The big picture

The previous subtopic (Subtopic 5.2 (/study/app/business-hl/sid-351-cid-762729/book/the-big-picture-id-39052/)) focused on how products are made. This subtopic will focus on how companies ensure that they produce products efficiently and with quality. It will explore two key ideas: lean production and quality management. Lean production involves a set of strategies that reduce waste in the production process. Quality management involves a set of strategies that ensure products meet or exceed customers' expectations. Without effective quality management, production standards are likely to fall and this results in lost sales, lower revenues, higher costs and more waste. Thus, lean production and quality management are related to one another.

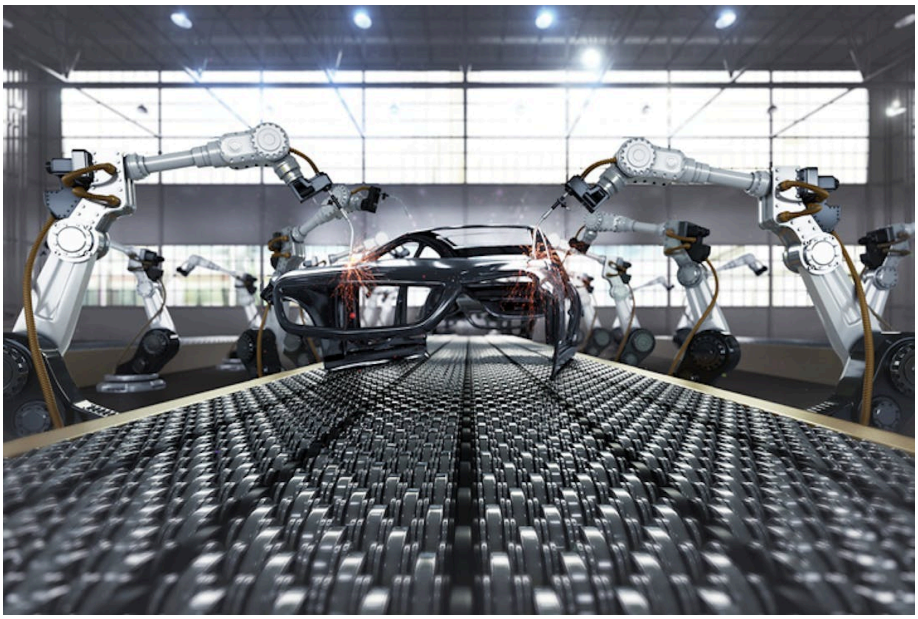


Figure 1. Many automobile manufacturers are very focused on increasing both efficiency and quality.

Credit: Yuichiro Chino, Getty Images

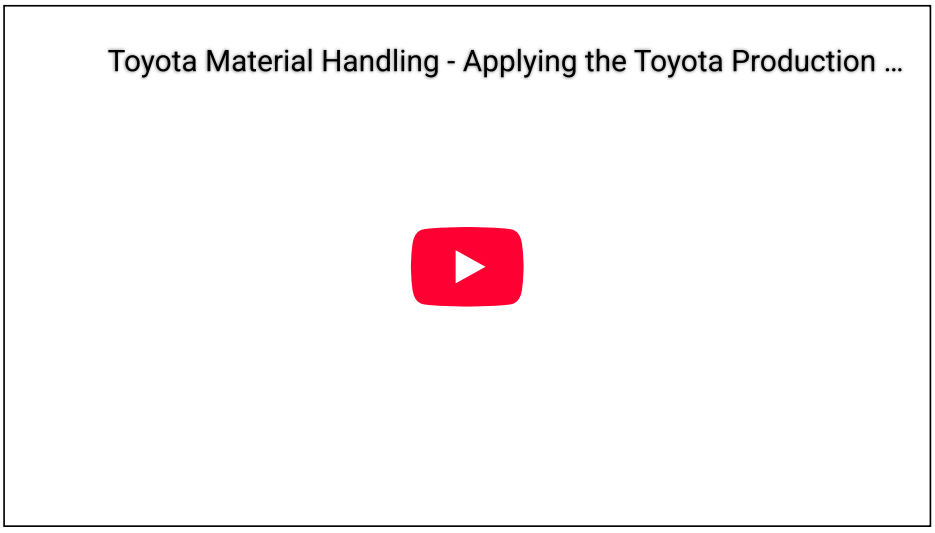
Overview (/study/app/business-hl/sid-351-cid-762729/o

The automobile manufacturer Toyota is widely regarded as the global leader in lean production and quality management. It uses a production control system called the Toyota Production System (TSP), which involves a process called continuous improvement (kaizen). Continuous improvement is the idea that, no matter how efficient a process is, it can always be improved further to reduce waste and increase quality. These improvements might involve reducing wasted materials, reducing wasted time or reducing defects. Toyota holds a series of ongoing, regular meetings in which staff discuss ideas for improving product quality. The company also carries out a thorough examination of all defective parts that are returned to the factory from customers. These inspections aim to discover and eliminate the root cause of each problem so that it does not occur again.

Toyota also seeks to treat stakeholders with respect, and systems are put in place to ensure stakeholders' needs are met. For example, workflows are designed to avoid putting too much stress on employees, allowing everyone time to complete their jobs. Toyota also aims to build long-term relationships with its suppliers and work in partnership with them, helping suppliers to improve quality and streamline their own production systems.

All of this has helped Toyota become the largest automobile manufacturer in the world, and to retain its lead through the COVID-19 pandemic.

Some of Toyota's strategies for lean production and quality management are shown in **Video 1**. While you watch the video, consider what actions the company takes to reduce waste. How is product quality ensured?



Video 1. How Toyota implements lean production.

Student view

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Concept

Creativity and sustainability

Creativity involves generating new ideas and considering existing ideas from new perspectives. Creativity may be evident in the use of inputs, business processes, product outputs and other solutions. The creation of ideas and solutions involves a process of synthesising and evaluating in response to surrounding changes.

Lean production and quality management both require creativity from business owners, managers and other employees. Those who work in the business can use their knowledge, skills and experience to find new ways to produce their products that reduce waste and improve quality. They can explore ideas from competitors in the industry, or apply ideas that come from different industries or even from different disciplines. Some of the best ideas in business come from those who have been able to apply novel ideas from completely different fields.

