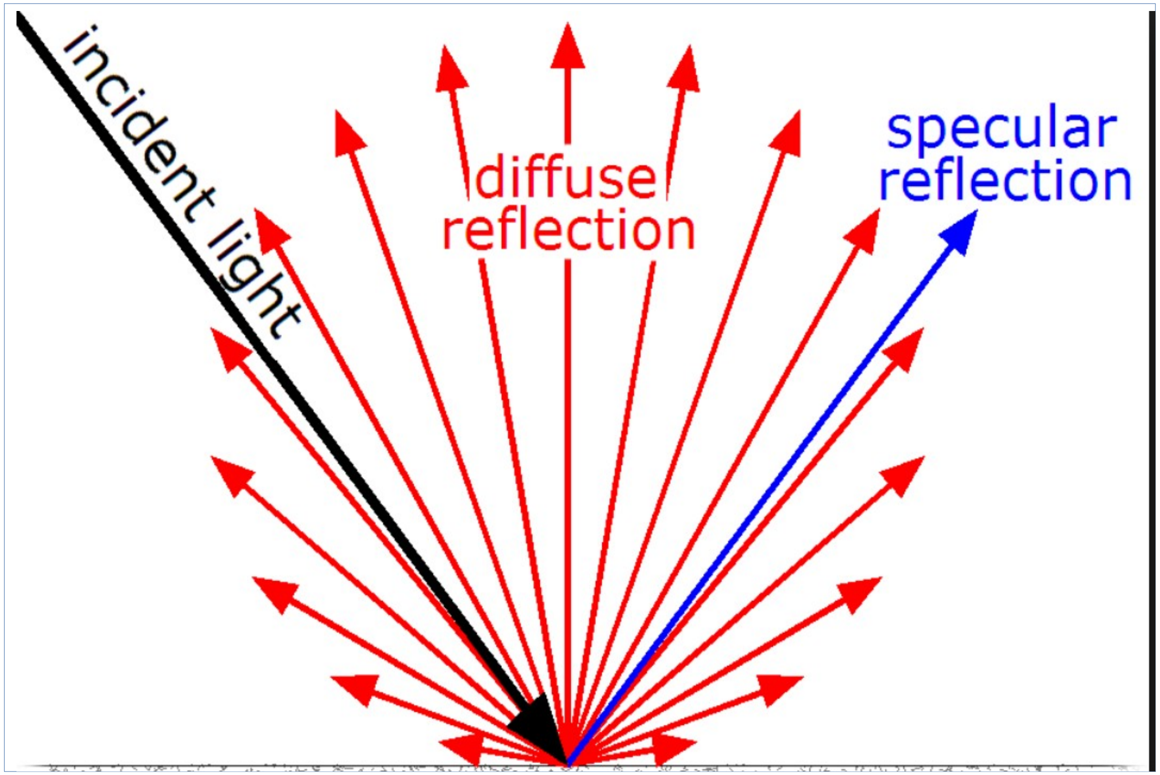
Diffuse Reflection



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

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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)

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

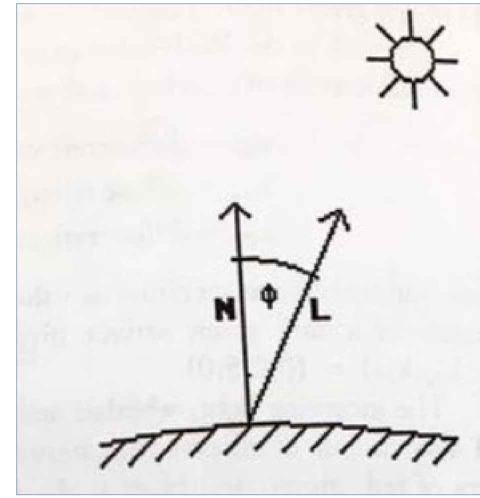
Object surface consists of reflectivity, e.g., coefficient of reflection

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

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:



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

where

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

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

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

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

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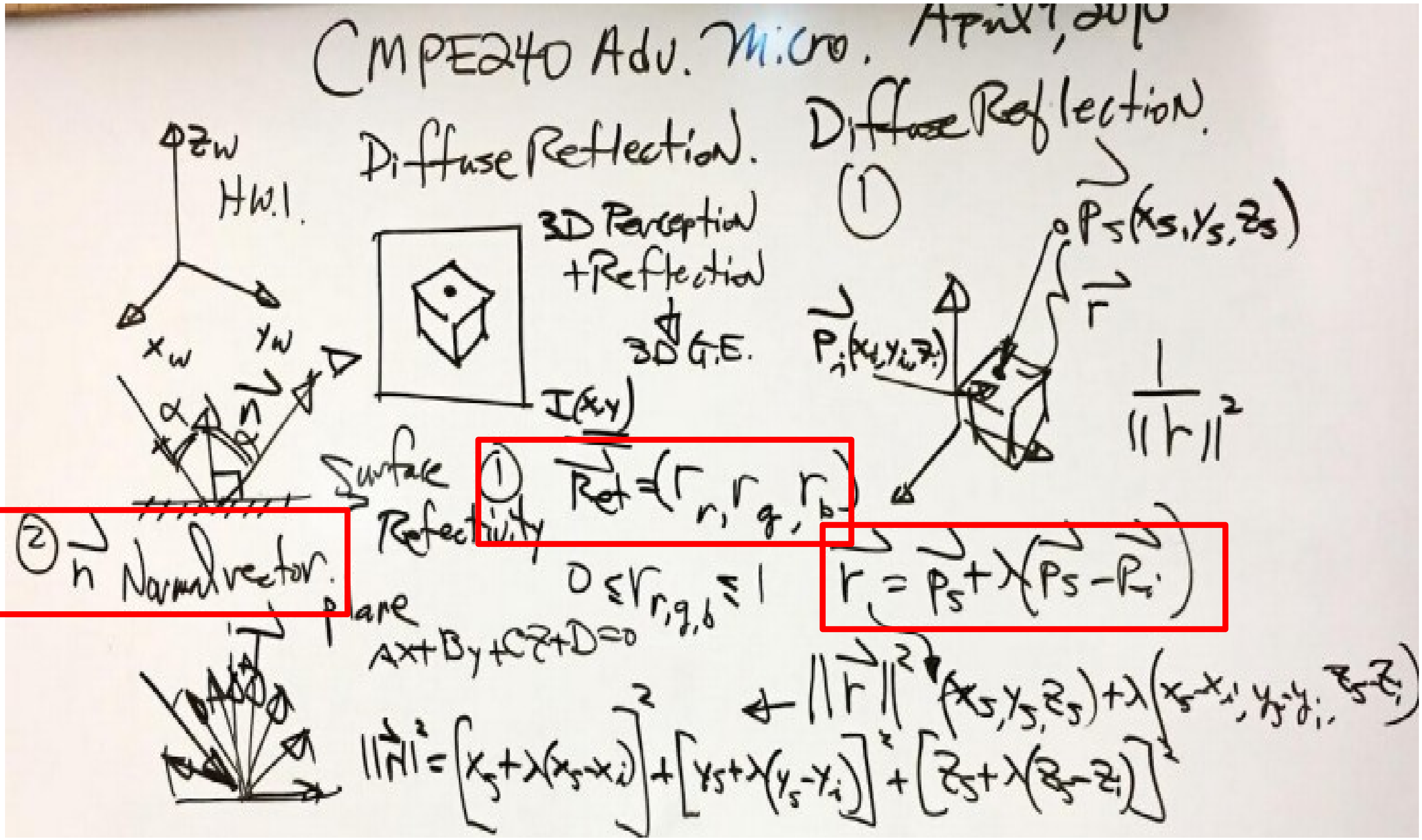
Formulation Of Diffuse Reflection Equation



