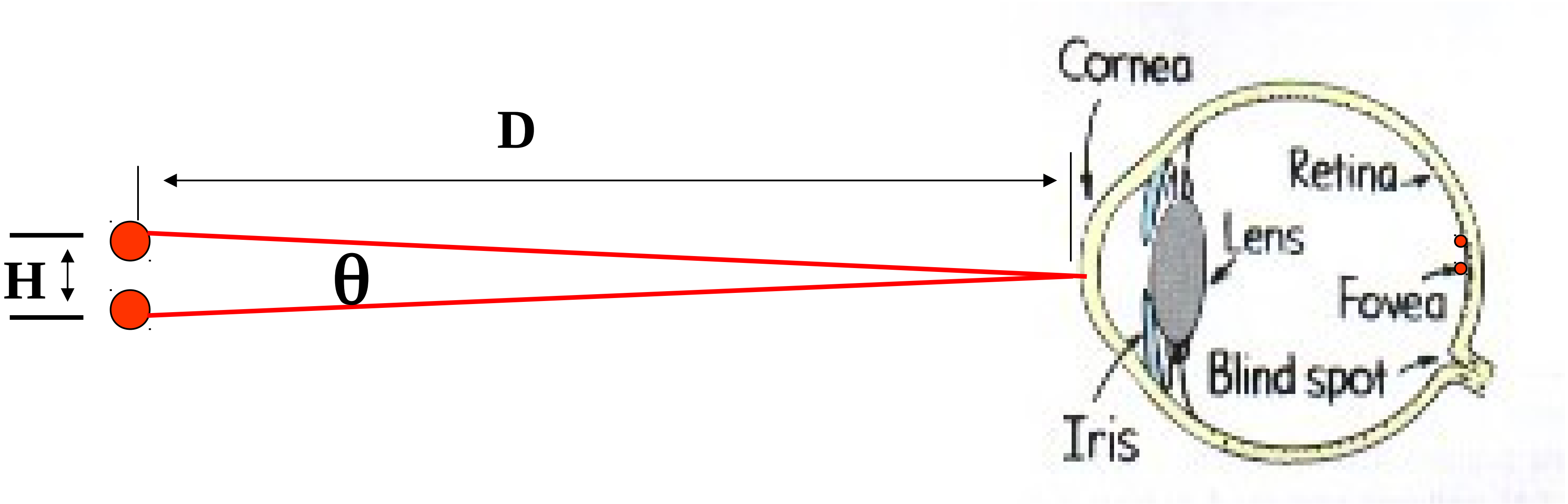
Spatial Resolution and Image Files

Spatial Resolution

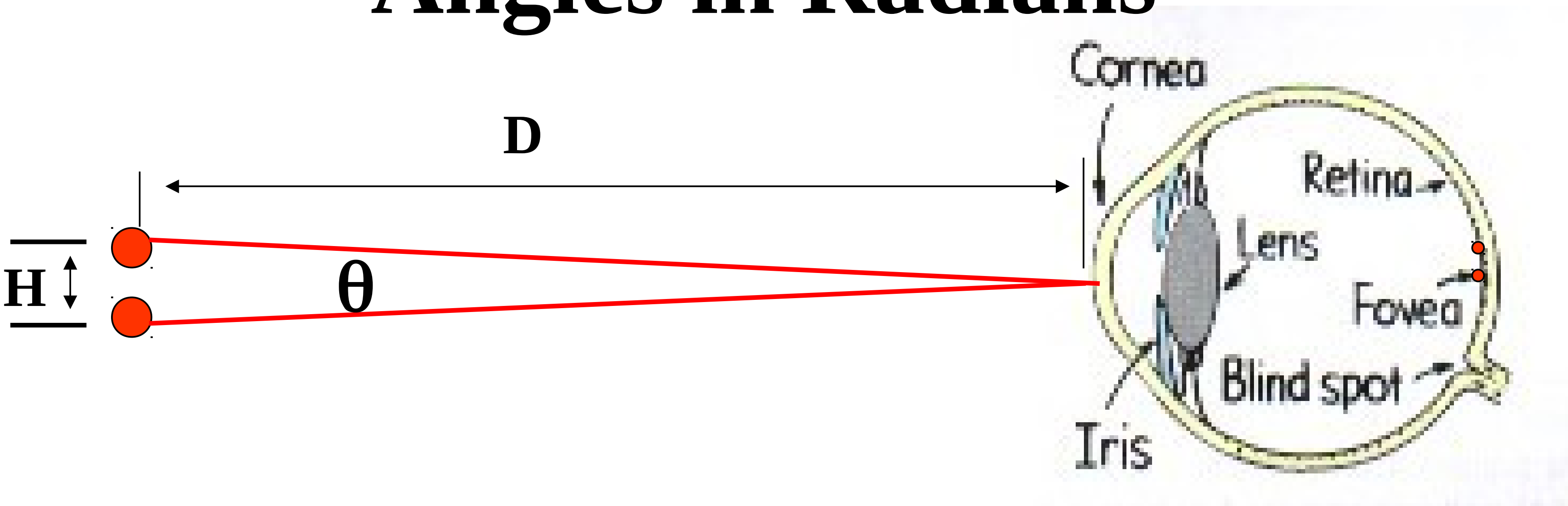


How far apart must the two lights be for us to see them separately?

Depends on how far away they are.

Best to think in terms of angles.

Angles in Radians



θ in degrees: one full turn = 360 degrees.

θ in radians: one full turn = 2π radians.

$$\theta_{radians} = \theta_{\deg} \frac{2\pi}{360}$$ **OR** $$\theta_{\deg} = \theta_{rad} \frac{360}{2\pi}$$

Radians more convenient in most cases.

$$\theta_{rad} \approx \frac{H}{D}$$ **Small angles**

Measuring Visual Acuity

We measured the angle needed for red and green LEDs to be distinguished for a few students. Found 10^{-3} radians in a rough experiment.

Accepted value = 3×10^{-4} radians or $1/60^{th}$ of a degree.

Note this depends on viewing conditions and varies between individuals, but this is the right order of magnitude and will serve as our "benchmark."

The concepts are mostly independent of the exact value.

Now we want to explore the implications of this measurement for storing and transmitting digital images.

A Digital Photograph

We will first consider an image held close for careful examination, e.g. a printed photograph.

How close should we assume people are holding the photo?

We measured approximately our near points (closest point at which an object can be focused).

This changes with age – elderly people have to hold a book or newspaper at some distance to see it.

We will use 25 cm as a benchmark for our calculations, but younger people can actually hold a photograph quite close and see more details.

Worksheet Answers

Using $\theta = 3 \times 10^{-4}$ radians and D = 25 cm, what is the maximum size of pixels to produce an image that is smooth to the human eye?

0.0075 cm