Learning objectives from the IBDP Business Management guide with assessment objective level:

- **Describe** the following features of lean production: (AO1)
  - less waste
  - greater efficiency
- **Explain** the following features of lean production: (AO2)
  - continuous improvement (kaizen)
  - just-in-time (JIT)
- **Explain** the features of cradle-to-cradle design and manufacturing (AO2)
- **Distinguish** between quality control and quality assurance (AO2)
- **Explain** the following methods of managing quality: (AO2)
  - quality circle
  - benchmarking
  - total quality management (TQM)
- **Discuss** the impact of lean production and TQM on an organisation (AO3)
- **Explain** the importance of national and international quality standards (AO2)
- **Apply** a Gantt chart in a given context (AO2) (HL)
- **Prepare** and **analyse** a critical path (network) diagram in a given context (AO4, AO2) (HL)

Student view

Lean production

Efficiency and waste

The terms efficiency and waste are interconnected; if waste can be reduced, then efficiency should improve. Efficiency refers to how well a business can transform physical, human and financial inputs into outputs. A business is more efficient if it can produce more products (output) using the same or even fewer resources (inputs). Improved efficiency reduces costs of production (see **Figure 1**). If more output is produced with the same inputs, or if the same output is achieved with fewer inputs, then the average cost per unit will fall.

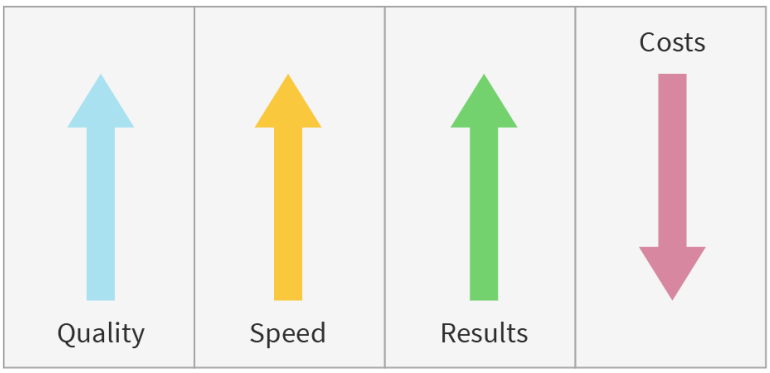

Figure 1. The benefits of efficiency.

For many companies, labour costs are the most expensive resource input. Labour efficiency can therefore have a significant effect on unit costs. If fewer employees are needed, or if the same number of employees can produce more, unit labour costs will be reduced.

Imagine, for example, that you run a large hotel chain. One of the biggest variable costs of selling a room for the night is the cost of cleaning the room after the guests have left. If you pay your cleaning staff $12 per hour and it takes one person 30 minutes to clean a room, then the average variable cost will be $6 per room. However, if you train your staff and give them the necessary tools to do their job, cleaning time could be reduced to 20 minutes per room. This increased efficiency will see the average variable cost fall to just $4 per room.

Overview (/study/app/hl/sid-351-cid-762729/o

Waste is any part of the production process that does not add value to the final consumer. Waste means resources are lost and often results in damage to people and the planet. If waste can be reduced, costs of production are also often reduced, leading to higher profits. Toyota has identified seven main categories of waste:

- **transportation** – moving components between workstations or from suppliers
- **inventory (stock)** – building up excessive stocks, resulting in storage costs
- **motion** – staff risking injury while making the product
- **waiting** – delays in the production process
- **over-processing** – adding features to a product that are not required by the customer and therefore do not add value
- **over-production** – producing an inventory of finished goods before they are needed
- **defects** – finished goods that do not meet quality control standards

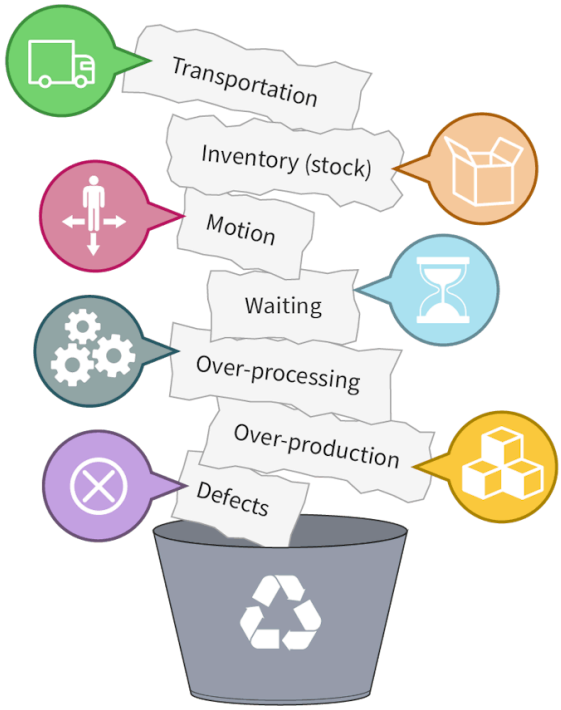

Figure 2. Types of waste.

More information for figure 2

The image depicts seven types of waste represented as individual labels, each associated with a unique icon, pouring into a recycling bin. The types are: Transportation (icon of a truck), Inventory or stock (icon of a box), Motion (person with arrows indicating movement), Waiting (hourglass icon), Over-processing (gears icon), Over-production (stacked boxes icon), and Defects (cross mark icon). Each type of waste is shown as torn paper fragments leading into the bin, emphasizing a flow of waste. This visual arrangement illustrates the 'TIM WOOD' mnemonic for waste management.

[Generated by AI]

Student view

Overview (/study/app/hl/sid-351-cid-762729/o

These types of waste can be remembered by using the mnemonic (memory aid) 'TIM WOOD' – the initial letter of each type of waste. **Table 1** provides an example of how each type of waste might occur in a hairdressing salon.

Table 1. Types of waste in a hairdressing salon.

Type of waste	Hairdressing salon example
Transportation	Clients moving between different stations for washing, cutting and colouring.
Inventory (stock)	Having excessive stock of hair colouring products that is unlikely to be needed.
Motion	Staff using faulty electrical equipment, such as hair dryers.
Waiting	Customers having to wait to see their stylist due to overbooking.
Over-processing	Offering additional hair treatments that the customer does not need or want.
Over-production	Making large amounts of coffee or snacks that customers do not ask for and that are eventually thrown away.
Defects	Poor quality hair services that lead to dissatisfied customers.

