

# Moo in practice - App::Math::Tutor

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## Part I

### Introduction

- 1 Introduction
  - Motivation
  - Audience

# Motivation

## Moo and App::Math::Tutor

- real world examples over far-fetched conceptuels
- MooX::Cmd, MooX::Options and MooX::ConfigFromFile provide way more features and flexibility than either
  - ▶ App::Cmd with Getopt::Long::Descriptive
  - ▶ MooseX::App::Cmd along with corresponding MooseX wrappers around related stuff
- 2<sup>nd</sup> generation of modern OO in Perl5

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- Add support for exercise types as children require
- provide extensible design to allow easy augment of exercise

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## App::Math::Tutor

- Allow parents help their children improving their mathematical skills
- Add support for exercise types as children require
- provide extensible design to allow easy augment of exercise
- **Goal:** Improve to Web-Service, eg. by mapping MooX::Cmd to URI path and MooX::Options to GET parameters

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## Prerequisites of the Audience

Following knowledge is expected:

- General knowledge about object oriented programming or concepts like
  - ▶ classes
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  - ▶ methods, class functions
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  - ▶ attributes, properties
- slightly above basic Perl experience
- ever heard of Smalltalk and its OO-concept is a strong bonus



## Part II

### Moo basics

- 2 Modules
  - Classes and Roles
- 3 Attributes
  - Attributes in Moo
  - Attribute Options
- 4 Methods
  - Method Examples
  - Method Modifiers

## Classes in Moo

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```
{
  package Natural;

  use Moo;

  sub _stringify { ... };
}
{
  package Roman;

  use Moo;
  extends "Natural";

  sub _stringify { ... };
}
my $natnum = Natural->new( value => 42 ); say $natnum->_stringify(); # 42
my $romnum = Roman->new( value => 42 ); say $romnum->_stringify(); # XLII
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```
{ package Printable;

  use Moo::Role; # now it's a role - no 'is a' relationship anymore

  sub print { my $self = shift; say $self->_stringify }
}

{ package Natural;

  use Moo; # class
  with "Printable"; # consumes a role

  sub _stringify { ... };
}

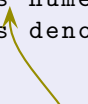
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## Attributes in Moo

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package VulFrac;  
  
use Moo;  
  
has numerator => ( is => "ro", required => 1 );  
has denominator => ( is => "ro", required => 1 );  
  
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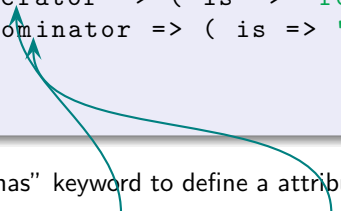
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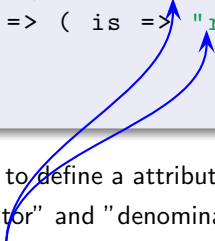


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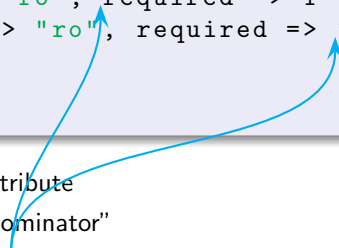
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- attributes are immutable and required

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**handles** defines a **role** or methods to dispatch to the attribute

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**predicate** takes a method name (string) which will return true if an attribute has a value (supports *attribute shortcut*)

## Methods in Moo I

```
package VulFrac;

use Moo;
use overload '""'    => "_stringify",
             '0+'    => "_numify",
             'bool'  => sub { 1 },
             '<=>'   => "_num_compare";

has numerator => ( is => "ro", required => 1 );
has denominator => ( is => "ro", required => 1,
                    isa => sub { $_[0] != 0 or die "Not != 0" } );

sub _stringify { my $self = shift;
                 return sprintf("\\frac{%s}{%s}",
                                $self->numerator, $self->denominator); }

sub _numify { $_[0]->numerator / $_[0]->denominator; }
...

```

## Methods in Moo II

```
package Rationale;

use Moo;

extends "VulFrac";

has digits => ( is => "ro", required => 1 );

sub _stringify {
    my $digits = $_[0]->digits;
    sprintf("%.${digits}g", $_[0]->_numify); }

```

## Methods in Moo II

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- nothing like MooseX::Declare - pure Perl5 keywords are enough for plain methods

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- No support for `super`, `override`, `inner` or `augment`

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- also possible from within roles and not restricted to inheritance
- ensures that inherited methods invocation happens right (mostly - remember around)



## Methods Modifiers - around avoid calling \$orig

```
package App::Math::Tutor::Role::Roman;

use Moo::Role;

with "App::Math::Tutor::Role::Natural";

{ package RomanNum;
  use Moo;
  extends "NatNum"; # derives overloading!
  sub _stringify { ... } }

around "_guess_natural_number" => sub {
  my $orig = shift;
  my $max_val = $_[0]->format;
  my $value = int( rand( $max_val - 1 ) ) + 1;
  return RomanNum->new( value => $value );
};
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- receives responsibility
- runtime of modified method completely eliminated

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- leaves most responsibility in modified method
- runtime of modified method added to this method's runtime

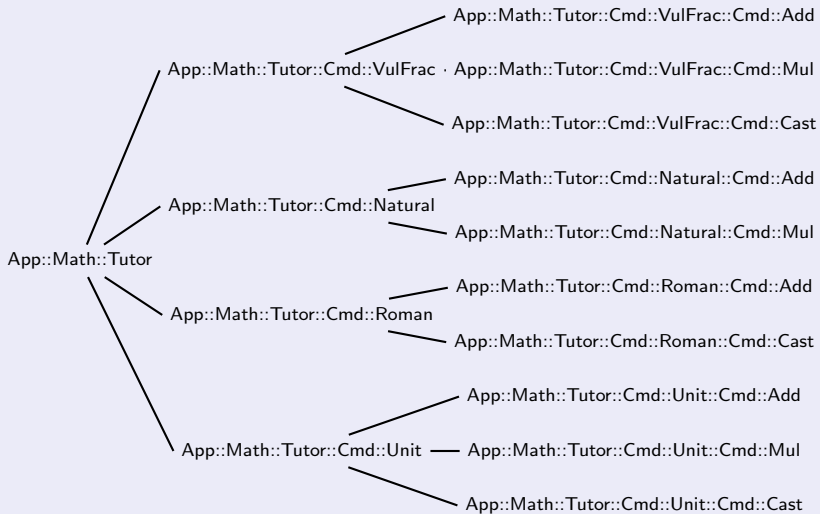


## Part III

### Math Tutor

- 5 Structure
  - Frontend
  - CLI Concept
- 6 Design
  - Simple Exercise
  - Derived Exercise
- 7 Improvements
  - Design

## Frontend (dictated by MooX::Cmd)



## Exercise Groups

`App::Math::Tutor::Cmd::VulFrac` Exercises in vulgar fraction calculation

`App::Math::Tutor::Cmd::Natural` Exercises in calculations using natural numbers

`App::Math::Tutor::Cmd::Roman` Exercises in calculations using natural numbers, but show them using roman number encoding (exercises and solutions)

`App::Math::Tutor::Cmd::Unit` Exercises in calculations using units (times, currency, ...)

`App::Math::Tutor::Cmd::Power` Exercises in calculations of power mathematics

`App::Math::Tutor::Cmd::Polynom` Exercises for polynomial mathematics (Zero of a function, Vertex, ...)

## Typical Exercise design

