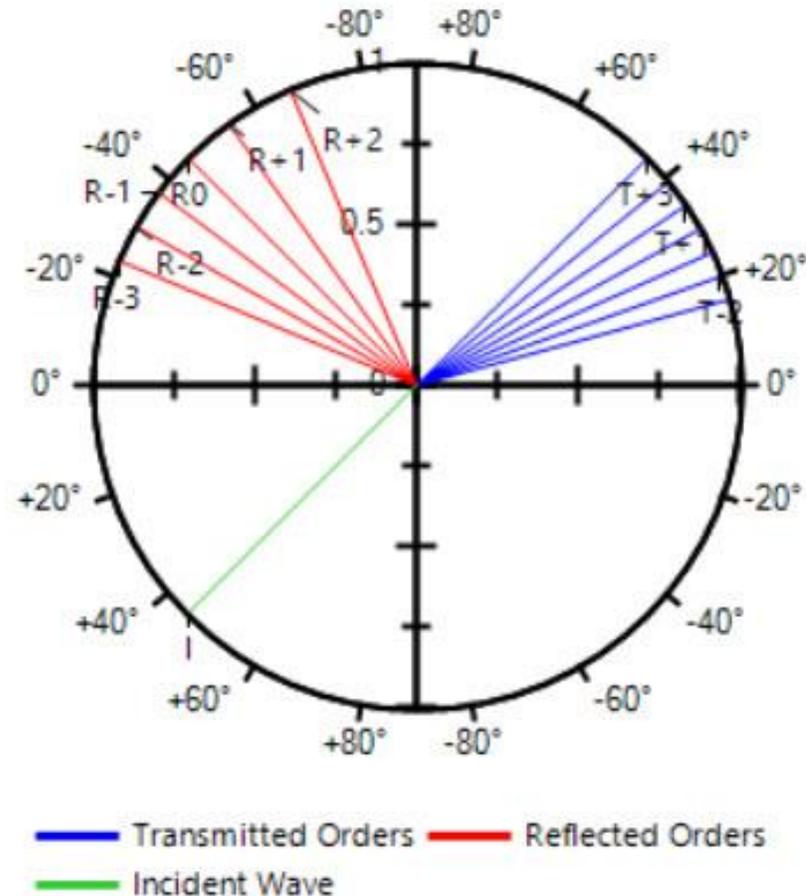


# Diffraction Angle Calculator

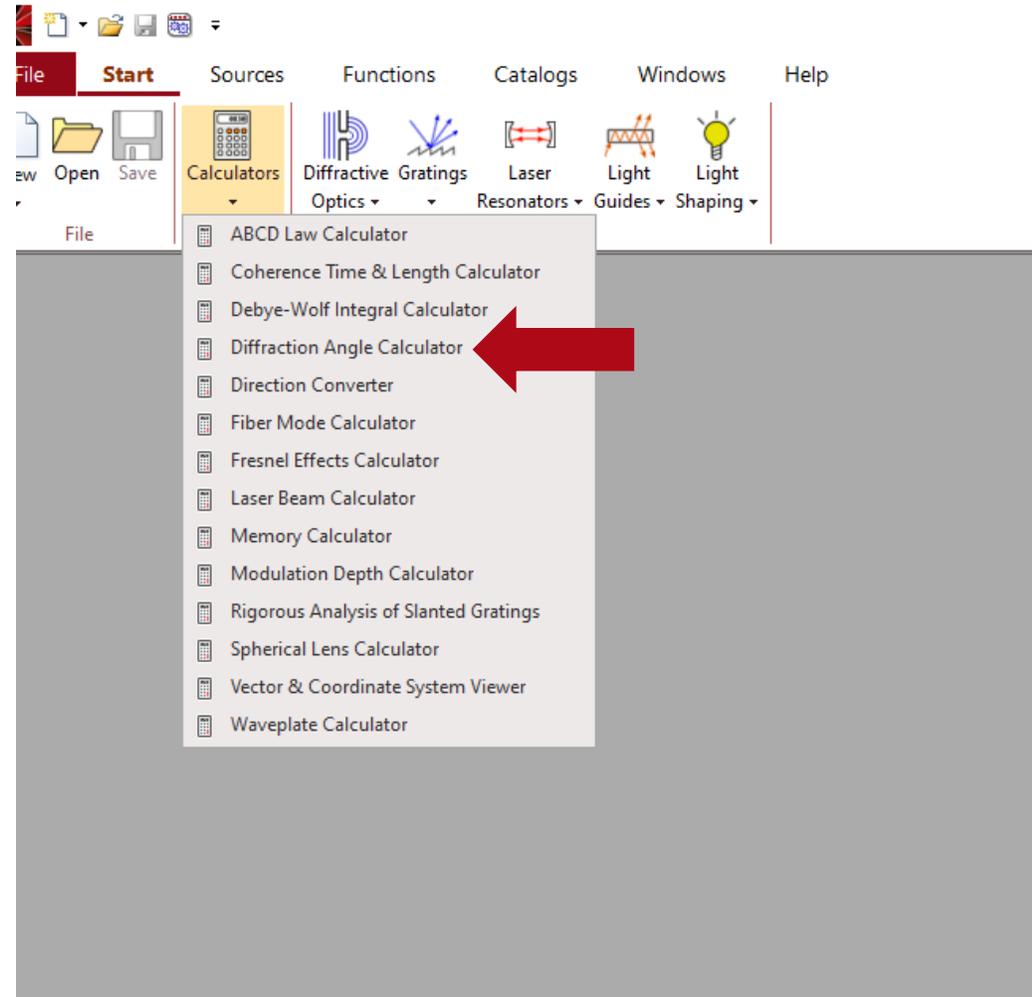
# Abstract



The defining characteristic of diffraction gratings is the periodicity of their structure which, as predicted by Fourier theory, causes incident light to be split into a discrete set of orders, both in transmission and reflection. How many of these propagating orders there are, as well as the deflection angle of each of them, depends on the wavelength of the radiation, the refractive indices of the media in front of and behind the grating, the period of the structure, and the angle of incidence. This dependence is mathematically encoded in the grating equation. In this use case we present the Diffraction Angle Calculator of VirtualLab Fusion, a convenient tool for calculations involving the grating equation.

# Open the Diffraction Angle Calculator

The *Diffraction Angle Calculator* can be accessed through the *Calculators* drop-down list under the *Start* tab.



# Setting the Input Parameters

1: Diffraction Angle Calculator

Grating Period

Incident Angle

Wavelength

Diffraction Orders

Maximum Shown Order

Reflected Orders Range  ..

Transmitted Orders Range  ..

First Material

Name

Catalog Material

State of Matter

Switch Materials

Second Material

Name

Catalog Material

State of Matter

Validity:

The user needs to input values for the *Grating Period*, *Incident Angle*, *Wavelength*, and define the materials in front of and behind the grating. The incident wave and the reflected orders reside in the *First Material*, while the transmitted orders are in the *Second Material*.

The *Switch Materials* button can be used to swap the two materials.

