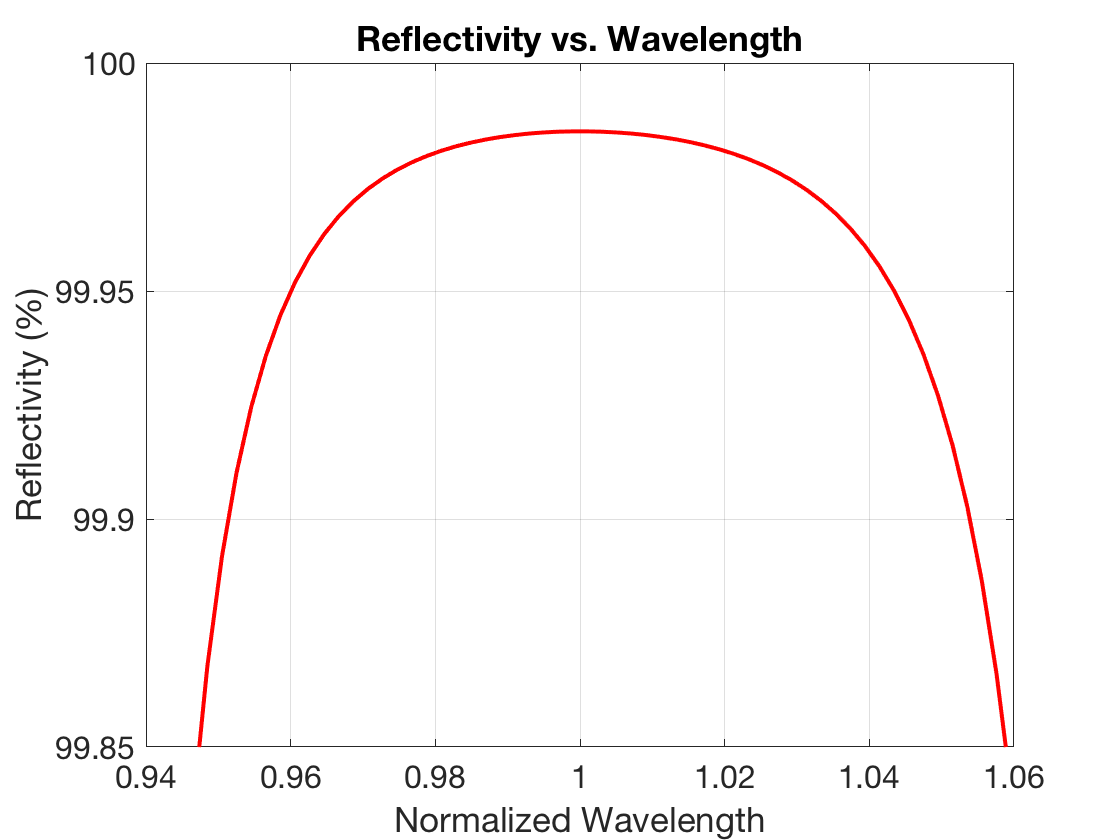
**Optics 408 – HM 7**

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**Problem 1**

1. The number of layers need to achieve the reflectivity in the graph is at least 21. I used 22 layers just to make sure we had a reflectance above 99.97% as provided on the website (and also closer match the plot).
2. The following plot is an attempt to recreate the one provided in the homework assignment.

****

MATLAB CODE:

ni = 1; % air

ns = 1.52; % glass substrate

n1 = 1.65; % CeF3

n2 = 2.1; % ZrO2

design\_lambda = 632.8e-9;

% function to determine reflectivity given the number of layer-pairs

R = @(N) (((ni/ns)\*(-n2/n1)^(2\*N)-1)/((ni/ns)\*(-n2/n1)^(2\*N)+1))^2;

% format long

% R(22) \* 100

% from trial and error, we need at least 22 layer pairs to match the

% reflectance

% designed for HeNe laser

d = design\_lambda / 4;

