Introduction to Manufacturing : The What, When, and Who of Manufacturing

Lesson 1 Overview

To understand manufacturing, you'll first have to understand the basics. Answering the questions *what*, *when*, and *who* when it comes to manufacturing will give you the background to learning more about how the industry came to be one of the most successful in history. In this lesson, you'll learn how to answer all of these questions. You'll also build a foundation for later learning on what this all means for the future of the manufacturing business and your role in it.

1.1 Describe manufacturing and its impact on society

What Is Manufacturing?

READING ASSIGNMENT

What Is Manufacturing?

Manufacturing is the production of surplus goods that can be sold or traded. A person who creates a single fishing rod from a tree branch isn't a manufacturer. A person or company who makes many fishing rods and sells most of them is a manufacturer.

In modern society, manufacturing extends and improves lives. Each person doesn't need to produce everything needed for his or her survival. Instead, a person can manufacture more goods than he or she needs, then trade the surplus to other people.

An image of a rolling mill flattening hot steel into sheets.

This rolling mill turns cast steel blooms into flat sheet for use in automobiles, appliances, and other applications. This is just one example of a manufacturing plant.

To fund the high initial cost of a manufacturing plant, many products are sold at a profit. The plant is financed by a group of venture capitalists called *investors*. These investors may not have studied manufacturing. Yet they have the money to build the plant and buy the equipment. If the plant is profitable, they make money. This means the plant remains open or expands. If the plant isn't profitable, its investors will look to recover their costs. This means closing or selling the plant and liquidating the equipment.

Money is the lifeblood of manufacturing. Without money, there's no return on investment for the investors. Without money, there's no way to pay employees. Without money, there's also no way to develop newer products. Making money is the only reason to open a manufacturing plant. To open a plant without a clear way to make money is dooming it to fail. Investors won't invest their money unless they can see profit.

If a manufacturing plant is losing money, changes must be made quickly. Even a profitable company can go bankrupt if it simply relies on “business as usual.” Manufacturing plants must look for ways to save money with reduced costs or increase their revenue. They must look for new market opportunities and new ways to expand their grip on their existing markets. In addition, they must do so without illegally monopolizing the industry.

Manufactured goods may be sold to the public. Televisions, automobiles, jewelry, and clothes are examples of such goods. Some manufactured goods may be sold to other manufacturers. For example, a steel foundry and rolling mill may sell strip steel to an appliance manufacturing plant.

Manufacturing plants must innovate and develop, or improve, their goods. In addition, manufacturers must do the following:

- Employ capable technicians to produce the goods
- Market their goods and reach their target customers
- Employ staff who can answer questions and complaints about the goods
- Motivate talented salespeople to move the goods
- Hire managers who keep production running while training and paying employees
- Employ accountants who balance the books
- Meet regulatory standards set forth by local, state, and federal governments

Advantages to Manufacturing

There are advantages to manufacturing goods. Crafting goods one by one takes time. Manufacturing utilizes a plant with skilled labor instead. The initial cost of building the manufacturing plant is high. However, more goods are produced in a short amount of time.

Manufacturing procedures are well documented. This is because identical parts can be created with good documentation. In a world without manufacturing, there are no standard parts. Each part requires hand finishing. If a part breaks, a new one must be crafted. Yet by manufacturing standard parts, a new part can replace the old part perfectly.

Standard parts help engineers quickly develop new goods. Instead of having to reinvent every nut and bolt, they can use parts that are waiting on the shelf. These items don't need to be redesigned and are readily available for purchase. In this way, engineers can design new goods without designing each and every bolt.

As new goods are developed, other engineers design even more goods. Inspired by one creation, an engineer creates something else. The entire process snowballs, and new goods are developed virtually every day.

Disadvantages to Manufacturing

Manufacturing requires a large initial investment. Factory floor space, specialized equipment, and skilled labor are expensive. Even a well-designed plant can go into debt. The economics must work out to justify creating the manufacturing plant. Even a good plant design may not justify the plant's construction.

Sometimes, it's better to outsource a design to another manufacturer. Or, it may be better to build a few well-made products instead of an entire manufacturing plant.

Manufacturing produces nearly identical parts. If a part needs to be custom-fitted, it will be harder to manufacture. For example, sometimes a horse's hoof is shaped oddly, and a custom horseshoe is needed. This horseshoe might need to be hand-fitted by a *farrier* (horseshoe maker). Similarly, some medical goods must be produced individually to meet the needs of individual human bodies.

Because manufactured parts are nearly identical, they don't reflect a personal touch. Some artistic ventures require craftsmanship, not manufacturing. At a car show, the car that draws the most attention is the one that's unique. As artistic works are reproduced, their values actually decrease. This is why cameras aren't allowed at most art shows. Artists are afraid that their works will be copied and thus lose their initial value.

Manufacturing Economics

Manufacturing revolves around money. As a result, manufacturing technicians must understand how this money flows. Manufacturing technicians directly impact a plant's financial bottom line.

Revenue is the money collected from selling goods or services. If there are buyers for all of the goods manufactured, then the more goods, the more revenue.

Manufacturing is a staple of the United States economy. Nearly every good you may purchase has been through at least some manufacturing processes. To learn more about manufacturing and the economy, look at [What is Manufacturing?](www.census.gov/newsroom/cspan/20121005_manufact/20121005_cspan_slides.pdf) (www.census.gov/newsroom/cspan/20121005_manufact/20121005_cspan_slides.pdf)

Costs are how much money is spent to keep the factory running. Costs fall into several major categories, including fixed costs and variable costs. *Fixed costs* are expenses that must be paid, regardless of whether goods are manufactured. Fixed costs include mortgages and building rents, technician salaries, and so on. If no goods are made, these costs still need to be paid. *Variable costs* depend on the number of goods manufactured. Variable costs include raw material costs, electricity, and so on. These costs will be greater depending on the number of goods manufactured.

Profits and losses are the end result of the revenue/cost cycle. If revenue is greater than costs, there's a *profit*. If costs are greater than profit, there's a*loss*. A plant can't run at a loss for long.

Profit is found by the following formula:

Profit = Revenue – Costs

However, making goods is only part of the financial struggle. To make a profit, these goods must sell. For a good to sell, it must be marketed and delivered to customers. Customers determine the best products through their choices. One might say that customers "vote" on the best goods with their wallets.

What determines the value of a good? One consideration is supply and demand. *Supply* is how much is available. *Demand* is how many customers would like the product. The process of supply and demand is like a seesaw or a balance beam. As the demand side increases, the prices go up, meaning profits can increase. As the supply side increases, prices go down, meaning profits decrease.

Manufacturing goods is more than just "making stuff." Management, marketing, and salespeople must predict the supply and demand curves. Then, they adjust the plant output accordingly. For example, toy manufacturers experience an increase in demand right before the winter holidays. Because of this, they must adjust their plant output accordingly. The toys that aren't produced in time for Christmas may not sell, ever. After the holidays, the plant may scale back production of certain toys.

A Mickey Mantle baseball card from the first year this Hall of Famer played baseball is worth a small fortune. This is because there aren't many of this baseball card left. Limited supply coupled with very high demand drives the price of the card higher.

THE FIDGET SPINNER FAD

An image of fidget spinners.

The year 2017 saw the fidget spinner fad. Originally, these small toys were in high demand and limited supply. Yet suppliers caught up, and soon the market was flooded with fidget spinners. As the fad died, retail stores put their surplus fidget spinners in discount bins. They hoped to sell them off, even at a loss. Fidget spinners ended with a large supply and little demand, driving down the price. At one point, it was cheaper to buy and disassemble a fidget spinner than it was to buy ball bearings.

Production

In terms of production, *throughput* is the number of goods that are produced per unit of time. Throughput is always a rate. For example, *500 cars per day*, *233 gallons per minute*, or *55 lbs per hour* are all throughputs.

In a perfect world, every good made would be sold. However, that's rarely the case. Defects and other problems mean that products are lost.

Defects occur when a good doesn't meet specifications. For example, a fishing rod may have a crack in it that prevents it from being sold. Sometimes, defects can be *reworked*, or repaired. Other times, the defective good is discarded. Every defective good, even if reworked, lowers profit. Rework wastes labor, time, and resources.