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (transfer)

Copy and complete the following table. Think about the types of waste outlined above in the context of your school. Consider examples of what waste would look like and what could be done to reduce that waste.

Type of waste	School example	Ideas for improvemer
Transportation		

Student view

Overview (/study/ap hl/sid-351-cid-762729/o

Type of waste	School example	Ideas for improvemer
Inventory (stock)		
Motion		
Waiting		
Over-processing		
Over-production		
Defects		

In a hairdressing salon that provides a service with a visible result, or in a factory producing a physical product, it may be easy to see the negative impact of waste on the business. Fewer customers can be served, fewer items produced. The waste may be very visible in terms of material resources.

- Why might the impact of waste in a school be more difficult to see and measure? Discuss with a partner, or in the class.

Case study

Food waste

According to the UNEP Food Waste Report (https://www.unep.org/resources/report/unep-food-waste-index-report-2021), almost a billion tonnes of usable food is wasted each year globally. This is about 17% of all food produced each year. **Figure 3** shows where that waste occurs after it leaves the farm.

Student view

Overview (/study/ap hl/sid-351-cid-762729/o

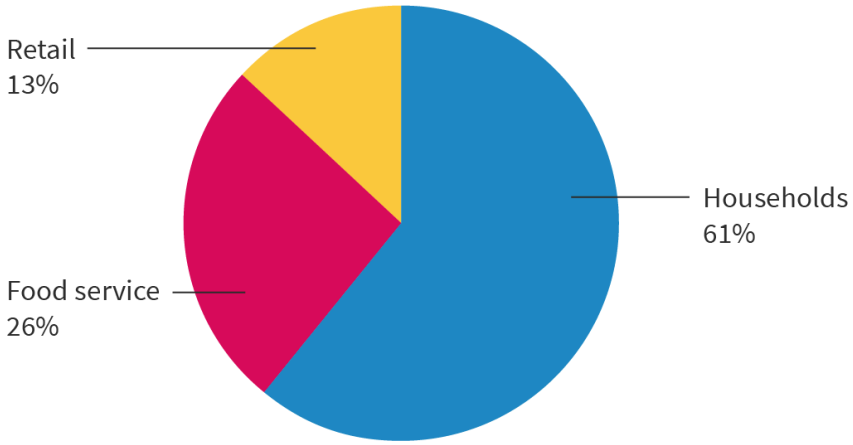

Figure 3. Proportion of total global food waste occurring in households, food service and retail.

Source: United Nations Environmental Programme (UNEP) Food Waste Index Report, 2021. Nairobi.

More information for figure 3

The image is a pie chart depicting the distribution of global food waste. It is divided into three segments. The largest segment represents households, which account for 61% of total food waste. The second segment indicates food service, contributing to 26% of the waste. The smallest section is retail, comprising 13% of the waste. Each segment is labeled accordingly with its percentage, indicating where food waste occurs globally after it leaves the farm.

[Generated by AI]

This food waste is a problem for both people and the planet. While food is wasted all along the food chain, the Food and Agriculture Organisation (FAO) reported in 2021 that more than 800 million people globally — more than 10% of the world's population — are malnourished. Hunger has worsened globally during the COVID-19 pandemic. Enough food is produced globally, often by those experiencing malnutrition themselves, to meet the needs of all. But the distribution of food needs to be improved, and waste needs to be reduced.

Food waste contributes significantly to climate change because, according to the UN, 8 to 10% of global carbon emissions are linked to food waste. Climate change increases food insecurity and increases the likelihood of waste due to increases in unpredictable and severe weather affecting agriculture. Food waste also causes increased pollution, loss of biodiversity, excessive land conversion and freshwater extraction, all of which threaten planetary boundaries and further worsen poverty and hunger.

Supermarkets can reduce waste by maintaining the quality and safety of produce on their shelves while using as little energy as possible. They can provide discounts earlier, when the sell-by dates of food approach, or they can donate surplus food to charities and community organisations to avoid throwing it away. Technology can also help. 'The internet of things' technology (HL Subtopic 5.9 (/study/app/business-hl/sid-351-cid-762729/book/the-big-picture-id-39043/)) can help to monitor storage conditions and stocks (inventory) to ensure that only what is needed is ordered.

Student view

Overview (/study/ap hl/sid-351-cid-762729/o

Restaurants can reduce food waste by cutting back the diversity and complexity of their menus. This would require fewer inputs to produce food for customers. They can also provide smaller-sized food portions. Any food waste that still occurs should be processed for energy and compost. Many businesses around the world offer such services to the food industry.

Households can reduce waste by more careful shopping. People should buy only what they need and plan meals to use what they already have. Like restaurants, left-over food and food scraps should become resources for food and energy systems.

Questions

- Explain why a pie chart, as opposed to another graphic form, is used for the data in **Figure 3**. [2 marks]
- Explain **one** reason why a restaurant would want to reduce its food waste. [2 marks]
- Using the Doughnut Economics model or the SDGs, explain how food waste is a problem for both the social foundation (human needs) **and** planetary boundaries. [4 marks]

Question 1

A pie chart is used for the data in **Figure 3** because the data represents parts of a whole that can be represented as slices of a pie. While a bar graph comparing the sectors could also represent the data, it would not convey the same meaning. This is because it would not be as clear that a whole is broken into parts. In this case, household waste comprising 61% of waste, food service comprising 26%, and retail comprising 13% adds up to 100% of the whole value of waste after leaving the farm.

Explain is an AO2 level command term, requiring a detailed account including reasons or causes.

- One mark is given for a partial explanation.
- Two marks are given for a full definition.
- Only one point needs to be made. Other responses are possible and would be rewarded if appropriate.
- To achieve full marks, you must always include theory and application to the case study in your responses.

Question 2

Waste is any part of the production process that does not add value to the final consumer. Waste means resources are lost. One reason for a restaurant to reduce food waste is to lower costs of production. If the restaurant pays money for resources but is not able to turn all of the resources into outputs that earn

Student view

Overview (/study/ap hl/sid-351-cid-762729/o

revenue, then this is inefficient. Reducing resource inputs and costs, with a better conversion of inputs to products that earn revenue, should raise profits for the restaurant.

