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# Lecture -15
# Angular Measurements (Part 2 of 2)

So, welcome back, let us continue with the Angular Measurement.

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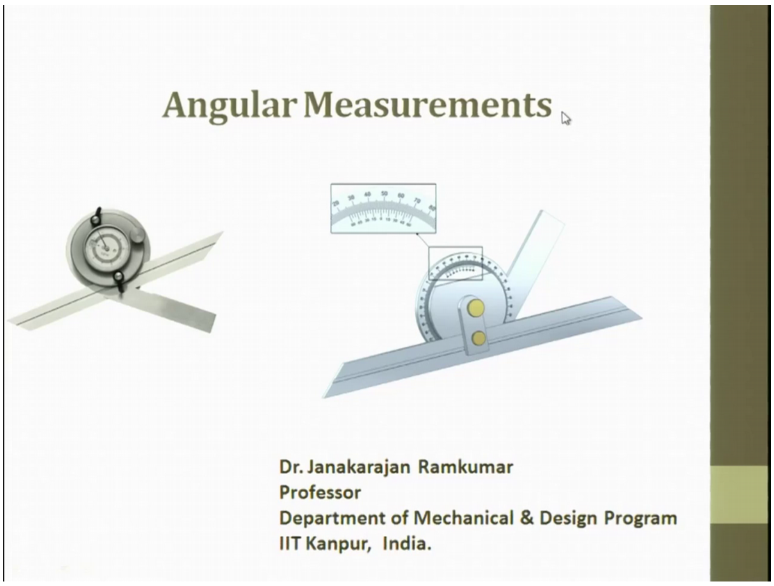


We are left with one last topic.

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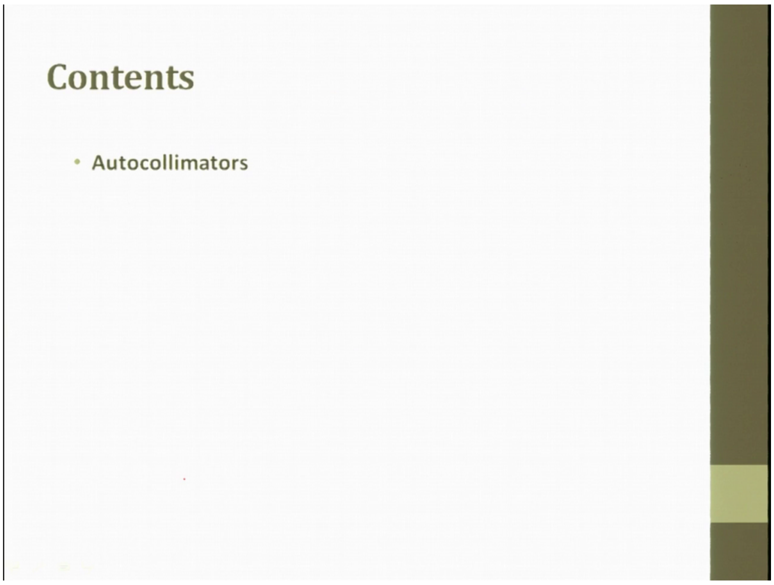


So, this is more focused towards auto collimator, so in this lecture we will try to cover autocollimator.

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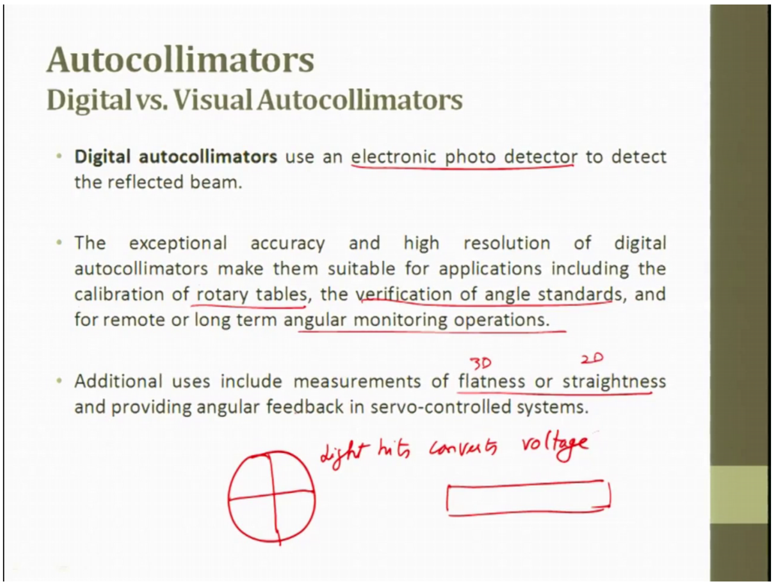


