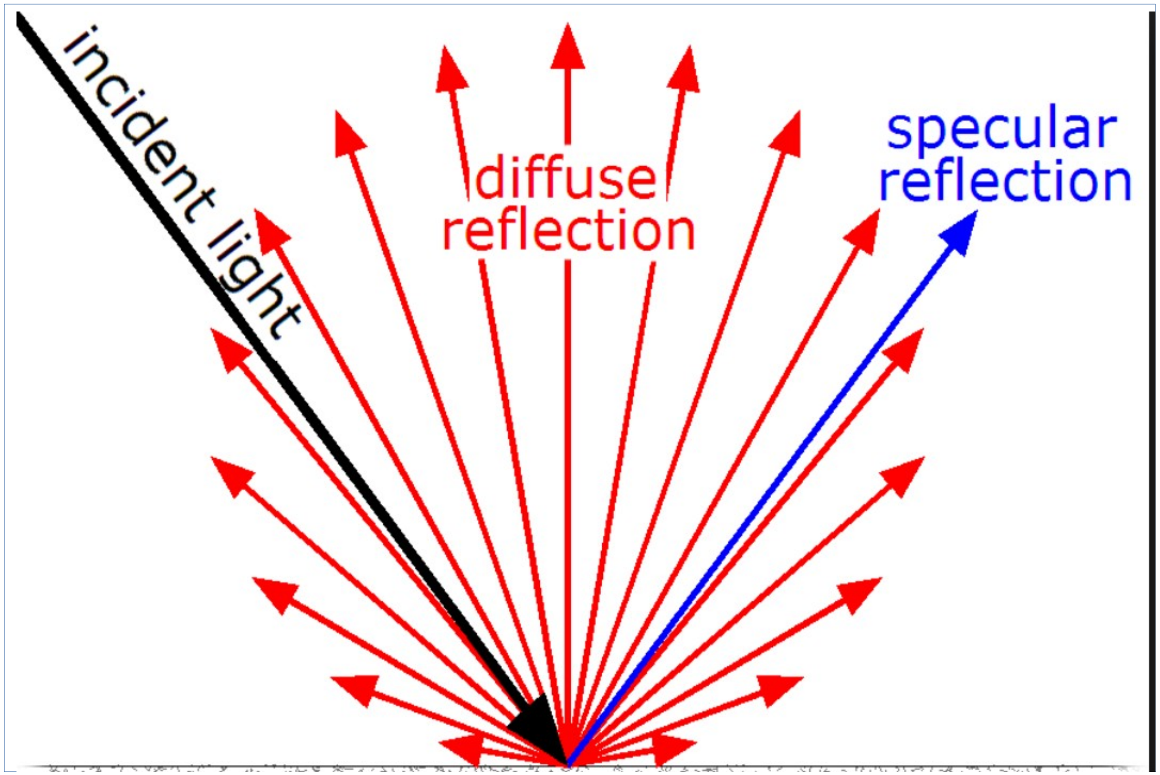
Diffuse Reflection



https://en.wikipedia.org/wiki/Diffuse_reflection

Diffuse Reflection: the reflection of light uniformly in all different directions, the surface of this reflection exhibits Lambert reflection, e.g., equal luminance when viewed from all directions.

Two Key Characteristics:

1. The surface with reflectivity as K_d = (k_r, k_g, k_b), e.g., diffuse coefficients;

2. The decay of incident light is inverse proportional to its distance from the source to the surface point. e.g., 1/(r*r), where r is bing the distance from the light source to the surface.
 Specular vs. diffuse reflection

Harry Li, Ph.D

Diffuse Reflection Formulation

Light source I_s(x,y) consists of r, g, b 3 primitive colors as follows, but let's simplify it as white color, so r, g, b all equal and have the highest value (if in graphics, they are 255)

$$\boxed{\vec{I_s}(x,y,z) = \left(I_r(x,y,z), I_g(x,y,z), I_b(x,y,z)\right)} \quad \ldots (1)$$

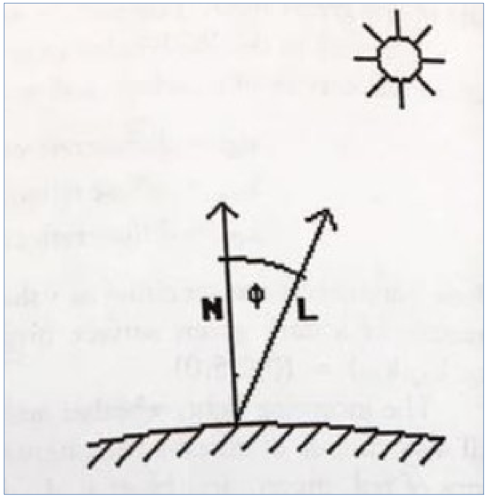
Object surface consists of reflectivity, e.g., coefficient of reflection

$$\boxed{\vec{K_d} = (K_r, K_g, K_b)} \quad \ldots (2)$$

r_d vector in Equation (1) is a ray equation, just like I_s(x,y,z) but has no r, g, b primitive color defined in it for the matter of simplicity.

