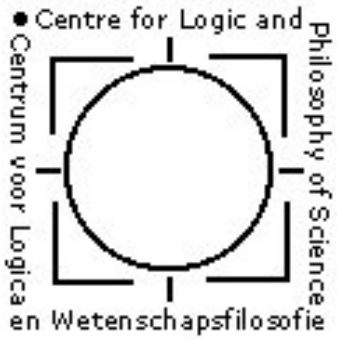

Problem Solving and Adaptive Logics.
A Logico-Philosophical Study

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1 The Problem, the Claim and the Plan

1.1 On Solving Problems

problem solving is central for understanding the sciences
in philosophy of science: since Kuhn, . . . , Laudan

from 1980s on: scientific discovery is specific kind of problem solving
(cf. also scientific creativity)

two kinds of contributions:

(i) A.I.: set of computer programs
too specific
(ii) philosophy of science:
informal, often vague (Kuhn > Laudan > Nickles)
Nickles: role of constraints (+ change + rational violation)
nothing on the **process**: how proceed in order to solve

we need (again) a general approach

here proposed: a formal approach (similar to a formal logic)

Is this possible?

main worries discussed in 1.2

first some more on problems

"problem" in broad sense:
in principle all kinds & all domains
scientific and everyday (same *kind* of reasoning behind them)

problems: difficulties vs. *questions*

justified questions derive from difficulties
questions answered from knowledge system / by extending it
knowledge system may involve / run into difficulties

whether a question is difficult to answer does not depend
on whether it derives from a difficulty

problem: will be written as a set of questions

consider:

original problem is $\{?\{A, \sim A\}\}$

if B, C and D, then A

leads to questions $?\{B, \sim B\}$, $?\{C, \sim C\}$ and $?\{D, \sim D\}$

but these are connected: if one of them receives the wrong answer, answering the others is useless with respect to the original problem

so (in this context) they form a single problem:
$\{?\{B, \sim B\}, ?\{C, \sim C\}, ?\{D, \sim D\}\}$
which is dropped as a whole if one of the questions has an unsuitable answer

actually: problem = set of questions + set of pursued answers
(but this will appear from the context)

a problem solving process (psp) has two important features:

(1) it contains *subsidiary* and/or *derived* problems

(derived from a previous problem
derived from previous problem + premises)

(2) it is goal-directed (unlike a proof on the standard definition)

all steps are sensible in view of the goal (the problem solution)

Note: a step may be sensible because it contributes to the solution of the problem, or because it shows that a certain road to that solution is a dead end

An example

Galilei looking for the law of the free fall

absence of adequate measuring instruments!

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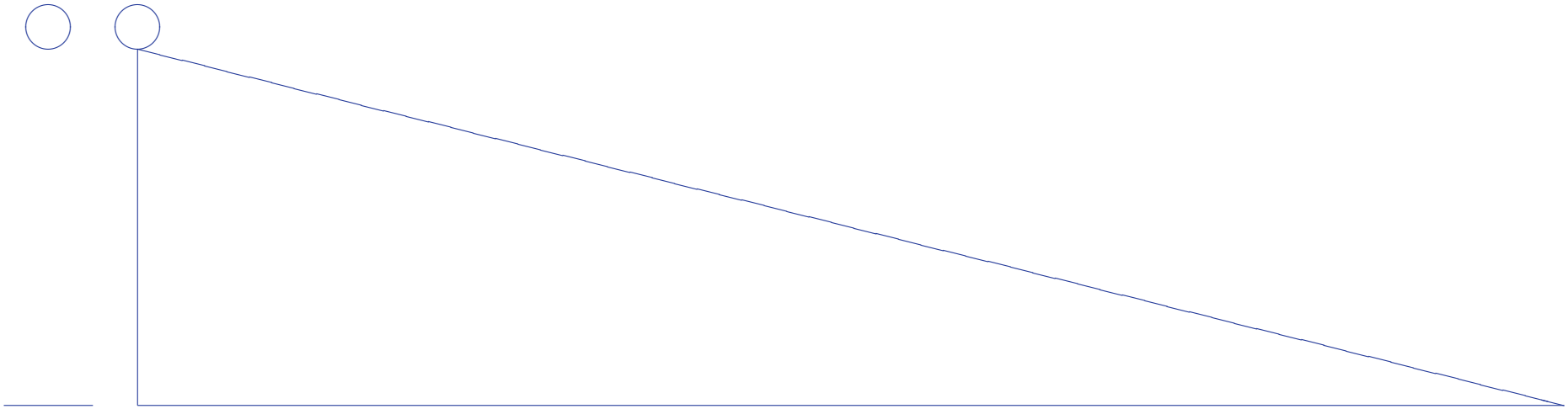

