

Extimates on Solutions of a New Quadruple Integral Inequalities
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 School of Mathematics and Physics, Hechi University, Hechi, Guangxi, China

*Correspon **Examplement Sciences (HSMS 2024)**
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Abstract: With the Estimates on Solutions of a New Quadruple Int**

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 \text{Integral, Differential Equation; Estimation\n} & \text{Based on the above research constructed the full nonlinear integral inequalities\n}$

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However, investigation on integral inequalitie systems. In economics, it is employed to develop
different economic models, predict market
trends, formulate economic policies, etc.
However, investigation on integral inequalities
provides a fruitful theoretical tool to

$$
u(t) \le c + \int_a^t f(s)u(s)ds \qquad (t \in [a,b]) \tag{1}
$$

$$
u(t) \le c \exp\left(\int_a^t f(s)ds\right) \qquad (t \in [a, b]) \tag{2}
$$

trends, formulate economic poincies, etc.

However, investigation on integral inequalities

provides a fruitful theoretical tool to solve

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Gronwall [1] developed the following integral

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Gronwall [1] developed the following integral
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the para provides a fruitful theoretical tool to solve
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Gronwall [1] developed the following integral
dependence of differential equation solutions on
the parameters.
 $u(t) \le c + \int_a^t f(s)u(s)ds$ $(t \in [a,b])$ (1)
Wher differential equations.

Gronwall [1] developed the following integral

inequalities to evaluate the continuous

dependence of differential equation solutions on

the parameters.
 $u(t) \le c + \int_a^t f(s)u(s)ds$ $(t \in [a,b])$ (1)

Wher Gronwall [1] developed the following integral
inequalities to evaluate the continuous
dependence of differential equation solutions on
the parameters.
 $u(t) \le c + \int_{a}^{t} f(s)u(s)ds$ $(t \in [a,b])$ (1)
Where constant $c \ge 0$. The est mequalities to evaluate the continuous
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 $u(t) \le c + \int_a^t f(s)u(s)ds$ $(t \in [a,b])$ (1)
Where constant $c \ge 0$. The estimated solution for
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 $u(t) \$ dependence of differential equation solutions of
the parameters.
 $u(t) \leq c + \int_a^t f(s)u(s)ds$ $(t \in [a,b])$ (1)
Where constant $c \geq 0$. The estimated solution for
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 $u(t) \leq c \exp(\int_a^t f(s)ds)$ $(t \in [a,b])$ (2)
Later, the parameters.
 $u(t) \le c + \int_a^t f(s)u(s)ds$ $(t \in [a,b])$ (1)

Where constant $c \ge 0$. The estimated solution for

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Later, it was seen that Gronwalltype integral

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the unknown function was
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Later, it was seen that Gronwalltype integral

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popularize it, so that its application range in
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Zareen [7] further explored nonlinear integral

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Zareen [7] further explored nonlinear integral
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[8-9] investigated a class of non the integral sign and their derivatives. In 2014,
Zareen [7] further explored nonlinear integral
inequalities. In 2019, Huang and Wang et al.
[8-9] investigated a class of nonlinear double
integral inequalities containing

derivatives:

$$
u'(\omega) \le p(\omega) + q(\omega) \{u(\omega) + \int_{\omega_0}^{\omega} [a(\xi)(u(\xi) + u'(\xi)) + a(\xi)]_{\omega_0}^{\xi} [c(\sigma)(u(\sigma) + u'(\sigma)) + c(\sigma)]_{\omega_0}^{\sigma} [d(\eta)((u(\eta) + u'(\eta)) + d(\eta)]_{\omega_0}^{\eta} [f(\varphi)u'(\varphi) + u'(\varphi) + g(\varphi)]d\varphi]d\eta]d\sigma d\xi\}
$$
\n(3)

$$
\omega \in [\omega_0, \infty) \tag{3}
$$

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various inequality analysis methods such as

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inequation.

$$
u(\omega) \leq a(\omega) + \int_{\omega_0}^{\omega} b(\omega)u(\omega) d\omega + \int_{\omega_0}^{\omega} c(\omega)u^2(\omega) d\omega \quad (\omega \in [\alpha, \infty)) (4) \quad + 2 f(\varphi) p(\varphi) q(\varphi) |z_1(\varphi) + [f(\varphi) q(\varphi) + f(\varphi) q(\varphi)] d\varphi
$$
\n
$$
= \int_{\omega_0}^{\omega} b(\omega) d\omega - \int_{\omega_0}^{\omega} c(\omega) d\omega > 0, \quad \text{then} \quad + f(\varphi) q^2(\varphi) |z_1(\varphi) + g(\varphi)| d\varphi |d\eta| d\sigma
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$$
= \int_{\omega_0}^{\omega} b(\omega) d\omega - \int_{\omega_0}^{\omega} c(\omega) d\omega > 0, \quad \text{then} \quad \omega \in [\alpha, \infty) \quad (\alpha \in [\alpha, \infty))
$$

 $(a) \leq \exp(m(a) - \int_{a}^{b} l(\mathbf{y} \cdot d\mathbf{y}) - \int_{a}^{b} d(\mathbf{y} \cdot d\mathbf{y})$ $(a \in [a, \infty))$ (5) Let $u(a) \leq (e^{c} \pi \theta \ln(a) - \int_{a}^{b} t(v) dv) - \int_{a}^{b} a(v) dv$ ¹ $(\omega \in (a, \infty))$ (5) Let

