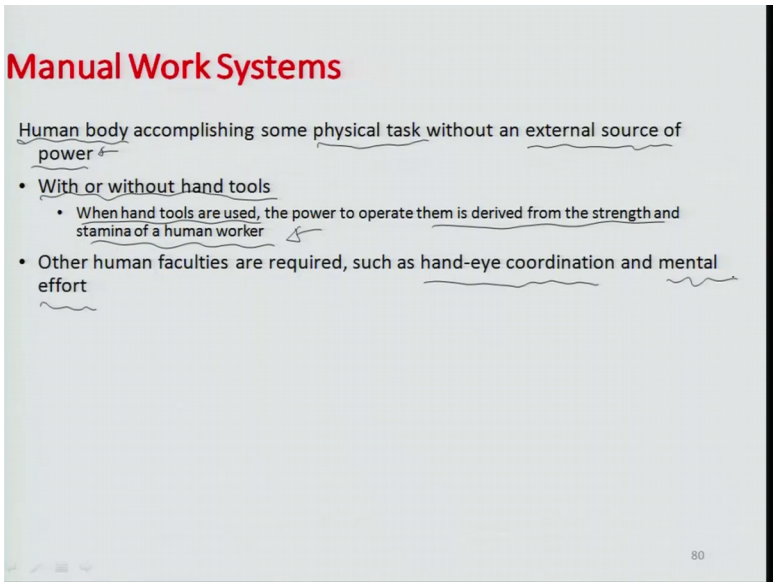
Applied Ergonomics
Prof. Shantanu Bhattacharya
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur
Dr. Ankur Gupta
School of Mechanical Sciences
Indian Institute of Technology, Bhubaneswar

Module - 02
Lecture – 09

Hello and welcome to this Applied Ergonomics lecture 9. We were talking about the different you know standard definitions associated with what is a work unit, what is unit operation. We also learned about the different systems including the completely manual system the man machine system and then the automated system how a work system can be classified.

(Refer Slide Time: 00:45)



So, let us talk a little more about the manual work systems. So, in the manual work system the human body accomplishes some task which can be a physical task and that to without any assistance from an external source external source of power for example, power tool.

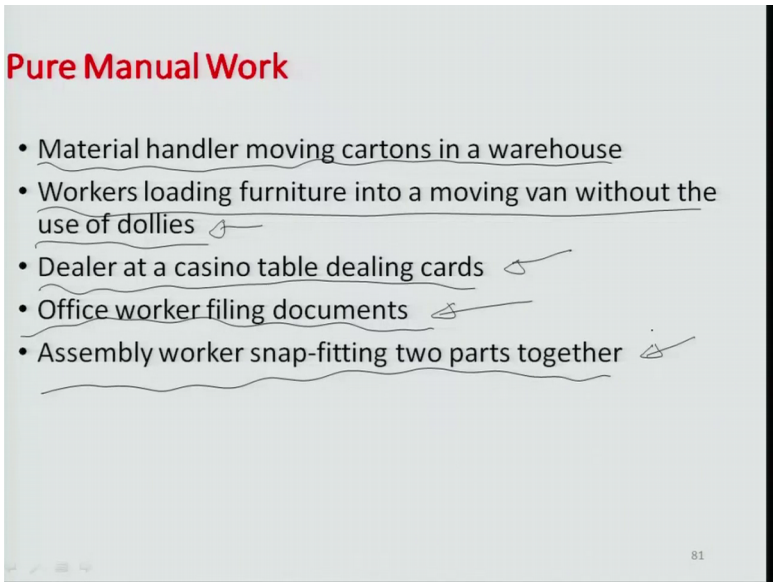
So, manual work systems could work with or without hand tools for example, something like a screw driver, hammer or a spanner which an operator uses to aid himself to do some operation or some activity is also a part of manual system because without using

the power of the human being that particular work cannot be done. So, this is one of the basic classification that even if a operator uses a hand tool is still considered to be a manual system because there is no separate power which is being given to that particular you know system to accomplish its task it is only the human power which is being involved. So, when a hand tool is used the power to operate them is derived from the strength and stamina of the human worker. So, that is why it is considered to be a manual work system.

So, other human faculties are also needed such as hand eye coordination, mental efforts these are without them you cannot accomplish any of these system like hammering for example, nail into a wall or for example, even tightening a nut and bolt where it is needed that some rotations be given you feel what is the torque of the bolt which is coming back to you through the spanner handle. So, these are all needing human involvement, human strength, human eye coordination, human hand coordination, mental effort on the part of the human being all these things are being involved.

So, such systems are known as manual work systems. So, I think you can work or you can look at whatever we have so far listed as an organized way of representing and critically examining work systems into such systems which are of the manual work system type, such system which are of the work machine type and such systems where there is an automation level involved.

