How to use the back calculator program “denomfind” for approximated proportions

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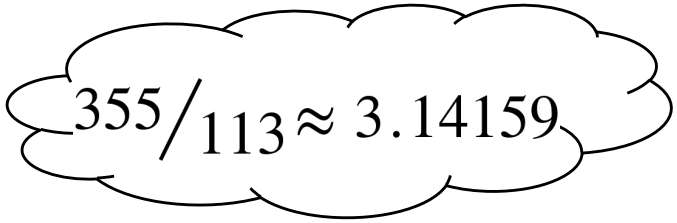
Terminology (1/2)



- A **fraction** is specified in the form of **numerator** / **denominator** .
- A **proportion** is the decimal value of a fraction. Its approximation is an **approximated proportion**, which would be simply called a proportion herein.

- $\mathbb{N} = \{1,2,3,\ldots\}$: The set of all natural numbers.
- $\mathbb{Z} = \{0 , \pm 1 , \pm 2 , \pm 3 , ..\}$: consists of integers.
- $\mathbb{R} = \{ x \mid -\infty < x < +\infty \}$: all the real numbers.

Terminology (2/2)

- There are many ways to **round** a number :
  - Round half up (most commonly used!)
  - Round up / Round down
  - Round half to even (ISO 31-0 , JIS Z 8401, IEEE 754)
  - Round half to odd
- **TSV** is Tab-Separeted Values (cf. CSV with comma).

Regarding this document :

- Explains
  - how to use the command **denomfind**.
- Not explains
  - the internal design in detail.

“denomfind” is a CLI program.

- CLI = Command Line Interface. Not a GUI.
- “denomfind” is a program of a Perl script.
- You can install :
  - By “cpan” or “cpanm” command.
    - cpanm is recommendable considering the un-installment.
    - **cpanm App::denomfind**
    - **cpanm –U App::denomfind # uninstall**
  - Not only from **metacpan.org** but also from **GitHub**.

Examples 1 — 0.3, 0.33, and 33.3%

```
> denomfind 0.3
denom    fit      0.3
3        1        1/3
4        1        1/4
6.       1        2/6
7        1        2/7
8.       1        2/8
9.       1        3/9
10       1        3/10
11       1        3/11
12       1        3/12~4/12
13       1        4/13
14.      1        4/14
15       1        4/15~5/15
```

```
> denomfind -M0 0.33
denom    fit      0.33
3        1        1/3
40       1        13/40
43       1        14/43
46       1        15/46
49       1        16/49
52       1        17/52
55       1        18/55
58       1        19/58
61       1        20/61
64       1        21/64
67       1        22/67
70       1        23/70
```

```
> denomfind -M0 -D-3% 33.3%
denom    fit      0.333
3        1        1/3-.033%
400      1        133/400+.050%
403      1        134/403+.049%
406      1        135/406+.049%
409      1        136/409+.048%
412      1        137/412+.048%
415      1        138/415+.047%
418      1        139/418+.046%
421      1        140/421+.046%
424      1        141/424+.045%
427      1        142/427+.045%
430      1        143/430+.044%
```

Each fraction is shown on each line.

- "***denom***" means **denominator**.
- 12 ***denoms*** $\in \mathbb{N}$ are **back calculated**
  with **a feasible numerator** $\in \mathbb{Z}$
  regarding the given proportion is **rounded**.
- Each of ***fraction form*** is shown in cyan color.
- -D-3% on the most right image specifies to show the **gap** to the proportion.
- "***fit***" (red) will be explained in next page.

Regarding the reducible fractions :

- A *denom* with period (.) :
  roughly means the fraction is **reducible**.
- To be more exactly (explained later) :
  the numerators and its corresp. denominators all combined are divisible by their GCD > 1.
- "**-M0**" specifies :
  not to show the the "reducible" fraction
  i.e. 2/6 = 3/9 = 4/12 = .. are hidden.