the same force that makes the ball fall, makes it roll down the slope

An example

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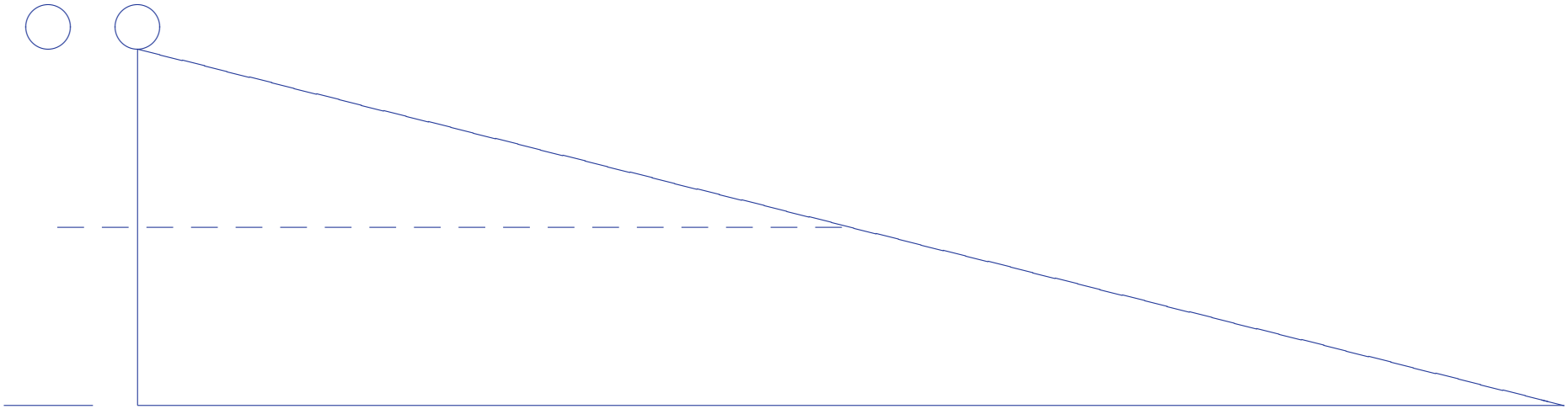


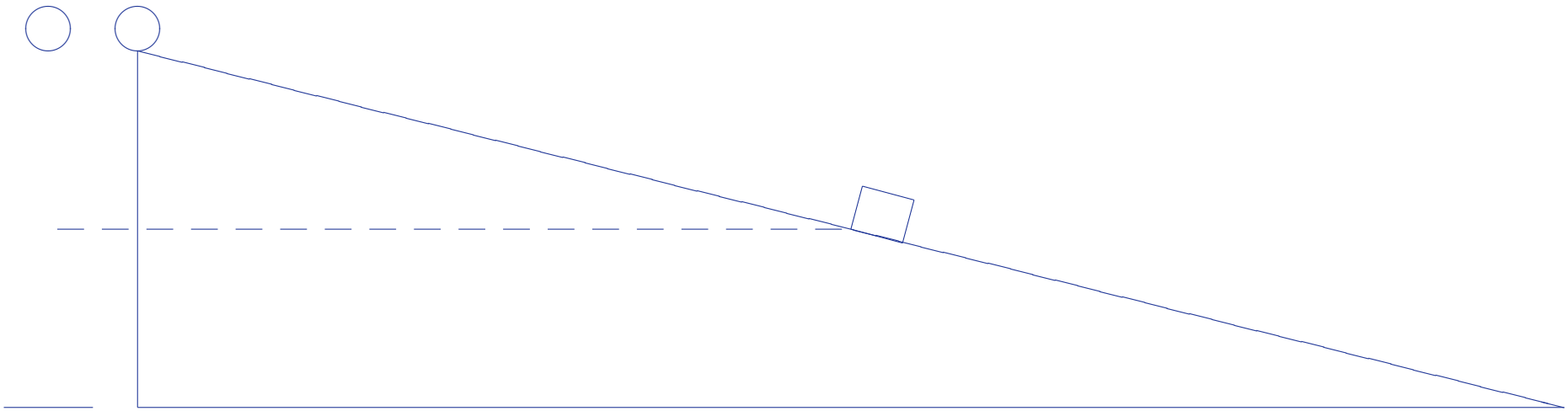
the same force that makes the ball fall, makes it roll down the slope

measuring the times?

