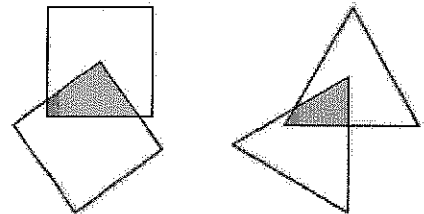


**2011 John O'Bryan Mathematical Competition**  
**Junior-Senior 5-person Team Test**

Abbreviated Instructions: Answer each of the following questions using separate sheet(s) of paper for each numbered problem. Place your team letter in the upper right corner of each page that will be turned in (failure to do this will result in no score). Problems are equally weighted; teams must show complete solutions (not just answers) to receive credit. More specific instructions are read verbally at the beginning of the test.

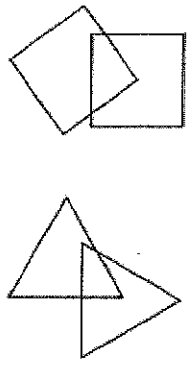
1. Two identical squares overlap with the corner of one square at the center of the other.

- a. Find the proportion of the area of each square that is in the overlapped section.
- b. Prove that the proportion of area in part (a) is independent of the relative positions of the two squares.
- c. If we replace the squares by identical equilateral triangles, with the corner of one at the center of the other, is the overlap still independent of relative positioning? Explain!

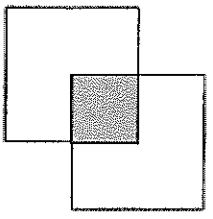


2. Two railroad cars (labeled A and B) are in a

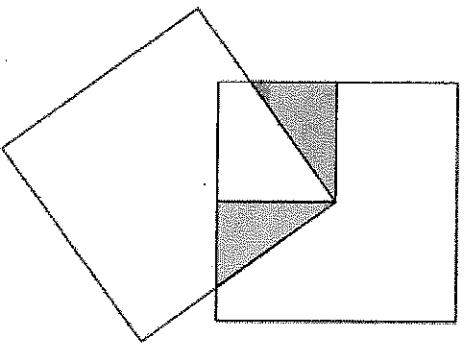
1. Two identical squares overlap with the corner of one square at the corner of the other.
- a. Find the proportion of the area of each square that is in the overlap.
  - b. Prove that the proportion of area in part a is independent of the angle of rotation.
  - c. If we replace the two squares by identical equilateral triangles, does the proportion of area in part a change?



a. By rotating the lower rectangle we see the area is obviously  $1/4$  of  $1$ .



b. In the following picture the two filled triangles have the same area.



c. No, the overlap now changes area. This is easiest seen by looking at the two shaded triangles. They are not congruent.

2. Two railroad car  
Either end of the

1. Use the engine to
2. Leaving car A with
3. Unhitch car B, m
4. Hitch to car B, m
5. Pull both cars bac
6. Unhitch car A. Dr
7. Drive the engine
8. Pull car A down t
9. Return the engine

3. 1

a. Jus

(1,

Every

b. Let

First:

First

Note:

c. It's

d. Ad

Page-

4. Asadi  
We know  
get

where

5. Let  $a$  and  $b$  be two  
If we look at the units  
If we sum these possible

6. What

Since 15

So there

7. If  $\sin x + \cos x$

$$\frac{1}{4} = (\sin x + \cos x)^2$$

We also have that

$$\text{So, } \sin^4 x + \cos^4 x$$