

Language

English

भाषा

Hindi

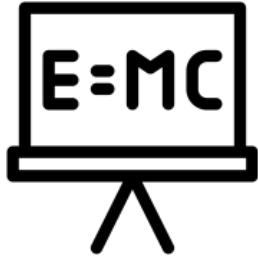
MathQA – A Mathematical Question Answering System

Search

खोज



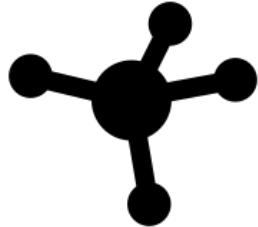
Overview



Concept Questions



Geometry Questions



Relationship Questions

$$\sqrt{\frac{x}{y}}$$

Formula Input



WIKIPEDIA
The Free Encyclopedia

arXiv.org



SimPy



Supervised Labeled Formula Data Query

```
# Find items with 'has part' (P527)      https://query.wikidata.org
'energy' (Q11379) and 'mass' (Q11423)
SELECT ?item ?itemLabel ?formula ?parts ?partsLabel
WHERE {
    ?item wdt:P527 wd:Q11379.          https://w.wiki/39RQ
    ?item wdt:P527 wd:Q11423.
    ?item wdt:P2534 ?formula.
    ?item wdt:P527 ?parts
SERVICE wikibase:label {
    bd:serviceParam wikibase:language "en". } }
```



SPARQL Query Language for RDF

<https://www.w3.org/TR/rdf-sparql-query>

Unsupervised Formula Labeling



WIKIPEDIA
The Free Encyclopedia

arXiv.org

EXAMPLE EVALUATION MODE 1 AND 4 RESULTS (FIRST TWO GOLDIDS) FOR IDENTIFIER SYMBOL-NAME RELATIONSHIP INDEX THAT WAS CREATED FROM THE NTCIR ARXIV 11/12 DATASET [6]. EXACT MATCH TO BENCHMARK SCORE 2 POINTS, ALSO RELEVANT RELATED RESULTS 1 POINT. THE LIST (MODES 1 AND 4) IS CONTINUED WITH 489 ADDITIONAL QUERIES (TOTAL 498) AND STRUCTURALLY IDENTICAL TO THE ONE FOR WIKIPEDIA (MODES 2 AND 5).

GoldID	Query	Benchmark	Matches	(Score, Rank)	DCG
310	a	acceleration	-	-	0
310	v	velocity	velocity, vector, speed	(2,2), (1,5), (1,10)	1,94
310	t	duration	time	(1,1)	1
310	acceleration	a	a, g	(2,1), (1,4)	1,69
310	velocity	v	v, c, V, u	(2,1), (1,2), (1,4), (1,5)	3,45
310	duration	t	τ	(1,3)	0,5
311	α	angular acceleration	-	-	0
311	ω	angular velocity	frequency, oscillator, harmonic	(1,1), (1,8), (1,9)	1,62
311	t	duration	time	(1,1)	1
312-375

EVALUATION MODE 1-15 RESULTS FOR FORMULA CONCEPT AND
IDENTIFIER NAME OR SYMBOL QUERIES USING ARXIV OR WIKIPEDIA
INDICES OR WIKIDATA SPAQRL QUERIES.

Mode	Query	Top1 Acc.	mean(DCG)
1	names to symbols, arXiv	0.24	0.82
2	names to symbols, Wikipedia	0.31	0.92
3	names to symbols, Wikidata	0.12	0.20
4	symbols to names, arXiv	0.37	0.79
5	symbols to names, Wikipedia	0.12	0.54
6	symbols to names, Wikidata	0.22	0.20
7	identifier names, arXiv	0.06	0.23
8	identifier names, Wikipedia	0.03	0.24
9	identifier names, Wikidata	0.85	0.98
10	identifier symbols, arXiv	0.00	0.00
11	identifier symbols, Wikipedia	0.24	0.98
12	identifier symbols, Wikidata	0.48	0.46
13	formula names, arXiv	0.00	0.00
14	formula names, Wikipedia	0.17	0.98
15	formula names, Wikidata	0.52	1.03

Query Mode Evaluation Results

$$DCG_p = \sum_{i=1}^p \frac{rel_i}{\log_2(i + 1)}$$

Comparison to commercial systems

MathQA

formula for speed

Search

$v = s/t$

Mathematical Question Answering System
(MathQA)

s (distance) t (duration)

Enter value Enter value

Submit

<https://mathqa.wmflabs.org>



WolframAlpha

Equation:

$v = a t$

v	speed
t	time
a	acceleration

Calculate: speed

» time:
1 s

» acceleration:
1 m/s²

Compute

<https://www.wolframalpha.com>

Google

s = speed

d = distance traveled $s = \frac{d}{t}$

t = time elapsed

<https://www.google.com>
English language

Comparison to commercial systems

QUERY RESULTS FOR FORMULA NAME QUESTIONS. FOR THE FIRST FIVE BENCHMARK EXAMPLES, THE FORMULA RETRIEVED BY MATHQA (BLUE) IS COMPARED TO THE RESULTS OF A COMMERCIAL KNOWLEDGE BASE (WOLFRAM ALPHA, PINK) AND SEARCH ENGINE (GOOGLE, LIME).

Query Concept Name	MathQA Formula	Wolfram Alpha Formula	Google Formula
acceleration	$a = dv/dt$	$v = at$	$\bar{a} = \Delta v/\Delta t$
angular acceleration	$\alpha = d\omega/dt$	$\omega = \alpha t$	$\alpha = \Delta\omega/\Delta t$
angular frequency	$\omega = 2\pi f$	$\nu = \omega/(2\pi)$	$\omega = 2\pi/t$
angular momentum	$L = r \times p$	$L = I\omega, \omega = 2\pi n$	$L = mvr$
angular velocity	$\omega = d\varphi/dt \cdot u$	$\omega = \alpha t$	$\omega = \Delta\theta/\Delta t$

Relevant	52%	48%	68% (58% boxed)
Calculation	80%	81%	2%

Demo Questions: Formula Concept Query

What is the formula for gas? Search

$PV = nRT$

T (temperature) R (gas constant)

Enter value 8.3144598

n (amount of substance)

Enter value Submit

Solution

P*V = 4.87e+03



Demo Questions: Geometry Query

what is the volume of a cube ? Search

$V = a^3$

a Source: www.wikidata.org/wiki/Q861555

Submit

Enter value

Demo Questions: Relationship Query

$$E = mc^2$$

c (speed of light) m (mass)

299792458 Enter value

Source: www.wikidata.org/wiki/Q35875

Demo Questions: Hindi Language

भाषा

Hindi ▾

पाइथागोरस प्रमेय के लिए फार्मूला क्या है ?

खोज

$c^2 = a^2 + b^2$

a b

Enter value Enter value

Source: www.wikidata.org

जमा करें

Demo Questions: Direct Formula Input

T = $\frac{\hbar c^3}{8\pi kGM}$

Search

$$T = \frac{\hbar c^3}{8\pi kGM}$$

G pi

Enter value Enter value

c k

Enter value Enter value

M hbar

Enter value Enter value

Submit



Future Work

