

# HUMAN FACTORS IN DESIGNING THE VISUAL SYSTEM FOR CONTROL ROOMS

Presented by:

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Thank-you  
for viewing this  
Presentation

# OVERVIEW

Explain human vision and physiological behavior

Highlight established industry specifications

Explain present technology limitations

Illustrate application and scenario

Sample, Hands-on, see for yourself

A  
BC

RDE

SCREEN  
DISPLAYS

COMMAND AND

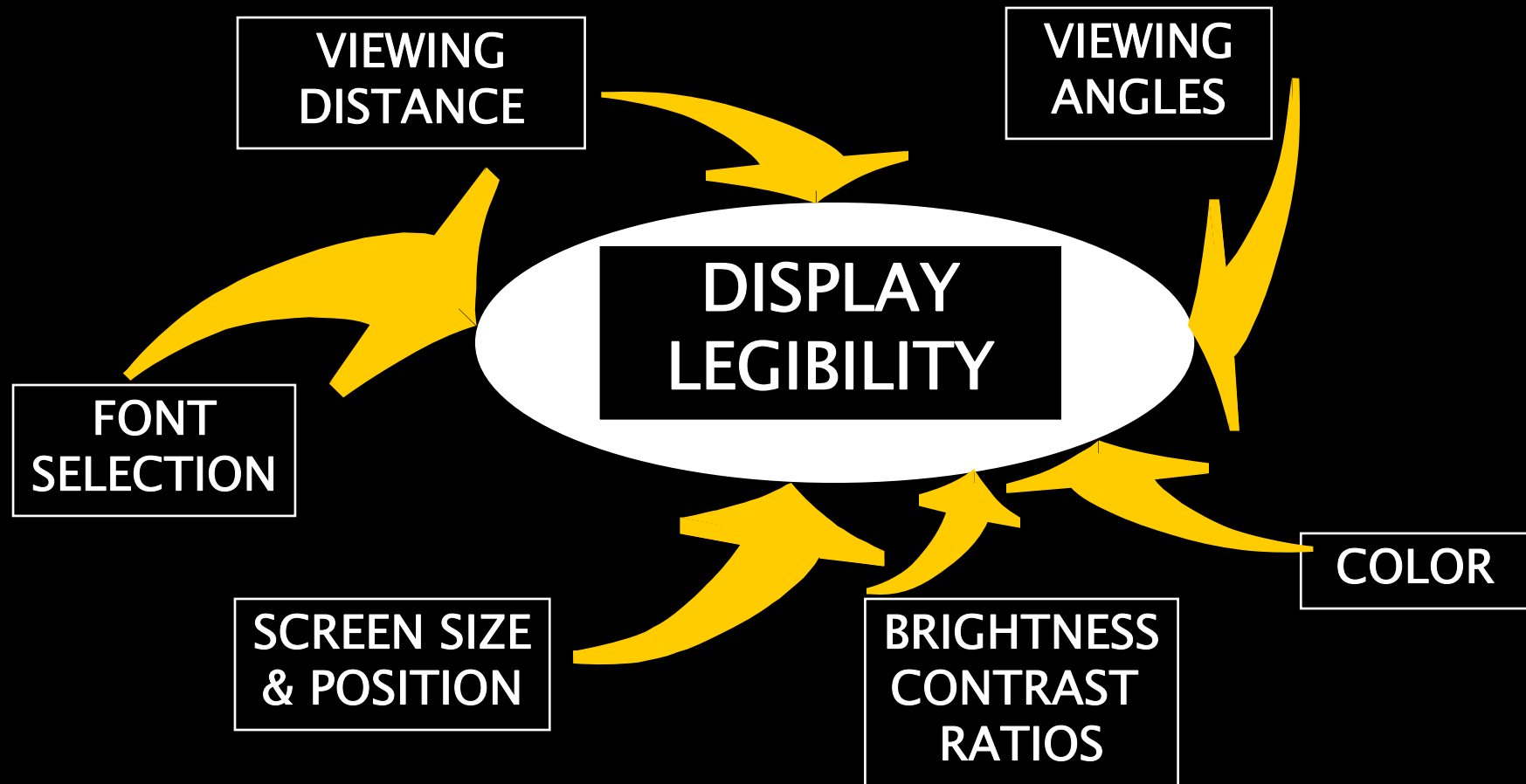
CONTROL WALL FABRICATIONS

SPECIALISTS BASED IN ORANGE, CALIFORNIA, U.S.A.