Waste is another example of loss in a manufacturing plant. In particular, agricultural industries worry about waste. *Waste* is when good product sits in storage and spoils before being sold. Waste is frustrating and costly. It represents good manufacturing hampered by problems in marketing and sales. Waste also involves goods that are damaged before leaving the manufacturing plant. For example, if a pallet of blenders falls off a forklift and is damaged, this is waste. The goods were manufactured correctly but some error caused them to be lost.

Shrink is another example of loss. This refers to goods that are lost or stolen. While not commonly thought of, theft does occur in manufacturing plants. A technician can be fired or jailed for stealing even the smallest good or part. In the end, losing goods to shrink hurts everyone in the plant.

Returns are one more type of loss. Sometimes, a good doesn't meet the customer's need or standard for service. This can become a major problem and is frustrating for everyone involved: the customer, who expected a working good, must be reimbursed or have a replacement good sent to him or her. This may annoy the customer and prompt him or her to buy from a competitor next time. In this way, returns are the worst kinds of defects.

Once the defective good returns to the plant, the engineering team may determine that the good was abused or otherwise doesn't meet the requirements for a replacement. Regardless, they'll keep records on all parts sent back to the plant. If they see a trend (lots of broken goods) they'll investigate to find a root cause.

Returns may even result in legal liability for the manufacturer. If a product fails in an unsafe manner, it may cause someone bodily injury or property damage. In this case, the engineering team will investigate immediately. They'll collect data to see who else might be affected by the defective product.

The worst case scenario is when a good must be recalled. A*recall* occurs when the company must buy back or replace all of a good that has been sold. This often happens when a defect led to a lawsuit.

To figure out how the number of saleable goods, one can use the following formula:

Saleable Goods = Throughput – Defects – Waste – Shrink – Returns

Note that it isn't possible to end with a value less than zero. (A plant can't have produced more failures than the number of goods it produced in the first place!)

The idea is to make the most saleable goods. This becomes possible by reducing defects, waste, shrink, and returns. It also may be possible by raising throughput.

THROUGHPUT VERSUS DEFECTS

Example 1. Computerized flash memory is made thousands of chips at a time in a semiconductor manufacturing plant. The process occurs very quickly but results in many defects. Plants can manufacture the chips much more slowly but with only slightly fewer defects. Current thinking on this problem is to crank out the chips as quickly as possible. This boosts the throughput to profitable levels, even with a high defect count.

Example 2. Tractor trailers are manufactured on an assembly line. What's most important is to keep the assembly line moving, even when a part doesn't get installed. This part can be added later through rework and the truck, sold. If the assembly line stops moving, throughput drops and the machines must be recalibrated. Thus, unless safety is at stake, the line shouldn't stop moving.

Example 3. A new piece of equipment in an adhesive factory makes a bad product batch 30 percent of the time. Running the equipment faster increases the number of defects. Slowing it down decreases this number. Engineers determine that it's more profitable to adjust the equipment and lower the number of defects.

Engineering and management employees often are most qualified to balance the saleable goods equation. However, suggestions from all employees should be considered. Often, a technician will suggest a method to lower the number of defects. He or she may work closely with the equipment and see something that others haven't noticed. Once the technician brings the matter up, engineers and managers may discuss it. Most importantly, they'll consider whether the suggested change will impact any other part of the manufacturing process.

Changes in Manufacturing

Manufacturing optimizes safety, time, money, and quality. As such, the manufacturing technician should consider the following questions:

- Can the process be done more *safely*?
- Can the process be done more *quickly*?
- Can the process be done *less expensively*?
- Can the process be done in a way that results in *higher quality*?

Safety Changes

Most employers value the input of technicians. Technicians are “in the trenches” and know the details of production. They also know the hazards of the job and can help reduce risks. Changes made to improve safety often include the following:

- Supplying special training for equipment
- Adding guards or interlocks on industrial equipment
- Changing a process to bring in safer machines or chemicals

Time Changes

An image of the concept that time is money, where both are represented as connected cogs.

When you save time, you're also saving money.

Time is money, and every second of lost time is lost money. Each minute of a technician’s time costs the manufacturer. Although technicians should seek ways to save time, "quickie" manufacturing shortcuts are always discouraged. Shortcuts that aren't well thought out can cause major problems down the road.

Changes to optimize time in the manufacturing process include the following:

- Removing process steps that don't improve safety or add value
- Changing the location of equipment for more efficient workflow
- Replacing older, less efficient equipment with more efficient equipment

Cost Changes

If the process can be made to cost less money, higher profit is attainable. This benefits the company's investors and often employees as well. Manufacturing plants are always looking for ways to reduce costs.

Changes to optimize costs include the following:

- Removing process steps that don't improve safety or add value
- Changing the location of equipment for more efficient workflow
- Replacing older, less efficient equipment with more efficient equipment

Quality Changes

Changes to improve quality often come from engineering and management. However, some major changes and great inventions have come from "the factory floor." For example, the automatic transmission was invented in part by assembly line technicians.

Changes to improve quality include the following:

- Adding or altering finishing steps
- Changing materials, equipment, or tooling for more precise control
- Developing a quality-testing plan so that only good products go to market

Changing a manufacturing process will affect all four of the preceding areas: safety, time, money, and quality. Because of this, changes must be made carefully. For example, a proposed change might make the process faster but unsafe. Or, a change might make a higher-quality good but cost too much. Thus, any changes to a process must be carefully evaluated.

In most plants, process changes are documented. Changes shouldn't be implemented permanently without proper authority or documentation.

Changing one part of a process without the proper authority can be dangerous. One part of the process may improve, but another may suffer. Always be mindful of a ripple effect: one sudden change may cause a problem further downstream.

CHANGES AT THE STEEL MILL

A steel mill was looking for a way to produce more steel per day. Adding a certain chemical to the steel caused it to flow and cast faster. The chemical was cheap, safe, and didn't impact the quality of the steel. At first glance, this seemed like a great way to increase the output of the mill.

An image of a worker overseeing processes in a steel mill.

However, after a few weeks, technicians on the melt shop floor found that the furnace lining was thin. The mill shut down, and the furnace lining was repaired. Business continued as usual until the furnace lining became dangerously thin again. Once again, the mill shut down, and the lining was strengthened.

The engineers soon learned that the new chemical was reacting with the furnace lining, causing it to wear more quickly. The accountants soon found that this wear on the furnace lining was becoming expensive. In addition, the extra steel being produced didn't cover these costs. Overall, the implementation of the new chemical didn't help the mill's profit line.

Any change that makes working conditions less safe should be avoided. It may look like safety protocols slow production, but they keep all employees safe. Changing these protocols or training procedures puts technicians at risk. Modifying or not wearing proper Personal Protective Equipment (PPE) also puts technicians at risk. Safety protocol changes must undergo thorough review at the engineering and management level.

Manufacturing technicians can identify safety concerns. They may see risks or improvements that engineers, foremen, and managers don't perceive. Therefore, manufacturing technicians should report safety concerns whenever they arise. Technicians are often asked to share their expertise with particular equipment. This way, safety protocols are developed using the best information available.

In one plant, technicians noticed that an interlock on an electrical panel always failed. The technicians could have bypassed this safety system. Instead, they brought it to the attention of the engineers. The interlock was repaired, fixing the problem and keeping everyone safe.

Shortcuts in time also may look like a good idea. However, many shortcuts compromise safety, cost, or quality. Procedures should be followed exactly as they're written.

THE COMPUTER CHIP PROBLEM

In one computer chip factory, equipment went through routine maintenance. A long checklist of steps was performed in order. Each item was checked off one at a time. One day, technicians decided to speed things up by checking off groups of steps instead of one step at a time. This made the maintenance process much quicker.

However, once the equipment was brought back online, it wouldn't pass test runs. The equipment was supposed to be dust-free, but there was dust found repeatedly. The equipment was shut down, and the maintenance was performed again. A valve was found open, yet the task of closing this valve had been checked off on the checklist. If the technicians had completed and checked off each task one at a time, this valve wouldn't have been missed. In the end, the technicians' ill-conceived shortcut cost the company thousands of dollars in lost revenue and time.

As stated previously, quality improvements typically come from engineering or management. These refinements typically involve changes to an operating procedure, raw material, or piece of equipment. Although such changes can increase costs or production time, the result may be a higher-quality good.

