Experiment 1:

To determine wavelength of (1) sodium and (2) spectral lines of the mercury light using plane diffraction grating.

Equipments to be used: A spectrometer, a spirit level, a sodium lamp, mercury lamp, an eye-piece, diffraction grating with clamping arrangement etc.

Learning Objectives:

1. The students will understand the concept of diffraction; Fresnel as well a Fraunhofer.
2. The students will learn about fringe width, diffraction patterns and diffraction gratings.
3. The students will have the idea of absent spectra.

Theory:
In optics, a diffraction grating is an optical component with a periodic structure, which splits and diffracts light into several beams travelling in different directions shown in fig.1. The directions of these beams depend on the spacing of the grating and the wavelength of the light so that the grating acts as the dispersive element. Because of this, gratings are commonly used in monochromators and spectrometers.

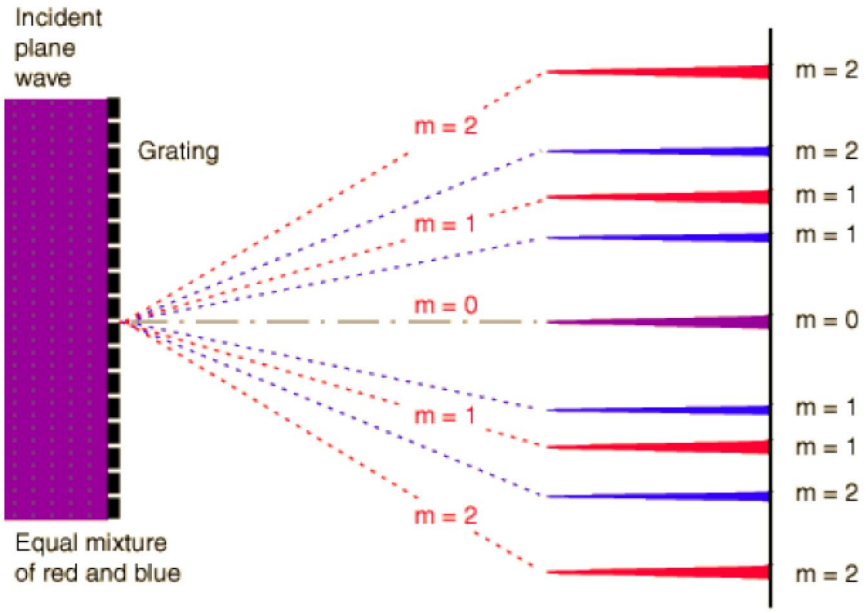

Fig.1 Diffraction pattern by Grating.

Observations: Vernier Constant =

Number of lines per inch on the grating N=

Grating element (a+b) = 2.54/ N = cm

Direct reading of telescope =

S. No	Order of Spectrum	Vernier	Telescope reading			Angle of diffraction			Grating element (a+b)
			Left	Direct	right	Left	Right	mean	
1	1st order								
2									
1	2nd order								
2									

Procedure:

1. Setting: Adjust the position of the eye-piece of the telescope so that cross-wires are clearly visible. Focus the telescope on a distant object and set it for parallel rays coming from sodium source. Level the spectrometer by the leveling screws and then the prism table with the help of a spirit level.

2. Fix the grating stand on the circular table with two screws in the holes drilled on one of the lines parallel to the line joining two of the screws meant for the purpose, say P and Q. The face of the stand to which the clamps are attached should be at the centre of

the table. Take out the grating carefully from the box, holding it from the edge and without touching its surface, fix it very carefully to the frame with its ruled surface towards the telescope.

3. Optical leveling of the grating table. Rotate the table so that the plane of the grating is approximately inclined at an angle of 45^0 to the axis of the collimator rotate the telescope to receive the reflected light from the grating surface. Rotate the table carrying the grating so that the plane of the grating is approximately perpendicular to the axis of the collimator. Look for the first order spectrum on one side of the direct image of the slit. Turn the telescope so that vertical cross-wire coincides with the first order diffracted image. If this image is not symmetrical with respect to the horizontal cross-wire, adjust it with the help of one of the screws. In this position the grating lines are parallel to the axis of the spectrometer. Now turn the telescope to the other side so that the vertical cross-wire again coincides with the first order diffracted image. If the adjustments are carefully done then the diffracted images of the slit will be symmetrical with respect to the horizontal cross-wire in all positions.

