Preface

Since the publication of the First Edition of *The Ergonomics Kit for General Industry*, the field has continued to grow in popularity. There is increasing hard evidence from a variety of industries that well-developed ergonomics programs can reduce costs and provide considerable value to business. Comprehensive programs have been in place in many companies for a decade, and data has begun to be generated. Despite the controversy of the U.S. Occupational Safety and Health Administration (OSHA) regulation — which was rescinded by an Act of Congress — ergonomics is becoming firmly rooted in day-to-day business in the workplace.

The biggest financial value of workplace ergonomics has been from protecting valuable human resources by reducing costly musculoskeletal injuries. Most companies that have applied the ergonomics process systematically have enjoyed substantial reductions in workers’ compensation costs.

Additionally, workplace ergonomics has increasingly shown its value in improving efficiency. In many companies, the ergonomics process is the only activity that is causing a task-by-task review of all operations with the explicit goal of finding improved methods. Consequently, employers are finding better ways of performing their operations. Similarly, many experts are discovering that the advanced methods of industrial work (whether in manufacturing or service industries) can only be optimized when the concepts of ergonomics are understood and applied.

However, to achieve good results employers need to incorporate an effective *process*. There are still too many cases where ergonomics efforts have failed because of inappropriate organizational systems. For example, some corporate programs are more bureaucratic than even the worst government agency. More commonly, task analysis worksheets and scoring systems are often too complicated to be much good. As a final example, there are still senior managers who do not understand what ergonomics is all about and the potential financial benefits it can provide. I hope the materials in this kit will help remedy these problems.

New Materials

The First Edition of *The Ergonomics Kit for General Industry* provided guidance on the fundamentals of setting up a program. This edition amplifies that advice with additional material on the actual process of solving problems. I have also added a number of success stories from my personal experience that serve to illustrate how the process works under various circumstances and organizational cultures. In each case, the emphasis is on simple, low-tech, and low-cost approaches.

One of the most frequently asked questions in the past decade has been “How do you create change?” Consequently a new section has been added to provide guidance.
The electronic versions of forms, worksheets, and PowerPoint presentations have proven to be popular with users of the First Edition. This edition continues this valuable support by making the electronic files available on the internet, where they are easier to update.

Everything in this book is still founded on practical experience. Nothing is based on what might "sound good" or be theoretically important. It is all rooted on what has actually succeeded on the workplace floor.

**International Application**

Sweden still leads the world in the development and application of the workplace ergonomics process, followed closely by the U.S. and Canada. The rest of the advanced industrial world from Singapore to Mexico to Spain is making great strides. The new industrial giants like China and India will undoubtedly follow soon, and with great vigor. Readers from these countries should find the ideas in this book as applicable in their homelands as in the U.S., where the materials were originally developed.

The book contains obvious reference to the U.S. and its legal and cultural background. Nonetheless, the process and concepts apply in any country. Often, the only differences between countries are the names of government agencies and their versions of recordkeeping forms. To be sure, there can also be a change in focus to some degree, as for example, the emphasis in countries like Singapore and Britain (at the time of this printing) on manual material handling or Sweden's emphasis on employee decision-making. But all in all, these materials should be helpful regardless of geography. The references to U.S. particulars should be easily understood and the concepts transferable.

**Some Simplified Spelling**

There is a great need to make English spelling more ergonomic and I have made a modest effort along these lines by using *thru*, *tho*, and *altho*. In the U.S., we use these simpler versions informally, but we seem to feel that we're doing something wrong in more formal settings.

In fact, these spellings were accepted by the 1898 convention of the National Education Association (NEA) as part of a mostly successful effort at that time to simplify several hundred spellings. Better spellings became common in the U.S. for words such as *draft* (instead of *draught*) and *catalog* (vs. *catalogue*). But for some reason, the words *thru*, *tho*, and *altho* never became common in formal writing as they were intended.

I would encourage all readers to adopt this practice in formal communication. These simplifications would represent a few more small steps along the way to a better system of spelling.
Program vs. Process

In recent years there has been a lot of commotion about process and its superiority over a program. This emphasis involves a valid point, that is (in this context), the term process highlights the importance of changing core practices, which is contrasted with program, which is considered to be an attempt to change surface behaviors without touching the underlying system. To some extent the term program has even become pejorative, indicating a sort of lip service to real change.

But this emphasis should not be taken too far. In many ways a process means more or less the same thing as program. Indeed, in this book the terms are sometimes used interchangeably.

