10/27/11

# H. C.

DIFFERENT REP FOR POINTS

**CART 3D**

$(X, Y, Z)$

**H C**

$(X_H, Y_H, Z_H, W)$

$X = \frac{X_H}{W}, \quad Y = \frac{Y_H}{W} \quad Z = \frac{Z_H}{W}$

$\left(\frac{1}{4}, \frac{2}{4}, \frac{3}{4}\right) \leftarrow (1, 2, 3, 4)$

$\left(\frac{1}{4}, \frac{2}{4}, \frac{3}{4}\right) \leftarrow (10, 20, 30, 40)$

H. C

**CART**

3x3 MAT

$M \longleftrightarrow$

4x4

$$\left(\begin{array}{ccc|c} & M & & \begin{matrix}0\\0\\0\end{matrix} \\ \hline 0 & 0 & 0 & 1 \end{array}\right)$$

## CART

SCALE BY (2, 3, 4)

$$\begin{pmatrix}4\\12\\20\end{pmatrix} = \begin{pmatrix}2&0&0\\0&3&0\\0&0&4\end{pmatrix}\begin{pmatrix}2\\4\\5\end{pmatrix}$$

## HOM

$$\begin{pmatrix}4\\12\\20\\1\end{pmatrix} = \begin{pmatrix}2&0&0&0\\0&3&0&0\\0&0&4&0\\0&0&0&1\end{pmatrix}\begin{pmatrix}2\\4\\5\\1\end{pmatrix}$$

$$\begin{pmatrix}8\\24\\40\\2\end{pmatrix} = \begin{pmatrix}4\\8\\10\\2\end{pmatrix}$$

HC UPWARD COMPATIBLE WITH CART

## ADV 1

TRANSLATION BY (4, 5, 6)

$$\begin{pmatrix}x+4\\y+5\\z+6\\1\end{pmatrix} = \begin{pmatrix}1&0&0&4\\0&1&0&5\\0&0&1&6\\0&0&0&1\end{pmatrix}\begin{pmatrix}x\\y\\z\\1\end{pmatrix}$$

YOU CAN SCALE HC POINT

$$2\begin{pmatrix}1\\2\\3\\1\end{pmatrix} = \begin{pmatrix}2\\4\\6\\2\end{pmatrix} = \begin{pmatrix}10\\20\\30\\10\end{pmatrix} \text{ ETC}$$

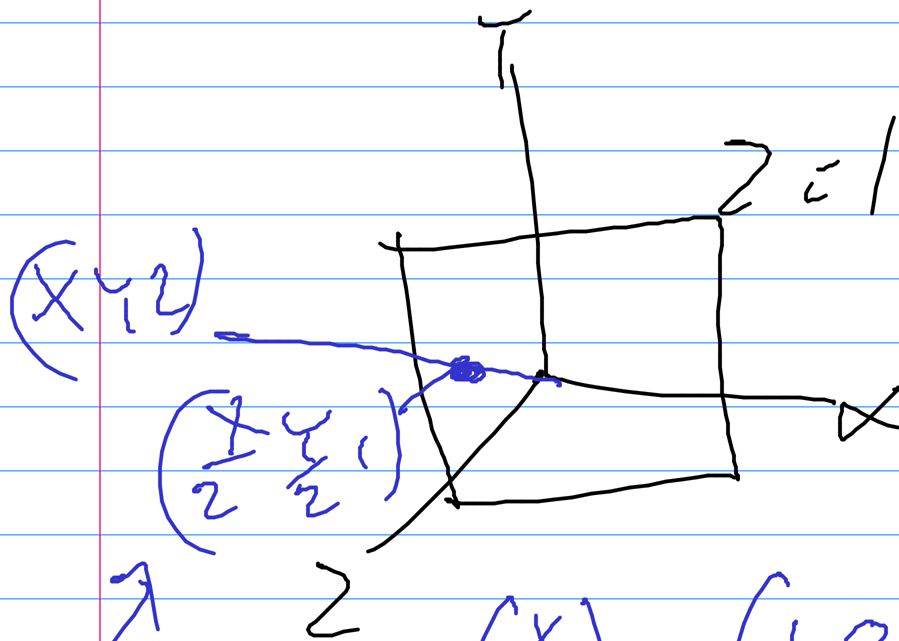
YOU CAN SCALE HC MAT

(4, 5, 6) TRANS

$$\begin{pmatrix}1&0&0&4\\0&1&0&5\\0&0&1&6\\0&0&0&1\end{pmatrix} = \begin{pmatrix}2&0&0&8\\0&2&0&10\\0&0&2&12\\0&0&0&2\end{pmatrix}\begin{pmatrix}X\\Y\\Z\\1\end{pmatrix}$$