AND NOW THE TEXT STARTS TO GET REALLY SMALL CAUSING EVERYONE TO SQUINT

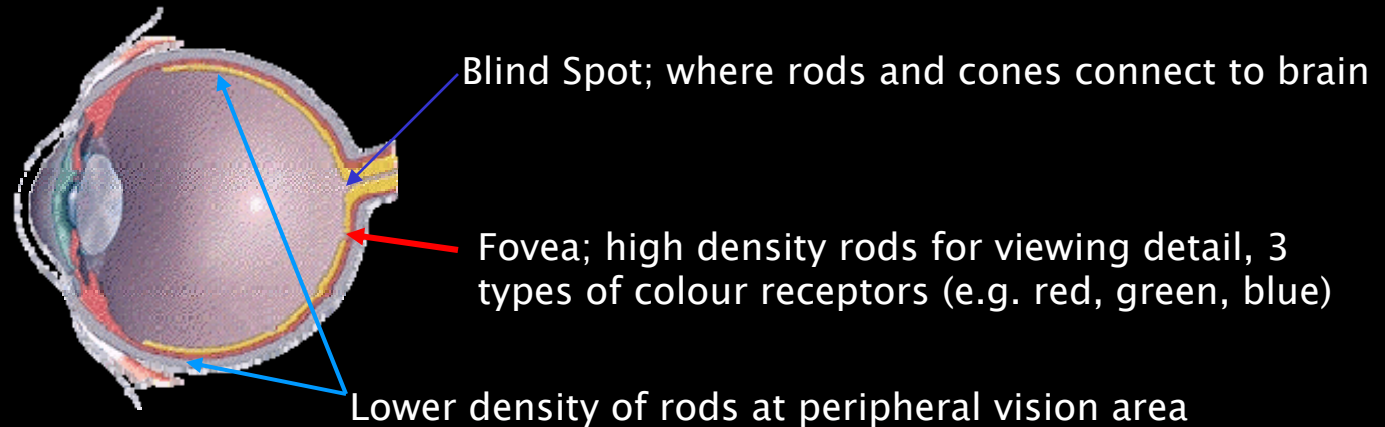
NOW WOULD YOU BE VERY COMFORTABLE OR WOULD YOU WANT TO LAUNCH MISSILES @ YOUR HOUSE BASED ON THIS TEXT?

# DISPLAY LEGIBILITY



# THE HUMAN EYE

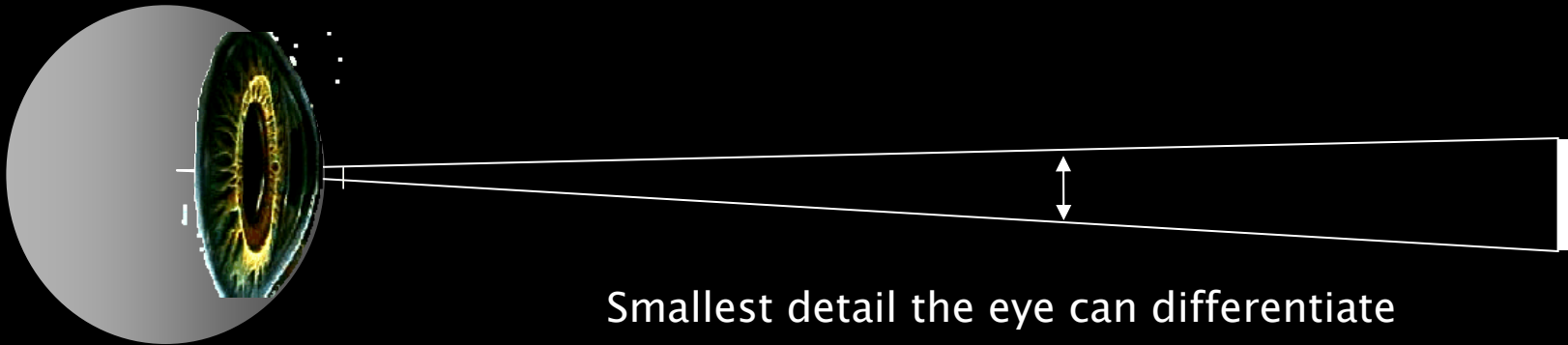
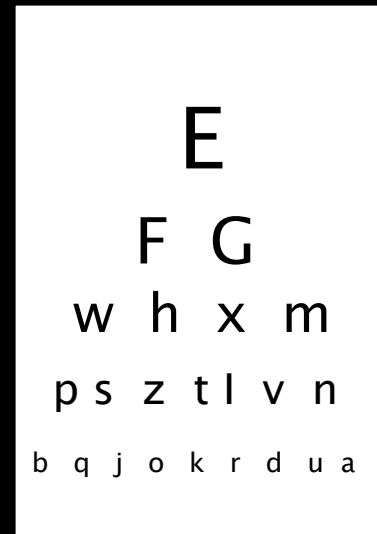
Elements: Rods and Cones  
Retina and Fovea



