pure element of R is unit, M is an R-module and $2M = 0$. Define the triangular matrix ring $T = \begin{pmatrix} R & M \\ 0 & R \end{pmatrix}$. Then T is $g(x)$-p-clean if and only if R is $g(x)$-p-clean.*

Proof. Follows from Corollaries 2.12 and 2.19. □

We conclude the article with the following two problems.

Problem 1. How do matrix rings behave when they are constructed over $g(x)$-p-clean rings?

Problem 2. How does the ring $R[x]$ behave across $g(x)$-p-clean rings?

3. Conclusions

In this paper, we introduced and investigated the class of $g(x)$-p rings, a new generalization that simultaneously extends both p-clean and $g(x)$-clean structures. By expressing each element of a ring as the sum of a pure element and a root of a fixed central polynomial $g(x)$, we developed a unified framework that encompasses several earlier notions studied in the literature.

We established fundamental properties of $g(x)$-p-clean rings, including their behavior under quotient constructions, direct products, idealizations, skew power series rings, and Morita context rings. In particular, we proved that the $g(x)$-p-clean property is preserved under ring homomorphisms and passes naturally to factor rings whenever $g(x) \in C(R/I)[x]$. We also characterized conditions under which p-clean and $g(x)$-p-clean rings coincide, especially for polynomials of the form $(x-d)(x-f)$ with central coefficients.

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References

[1] A. S. Mohammed, I. S. Ahmed and S. H. Asaad, Study of the rings in which each element express as the sum of an idempotent and pure, *Int. J. Nonlinear Anal. Appl.* **12** (2021) 1719 – 1724, https://doi.org/10.22075/IJNAA.2021.5311.

[2] D. D. Anderson and V. P. Camillo, Commutative rings whose elements are a sum of a unit and an idempotent, *Comm. Algebra* **30** (2002) 3327 – 3336, https://doi.org/10.1081/AGB-120004490.

[3] W. K. Nicholson, Lifting idempotents and exchange rings, *Trans. Amer. Math. Soc.* **229** (1977) 269 – 278, https://doi.org/10.2307/1998510.

[4] V. Camillo and J. J. Simon, The Nicholson-Varadarajan theorem on clean linear transformations, *Glasg. Math. J.* **44** (2002) 365 – 369.

[5] L. Fan and X. Yang, On rings whose elements are the sum of a unit and a root of a fixed polynomial, *Comm. Algebra* **36** (2008) 269 – 278, https://doi.org/10.1080/00927870701665461.

[6] N. Ashrafi and Z. Ahmadi, Weakly $g(x)$-clean ring, *Iran. J. Math. Sci.* **7** (2012) 83 – 91, https://doi.org/10.7508/ijmsi.2012.02.008.

[7] M. EL Maalmi and H. Mouanis, On $g(x)$- invo clean rings, *Commun. Korean Math. Soc.* **35** (2020) $455-468$, https://doi.org/10.4134/CKMS.c190140.

[8] F. Rashedi, Weakly $g(x)$-invo-clean rings, *Quasigroups Related Systems* **31** (2023) $285-292$, https://doi.org/10.56415/qrs.v31.22.

[9] F. Rashedi, On weakly k-clean rings, *Jordan J. Math. Stat.* **16** (2023) $507-513$.

[10] F. Rashedi, Weakly $g(x)$-quasi invo-clean rings, *Trans. A. Razmadze Math. Inst.* **178** (2024) $111-114$.

[11] F. Rashedi, On weakly f-clean rings, *Quasigroups Related Systems* **32** (2024) $109-118$, https://doi.org/10.56415/qrs.v32.09.

[12] E. H. Ramzi and A. S. Mohamme, On p-clean rings, *Journal of Al-Qadisiyah for Computer Science and Mathematics*, **14** (2022) $46-53$, https://doi.org/10.29304/jqcm.2022.14.2.949.

[13] A. Majidinya, A. Moussavi and K. Paykan, Rings in which the annihilator of an ideal is pure, *Algebra Colloq.* **22** (2015) $947-968$.

[14] S. A. Amitsur, Rings of quotients and Morita contexts, *J. Algebra* **17** (1971) $273-298$, https://doi.org/10.1016/0021-8693(71)90034-2.

[15] H. Bass, *The Morita Theorems, Mimeographed Notes, Oregon*, University of Oregon, 1962.

[16] A. D. Sands, Radicals and Morita contexts, *J. Algebra* **24** (1973) $335-345$, https://doi.org/10.1016/0021-8693(73)90143-9.

[17] G. Tang, C. Li and Y. Zhou, Study of Morita contexts, *Comm. Algebra* **42** (2014) $1668-1681$, https://doi.org/10.1080/00927872.2012.748327.

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