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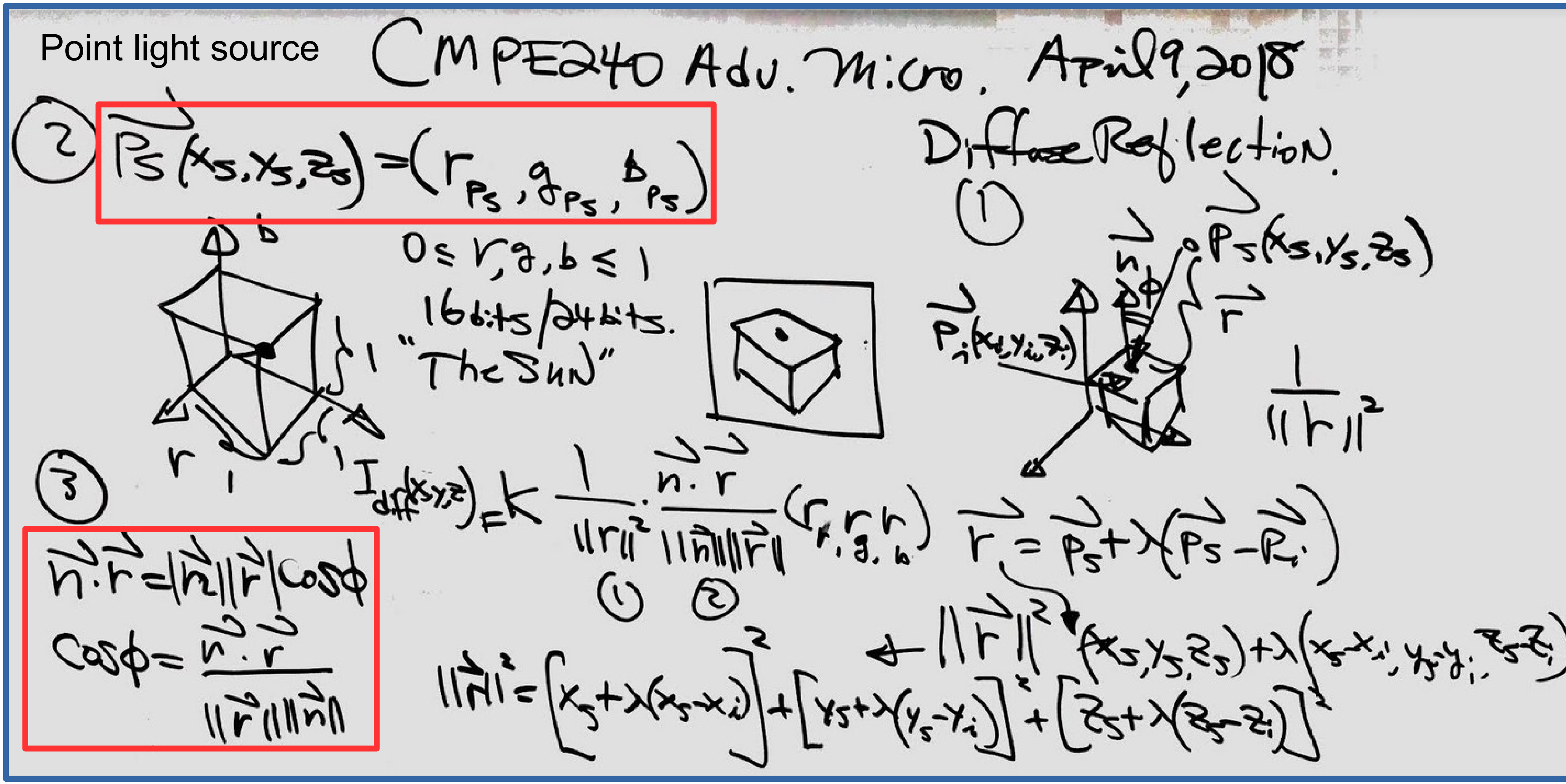