$$\begin{pmatrix}2X+8\\2Y+10\\2Z+12\\2\end{pmatrix} \rightarrow \begin{pmatrix}X+4\\Y+5\\Z+6\\1\end{pmatrix}$$

# PROJECTION IS A MATRIX




$$\begin{pmatrix} X \\ Y \\ Z \\ Z \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \\ 1 \end{pmatrix}$$

CART

$$\begin{pmatrix} X/2 \\ Y/2 \\ 1 \end{pmatrix}$$

$$p = \underbrace{P\,T_2\,R_2\,S_1\,T_1\,R_1}_{M}\,(p)$$

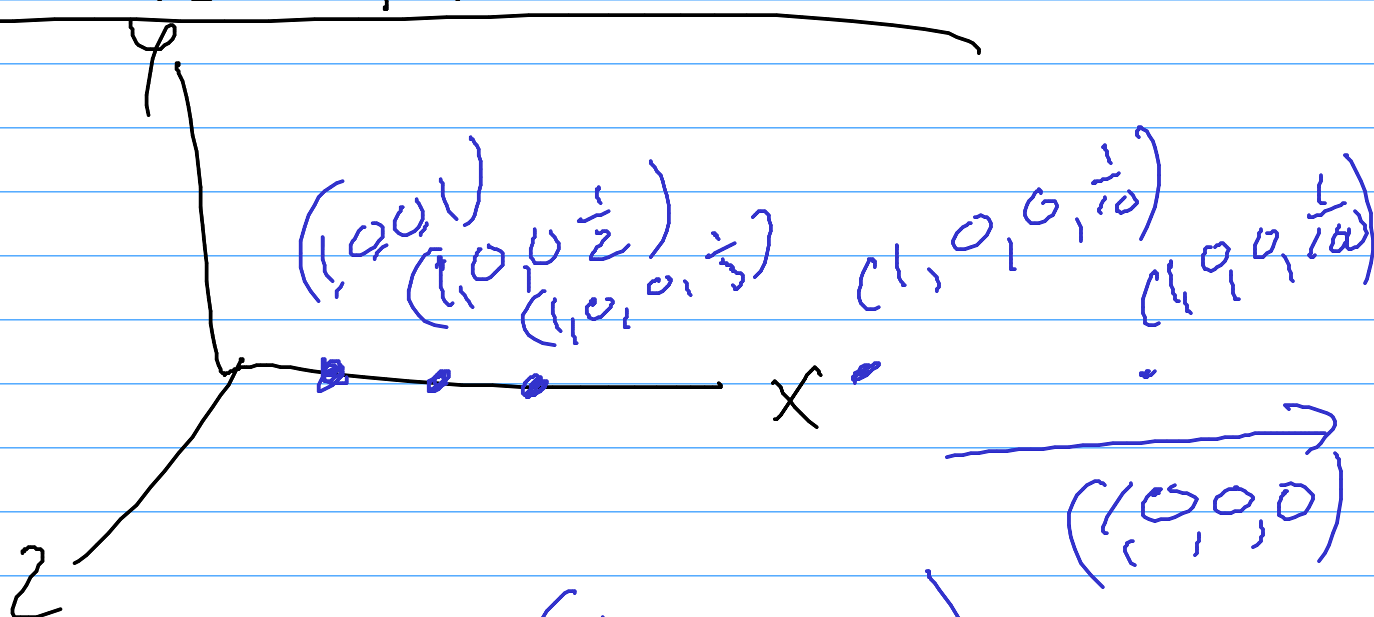
VIEW NORMALIZATION IS ALSO A HC MATRIX

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} \rightarrow \begin{pmatrix} X/Z \\ Y/Z \\ 1/Z \end{pmatrix}$$

$$\begin{pmatrix} X \\ Y \\ 1 \\ Z \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \\ 1 \end{pmatrix}$$

