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Physics IB, 16/10/05

IB Lab - The Addition and Resolution Of Vectors: The Force Table

Aim:

To investigate the relationships and accuracies between the three various methods (graphical, analytical, and experimental) for calculating vector addition and vector resolution.

Hypothesis:

Both the graphical and mathematical methods should not only have the same results to each other, but if accuracies are avoided, the results should correspond to the experimental force table method.

Although there can be many ways to calculate vector addition, in the end they all are relatively similar and since trying to achieve the exact same objective, should have identical answers. I would hypequivalent graphical methods for adding two vectors, the first the parallelogram method, the other is the tail-to-head method, and the last is by using vector components. There is also the mathematical method which requires no scaled diagram (perhaps a small sketch) but does requireothesize that the results from the graphical method will at times differ from the analytical (mathematical) method since accuracy is limited greatly in the graphical way whereas by the mathematical method it is as exact as it can get.

There are three the manipulation of several mathematical laws and formulas, such as being able to use Pythagoreans Theorem, sine, cosine and tangent, and the sine and cosine laws.

<u>Pythagoreans Theorem</u>: $\mathbf{a^2 + b^2 = c^2}$ where **c** is the hypotenuse while **a** and **b** are the sides of the triangle.

<u>Sine, Cosine, Tangent</u>: For any unknown angle Ø within a **right-angled** triangle, sin Ø = opposite/hypotenuse, cos Ø = adjacent/hypotenuse and tan Ø = opposite/adjacent sides.

<u>Sine Law</u>: For any triangle, sin(a)/a = sin(b)/b = sin(g)/c

<u>Cosine Law</u>: For a triangle with sides of length a, b and c, and angle θ opposite the side of length c, the cosine law says that, $c^2 = a^2 + b^2 - 2ab\cos(\theta)$.

The last method we are asked to investigate in the lab is the practical experimental method which involves using the force table equipment. This method differs greatly from the others since it is not actually a proper way to calculate the addition of vectors (unless you guess and check). It is useful however to test and prove the accuracy of the results obtained from any of the other methods, when you already know the resultant.

A force table has three cables connected to a center ring. The cables exert forces upon the center ring in three different directions. It is important to note that on the force board, we are looking at the **equilibrant** force of 2 vectors that are added, not the **resultan**t force as we will in the graphical and mathematical methods. If an object is in balance, which is what we aim for with the force table, than the equilibrant force is equal in magnitude to the resultant and its direction is 180 degrees more than the resultant (opposite direction).

Variables:

In this experiment, the independent variable would definitely be the positioning and size of the weights on the force table. Throughout the four procedures, we had to add/remove weights and rotate the strings in order to complete it. The amount to add on, or the angle which to change to therefore it would have been wise to stick on original type of force table from the start. This also goes for the other equipment used such as rulers, protractors and types of weights. Throughout, was defined by the working out I had previously done

With regards to the dependant variable, the thing that changed throughout the experiment and that relied on the independent variable was whether or not the force table balanced. If the weights.

Many things remained the constant throughout the experiment such as the type of force table I used. There are several types of tables available, some with less friction on the strings than others; all four procedures the same standards of measurements were taken and units used. Also it was important did indeed create a perfect equilibrium, then the force table did not topple over once the pin was removed to remove any sort of outside interference such as an uneven level, therefore we used a flat table surface.

Working Out:

See following pages

Results:

Result Table – the following shows the magnitudes and directions of the resultant forces for the graphical and analytical methods, and says whether those results showed a balance on the force table.

Vector Addition 1	Graphical		Analytical		Experimental
	Magnitude	***Direction***	***Magnitude***	***Direction***	***Balanced?***
Results:	**0.29 g N**	**75º**	**0.28 g N**	**75º**	**Yes**
Vector Addition 2	Graphical		Analytical		Experimental
	Magnitude	***Direction***	***Magnitude***	***Direction***	***Balanced?***
Results:	**0.30 g N**	**45º**	**0.30 g N**	**46º**	**Yes**
Vector Addition 3	Graphical		Analytical		Experimental
	Magnitude	***Direction***	***Magnitude***	***Direction***	***Balanced?***
Results:	**0.28 g N**	**45º**	**0.28 g N**	**45º**	**Yes**
Vector Resolution	Graphical		Analytical		Experimental
	Fx Mgnt.	***Fy Mgnt.***	***Fx Mgnt.***	***Fy Mgnt.***	***Balanced?***
Results:	**0.15g N**	**0.26g N**	**0.15g N**	**0.26g N**	**Yes**

