Work System Design
Dr. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology – Roorkee

Lecture - 32
Cycle Graph and Chronocycle Graph

Namaskar friends. Welcome to session 32 in our course on work system design and currently we are in the 7th week of our discussion on this topic. This is an important topic from the point of view of understanding that how we can improve the current method of doing the work and if you see that what we are discussing for the last maybe probably 3 weeks we have already completed.

We are trying to find out or learn tools and techniques that help us to represent illustrate diagrammatically represent or graphically represent the methods that we are following for doing the current work. If you remember the cases that we have taken, nurse is serving food to all the patients in the ward. That example I think we have taken in two, three different sessions.

Then, we have seen a material type of flow process diagram in which the material is being received and then we are tracing the path of the material inside the shop floor before it is being stored in the bins or it is stacked. So we are trying to see that when the work is being done, it is being done in a particular manner, that manner may not be the best manner for doing that work.

There can be a scope for improvement and what is that scope for improvement that we are trying to identify by graphically representing the way we are doing the work in the current form and for that we now know so many different techniques. I think if I ask you to pen down all the techniques, all of you will be very easily able to write the names of at least 5 techniques of graphically representing the different types of work being done in the organization.

So we have seen the analysis level maybe different, at top level or at a very broader level of analysis, we may like to draw operation process chart. A more detailed version can be a flow process chart. Then may be at a very, very, very, very basic level when we want to see a

person doing a work, for example I am recording here, I am picking up this pen, so going to that level of analysis we can go to the micro motion study.

Or we can say we represent the basic body motions with the help of therbligs. So we can have a broader analysis or a bird's eye view of the organization and see the movement of men and material with the help of operation process chart and on the other end we can focus only on a person who is working on the shop floor. For him also we are focusing on the various body motions of that worker.

So that is basically a micro motion study and in the previous session we started the discussion for week 7 with the memo motion study which is a special form of a micro motion study. So with this I think we can now represent easily that how the work is being done and in many cases in most of the cases that we have discussed today we have tried to represent the solution also.

We have shown that for example a flow process chart, this is the current method or the flow process chart depicting the current method and side by side only we have shown that how the method was, how we have not shown but we have assumed that there can be a better method and the better method also has been shown. So the transition from the current method to the better method that is in between that critical examination of the current method using the questioning technique that we have not seen as yet.

And that we are going to see in the next session of critical examination technique or the questioning technique for developing a better method but by now our target was to learn different tools and techniques which can help us to depict the work being done and in that line only, in that sequence only, in that series only the last session today that we are going to discuss regarding these techniques is the cycle graph and the chronocycle graph.

We will try to see that how the cycle graph and chronocycle graph is different from the micro motion study and the memo motion study and how we depict the work being done by the operator. As I have already highlighted, the learners must not get confused that there are so many techniques of depicting the work which one has to be applied where, so that depends upon the type of analysis that we want to do.

Now depending upon the type of analysis we will have a specific technique that we can employ and for each specific technique there is going to be a specific application area that this technique can be applied for this particular application area. To be fair, I must say that string diagrams which we have seen can be employed for redesigning our layout.

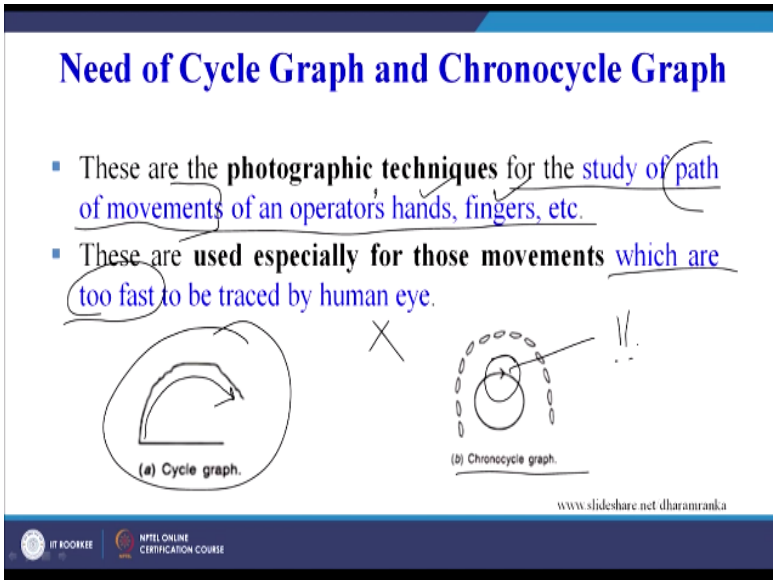
So when we have to change the layout, when we have to reduce the movement of men and materials in a particular shop floor or when we have to reduce the lot of congestion or backtracking movements in the shop floor we will follow the string diagram. String diagram will help us to identify the routes which are congested where there is lot of movement of men and material where there is unnecessary movement of men and material.

