Teaching computational physics to undergraduates in Kolkata

Ananda Dasgupta[1]

[1]Indian Institute of Science, Education and Research Kolkata

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Outline

- The experience at St. Xavier's.

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- The experience at IISER-Kolkata.

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- Future directions.

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Students were encouraged to *think* about the physical reasons once simulations gave them results.

Background - the CU scenario

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- No practical examination - students just had to write 10 programs over the duration of the course.

Background - the CU scenario

Current syllabus for Paper VIIB

- Sorting.
- Mean, median and mode of n numbers.
- Sum of a G.P. series.
- Solution of simple algebraic equations.
- Sum of an infinite series.
- Integration by Simpsons rule.
- Linear least squares fit.

Apart from executing the eight programmes prescribed in the syllabus, students should be encouraged to execute other problems of physics particularly asssociated with practical with the help of a computer, using available software packages (e.g. graph plotting etc.)

CNB : 5, Viva - 10, Experiment : Computer-20

The St. Xavier's course then - a glimpse

Some problems that were tackled were :

- Motion of a particle under gravity and drag.
- Study of a harmonic oscillator.
- Forced oscillations and resonance.
- Study of an anhramonic oscillator.
- Coupled oscillations.
- Bifurcation and chaos in nonlinear maps.
- Laplace's equation
- Radioactive decay
- ...
- As well as plotting and data analysis using a plotting program.

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They were asked to do this for four different initial conditions :

$$\begin{aligned} x_1 = 1, x_2 = 0 \qquad & v_1 = v_2 = 0 \\ x_1 = 0, x_2 = 1 \qquad & v_1 = v_2 = 0 \\ x_1 = 1, x_2 = 1 \qquad & v_1 = v_2 = 0 \\ x_1 = 1, x_2 = -1 \qquad & v_1 = v_2 = 0 \end{aligned}$$

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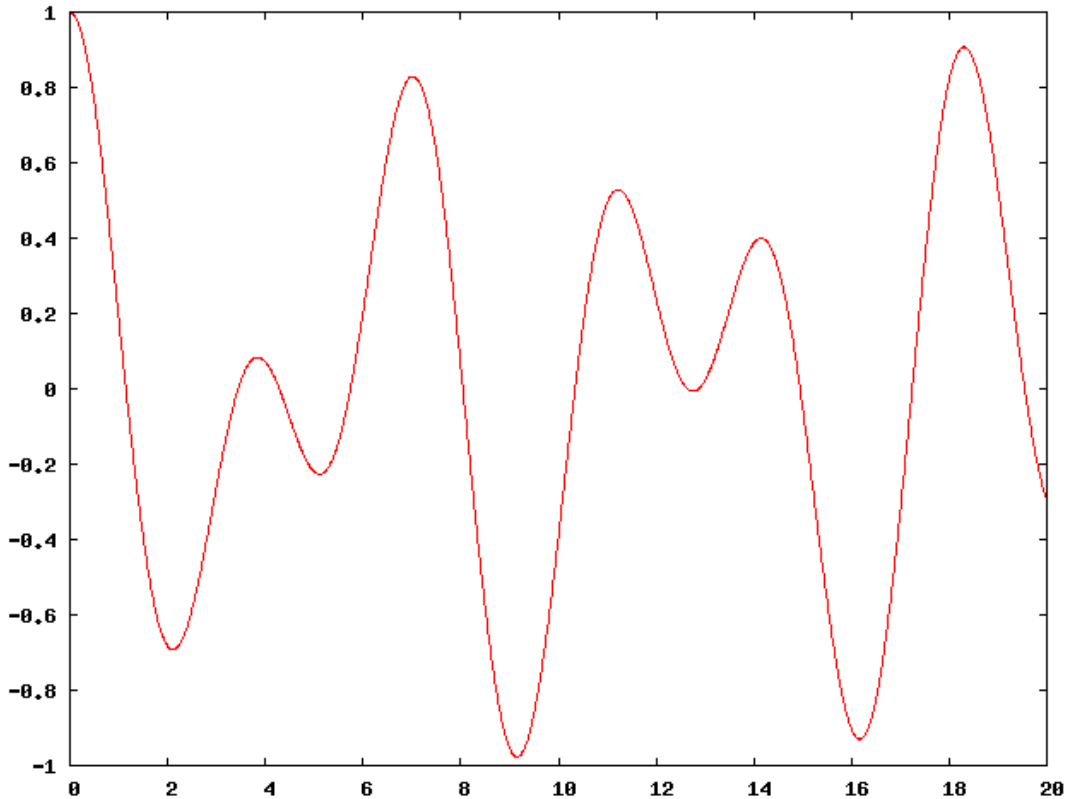

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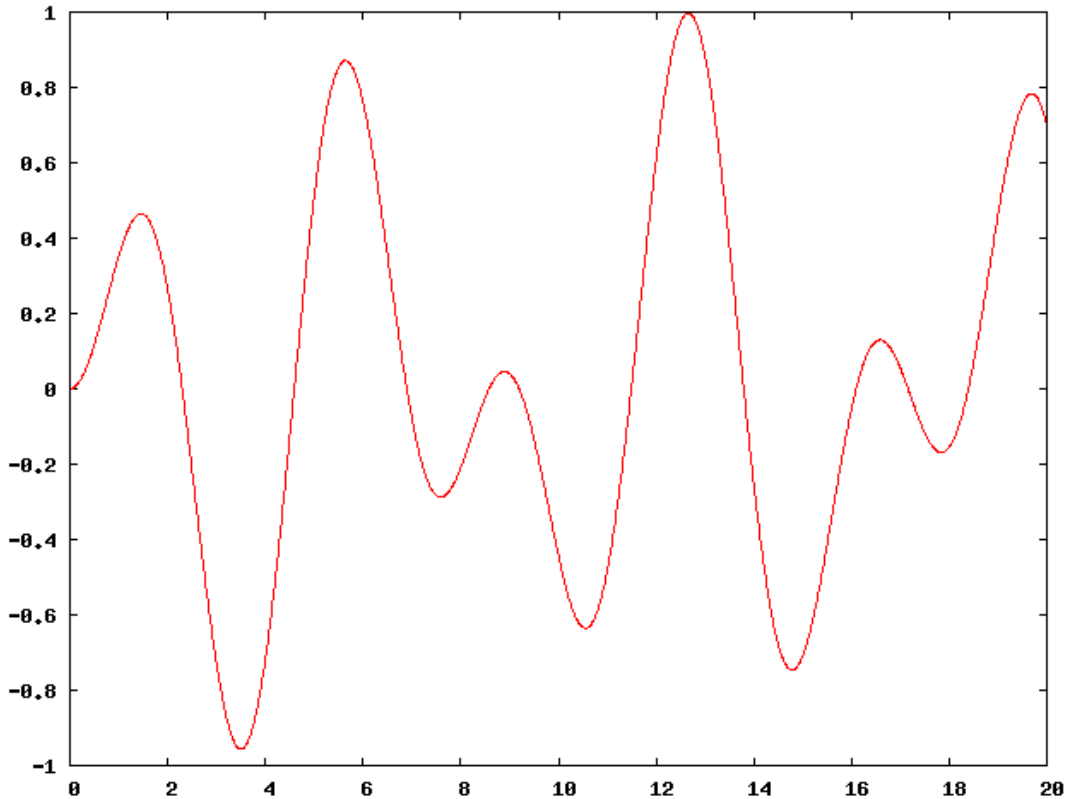