On yet a different level, there are times when these words actually mean different things. There are occasions in this book — and these cases should be self-evident to the reader — that program is intended to mean the organizational structure that is established, such as committees and training classes, and process is intended to mean the sequence of events that bring about an action. For example, you would establish a program that is intended to change the process of handling problems in the workplace on a day-to-day basis.

Format

Because of the worksheets and checklists that are included, it was logical to keep the page size of the book the same as those materials. However, typewritten text across the full width of a page this size is difficult to read; columns of text are much easier to read.

Consequently, I adopted a style of subheads or illustrations along the left-hand column and text in a right-hand column. This format should help you easily find items that you need, plus make it easier to read. The extra white space also provides a place for you to jot down notes and ideas on how to adapt generic points to your facility.

Finally, for certain background comments like this, I have used a center column format. In total, I hope this provides a clean and friendly organization of the material.

Companion Book — The Rules of Work

This book is a companion to The Rules of Work, written by the same author and also from Taylor and Francis. Whereas The Ergonomics Kit for General Industry describes “how to set up the process,” The Rules of Work describes “what is ergonomics,” with many examples of how to solve specific problems and an introduction to common measuring techniques. Both books should be valuable in any workplace.
About the Author

Dan MacLeod is one of the leading practitioners of workplace ergonomics, widely recognized for his down-to-earth approach and his emphasis on low-cost, low-tech job improvements. He served as a consultant to employers, trade associations, and unions for over 30 years, and has developed innovative corporate programs that have resulted in thousands of ergonomic improvements and savings of millions of dollars. In all, he has conducted evaluations in over 1200 workplaces in his lifetime, assessing thousands of individual tasks.

He was instrumental in the late 1970s in recognizing the widespread impact of work-related musculoskeletal disorders. In 1982, he authored the first lay language training materials in North America on workplace ergonomics, a work that was later republished in four foreign languages. He has comprehensive experience in multiple industries, ranging from the office environment and hospitals to underground mining and steel mills. He has worked with small organizations as well as some of the largest corporations in the U.S.

His work has helped change entire industries. In the late 1970s, he pioneered the first workplace ergonomics programs in car assembly operations. In the 1980s, he was heavily involved in the meatpacking industry, where he represented the industry in working with OSHA to develop the meatpacking guidelines.

He has worked and traveled widely in Europe, Central America, and Asia. He speaks several languages with varying degrees of fluency: Swedish, French, German, and Spanish, plus rudimentary Chinese.

Dan is the author of other full-length books on practical ergonomics, plus a wide variety of training manuals, booklets, and videotapes. He is a Certified Professional Ergonomist (CPE) and holds master’s degrees in both occupational health and industrial relations.

He works as an independent consultant. For more information, see www.danmacleod.com.
Introduction

So now you’re supposed to do ergonomics!? 

If you’re like a lot of people, you’ve just been volunteered to take on responsibilities for ergonomics in your workplace (and you hardly know how to spell the word). Maybe you’re even the coordinator of the effort. Undoubtedly you have to add this responsibility to many others that you already have.

But fear not. This kit gives you ample support and guidance.

Don’t be overwhelmed by all the material in the following pages. You don’t need to read or use everything. Many sections of the book may not apply to your situation at all. However — and this is a point of reassurance — if you do need help on a certain topic, it is likely that there is support material for you.

Moreover, the ergonomics process is flexible enough to support your other responsibilities, and indeed, may make many of these other duties easier. Finally, ergonomics can be fun and rewarding, so being active in the ergonomics effort in your workplace need not be a burden at all.
Five Ways to Get Started

1. **Read the introduction** to this book to begin learning the basics of what you need to look for and do.

2. **Go around and look.** The key is simply putting on your "ergonomics glasses," looking at jobs, and thinking of ways to make things better. You don't even need to use any of the checklists at first. Start getting some experience under your belt by making a few obvious changes. Even simple things can provide a good beginning.

3. **Form a team** — "TeamErgo" — either a site-wide group, or a subcommittee of your Safety Committee, or any other way to gain some strength in numbers.

4. **Do the brainstorming exercises** on getting started in the pages of Chapter 10 *Worksheets*.

5. **Review injury and illness logs** such as the OSHA 300 form. Identify the ones that appear to be related to over-exertion or repetitive motion.

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**Putting on Your Ergonomics Glasses**

Much of the task before you simply amounts to "putting on your ergonomics glasses," that is, learning to look at routine activities from a new perspective.

While there is certainly much more to the field of ergonomics than the basic information provided in this kit, learning and then applying these concepts do not need to be forbidding tasks.
The Next Steps

6. Read or skim Chapter 4 Case Examples to get a feel for what some other successful organizations have done.

7. Review the tips and ideas described in the rest of the book that appear to apply to you.

8. Begin to write down your own process and plan based on Chapter 5, Setting Up a Program, plus using the worksheet, 20 Steps to Develop a Plan, found in Chapter 10. Just get started. You can flesh out a full program later.