Autocollimator is a device where in which we used light this light will be hitting at a mirror, this mirror will be placed on a surface where you want to do measurement. Based upon the reflection we capture it back and then we try to figure out from the inference pattern or from the shift in cross section or cross wire we try to find out the shift from that we try to calibrate the angular deviation which is on a surface.

When does this angular deviation come on the flat surface whenever we want to do a precise measurement? So, we will always try to take flat, we will always try to take a flat surface where there is a precision already there, but still you want to find what is the deviation in the flatness then you use this autocollimator. So, this can be analogous or can that means, go say visual base or it can also be digital. So, in a digital what we do is we use an electronic photodiode see basically what happens in all the your photodiode you have 4 quadrants or there are inter prints patterns which can be counted from those prints patterns you can try to find out the displacement.

So, you have photodiode; photodiode is nothing, but when light hits the surface light hits its converts into voltage, when light hits the surface it converts into voltage from the voltage we try to find out the displacement. So, uses an a electronic photo detector to detect the reflected beam, the reflected beam is form the work piece it is from the flat surface where ever you had a mirror. The exceptional accuracy and high resolution of the digital autocollimator makes it suitable for, for applications including calibration of rotary table rotary table. So, these rotary tables are used in CNC machine, CMM machines and very other high measurement devices we use a rotary table.

The verification of angular standards and remote or long term angular monitoring operations we try to use this digital autocollimator. Additional use of use includes measurements of flatness and straightness flatness 3D, straightness 2D and provide an angular feed back in a servo controlled system we try to go for digital.

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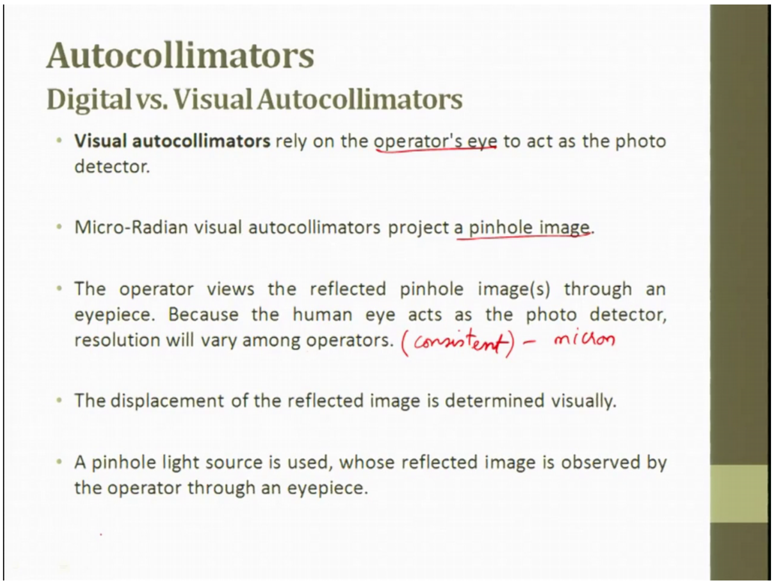


The visual autocollimator the first one what we saw they lies totally on the operates eye right. The micro radiant visual autocollimator projects a pinhole image; the operator views the reflected pinhole image through an eyepiece. Because of the human eye acts as a photo detector the resolution will vary from operator to operator, so it is not consistent.

And here we talk about in microns or less than microns or when you talk about angular it is all in radians or micro radians. The displacement of reflected image is determined visually a pinhole light source is used whose reflected image is observed and the towards the operator eyes.