And it will help us to reallocate, relocate the facilities on the shop floor for minimizing the congestion, for improving the way the men and material are moving to reduce the transportation of men and material in the shop floor. So the string diagram has got its own applications. Similarly, when we want to analyze we want to economize the body motions of a worker we may refer to a simo chart.

We may film the whole operation, then we may try to identify the various therbligs and then with the help of the therbligs and the time recorded with the help of the timing device we can prepare a simo chart. So depending upon a specific application, we will select the specific method that we have learnt and all these methods have got their application areas and in the same line only cycle graph and chronocycle graph also have got their specific applications areas.

So what are the cycle graph and chronocycle graph? That is the object of our discussion today or the objective with which we are discussing the topic of work system design. Now what is the need of a cycle graph and chronocycle graph?

(Refer Slide Time: 07:36)



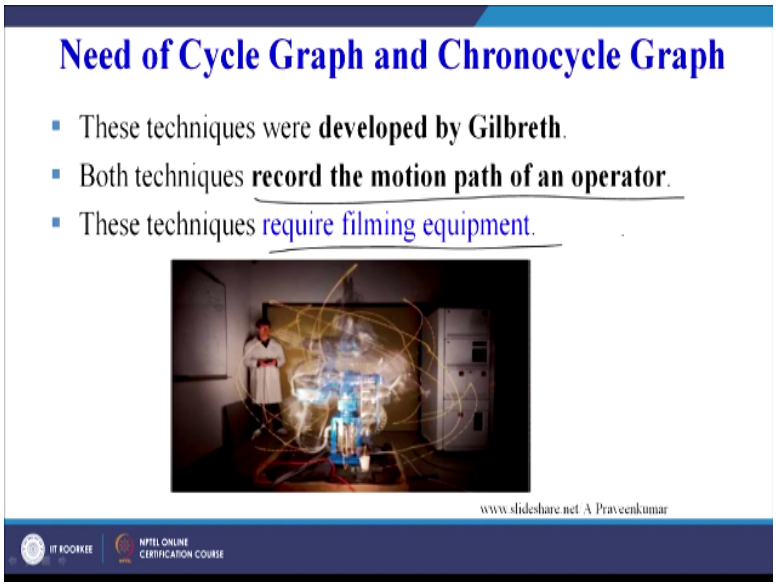
These are the photographic techniques for the study of path of movements of an operator's hands and fingers. So basically we are interested in studying paths of the hands or the fingers of a worker. In case of micro motion, we have seen the various body motions we are trying to study, the transport empty, transport loaded, grasp, hold, release, position, so there our focus is slightly different.

Here our focus is primarily on the movements or we can say the motions of the body parts, for example the hands or the feet whatever we want to study. So these are the photographic techniques for the study of path of movements. This is very, very important, path of movements of an operator's hands or fingers. These are used especially for those movements which are too fast to be traced by human eye.

So with human eye we may not be able to trace these movements or to identify these movements in that case we will try to trace them with the help of instruments, with the help of photography techniques. Now this is an example of a cycle graph which is showing a continuous movement of hand and this is showing a chronocycle graph and the direction also is mentioned here.

This direction is very, very important and we will see this direction, why this directionality, we are able to achieve this direction also or depiction of the direction also in case of chronocycle graph. So both are different but both depict the path of movement of the human hands or fingers. So need of a cycle graph and chronocycle graph these techniques were developed by Gilbreth.

(Refer Slide Time: 09:51)