% function of the actual wavelength where d is held fixed

% assuming at incidence

f\_delta = @(lambda) 2 \* pi / lambda \* d;

% alpha is really n/neta but the neta term cancels I believe

a1 = n1;

a2 = n2;

% M is the numbers of wavelengths (for creating plot)

M = 100;

% N is the number of layers

N = 22;

% create a range of lambdas from 0.9 \* HeNe to 1.1 HeNe wavelength

lambdas = linspace(0.9\*design\_lambda, 1.1\*design\_lambda, M);

% reflectance

r = zeros(M,1);

% First create select lambda and update delta

for i=1:M

delta = f\_delta(lambdas(i));

% Next, we recreate the F matrix and determine r

% F is the result of multiple matrix multiplication

% Reset each loop

F = eye(2,2);

for j=1:N

F1 = [cos(delta), -1i\*sin(delta)/a1; -1i\*sin(delta)\*a1, cos(delta)];

F2 = [cos(delta), -1i\*sin(delta)/a2; -1i\*sin(delta)\*a2, cos(delta)];

F = F \* F1 \* F2;

end

% determine the reflectance for a given lambda

r(i) = abs( ((ni \* F(1,1) + ni \* ns \* F(1,2) - F(2,1) - ns \* F(2,2)) / (ni \* F(1,1) + ni \* ns \* F(1,2) + F(2,1) + ns \* F(2,2))).^2 );

end

plot(lambdas / design\_lambda, r \* 100, 'r', 'LineWidth', 2)

ylim([99.85, 100.00])

ylabel('Reflectivity (%)')

xlabel('Normalized Wavelength')

title('Reflectivity vs. Wavelength')

grid on

set(gca,'fontsize',16)

1. The RMS phase right in a reflected full aperture light beam is as follows.

The surface flatness is the design phase should be around . What happens is this actually introduces an uncertainty in the actual target phase.

We want the phase at a given wavelength to be around but due to the surface flatness there is an uncertainty of introduced.

1. The following calculation outlines comparison of cost between this mirror and gold.

First find the volume of the mirror:

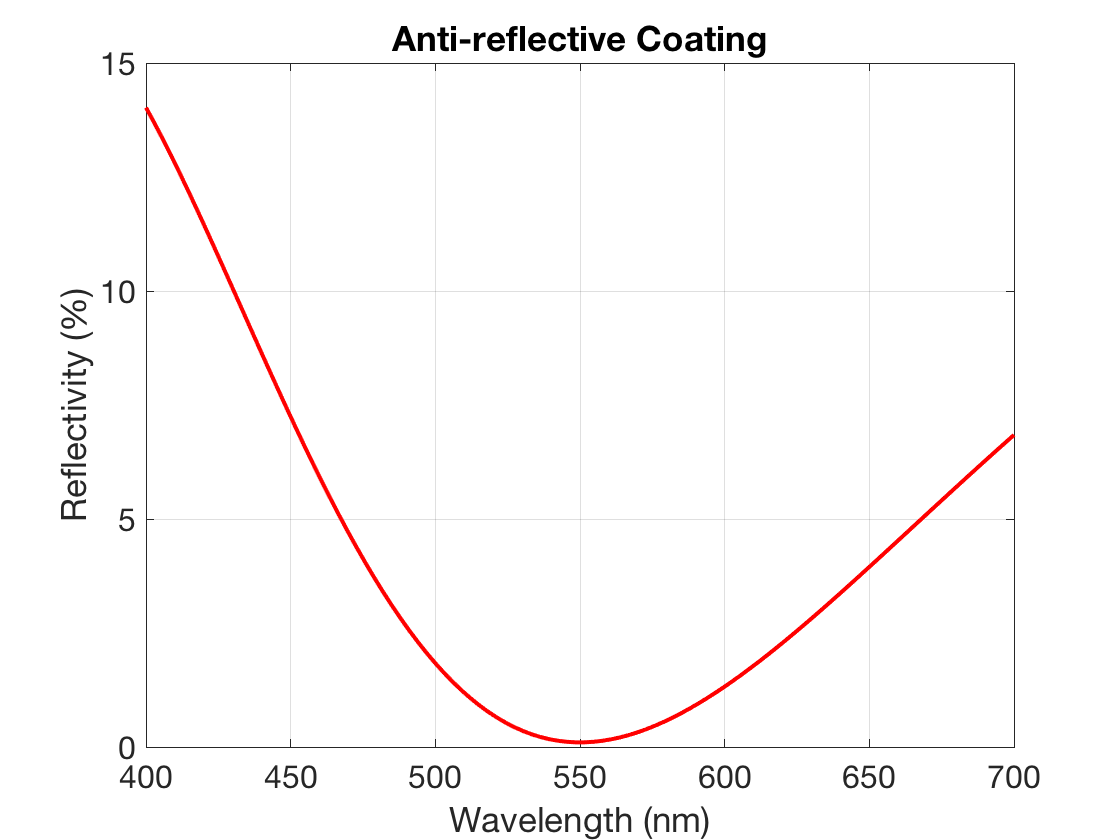
The density of gold is 19.32 g/cm^3, with this we can determine the mass of gold.