Theorem 1. Suppose $p(a) q(a) q(a) q(a) q(a) d(a) f(a) q(a)$ to be $[a_0, \infty)$, respectively, and $a(\omega)$ be an increasing $a(\omega) \int_{\omega_0}^{\infty} [c(\sigma)p(\sigma) + c(\sigma)]$

tunction on $[a_0, \infty)$. Then, $u(\omega)$ would be $u(\omega) \leq a(\omega) + \int_{\omega_0}^{\infty} b(u/\psi) d\psi + \int_{\omega_0}^{\infty} c(\psi) d\psi$ (we $[a_0, \infty)$)(4) $a(\omega) \leq a(\omega$ inequation. $\begin{aligned}\n &+ d(\eta) \int_{\omega_0}^{\eta} [f(\varphi)] u(\omega) \leq d(\omega) + \int_{\omega_0}^{\infty} b(\nu) u(\nu) d\nu + \int_{\omega_0}^{\infty} d(\nu) u^2(\nu) d\nu \quad (\omega \in [a_0, \infty)) (4) \\
 &+ 2 f(\varphi) p(\varphi) q(\varphi) d\n\end{aligned}$ If $\exp(-\ln a(\omega) - \int_{\omega_0}^{\infty} b(\nu) d\nu - \int_{\omega_0}^{\infty} c(\nu) d\nu > 0$, then
 If

$$
\exp\left(-\ln(u(a_1) + \int_{a_0}^{\infty} A(u)du\right) - \int_{a_0}^{\infty} B(u)du\right) = \int_{a_1}^{\infty} C(u)du > 0 \quad (\omega \in [a_1, \infty)) \quad (6) \qquad \text{Then } z_2(a_0) = z_1(a_0)
$$

then

$$
u(\omega) \le u(\alpha) + \int_{\alpha_0}^{\infty} p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega)(1 + a(\omega) + c(\omega) + d(\omega)) \quad (7)
$$
\n
$$
= \alpha(\omega) + a(\omega) + d(\omega) + d(\omega) \quad \text{(a) } \in [a, \infty)
$$
\n
$$
= p(\omega)[1 + a(\omega)] + [q(\omega) + a(\omega) + a(\omega) + d(\omega)]
$$
\n
$$
= p(\omega)[1 + a(\omega)] + [q(\omega) + a(\omega) + a(\omega)]
$$

where

$$
Z(\omega) := (\exp\{-\ln(u(\omega_0) + \int_{\omega_0}^{\omega} A(\nu) d\nu) - \int_{\omega_0}^{\omega} B(\nu) d\nu) - \int_{\omega_0}^{\omega} C(\nu) d\nu\}^{-1} \quad (8)
$$
 Differentiating $z_2(\omega)$ with

$$
A(\omega) = f(\omega)p^{2}(\omega) + [1 + a(\omega) + c(\omega) + d(\omega)]p(\omega) + g(\omega)
$$
 (9) (17) gives

$$
B(\omega) := q(\omega) + a(\omega) + a(\omega)q(\omega) + c(\omega) + c(\omega)q(\omega)
$$

(10)
$$
z_2(\omega) = z_1'(\omega) + c(\omega)p(\omega) + c(\omega)(1 + q(\omega))z_1(\omega) + c(\omega)\int_{\omega_0}^{\omega_0} [d(\eta)p(\eta)]d\mu
$$

 $+d(\omega)+d(\omega)q(\omega)+f(\omega)p(\omega)+2f(\omega)p(\omega)q(\omega)$ $C(\omega)$: = $f(\omega)q(\omega) + f(\omega)q^{2}(\omega)$ (11)

$$
C(\omega) = f(\omega)q(\omega) + f(\omega)q^{2}(\omega)
$$

Proof. Let

$$
z_1(\omega) = u(\omega) + \int_{\omega_0}^{\omega} [a(\xi)(u(\xi) + u'(\xi)) + a(\xi)]_{\omega_0}^{\zeta} [c(\sigma)(u(\sigma) + u'(\sigma))
$$

$$
+ c(\sigma) \int_{-\omega_0}^{\omega_0} [d(\eta)((u(\eta) + u'(\eta)) + d(\eta)]^{\gamma} [f(\varphi)u'(\varphi)] + c(\omega) p(\omega) + c
$$

$$
+c(\sigma)\int_{\omega_0}^{\sigma} [d(\eta)((u(\eta)+u'(\eta))+d(\eta)]_{\omega_0}^{\eta} [f(\varphi)u'(\varphi)] +c(\omega)\int_{-\infty}^{\infty}d(\eta+\sigma)\int_{\omega_0}^{\infty}d(\eta+\sigma)\int_{-\infty}^{\infty}d(\eta+\sigma)\
$$

$$
\omega \in [\omega_0, \infty) \tag{1}
$$

From (3) and (12), we
\nhave
$$
z_1(\omega_0) = u(\omega_0) \cdot u(\omega) \le z_1(\omega)
$$
 = $p(\omega)$

$$
u'(\omega_0) - u(\omega_0) \cdot u(\omega) \geq 2_1(\omega)
$$

$$
u'(\omega) < p(\omega) + q(\omega) \cdot z(\omega) \tag{13}
$$

$$
u(\omega) \le p(\omega) + q(\omega)z_1(\omega)
$$

ntiating $z(\omega)$ with respect to. using (3)

