

Automated Development of Online Learning Systems by Using Predictive Methods and Large Language Models

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Outline

- 1 Sample Online System in PHP
- 2 Large Language Models
- 3 Automatically Generated Examples
- 4 Step-by-step Solutions
- 5 Conclusions

Motivation

Sample Online
System in
PHP

Large
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Figure: Scientific calculator

Login Page

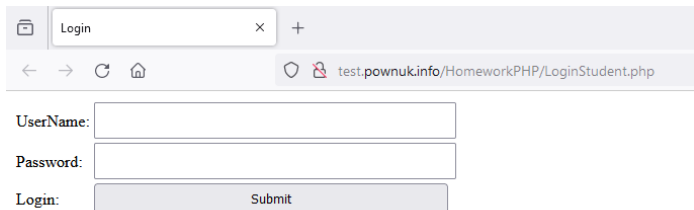
Sample Online
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The screenshot shows a web browser window with a single tab titled "Login". The address bar contains the URL "test.pownuk.info/HomeworkPHP/LoginStudent.php". Below the browser, there is a login form with the following elements:

- UserName:** A text input field.
- Password:** A password input field.
- Login:** A button labeled "Submit".

Figure: Test system in PHP

Main Page with the List of Assignments

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First Name:	FName1
Last Name:	LName1
CRN:	30434
COSC	1437
Class Description:	CS2
Time Login:	04/02/2024 05:50:31 pm
<input type="button" value="Logout"/>	

Homework List

Homework ID	Grade	Due Date	Link
Homework 1	0	2023-08-12	Link
Homework 2	0	2023-08-12	Link

Test List

Test ID	Grade	Due Date	Link
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Figure: Test system in PHP

Sample Assignment

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Homework02

First Name:	FName1
Last Name:	LName1
CRN:	30434
COSC	1437
Class Description:	CS2
Time Login:	04/02/2024 05:50:31 pm
Grade:	100
<input type="button" value="Logout"/> <input type="button" value="Move to the main page"/>	

Find the following integral:

$$\int_0^1 2x dx$$

<input type="text" value="1"/>	<input type="button" value="Submit the answer"/>
--------------------------------	--

Sample Assignment

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Find the solution of the wave equation

$$c^2 \frac{\partial^2 y}{\partial x^2} = \frac{\partial^2 y}{\partial t^2}$$

$$y(0, t) = 0, y(L, t) = 0$$

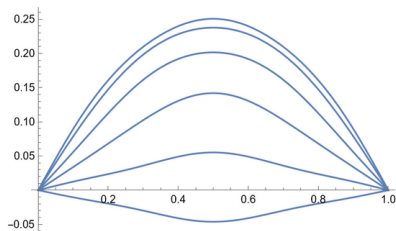
$$y(x, 0) = y_0 = x(L - x)$$

$$\frac{\partial y(x, 0)}{\partial t} = v_0(x) = 0$$

where $c = 1, L = 1$.

Find coefficients of the Fourier series

$$y(x, t) = \sum_{n=1}^{\infty} \sin\left(\frac{n\pi x}{L}\right) \left(A_n \cos\left(\frac{n\pi ct}{L}\right) + B_n \sin\left(\frac{n\pi ct}{L}\right) \right)$$



$A_1 =$

$A_2 =$

$A_3 =$

Submit answer

Distributed Computing

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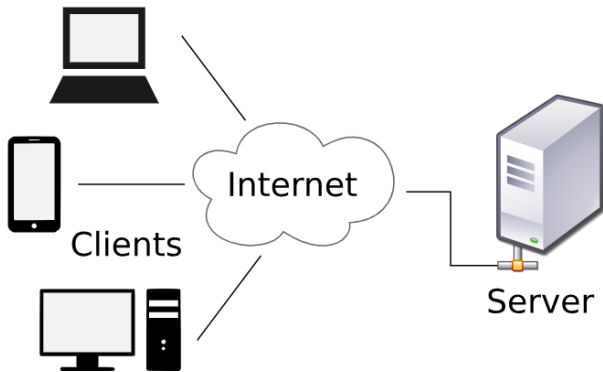


Figure: Online Assignments Are Distributed Programs Which Communicate Over The Internet