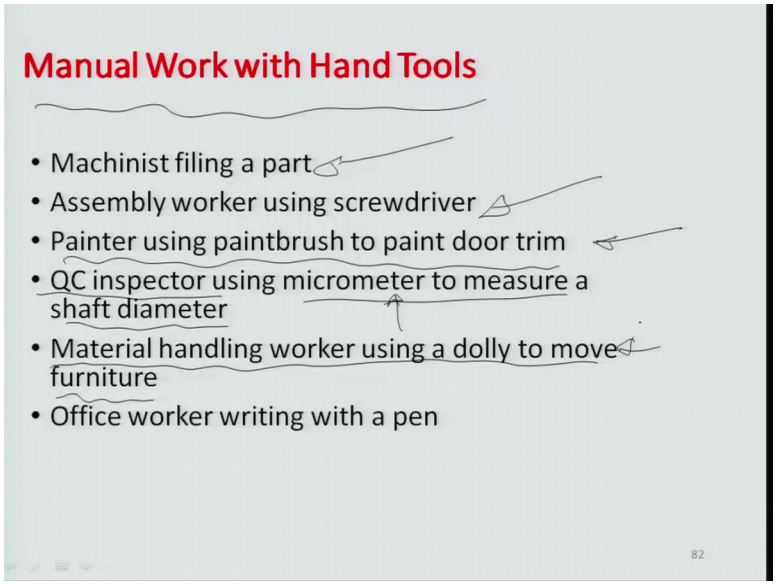
(Refer Slide Time: 02:43)



So, the pure manual work would typically be something like for example, a material handler moving cartons into a warehouse where you have to pick up the carton from somewhere using your hand or maybe a machine which again drives or its not powered it is just that using that for carrying the load from the point of its loading to the carrier trolley, but using completely your own effort.

Then workers loading furniture into a moving van without the use of dollies etcetera this could also be considered to be a pure manual work system, dealer at a casino table dealing with cards they again are completely based on hand eye motion and also stamina and effort on the part of the individual again a manual work system. There could an office worker filing documents into cardboards of an office which could again be a pure manual work system you could also have an assembly workers snap fitting two parts together whether you are using some hammer or something to drive off the fastener still it is the effort is being done by the particular worker. So, therefore, it is that is a pure manual work system. So, where no energy from external means no power from external means are utilized could be classified into such kind of manual work systems.

(Refer Slide Time: 04:02)



Let us talk of again manual work with hand tools for example, let us say machinist filling filing a part could be a manual you know manual effort on the part of a an operator again a manual work system there is a part there is a file of a particular grade, so you choosing what is that grade and then you basically rubbing the file on the top of the part and trying

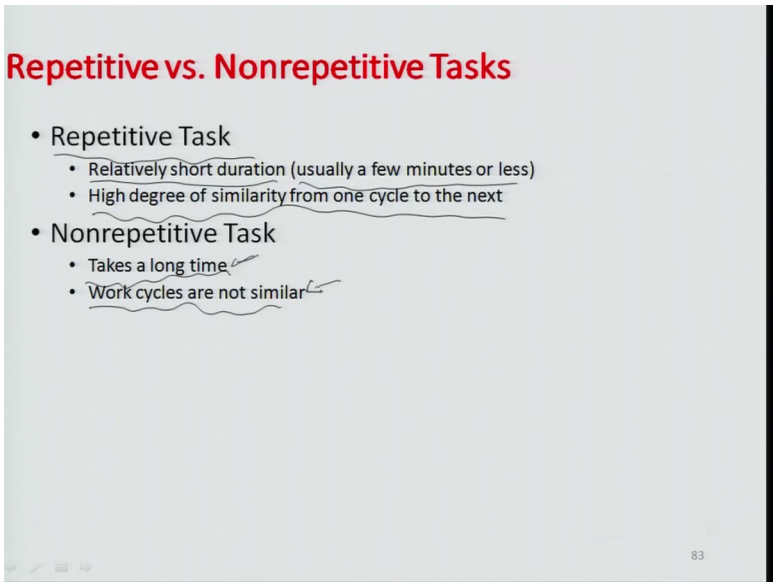
to see every time or inspect every time. So, a lot of hand eye coordination is involved lot of effort is involved.

Assembly worker using a screwdriver again is a manual work with hand tool the screwdriver here is a hand tool which gives you enough torque to turn a plus head system or a minus head system of a screw you have a painter using paintbrush to paint the door trim for example, of a door assembly. So, that itself is again a manual work system the precision accuracy in how you guiding the paintbrush. So, that it does not go off board and create a dent or create a paint spot in some other region other than where it is intended to would actually need a lot of hand eye coordination again on the part of the painter this is again a manual work system.

A QC inspector using micrometer to measure a shaft diameter using a tool to do that, but then again this tool the screws on the micrometer the way you grip the job the way you align the micrometer with respect to the job again is dependent completely on the inspector who is doing it, so that is a manual work system. Material handling worker using a dolly to move a furniture again there is a small hand tool which is used, but then again it is a manual work system because the dolly also is dependent on the guidance and the positioning done by the operator who is picking up that that piece of material to put it in some other place.

Again office worker working with a pen writing with a pen, pen is the tool which actually writes or creates impression on the top of a sheet, but then you are using the hand tool the pen to scribble something on a sheet which is again all your coordination, the mental effort, the physical effort as well as the hand and eye coordination all a part of the manual system. So, all these are quote unquote where you can say that they are completely manual work systems.

(Refer Slide Time: 06:26)



So, such systems are used to either do repetitive or non repetitive tasks and we can classify such systems to have delivered some task which are called repetitive where relatively short duration usually a few minutes or less is used for every step of that particular task and you basically repeating that every time and there is a high degree of similarity from one cycle to the other.