gives

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Estimation of unknown function in quadruple integral inequality (3) was performed using various inequality and	$z(\omega) = u'(\omega) + a(\omega)[u(\omega) + u'(\omega)] + a(\omega)[\frac{a}{m}(\sigma(x)(u(\sigma) + u'(\sigma)))$ various inequality analysis methods such as variance substitution, and integration and integration.	$+\alpha(\sigma)[\frac{a}{m}(\sigma(x)(u(\eta) + u'(\eta)) + d(\eta)]\frac{a}{m}[(\sigma(\psi)(\sigma(\eta) + \eta(\sigma)) + d(\eta)]\frac{a}{m}[(\sigma(\psi)(\sigma(\eta)))$ and
Quariable substitution and integration.	$\phi(\omega) = \frac{a}{m}(\sigma(\sigma(x))\frac{a}{m}(\sigma(x)) + q(\omega) + q(\omega)z_1(\sigma))$ $+\alpha(\sigma)[\frac{a}{m}(\sigma(x)) + q(\sigma) + q(\sigma)z_1(\sigma)]$	
2. Main Result	In order to simplify the proof of the results, the following Lemma was developed.	$+ a(\sigma)[\frac{a}{m}(\sigma(x)) + q(\sigma) + q(\sigma)z_1(\sigma))$ $= p(\omega)[1 + a(\omega)] + q(\sigma) + q(\sigma)z_1(\sigma)$
Lemma 1. [8] Let $a(\omega)$, $b(\omega)$, $c(\omega)$ be $= p(\omega)[1 + a(\omega)] + q(\omega) + a(\omega) + a(\omega)q(\omega)[z_1(\omega)$ $= p(\omega)[1 + a(\omega)] + q(\sigma) + a(\omega) + a(\omega)q(\omega)[z_1(\omega)$ $= p(\omega)[1 + a(\omega)] + q(\sigma) + a(\omega) + a(\omega)q(\omega)[z_1(\omega)$		
function on $[\omega_8, \infty)$. Then, $u(\omega)$ would be unknown function satisfying the following inequation.	$+ a(\sigma)[\frac{a}{m}(\sigma(x)) + q(\sigma) + q(\sigma) + q(\sigma)z_1(\sigma)$ $= p(\omega)[1 + a(\sigma) + q(\sigma)$	

Let

 on),[⁰ . The unknown functions *^u*)(and *^u*)(are defined on),[⁰ . Then, *^u*)(would *dddgzqfqf zqpf pfpfd zqdpdc zqcpczz*]])]()()]()()()([)()]()()(2)()([)()([)()())(1)(()()([)()())(1)(()()([)()(2 1 2 1 2 1 2 1 1 0 0 0),[⁰ (15) From (14)-(16), we have Differentiating)(*^z* ² with respect to , using (17) gives

 $\int_{a_0}^{\infty} a(v) dv > 0$ ($\omega \in [a_0, \infty)$) (6) Then $z_2(\omega_0) = z_1(\omega_0) \cdot z_1(\omega) \le z_2(\omega)$ $\omega \in [\omega_0, \infty)$ (16)

$$
z'_{1}(\omega) \le p(\omega)[1+a(\omega)]+[q(\omega)+a(\omega)q(\omega)]z_{1}(\omega)+a(\omega)z_{2}(\omega)
$$

\n
$$
\le p(\omega)[1+a(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)]z_{2}(\omega)
$$

$$
\omega \in [\omega_0, \infty) \tag{17}
$$

 ω θ

$$
z(\omega) = (\exp(-\ln(u/a_0) + \int_{a_0}^{\infty} A(u)dv) - \int_{a_0}^{\infty} B(u)dv) - \int_{a_0}^{\infty} C(u)dv + \nu(\omega)
$$
\n
$$
= q(\omega) + a(\omega) + a(\omega) + a(\omega)q(\omega) + c(\omega)q(\omega)
$$
\n
$$
= q(\omega) + a(\omega) + a(\omega)q(\omega) + c(\omega)q(\omega)
$$
\n
$$
= f(\omega)q(\omega) + f(\omega)p(\omega) + 2f(\omega)p(\omega)q(\omega)
$$
\n
$$
= f(\omega)q(\omega) + f(\omega)q(\omega)
$$
\n
$$
= f(\omega)q(\omega) + f(\omega)q^2(\omega)
$$
\n
$$
= f(\omega)q(\omega) + g(\omega)q^2(\omega)
$$
\n
$$
= f(\omega)q(\omega) + g(\omega)q^2(\omega)
$$
\n
$$
= f(\omega)q
$$

 $\times z_2(\varphi) + [f(\varphi)q(\varphi) + f(\varphi)q^2(\varphi)]z_2^{2}(\varphi) + g(\varphi)]d\varphi]d\eta$

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Let

 ddgzqf qfzqpf pfpfd zz zqdpd])]()()]()()()([)()]()()(2)()([)()([)()())(1)(()()([)()(2 2 2 2 2 0 0 From (18)-(20), we have

then $z_1(\omega_0) = z_2(\omega_0)$, $z_2(\omega) \le z_3(\omega)$, $\omega \in [\omega_0, \infty)$ (20) $\leq p(\omega)[1+a(\omega)+c(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)$ both sides of $+c(\omega)q(\omega)z_2(\omega)+c(\omega)z_3(\omega)$ By replacing $z'_{2}(\omega) \le p(\omega)[1 + a(\omega) + c(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega)$ where. +2*j*(φ)*p*(φ)*jq*(φ)₁₂₂(φ)+1*j*(φ)*q*(φ)
+*f*(φ)*q*²(φ)¹z₂²(φ)+*g*(φ)]*d* φ]*dn*
 $\omega \in [\omega_0, \infty)$

then $z_3(\omega_0) = z_2(\omega_0) z_2(\omega) \le z_3(\omega)$, $\omega \in [\omega_0, \infty)$

From

 $+c(\omega)+c(\omega)q(\omega)z_1(\omega)$ from ω to give $3⁽ω)$

$$
\omega \in [\omega_0, \infty) \tag{21}
$$

$$
z_3^{\prime}(\alpha) = z_2^{\prime}(\alpha) + d(\alpha) \rho(\alpha) + d(\alpha) \left(1 + \rho(\alpha) z_2(\alpha) + d(\alpha)\right) \left[\int_0^{\infty} f(\alpha) p^2(\alpha) \right]
$$

 $\mathcal{L}f(\phi p(\phi) + 2f(\phi p(\phi q(\phi) \xi(\phi))))$ could be obt $2\sqrt{2}$

 $f(\phi q(\phi) + f(\phi q^2(\phi) \xi^2(\phi) + g(\phi) d\phi)$ $z_4(\phi) \leq (\exp{d\phi})$