Example 2:
proportions with **a common denominator**

```
> tabs -4
> denomfind -y3..4 -D5% 63.3% 54.6% 13.3% 10.3%
denom   fit 0.633   0.546   0.133   0.103
196 3   124/196=63.26531%   107/196=54.59184%   26/196=13.26531%    [20.09 20.286)
218 3   138/218=63.30275%   119/218=54.58716%   29/218=13.30275%    [22.345 22.563)
240 3   152/240=63.33333%   131/240=54.58333%   32/240=13.33333%    [24.6 24.84)
271 3   [171.4075 171.6785) 148/271=54.61255%   36/271=13.28413%    28/271=10.33210%
300 3   190/300=63.33333%   [163.65 163.95) 40/300=13.33333%    31/300=10.33333%
324 3   205/324=63.27160%   177/324=54.62963%   43/324=13.27160%    [33.21 33.534)
330 3   209/330=63.33333%   [180.015 180.345)   44/330=13.33333%    34/330=10.30303%
339 3   [214.4175 214.7565) 185/339=54.57227%   45/339=13.27434%    35/339=10.32448%
346 3   219/346=63.29480%   189/346=54.62428%   46/346=13.29480%    [35.465 35.811)
360 3   228/360=63.33333%   [196.38 196.74) 48/360=13.33333%    37/360=10.27778%
368 4   233/368=63.31522%   201/368=54.61957%   49/368=13.31522%    38/368=10.32609%
377 3   [238.4525 238.8295) 206/377=54.64191%   50/377=13.26260%    39/377=10.34483%
4 ratios are given. 12 denominators have found up to 377. (denomfind)
```

- The output forms **a TSV table**.
- The **right 4 columns** here corresponds with proportions 63.3%, 54.6%, 13.3%, 10.3%.
- The 2nd column ***fit*** means how many among the (4) proportions can get at least a numerator $\in \mathbb{Z}$ with each ***denom*** value.
- **-y3..4** specifies filtering on ***fit***. i.e. ***fit*** with the value 0,1,2 are omitted.
- **-D5%** specifies to show the retrieved fraction value with 5 decimal places in %.
- The intervals in faint color indicate the set of the possible numerator on $\mathbb{R}$, which does not contain any integer $\mathbb{Z}$.
- The command **tabs -4** adjusts the screen setting of tab intervals.
- The smallest possible denominator $\in \mathbb{N}$ to yield the 4 rounded proportions is **368**.

Usage of denomfind

1. To **find** the possible denominator
   with given multiple rounded proportions.
   - One can check whether the sample size is large enough.
2. To **check** and to **correct** the numbers
   such as denominator and rounded proportions.
   - Quite often, numbers appearing on reports contain a small number of mistakes.
3. To know how the proportions are rounded.
   - If the rounding half up is performed on a number twice in a specific way, 3.45% can turn to be 4% via 3.5%.
   - Deciphering how the numbers are rounded may conclude **how carefully the document is yielded**.

