重庆大学-辛辛那提大学联合学院

学生实验报告

CQU-UC Joint Co-op Institute (JCI)
Student Experiment Report

实验课程名称 Experiment Course Name 大学物理实验（I）

开课实验室（学院）Laboratory (School) JCI

学院 School CQU-UC 年级专业班 Student Group 18ME01

学生姓名 Student Name 易弘睿 学号 Student Number 20186103

学年 Academic Year 2019 学期 Semester Spring

成绩 Grade	
教师签名 Signature of Instructor	

批改说明 Marking instructions:

指导老师请用红色水笔批改，在扣分处标明所扣分数并给出相应理由，在封面的平时成绩处注明成绩。

Supervisors should mark the report with a **red ink pen**. Please write down **the points deducted** for each section when errors arise and specify the corresponding reasons. Please write down **the total grade** in the table on the cover page.

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JCI Experiment Report

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姓名 Name 易弘睿 学号 Student Number 20186103

开课学院、实验室 Academic School/ Laboratory CQU-UC

实验时间 Date of Experiment 2019 年 Year 03 月 Month 02 日 Day

报告时间 Date of Report 2019 年 Year 03 月 Month 08 日 Day

课程名称 Course Name		实验项目名称 Experiment Project		实验项目类型 Type of experiment project				
				验证 Verification	演示 Presentation	综合 Comprehensive	设计 Design	其他 Others
指导老师 Supervisor		成绩 Grade						

实验目的 Description/Instruction:

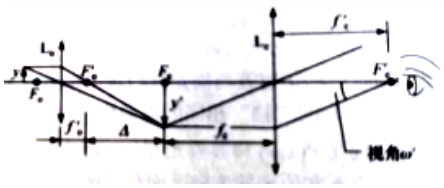
Microscope and telescope are two great inventions of modern science and technology, with epoch-making significance. Microscopes and telescopes are commonly used optical aids and have a wide range of applications. Understanding their construction principles and designing and assembling microscopes and telescopes by ourselves will not only help to deepen the understanding of the imaging law of lenses, but also help to adjust and use other optical instruments.

原理和设计 Principle and Design:

1. Microsoft

（1） The basic structure of the microscope:

The microscope consists of two convex lenses, one crop mirror l. One for eyepiece l. Its basic optical system such as shown in the following figure, the tiny object y located outside the object-side focus of the objective lens is magnified into an inverted real image y by the objective lens, and then magnified into a virtual image at infinity by the eyepiece, and both magnifications increases the viewing angle. in order to be suitable for observing nearby tiny objects. The focal length of object and microscope objective is very short, but compared with eyepiece, it is longer.



(Graph 1: The basic optical system of a microscope)

（2）The visual amplification MT:

The distance between the image-side focal point F0 of the microscope objective lens and the object-side focal point Fe, uh, of the eyepiece is called the optical interval. when the magnification reaches a certain degree, the optical interval and barrel length are also a constant value. Microscopes are defined as the ratio of the tangent of the opening angle with respect to the human eye to the tangent of ten pairs of human eyes' angles at the apparent distance of 250mm.

$$M_T = \frac{tanw\prime}{tanw}$$

Because $tanw' = \frac{y\prime}{f\prime}$, tanw = $\frac{y}{D}$, we have:

$$M_T = \frac{tanw\prime}{tanw} = \frac{y'/fe\prime}{y/D} = \frac{Dy\prime}{fe\prime y} = \frac{D\Delta}{fe\prime fo\prime} = MoMe$$

In the above equation, m0 is the magnification of the objective lens me eyepiece, and from the above directors, it can be seen that the shorter the focal length of the objective lens eyepiece, the larger the magnification of the microscope.

