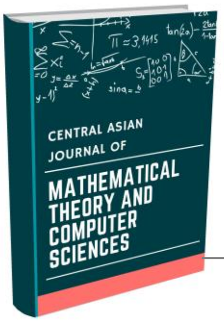

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Using Maple Programs in Higher Mathematics. Triangle Problem Constructed on Vectors in Space

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Abstract:

Today it is important to use advanced information technologies in the study of subjects taught in higher educational institutions [1]. It is shown that the use of modern software Maple in research and solving problems in higher mathematics is effective and efficient. Mathematisation technical sciences can be characterized as consistent expansion and complication of the mathematical apparatus and methods used in engineering. Engineering studies are largely dependent on the choice of the mathematical apparatus and the accuracy of such decisions carried out, which would be adequate to the task.

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Introduction

Reducing the hours of lectures and practical classes in teaching higher mathematics in higher technical educational institutions creates problems in the quality and timely assimilation of topics. The potential of the Maple system with the systematic use of information technologies to overcome these problems is great [1].

The Malpe system can be used for fast and accurate, high-quality problem-solving in the sections of analytical geometry and mathematical analysis of higher mathematics, as well as the ability to create animated graphics, figures in 2D and 3D formats [4].

The three-part textbook "Solving the problems of higher mathematics according to the Malpe program" and the two-part textbook "Solving the problems of analytical geometry in the Maple system", created by M.E. Mirzakarimov and published on the basis of a certificate from the Ministry of Higher Education. Textbooks are useful for students and teachers [1,2,3].

There are several ways to solve the triangle problem in the Maple system, which includes operations with given vectors in space [2].

1.In space, the points A (3; 0; 0), B (–2; 4; 1), C (2; 3; 2) are specified.

Need to find:

1) *coordinates and lengths of vectors* $\overrightarrow{AB}, \overrightarrow{AC}, \overrightarrow{AD}$;

2) *construct the projections of the vector* $\overrightarrow{AB}$ *on the coordinate axes;*

3) *reference cosines of* $\overrightarrow{AB}$ *vector;*

4) $\overrightarrow{AB}$ *and* $\overrightarrow{AC}$ *the scalar product of vectors;*

5) $\overrightarrow{AB}$ *and* $\overrightarrow{AC}$ *the angle between the vectors;*

6) $\overrightarrow{AH}$ *height and* $\overrightarrow{AM}$ *bisector;*

7) *the point E and the median* $\overrightarrow{AE}$ *vector in the middle of the section BC;*

8) *projection of the median* $\overrightarrow{AE}$ *vector on the* $\overrightarrow{AC}$ *vector;*

9) *ABC triangle perimeter;*

10) *the face of the triangle ABC;*

11) *Construct the triangle ABC.*

2. Analytical solutions to the above problems can be found in a number of publications [2-7]. Solve the problem of determining and constructing a triangle using vectors given the coordinates of the ends in space on the basis of the Maple program [8-16].

Maple software:

> restart; with(plottools): with(plots):

> with(Physics:-Vectors):

Coordinates of triangular ends:

> x1:=-1: y1:=-2:z1:=3: x2:=5: y2:=6:z2:=12:

x3:=4: y3:=-6: z3:=-2: x4:=2: y4:=3: z4:=18:

Determining the $\overrightarrow{AB}$ *vector:*

> VAB:={x2-x1,y2-y1,z2-z1}; $VAB := \{6, 8, 9\}$

> VAB:= (x2-x1)* _i + (y2-y1)* _j + (z2-z1)* _k;

$VAB := 6\ \_i + 8\ \_j + 9\ \_k$

> UAB:=Norm(VAB); $UAB := \sqrt{181}$

Determining the direction of the $\overrightarrow{AB}$ *vector:*

> cos(alpha):=(x2-x1)/UAB; $\cos(\alpha) := \frac{6}{181}\sqrt{181}$

> evalf(arccos((x2-x1)/UAB),4)*180/3.14; 63.57324840

> cos(beta):=(y2-y1)/UAB; $\cos(\beta) := \frac{8}{181}\sqrt{181}$

> evalf(arccos((y2-y1)/UAB),4)*180/3.14; 53.5528662

> cos(gamma):=(z2-z1)/UAB; $\cos(\gamma) := \frac{9}{181}\sqrt{181}$

> evalf(arccos((z2-z1)/UAB),4)*180/3.14; 48.0554140

Determining the direction of the $\overrightarrow{AC}$ *vector:*

> VAC:={x3-x1,y3-y1,z3-z1}; $VAC := \{-5, -4, 5\}$

> VAC:= (x3-x1)* _i + (y3-y1)* _j + (z3-z1)* _k;