Diffuse Reflection Equation

Let's consider white color of the point light source, then each primitive color r, g, b of the object surface I(x,y,z) can be computed as follows:



$$I_r = K_{d_r} \frac{\vec{n}\cdot\vec{r} \quad 1}{\|\vec{n}\|\|\vec{r}\| \, \|\vec{r}\|_2^2} \quad \ldots (1.1)$$

where

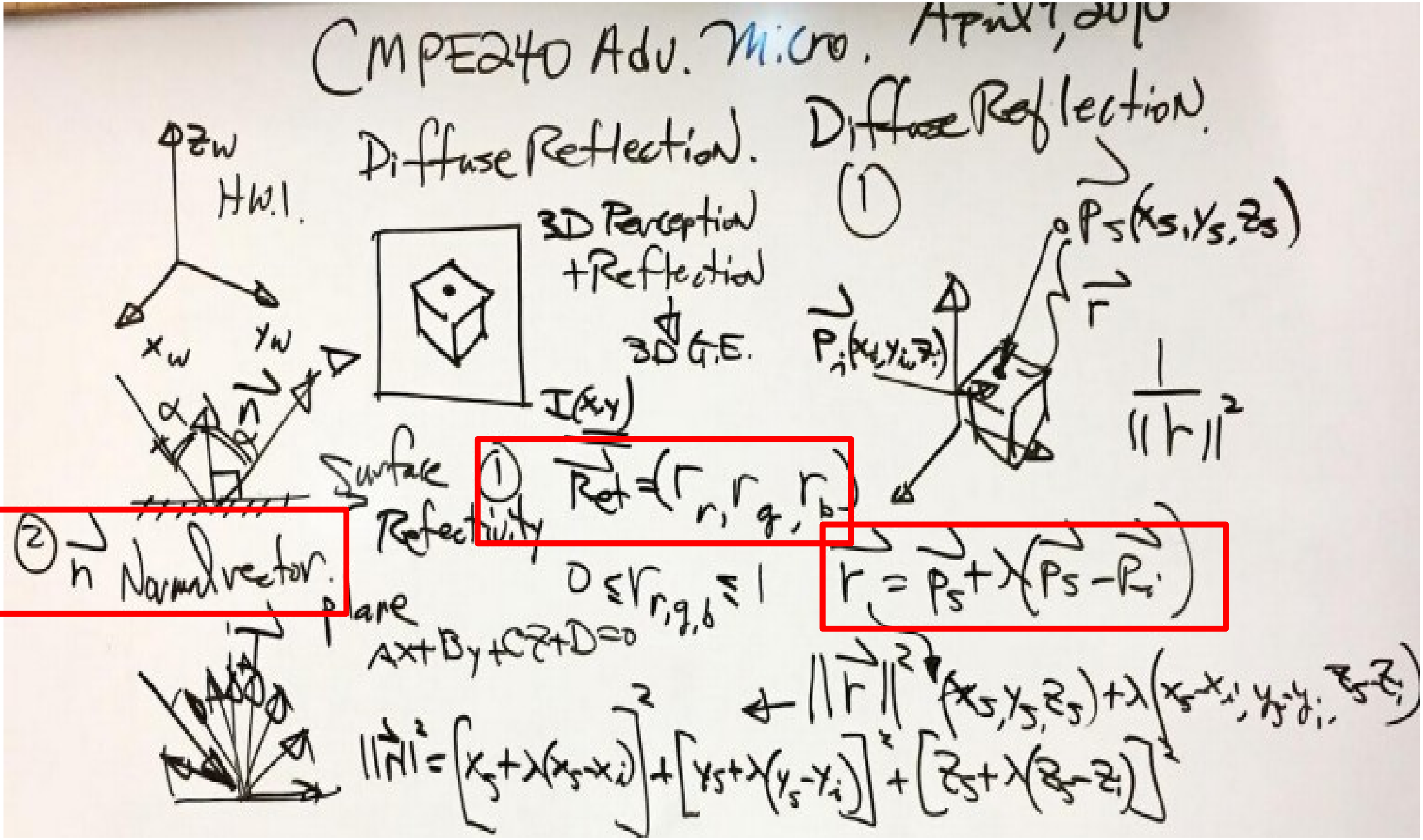
$$\|\vec{r}\|_2^2 = x_r^2 + y_r^2 + z_r^2$$

$$I_g = K_{d_g} \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} \cdot \frac{1}{\|\vec{r}\|_2^2} \quad \ldots (1.2)$$

$$I_b = K_{d_b} \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} \cdot \frac{1}{\|\vec{r}\|_2^2} \quad \ldots (1.3)$$