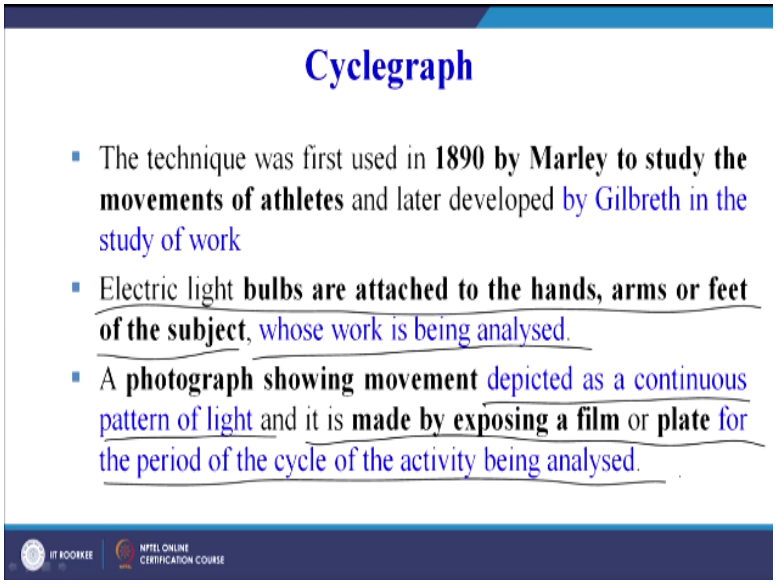


Both techniques record the motion path of an operator. These techniques require the filming equipment. So basically we have seen that the path of movement of a person, not the person but may be that can also be one of the special cases of chronocycle graph or cycle graph but majorly we try to trace the path of movements of the hands or the fingers. Why do we need to do this? we need to do this to economize the human effort.

There may be some wrong movements or some clumsy movements or sometimes the worker is getting confused every time when he or she is performing the work, so those clumsy movements can be traced and the worker can be trained to avoid those clumsy movements of the hands or the feet. So that is one of the outputs or one of the requirements for which we go for a cycle graph or a chronocycle graph.

Now let us first see cycle graph that what is the cycle graph and then we will go to the chronocycle graph and try to differentiate between the two but the major objective of both is to trace the paths of movements of the human limbs especially the hands or the fingers.

(Refer Slide Time: 11:06)



The technique was first used in 1890 by Marley to study the movements of athletes and later developed by Gilbreth in the study of work. So may be for example specially in case of cricket we have a problem of chucking maybe we can but a bulb or a sensor on the hand and try to trace the movement of the bowler who is trying to deliver the ball and that path of movement can be observed number of times.

And number of readings can be taken and a decision can be taken whether the bowler is actually checking or he is not checking. So that type of movement that is maybe for sports there are applications and many times when you are serving in lawn tennis the movement of the hand plays a very important role and in that case also it can be used in sports to see that what is the movement of the hand when you are serving the ball or serving the volley.

In that case also, athletes can use it to improve their actions or improve their body motions in order to improve their efficiency or in order to improve their performance. If you take an example of a discus thrower or a short putter, they also have coordinated body motions of feet, hand, torso and the shoulder so in that case also they can try to economize their body movements in such a way that their performance is enhanced.

In that case also it was started in 1890 by Marley to study the movements of athletes and later for the workers who are performing various operations on the shop floor or in the factory Gilbreth has used it for motion and time study. In this case what happens is electric light bulbs are attached to the hands, arms or feet of the subject whose work is being analyzed. So maybe we are having light source which will help us.

So basically we do this in slightly darker room and try to trace the movement of this light source and try to plot that light source and the movement or path of this light source which is attached to suppose my finger will give me the motion that my hand is moving in this particular direction. So the electric bulbs are attached to the hands for whatever limb or whatever body part we want to trace the path of movement.

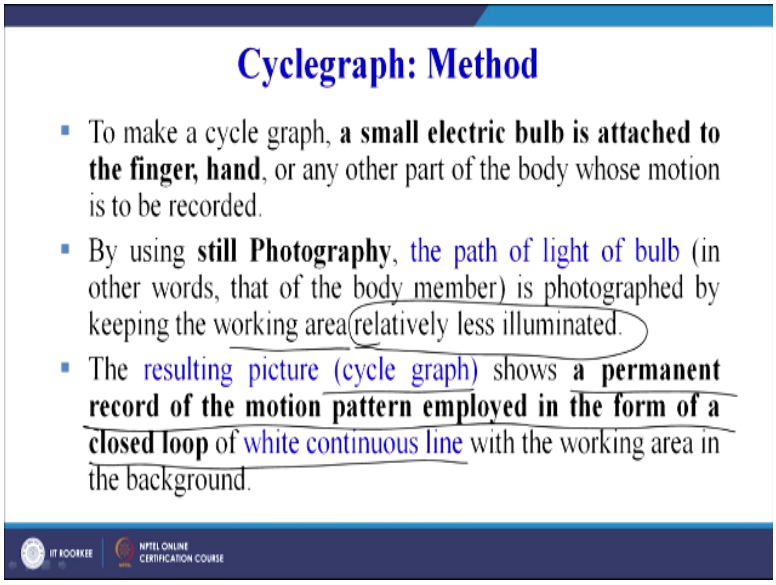
So for that part or that particular part of the body we will attach a light source which can be an electric bulb. In this case, it can be a LED lights also to the electric and if you can see that maybe this can be from the performance or entertainment point of view we have some dancers who attach all these lights to the different body parts and then in the dark they perform the various choreographic movements.

