GENERIC NUMERICAL CHALLENGES *

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Background:

Generic Numerical Challenges is based on an idea originally conceived over a century ago by William Rouse Ball [1]. Martin Gardner popularized this by challenging his readers to solve a set of problems in "The Numerology of Dr. Matrix" [2]. In 2008, the author introduced this concept as Digital Challenges and later in 2010 as Numerical Challenges to the Gardner Gathering audience [3], [4]. In 2012, a more recent reference to this idea appeared [5].

The general objective of these challenges is to develop mathematical expressions which equal a given **target number** using a given set of **base digits** selected from the ten integers (0 though 9). Allowed mathematical **operations** may be either ***elementary***, which include addition [+], subtraction [-], multiplication [x], and division [/]; ***intermediate***, which also allows decimals [.]; or ***advanced***, which allows other variations such as exponents [^], roots [√], factorials [!], repeating digits [.nr] or concatenation [nn].

Some examples of these for a target of *ten* using the base digit set of *one, two, three, and four* are shown here:

Elementary Operations:	$10 = 1 + 2 + 3 + 4$	$10 = (1)(3)(4) - 2$
Intermediate Operations:	$10 = (2 + 3 - 4) / .1$	$10 = (2 / .4)(3 - 1)$
Advanced Operations:	$10 = 3^{\sqrt{4}} + 1^2$	$10 = 3!! / ((1 + 2)(4!))$

Concept of Generic Digits:

It is interesting to note that some of the base digits need not be exactly specified, that is, they may be unknown in value. We will call these ***generic digits*** designated by the letter *g*. Interestingly, if we have a *pair* of unknown but equal generic digits, many precise values may be determined.

For example: $g - g = 0$ and $g / g = 1$

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By allowing *decimals*: .g / g = 1/10 or .1 and g / .g = 10

By allowing *repeating decimals*: .gr / g = 1/9 or .111... (i.e. .1r) and g / .gr = 9

.g / .gr = 9/10 and .gr / .g = 10/9 or 1.111... (i.e. 1.1r)

If *roots* are allowed: $\sqrt{.gr/g} = 1/3$ or .333... (i.e. .3r) and $\sqrt{g/.gr} = 3$

Also, using *factorials*: $(g - g)! = 1$ and $\sqrt{g/.gr}! = 6$ and $\sqrt{g/.gr}!! = 720$ and so forth.

This generic concept forms the basis for several challenges by using letters and numbers in the Gardner Gathering logo(s), G4G10 and G4GX.

Specific Challenges:

Listed below are several challenges all requiring a set of base digits taken from the symbols found in the Gardner Gathering logo. All except the last of these asks for solutions to produce a particular target number. In every case, use of advanced operations is allowed.

* Target = 5 using base set = 4, 10, g, g (seven different solutions known).
* Target = 7 " " " = 0, 1, 4, g, g (sixteen " " ").
* Target = 10 " " " = 0, 1, 4, g, g (thirteen " " ").
* Target = 47 " " " = 0, 1, 4, g, g (seven " " ").
* Target (X = 0 ... 15) using base set = 4, g, g forms the basis for exchange "Logo Puzzle".

Related Follow up:

Math Dice™, invented by Sam Ritchie and produced by Thinkfun ©, consists of problems using ordinary dice which are thrown to produce both a target number and also a "scoring number" (base set of numerical digits). In this game the player is asked to use math skills to come closest to the given target number.

Finally, more than two of the base digits could be generic. It is interesting to note that with *three* generic digits (g, g, and g), forty other values including 2, 5, 8, and 11 are possible.

References

[1] W. W. Rouse Ball, *Mathematical Recreations and Essays*, Macmillan and Co., NY, 1892.

[2] Martin Gardner, *The Numerology of Dr. Matrix*, Simon and Schuster, New York , 1967.

[3] R. Wainwright, *Eighth Gathering for Gardner*, Atlanta, 2008.

[4] R. Wainwright, *Ninth Gathering for Gardner,* Atlanta, 2010.

[5] R. Wainwright, A Numerical Challenge, *College Math J.*, **43**, 1; (2012) 19.

For further information including solutions to the *Challenges* presented, please contact:

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