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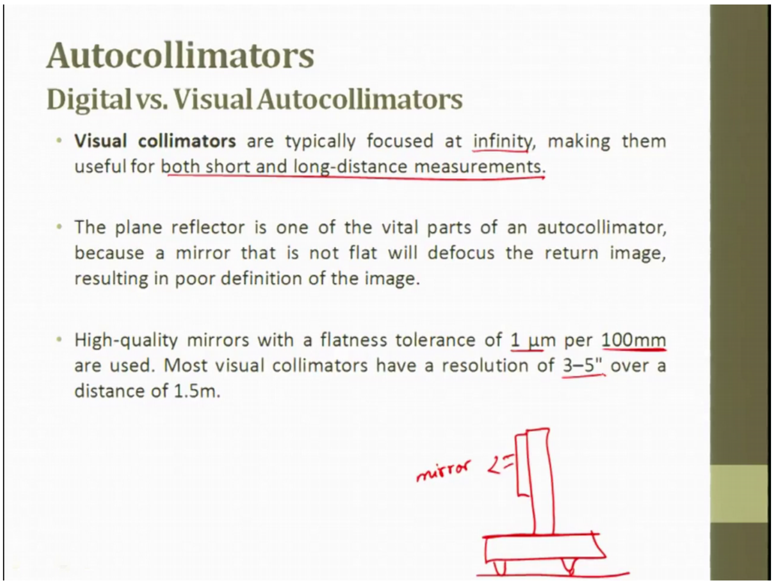


So, this is what we are trying to say, so it depends more on the operator eye and it he uses judgment. So, when you visual autocollimator a typical, that are typically focused on at infinity make them useful for both short and long distance measurement, a plane reflection a reflector, a plane reflector is used is one of the vital part of the autocollimator this is the plane reflector is that which is placed. So, you have a reflector which is placed on a stand and this stand is placed on the surface plate.

So, a plane reflector is one of the vital part of an auto collimator because a mirror that is not flat this is also very important, not flat will defocus the return image resulting in a poor definition of the image high quality mirror. So, when we have to use autocollimator this mirror surface has to be as flat as possible and it has to be a high precision. So, the high quality mirror with flat flatness tolerance of 1 microns per 100 millimeter, please note down if the mirror size goes more than 100 you are allowed to go to 2 micron anything less than 100 millimeter at this 10 centimeter the flatness tolerance the deviation can be only one. Most visual collimator have a resolution of 3 to 5 minutes over a distance of 1.5 meters.

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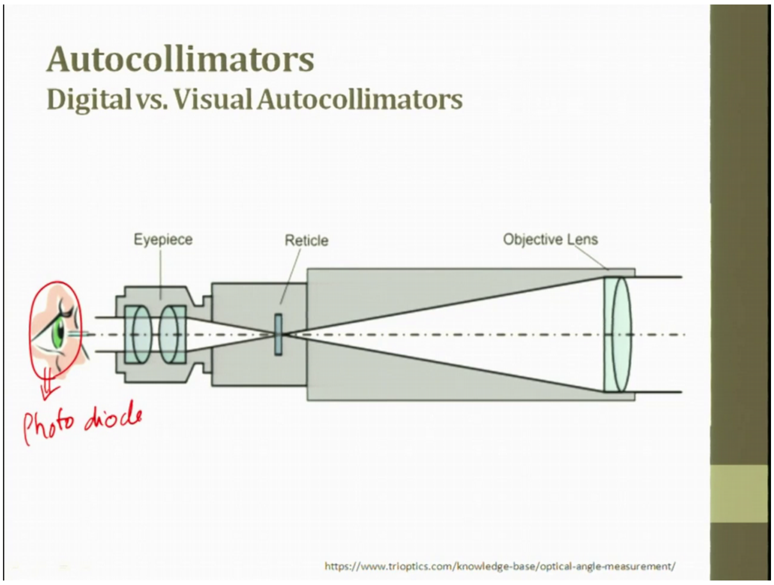


So, this is how we test, so here is the objective lens this is the eyepiece and you have reticles here, so here is an operator the operator eye is otherwise converted in a digital form it is converted into a photodiode, so it is a photodiode.