# THE HUMAN EYE

Human Eye Acuity; "1 minute arc"

Equivalent to 1/60 degree

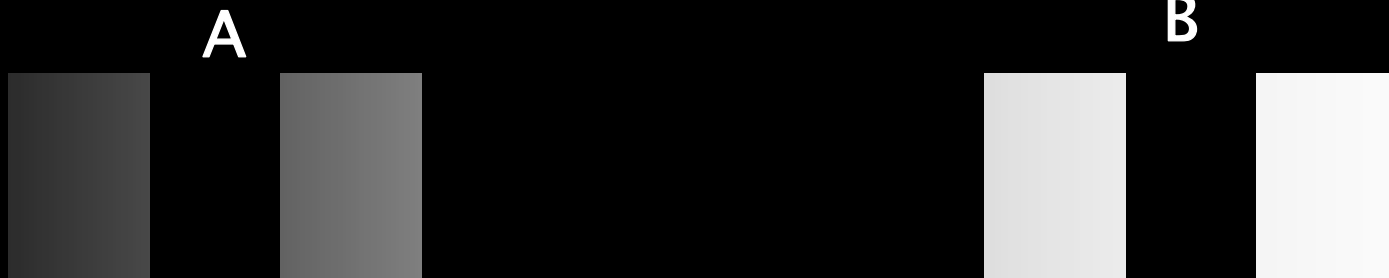


Smallest detail the eye can differentiate

# VISUAL BEHAVIOR

Grayscale: most sensitive aspect of vision

Contrast ratio: 10:1 or 100:1



A and B have the same ratio difference. However, the eye is more sensitive at lower levels. Most people cannot see the difference in B.

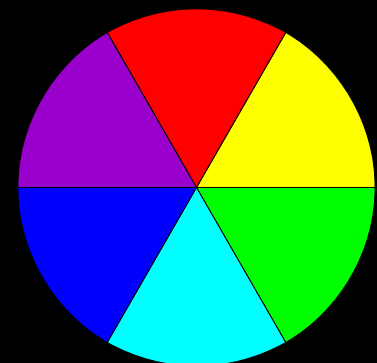
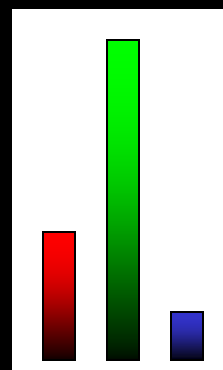
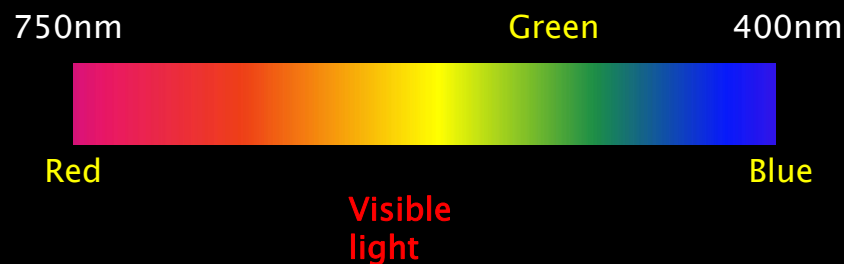
# VISUAL BEHAVIOR