You may also have referred to the negative social or environmental impacts of food waste.

Explain is an AO2 level command term, requiring a detailed account including reasons or causes.

- One mark is given for a partial explanation.
- Two marks are given for a full definition.
- Only one point needs to be made. Other responses are possible and would be rewarded if appropriate.
- To achieve full marks, you must always include theory and application to the case study in your responses.

Question 3

Food waste is a problem for the social foundation. In the Doughnut Economics model, food is one of the basic human needs. SDG2 No Hunger aims to eliminate hunger in the world by 2030. There is enough food in the world to meet everyone's nutritional needs, but the combined problems of distribution and waste currently prevent the efficient use of food to meet human needs.

Food waste is also a problem for planetary boundaries. Climate change, biodiversity loss, land conversion and freshwater extraction are all made worse by excessive food production and food waste. According to the case study, 8 to 10% of CO_2 emissions are caused by food waste alone. Reducing waste would lower these emissions. Fewer resources would be required, which would reduce biodiversity loss, require less land conversion and less water use. These improvements would also have positive impacts on human wellbeing in a virtuous feedback loop.

Explain is an AO2 level command term, requiring a detailed account including reasons or causes.

- One mark is given for a partial explanation.
- Two marks are given for a full definition.
- Two points need to be made. Other responses are possible and would be rewarded if appropriate.
- To achieve full marks, you must always include theory and application to the case study in your responses.

Student view

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Making connections

Young activists around the world are exposing food waste in supermarkets by investigating what gets disposed of in supermarket dumpsters. Matt Homewood (https://www.matthomewood.com/) is one such activist, exposing high levels of food waste in Copenhagen, which is considered one of the more sustainable cities in the world.

Investigating and taking action to reduce food waste in your home, school, and/or local restaurants and supermarkets can be an interesting CAS project. You can use the Youth Mayors Field Guide (https://sites.google.com/uwcmaastricht.nl/youth-mayors-curriculum/home) to help you organise the investigating, planning and designing, taking action, sharing and scaling of such a project.

Lean production

Lean production refers to a set of strategies to reduce waste in the production process. The objective of lean production is to produce a high-quality product using minimal resources. There is always room for new, creative ideas for reducing waste in production. This creative mindset has led businesses that practise lean production to cut costs and reduce defects year after year. The principal methods of lean production covered in this section are:

- continuous improvement (kaizen)
- just-in-time (JIT) production

Continuous improvement (kaizen)

Meaning ‘change for the better’ in Japanese, kaizen is both a process and a philosophy. It involves businesses holding regular, scheduled meetings where staff are invited to give their opinions and suggest improvements.

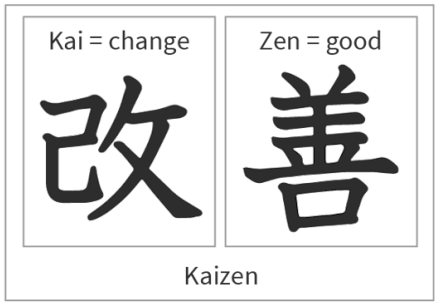

Figure 4. Continuous improvement or kaizen.

Student view

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Thousands of ideas are suggested each year in the kaizen process. Clearly, not all these ideas are used, but at least some will be of value to the business. These meetings can reduce costs and drive up product quality. They also have another benefit, which is that staff feel respected because their ideas are taken seriously. This can lead to a boost in motivation and further gains in productivity. **Table 2** outlines the main benefits and limitations of continuous improvement (kaizen).

Table 2. Benefits and limitations of continuous improvement (kaizen) for a business.

Benefits of continuous improvement (kaizen)	Limitations of continuous improvement (kaizen)
Diversity of ideas. A range of ideas is suggested so the business is more likely to make the 'best' decision.	**Lower productivity.** Meetings and evaluation of ideas takes time, possibly reducing productivity.
Better ideas. Employees may have a greater knowledge of the problem than the managers/directors that may traditionally make decisions.	**Higher labour costs.** Involving staff in improvements may result in them demanding higher wages for increased responsibility.
Employee motivation. Involving staff helps them to feel valued, improving motivation.	

Theory of Knowledge

Toyota provides an excellent example of success in the reduction of production waste resulting from the implementation of lean production and quality control. Some of the most innovative approaches to reducing waste in production and quality control have come from Japanese companies and have quickly been adopted by other businesses.

This poses the question of whether the consideration of production waste and product quality is related to the culture of the producers and consumers.

- What is the role of both organisational culture and national culture in the innovations related to waste reduction and product quality?

Just-in-time (JIT) production

Student view

Traditionally, companies liked to hold large quantities of stock (inventory) 'just in case' it was required for an unexpected order or there was a problem with the supply chain (such as a delayed delivery). However, this system of inventory control proved expensive. It led to high

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storage costs and potential waste if the product went out of date or was damaged in storage. It also involved committing large amounts of cash to stock purchases; this cash could be put to better use elsewhere in the business.

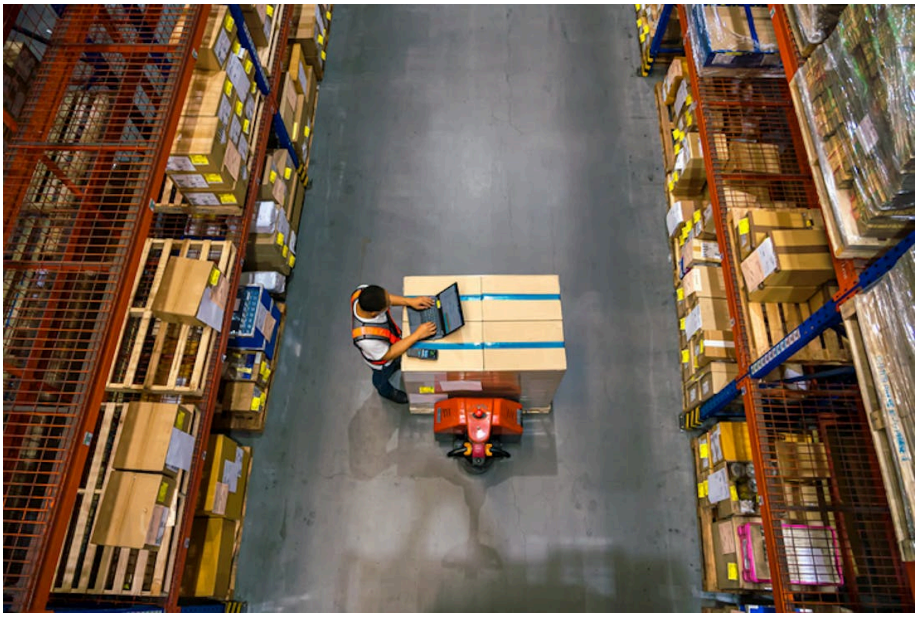

Figure 5. Just-in-time production means that resources are delivered just before they are needed, reducing the need to store inventory (stock).

