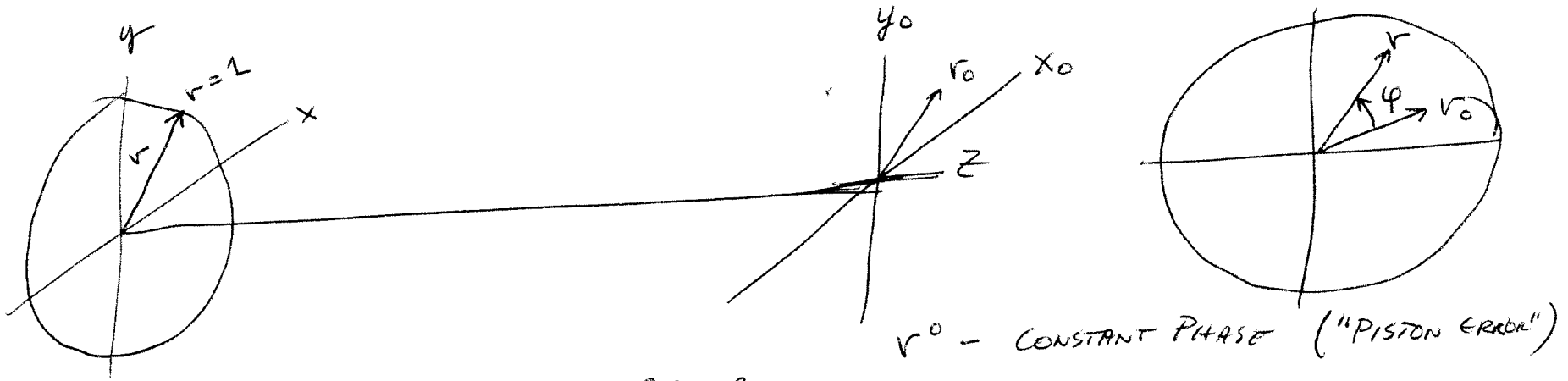


1/6/2010

MIDTERM EXAM 1/20/10 (W)

1

ABERRATIONS — DEVIATIONS OF WAVEFRONT EMERGING FROM XP RELATIVE TO IDEAL SPHERICAL WAVE



ΔW — WAVEFRONT ERROR

r^0 — CONSTANT PHASE ("PISTON ERROR")

~~2ND ORDER~~ $r^m r_0^l$

$r_0^2 \rightarrow$ PISTON ERROR

$r_0 r \rightarrow$ TIP TILT

$r^2 \Rightarrow$ DEFOCUS

1/6/10 (2)

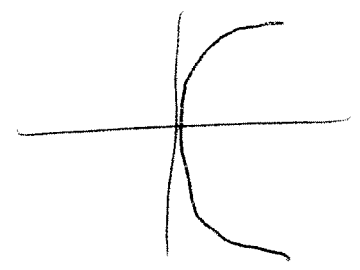
4th-order Terms
(3rd-ORDER)