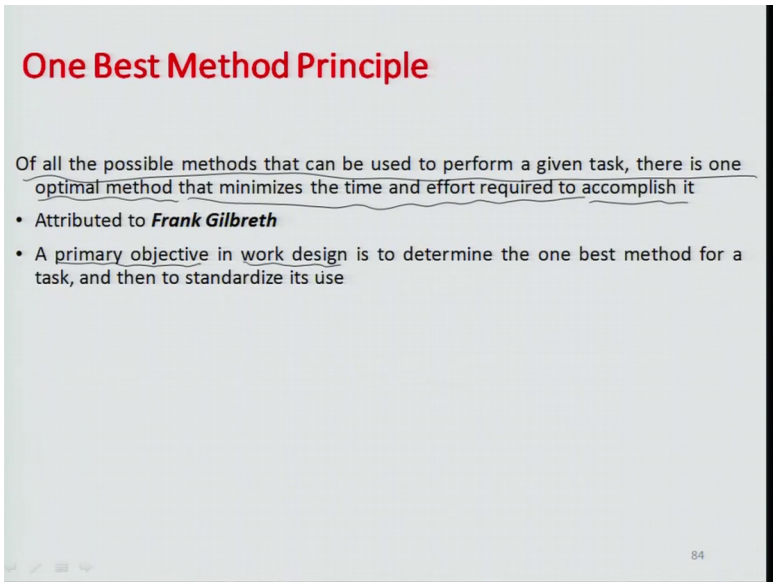
So, there is not much like for example, in striking a mark on a paper by a pen essentially writing a letter and then between the two letters there may be some small time change, but as you are scribbling one letter with respect to the other letter each of them is considered to be a cycle, at one stroke of the pen sometimes there is a letter where maybe multiple stroke is needed, but I am talking about those letters where there is only one stroke whether the pen coming off the paper that could be treated as a repetitive task on the part of the manual system.

There can be non repetitive task which takes slightly longer time and the work cycles are not similar for example, when we are talking about let us say you know cleaning the shelf of a particular office as oppose to stacking the shelf with respect to files these two are different tasks done in different point of times. The first step is actually involving just one kind of work or one type of work and the second is basically about shelf you know filling up those shelves with files and file holders. So, that is another kind of work, but both of them are spaced in time so you have different work cycles to determine both and

they are not identical or they are not similar to each other at all. So, these are non repetitive tasks.

So, any work system like this can be again which is manual in nature can be either comprised of those task which you repeat once and all or from time to time and another where you have set of task which once executed may not be repeated up till a very very long duration of time occurs in between right. So, you have to classify them into repetitive and non repetitive on that in that manner. So, what we want to now actually do is what has been actually stated by Frank Gilbreth I think I had mentioned this earlier while doing work study.

(Refer Slide Time: 08:44)

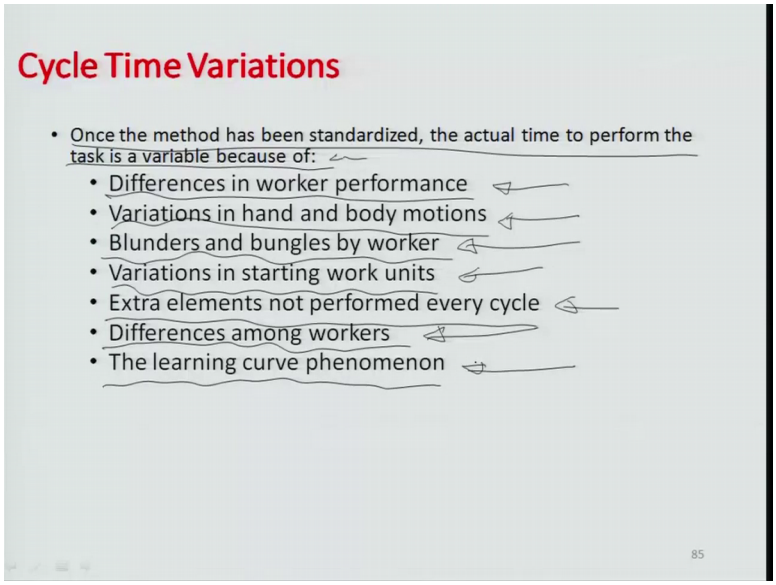


So, in case a manual systems the principle the basic principle which Frank Gilbreth assumed is that of all the possible methods that can be used to perform a given task there is probably one optimal method through which there will be minimization of time and effort required to accomplish the task. So, this becomes a sort of a primary work you know work design objective which is about how to standardize such work motions in terms of time in terms of different tasks or task sequences and how to determine the best possible method from those tasks so that its use can be standardized over the whole domain of operation. So, you have now very well defined quantum of task which is subjected to absolutely no variability even if there is a new operator a new machine which comes into place. So, the task system as such starts defining the various paradigms

which get associated in terms of machine component or the human component to a work system.

So, it is basically taking lead over the work system. So, that is all that is you know probably one of the most important utilities that this whole study in organized manner of work systems leads to. So, we will try to now see some of the reasons for if supposing there are repetitive operations now what is the cycle time variation and what are the reasons why cycles cycle time should vary.