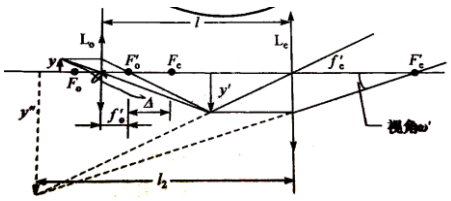
（3） The actual amplification:

From the following figure, it can be seen that the object passes through the objective lens, and then an enlarged inverted real image y1 is formed on the focal plane of the eyepiece, which is magnified into virtual image y2 through the eyepiece, and there can be obtained according to the definition of magnification of the microscope

$$M = \frac{tanw\prime}{tanw} = \frac{y''/(l2+fe')}{y/D} = \frac{y''/(l2+fe')}{y'/D}\frac{y\prime}{y} = \frac{Dy\prime}{fe\prime y} = MoMe$$

At this moment, the magnification can be obtained by directly comparing the measured image length with the image plane of the microscope with a semitransparent mirror which forms a 45 - degree angle with the main optical axis and putting the scale into a virtual image.

$M_a = \frac{y''}{y}$



(Graph 2: The imaging optical path of a microscope)

2. Telescope:

(1) The basic structure:

Ordinary telescope is composed of objective lens and eyepiece, and its basic optical system is as shown in

the following figure. after passing through the objective lens, the distant object is in the square focal plane of the object image, and it is formed into an inverted and reduced real image, which is magnified and imaged in infinite distance through the eyepiece, so that its viewing angle is increased for convenience of observing distant objects. the focal length of the telescope objective lens is generally longer and the focal length of the eyepiece is shorter.

(2) The visual amplification M_t

The apparent magnification of telescope is defined as the ratio of the right image of visual optical instrument to the opening angle w of human eyes to the tangent of the opening angle w of the opposite person who directly observes the object with eyes.

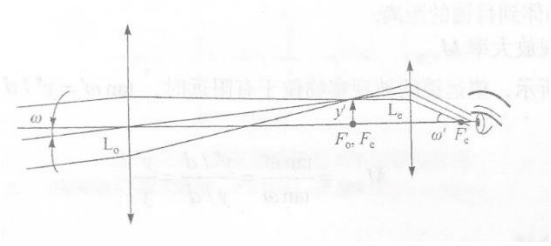
$$M = \frac{tanw\prime}{tanw}$$

(3) The visual magnification of a telescope is observed in distant objects. M_t

As is shown in the figure, when the object is at infinity, the object is directly opposite to the Angle of the human eye, which is the Angle of the telescope, according to the geometrical light path we can see that $tanw = \frac{y\prime}{f0\prime}$, $tanw' = \frac{y\prime}{fe\prime}$, its visual amplification is

$$M_t = \frac{tanw\prime}{tanw} = \frac{y'/fe\prime}{y'/fo\prime} = \frac{fo\prime}{fe\prime}$$

As can be seen from the formula, the longer the focal length of the objective lens, the shorter the focal length of the eyepiece, the greater the power of the telescope.



(Graph 3: The basic optical system of a telescope)

The visual magnification of a telescope at a nearby object M_t:

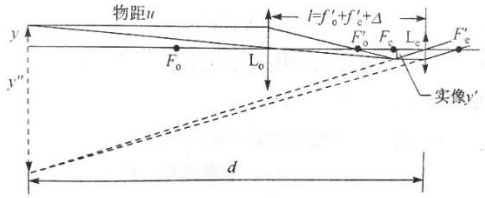
As shown in the following figure, when the object is at a limited distance, the apparent magnification of the telescope can be measured by moving the eyepiece to push y2 away to a plane with the object Y.

It is known by the telescope's apparent magnification.

$$M_t = \frac{tanw\prime}{tanw} = \frac{y''/(d+fe')}{y/(d+fe')} = \frac{y'/fe\prime}{y'/(d+fe')} = \frac{y\prime}{y}\frac{d+fe\prime}{fe\prime}$$

It is known from the convex lens imaging formula.

$$M_t = \frac{f0\prime}{fe\prime}\frac{d+fe\prime}{u-f0\prime}$$



(Graph 4: The imaging optical path of a telescope)

D Is the distance from a distant object to eyepiece

(4) the actual visual amplification

$$M_a = \frac{y''}{y}$$

3. Practical eyepiece introduction.

Eyepiece is an important part of microscope and telescope. its function is equivalent to a magnifying glass. at present, the image of the objective lens is further enlarged to make its apparent distance equal to 250 mm or infinite distance. at present, the eyepiece of commonly used microscope and telescope has a single convex lens eyepiece, huygens eyepiece, etc. in this experiment, a single convex lens is adopted as the eyepiece.

