Unit 12 · Diffraction

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

1 Key words [4]

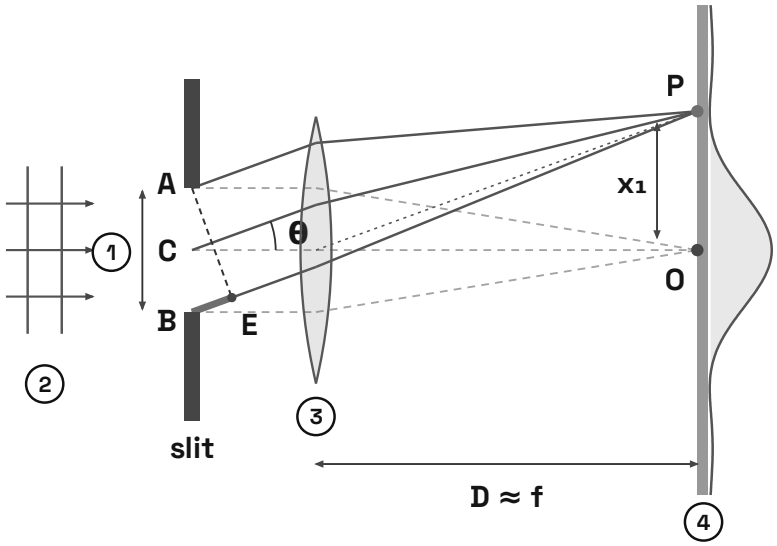
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

coherence	**diffraction**	**diffraction grating**	**Fraunhofer diffraction**	**Fresnel diffraction**
grating element	**numerical aperture**	**polarization**	**Rayleigh's criterion**	**resolving power**

The bending of light round the edges of an obstacle or an opening, into its geometrical shadow, is _____. When the source and the screen are close to the opening, so that the wavefronts are curved, it is _____; with plane wavefronts, it is _____. A plate with a very large number of equally spaced parallel slits is a _____; the distance (a + b) from the start of one slit to the start of the next is its _____. The ability of an instrument to show two close objects as separate is its _____. Two images are just resolved when the center of one falls on the first dark ring of the other: this is _____. For a microscope, $\mu \sin \theta$ is the objective's _____.

2 Label the diagram [2]

The diagram shows Fraunhofer diffraction at a single slit. Write the label that belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. Light of wavelength 580 nm falls on a slit 0.29 mm wide. The first dark band is at an angle of: [1]

a. 5.0×10^{-4} rad **b.** 2.0×10^{-3} rad

c. 4.0×10^{-3} rad **d.** 0.50 rad

ii. A grating has 3000 lines per centimeter. Light of wavelength 540 nm falling normally on it gives its first-order maximum at about: [1]

a. 9.3° **b.** 18.9°

c. 0.16° **d.** 30°

iii. In a single-slit diffraction pattern, the central maximum compared with each of the other maxima is: [1]

a. the same width and brightness **b.** twice as wide and much brighter

c. half as wide and much brighter **d.** twice as wide and dimmer

iv. Light of wavelength 620 nm falls normally on a grating of 4500 lines per centimeter. The highest order of maximum that can be seen is: [1]

a. 2 **b.** 3

c. 4 **d.** 36

v. With the same microscope, two very close points are more likely to be seen as separate in: [1]

a. blue light, since its wavelength is shorter

b. red light, since its wavelength is longer

c. either color, since resolution depends only on the lens

d. dim light

4 Short answers [7]

Write short answers to the following questions.

a. Write any two differences between Fresnel and Fraunhofer diffraction. [2]

b. Write any two differences between the fringes of Young's double slit and the bands of single-slit diffraction. [2]

c. A telescope's objective is 0.10 m across. Taking $\lambda = 550$ nm, find the smallest angle it can resolve. How far apart must two craters on the Moon (3.84×10^8 m away) be to be seen as two? **[3]**

5 Long answer **[4]**

Write a long answer to the following question.

Light of wavelength λ falls normally on a single slit of width d. By dividing the slit into halves, show that the first dark band is at $\sin\theta = \lambda/d$, and explain why there is a dark band at $\sin\theta = 2\lambda/d$ too.

6 Numerical problems **[8]**

Solve the following problems. Show your working.

a. Light of wavelength 590 nm falls on a slit 0.12 mm wide, and the pattern is seen on a screen 1.5 m away. Find i. the angle of the first minimum, ii. the width of the central maximum, iii. the distance of the third minimum from the center, and iv. roughly where the first secondary maximum is. **[4]**

Answer:

b. Light from a hydrogen lamp, with a red line of 656 nm and a blue line of 486 nm, falls normally on a grating of 3500 lines per centimeter. Find i. the grating element, ii. the first-order angles of the two lines, iii. the second-order angle of the red line, and iv. the highest order in which the red line can be seen. **[4]**

Answer: _____

7 Think **[3]**

Why can no ordinary light microscope show a single atom (about 10^{-10} m across), however strong its lenses? Use the microscope's limit with visible light (500 nm) and a numerical aperture of 1.4.

8 Activity: Look through cloth (not marked)

In a dark room, look at a small, distant lamp (or a street light at night) through a fine handkerchief, an umbrella's cloth or a bird's feather held close to your eye. Turn it slowly.

What you look through	What you see	Spots closer or farther apart?
Fine handkerchief		
Coarser cloth		
Feather		

Why do you see a pattern of spots, and why do they turn as you turn the cloth?