Most consumers are willing to spend more to get a higher-quality product. Many of us have bought a cheaper product at some time and been disappointed with its quality. This is why, say, a name-brand coffee shop can charge more for a cup of coffee than a gas station can.

Key Points and Links

READING ASSIGNMENT

Key Points

- Goods are manufactured when they're produced at a surplus for sale or trade.
- Manufacturing makes more goods available to more people.
- Profit = Revenue – Costs
- Saleable Goods = Throughput – Defects – Waste – Shrink – Returns
- Manufacturing is designed to optimize safety, time, and money.
- Changes to procedures must be reviewed by management and engineering.
- Shortcuts can be dangerous and cause problems.

Links

What is Manufacturing?
(www.census.gov/newsroom/cspan/20121005_manufact/20121005_cspan_slides.pdf)

Discover More: Manufacturing Basics

Respond to the following based on your reading.

1. What happens to prices when there's an imbalance between supply and demand?
2. Why might defect count be less important than throughput?

Discover More Answer Key:
Discover More: Manufacturing Basics

1. If there's more supply than demand, the price of the good drops. If there's more demand than supply, the price of the good increases.
2. Sometimes, higher throughput can make up for a few extra defects. Economics decides how many defects and how much throughput are needed.

1.2 Identify important breakthroughs in manufacturing history

The History of Manufacturing

READING ASSIGNMENT

Humans started manufacturing as soon as they learned to trade. When there was a reason to make a surplus, they did. Throughout human history, humans have improved manufacturing processes.

Modern manufacturing was made possible through several key inventions, which you'll learn about in this section. These inventions led to many smaller inventions that were no less important. That's how industrial progress works: each new development inspires future developments.

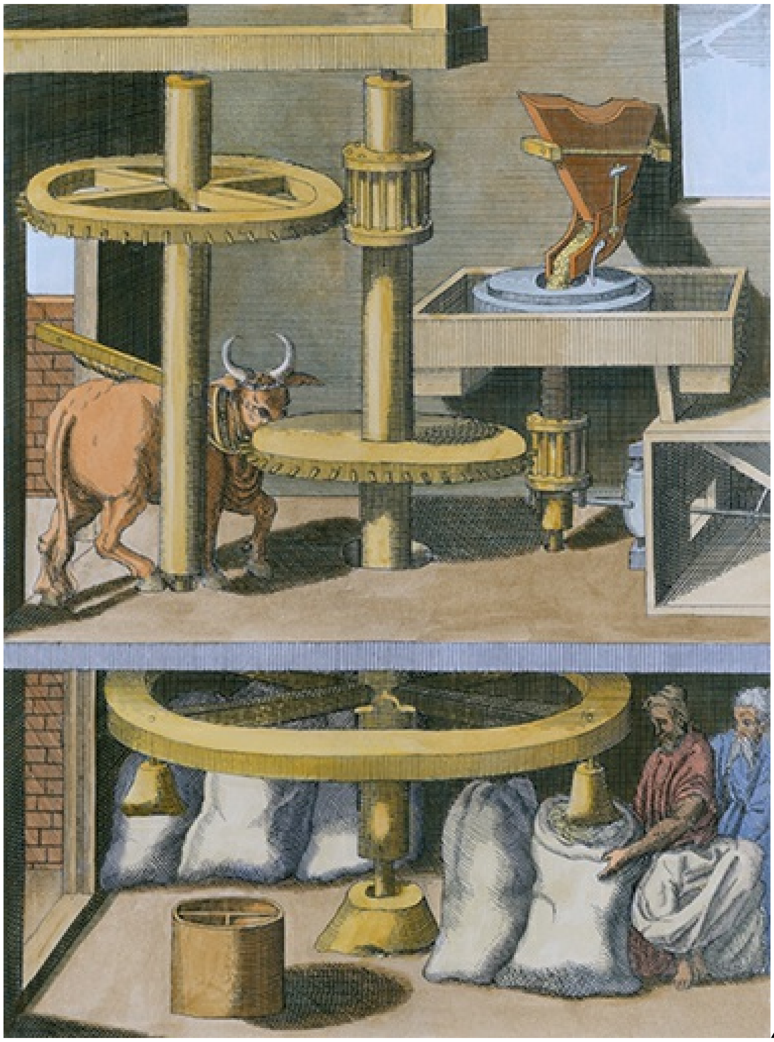
Early History

Early industries included mining, metallurgy, building materials, farming, fishing, and shipbuilding. Many of these industries were run by the government as state-owned entities. Workers planted and harvested crops, but they ended up in communal silos. The government then distributed the food.

Any other goods that were needed for survival were crafted at home. Clothing, bedding, furniture, and so on were often handmade in this environment. As civilizations became more advanced and trade increased, these crafts left the home. Soon, they became manufacturing industries as well. The Roman Empire had furniture, textile, and olive oil industries, trading all over the Mediterranean.

Goods flowed into and out of major cities, and manufacturing improved. Manufacturing involved the use of animals, slaves, and working men. Some plants of the day were harvested via wind and water power. Wind was used to grind grain into meal. Waterwheels ground grain or turned large saws for making lumber.

An image of an ox-powered grinding mill.


Animals were used as a power source. This ox walks in a circle, rolling one heavy grinding stone over another to process coconuts.

The history of manufacturing is long and extensive. For more background on how this flourishing industry got its start, visit [The History of Manufacturing—Part 1: Prehistory to Antiquity](www.allaboutlean.com/firstlecture_hom_1/) (www.allaboutlean.com/firstlecture_hom_1/) .

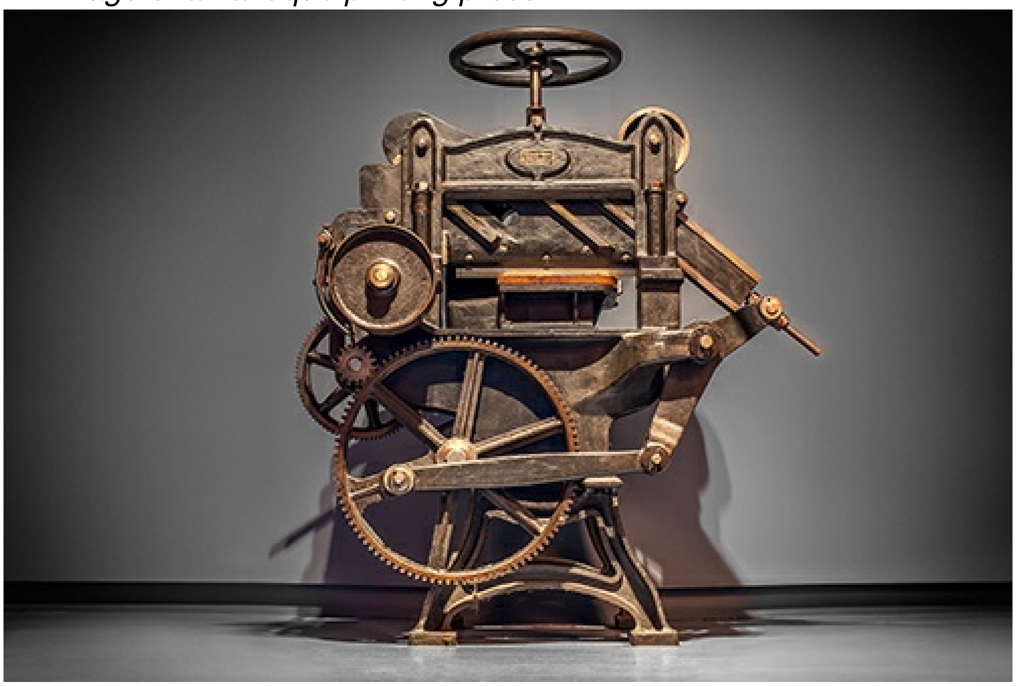
The Dark Ages and Scientific Revolution

During the *Dark Ages*—from approximately the fifth to fifteenth century AD—scientific discovery was discouraged, and technology was at a virtual standstill. The term “scientist” barely existed, and the few who did practice science were often punished. Any act of scientific discovery was treated as religious heresy. Thus, the news of scientific development rarely spread beyond the walls of a scientist’s private quarters, for fear of punishment.