Those can be may be one example of this cycle graph or chronocycle graph so if the hand is moving very fast, we will see a different type of pattern and if the hand is moving very slow we will see a different type of pattern when the light source is attached to our hand but from application point of view our target is to economize these movements to reduce the clumsy movements to may be reduce the unnecessary movements of the human body when we are performing a work on a shop floor or when we are performing a particular operation.

So electric bulbs are attached to the hands, arms, or feet of a subject whose work is being analyzed. I think you have now been able to understand that what is the importance of using these cycle graph and chronocycle graph. A photograph showing the movement depicted as a continuous pattern of light and it is made by exposing a film or plate for the period of cycle of the activity being analyzed.

So you record this movement maybe using a picture and these pictures can be later on analyzed and I will show you some of the pictures today of the cycle graph and the chronocycle graph. So photograph showing the movement depicted as a continuous pattern of light and it is made by exposing a film or plate for a period of cycle of the activity being analyzed for whatever period of activity we want to analyze we will record this movement of this light source which is attached to the human body part.

(Refer Slide Time: 15:53)



To make a cycle graph, a small electric bulb is attached to the finger, hand or any other part of the body whose motion is to be recorded which I have already explained. By using still photography, the path of light of bulb in other words that of the body member because the electric or the light source is attached to the human body. So the path of light of the bulb is photographed by keeping the working area relatively less illuminated.

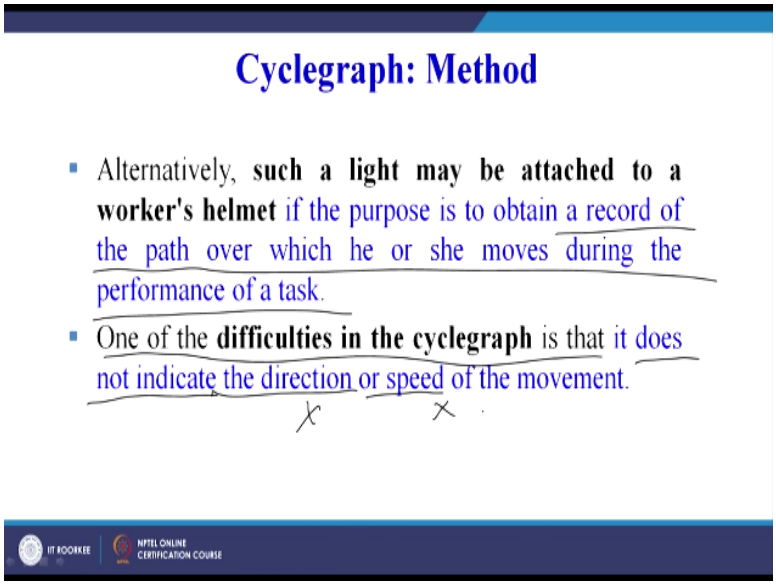
So less illuminated means that the light is less, the illumination is less, so this may be one of the deterrence for the worker who is performing his task. In one of the principles of motion economy if you remember we have studied in the previous week, proper illumination must be there when the worker is performing the task and this is contradicting that that we must have lesser illumination.

Why? Because we want to record that light source that is the body motion of the worker that is depicting the body motion of the work. So may be slight contraindication is there but in order to economize the body motions we need to do this analysis, so therefore we may slightly reduce the illumination levels when we are doing or when we are doing the photography for preparing our cycle graph.

So the working area is relatively less illuminated. The resulting picture which we call as the cycle graph shows a permanent record of the motion pattern employed in the form of closed loop of white continuous line with the working area in the background. So we will see some examples, some pictures of cycle graph or how the cycle graph will look like.

So the resulting picture shows a permanent record of the motion pattern employed in the form of a closed loop or white continuous line, so this white continuous line is the illumination or the light produced by that electric bulb which is attached to the human body. So this is showing and the background the person is shown in the picture who is doing the task.

(Refer Slide Time: 18:06)



Alternatively, such a light maybe attached to a worker's helmet if the purpose is to obtain a record of the path over which he or she moves during the performance of the task. So if we want to see or we want to record the movement of the worker, the light source can be attached to the helmet and then the light source can be depicted that how within this room suppose a person or maybe a lady is cooking food or a person or a chef is preparing food in the kitchen and his movement has to be traced.

So light source can be attached to the hat or the cap and then in a slightly less illuminated area or working area the movement of the light source can traced and it can be seen that what are the necessary movements, what are the unnecessary movement, how the layout may be redesigned so that this movement is minimized. So it can be attached to the part which we want to analyze.