10. Get ready to have fun and gain personal satisfaction by making your workplace safer, better, and more efficient.

Multiple Benefits

In the illustration above left, it is difficult for the employee to see and difficult for him to make accurate movements. Plus, it is fatiguing and painful on his back. It all adds up to making it hard to do the job well.

By using a tilter for the product, as shown at right, the setup enables greater accuracy, easier actions, more energy, and less pain. All of this results in being able to accomplish the task more efficiently with better quality and higher employee morale. The ergonomics process can help you find simply better ways of doing work.
What is Ergonomics?

Fit the task to the person

Probably the best phrase that describes the field is: “Fit the task to the person, rather than the person to the task.” Whenever we set up a piece of equipment, we need to ask: “How does the human fit in?” When designing a tool or planning a task, we need to consider human strengths and limitations.

Make things user-friendly

The term user-friendly is identical with ergonomics. Anything that can be described as user-friendly can also be said to be ergonomic. Conversely, unfriendly items are not ergonomic.

User-friendly means that things are easy to understand and apply, that mistakes are reduced, and that the human is treated well in the process. The concepts apply to both physical issues as well as mental or cognitive ones.

Work smarter, not harder

A time-worn phrase that almost everyone seeks to do is “work smarter, not harder.” Normally, how one actually goes about doing so is left unstated. But ergonomics remedies this by providing a method for finding smarter ways of performing manual work.

The rules of work

Finally, it is instructive to know that the term ergonomics was coined from the Greek words *ergon* (meaning “work”) and *nomos* (meaning “rules”). So the literal meaning is “the rules of work,” which has a nice ring to it. We all need to know the “rules” for optimizing work.
Formal definition  

Ergonomics: the field of study that seeks to design tools, equipment, and tasks to optimize the interface between humans and systems.

This interface can be as simple as that between a human and a chair (such as the back rest, the cushioning, or the height) or a much more complex interrelationship between an employee and an entire production line.

Other terms often used for the field include:
- Man-Machine Systems
- Human-System Interface
- Human Factors Engineering

MSD Prevention  

Ergonomics has gained recognition in industry for its value in preventing musculoskeletal disorders (MSDs), a class of injuries that basically amounts to “wear and tear” on the human body (and described in more detail in Chapter 3, Understanding MSDs). Consequently, there is a tendency to use the two terms interchangeably, which is not technically correct.

As we will see, there is certainly more to ergonomics than preventing MSDs and vice versa. As an example of this confusion, OSHA’s “ergonomics” standard was a misnomer and really should have been called “MSD Prevention Standard.”

Applications

The possible uses of ergonomics include just about every activity that people do both on and off the job.
- Manufacturing
- Service industry
- Office work
- Home chores and leisure activities
- Consumer products

Ergonomics provides a way of thinking about all of these tasks and how to make them more efficient and easier to do. In these materials we are going to focus on the workplace. But just remember that you can apply what you learn to almost any activity.
Perspectives

Before we go any farther, we need to adopt a few practical perspectives. The term “ergonomics” might sound hard and it has an undeserved reputation for involving expensive products. Furthermore, it sounds like a new field of study, maybe one that is a bit too far-fetched for the hard realities of modern business life. But it’s not necessarily so.

It doesn’t have to be hard

For almost every aspect of ergonomics, we can address the issues on two levels: (1) as a subject for sophisticated science and (2) as a matter of common sense. Both are equally important, but the latter takes more priority in most workplaces:

Sophisticated science

On every issue, we can apply the scientific method. Researchers can conduct rigorous studies, measure human attributes, and build mathematical models. There are topics such as “biomechanics” (studying the human body strictly as a mechanical system) and “anthropometry” (measurement of humans) that require special training and experience.

There is an increasing stock of measuring techniques that can be applied in the workplace. These methods have value, but some can be daunting for people who aren’t specialists in the field.

Common sense

But it doesn’t have to be that complicated. Much of ergonomics amounts to common sense once you start thinking about it. Ordinary people can provide many ideas about improving the tools, equipment, and tasks in the workplace, particularly once they receive training in basic principles.

Most everyone has done “ergonomics” all their lives, without using the word. We all have moved things around or used a tool to make a task easier for us.

There’s an ergonomist in every one of us. We all have certain inclinations to modify our surroundings to fit us. Much of ergonomics can be common sense — once you put on your ergonomics glasses.
It doesn't have to be expensive

The expense of applying ergonomics can fall within a wide range. Some things are expensive, although they usually pay for themselves in the long run. But many changes can be made with little or no cost.