# Define Diffraction Orders

1: Diffraction Angle Calculator

Grating Period

Incident Angle

Wavelength

**Diffraction Orders**

Maximum Shown Order

Reflected Orders Range

Transmitted Orders Range

First Material

Name

Catalog Material

State of Matter

Switch Materials

Second Material

Name

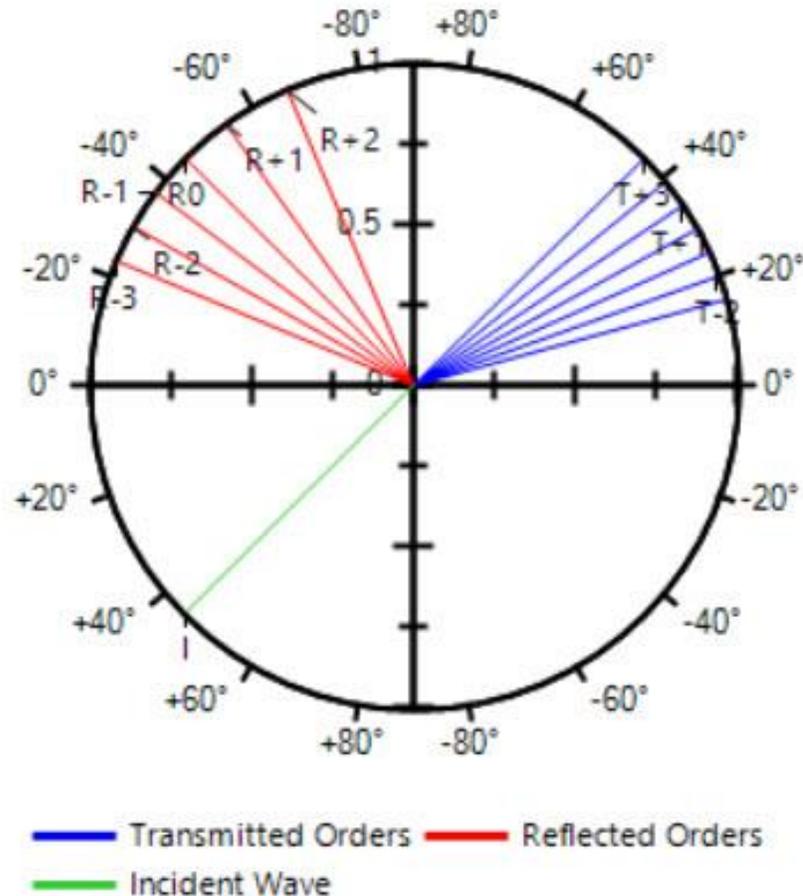
Catalog Material

State of Matter

Validity:

Within the *Diffraction Orders* box, you have the option to specify the *Maximum Shown Order*. This parameter dictates the number of propagating orders that will be visible. The