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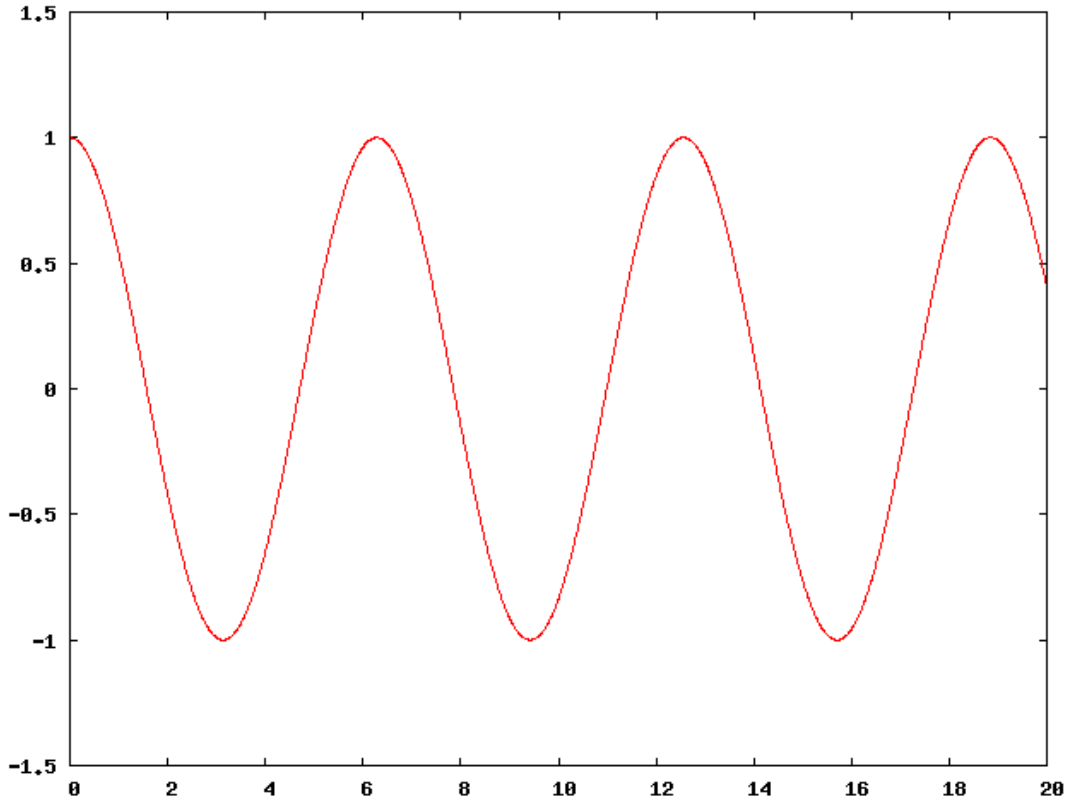

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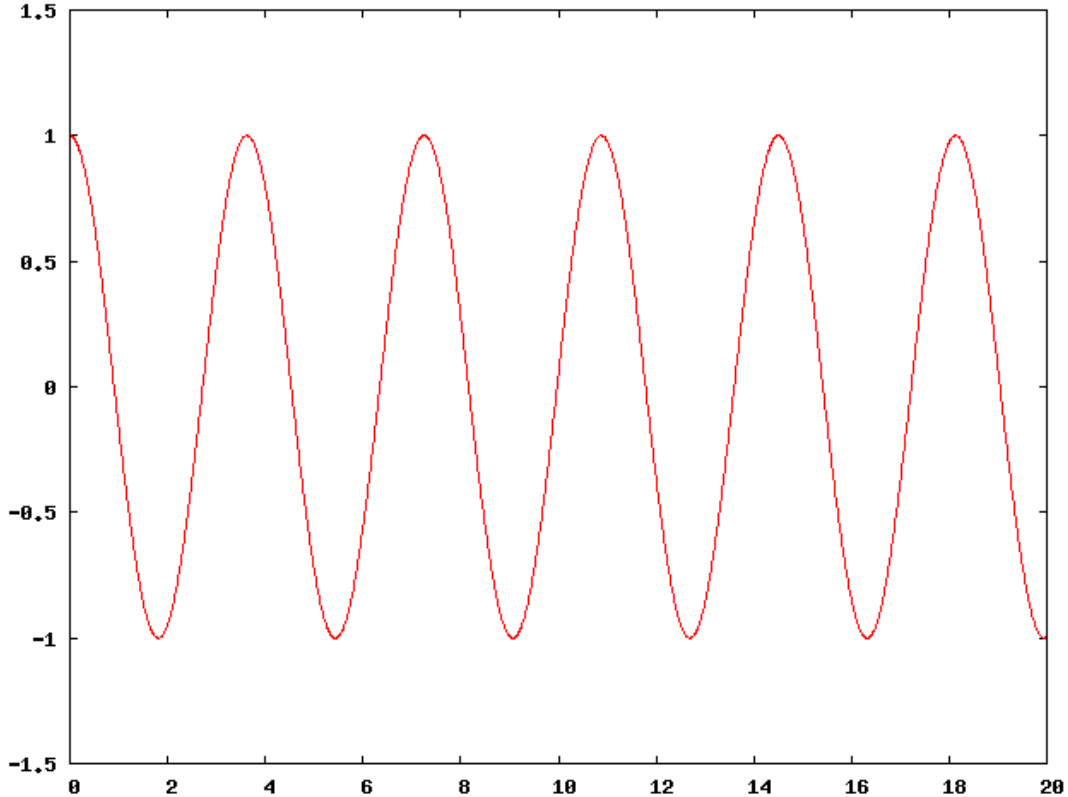