$VAC := 5\_i - 4\_j - 5\_k$

> UAC:=Norm(VAC); $UAC := \sqrt{66}$

> cos(alpha):=(x3-x1)/UAC; $\cos(\alpha) := \frac{5}{66}\sqrt{66}$

cos(beta):=(y3-y1)/UAC; $\cos(\beta) := -\frac{2}{33}\sqrt{66}$

cos(gamma):=(z3-z1)/UAC; $\cos(\gamma) := -\frac{5}{66}\sqrt{66}$

Determine the $\overrightarrow{BC}$ *vector and direction:*

> VBC:={x3-x2,y3-y2,z3-z2}; $VBC := \{-14, -12, -1\}$

>VBC:= (x3-x2)* _i + (y3-y2)* _j + (z3-z2)* _k;

$VBC := -\_i - 12\_j - 14\_k$

> UBC:=Norm(VBC); $UBC := \sqrt{341}$

> cos(alpha):=(x3-x2)/UBC; $\cos(\alpha) := -\frac{1}{341}\sqrt{341}$

cos(beta):=(y3-y2)/UBC; $\cos(\beta) := -\frac{12}{341}\sqrt{341}$

cos(gamma):=(z3-z2)/UBC; $\cos(\gamma) := -\frac{14}{341}\sqrt{341}$

Determine the angle between the AB and AC sides of the triangle ABC:

1)> cos(phi):=VAB.VAC/(Norm(VAB)*Norm(VAC));

$\cos(\phi) := -\frac{47}{11946}\sqrt{181}\sqrt{66}$

> evalf(arccos(VAB.VAC/(Norm(VAB)*Norm(VAC))),4)* 180/3.14; 115.566879

2)> with(LinearAlgebra):

> VAB1:=Vector[row]([x2-x1, y2-y1, z2-z1]);

$VAB1 := \begin{bmatrix} 6 & 8 & 9 \end{bmatrix}$

> VAC1:=Vector[row]([x3-x1, y3-y1, z3-z1]);

$VAC1 := \begin{bmatrix} 5 & -4 & -5 \end{bmatrix}$

> VectorAngle(VAB1, VAC1); evalf(%,4)*180/3.14;

$\pi - \arccos\left(\frac{47}{11946}\sqrt{181}\sqrt{66}\right)$ 115.566879(

> VBC1:=Vector[row]([x3-x2,y3-y2,z3-z2]);

$VBC1 := \begin{bmatrix} -1 & -12 & -14 \end{bmatrix}$

Determining the projection of the $\overrightarrow{AB}$ *vector on the* $\overrightarrow{AC}$ *vector:*

> PRABAC:=VAB1.VAC1/Norm(VAC1); $PRABAC := -\frac{47}{5}$

> evalf(%); $-9.40000000($

Determining the projection of the vector $\overrightarrow{AB}$ *on the vector* $\overrightarrow{BC}$ *:*

> PRABBC:=VAB1.VBC1/Norm(VBC1); $PRABBC := -\frac{114}{7}$

> evalf(%); $-16.2857142($

Determine the height AH and the point H drawn from the end A of the triangle ABC to the side BC:

> with(geom3d):#with(LinearAlgebra):

> triangle(ABC, [point(A,x1,y1,z1), point(B,x2,y2,z2), point(C,x3,y3,z3)]); ABC

> altitude(hA,A,ABC,H); h:=coordinates(H);

$hA\, h := \left[\frac{1477}{341}, -\frac{690}{341}, \frac{900}{341}\right]$

> xH:=h[1]; yH:=h[2]; zH:=h[3];

$xH := \frac{1477}{341}\; yH := -\frac{690}{341}\; zH := \frac{900}{341}$

Determine the bisector AM and the point M drawn from the end A of the triangle ABC to BC:

> d1:=distance(A,B); d2:=distance(A,C);

$d1 := \sqrt{181} \quad d2 := \sqrt{66}$

> k:=d1/d2; $k := \frac{1}{66}\sqrt{181}\sqrt{66}$

> OnSegment(M,B,C,k); coordinates(M): M

> bis:=evalf(%); $bis := [4.376502249, -1.481973034, 3.271031460]$

> xM:=bis[1]; yM:=bis[2]; zM:=bis[3];

$xM := 4.376502249 \quad yM := -1.481973034 \quad zM := 3.271031460$

Determine the midpoint E of the BC section and the median vector $\overrightarrow{AE}$ *:*

> xE:=(x2+x3)/2: yE:=(y2+y3)/2: zE:=(z2+z3)/2:

> AE:=(xE-x1)*_i + (yE-y1)*_j + (zE-z1)*_k;

$AE := \frac{11}{2}\_i + 2\_j + 2\_k$

Determine the product of the vectors $\overrightarrow{AB}$ *and* $\overrightarrow{AC}$:

> VAxB:=VAB1 &x VAC1; $VAxB := \left[\begin{array}{ccc} -4 & 75 & -64 \end{array}\right]$

> with(VectorCalculus):

CrossProduct(<x2-x1,y2-y1,z2-z1>,<x3-x1,y3-y1,z3-z1>);

$-4e_x + 75e_y - 64e_z$

Calculate the face of triangle ABC in space:

> SABC:=Norm(VAxB)/2; $SABC := \frac{1}{2}\sqrt{9737}$

> evalf(%); 49.3381191

> AH:=SABC/Norm(VBC1); $AH := \frac{1}{682}\sqrt{9737}\sqrt{341}$

> evalf(%); 2.671808948

Construct an ABC triangle in space based on the coordinates of its ends:

> Ant:=[0,0,0], [x1,0,0], [x1,y1,0], [x1,y1,z1]:

> Bnt:=[0,0,0], [x2,0,0], [x2,y2,0], [x2,y2,z2]:

> Cnt:=[0,0,0],[x3,0,0], [x3,y3,0], [x3,y3,z3]:

> AN:=display(curve([Ant]),color=black,thickness=1, linestyle=dash);

> BN:=display(curve([Bnt]),color=black,thickness=1, linestyle=dash);

> CN:=display(curve([Cnt]),color=black,thickness=1, linestyle=dash);

Construct the sides of a triangle ABC in space based on vectors:

> AB:=arrow(<x1,y1,z1>,<x2,y2,z2>,axes=normal,width= 0.2, difference, color=blue, thickness=3);

AB := PLOT3D(...)

> AC:=arrow(<x1,y1,z1>,<x3,y3,z3>,axes=normal, width=0.2, difference, color=blue, thickness=3);

AC := PLOT3D(...)

> BC:=arrow(<x2,y2,z2>, <x3,y3,z3>, axes=normal,

width = 0.2, difference, color=red, thickness=3);

BC := PLOT3D(...)

> AE:=arrow(<x1,y1,z1>,<xE,yE,zE>,axes=normal, width=0.2, difference, color=yellow,thickness=3);

AE := PLOT3D(...)

> VAH:=arrow(<x1,y1,z1>,<xH,yH,zH>,axes=normal,

width = 0.2, difference, color=black,thickness=3);

VAH := PLOT3D(...)

> VAM:=arrow(<x1,y1,z1>,<xM,yM,zM>,axes=normal,

width = 0.2, difference, color=orange, thickness=3):

Construction of coordinate planes in space:

> infolevel[Student[LinearAlgebra]]:=1: with(Student[LinearAlgebra]):

> Oxy:=PlanePlot(<0,0,15>);Oxz:=PlanePlot(<0,15,0>); Oyz:=PlanePlot(<15,0,0>);

> display({AB,AC,BC,AN,BN,CN,Oxy,Oxz,Oyz,AE,VAH,VAM}, orientation=[-37,74]); (figure 1)

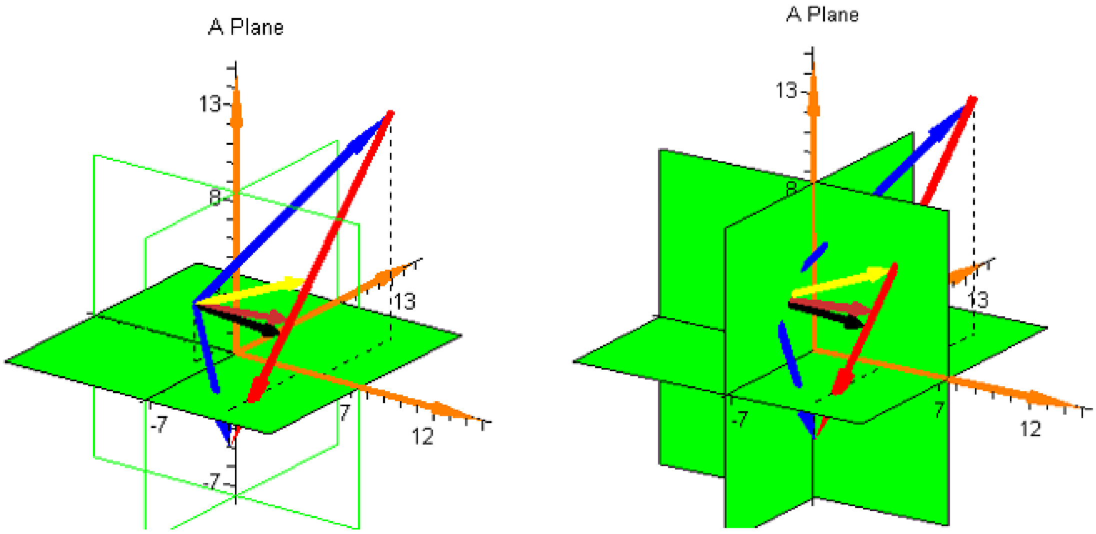

Figure 1. Construction of a triangle in space.

Conclusion

When studying analytical geometry in space, it is necessary to consider in detail the surfaces of the first and second order. As you know, surfaces make up a huge variety of objects in three-dimensional space, and human engineering activity is directly related to the design and manufacture of various surfaces.

Experience shows that students are interested in this type of assignment. Many first-year students perform graphs in applied mathematical packages on a computer, which is undoubtedly welcomed at a technical university.

The three-part textbook "Solving the problems of higher mathematics according to the Malpe program" and the two-part textbook "Solving the problems of analytical geometry in the Maple system", created by M.E. Mirzakarimov and published on the basis of the decision of the Ministry of Higher Education, are useful to students and teachers.

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