Yet the human mind is naturally scientific. It seeks to discover. A few new inventions and discoveries loosened the grip of religious leaders. In time, this brought an end to the Dark Ages, leading to a period known as the *Scientific Revolution*. During the Scientific Revolution, scientists began to discover more about the world. These discoveries led to new inventions, which in turn led to more discoveries. With the invention of the printing press (which you'll read about next), news of scientific discoveries traveled the world on a much greater scale.

A Game Changer: The Printing Press

An image of an antique printing press.



The printing press allowed the Scientific Revolution to bring Europe out of the Dark Ages.

The invention of the printing press happened prior to the Industrial Revolution. However, the Industrial Revolution wouldn't have been possible without it. Before the invention of the printing press, each book and newspaper had to be handwritten. This meant that written documentation of ideas and processes was scarce. People were largely illiterate and shared ideas through speaking and listening. Even important historical documents, such as the Bible and other religious texts, were kept inside houses of worship. They weren't available to the average person. (Not that the average person would have been able to read them if they *were* available.)

The printing press didn't merely enable an extra copy or two of a book or pamphlet. It could print many copies of these items in a relatively short period of time. Printing presses could reprint religious texts and make them available for the masses. This prompted many to learn to read—and write. Ideas, including scientific ideas, were developing rapidly . . . and *spreading* rapidly.

Without a means to spread knowledge on a large scale, the Industrial Revolution never would have occurred. During the *Industrial Revolution*, developments in science and knowledge led to huge advancements in manufacturing technology.

Developments of the Industrial Revolution

The Steam Engine

The defining invention of the Industrial Revolution was the steam engine. This device replaced beasts for *motive power*, which is the energy used to activate machinery. For example, animals walked in circles, bound to a mill to grind grain into flour. This was costly and time consuming. A steam engine could grind the grain more quickly, ultimately costing less to maintain than animals.

Without the invention of the steam engine, modern manufacturing never would have been possible. The steam engine showed the tremendous power that was available for humankind. It also showed that there was money to be made in manufacturing goods quickly. The steam engine soon revolutionized the machining and transportation industries.

A steam engine converts chemical energy into thermal energy and then into mechanical energy. Chemical bonds are broken when a fuel is burned, releasing heat energy. This heat energy is used to vaporize water, creating steam. When water becomes steam, its volume expands. This volume expansion is used to push a piston, creating motion, or *kinetic energy*.

The kinetic energy created by the piston's motion is used in many ways. It can be used to push a wheel forward, as in a railway locomotive. It can be used to turn pulleys or gears, as was the case in many early manufacturing plants. Steam also can be released to create an impact, as in a forge.

The steam engine has several important parts. First, there's the *firebox*, where fuel is placed and burned. Above the firebox is the *boiler*. This contains thin tubes of water. Heat from the firebox rises and turns the water to steam. A boiler is sometimes referred to as a *heat exchanger*. This is because heat is taken from the fire and added to the water. Boilers also can be thought of as "reverse" radiators. The radiator in a car engine takes heat *away* from the engine.

A good boiler contains many tubes spaced slightly apart. This provides a lot of pipe surface area to heat. It's easier to heat many small tubes than it is to heat one large tube.

Because it could replace many hours of hard labor, the steam engine transformed how humans thought about work. In addition, a steam locomotive engine or boat made travel faster and more reliable. Basically, any machine that performed work via person, beast, water, or wind could be redesigned to use steam. Steam-powered lathes, drill presses, looms, and mills were commonplace by the late 1800s.

The steam engine was an integral part of the Industrial Revolution. For more background on the history leading up to the Industrial Revolution and the invention of the steam engine, view [The History of Manufacturing—Part 2: Middle Ages to Industrial Revolution](www.allaboutlean.com/firstlecture_hom_2/) (www.allaboutlean.com/firstlecture_hom_2/) .

An image of a modern power plant steam turbine.

Steam is fed into the center of this turbine, where the blades are small and thin. The steam travels toward the larger blades, continuing to turn the turbine.

Early steam engines used wood for fuel. However, England used up their trees for ships, buildings, and firewood. In the Americas, coal was abundant. This fossil fuel could be burned to form *coke*, which actually was better than wood at firing the steam engines.

Today, steam is created by burning coal, natural gas, oil, or trash. At power plants, nuclear fission also creates steam. This steam is fed through a turbine, which generates electricity at the plant.

Interchangeable Parts

Interchangeable parts were developed soon after the invention of the steam engine. In particular, this showed up in the manufacturing of muskets, which were early rifles. Before interchangeable parts, each musket had hand-fitted parts. These parts were labor-intensive and cumbersome. In time, developers hit on a better system, making all of the parts identical. That way, if a part failed, it could be easily and quickly replaced. This meant muskets could be repaired right on the battlefield instead of in a blacksmith’s shop.

Interchangeable parts are taken for granted today. If an engine needs a new set of cylinder heads, technicians simply order a new set and bolt them into place. Hand-fitting in today's manufacturing is rare. Yet easy, quick replacement was a new concept in the mid-1800’s.

Interchangeable parts also made machining easier, and standard part sizes developed. Before standard sizes, each component was fitted by hand. If a part failed, it would have to be repaired or replaced in the shop that made it. And, if that shop wasn't available, another shop would have to try and fix it. Today, nuts, bolts, screws, and similar small parts have standard sizes. If a bolt gets broken, the customer can go to the local hardware store or a chain store and find a replacement.

Finally, interchangeable parts have sped up the invention process. No longer does an inventor have to develop every part of a new invention. Instead, he or she can use standardized parts within the new design. This is a tremendous time-saver. Inventors also are inspired by looking at existing goods and designing improvements. Today, they use standardized parts to build and modify prototypes quickly.

The Assembly Line

Prior to industrialization, a person worked on a handcrafted good from start to finish. In other words, this craftsman went through each stage of production until the product was completed. If a shop had ten craftsmen, all ten might work on the same stage of production. Often, there were no goods to sell until they had finished. Then, when they finished, there was a very limited number of goods for sale.

The meatpacking industry was perhaps the first to see the problem with this system. Once it's removed from the animal, meat needs to be packed quickly. Otherwise, it will go to waste. So the butchers and meat packers worked together to find a better system.

Whalers of the time were in the same dilemma. They had limited time to harvest the oil from a captured whale. It stood to reason that if workers split up the task of processing the whale, they could work more quickly. This would result in more oil and more money. (Inevitably, however, the whaling industry would fade away as the hunted whales became scarcer and scarcer.)

Between the whalers and the meat packers, the concept of an assembly line developed. In an *assembly line*, goods move in succession past a series of workers, who each add their own piece or perform a specific task. Once a worker finishes his or her step, the goods move farther down the line.

Assembly lines accomplish several goals. To begin with, workers become skilled at performing their part in the process. In addition, production achieves a level of consistency. Each worker does the same thing every time, and the finished goods come out identical.

The assembly line also improves throughput and makes it more predictable. In the craftsman's shop, goods were produced in spurts. Some days, there were ten goods for sale, and other days there were none. Yet the manufacturing plant produced a steady number of goods every day. The assembly line became a virtual pipeline for goods. Once the pipeline was full, new goods could roll out every day.

Henry Ford was one of the first inventors to see the value of the assembly line. In the food industry, it was a necessity. Yet Ford saw it as a way to assemble his automobiles at a much faster rate. Instead of technicians teaming up on one car at a time, they could work on many different ones at the *same* time.

An image showing an assembly line of workers in an old automotive factory putting hubcaps on cars.


Assembly lines changed the way the manufacturing business functioned and made commodity goods like cars more widely available and affordable for many people.

Henry Ford is one of the most influential users of the assembly line. His innovation in the automotive industry is one of the most iconic examples of this process. To learn more about Ford's use of the assembly line and the flexibility it added to the market, view [The History of Manufacturing—Part 3: Luddism to Henry Ford](www.allaboutlean.com/firstlecture_hom_3/) (www.allaboutlean.com/firstlecture_hom_3/) .

Henry Ford's automobile assembly lines made him a lot of money. They also made cars accessible to many more people. Before the assembly line, cars were largely custom-made toys for the rich. The assembly line was able to produce autos quickly and much more affordably. As more cars rolled off the assembly line, the price of each one dropped. Of course, as prices dropped, more families could afford to own a car.

