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Verification of Taylor's theorem

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Abstract. Multivariate function calculus is an important part of mathematical analysis courses, and most conclusions can be found and generalized in univariate calculus. However, the biggest difficulty in teaching multivariate calculus lies in its abstraction, such as Taylor's theorem, multiple integral regions drawing, and integral variable transformation. At the same time, ordinary differential equations are also one of the basic courses of the profession, and dynamic systems based on ordinary differential equations have extensive applications in mathematical models of continuity problems and optimal control problems. Software such as Mathematica, Python, Matlab, etc. can solve similar problems. Therefore, this article will use the visualization and computational capabilities of Mathematica to validate important definitions and conclusions in multivariate calculus, and compare the differences among the three software in solving approximate numerical solutions of dynamic systems of ordinary differential equations from different perspectives.

Keywords: Taylor's theorem for multivariate functions, integral transformations, ordinary differential equations, dynamic systems

1. Introduction

In differential calculus of one variable, we obtained$f(x) = \sum_{i=0}^{n} \frac{f^{(n)}(x_0)}{n!}(x - x_0)^n + R_{(n)}(x)$.By drawing a function image, it is not difficult for us to verify$\sin x = x + o(x^2)(x \to 0)$.Draw C1: y=x C2: y=sinx in the same Cartesian coordinate system, observe the neighborhood U (0, δ). When δ is not too large, the two function images basically overlap);Similarly, it can be verified that: $\sin x = x + \frac{1}{3!}x^3 + o(x^4)(x \to 0)$On this basis, it is extended to $\sin x = \sum_{i=0}^{n}(-1)^k \frac{x^{2k+1}}{(2k+1)!} + o(x^{2n+2})$However, the image verification of the binary Taylor theorem requires high spatial imagination, requiring the imagination of the three-dimensional form of the binary function image. Therefore, Mathematica's 3D drawing function can leverage its advantages. We first present Taylor's theorem for binary functions (Theorem 1.1) and use two common examples to gradually verify it.

2. Verification of Taylor's theorem

In Variable transformation of multiple integrals, the computational complexity of double integrals is often much greater than that of single definite integrals, but the transformation of integral variables can sometimes significantly reduce the computational complexity. [1] The common transformation methods in mathematical analysis include polar coordinate transformation, cylindrical coordinate transformation,

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and spherical coordinate transformation. Focusing on two types of transformations: A. polar coordinate transformations for double integrals and B. (generalized) spherical coordinate transformations for triple integrals. Based on Mathematica's strong drawing function, the integration area before and after coordinate transformation can be easily visualized when calculating double integrals using polar coordinates [2] (When the integration region is a circular domain or part of a circular domain, or the form of the integrated function is f(x^2+y^2), polar coordinate transformation is used).

For example, we first provide Theorem 4.1 on the polar coordinate transformation of double integrals: Theorem 4.1 (Integral Formula for Polar Coordinate Transformation) Let the bivariate function f be integrable on a bounded closed domain D, and under polar coordinate transformation, on the xy plane, bounded closed regions D corresponds to Δ on plane.

At the same time, double integrals can be transformed into cumulative integrals in polar coordinates [3]. A typical instance of this phenomenon is Polar Transformation Model - Vivianni, finding the volume of a sphere x^2+y^2+z^2≤R^2 cut by a cylindrical surface x^2+y^2=Rx. Several steps can be taken. Step 1 is overall drawing by using the command of ParametricPlot 3D. While the second step is partial drawing. The third step is more complicated [4]. From the symmetry of the obtained solid, we can know that simply calculate the volume in the first octant and multiply by 4 to obtain the volume of the obtained solid [5]. The solid in the first octant is a curved top cylinder, with its base being the area determined by y≥0 and x^2+y^2≤Rx in the xy plane. From the symmetry of the obtained solid, we can know that simply calculating the volume in the first octant and multiply by 4 to obtain the volume of the obtained solid is very feasible [6]. The solid in the first octant is a curved top cylinder, with its base being the area determined by y≥0 and x^2+y^2≤Rx in the xy plane. Therefore, the equation for the curved top is practical [7]. Among them, D={(x,y)}|y≥0,x^2+y^2≤Rx}, the integration region is shown in the following figure. The forth, saying, the last step, is that after using polar coordinate transformation, we can obtain The Theorem of Target Verified with Mathematica.