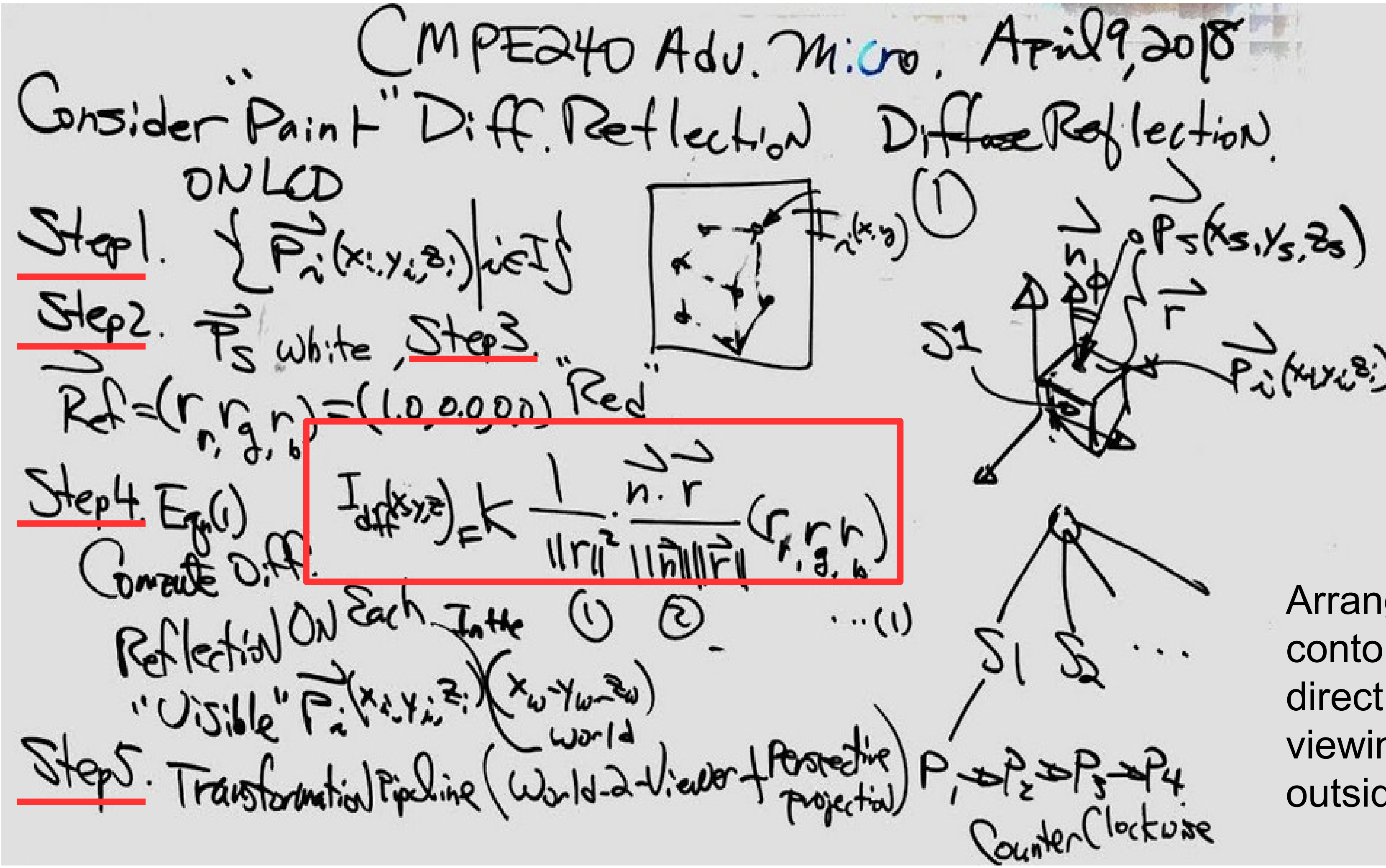
Point Light Source And Incident Angle



