Virtual Lab

Diffraction Grating

(Expt. 03)

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Div: J1 **Branch: Computer Engineering**

Aim:

1. To determine the number of lines per millimeter of the grating using the green line of the mercury spectrum.
2. To calculate the wavelength of the other prominent lines of mercury by normal incidence method.

Apparatus:

Spectrometer, diffraction grating element and mercury vapor lamp.

Theory:

When a wave train strikes an obstacle, the light ray will bend at the corners and edges of it, which causes the spreading of light waves into the geometrical shadow of the obstacle. This phenomenon is termed as diffraction.

Single slit diffraction:

When waves pass through a gap, which is about as wide as the wavelength they spread out into the region beyond the gap. Huygens considered each point along a wave front to be the source of a secondary disturbance that forms a semi-circular wavelet. Diffraction is due to the superposition of such secondary wavelets. The secondary wavelets spread out and overlap each other interfering with each other to form a pattern of maximum and minimum intensity. The pattern formed on a screen consists of a broad central band of light with dark bands on either side. The dark bands are caused when the light from the top half of the slit destructively interferes with the light from the bottom half.

Consider a slit of width ‘a’. Let at an angle θ, the path difference between the top and bottom of the slit is a wavelength. This causes destructive interference to occur because the path difference between the top and the middle of the slit is half of the wavelength. At this angle

all the light from the top half of the slit will get cancelled with the light from the bottom half to produce a dark band.

$$\therefore \Delta S = a \sin\theta \quad \text{---------- (1)}$$

Intensity minima will occur if this path length difference is an integer number of wavelengths.

$$a * \sin(\theta) = n\lambda \quad \text{----------(2)}$$

Where,

n is the order of each minimum

λ is the wavelength,

a is the distance between the slits

θ is the angle at which destructive interference occurs.

Intensity is given by,

$$I = I_0 \frac{\sin^2\left(\frac{N\delta}{2}\right)}{\left(\frac{\delta}{2}\right)^2} \quad \text{----------(3)}$$ where

δ is the total phase angle , it can be related to the deviation angle,

$$\delta = \frac{2\pi a * \sin(\theta)}{\lambda} \quad \text{----------(4)}$$

I_0 is the maximum intensity λ is the wavelength of the light and a is the slit width.

Diffraction grating is an optical component having a periodic structure which can split and diffract light t several beams travelling in different directions. This depends on the spacing of the grating and the wavelength of the incident light. At normal incidence,

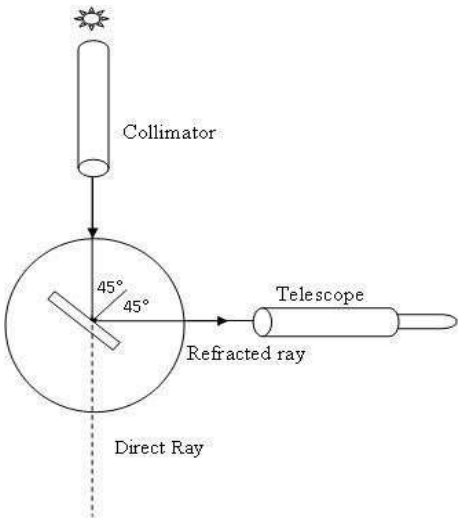
$$Sin\theta = Nn\lambda \quad \text{----------(5)}$$

where,

N is the number of lines per unit length of the grating

n is the order of the spectrum

λ is the wavelength of light. θ is the diffraction angle.



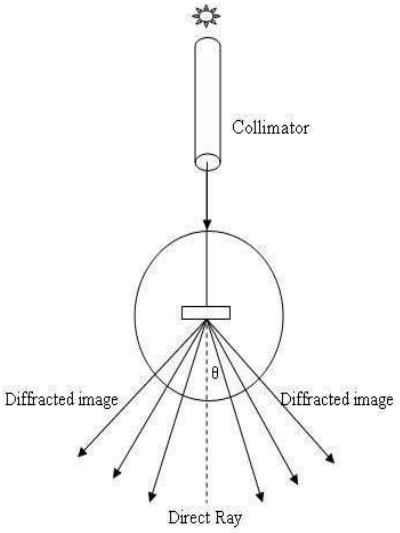
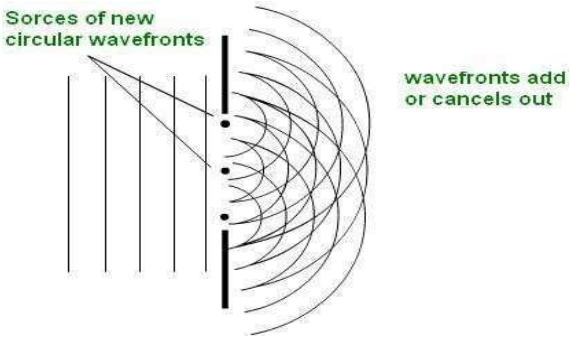
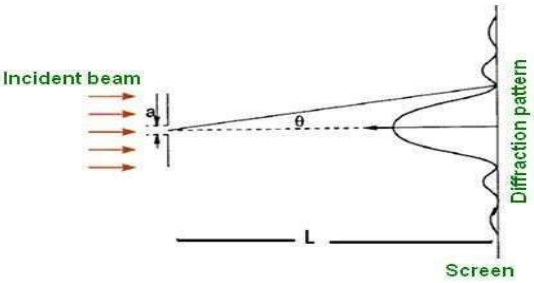