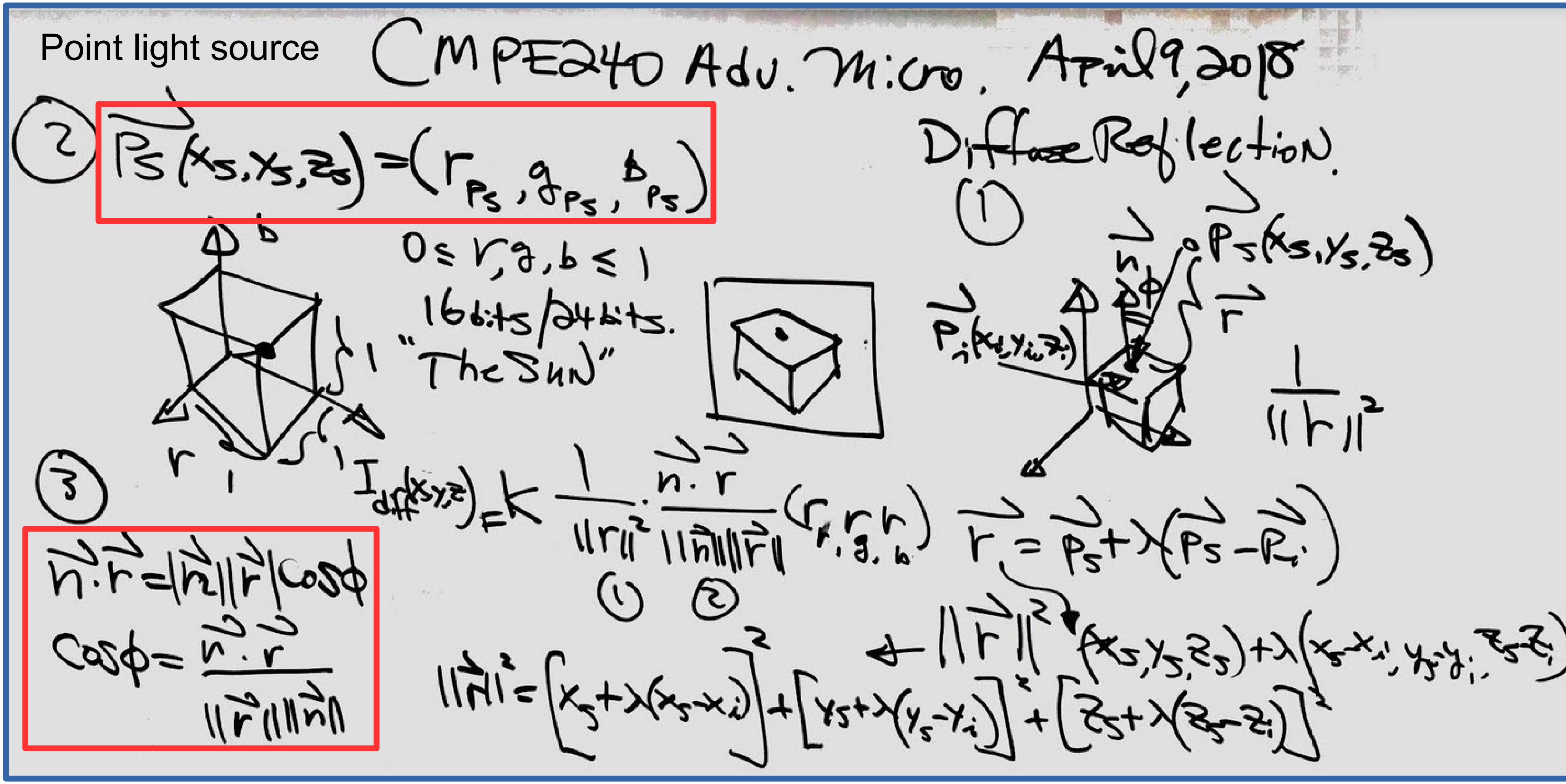
Reference: Computer Graphics, C. K. Pokorny, C. F. Gerald, pp. 514