 $+c(\omega)q(\omega)z_3(\omega)+d(\omega)p(\omega)+d(\omega)(1+q(\omega))z_3(\omega)$ **Examediately** $\leq p(\omega)[1+a(\omega)+c(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)+c(\omega)]$

 $\mathcal{L}(\omega) \bigg(\int_0^{\infty} [f(\varphi) p^2(\varphi) + [f(\varphi) p(\varphi) + 2f(\varphi) p(\varphi) q(\varphi)] z_3(\varphi) \bigg) = z_1(\omega_0) = z_2(\omega_0) = z_3(\omega_0)$ $d(\omega)$ _{oo} $[f(\varphi)p^2(\varphi)+[f(\varphi)p(\varphi)+2f(\varphi)p(\varphi)q(\varphi)]z_3(\varphi)$ $+d(\omega)\int_{\omega_0}^{\omega} [f(\varphi)p^2(\varphi)+[f(\varphi)p(\varphi)+2f(\varphi)p(\varphi)q(\varphi)]\zeta_3(\varphi)$ $u(\omega_0)=z_1(\omega_0)=z_2(\omega_0)$

 $\mathcal{L}[f(\varphi)q(\varphi)+f(\varphi)q^2(\varphi)z_3^2(\varphi)+g(\varphi)]d\varphi$ **herefore** $+c(\omega)q(\omega)+d(\omega)+d(\omega)q(\omega)z_1(\omega)$ $= p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega) + c(\omega)$ $z_a(\omega) \leq (\exp{\ln(a\omega)} + a(\omega))$ $3(\omega)$

$$
+d(\omega)\int_{\omega_0}^{\omega} [f(\varphi)p^2(\varphi)+[f(\varphi)p(\varphi)+2f(\varphi)p(\varphi)q(\varphi)]z_3(\varphi)
$$
 where $z(\omega)$ is defined

 $f(\varphi)q(\varphi) + f(\varphi)q^2(\varphi)z_3^2(\varphi) + g(\varphi) d\varphi$ Substituting (30) into (

Let

$$
+c(\omega)q(\omega)+d(\omega)+d(\omega)q(\omega) |z_3(\omega)
$$
\n
$$
+d(\omega)\int_{\omega_0}^{\omega} [f(\varphi)p^2(\varphi)+[f(\varphi)p(\varphi)+2f(\varphi)p(\varphi)q(\varphi)]z_3(\varphi)
$$
\nwhere, $Z(\omega)$ is de
\n $+ [f(\varphi)q(\varphi)+f(\varphi)q^2(\varphi)]z_3^2(\varphi)+g(\varphi)]d\varphi$
\n $\omega \in [\omega_0, \infty)$
\nLet
\n $z_4(\omega) = z_3(\omega)+\int_{\omega_0}^{\omega} [f(\varphi)p^2(\varphi)+[f(\varphi)p(\varphi)]d\varphi$
\n $+2f(\varphi)p(\varphi)q(\varphi)]z_3(\varphi)$
\n $+2f(\varphi)p(\varphi)q(\varphi) |z_3(\varphi)+g(\varphi)]d\varphi$
\n $\omega \in [\omega_0, \infty)$
\nThen
\n $z_4(\omega_0) = z_3(\omega_0) \cdot z_3(\omega) \le z_4(\omega) \cdot \omega \in [\omega_0, \infty](23)$
\nThen
\n $z_4(\omega_0) = z_3(\omega_0) \cdot z_3(\omega) \le z_4(\omega) \cdot \omega \in [\omega_0, \infty](24)$
\nFrom (22)-(24), we have
\n $z'_3(\omega) \le p(\omega)[1+a(\omega)+c(\omega)+d(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)$
\n $+c(\omega)+c(\omega)q(\omega)+d(\omega)q(\omega) |z_3(\omega)+d(\omega)z_4(\omega)$
\nFrom (29) we know
\n $\le p(\omega)[1+a(\omega)+c(\omega)+d(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)$
\nhave
\n $z(\omega) \le p(\omega) \le p(\omega) \cdot \frac{e}{\omega} \cdot \frac{e}{\omega$

Then
$$
z_4(\omega_0) = z_3(\omega_0) \cdot z_3(\omega) \le z_4(\omega) \cdot \omega \in [a_0, \infty)
$$

\nFrom (22)-(24), we have\n
$$
+ d(\omega) + d(\omega) + d(\omega)q(\omega)
$$

 $+c(\omega)+c(\omega)q(\omega)+d(\omega)+d(\omega)q(\omega)z_4(\omega)$ $z_3(\omega)\geq u(\omega_3)+\int_{\omega_3}$ $\leq p(\omega)[1+a(\omega)+c(\omega)+d(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)]$ $+c(\omega)+c(\omega)q(\omega)+d(\omega)q(\omega)z_3(\omega)+d(\omega)z_4(\omega)$ **i** folio (2) we know $u(\omega_0)$ $z'_3(\omega) \le p(\omega)[1+a(\omega)+c(\omega)+d(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)]$ $4(\omega)$ +2f(φ) $p(\varphi)q(\varphi) | z_3(\varphi)$
+[$f(\varphi)q(\varphi) + f(\varphi)q^2(\varphi) | z_3^2(\varphi) + g(\varphi)]d\varphi$
 $\varphi \in [\omega_0, \infty)$
Then $z_4(\omega_0) = z_3(\omega_0) z_3(\omega) \le z_4(\omega)$, $\omega \in [\alpha_0, \infty)$
From (22)-(24), we have
 $z'_3(\omega) \le p(\omega)[1+a(\omega)+c(\omega)+d(\omega)]+[q(\omega)+a(\omega)+a(\omega)q(\omega)+c$

