Computer Organization and Architecture: A Pedagogical Aspect

Prof. Jatindra Kr. Deka
Dr. Santosh Biswas
Dr. Arnab Sarkar
Department of Computer Science & Engineering
Indian Institute of Technology, Guwahati

Lecture – 04
Storage Devices

Hello everybody, welcome back to the online course on Computer Organization and Architecture. We are in module, input output subsystem and today we are in unit 4 and we are going to discuss about storage devices ok. As usual, now let us see what are the objective for this particular unit?

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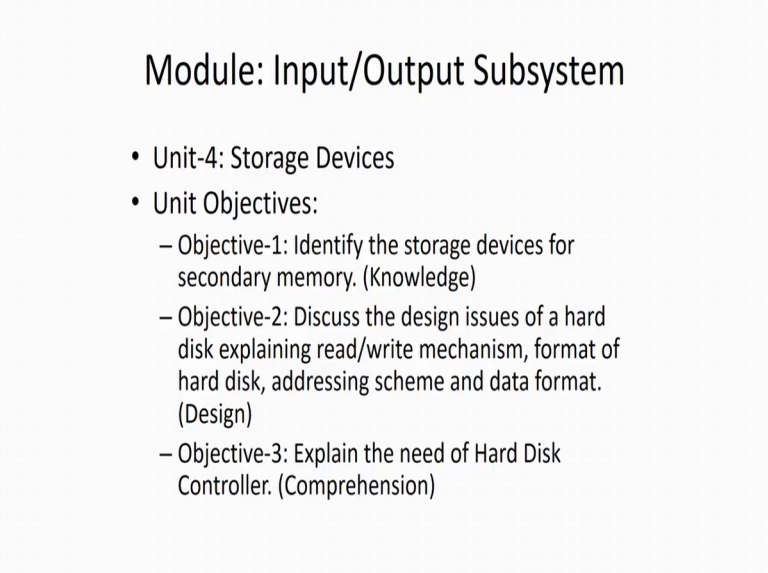

So, I have stated three different objectives for this particular unit. Objective 1: Identify the storage devices for secondary memory. So, we are going to just give a idea about in knowledge level. What are the different storage devices we have? Discussed, the design issues of a hard disk explaining read write mechanism, format of hard disk, addressing scheme and data format. So, this will be in the design level. So, we will see what are the design issues that we have for an hard disk.

Objective 3: Explain the need of hard disk controller. So, why you need them? Why you need a hard disk controller? We are going to just give idea about it, so it will be in a

comprehension level. So now why we required hard disks or storage devices? We know that computer works on Von Neumann stored program principle and processor is going to work with the data available in the main memory.

So, main memory is a semiconductor memory or semiconductor device. Again we know that it is volatile in nature. So, once we switch on the machine information will simply go from the memory, so we need some permanent storage devices ok. Secondly, we know that in main memory we are having a limited capacity; it may be either 2 GB or 4 GB, in the current scenario earlier it was very less.

So, in that particular memory we have to load operating system many more application software along with that our program and data, so it is not sufficient, so we need the secondary storage devices. So, one of the most common secondary storage devices is your hard disk. So, in this particular lecture we are going to briefly explain about the hard disk.

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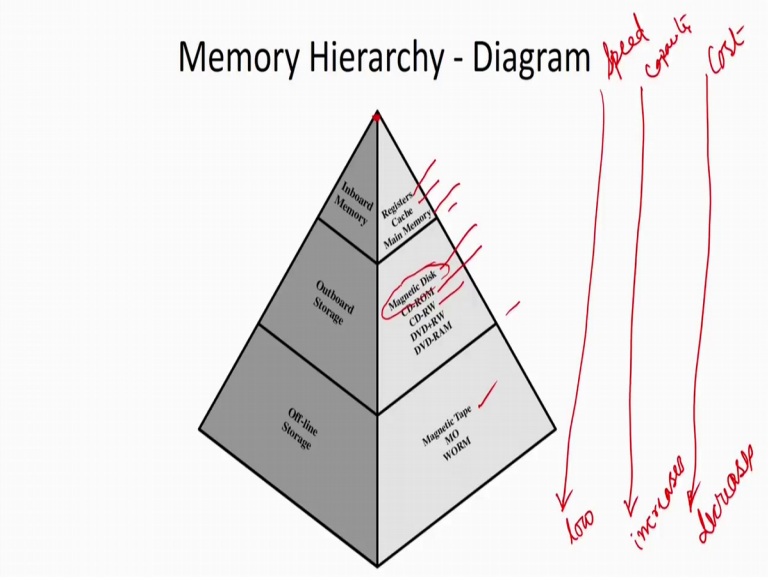

So, if you look into the memory hierarchy, so, in this case we are going to say that in the in board memory; that means, maybe it is inside the processor or it may be in a motherboard, because all indicated component of a processor or that computer will be put in a board and you say this is the motherboard. So, in board memory you are having the registers, we know these are the temporary working space inside the processor. Then next level we are having the cache memory we know that to increase the performance, to

increase the speed of the processor, we used to put some high speed memory between processor and main memory.

So, we say this is the cache memory and after that we are having main memory which is basically RAM random access memory, it is a semiconductor memory, and processor is going to work with the information available in the main memory. So, this is the memory that we are having in board then already I have mentioned that we are having a limited memory space, or storage space inside the processor or in main memory.

So, for that we need some other memory element which are permanent in nature. We are going to store all the information on those particular devices and we say these are your out board storage and from that particular storage unit we are going to keep we are going to first bring the information to the main memory. So, in that particular case one is your magnetic disk or the hard disk that we used to say, most of you say that in your machine you are having either disk or hard disk of capacity say 500 GB, or 1 terabyte like that. So, this is the magnetic disk and it is stuff working principle is an magnetism.

We are having CD-ROM also, you know about compact disk; this is your CD ROM read only memory. So, CD ROM basically it works on optical property. Similarly again we are having CD it is again a read write; that means, you can write and you can read it also later on. So, sometimes you can store our information you can first write the information in the disk then from that particular disk we are going to retrieve it or we are going to delete. But in case of ROM CD ROM only we are going to have the information in the particular ROM we can just retrieve it. So, like that we are having DVD, DVD read write or DVD RAM like that.

So, these are basically out board storage or we can say some up to some extent we can say that this is these are online storage also because that processor is going to access those particular devices and while working with the processor, processor can take information from those particular devices also like that when we are going to do some data processing my information may be in a file that file will reside in this particular hard disk.

And processor is going to take the information from hard disks and bring it to the memory. On the other hand we can say that many a time we used to see a movie and that movie is in your CD. So, we are having a video player or MP 3 player. So, in that

particular player it needs data to display or display a movie, so it is going to take the information from those particular CD and process it and accordingly it will display in the monitor, so that is why sometimes we say these are our online memory also online storage.

So, one more memory we are saying about that offline storage these are basically used for backup purposes. So, one type is your magnetic tape or do you having deformities we say WORM write once read more ok. So, this is the way we can say so these are basically offline. Why we are saying this is a offline? We are going to keep information also this is for keeping the backup of our data.

So, whenever we are going to work with those backup copies processor may not directly access the data from those particular devices. Somehow you have to bring it to some online devices and from online devices processor is going to access this data. So, in our computer system this is the total memory hierarchy. So in this particular hierarchy what will happen? If you go, then speed decreases. So, this is your low speed if you go from this top to the bottom of this pyramid. So, that registers is having a higher speed than cache memory and after the main memory like that we are having the switch.

So, if you are go from the tip of the pyramid to the bottom of the pyramid that speed decreases, so this is the higher speed and here we are having the lower speed. Secondly, if you look into a capacity then capacity increases when I go from this top to bottom. So, we are having we know that we are having very limited number of registers maybe 8, or 16, but cache memory you may have in that you know your megabyte, if you are going to talk about main memory it is in a gigabyte.

So, like that in magnetic disk now we are going to get around say terabyte capacity like that; capacity is increasing in that particular case. Also if you are going from this tip to bottom then if you consider about cost that cost also decreases. Since these are high speed more performance better, so we have prepared more cost.

Like that if I will go there then what will happen that cost gradually decreases and we are going to get a low cost memory devices in this particular case. So, if we are going for better performance then we have to pay more cost, so this is the way we can look at it. So, this is the total memory hierarchy in a computer system and today we are going to discuss about the working principle of this particular magnetic disk.

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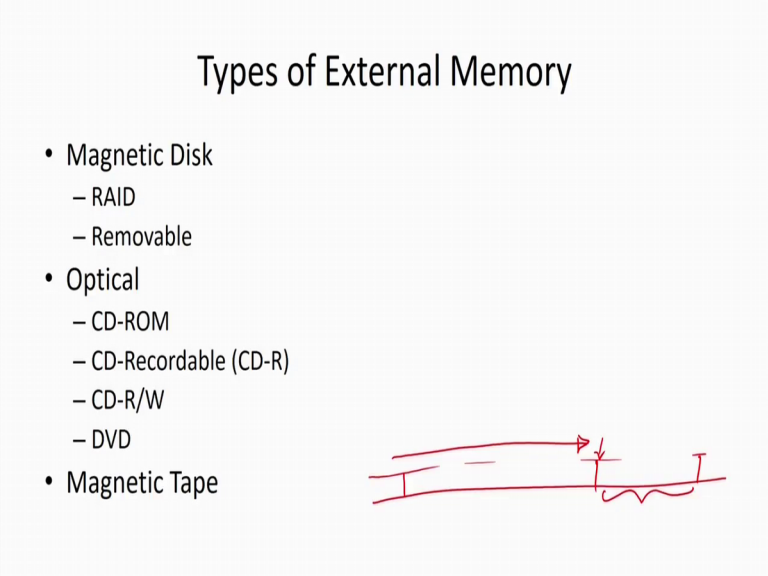

So, these are the type of external memory that already I have mentioned. So, the magnetic disk we have RAID, and removable. RAID stands for redundant array of independent disks. So, generally nowadays in most of the server and most of the computer system we use the RAID configuration, it is a redundant; basically we are keeping the information in a redundant way, so, that if something fails if one hard disk fails then we can retrieve it from the second hard disk. So, that is why you say this is a redundant array of independent disk.

So, just we are making some redundancy on the data so that if there is some problem with one particular disk then you can retrieve it from the other disk. Again it is talking about a removable; that means, what will happen? We can remove the disk from the system and you can put it somewhere else or you can take this particular disks to some other system. So, it will help us to port the data from one system to other system, so they are magnetic in nature.

So, other one is optical already I have mentioned that CD compact disk. These are basically optical in nature and you just see that in most of the cases these are removable in nature we just put the CD on a CD drive, we will operate it then we can take it out, so it can be taken to (Refer Time: 09:53).