Expensive long-term investments

There are times when new capital-intensive equipment may be required or new facilities built. Elaborate studies may be needed. A long process of design may be necessary.

As an example, the workstation that has been studied more than any other using formal techniques of ergonomics is the airplane cockpit. Evaluating and improving the design of an airplane cockpit is not an inexpensive proposition, either to determine what types of changes might be made, or to implement them. However, it does have a clear payback of helping pilots fly safely.

Similarly, large-scale industrial processes may take considerable resources to investigate and design properly. Some equipment indeed is more costly than the standard alternatives. The resulting improvements may still have a positive financial return but the changes may demand a large initial investment.

Low cost

But improvements do not always need to be expensive. It is often surprising what can be done for low cost by using a little imagination. Some companies estimate that there are 20 low-cost fixes for every one that takes some investment.

As an example of a quick fix, you can raise a computer monitor by placing it on top of a thick book. Awkward heights can often be made better by such simple measures. Indeed tasks can often be improved with a variety of low-cost, or even zero-cost, changes:

- Rearranging layouts
- Adjusting equipment properly
- Inexpensive rests and padding, etc.

More detailed examples of cost-free or low-cost improvements are provided in this book. As part of the day-to-day workplace ergonomics process, you should deliberately seek these opportunities.
Sometimes it seems like ergonomics is all brand new, because we may have heard the term for the first time in recent years, or because we see unusual products available on the market.

Consequently, it is possible to get the impression that ergonomics is not quite ready for the here and now. Some people might even have the notion that it might be best to wait a while to see if ergonomics is just a passing fad.

But this isn’t quite right; in many ways, ergonomics is nothing new. In a way, humans have been doing ergonomics for about 40,000 years, ever since the first human picked up a rock to use as a hammer or a stick as a pry bar.

A good example is a great ergonomic product invented in the 19th century — the long-handled scythe. Note the ergonomic features of the two-handed scythe compared to a one-handed sickle.

You can work upright, keeping the natural curves of the lower back; the grips move up and down to adjust for the farmer’s height; the grips can be angled to keep the wrists in their neutral postures; and the very shape of the scythe takes advantage of the larger muscles and mechanical structure of the upper torso.

And the bottom line is well known. The ergonomic device is clearly easier on the human and much more productive than the non-ergonomic device. (And in a spirit of continuous improvement, the mechanical harvester later on was even better.)

**The big difference between old and new**

There is a difference, however, between old-fashioned and modern ergonomics. Old-fashioned ergonomics was haphazard, a process of trial and error thru the years. Modern ergonomics has the advantage of the scientific method and being systematic. Today we can measure, use analytic techniques, and refer to a growing database of knowledge.

The promise of modern ergonomics is that if we systematically evaluate every task that we do, we can systematically develop equivalents of the two-handed scythe. What now lies before us is to take this natural tendency to modify our surroundings for our benefit and turn it into a conscious approach to management and design.
Principles of Ergonomics

The following are 10 basic principles that summarize the field of physical ergonomics. There is some overlap to these principles, but taken as a whole, they represent a set of prescriptive statements that can help you learn what to look for and find smarter ways to work.

1. Work in neutral postures
2. Reduce excessive force
3. Keep everything in easy reach
4. Work at proper heights
5. Reduce excessive motions
6. Minimize fatigue and static load
7. Minimize pressure points
8. Provide clearance
9. Move, exercise, and stretch
10. Maintain a comfortable environment

Each of these principles is described in more detail in the following section, including a generic explanation and some examples. Note that there are thousands of good examples that could be shown, but these few should suffice to give you a good idea of the basic concept.

Also, note that while many of these principles may appear simple and self-evident, they are routinely unmet in the workplace. Furthermore, one should not underestimate the power of a few fundamental ideas applied systematically.

The Power of a Few Principles

A good example of the need to emphasize principles rather than specific applications is the debate about using wrist rests at computer workstations. In reality, the issue is not whether or not wrist rests should be provided to everyone; rather, the issue is the posture of the wrist. If the posture conforms to good principles, then a wrist rest is not needed. If the wrist is bent, a wrist rest is one of many ways to make the needed improvement. Understanding the underlying principles helps resolve the disputes.

Consequently, it is much more important for you to learn the underlying principles rather than the details of current prescriptions for specific problems.
• By learning the principles you will understand how to evaluate changes in technology and new products that will become available in the future.

• The principles will help you to evaluate any task, whether at home, in the office environment, or in general industry.