```
App::Math::Tutor::Cmd::VulFrac::Cmd::Add
```

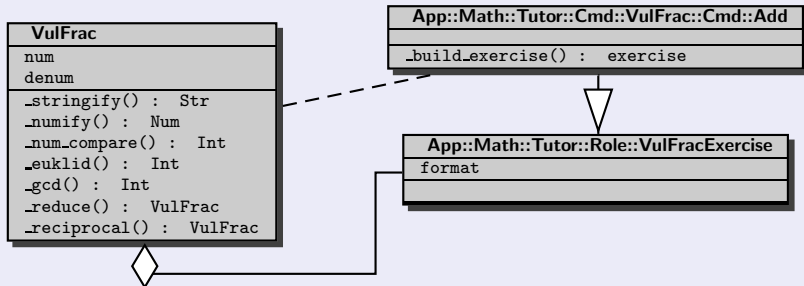
```
_build_exercise() : exercise
```

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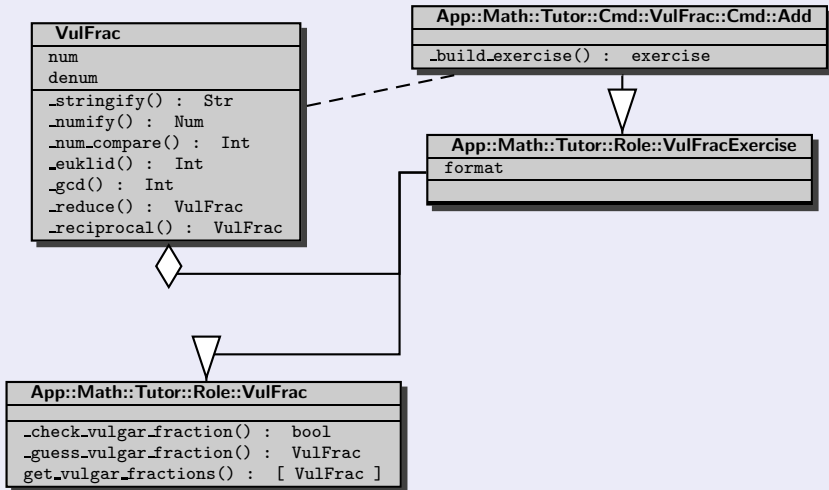
<b>VulFrac</b>
num
denum
<code>_stringify() : Str</code>
<code>_numify() : Num</code>
<code>_num_compare() : Int</code>
<code>_euklid() : Int</code>
<code>_gcd() : Int</code>
<code>_reduce() : VulFrac</code>
<code>_reciprocal() : VulFrac</code>

<b>App::Math::Tutor::Cmd::VulFrac::Cmd::Add</b>
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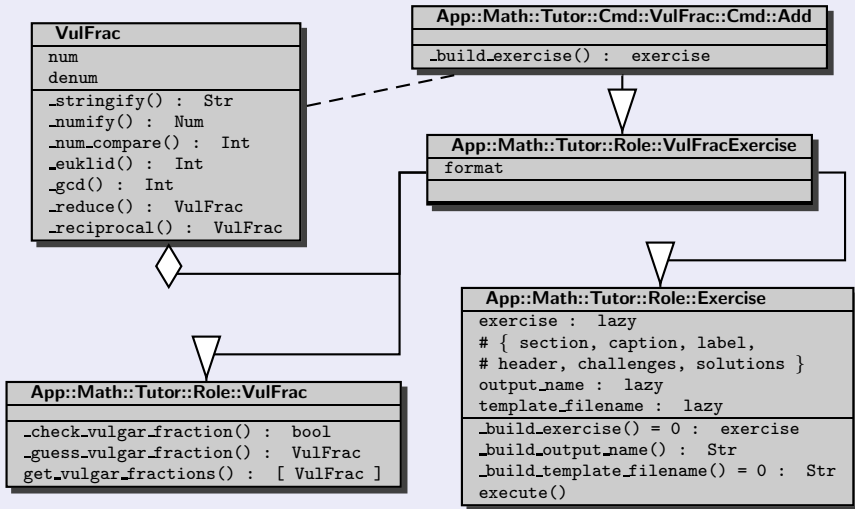
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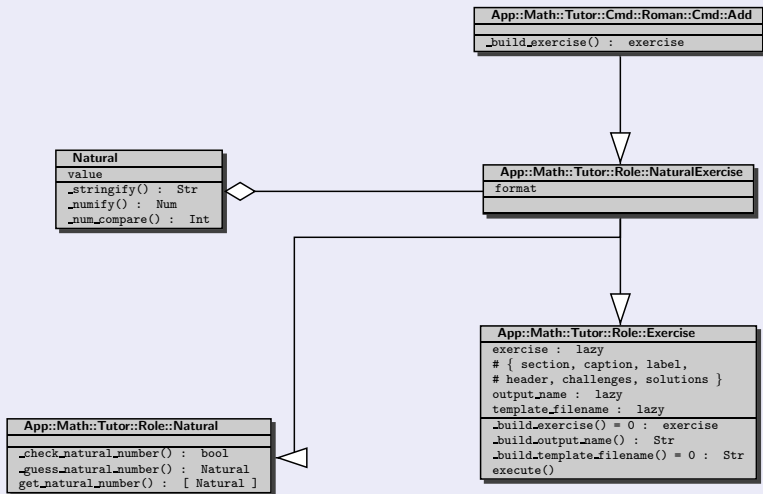


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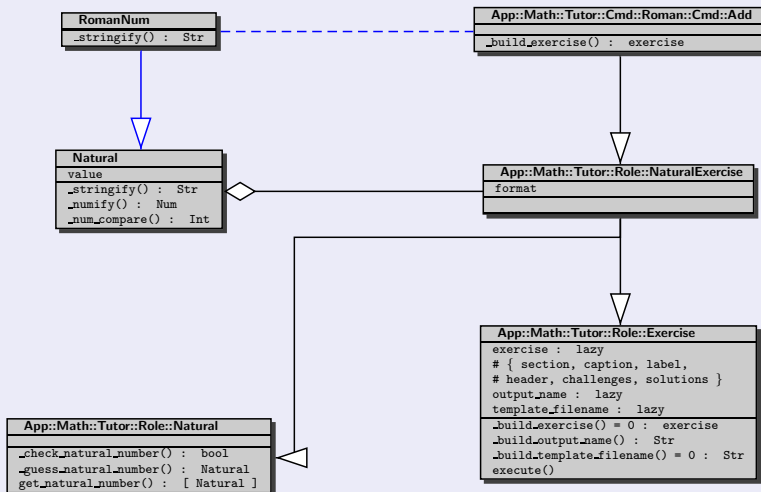