Affordable cars revolutionized transportation. Before the assembly line, there was little demand for cars. Their high prices kept them from being everyday items. Yet when prices dropped, demand for cars increased throughout the social strata.

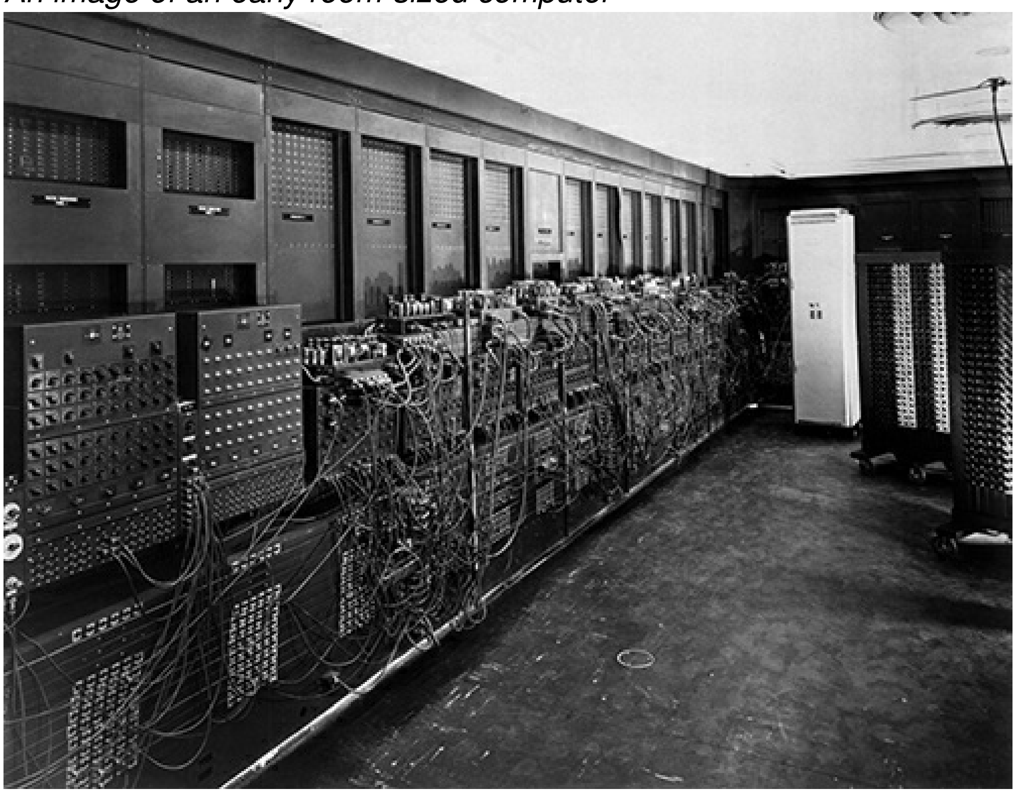
The assembly line wasn't without its problems, and these often plagued Ford's operations. First, there was no customization. Today, cars come in a variety of colors and styles. Yet in the early 1900s, Henry Ford was famous for offering only black cars.

Assembly line work also could become tedious. Formerly, when a worker or craftsman was involved in all parts of the process, the work might vary each day. But on the line, workers did the same job every day. Recognizing the value and welfare of his workers, Ford would soon establish an eight-hour workday in his plants. Prior to this, work shifts in factories were often gruelingly long.

Transistors and Computers

Early computers were extremely large, often filling entire rooms. These computers, made of mechanical relay switches, would find answers to complex problems.

An image of an early room-sized computer

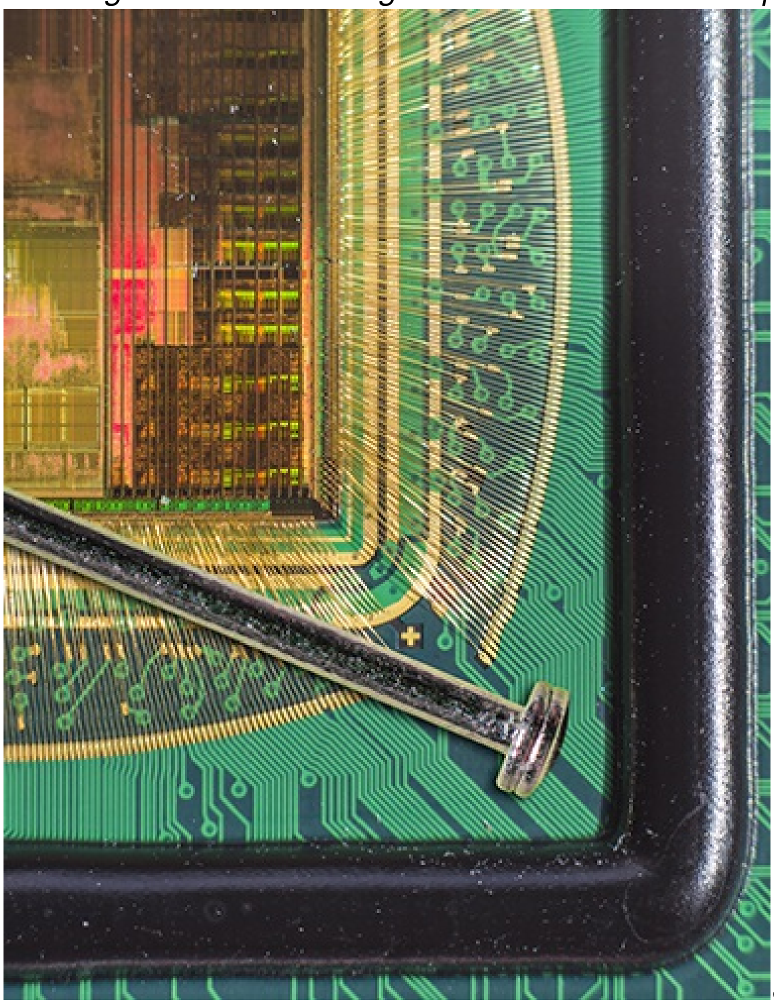


Computers were once based on opening and closing mechanical relays. These computers filled large rooms, and calculations were slow.

Legend has it that the term *debugging*, which is the removal of faulty computer code, came from these early computers. After a Navy computer stopped working, an engineer crawled through the room-sized device. The engineer soon found a dead moth that had been smashed by a relay. Scraping the dead bug from the relay contacts, the engineer soon had the computer working again. Of course, this early instance of "debugging" was much more literal than the repairing processes done today!

An important advance in computer technology occurred in the late 1940s with the invention of the transistor. The *transistor* could be used as a signal switch or amplifier. This replaced the cumbersome, inconvenient work of mechanical relays and vacuum tubes in most applications.

An image of a small sewing needle on a modern computer chip.



Shown here is a small sewing needle on top of a modern computer chip. Transistors made computer miniaturization possible.

Transistors also made possible the miniaturization of computers. No longer did a computer require an entire room. Computer chips contain many transistors in a very small space, greatly increasing computing power. And progress never stops in this area. According to *Moore's Law*, the number of transistors a chip holds doubles every 18 months. This is why "new" computers become obsolete so quickly. It's also why computer technology makes such massive strides in such a relatively short amount of time.

The manufacturing industry has come a very long way since the 1950s. To finish your review of the industry's history, read The History of Manufacturing—Part 4: Toyota and Lean (www.allaboutlean.com/firstlecture_hom_4/) .

The Future of Manufacturing

It costs money to store goods. The shorter the time a good spends in storage, the higher the company's profit. That's why when buyers exist for every good that rolls off a company's assembly line, it benefits the company enormously. Current manufacturing research focuses on *just-in-time* manufacturing, or *JIT*. This is the art of predicting the market and producing exactly the needed number of goods.

JIT is the future of the modern assembly line. In the near future, parts will be *nearly* completed. The customer will place an order online, and the assembly line will finish the good to the customer's requirements.

Key Points and Links

READING ASSIGNMENT

Key Points

- Early manufacturing was done slowly by craftsmen.
- There was little scientific discovery during the Dark Ages.
- The Scientific Revolution ended the Dark Ages.
- The printing press allowed ideas to be communicated farther and more easily.
- One defining development of the Industrial Revolution was the steam engine.
- The steam engine used expanding steam to perform work.
- The invention of interchangeable parts made repairs—and new inventions—easier.
- The assembly line sped up production of many products.
- The invention of the transistor led to modern computers.
- The more transistors on a computer chip, the more computing power available.