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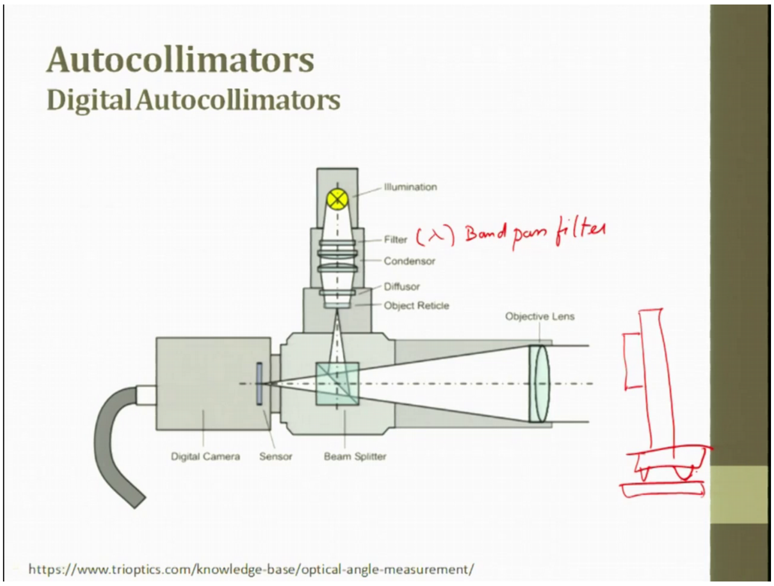


So, digital when you look at digital autocollimator you see that there is an objective lens then there is a beam splitter, beam splitter is there for both. Then this beam splitter goes to an objective reticles then diffuser condenser to condense this and then you have filters. This filters can be more or less you can decide what filter to use and you can decide what filter for example, you can fix a wave length and say please try to avoid this wave length or this wave length it again here filters can be can be bandpass filter.

So, it can cut down the lower and the higher wave lengths of light and only a particular wave length is take so that you can make that the image much sharper and then finally, so you can get so this is illumination. So, it can be done filter and then it is to the sensor and from the sensor it is recorded in the camera and you can start storing the image.

So, what you get from here is going to be a very strong image. So, here illumination filter, condenser diffuser it goes to a beam splitter, beam splitter it for further and then one half goes here. So, that you try it on from here you go to be mirror whatever was placed in the object this is a mirror. And by the way the mirror has to rest on mirror flat butting surface should also be should also be perfectly flat.

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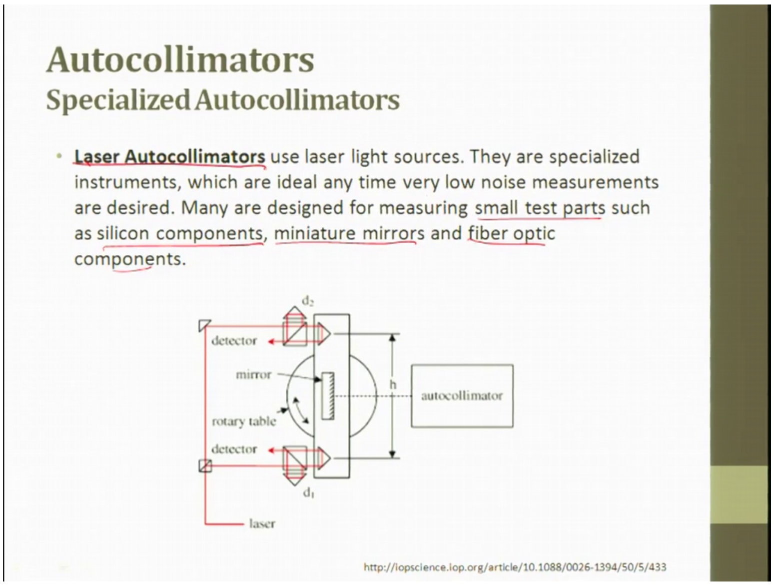


There is also a specialized autocollimator which is called as laser autocollimator here we use a laser light. So, then we have a splitter this is a autocollimator here is a mirror. So, here is a rotatory table on which the autocollimator is kept, so you are a detector. So, it you have beam splitter it goes hits and then it gets reflected, so here is a detector, so again here also you can have the other thing which is done detector. So, you can try to get one, so that the difference between d 1 and d 2 is recorded and we can use it for measurement.