$$
\omega \in [\omega_0, \infty) \tag{25}
$$

),[⁰ (18))()]()()(2)()([)()()()(3 2 4 3 *zqpfpfpfzz* ${}_{1}f(\varphi)p(\varphi)q(\varphi)]z_{2}(\varphi) + [f(\varphi)q(\varphi)$
= $[f(\omega)p^{2}(\omega) + [1 + a(\omega) + c(\omega) + d(\omega)]p(\omega) + g(\omega)]$ $\mathcal{L}_3(\omega) = z_2(\omega) + \int_{\omega_0}^{\omega} [d(\eta)p(\eta) + d(\eta)(1 + q(\eta))z_2(\eta) + c(\omega) + c(\omega)q(\omega) + d(\omega)q(\omega)]z_4(\omega) + d(\omega)q(\omega) + d(\omega)q(\omega) + d(\omega)q(\omega) + d(\omega)q(\omega) + d(\omega)q(\omega)$ $+(q(\omega)+a(\omega)+a(\omega)+a(\omega)+a(\omega)+c(\omega)+c(\omega)+c(\omega)+c(\omega)$ $+(d(\eta))\int_{0}^{\eta} [f(\varphi)p^{2}(\varphi) + [f(\varphi)p(\varphi)]\n+ f(\omega)p^{2}(\varphi) + [f(\omega)p(\varphi) + 2f(\omega)p(\omega)q(\omega)]z_{4}(\omega)$ $\omega \in [\omega_0, \infty)$

(19)
 $+ [f(\omega)q(\omega) + f(\omega)q^2(\omega)]z_4^2(\omega)$
 $+ [f(\omega)q(\omega) + f(\omega)q^2(\omega)]z_4^2(\omega)$ $(z_2(\omega) \le z_3(\omega), \omega \in [\omega_0, \infty)$ (20) $= A(\omega) + B(\omega) z_4(\omega) + C(\omega) z_4^2(\omega)$ $\begin{array}{lllllll} & & & + [f(\omega)q(\omega)+f(\omega)q^{2}(\omega)]z_{z}^{2}(\omega)+g(\omega)\\ & & + 2f(\varphi)p(\varphi)q(\varphi)|z_{z}(\varphi)+[f(\varphi)q(\varphi) & & -[f(\omega)p(\omega)+a(\omega)+(a\omega)+(c\omega)]e(\omega)+g(\omega)]e(\omega)\\ & & + f(\varphi)q^{2}(\varphi)+g(\varphi)q(\varphi)q\varphi\end{array}$

then $z_{3}(\omega_{0})=z_{3}(\omega_{0})\cdot z_{2}(\omega)+g(\omega)g(\omega)+g(\omega)g(\omega)\\ & & \omega\in\math$ $+[f(\omega)q(\omega)+f(\omega)q^2(\omega)]z_3^{2}(\omega)+g(\omega)$ $+[f(\omega)q(\omega)+f(\omega)q^2(\omega)]z_4^{2}(\omega)+g(\omega)$ $\leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega)]$ $4(\omega)$ $+d(\omega)q(\omega)+f(\omega)p(\omega)+2f(\omega)p(\omega)q(\omega)]z_4(\omega)$ $\omega \in [\omega_0,\infty)$ (26) $\begin{array}{l} \mathcal{Z}_4(\omega) = \mathcal{Z}_3'(\omega) + f(\omega)p^2(\omega) + [f(\omega)p(\omega) + 2f(\omega)p(\omega)q(\omega)] \mathcal{Z}_3(\omega) \\ \quad + [f(\omega)q(\omega) + f(\omega)q^2(\omega)] \mathcal{Z}_3^2(\omega) + g(\omega) \\ \quad \leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega) \\ \quad + c(\omega) + c(\omega)q(\omega) + d(\omega) + d(\omega)q(\omega)] \mathcal{Z}_4(\omega) \\ \quad + f(\omega) p^2(\omega) + [f(\omega)p$ $z_4(\omega) = z_5'(\omega) + f(\omega)p^*(\omega) + [f(\omega)p(\omega) + 2f(\omega)p(\omega)g(\omega)]z_5(\omega)$
 $+[f(\omega)q(\omega) + f(\omega)q^2(\omega)]z_3^2(\omega) + g(\omega)$
 $\leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega)$
 $+ c(\omega) + c(\omega)q(\omega) + d(\omega) + d(\omega)q(\omega)]z_4(\omega)$
 $+ f(\omega)p^2(\omega) + [f(\omega)p(\omega) + 2f(\omega)p(\omega)g(\omega)]z_4(\omega)$
 +[$f(\omega)q(\omega) + f(\omega)q^*(\omega)]=g(\omega) + g(\omega)$
 $\leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega)$
 $+ c(\omega) + c(\omega)q(\omega) + d(\omega) + d(\omega)q(\omega)]z_4(\omega)$
 $+ f(\omega) p^2(\omega) + [f(\omega) p(\omega) + 2f(\omega) p(\omega)q(\omega)]z_4(\omega)$
 $+ [f(\omega)q(\omega) + f(\omega)q^2(\omega)]z_4^*(\omega) + g(\omega)$
 $= [f(\omega) p^2(\omega) + [1 +$ + $[q(\omega) + a(\omega) + a(\omega)q(\omega) + c(\omega)q(\omega) + d(\omega)$

+ $d(\omega)q(\omega) + f(\omega)p(\omega) + 2f(\omega)p(\omega)q(\omega)]z_*(\omega)$

+ $[f(\omega)q(\omega) + f(\omega)q^2(\omega)]z_*^2(\omega)$

+ $[f(\omega)q(\omega) + f(\omega)q^2(\omega)]z_*^2(\omega)$
 $\omega \in [\omega_0, \infty)$

where, $A(\omega), B(\omega), C(\omega)$ is defined by (9)-(11).