Credit: Kmatta, Getty Images

Just-in-time (JIT) production aims to minimise costs by reducing or even eliminating the stock (inventory) being held by a company. JIT works on the principle of placing smaller, regular orders that are delivered just in time for them to be used. Major global supermarket chains have fully implemented JIT delivery systems. Sophisticated IT systems allow new products to be ordered from suppliers the instant they are scanned at the sales checkout. As a result, stores receive deliveries from suppliers 24 hours a day, meaning that shelves are rarely empty or under-stocked. This has also allowed the stores to convert now empty stock rooms into additional retail space.

To be successful, just-in-time production requires excellent relationships and regular communication between a company and its suppliers. The suppliers must deliver their goods more regularly and in smaller batches, increasing their distribution costs. In addition, a company may ask its suppliers to react quickly to changing demand for products. To help overcome these problems, companies using just-in-time production usually seek to develop long-term partnerships with a limited number of suppliers. Giving these suppliers guaranteed sales over a period of time makes them more willing to meet the increased demands placed upon them. **Table 3** outlines some of the benefits and limitations of just-in-time production for a business.

Student view

Overview (/study/ap hl/sid-351-cid-762729/o

Table 3. Benefits and limitations of just-in-time production for a business.

Benefits of just-in-time production	Limitations of just-in-time production
Improved cash flow and reduces costs. Businesses can reduce costs by reducing the stock (inventory) they hold. They can then use the money saved for other operations (Subtopic 3.7 (/study/app/business-hl/sid-351-cid-762729/book/the-big-picture-id-39317/)).	**Reduced economies of scale.** Businesses will make smaller orders, possibly reducing purchasing economies of scale (Section 1.5.2 (/study/app/business-hl/sid-351-cid-762729/book/internal-and-ext-economies-id-36534/)).
Improved operations. Employees know they need to be careful in operations, because there is no spare stock (inventory) to rely on.	**High risk.** Production may halt if a small part of the supply chain breaks down. Any delay in delivery becomes critical for production.
Increased capacity. With less storage space needed for stock (inventory), more space can be allocated to production.	**Reduced resilience.** Businesses may be unable to adapt to changes in the internal or external environment (related to risk). JIT may not be suitable for businesses with seasonal demand.

Making connections

HL students will learn more about just-in-time production and contrast it with just-in-case production in Subtopic 5.6 (/study/app/business-hl/sid-351-cid-762729/book/the-big-picture-id-39337/).

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (transfer)

Find out whether your school uses lean production strategies in its operations.

- Does the school hold regular meetings where employees are invited to provide feedback for improvement of the school and its processes?
- Does the school have any strategies to order supplies only when needed to avoid inventory costs?

Student view

International Mindedness

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For many years, businesses seeking lower costs of production have sourced component parts and products from other countries, where just-in-time production is also used to reduce stock (inventory) costs. When global supply chains work well, these complex chains and just-in-time production are beneficial. When there is a disruption to the external environment however, as was the case with the pandemic, these supply chains can break down, leading to production disruption and higher costs.

The COVID-19 pandemic forced many businesses to rethink their long and complex supply chains. As a result of the pandemic, many businesses are considering moving to higher cost (but lower risk) localised suppliers. Businesses must always weigh up the trade-off between cost and risk/resilience.

4 section questions

Question 1

Which of the following is **not** a category of waste?

1 Over-use ✓

2 Inventory (stock)

3 Motion

4 Transportation

Explanation

The seven main categories of waste are:

- transportation
- inventory
- motion
- waiting
- over-processing
- over-production
- defects

Over-use is not one of these categories.

Student view

Question 2

Overview (/study/ap hl/sid-351-cid-762729/o

What could be a disadvantage of high productivity?

1 Declining quality ✓

2 Higher output

3 More motivated staff

4 Higher costs of production

Explanation

If work is rushed, or workers are put under too much pressure, then mistakes will be made. This can lead to increasing amounts of waste or, worse still, faulty products. High output and motivated staff are generally considered benefits, while high productivity will lead to lower not higher average costs.

Question 3

Which of the following is a disadvantage of using continuous improvement (kaizen) as a lean production strategy?

1 Production time may be lost due to meetings. ✓

2 Employees may be motivated by empowerment.

3 Stock (inventory) may run out while waiting for deliveries.

4 It can be difficult to react to large, unexpected orders.

Explanation

Following continuous improvement (kaizen) principles may lead to lost production time as a result of meetings and evaluation of ideas, possibly reducing productivity.

Motivation of staff is considered an advantage. The other two options are seen as potential disadvantages of using a just-in-time model of production, rather than of using continuous improvement (kaizen).

Question 4

Student view

Just-in-time (JIT) production may reduce 1 resilience ✓ of a business. This is because low stock (inventory) levels can make the business unable to respond and adapt to unexpected changes to the external environment, such as sudden increased demand.

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Accepted answers and explanation

#1 resilience

General explanation

Resilience refers to the ability of an individual or group/organisation to respond or adapt well to disruptions. Because just-in-time (JIT) production brings resources to a business just before it requires them, any change to the external environment could completely disrupt the production process, even causing production to stop completely.