minimum and maximum propagating orders, for both reflection and transmission, are displayed as the *Reflected Orders Range* and *Transmitted Orders Range*, respectively.

# Grating Equation



The *Diffraction Angle Calculator* shows the resulting diagram in x-z plane. The angles can be calculated from the wave vector and vice versa. Quantitatively, the wave vector  $k_{\text{out}}$  of a diffraction order  $l$  is calculated by the grating equation,

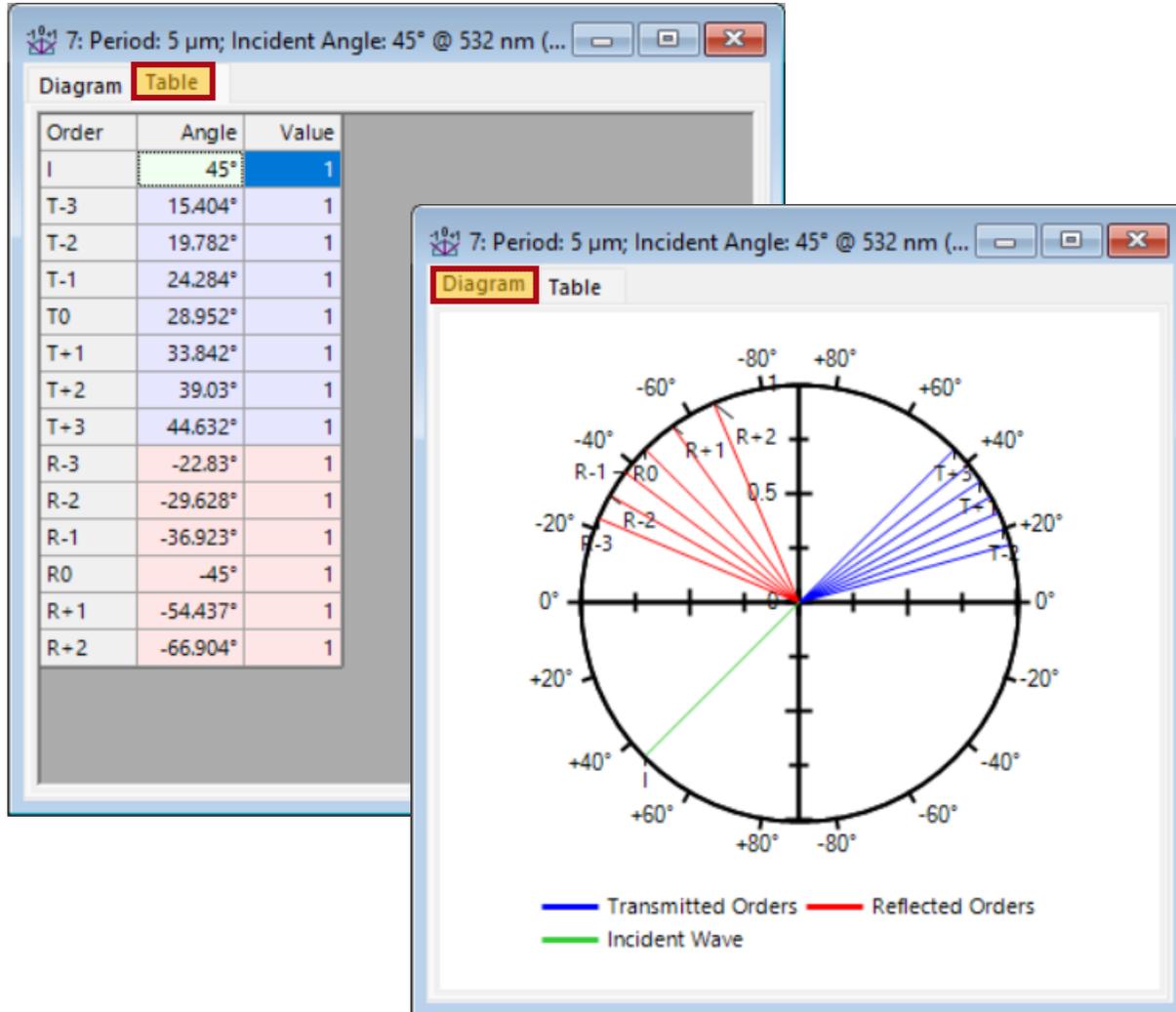
$$k_{\text{out},x} = k_{\text{in},x} + \frac{2\pi l}{P_x}$$