Links

- The History of Manufacturing—Part 1: Prehistory to Antiquity (www.allaboutlean.com/firstlecture_hom_1/)
- The History of Manufacturing—Part 2: Middle Ages to Industrial Revolution

(www.allaboutlean.com/firstlecture_hom_2/)
- The History of Manufacturing—Part 3: Luddism to Henry Ford (www.allaboutlean.com/firstlecture_hom_3/)
- The History of Manufacturing—Part 4: Toyota and Lean (www.allaboutlean.com/firstlecture_hom_4/)

Discover More: How Electricity Is Generated

Watch the following video:

Alabama Power's Plant Miller How Electricity Is Generated 3D Animated Tour (www.youtube-nocookie.com/embed/0ftl-WM6wms?rel=0)

Respond to the following based on the video.

1. What's done to the coal after it arrives?
2. Where does the steam go after it leaves the boiler?

Discover More Answer Key:
Discover More: How Electricity Is Generated

1. The coal is measured, then crushed to the consistency of baby powder. It's then blown into the fire box.
2. It's injected into the high-pressure turbine and then the medium pressure turbine. It must be reheated before entering the low-pressure turbine.

1.3 Identify manufacturing job titles and positions

Life in Manufacturing

READING ASSIGNMENT

Careers in Manufacturing

At the start of the Industrial Revolution, plants used unskilled labor. As technology improved, however, plants needed skilled technicians. Today, the days of technicians repeating the same steps for eight hours a day are over. More and more, processes that are repetitive, dangerous, tedious, or require high accuracy have become automated. That trend should continue well into the future.

Yet there are still plenty of careers in manufacturing. With the rise of automation, manufacturing jobs require critical thinking skills. They also require the technician to change as markets and technologies change. Machines and computers can't do either of these things on their own.

Technicians in manufacturing must be flexible and willing to learn. They must adapt to new technologies and markets. They also must seek out opportunities to learn new skills. For example, suppose a foundry technician installs cores in sand molds. If the process is repetitive and boring (in other words, a candidate for automation), this technician should be looking for new skills to learn. Tomorrow, it's possible that a machine will place the cores in molds. When that happens, the foundry won't employ core installers anymore. Yet if the technician has developed other skills, he or she can find work in another part of the plant.

This is the natural order of technology. As you've learned, Moore's Law holds that the number of transistors on a computer chip will double every 18 months. This means that technology is always evolving. It stands to reason that careers in manufacturing must change over time as well.

The old model of manufacturing careers set in the 1950s no longer applies. Technicians can't expect to do the very same job for 20, 30, or 40 years and into retirement. Today, they'll change titles, careers, and companies over time.

It's more the norm today for companies to change names and owners fairly often. New technology develops and changes manufacturing processes. Sometimes, technicians work at a plant only long enough to automate production. Once that plant is automated, the company sends them to automate another plant. This is the new world of manufacturing.

Although manufacturing is ever-changing, some roles are common to all plants. The specifics of their jobs may change, but the roles are universal.

For more facts and figures on the manufacturing industry, readGot Skills? (www.bls.gov/careeroutlook/2014/article/manufacturing.htm) from the Bureau of Labor Statistics.

Technician

Typically, there are more technicians in a plant than any other company position. These are often entry-level roles. Candidates are trained in the specific skill sets needed for the job.

An image of a technician calibrating equipment in a plant.

Technicians are the backbone of a manufacturing plant. They keep the plant running by keeping high-quality goods moving out the door.

Technicians are an important part of the manufacturing plant. However, the plant doesn't run by technicians alone. They must communicate with workers in other roles. Technicians should learn how the plant and its people function together. By studying other roles within the plant, the technician may be preparing for future career opportunities.

There are many types of technicians in a typical manufacturing plant. Machinists, materials handlers, welders, assemblers, and programmers are all technicians. Most technicians will have a generic title but a more specific duty. For example, a job title may be "semiconductor-manufacturing technician." Yet the specific duty may involve running a chemical vapor deposition chamber for coating silicon wafers.

Maintenance Technician

Plant machinery requires routine maintenance or repairs. Sometimes, it's better to have trained technicians handle these maintenance procedures. This is what maintenance technicians do.

An image of two maintenance technicians working together to repair equipment in a plant.


Maintenance technicians keep the machinery running by repairing, cleaning, and caring for the equipment.

In a large plant, you'll find maintenance technicians on every shift. They're ready to repair equipment no matter when it breaks. In a smaller plant, maintenance technicians may only work day shifts.

Maintenance technicians often work with engineers to troubleshoot problems. They also schedule routine maintenance for convenient times, such as low-production periods. This keeps things running with minimal interruption—and prevents future interruption caused by mechanical breakdown.

Maintenance technicians often train other manufacturing technicians. Such training is sometimes months-long and very specific. With the correct supervision, there are many opportunities for on-the-job, hands-on training in a manufacturing plant.

Engineer

Plant engineers are specially trained in data analysis and fact-based optimization. All design changes go through the engineering department. Engineers are often responsible for developing new products and processes as well. They may conduct targeted experiments for new products, new processes, new equipment, or new protocols.

An image of two engineers working together on designs for a CNC plant.

Plant engineers are in charge of making design changes and decisions.

To be an engineer, a person must have a degree from an accredited engineering school. (A bachelor's degree is required, and a master's degree is even more desired.) Training covers data analysis, engineering calculations, and mathematics, among other topics.

Even with their extensive training, engineers still make mistakes. They need input from technicians at all levels of the manufacturing plant. Indeed, a good engineer communicates with technicians and brings them into the decision-making process.

Supervisors

Throughout the manufacturing environment, there are many levels of supervisors. Some supervisors have control over equipment or a process. Others will be in charge of a shift. Technicians in the plant may answer to multiple levels of management in multiple areas.

An image of a female supervisor instructing a maintenance technician on the care of a solar panel.

Supervisors oversee technicians and the processes of a plant.

The role of the supervisor is to manage a small group of technicians. They may resolve disputes among those they manage. They also represent their technicians to higher levels of management. Supervisors should have a good understanding of their managerial duties.

Although you may hear the older title of *foreman* used in a manufacturing environment, this term is gradually fading from common usage. Many "foremen" today are actually women. The gender-neutral terms of *shop manager* and *supervisor* have become favored terms in the industry.

Above the supervisor may be an *area manager* or *area supervisor*. This person will be in charge of all things related to a specific segment of the plant. For example, a large machine shop may have a lathe manager (or area manager of the lathe department).

Finally, there's a *plant manager* who is in charge of the entire plant operation. Plant managers keep track of overall production numbers, costs, and so on. They may not know the specifics of each piece of equipment used. However, the wise plant manager stays as well informed as possible on these types of details. Generally, plant managers keep an eye on the bigger picture—as it's portrayed in dollars and cents.

A TALE OF TWO PLANTS

Read the following scenario concerning a problem in a manufacturing plant.

A medium-sized machine shop has run smoothly for some time. There are two shifts, day and night, each with a shift supervisor and a group of technicians. The quality engineer has recently noticed that there are more defects on the night shift than on the day shift. This engineer is a new employee at the plant, having just finished school.

This problem can be approached in one of two ways.

APPROACH #1: PLAYING THE BLAME GAME

The engineer assumes that workers on the night shift are lazier and calls a meeting with the night-shift supervisor. In a discussion that's both heated and awkward, the engineer accuses the supervisor of letting production slide. The supervisor, now in a foul mood, yells at her technicians for allowing defects through. The technicians receive the reprimand and then go back to work, business as usual.

Word of this incident gets around to the day shift. They begin to blame all plant problems on the night shift. Soon, almost everyone on day shift believes that the night shift workers are careless and do bad work.

Meanwhile, night-shift defect counts remain high. The engineer, seeing no reduction in their frequency, instructs the night-shift technicians on how to do their job better. The lead technician, a 15-year employee, knows that these instructions are faulty and will lead to more problems. Though the lead technician voices his concerns, the engineer ignores them.

After a few more weeks, defect numbers remain high. Learning that the lead technician ignored his instructions, the engineer escalates the situation to the plant manager. The plant manager barely knows the lead technician or the engineer but defaults to the engineer’s judgment. The lead technician is reprimanded.