We use laser light, so this is very powerful long distance can be measured this is more and here we compared to two detectors and then we start finding out what is the difference in the reading. They are specialized instruments which are ideal any time very low noise measurement as desired many are designed for measuring small test parts, such as silicon wafer silicon wafer flatness plays a very important role. If you want to measure the silicon wafers flatness so silicon components miniature mirrors and fiber optic components are found out by using this laser autocollimator.

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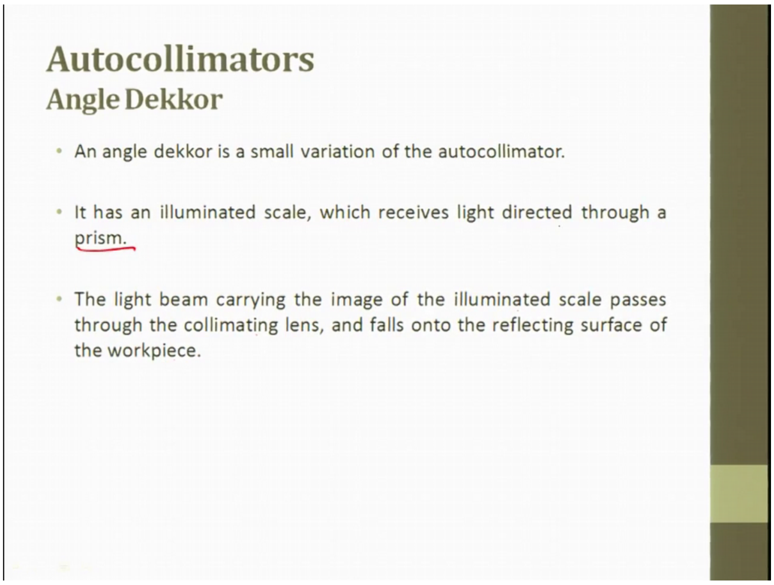


The last thing is a angle dekkor and angle dekkor is a small variation of a autocollimator it has an illuminated scale which receives lights directly through a prism. The light beam carrying the image of the illuminated scale passes through the collimated lens and falls into a reflected surface.

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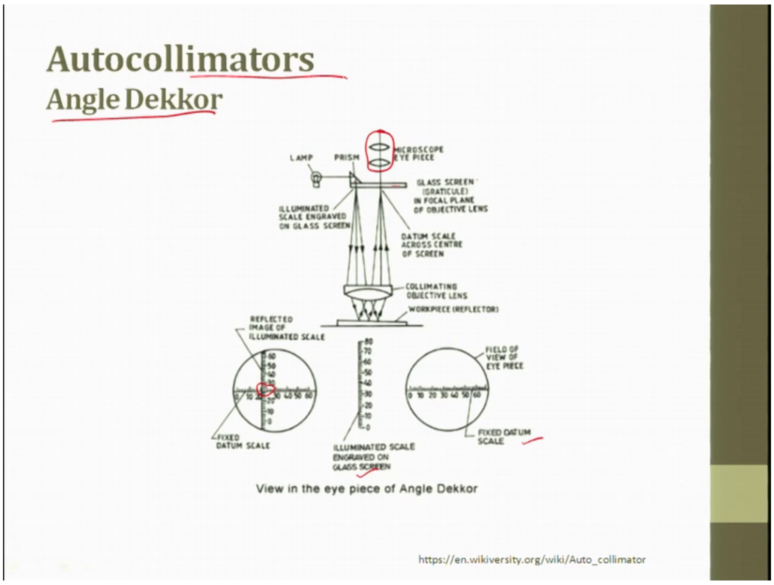


So, this is an auto dekkor, so you have lamp this is a prism. So, have a microscope from here the light goes hits at a collimator and this is the collimating and this is an objective lens, here is the work piece surface it reflects back and then we have a glass screen which is in the focal plane of the objective lens we have. So, from here we try to see through the eyepiece and try to get the data.