(Refer Slide Time: 10:14)



So, once the method has been standardized, so the actual time to perform the task is variable because of differences in worker performances. So, you should have that component there and I am talking about now only manual systems in the similar manner I had talked about generally the field of work systems. So, I had told you about aspects related to a reading factor between different workers you know based on their ability to execute a particular task in a particular manner and their deliverability.

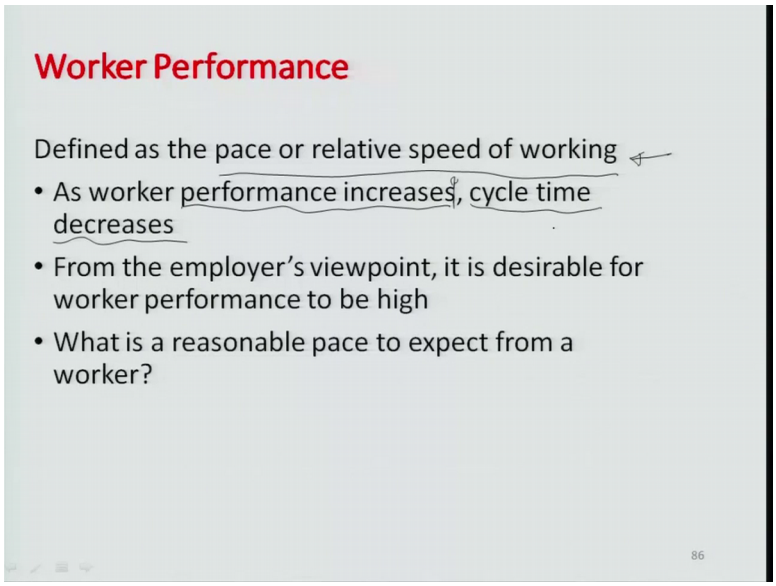
So, then there are variations in hand and body motions which can actually lead to again variation in cycle time there can be many kind of blunders and bungles by workers for example, in some cases workers may damage intentionally some production unit or let us say or some work unit and it may lead to again necessary rework which is there and then there is some idling aspect which is there of different workers, so their performance would vary based on that cycle time would vary based on that. There are variations in the

starting work unit supposing the start work unit arrives late to a particular station so; obviously, the cycle time would vary based on how late it is arriving, per unit of operation that is being done by that work station on to the different work units.

Then there are extra elements not performed on every cycle which could result in some kind of cycle time variations; obviously, let us say if the seat has not been mounted properly and there is a bolt which is missing and then you basically trying to torque the remaining bolts one bolt which is missing will not be torqued. So, that torquing operation has to be then now carried forward and that leads to overall there cycle time variation because an operation on which another operation suppose to be done could not get executed at the first place. So, that this operation this later on operation also does not get executed. So, it leads to a change in cycle time.

There are many subtle differences and major differences between workers every worker may not have equal amount of attitude or skill level to work and therefore, worker may be slow worker or a fast worker. And then there is of course, a learning curve phenomenon when supposing somebody is new as taken up on a particular line in a particular station. The person maybe not very organized to learn he may have a weaker learning or a or let us say a learning curve with a lower slope and a fast you know a overall longish learning time. So, in between all this happens and in between the worker becomes completely skilled there can be a huge amount of variation in the overall cycle time based on such issues.

(Refer Slide Time: 12:55)



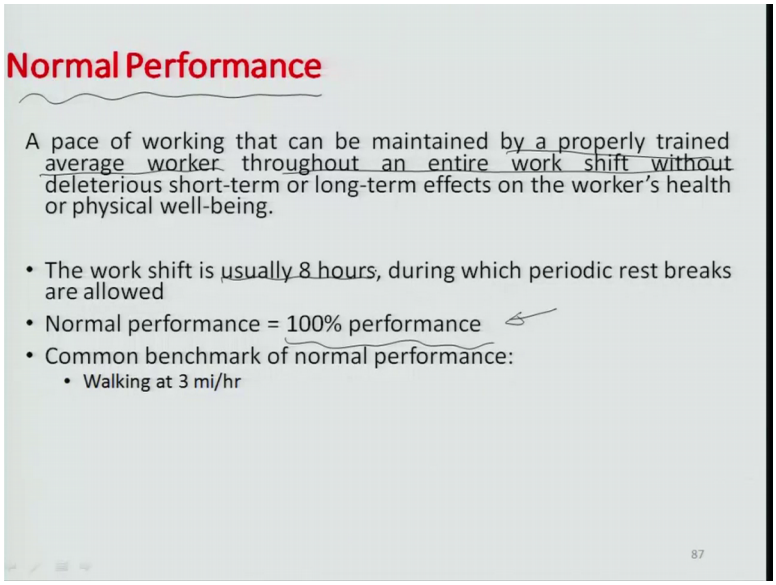
Let us talk about worker performance a little more detailed. So, defined as pace or relative working speed we could say that you know the performance increases and if that happens then the cycle time would automatically decrease because now the worker would be idle to the time that he has been overall given because he is delivering faster on it and this would give us a slack for us to actually load more work unit on that particular or let us say more task on that particular individual or activities so that the idle time can be eliminated.

From a employers point of view it is always beneficial that the operator performances higher or worker performances higher and; however, for a task study point of view and standardization post of view point of view, you have to consider the fact that one particular worker operating on a particular activity maybe very efficient and that may not really be a realistic time scale for any other worker to come and work on it.

