Assignment 1: Optics / Snell

Pratheep Kumar Chelladurai

Please “check the math” on this. Assume the equilateral prism is made of flint glass, whose index of refraction *n* depends on wavelength according to the table below. The white light angle of incidence is 55° from normal.

Wavelength (nm)	440 (blue)	560 (green)	620 (red)
IOR	1.6410	1.6226	1.6175

Question 1a:

What percent of the unpolarized incident light, at each wavelength, is reflected from the first surface of the prism (see Eqs 1.1-1.3)?

```
n_material = [1.6410 1.6226 1.6175];
n_air = 1;
angle_incidence = 55;
surface_reflection = zeros(3,0);

for i = 1 : length(n_material)

r_parallel = ((cosd(angle_incidence) - ...
    sqrt((n_material(i)/n_air)^2 - sind(angle_incidence)^2)) ...
    / ...
    (cosd(angle_incidence) + ...
    sqrt((n_material(i)/n_air)^2 - sind(angle_incidence)^2)))^2 ;


r_perpendicular = ((((n_material(i)/n_air)^2)*(cosd(angle_incidence)) - ...
    sqrt((n_material(i)/n_air)^2 - sind(angle_incidence)^2)) ...
    / ...
    (((n_material(i)/n_air)^2)*(cosd(angle_incidence)) + ...
    sqrt((n_material(i)/n_air)^2 - sind(angle_incidence)^2)))^2 ;

surface_reflection(i) = ((r_parallel + r_perpendicular ) / 2) * 100;

end

surface_reflection_table = array2table(surface_reflection);
surface_reflection_table.Properties.VariableNames = {'Blue (in %)';...
    'Green (in %)';'Red (in %)'};
surface_reflection_table
```

`surface_reflection_table = 1×3 table`

	Blue (in %)	Green (in %)	Red (in %)
1	9.1223	8.8461	8.7693

Question 1b:

What are the three angles of transmission, corresponding to the tabulated wavelengths, inside the prism (see Snell's Law, Eq 1.5)?

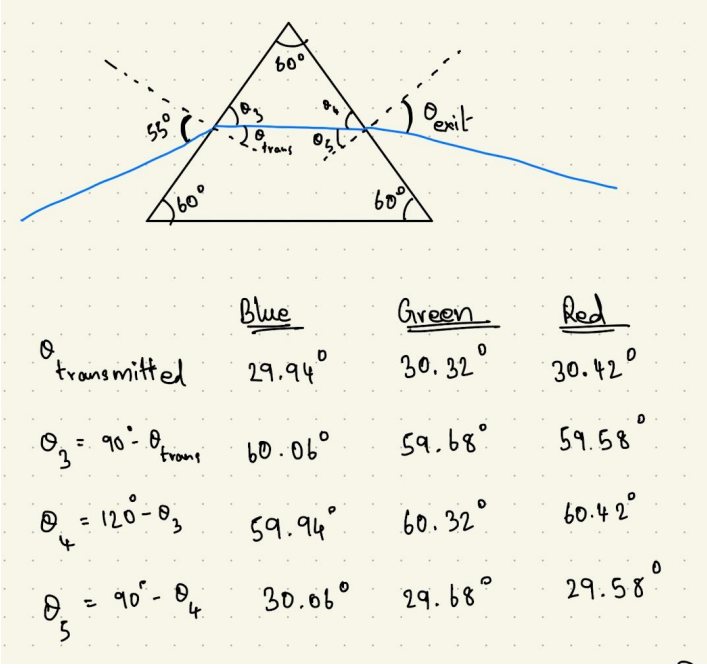
```
angle_of_transmission = zeros(3,0);
for i = 1:length(n_material)
    angle_of_transmission(i) = asind((n_air/n_material(i))...
        *sind(angle_incidence));
end

angle_of_transmission_table = array2table(angle_of_transmission);
angle_of_transmission_table.Properties.VariableNames = {'Blue (in deg)';...
    'Green (in deg)';'Red (in deg)'};
angle_of_transmission_table
```

angle_of_transmission_table = 1×3 table

	Blue (in deg)	Green (in deg)	Red (in deg)
1	29.9457	30.3207	30.4264

Question 1c:

What are the three angles of exit from the prism?



