Table of Contents


```
% /home/chuck/Documents/working/12567/hw/hw1sol.m
% Sat Oct 11 15:50:42 2025
% Some from...
%/home/dimarzio/Documents/working/12448/hw/hw1sol.m
% /home/dimarzio/Documents/working/12448/hw/hw2sol.m
```

HW1/2 Solutions

```
constant;  % recall some constants
```

Problem 1 Photon Momentum

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

% force = hN_t/lambda

% density=2.5;  g/cc
density=2.5*10^6/10^3; % kg/m^3
g=10; % gravity acceleration, m/s^2

r=50e-6/2; % radius of bead
volume=4/3*pi*r^3;
mass=volume*density
force=mass*g

lambda=500e-9; % Assume green light

N_t=force*lambda/h % photons per second

photon_energy=h*c/lambda;
power=N_t*photon_energy
```

```
----------------------------------------------------------------
Problem 1
```

```
mass =
   1.6362e-10
force =
   1.6362e-09
N_t =
   1.2347e+18
power =
    0.4905
```

Problem 2 Fields

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

p_laser=1; % Watt
r_beam=5e-6; % beam radius, meters
irradiance_laser=p_laser/(pi*r_beam^2) % Watts/meter^2

% irradiance = E^2/Z
Z=sqrt(mu_0/epsilon_0) % Impedance of space
E=sqrt(irradiance_laser*Z) % V/m
H=E/Z % A/m
B=mu_0*H % Vs/m^2 = Weber/m^2 = Tesla
```

```
----------------------------------------------------------------
Problem 2
irradiance_laser =
   1.2732e+10
Z =
  376.7303
E =
   2.1901e+06
H =
   5.8135e+03
B =
    0.0073
```

Problem 3 Raman Spectroscopy

```
disp(repmat('-',1,64));
disp('Problem 3');
% Carbon Tetrachloride
lambdanm=532;
lambda1nm=1./(1./(lambdanm/1e7)-[288,314,459])*1e7

disp('Anti=Stokes lines are weaker because the populations of the')
disp('higher end state are lower by the Boltzman distribution.');
disp(' ');
disp('The extra energy comes from the thermal excitation of that');
disp('state.  At absolute zero the population would be zero and');
disp('there would be no anti-Stokes emission.');
```

```
----------------------------------------------------------------
Problem 3
lambda1nm =
  540.2779  541.0379  545.3160
Anti=Stokes lines are weaker because the populations of the
higher end state are lower by the Boltzman distribution.

The extra energy comes from the thermal excitation of that
state.  At absolute zero the population would be zero and
there would be no anti-Stokes emission.
```

Problem 4 Laser Radar

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

microsec=1e-6 % sec
millisec=1e-3 % sec

distance_microsec=c*microsec/2
distance_millisec=c*millisec/2
```

```
----------------------------------------------------------------
Problem 4
microsec =
   1.0000e-06
millisec =
   1.0000e-03
distance_microsec =
  149.8962
distance_millisec =
   1.4990e+05
```

Problem 5 OCT Imaging

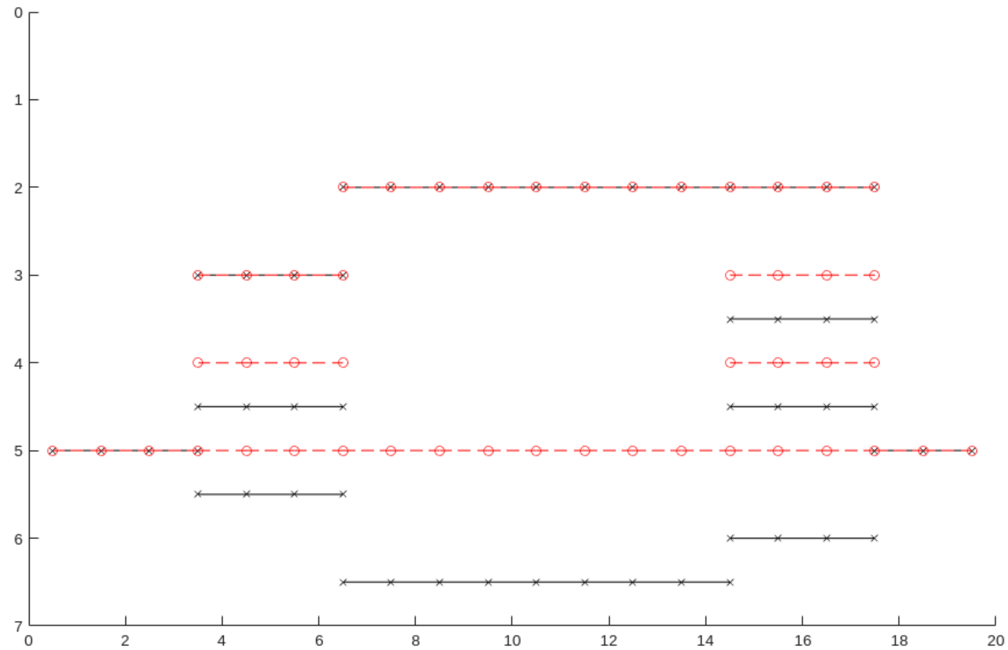
```
disp(repmat('-',1,64));
disp('Problem 5');