So, you have to keep sort of reasonable pace at least knowledge wise to what you expect from a standard an average worker working in a particular activity or a particular task and this is one of the bases of how you gauge worker performance. And this comes as a matter of experience out of supervision experience maybe for a side slight longer duration of time where you yourself have worked on a particular area and then you gauging others who were working on that particular area for quite some years of experience at your back.

So, therefore, it is pertinent that you know the worker performance and gauge in terms of a normal performance.

(Refer Slide Time: 14:27)

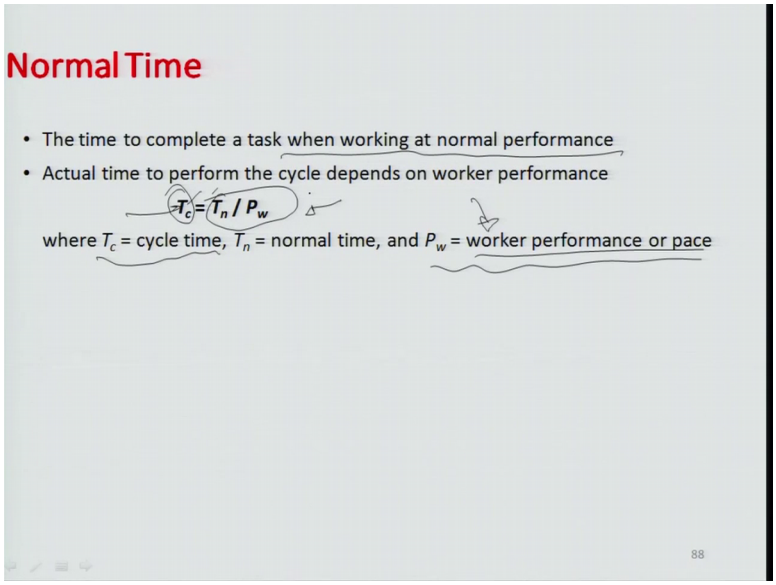


So, normal performance is typically hundred percent performance and not over performance, please understand that because of skill levels and because of different attitude of different workers there may be a case where a per delivers a worker delivers at a much faster pace. So, this is not a very good ideal assumption for a certain work time interval being given to a certain process because there may be variations in that quite a bit. So, there therefore, we are talking about the average time that we can allot to such a task or such an activity.

So, a pace of working that can be maintained by a properly trained average worker throughout an entire work shift is really what we are intending to when we are talking about normal performance or normal performance time the work shift is usually 8 hours. So, typically at the very beginning the efficiency level is very high in comparison to what is there towards the end and so therefore, an average normal time that can be done would kind of balance with an issue of worker trying to settle his total work content per cycle much faster towards the beginning and resting quite a bit. And then towards the later half of the day or later half of the shift efficiency falls down he has much lesser time. So, time normal time should be in a manner which balances the shift beginning shift and kind of problems which are there.

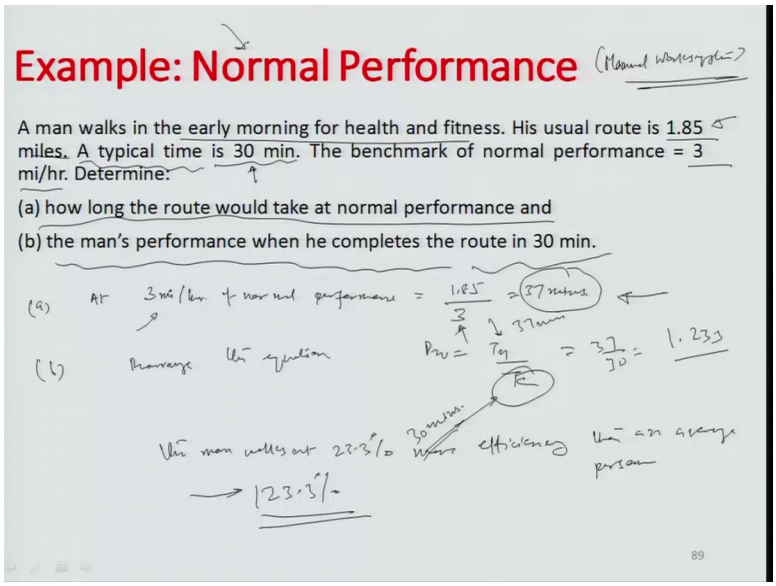
So, the normal performance is typically 100 percent performance and the common benchmark of normal performance needs to be made. For example, if a person is walking at a certain speed normal human being works at walks at typically 3 miles a hour, so that is the normal performance of an average individual an adult individual who is executing this action of working. So, I think in this case as well in manual system as well just what we learnt prior in case of generally work systems the time to complete a task when working at a normal performance is really related to the total cycle time, that a person would take multiplied by the worker performance or pace. So, if you look at this particular equation right here it talks about how you relate the cycle time to the normal time.

(Refer Slide Time: 16:21)



So, the cycle time is related to the normal time by T n by Pw where pw is the performance or pace of the worker. So, supposing a worker is working at 100 percent pace then in that event the cycle and normal time are equal. So, you know if the worker is less efficient then the cycle time will have to be more and if the worker is more efficient cycle time has to be less. So, this equation holds kind a valid for both the cases.