And another one is your magnetic tape this is basically offline devices which works on magnetic in nature and this is basically tape. So, now if you compare like that what will

happen? You can see about a magnetic disks and magnetic tape; this tape is something related to your audio tape or say video tape.

So, here if we are going to access a information then what will happen since it is a continuous tape then what will happen? So, if I want to retrieve the information that is stored in this particular portion you have to skip those particular position and we can come to this particular point. But in case of your magnetic disk it is random in nature like your record player; we can put the head in a particular track, and we can start playing the song from that particular track. So, this is like the random in nature and then only we can go to a particular position and you can start seeing information from that particular point.

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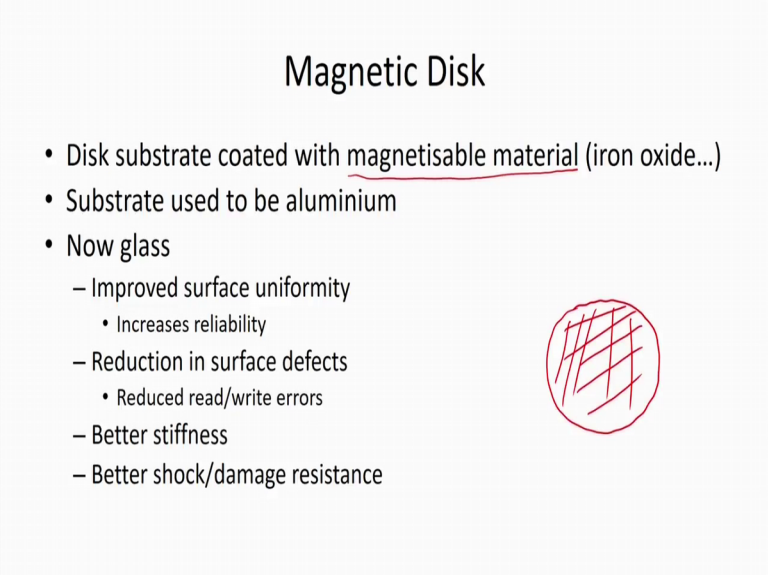

Now, what is the basic things about magnetic disk? Just I am mentioning over here it is we are having a disk substrate coated with magnetic materials. So, basically in most of the cases you will find that this is some sort of your circular plate and the surface of this player will be coated with magnetisable material magnetisable material or say magnetic material, so that we can magnetize it in some polarity. And initially that substrate that the material used for preparing a substrate was a aluminum, but nowadays we are using glass.

So, when we are using glass basically this improve the uniformity of the surface. So, in case the reliability, so it is reduce the read, write errors. Because now it is going to reduce the defect, it is better stiffness and it has better shock and damage resistance. So,

nowadays most of the substrate or most of the disk circular plate that we are going to use is glass and the glass will be coated with magnetic material. So, that it can be magnetized in some polarity and we are going to store our information as a magnetic property in the disk. So, that is why I say it is a magnetic disk or in hard disks is basically magnetic in nature.

So, here we should have two operations basically one is your read, and another one is right. So, in case of read we are going to retrieve the information from disks, I am going to bring it to the processor inside the computer while they are bring it to the computer means we are going to put it into memory. Second is your write operation; in case of write operation, whatever data processing we are doing in our computer that is residing in our main memory because it works on Von Neumann stored program principle, and from main memory we are going to store it in our hard disk, so this is the right mechanism.

So, when you are storing it into the hard disk then it becomes permanent ok. So, if we now modify it then only contents will get charged, but when it is in the main memory this is not permanent it is polygonal in nature. I think you have experienced many a time say you are doing some work in the computer suddenly something happens to the computer maybe there is a power failure, then system is going to shut down immediately it will switch off. When we switch on it then what will happen? Some of the recent information may not be available because we have not stored it in a permanent devices.

So, whatever you have stored in a permanent devices till that point we can retrieve it, some of the decision modification cannot be retrieved because it was in the main memory and it has gone up as soon as we have switch off the machine or powers goes off. So that is why we need these two mechanism; one is your read and write. So, what read is doing recording and retrieving via conductive coil called head.

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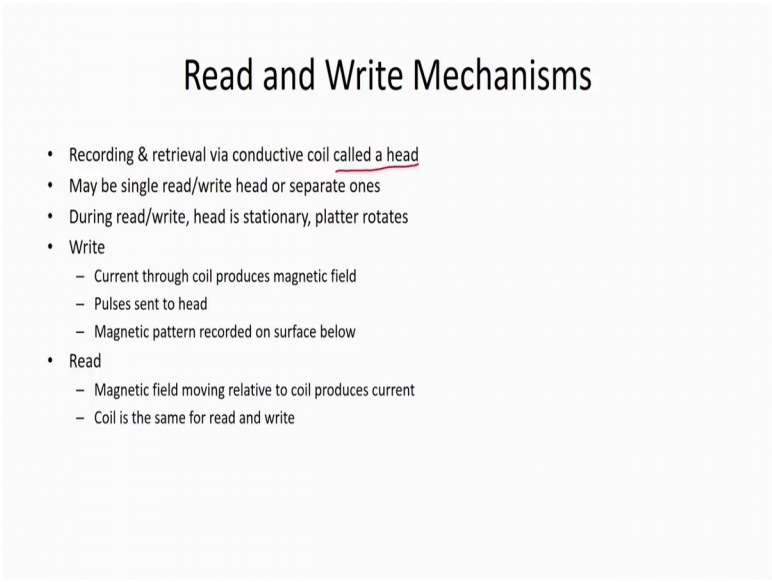

So, you are using a read write head and through this particular head we are going to either read the information or write the information. We will say how we are going to do it, but it is basically magnetic in nature we are storing information is a magnetic polarity. Maybe single read write head or separate one. So, it depends on how we are going to construct a going to construct it? We may have one read write head or we may have several read write head. During read write head is stationary, platter rotates. We will discuss it how why it is required and how it has going to access it.

So, in case of write what will happen? We are going to pass the current through the coil, which produces a magnetic field and that magnetic field we are going to captured in a magnetic material that we are having in the particular platter or particular disk or particular surface. Pulses sent to the head, we are going to send some current pulses to the head and it is going to create the magnetic field and that magnetic field is going to be recorded in the surfaces magnetic surfaces; magnetic platter recorded on the surface below, so this is the write mechanism.

In case of read mechanism magnetic field moving relative to the coil and it produces current and by looking into the direction of current we are going to change it and we are going to say that we are retrieving some information and along that same coil may be used for both read and write or we may use to define mechanism for read and write. So in that particular case so you just see that we are having a surface platter, where we are

going to coated with magnetic material and we are going to store information as a magnetic polarity and to this to store information or retrieve information we need an mechanism and we say this is the read write head ok.

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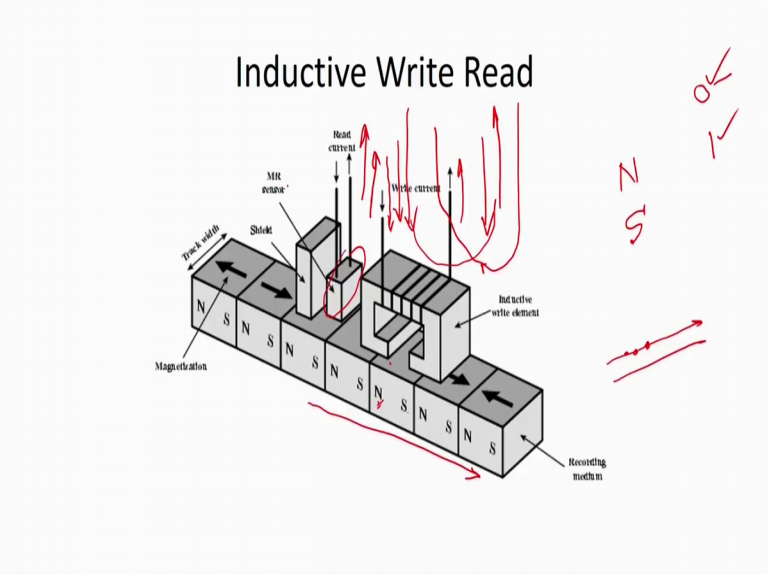

Now the read write head will look something like that. So, this is basically you can see that we are having a mechanism like that some iron or coil iron substrate inductive write element. So, here we are going to have a coil, we are going to put a coil. So, it is very much similar to I can tell you some sort of your DC electrical motors or electrical generators.

So, here we are having a shaft and we are having a coil. So, this is basically shaft and this is coil. Now what will happen? If we are going to pass current through this particular coil then current will move in the particular direction. So, due to that due to this flow of current it is going to generate an magnetic field.

So, depending on the direction of the current that is having a particular polarities. I say that this is the polarity and on North Pole on north polarity. Now once we change the direction of the current say now I am going to give the current for the different direction again this substrate is going to produce a magnetic field but this time the polarity of that field will be defined, so it will be in a South polarity ok. Now simply changing the directional current we are changing the polarity of the magnetism, and whatever

magnetic field it is general producing that will be stored in this particular magnetic material. So, now we have to just simply change the direction.

Now what will happen? We are having two kind of information one is 0, and second is 1 or maybe in case of 0 it is low voltage and in case of one it is high voltage. So, depending on the information we are going to give the direction of the current; say for 0, if I am having this particular direction then for 1, the current will move in the opposite direction. So, whatever information we have in memory depending on that we are going to produce the appropriate current for appropriate direction and depending on the direction of the current what will happen? It is going to produce magnetism and that magnetism will be stored in this particular magnetic material ok.

Now, once you store one bit of information then this particular platter will rotate. So, it will move, so if I am storing one bit of information over here then second bit will be stored in the next position, third bit will be stored in the next to it like that it will move we are going to rotate the disks. So, depending on the rotation of the disks we are going to store the information in this particular position, so this is the way we are going to write information.

So, now read; what will happen basically it will read? So basically you just see when we are writing it now it is we are giving the current. So, it is going to work as a some sort of electrical motor it will generate the magnetic field and depending on the magnetic field our soft rotates in a motor. So, it is some sort of the principle that we are using a motor. But what is the write mechanism? In case of write mechanism what will happen we are going to move this particular magnetic surface. So, when we move the magnetic surface then what will happen? It is going to generate current on this particular coil that we are having the shaft.

So, the principle is similar to your current generator. So, when we are moving it depending on the polarity of the magnetism it is going to generate current. So, in for say one particular polarity north polarity if current produces say in this direction for the south polarity current will be produce in the other direction. So, in case of one polarity it will generate in this particular direction, but for second one current will be generated in the other direction. So, now, by depending on the direction of the current we are going to

interpret it is either 0 or 1. Basically we are storing two kind of information one is 0, and 1.