So, here you will have illumination engraved on the glass screen. So, glass screen here will be in the x direction, so or in the y direction and in the x direction. So, we can see a reflected image of the illuminated scale will be this and this is the fixed datum ok. So, this is the fixed datum this is the illuminated scale engraving glass light. So, you will see this in the screen like this, so this is used for measuring very small angles.

The difference between auto dekk and auto collimator is the prism is used here the light beam carrying the image of the illuminated scale passes through a collimating lens falls on to the reflecting surface of the work piece, then it passes through a prism.

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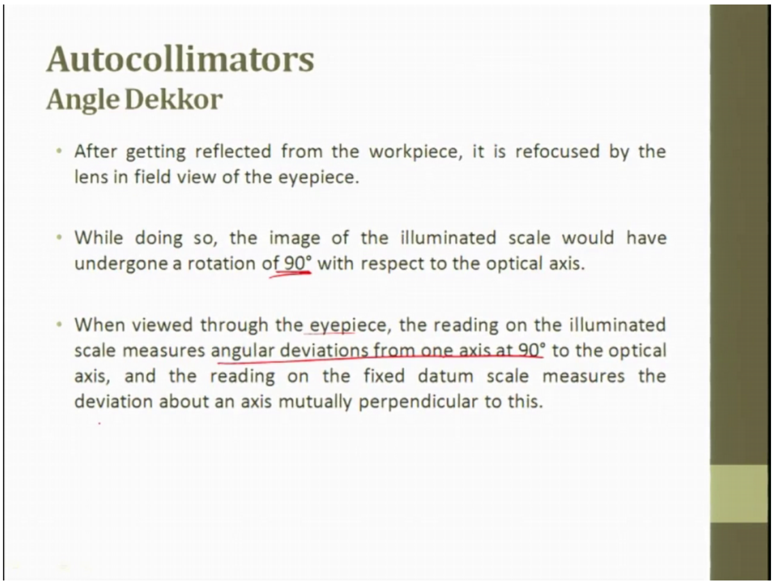


And after if getting reflection from the work piece it is focused by the lens in the field of view of the eye while doing. So, the image of illuminated scale would have undergone a rotation of 90 degrees that is why you see here this is the fixed datum field of view of eyepiece. This is the illuminated scale engraved on the glass screen and this, these two are merged. So, you see the fixed datum here and you see the reflected datum here.

And how does it happen the image of the illuminated scale which has undergone a rotation of 90 degrees with respect to optical axis. When there is a small reflection while viewing through the eyepiece the reading of the illuminated scale measures angular deviation from 1 axis at 90 or to the optical axis and reading the fixed datum scale the deviation from an axis mutually is perpendicular to this. So, this is what we are trying to say you see here this is 0 and somewhere here you see there is a to measure this reading here this is measured.

When viewed through the eyepiece the reading of on the illuminating scale measures angular deviation from 1 axis at 90 degrees to optical axis, and the reading on the fixed datum scale measures the deviation about an axis mutually perpendicular, so this is how an auto dekkor works. Here we use a prism, light prism collimating you have an objective hits at a flat surface reflection happens there is a screen where there is an engraving, the reflected data is gone there the screen has its own data the deviation between this two measured through the eyepiece. So, this is auto dekkor, so auto dekkor is a special kind of autocollimator this is also used for angular measurement.

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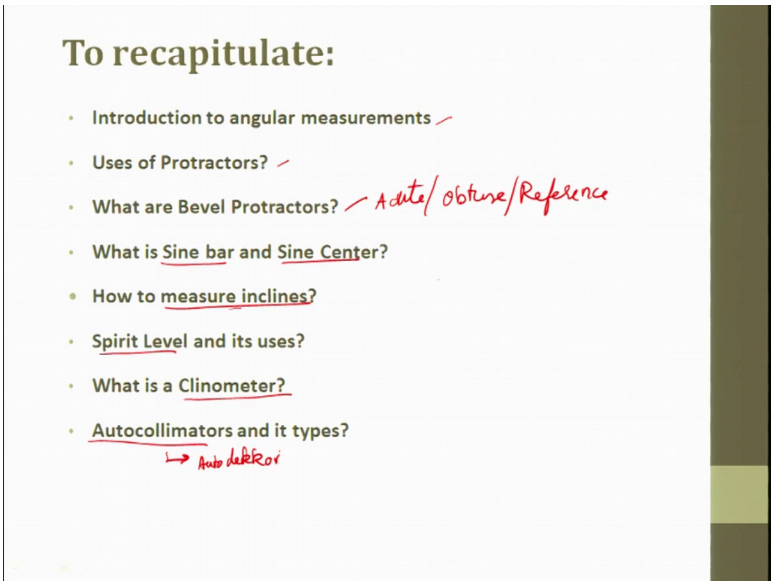