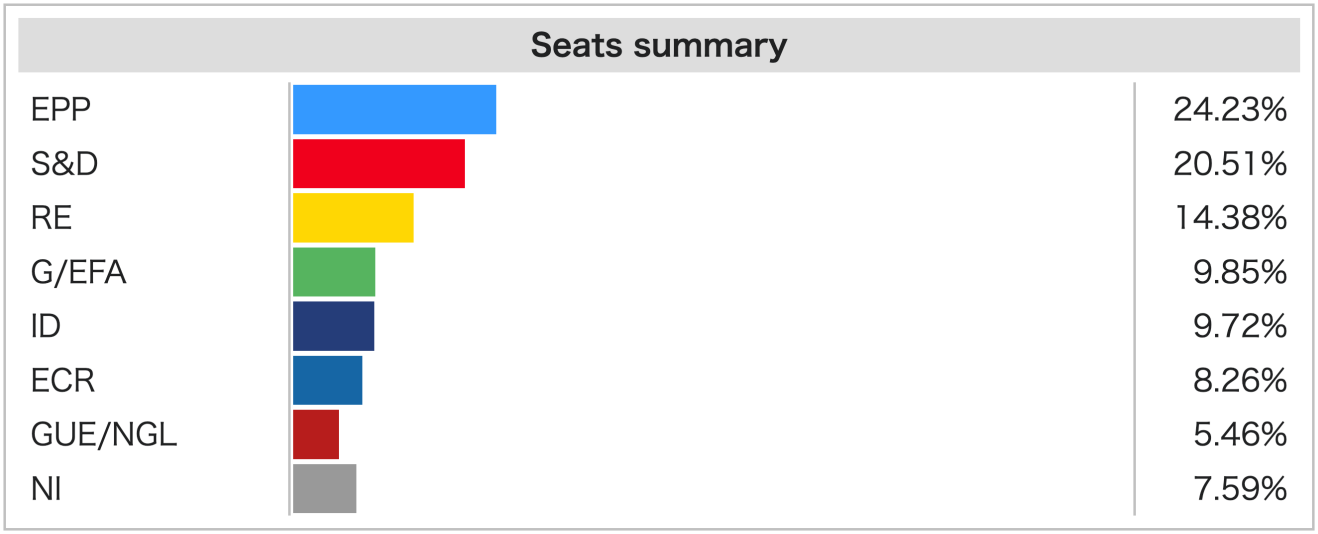
Feature of denomfind

Simple interface despite the various options.

— How to interact with the program is intentionally designed.

1. Run such as **denomfind 0.167 0.714** firstly.
2. The output is easily understandable.
3. You gradually increase functions to use such as options and other commands.
4. The necessary functions are abundantly provided.
5. Online manual is provided : **denomfind --help**
6. Demo is also provided.
   You can try **denomfind –T1** (1 is changeable.)

Example 3. Seats summary of 2019 European Parliament Election



https://en.wikipedia.org/wiki/2019_European_Parliament_election

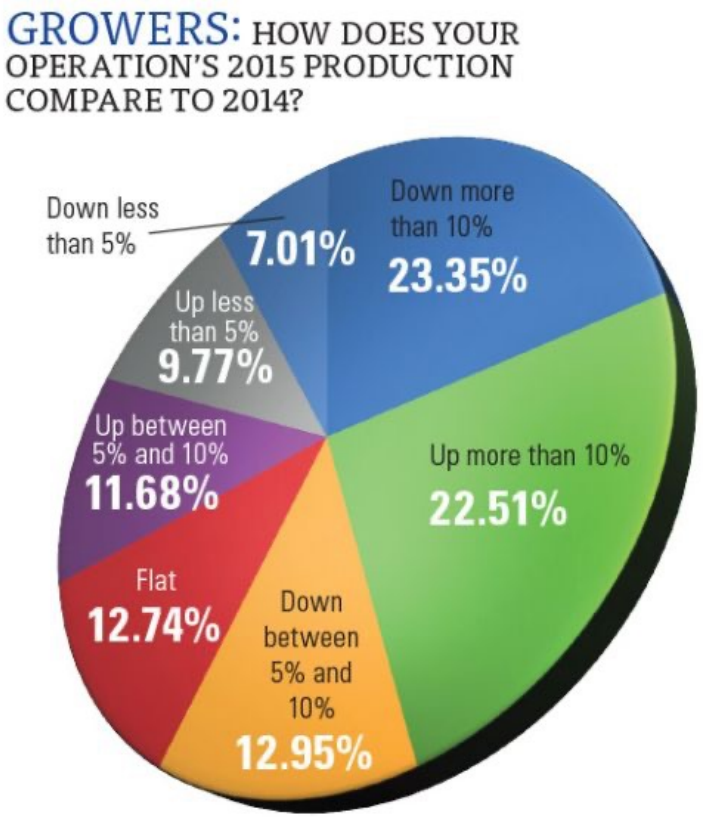
```
> tabs -6
> denomfind -y, -g7 -% 24.23 20.51 14.38 9.85 9.72 8.26 5.46 7.59
denom fit   0.2423      0.2051      0.1438      0.0985      0.0972      0.0826      0.0546      0.0759
751   8     182/751     154/751     108/751     74/751      73/751      62/751      41/751      57/751
1502. 8     364/1502    308/1502    216/1502    148/1502    146/1502    124/1502    82/1502     114/1502
2253. 8     546/2253    462/2253    324/2253    222/2253    219/2253    186/2253    123/2253    171/2253
3004. 8     728/3004    616/3004    432/3004    296/3004    292/3004    248/3004    164/3004    228/3004
3755. 8     910/3755    770/3755    540/3755    370/3755    365/3755    310/3755    205/3755    285/3755
3900  8     945/3900    800/3900    561/3900    384/3900    379/3900    322/3900    213/3900    296/3900
4032  8     977/4032    827/4032    580/4032    397/4032    392/4032    333/4032    220/4032    306/4032
8 ratios are given. 7 denominators have found up to 4032. (denomfind)
>
```

The total seat number seems **751** (if < 1000)
from the 8 proportion percentages.