So, when we are going to store it in a magnetic material for one case say for 0, we are going to store it is a North Pole; for 1 we are going to store it as the South Pole. So, while we are retrieving it so in that particular case for North polarity it is going to give me current in one direction, we are going to interpret as 0, and for South Pole we are going interpret as 1. So, this is the write read write mechanism of our hard disks and we say this is the read write head. On the other hand in some cases we are going to use say it can be used as a write head and read head may be different one.

So, this is some magnetic regenerator sensor basically. So, magnetic regenerator can be used for retrieve the polarities of this particular magnetic surface and depending on that we are going to have current in different directions. So, either we can use one particular head for both read and write purposes, but we can use two different mechanism also. So, this is the basic principle, how we are storing in our magnetic surface. Now we have to know what information we have store, where we have stored. So, we are going to see those particular issues also.

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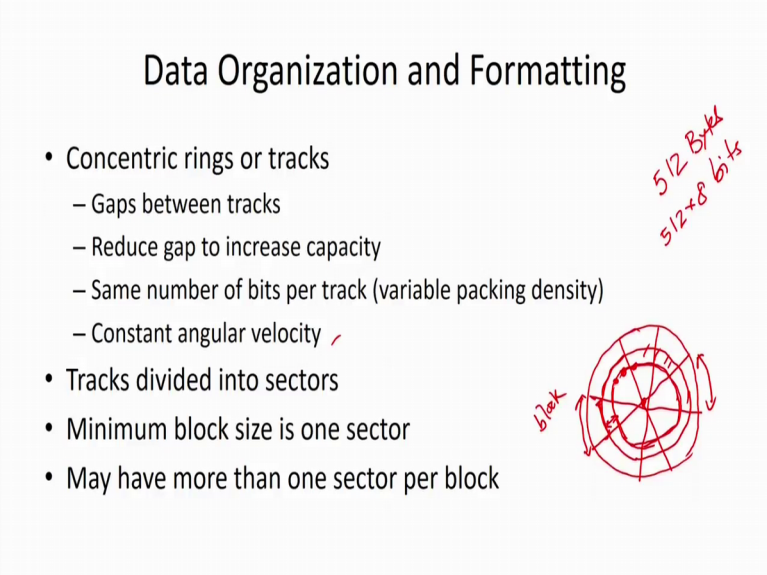

Now, how we are going to organize the data organization and formatting. Now what happens? You are saying that basically we are going to have a circular disk. So, we are going to make concentric ring and on those particular ring we are going to store our

information and we are having a gap between two ring, just to remove the interference, so, this may be gap we are not storing it. So, we may reduce this particular gap to increase the capacity. Again we are having a limited capacity. So, we are going to store a particular number of bits in a particular track and this will move in a constant angular velocity, so you have to rotate it in a constant angular velocity.

So, why you have to rotate it? When we are going to read it when we are going to write it then first bit we are going to write it over here, second bit I am going to write in an expression like that, so we have to rotate it. Secondly, when we are going to read it? We have to move this particular magnetic surface to generate current. So, whatever is there between the head it is going to change this particular polarity and depending on that we are going to have some current and we are going to work with the current. So, this is the way we are going to store it.

Again it says that tracks we are having some tracks and those tracks will be divided into some sector maybe we can put divide and you can say this is a sector in that particular disk. So, minimal block size is your one sector, will come to distance of whatever information we can store in a particular sector is known as your block ok. If I say that block size is your say 512 bytes, then what will happen? In this particular block I can store 512 bytes of information; that means, 512 into 8 bits; 1 bytes is equal to 8 bits.

So, that many bits can to be stored in a particular sector and this is the minimum block size in one sector. And this is have being some importance in subsequent slide I am going to show it what is the importance basically while you should know what is the block size or how many information you can store in a particular track; may have more than one sector of per track of course.

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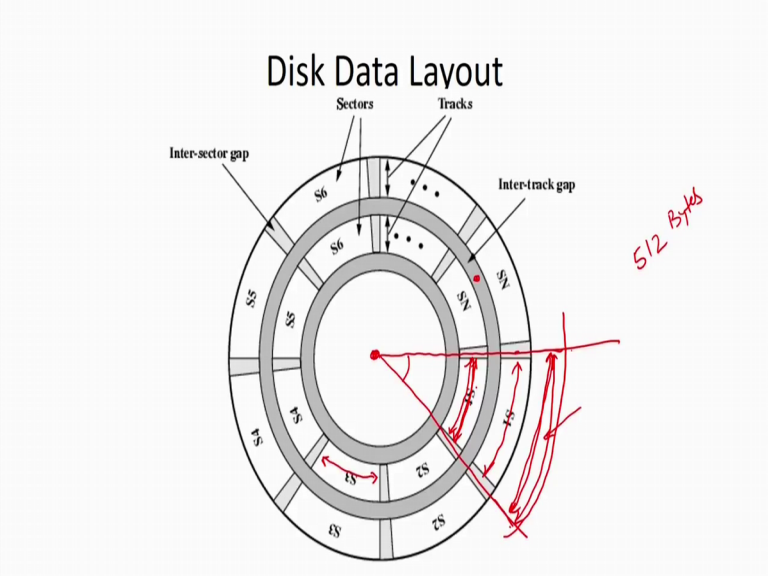

Now, this is the whatever I have discussed whatever I have explained in the last slide this is the diagram neat diagram that we are having. So, these are basically Inter track gap, these are the inter sector gap and these are of different track and tracks are divided into different sectors. So, this is a sector 1, sector 2, sector 3, like that we are having several sectors and total n sectors which is going up to SN, this is a track 1, then this will be track 2, so we are having several tracks. So, this is the organization of our disk and data's are organized in this particular way. So data's will be stored in this particular sector.

So, now to have this things what will happen? Increase the spacing between bit in different tracks I think now you understand. What will happen say I am saying that is the same block size? So, I am having 512 bytes; that means, in this particular position I am storing 512 byte because this is a sector. So, similarly this is another sector in the next track we are storing 512 bytes, like that if I am going for a next track then what will happen now I am going to have store 512 bytes here also.

Now, you just see the area, circumference that we are having in this sector is less than the circumference area of this particular track. So, when we are moving out from the center then what will happen? The sector size is more and we are coming near to the center then sector size is less, but we are storing the same amount of information in a particular sector. So, we can say that bit density is low in the outer track and bit density is more in

inner track; that means, in a small sector we are storing more information. So, bit density is more here, but in the outer track bit density is less, so this is one.

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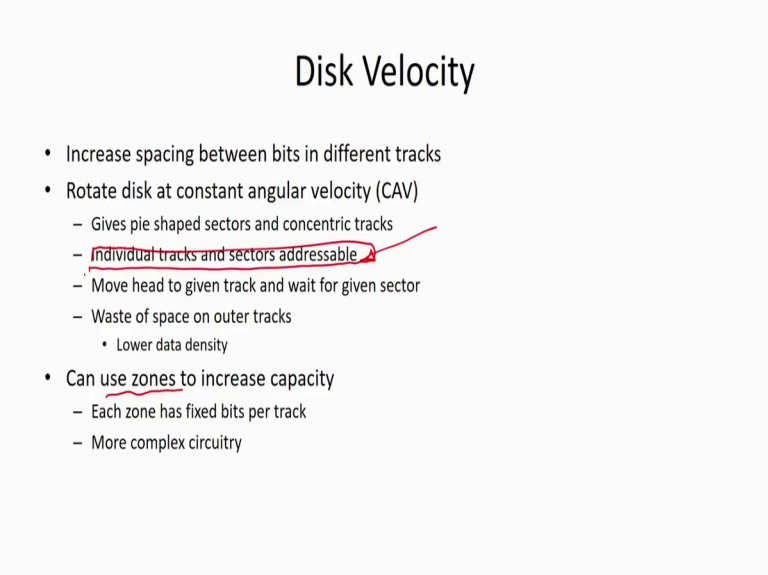

Secondly disk rotate in a constant angular velocity. Now you just see since it is rotating a constant angular velocity, so the time required to cover this particular length will be equal to time required to traverse this particular length, because it is rotating in a constant angular velocity. So, this angular velocity is constant same. So, this since it is angular velocity is same. So, this cone will be traversed in a constant time so; that means, this information will be retrieve in lesser time and that information also retrieve in the same time ok. But here we are traversing more amount of time, so it is traverse in a constant angular velocity.

So, time required to retrieve the information from a particular sector is same whether it is an inner track or a outer track ok, so it works on constant angular velocity. So, give pie shaped sector, and concentric track, we can see it; individual track and sector addressable. Now we see why we say that individual tracks and address of sector rule. Move head to give track and wait for a given sector then waste of space in outer track because already I have mentioned that it is having a lesser bit density. So, we are wasting some space at that time.

So, for that to reduce it to reduce the wastage we can use the concept of zones; that means, tracks will be different zones, and we are coming to the zoning concept then

tracking density or bit density same in all the track. So, we are storing less number of information in inner track and more number of information in the outer track, so that density bit density will remain same. But here the control circuitry will be a complex one.

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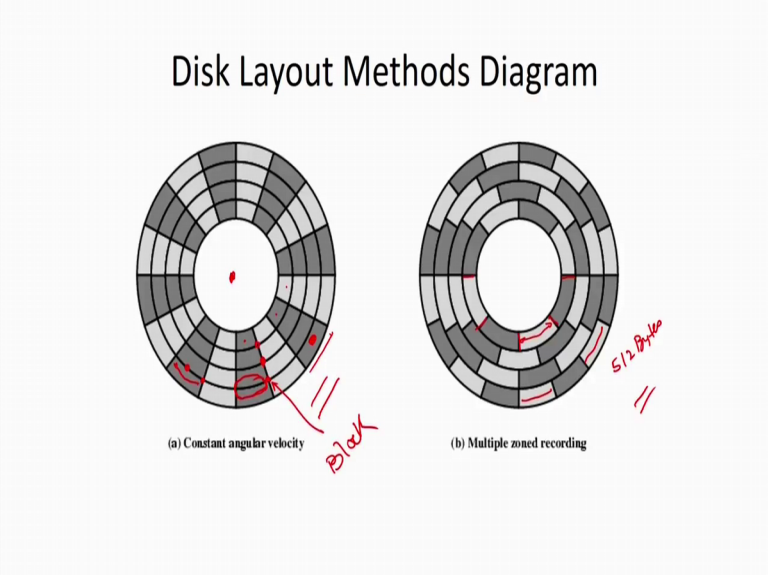

Now, you just see that here what will happen? We are having concentrating ring and we are dividing into different sectors. So, we can access the information from those particular sector, but here what will happen we are creating zone, the length of those zones are your same ok; that means, we are storing some information and we are keeping same number of space to store the information, so like that we are also we are having this thing.