VIEW NORM

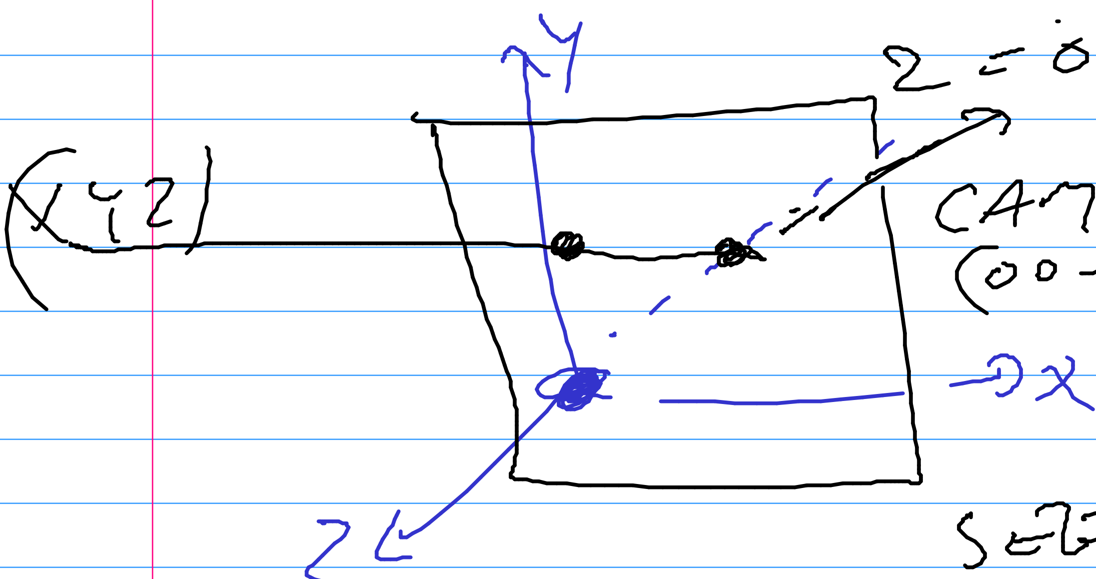
POINTS AT ∞




LIMIT FOR (1,0,0,W) AS W → 0 IS POINT AT AT END OF X AXIS.

USE? A PARALLEL PROJ
IS A PERSPECTIVE PROJ
WITH CAMERA AT ∞.

ONE LESS SPECIAL CASE




CAM AT (0, 0, -1)
(0 0 -1) (0 0 -2)
(0 0 -10)
. . .