$$r^n r_0^l \cos^m \varphi$$

$r^4 r_0^0 \cos^0 \varphi \rightarrow$ QUARTIC PHASE AT PUPIL

SPHERICAL ABERRATION

W_{040}



W_{311} $r^3 r_0^1 \cos^1 \varphi$ - DISTORTION

W_{222} $r^2 r_0^2 \cos^2 \varphi$ W_{222} - ASTIGMATISM

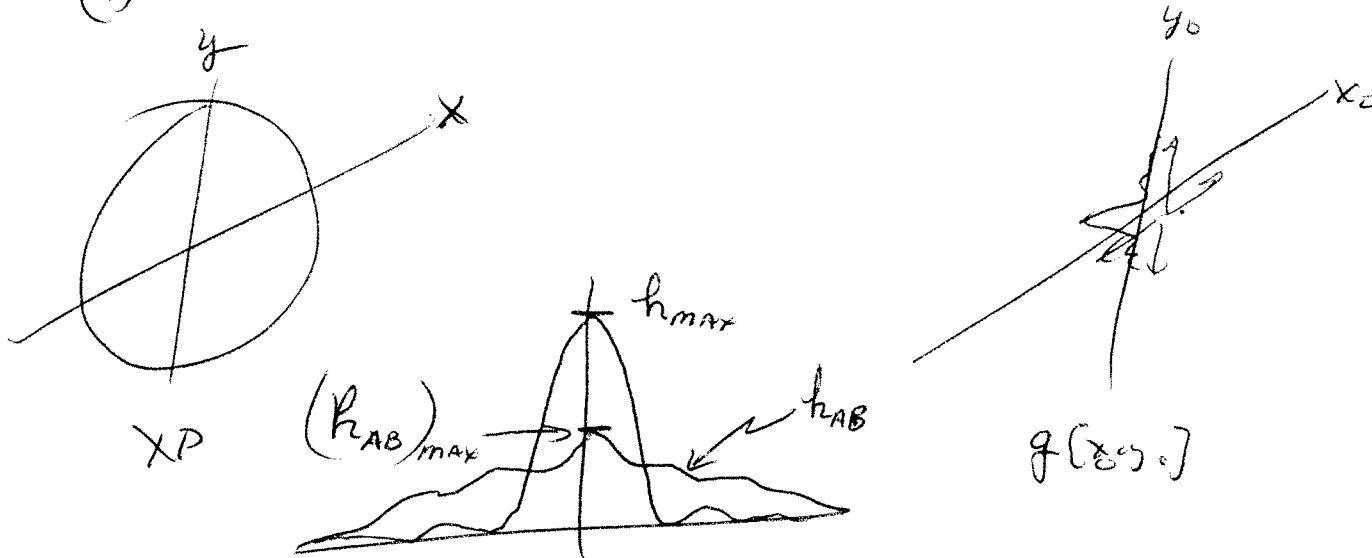
W_{220} $r^2 r_0^2$ CURVATURE FIELD

W_{131} $r^3 r_0 \cos \varphi$ COMA

1/6/10 - ③

METRICS OF IMAGE QUALITY

(1) STREHL RATIO



$$\frac{(h_{AB})_{\max}}{(h_{UN})_{\max}} = \text{STREHL ABERRATION} \quad -0 \leq \mathcal{D} \leq 1$$
$$\mathcal{D} \approx 0.8$$

1/6/10 - (4)

PSYCHOLOGICALLY $\mathcal{D} = 0.8 \iff \mathcal{D} = 1.0$

WHAT $\Delta W \Rightarrow \mathcal{D} = 0.8$?