So, you just see that if I am storing 512 byte over here then same 512 byte will store here also in one zone, so in same area we are storing the same information, so bit density is same. And in that particular case you just see that in the inner track we are having less number of zone in outer track we are having a more number of zone; that means, in outer track we are storing more information. But when we are having a concentrating ring we are storing same information in all the track, same amount of information in all the track. So, that is why bit density is more in inner track and bit density is less in the outer track. So, this is one advantage we are getting.

Now, we can store more information, but to store information and retrieve information the circuitry that we are going to design will be a more complex one, but for this particular organization we are going to get a simple circuit because again that designing and implementing a complex circuit is going to cost more. So, this is the trade off where we are going to have in most of the cases we are going to use this one only.

Now what is the characteristics of this particular disk? Now here we have mentioned one thing that individual track and sectors are addressable; this is one important point. Why you are saying? You just see that I know the track number, and I know the sector number ok. Then I can go to a particular track and in that particular track we can go to a particular sector. So, this is basically we can say what is the track number and what is the sector number, but straightaway I cannot go to this position because this is some position where we are storing one particular bit. We can go to it provided again we can have this is addressable.

So, in that particular case to make it simple what will happen? We give the we are going to identify those particular track and sector junction and we can go to a particular sector. After coming to this particular sector what will happen? Sequentially we have to access this information; whether it is read information or write it; what is it is a read operation or write operation.

So, I am going to work with this particular entire information. So, this is basically known as my block of the disks, so we are going to work with the block of a disk. Straightaway I cannot identify this particular position and I go to that point I can very well come to the start of this particular sector and from that way I am going to access the information. So, it is basically a block access mechanism we are going to access block wise not an individual bitwise or byte wise.

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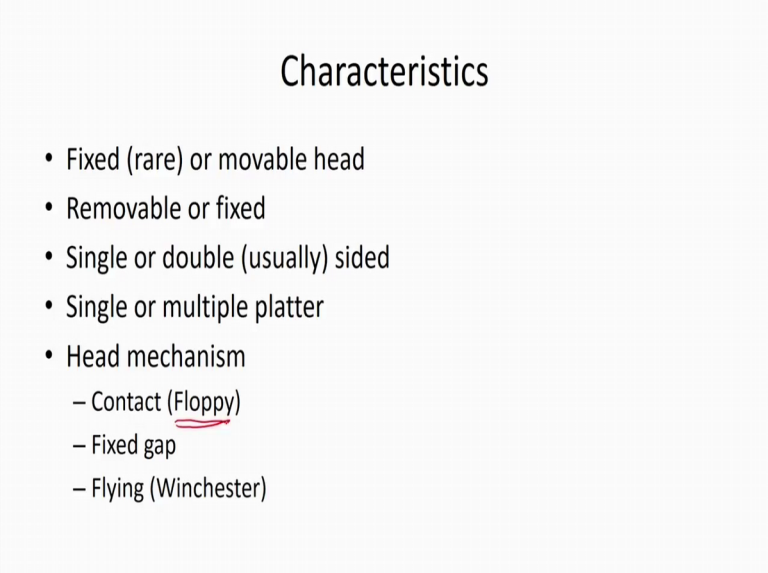

Now, what are the characteristics it says that fixed or removable head movable head removable disks, or fixed disks, single or double sided disks, single and multiple platter head mechanism. We are having say different way of having the head mechanism one is contact fixed gap and flying. I think nowadays I doubt whether you have seen floppy disks or not, but earlier days this is also a kind of your storage devices which is your basically removable disks we can just put into a CD floppy drive write it and take it back

Nowadays, that you are using CD drive so this is magnetic in nature. So, these are different head mechanism it is a contact fix gap and flying we will just log about the fix. So, what are those characteristics one is saying that fix, and movable head.

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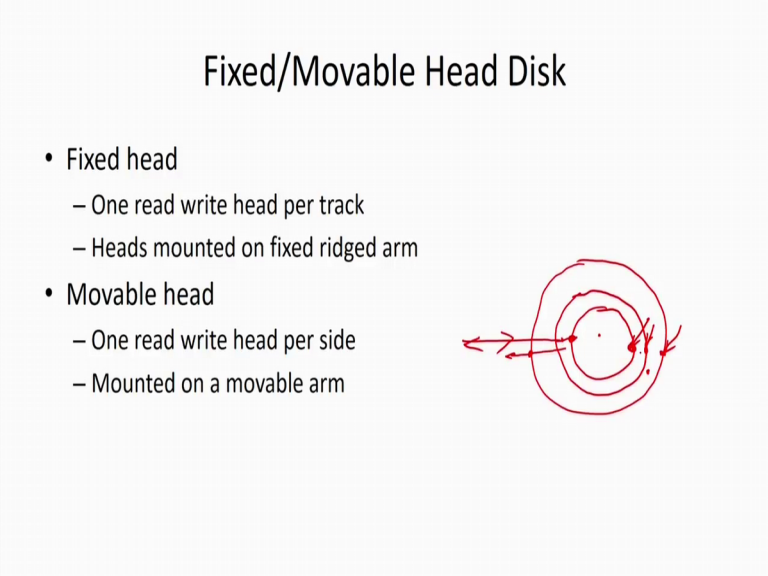

Now in that particular case now say I am having concentrated track now I have to read information from those particular track. So, in case of fix set what will happen I am having separate head for each and every track this is talk about the fix set. So, for each and every track we are going to keep one head and that head is responsible of read information or write information from that particular track.

But in case of movable head what will happen that we are having one particular head ok, that head will move outward and inward. So, if it is moving inward then we are coming to the innermost track and when I move outward then it is coming to the outermost track. So, this is the movable head; so that means, we are having only one read write head and that read write head is responsible to read and write operation or doing the read and write operation in each and every track. So, it will move from track to track, but in case of fix set for every track we are having a separate read write head.

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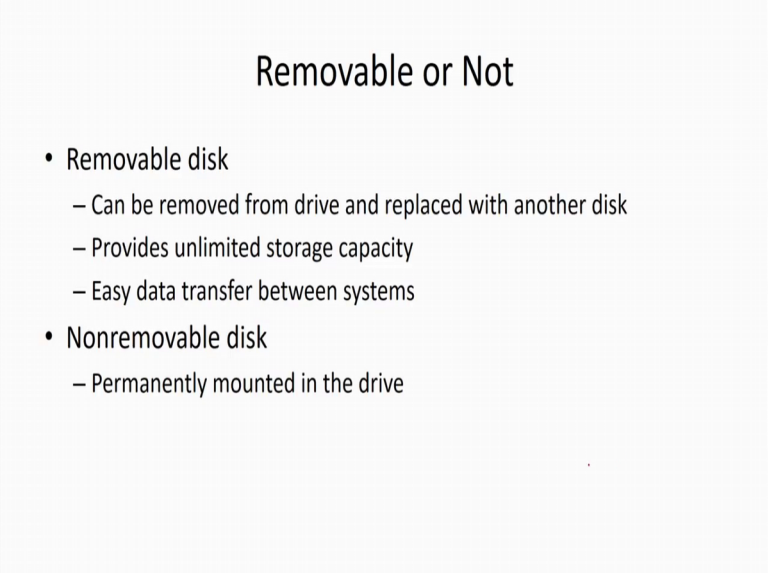

Removable or not this is basically a disk property. So, in case of your removable disk what will happen? We are having a disk drive. We can put one disk, you can move work with that particular disk or we can remove it place another one. So, like that your record player we are going to place different record like that, but in case of your fix your disk things, if it is not removable then what will happen? It is will be a permanently mounted.

Nowadays say whatever laptop you are using or whatever desktop you are using this disk is basically not removable, so it will remain in that particular drive and we are going to work with this disks. But in case of removable one what will happen? Drive will be there, we can remove the disks that storing surfaces.

And you can put a new disks over here, but do not confuse with your portable hard disk. Portable hard disk is slightly different. It is whole drive will be portable whole drive will be detached, but in case of removable one drive will be there, but only disks we are removing it. So, multiple platter; so basically we are talking about one particular surface, we are going to store it.

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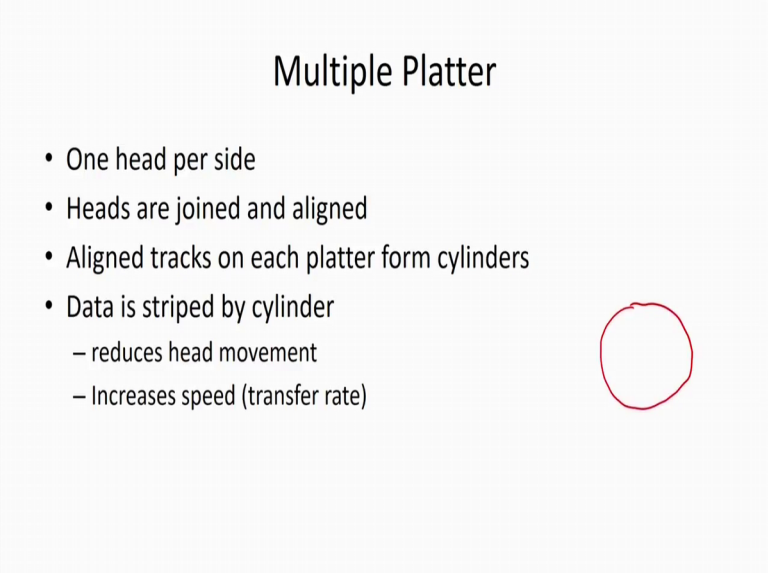

So, what will happen? We can have a pile of platters. I am going to have one drive; so that means, you are having multiple platters and we are going to store our information in multiple surfaces.

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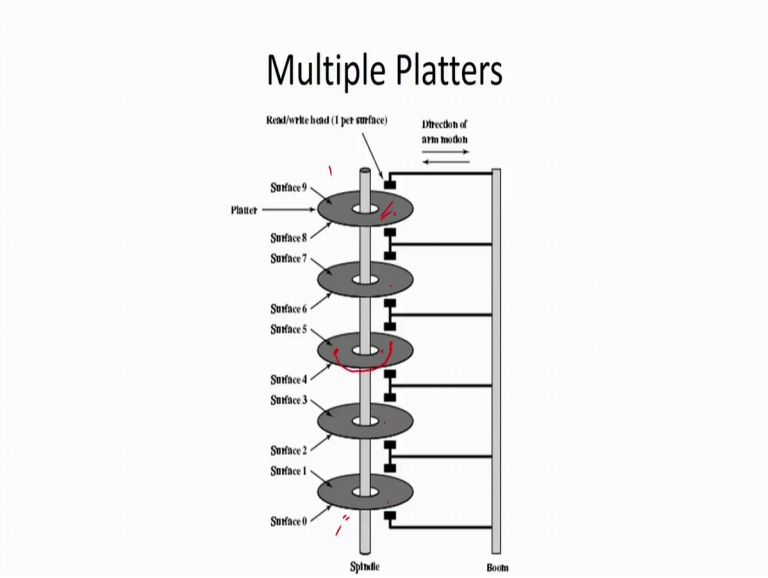

So, this is basically the complete scenario, so the way you are showing this is the read write head. So, in that particular case this arrangement is that we are having it is your not fix, but movable. So, this head will move inward to outward to go to a particular track ok. So for one head is used to read and write for a particular track. Now these are the

several platters ok. So we are having several surfaces to store our information generally, those platter also we can use either both the side or one side. In most of the cases it is both the side, one top surface and bottom surface platters basically we are using one surfaces, for safety reason; top is not used and here the bottom one will not use, but intermediate platters will be used in both the side there.