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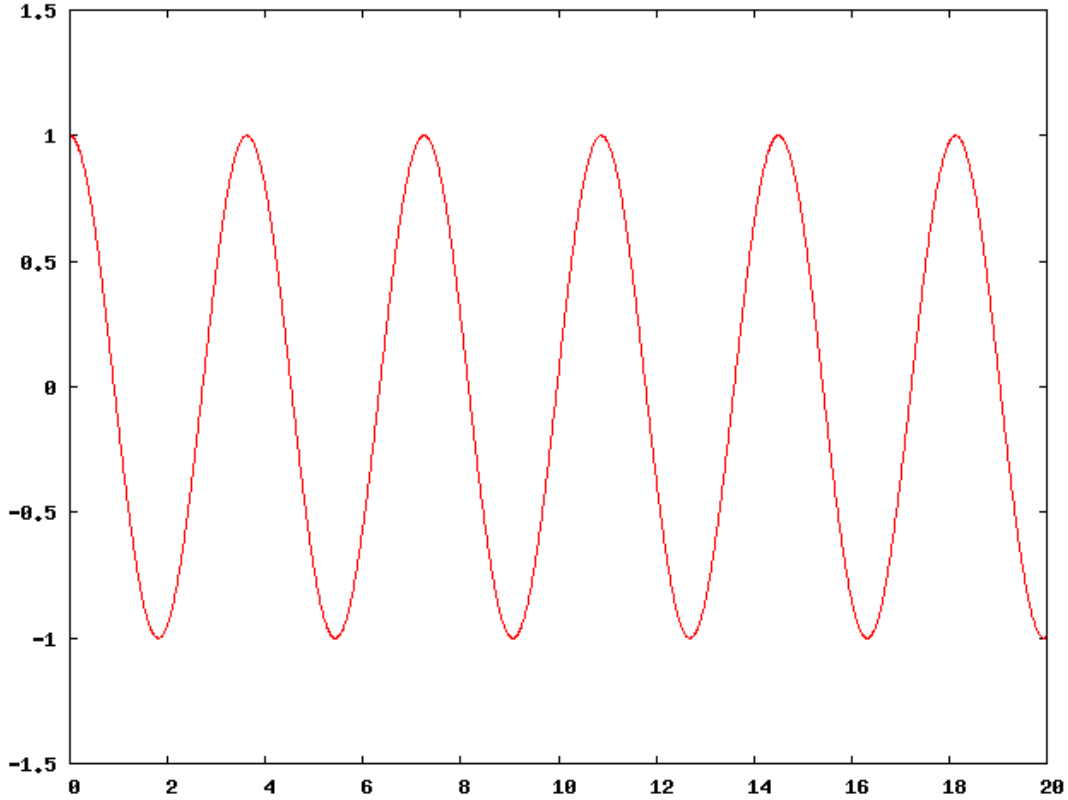

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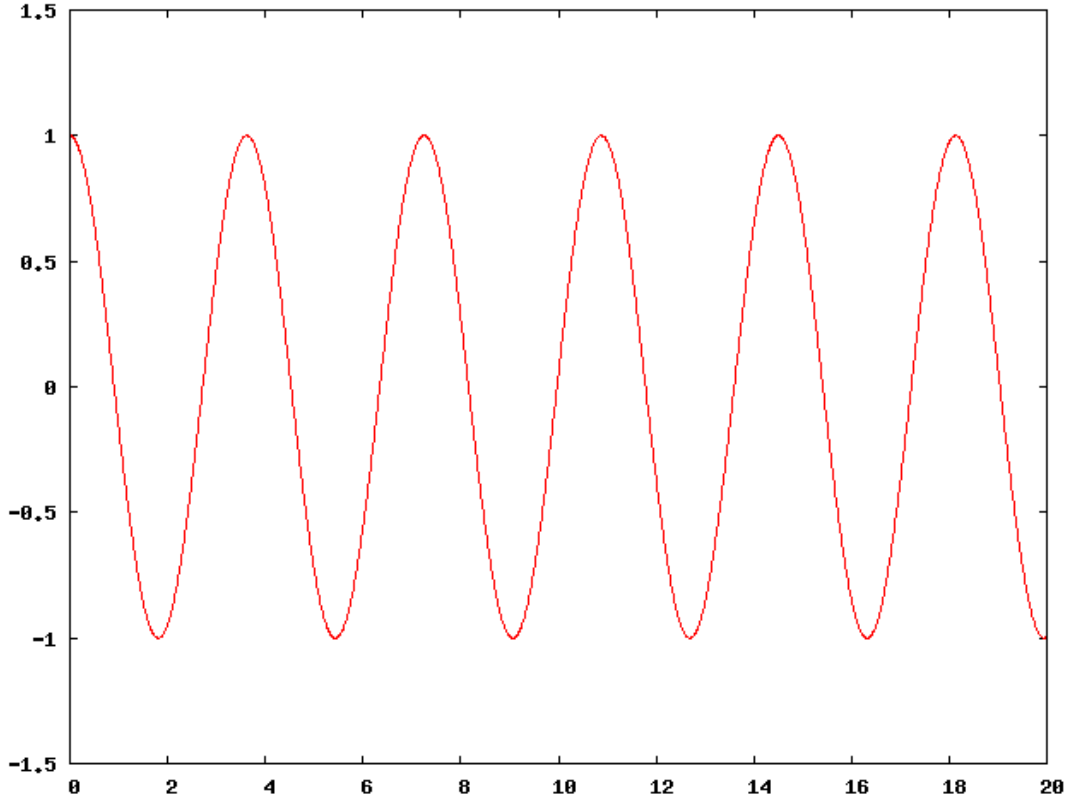

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The discovery of normal modes!!!

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- However, once the exams neared, student enthusiasm dropped.
- *The fact that there were no marks to be obtained from this course took its toll.*

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- There is a proposed Advanced computational physics course as an elective in the fourth year.

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- A programming language that is *open source*, *free*, **simple** *and* **powerful**
  - **Python!**

Course structure for CS111

- No separate lectures.
- Lab classes used worksheets which had both the background as well as problems.
- Some handouts provided on the (internal) course website.
- Total marks : 100
  - Continuous evaluation : 70
  - Final examination : 30

Course structure for PH221

- 1 lectures per week last year, but none this year.
- Handouts (mostly last years course notes) provided on the course website.
- Lab classes used worksheets which had problems to be worked out in the lab, as well as homework problems.
- Total marks : 50
  - Continuous evaluation : 20
  - Final examination : 15
  - Project : 15
- The final exam is takehome (with a duration of 1 week) and a viva.
- Students are encouraged to choose their own projects.

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- Allows reuse of legacy software by wrapping.

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  - Program developement is a lot faster, though!
  - Except for very computation intensive application, the latter more than compensates for the former!

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List comprehension : produces a new list [1.0,.25,...,1.e-10]

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Prints out the sum.