Color: exists only as a result of a learnt response

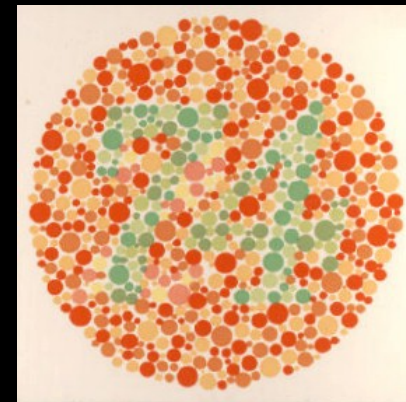
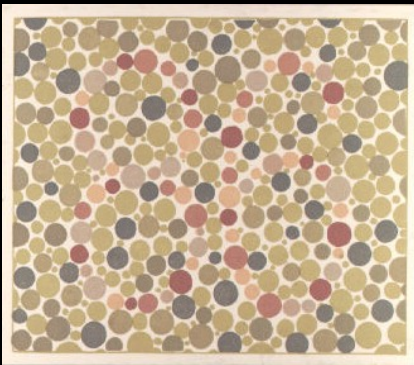
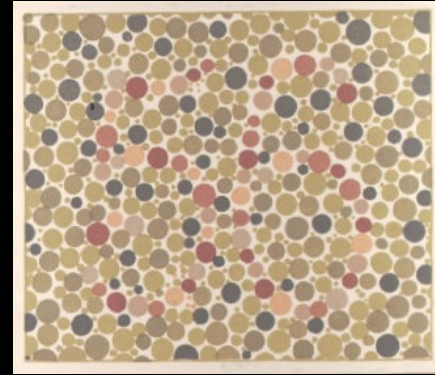
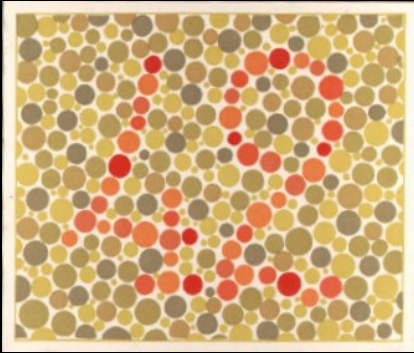
Color is not universal (i. e. colour blindness)

Use the highest colour difference complements.

(ie: use primary or opposing colours in colour wheel)



# COLOUR DETECTION



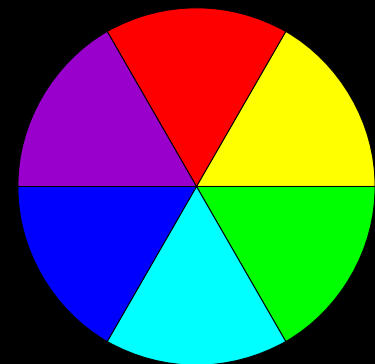
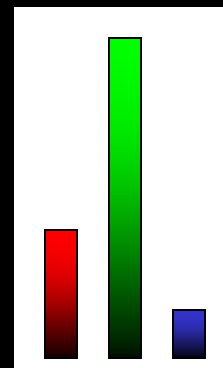
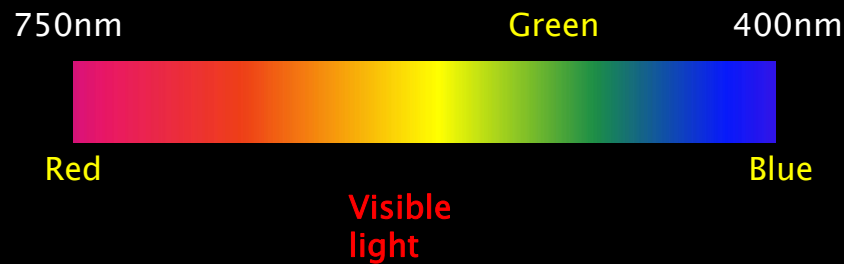
# VISUAL BEHAVIOR

White is comprised of the following colors:

Green = Brightness 60%

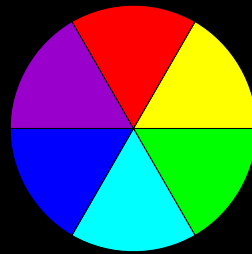
Red = Sharpness 30%

Blue = Whiteness 10%



This text should give good contrast according to the colour wheel systems.

This text should give good contrast according to the colour wheel systems.



This text should give poor contrast according to the colour wheel systems.

This text should give poor contrast according to the colour wheel systems.

# VISUAL BEHAVIOR

Color or wavelength of blue is difficult to focus sharply.

A B C

A B C

A B C

A B C

A B C

A B C

Edge enhancement  
benefits blue text  
the most.