So, for every side we are having one read write head but for one particular side one particular surface we are having only one head. So, this is movable it move up and down and this is the spindle, so that spindle will help to rotate the disk. So, if I want to read the information from that particular point then what will happen? First it will rotate it and bring it to the bottom of this particular read write head then we are going to do a operation over here. If it is a read operation we are going to retrieve it, if it is a write operation we are going to write a new information over here.

So, this is the some scenario about the hard disk. So in that particular case I am talking about the fix and removable. So, in case of fix those platters will remain fix it will come inside a cabinet and we are going to work with it. In case of movable what will happen this disk pack can be removed and you can put another new disk pack over here to work with it. Now when we are talking about the tracks now there is a concept called cylinder also. Now what will happen? We are having concentric track and we are having several surfaces. If we are going to consider particular track then what will happen all the track of that particular position is going to form a cylinder just see that.

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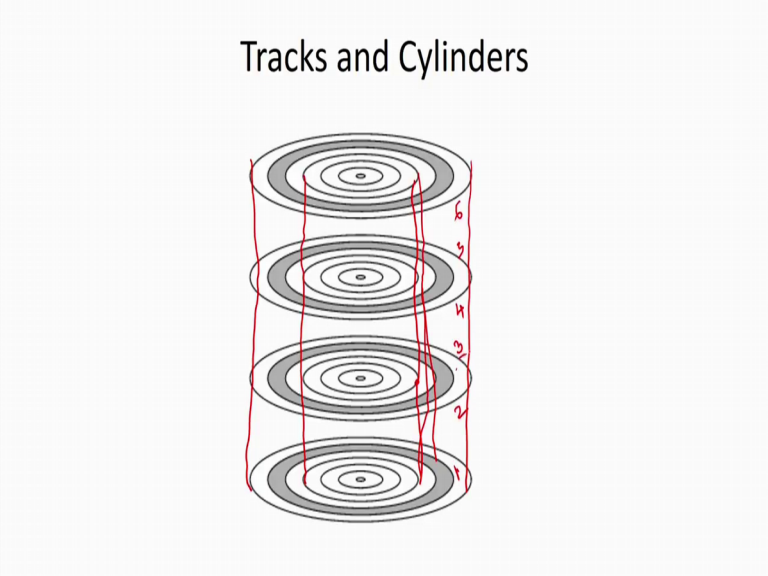

If I am going to consider about this particular track, this particular track ok, I am taking the same track of all the surfaces, so you can consider this as a cylinder. So, like that if I am coming for that outer track then those outer tracks are forming a cylinder. So, this is basically nothing but the collection of tracks of the same position of all the disks and we are going to treat these things as cylinder.

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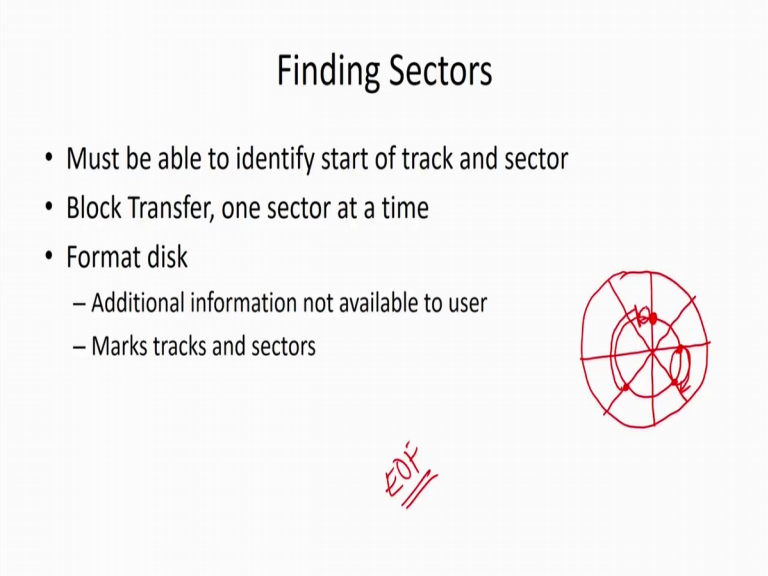

Now how to finding a sector? I am saying that when I am going to store information in a disks then what will happen? It is divided into several sector and you are going to work

with these particular sectors. So, somehow you have to identify this particular sector then only we can work with this thing. So, main emphasis is to finding a sector and already we have finding the starting of the sector then what will happen I have to access all the information of this particular sector ok.

So, in that particular case now we are having that block transfer and we are going to transfer the entire information of this particular block. If it is a read operation I am going to take that information of the entire block I am going to bring it to the disks. And when it is a write operation I am going to take it from the computer I am going to put in this thing. Now, generally we are having some idea about the file we said that we are storing some file in hard disks and we generally access those particular file.

Now to indicate the completion of the file and of the file there is a call end of file marker. Now when we are storing it say I am starting from this particular point and storing our information of the file you just say that it is taking complete two sector, and say somewhere it finishes, so this is the end of the file marker and I have store it.

Now, in that particular case when I am going to store another file I cannot start from this particular point because I cannot address that particular point. So, maybe next file I am going to store start from this particular sector, so in this particular portion we are not storing any information. So, these are some sort of intermediate wastage that we are having. So, this is we have to sacrifice because we cannot identify this thing we may have mechanism, but why unnecessary complicated design we should do. So, to make it simpler we are going to do this thing.

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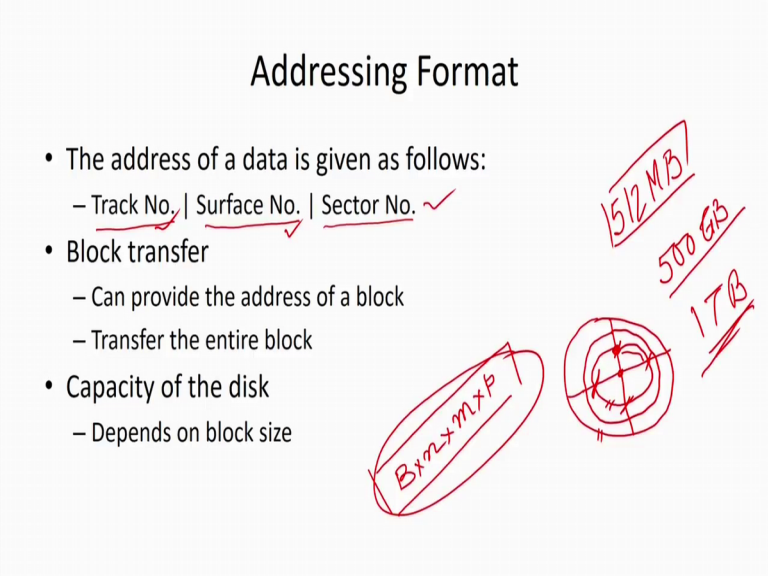

So, our emphasis is now I have to identify this particular position then only I can work with read write operation. Now for that we have to give the address. Now what is the addressing format? You just see that we are having the format like that it is talking about that sector number, surface number, and track number. So, this is the format say now what will happen say I am having several surfaces are maybe this is the first surface, bottom one is second, top one is 3rd, 4th, 5th, and say this is the 6th surface.

So, I can think these are the 6 surfaces; top and bottom we are not storing it because this is will be exposed, so say these are the 6 surface. Now where I am having my data; say if it is having in some position over here and then I have to first get the surface number in which surface we are having it. Then once I get the surface number then in that particular surface I have to say in which sector we are storing it and we must know in which track we have store it because we are having several track.

So, now, you just see that if I know the sector number, surface number and track number then we can go to that particular point. So, this is the addressing format of this particular disk. Then after that after coming to that particular starting position then it is basically block transfer, I am going to transfer the entire block. So, because you can provide the address of a block, so this is transfer is your block and what is the capacity of the disk?

So, it depends on the block size. I am saying that if the block size is B, then we have to say how many sectors we are having in a track say block size is B, say they are having n

sector in a track. So, I am going to store B into n and if I am having m track then same amount I am going to store in those particular m track and if I am having say p surfaces then same amount will be stored in each and every surfaces; so this will be the total capacity of my disk.

So, here what will happen? I am storing in a sector form but if we are going to use the concept of zone then capacity will increase because in this particular case packing density is more over here but we are storing very less information into the outer bit ok. So this is the way you can calculate what is the capacity of a hard disk. Now you say that now you are having a hard disk of say 512 MB, sorry this is too less nowadays we can say that you are having either 500 GB disks or you can say that 1 TB, 1 terabyte disk.

Basically I think most of you have nowadays processing that portable disk and the capacity of portable disk is like that 500 GB or 1 terabyte like that. So, by looking into it now we can find out or you can see that it is basically organized in this particular way. How many surfaces we have? How many sectors it is divided? How many tracks we have and secondly, what is the block size how many bits you are going to store in a particular sector? So, by looking into these thing we can find out the total capacity of the disk.

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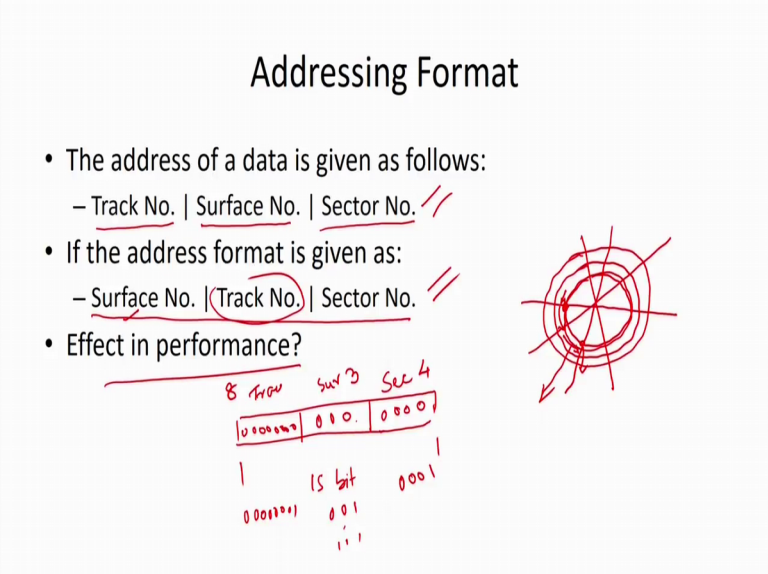

Now here we are saying that one I am saying it what is the addressing format? This is your sector number, surface number, and track number. So, in that particular case what

will happen? First we are identifying the sector say we are going to work with this particular sector. Then we are going to look for the surface in which surface we are? Then I am giving that track number ok. So, this is the way that I am going to say this is my address now the simple things I am going to say this is the sector number, surface, sector, surface and say track. Just say that this is I am storing 4 bit, in surface I am storing 3 bit, and say here I am storing 8 bit of information.