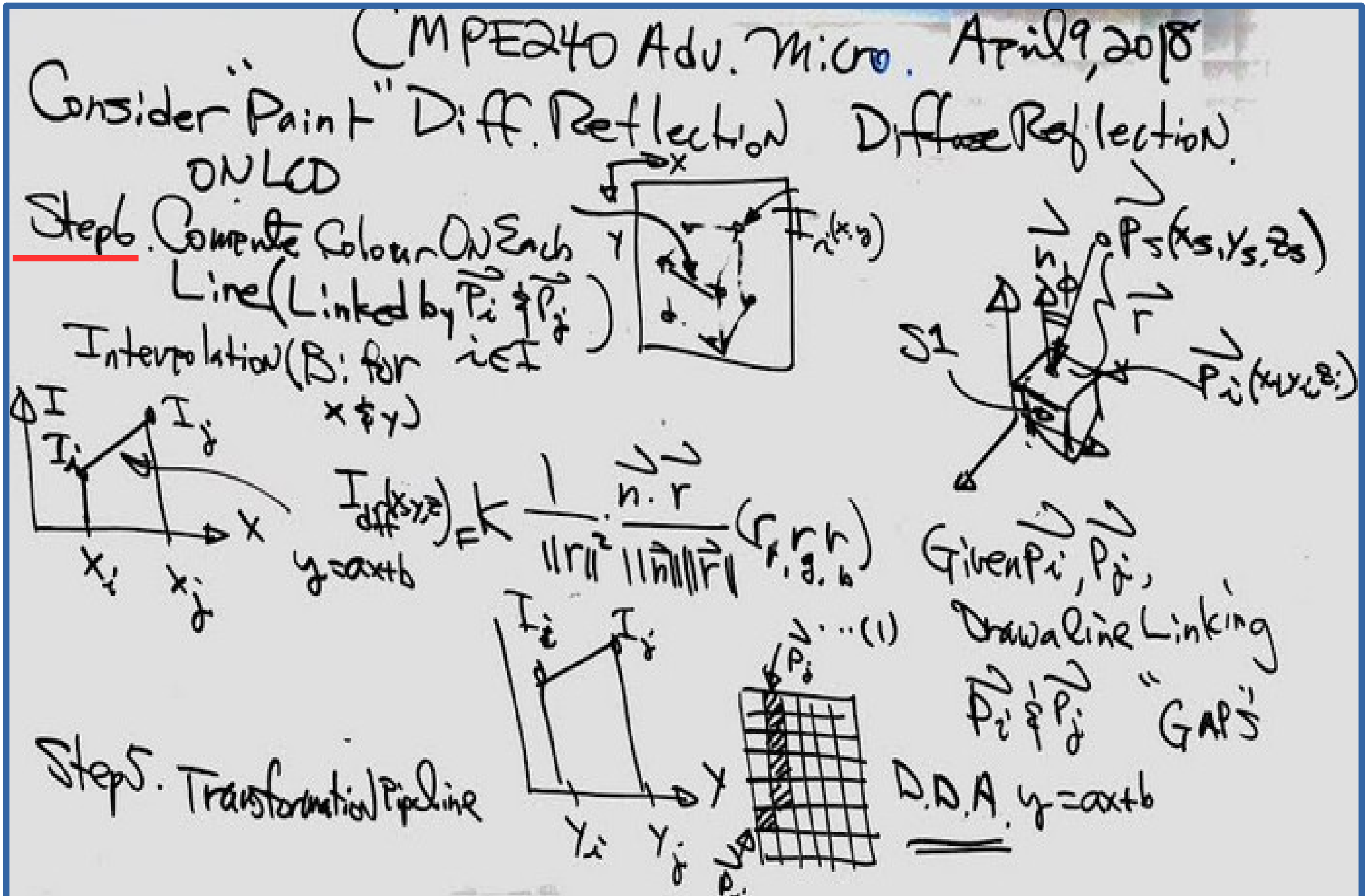
Angle of
incident light

Step 1-5 For Diffuse Reflection Computation



Arrange vertex in contour clock wise direction when viewing from outside

