How to use the script tmm.m: some examples
(NOTE: the imaginary part of the refractive indices must have + sign!)

```
function T_R_A=tmm(lam,theta,n_layers,d_layers,n_input,n_output,pol)
```

Example 1: Calculate T, R, and A for green light (lam=532e-9 m) incident from free space (n_input=1) into glass (n_output=1.5) at 45 degrees with TM polarization.

Solution:
In this case, thre are no layers between n_input and n_output, therefore
we can arbitrarily set n_layers=1 and d_layers=0 (a free space layer with zero thickness)
So we can simply write:

```
T_R_A=tmm(532e-9,45,1,0,1,1.5,1);
T=T_R_A(1)
R=T_R_A(2)
A=T_R_A(3)
```

Example 2: A single film with refractive index n=3+1i*0.2 with thickness d=100nm has been deposited on a glass substrate (n_input=1.5). The material on top of the film is air (n_output = 1).
The film is illuminated with infrared light (lam=800 nm) incident at 0 degree (normal incidence) from the glass side. Find transmittance, reflectance, and absorption.

Solution:
In this case we will write:

```
T_R_A=tmm(800e-9,0,3+1i*0.2,100e-9,1.5,1,0);

T=T_R_A(1)
R=T_R_A(2)
A=T_R_A(3)
```

Example 3: A single film with refractive index n=3+1i*0.2 with thickness d=100nm has been deposited on a glass substrate (n_input=1.5). The material on top of the film is air (n_output = 1).
The film is illuminated with a TE-polarized broadband visible light (from 400 to 700 nm).
Find (and plot) transmittance, reflectance, and absorption at normal incidence as a function of wavelength.

Solution:
We need a single "for" cycle over a wavelength vector. The script to run is:

```
clear all;
N_wavelengths=100;  % we set 100 wavelengths in the interval between 400 and 700nm;
```

```
wavelengths=linspace(400e-9,700e-9,N_wavelengths);
for ii=1:N_wavelengths,
T_R_A=tmm(wavelengths(ii),0,3+1i*0.2,100e-9,1.5,1,0);
T(ii)=T_R_A(1);
R(ii)=T_R_A(2);
A(ii)=T_R_A(3);
end
figure; plot(wavelengths,T); hold on; plot(wavelengths,R); plot(wavelengths,A);
```

Example 4: A single film with refractive index n=3+1i*0.2 with thickness d=100nm has been deposited on a glass substrate (n_input=1.5). The material on top of the film is air (n_output = 1). The film is illuminated with a TE-polarized light of wavelength lam = 532 nm. The angle of incidence is varied from 0 to 89 degrees from the glass side. Find (and plot) transmittance, reflectance, and absorption as a function of the angle of incidence.

Solution:
We need a single "for" cycle over the angle of incidence vector. The script to run is:

```
clear all;
N_angles=90; % we set 90 angles between 0 and 89 degrees;
angles=linspace(0,89,N_angles);
for ii=1:N_angles,
T_R_A=tmm(532e-9,angles(ii),3+1i*0.2,100e-9,1.5,1,0);
T(ii)=T_R_A(1);
R(ii)=T_R_A(2);
A(ii)=T_R_A(3);
end
figure; plot(angles,T); hold on; plot(angles,R); plot(angles,A);
```

Example 5: A single film with refractive index n=3+1i*0.2 with thickness d=100nm has been deposited on a glass substrate (n_input=1.5). The material on top of the film is air (n_output = 1).
The film is illuminated with a TE-polarized broadband visible light (from 400 to 700 nm) incident with variable angle of incidence from 0 to 89 degrees from the glass side.
Plot a color map of the transmittance, reflectance, and absorption as functions of the two variables wavelength and angle of incidence.

Solution:
We need two indented "for" cycles over the wavelength and angle of incidence vectors. The script to run is:

```
clear all;
N_angles=90; N_wavelengths=100;
angles=linspace(0,89,N_angles);
wavelengths=linspace(400e-9,700e-9,N_wavelengths);
```

```
for ii=1:N_angles,
 for jj=1:N_wavelengths,
     T_R_A=tmm(wavelengths(jj),angles(ii),3+1i*0.2,100e-9,1.5,1,0);
     T(ii,jj)=T_R_A(1);
     R(ii,jj)=T_R_A(2);
     A(ii,jj)=T_R_A(3);
  end
end
figure; surf(wavelengths,angles,T); colorbar; shading interp; view(2);
title('Transmittance');
figure; surf(wavelengths,angles,R); colorbar; shading interp; view(2);
title('Reflectance');
figure; surf(wavelengths,angles,A); colorbar; shading interp; view(2);
title('Absorption');
```