Diagram:





Working Process:

The simulation virtualizes the Mercury spectrum experiment. The user can use a grating spectrometer to measure the wavelengths of Yellow, Green, Violet and Red lines in the visible spectrum of Mercury.

Components:

Spectrometer, Grating and Mercury Vapour Lamp.

Variable Region:

1. **Telescope Calibrate Slider** : This slider helps the user to change the focus of telescope.
2. **Start Button** : Helps the user to start the experiment after setting the focus of telescope. The Start Button can be activated only if the focus of the telescope is proper.
3. **Light Toggle Button** : Helps the user to switch the lamp ON or OFF.
4. **Grating Toggle Button** : Helps the user to place or remove the grating.
5. **Telescope Angle Slider** : This slider helps the user to change the angle of telescope.
6. **Vernier Angle Slider** : This slider helps the user to change the angle of the Vernier.

7. **Telescope Angle Slider** : Helps make minute changes of the telescope angle.
8. **Calibrating Telescope Button** : Helps the user to calibrate the telescope after starting the experiment, if needed.

Procedure for simulation:

To standardise the grating:

- Turn the telescope to obtain the image of the slit.
- Turn the telescope to both sides to obtain green lines. Note the reading of both the verniers.
- Calculate the difference in the reading to obtain the diffraction angle. Then from the equation, number of lines per unit length of the grating can be calculated.

To calculate the wavelength of different lines:

- Obtain the direct image.
- Telescope is moved to make the cross-wire coincide with each line of the spectrum.
- Note the readings on the verniers and calculate the diffraction angle.
- Then calculate the wavelength of each colour.

Observations and Calculations:

1. Standardization of equipment:

Green λ (nm)	Left		Right		Difference Reading (2θ)		Mean θ	$N = \sin\theta / n\lambda$
	Ver I	Ver II	Ver I	Ver II	Ver I	Ver II		
546.1	-19°46'	160°22'	19°12'	199°10'	38°58'	38°48'	19°26'	609247

For green light, λ = 546.1nm

2. Determination of wavelength for prominent lines:

Colour	Left		Right		Difference Reading (2θ)		Mean θ	$\lambda = \frac{\sin\theta}{nN}$ (nm)
	Ver I	Ver II	Ver I	Ver II	Ver I	Ver II		
Yellow I	-20°12'	159°45'	20°6'	200°15'	40°18'	40°30'	20°12'	566.76
Yellow II	-19°46'	160°22'	19°12'	199°10'	38°58'	38°48'	19°26'	546.1