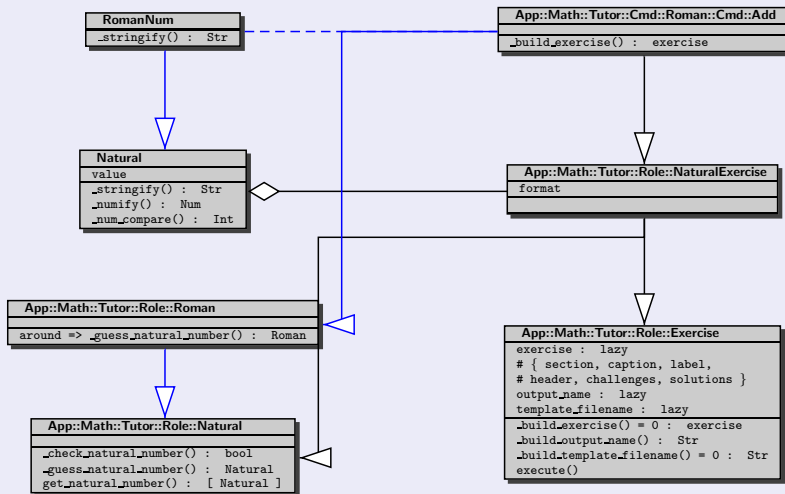
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## Improving design

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## Design future

- Modern Perl-OO allows easy refactoring to apply above improvements

## Part IV

### Moo eXtensions

- 8 MooX
  - General purpose eXtensions
  - CLI related eXtensions

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Some Moo extensions for getting a picture - the list is neither complete nor is it intended to be

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**MooX::Singleton** turn your Moo class into singleton

**MooX::Aliases** easy aliasing of methods and attributes in Moo

# MooX Distributions for CLI

## MooX::Cmd

- giving an easy Moo style way to make command organized CLI apps
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## MooX::ConfigFromFile