ChatGPT Used in Standardised Tests

Sample Online System in PHP

Large Language Models

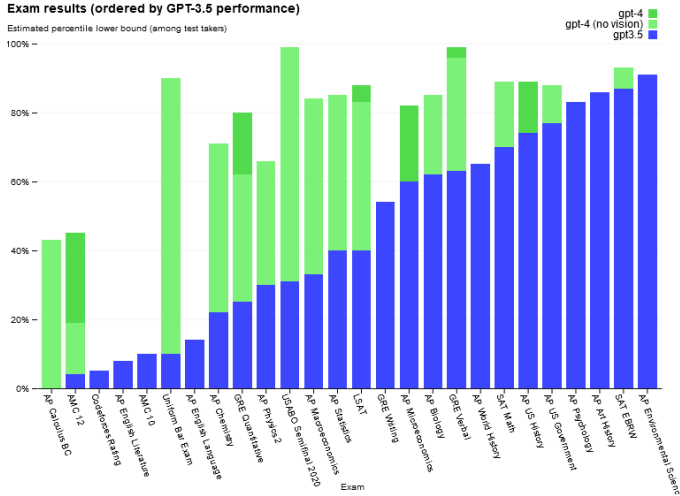
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Exam results (ordered by GPT-3.5 performance)

Estimated percentile lower bound (among test takers)



Google Gemini Used in Standardised Tests

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	Gemini Ultra	Gemini Pro	GPT-4	GPT-3.5	PaLM 2-L	Claude 2	Infection-2	Grok 1	LLAMA-2
MMLU Multiple-choice questions in 57 subjects (professional & academic) (Hendrycks et al., 2021a)	90.04% CoT@32*	79.13% CoT@8*	87.29% CoT@32 (via API**)	70% 5-shot	78.4% 5-shot	78.5% 5-shot CoT	79.6% 5-shot	73.0% 5-shot	68.0%***
	83.7% 5-shot	71.8% 5-shot	86.4% 5-shot (reported)						
GSM8K Grade-school math (Cobbe et al., 2021)	94.4% Maj1@32	86.5% Maj1@32	92.0% SFT & 5-shot CoT	57.1% 5-shot	80.0% 5-shot	88.0% 0-shot	81.4% 8-shot	62.9% 8-shot	56.8% 5-shot
MATH Math problems across 5 difficulty levels & 7 subdisciplines (Hendrycks et al., 2021b)	53.2% 4-shot	32.6% 4-shot	52.9% 4-shot (via API**)	34.1% 4-shot (via API**)	34.4% 4-shot	—	34.8%	23.9% 4-shot	13.5% 4-shot
			50.3% (Zhang et al., 2023)						
BIG-Bench-Hard Subset of hard BIG-bench tasks written as CoT problems (Srivastava et al., 2022)	83.6% 3-shot	75.0% 3-shot	83.1% 3-shot (via API**)	66.6% 3-shot (via API**)	77.7% 3-shot	—	—	—	51.2% 3-shot
HumanEval Python coding tasks (Chen et al., 2021)	74.4% 0-shot (IT)	67.7% 0-shot (IT)	67.0% 0-shot (reported)	48.1% 0-shot	—	70.0% 0-shot	44.5% 0-shot	63.2% 0-shot	29.9% 0-shot
Natural2Code Python code generation. (New held-out set with no leakage on web)	74.9% 0-shot	69.6% 0-shot	73.9% 0-shot (via API**)	62.3% 0-shot (via API**)	—	—	—	—	—
DROP Reading comprehension & arithmetic. (metric: F1-score) (Dua et al., 2019)	82.4 Variable shots	74.1 Variable shots	80.9 3-shot (reported)	64.1 3-shot	82.0 Variable shots	—	—	—	—
HellaSwag (validation set) Common-sense multiple choice questions (Zellers et al., 2019)	87.8% 10-shot	84.7% 10-shot	95.3% 10-shot (reported)	85.5% 10-shot	86.8% 10-shot	—	89.0% 10-shot	—	80.0%***
WMT23 Machine translation (metric: BLEURT) (Tom et al., 2023)	74.4 1-shot (IT)	71.7 1-shot	73.8 1-shot (via API**)	—	72.7 1-shot	—	—	—	—