Formulation Of Diffuse Reflection Equation



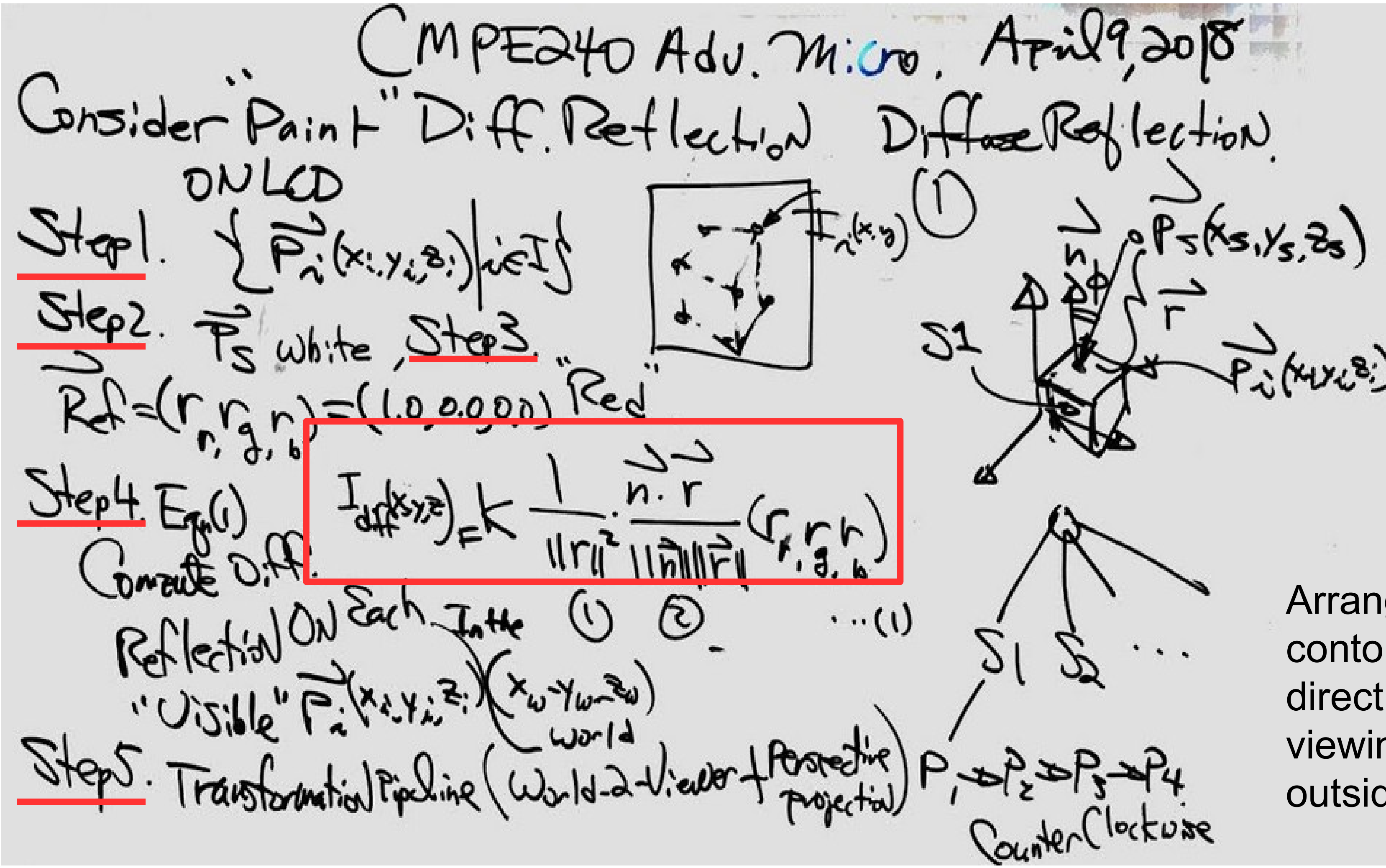
Harry Li, Ph.D

Point Light Source And Incident Angle



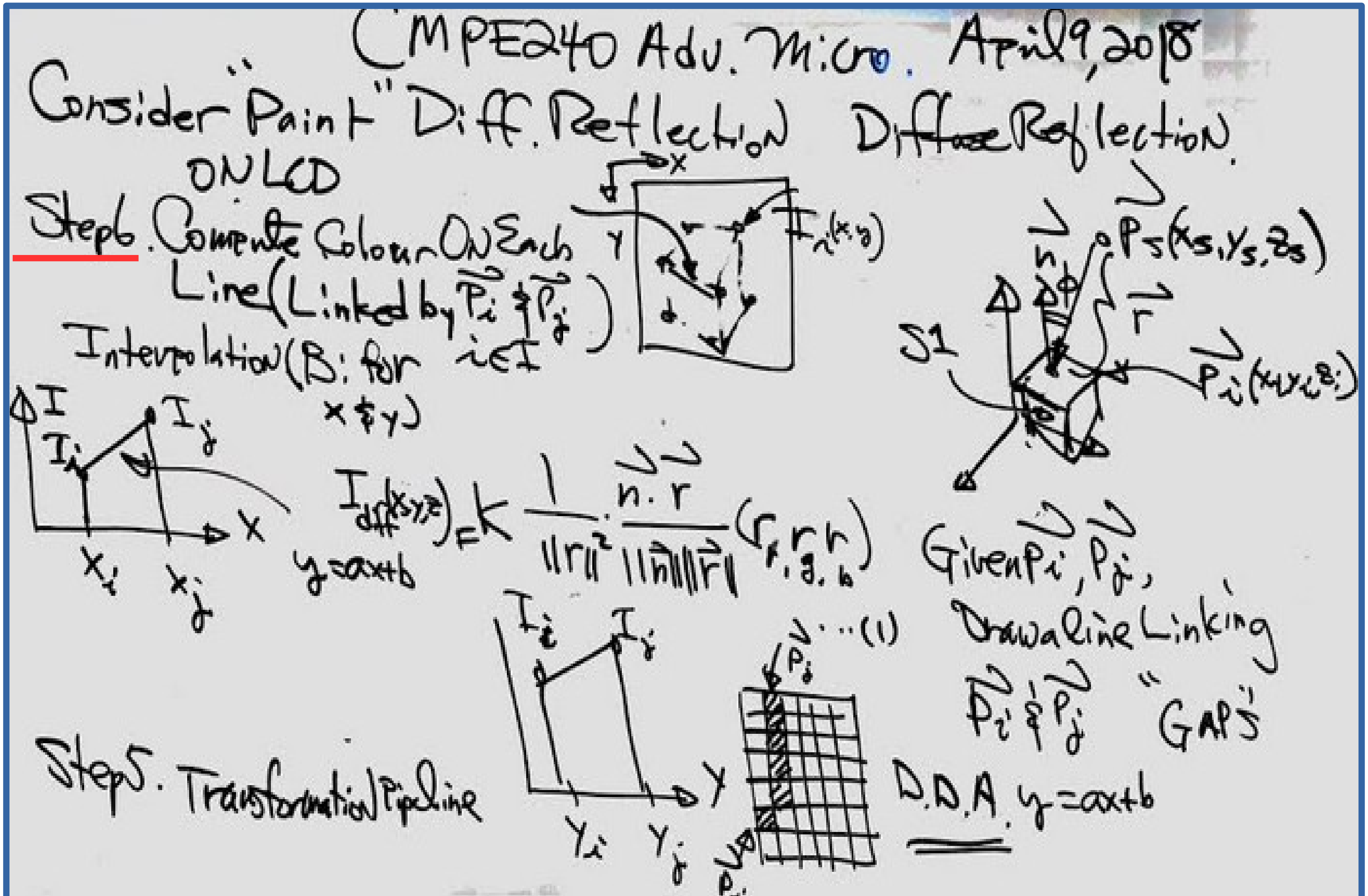
Angle of incident light

Step 1-5 For Diffuse Reflection Computation

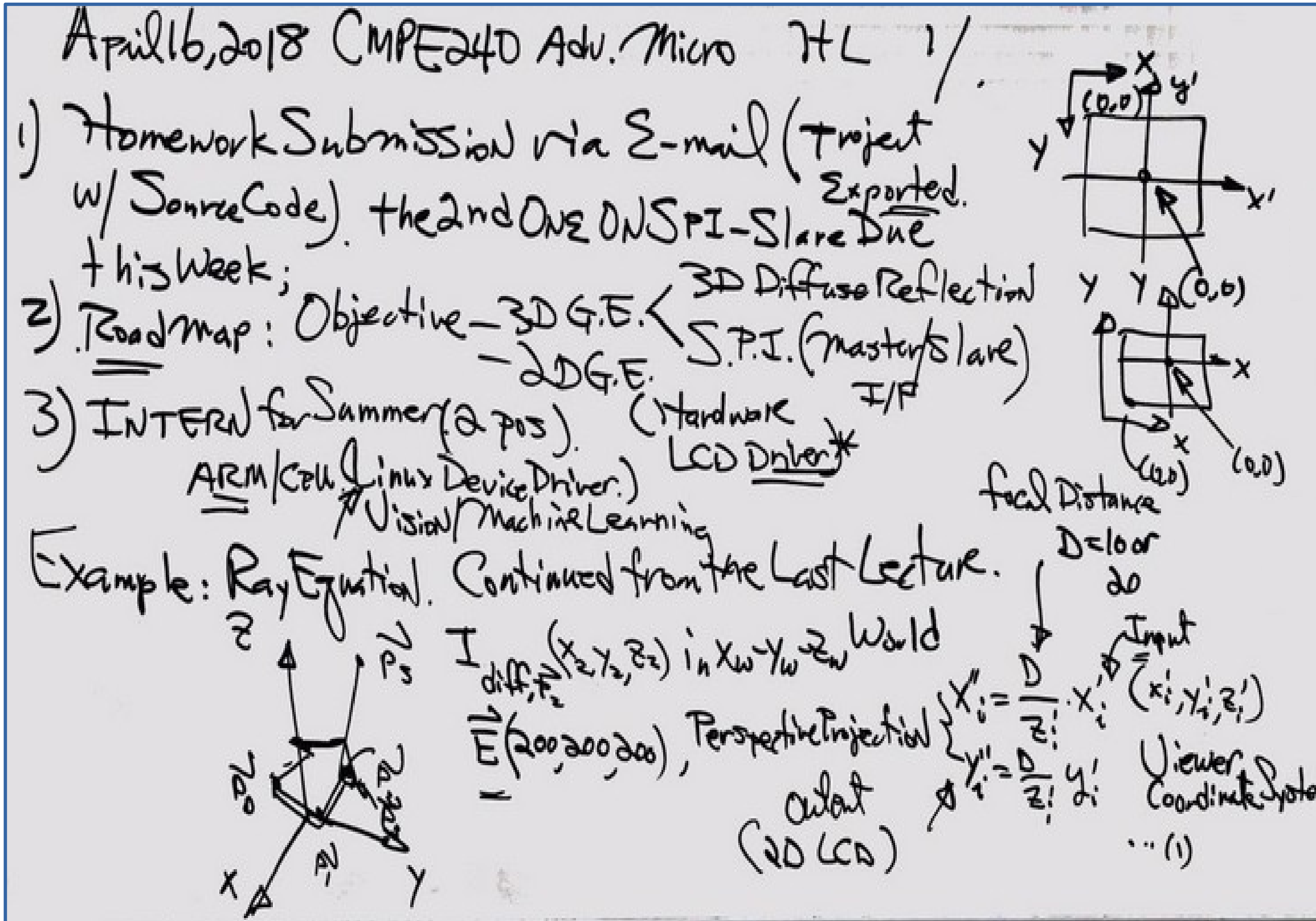


Arrange vertex in contour clock wise direction when viewing from outside

Step 6 For Diffuse Reflection Computation



Example On Diffuse Reflection Computation (1)



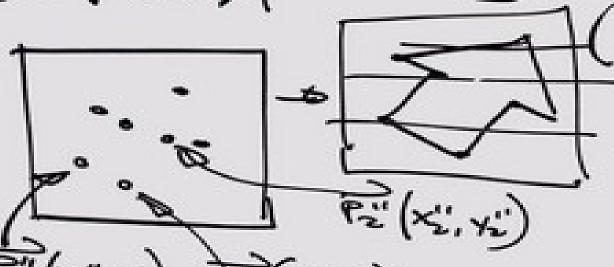
Example On Diffuse Reflection Computation (2)

