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```
% /home/chuck/Documents/working/12567/hw/hw3sol.m
% Fall 2025
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```

HW3/4 Solutions

Problem 1 Meniscus Lens

```
disp(repmat('-',1,64));
disp('Problem 1');

n_ell=4;
z12=6;

% (r1+r2)/(r1-r2)=5;
% r1/r2+1 = -5(r2/r1)+5;
% r2=2r1/3;
% 1/f=(n_ell-1)*(1/r1-1/r2)=-1/30


r1=30*(n_ell-1)/2
r2=2*r1/3
P1=(n_ell-1)/r1 % Slides 2r5-32
P2=(1-n_ell)/r2
P=P1+P2-z12/n_ell*P1*P2  % slides 3r3-24
f_actual=1/P
h=-1/n_ell*P2/P*z12   % slides 3r3-24
hprime=-1/n_ell*P1/P*z12  % slides 3r3-24

-----------------------------------------------------------------
Problem 1
r1 =
    45
r2 =
    30
P1 =
    0.0667
P2 =
    -0.1000
```

```
P =
    -0.0233
f_actual =
   -42.8571
h =
   -6.4286
hprime =
    4.2857
```

Problem 1 Meniscus Lens as Intended

```
disp(repmat('-',1,64));
disp('Problem 1');

disp('I got caught in the inconsistent sign convention');
disp('I accepted any reasonable solution you came up with');

n_ell=4;
z12=6;
% (r1+r2)/(r1-r2)=5;
% r1/r2+1 = -5(r2/r1)+5;
% r2=2r1/3;
% 1/f=(n_ell-1)*(1/r1-1/r2)=1/30

% (r1-r2)/(r1+r2)=5;
% r1/r2-1 = 5(r2/r1)+5;
% -4*r1/r2 = 6;
% r2=-2r1/3; (A)

% 1/f=(n_ell-1)*(1/r1+1/r2)=1/30;
% 1/f=(n_ell-1)*(1/r1-3/(2*r1))=1/30
% 1/f=(n_ell-1)*(-1/(2*r1))=1/30
% -2*r1/(n_ell-1)=30;
% r1=-30*(n_ell-1)/2; (B)

r1=-30*(n_ell-1)/2 % (B)
r2=-2*r1/3 % (A)
P1=(n_ell-1)/r1 % Slides 2r5-32
P2=-(1-n_ell)/r2
P=P1+P2-z12/n_ell*P1*P2  % slides 3r3-24
f_actual=1/P
h=-1/n_ell*P2/P*z12    % slides 3r3-24
hprime=-1/n_ell*P1/P*z12  % slides 3r3-24

----------------------------------------------------------------
Problem 1
I got caught in the inconsistent sign convention
I accepted any reasonable solution you came up with
r1 =
    -45
r2 =
     30
P1 =
```

```
    -0.0667
P2 =
     0.1000
P =
     0.0433
f_actual =
    23.0769
h =
    -3.4615
hprime =
     2.3077
```