(Refer Slide Time: 17:05)



Let us look at an example to understand this more particularly in case of manual work systems. So, let us only talk about you know the walking a man let us say walks early morning for health and fitness and his usual route is about 1.85 miles and typically the time that is taken is about 30 minutes to accomplish this 1.85 miles the benchmark of normal performance is 3 miles an hour. So, that is how the normal speed would be sort of related and we have to determine how long the route would take at normal performance and if the mans performance, the mans performance when he completes the route in 30 minutes what is going to be that particular performance factor of or whether he is working at 100 percent or more than 100 percent or less than that when we talk about accomplishing that at 30 minutes.

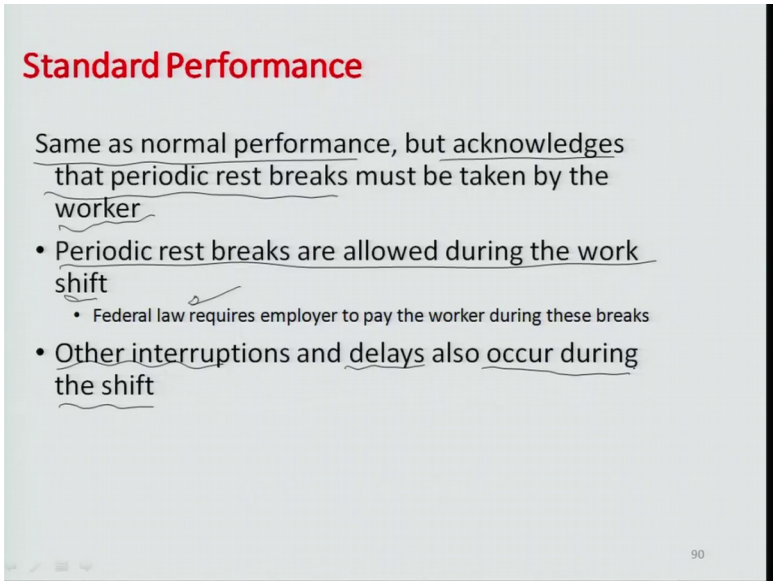
So, we know that at 3 miles per hour of normal performance of a person the total time that he will take to cover 1.85 miles is about 37 minutes. Now, therefore, you know he is you can say walking a little slow because earlier you know. So, typical walking a little fast than the normal performance because he is taking only 30 minutes and a person working walking at a normal speed or let us say a normal typical walking speed of 3 mile an hour would take about 37 minutes. So, its 7 minutes extra that some person will take working; he is working at a higher efficiency.

So, and if you wanted to compare how we calculate that efficiency, we will just simply rearrange the equation mentioned earlier as pw equals T n by T c, here the T c value is

the time taken by the individual which is thirty minutes you know his cycle time is 30 minutes and the T n that is there for a normal individual is about 33 minutes so; obviously, is about 33 percent more efficient. So, the man walks at 23.3 percent more efficiency than an average person or in other words he walks at 123.3 percent of what a normal person would actually do.

So, let us look at now standard performance. So, in manual work systems you see how normal performance is defined.

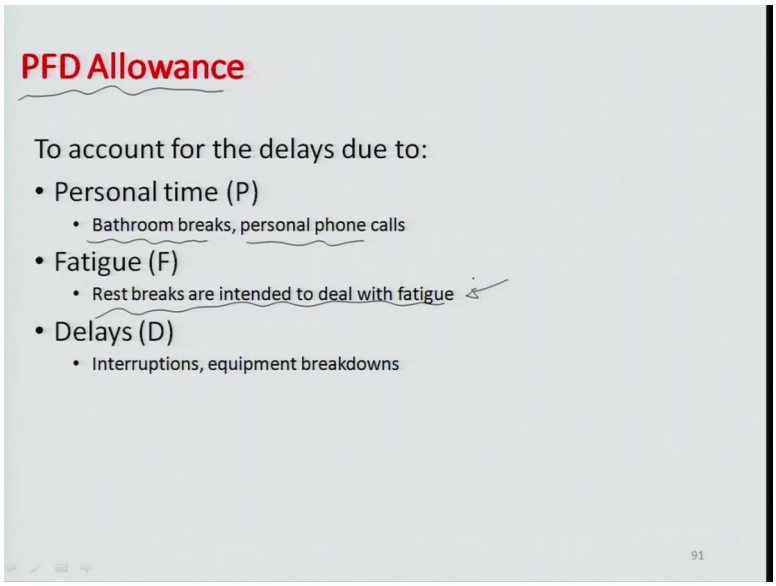
(Refer Slide Time: 20:06)



So, the standard performance again is same as the normal performance, but acknowledges that periodically he would need to take some rest breaks or some you know some maybe bio breaks or something which has to been by any human subject working on manual working system. So, the periodic rest breaks are allowed during the work shift and so there are certain governing laws you know which would need these breaks to be necessarily there considering the humanistic aspects or the regulatory aspects of the you know generally human subjects associated with human subjects.