An example

Galilei looking for the law of the free fall

absence of adequate measuring instruments!



weigh the amount of water flowing in a vessel from the start to the point where the ball hits the wooden block

compare the weights for different positions of the block
(only the ratios matter)

interesting example:

- admittedly: no conceptual changes involved
- some sophistication
  - solution is a generalization (not a singular statement)
  - new empirical data required
  - experiments required
  - experiments had to be devised

1.2 Worries from the Philosophy of Science and from Erotetic Logic

aim: devise formal procedure that explicates problem solving

outdated? cf. Vienna Circle

Nickles: no logic of discovery, only local logics of discovery

touchy: how do (changing) constraints surface in a formal psp?

- changing premises
- changing logics

standard erotetic logic

- insufficiently goal directed
- too restrictive (except for yes–no questions)

1.3 Mastering Proof Heuristics

logicians: good practice in solving specific type of problems: $\Gamma \vdash A$?

find a proof if there is one (in most cases)

see when there is no proof (in most cases)

demonstrate that there is no proof if there is none (in most cases)
tableau methods and other kinds of procedures (see later)

$\mathbf{CL}$ is not decidable, there only is a positive test (is partially recursive)
so non-derivability cannot always be demonstrated

usual positive tests are rather distant from proofs
and so are (partial) methods for showing non-derivability

Ghent result: push (most of) the proof heuristics into the proof

$\Rightarrow$ side effect of dynamic logics (prospective dynamics)

simple idea: if you want to obtain $\boldsymbol{A}$, and $\boldsymbol{B} \supset \boldsymbol{A}$ is available, look for $\boldsymbol{B}$

$\Rightarrow$ add to the proof: $[\boldsymbol{B}]\,\boldsymbol{A}$

if you want to obtain $\boldsymbol{A}$, and $\boldsymbol{A} \vee \boldsymbol{B}$ is available, look for $\sim\boldsymbol{B}$

$\Rightarrow$ add to the proof: $[\sim\boldsymbol{B}]\,\boldsymbol{A}$

etc.

result: a procedure (see later) with the properties:

(1) if $\mathbf{\Gamma} \vdash_{\mathbf{CL}} \boldsymbol{A}$, then the procedure leads to a proof of $\boldsymbol{A}$ from $\mathbf{\Gamma}$

(2) if the procedure leads to a proof of $\boldsymbol{A}$ from $\mathbf{\Gamma}$, then $\mathbf{\Gamma} \vdash_{\mathbf{CL}} \boldsymbol{A}$

(3) if the procedure stops, not providing a proof, then $\mathbf{\Gamma} \nvdash_{\mathbf{CL}} \boldsymbol{A}$

(4) for decidable fragments of $\mathbf{CL}$: if $\mathbf{\Gamma} \nvdash_{\mathbf{CL}} \boldsymbol{A}$, then the procedure stops

casual comments:

no way to strengthen (4)

algorithm for turning the prospective proof into a standard proof

other (standard) logics:
rather straightforward way to turn inference rules into prospective rules
and to turn prospective proofs into standard proofs

1.4 Unusual Logics Needed

problem solving requires reasoning processes for which there is no positive test
(= that are not even partially recursive)

inductive generalization, abduction to the best explanation, etc.

traditionally seen as beyond the scope of logic

adaptive logics are capable of explicating such reasoning processes

the claim:
formulating prospective proofs for adaptive logics provides us with a formal approach to problem solving

1.5 The Traditional View On Logic

main point:

adaptive logics do not suit the standard view on logic

no logic (not even $\mathbf{CL}$) fits the standard view on logic of 1900

because that view was provably mistaken
(and was proven to be mistaken)

I do not claim that logics that fit the present standard view are not sensible

I only claim that, in departing slightly from the standard view, one is able to decently explicate forms of reasoning that
(i) are extremely important in human (scientific and other) reasoning
(ii) do not fit the standard view

1.6 Logical Systems vs. Logical Procedures

standard definition of logical system: set of rules, governing proofs

any extension of a proof with an application of a rule is a proof

procedure:
- set of rules
- for each rule: permission/obligation depending on stage of proof

standard definition: rules + universal permission

this is not a sensible explication of human reasoning (goal directed)

example:
on the prospective-dynamics procedure, a premise cannot be added to the proof unless a present target can be obtained from the premise by means of subformulas and negations of subformulas of the premise

if the target is p, $p \supset q$ cannot be added, but $q \supset p$ can

1.7 The Plan

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