<Chap. 2 Optics>

1.Light directivity

Light directivity can be seen using smoke and milky water in a plastic bottle



<u>Principle of pinhole camera (γ ray camera)</u>

Dark image



We can see the image of the object without lens

The image consists of many light spots that come from the hole

<Experiments to understand the principle of pinhole camera>





Using candle: Please think what are the parameters that can be changed, and try to change it !





Dark Room itself becomes Pinhole camera.

improved pinhole camera

eye

waste tissue

box

white paper board

ordinary pinhole camera



waste milk pack bright image



Old camera is functioned into pinhole camera by removing the lens and replaced it with a pinhole cup.

Enlargement using the directivity of light

Simple but very useful concept ---→ X-ray microscope (laser plasma light source)





From point light source will generate, light which propagates straightly to all directions

Interior decoration using light directivity





<u>Perspective</u>

The parallel light beams which come from far distance looks like radial light beam.



Sun light is parallel beam.



Road is parallel.

]

2.Refraction of light and total refraction

Object looks shorter in water





Please trace the light propagation by using water cell.



Total reflection







Laser

Due to total reflection, robot legs are shaded.





The bending of light ray in air and liquid



Laser beam will be expanded by applying a convex lens



Road mirage phenomena



Road mirage



We can see the process of alcohol mix with water by shadow method.

Please also try to see plastic distortion by shadow method.

Measurement of refractive index using Snell's law





3. Water lens microscope and principle of telescope and microscope

The magnification is 25 if we set f equals to 10mm, thus enough for children to do observation of small objects.



Important points

*We should make a good shape of droplet by controlling the amount of water.

*We can improve the lens quality by putting an aperture.

*We put black paper in order to shade the light except for the light through the water lens.

*We should adjust the focus by changing the distance between lens and object.

*We should illuminate the sample in order to get bright image. We can use low Price LED light source.

*We can look for interesting samples to be observed such as ants, insects, pollens, etc.

Please enjoy the observation at least for ten hours in total!!, Thus you will

Have potential to become a scientist.

If you cannot focus to this activity, may be you don't have aptitude to become scientist or engineer!!!.

Confirmation of water functions as a lens





When observing, please put your eyes closer to the water lens.



For low magnification: (ring r = 8mm)



For high magnification: (ring r = 4mm)



Magnification can be varied by changing the swelling of the droplet and actual magnification is in the range of $10\sim 25$ times.

Experiments to understand the principle of microscope



Experiments to understand the principle of telescope



First lens works like camera lens (demonstrate camera principle using LED light source).





Ring made of thick paper



Telescope constructed using an old man glass lens (+1.5) and loupe (x15). Body is made of paper pipes. Total cost is only US\$ 10, magnification is about 30 times, and it is enough to see craters on moon surface.

Loupe is fixed at the end of the paper pipe.

4. Light dispersion and principle of spectroscope

Light dispersion.



When light ray enters in transparent object of which planes are in parallel, bending does not happen, regardless to the wavelength. Shorter wavelength light has larger deviation angle when enters in a glass prism: The wavelength of green laser is shorter than red laser.



When the white parallel beam is bright enough, please make D as long as 2 to 3m so that the color can be separated widely. Please observe the light ray traces in aquarium filled with incense smoke.



Principle of direct view spectroscope





We can see **the image of the slit** at different positions which depends on the light wavelength.



Construction of a CD spectroscope will be made as one of activities today afternoon

<u>Construction of direct view spectroscope using plastic grating</u> <u>Light dispersion due to plastic grating</u>

Plastic grating



White parallel light source with a narrow slit





Please notice the color order is different from the case of prism.

 \mathbf{Screen}

*Please see the fluorescence lamp through the plastic grating *Please see the fluorescence lamp with a slit through the plastic grating

<u>Construction of direct view spectroscope using plastic grating</u>



Please see the spectrum of many kinds of light sources such as fluorescence lamp, sun, candle, laser pointer and LED.

5. Blue skies and sunset

Scattering of light



We cannot see particles themselves because of its small size

electrons

of



Scattering due to spider string



Sugar candy become white after crushed to powder due to scattering

Light scattering by very small particles



Depending on the sky position, blue color changes, from cobalt blue to white blue



Short wavelength light scattered more than long wavelength, thus smoke looks blue color



Far distant mountain looks blue, but mountain itself is never blue



Demonstration to prove that mountain works as the background when we see the scattered light



Scattered light is polarized. Depending on the directions of observation, degree of polarization varies.

Mechanism of sunset



In the sunset, sun looks red



Blue and green color disappear during the long distance travelling in atmosphere.



Experiment to demonstrate the principle of sunset: intensity of shorter wavelength color decreases by increasing the number the milk droplets in the water.



Why do we use Na lamp (orange color) in order to illuminate the road in the tunnel?