In this summer semester, the ninth group of students in the course was conducted for freshmen to sophomores [8]. The heated discussions and active cooperation in quality development education played a significant role in helping us develop our personal abilities both physically and mentally [9]. In the quality expansion education held by the school, students actively participate and listen attentively, which not only broadens their horizons but also enhances their abilities, laying a good foundation for future development [10].

In the process of practical quality development education, the five classes per week are very fulfilling and full of resources. Through free group discussions, we have honed the teamwork ability of college students. At the same time, our ninth group also named the team and designed a logo and slogan with a unique meaning of slowly advancing, surpassing oneself, and contributing to the development of the world. We also presented it on stage and designed a preliminary questionnaire to investigate the cognitive situation of college students in society towards quality expansion education, In this process, I also developed my psychological qualities of not being afraid of others and my ability to communicate with others; After a brilliant and humorous group presentation, college students walked into Shanghai's through a video. All kinds of vocal and emotional performances also deeply touched the hearts exercised the students' ability to practice and innovate, and stimulated the development of culture, art, and body and mind; Continuing the richness and excitement of the next lesson with a strong sense. I experienced the profound connotations past and present. Through watching videos and listening to the teacher's vivid explanations [11].

In terms of suggestions, college students in today's era are gradually lost in the turmoil of society, becoming insignificant waves in the "post wave" and unable to find specific future development directions. At this time, the quality expansion education for college students is particularly important. Through various forms of education, college students' abilities in social practice and volunteer service, academic technology, innovation and entrepreneurship, club activities, and social work can be exercised [12], enabling them to better understand themselves and the world in the times, find specific career development directions, and more efficiently assist in the development of society. With the continuous improvement of psychological, moral, ideological, political, physical [13], and labor qualities in the

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process of quality expansion education, college students can also establish a sense of justice and responsibility in this rapidly developing era, enhance their ability to withstand setbacks and overcome difficulties, and face everything unknown and beautiful in the future [14].

Namely, theorem 4.2 (Integral Formula for Spherical Coordinate Transformation). When the function satisfies the generalization of Theorem 4.1, then there is the calculation I =∭zdxdydz, where V is the area intersected by x^2/4 +y^2/9 +z^2/1 ≤ 1and z ≥ 0.

Similar to the previous instance, Step 1 is to draw the integration region before spherical coordinate transformation. Then step 2 is to combine the examples. According to Theorem 4.2 [15], we can perform a generalized spherical coordinate transformation and draw the integration region after the spherical coordinate transformation. Though seemingly a little bit complicated, step 3 is using Mathematica to solve the cumulative integration above. In specific, for ease of verification and drawing, we take a=2, b=3, c=1, then draw the integration area before the spherical coordinate transformation, as shown in the following figure presented on the known web [16]. According to Theorem 4.2, perform a generalized spherical coordinate transformation and draw the integration region after the spherical coordinate transformation, as shown in the following figure equation. I =∭zdxdydz, where V is the area intersected byx^2/4 +y^2/9 +z^2/1 ≤ 1and z ≥ 0. By the way, we can use Mathematica to solve the cumulative integration above.

Calculus with variable functions is an important part of mathematical analysis courses, and most conclusions can be found and generalized in univariate calculus. However, the biggest difficulty in teaching multivariate calculus lies in its abstraction, such as Taylor's theorem, multiple integral product partition city drawing, integral variable transformation, etc. [17].

However, just to mention, Mathematica is not suitable for juice calculation, including multiple things like a square or square containing initial conditions or other constraints [18]. The calculations suitable for Mathematica include groups like conventional equations and systems referring to those without initial conditions. It is not possible to manually convert into n-fold integrals with repeated integrals, or other constraints [19]. Based on practical mathematical problems with things like optimal control problems, topics of two one parameter integrals, uses are converted into three after repeated integrals, double integral [20]. Using the code provided to solve the newly released MMA. The three Basic Algebraic Calculation with Parameters which is suitable for utilizing its own internal functions is useful, too. There is also conventional use of intelligent graphics, text boxes, shapes, and arrangement applications.

Now, let's dig deep into the topics.