• The principles will remain the same, even when advancements in knowledge are made in the field of ergonomics.

**Low Tech**

The approach of the following section is low tech and differs from the quantitative style of ergonomics that emphasizes the evaluation of workstations in terms of centimeters, degrees, and precise placement. Quantification can be important, but for practical purposes, this down-to-earth orientation is generally more accessible and useful, particularly for newcomers to the ergonomics process.

**Caveats**

It is important for you not to misinterpret these principles. It is not possible to meet all these conditions for every job and no claim is made here that the improvements are always feasible, either technologically or economically. These principles are design goals, not rigid requirements. The point is to keep them in mind as you evaluate jobs and take advantage of the opportunities that do arise when improvements are feasible.
Principle 1
Work in Neutral Postures

Working in awkward, contorted postures increases fatigue and physical stress on the body, plus reduces strength and dexterity, thereby making it more difficult to do a task.

Maintain the natural curve of the spine

One of the most common things to look for when evaluating jobs is the position of the back — you don’t want to work for sustained periods with a bent or twisted back. If you see a situation like this, then you typically want to start thinking about ways to make changes so that the person can work in an normal upright position.

In its natural position, the lower back has a slight arch or “swayback.” You need to maintain this arch whether sitting or standing.

The neck is part of the spinal column and thus is subject to the same requirements as the lower back. Consequently, another issue to look for is prolonged twisting or bending of the neck. You put on your ergonomics glasses and observe people who might be working in an awkward neck posture. If you see anyone like this, then you think of possible improvements.

The optimal position for your arms is with your elbows held comfortably at the sides of your body. The shoulders should be relaxed and not hunched. If you work with your elbows winged out, it can add strain to the shoulders and cause fatigue and discomfort. Plus, working with the arms outstretched, like other awkward postures, can reduce strength and dexterity and thus interfere with people’s ability to do their jobs well.

The hands should be kept in the same plane as the forearm, which is to say that the wrists should not be bent or twisted. There’s more to the issue of wrist posture than this (as there is to the whole topic of working posture), but this simple direction should be enough to get you started.

A final remark: the message here is not that you should never deviate from these postures. The points apply to sustained work . . . and when feasible.
Principle 2
Reduce Excessive Force

Excessive force can overload the muscles, creating fatigue and potential for injury. Furthermore, if you need to apply excessive force to perform a task, it can slow you down and interfere with your ability to perform the task well. Consequently, almost anything that you can do to minimize the exertion required for the task will make it easier and more efficient.

Loads on the back

Push/pull forces on the arm

In addition to looking at the posture of the back, you need to evaluate the load on the back too, that is, if there is any lifting, pushing, and/or pulling. Likewise, in addition to evaluating the postures of the arms and wrists, you must consider the loads on these joints as well.

Then, if you notice excessive exertion, you should start thinking of ways to reduce the force. It is possible to measure many these forces to see if guidelines are exceeded, but usually it is better to immediately brainstorm possible alternatives. Maybe there is an inexpensive way to make it better.

Push/pull forces on the arm

There are countless ways to reduce force. In fact, finding ways to reduce force has been one of the hallmarks of human progress over past centuries. It is helpful to think in terms of basic strategies that can be used depending upon the situation:

- levers
- conveyors, slides, and skids
- counterbalances
- improved grip design
- changed methods
- using body position to best advantage
- fixtures and backstops
- tools and machines

Grasping and pinching force

What is important is to get people thinking about what they do and get into the habit of always searching for better ways. At this level, ergonomics is not technically difficult. The hard part is learning to see things that you normally walk right by and then challenging “the way we’ve always done it.”
Principle 3
Keep Everything in Easy Reach

An easy way to make your work more user-friendly is to keep products, parts, and tools that are frequently needed within easy reach. Long reaches often cause you to twist, bend, and strain, which makes work more difficult and time-consuming.

A good rule is to keep frequently used materials within the “reach envelope” of the arm. Moreover, things you use almost constantly should be within the reach envelopes of the forearms. Note that this envelope is a semi-circle, not the rectangle that we typically use for work surfaces.

The easiest way of applying the rule is simply to see if it is possible to rearrange the layout of tools and equipment. It is surprising how often we can move things closer. We easily become so used to reaching that we don’t even notice it, even tho it may be causing problems.

In some cases it is helpful to reduce the size of a given work surface. As another alternative, if you need a lot of work surface but still have trouble with far reaches, it is possible to have a cutout made within the work surface rectangle.