$$k_{\text{out},z} = \text{sign}(n_{\text{out}}) \sqrt{\left(\frac{2\pi n_{\text{out}}}{\lambda}\right)^2 - k_{\text{out},x}^2}$$

where  $P_x$  is the grating period,  $n$  is the refractive index,  $\lambda$  is the vacuum wavelength.

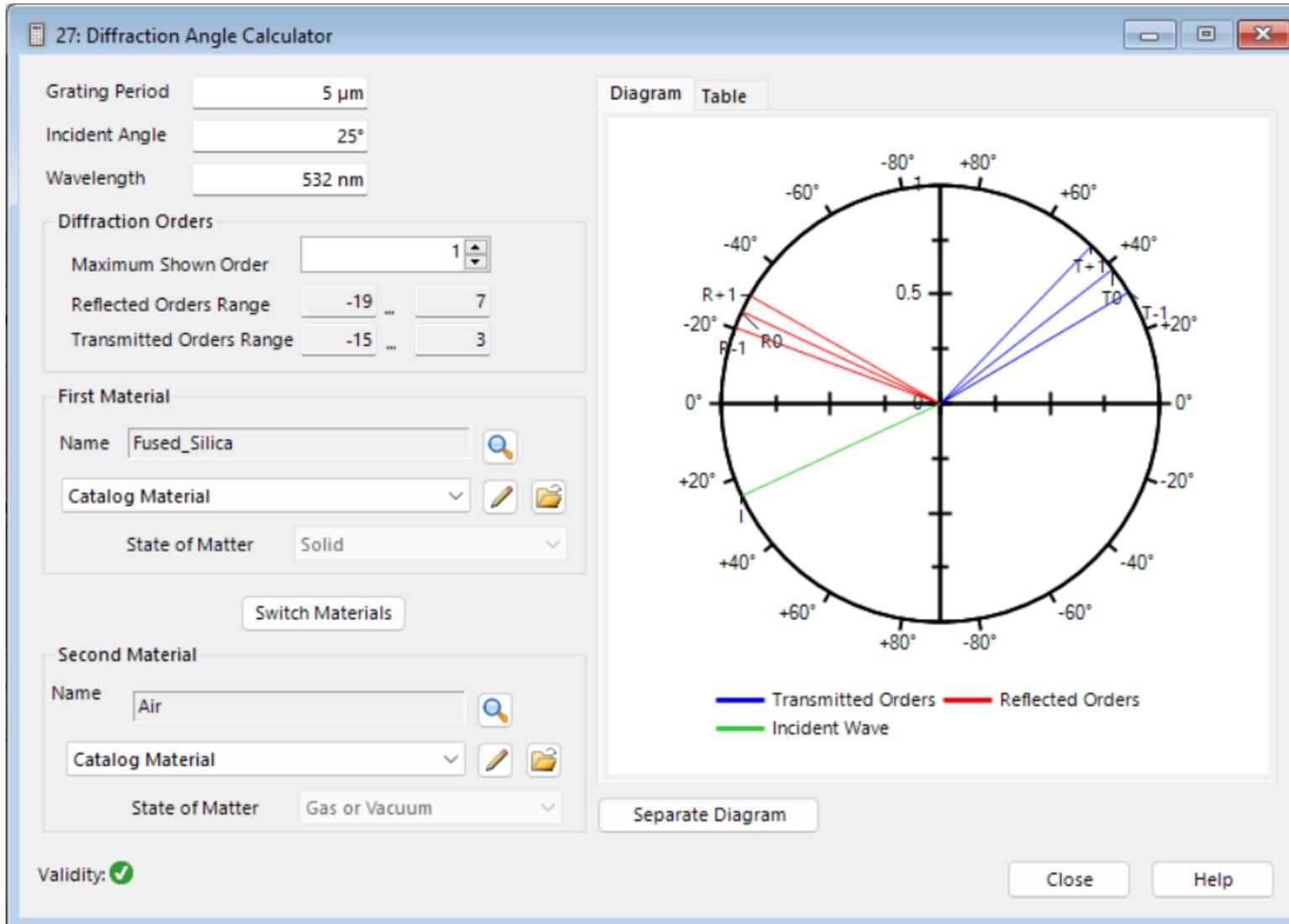
$2\pi/P_x$  is often referred to as the x-component of the grating vector.