SEE WEB SITE

7

$$X' = X\left(\frac{D}{Z+D}\right) = X\left(\frac{1}{\frac{Z}{D}+1}\right)$$

$$Y' = Y\left(\frac{D}{Z+D}\right)$$

$$Z' = 0$$

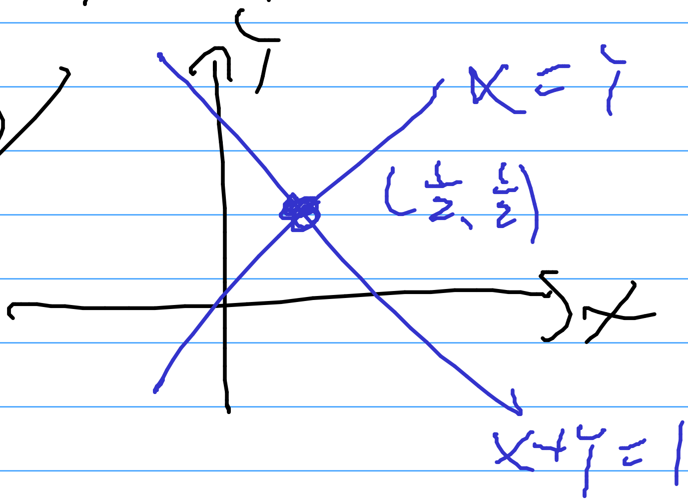
IF $D = \infty$

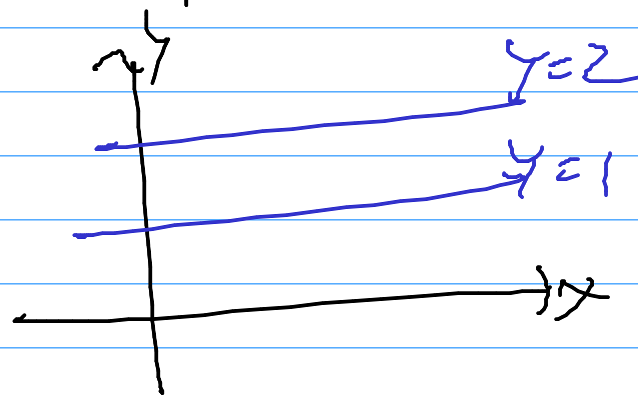
$$X' = X$$
$$Y' = Y$$
$$Z' = 0$$

# MORE ADVANTAGES

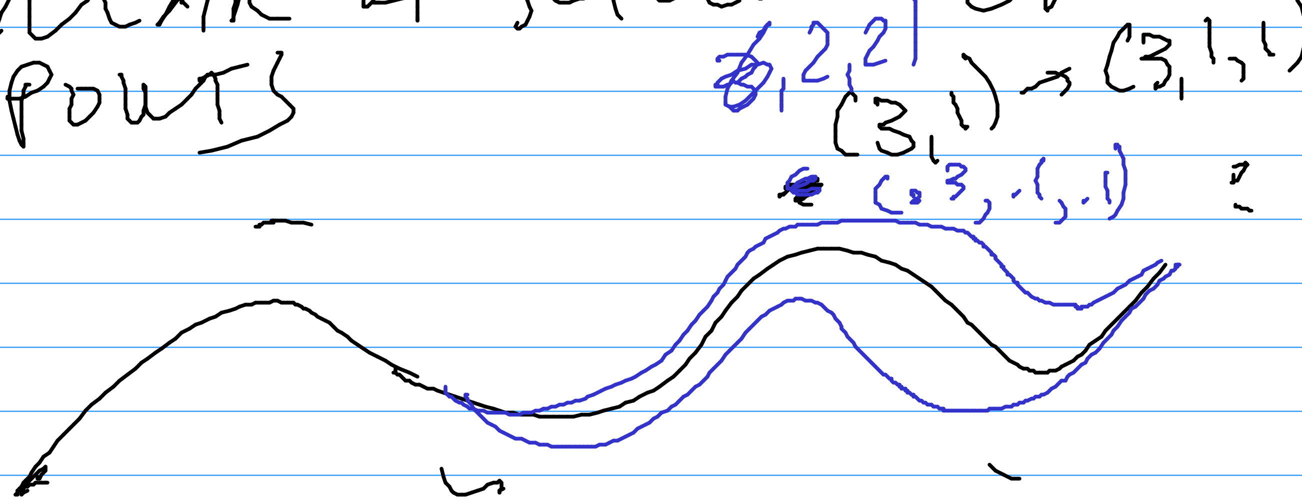
PARALLEL LINES INTERSECT AT AN INFINITE POINT.

~~2D~~




CAD: FIT A CURVE NEAR A SEQUENCE OF POINTS




INCREASING $w$ INCREASES THAT POINT'S WEIGHT.

~~ADV~~

CIRCLE IS E~~X~~ACT.