Consider an image that fills most of an A4 sheet, perhaps 18 cm x 26 cm. How many pixels will be needed?

8,320,000 pixels

If the image uses 24 bit colour, how many bytes of data is involved?

25 Million Bytes

Using the pixel size you calculated in step one, find the number of pixels per inch along a line on the paper. 1 inch = 2.54 cm. Comment on your result in terms of printer specifications you have seen advertised.

340 dpi

Worksheet Answers Continued

Consider a data projector used to display an image that has XGA resolution (1024 x 768). Assuming the image on the screen is 2 meters wide and 1.5 meters tall, how close would you have to sit to resolve individual pixels? Hint: first find the size of one of the pixels on the screen.

Pixel about 2mm across.

$0.002 m/D = 3 \times 10^{-4}$ so $D = 6.7$ m

A Movie?

Human eye is actually a movie camera.

Snaps about 20 frames per second, depends on circumstances.

Changes from one frame to the next at more than 20 frames per second give the perception of continuous motion.

Movies are often displayed at 25 frames per second.

Calculate the number of bytes in a two hour movie displayed at XGA (1024x768) resolution at 25 frames per second.

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425 Billion Bytes ????

Compression

Need some way to compress the data.

Consider a single image that is 250 x 400. Really just need to say 250 x 400 all same colour - say 65280. Shouldn’t take 300,000 Bytes!

Summary

Using our understanding of the spatial resolution of the human eye we can calculate how large our pixels need to be to give a smooth image in a variety of circumstances.

Then we can calculate the amount of memory we need.

The amount of memory we need for images is HUGE.

Need to find a way to compress the data.

That’s the topic for later.