20. A diffraction grating has 2604 lines per centimeter, and it produces a principal maximum at θ= 30.0°. The grating is used with light that contains all wavelengths between 410 and 660 nm. What is (are) the wavelength(s) of the incident light that could have produced this maximum?

For a diffraction grating the condition for bright spots is given by

$$\boldsymbol{d\sin(\theta) = m\lambda}$$

Solve for wavelength

$$\boldsymbol{\lambda = \frac{d\sin(\theta)}{m}}$$

Now what wavelength has m = 1?

$$\boldsymbol{\lambda = \frac{d\sin(\theta)}{m} = d\sin(\theta) = \left(\frac{10^{-2}m}{2604\ lines}\right)\sin(30.0°) = 1.92\ x\ 10^{-6}\ m = 1920\ nm}$$

Clearly too large!

Now what wavelength has m = 2?

$$\boldsymbol{\lambda = \frac{d\sin(\theta)}{m} = \frac{d\sin(\theta)}{2} = \left(\frac{10^{-2}m}{2604\ lines}\right)\frac{\sin(30.0°)}{2} = 9.60\ x\ 10^{-7}\ m = 960\ nm}$$

Still too large!

Now what wavelength has m = 3?

$$\boldsymbol{\lambda = \frac{d\sin(\theta)}{m} = \frac{d\sin(\theta)}{3} = \left(\frac{10^{-2}m}{2604\ lines}\right)\frac{\sin(30.0°)}{3} = 6.40\ x\ 10^{-7}\ m = 640\ nm}$$

That works!

Now what wavelength has m = 4?

$$\boldsymbol{\lambda = \frac{d\sin(\theta)}{m} = \frac{d\sin(\theta)}{4} = \left(\frac{10^{-2}m}{2604\ lines}\right)\frac{\sin(30.0°)}{4} = 4.80\ x\ 10^{-7}\ m = 480\ nm}$$

That works!

Now what wavelength has m = 5?

$$\boldsymbol{\lambda = \frac{d\sin(\theta)}{m} = \frac{d\sin(\theta)}{5} = \left(\frac{10^{-2}m}{2604\ lines}\right)\frac{\sin(30.0°)}{5} = 3.84\ x\ 10^{-7}\ m = 384\ nm}$$

Ok, now too small. So we have found them and there are two!

$$\boxed{\boldsymbol{For\ m = 3, \lambda = 640\ nm}}$$

$$\boldsymbol{For\ m = 4, \lambda = 480\ nm}$$

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Please send any comments or questions about this page to ddonovan@nmu.edu

This page last updated on January 7, 2021