A common problem in many industries is reaching into or working out of containers. Possible improvements are:
- Propping up a container on one end
- Tilt tables or stands
- Lazy Susans
- Spring-loaded bins
- Adjustable-height stands
- Containers with drop-down sides
- Chutes and hoppers
- Smaller lot sizes and thus smaller containers

A useful rule of thumb is that reach distances should be established to accommodate smaller-statured people when possible. The idea is: If shorter people can reach, so can everyone else. (We will see a reverse rule for clearance in Principle 8).
Principle 4
Work at Proper Heights

A common workplace problem is a mismatch in heights between employees and the work that they are doing. This leads to poor postures and related fatigue, discomfort, and potential damage to soft tissue, plus, quite often, unnecessarily harder work.

Elbow height

Generally, work is best done at about elbow height, whether sitting or standing. This is true for computer keyboards plus other kinds of work such as manufacturing and assembly.

Note that it is the work itself that should be at elbow height, not the desk or work surface. For example, if unusually large products are being used, the height of the supporting surface should be adjusted accordingly. The issue is the height of the task being done, not the height of the work surface.

The nature of the work also affects the proper height. Heavier work, requiring upper body strength, should usually be lower than elbow height. Lighter work, such as precision work or inspection tasks, should be higher.

Consequently, you must take into account the nature of the task when designing proper heights. It is not always sufficient to look up a number in a book.

Since people vary in height, good design usually involves providing some sort of height adjustment. There are a variety of ways to meet this need.

When possible, the best approach is to adjust the height of the workstation itself, either permanently for an individual or as needed when several people use the same workstation.

An alternative is to provide a platform for shorter people. This approach is usually second best, since it creates more congestion, requires stepping up and down, and/or creates a potential trip and fall hazard. However, a standing platform is sometimes the only realistic option.

Providing for adjustable height for materials being worked with is also important. Methods like powered pallet lifts and spring-loaded surfaces or dispensers have been successful.
Principle 5
Reduce Excessive Motions

The number of motions required to do a task can have a profound impact on both efficiency and wear and tear on the body. Excessive motions can create injury to sensitive tissue and joints, as well as waste time. Whenever feasible, reduce unnecessary motions.

Design for motion efficiency

A good way to reduce motions is to improve layouts and organization. Materials should be presented in the correct orientation as close as possible to the point of use. Smooth flow of materials at correct heights and in correct sequence also reduces wasted motions.

Many of these ideas amount to old-fashioned methods engineering, ideas that have perhaps been neglected in an era of high technology. Nonetheless, consciously striving for motion efficiency is a strategy that can be readily used in many workplace ergonomics activities.

A good strategy in many instances is to slide items that must be handled repetitively, rather than pick them up one at a time to place in their locations. Note that although there are still motions involved when sliding items, the total number of motions is usually reduced.

Individual work methods are also part of the solution. It is not uncommon to see two individuals doing the same task, one smoothly with few motions and the other inefficiently.

Let the tool do the work

One of the best ways to reduce repetitions is to allow machines and tools to do the movement for you. Machines and power tools are good at performing repetitive tasks endlessly — so let them do the work.

There is nothing particularly remarkable about this concept; this is something we all do every day. Yet, it is worth mentioning because there is often confusion about how to reduce repetitive motions, and sometimes the obvious gets overlooked.

Motion-saving mechanisms

There are numerous mechanical techniques that can be use to reduce repetitive motions, such as gearing or rack-and-pinion, where one motion yields multiple turns. Ratchets and Yankee-drill mechanisms also reduce motions.
Principle 6
Minimize Fatigue and Static Load

Overloading physical and mental capabilities can lead to lost production, poor quality, accidents, and wear-and-tear injuries. Fatigued muscles slow you down plus are more prone to injury.

Fatigue can obviously result from heavy, exhausting activity, where you sweat and burn calories. This activity is known as *metabolic load* (from “high metabolism”) and has been largely eliminated in the 20th Century as a result of machines, mechanical equipment, and robots.

Other ways to reduce this type of fatigue are to:

- Spread peak loads over more time
- Take frequent, short rest breaks
- Rotate with less demanding tasks
- Add staffing

Holding the same position for a period of time, known as *static load*, can cause pain and fatigue. A good example of static load that everyone has experienced is writer's cramp. After you hold onto a pencil for a while your muscles tire and begin to hurt. You do not need to hold it with a death grip for this to happen — just holding it loosely for a long time can make your hand hurt.

Pain and discomfort from static load is noticeable within minutes. Furthermore, continuous static loading of the muscles over months and years can contribute to long-term damage to tissue in the hand and wrist.

One of the best ways to reduce static load is to find some mechanical way of supporting the load other than with your muscles. Often, these devices can be quite simple and inexpensive.