PARAMETRIC EQNS ARE COMMON

$X = X(T)$

~~Y(t)~~ $Y = Y(T)$

$X_H = T^2 - 1$

$Y_H = 2T$

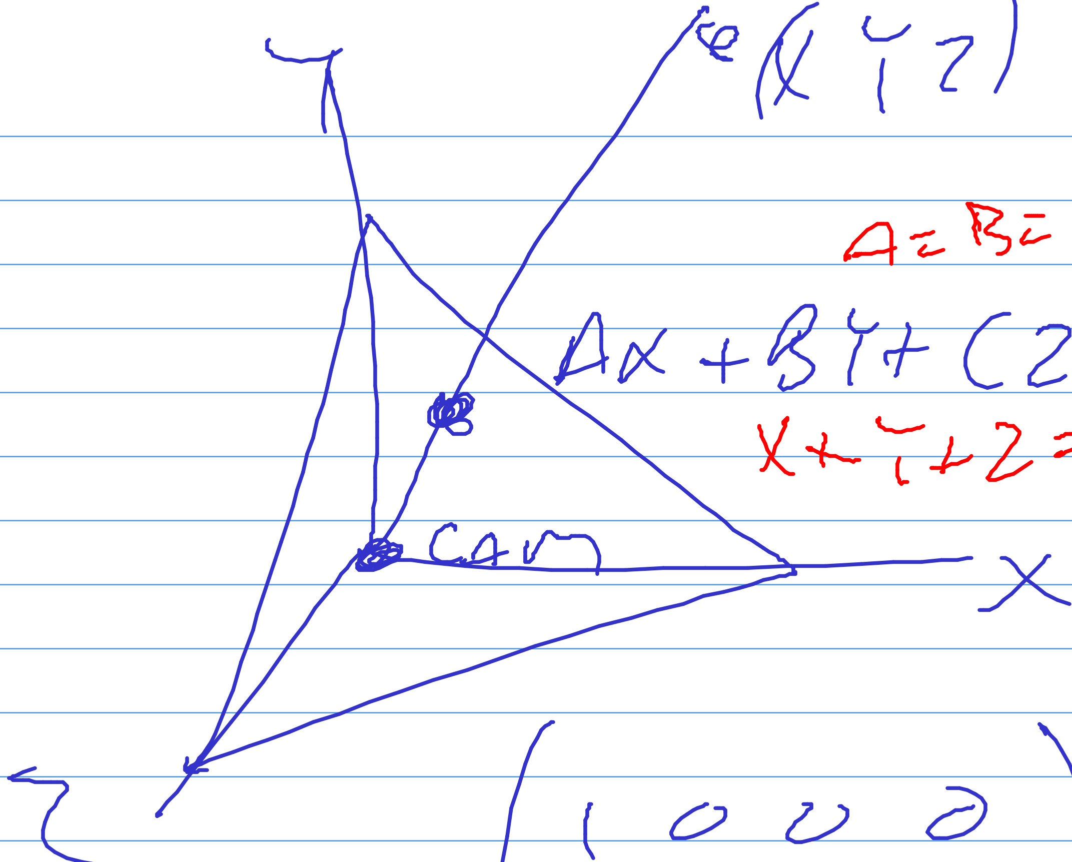
$W = T^2 + 1$

CIRCLE

~~CALC~~

$$X = \frac{T^2 - 1}{T^2 + 1} \qquad Y = \frac{2T}{T^2 + 1}$$

$$X^2 + Y^2 = \frac{T^4 - 2T^2 + 1 + 4T^2}{T^4 + 2T^2 + 1} = 1$$




$A = B = C = 1$

$Ax + BY + CZ = 1$

$X + Y + Z = 1$

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ A & B & C & 0 \end{pmatrix}$$

$$\begin{pmatrix} 1 \\ 3 \\ 5 \\ 9 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 3 \\ 5 \\ 7 \end{pmatrix}$$

$$\left( \frac{1}{9}, \frac{3}{9}, \frac{5}{9} \right) \qquad \left( \frac{1}{7}, \frac{3}{7}, \frac{5}{7} \right)$$