Finally, the lead technician consents to follow the engineer’s instructions. Equipment is damaged as a result . . . and still, the defect count remains high. The lead technician soon finds a job at another plant.

APPROACH #2: WORKING TOGETHER AS A TEAM

The engineer notices the high defect count on the night shift. He realizes that he doesn't yet fully understand how this plant operates or where the defects might be coming from. Thus, he asks for a sit-down with the shift supervisors. During this meeting, the engineer asks questions and learns more about the overall process. He also informs the supervisors of the defects he has found but doesn't point a finger at anyone. Both shift supervisors begin searching for the cause of the defects.

A few days pass, and the defects don't let up. The shift supervisors each call meetings with their technicians. Each technician is given an opportunity to explain how he or she performs a given task, and the supervisors take notes. Then, the shift supervisors send their findings to the engineer.

The engineer reviews the notes and finds big differences in the way technicians carry out their procedures. Confused himself, the engineer reviews the plant's technical documents regarding the procedure. Soon, the engineer finds that certain wording in the technical instructions is vague. This wording can be interpreted in two different ways, but only one will result in fewer defects. The engineer clarifies the wording and notifies both shift supervisors of the change. The supervisors, in turn, notify their technicians.

The number of defective parts soon decreases radically.

In reality, what happens in most manufacturing plants falls somewhere between these two approaches. Each technician has a say in how a factory will react to problems. However, if technicians across all levels are communicating and sharing knowledge, the plant is more likely to stay successful.

Life on-Shift

In a large manufacturing facility, you may find multiple shifts—that is, more than just "day" and "night." In addition, one shift may have more than one supervisor. These supervisors are known as *shift supervisors*. They meet routinely to discuss problems and formulate solutions. This ensures that valuable information from one shift can be transferred to others.

Plants develop their own shift schedules to meet their production needs. In a smaller facility, technicians may work one eight-hour shift a day. The plant may operate from 8 AM to 5 PM, five days a week. Other plants operate 24 hours a day, seven days a week, every day of the year. These larger plants need several shifts to keep the plant functional, often running complex or expensive processes.

Conversely, a smaller plant may shut down for nights, weekends, or holidays.

Workers may shut down the entire plant to perform maintenance, upgrades, and repairs. A large plant will have maintenance, upgrades, and repairs built into its regular schedule. As you read earlier in the lesson, maintenance technicians may be kept on shift round the clock to deal with unexpected problems. Or, there may be an *on-call system* for handling emergencies and critical repairs. This means that engineers or maintenance technicians remain within communication range of the plant—“on-call”—so that they can be reached to come in when needed.

An image of two engineers talking during a passdown meeting

Two engineers meet for passdown to discuss the status of projects during a shift change. Passdown rarely happens in a meeting room; it often occurs right in the plant.

Although shifts vary among different plants, all shifts have a few things in common. For example, typically, the shift begins with passdown. During *passdown*, the technicians who are finishing their shifts talk to the technicians who are starting theirs. Important information is relayed, or "passed down" from one shift to the next. Technicians may discuss long-term projects, equipment maintenance, and other subjects. Passdown lasts for 10 to 15 minutes at the beginning and end of every shift. It often serves to give the incoming shift a head start or "heads up" on important items that need tending to.

Note: Passdown is never meant to replace written documentation!

Key Points and Links

READING ASSIGNMENT

Key Points

- All plant employees must communicate and work together.
- Technicians answer to a shift supervisor and a plant supervisor.
- Maintenance technicians keep the machines in a plant running.
- Engineers solve problems and make decisions about quality.
- During passdown, employees meet to discuss what happened during the shift that's ending.

Links

- Got Skills? (www.bls.gov/careeroutlook/2014/article/manufacturing.htm)

Discover More: Switching Shifts

A semiconductor plant moves from a constant schedule of 8-hour shifts to 12-hour shifts that alternate from three to four days a week. Longer shifts mean that technicians can get farther into a complicated repair before leaving for the day. That means that repairs take fewer shifts to complete, and less time is spent passing down information between shifts.

Every other weekend has now extended to either three or four days for the technicians. In addition, the "long" week results in overtime hours—and pay. The company also grants technicians a bonus for the compressed work week.

Respond to the following based on the reading.

1. Over a two-week period, how many hours does a technician now work?
2. What advantages do the technicians see by switching to 12-hour shifts?

Discover More Answer Key:
Discover More: Switching Shifts

1. A technician works 36 hours one week (3 days × 12 hours), then 48 hours the second week (4 days × 12 hours) for a total of 84 hours over two weeks.
2. Technicians get a three- or four-day weekend every week. On the four-day work weeks, the technicians make overtime pay.

Lesson 1 Review

Self-Check

1. The purpose of manufacturing goods is to
- a. lower the quality of goods on the market.
- b. produce a surplus of goods to be sold or traded.
- c. promote scientific discoveries.
- d. make a few goods for friends and family.

2. A furniture company produces 50 chairs an hour. On average, three chairs are defective, and one is misplaced or damaged per hour. How many saleable goods are produced per hour?
- a. 4 chairs
- b. 49 chairs
- c. 46 chairs
- d. 44 chairs

3. Which of these is an example of a *good* manufacturing process change?
- a. Speeding up a process by lowering the quality
- b. Adding a step that doesn't increase value to the product or improve safety
- c. Removing a safety protocol to save time
- d. Removing an unnecessary step in a process to save time

4. Which invention spurred the Industrial Revolution?
- a. The transistor
- b. The steam engine
- c. The assembly line
- d. The printing press

5. The two most important parts of the steam engine are the
- a. boiler and radiator.
- b. boiler and transistor.
- c. firebox and transistor.
- d. firebox and boiler.

6. Which of these is an advantage to using an assembly line?
- a. Technicians see the process from start to finish.
- b. Jobs change every day.
- c. Goods can be customized easily.
- d. Goods are likely to be identical.

7. A technician and a maintenance technician have a disagreement on a technical problem. Who should they consult *first*?
- a. An engineer
- b. The plant manager
- c. The shift supervisor

d. Another technician

8. Who are *most* likely to be placed on call?

a. Engineers and maintenance technicians
b. Plant managers
c. Shift supervisors
d. Technicians

9. Which of the following is *most* likely discussed during passdown?

a. An inspirational quote
b. How a specific piece of equipment was functioning
c. An employee's time-off request
d. The company’s mission statement

10. Which of the following would impact the supply of a good, thus *raising* its price?

a. A price increase for the raw materials used
b. A competitor leaving the market
c. A recall of the good
d. A new competitor entering the market

11. Which of the following would impact the demand of a good, thus *lowering* its price?

a. A price increase in the raw materials used
b. A union strike at the plant
c. A recall of the good
d. A celebrity endorsement

12. Who among the following was the *first* to realize the importance of the assembly line in modern manufacturing?

a. Bill Gates
b. Alexander Graham Bell
c. Henry Ford
d. James Watt

13. Which of the following is a common complaint with assembly line work?

a. The assembly lines are too loud.
b. The goods come out too different from each other.
c. The goods are made too slowly.
d. The work is repetitive and boring.

14. One of the large ice cream freezers at your dairy plant has some “cold spots.” The ice cream stored in these areas develop freezer burn and can't be sold. The plant would classify the affected ice cream as

a. recall.
b. rework.
c. shrink.
d. waste.

15. You discover a defect in many of the two-by-fours leaving your sawmill. Each board has a small crack at one end. If you let this defect go unreported, what's the *worst* thing that could happen?

a. The boards are sold, fail, and injure or kill someone.

b. Engineers find that the cost of fixing the saw that's causing the defects is too high.

c. The boards are sold but returned for their defects.

d. Nothing; every two-by-four likely has a small crack.

16. Your company has been stable, producing plastic sunglasses for several years. Every pair of sunglasses is bought soon after it leaves the plant. Which of the following might *decrease* your profits?

a. New improvements increase the quality of your sunglasses.

b. A new competitor starts making plastic sunglasses.

c. The price of plastic increases.

d. An old competitor stops making plastic sunglasses.

17. What made the development of the printing press so important?

a. The printing press burned coal, and that led to the development of the steam engine.

b. The printing press required interchangeable parts.

c. The printing press made it possible for inventors to copy the work of other inventors.

d. The printing press made it possible to spread ideas over great distances more quickly.