	Blue	Green	Red
$\theta_{transmitted}$	29.94°	30.32°	30.42°
$\theta_3 = 90° - \theta_{trans}$	60.06°	59.68°	59.58°
$\theta_4 = 120° - \theta_3$	59.94°	60.32°	60.42°
$\theta_5 = 90° - \theta_4$	30.06°	29.68°	29.58°

```
theta_5 = [30.06 29.68 29.58];
exit_angle = zeros(3,0);
for i = 1:length(n_material)
    exit_angle(i) = asind((n_material(i)*sind(theta_5(i)))/n_air);
end
exit_angle_table = array2table(exit_angle);
exit_angle_table.Properties.VariableNames = {'Blue (in deg)';...
    'Green (in deg)';'Red (in deg)'};
```

```
exit_angle_table
```

exit_angle_table = 1×3 table

	Blue (in deg)	Green (in deg)	Red (in deg)
1	55.2843	53.4598	52.9833

Question 1d:

What happens if the angle of incidence is 25° from normal?

```
angle_incidence = 25;
angle_of_transmission = zeros(3,0);
thetha_I = zeros(3,0);
critical_angle = zeros(3,0);

for i = 1:length(n_material)
    angle_of_transmission(i) = asind((n_air/n_material(i))...
        *sind(angle_incidence));
    thetha_I(i) = 60 - angle_of_transmission(i);
    critical_angle(i) = asind((n_air/n_material(i))*sind(90));

end

thetha_c_table = array2table([thetha_I; critical_angle]);
thetha_c_table.Properties.VariableNames = {'Blue (in deg)';...
    'Green (in deg)';'Red (in deg)'};
thetha_c_table.Properties.RowNames = {'thetha_I','Critical Angle'};
thetha_c_table
```

thetha_c_table = 2×3 table

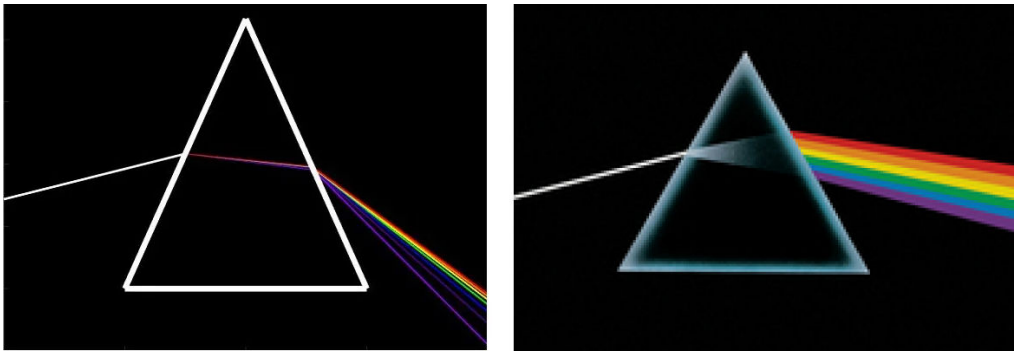
	Blue (in deg)	Green (in deg)	Red (in deg)
1 thetha_I	45.0760	44.9028	44.8541
2 Critical Angle	37.5450	38.0461	38.1876

On comparing the row 1 and row 2 from the above table, incidence angle is greater than critical angle. In such case, total internal reflection occurs. Therefor no light will pass through the exit.

Question 1e:

Is The Dark Side of the Moon "correct"?

No it is not accurate. Difference in angle of dispersion between the wavelengths will not be linear. The designer the poster might followed the same difference to make it visually consistent. The following image shows the mathematically corrected dispersion (left) vs the dispersion from the poster (right). Also, the light will be in the prism before dispersing again. But it is not depicted clearly in the prism.



Question 1e:

What's your favorite song on this album?

I haven't heard the album yet.