–y, filters the *fit* number being the largest (8; the number of proportions).

–g7 specifies to get 7 candidates. **–%** specifies percentages are given.

Example4. A pie chart (7 divisions)




```
> denomfind  -M0 -a0.01%  -y, -% 23.35 22.51 12.95 12.74 11.68 9.77 7.01
denom    fit      0.2335   0.2251   0.1295   0.1274   0.1168   0.0977   0.0701
471      7        110/471  106/471  61/471   60/471   55/471   46/471   33/471
2270     7        530/2270 511/2270 294/2270 289/2270 265/2270 222/2270 159/2270
2425     7        566/2425 546/2425 314/2425 309/2425 283/2425 237/2425 170/2425
2510     7        586/2510 565/2510 325/2510 320/2510 293/2510 245/2510 176/2510
2527     7        590/2527 569/2527 327/2527 322/2527 295/2527 247/2527 177/2527
2612     7        610/2612 588/2612 338/2612 333/2612 305/2612 255/2612 183/2612
2639     7        616/2639 594/2639 342/2639 336/2639 308/2639 258/2639 185/2639
2724     7        636/2724 613/2724 353/2724 347/2724 318/2724 266/2724 191/2724
2741     7        640/2741 617/2741 355/2741 349/2741 320/2741 268/2741 192/2741
2835     7        662/2835 638/2835 367/2835 361/2835 331/2835 277/2835 199/2835
2866     7        669/2866 645/2866 371/2866 365/2866 335/2866 280/2866 201/2866
2879     7        672/2879 648/2879 373/2879 367/2879 336/2879 281/2879 202/2879
7 ratios are given. 12 denominators have found up to 2879. (denomfind)
>
```

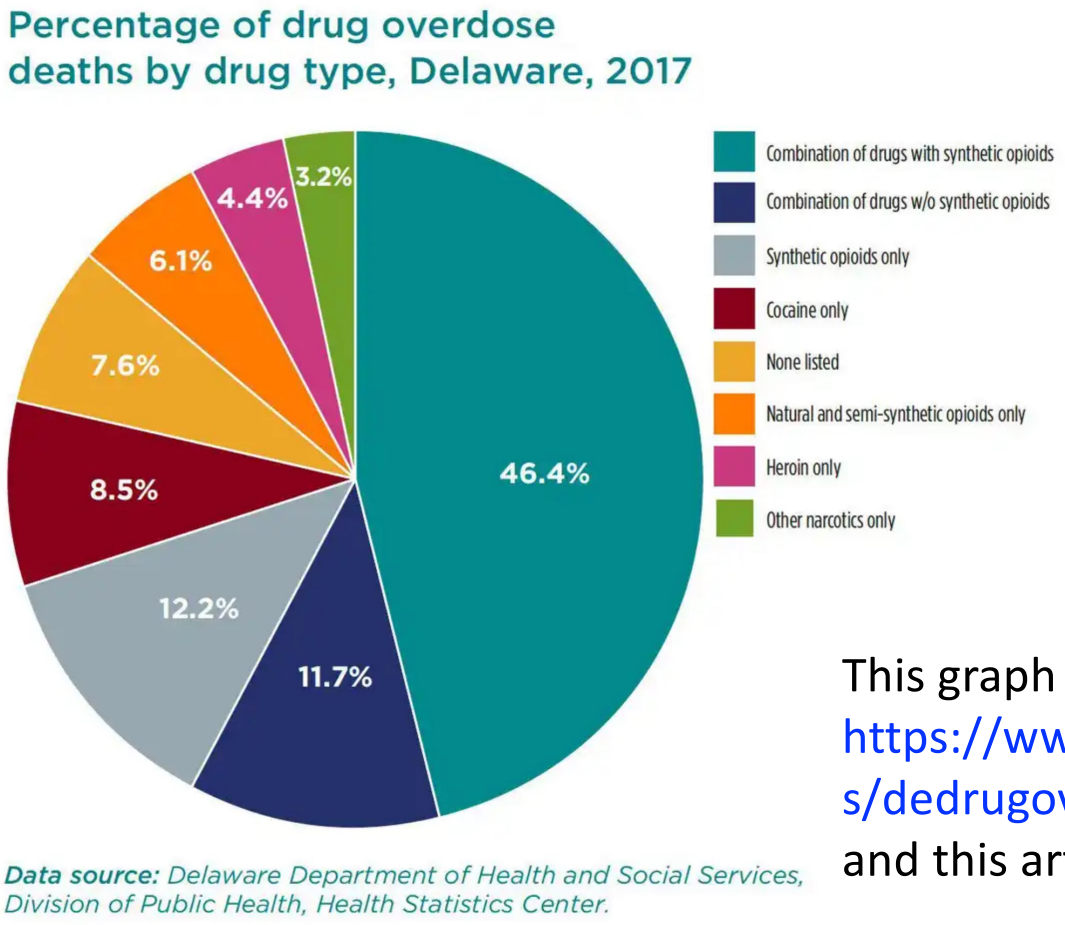
The total number of answerer seems to be **471**.