**THE MORE MATURE...**

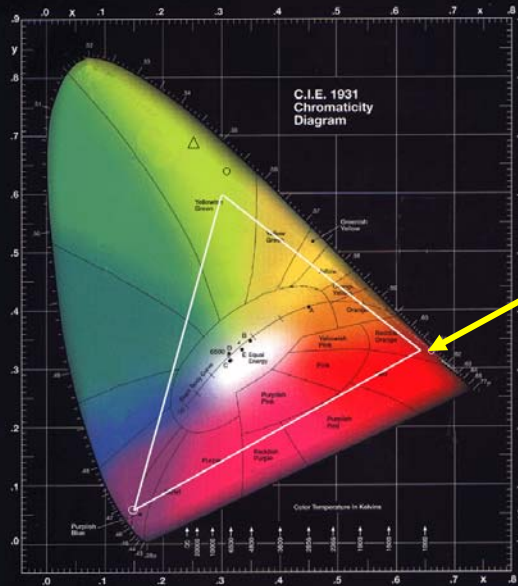
**THE MORE BRIGHTNESS**

**TO SEE COLOR**

# VISUAL BEHAVIOR

In projection displays, X Y co-ordinates from the 1931 CIE (Commission Internationale de L'Eclairage) are used to specify exact colours.

Hue, Saturation, Gamut

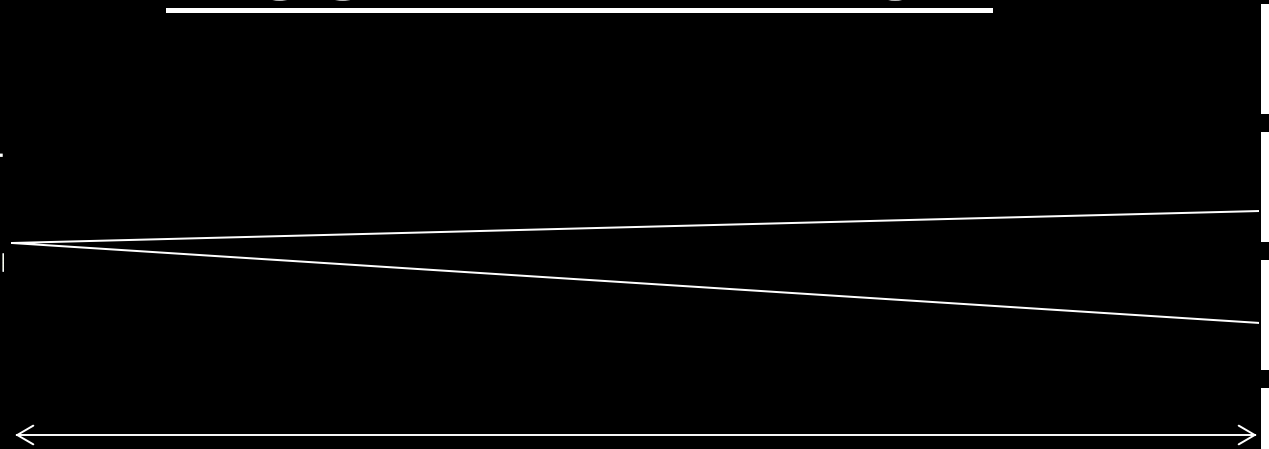


Limitation of today's display technologies. Colours outside of triangle can not be reproduce by electronic displays.

Significance of chart illustrates colours on print are not necessarily reproducible electronically.



# VISUAL BEHAVIOR



Minimum Viewing distance before pixel structure is detected.

$$\begin{aligned} \text{Viewing distance} &= (1/2) / \tan (1/120) \\ &= (3438/\text{vertical pixels}) \times \text{screen height} \end{aligned}$$

E.g. For xga display with 30" screen height, min. viewing distance is 134"

For sxga display with 30" screen height, min. viewing distance is 100"

# VISUAL BEHAVIOR

## Control your Pupil

When the eye goes from bright to dark or vice versa, the size of the pupil changes. This muscle movement like any other can get tired or fatigued.

Avoid excessive high contrast either on the display or its surroundings.