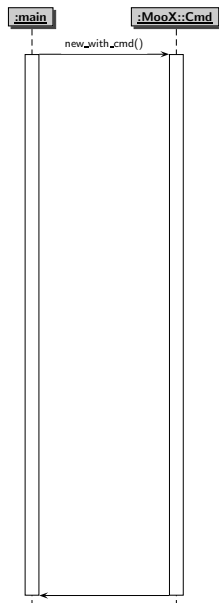
- Moo eXtension for initializing objects from config file
- RC files with structures (JSON, INI, YAML, XML, ...)

# General CLI Construction Flow

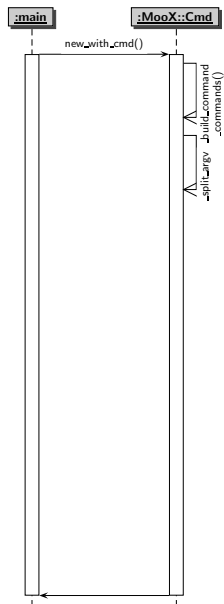
.main

The diagram consists of a small rectangular box at the top containing the text `.main`. A vertical line extends downwards from the bottom center of this box. The line is solid at the top and bottom, with a dashed section in the middle. At the very bottom of the line, there is a small vertical tick mark.

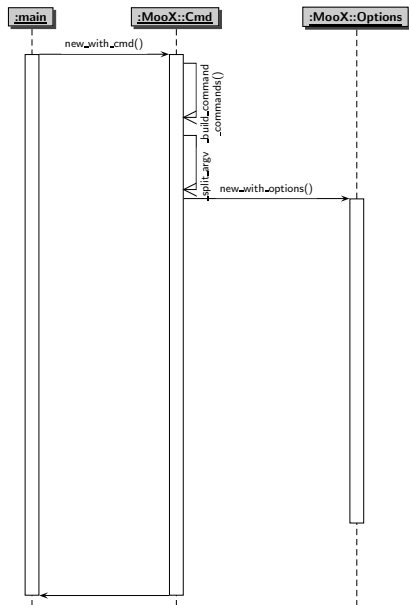
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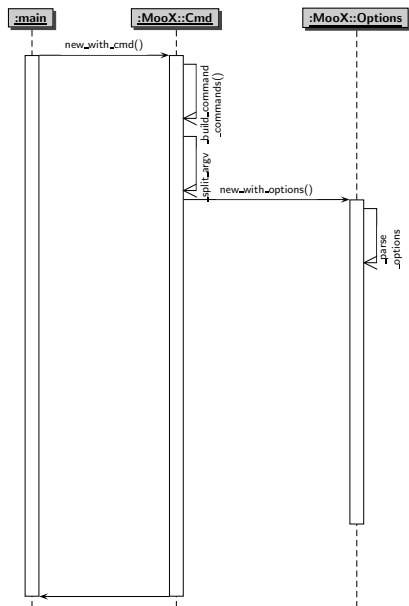
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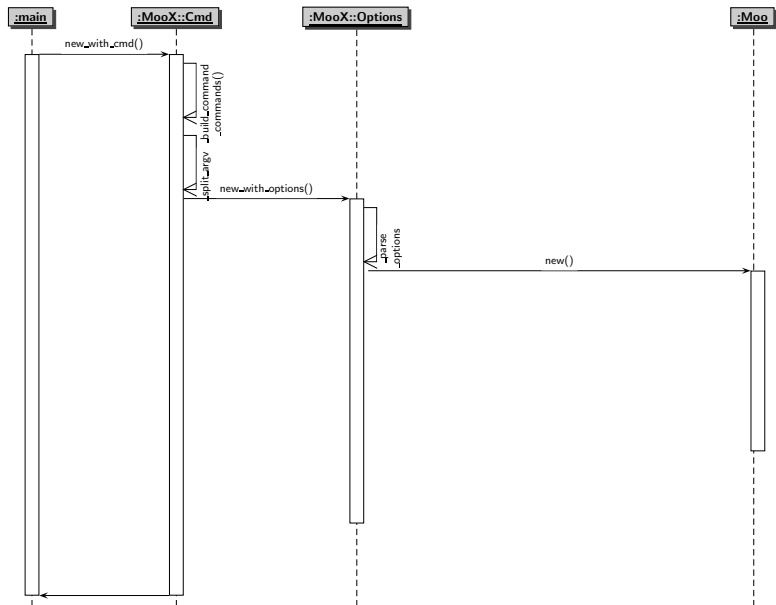