Question 2

Consider a piece of black plastic with index of refraction n = 1.46. The front-surface reflection depends strongly on the angle of incidence

Question 2a

Compute the unpolarized front surface reflection in percent for angles of incidence of 0, 10, ..., 80° from normal, and plot the results as a function of angle

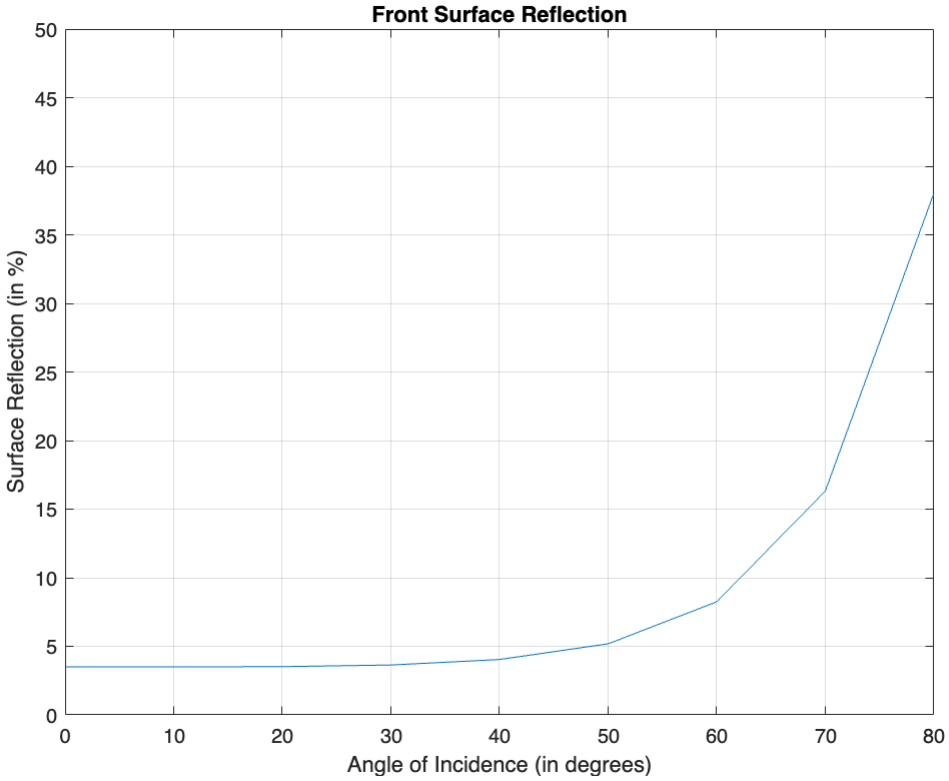
```
n_material = 1.46;
n_air = 1;
surface_reflection = zeros(9,1);
angle_incidence = linspace(0,80,9);

for i = 1 : length(angle_incidence)
    r_parallel = ((cosd(angle_incidence(i)) - ...
        sqrt((n_material/n_air)^2 - sind(angle_incidence(i)) ^ 2)) ...
        / ...
        (cosd(angle_incidence(i)) + ...
        sqrt((n_material/n_air)^2 - sind(angle_incidence(i)) ^ 2)))^2 ;


    r_perpendicular = ((((n_material/n_air)^2)*(cosd(angle_incidence(i))) - ...
        sqrt((n_material/n_air)^2 - sind(angle_incidence(i)) ^ 2)) ...
        / ...
        (((n_material/n_air)^2)*(cosd(angle_incidence(i))) + ...
        sqrt((n_material/n_air)^2 - sind(angle_incidence(i)) ^ 2)))^2 ;
```

```
   surface_reflection(i) = ((r_parallel + r_perpendicular ) / 2) * 100;
end

array2table(surface_reflection)
```

ans = 9×1 table

	surface_reflection
1	3.4966
2	3.4980
3	3.5215
4	3.6398
5	4.0391
6	5.1825
7	8.2454
8	16.3253
9	38.0434

```
h = figure;
plot(angle_incidence,surface_reflection)
grid on

datacursormode(h,'on');
xlabel('Angle of Incidence (in degrees)')
ylabel('Surface Reflection (in %)')
title('Front Surface Reflection')
ylim([0 50])
```



Question 2b

Compute the unpolarized front surface reflection in percent for angles of incidence of 0, 10, ..., 80° from normal, and plot the results as a function of angle