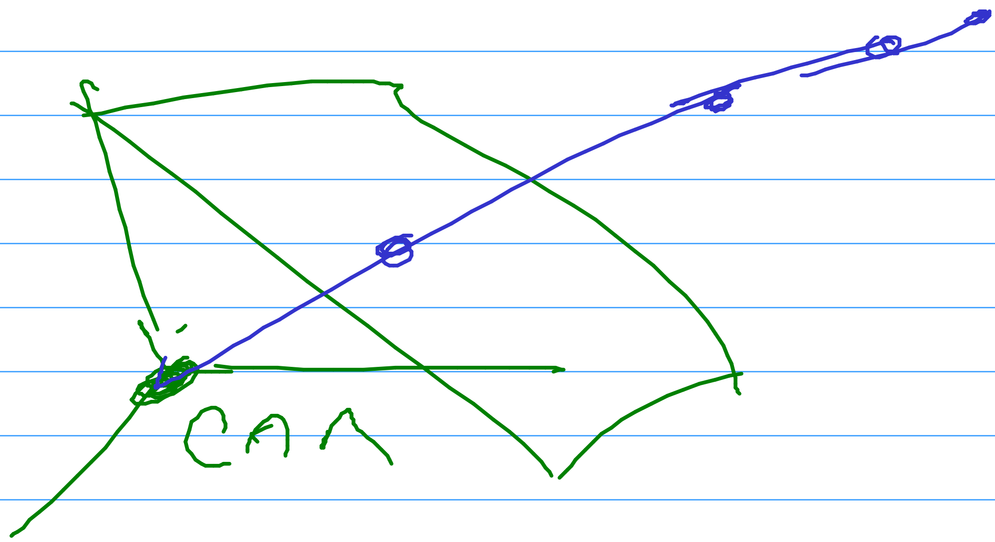
IS THIS GOOD?

1. PROJ POINT IS THE ORIG POINT SCALED (SINCE CAM IS @ (0 0 0))
2. PROJ POINT IS ON $X+Y+Z=1$ ✓

R?

Q: WHAT HAPPENED TO W?
THE W OF THE ORIGINAL POINT DOES NOT AFFECT THE PROJECTED POINT.

A: YES. THE CAMERA IS AT (0 0 0) SO (X, Y, Z), (2X, 2Y, 2Z), (5X, 5Y, 5Z) $\in \mathbb{R}$
ALL PROJECT TO SAME POINT.