$\{\vec{P_i}(x_i', y_i', z_i') \mid i = 0, 1, \ldots, 6\}$

Hence, from P.P. (Eqn-1), we have

Suppose $D = 10$, find

$\{\vec{P_i}''(x_i'', y_i'') \mid i = 0, 1, \ldots, 6\}$



(Location + Color)

$\boxed{\begin{cases}\text{Interpolation to find Color on Boundary(s)}\\ \text{Find Boundaries?}\end{cases}}$

Find Boundary : $y = ax + b$ $\begin{cases}\text{"GAPs"}\\ \text{mult}\end{cases}$

$y_{k+1} = ax_{k+1} + b, \; x_{k+1} = x_k + 1$

$\boxed{\text{D.D.A. (Digital Differential Algorithm)}}$

Example: Given $(x_0, y_0) = (1,1)$, $(x_1, y_1) = (3,5)$

$\boxed{\text{D.D.A. to Draw a Line}}$

$\text{Slop} = a = \frac{y_1 - y_0}{x_1 - x_0} = \frac{5-1}{3-1} = 2$

(Note. if $|a| < 1$, then No GAP, $y_{k+1} = ax_{k+1} + b$, $x_{k+1} = x_k$)

Swith x and y.

$\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$,

$y = y_1 + \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$

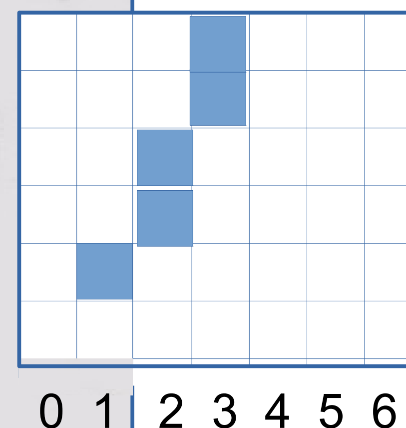
$= \frac{y_2 - y_1}{x_2 - x_1} x + y_1 - \frac{y_2 - y_1}{x_2 - x_1} x_1$

$y = ax + b$, $\frac{1}{a} y = x + \frac{b}{a}$ (1,1)

$\therefore x = \frac{1}{a} y - \frac{b}{a} \quad \ldots(2)$

$x = \frac{1}{2} y + \frac{1}{2}$

$\begin{cases} y_{k+1} = y_k + 1 \\ x_{k+1} = \frac{1}{2} y_{k+1} + \frac{1}{2} \end{cases}$



Use DDA Algorithm To Find Boundary Points

Algorithm: 1° Given (x_0, y_0) Starting pt, (x_{N-1}, y_{N-1}) Ending pt. Find Slop a;

2° if $|a|<1$, then $\begin{cases} x_{k+1}=x_k+1 \\ y_{k+1}=ax_{k+1}+b \end{cases}$

o/w $x=\frac{1}{a}y-\frac{b}{a}$, then $\boxed{\begin{cases} y_{k+1}=y_k+1 \\ x_{k+1}=\frac{1}{a}y_{k+1}-\frac{b}{a} \end{cases}}$

3° Finish all pts till Reaching (x_{N-1}, y_{N-1})

DDA Algorithm

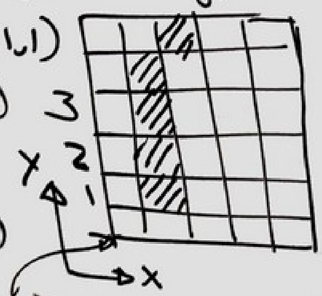
Harry LI CMPE240 Adv. Micro April 18, 2018. Y.

Diffuse Reflection Computation.

D.D.A (github/hualili)

Example: Starting pt. (1,1) Ending. (2,5)

Fig. 1



Slop: $\frac{y_2-y_1}{x_2-x_1}=\frac{5-1}{2-1}$

= . → "GAPs"

$y=ax+b \Rightarrow x=\frac{1}{a}y+\left(-\frac{b}{a}\right)$

Indep. $\boxed{y_{k+1}=y_k+1}\Big|_{y_k=1} = 1+1=2$, $\boxed{x_{k+1}=\frac{1}{a}y_{k+1}+\left(-\frac{b}{a}\right)}$

$=\frac{1}{4}\cdot 2+\left(-\frac{-1}{4}\right)=\frac{3}{4}$

For $y_3=y_2+1=2+1=3$

$x_3=\frac{1}{a}y_3+\left(-\frac{b}{a}\right)\Big|_{b=-1}=\frac{1}{a}3+\frac{1}{a}$

