Physics Challenge for Teachers and Students

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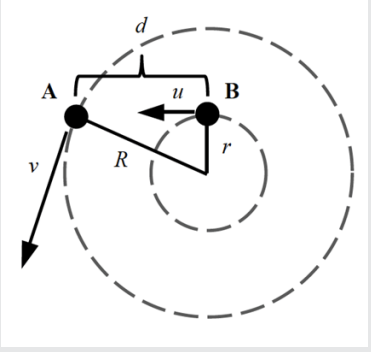
Solution to October 2016 *Challenge*

A big spider chase

Two spiders, Alex and Ben, participate in a friendly chase. They draw a large circle of radius R on the floor. Alex starts out on the circle and Ben at the center of the circle. They begin to run simultaneously. At all times, Alex runs along the circle at a speed v while Ben runs directly toward Alex at a speed u ($u < v$). After a while, Ben notices that the distance between them is no longer changing. What is that constant distance?

Solution:

In order for Ben (B) to remain a constant distance d from Alex (A) and always be moving toward Alex, Ben must be going around a smaller circle with the same angular speed as Alex. The relative positions of the two spiders are shown in the diagram below.



If the radius of the smaller circle is r, then the spiders having equal angular speeds means that

$$\frac{u}{v} = \frac{r}{R}. \qquad (1)$$

the velocity of Ben is tangent to the circle, the distances form a right triangle and

$$R^2 = r^2 + d^2. \qquad (2)$$

Combining equations (1) and (2) yields

$$d = R\sqrt{1-\left(\frac{r}{R}\right)^2} = R\sqrt{1-\left(\frac{u}{v}\right)^2}.$$

In addition to the analytical solution, here is a simple simulation of the problem which can be viewed at http://www.glowscript.org/#/user/AJD/folder/Public/program/SpiderChase

Alex travels on a circle with a radius of 1 and Ben starts at a random location with x and y between -2 and 2. The system comes to equilibrium after a few rotations.

(Submitted by Alan J. DeWeerd, University of Redlands, Redlands, CA)

We also recognize the following successful contributors:

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Guidelines for contributors:

- We ask that all solutions, preferably in Word format, be submitted to the dedicated email address ***challenges@aapt.org***. Each message will receive an automatic acknowledgment.
- The subject line of each message should be the same as the name of the solution file.
- The deadline for submitting the solutions is the last day of the corresponding month.
- Each month, a representative selection of the successful solvers' names will be published in print and on the web.
- If your name is—for instance—Hillary Clinton, please name the file "**Clinton17Jan**" (do not include your first initial) when submitting the January 2017 solution.
- If you have a message for the Column Editor, you may contact him at ***korsunbo@post.harvard.edu***; however, please do not send your solutions to this address.

Many thanks to all contributors; we hope to hear from many more of you in the future.
We also hope to see more submissions of the original problems – thank you in advance!

Boris Korsunsky, Column Editor