# COLOR + LIGHT



GVHA CH 11 p 405

VISIBLE LIGHT

V B C G Y O R

400 nM — 700 nM

4000 Å

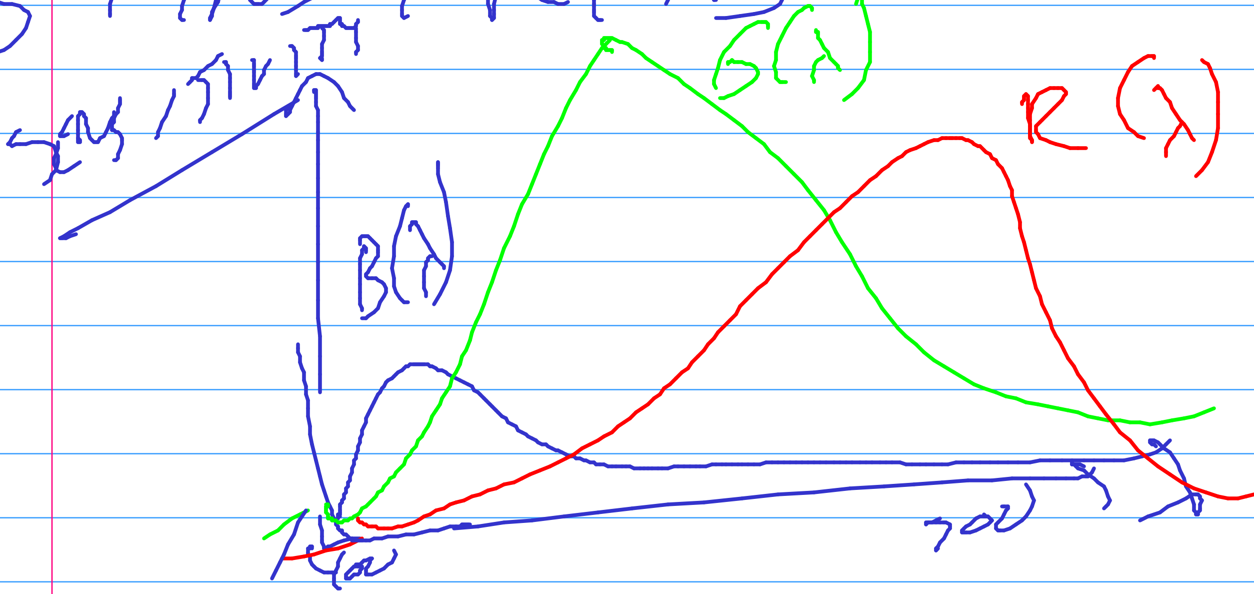
INCOMING LIGHT IS A CONTINUUM

$I(\lambda)$

MAGENTA

COLOR SENSORS IN EYE

3 TYPES ; R, G, B



APPARENT REDNESS OF LIGHT $R = \int R(\lambda) I(\lambda) d\lambda$

$G = \int G(\lambda) I(\lambda) d\lambda$

$B = \int B(\lambda) I(\lambda) d\lambda$

PERCEIVED COLOR IS (R, G, B)
3D

THERE ARE AN ∞ NUMBER OF DIFFERENT COLORS THAT ARE PERCEIVED THE SAME.

MERAMORPHIC

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WE TALK ABOUT (RGB) COLORS.


ADDITIVE COLORS

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# ADDITIVE COLORS

OVERLAPPING SPOTLIGHTS ONTO DARK SCREEN

SUBTRACTIVE

OVERLAPPING INKS ONTO WHITE PAPER


ALSO USE BLACK INK

CMYK

# HSV

HUE SATURATION VALUE

RGB 3D VECTOR

YOU CAN CHANGE BASIS.

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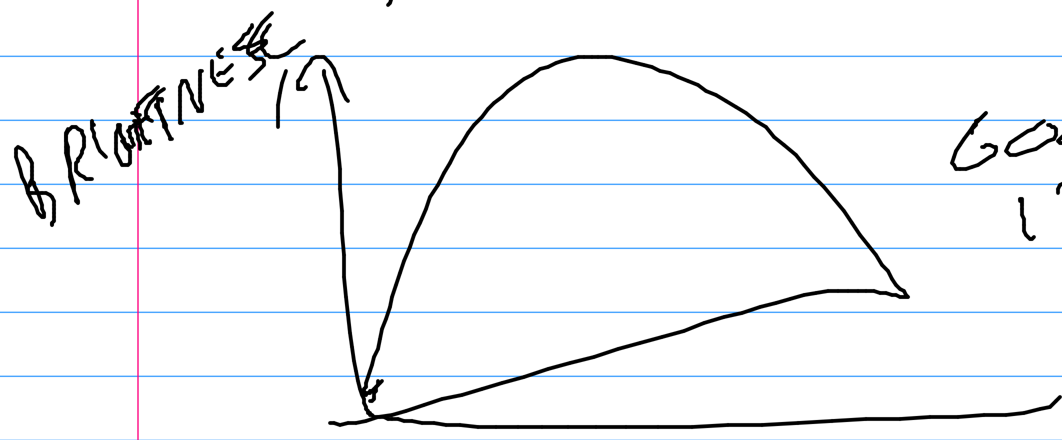
## CIE CHROMATICITY DIAGRAM

Q SUPPOSE A LIGHT AT $\lambda = 500$nm
& A LIGHT $\lambda = 700$nm OVERLAP.
YOU WILL SEE ONE COLOR.
WHAT IS IT?




GOOGLE IT

THIS MAPS COLORS INTO A PERCEPTUAL COORDINATE SYSTEM.

ABOVE WAS GENERAL
STUFF ABOUT PEOPLE +
COLOR

NOW WE'LL SEE
COLOR + OPENGL / DIRECTX.

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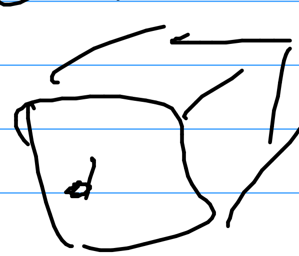
PHONG'S
LIGHTING
MODEL

≠ PHONG SHADING
OF A PATCH

KEY CONCERN IN GRAPHICS
IS APPARENT COLOR OF AN
OBJECT



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SPECULAR - SHININESS

+ DIFFUSE

+ AMBIENT

= TOTAL LIGHT AT EACH POINT OF SURFACE OF OBJECT.