2-18

Eqn (2-23):

$$\frac{n_w}{s_1} + \frac{n_L}{s_1'} = \frac{n_L - n_w}{R}$$

$$s_1' = \frac{n_L}{\frac{n_L - n_w}{R} - \frac{n_w}{s_1}}$$

Eqn (2-24):

$$\frac{n_L}{s_2} + \frac{n_a}{s_2'} = \frac{n_a - n_L}{R}$$

$$s_2' = \frac{n_a}{\frac{n_a - n_L}{R} - \frac{n_L}{s_2}} = \frac{n_a}{\frac{n_a - n_L}{R} + \frac{n_L}{n_L / \left[\frac{(n_L - n_w)}{R} - \frac{n_w}{s_1}\right]}}$$

$$= \frac{n_a}{\frac{n_a - n_w}{R} - \frac{n_w}{s_1}}$$

octave:4> na=1; nw=4/3; nl=1.5; R=30; s1=20; s2p=na/((na-nw)/R+nw/s1)

$$m = \frac{s'}{s} = \frac{18}{20} = 0,9$$

2-20

Eqn (2-28)

$$\frac{1}{f} = \frac{n_{oil} - n_{glass}}{n_{glass}} \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$R_1 = -R_2 = -15 \text{ cm}$$

$$f = \left[\frac{n_{oil} - n_{glass}}{n_{glass}} \left(\frac{2}{R_1} \right) \right]^{-1}$$

```
octave:5> noil=1.65; nglass=1.5; R=-15; f=((noil-nglass)/nglass*(2/R))^(-1)
f = -75.000
```

2-24

$$\frac{1}{f_{air}} = \frac{n_{glass} - n_{air}}{n_{air}} \left(\frac{2}{R}\right)$$

$$R = 2 f_{air} \left(\frac{n_{glass} - n_{air}}{n_{air}}\right)$$

$$\frac{1}{f_{liq.}} = \frac{n_{glass} - n_{liq.}}{n_{liq.}} \left(\frac{2}{R}\right) = \frac{n_{glass}}{n_{liq.}} \frac{2}{R} - \frac{2}{R}$$

$$n_{liq.} = \frac{n_{glass}}{\frac{R}{2 \cdot f_{liq.}} + 1}$$

```
octave:8> nglass=1.5; fliq=-188; nair=1; fair=30; R=2*fair*(nglass-nair)/nair; nliq=nglass/(R/2/fliq+1)
nliq =  1.6301
```

2-31

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$$

$$s' = \left[\frac{1}{f} - \frac{1}{s}\right]^{-1} = \frac{fs}{s-f}$$

$$D = s + s' = s + \frac{fs}{s-f} = \frac{s^2 - fs + fs}{s-f} = \frac{s^2}{s-f}$$

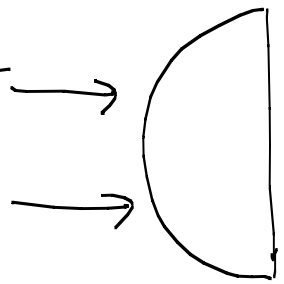
$$\frac{d}{ds} D = 0 = \frac{2s}{s-f} - \frac{s^2}{(s-f)^2} = \frac{2s^2 - 2sf - s^2}{(s-f)^2} = \frac{s^2 - 2sf}{(s-f)^2} = 0$$

$$s(s-2f) = 0$$

$$s = 0 \text{ or } 2f$$

$$s' = \frac{fs}{s-f} = \frac{2f^2}{2f-f} = 2f \qquad \text{so} \qquad D = s + s' = 2f + 2f = 4f$$

2-33



Curved side:

$$\frac{n_1}{s_1} + \frac{n_2}{s_1'} = \frac{n_2 - n_1}{R_1}$$

Eqn (2-23)

$$s_1' = \frac{n_2}{\frac{n_2 - n_1}{R_1} - \frac{n_1}{s_1}}$$

Eqn. (2-25)

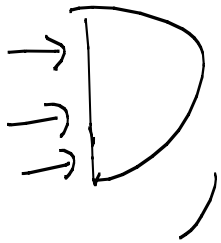
$$s_2 = +-s_1' = +- \frac{n_2}{\frac{n_2 - n_1}{R_1} - \frac{n_1}{s_1}}$$

flat side:

Eqn (2-24) $\frac{n_2}{s_2} + \frac{n_1}{s_2'} = \frac{n_1 - n_2}{R_2}$

$$s_2' = \frac{n_1}{\frac{n_1 - n_2}{R_2} - \frac{n_2}{s_2}} = \frac{n_1}{\frac{n_1 - n_2}{R_2} - \frac{n_2}{+- \frac{n_2}{\frac{n_2 - n_1}{R_1} - \frac{n_1}{s_1}}}}$$

```
octave:6> s1=Inf; n1=1; n2=1.5; R2=Inf; R1=4; t=4; n1/((n1-n2)/R2-n2/(t-(n2/((n2-n1)/R1-n1/s1))))
ans =  5.3333
```

for  first interface does nothing. Only need

Eqn (2-23): $\frac{n_1}{s_1} + \frac{n_2}{s_1'} = \frac{n_2 - n_1}{R_1}$

$$\frac{1}{s_1} = \frac{n_2 - n_1}{R_1}$$

$$s_1 = \frac{R_1}{n_2 - n_1} = \frac{4\,cm}{1.5 - 1} = 8\,cm \quad \text{from center.}$$

2-35

$$m = \frac{1}{5\times10^{4}} = \frac{5'}{S} = \frac{0.5\,ft}{S}$$

$$S = 2.5\times10^{4}\,ft = 25{,}000\,ft.$$