- Arm rests to support outstretched arms
- Fixtures, straps, or hooks to hold an item
- Shelves or rails on which to support a load

Other approaches include: reducing force, improving working posture, and providing for rest breaks or opportunities to move. Examples of movement include sit/stand workstations or footrests (like the brass rail in a tavern).
Principle 7
Minimize Pressure Points

Direct pressure or “contact stress” is a common issue in many workstations. In addition to being uncomfortable, it can inhibit nerve function and blood flow.

Provide padding for hand grips

An example of pressure points that almost everyone has experienced is gripping hard onto a pair of pliers. The edges of the metal grips dig into your hand and can create considerable pain and discomfort.

Changing the shape, contour, size, and covering of tool handles can distribute the pressure more evenly over of the palm.

Provide padding for forearms

A similar problem is leaning your forearms against sharp or hard edges for support. The goal is to distribute the pressure over a larger surface area of the body. Improvements include:
- Padding the edge
- Rounding the edge
- Providing arm rests
- Redesigning the task
- Changing layout to avoid leaning

Provide cushioning for feet

Standing for long periods of time on hard surfaces (especially concrete floors) can damage tissue in the heels, contribute to other leg disorders, and increase fatigue. Options for making improvements include:
- Anti-fatigue mats
- Fiberglass grating on mounts (for chemical facilities or sanitized food processing plants where mats often cannot be used)
- Cushioned insoles

Chair cushioning

The epitome of pressure points is sitting on a metal folding chair for a long time. Clearly, good cushioning is important for chairs.

Proper seat height also affects the pressure points. If the seat is too high, the legs dangle, creating pressure behind the knee. If the seat is too low, the weight of the body presses on the buttocks.
Principle 8
Provide Clearance

It is important to have both adequate workspace and easy access to everything that is needed, with no barriers in the way. Lack of clearance can create bumping hazards or force you to work in contorted postures. It can increase long reaches, especially if there is inadequate space for knees or feet.

Design for tall people

In general, the goal is to make sure that tall people have enough clearance, that is, room for the head, knees, elbows, and feet. If tall people can fit, then so can everyone else. To improve access:

- Reorganize equipment, shelves, etc.
- Increase the size of openings
- Eliminate obstructions between the person and the items needed to accomplish the task

A common problem is lack of knee or thigh clearance on desks, workbenches, or other types of equipment where people sit. Fixes include:

- Thin surfaces, with no hindering drawers
- Removal of obstacles

Maintainability

Probably the single biggest problem that maintenance personnel encounter in their tasks is lack of clearance. Many activities would be easy to perform, if you could only reach an item and work on it with easy access. Unfortunately, too often the items to be maintained are buried deep within the equipment. The remedy is designing with easy access in mind — quick disconnects, removable panels, improved configuration, and relocation of frequently accessed equipment.

Provide visual access

A similar issue is visual access. Visual access is the ability to see what you are doing or to see dials and displays.

A common issue is inability to see when moving a cart or lift truck. Equally common are machines where various gauges are distant from the operator's position. General workstations can also suffer from the same problem, much of which can be improved by removing barriers and changing layouts to provide better line of sight.
Principle 9
Move, Exercise, and Stretch

The human body needs to exercise and stretch. You should not conclude after reading all the preceding information about reducing repetition, force, and awkward postures, that you are best off just lying around and pushing buttons.

To be healthy, the human body needs activity. You need to stretch to the full range of motion for each of your joints occasionally throughout the day. Your heart rate needs to rise for a period of time every day. Your muscles need to be loaded on occasion.

Unfortunately, most jobs don’t promote these activities. And where there is movement or exertion, it’s often too much of the wrong kind.

For strenuous tasks, it is helpful to warm up beforehand, just like any professional athlete would. It is not uncommon these days for employees like order pickers in warehouses to start the workday with group exercises.

For sedentary tasks, it is good to stop and stretch from time to time and even do some aerobic activity. Some companies are building these types of warm-ups and “energy breaks” into daily work life. In these situations, fitness instructors come into the work area, put on music, and lead the employees in a brief routine. In those companies that have been providing these energy breaks for some time, the group exercise has become ingrained in the culture and no one thinks twice about participating.

It is good to change and move. There is no one “correct” posture that is best for an entire workday. Adjustable equipment can facilitate such movement, but even without it you can often still change positions. If you have adjustable equipment, take advantage of it.

An increasingly common approach is the “sit-stand” workstation. Sometimes, the whole worksurface can be designed to move up and down. Other times it is possible to design the workstation for a standing posture, and then use a tall stool to sit on as needed.