Theorem 1.1 (Taylor's Theorem)

If the function f is at point $P_0(x_0, y_0)$ If there is a continuous partial derivative of order n+1 on a neighborhood $U(P_0)$ of $(x_0 + h, y_0 + h)$, then for any point on $U(P_0)(x_0 + h, y_0 + h)$, there is a corresponding$\theta \in(0,1)$,such that$f(x_0 + h, y_0 + h) = \sum_{i=0}^{n} C_n^i \frac{\partial^n}{\partial x^i \partial y^{n-i}} f(x_0, y_0) h^i k^{n-i}$

Example 1.1:

Verify that the Maclaurin series of the binary function $f(x_0, y_0) = \ln(1 + x + y)$ is $\sum_{i=0}^{\infty}(-1)^{p-1}\frac{(x+y)^p}{p}$. By drawing an image with f (x, y)=ln (1+x+y), where x, y ∈ (0,5); And according to Taylor's theorem (Theorem 1.1). Compare the image with f (x, y)=ln (1+x+y) and draw f (x, y)=x+y in a three-dimensional space.

```
Show1=Plot3D[Log[1+x+y],{x,0,5},{y,0,5}, PlotStyle→RGBColor[0.1,0.8,0.2]];
Show2=Plot3D[x+y,{x,0,5},{y,0,5}];
Show [show1, show2]
```

We can easily find the binary function at the origin, the image of f (x, y)=ln (1+x+y) and f (x, y)=x+y almost coincident, which validates Taylor's theorem ln (1+x+y)=x+y+o, where o is an infinitesimal quantity. According to Theorem 1.1, our conjecture the image of $f(x, y) = x + y - \frac{(x+y)^2}{2}$ at the origin of the original function should be closer to that of the function f (x, y)=x+y, which satisfies $\ln(1 + x +$

$y) = x + y - \frac{(x+y)^2}{2} + o$,Where o is an infinitesimal quantity. Therefore, we will draw the image of f (x, y)=ln (1+x+y) and $f(x,y) = x + y - \frac{(x+y)^2}{2}$ in a three-dimensional space.

Show1=Plot3D[Log[1+x+y],{x,0,5},{y,0,5}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y - \frac{(x+y)^2}{2}$,{x,0,5},{y,0,5}];

Show [show1, show2]

From Figure 3, it can be observed that in the rectangular region of $(0,1] \times (0,1]$, the images of the two functions almost coincide, and at this point they still follow the trend described in Theorem 1.1, i.e $\ln(1 + x + y) = x + y - \frac{(x+y)^2}{2} + o$, where o is an infinitesimal quantity. We continue to combine the image of f (x, y)=ln (1+x+y) with Theorem 1.1. $f(x,y) = x + y - \frac{(x+y)^2}{2} + \frac{(x+y)^3}{3}$. Draw in a three-dimensional space and observe the difference between the two functions near the origin. Ideally, the situation should be closer to Figure 3 and the fitting range should be larger than Figure 3 [21].

Show1=Plot3D[Log[1+x+y],{x,0,5},{y,0,5}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y - \frac{(x+y)^2}{2} + \frac{(x+y)^3}{3}$,{x,0,5},{y,0,5}];

Show [show1, show2]

From Figure 4, we can see that in the rectangular region of $(0,2] \times (0,2]$ the images of the two functions almost overlap, which is consistent with our conjecture made before the fourth step of the experiment, and also means that theorem 1.1 is still met. At this point, we can obtain $\ln(1 + x + y) = x + y - \frac{(x+y)^2}{2} + \frac{(x+y)^3}{3} + o$. Due to the impossibility of infinite validation and the fact that the two function images almost completely coincide at the origin, we conducted our final experiment on this issue [22]. On the basis of step four, continuously increase the expansion by two orders to verify the correctness of Theorem 1.1. In this step, we will draw the image of f (x, y)=ln (1+x+y) and$f(x,y) = x + y - \frac{(x+y)^2}{2} + \frac{(x+y)^3}{3} - \frac{(x+y)^4}{4} + \frac{(x+y)^5}{5}$in a three-dimensional space.