disp('Map of index of refraction in 2d');

x=1:19; % For each of the arrows in the figure
n=ones(4,19); % Assume 2 rows of air above first coverslip
n(3,[7:17])=1.5; % each coverslip one unit thick
n(4,[4:14])=1.5;
n(5,:)=n(3,:);
n
% Find the place where the index changes
% The number of places changes with the column number
test=[~(n(2:end,:)==n(1:end-1,:));ones(1,19)]
[row,column]=find(test);
% Calculate the opd to the bottom of each row
for m=1:5;opd(m,:)=sum(n(1:m,:),1);end;
figure;hold on;  % Prepare to plot a line for each return
```

```
for m=1:length(row);
    plot(column(m)+[-0.5,0.5],opd(row(m),column(m))*[1,1],'k-x');
    plot(column(m)+[-0.5,0.5],row(m)*[1,1],'r--o');
end;hold off;axis ij
axis([0,20,0,7]);
disp('Black -x for signals, Red --o for physical depth');
```

```
---------------------------------------------------------------
Problem 5
Map of index of refraction in 2d
n =
  Columns 1 through 7
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.5000
    1.0000    1.0000    1.0000    1.5000    1.5000    1.5000    1.5000
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.5000
  Columns 8 through 14
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    1.5000    1.5000    1.5000    1.5000    1.5000    1.5000    1.5000
    1.5000    1.5000    1.5000    1.5000    1.5000    1.5000    1.5000
    1.5000    1.5000    1.5000    1.5000    1.5000    1.5000    1.5000
  Columns 15 through 19
    1.0000    1.0000    1.0000    1.0000    1.0000
    1.0000    1.0000    1.0000    1.0000    1.0000
    1.5000    1.5000    1.5000    1.0000    1.0000
    1.0000    1.0000    1.0000    1.0000    1.0000
    1.5000    1.5000    1.5000    1.0000    1.0000
test =
  Columns 1 through 13
     0     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     1     1     1     1     1     1     1
     0     0     0     1     1     1     0     0     0     0     0     0     0
     0     0     0     1     1     1     0     0     0     0     0     0     0
     1     1     1     1     1     1     1     1     1     1     1     1     1
  Columns 14 through 19
     0     0     0     0     0     0
     1     1     1     1     0     0
     0     1     1     1     0     0
     0     1     1     1     0     0
     1     1     1     1     1     1
Black -x for signals, Red --o for physical depth
```



Problem 6 Energy