5. Operations management / 5.3 Lean production and quality management (HL)

Cradle-to-cradle design and manufacturing

Cradle to cradle design and manufacturing (HL)

Section Student... (0/0) Feedback Print (/study/app/business-hl/sid-351-cid-762729/book/cradletocradle-design-and-manufacturing-id-39485/print/) Assign

Cradle-to-cradle design and manufacturing is a model of designing and creating products in a way that minimises waste and negative effects on the environment and on all stakeholders. It is a model that focuses on sustainability. This could include making products durable so they do not have to be replaced, using recyclable materials or choosing production methods that reduce pollution. **Figure 1** illustrates two of the fundamental ideas that underpin cradle-to-cradle design. These ideas are now being used by thousands of businesses around the world.

In the biological cycle, biodegradable raw materials are used. These products or materials are broken down (turned back into raw materials) naturally by biological agents such as bacteria and fungi. Biodegradable soaps, dishwasher detergents and laundry detergents are now widely available (the non-biodegradable forms of which are considered major sources of underground water pollution). Other examples of products that are available in biodegradable form are glass, multipurpose cleaners, nappies, pet waste bags, rubbish bags and eating utensils.

Student view

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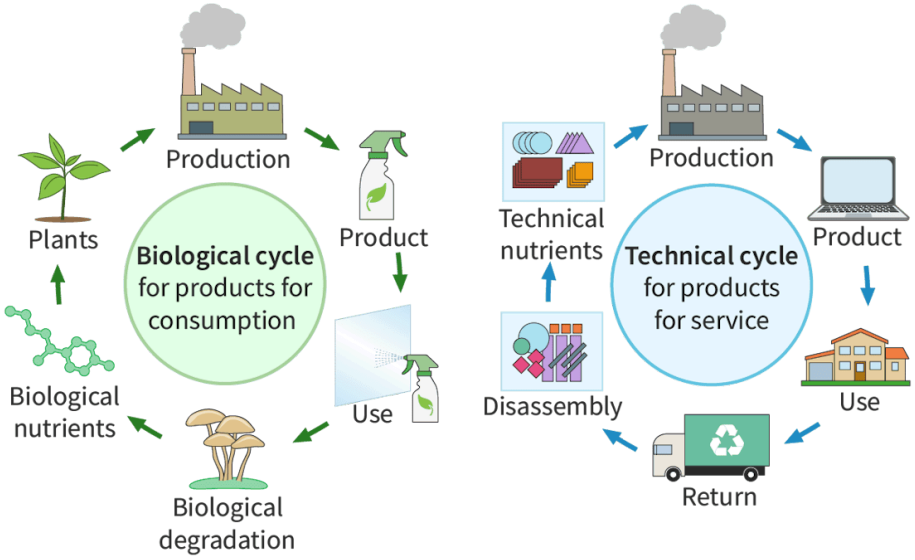


Figure 1. Cradle-to-cradle design and manufacturing aims to reduce waste.

More information for figure 1

The image depicts two cycles side by side: the Biological Cycle and the Technical Cycle.\n\nIn the Biological Cycle on the left:\n- It starts with a factory icon labeled 'Production' leading to 'Product' with a bottle icon.\n- Below is 'Use,' leading to 'Biological degradation' depicted by mushrooms and arrows pointing to 'Biological nutrients.'\n- The cycle completes with 'Plants' returning to 'Production.'\n\nIn the Technical Cycle on the right:\n- A factory labeled 'Production' leads to 'Product,' represented by a laptop.\n- This leads to 'Use,' which is illustrated with a house icon.\n- The cycle continues to 'Return,' represented by a recycling truck icon, then to 'Disassembly,' showing various materials being disassembled.\n- It completes the cycle by moving back to 'Technical nutrients,' which then go to 'Production.'\n\nArrows connect each stage, indicating a circular flow for both biological and technical processes, emphasizing sustainability through reuse and recycling.

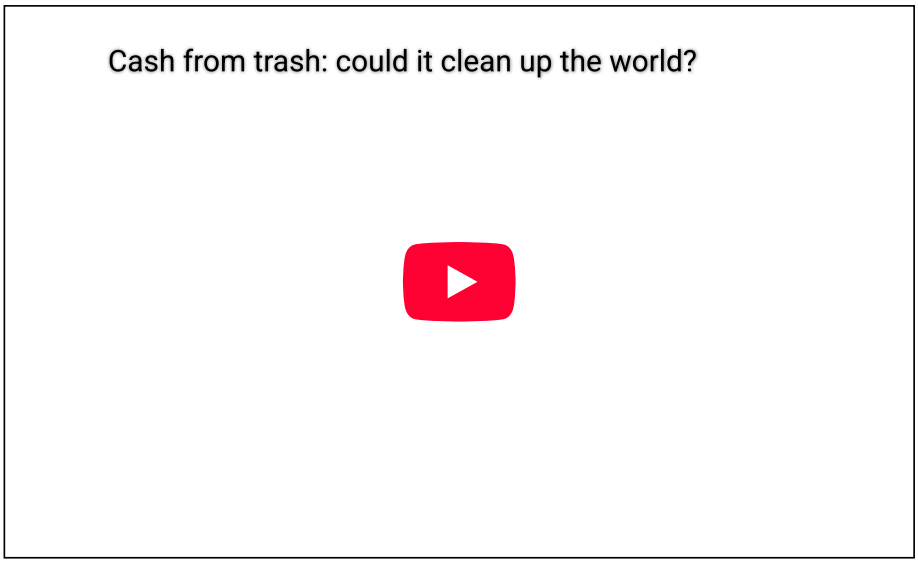
[Generated by AI]

The technical cycle focuses on the ideas of reuse and recycling. Products are made using sustainable materials, which can then be disassembled and reused once the original product is no longer needed. Using glass instead of plastic to design drinks bottles is a good example of the technical cycle in action. Plastic drinks bottles are a major source of waste, whereas glass bottles can be recycled or reused, minimising environmental impact.

Video 1 outlines Taiwan's experience with improving technical cycles to better manage waste in its economy. The video emphasises, however, that cradle-to-cradle, or circular, strategies alone will not fix the waste problem. We have to design out waste in the first instance if we want to improve sustainability.

Student view

Overview (/study/ap hl/sid-351-cid-762729/o



Video 1. Changes in waste management in Taiwan allow for the capture of more resources for recycling.