Problem 2 Compound Lens

```
disp(repmat('-',1,64));
disp('Problem 2');

nbk7_550=1.5185;% For HW5
nglass=1.5

id=1;n(id)=1;nprime(id)=nglass;r(id)=0.10;
  R1=[1,0;(n(id)-nprime(id))/nprime(id)/r(id),n(id)/nprime(id)]

z12=0.006;T12=[1,z12;0,1]

id=2;n(id)=nprime(id-1);nprime(id)=1;r(id)=inf;
  R2=[1,0;(n(id)-nprime(id))/nprime(id)/r(id),n(id)/nprime(id)]

L12=R2*T12*R1
L12s=getlensdata(L12,n(1),nprime(2))


id=3;n(id)=nprime(id-1);nprime(id)=nglass;r(id)=inf;
  R3=[1,0;(n(id)-nprime(id))/nprime(id)/r(id),n(id)/nprime(id)]

z34=0.01;;T34=[1,z34;0,1]

id=4;n(id)=nprime(id-1);nprime(id)=1;r(id)=-0.30;
  R4=[1,0;(n(id)-nprime(id))/nprime(id)/r(id),n(id)/nprime(id)]

L34=R4*T34*R3
L34s=getlensdata(L34,n(3),nprime(4))

z23=0.05;
T23=[1,z23;0,1]

M=R4*T34*R3*T23*R2*T12*R1

n0=n(1);nprime0=nprime(4);
Ms=getlensdata(M,n0,nprime0)

s1=L12s.f  % Object distance from H of first lens
w1=s1+L12s.h   % Object distance from front Vertex of first lens
```

```matlab
                % also front vertex of the system
stest=w1-Ms.h % Object distance from H of system
stestp=1/(1/Ms.f-1/stest) % Image distance from H' of system
wtestp=stestp+Ms.hprime % Image distance from back vertex of system
                        % Also back vertex of lens 34
s4p=wtestp-L34s.hprime % Image distance from H' of Lens 34


disp('For Zemax');
r
zo1=w1
z12
z23
z34
z4i=wtestp


w=[1:1000]*1e-3;
s=w-Ms.h;
sprime=1./(1/Ms.f-1./s);
wprime=sprime+Ms.hprime;
figure;plot(w*100,wprime*100,'g-o',s*100,sprime*100,'r-+');grid on;
moose=axis;axis([moose(1:2),50*[-1,1]]);
xlabel('w, s, cm');ylabel('w'', s'', cm');
legend('w','s');

disp('Following should help with HW5');
% Distance between H' for Lens 12 and H for lens 34; keep the same
zh23=z23-L12s.hprime-L34s.h
s1=L12s.f
w1=stest+L12s.h
s4prime=L34s.fprime
w4prime=s4prime+L34s.hprime

figure;hold on;
pplot(0,0,'d','b');text(0,0.5,'Obj');
pplot(zo1,0,'o','k');text(zo1,1,'V1');
pplot(zo1+z12,0,'o','k');text(zo1+z12,0.5,'V2');
pplot(zo1+z12+z23,0,'o','k');text(zo1+z12+z23,1,'V3');
pplot(zo1+z12+z23+z34,0,'o','k');text(zo1+z12+z23+z34,0.5,'V4');
pplot(zo1+z12+z23+z34+z4i,0,'d','b');text(zo1+z12+z23+z34+z4i,1,'im');

