AL-Mustaqbal University College
Department of Medical Physics
Lasers in medicine
Class : Third Stage

كلية المستقبل الجامعة
قسم الفيزياء الطبية
المرحلة الثالثة
الليزر في الطب

الليزر في الطب

المحاضرة الثالثة

م.م نور ضياء محمد تقي الربيعي

Specular Reflection

reflection of light where the angle of reflected light equals the angle of incident light, but on the opposite side of the surface normal.

The classical type of light reflection is that of specular reflection, from the Latin word speculum (mirror), or alternatively regular reflection. That kind of reflection is encountered on smooth surfaces, e.g. of polished metal or glass pieces, including cases with total internal reflection, or on surfaces of liquids. Here, the angle of the reflected light, as measured against the surface normal, equals that angle for the incident light (see Figure 1). That situation is usually found with high accuracy on various types of flat mirrors. For curved reflecting surfaces, one also obtains a

specular reflection; the angles of incidence and output are then measured against the local normal direction.

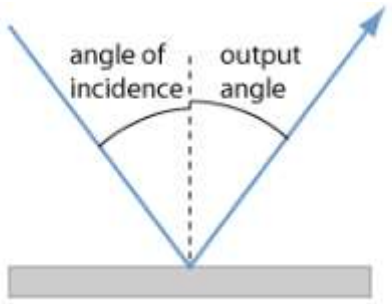
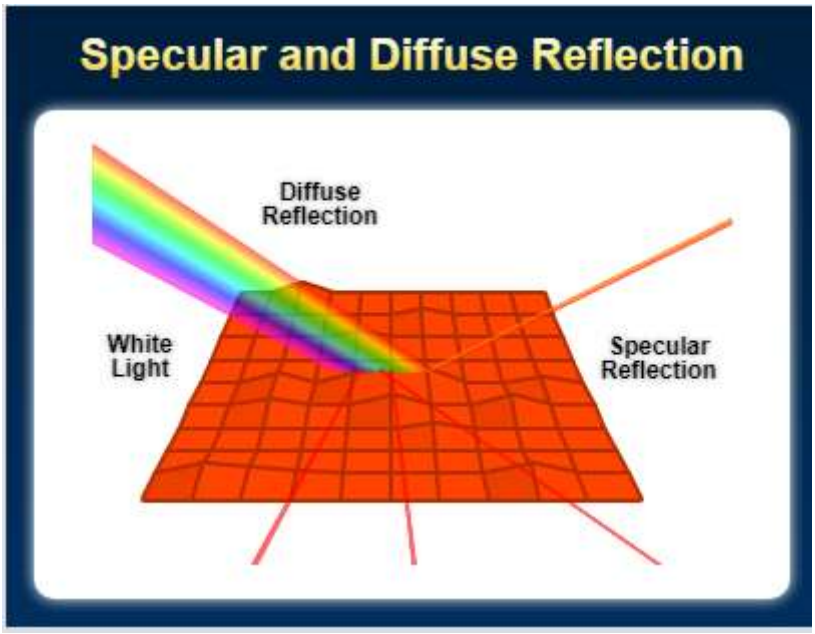


Figure 1: Specular reflection at a flat surface, where the output angle equals the angle of incidence.

The common law of reflection (Reflection angle= angle of incidence) is related to the fact that the component of the wave vector along the reflecting surface.

Specular and Diffuse Reflection

The amount of light reflected by an object, and how it is reflected, is highly dependent upon the smoothness or texture of the surface. When surface imperfections are smaller than the wavelength of the incident light (as in the case of a mirror), virtually all of the light is reflected equally. However, in the real world most objects have convoluted surfaces that exhibit a diffuse reflection, with the incident light being reflected in all directions. This interactive tutorial explores how light waves are reflected by smooth and rough surfaces.



diffuse reflection, which is produced by rough surfaces that tend to reflect light in all directions (as illustrated in Figure 1). There are far more occurrences of diffuse reflection than specular reflection in our everyday environment. Examples for Fresnel Reflections

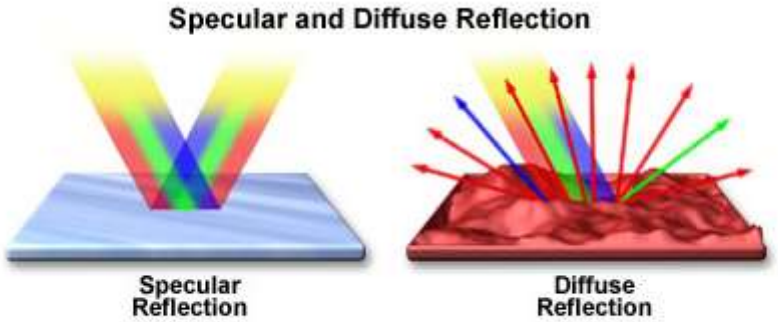


Figure 1

To visualize the differences between specular and diffuse reflection, consider two very different surfaces: a smooth mirror and a rough reddish surface. The mirror reflects all of the components of white light (such as red, green, and blue wavelengths) almost equally and the reflected

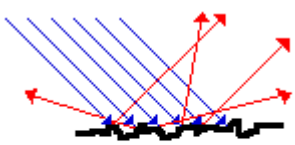
specular light follows the same angle from the normal, as does the incident light. The rough reddish surface, however, does not reflect all wavelengths because it absorbs most of the blue and green components, and reflects the red light. Also, the diffuse light that is reflected from the rough surface is scattered in all directions.

Perhaps the best example of specular reflection, which we encounter on a daily basis, is the **mirror image** produced by a household mirror that people might use many times a day to view their appearance. The mirror's smooth reflective glass surface renders a **virtual image** of the observer from the light that is reflected directly back into the eyes. This image is referred to as "virtual" because it does not actually exist (does not produce light) and appears to be behind the plane of the mirror due to an assumption that the brain naturally makes. The way in which this occurs is easiest to visualize when looking at the reflection of an object to one side of the observer, so that the light from the object strikes the mirror at an angle and is reflected at an equal angle to the viewer's eyes. As the eyes receive the reflected rays, the brain assumes that the light rays have reached the eyes in a direct straight path. Tracing the rays backward toward the mirror, the brain perceives an image that is positioned behind the mirror. An interesting feature of this reflection artifact is that the image of an object being observed appears to be the same distance behind the plane of the mirror as the actual object is in front of the mirror.

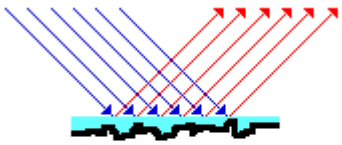
Applications of Specular and Diffuse Reflection

There are several interesting applications of this distinction between specular and diffuse reflection. One application pertains to the relative difficulty of night driving on a wet asphalt roadway compared to a dry asphalt roadway. Most drivers are aware of the fact that driving at night

on a wet roadway results in an annoying glare from oncoming headlights. The glare is the result of the specular reflection of the beam of light from an oncoming car. Normally a roadway would cause diffuse reflection due to its rough surface. But if the surface is wet, water can fill in the crevices and smooth out the surface. Rays of light from the beam of an oncoming car hit this smooth surface, undergo specular reflection and remain concentrated in a beam. The driver perceives an annoying glare caused by this concentrated beam of reflected light.



A dry asphalt roadway diffuses incident light.



When wet, water fills in the crevices, resulting in specular reflection and a glare.

Condition for Specular Reflection

Because the wavelengths of visible light are rather small (well below 1 μm), pure specular reflection requires a high degree of surface flatness – much more than for microwaves, for example. Therefore, a metal surface, for example, needs to be very carefully polished to obtain nearly perfect specular reflection.