Gravity and VECTORS

Outline

• Vectors and their description
• Adding and Subtracting Vectors
• What Vectors can represent
• The Second Experiment—Gravity measurement and the Force Table
• Problems to work in class

Additional Vector Information

• A vector has a MAGNITUDE, and we can think of this as a LENGTH.
• A vector has a DIRECTION
  – Like an arrow, it has a HEAD and a TAIL
  – Or, a point and an origin
• We can ADD or SUBTRACT vectors
  – Put the tail of the second vector at the head of the first.

How do we describe a Vector?

• In this course we will mostly use a Cartesian Coordinate System

• We define unit vectors of length 1
  – i is the unit vector in the x direction, j is the unit vector in the y direction (k would be the unit vector in z dir.)
Sometimes it is best to rotate the coordinate system. Consider the mountain climber example (Book, page 53):

Adding and Subtracting Vectors

- To add vectors put the tail of the next vector at the head of the previous vector.
- To subtract vectors first reverse the direction of the second vector, and then put its tail at the head of the first vector.

What can Vectors represent?

- A. Distance and Velocity
- B. Acceleration
- C. Forces
- D. All of the above.

Correct answer is D. Force=mass x acceleration, and that defines direction.
Measuring the Acceleration of Gravity

- This part of the experiment will be done as a demonstration.
- A weight is dropped that pulls a strip of paper past a spark generator, operating at a constant frequency.
- The spacing of the spark dots is constant in time, but different in distance.
- We measure the distance, both between the dots and between each dot and the starting point.
- With this information, along with the time between each of the dots, g, acceleration of gravity, can be calculated.

### Sample calculation

<table>
<thead>
<tr>
<th>index</th>
<th>time (sec)</th>
<th>x(cm)</th>
<th>delta x(cm)</th>
<th>v(cm/s)</th>
<th>delta v(cm/s)</th>
<th>g(cm/sec²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.05</td>
<td>0</td>
<td>---</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>0.1</td>
<td>6.3</td>
<td>6.3</td>
<td>63</td>
<td>--</td>
<td>580</td>
</tr>
<tr>
<td>3</td>
<td>0.15</td>
<td>10.9</td>
<td>4.6</td>
<td>92</td>
<td>29</td>
<td>580</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
<td>17.75</td>
<td>6.85</td>
<td>137</td>
<td>45</td>
<td>900</td>
</tr>
</tbody>
</table>

To calculate g we take the value of delta v and divide by the delta t, which is 0.05 seconds. Note that the value of g is closer to the true value of g for the last calculation. Why is this?

- A. Friction slows the paper tape initially. B. The timer does not time evenly. C. Tape friction decreases in importance with increasing velocity. D. A and C correct answer is D.

### Vector Addition of Forces

- In the SI system of units, we express Force as Newtons. Since a force can be expressed as a mass times acceleration, what are the units of a Newton?
  - A. Kg/sec.  B. Kg m/sec.
  - C. Kg m/sec²  D. Kg /sec² correct answer is C.
Vector Addition of Forces (cont)

- In the laboratory manual you are given two forces, each with a magnitude and a direction, and you are asked to determine a third force and direction that will balance the other two.
- Three different sets of forces will be used.
- The force table is the apparatus that we will use to make this determination.

The Force Table

How to do the force vector calculation:

- Case 1 from the lab: $\mathbf{A} = 0.98\text{N at 0}^\circ$  
  $\mathbf{B} = 0.686\text{ N at 60}^\circ$

We need to find $\mathbf{C}$, the sum of $\mathbf{A}$ and $\mathbf{B}$, and then orient a force in the direction opposite of $\mathbf{C}$, such that $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$

Let us define the y axis as $0^\circ$, and the $60^\circ$ will then be measured clockwise from the y axis.

The vector calculation (cont.)

$\mathbf{C} = \mathbf{A} + \mathbf{B}$

$\mathbf{C}_x = -(A_x + B_x) = 0 + B \sin(60^\circ) = 0.686 \times 0.866 = 0.594\text{N}$

$\mathbf{C}_y = -(A_y + B_y) = -(A + B \cos(60^\circ)) = -0.98 - 0.343 = -1.323\text{N}$

$\mathbf{C} = -0.594\mathbf{i} - 1.323\mathbf{j}$

Magnitude of $\mathbf{C} = \sqrt{(-0.594)^2 + (-1.323)^2} = 1.45\text{N}$

This angle $\equiv \tan^{-1}(\frac{0.594}{1.323}) = 24.18^\circ$

So, measured from $0^\circ$, the angle is $180 + 24.18 = 204.18^\circ$. 

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Vector calculation, concluded

- Finally, how do we determine the weights? Remember that $F = ma$, so $m = F/a$
- So, for force A we have $0.98/9.8 = 0.1$ Kg, or 100 g. Subtracting 50 g for the hanger, we have to add 50 g for force A.
- For force B, $0.686/9.8 = 0.07$ Kg, or 70 g and we add 20 g for force B.
- For force C, $1.45/9.8 = 0.148$ Kg, or 148 g so we add 98 g for force C.

A Vector addition problem

- The SUM of A and B is:

  ![Diagram]

- A. Both of the vectors
- B. Neither of the vectors
- C. Vector C
- D. Vector D correct answer

What are the COMPONENTS of Vector A?

![Diagram]

- A. $A(\sin \theta) + A(\cos \theta)$
- B. $A(\sin \theta)i + A(\cos \theta)j$
- C. $A(\cos \theta)i + A(\sin \theta)j$
- D. $A(\cos \theta) + A(\sin \theta)$

Correct answer is C

You travel north for 30 minutes at 60 Km/H. Then you travel east for 1 hour at 40 Km/H. How far away from the starting point are you?

- A. 70 Km
- B. 50 Km Correct answer
- C. 60 Km
- D. 40 Km

- What has been your speed for this trip? C
- A. 33 Km/H; B. 54 Km/H C. 47 Km/H
- What was your velocity for the trip? A.
Assignment

• Read over Laboratory Number 2, Measurement of the Acceleration of Gravity and Vector Addition of Forces
• Read Chapter 3
• Do Problems 3, 5, 21, 27, 29, 31, 45, 57