People who routinely sit should get in the habit of changing the position of their chairs: raise it, lower it, tilt it forward, lean back, etc.
Principle 10
Maintain a Comfortable Environment

Humans often do not perform well in less-than-ideal environments. Excessive heat and humidity slow us down; excessive cold hinders effective work. Toxic chemicals can damage our health; vibration can injure sensitive tissue.

This principle is more or less a catch-all category in ergonomics. Some issues are normally addressed by other fields, such as industrial hygiene for toxic chemicals. But other issues, such as lighting, have been raised as part of the growth of workplace ergonomics.

Good lighting

The quantity and quality of light at the workstation can either serve to enhance or obscure the details of the work. Common problems include:

- Glare that shines in your eyes
- Shadows that hide details
- Poor contrast between your work and the background

One good way to improve lighting is use of task lights, rather than trying to provide all lighting from the ceiling. There are a number of important advantages of task lighting, including better control of glare, shadows, and brightness at each person’s workstation.

Other ways to make improvements include:

- Diffusers or shields to minimize glare
- Better placement of lights or equipment

Isolate vibration

Working with vibrating tools or equipment can potentially cause carpal tunnel syndrome, plus other types of disorders such as Reynaud’s phenomenon (“white finger”). Vibration can be reduced with:

- Better tool design
- Preventative maintenance
- Dampened tool grips
- Vibration-dampening gloves

Temperature extremes

Sometimes the source of extreme heat and cold is inherent in the work (such as outdoor work, heat around furnaces, and the cold in meat and poultry plants) and little can be done about root causes. However, some steps can be taken to avoid some specific problems, such as using deflectors to keep cold air from blowing directly onto people.
Other Subfields

This kit deals almost exclusively with physical issues like exertion, heights, and repetitive motions. But there are other, equally important spheres within the overall field of ergonomics.

The most important other branch is cognitive ergonomics (sometimes called human factors engineering). Historically, cognitive ergonomics has been the larger and more advanced branch compared to physical ergonomics.

Cognitive ergonomics

Cognitive ergonomics addresses how we conceive information, process it mentally, and decide on correct responses. By designing displays and controls — and in fact every type of information that we handle mentally — to take into account human perceptions and expectations, it is possible to reduce errors and improve performance.

A good example is the common light switch. Most North Americans would expect that if you want to use the switch illustrated at the left to turn lights on, you would flip up the switch. The design conforms to our expectations.

However, when confronted with a nonstandard design, such as that in the lower illustration, we get confused. The design is void of any feature that helps us decide which way to flip the switch. Moreover, people in other countries may react differently or have completely different types of light switches, which is part of the issue.

Broad scope — The application for cognitive ergonomics in designing things so that they are not confusing is incredibly broad. Examples include: television remote controls, road signs, written directions, bureaucratic forms, and warning signs.

Design principles — As with physical ergonomics, there are a number of general principles that can help guide us when we design or build things. A few examples are:

- Standardize — Make sure that similar devices work the same way or that color coding of wires and pipes is consistent.
- Use "stereotypes" — Incorporate common conventions, like red for warning or stop, or turning a dial to the right to increase speed or power.
- Use patterns and images — Take advantage of our visual capability to recognize shapes and patterns very easily (and our tendency not to read signs).
A final general area of ergonomics has to do with the underlying design of work. Examples include:

**Task allocation** — How should tasks be divided and assigned to accomplish goals? Is it better to have many people equally capable of doing many tasks? Or is it better to have a narrow division of labor, so that individuals can be extremely highly qualified at specific tasks?

**Assembly line or work cells** — Should the technology and equipment of the workplace be designed so that tasks are narrowly defined? Or should the physical layout promote team activities?

**Shift work** — Should there be more than one shift in a given workplace? And, if so, should employees be assigned to just one shift (thus prohibiting some people from enjoying normal life), or should they be rotated between shifts every couple of weeks (thus forcing everyone to disrupt their biological time clocks)?

**Reward systems** — How should people be compensated for their activities? What are the actions that are rewarded? Should people be compensated for how much they put into a task (hours and effort), or how much they put out (quality and quantity of product)?

Other fields of study have obviously addressed these issues in great detail, but ergonomics provides a certain perspective. For example, management science and organizational psychology address many of these areas, but they do not always capture the technical side. Conversely, engineering addresses much of this subject, but it does not always capture the human side. The combination of the two is what interests ergonomists — the interface between humans and systems.

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**You're Off and Running!**

Armed with just these simple ideas and principles, you can make many improvements in the tasks that people perform in your workplace. As you continue to learn more details on each of the principles, you will continue to increase your ability to identify issues and ideas for improvement.