Good  
example

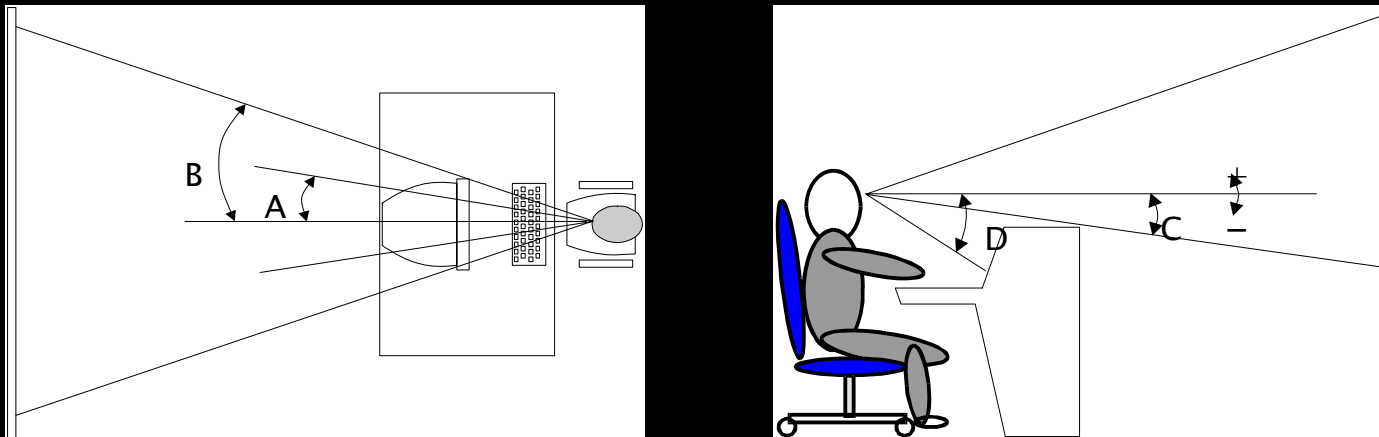
Too  
dark



# ERGONOMIC STANDARDS

## Viewing Angle

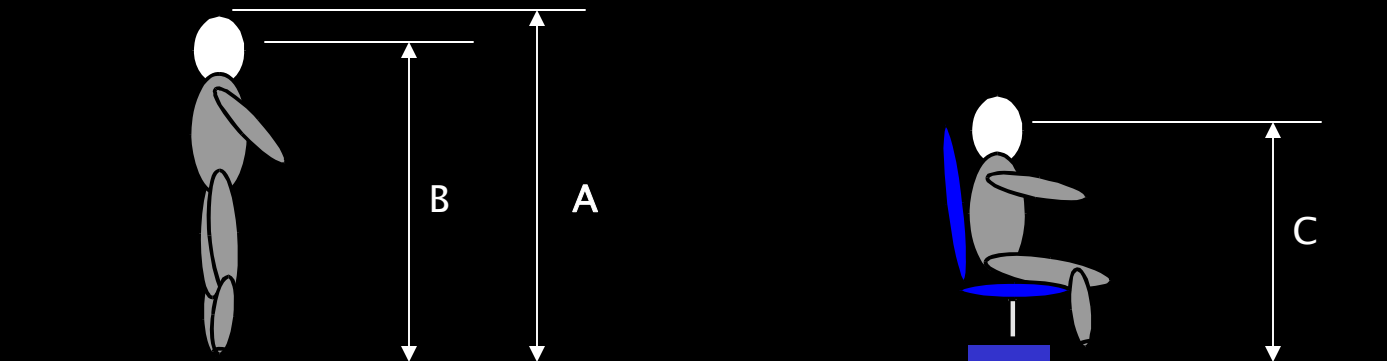
	Restrict Horizontal Movement		Restrict Vertical Movement	
	Ideal limit (A)	Max. limit (B)	Ideal limit (C)	Max. limit (D)
Eye Movement	+/- 15	+/- 35	+ 0, - 30	+ 25, - 35
Head Movement	non	+/- 60	non	+/- 50
Total Movement	+/- 15	+/- 95	+ 0, - 30	+/- 75



Source:  
MIL-STD-  
1472D

# ERGONOMIC STANDARDS

Body Characteristics		P5	P95
Standing	A	4' 6" (1390mm)	6' 1" (1910mm)
Standing eye level	B	50" (1270mm)	70.5" (1790mm)
Sitting eye level	C	24.4" (620mm)	34.6" (880mm)



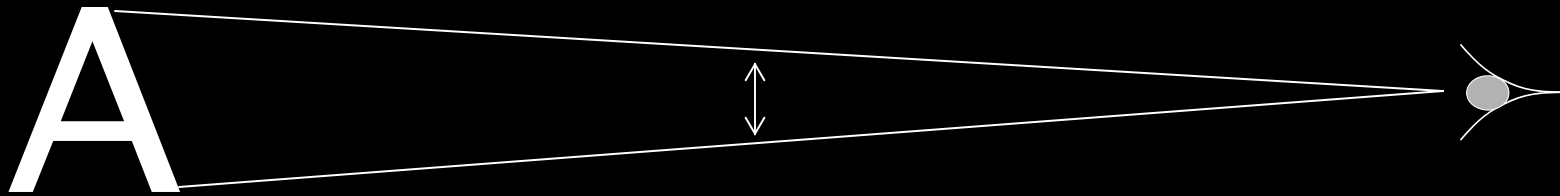
P5 – Only 5 percent of the world population would be below this figure.