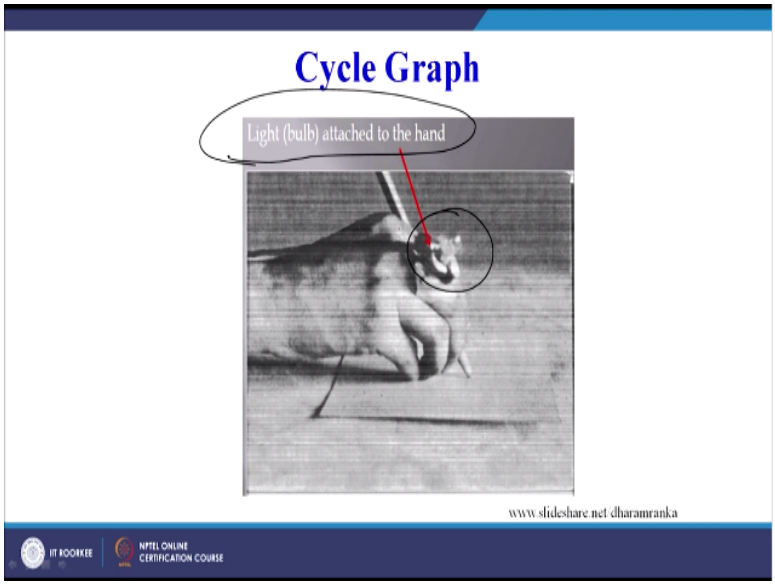
And if we want to analyze the whole body of the movement of a person in that case it may be attached to the helmet also. Alternatively, such a light may be attached to a worker's helmet if the purpose is to obtain a record of the path over which he or she moves during the performance of a task. One of the difficulties in the cycle graph is now how our chronocycle graph is better than the cycle graph it is depicted here.

One of the difficulties in the cycle graph is that it does not indicate the direction or the speed of the movement. It shows that this is the path but it does not show the direction that whether it will show a path, for example my hand moves in this direction and then same path it trace in this direction, so this direction will not be depicted that my hand is moving in this direction only.

I do not know whether the hand is moving in this direction or this direction but yes it will depict that there is a movement across this line. So that movement will be depicted without the direction. Moreover, the speed, I am moving like this or I am moving like this, the speed also will not be depicted by the cycle graph but this facility is there in case of a chronocycle graph.

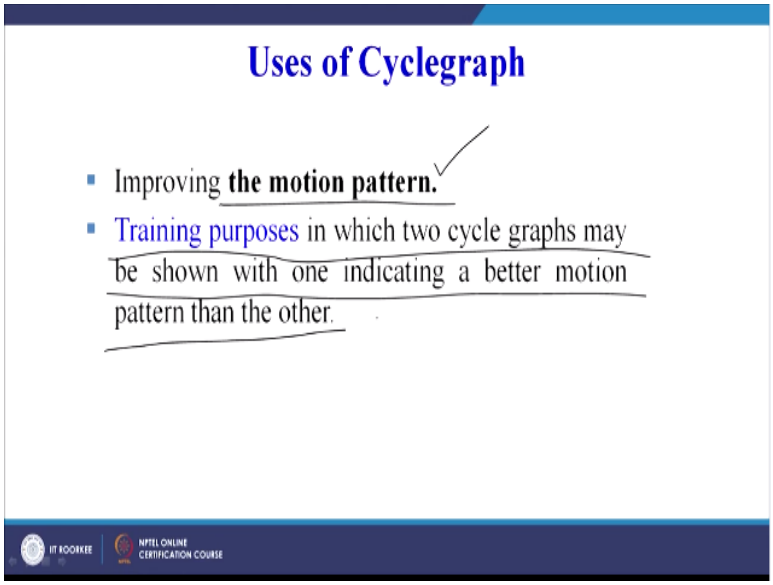
So the direction is not possible using cycle graph and the speed also is not possible using the cycle graph.

(Refer Slide Time: 20:42)



Now this is one cycle graph, how it can be depicted, light bulb attached to the hand and here we can see this is the light bulb which is attached to the hand. So the path can easily be traced and how the person is writing on the piece of paper.

(Refer Slide Time: 21:00)



Now what can be the applications of cycle graph, now all of you have become experts now in method study, you can very easily see that if we are able to trace the paths of movement of the human hand, we can very easily if I show you some of the pictures which are depicting the light source or the movements of the light source or the movement of the human body part you will say that there is so much of clumsy movements here.