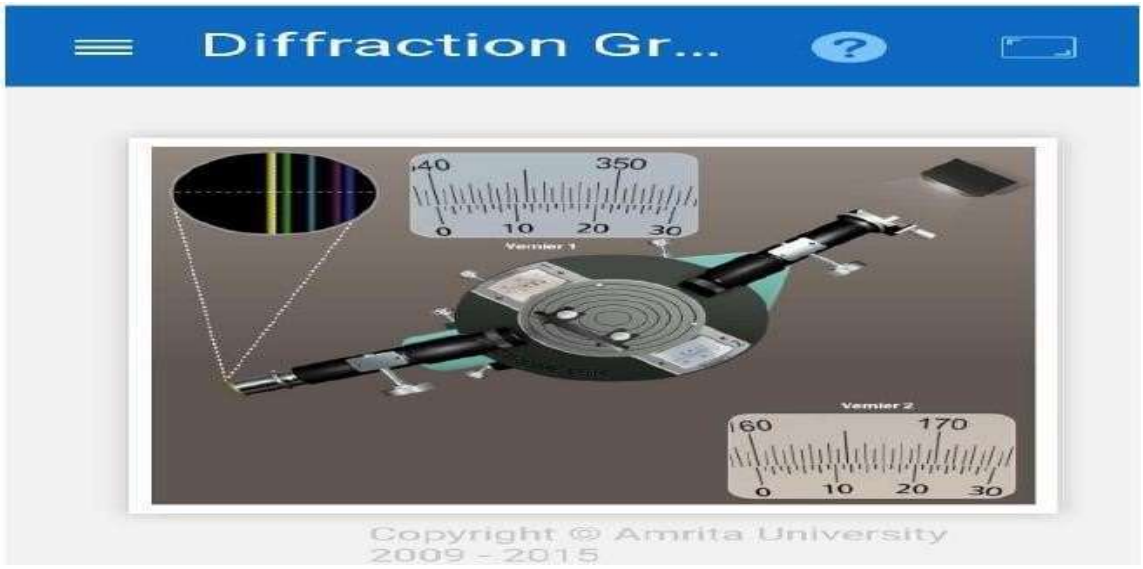
Blue - Green	**-16°24'**	**163°54'**	**17°2'**	**197°20'**	**33°26'**	**33°26'**	**16°43'**	**472.12**
Violet I	**-15°18'**	**164°30'**	**15°14'**	**195°22'**	**30°32'**	**30°52'**	**15°21'**	**434.49**
Violet II	**-14°9'**	**165°48'**	**14°16'**	**194°4'**	**28°25'**	**28°16'**	**14°10'**	**401.71**

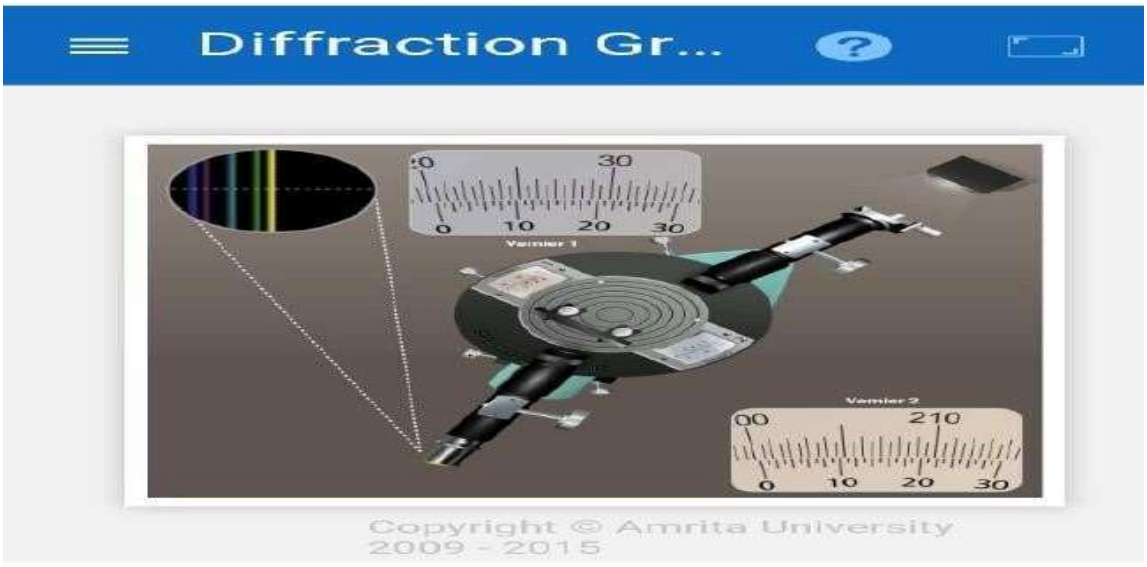
Result:

The wavelength of Yellow I = **566.76 nm**
The wavelength of Yellow II = **546.1 nm**
The wavelength of Blue - green = **472.12 nm**
The wavelength of Violet I = **434.49 nm**
The wavelength of Violet II = **401.71 nm**

My Observations:

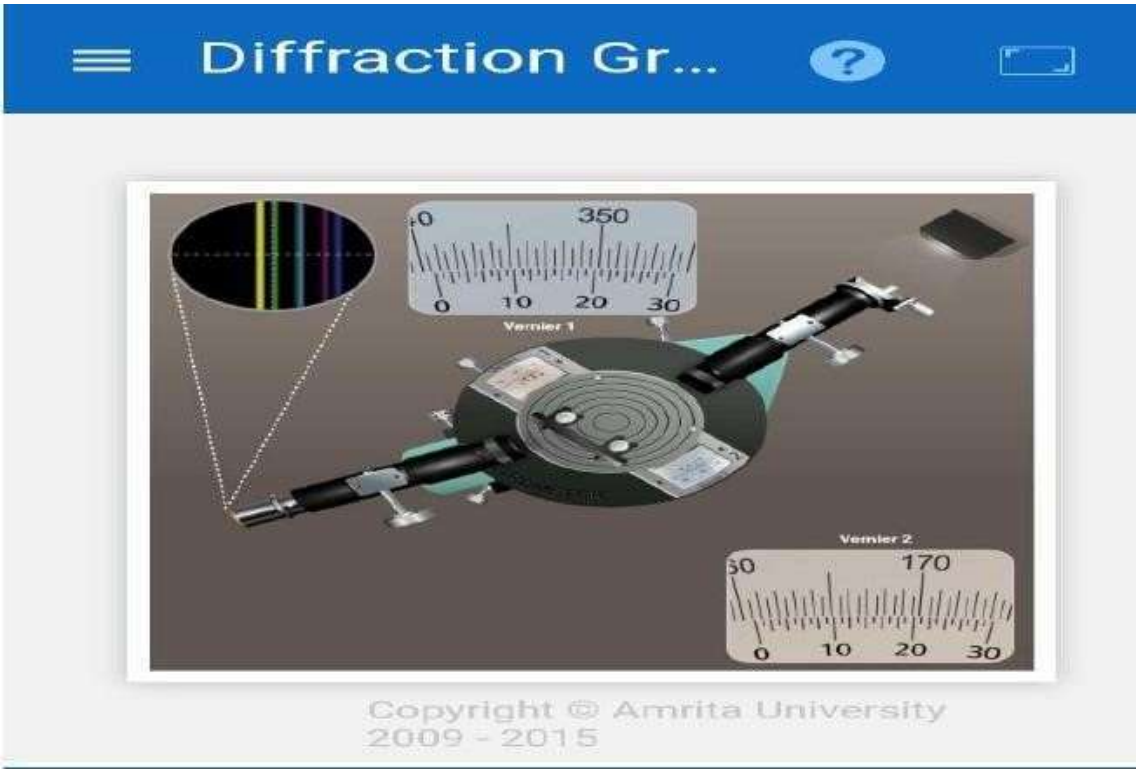
1. Yellow I





2.