The cost of gold per gram is $42.33 (USD) so the final cost is the following:

The density of glass is around 2 g/cm^3 and the cost of the mirror is $1320 so the cost per gram is around $205 for the mirror. We can see that cost of gold isn’t that much compared to this really expense fancy physics one.

**Problem 2**

The following plot was generated for the anti-reflective coating. The total thickness of the coating is as follows:



Q: At 400 nm, how bright will the secondary images caused by light bouncing within the glass

lenses be compared to the primary image? Would this anti-reflection coating be acceptable?

The reflectivity at 400nm is around 14%, one could then expect the intensity of the image at 400nm to be 0.14 \* I (where I is the incident intensity). Therefore, the image would be 14% as bright as the incident image. This isn’t really acceptable as an anti-reflection coating as you would still be able to clearly see the image but it would just appear much darker.

MATLAB CODE:

ni = 1; % air

ns = 1.52; % glass substrate

n1 = 1.65; % CeF3

n2 = 2.1; % ZrO2

design\_lambda = 550e-9;

% designed for HeNe laser

d = design\_lambda / 4;

% function of the actual wavelength where d is held fixed

% assuming at incidence

f\_delta = @(lambda) 2 \* pi / lambda \* d;

% alpha is really n/neta but the neta term cancels I believe

a1 = n1;

a2 = n2;

% M is the numbers of wavelengths (for creating plot)

M = 100;

% create a range of lambdas from 0.9 \* HeNe to 1.1 HeNe wavelength

lambdas = linspace(400e-9, 700e-9, M);

% reflectance

r = zeros(M,1);

% First create select lambda and update delta

for i=1:M

delta = f\_delta(lambdas(i));

% Next, we recreate the F matrix and determine r

% F is the result of multiple matrix multiplication

% Reset each loop

F = eye(2,2);

F1 = [cos(delta), -1i\*sin(delta)/a1; -1i\*sin(delta)\*a1, cos(delta)];

F2 = [cos(delta), -1i\*sin(delta)/a2; -1i\*sin(delta)\*a2, cos(delta)];

F = F1 \* F2;

% determine the reflectance for a given lambda

r(i) = abs( ((ni \* F(1,1) + ni \* ns \* F(1,2) - F(2,1) - ns \* F(2,2)) / (ni \* F(1,1) + ni \* ns \* F(1,2) + F(2,1) + ns \* F(2,2))).^2 );

end

plot(lambdas \* 10^9, r \* 100, 'r', 'LineWidth', 2)

% ylim([99.85, 100.00])

ylabel('Reflectivity (%)')

xlabel('Wavelength (nm)')

title('Anti-reflective Coating')

grid on

set(gca,'fontsize',16)