It means the person is confused that how to perform the task accurately, there may be the task is being done in a haphazard manner or may be in a clumsy manner. So we can find out the areas for improvement. So we can see we can also identify that the work has to be done here, there are 3 movements which are just outside the working area, so we can think we can analyze that why this movement is there, this has nothing to do with assembly operation which the person is supposed to do.

So those unnecessary movements can also be identified with the help of a cycle graph. So this can help us to economize the motion of the human body or micro motions of the human body, so improving the motion pattern that is one advantage, that we can find out the best sequence of body motions or the hand motions which can help us to achieve the target of doing the work in the most appropriate manner, most optimal manner, most economical manner, most safe manner, most effective manner, more efficient manner.

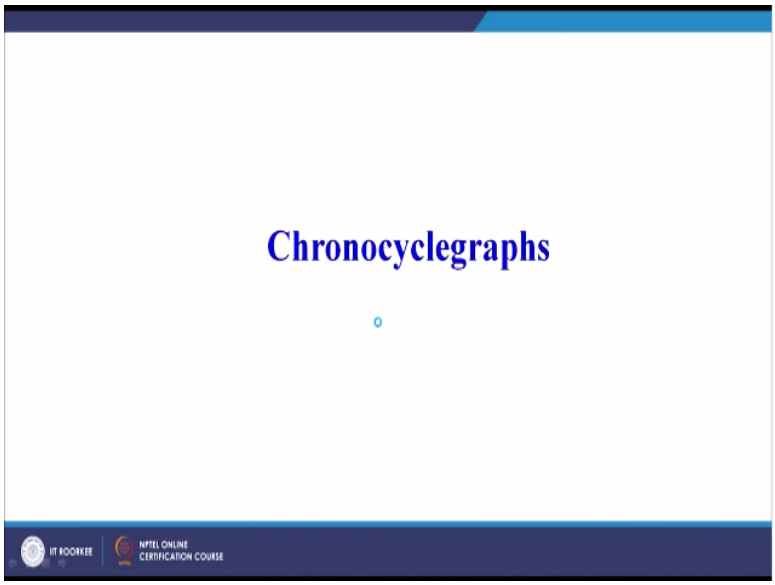
So it can help us to find out the right sequence of body motions which will help us to perform our task in a better way. Also the cycle graph can help us in the training purposes also in which two cycle graphs may be shown with one indicating a better motion pattern than the

other or in other words which I have been repeating numerous times that it can also depict the difference between the current method of doing the work and the improved method of doing the work or a better method of doing the work.

So we can call a meeting of all the workers working on a particular assembly operation and then we can tell them that this is the current method which you are following which is not correct which is leading to lot of fatigue and tired nature in all of you, so therefore if you follow this right method or the better method you will feel less tired after a long work or long shift of 8 hours.

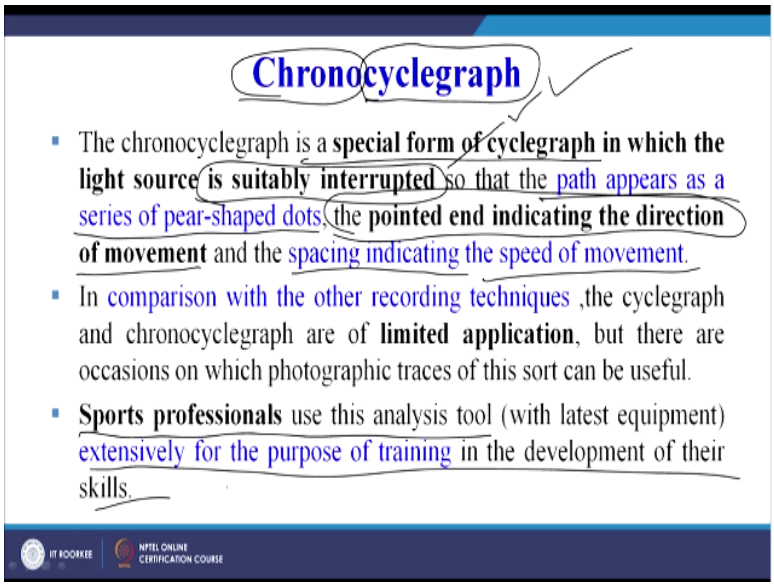
So they can then follow the better method for doing their work by adopting the right sequence of body motions.

(Refer Slide Time: 23:52)



Now let us quickly move towards the chronocycle graph, a very busy slide but we will try to understand, if you have understood the basic purpose of cycle graph how it can be made then very easily you will be able to understand the chronocycle graph also.