实验器材 List of instruments and materials:

Light holder, convex lens group (focal length is - 30 mm, 25 mm, 30 mm, 200 mm), grating (grating constant is 0.2 mm), color bar screen, steel ruler, plane mirror, observation screen, table lamp.

实验步骤 Implementation:

(1) Design and assemble a microscope with a given experimental instrument, whose observation point is located at the rear focus of the eyepiece, which is imaged at the visual distance D=250mm and the visual magnification M=250, and actually measure the visual magnification of the microscope.
(2) A telescope with a visual magnification of 4-8 was designed and assembled with a given experimental instrument. Its visual magnification was measured and compared with the theoretical value of the calculated visual magnification.
(3) Draw a simple principled optical path diagram and explain it briefly.
(4) Designing data tables, correctly processing data and analyzing errors in words.
(5) Writing a complete experiment report.

实验结果和数据处理 Results and Data processing:

Results：

显微镜数据记录表（Microscope Data Recording form)(单位：mm)									
显微镜 （Microscope)	fe	fo	Δ	y	y 上	y 下	y''	M 测(Mm)	M 理(Mt)
fe>fo	30	25	160	0.2	60	69	9	45	45.87
fo>fe	25	30	160	0.2	58	68	10	50	45.87

(Table 1)

望远镜数据记录表（Telescope Data Recording form)(单位：mm)											
望远镜类型 Type of Telescope	fe	fo	X 物	Xe	Xo	y'' (条)	Y (条)	像特征	视场大小 (条)	M 测 (Mm)	M 理 (Mm)
开普勒 Kepler	30	200	1000	0	300	17	1	倒立虚像	3	17	13.73
伽利略 Galileo	30	200	1000	0	300	8.5	1	正立虚像	1.5	8.5	

(Table 2)

Data processing:

According to Table 1, after calculation:

when fe $>$ fo, $\mathrm{Mm} = \frac{9}{0.2} = 45, \mathrm{Mt} = \frac{(30+25+160)*160}{30*25} = 45.87, error = \frac{45.87-45}{45.87} = 1.90\%$;

when fe $<$ fo, $\mathrm{Mm} = \frac{10}{0.2} = 50, \mathrm{Mt} = \frac{(30+25+160)*160}{30*25} = 45.87, error = \frac{50-45.87}{45.87} = 9.00\%$,.

According to Table 2, after calculation:

for Kepler's Telescope, $\mathrm{Mm} = \frac{17}{1} = 17$, $\mathrm{Mt} = \frac{200*(1000+30)}{30*(700-200)} = 13.73$, $error = \frac{17-13.73}{53.33} = 6.13\%$.

实验讨论 Discussions:

1. What are the similarities and differences between a microscope and a telescope in their structural principles?
   Similarities: They are made up of two parts, the objective lens and the objective lens. Difference:
   (1) The eyepieces of a microscope are usually convex lenses, and some of the eyepieces of a telescope contain concave lenses.
   (2) The objective of a microscope is short focal length, the eyepiece is long focal length, and the telescope is opposite.
   (3) Microscope is a virtual image, telescope is a real image.

2. Why should we adjust the optical elements on the optical pedestal with equal-altitude coaxiality? If the optical elements are not equal-altitude coaxiality, what kind of state will occur?
   This experiment is based on geometrical optics. If the center of the element is not adjusted to the coaxial axis, the measured image is off the plane of the optical axis, and there is a large error with the true focal length.

3. When assembling a microscope, why should the object be placed beyond one focal length and within two focal lengths?
   The objective and eyepiece of a microscope are equivalent to the familiar projector and magnifying glass. The image of the object being observed between the double focal length and the double focal length of the objective lens is the largest. The function of the eyepiece is to magnify the magnified image of the first time again for easy observation.