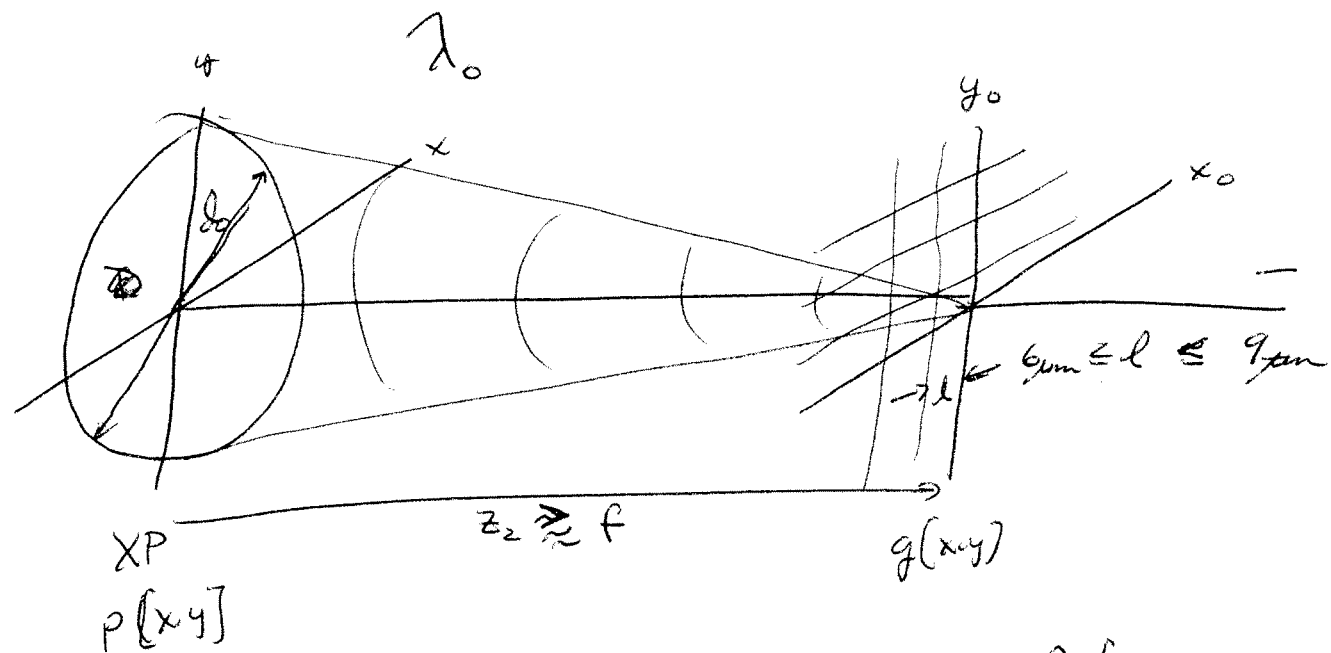


- (1) "AVERAGE" WAVEFRONT ERROR ACROSS PUPIL $\leq \frac{\lambda_0}{14}$
 $\Rightarrow \mathcal{D} \geq 0.8$ IF $\sigma_{\Delta W} \leq \frac{\lambda_0}{14}$ MARECHAL'S METRIC
- (2) "PEAK" WAVEFRONT ERROR AT PUPIL $\leq \frac{\lambda_0}{4} \Rightarrow \mathcal{D} \geq 0.8$

IF $\Delta W_{\max} \leq \frac{\lambda_0}{4} \Rightarrow$ WHICH ABERRATION IS DOMINANT
DOES NOT MATTER

RAYLEIGH'S QUARTER-WAVE RULE

1/6/10 - (5)



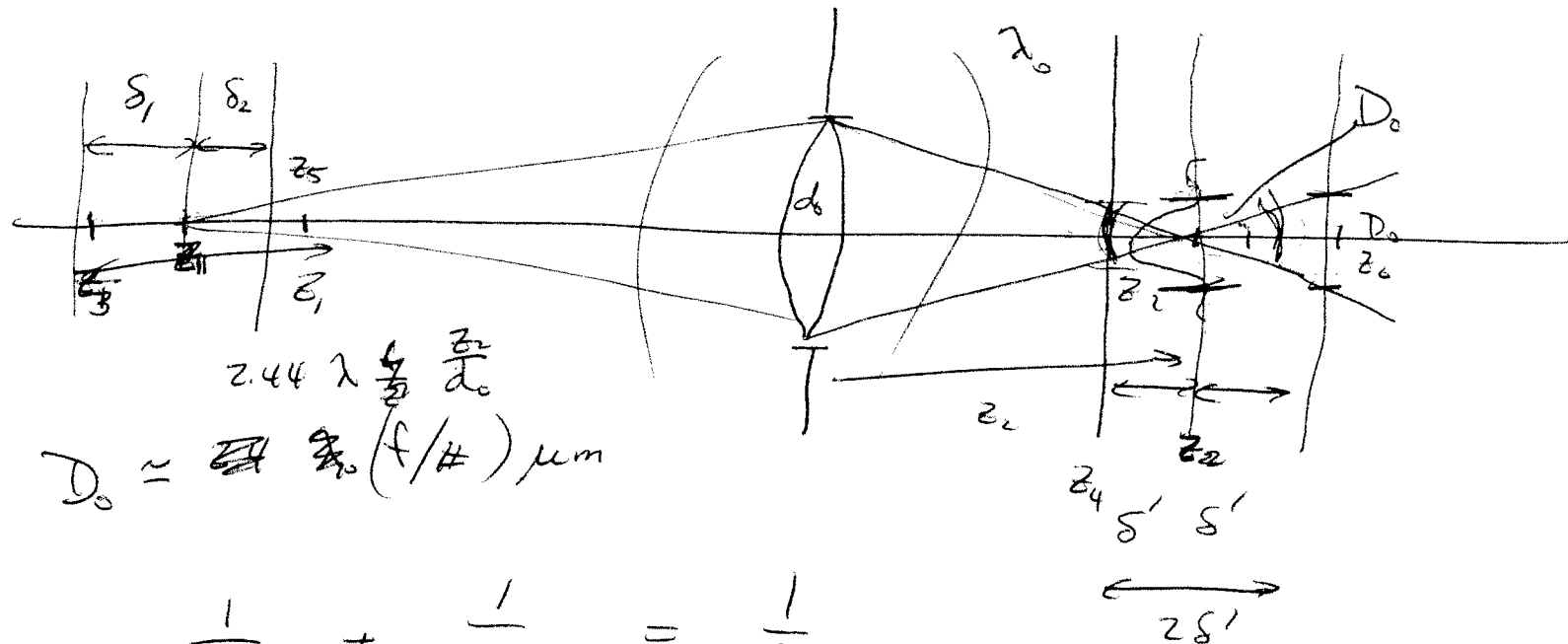
DIAMETER OF AIRY DISK $2.44 \frac{\lambda_0 f}{d_0} = 2.44 \lambda_0 \left(\frac{f}{\#}\right) = D_0$