Yellow II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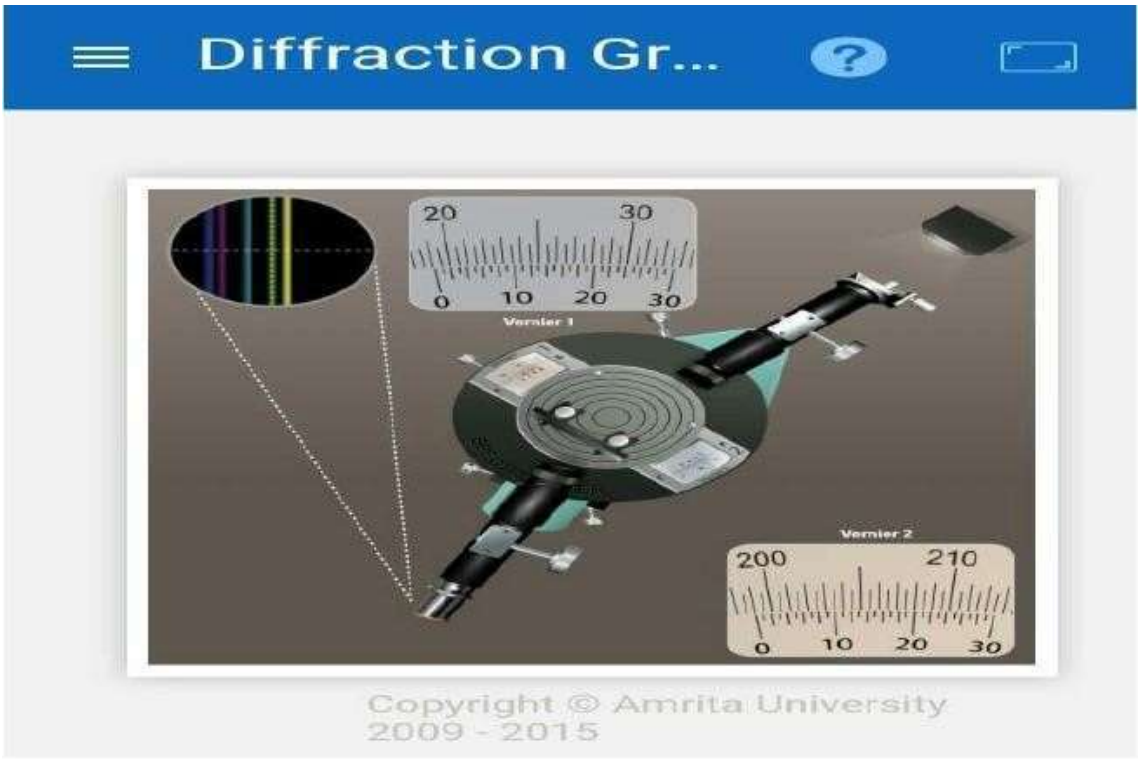
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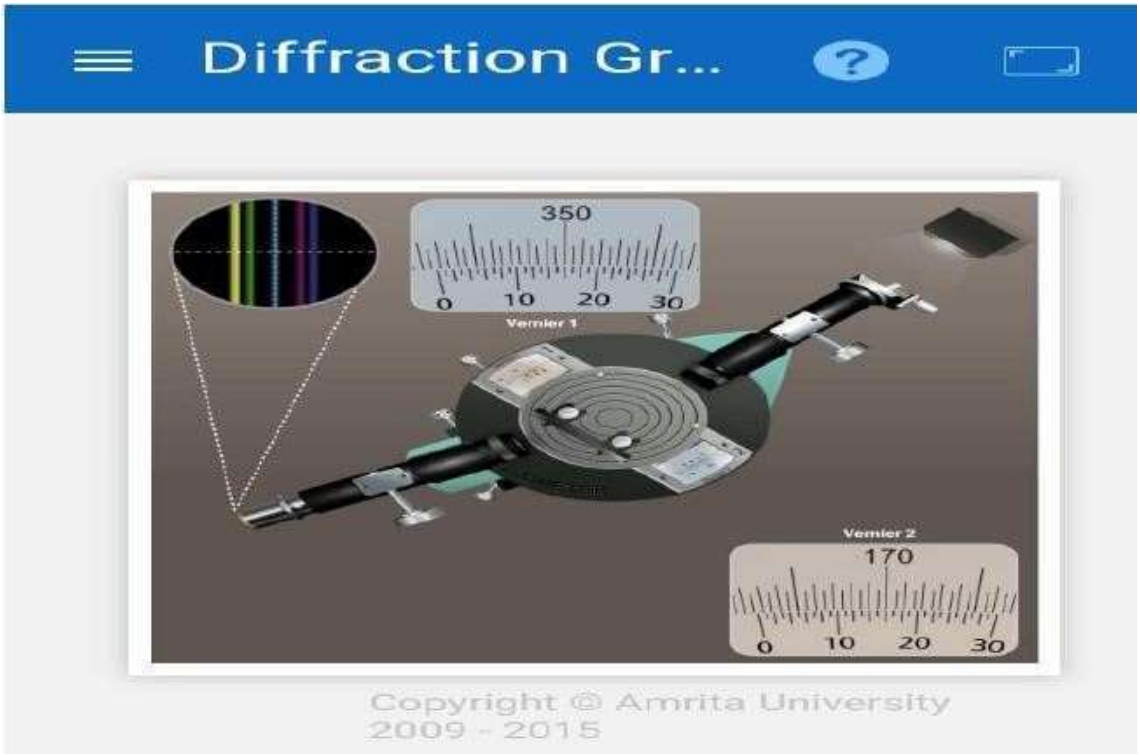