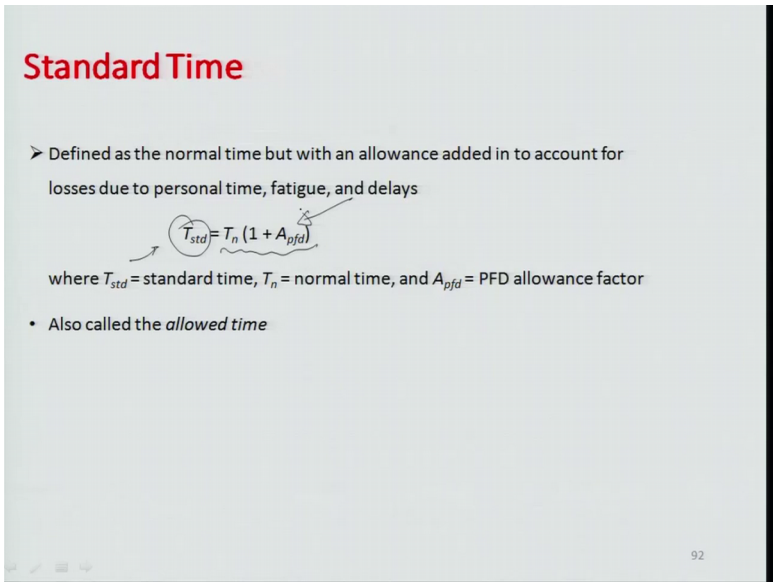
So, therefore, this time has to be introduced as the slack time on to the overall normal time of an individual or a operator and there are other interruptions which could happen for example, there can be delays there can also be some kind of you know machine break down or something which happens because of which there are certain you know stallings in the normal activity associated with the manual performance.

(Refer Slide Time: 21:18)



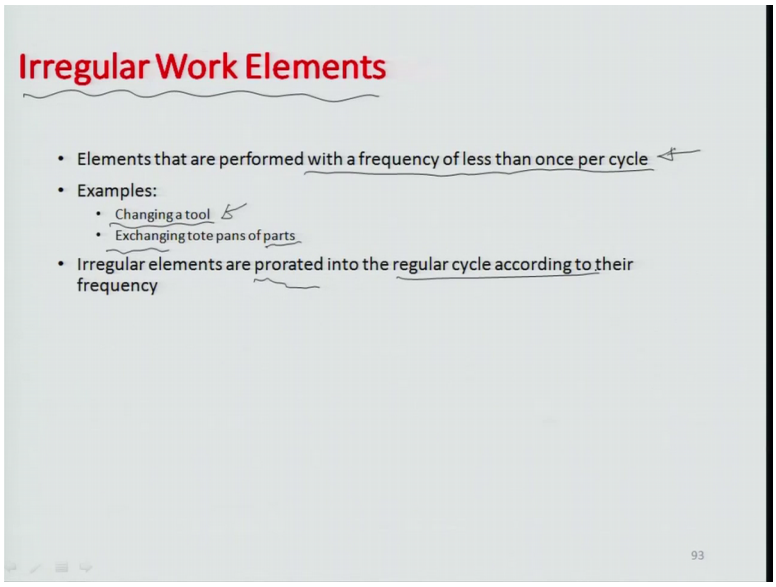
So, therefore, we need to club in this case also a sort of an allowance you know which could be also better recorded ad PFD allowance - P means personal times its basically something related to bathroom breaks, personal phone calls attending etcetera, F is the fatigue time which is sort of rest breaks which are intended to deal with fatigue. So, in all assembly lines for example, there are relieving of work stations which are being carried out in a cyclic manner of all the operators involved in the assembly line because they have to take this rest period for avoiding fatigue and avoiding quality losses, which otherwise would happen because of the higher quantum of work being done by an individual. Then there are allowances related to delays for example, interruptions because of equipments or material not arriving in time online because of which you have to count for these allowance times, and so therefore, there is always an allowance time in this case also just as we did the overall work system design we did all these allowances here.

(Refer Slide Time: 22:07)



So, the standard time which comes out is typically more than the normal time accommodating this allowance factor or the allowed time is T n by T n times of one plus a PFD.

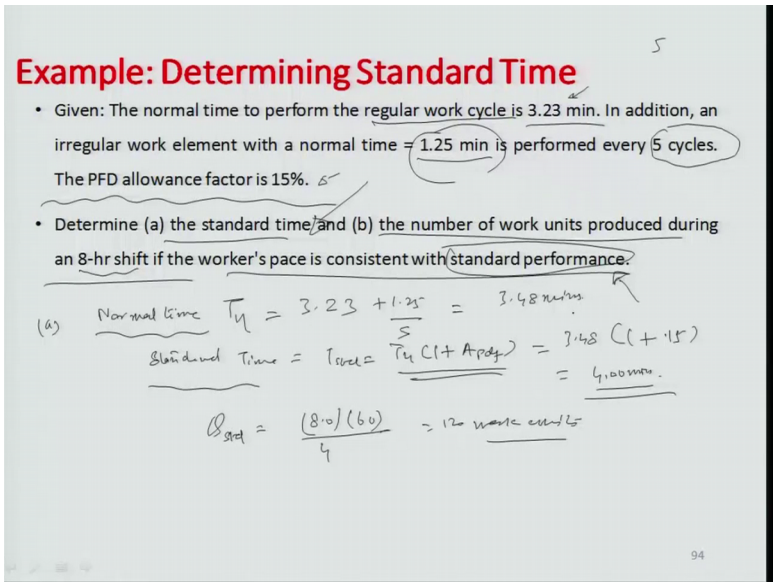
(Refer Slide Time: 22:28)



