

# Sports Photography

## The Movie:

Sports photography requires an expert's understanding of light, lenses and shutter speed.

Featured: Tracy Frankel. (Movie length: 3:42)



## Background:

Few activities join art, mathematics, technology and science as photography does. Getting the perfect picture is a matter of exact timing, careful measurements, a thorough knowledge of equipment and materials, and a refined aesthetic sense for the interplay of light and shadow that makes up the things we see. The result of all of that work and knowledge can be ruined, or salvaged, by what happens in the darkroom afterwards. If it's going to turn out to really be worth 1,000 words, a picture requires 1,000 skills.

## Curriculum Connections:

### Decimals

1

Photographic film contains very small particles which change color when exposed to light. The diameter of these particles is around .002 millimeters. About how many particles would there be from one side to the other of a piece of film that is 35 millimeters wide?



### Fractions, Decimals

2

The "shutter speed" of a camera is actually not a "speed" at all. It is the length of time that the shutter stays open (allowing light to enter the camera and strike the film) when a photograph is taken. Usually it is stated as a fraction of a second, such as  $\frac{1}{2}$ ,  $\frac{1}{4}$ ,  $\frac{1}{8}$ ,  $\frac{1}{15}$ ,  $\frac{1}{30}$ ,  $\frac{1}{60}$ ,  $\frac{1}{125}$ ,  $\frac{1}{500}$ , and  $\frac{1}{1000}$ . Which of these are longer than .02 second? Which are shorter than .005 second?

### Measurement (speed)

3

If a sprinter runs a 50 yard dash in 6 seconds, how fast is he traveling in inches per second? If you try to take a photograph of him during the race, using an exposure time of  $\frac{1}{4}$  second, how far will he move during the exposure? An exposure time of  $\frac{1}{1000}$  second?

### Measurement (rate)

4

A movie film camera records images at the rate of 24 pictures per second. How many such images would there be in a movie lasting 106 minutes?

## Ratios

5

When you develop film, you usually mix the developing chemicals with water in a certain ratio. If the instructions for one kind of developing chemical are to mix it with water in a 1:9 ratio, how much of the chemical should you mix with 450 milliliters of water? What volume of mixture will you have?



## Ratios

6

The *aspect ratio* for a photograph or other image is the ratio of the height of the image to its width. A common aspect ratio for photographs is 2:3.

- If a 4" high photographic print has an aspect ratio of 2:3, what is its width?
- Measure the height and width of a television screen. Does it have a 2:3 aspect ratio?
- Suppose you enlarge a 4" by 6" photo so that it is 34 inches high. If the aspect ratio is not changed, what is its width?

## Geometry (rectangles)

7

These are standard rectangular film sizes. For each, compute the area of the film and the length of the diagonal of the rectangle.

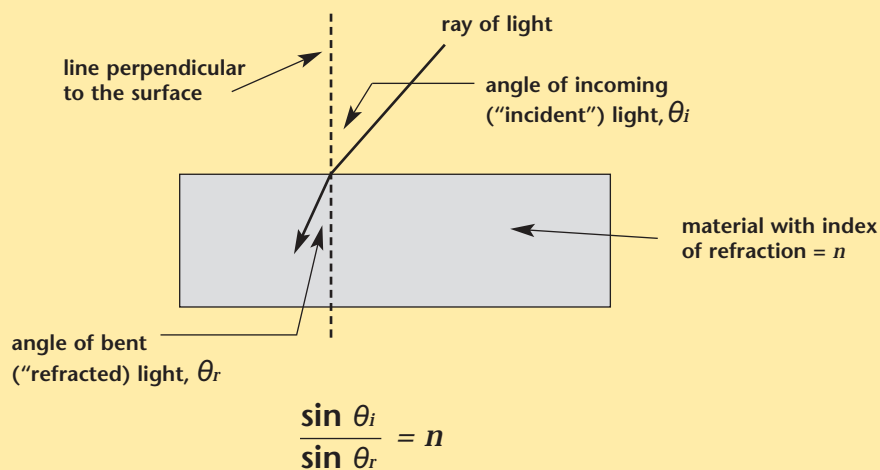
Width	Height	Area	Diagonal
36mm	24mm		
56mm	41.5mm		
56mm	56mm		
69.5mm	56mm		
89.5mm	56mm		

Which film would require the highest exposure time, all other things being equal? Why?

## Trigonometry

8

The lens in a camera works by bending light. Some kinds of glass bend light more strongly than other kinds; the degree to which a material will bend light is called its *index of refraction*.



Suppose the angle of incidence is  $45^\circ$ , and the index of refraction of the lens material is 1.33. What will be the angle of refraction? If another material is used, with an index of refraction of 1.5, what will be the angle of refraction? Which material bends the light more?

### Geometry (circles, ratios)

9

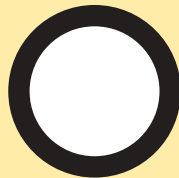
One common camera lens diameter is 52 mm, another is 58 mm. Keep in mind that the amount of light that passes through a lens is proportional to its *area*, not its diameter. What is the ratio of the areas of these two lenses?



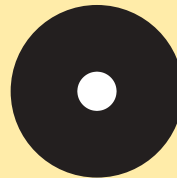
### Powers, Algebra (patterns and functions)

10

The “f-stop” setting on a camera determines how widely the shutter opens. A low f-stop number, like 1.4, means that the shutter opens very widely; a higher f-stop number, like 8, means the shutter doesn’t open nearly so far.



F stop = 1.4



F stop = 8

These f-stop settings are commonly available on cameras: 1.4, 2, 2.8, 4, 5.6, 8, 11, 16. Square each of these numbers and round the answer to the nearest whole number. Is there a pattern?

### Algebra (equations and expressions)

11

The focal length ( $f$ ) is related to the distance from the lens to the object ( $D_o$ ) and the distance from the lens to the image that is created ( $D_i$ ) by this equation:

$$f = \frac{D_o D_i}{D_o + D_i}$$

### Algebra (variables)

12

- Size of lens aperture
- The amount of light that strikes the film
- The duration of the exposure ("exposure time")
- "Speed" of film (refers to how sensitive the film is to light—high-speed film is more sensitive, meaning that you can make an image with less light, which permits a faster shutter speed).
- Distance between lens and object being viewed (usually symbolized as  $D_o$ )
- Distance between lens and the image that is formed by the lens (usually symbolized as  $D_i$ )



### Algebra (patterns, relations and functions)

13

- The amount of light is related to the size of the shutter opening.
- The amount of light is related to the length of the exposure.
- The intensity of light from a source is related to the distance from the source.

### Algebra (patterns, relations and functions)

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Some film will capture an image faster than other film, and the "speed" of a film is indicated by a special number called its ISO number (ISO = International Standards Organization). The table below shows the ISO numbers in which film is usually available. Can you find a rough pattern to this data? What would the next ISO number be? Can you describe the pattern mathematically?

40, 50, 64, 80, 100, 125, 160, 200, 250, 320, 400, 500, 640, 800, 1000

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