Show1=Plot3D[Log[1+x+y],{x,0,5},{y,0,5}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y - \frac{(x+y)^2}{2} + \frac{(x+y)^3}{3} - \frac{(x+y)^4}{4} + \frac{(x+y)^5}{5}$,{x,0,5},{y,0,5}];

Show [show1, show2]

Example 1.2:

Verify that the Maclaurin series of the binary function $f(x,y) = sin(x + y)$ is $\sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!}(x + y)^{2n+1}$. Draw an image with f (x, y)=sin (x+y), where x, y ∈ (− 2 π, 2 π)

Plot3D[Sin[x+y],{x,-2π,2π},{y,-2π,2π}]

According to Taylor's theorem (Theorem 1.1), draw an image of f (x, y)=sin (x+y) and an image of f (x, y)=x+y in a three-dimensional space

Show1=Plot3D[Sin[x+y],{x,-2π,2π},{y,-2π,2π}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y$,{x,-2π,2π},{y,-2π,2π}];

Show[show1,show2]

We can easily find the binary function at the origin, the image of f (x, y)=sin (x+y) almost coincides with f (x, y)=x+y, which verifies Taylor's theorem Sin (x+y)=x+y+o, where o is an infinitesimal quantity. According to Theorem 1.1, our conjecture F (x, y)=x+y − (x+y)/3^ The image at the origin of the original function should be closer to the function f (x, y)=x+y, which satisfies Sin (x+y)=x+y+o, where o is an infinitesimal quantity. Therefore, we compare the image of f (x, y)=sin (x+y) with $f(x,y) = x + y - \frac{(x+y)^3}{3!}$ The image of 3 is drawn in a three-dimensional space.

Show1=Plot3D[Sin[x+y],{x,-2π,2π},{y,-2π,2π}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y - \frac{(x+y)^3}{\text{Factorial[3]}}$,{x,-2π,2π},{y,-2π,2π}];

Show[show1,show2]

From Figure 8, it can be observed that in the rectangular area near the origin, the images of the two functions almost overlap, and at this point, they still follow the trend described in Theorem 1.1, which satisfies $\sin(x+y) = x + y - \frac{(x+y)^3}{3!} + o$ Where o is an infinitesimal quantity. We continue to apply Theorem 1.1 to the image with f (x, y)=sin (x+y) and $f(x,y) = x + y - \frac{(x+y)^3}{3!} + \frac{(x+y)^5}{5!}$ The image of 5 is drawn in a three-dimensional space, and when observing the difference between two functions near the origin, the ideal situation should be closer to the situation in Figure 8, and the fitting area should be larger than that in Figure 3.

Show1=Plot3D[Sin[x+y],{x,-2π,2π},{y,-2π,2π}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y - \frac{(x+y)^3}{\text{Factorial}[3]} + \frac{(x+y)^5}{\text{Factorial}[5]}$,{x,-2π,2π},{y,-2π,2π}];

Show[show1,show2]

The image of f (x, y)=sin (x+y) and $f(x,y) = x + y - \frac{(x+y)^3}{3!} + \frac{(x+y)^5}{5!}$ Through Figure 9, we can see that in the rectangular area near the origin, the two function images almost overlap, which is consistent with our conjecture made before the fourth step of the experiment, and also means that theorem 1.1 is still met. At this point, we can obtain $\sin(x+y) = x + y - \frac{(x+y)^3}{3!} + \frac{(x+y)^5}{5!} + o$. The two function images have almost completely overlapped at the origin, so we will conduct our final experiment on this problem. On the basis of step four, continuously increase the expansion by two orders to verify the correctness of Theorem 1.1. In this step, we will combine f (x, y)=sin (x+y) with $f(x,y) = x + y - \frac{(x+y)^3}{3!} + \frac{(x+y)^5}{5!} - \frac{(x+y)^7}{7!} + \frac{(x+y)^9}{9!}$ The image of 9 is drawn in a three-dimensional space.$\sin(x+y) = x + y - \frac{(x+y)^3}{3!} + \frac{(x+y)^5}{5!} + o$

Show1=Plot3D[Sin[x+y],{x,-2π,2π},{y,-2π,2π}, PlotStyle→RGBColor[0.1,0.8,0.2]];

Show2=Plot3D[$x + y - \frac{(x+y)^3}{\text{Factorial}[3]} + \frac{(x+y)^5}{\text{Factorial}[5]} - \frac{(x+y)^7}{\text{Factorial}[7]} + \frac{(x+y)^9}{\text{Factorial}[9]}$,{x,-2π,2π},{y,-2π,2π}];

Show [show1, show2]