Sample Assignments

Sample Online System in PHP

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You
write a code for bubble sort algorithm in c#

ChatGPT
Sure, here is an example of a bubble sort algorithm implemented in C#:

```
using System;

public class BubbleSortExample
{
    public static void Main()
    {
        int[] array = { 8, 2, 9, 4, 5, 6 };

        Console.WriteLine("Original array:");
        PrintArray(array);

        BubbleSort(array);

        Console.WriteLine("Sorted array:");
        PrintArray(array);
    }

    public static void BubbleSort(int[] arr)
    {
        int n = arr.Length;
        for (int i = 0; i < n - 1; i++)
        {
            for (int j = 0; j < n - 1 - i; j++)
            {
                if (arr[j] > arr[j + 1])
                {
                    // Swap arr[j] and arr[j+1]
                    int temp = arr[j];
                    arr[j] = arr[j + 1];
                    arr[j + 1] = temp;
                }
            }
        }
    }

    public static void PrintArray(int[] arr)
    {
        foreach (var item in arr)
        {
            Console.Write(item + " ");
        }
        Console.WriteLine();
    }
}
```

Sample Assignment

Sample Online System in PHP

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You

can you write quantum teleportation algorithm in Q#

ChatGPT

Certainly! Below is the implementation of the quantum teleportation algorithm in Q#:

```
qsharp Copy code
namespace QuantumTeleportation {
    operation TeleportationAlgorithm ( ) : Unit {
        // Allocate three qubits for Alice (source), Bob (destination), and the message qubit
        using ((alice, bob, message) = (Qubit(), Qubit(), Qubit())) {
            // Initialize the state to be teleported (in this case, a superposition state)
            H(alice);

            // Entangle Bob's qubit with the message qubit
            CNOT(message, bob);
            H(message);

            // Perform a Bell measurement on Alice's qubit and the message qubit
            // and store the results in classical bits
            let aResult = M(alice);
            let bResult = M(message);

            // Apply Pauli operations on Bob's qubit based on the measurement results
            if (bResult == One) {
                Z(bob);
            }
            if (aResult == One) {
                X(bob);
            }

            // Print the teleportation results
            Message("Teleportation complete. Bob's qubit state: " + Measure(bob));
        }
    }
}
```

Sample Assignment

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AI You

Find the equation of line that passes through the following points (0,0) and (1,1)

AI ChatGPT

To find the equation of a line passing through two points, we can use the point-slope form of the equation of a line. The point-slope form is given by:

$$y - y_1 = m(x - x_1)$$

where (x_1, y_1) are the coordinates of a point on the line, and m is the slope of the line.

Given the points (0,0) and (1,1), we can first calculate the slope m :

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$
$$m = \frac{1 - 0}{1 - 0}$$
$$m = 1$$

Now that we have the slope $m = 1$, we can choose either of the given points to plug into the point-slope form. Let's use (0,0) as (x_1, y_1) :

$$y - 0 = 1(x - 0)$$
$$y = x$$

Automatically Generated Reports in Latex

Sample Online
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Automated Examples Generated on HDD

Multiple Files

Sample Online
System in
PHP

Large
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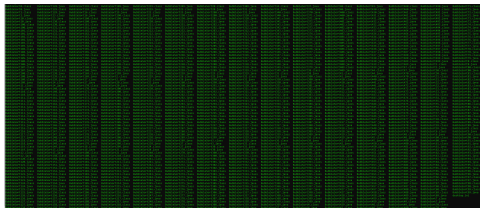
Automatically
Generated
Examples

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Description	Examples/second
Dell Precision 3610 with Xeon E5-1620	300
Dell Latitude 7420 with i5-1145G7	200
Macbook Pro M1	10000

Calculations done by using Python.