pplot(zo1-L12s.h,2,'s','g');text(zo1-L12s.h,3,'H12');
pplot(zo1+z12+L12s.hprime,2,'s','g');text(zo1+z12+L12s.hprime,2.5,'H12''');

pplot(zo1+z12+z23-L34s.h,2,'s','g');text(zo1+z12+z23+L34s.hprime,3,'H34');
pplot(zo1+z12+z23+z34+L34s.hprime,2,'s','g');
   text(zo1+z12+z23+z34+L34s.hprime,2.5,'H34''');

pplot(zo1-Ms.h,4,'s','g');text(zo1-Ms.h,5,'H');
pplot(zo1+z12+z23+z34+Ms.hprime,4,'s','g');
   text(zo1+z12+z23+z34+Ms.hprime,4.5,'H''');

pplot(zo1-Ms.h-Ms.f,4,'v','r');text(zo1-Ms.h-Ms.f,5,'F');
```

```matlab
pplot(zo1+z12+z23+z34+Ms.hprime+Ms.fprime,4,'v','r');
   text(zo1+z12+z23+z34+Ms.hprime+Ms.fprime,4.5,'F''');
grid on;

hold off;
axis([-0.1,1,-1,10]);
```

```
---------------------------------------------------------------
Problem 2
nglass =
    1.5000
R1 =
    1.0000         0
   -3.3333    0.6667
T12 =
    1.0000    0.0060
         0    1.0000
R2 =
    1.0000         0
         0    1.5000
L12 =
    0.9800    0.0040
   -5.0000    1.0000
L12s =
  struct with fields:

           h: 0
      hprime: -0.0040
     diopters: 5
            f: 0.2000
       fprime: 0.2000
R3 =
    1.0000         0
         0    0.6667
T34 =
    1.0000    0.0100
         0    1.0000
R4 =
    1.0000         0
   -1.6667    1.5000
L34 =
    1.0000    0.0067
   -1.6667    0.9889
L34s =
  struct with fields:

           h: -0.0067
      hprime: 0
     diopters: 1.6667
            f: 0.6000
       fprime: 0.6000
T23 =
    1.0000    0.0500
         0    1.0000
```
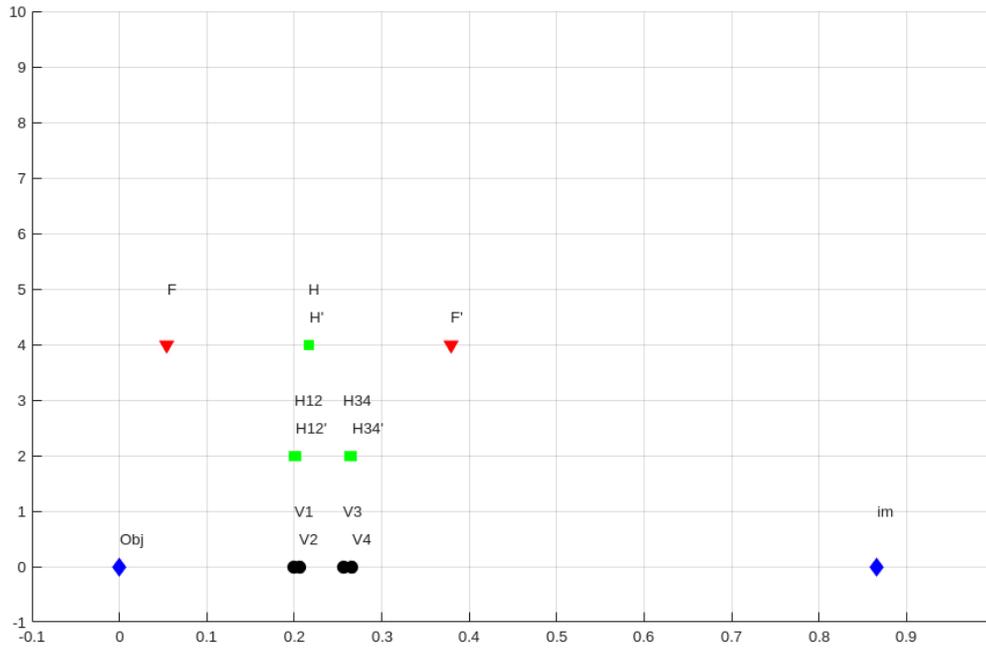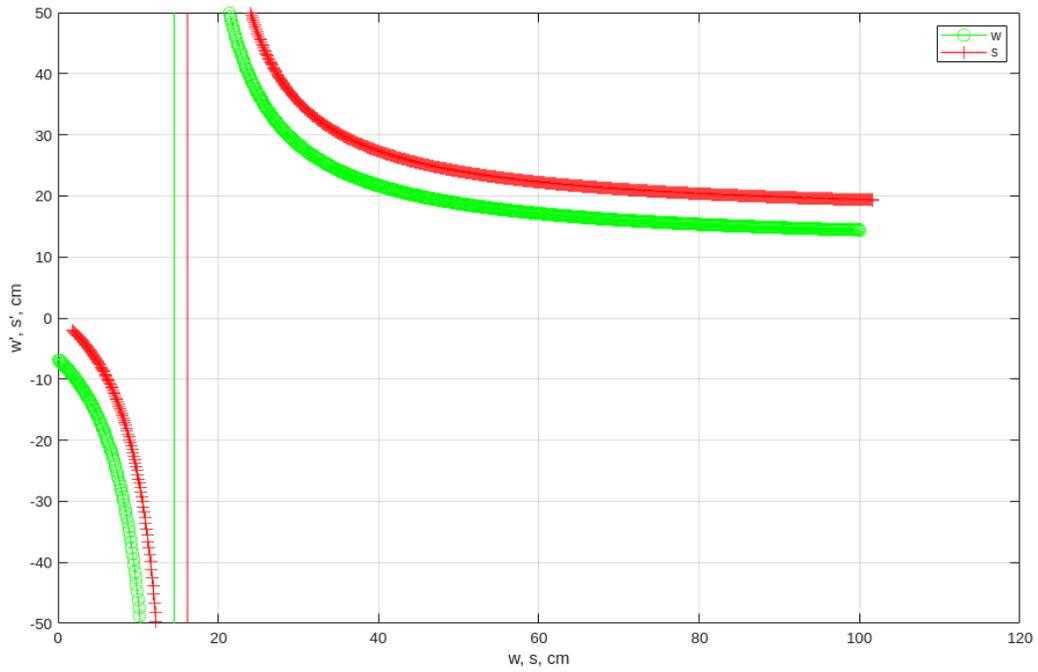
```
M =
    0.6967    0.0607
   -6.1611    0.8989
Ms =
  struct with fields:

          h: -0.0164
     hprime: -0.0492
    diopters: 6.1611
          f: 0.1623
     fprime: 0.1623
s1 =
    0.2000
w1 =
    0.2000
stest =
    0.2164
stestp =
    0.6492
wtestp =
    0.6000
s4p =
    0.6000
For Zemax
r =
    0.1000        Inf        Inf   -0.3000
zo1 =
    0.2000
z12 =
    0.0060
z23 =
    0.0500
z34 =
    0.0100
z4i =
    0.6000
Following should help with HW5
zh23 =
    0.0607
s1 =
    0.2000
w1 =
    0.2164
s4prime =
    0.6000
w4prime =
    0.6000
```