(Refer Slide Time: 24:07)



Because this much portion already you have understood, only thing is the chrono part and chrono if you can understand the literal meaning of chrono it is related to time and now time has been incorporated into the cycle graph that we will try to understand now and what are the two limitations of the cycle graph that we have already seen. What are these two limitations?

That the cycle graph is not able to depict the direction of movement of the human limb or the hand or the finger. So direction is one limitation of the cycle graph or the direction of movement is one limitation of the cycle graph and similarly it is not able to show the speed at which the limb is moving or the hand is moving. So both these things can be achieved using the chronocycle graph.

Now let us see the chronocycle graph. The chronocycle graph is a special form of cycle graph in which the light source is suitably interrupted. So that the path appears as a series of pear-shaped dots, the pointed end indicating the direction of the movement and the spacing indicating the speed of the movement. So these were the two limitations of the cycle graph and the chronocycle graph we are slightly modifying our light source.

That is the light source is suitably interrupted, so that the path appears as a pear-shaped dots. Now in case of a cycle graph, we have a continuous movement but here the light source is suitably interrupted and it is interrupted in such a way that the dots appear as pear-shapes and the pointed end indicate towards the direction of the movement. So very easily now using a chronocycle graph we can depict the movement.

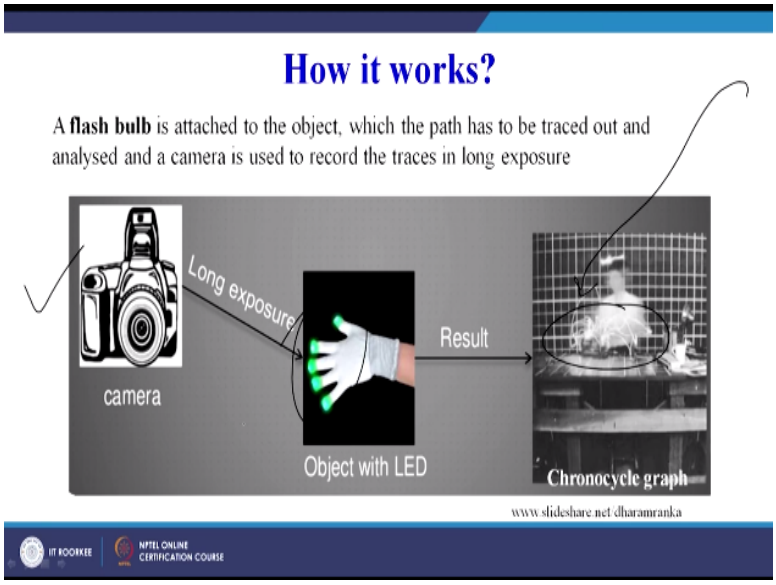
Now suppose my hand is moving like this, it can be very easily depicted with the dots and the direction also is possible because the dots are of pear shaped. Moreover, the spacing between the dots will also help us to correlate the speed of body motion also, the speed of the human body motion also, speed of the hand also. If it is very fast, the dots will appear we can say at a large distance and if it is very slow we will have dots accordingly adjusted.

So we will see that how the difference of the dots will depict the speed of the human body limb or the human body or the hand or the finger wherever the light source is attached. So we can very easily understand that with the help of a chronocycle graph by adjusting the light source or by suitably interrupted light source, we can very easily depict the direction as well as the speed of the human limb or the body motion.

In comparison with other recording techniques, the cycle graph and chronocycle graph are of limited application but there are occasions on which the photographic traces of this sort can be useful. As I have very clearly indicated in the beginning of today's session only that each technique that we are learning has got specific application areas and therefore cycle graph and chronocycle graph also are limited in their application to specific areas only or specific applications only.

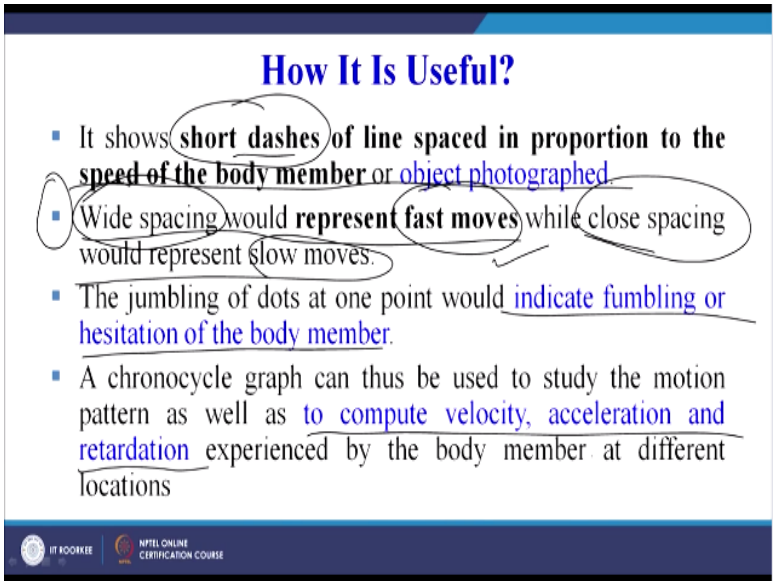
Sports professionals use this analysis extensively for the purpose of training in the development of their skills and in the development of their skills for enhancing their performance. How it works, very quickly we can see.