Automated Examples Generated in Memory (Single Block of Data)

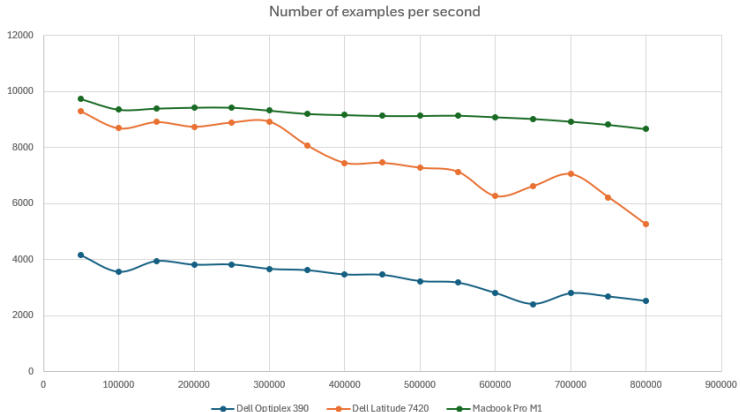
Sample Online
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Calculations done by using Python.

Automated Examples Generated in Memory

Single Block of Data

Sample Online
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Description	Examples/second
Dell Precision 3610 with Xeon E5-1620	35062.1
Dell Latitude 7420 with i5-1145G7	51721.2
Macbook Pro M1	42807.8

Calculations done by using C++.

Automatically Generated Examples Code

Sample Online System in PHP

Large Language Models

Automatically Generated Examples

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```
import java.util.*;

class BubbleSort0 {
    void bubbleSort(int arr[])
    {
        int n = arr.length;
        for (int i = 0; i < n - 1; i++)
            for (int j = 0; j < n - i - 1; j++)
                if (arr[j] > arr[j + 1]) {
                    // swap arr[j+1] and arr[j]
                    int temp = arr[j];
                    arr[j] = arr[j + 1];
                    arr[j + 1] = temp;
                }
    }

    /* Prints the array */
    static void printArray(int arr[])
    {
        int n = arr.length;
        for (int i = 0; i < n; ++i)
            System.out.print(arr[i] + " ");
        System.out.println();
    }

    // Driver method to test above
    public static void main(String args[]){
        int arr[] = { 8,13,18,15,39,22,5,3,16,27,41,33,6,46,36,28,38 };

        System.out.println("Given array is");
        printArray(arr);

        BubbleSort0 ob = new BubbleSort0();
        ob.bubbleSort(arr);