Case study

Zero-waste fashion

Watch **Video 2**, which tells the story of fashion brand Tonlé, a company using the cradle-to-cradle design philosophy.

Video 2. Cradle-to-cradle manufacturing at Tonlé.

Tonlé, a fashion label based in Cambodia, has developed a production system that generates zero waste. The process begins with Tonlé employees scavenging local rag markets looking for fabrics that have been discarded by other clothing manufacturers. These scraps are delivered to the factory where new clothes are made from them. The process is so efficient that the small amount of waste cloth that cannot be used is collected and turned into paper! Tonlé ensures its workers are paid a living wage and provides other benefits, such as health care and long-term contracts of employment.

Questions

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1. Define cradle-to-cradle production. [2 marks]
2. Explain how Tonlé's cradle-to-cradle production strategies improve both environmental and social sustainability. Use either the Doughnut Economics model or the SDGs in your response. [4 marks]

Question 1

Cradle-to-cradle production is a model of designing and creating products in a way that minimises waste and negative effects on the environment and all stakeholders. It focuses on sustainability.

Define is an AO1 level command term, requiring the precise meaning of a term.

- One mark is given for a vague definition.
- Two marks are given for a complete definition.
- Definitions do not require application to the stimulus material.

Question 2

Sociocultural sustainability refers to business practices that provide for human needs and are interdependent with the communities they serve. Businesses have a responsibility to support the wellbeing of all stakeholders through generative and distributive practices. One way that Tonlé is supporting sociocultural sustainability is by providing income and work (Doughnut Economics model, SDG8 'decent work') to women in poor communities in Cambodia. Tonlé provides living wages, health care and long-term contracts. It also provides ample opportunities for creative collaboration and promotion of employees, which increases employee motivation.

Environmental sustainability refers to practices that meet the needs of today without harming the ability of future generations to meet their own needs. Businesses should be striving to do more than just minimise the negative environmental impact of their activities; they should strive to be regenerative, working to improve the ecosystems on which we depend. Tonlé is intercepting fabric waste from other manufacturers before it reaches landfills and incinerators. It uses that waste to create new value and is focused on generating zero waste from its own production. Even the smallest scraps of material are used to make paper. While Tonlé itself is not regenerating the environment, the company is preventing some of the damage that would have otherwise occurred. And it is doing this in a way that generates value for multiple stakeholders and generates zero waste from its own activities (related to SDG).

Explain is an AO2 level command term, requiring a detailed account including reasons or causes. Explain *why*, explain *how*.

- Only one benefit and one limitation need to be explained. Other responses are possible and would be rewarded if appropriate.

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- To achieve full marks, you must always include theory and application to the case study in your responses to the **explain** command term.

The Cradle to Cradle Products Innovation Institute is an independent non-profit organisation that provides certification of companies that operate within the cradle-to-cradle principles. It has identified five areas where companies can apply the cradle-to-cradle ethos. In Section 1.3.7 (/study/app/business-hl/sid-351-cid-762729/book/terminology-exercise-id-36522/), you also learned about the Ellen MacArthur Foundation (https://ellenmacarthurfoundation.org), which does similar work with businesses to help them move to a circular economy and meet their ethical obligations to people and the planet.

Concept

Creativity, Sustainability and Ethics

Moving from a take—make—waste linear economic system to a more sustainable and ethical production system — based on cradle-to-cradle or circular principles — requires that designers and manufacturers think creatively. From the moment they have an idea about meeting a human need or solving a problem, they need to consider how to embed circularity into choices of materials, manufacturing process and the product's end of life.

This requires moving away from current materials and processes and reimagining or inventing new materials, manufacturing and recovery. New business models need to be used, requiring flexible thinking across traditional disciplines. You learned about circular business models in Section 1.3.7 (/study/app/business-hl/sid-351-cid-762729/book/terminology-exercise-id-36522/). These circular business models help businesses move to cradle-to-cradle production, which is essentially the same idea as the circularity concept you have already learned about.

Exam tip

Using cradle-to-cradle strategies may increase costs of production for a business in the short term. However, businesses can see reduced costs in the long term if they do not have to buy as many resources to produce their products, or if they already have production processes that future environmental laws will likely require.

It is also important to realise that, though some businesses may see higher costs, these are not new costs. They are costs that the broader society and environment have been experiencing through waste and pollution from business activity. So, moving to cradle-

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to-cradle or circular strategies makes businesses more responsible for the full costs of the waste they produce.

The business may also see an increase in revenues, as conscientious consumers move more and more to purchasing ethical products, designed with a circular strategy. This can be a unique selling point (USP) for a business.

When discussing cradle-to-cradle production or circular business strategies, make sure you are aware of these different ways to discuss costs and revenues related to the practices.

2 section questions

Question 1

1 Cradle-to-cra... ✓ design and manufacturing is a strategy for producing products in a way that minimises waste and negative effects on the environment and all stakeholders.

Accepted answers and explanation

#1 Cradle-to-cradle
Cradle to cradle
Circular

General explanation

Cradle-to-cradle design and manufacturing is contrasted with cradle-to-grave design and manufacturing. It changes production from a take—make—waste model to one that cycles resources through production systems again and again. Cradle-to-cradle design and manufacturing is often used synonymously with circular design and manufacturing.

Question 2

Cradle-to-cradle design and manufacturing may result in higher costs of production for a business in the 1 Short ✓ term but can lower costs in the 2 Long ✓ term if the business can recover and reuse resource inputs.

Accepted answers and explanation

#1 Short

#2 Long

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General explanation

Redesigning and recapturing material inputs can cause costs of production to increase in the short run. New products, new designs, and processes for recapturing materials need to be created.

However, in the long-run if businesses can reuse materials, they may be able to lower costs of production.

In any case, the move to circular strategies shifts more of the responsibility and costs for the environmental damage of take-make-waste linear system to business and away from broader society and the environment.

Quality control and quality assurance

Quality control and quality assurance (HL) Methods of managing quality (HL) Impact of lean production and TQM (HL) National and international quality standards (HL)

Section Student... (0/0) Feedback Print (/study/app/business-hl/sid-351-cid-762729/book/quality-control-and-quality-assurance-id-39486/print/) Assign

Quality is about customer satisfaction. If a company's product meets or exceeds its customers' needs, it has produced a quality good or service. This could be a taxi company that provides a safe, punctual journey or a restaurant that prepares a salad just the way the customer likes it. If a business is unable to meet the needs of its target market, it will go out of business very quickly.