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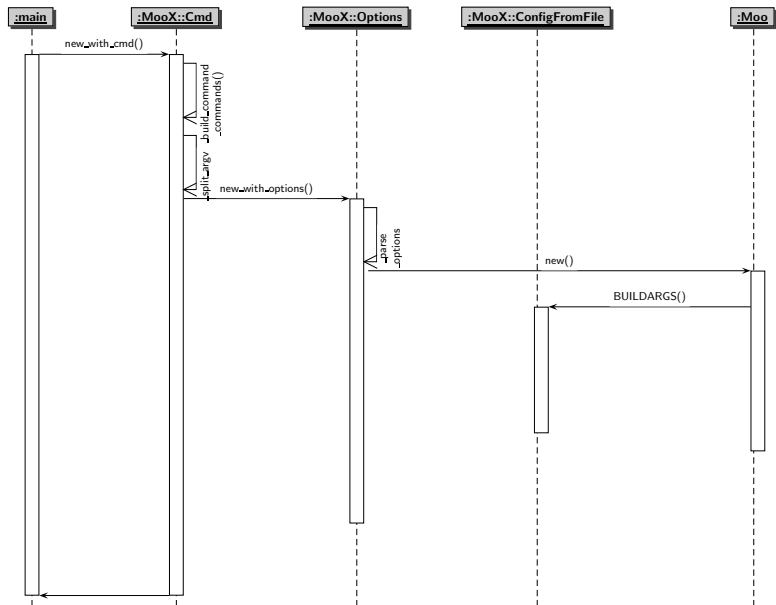
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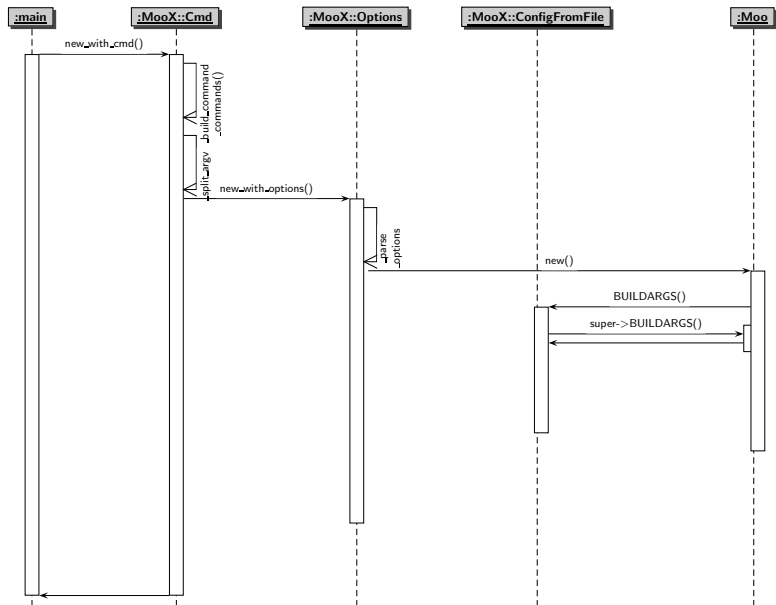


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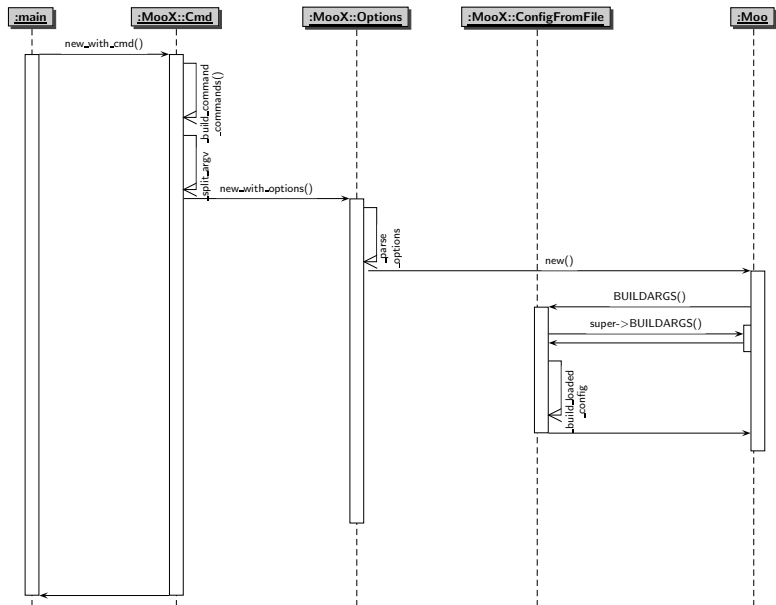




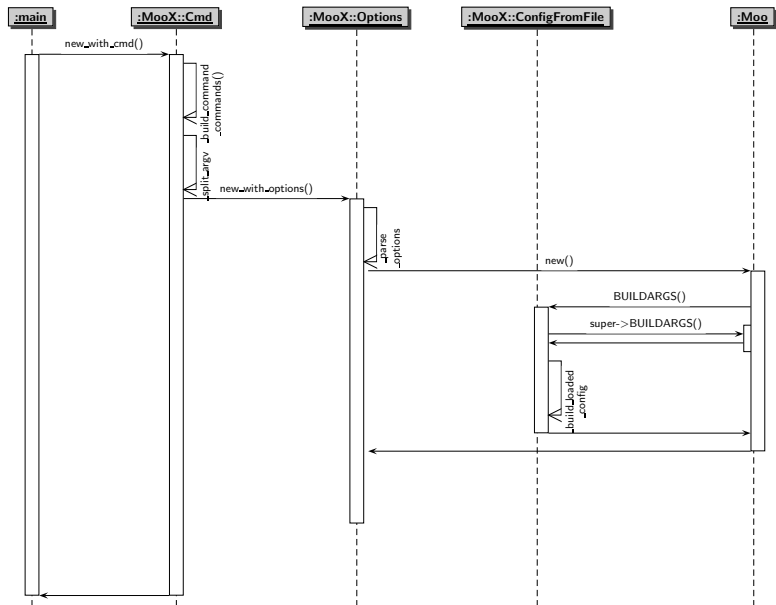
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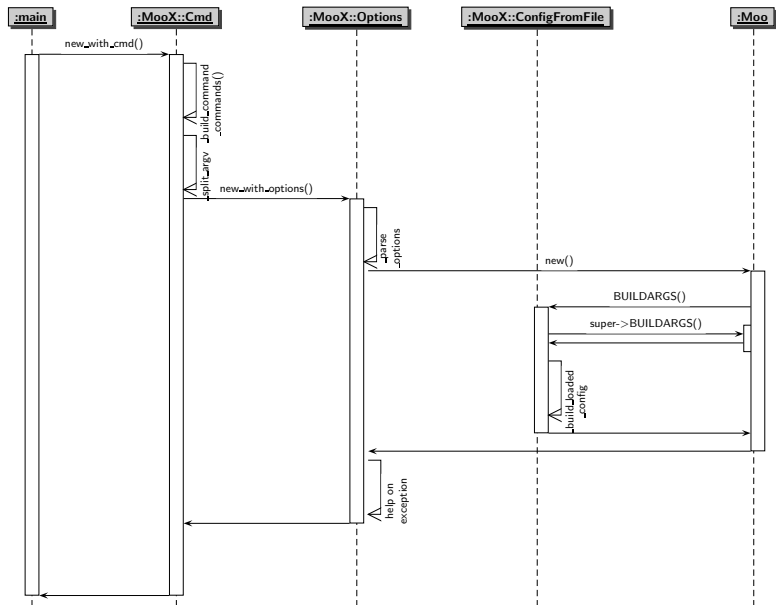
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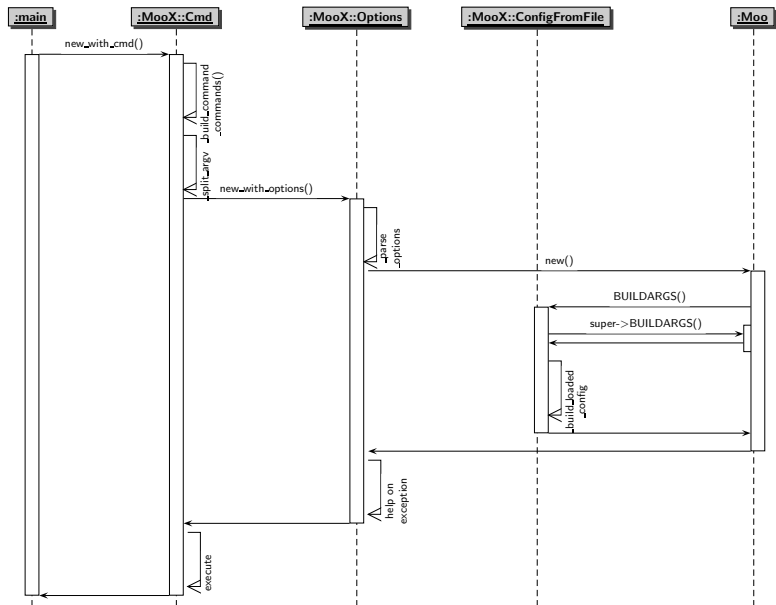
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## Part V

### Current Practice

- 9 Provided Framework
  - Exercise Role
  - Vulgar Fraction Exercise Role
- 10 Create Exercise
  - Preamble
  - Create Exercise Numbers
  - Format Challenge / Solution
  - Format Solutions
- 11 Created Exercise Output
  - Challenges
  - Solutions