By replacing

from $_{q}$ to $_{\omega}$ gives + $d(\omega)q(\omega) + f(\omega)p(\omega) + 2f(\omega)p(\omega)q(\omega)\vert z_4(\omega)$
+ $[f(\omega)q(\omega) + f(\omega)q^2(\omega)\vert z_4^2(\omega)$
+ $[f(\omega)q(\omega) + f(\omega)q^2(\omega)\vert z_4^2(\omega)$
 $\omega \in [\omega_0, \infty)$
 $\omega \in [\omega_0, \infty)$
Where, $A(\omega), B(\omega), C(\omega)$ is defined by (9)-(11).
By replacing ω with ν in (26) = $A(\omega) + B(\omega)z_4(\omega) + C(\omega)z_4^2(\omega)$
 $\omega \in [\omega_0, \infty)$ (26)

where, $A(\omega), B(\omega), C(\omega)$ is defined by(9)-(11).

By replacing ω with ω in (26), then integrating

both sides of the inequality with respect to ω

from a_0 to

$$
\omega \in [\omega_0, \infty) \qquad (21)
$$
\nwith respect to ω , using\n
$$
z_4(\omega) \leq z_4(\omega_0) + \int_{\omega_0}^{\omega} A(\omega) d\omega + \int_{\omega_0}^{\omega} B(\omega) z_4(\omega) d\omega + \int_{\omega_0}^{\omega} C(\omega) z_4^2(\omega) d\omega
$$
\n
$$
\omega \in [\omega_0, \infty) \qquad (27)
$$

 $\epsilon_{\text{F}}^{\text{o}}$ Since equation (27) s By replacing ω with ν in (26), then integrating
both sides of the inequality with respect to ν
from a_0 to ω gives
 $z_4(\omega) \le z_4(\omega_0) + \int_{\omega_0}^{\infty} A(\nu) d\nu + \int_{\omega_0}^{\infty} B(\nu) z_4(\nu) d\nu + \int_{\omega_0}^{\infty} C(\nu) z_4^2(\nu) d$ Since equation (27) satisfies the requirements of
the lemma, an estimate of $z_4(\omega)$ in equation (27)
could be obtained according to the lemma.
 $z_4(\omega) \leq (\exp\{ \ln t_4(\omega) + \int_{\omega_0}^{\omega} A(t) dt \} - \int_{\omega_0}^{\omega} B(t) dt \} - \int_{\omega_0}^{\omega} (L(t)$

$$
+ [f(q)q(q) + f(q)q^2(q) + g(q)q]q^2
$$

\n
$$
= [f(q)q^2(q) + g(q)q^2(q) + g(q)q^2(q)
$$

 $\omega \in [\omega_0,\infty)$ (28)

 $u(\omega_0) = z_1(\omega_0) = z_2(\omega_0) = z_3(\omega_0) = z_4(\omega_0)$ (29) (29) Therefore

the lemma, an estimate of
$$
z_4(\omega)
$$
 in equation (27)
\ncould be obtained according to the lemma.
\n $z_4(\omega) \leq (exp\{ln(z_4(\omega_i)) + \int_{\omega_0}^{\omega} A(\omega)d\omega\} - \int_{\omega_0}^{\omega} B(\omega)d\omega \} - \int_{\omega_0}^{\omega} (L(\omega)d\omega)^{-1}$
\n $\omega \in [\omega_0, \infty)$ (28)
\nFrom (13),(16),(20),(24), we have
\n $u(\omega_0) = z_1(\omega_0) = z_2(\omega_0) = z_3(\omega_0) = z_4(\omega_0)$ (29)
\nTherefore
\n $z_4(\omega) \leq (exp\{ln((\omega_i)) + \int_{\omega_0}^{\omega} A(\omega)d\omega\} - \int_{\omega_0}^{\omega} B(\omega)d\omega\} - \int_{\omega_0}^{\omega} C(\omega)d\omega^4 = Z(\omega)$
\n $\omega \in [\omega_0, \infty)$ (30)
\nwhere, $Z(\omega)$ is defined by (8).
\nSubstituting (30) into (25), gives
\n $z'_3(\omega) \leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega)q(\omega) + c(\omega)q(\omega) + d(\omega) + d(\omega)q(\omega)]Z(\omega)$ (21)

$$
,\infty)
$$

),[⁰ (22))]()()(1)[()(³ *dcapz*

+
$$
[q(\omega)+a(\omega)+a(\omega)q(\omega)+c(\omega)+c(\omega)q(\omega)
$$

+ $d(\omega)+d(\omega)q(\omega)]Z(\omega)$

$$
\omega \in [\omega_0, \infty) \tag{31}
$$

Integrating both sides of (31) gives

$$
\rho + [f(\varphi)p(\varphi) + 2f(\varphi)p(\varphi)q(\varphi)]\epsilon_{3}(\varphi)
$$
\n
$$
\rho^{2}(\varphi)\epsilon_{3}^{2}(\varphi) + g(\varphi)q(\varphi)\epsilon_{4}(\varphi) + g(\varphi)q(\varphi)\epsilon_{5}(\varphi)
$$
\nTherefore\n
$$
\tau(\omega_{0}) + [q(\omega) + a(\omega) + a(\omega)q(\omega) + c(\omega)
$$
\n
$$
z_{4}(\omega) \leq \exp(\ln((\alpha)) + \frac{a}{2}(\omega)q(\omega) +
$$