An example program

```
# A program for studying motion under drag
# Uses the Euler algorithm
f = open('drag.out','w')
m,g,k = 1.0,10.0,0.1   # parameters
xi,vi = 10.0,0.0      # initial conditions
ti,tf,dt = 0.0,10.0,.001
t,x,v = ti,xi,vi
while t<tf:
    a = -g-k*v/m
    v += a*dt
    x += v*dt
    t += dt
    if x<0.0:
        x=0.0
        v = -v
    print >>f, t,v,x
f.close()
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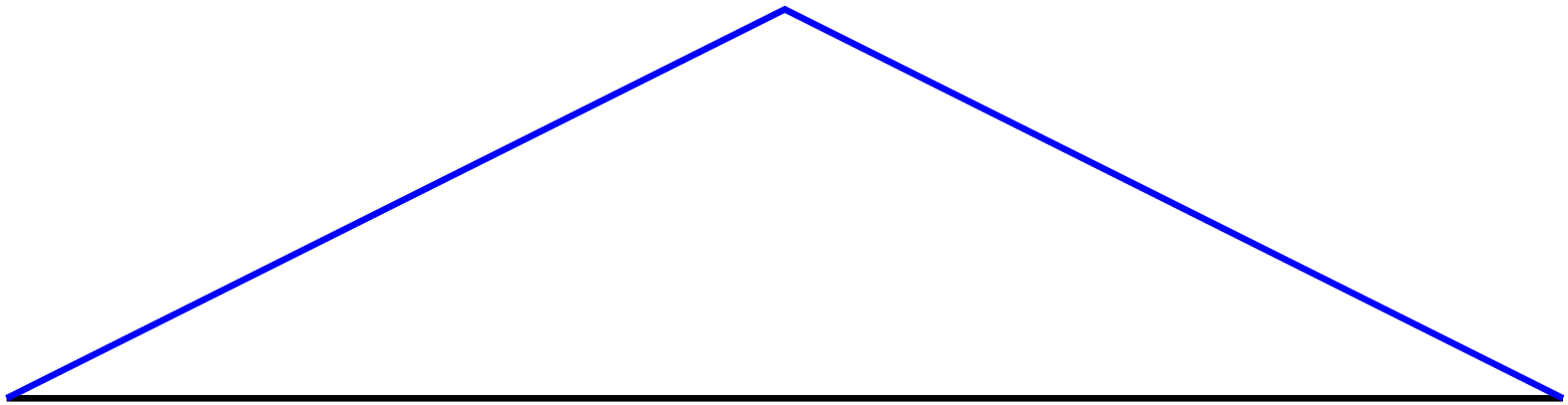

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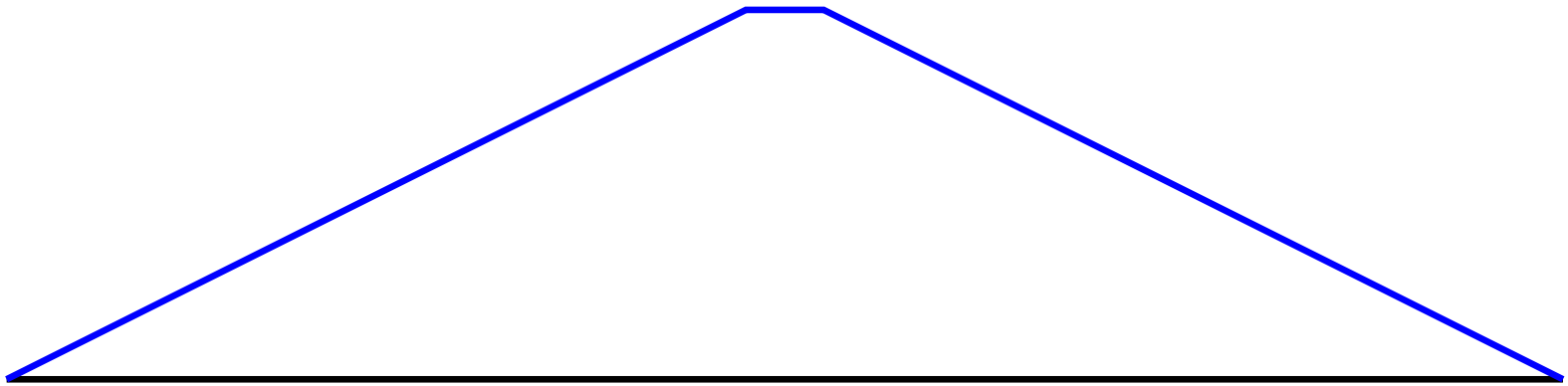