        System.out.println("\nSorted array");
        ob.printArray(arr);
    }
}
```

Automatically Generated Examples

500 Examples

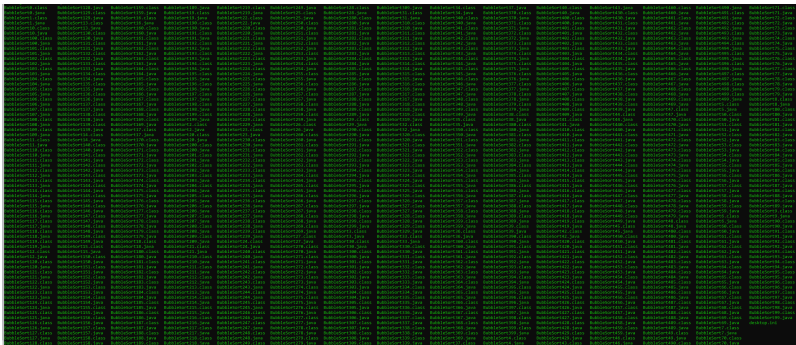
Sample Online
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Automatically Generated Examples

192 000 Examples

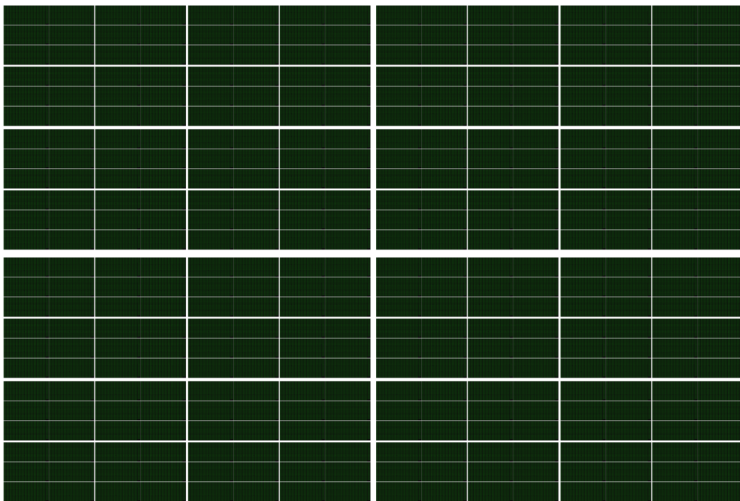
Sample Online
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Automatically Generated Examples

49 152 000 Examples

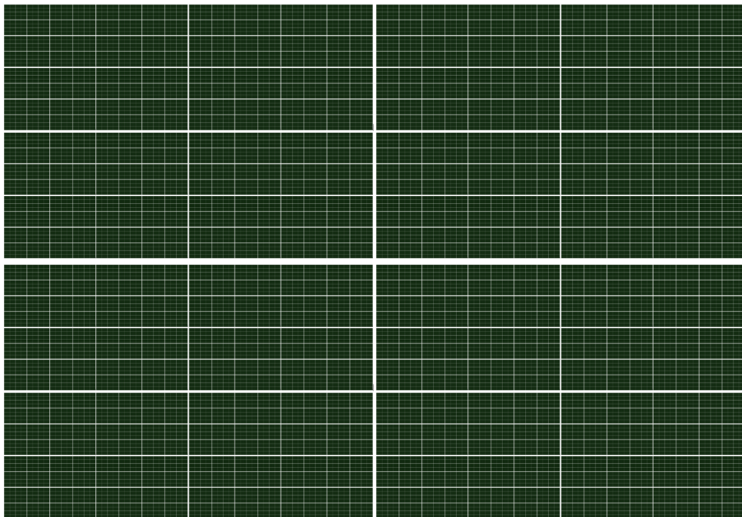
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Automatically Generated Examples

Time of Calculations

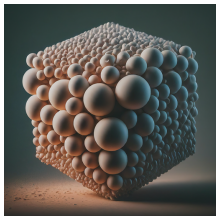
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50 000 000 examples.

Dell Precision 3610 with Xeon E5-1620

Time of calculations: 24 min

Number of examples per second: 35351.2

C++ code.

The library at UTEP has 1000000 books. Assuming that the book has 500 pages then it is necessary to use 8 hours to generate this amount of text.

Automatically Generated Directory Structure And Upload To The Server

Sample Online
System in
PHP

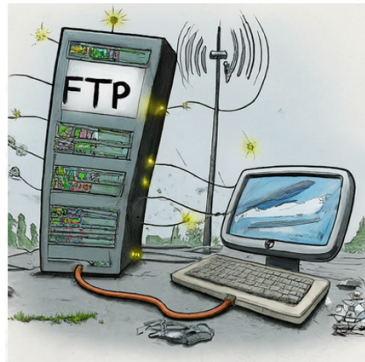
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- ▼ [Homework]
 - [Homework01]
 - [Homework02]
 - [Homework03]
 - [Homework04]
 - [Homework05]
 - [Homework06]
 - [Homework07]
 - [Homework08]
 - [Homework09]
 - [Homework10]
 - [Homework11]
 - [Homework12]
 - [Homework13]
 - [Homework14]
 - [Homework15]
 - [Homework16]
 - [Homework17]
 - [Homework18]
 - [Homework19]
 - [Homework20]



Automatic Database Update On The Server

Sample Online
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Automated Theorem Proving and Step-by-step Solutions

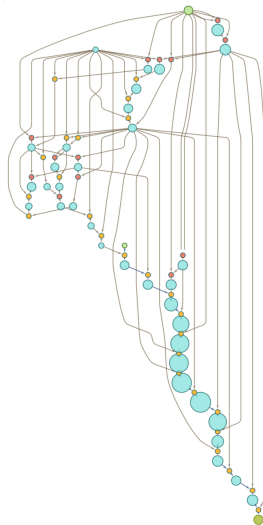
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AlphaGeometry

Step-by-step Solutions in Geometry

Sample Online
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IMO 2015 P3

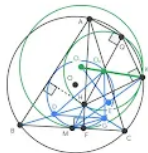
Let ABC be an acute triangle, H its orthocenter, and F the foot of the altitude from A . Let M be the midpoint of BC . Let Q be the point on (O) such that $QH \perp QA$ and let K be the point on (O) such that $KH \perp KQ$. Prove that the circumcircles (O_1) and (O_2) of triangles FKM and KQH are tangent to each other.



AlphaGeometry

Solution