Problem 3 Microscope

```
disp(repmat('-',1,64));
disp('Problem 3');
```

```
ftube=200;fieldstop=20;M=20;NA=0.5;
delta_s=20;

fobj=ftube/M

Z_Hprimeobj_aperture=fobj

aperturestopdiameter=fobj*tan(asin(0.5))*2

FOV=fieldstop/M

NA_image=NA/M

-----------------------------------------------------------------
Problem 3
fobj =
    10
Z_Hprimeobj_aperture =
    10
aperturestopdiameter =
   11.5470
FOV =
     1
NA_image =
    0.0250
```

Problem 4 Laser Radar

```
disp(repmat('-',1,64));
disp('Problem 4');

fp=200;dp=12.5; % primary
d_in=1;d_out=10; % Laser Beam

fs=fp*d_in/d_out % Secondary

s_aperture_stop=fp+fs % aperture stop is primary
sprime_aperture_stop=1/(1/fs-1/s_aperture_stop)
dprime_aperture_stop=dp*sprime_aperture_stop/s_aperture_stop

figure;
ang=[0,10,20,30];
for n=1:4;
subplot(2,2,n);
circle(0,0,dp/2,'k');
center=delta_s*tand(ang(n));
circle(center,0,1*s_aperture_stop/sprime_aperture_stop/2,'r-');
title(['Scan ',num2str(ang(n)),' Degrees']);
axis equal;
axis(20*[-1,1,-1,1]);
end;
```
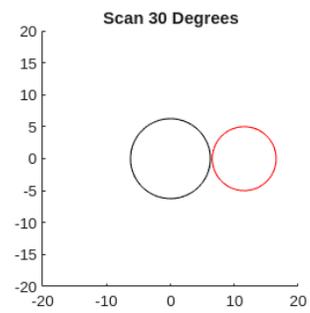
```
---------------------------------------------------------------
Problem 4
fs =
    20
s_aperture_stop =
   220
sprime_aperture_stop =
    22
dprime_aperture_stop =
    1.2500
```
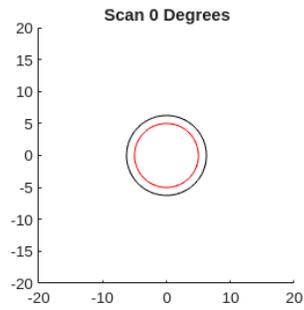
Scan 0 Degrees

Scan 10 Degrees

Scan 20 Degrees

Scan 30 Degrees
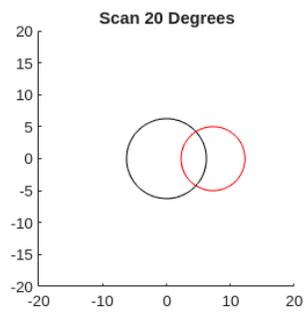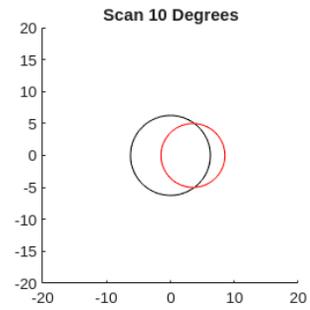
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