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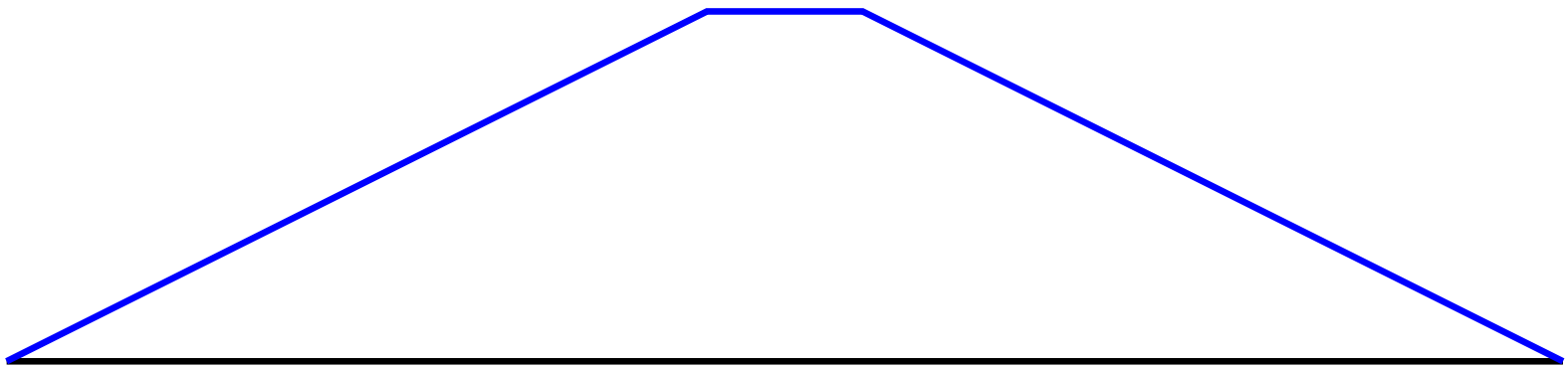

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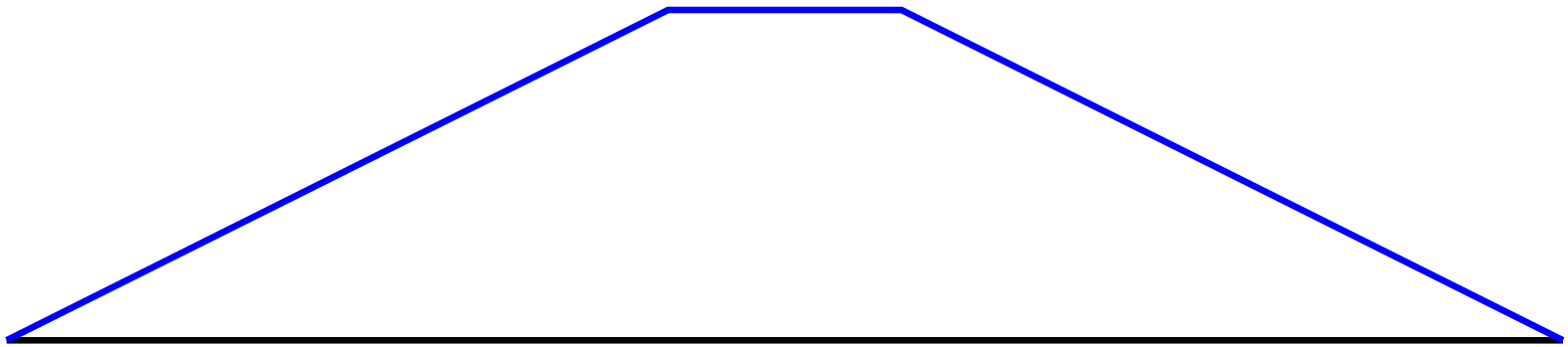

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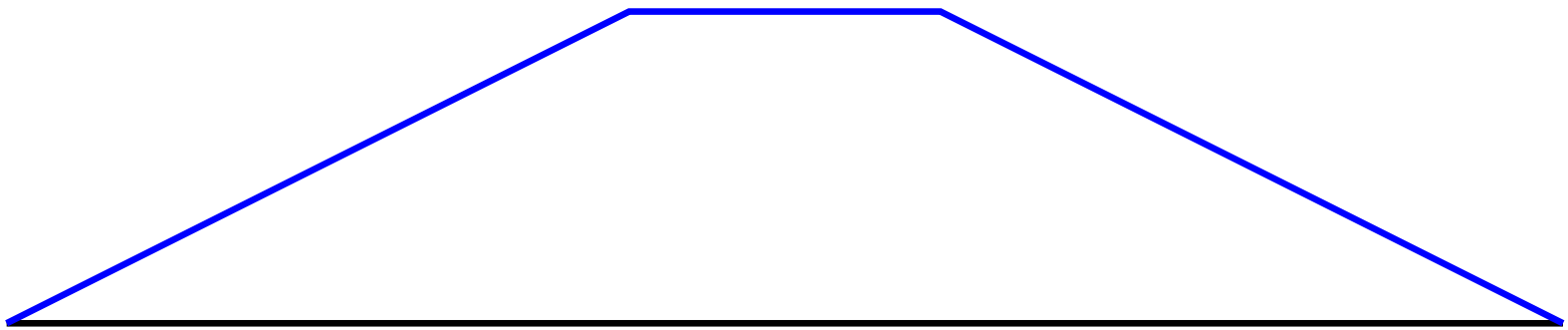

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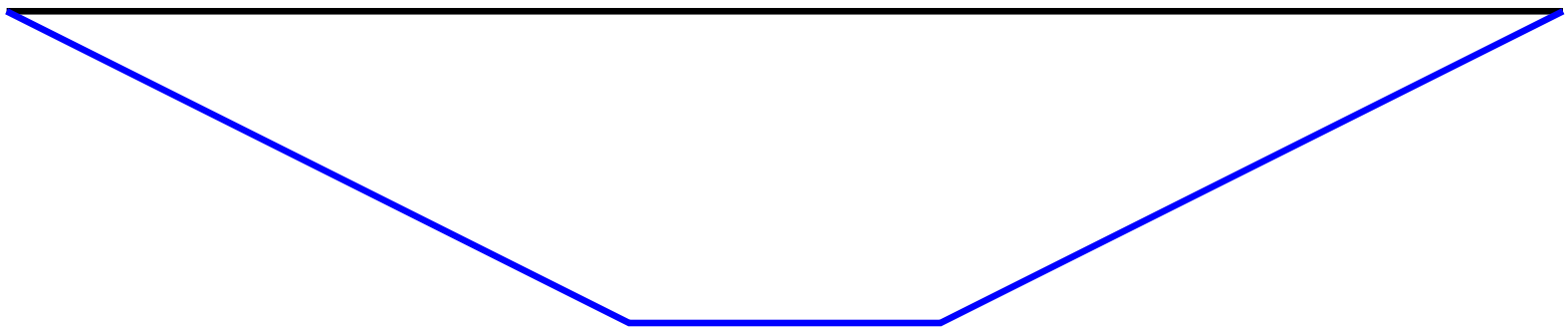

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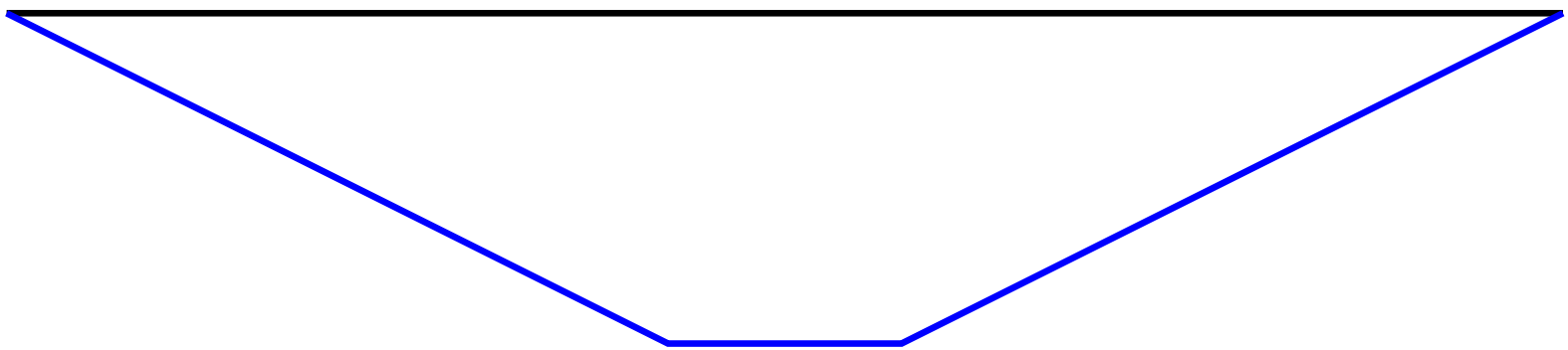

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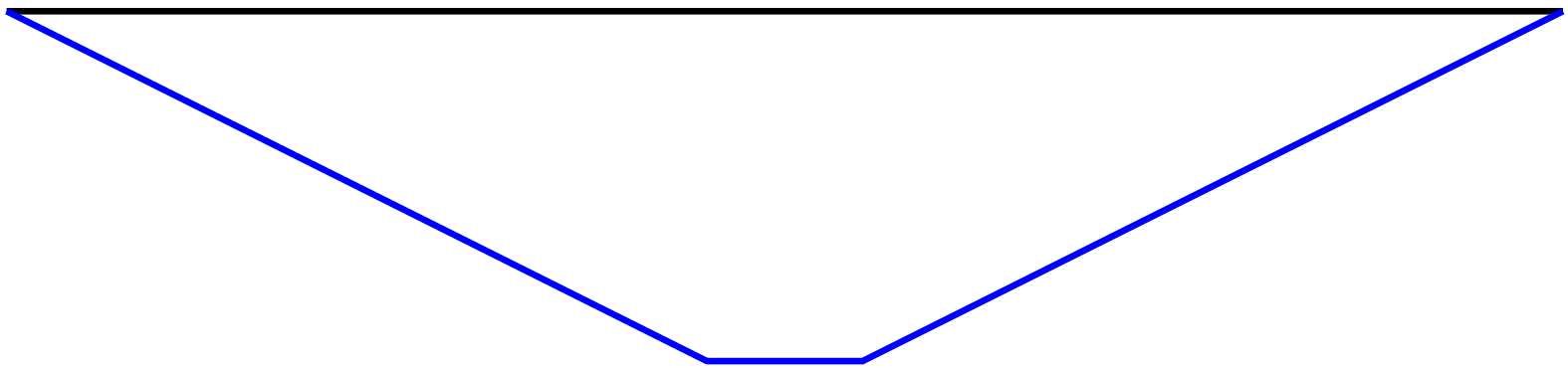