Step 6 For Diffuse Reflection Computation



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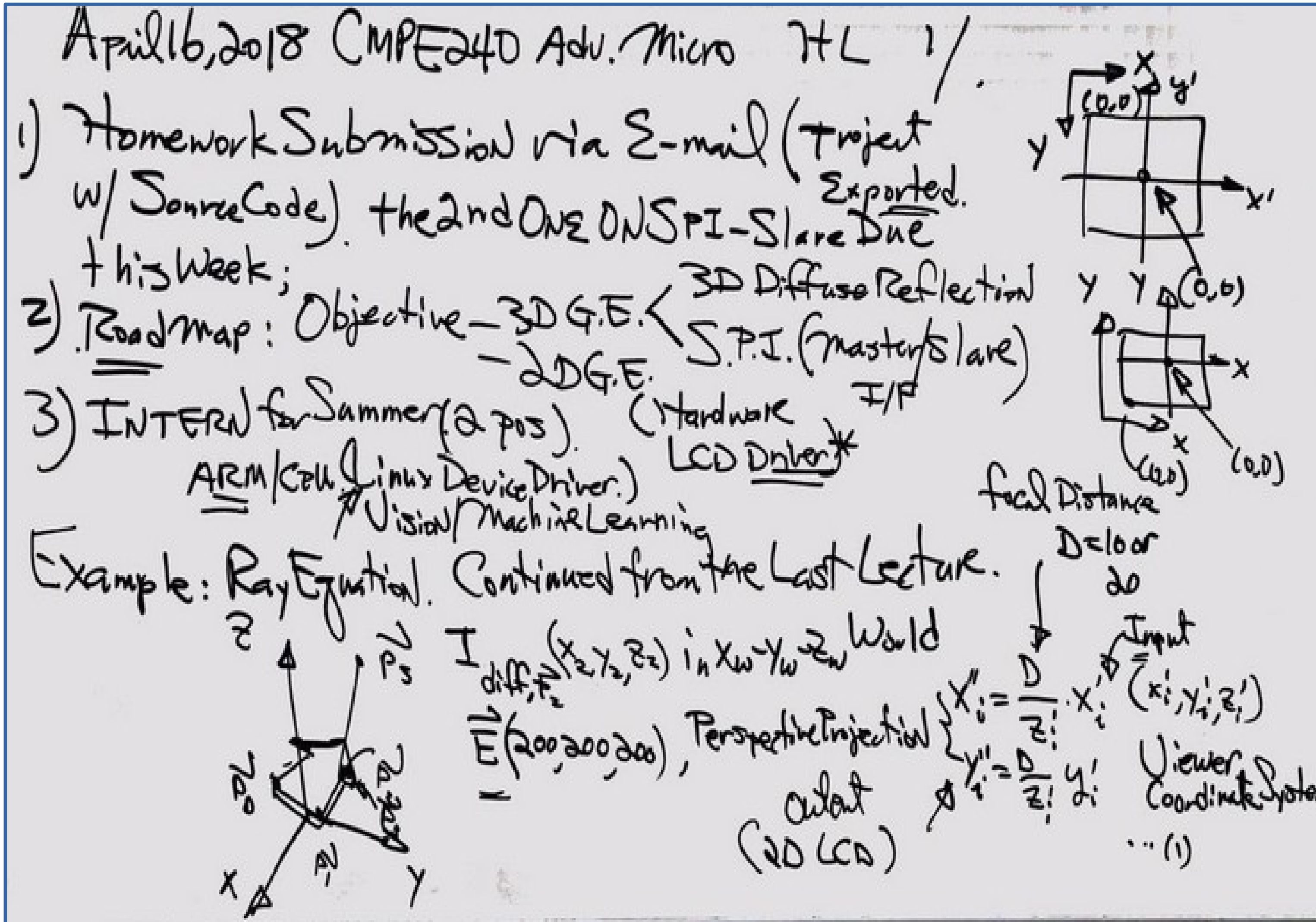
Example On Diffuse Reflection Computation (1)