```
package App::Math::Tutor::Role::Exercise;

use strictures; # instead of strict + warnings
use Moo::Role; use MooX::Options;

option quantity => (
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    doc         => "Specifies number of exercises to generate",
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                . "In case of several kind of ...",
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    default    => sub { 15 },
);

has output_name => ( is => "lazy" );
sub _build_output_name {
    join( "", map { $_->command_name || "" } @{$_[0]->command_chain} );
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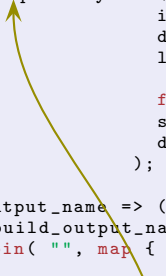
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- defining an attribute which will be initialized by command line

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- method to satisfy `MooX::Cmd`
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- build full qualified path of template file name residing in app's share directory, instantiate template processor and run it
- force output format "pdf" (`Template::LaTeX` will be instructed by template)

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is          => "ro",
  doc        => "specifies format of numerator/denominator",
  long_doc   => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
    and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
  },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
    );

```

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is          => "ro",
  doc        => "specifies format of numerator/denominator",
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  isa => sub { defined( $_[0] ) and !ref $_[0]
              and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
            },
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    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
            );

```

- be a nice package

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is      => "ro",
  doc     => "specifies format of numerator/denominator",
  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
    and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
  },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
);

```

- be a nice package ^Wrole,

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is      => "ro",
  doc     => "specifies format of numerator/denominator",
  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
             and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
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  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
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    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
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    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
);

```

- be a nice package ^Wrole, intending to provide command line options for instantiation

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is      => "ro",
  doc     => "specifies format of numerator/denominator",
  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
    and $_[0] !~ m, ^\d?n+(?:/\d?n+)?$, and die("Invalid format");
  },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m, ^(\d?n+)(?:/(\d?n+))?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
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    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
);

```

- be a nice package ^Wrole, intending to provide command line options for instantiation
- compose role behavior using Exercise and VulFrac

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is      => "ro",
  doc     => "specifies format of numerator/denominator",
  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
    and $_[0] !~ m, ^\d?n+(?:/\d?n+)?$, and die("Invalid format");
  },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m, ^(\d?n+)(?:/(\d?n+))?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
);

```

- be a nice package ^Wrole, intending to provide command line options for instantiation
- compose role behavior using Exercise and VulFrac



```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

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  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
             and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
  },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
  );

```

- be a nice package ^Wrole, intending to provide command line options for instantiation
- compose role behavior using Exercise and VulFrac
- define option

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is      => "ro",
  doc     => "specifies format of numerator/denominator",
  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
             and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
  },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
);

```

- be a nice package ^Wrole, intending to provide command line options for instantiation
- compose role behavior using Exercise and VulFrac
- define option coercing option string into array

```

package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
  is      => "ro",
  doc     => "specifies format of numerator/denominator",
  long_doc => "Allow specifying the format of the numerator/denominator ...",
  isa => sub { defined( $_[0] ) and !ref $_[0]
             and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
        },
  coerce => sub { ...
    my ( $fmta, $fmtb ) = ( $_[0] =~ m,^\d?n+(?:/\d?n+)?$, );
    $fmtb //= $fmta;
    my $starta = "1"; my $startb = "1";
    $fmta =~ s/^\d(.*)/$2/ and $starta = $1;
    $fmtb =~ s/^\d(.*)/$2/ and $startb = $1;
    [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
  },
  default => sub { return [ 100, 100 ]; }, format => "s",
);

```

- be a nice package ^Wrole, intending to provide command line options for instantiation
- compose role behavior using Exercise and VulFrac
- define option coercing option string into array ensuring the array ref as value

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is          => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is      => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

• \$ mtut

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is      => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

- \$ mtut vulfrac

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is      => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

- \$ mtut vulfrac add

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is          => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

- \$ mtut vulfrac add
- we're of course a nice class



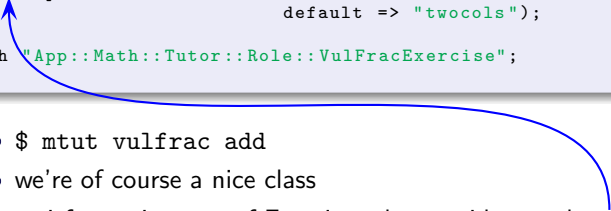
```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is          => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```



- \$ mtut vulfrac add
- we're of course a nice class
- satisfy requirement of Exercise role: provide template\_filename

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
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has template_filename => ( is      => "ro",
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with "App::Math::Tutor::Role::VulFracExercise";
```

- \$ mtut vulfrac add
- we're of course a nice class
- satisfy requirement of Exercise role: provide template\_filename – two column template (for addition and subtraction)

```
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is      => "ro",
                          default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

- \$ mtut vulfrac add
- we're of course a nice class
- satisfy requirement of Exercise role: provide template\_filename – two column template (for addition and subtraction)
- compose role ...VulFracExercise

```
sub _build_exercises {
  my ($self) = @_;

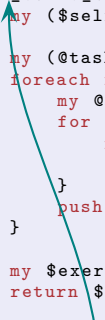
  my (@tasks);
  foreach my $i ( 1 .. $self->amount ) {
    my @line;
    for ( 0 .. 1 ) { # 0: +, 1: -
      my ( $a, $b ) = $self->get_vulgar_fractions(2);
      push @line, [ $a, $b ];
    }
    push @tasks, \@line;
  }

  my $exercises = ...;
  return $exercises;
}
```

```
sub _build_exercises {
  my ($self) = @_;

  my (@tasks);
  foreach my $i ( 1 .. $self->amount ) {
    my @line;
    for ( 0 .. 1 ) { # 0: +, 1: -
      my ( $a, $b ) = $self->get_vulgar_fractions(2);
      push @line, [ $a, $b ];
    }
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  }

  my $exercises = ...;
  return $exercises;
}
```



- exercise builder has to be provided by individual exercise

```
sub _build_exercises {
    my ($self) = @_;

    my (@tasks);
    foreach my $i ( 1 .. $self->amount ) {
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            push @line, [ $a, $b ];
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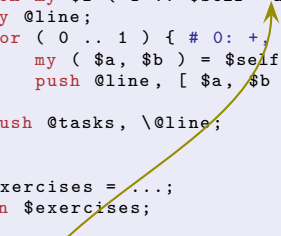
    my $exercises = ...;
    return $exercises;
}
```

- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet

```
sub _build_exercises {
  my ($self) = @_;

  my (@tasks);
  foreach my $i ( 1 .. $self->amount ) {
    my @line;
    for ( 0 .. 1 ) { # 0: +, 1: -
      my ( $a, $b ) = $self->get_vulgar_fractions(2);
      push @line, [ $a, $b ];
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    push @tasks, \@line;
  }

  my $exercises = ...;
  return $exercises;
}
```



- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet
- how many tasks per sheet?

```
sub _build_exercises {
  my ($self) = @_;

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      my ( $a, $b ) = $self->get_vulgar_fractions(2);
      push @line, [ $a, $b ];
    }
    push @tasks, \@line;
  }

  my $exercises = ...;
  return $exercises;
}
```

- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet
- how many tasks per sheet? (remember the option in ...Role::Exercise)



```
sub _build_exercises {
  my ($self) = @_;

  my (@tasks);
  foreach my $i ( 1 .. $self->amount ) {
    my @line;
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      push @line, [ $a, $b ];
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    push @tasks, \@line;
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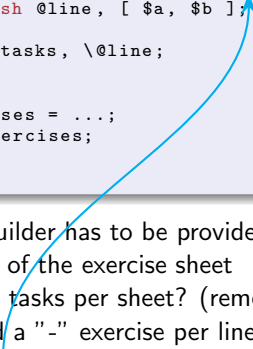
  my $exercises = ...;
  return $exercises;
}
```

- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet
- how many tasks per sheet? (remember the option in ...Role::Exercise)
- a "+" and a "-" exercise per line

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- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet
- how many tasks per sheet? (remember the option in ...Role::Exercise)
- a "+" and a "-" exercise per line
- invoke factory per task

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sub _build_exercises {
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        push @tasks, \@line;
    }

    my $exercises = ...;
    return $exercises;
}
```

- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet
- how many tasks per sheet? (remember the option in ...Role::Exercise)
- a "+" and a "-" exercise per line
- invoke factory per task
- save each line for processing

```
my $exercises = {
    section => "Vulgar fraction addition / subtraction",
    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

foreach my $line (@tasks) {
    my ( @solution, @challenge );
    foreach my $i ( 0 .. 1 ) {
        my ( $a, $b, @way ) = @{ $line->[$i] }; my $op = $i ? '-' : '+';
        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}
```

```

my $exercises = {
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        ...
    }
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}

```

- create exercise structure containing

```
my $exercises = {
    section => "Vulgar fraction addition / subtraction",
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        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}
```

- create exercise structure containing challenges and solutions

```
my $exercises = {
    section => "Vulgar fraction addition / subtraction",
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    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

foreach my $line (@tasks) {
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        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
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        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
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}
```

- create exercise structure containing challenges and solutions

```

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        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}

```

- create exercise structure containing challenges and solutions
- loop over created tasks



```

my $exercises = {
    section => "Vulgar fraction addition / subtraction",
    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
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foreach my $line (@tasks) {
    my( @solution, @challenge );
    foreach my $i ( 0 .. 1 ) {
        my( $a, $b, @way ) = @{ $line->[$i] }; my $op = $i ? '-' : '+';
        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}

```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line

```

my $exercises = {
    section => "Vulgar fraction addition / subtraction",
    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

foreach my $line (@tasks) {
    my ( @solution, @challenge );
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        my ( $a, $b, @way ) = @ { $line->[$i] }; my $op = $i ? '-' : '+';
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    push( @ { $exercises->{challenges} }, \@challenge );
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```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator `'"` of VulFrac objects

```

my $exercises = {
    section => "Vulgar fraction addition / subtraction",
    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

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        my ( $a, $b, @way ) = @ { $line->[$i] }; my $op = $i ? '-' : '+';
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```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator '-' of VulFrac objects

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        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
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}

```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator `'"` of VulFrac objects

```

my $exercises = {
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    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

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    my ( @solution, @challenge );
    foreach my $i ( 0 .. 1 ) {
        my ( $a, $b, @way ) = @{ $line->[$i] }; my $op = $i ? '-' : '+';
        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}

```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator `'"` of VulFrac objects
- same (but different) opening `"way"`

```

my $exercises = {
    section => "Vulgar fraction addition / subtraction",
    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

foreach my $line (@tasks) {
    my ( @solution, @challenge );
    foreach my $i ( 0 .. 1 ) {
        my ( $a, $b, @way ) = @{$ $line->[$i] }; my $op = $i ? '-' : '+';
        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{$ $exercises->{challenges} }, \@challenge );
    push( @{$ $exercises->{solutions} }, \@solution );
}

```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator '-' of VulFrac objects
- same (but different) opening "way"

```

my $exercises = {
    section => "Vulgar fraction addition / subtraction",
    caption => 'Fractions',
    label   => 'vulgar_fractions_addition',
    header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction S
    challenges => [], solutions => [],
};

foreach my $line (@tasks) {
    my ( @solution, @challenge );
    foreach my $i ( 0 .. 1 ) {
        my ( $a, $b, @way ) = @{ $line->[$i] }; my $op = $i ? '-' : '+';
        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}

```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator `'"` of VulFrac objects
- same (but different) opening `"way"` and remember the little thingsies ...