Analyzing results (Differences):

For vector questions 3 and 4, my mathematical and analytical results were identical; therefore I cannot try to find the difference error. However for vector one and two, in the first case the
magnitude in the analytical method exceeded the value in the graphical by .01 decimal
Addition 1, step b, "why can you use tan Ø?"

In this case, the tangent rule can be used since it is a right-angle triangle where we had an unknown resultant, and two sides, one opposite of the angle and one adjacent. Remember that for any unknown angle place, and in the second case the degree of the direction was one more in the analytical than the graphical method. To find these percentage errors:

(Vector Addition 1) $\dfrac{0.29\text{g N} - 0.28\text{ g N}}{0.28\text{g N}}$ x 100 (%)

= 3.5% percentage error

(Vector Addition 2) $\dfrac{46^{\circ}-45^{\circ}}{46^{\circ}}$ x 100(%)

= 2.2% percentage error

Questions:

From Vector

Ø within a **right-angled** triangle,

tan Ø = opposite/adjacent sides.

From Vector Addition 2, "Can you use tan Ø = F2/F1 in this case?"
No in this case the tangent rule may not be applied since it's not a right-angled triangle; it is 60º and not 90º therefore the rule does not apply, the cosine law must be used.

Conclusion

My hypothesis seemed to be completely accurate after I had finished the experiment. As I had predicted, the calculations and results of all three of the methods to find vector addition or resolution would be either equal or nearly the same. The mathematical and graphical methods corresponded 2 out of the 4 trials, and the force table was balanced for both. However in the first vector addition, the magnitudes from both methods were 3.5% different yet still had no real effect since the force table balanced out for either of the results. Also for the second vector addition, where the angle was one degree, or 2.2% different from the other method, the force table nonetheless balanced. since it will give the most possible correct answer apparatus and thus not much can be done about it. Several of the weights used looked chipped and it could have had a slight impact on its actual mass in comparison to what the label on it said. Also we did not take into account the weight of the strings or metal hangers from the board which could have since it does not involve any reading errors of any sort, only uncertainties within the calculating equipment itself. Both graphical and analytical methods are perfectly fine. The disadvantage of using the mathematical/ analytical method is that you must familiarize yourself with many

Evaluation

The procedures throughout the lab went smoothly and with limited inaccuracy. Our force table did not break and worked the same at the end of the experiment as the start. Some of the apparatus used obviously has its own limitations such as the precision of only 0.1 cm on a ruler or 1 degree on the protractor. Also, there was surely friction and some other faults on the force board which led to slight errors, however this is an inaccuracy within the differed. It would also be geo

It would be safe to conclude that if done accurately, the graphical method will give you a good rounded answer for a vector resultant, which, by means of the force table, is "accurate" enough. If however you are trying to get an exact figure or are working with larger quantities, the analytical method is the safer way to go metric formulas and be able to manipulate them correctly however you do receive a correct answer. Disadvantages of using the graphical method is that it is not exact at all since the thickness of the markers on the ruler or protractor are not precise and also when using the graphical method you yourself must avoid being careless and try to do everything with as much accuracy as possible however you it is more straightforward and basic than the mathematical method. Any known textbook method for calculating vectors will be adequate, you yourself must choose which suits you best.interesting to find out more about the accuracies of the table, since in our remaining time, my group found it strange that the table was still balanced +/- 200 grams where the weight hanging on the equilibrant is only 300.

Improvements and modifications for the lab include several more procedures that dealt with more than two vectors since it would be interesting to see how that works on the force table. Also more specifically students should have some sort of background understanding of several geometric formulas, as it seemed that many struggled. I would also be tempted to do graphical diagrams on larger paper and in larger scale, increasing accuracy significantly. Nonetheless the lab objective was achieved and my hypothesis stood correct.