(Refer Slide Time: 28:27)



A flash bulb is attached to the object which the path has to be traced out and analyzed and a camera is used to record the traces in the long exposure and here you can see the white lines are there, these are the traces of the movement recorded by the camera and we have this light source attached to the fingers. So the LED light source is attached to the finger and this is recorded with the help of a camera.

(Refer Slide Time: 28:58)



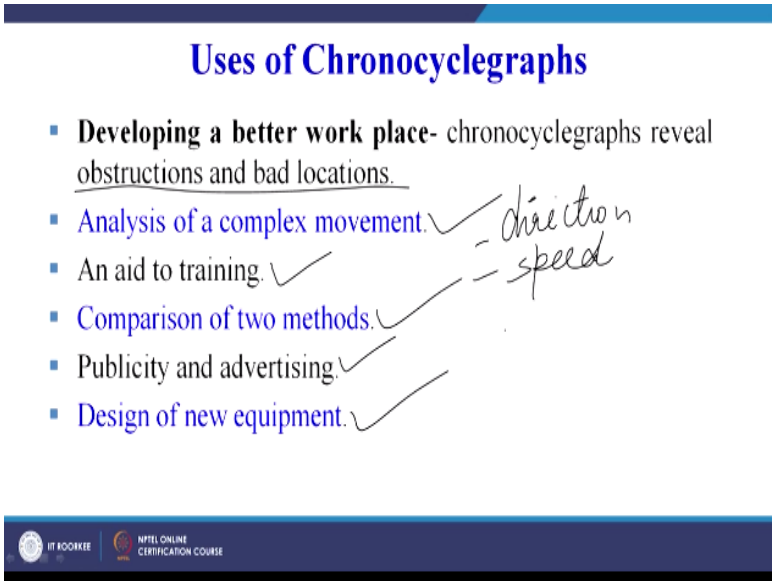
How it is useful? It shows the short dashes of line spaced in proportion to speed of the body member or the object being photographed, so short dashes or spots are used. These spots will help us to indicate the direction of body motion also as well as speed of the body motion also. This is very, very important, I have highlighted it again. Wide spacing would represent fast movement.

One record here, another here, wide spacing between the two dots shows fast movements. So wide spacing fast movement, close spacing would represent slow moves. So close spacing may be it is continuous so the movement is slow, very small gap between the individual dots so we will say slow movement. Wide spacing it means it is a very fast movement. The jumbling of the dots at one point would indicate fumbling or hesitation of the body member.

So this is what we have to try, we have to find out the clumsy movements also. A chronocycle graph can thus be used to study the motion pattern as well as to compute the velocity, acceleration and retardation experienced by the body member at different locations. At some place our hand is moving very fast, can easily be traced by the chronocycle graph or somewhere it is retarded, some movement is retarded.

Why it is retarded? We can analyze that and try to improvise on that, try to remove that retardation because of that may be because of any reason we can try to identify the reason and improvise on that reason.

(Refer Slide Time: 30:42)



Now uses of chronocycle graphs, it can be used for developing a better work place, chronocycle graph reveals obstructions and bad locations. Analysis of a complex movement can be done using because here both can be done; the direction of movement is also depicted as well as the speed of movement is also depicted. So we can try to analyze a complex movement, it can be used as an aid to training, it can also be used for comparison of two methods.

Numerous times I have explained; we can have a chronocycle graph or a current method. Chronocycle graph or a better method and both can be shown in a group to the workers. For it can be show publicity and advertising, it can be used for design of a new equipment. So design of a new equipment because wherever we see the movements or clumsy in that case we can try to develop a fixture or a device which can help the worker to perform the task in a better manner.

So with this we conclude the today's session. In our next session, we will discuss regarding the critical examination method for developing a better method of doing the job. By now we have finished all the tools and techniques which help us to represent the current method of doing the work and we have seen that how these can be useful for conducting the method study. Thank you.