So, what is the total size of the address? 8 plus 4 12; 15; so total 15 bit address. Now say this is sector, so I can use any 4 bit, so whatever say 0000, surface is also 000, track is also so 000. So, this is the address; that means you are coming to the zeroth sector of zeroth surface and zeroth track, so you are going to start it from here. Now after that you just see the after coming completing this particular sector then what will happen? This sector number will move from 0001; so that means, we are going to the next sector.

So, like that we will complete this particular track. Once you complete this particular track, then what will happen? Now surface number changes. Now from 000 it will become 001; that means, we are changing the surface. Now like that if I am going to all the track of all the surfaces then what will happen? So it will go from 000 to 111, then it will going to change the track from 000 to 001; that means, now it will from this particular track it is moving to this point, so this is one issue.

Now, in this particular case what will happen? First we are going one particular track. Now after completion of this particular track if I complete all the sectors then we are going to change the track number; that means, we are going to outer track. So, like that I am going to complete all the tracks of this particular surface, one will complete all the tracks then we are changing the surface number then from this surface we will go to the next surface. Now this is the two way different way I can give my format; whatever you like you can use it. But you have to see the effect in performance, which one is going to give a better performance we have to see.

Now, how we can measure the performance once we know the access time? The time required to access the information from disk ok. So, in that particular case do you having some component over here to measure the performance, basically look into the speed of data transfer. So, one is talking about the seek time. What is the seek time?

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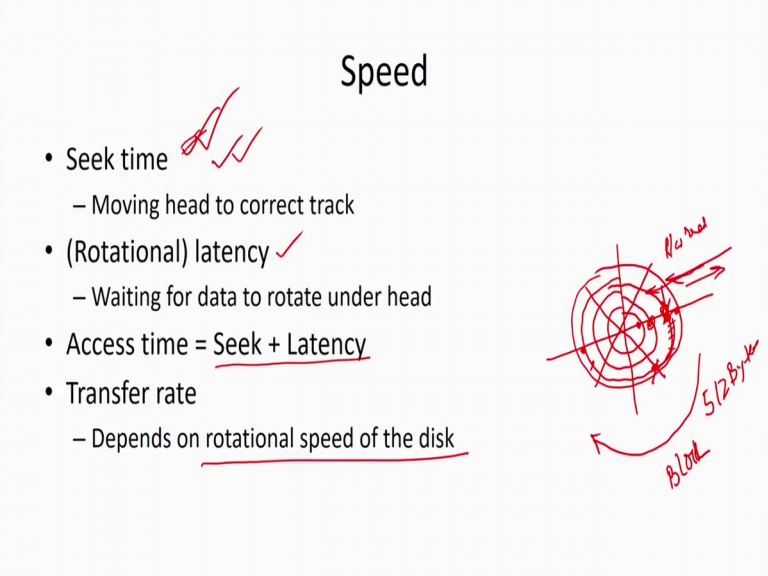

It says that moving the head to correct track. So, now what will happen? I am having this particular track, now here I am having the read write head. It can go from the outer track to the inner track. So, now what will happen? When I given particular address say address is coming in this particular form sector number, surface number, track number. Then we know from which track we need to get the information so that read write will have to place into the appropriate track; that means, either it will move inward, or we will have to move outward to place it into the appropriate track.

So, this time required to put the head into the appropriate track is known as your seek time. Because once I am going to read a file; that means, I have to provide the starting address of that particular file; that means, what I have to give track number sector number and surface number. So, once I know the track number then what will happen? I have to place the read write head into the appropriate track. So, this time required to move this head to the appropriate track is known as your seek time ok.

Now once I identify this particular track then what will happen? Now I have place the read write head here, but my information may start from say this particular sector ok. Now what will happen? Now I have to bring this particular appropriate sector beneath this particular read write head, so it will take some time.

So, this time is known as your rotational delay, or rotational latency or latency time. So that means, to bring the appropriate to bring the head to the appropriate track is known as

your seek time, to bring the appropriate sector below the read write head is known as your latency rotational latency. And the total access time is known as this seek time plus latency; that means, we are going to access the starting point of that particular file or particular address.

So, this is the basically access time seek time. After that after placing the appropriate track and seek curve which load this particular head. Then what will happen? Now we have to transfer it then this disk will rotate in an angular velocity, constant angular velocity. So, it will take some time to cover from the starting position of this sector to the ending position of this sector.

So, during that time I am going to transfer the information in this particular way. So this time is known as my transfer time. And this transfer time depends on the rotational speed of the disk, so if rotate in a particular speed because it will take a particular amount of time to traverse this particular distance complete sector. So, this is the time required to transfer the whole information a whole block; that means, if in a block if I am storing 512 byte, then we can transfer it and which depends on the angular velocity of the disk. So, this is the transfer head we are going to say and this is the rate at which you are transferring a information which depends on the angular velocity of the disk.

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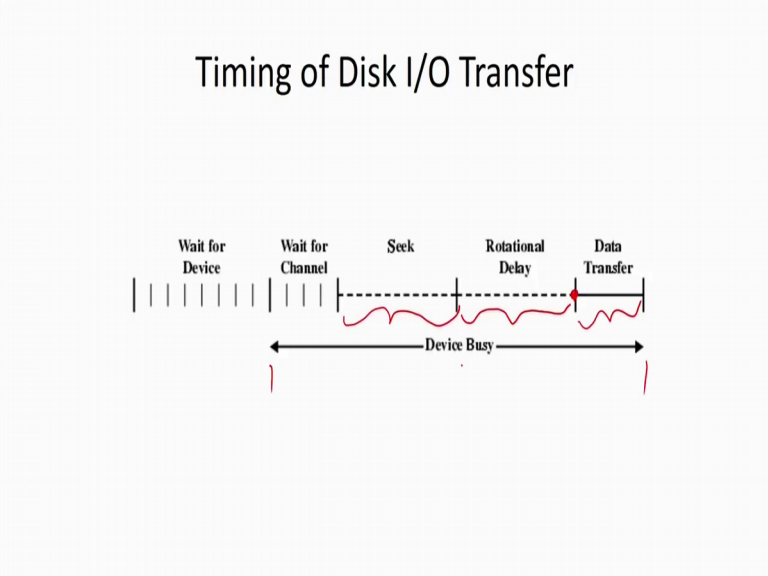

So, finally, this is the timing diagram just we are saying say; this is a wait for device basically say and it is looking for the device then wait for channel basically. Now what

will happen that basically you can think about that I am going to get that system bus. So, in case of DMA controller, then what will happen? DMA controller will get hold of the system bus from the processor, so this is basically waiting for getting this particular channel to transfer? Then first point will come sometime is required for seek time to place the head in appropriate track, then some of the time will needed to bring the appropriate sector below the head.

So, this is basically seek time, and rotational delay is known as my access time. I am going to access my sector, then depending on the rotational delay is angular velocity it will take some time to transfer the entire block. So, this is the time required to transfer the information and this is the portion I can say the device is busy during transfer bus; getting hold of the channel then place a appropriate position seek time and rotational delayed and transfer it. So, this is the time required to transfer the information, and inside this is the device busy period.

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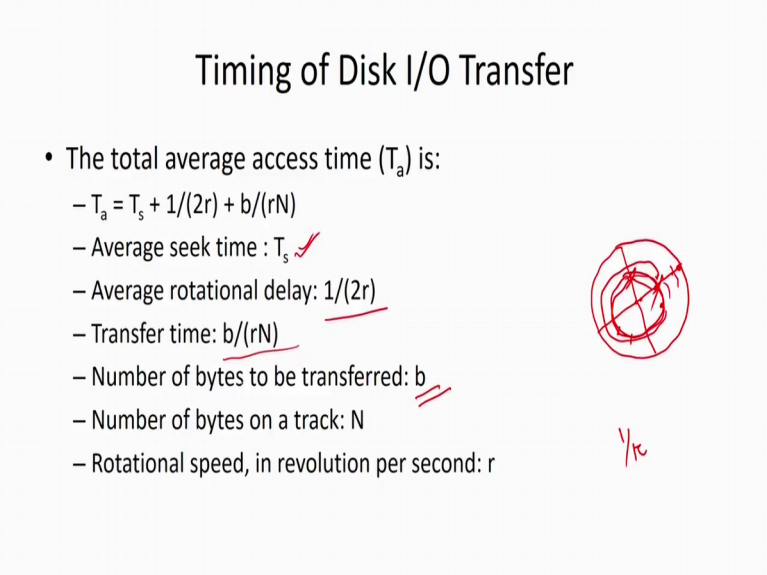

Now what is that timing of I O transfers? So, it depends on angular velocity. So, it says that the total average access time is T a. So, what is that T a basically? T a is nothing, but T s plus 1 upon 2 r plus b upon b by r N, so this is a disk, it is rotating in constant angular velocity. Now, what are those term that T s is saying that average seek time. So, what we are saying average seek time? Basically it will sometimes you have to move from outer

track to the inner track or sometimes you have to simply move one track only; say it is my head is here, but I have to go to this thing.

So, just I am taking a average. So, this is average seek time is your T s; now average rotational delay is 1 by T r. What is r over here? This is the rotational speed in revolution per second. So, if I am having say r revolution per second to make one revolution it will take 1 by r second, so this is 1 by r is going to give me the revolution for 1 cycle. So, now what I am going to bring the appropriate sector below the head and what will happen sometimes it have to rotate from this point to this point.

So, in that particular say in some time it is in the appropriate sector or in sometimes it is the very far sector. So, we have to rotate everything and bring it to here; that means, rotation of the entire disk. So that is why you are taking it is a average. So, if this from 1 to 1 where, so it is 1 by 2 at a average 1. So this is the transfer rate if I am going to number of byte to be transferred is b, so in case of and number of bytes on a track is N. So, it is b by r N is going to give me this particular transfer rate transfer time ok. So, basically in r 1 by r is time required to rotate one particular these things; now the number of bytes in your track is your N.