# Diffraction Order Diagram



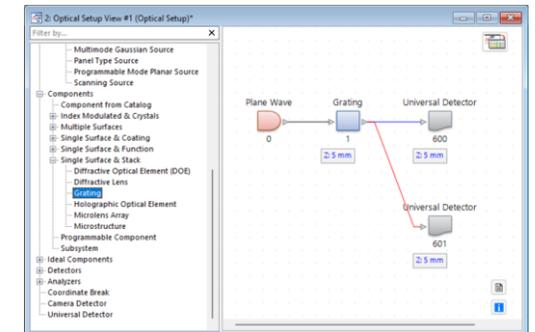
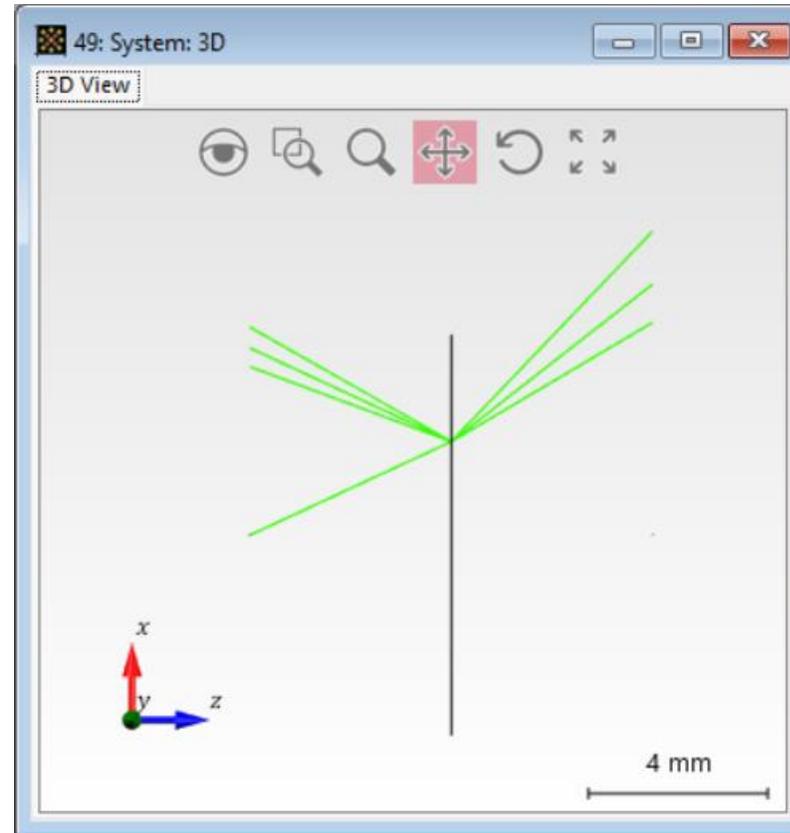
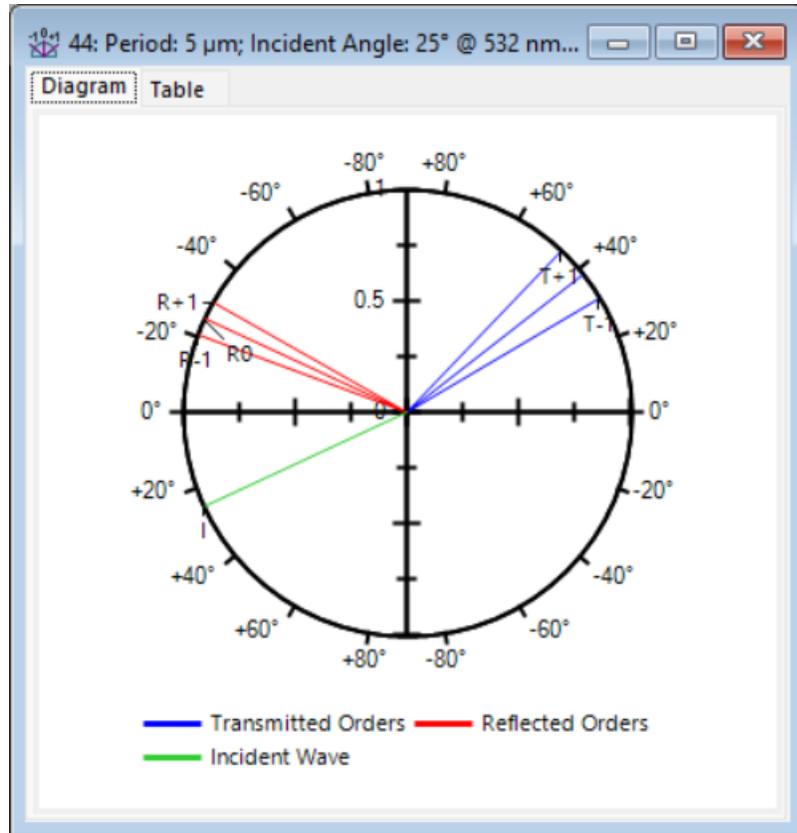
The user can generate a separate window for the diagram, which can be saved and zoomed into, by clicking on *Separate Diagram*. Additionally, a table displaying the diffraction angles is also provided.

# An Example



Let us now consider another example. For this case, we choose the *First Material* as fused silica and the *Second Material* as air, with an *Incident Angle* of 25°. We limit the *Maximum Shown Order* to 1.

# The Example in General Optical Setup



We employ a *General Optical Setup* to simulate an analogous system. The diffraction grating is described by a *Grating Component*, using the FMM/RCWA [S-Matrix] solver. We can see that this yields the same results as the *Diffraction Angle Calculator*, where the outcome is directly computed by the grating equation.

# Document Information

title	Diffraction Angle Calculator
document code	SWF.0037
document version	1.0
software edition	<ul style="list-style-type: none"><li>• VirtualLab Fusion Basic (for the calculator)</li><li>• VirtualLab Fusion Advanced (for the Grating Component used for comparison)</li></ul>
software version	2023.1 (Build 1.556)
category	Feature Use Case
further reading	