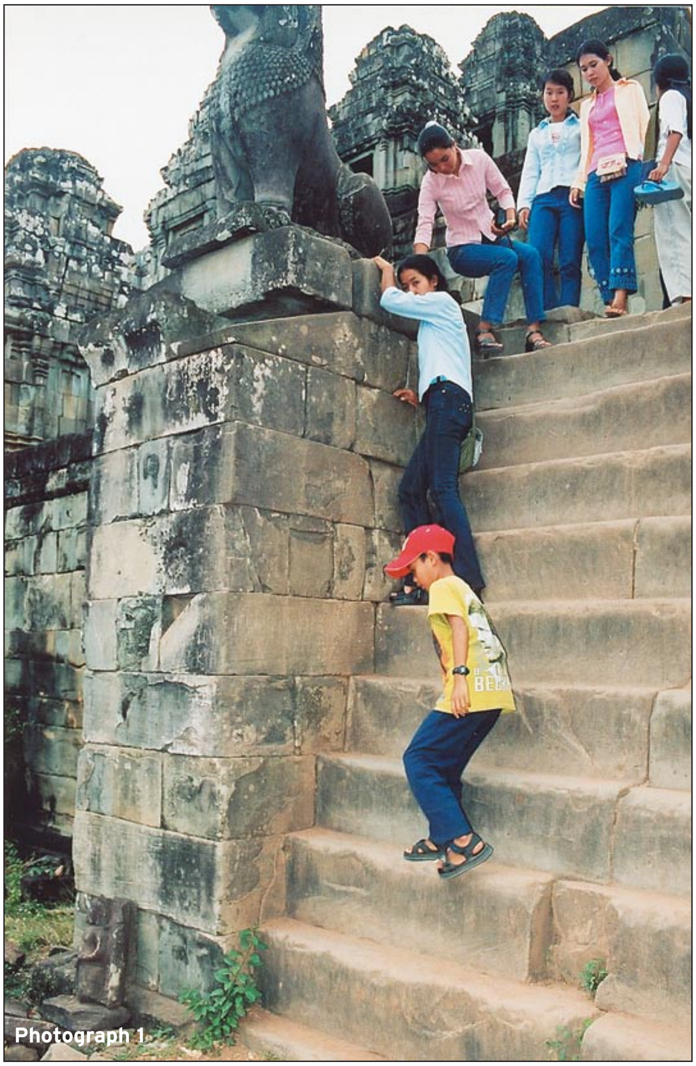
MATHEMATICAL lens



Photograph 1


Photograph 2
Angkor Wat, Cambodia

"Mathematical Lens" uses photographs as a springboard for mathematical inquiry. The goal of this department is to encourage readers to see patterns and relationships that they can think about and extend in a mathematically playful way.

Edited by ***Ron Lancaster***
ron2718@nas.net
University of Toronto
Toronto, Ontario M5S 1A1
Canada

Brigitte Bentele
brigitte.bentele@trinityschoolnyc.org
Trinity School
New York, NY 10024

Ron Lancaster, one of the editors of this column, visited Angkor Wat, Cambodia, in March 2003. Along with other visitors to a shrine for the Buddha (**photograph 1**), Ron had difficulty descending the very steep steps. According to religious custom, one is not allowed to turn one's back to the Buddha at the top of the steps. Thus, the steps are designed so that it is not possible to walk down them facing forward, with one's back to the statue. One must either descend sideways, as the young boy is doing, or facing the steps, as one often does when going down a ladder.

1. Without knowing the scale of the stones shown in **photograph 2**, is it possible to compute the slope of the steps? If so, compute the slope. If not, explain why it is not possible.

2. Find the slope of five different sets of stairs in your school or neighborhood. Do the slopes tend to be the same? Is there any reason this may be desirable?

3. Estimate for what slope it would be difficult to walk down the steps while facing forward.

4. List several ways in which a handrail could be used to find the slope of a set of stairs.

Photograph 3
A trinity home in Philadelphia

Photograph 4
Temple stairs, Quatab Minhar, India

5. Brigitte Bentele, the other co-editor of this department, recalls visiting friends in Philadelphia who lived in "trinity" homes. These homes typically have one room on each of three floors connected by a spiral staircase. The second step on the ground floor is often a little bit higher than all the other steps in the home. Brigitte recently traveled to Philadelphia to take photographs of the stairs in a trinity home. **Photograph 3** gives some sense of the difference in rise of the steps. What could be a reason for making this step unequal to all the others? We hope this question doesn't trip you up.

6. Carol Jacques, Brigitte's friend from Philadelphia, was recently in Quatab Minhar, India, and took photographs of a highly intricate network of steps. **Photograph 4** offers a truly stunning and breathtaking view of these steps. What is the advantage of the architecture of these steps?

MATHEMATICAL LENS solutions

1. It is possible to compute the slope of the steps because the slope is equal to the ratio of the step's rise to their run. It is not necessary to have actual values for the size of the run and the rise. One way of finding the slope is to use a ruler to measure the rise and the run directly on **photograph 2**. Or the photograph can be pasted into an interactive geometry software program such as The Geometer's Sketchpad or Cabri, where segments can be constructed and measured right on the photograph (**fig. 1**). Whatever method is used, readers should find that the slope is approximately equal to 2:1. If the photograph had been taken from a side view, a more accurate answer could be obtained.

2. Answers will vary from one community to the next, but within a school or a city, there will be some consistency because of building codes. A common building code specifies acceptable stair slopes ranging from 0.711 to 0.775. If the slopes of stairs varied wildly, especially within a given set of stairs, people would be constantly tripping because the lack of a pattern would make it difficult to judge how to move up or down without thought.

3. Answers will vary depending on the individual. Since building codes are usually written for safety reasons, stairs steeper than 0.775 would likely be difficult to use.

4. First, note that the slope of the stairs should always be equal to the slope of the handrail. Can you see why this makes good sense? To find the slope of the stairs using the handrail, you could pick two points on the handrail, mark off a right-angled triangle, and estimate the rise and run. Or you could measure the angle of inclination of the handrail and then use the inverse tangent function to find the slope.

5. While it is highly unusual to have one step of a set of stairs fail to conform to the rest of the stairs, builders did this intentionally so that if the house were broken into, the thief would trip when running up the stairs.

6. In addition to its exquisite beauty, the design of the steps allows many people to descend and arrive at the bottom at the same time. ∞

rise = 6.35 cm

run = 3.00 cm

$$\frac{\text{rise}}{\text{run}} = 2.12$$

Fig. 1 A way to solve question 1

Have you ever seen a building, a bridge, a sign, or a natural phenomenon that stimulated mathematical thoughts? Why not take a photograph and send it to NCTM, along with the mathematical questions that the photograph inspires? The questions can be playful, imaginative, curious, and inventive; they can also be mathematical extensions sparked by the photograph.

If the photograph includes identifiable people, the photographer must obtain signed release forms. Photographers must also obtain release forms if trademarked items are shown. Original photographs must be either in hard copy or supplied digitally as 300 dpi images in .jpg format. For details on releases and digital standards, please see the NCTM Web site. Photographs will not be returned.

Send the photographs, diagrams, list of questions, solutions, and completed release forms to the "Mathematical Lens" editors.

Members who wish to use this month's photographs in a classroom setting can download the image from NCTM's Web site, www.nctm.org. Follow links to *Mathematics Teacher*, and choose Current Issue. Then select Mathematical Lens from the Departments, and look for the link to the image.