So, there can be a lot irregularity in the work elements for example, elements can be performed with a frequency of less than one per cycle sometimes. So, examples are changing of tool for example, you know that can be a source of sort of irregular work elements which come up front you are not planned to change the tool in between and the

tool breakage happens or there can be something related to exchanging of let us say bins of parts when some part which has come is not appropriate or maybe quality compromised. So, those kind of irregular work elements do pop up from time to time in a work study and therefore, it is imperative for inclusion or for including some of these regular elements as a prorated you know time into the regular cycle time associated with different frequencies.

(Refer Slide Time: 23:33)



So, if I wanted to look at you know how the standard time can be determined. So, let us say we have a case here that the normal time to perform a regular work cycle is about 3.23 minutes and in addition an irregular work element with a normal time of 1.25 minutes is performed every 5 cycles. So, this does not come up in every cycle, but after every 5 cycles this irregular work element sort of comes in and we have a you know performance fatigue delay factor allowance factor of about 15 percent in case of manual work systems. So, we determine what is the standard time and then we also determine the number of work units produced during an 8 hours shift if the worker pace is consistent with the standard performance.

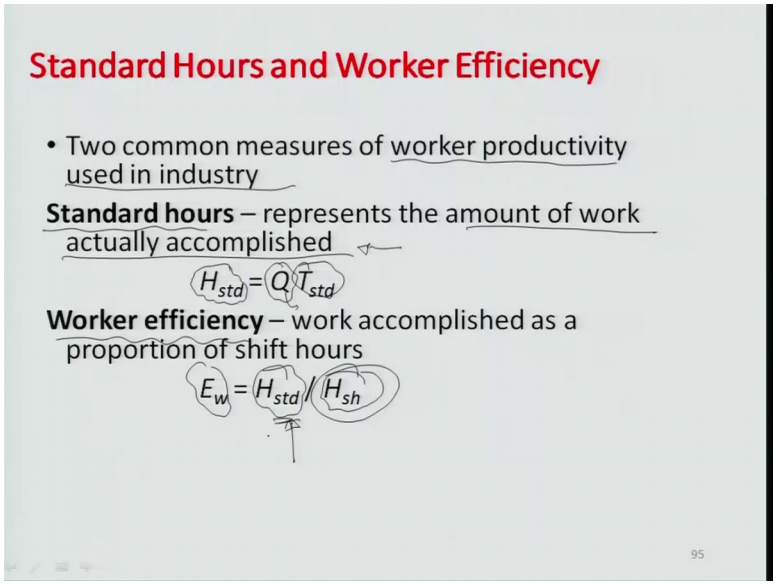
So, let us see how we do this. So, in first case the normal time that comes up T n can be recorded as the regular work circle cycle time which is 3.23 minutes and let us say if out of every 5 cycles we spend an addition of 1.25 minutes. So, per cycle there is an addition of 1.25 by 5 minutes which gets added up uniformly in order to result in this 1.25. Now

here the 1.25 times irregular work cycle happens after every 5th cycle, but we are taking this time into account as an average between all the 5 cycles to ease our calculations or procedures.

So, this comes out to be 3.48 minutes and we want to determine the standard time. So, the standard time as you know is dependent on the allowance factor. So, basically standard time is nothing, but the allowance time the normal time times of the allowance factor which is there as we calculated earlier. So, in this case it is 3.48 times of 1 plus is a 15 percent performance delay performance fatigue delay factor. So, let us say 1.15, so this becomes about 4 minutes.

So, the standard time for this cycle would become now 4 minutes and if I wanted to determine how much number of work units would be produced with standard performance of a 8 hour shift. So, the total amount of standard work unit which can be produced in a 8 hour shift is 8 into 60 divided by 4 which is about 120 work units. So, this is how you actually calculate the standard time as well as the standard performance of a in terms of numbers produced in a work system.

(Refer Slide Time: 26:01)



So, therefore, two common measures which would associate with manual work systems and give an essence of worker productivity in industry are standard hours which typically represent the amount of work actually accomplished. So, therefore, the total standard time for example, for producing Q units which is done in let us say one particular shift is

essentially Q times of how much standard time would be associated with each unit of production. So, Q times T std, T std becomes H std.

And if I wanted to compute the worker efficiency based on that out of a otherwise available shift hour H shift let us say. So, the efficiency is at how much standard you know time or standard time where standard hours which are involved in actual deliverance towards the making of Q units in a shift is per unit the number of hours in a particular shift. And this gives percentage efficiency now this can also be more than one because if there is a set of operators who are working at very high performance and they have a higher standard time then the shift hours it means that the shift is operating more than normal time or normal performance which is actually good. So, it gives you a rating to be an administrator or a manger for your performance health of the associated system that you are involved in.

So, I would sort of end this session here and in the next session we will talk more about the work machine systems and the automated systems and try to do the similar kind of time study in that those two systems as well to give you an idea of what are the different paraphernalia associated with those systems. So, thank you very much as of now.

Thank you.