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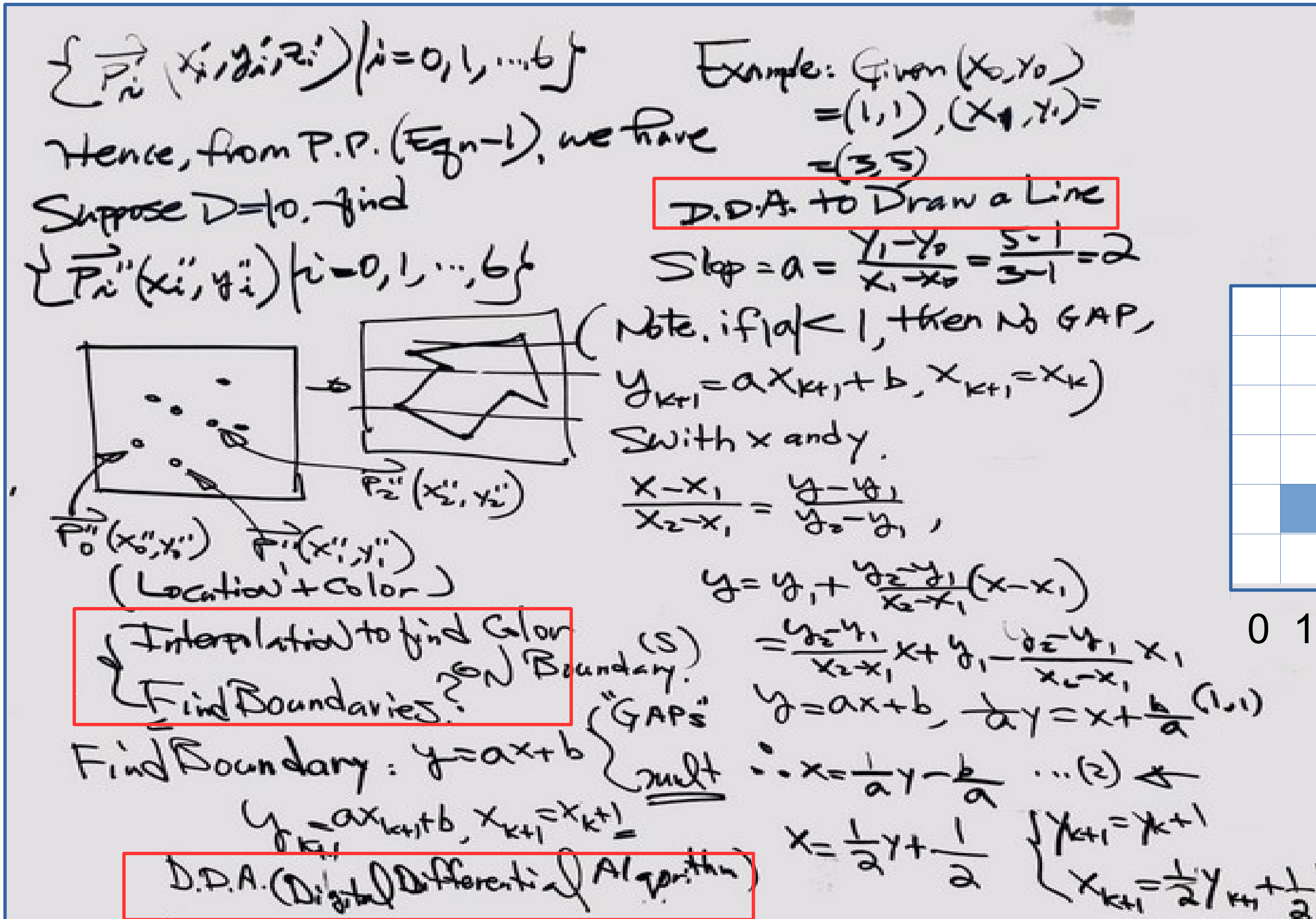
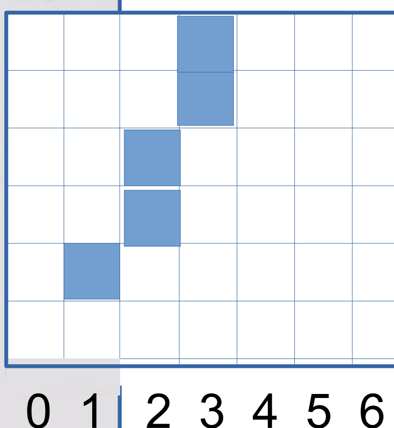
Example On Diffuse Reflection Computation (2)





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 $\begin{cases} x_{k+1} = x_k + 1 \\ y_{k+1} = a x_{k+1} + b \end{cases}$
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

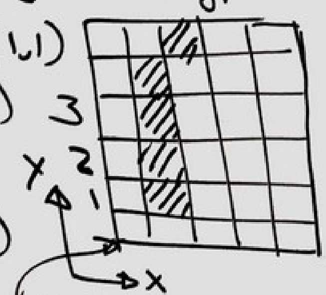
Harry LI CMPE240 Adv. Micro April 18, 2018. Y.