P95 – Only 5 percent of the world population would be above this figure.

Source: International labour office, Geneva Switzerland

# CHARACTER LEGIBILITY STANDARDS

	Minimum	Primary Operator	General/Public Viewing
Arc Minute	10	15 - 20	> 30
Degrees	0.166	0.25 - 0.33	> 0.5



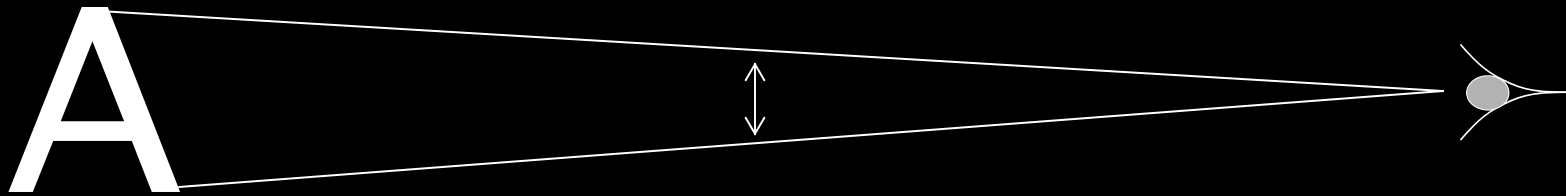
Recommendations based on fixed pixel structure displays.

# ERGONOMIC STANDARDS

Sample calculation:

Viewing Distance	Minimum (10')	Primary Operator (18')	General/Public Viewing (30')
120	0.35	0.63	> 1.0
180	0.52	0.94	> 1.5

All dimensions in inches



# HOW DOES THIS RELATE TO OTHER *"RULES OF THUMB"*

- 1. The Old Eye Chart Rule
  - Minimum legibility and go up two lines
- 2. Size of Character to Viewing Distance
  - 1" to 120" Rule (Oversized)
  - OR 1" to 200" (Ideal)
  - OR 1" to 360" (Minimum)
- 3. 2,4,7 Rule
  - 2 Time Width = Graphics (1280 x 1024)
  - 4 Times Width = Data (1024 x 768)
  - 7+ Times Width = Video
- 4. ARC Minutes:
  - 9 Minutes of Arc Vertically
  - 12 Minutes of Arc Horizontally
  - 15 Minutes of Arc Diagonal

WHICH EQUALS =  $MDV \times .0029$  (for 20/20 - 1280x1024)

# TECHNOLOGY FACTORS

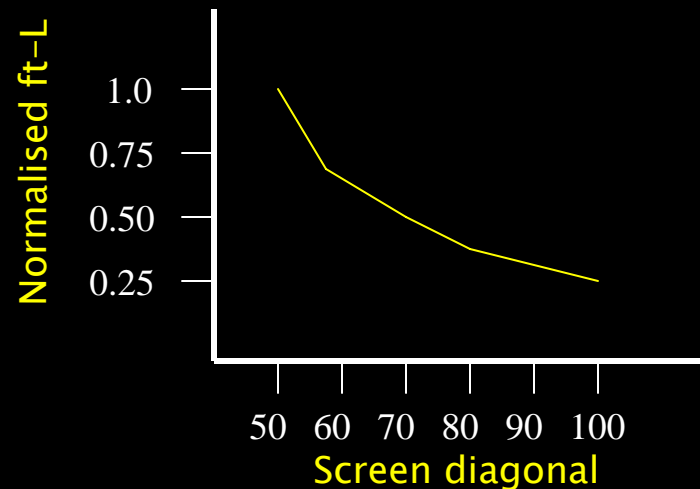
## Screen Brightness

Light Output (ft-L) = [projector output (lumens) / screen area (sq. ft) ] x screen gain