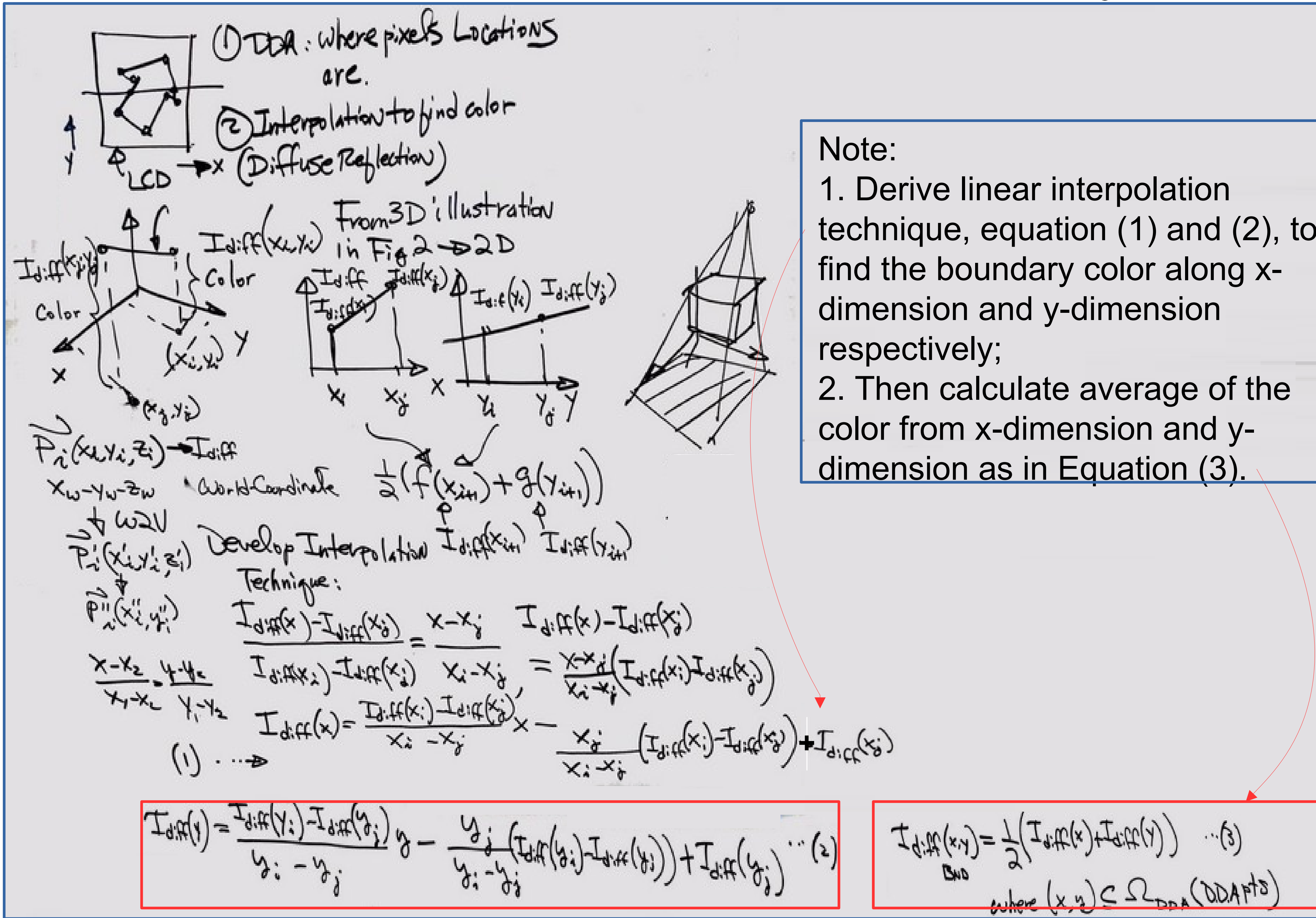
$=\frac{4}{a}\Big|_{a=4}=1$

For $y_4=y_3+1=3+1=4$,

$x_4=\frac{1}{a}y_4+\left(\frac{-b}{a}\right)\Big|_{b=-1}=\frac{4}{a}+\frac{1}{a}\Big|_{a=4}=\frac{5}{4}$

Next. Diffuse Reflection ON Boundaries.

Bilinear Interpolation To Find Boundary Color

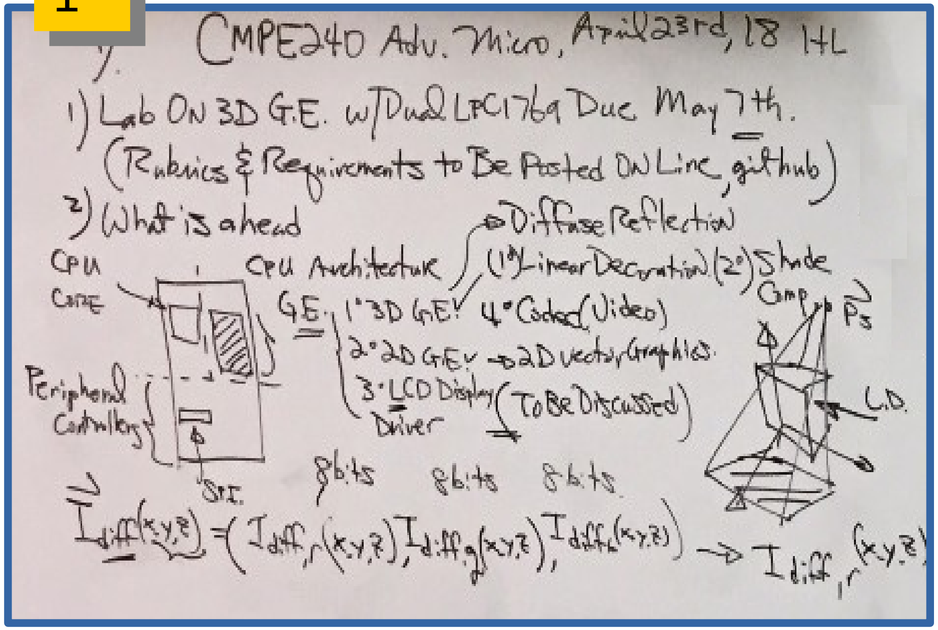


Note:

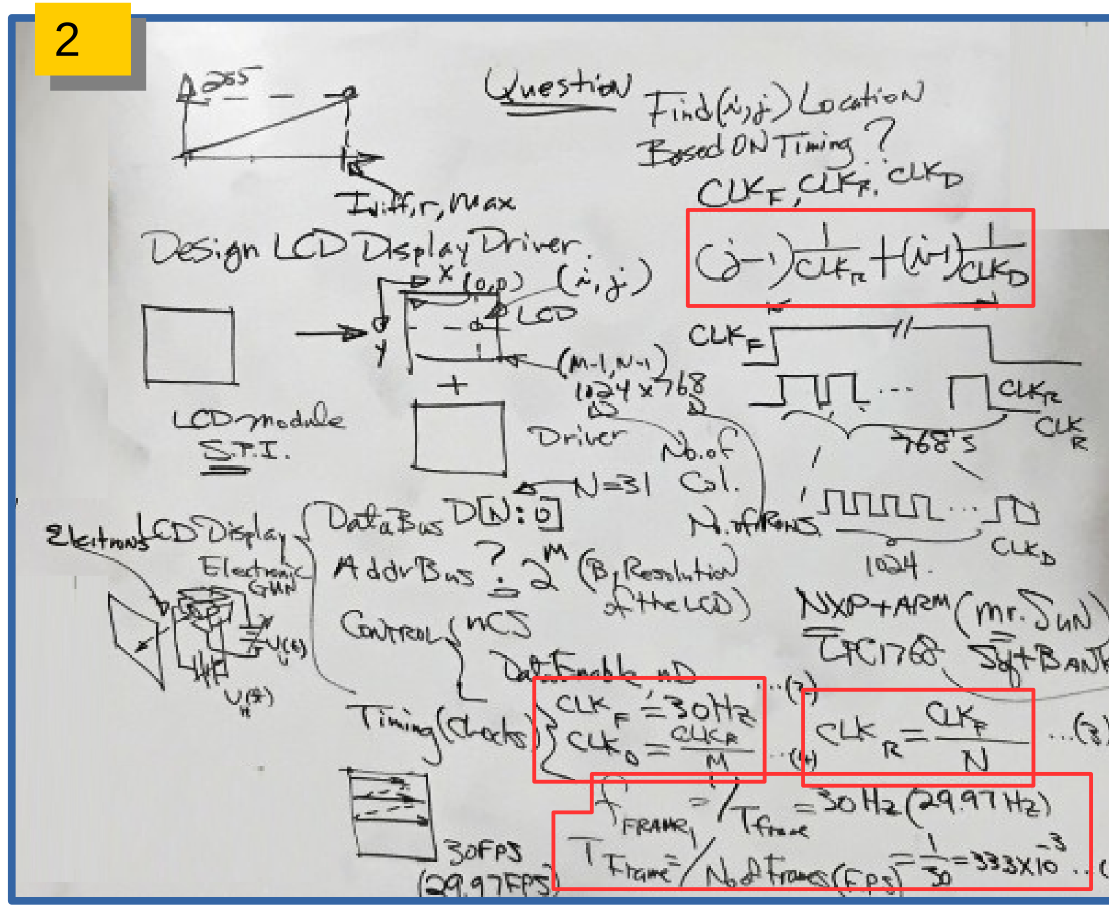
1. Derive linear interpolation technique, equation (1) and (2), to find the boundary color along x-dimension and y-dimension respectively;
2. Then calculate average of the color from x-dimension and y-dimension as in Equation (3).

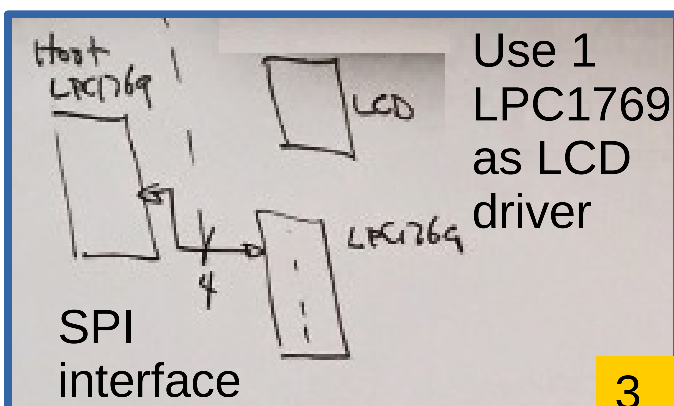
GE (Graphics Engine) Aspects

1



2





Use 1 LPC1769 as LCD driver

SPI interface

3

Harry Li, Ph.D