have

$$
z_4(\omega) = z_3(\omega) + \int_{\omega_0} [J(\psi)p(\psi)]z_3(\varphi)
$$
\n
$$
+2f(\varphi)p(\varphi)q(\varphi)z_3(\varphi)
$$
\n
$$
+2f(\varphi)p(\varphi)q(\varphi)z_3(\varphi)
$$
\n
$$
+2f(\varphi)p(\varphi)q(\varphi)z_3(\varphi)
$$
\n
$$
= z_3(\omega_0) \cdot z_3(\omega) \leq z_4(\omega_0), \quad \omega \in [\omega_0, \infty)
$$
\n
$$
z_3(\omega) \leq z_3(\omega_0) + \int_{\omega_0}^{\omega_0} \{p(\psi)[1 + a(\psi) + c(\psi) + d(\psi)]
$$
\nThen $z_4(\omega_0) = z_3(\omega_0) \cdot z_3(\omega) \leq z_4(\omega_0), \quad \omega \in [\omega_0, \infty)$ \n
$$
z_3(\omega) \leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega)]
$$
\nFrom (22)-(24), we have\n
$$
z'_3(\omega) \leq p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)] + [q(\omega) + a(\omega) + a(\omega)q(\omega)]
$$
\n
$$
+c(\omega) + c(\omega)q(\omega) + d(\omega)q(\omega)z_3(\omega)
$$
\n
$$
+c(\omega) + c(\omega)q(\omega) + d(\omega)q(\omega)z_4(\omega)
$$
\n
$$
+c(\omega) + c(\omega)q(\omega) + d(\omega)q(\omega)z_4(\omega)
$$
\n
$$
+c(\omega) + c(\omega)q(\omega) + d(\omega)q(\omega)z_4(\omega)
$$
\n
$$
= c[\omega_0, \infty)
$$
\n
$$
z_3(\omega) \leq u(\omega_0) + \int_{\omega_0}^{\omega_0} \{p(\psi)[1 + a(\psi) + c(\psi) + d(\psi)]
$$
\n
$$
= u(\omega_0) + \int_{\omega_0}^{\omega_0} \{p(\psi)[1 + a(\psi) + c(\psi) + d(\psi)]
$$
\n
$$
+d(\psi) + d(\psi)q(\psi)z_4(\omega)
$$
\n $$

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Arcademic Education		International Co
\bullet Fublisbing House	and Mana	
$\omega \in [\omega_0, \infty)$	(33)	theorem 1, the module of equi
$\mu(\omega) \leq z_1(\omega) \leq z_2(\omega) \leq z_3(\omega) \leq z_4(\omega)$	(34)	using theorem 1
$\mu(\omega) \leq \mu(\omega_0) + \int_{\omega_0}^{\omega} p(\nu)[1 + a(\nu) + c(\nu) + d(\nu)]$	(34)	Using theorem 1

 $u(\omega) \le z_1(\omega) \le z_2(\omega) \le z_3(\omega) \le z_4(\omega)$ (34) using theorem 1.

Therefore,

 $u(\omega) \le u(\omega_0) + \int_{\omega_0}^{\omega} p(\omega)[1 + a(\omega) + c(\omega) + d(\omega)]$ In this res ω

 $+ [q(v)(1+a(v)+c(v)+d(v))+a(v)+c(v)+d(v)]Z(v)\}dv$ integra

2. Academic Education
 $\omega \in [\omega_0, \infty)$

From (13), (16), (20), (24), we have
 $u(\omega) \le z_1(\omega) \le z_2(\omega) \le z_3(\omega) \le z_4(\omega)$

Therefore,
 $u(\omega) \le u(\omega_0) + \int_{\omega_0}^{\omega} p(\omega)[1+a(\omega)+c(\omega)+d(\omega)]$
 $+[q(\omega)(1+a(\omega)+c(\omega)+d(\omega))+a(\omega)+c(\omega)+d(\omega)]$
 3. Appli From (13), (16), (20), (24), we have
 $u(\omega) \le z_1(\omega) \le z_2(\omega) \le z_3(\omega) \le z_4(\omega)$ (34)

Therefore,
 $u(\omega) \le u(\omega_0) + \int_{\omega_0}^{\omega} p(v)[1+a(v)+c(v)+d(v)]$
 $+[q(v)(1+a(v)+c(v)+d(v))+a(v)+c(v)+d(v)]Z(v)}dv$
 $\omega \in [\omega_0, \infty)$ (35)

3. Application

In this section

$$
x'(\alpha) = p(\alpha) + q(\alpha) \mathcal{A}(\alpha) + \int_{\alpha}^{\alpha} F(\xi, x(\xi), x'(\xi)) d\xi, \quad x(0) = c \quad (36)
$$

where, $\begin{vmatrix} i \\ k \end{vmatrix}$ is a normal number and $p(\omega), q(\omega)$

$x(a)=p(a)+q(a) * (a)+1$	$x(x)=f(a)+q(a) * (a)+1$	$x(x)=f(a)$	$x(0)=f(a)$	$x(x)=f(a)$																																																
--------------------------	--------------------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------

$$
|H(\omega, x_1, x_2)| \le d(\omega) \{|x_1| + |x_2| + \int_{\omega_0}^{\omega} |W(\omega, x_1, x_2)| d\omega\}
$$
 References
[1] Gronwall T H. Note on the

 $|W(\omega, x_1, x_2)| \le f(\omega)|x_2| [x_1| + |x_2| + g(\omega)]$ (37)

Suppose $c|_q, a(\omega), c(\omega), d(\omega), f(\omega), g(\omega)$ satisfies [2] Bellman R. The

$$
\exp(-\ln(|c| + \int_{\omega_0}^{\omega} A(\xi)d\xi) - \int_{\omega_0}^{\omega} B(\xi)d\xi) - \int_{\omega_0}^{\omega} C(\xi)d\xi > 0 \tag{31} \text{ Zheng B. (G/G)-expansion} \text{fractional partial solving} \text{fractional partial} \tag{38}
$$

$$
|H(\omega, x_1, x_2)| \leq d(\omega) \{|x_1| + |x_2| + \int_{\omega_0}^{\omega} |W(\omega, x_1, x_2)| d\omega\rangle
$$