Light Output (nits) = ([projector output (lumens) / screen area (sq. m) ] x screen gain)/pie

pie =  
3.141592654

### Screen brightness vs Screen size

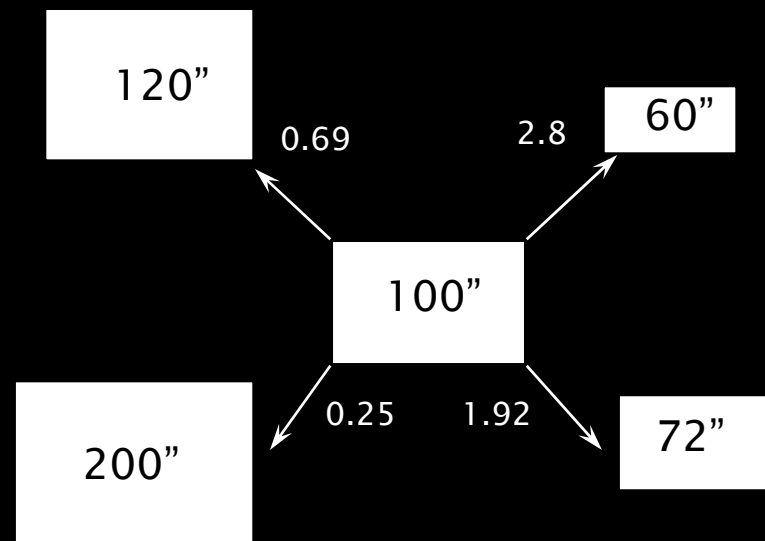


Screen light output  
will decrease faster  
than increase in  
screen size

# SCREEN BRIGHTNESS & SIZE

- The rule with regards to image (relative to projection screen gain) is: the larger the image size, the greater the need for a high gain screen. Recent technology advancements with projector technology / increased lumens are continually impacting screen developments.

The brightness is in inverse proportion to the screen area. In other words, the smaller the screen, the brighter the image. When the screen size is changed from 100" to 72", the brightness is 1.92 times higher



*\*Assume the brightness of the 100" screen is 1.*

# TECHNOLOGY FACTORS

## Ambient Brightness

### Screen/Display

<b>Typical display devices</b>	
<b>Application</b>	<b>Screen Brightness (ft-L)</b>
Projection Cubes	+100
Plasma displays	50 - 90
Desktop monitors (CRT)	30 - 50
Average Television	40 - 60
Cinema Screens	12 - 16

ft-L = foot  
Lamberts

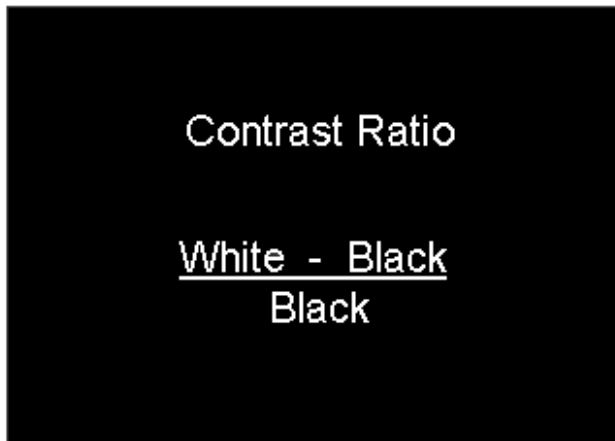
### Ambient

<b>Typical environments</b>	
Office with windows (on sunny day)	+100
Factory assembly floor	+30
Office with no windows	+15
Living room	10
Cinema	1

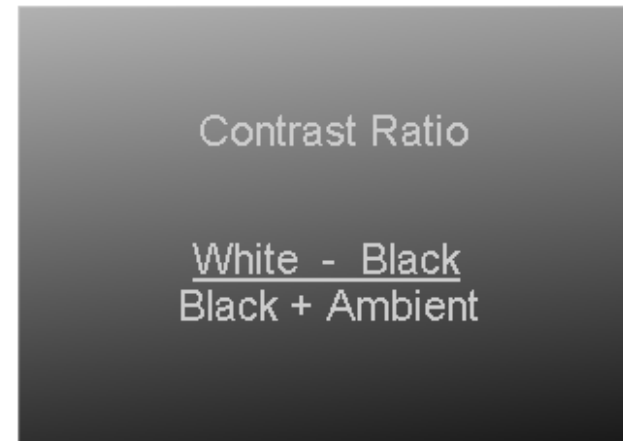
foot  
candle

# TECHNOLOGY FACTORS

## Ambient Light and Contrast Ratio



Maximum contrast ratio is already achieved at initial design. Implementation will only make it worse.



Poor control over ambient light causes black areas to be bright and reduces contrast ratio.

The Higher the Resolution

The Higher the Brightness

The Higher the Contrast

The Higher the Bandwidth

and in control rooms ... the cost to maintain

