

Automatic solving of physics word problems

Ruslan Popov, Nadiia Karpenko

Oles Honchar Dnipro National University (Ukraine)



Scientific Basis of the Project

Object: automatic word problem-solving.

Subject: automatic solving of physics word problems.

Methods: developed a program and algorithms to analyze PWP.

Link: <https://inanyan.pythonanywhere.com/>.

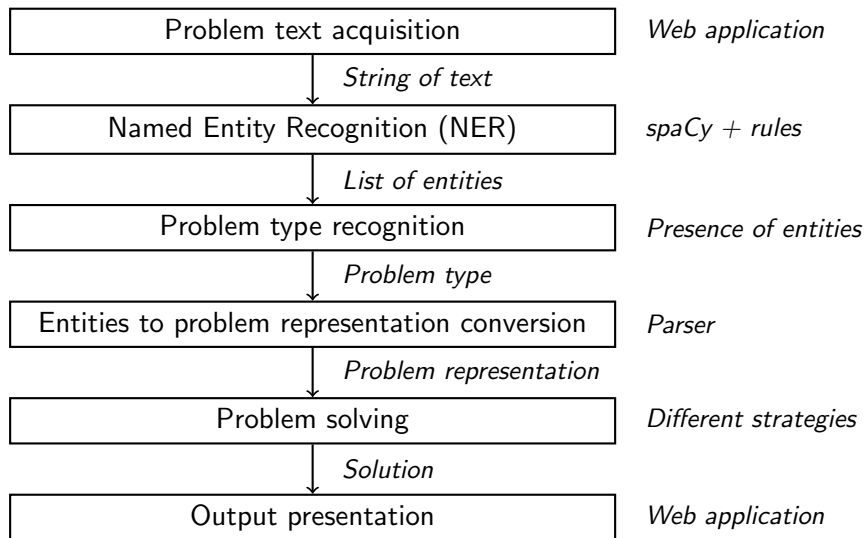
Technological stack:

- Python (*implementation*)
- spaCy (*NLP*)
- SymPy (*math*)
- Django (*web-framework*)
- MathJax (*L^AT_EX* output)
- Bootstrap CSS (*UI*)

The screenshot shows a web application titled "Physics word problem solver (basic)". It features a section for "Natural language input" with a text area labeled "Problem text:" and a green "Solve" button. Below this, there is a section titled "Try these examples:" which lists several physics problems as bullet points, such as "The car is traveling at a speed of 108 kilometers per hour. Represent this speed in meters per second." and "How many times will the speed of wave propagation increase if the wavelength increases by 3 times and the period of oscillation remains unchanged?".

Web-application

Our Algorithm: A Step-by-Step Approach



NER: The Foundation of Our Solution

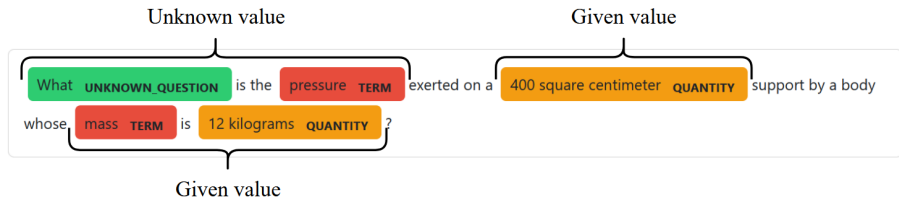
Entity Type	Examples
Units	meters, seconds, kilograms, kilometers per hour, Newtons
Quantities	10 meters, 30 seconds, 60 kilograms, 45 kilometers per hour, 100 Newtons
Terms	velocity, force, acceleration, work, energy, momentum
Question Words	what, determine, find, calculate, how much/many
...	

The car drove for 40 minutes **QUANTITY** at a speed **TERM** of 144 kilometers per hour **QUANTITY**. How far **UNKNOWN_HOW_QUESTION** did the car travel?

What **UNKNOWN_QUESTION** is the pressure **TERM** exerted on a 400 square centimeter **QUANTITY** support by a body whose mass **TERM** is 12 kilograms **QUANTITY**?

What **UNKNOWN_QUESTION** is the optical power **TERM** of a collecting **CONTEXT** lens with a focal length **TERM** of 40 centimeters **QUANTITY**?

Entity Conversion: Building a Problem Representation



Given values: $S = 400 \text{ cm}^2$, $m = 12 \text{ kg}$.

Unknown values: $p - ?$.

Finding the Path to the Solution: Student's POV

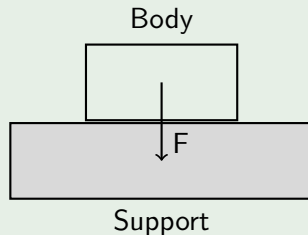
Problem

What is the *pressure* exerted on a **400 square centimeter** support by a body whose *mass* is **12 kilograms**?

Student's thought process

1. I need to find p .
2. Found a formula: $p = \frac{F}{S}$.
3. S is given.
4. F is not a given value.
5. Found a formula: $F = mg$.
6. g is a constant.
7. m is a given value
8. Now, I can apply $F = mg$!
9. Now, I can apply $p = \frac{F}{S}$!
10. Done!

Diagram



The program output

Givens:	Solution:
$S = 400 \text{ cm}^2$	$F = \frac{9.8mN}{\text{kg}} = \frac{9.8 \cdot 12.0\text{kgN}}{\text{kg}} = 117.6 \text{ N}$
$m = 12 \text{ kg}$	$p = \frac{F}{S} = 117.6\text{N}(400.0\text{cm}^2)^{-1} = 0.294 \frac{\text{N}}{\text{cm}^2}$
$p = ?$	Answer: $0.294 \frac{\text{N}}{\text{cm}^2}$.

Conclusions

Thanks for attention!

Additional information

Source code:

- https://github.com/InAnYan/physics_solver.
- https://github.com/InAnYan/physics_solver_web.

Paper:

<https://github.com/InAnYan/papers/blob/main/PhysicsSolver/Paper.pdf>.

Email: popov_ro@ffeks.dnu.edu.ua.

Authors

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