So, total in one revolution I can access those entire information and, but in one track sector I mean say b bytes per sector. So, we need we want to transfer only this b byte, so this is the transfer time b upon r by N. So it depends on the rotational speed of this particular disk, secondly the number of information that we are storing in a particular sector ok. So, this is the I O transfer. Now, for that we need one way I am going to work with these things while need an hard disk controller also. So, what is that hard disk controller does basically? It is going to handle the mechanical movement.

So, you have to rotate the disk, you have to move the read write head; to do all those things we have to initiate it, we have to give the signal from the processor and we are going to do all those mechanical information, then convert one from the other form. Now you just see that in hard disk what we are doing? We are storing information in magnetic form. So, when I am going to store it I am giving electrical signals, so 0s and 1 will be either stored as a 0 volt and some high volts. So, this electrical signal will be converted to magnetic property I am going to magnetize this particular disk. So this is your writing.

In case of read that magnetic property will be converted to the electrical one that electrical signal will be transferred to this thing.

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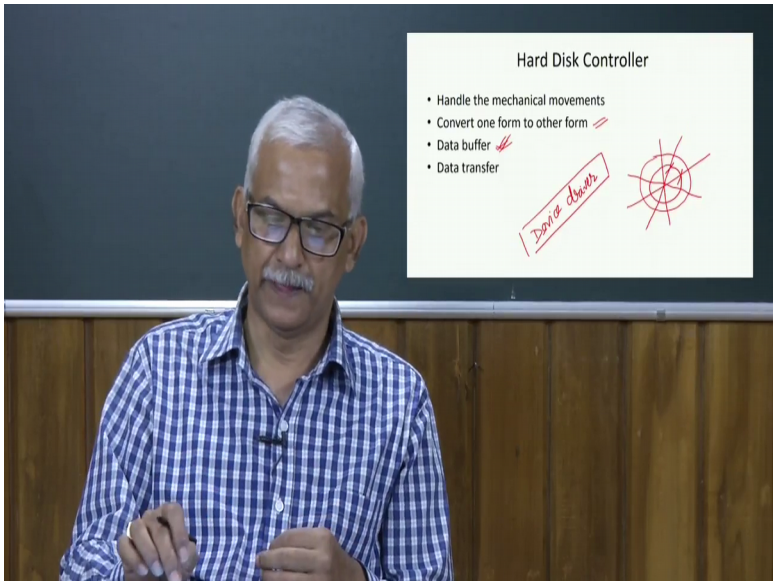

So, we have need to convert this information also from one form to another form, so from say magnetic signal to electrical signal or from electrical signal to magnetic signal. Then data buffer; now what I am saying that I am going to transport block version, what is a block? This is nothing, but the information in a particular sector. So, you are going to first collect the information and we are going to transfer it.

So, we should have some data buffering capacities also in this hard disk controller and along with that after that it should have this data transfer mechanism, we are going to transfer it from this particular data buffer to that time. So, this is the hard disk controller and to work with this particular hard disk we need an program ok. So, through that particular program we are going to control this particular hard disk controller. So; that means, we need an device driver, so because for every device we need a device driver which is nothing, but a software program.

So, we are going to have a device driver to control this particular hard disk controller. So, device driver is nothing, but an software routine and we are going to control this particular controller with the help of disk device driver, so we are having a disk device driver which is going to control the controller of the hard disk and appropriately transfer the information from disk to processor or processor to disk. So, these are the things that

we required when we are going to work with an input output devices and in this particular case we are just discussing about the hard disk, which will be used for input devices as well as output devices.

So, for input devices we are going to read file, I am going to process the information that process data again we have to store it we are going to store it in another file. So, this hard disk will be used as an input as well as output device. And these are the things required to work with hard disks we are having a hard disk controller which this built in the hard disk itself. So, it is going to have going to control the mechanical movement and we are going to control this particular hard disk, with the software driven which is known as your device driver or disk device driver.

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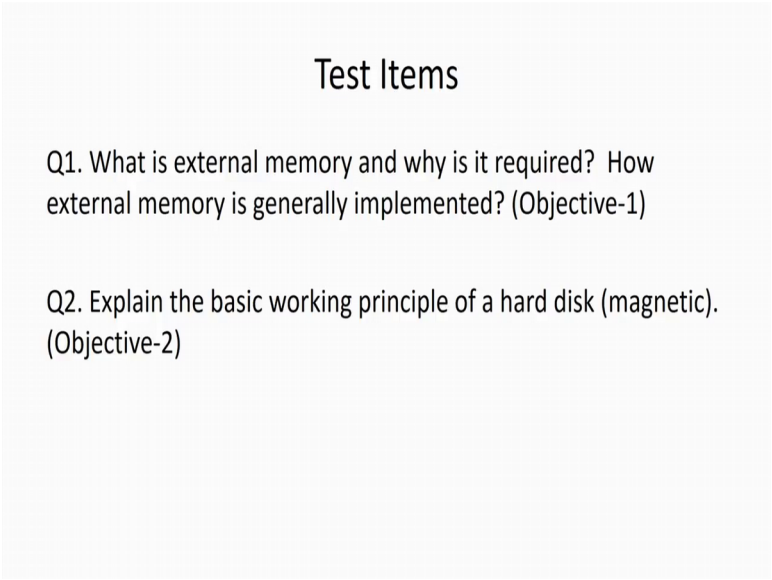

So, now that is all about the working principle of hard disk and just we are discussing in a nutshell, how it works? And how we are going to store information? And how we are going to organize the information? Now just look for some questions over here. So first question I am saying that what is external memory and why it is required? How external memory is generally implemented? So, this is basically tells the time to meet the objective one, already I have mentioned that that main memory is volatile in nature to permanent storage we need this particular external memory. And how they are generally implemented? It depends specific to the devices some are of magnetic in nature, some are optical in nature, so you know that magnetic disk or CD etceteras.

Now, question 2, explain the basic working principle of a hard disk. So, if you are talking about hard disk basically I am mentioning about the magnetic disk. So, this is the design principle I am asking, so working principle already we have discuss about the design issues of hard disk, so I think you will be able to explain these things also. So, we are meeting this objective 2. Now question number 3 how is data organized and accessed in a magnetic disk? I think we have explained it. It is a sector, track, and surface.

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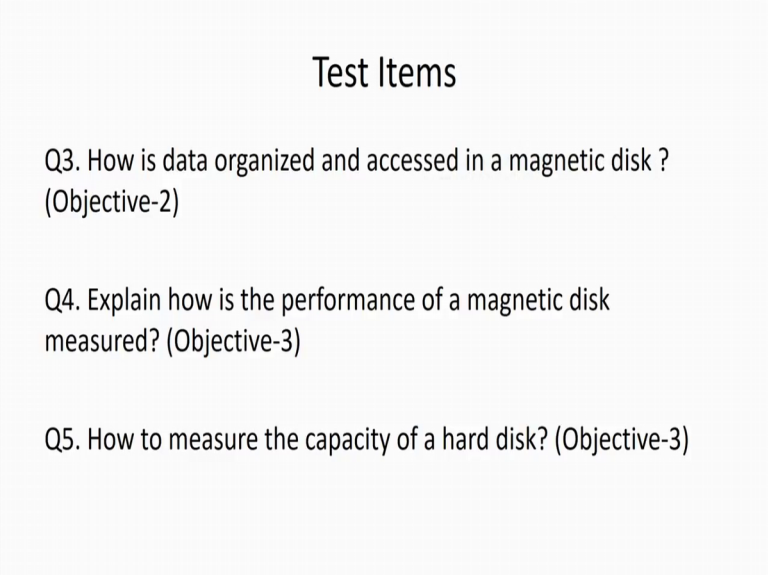

Explain how is the performance of a magnetic disk measured? So, this depends on the data transfer. How to measure the capacity of a hard disk? So, again you just see how we are going to measure a capacity of a hard disk; we know the number of track, number of sector, number of surface and the block size depending on this things we can calculate the capacity of the hard disk. Now performance of a magnetic disk is measured. It is basically related to the time required to the transfer a information. Now I think when we discuss about the addressing format I have mentioned something that we are having two format.

Now, again I said that effect of performance; now either we can use this particular format, or in this particular format. Whether does changing the format at this information whether it is going to have some effect of performance? You just see when I am talking about sector number, surface number and track number, in that particular case what will happen? I am reading complete information of a track. Then after completion of this

particular track we are changing the surface number; that means, from surface 1, we are going to the surface 2.

So, when we are going from surface 1 to surface 2; you just see this is a switching only; I am changing the head, now these things read write head number from this particular read write head to this particular read write head. So, this is only a circuit switching. We are having a circuit to just make it out and make it on, so it will hardly take any time. So, once you complete all the surfaces of that position; that means we are reading the complete cylinder. Once we read the complete cylinder then we are going to change the track number. So, we are moving the read write head.

So, this is a mechanical movement it will take time. So this is the way we are organizing our data and we are transferring it. Now second format you just see; first sector numbers, I am completing all the sector of a track. Then after that what will happen? I am changing the track number. When I change the track number from this track I am going to the next track, then there is a movement; mechanical movement.

So, for every track we are moving it, so it is having a mechanical movement. So, changing of track is going to take slight time ok. So you just see that I am changing it after completion of all the track, now I am changing a surface now which is nothing, but a electrical switching only. So, here you just see that a more number of movement of the head, so it will take more time. So, this particular format is going to take slightly more time when we are going to access the data from the disk. So, performance is less over here because access time is more now after completing every track there is a mechanical movement.

But in this particular first movement we are avoiding this particular mechanical movement; movement of the head after completion of one cylinder we are changing this particular head. So, you can now understand we are reducing the number of mechanical movement over here, so that is why this is going to give me a slightly better performance. So this is the things that what we are having about question 4; explain how the performance of a magnetic disk measured ok. So, this is basically you have to find out those particular component seek time, rotational delay, and transfer rate; transfer rate depends on the rotational speed of above ok.

Now, with this I am coming to the end of this particular module input output subsystem. So, you have discussed about the input output subsystem, we have seen that there are three ways of transferring information programmed IO, interrupt driven IO and DMA. Along with that I have just discuss about one particular storage device, how we are going to store information, and how it is become permanent and what is the organization of this particular hard disk.

So, once you understand the organization of the hard disk I think if you slightly go through the text book you will understand how we are storing information in our optical disk or CD. Because you are storing mechanism in optical, but other at this thing another format we will almost remain same because you have to identify the start of a sector. So, to discuss this particular input output subsystem we have divided the modules into 4 units.