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"

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

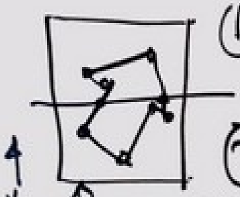
Indep. $\boxed{Y_{k+1} = Y_k + 1}\Big|_{Y_k=1} = 1 + 1 = 2$, $\boxed{X_{k+1} = \frac{1}{a} Y_{k+1} + \left(-\frac{b}{a}\right)}$
$= \frac{1}{4} \cdot 2 + \left(-\frac{-1}{4}\right) = \frac{3}{4}$

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 $Y_4 = Y_3 + 1 = 3 + 1 = 4$,
$X_4 = \frac{1}{a} Y_4 + \left(\frac{-b}{a}\right)\Big|_{b=-1} = \frac{4}{a} + \frac{1}{a}\Big|_{a=4} = \frac{5}{4}$

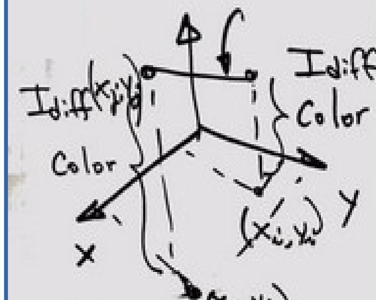
Next. Diffuse Reflection ON Boundaries.

Bilinear Interpolation To Find Boundary Color

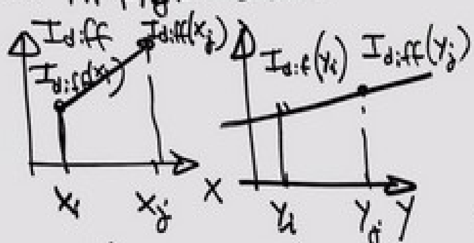


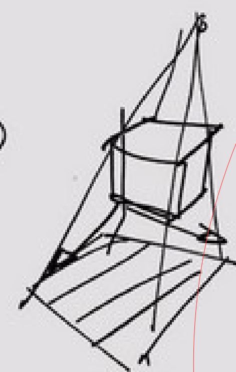
① DDA: where pixels Locations are.

② Interpolation to find color (Diffuse Reflection)



From 3D illustration in Fig 2 → 2D





$\vec{P}_i(x_i,y_i,z_i) \to I_{diff}$

$x_w-y_w-z_w$ World Coordinate

↓ W2V

$\vec{P}'_i(x'_i,y'_i,z'_i)$

↓

$\vec{P}''_i(x''_i,y''_i)$

$\frac{1}{2}\left(f(x_{i+1})+g(y_{i+1})\right)$

$I_{diff}(x_{i+1})$ $I_{diff}(y_{i+1})$

Develop Interpolation Technique:

$$\frac{I_{diff}(x)-I_{diff}(x_j)}{I_{diff}(x_i)-I_{diff}(x_j)} = \frac{x-x_j}{x_i-x_j}, \quad I_{diff}(x)-I_{diff}(x_j) = \frac{x-x_j}{x_i-x_j}\left(I_{diff}(x_i)-I_{diff}(x_j)\right)$$

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

(1) ...→ $$\boxed{I_{diff}(x)=\frac{I_{diff}(x_i)-I_{diff}(x_j)}{x_i-x_j}x-\frac{x_j}{x_i-x_j}\left(I_{diff}(x_i)-I_{diff}(x_j)\right)+I_{diff}(x_j)}$$

$$\boxed{I_{diff}(y)=\frac{I_{diff}(y_i)-I_{diff}(y_j)}{y_i-y_j}y-\frac{y_j}{y_i-y_j}\left(I_{diff}(y_i)-I_{diff}(y_j)\right)+I_{diff}(y_j) \quad \cdots(2)}$$

$$\boxed{I_{diff}(x,y)=\frac{1}{2}\left(I_{diff}(x)+I_{diff}(y)\right) \quad \cdots(3)}$$

and where $(x,y)\subseteq\Omega_{DDA}$ (DDA pts)

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).