4. Setting the grating normal to the incident sodium light. Place the telescope in line with the collimator so that the vertical cross-wire falls exactly in the centre of the image of the slit. Note the scale reading. Add 90 to the reading and place the telescope at this reading to set it perpendicular to the axis of the collimator. Clamp it in this position. Rotate the grating table till the plane face of the grating is facing both the collimator and the telescope. Look through the telescope and turn the table very slowly till the centre of the slit falls exactly on the vertical cross-wire. In this position the plane of the grating is inclined at an angle of 45^0 to the incident light. Note the reading. Turn the table through 45^0 from this position so that the plane of the grating is normal to the incident light with its plane face towards the collimator. The grating is now set normal to the incident light with its rules surface away from the collimator. Clamp the table in this position. Take reading on both the venires.

6. Similarly note the reading of the verniers by setting the telescope on the second order diffracted image on either side of the direct light.

7. Repeat the above observation three times.

8. Note the number of lines per inch as marked on the grating and replace it carefully in the box with ruled surface upwards.

9. Now replace sodium source with mercury source. Rotate the telescope to the left side of direct image and adjust the different spectral lines (violet, green, blue and red etc.) turn by turn on the vertical cross wire for first order. Note down the reading of both the

verniers in each setting.

10. Rotate the telescope further to obtain the second order spectrum and again the spectral lines on the vertical cross wire and note the readings.

11. Now rotate the telescope to the right of the right of the direct image and repeat the above procedure for first order as well as for second order.

12. Find out the difference of the same kind of verniers (V1 fromV1 and V2 fromV2) for each spectral line in the first order and then in the second order. The angle is twice the angle of diffraction for that particular color. Half of it will be angle of diffraction.

13. Find out the angles of diffraction for other colors in first and second orders.

Required Results:

1^{st} Order spectrum $\lambda = (a+b) \sin \theta_1 = $ cm

2^{nd} Order spectrum $2\lambda = (a+b) \sin \theta_2 = $ cm

Mean Wavelength $\lambda = \ldots$cm = …m

Precautions:

1. The grating should be held from the edges and the rules surface should not be touched.
2. The telescope should be focused on the brightest image of the slit while seeing the reflected image.
3. The ruled surface should face away from the collimator.
4. The light should fall on the whole of the grating surface

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication,19th edition(2010)

2. B.Sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication,1^{st}edition(2011)

Websites: https://www.youtube.com/watch?v=SO7ZlMJv5ZM

Worksheet of the student

Date of Performance Registration Number:

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Direct reading of telescope =

Table 1
To set the unruled surface of the grating for normal incidence

Direct reading of the telescope without grating			**Telescope is rotated through 90^o and set at angle**	**Reading of the prism table when the angle of indicence is 45^o**			**Prism table is rotated through 45^oor 135^o and set at angle**
M.S. (M)	**V.S. (V)**	**Total (T=M+V)**		**M.S. (M)**	**V.S. (V)**	**Total (T=M+V)**	

Table 2 (using sodium light)

S. No.	Order of spectrum	Vernier	Telescope reading			Angle of diffraction		
			Left	Direct	Right	Left	Right	mean
1	1^{st} order							
2								
1	2^{nd} order							
2								

Table 3 (using Mercury light)

Order of Spectrum	Color of light	Vernier	Telescope reading			Angle of diffraction		
			Left	Direct	Right	Left	Right	Mean (θ)
		V1 V2						
		V1 V2						
1st order		V1 V2						
		V1 V2						
2nd order		V1 V2						
		V1 V2						

Calculation: Wavelength of sodium light as calculated from

1st Order spectrum $\lambda = (a+b) \sin \theta_1$ = cm

2nd Order spectrum $2\lambda = (a+b) \sin \theta_2$ = cm

Mean Wavelength λ = cm = m

Result and Discussion:

Color of Spectral line	λ (Observed)	λ (Standard)	% Error

Error Analysis:

Learning Outcomes (what I have learnt):

To be filled in by Faculty

S. No.	Parameter	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	