At the same time, ordinary differential equations are also one of the basic courses of the profession, and dynamic systems based on ordinary differential equations have extensive applications in mathematical models of continuity problems and optimal control problems. Software such as Mathematica, Python, Matlab, etc can solve similar problems. Therefore, this group will use the visualization and computational capabilities of Mathematica to validate important definitions and conclusions in multivariate calculus, and compare the differences among the three software in solving approximate numerical solutions of dynamic systems of ordinary differential equations from different perspectives such as Multivariate Functions, Taylor Theorem, Integral Transformation, Ordinary Differential Equations and Dynamic Systems [24]. This small but fine section will focus on the sufficient and necessary conditions for the unconditional extreme determination of binary Western numbers. In the classroom of mathematical analysis and other program concerning mathematical analysis and the practical use of it, more emphasis is placed on theoretical derivation, which is derived from the Taylor formula of multivariate functions and has a certain degree of abstraction. However, Mathematica can visualize the images of binary functions in three-dimensional space, thus visually verifying whether the necessary and sufficient conditions for extreme values are valid, and enhancing students' ability to calculate unconditional extreme values. In places like verification of the Independence of Green's Formula and Integration Path, the section validates an important formula that can transform domain integrals into integrals on domain boundaries - the Green formula, and builds a bridge between double integrals and second type curve integrals [25]. At the same time, four equivalent propositions that are independent of the integration path for curve integrals were verified, so this section serves as an important chapter for transitioning to multiple integrals like the dynamic system of ordinary differential equations in solving continuity problems. Widely used, this section will use Mathematica, MATLAB, and Python to complete two experimental tasks: the first one is solving an approximate numerical

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solution and image of a dynamic system with practical significance. The second one is basing on the dynamic system, to solve an optimization model with practical significance. In the first four parts, Mathematica exploited its powerful potential. In this section, we will compare the differences between three languages in solving the same problem by solving the two experimental tasks mentioned above, and discover the weaker side of Mathematica [26]. Like Advantages and disadvantages, 2D and 3D image rendering complex analytical calculations, it is necessary to use the function limit value of Taylor's formula with simple symbol calculation and numerical calculation of complex systems. (A system of ordinary differential equations with a large number of equations is inferior to MATLAB). Numerical calculation can also be used. (A single ordinary differential equation is better than MATLAB). The solution format for partial differential equations is more convenient.

3. Conclusion

It is evident that the green and orange surfaces intersect near the origin and almost completely coincide, which fully conforms to the equation given in Theorem 1.1. Based on the above analysis, we can conclude that: The Maclaurin series of a binary function f(x,y)=ln(1+x+y) is $\sum_{i=0}^{\infty}(-1)^{p-1}\frac{(x+y)^p}{p}$ Meanwhile, Example 1.1 indirectly verifies Theorem 1.1.Observing Figure 10, we found that the conclusion is very obvious that the surface has undergone large areas of almost complete overlap, which fully conforms to the equation given in Theorem 1.1. Based on the above analysis, we can conclude that: The binary function f (x, y)=sin (x+y) Maclaurin series is $\sum_{n=0}^{\infty}\frac{(-1)^n}{(2n+1)!}(x+y)^{2n+1}$, and Example 1.2 indirectly verifies Theorem 1.1.

References

[1] Li Wei, Zhu Luyao & Cambria Erik. (2021). Taylor's theorem: A new perspective for neural tensor networks. Knowledge-Based Systems.

[2] Ali Ahmed Mohammed, Abdullah Herish Omer & Saleh Gashaw Aziz Mohammed. (2022). Hosoya polynomials and Wiener indices of carbon nanotubes using mathematica programming. Journal of Discrete Mathematical Sciences and Cryptography (1), 147-158.

[3] Khemane Thabiso, Padayachee Pragashni & Shaw Corrinne. (2023). Exploring the complexities of swapping the order of integration in double integrals. International Journal of Mathematical Education in Science and Technology (9), 1907-1927.

[4] Ferreira Chelo, López José L. & Pérez Sinusía Ester. (2023). A convergent version of Watson's lemma for double integrals. Integral Transforms and Special Functions (3), 196-210.

[5] Amin Zahurul & Sharif Sazzad Bin. (2022). Use of integration to calculate the magnetic field in a space by using mathematica software for the effective production of nano-particles. Journal of Interdisciplinary Mathematics (7), 2007-2017.

[6] Arkhipov I. A., Movsesyan S. O., Khalikov S. S., Khakina E. A., Varlamova A. I., Khalikov M. S. & Ilyin M. M.. (2023). Influence of Different Methods of Obtaining Solid Dispersions and Crystals of Fenbendazole on Biological Activity. Biology Bulletin (4), 500-508.