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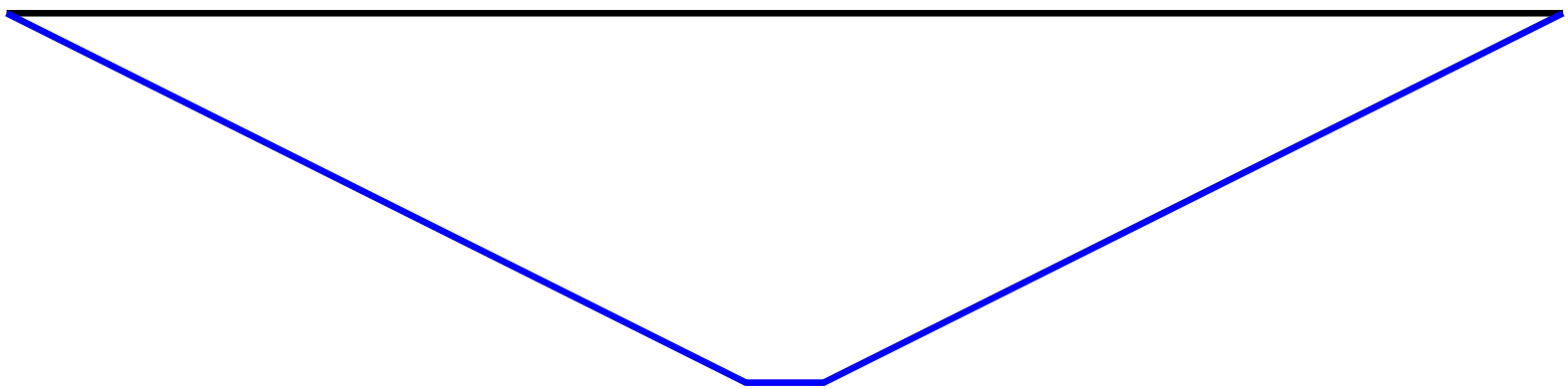

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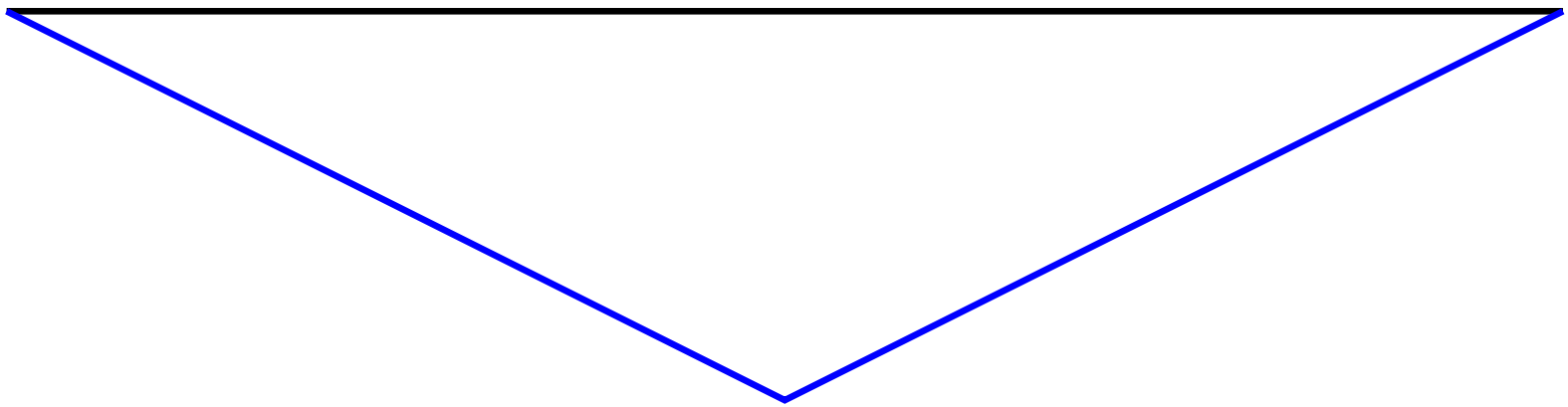

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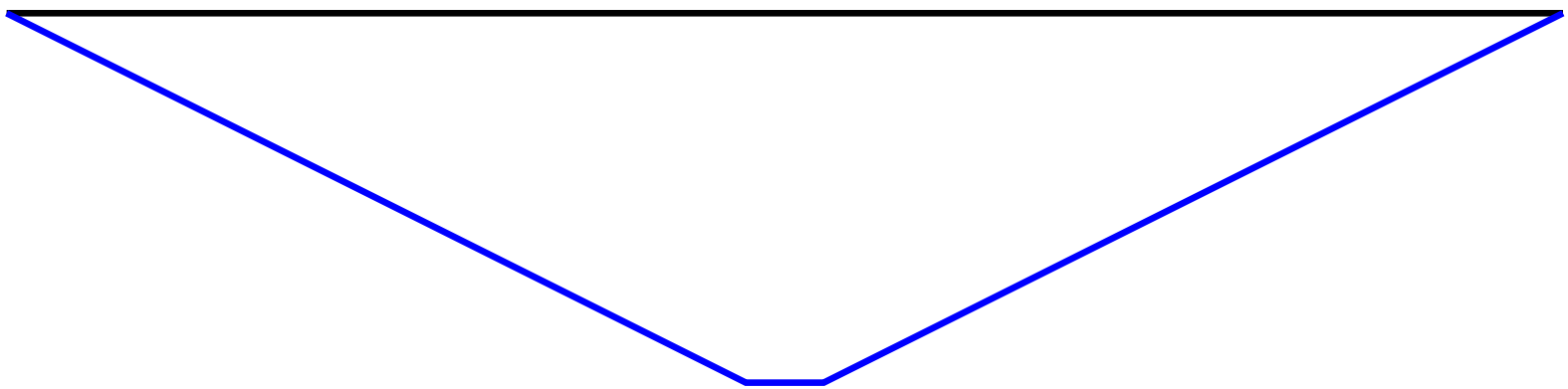

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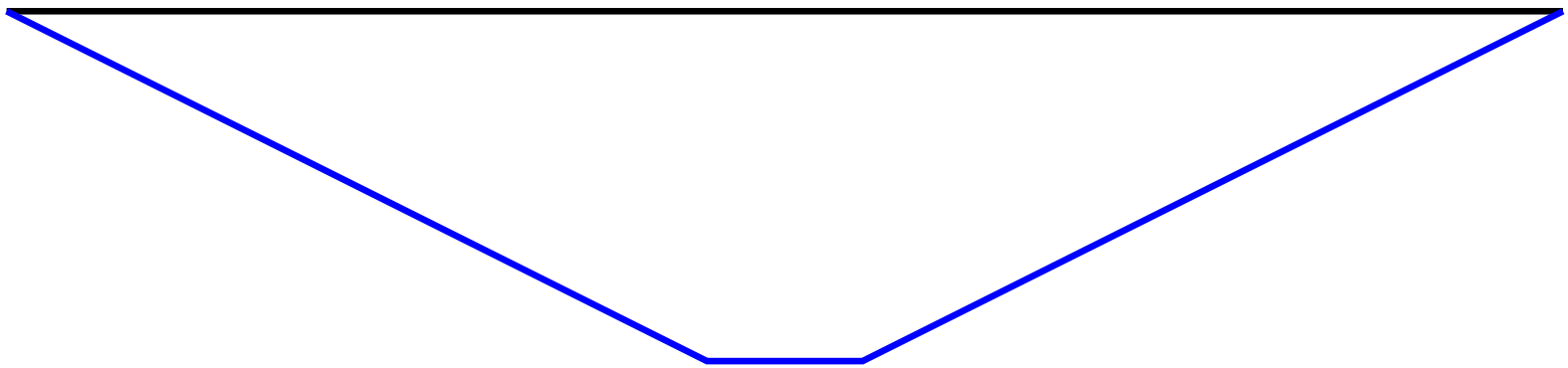

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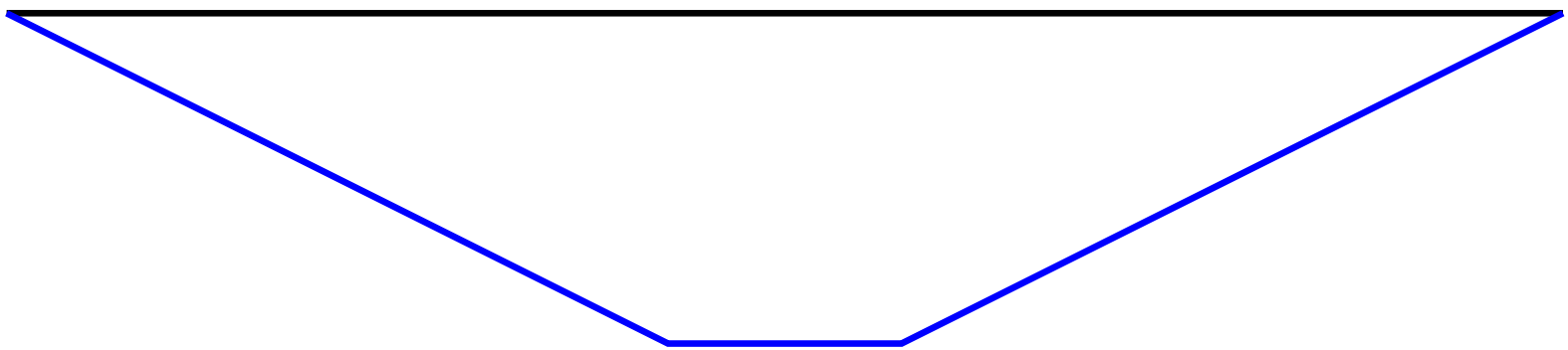

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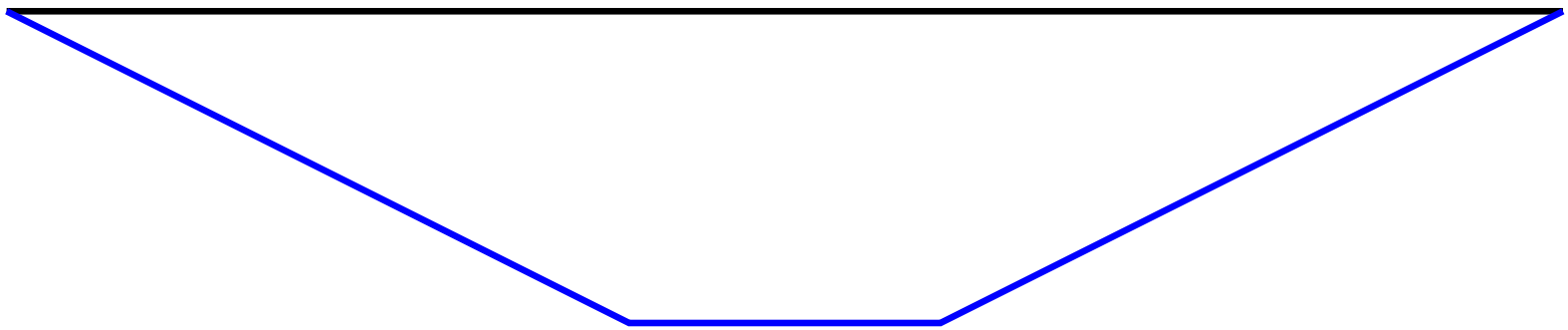