IN VISIBLE LIGHT $2.44 \lambda_0 \approx 1 \mu m$

f/# SYSTEM $\Rightarrow D_0 \approx 8 \mu m$

DEPTH OF FOCUS OR DEPTH OF FIELD
 (IMAGE SPACE) (OBJECT SPACE)

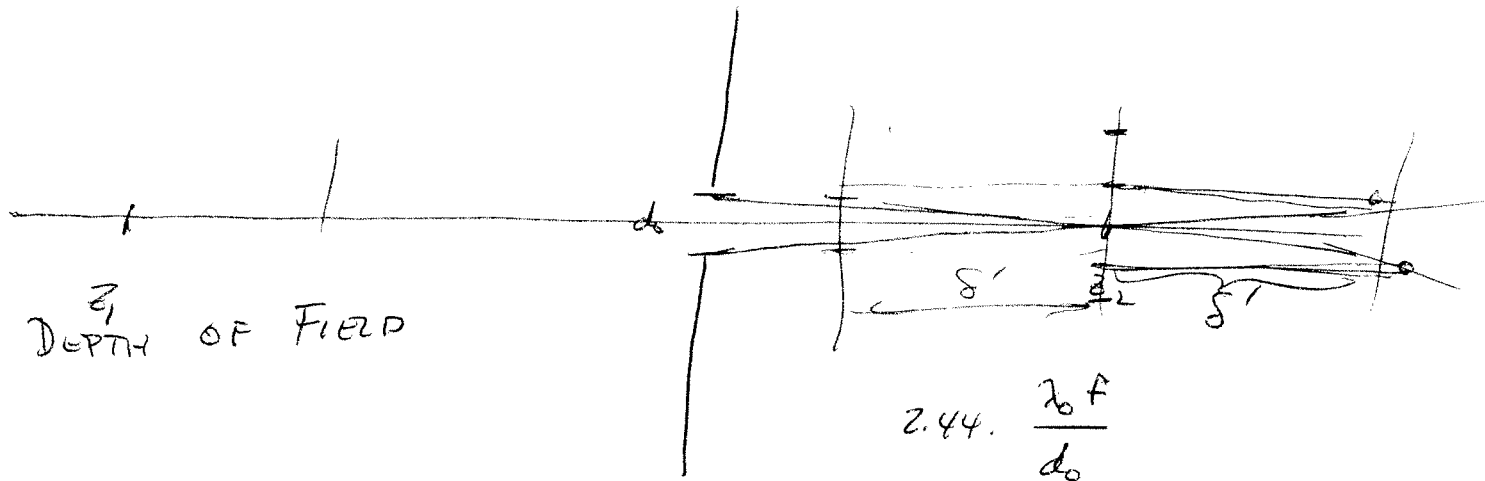
1/6/10 - ⑥



$$D_0 \approx 2.44 \lambda \frac{z_2}{d_0} (f/\#) \mu\text{m}$$

$$\frac{1}{z_{\text{OBJ}}} + \frac{1}{z_{\text{IMAGE}}} = \frac{1}{f}$$

1/6/10 - ⑦



$$\delta' \propto \left(\frac{f}{H}\right)^2$$

$$2.44 \cdot \frac{\lambda_0 f}{d_0}$$

DEPTH OF FOCUS