[7] Mysak Yosyf, Pona Ostap, Shapoval Stepan, Kuznetsova Marta & Kovalenko Tetiana. (2017). Evaluation of energy efficiency of solar roofing using mathematical and experimental research. Eastern-European Journal of Enterprise Technologies (8 (87)), 26-32.

[8] Wang Zi Yang, Song Jie & Feng Xing Lin. (2022). A prediction model of patient satisfaction: policy evaluation and sensitivity analysis. Flexible Services and Manufacturing Journal (2), 455-486.

[9] E de Doncker & F Yuasa. (2017). Feynman loop numerical integral expansions for 3-loop vertex diagrams. Procedia Computer Science 1773-1782.

[10] M. Maniatis. (2018). Application of the Feynman-tree theorem together with BCFW recursion relations. International Journal of Modern Physics A (7), 83-172.

DOI: 10.54254/2753-8818/43/20241022

[11] Yamazaki Kazuo. (2020). A note on the applications of Wick products and Feynman diagrams in the study of singular partial differential equations. Journal of Computational and Applied Mathematics (prepublish), 113-338.
[12] Aguilera Verdugo J. Jesús, Hernández Pinto Roger J., Rodrigo Germán, Sborlini German F. R. & Torres Bobadilla William J.(2021). Causal representation of multi-loop Feynman integrands within the loop-tree duality. Journal of High Energy Physics (1) ,11-33.
[13] (2020). Mathematics - Computational Geometry; Research Data from University of Aveiro Update Understanding of Computational Geometry (An Exploration of Locally Spherical Regular Hypertopes). News of Science.
[14] Hoback Sarah & Parikh Sarthak. (2021). Towards Feynman rules for conformal blocks. Journal of High Energy Physics (1),256-658.
[15] Le Chen, Yaozhong Hu & David Nualart. (2017). Two-point Correlation Function and Feynman-Kac Formula for the Stochastic Heat Equation. Potential Analysis (4), 779-797.
[16] Abreu Samuel, Britto Ruth, Duhr Claude & Gardi Einan. (2017). Algebraic Structure of Cut Feynman Integrals and the Diagrammatic Coaction. Physical review letters (5), 051601.
[17] Bourjaily Jacob L., Hannesdottir Holmfridur, McLeod Andrew J., Schwartz Matthew D. & Vergu Cristian. (2021). Sequential discontinuities of Feynman integrals and the monodromy group. Journal of High Energy Physics (1),532-653.
[18] Mauro Marco Di, De Luca Roberto, Esposito Salvatore & Naddeo Adele. (2021). Some insight into Feynman's approach to electromagnetism. European Journal of Physics (2), 25-206.
[19] (2021). Improved computation in terms of accuracy and speed of LTI system response with arbitrary input. Mechanical Systems and Signal Processing 107252-107521.
[20] Hai Cao & Yaoqing Gong. (2021). The torsional centre position of stocky beams with arbitrary noncircular cross-sectional shapes and with arbitrary elastic material properties. European Journal of Mechanics / A Solids (prepublish), 72-521.
[21] Joeun Jung. (2017). Iterated trilinear Fourier integrals with arbitrary symbols. Journal of Functional Analysis (10), 3027-3060.
[22] Ouail Ouchetto, Brahim Essakhi, Said Jai-Andaloussi & Saad Zaamoun. (2018). Handling periodic boundary conditions on arbitrary mesh. IET Microwaves, Antennas & Propagation (8), 1266-1272.
[23] (2013). General Science; Studies from University College London Have Provided New Information about General Science. Science Letter.
[24] Liujun Xu & Jiping Huang. (2018). A transformation theory for camouflaging arbitrary heat sources. Physics Letters A (46), 3313-3316.
[25] Nikolaos S. Papageorgiou, Vicenţiu D. Rădulescu & Dušan D. Repovš. (2018). Double-phase problems with reaction of arbitrary growth. Zeitschrift für angewandte Mathematik und Physik (4), 1-21.
[26] Marcin Mińkowski & Magdalena A Załuska-Kotur. (2018). Collective diffusion of dense adsorbate at surfaces of arbitrary geometry. Journal of Statistical Mechanics: Theory and Experiment (5), 053208-053208.