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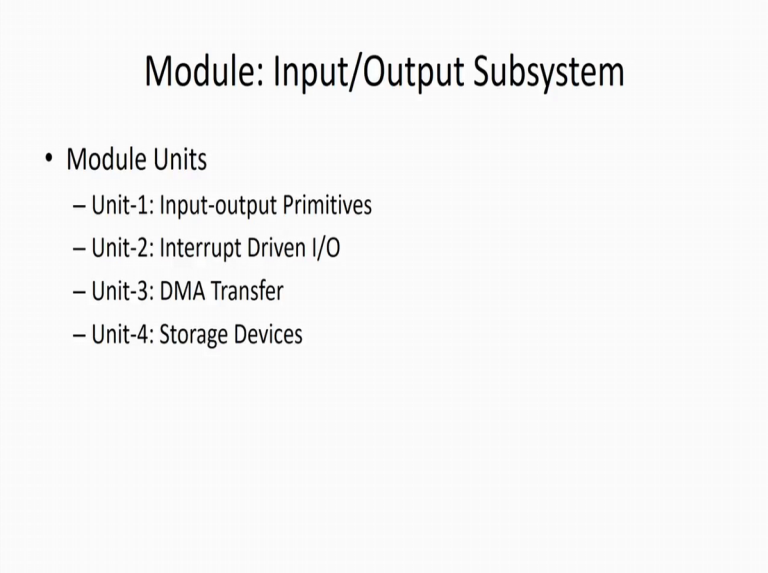

So this 4 units are basically like that, first unit is input output primitives, unit 2 is interrupt driven IO, unit 3 is DMA transfer and unit 4 is your storage devices. So, this module we have addressed with the help of this particular 4 unit. And in every unit I am giving some test item and question to see what are the concept that we have learned in that particular unit. Now after combining those particular unit or if you look the objective of all the units I think we have achieved the objective that we have cited at the very

beginning for this particular module input output subsystem. So, again I am just citing it what are our module objectives that we have cited.

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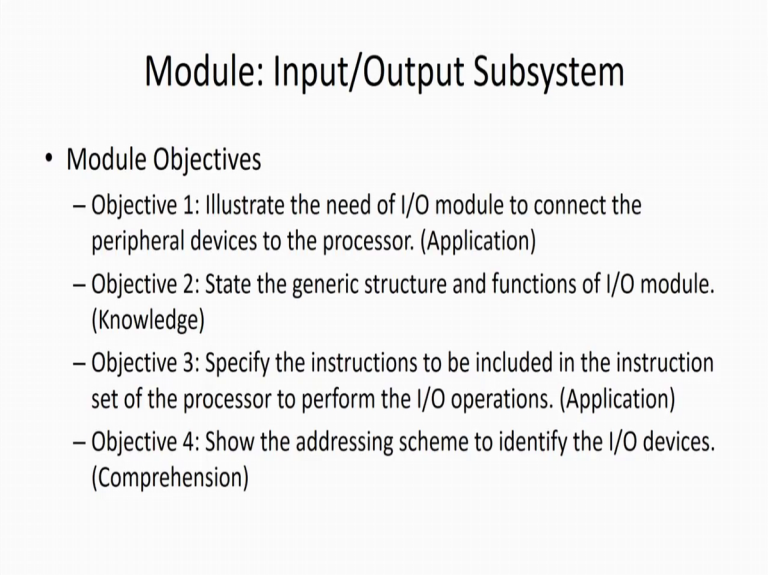

So, objective 1, we said that illustrate a need of I O module to connect peripheral devices to the processor, it is in the application level, I think now you have idea why we need that I O module? Why we are directing or connecting all the devices. Objective 2, state the generic structure and function of the I O module, thus in knowledge level we have discuss it that what are the components that we have and how it is going to interface the processor with the I O devices and how transfer takes place.

Objective 3; specify the instruction to be included in the instruction set of the processor to perform the I O operation. So, we need some I O instruction, already I have discuss it. We are having two ways of mapping it; memory mapped I O and isolated I O. So, for that we need instruction and we have said in which cases we need separate instruction, in which cases we can use the same sort of memory read and memory write operation. Objective 4; so the addressing scheme to identify the I O devices, we have explained it I think in unit 1 itself because after giving the addressing scheme then we have discussed about the programmed I O techniques.

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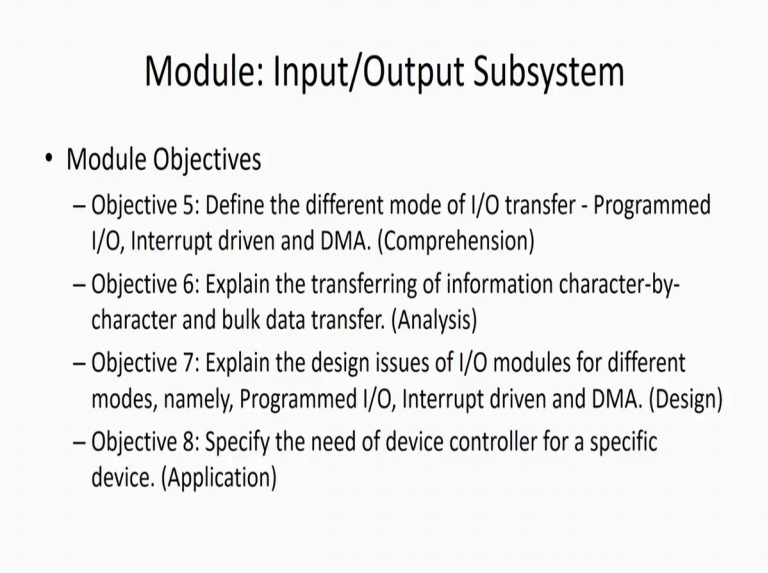

Objective 5; define a different mode of I O transfer like programmed I O, interrupt driven and DMA. So, in comprehension level we have discussed those things, objective 6; explain the transferring of information character by character and bulk data transfer. So this is in the analysis level, we have seen if it is basically DMA when we are going to use DMA, when we are going to look for a bulk data transfer but for character by character it may be your programmed I O, and interrupt driven I O.

Objective 7; explain the design issues of I O modules for different modes namely programmed I O, interrupt driven, and DMA. So, it is in the design level and I think we have explained about the design issues and I have mentioned that since we have discussed about the design of the control unit of the processor which is a more complex one. So, by knowing those particular design issues of the control unit of our processor these are very simple one; you can follow the same similar approach and you can design this particular control unit also.

Objective 8; specify the need of device controller for a specific device. I think we have mention about the device controller for your hard disk like that for every devices we need a device controller and this device controller will be controlled by a device service routine. So, whatever objective we have cited at the very beginning of this particular module I think we have made this particular objective after going through the units of this particular module.

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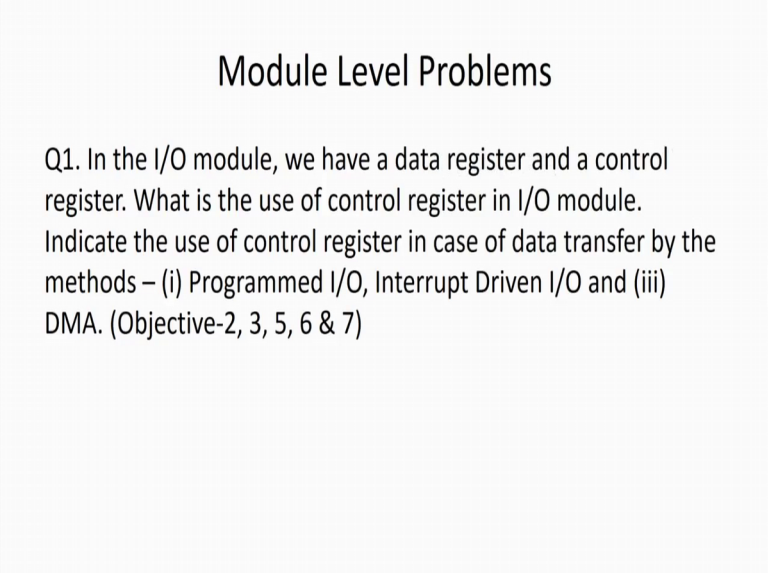

You just see we have in some module level problems; let us see now to solve this particular program, we need the knowledge of the entire model; that means, we need the knowledge of those particular 4 units. I think very simple question I am putting over here so that you can visualize it; it is a question 1, what I am saying. In the I O module we have a data register and a control register.

What is the use of control resistor in I O module? Indicate the use of control register in case of data transfer by the methods, programmed I O, interrupt driven I O, and DMA. So, if you can able to solve these things and to solve these things we have made the objective 1, 3, 5, 6, and 7. So, these are the objective already I have cited over here. So, you can solve this particular problem basically you are meeting the objective those particular objective.

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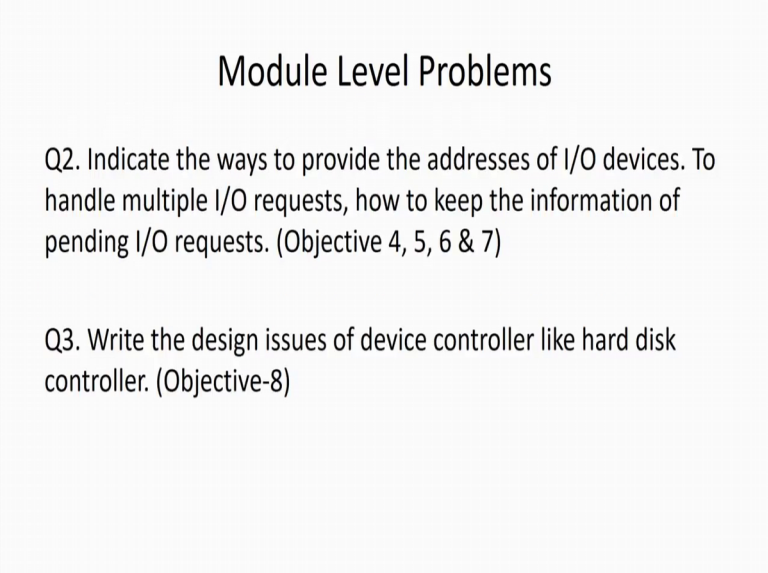

So, similarly question 2 I am saying that indicate the ways to provide the address of the I O device. To handle multiple I O requests, how to keep the information of the pending I O request. So, already we have discussed it how to handle multiple interrupts or multiple I O devices. Sometimes we have to assign priorities, so we have to maintain everything, so for that we have to design the appropriate controllers. So, if you can able to do this thing then we are meeting the objective 4, 5, 6, and 7.

Question 3; write the design issues of device controller like the hard disk controller. Now we have discussed about it I think this is a simple question I am giving just see what are the design issues that we have. Basically when we are going to design the controller for hard disk at least you should have mechanism to move the read write head, you should have mechanism or you should have a motor to rotate the platters and all those things need to be control appropriately by a control logic, so this is the issues that we are having.

And if you can do this thing; that means, you are meeting the objective. So, with that we are coming to the end of this particular module input output subsystem and if you now go to the study material that already we have mentioned in the module learning strategy I think you will be able to understand and I think you will able to grabs the need of input output subsystem. And what are the functionalities of those input output subsystem. So, with this I wind up here today.

Thank you very much.