Blue- Green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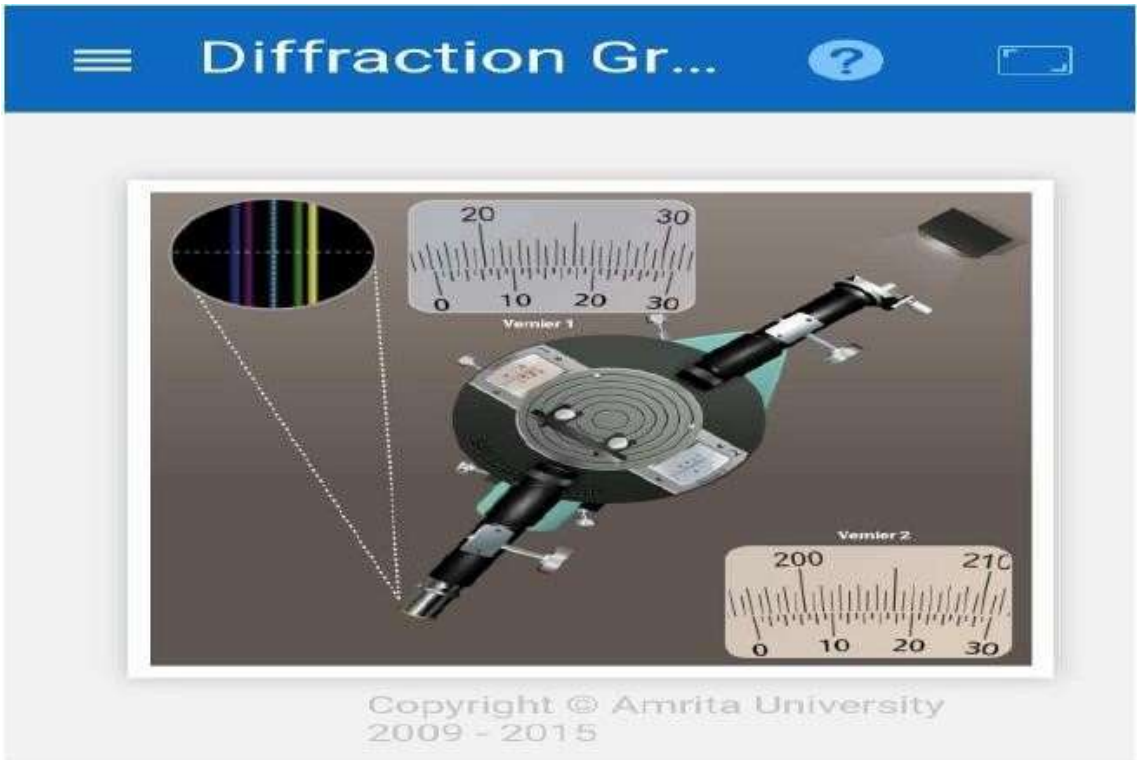
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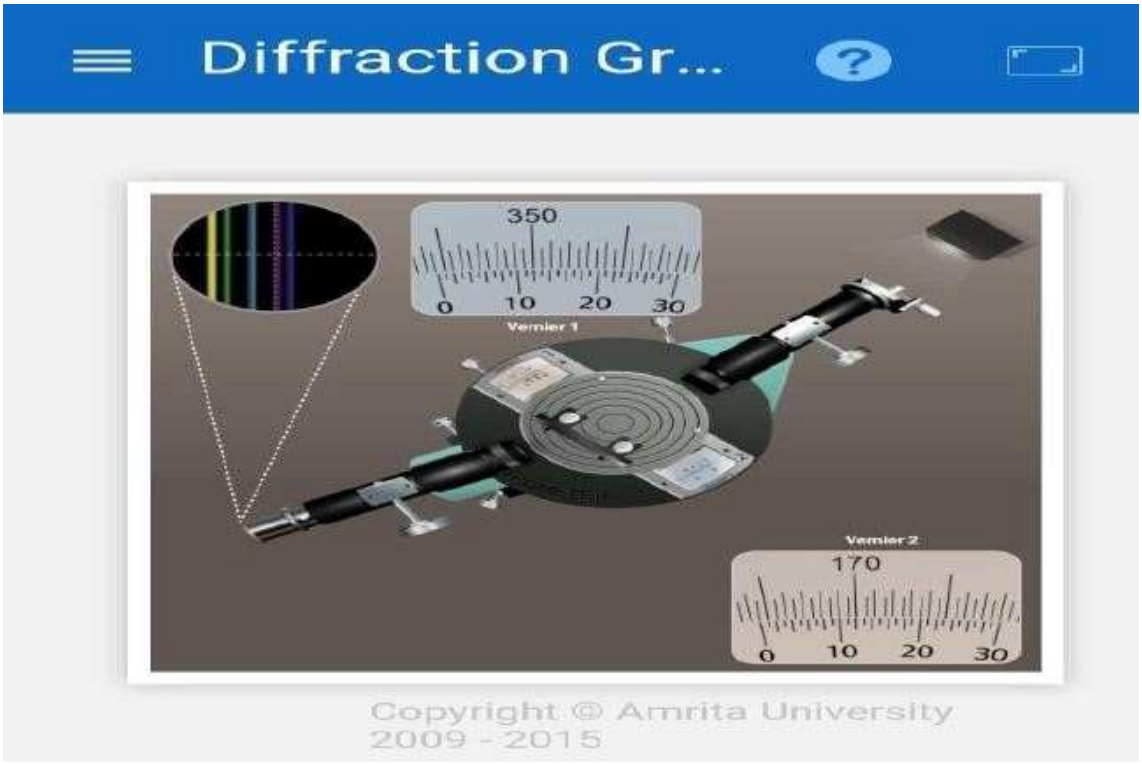