\nwhere $a(\omega)$, $c(\omega)$, $d(\omega)$, $f(\omega)$, $g(\omega)$ is defined by
\n ω , $f(\omega) = \int_{\omega_0}^{\omega} B(\zeta) d\zeta$
\n ω (where $a(\omega)$, $c(\omega)$, $d(\omega)$, $f(\omega)$, $g(\omega)$ satisfies
\n ω (where $a(\omega)$, $c(\omega)$, $d(\omega)$, $f(\omega)$, $g(\omega)$ satisfies
\n ω (where ω (the following conditions)
\n ω (the equation (36), we can
\nestimate the magnitude of $x(\omega)$.
\n ω (28)
\n ω (38)
\n ω (39)
\n ω (1943:10, 643 pages, 1943.
\n ω

where

 $\widetilde{Z}(\omega) := (\exp(-\ln(|\mathbf{c}| + \int_{\omega_0}^{\omega} A(\xi) d\xi) - \int_{\omega_0}^{\omega} B(\xi) d\xi)^{-1}$ (b)
 vOIUCITA-PUUIIOIIIP-type HOIIIIIEC

}]]])]())()(()()([)())()()((([)())()()(([)())()()(([)(){()()(0 0 0 0 *ddddgxxxfd ssdcxxca xqpx xxa* Since equation (41) has the form of inequality (3) and satisfies the corresponding conditions in

$$
\in [\omega_{0},\infty)
$$

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theorem 1, the estimator (39) of the solution
module of equation (36) can be obtained by nternational Conference on Humanities, Social

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theorem 1, the estimator (39) of the solution

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theorem 1, the estimator (39) of the solution

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4. Conclusion

In this resear

 $\omega \in [\omega_0, \infty)$ (35) has been discussed. Using various inequality
analysis methods such as variable substitution, **IFFORM COLLUME COLLU EXECTE CONSTRANT AND SET ALL CONCED CONSTRANT AND SET ALL CONSTRANT AND THEORY (33)** theorem 1, the estimated $u(\omega) \leq z_1(\omega) \leq z_2(\omega) \leq z_3(\omega) \leq z_4(\omega)$
 $u(\omega) \leq u(\omega) \leq u(\omega) + \int_{-\infty}^{\infty} p(\nu)[1+a(\nu)+c(\nu)+d(\nu)]$ (34) using theo $\epsilon z_1(\omega) \le z_3(\omega) \le z_4(\omega)$
 $+\int_{\omega_0}^{\omega} p(\omega)[1+a(\omega)+d(\omega)+d(\omega)+d(\omega)]d(\omega)$

In this research, a class of four-fold nonline
 $\pi(\omega)(1+a(\omega)+d(\omega)+d(\omega)+d(\omega))d(\omega)$

(35) integral inequalities with unknown derivation
 $\omega \in [\omega_0, \infty)$ (35) a **4. Conclusion**
 $u(\omega) \le u(\alpha_0) + \int_{\alpha}^{\alpha} \chi(u)(1 + a(u) + c(u) + d(u)) + d(u) + c(u) + d(u))\chi(u)$ in this research, a class of four-fold
 $+ [q(u)(1 + a(u) + c(u) + d(u)) + c(u) + d(u))\chi(u)$
 $= [a_0, \infty)$
 3. Application

In this section, we apply Theorem 1 to **4. Conclusion**
 $u(\omega) \le u(\alpha_0) + \int_{\alpha_0}^{\alpha} p(x)[1+a(u)+c(u)+d(u)+d(u)+c(u)+d(u)]dx$ in this research, a class of f
 $+(q(u)(1+a(u)+c(u)+d(u)+c(u)+d(u)) + d(u))$
 $= (F(\alpha_0, x))$
 3. Application

In this section, we apply Theorem 1 to estimated inequalities **4. Conclusion Example 15**
 International Conference on Humanities, Social
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 Integration 11.
 4. Conclusion
 In this research, a class of four-fold nonlinear
 In this research, a class of four integral inequalities with unknown derivations **Example 12**
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theorem 1, the estimator (39) of the solution

module of equation (36) can be obtained by

using theorem 1.
 4. Conclu Example 12
 Analytical and Management Sciences (HSMS 2024)

theorem 1, the estimator (39) of the solution

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 4. Conclusion

In this research, a class of fou **Example 12**
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In this research, a class of four-fold nonlinear
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theorem 1, the estimator (39) of the solution
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In this research, a class of four-fold nonlinear
integral ine solutions. **4. Conclusion**
In this research, a class of four-fold nonlinear
integral inequalities with unknown derivations
has been discussed. Using various inequality
analysis methods such as variable substitution,
amplification, d **4. Conclusion**

In this research, a class of four-fold nonlinear

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analysis methods such as variable substitution,

amplificatio In this research, a class of four-fold nonlinear
integral inequalities with unknown derivations
has been discussed. Using various inequality
analysis methods such as variable substitution, the
amplification, differentiatio integral inequalities with unknown derivations
has been discussed. Using various inequality
analysis methods such as variable substitution,
amplification, differentiation and integration, the
unknown functions in four-fold

Acknowledgements

research Project has been discussed. Using various inequality
analysis methods such as variable substitution,
amplification, differentiation and integration, the
unknown functions in four-fold integral
inequalities were estimated. The obta analysis methods such as variable substitution,
amplification, differentiation and integration, the
unknown functions in four-fold integral
inequalities were estimated. The obtained results
can be applied to estimate diffe can be applied to estimate differential equation
solutions.
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 $|H(\omega, x_1, x_2)| \le d(\omega) \{|x_1| + |x_2| + \int_{\omega_0}^{\infty} |W(\upsilon, x_1, x_2)| d\upsilon\}$

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 $|W(\omega, x_1, x_2)| \le f(\omega) |x_1||x_1| + |x_2| + g(\omega)$

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