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+/$);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}

```



```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$' . join( " = ", @way ) . '$' );
}

```

- try to reduce operands

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$' . join( " = ", @way ) . '$' );
}

```

- try to reduce operands and add them to opening

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$' . join( " = ", @way ) . '$' );
}

```

- try to reduce operands and add them to opening when successful

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine greatest common divisor of operands denominator,

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
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  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$' . join( " = ", @way ) . '$' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine greatest common divisor of operands denominator, format subsequent

```

sub _build_exercises {
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  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$' . join( " = ", @way ) . '$' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine greatest common divisor of operands denominator, format subsequent steps to reach

```

sub _build_exercises {
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    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

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  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num / $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$' . join( " = ", @way ) . '$' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine greatest common divisor of operands denominator, format subsequent steps to reach the solution



```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine greatest common divisor of operands denominator, format subsequent steps to reach the solution
- remark possible reducing,

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine greatest common divisor of operands denominator, format subsequent steps to reach the solution
- remark possible reducing, mixed fraction,

```

sub _build_exercises {
  ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
  push @way, sprintf( '%s %s %s', $a, $op, $b )
    if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

  my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
  my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
  push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
    $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
  push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
    $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
  push @way, sprintf( '\frac{%d %s %d}{%d}',
    $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
  my $s = VulFrac->new( denum => $a->denum * $fa,
    num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+);
  push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way,
  $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

  push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}

```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine geatest common divisor of operands denominator, format subsequent steps to reach the solution
- remark possible reducing, mixed fraction, cord it and go ahead

## Vulgar Fraction Addition

$$\frac{99}{67} + \frac{43}{84} =$$

$$\frac{19}{7} + \frac{16}{54} =$$

$$\frac{38}{82} + \frac{38}{99} =$$

$$\frac{96}{80} + \frac{46}{39} =$$

$$\frac{72}{68} + \frac{46}{99} =$$

## Vulgar Fraction Subtraction

$$\frac{45}{41} - \frac{32}{48} =$$

$$\frac{51}{47} - \frac{49}{65} =$$

$$\frac{56}{33} - \frac{30}{32} =$$

$$\frac{49}{79} - \frac{29}{82} =$$

$$\frac{42}{49} - \frac{38}{59} =$$

## Vulgar Fraction Addition

$$\frac{99}{67} + \frac{43}{84} = \frac{99 \cdot 84}{67 \cdot 84} + \frac{43 \cdot 67}{84 \cdot 67} = \frac{8316}{5628} + \frac{2881}{5628} =$$

$$\frac{8316+2881}{5628} = \frac{11197}{5628} = 1 \frac{5569}{5628}$$

$$\frac{19}{7} + \frac{16}{54} = \frac{19}{7} + \frac{8}{27} = \frac{19 \cdot 27}{7 \cdot 27} + \frac{8 \cdot 7}{27 \cdot 7} = \frac{513}{189} +$$

$$\frac{56}{189} = \frac{513+56}{189} = \frac{569}{189} = 3 \frac{2}{189}$$

$$\frac{38}{82} + \frac{38}{99} = \frac{19}{41} + \frac{38}{99} = \frac{19 \cdot 99}{41 \cdot 99} + \frac{38 \cdot 41}{99 \cdot 41} = \frac{1881}{4059} +$$

$$\frac{1558}{4059} = \frac{1881+1558}{4059} = \frac{3439}{4059}$$

$$\frac{96}{80} + \frac{46}{39} = \frac{6}{5} + \frac{46}{39} = \frac{6 \cdot 39}{5 \cdot 39} + \frac{46 \cdot 5}{39 \cdot 5} = \frac{234}{195} + \frac{230}{195} =$$

$$\frac{234+230}{195} = \frac{464}{195} = 2 \frac{74}{195}$$

$$\frac{72}{68} + \frac{46}{99} = \frac{18}{17} + \frac{46}{99} = \frac{18 \cdot 99}{17 \cdot 99} + \frac{46 \cdot 17}{99 \cdot 17} = \frac{1782}{1683} +$$

$$\frac{782}{1683} = \frac{1782+782}{1683} = \frac{2564}{1683} = 1 \frac{881}{1683}$$

## Vulgar Fraction Subtraction

$$\frac{45}{41} - \frac{32}{48} = \frac{45}{41} - \frac{2}{3} = \frac{45 \cdot 3}{41 \cdot 3} - \frac{2 \cdot 41}{3 \cdot 41} = \frac{135}{123} - \frac{82}{123} =$$

$$\frac{135-82}{123} = \frac{53}{123}$$

$$\frac{51}{47} - \frac{49}{65} = \frac{51}{47} - \frac{49}{65} = \frac{51 \cdot 65}{47 \cdot 65} - \frac{49 \cdot 47}{65 \cdot 47} = \frac{3315}{3055} -$$

$$\frac{2303}{3055} = \frac{3315-2303}{3055} = \frac{1012}{3055}$$

$$\frac{56}{33} - \frac{30}{32} = \frac{56}{33} - \frac{15}{16} = \frac{56 \cdot 16}{33 \cdot 16} - \frac{15 \cdot 33}{33 \cdot 16} = \frac{896}{528} -$$

$$\frac{495}{528} = \frac{896-495}{528} = \frac{401}{528}$$

$$\frac{49}{79} - \frac{29}{82} = \frac{49 \cdot 82}{79 \cdot 82} - \frac{29 \cdot 79}{82 \cdot 79} = \frac{4018}{6478} - \frac{2291}{6478} =$$

$$\frac{4018-2291}{6478} = \frac{1727}{6478}$$

$$\frac{42}{49} - \frac{38}{59} = \frac{6}{7} - \frac{38}{59} = \frac{6 \cdot 59}{7 \cdot 59} - \frac{38 \cdot 7}{59 \cdot 7} = \frac{354}{413} - \frac{266}{413} =$$

$$\frac{354-266}{413} = \frac{88}{413}$$

## Part VI

### Finish

12 Conclusion

13 Resources

- Resources
- Thank you

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- lazy attributes allow designing a multi-stage initialization phase
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  - ▶ DBIx::Class
  - ▶ Web::Simple (Jedi)
- improve design by
  - ▶ using roles for behavioral design (avoid duck typing)
  - ▶ using explicit patterns for clear separation of concerns
  - ▶ express intentions clearer for method overloading by using *method modifiers*

# Resources

## Software

<https://metacpan.org/pod/Moo/>

<https://github.com/moose/Moo>

<https://metacpan.org/search?q=MooX>

<https://metacpan.org/pod/MooX::Cmd>

<https://metacpan.org/pod/MooX::Options>

<https://metacpan.org/pod/MooX::ConfigFromFile>

<https://github.com/rehsack/App-Math-Tutor>

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## IRC

<irc://irc.perl.org/#moose>

<irc://irc.perl.org/#web-simple>

Thank You For Contributing

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Curtis "Ovid" Poe Final review and figured out missing fundamentals

# Thank You For Listening

Questions?

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