Violet I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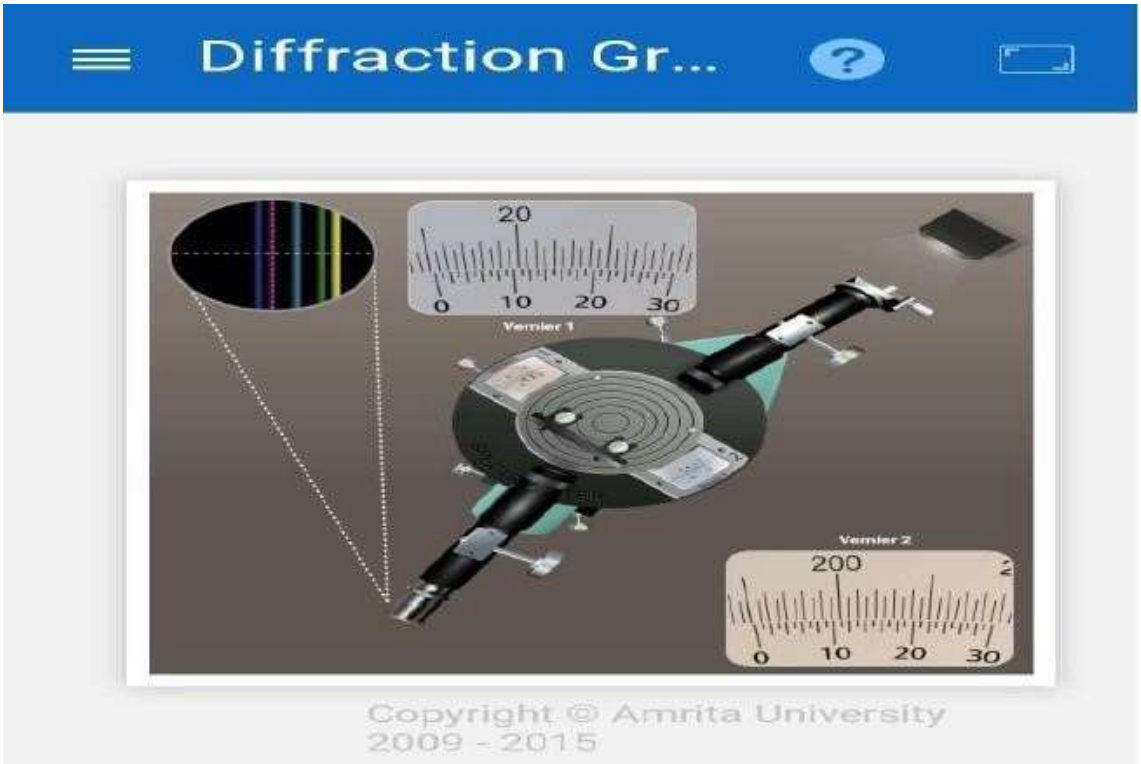
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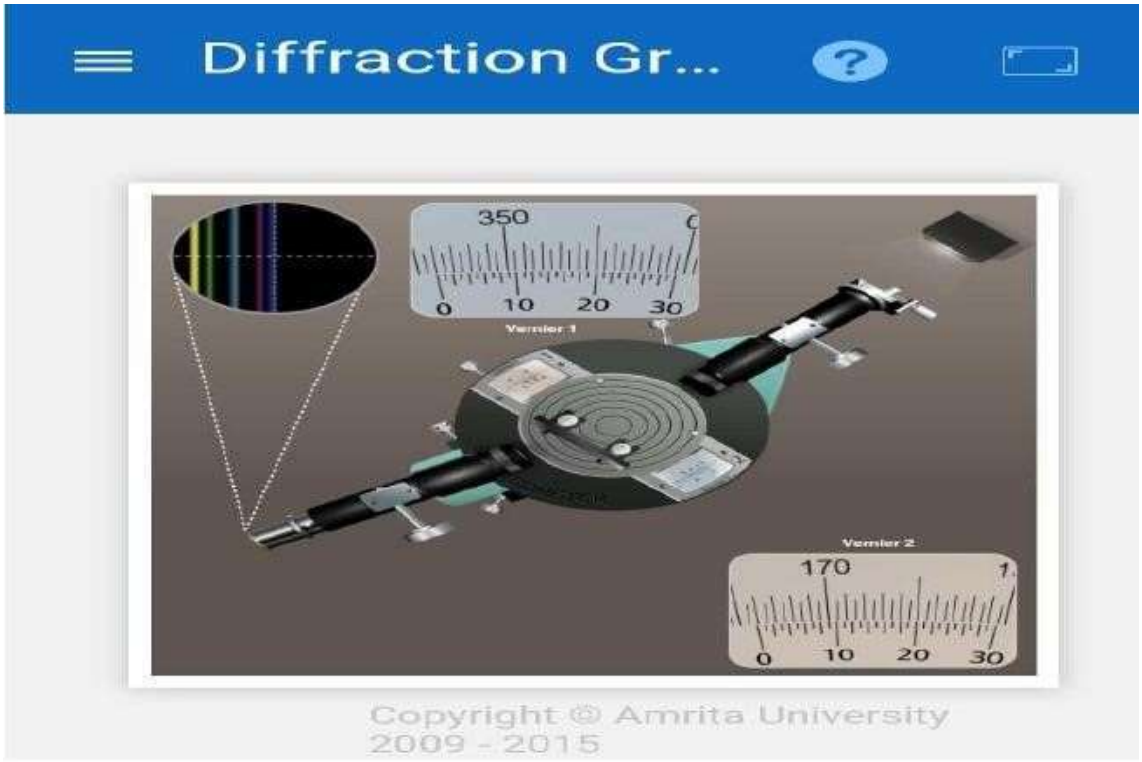
5.