```
disp(repmat('-',1,64));
disp('Problem 6');

p_laser_defrost=100

disp('Assume Area of 1 square meter');
thickness=2e-3;area=1;
volume=thickness*area;
volume_cm=volume*1e6
mass_grams=volume_cm

heat_of_fusion=334 % Joules/gram
energy_needed=mass_grams*heat_of_fusion

seconds_to_melt=energy_needed/p_laser_defrost

disp('Bottom Line:  Not very good');
```

```
----------------------------------------------------------------
Problem 6
p_laser_defrost =
   100
Assume Area of 1 square meter
volume_cm =
        2000
mass_grams =
        2000
```

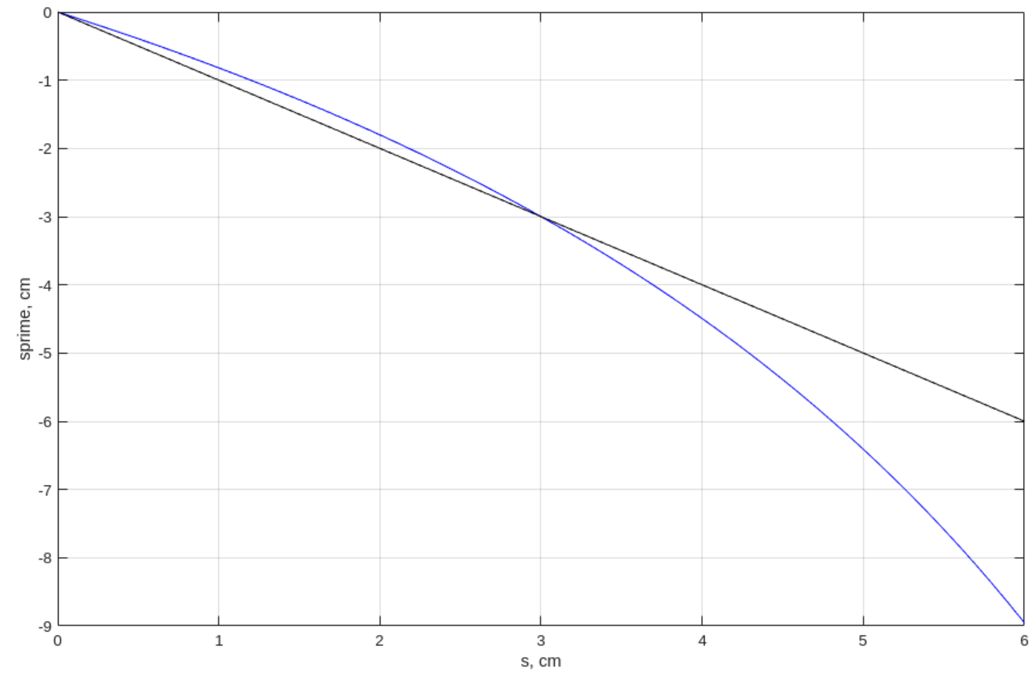
```
heat_of_fusion =
   334
energy_needed =
      668000
seconds_to_melt =
        6680
Bottom Line:  Not very good
```

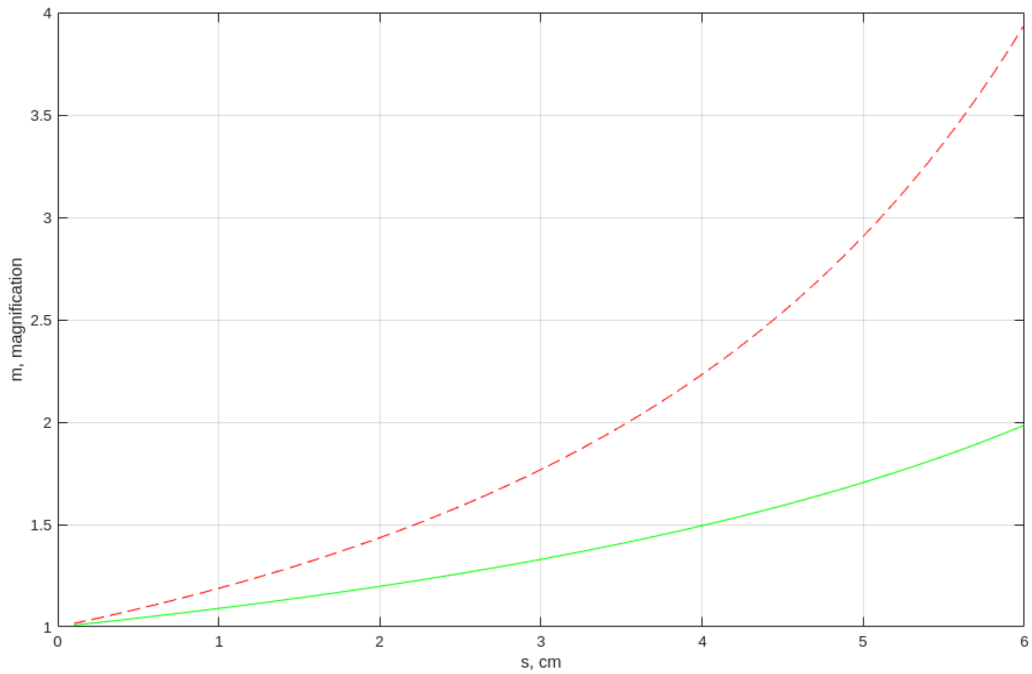
Problem 7 Snow Globe