18. In what industry were assembly lines first developed?

a. Steam engine

b. Electronics

c. Meat and whale oil processing

d. Automobile and factory automation

19. Which of the following statements is *true*?

a. The Dark Ages were ended in part by the invention of the printing press.

b. The Dark Ages were ended in part by the invention of the transistor.

c. The Dark Ages were ended in part by the invention of the assembly line.

d. The Dark Ages were ended in part by the invention of the steam engine.

20. You've been promoted to shift supervisor at your plant. Which of the following is a task you might have to do?

a. Repair a piece of equipment that has failed

b. Make technical decisions about the specifics of a design

c. Settle an argument between two technicians

d. Keep the entire plant running efficiently

Self-Check Answer Key

1. produce a surplus of goods to be sold or traded.
   Explanation: Manufacturing is about producing goods for sale on the market. While scientific discoveries may occur during the manufacturing process, it isn't the overall purpose of manufacturing.
   Reference: Section 1.1

2. 46 chairs
   Explanation: The throughput is 50 chairs per hour. The defects are three chairs per hour. The shrink is one chair per hour. Saleable Goods = 50 – 3 – 1 = 46 chairs per hour
   Reference: Section 1.1

3. Removing an unnecessary step in a process to save time
   Explanation: By removing an unnecessary process, more parts can be manufactured in the same amount of time. When a step is removed, safety, quality, and cost shouldn't be impacted. When a step is added, it will increase time (and perhaps cost), so it must improve safety or quality.
   Reference: Section 1.1

4. The steam engine
   Explanation: The steam engine was the most important invention of the Industrial Revolution. The printing press was part of the Scientific Revolution. The assembly line and transistor were invented much later.
   Reference: Section 1.2

5. firebox and boiler.
   Explanation: Fuel is burned in the firebox, and the heat is used to boil water in the boiler. Transistors are parts of a computer. Radiators are used to cool the engine or heat a room, not boil water.
   Reference: Section 1.2

6. Goods are likely to be identical.
   Explanation: Goods are likely to be identical because technicians perform the same tasks over and over again. This means that jobs are repetitive and don't change every day. Technicians see only one part of the process. Goods can *not* be customized easily on an assembly line.
   Reference: Section 1.2

7. An engineer

Explanation: Talking to the engineer would be a good first step. The other people might be helpful, but the engineer is skilled in technical issues.
Reference: Section 1.3

8. Engineers and maintenance technicians
   Explanation: When there are technical issues, engineers and maintenance technicians are the first people called. The shift supervisor is rarely put on call since he or she manages a shift. The plant manager can be notified of major problems but only after all other options have been pursued.
   Reference: Section 1.3

9. How a specific piece of equipment was functioning
   Explanation: The performance of certain equipment is something that very likely could be discussed. None of the other choices fall under the purpose of passdown.
   Reference: Section 1.3

10. A competitor leaving the market
    Explanation: A competitor leaving the market would affect the supply of a good by lowering the available options for purchasing the good. This would in turn raise the good's price.
    Reference: Section 1.1

11. A recall of the good
    Explanation: If a good is recalled, that impacts the reliability and demand of that good, which will lower the price in turn.
    Reference: Section 1.1

12. Henry Ford
    Explanation: Of those listed, Henry Ford was the first to realize the importance of the assembly line in his manufacturing of vehicles.
    Reference: Section 1.2

13. The work is repetitive and boring.
    Explanation: Although effective at manufacturing products quickly and cost-effectively, assembly line work is known to be repetitive and boring.
    Reference: Section 1.2

14. waste.
    Explanation: The ice cream is classified as waste because it was spoiled in

storage and can't be sold.
Reference: Section 1.1

15. The boards are sold, fail, and injure or kill someone.
Explanation: Reporting the defects to make sure the boards don't go on the market is critically important. If the boards fail and cause serious injury or death, the plant and the company will be liable as a result of your neglect.
Reference: Section 1.1

16. A new competitor starts making plastic sunglasses.
Explanation: If a new competitor enters the market, it increases the overall supply while lowering demand because of the availability of more product. This will cause a decrease in your profits.
Reference: Section 1.1

17. The printing press made it possible to spread ideas over great distances more quickly.
Explanation: The invention of the printing press made it quick and easy to spread updated news in a timely manner to a larger audience.
Reference: Section 1.2

18. Meat and whale oil processing
Explanation: Assembly lines started in meat and whale oil processing because the product was spoiling too quickly. A new way of manufacturing needed to be adapted to prevent this waste. Later, the assembly line's effectiveness lent itself to other industries.
Reference: Section 1.2

19. The Dark Ages were ended in part by the invention of the printing press.
Explanation: With the invention of the printing press, news and ideas were being distributed to a wider audience. This helped bring about the end of the Dark Ages.
Reference: Section 1.2

20. Settle an argument between two technicians
Explanation: Engineers generally handle technical decisions, while maintenance technicians repair equipment. As a shift supervisor, it isn't your sole responsibility to make sure that the entire plant is running efficiently—you have a whole team for that, each with their own specific job. However, it *is* your job to supervise your team, which would include settling an argument between

employees.
Reference: Section 1.3

Flash Cards

1. Term: Manufacture
Definition: To make goods to sell or trade

2. Term: Plant
Definition: Factory where goods are manufactured

3. Term: Quality
Definition: Final evaluation of a product, as determined by the customer

4. Term: Optimize
Definition: To change a process by reducing the time or cost associated with production

5. Term: Profit
Definition: The money a company makes after expenses; expressed formulaically as *revenue – costs*

6. Term: Fixed Costs
Definition: Money spent regardless of how many goods are manufactured

7. Term: Variable Costs
Definition: Money spent that depends on the number of goods manufactured

8. Term: Revenue
Definition: Income from selling goods

9. Term: Defect
Definition: Something that prevents a good from being sold in its present condition

10. Term: Shrink
Definition: Refers to the number of goods lost or stolen in a plant

11. Term: Returns
Definition: Defective goods sent back to the company by customers

12. Term: Recall

Definition: When a company must ask customers to return a good due to defects

13. Term: Waste
Definition: Goods that have expired and can no longer be sold

14. Term: Throughput
Definition: Amount of goods manufactured per unit time

15. Term: Saleable Goods
Definition: The number of goods that are sold

16. Term: Supply and Demand
Definition: Balance between the number of goods available and the number of goods wanted

17. Term: Dark Ages
Definition: A period characterized by little scientific advancement, extending from the fifth to fifteenth century AD

18. Term: Scientific Revolution
Definition: An era of rapid scientific discoveries that ended the Dark Ages

19. Term: Printing Press
Definition: An invention that allowed books and other printed materials to be easily reproduced

20. Term: Industrial Revolution
Definition: A period of rapid technological advances in manufacturing, kicking off in the mid-eighteenth century

21. Term: Steam Engine
Definition: An invention that harnessed steam expansion to perform work

22. Term: Firebox
Definition: The part of a steam engine in which fuel is burned to generate heat

23. Term: Boiler
Definition: The part of a steam engine in which water is heated and boiled

24. Term: Heat Exchanger

Definition: A device such as a boiler that transfers heat from one element (fire) to another (liquid)

25. Term: Interchangeable Parts
Definition: Replaceable product parts that meet an agreed-upon standard

26. Term: Assembly Line
Definition: A method of manufacturing in which products pass from one worker to another, each worker performing a separate production task

27. Term: Transistor
Definition: An electronic device that's used as a switch or amplifier on electronic signals

28. Term: Debugging
Definition: The removal or repair of defective computer code

29. Term: Moore's Law
Definition: A rule stating that the number of transistors a computer chip can hold doubles every 18 months

30. Term: Technician
Definition: A plant employee with a specific set of skills

31. Term: Maintenance Technician
Definition: A technician who performs upkeep on and repairs machinery

32. Term: Engineer
Definition: An employee who makes technical decisions and troubleshoots problems in the plant

33. Term: Shift Supervisor
Definition: A manager who makes decisions for a specific shift

34. Term: Foreman
Definition: An outdated, gender-specific term for a male shift supervisor

35. Term: Plant Manager
Definition: A manager who whose focus is the overall running and productivity of the plant

36. Term: Automation
Definition: The use of robots and computers to perform tasks