”The response was overwhelming, as **750** of you weighed in — including **545** growers — providing valuable insight in an online survey. ”

https://www.growingproduce.com/fruits/fruit-growers-expect-sweet-16/

Example 5. A pie chart (8 divisions)

https://www.helpisherede.com/health-care-providers



From the 8 numbers, 46.4% 11.7% 12.2% 8.5% 7.6% 6.1% 4.4% 3.2%, also with the assumption that the rounding was done by **rounding half up**, the possible denominator value is either of
343, 590, 591, 657, 658, 683, 686, 720, 727, 752, 754, 772, and more in the ascending order.

This graph is cited from :
https://www.dhss.delaware.gov/dhss/dph/files/dedrugoverdosemortsurvrpt2017.pdf
and this article says the original number is **343**.

A byproduct question : when the candidates of possible integer denominators are calculated, the minimum value among them is quite often the true value. Why?

Various options in rounding

Assuming the rounding

- "round down" (floor ; e.g. 0.345 → 0.34) : **–f**
- "round up" (ceil ; e.g. 0.345 → 0.35) : **–c**
- "round half up" is done twice (*e.g.* 0.345→0.35→0.4) : **-5 2**
- "round half to even" (e.g. 0.335 and 0.345 → 0.34) : **-5 e**
- "round half to odd" (e.g. 0.345 and 0.355 → 0.35) : **-5 o**

- Allowing the error within $\pm$ *1%* : **-a 0.01** or **-a 1%**

Options in the denominator filtering

- -g 100 : getting 100 candidates in denominators from the smallest (1).
- -g 123,100 : getting 100 candidates in denominators from the 123.
- -g 123,-10 : getting 10 candidates from the 123 in descending order.

- -y .. : showing **every denominator** as long as specified by **–g** option.
- -y , : only showing the denominators when **every given proportion** has at least one corresponding integer numerator.
- -y 1.. : showing the denominators when at least one of given proportion has the corresponding integer numerator. (**Default**)
- -y -2.. : showing the denominators when every given proportion has the corresponding integer numerator allowing the **exceptions** within 2 of the proportions.

N..M means the numerical range. N.. means n to the maximum. ..M means zero to M. When N or M is negative, it means (the maximum)-abs(N or M). Those types of range or a single number can be combined by comma(,).

Options in output

- -D0 : showing the fraction form such as **10/33**. (**Default** ※)
- -D3 : showing also with 3 decimal places such as **10/33=.303**
- -D4% : in 4 decimal places in percentage such as **10/33=30.3030%**
- -D-5 : showing the difference to realize the given proportion with 5 decimal places **10/33-.00003** for a given proportion 0.303
- -D-6% : showing the difference to realize the given proportion with 6 decimal places such as **10/33-. 00303%** for a proportion 0.303

- **-I** : showing the interval of possible numerators on $\mathbb{R}$, not only $\mathbb{Z}$.
  If the interval contains any integer it is shown in green color.
- **-Q** : showing the numerators in a simplest way.
  Extra1. When only one proportion is given,
  the denominator is shown with its prime factorization as well.
  Extra2. To see all the numerators are odd (2q+1) or even (2q),
  if they have a common reminder R against a devisor D,
  they are shown with a form "(Dq+R)" as well.

※ If **–D** , **–I** and **–Q** are not given, **-D0** is regarded to be specified internally.