So, to recap if this chapter what all we have seen we have seen what is the need for angular measurements then we saw a normal protractor what we used in school and a same thing also used. So, then we realized that this protractor has limitations, so we went for a bevel protractor in bevel protractor we can measure acute angle, obtuse angle, acute slash, obtuse. And then you can also have various reference planes on this we can try to measure the angle went through sine bar, sine center, sine bar is basically have a fixed length you have a roller on top of a roller there is a flat surface and this is inclined, this is this sine bar is kept at an inclined angle and we try to measure the height.

So, with this height we put a dial gate on top we try to use sine bar for measurement sine center for measurement, then how to measure inclination we saw then spirit level and their issues we saw, then clinometer spirit level has smaller graduations. So, we went for a higher one which is the clinometer, so here we can measure much larger deviation in a angle. Finally we went into auto collimator which is used for measuring very small angles and special type of autocollimator is auto dekkor this was also covered in this chapter.

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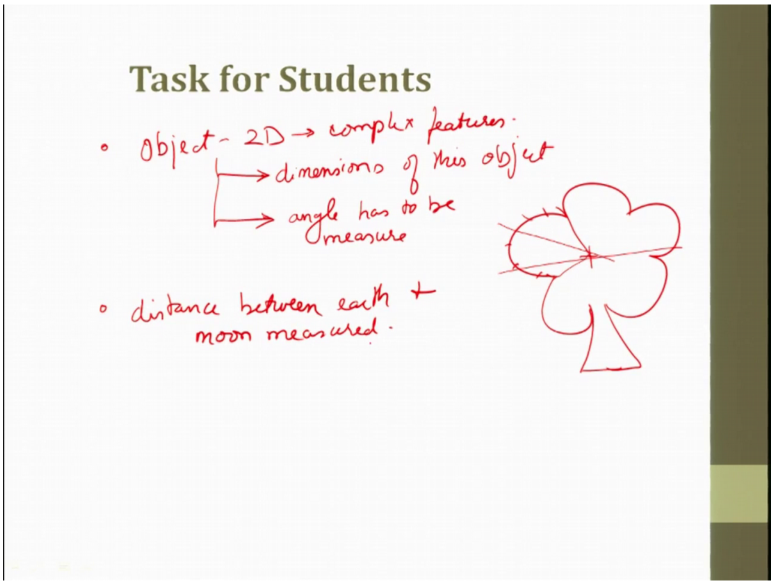


So, task for students is try to take try to take any object which has and try to take a 2D object ok, or you project it on a screen or something like that 2D object and then try to take the object must have complex features.

So, or you take complex features for example, what I am trying to say is it should have something like this. So, now, you are supposed to find out the dimensions of this objects ok. So, you will have to measure the angle also and since it is 2D, so you are not worried about the surface flatness. Please try this and see then you will start appreciating how difficult it is to measure the angle for any given object for example, you will draw a straight line, then you will try to put an angle then you will try to tell what an angle of this variation, what angle is this variation.

So, you have to start constructing it, and second thing is see when you do this it is also easy for you to tell the radius ok, but it will be good if you can take discretised point here moment you take discretetised point then you will see a variation in the data. So, try this, so that you will start appreciating this. Second question is I just wanted to through a very very generic question how is the distance between earth and moon measured. Please try to think about it and if you have solutions that will be nice if not at least start looking for references and see how do they measure the distance from here to moon.

Thank you very much.