```
[...]
Construct D: midpoint BH [a]
[a], O, midpoint HQ  $\Rightarrow$  BQ  $\parallel$  O1D [20]
[...]
Construct G: midpoint HC [b]
 $\angle GMD = \angle GO_1D \Rightarrow M, O_1, G, D$  cyclic [26]
[...]
[a], [b]  $\Rightarrow$  BC  $\parallel$  DG [30]
[...]
Construct E: midpoint MK [c]
[c]  $\Rightarrow \angle KFC = \angle KO_1E$  [104]
[...]
 $\angle FKO_1 = \angle FKO_2 \Rightarrow KO_1 \parallel KO_2$  [109]
[109]  $\Rightarrow O_1, O_1, K$  collinear  $\Rightarrow (O_1), (O_2)$  tangent
```



AlphaGeometry

Quality of the Solutions

Sample Online
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PHP

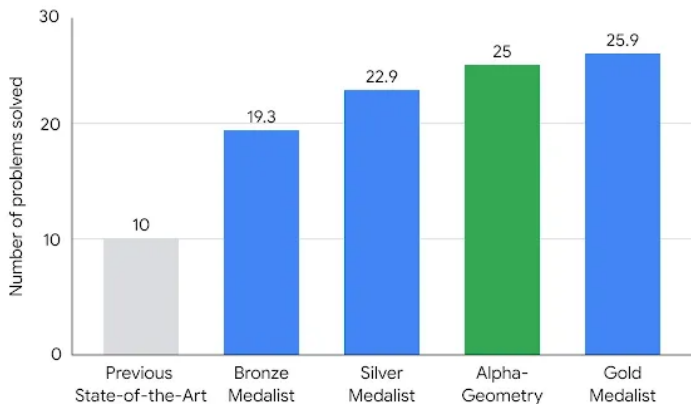
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Approaching the Olympiad gold-medalist standard



Automatically Generated Equilibrium Equations

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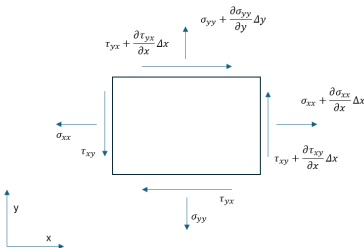
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$$-\sigma_{xx}\Delta y - \tau_{xy}\Delta x + \left(\sigma_{xx} + \frac{\partial\sigma_{xx}}{\partial x}\Delta x\right)\Delta y + \left(\tau_{xy} + \frac{\partial\tau_{xy}}{\partial y}\Delta y\right)\Delta x + \rho f_x\Delta x\Delta y = \rho\Delta x\Delta y a_x$$

After calculating limits

$$\frac{\partial\sigma_{xx}}{\partial x} + \frac{\partial\tau_{xy}}{\partial y} + \rho f_x = \rho a_x$$



Automatically Generated Problems in Engineering

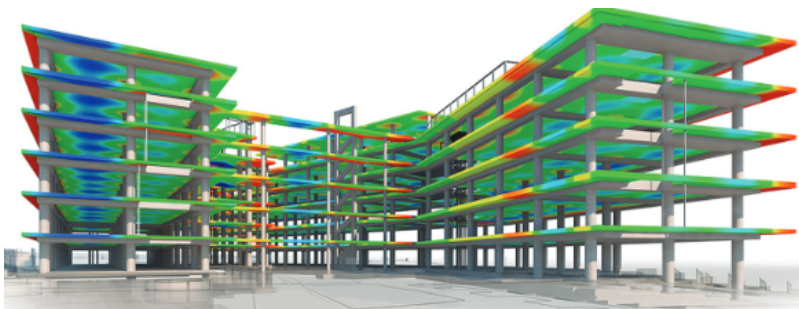
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Acknowledgments

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Conclusions

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Conclusions

- Online assignments are widely used in education.
- Online assignments are distributed programs which communicate with students and the server.
- By using Turing completed programming languages it is possible to describe wide range of scientific problems as online assignments.
- Large language models can be used as source of the solution of typical assignments.
- It is possible to fully automate some aspects of development of online assignments.

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Thank You