Violet II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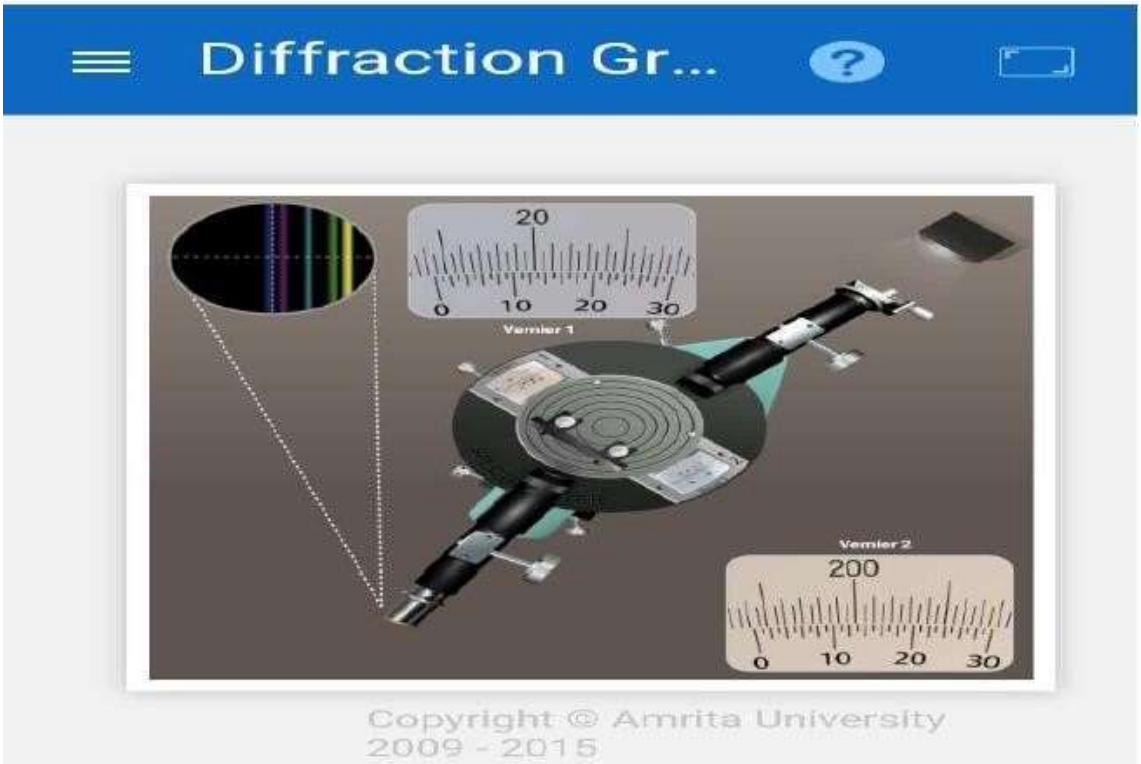
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