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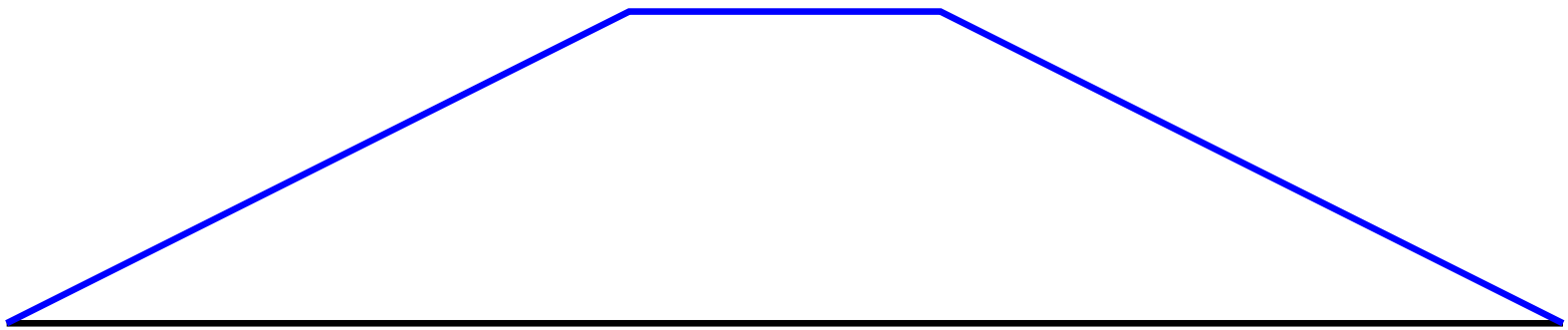

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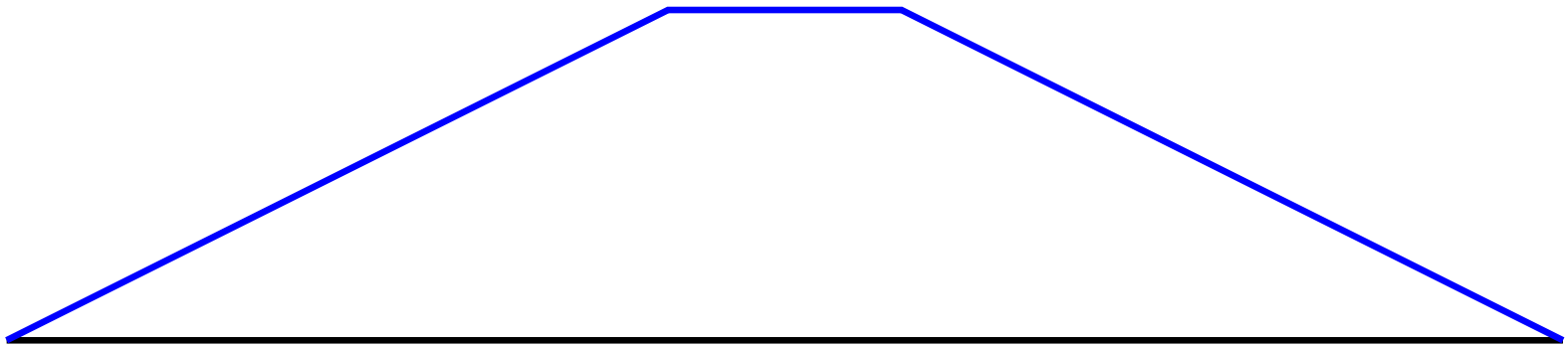

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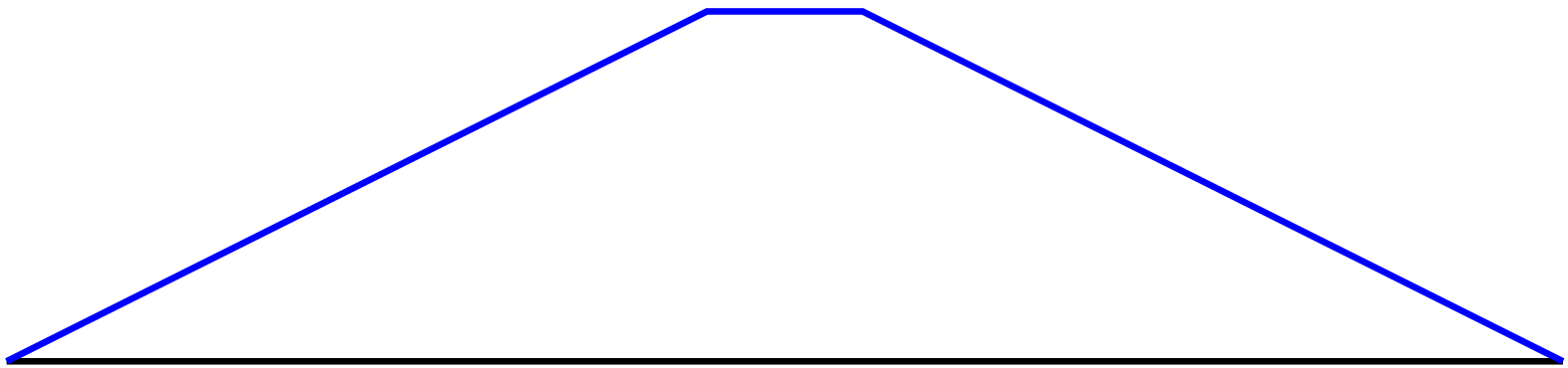

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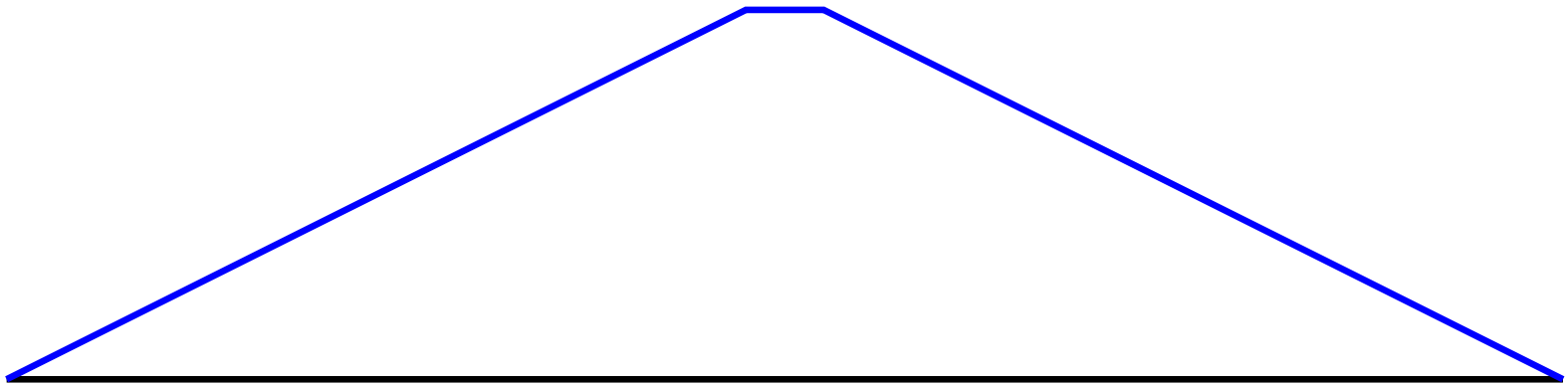

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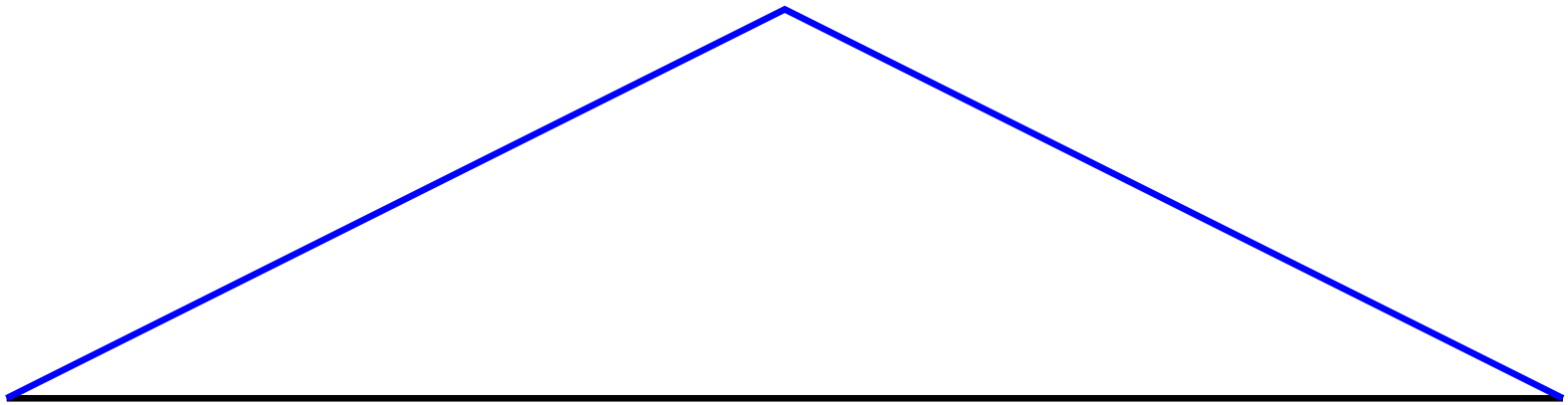

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There is a proposal to shift the course to the second semester - with one project each to be done over the next two semesters.

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- It is a bit early to tell whether the course is a really successful!

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- The language, combined with appropriate modules is sufficiently powerful for most applications.
- Once the art of coding has been mastered by the student, picking up another language is relatively easy.

Acknowledgements

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