```
disp(repmat('-',1,64));
disp('Problem 7');

n=1.33;nprime=1;
r=-3; % Units in cm.
s=[0:0.1:6];
% n/s + nprime/sprime = (nprime-n)/r = P
disp('Following 3 not asked but needed for solution');
P=(nprime-n)/r % Refracting Power
%  nprime/sprime = P - n/s
% sprime/nprime=1/( P - n/s)
fprime=nprime/P
f=n/P
sprime=nprime./( P - n./s);
m=-n*sprime/nprime./s;
figure;plot(s,sprime,'b-',...
        [s(1),s(end)],[-s(1),-s(end)],'k');grid on;
xlabel('s, cm');ylabel('sprime, cm')
figure;plot(s,m,'g-',s,m.^2,'r--');grid on;
xlabel('s, cm');ylabel('m, magnification')
```

```
----------------------------------------------------------------
Problem 7
Following 3 not asked but needed for solution
P =
    0.1100
fprime =
    9.0909
f =
   12.0909
```





Problem 8 Oil-Immersion Lens

```
disp(repmat('-',1,64));
disp('Problem 8');
```

```
n=1.5;nprime=1;
fprime=2; % mm
P=nprime/fprime % Refracting power
f=fprime*n/nprime

% n/s + nprime/sprime = P = nprime/fprime
m=-100;
% m = -n*sprime/(nprime*s) so sprime=-m*s*nprime/n
% sprime=-s*m*nprime/n Save to substitute in lens equation
% Lens equation
% n/s+nprime/sprime=P
% n/s+nprime/(-s*m*nprime/n)=P
% substitute for sprime
% (n+nprime/(m*nprime/n))/s=P
s=(n+nprime/(-m*nprime/n))/P
sprime=-s*m*nprime/n % From above
ds=5e-3; % mm
mz=-n/nprime*m^2
dsprime=mz*ds % mm
```

```
----------------------------------------------------------------
Problem 8
P =
    0.5000
f =
     3
s =
    3.0300
sprime =
   202
mz =
      -15000
dsprime =
   -75
```

Problem 9 Thin Lenses

```
disp(repmat('-',1,64));
disp('Problem 9');
disp('Units are Meters');
f=0.10 % Meters
P=1/f
Psurface=P
disp('P=(nprime-n)/r from Slide 2r1-35');
r2=(1-1.5)/(-Psurface)
disp('2 identical lenses');
P2=2*P
f2=1/P2
```

```
----------------------------------------------------------------
Problem 9
Units are Meters
f =
```

```
    0.1000
P =
    10
Psurface =
    10
P=(nprime-n)/r from Slide 2r1-35
r2 =
    0.0500
2 identical lenses
P2 =
    20
f2 =
    0.0500
```

Problem 10 Dogleg

```
disp(repmat('-',1,64));
disp('Problem 10');
disp('See Text for Solutions');
```

```
----------------------------------------------------------------
Problem 10
See Text for Solutions
```

Published with MATLAB® R2025a