**VECTORS** Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Partners:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   Course:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Purpose: To determine
(a) the resultant and equilibrant of two or more vectors
(b) the components of a vector
analytically and to verify the results using a force table and a website.

Apparatus: force table with pulleys, mass hangers, mass set, string, level, and PC.

Theory: a) analytical method

Let's say two forces F1 (making an angle θ1 with the +X-axis) and F 2 (making an angle θ2 with the +X-axis) are acting on an object. To find the resultant force we will do the following:

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| --- | --- | --- |
| Force | X-component | Y-component |
| F1 | F1 Cos θ1 | F1 Sin θ1 |
| F2 | F2 Cos θ2 | F2 Sin θ2 |
| $$F\_{R}=F\_{1}+F\_{2}$$ | Fx = F1 Cos θ1+ F2 Cosθ2 | Fy = F1 Sin θ1 + F2 Sin θ2 |

Magnitude of the resultant (FR) is given by;    FR 2=  Fx 2 + Fy 2

Direction of the resultant, θR, measured from the +X - axis depends on the signs of Fx and Fy.

When  Fx > 0 and  Fy >0; *θR* = tan-1(Fy/Fx).

When one or both of the components are negative go the appropriate quadrants and determine *θR*.

You will need the equilibrant vector when you use the force table. The magnitude of the equilibrant is same as the resultant. The direction is in the opposite direction of the equilibrant.
 Magnitude of the equilibrant = magnitude of the resultant.
 Direction of the equilibrant = *θE*= $θ\_{R}\pm 180.$

Procedure

A) From the website: <http://www.1728.org/vectors.htm>

1. Open the above website, enter the vectors, and obtain the resultant.

B) Analytical Method

Using the analytical method (component method) find the magnitude and the direction of the resultant. Also estimate the direction of the equilibrant.

C) Force Table Check

Addition of two vectors:

1) Use a level to make sure the force table is leveled.

2) Mount a pulley on the 0 degree mark and suspend a 50 gram mass hanger. Mount a second pulley on the 90 degree mark and suspend a 100 gram mass (hanger and a 50 gram mass).

3) Set up the equilibrant on the force table and test the system for equilibrium.

4) Remove all the masses from the force table.

5) Mount a pulley on the 20 degree mark and suspend a 50 gram mass. Mount a second pulley on the 120 degree mark and suspend a 250 gram mass.

6) Set up the equilibrant on the force table and test the system for equilibrium.

7) Remove the equilibrant mass.

Addition of three vectors:

1) Mount a pulley on the 300 degree mark and suspend a 300 gram mass (masses 50 gram and 250 gram are already there).

2) Set up the equilibrant on the force table and test the system for equilibrium.

3) Remove all the masses from the force table.

Addition of four vectors:

1) Mount a pulley on the 30 degree mark and suspend a 100 gram mass. Mount a second pulley on the 140 degree mark and suspend a 150 gram mass. Mount a third pulley on the 200 degree mark and suspend a 125 gram mass. Mount a fourth pulley on the 300 degree mark and suspend a 200 gram mass.

2) Set up the equilibrant on the force table and test the system for equilibrium.

3) Remove all the masses from the force table.

Vector resolution:

1) Mount a pulley on the 30 degree mark and suspend a 300 gram mass over it.

2) Find the magnitudes of the components along the 0 degree (X- axis) and 90 degree (Y-axis) directions.

3) Set up the above components as they have been determined. Move the 300 gram mass to, 30 + 180 = 210 degrees, which is the direction of the equilibrant. Test the system for equilibrium.

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| [Equilibrant vector](http://capone.mtsu.edu/phys2010/Lectures/Part_2__L6_-_L11/Lecture_8/R_and_E_Vectors/r_and_e_vectors.html): A single vector that will make a system to be in equilibrium. |
| For a single vector | Resultant Vector | Show the Equilibrant vector below  | Force Table Check |
| 100 g @ 00 |  |  | \_\_\_\_\_\_\_ |

 Addition of Vectors:

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| --- | --- | --- |
| Addition | Resultant Vector | Force Table Check |
|  | From website:<http://www.1728.org/vectors.htm> | Analytical method |  |
| 100 g @ 00100 g @ 900 | *FR=**θR=*  | *FR=**θR=**θE=* | \_\_\_\_\_\_\_\_ |
| 50 g @ 200150 g @ 1500200 g @ 2500 | *FR=**θR=*  | *FR=**θR=**θE=* | \_\_\_\_\_\_\_\_ |





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| --- | --- | --- |
| Addition | Resultant Vector | Force Table Check |
|  | From website | Analytical method |  |
| 50 g @ 00and100 g @ 900 | *FR=**θR=*  | *FR=**θR=**θE=* | \_\_\_\_\_\_\_\_ |
| 50 g @ 200and250 g @ 1200 | *FR=**θR=*  | *FR=**θR=**θE=* | \_\_\_\_\_\_\_\_ |
| 50 g @ 200250 g @ 1200300 g @ 3000 | *FR=**θR=* | *FR=**θR=**θE=* | \_\_\_\_\_\_\_\_ |
| 100 g @ 300150 g @ 1400125 g @ 2000200 g @ 3000 | *FR=* *θR=* | *FR=**θR=**θE=*  | \_\_\_\_\_\_\_\_\_ |
|  | *FR=* *θR=* | *FR=**θR=**θE=*  | \_\_\_\_\_\_\_\_\_ |
| Resolution | *XXXXXXXXXX* | *XXXXXXXXX* | XXXXXXXXX  |
| 300 g @ 300 | *XXXXXXXXXX* | *Fx=**Fy=* | \_\_\_\_\_\_\_\_\_ |

Exercises

1. Use the definition of scalar product, **·** = *ab* cos θ, and the fact that
**·** = *axbx* + *ayby* + *azbz* and $a=\sqrt{a\_{x}^{2}+a\_{y}^{2}+a\_{z}^{2}}$ to calculate the angle between the two vectors given by: $\vec{a}=2\hat{i}-3\hat{j}-5\hat{k}$ and $\vec{b}=3\hat{i}-4\hat{j}+2\hat{k}$

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2. Here are three vectors in meters: $\hat{d\_{1}}=2\hat{i}-3\hat{j}+4\hat{k}$   $\hat{d\_{2}}=\hat{i}-3\hat{j}+2\hat{k}$    $\hat{d\_{3}}=2\hat{i}+4\hat{j}-4\hat{k}$

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| http://edugen.wiley.com/edugen/courses/crs4957/common/art/pixel.gif |
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| http://edugen.wiley.com/edugen/courses/crs4957/common/art/pixel.gif |

What results from the following including unit? (a)$ \vec{d\_{1}}+2\vec{d\_{2}}-\vec{d\_{3}}$ (b) http://edugen.wiley.com/edugen/courses/crs4957/halliday9118/halliday9118c03/math/math146.gif, (c) http://edugen.wiley.com/edugen/courses/crs4957/halliday9118/halliday9118c03/math/math147.gif, and (d) http://edugen.wiley.com/edugen/courses/crs4957/halliday9118/halliday9118c03/math/math148.gif  |