It is important to stress that quality is defined by the target market of a product. Decisions about quality therefore need to reflect a business's customers. It is unlikely, for example, that your parents shop in the same clothes shops or stream the same music as you. This is because different generations have different tastes and different needs. The clothes that meet the needs of a 50-year-old can be said to be of good quality for that target market. The fact that you would not be seen wearing the same clothes is mostly irrelevant. Decisions about quality therefore reflect the market segment at which products are aimed and a business's position within that segment.

Quality control and quality assurance

Quality control refers to the inspection of a product in order to find defects and remove them before they are delivered to retailers or customers. This quality management strategy only catches problems after they happen; it does not directly improve production to prevent defects in the first place. It may even contribute to increasing defects, if employees are careless because they know that faulty products will be removed.

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Figure 1. Quality control requires inspections of the final product to find defects before they reach the retailer or customer.

Credit: alvarez, Getty Images

Quality assurance, on the other hand, includes strategies to prevent defects and improve products. Generally speaking, quality assurance requires employees to check their own work, take responsibility for their own mistakes and identify defects that are not their own fault. Every employee – not just a final inspector – has a responsibility to ensure the quality of the product.

Quality assurance is a form of empowerment, which you learned about in Section 2.4.6 (/study/app/business-hl/sid-351-cid-762729/book/rewards-id-39419/). Empowerment can lead to higher employee motivation and engagement. For quality assurance to work well, it is important that all employees receive training in how to spot and deal with defects and other production problems. They also need to have the authority to remove faulty products.

Methods of quality management

Businesses use a number of strategies to improve quality management, including quality circles, benchmarking and total quality management (TQM).

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Figure 2. A quality circle.

Credit: vm, Getty Images

A quality circle is a group of employees who meet regularly to discuss potential improvements to product quality. Employees usually come from diverse areas of the company to provide a range of different perspectives. For example, an employee from the marketing department might offer feedback related to decisions based on market research, while operations employees could provide insights into decisions about how waste can be reduced. **Table 1** outlines some benefits and limitations of quality circles.

Table 1. Benefits and limitations of quality circles.

Benefits of quality circles	Limitations of quality circles
Motivation. Empowering employees to make changes to product quality increases their engagement with the business, improving employee satisfaction.	**Reduced productivity.** Participating in quality circles takes time away from production and can lower output per worker.
Improved quality. Making everyone responsible for product quality is likely to reduce mistakes.	**Training costs.** Employees may need training to participate in quality circles, which costs money.
Reduced costs. Quality inspectors may not be needed; better quality and reduced waste can also reduce costs.	**Not suited to every organisation.** Quality circles work best when the organisational culture already has democratic or laissez-faire leadership in place, or where the organisational structure is flatter.

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Making connections

You studied democratic leadership styles in Section 2.3.2 (/study/app/business-hl/sid-351-cid-762729/book/leadership-styles-id-39394/). A business with a democratic leadership style is more likely to use quality circles to improve operations.

You studied motivation in Subtopic 2.4 (/study/app/business-hl/sid-351-cid-762729/book/the-big-picture-id-39054/). Businesses that use quality circles are likely to see higher employee motivation because employees appreciate having their voices heard in the direction of their organisations.

Benchmarking

Benchmarking is the process by which a business compares itself – on certain criteria – with the industry leaders to see what it can learn from others' techniques.

Benchmarking is not copying. It is the process of exploring areas in which performance can be improved. For example, you might benchmark your performance in Business Management tests against your classmates. Through this benchmarking, you might identify that you need to do more work on finance-related topics. You would then examine how you could improve in this area, perhaps by researching how your classmates revise the finance topic and adapting that to suit your learning style.

The same principles apply to businesses. Benchmarking is about learning from the competition or businesses in other industries in order to gain useful insights into possible performance improvements. This process is a part of quality improvement.

There are two steps involved in benchmarking:

1. Identifying which companies have the best processes or results in a certain area.
2. Finding out how those companies do things and learning from those processes.

Any part of a business can be improved by benchmarking. Companies are constantly looking at other businesses to work out what lessons can be learned from their success. Remember that these other businesses do not need to be in the same industry. A cinema, for example, might benchmark its ticketing systems against the systems used by the Tokyo Metro. Learning how the Tokyo Metro deals with millions of customers per day might offer the cinema useful insights into improvements in its own, much smaller, ticketing systems. **Table 2** outlines some ways that businesses can use benchmarking to improve operations and **Table 3** outlines some benefits and limitations of benchmarking.

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Table 2. Opportunities for benchmarking in the main business functions.

Business function	Potential improvement	Benchmarking indicator
Human resources	Lower labour turnover	Wages and benefits
Finance and accounts	Improved cash flow	Credit control
Marketing	Higher customer loyalty	After-sales service
Operations	Improved product quality	Quality control systems

Table 3. Benefits and limitations of benchmarking.

Benefits of benchmarking	Limitations of benchmarking
Improved quality. The business is able to improve itself by looking at examples and using the experiences of others to improve.	**Lack of transferability.** There is no guarantee that a process that works in another business will be successful when transferred to a new context.
Understand competitors and consumers. Looking outside the organisation for examples of good practice informs the business of both the competition it faces and customers' needs.	**Lack of information.** It may be difficult, or even impossible, to get the information needed about other businesses in order to benchmark effectively.
Customer satisfaction/increased revenues. Improved quality should lead to higher sales if customers are happy with the product.	**Selecting the right benchmark.** Businesses must be careful to select the right benchmark for what they are trying to achieve.

Theory of Knowledge

Benchmarking can help a business improve quality and operations. However, there are significant differences between businesses in different industries and countries. There are even significant differences between businesses operating in the same industry and country.

- To what extent is knowledge transferable from one organisation to another? What internal and external factors might hinder the successful adoption of strategies and tactics?

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In total quality management (TQM) systems, every employee is jointly responsible for maintaining the overall quality of the final product. There are two fundamental principles behind TQM: empowerment – which gives employees the authority to change or improve part of their role – and internal customers.

In TQM systems, employees are always encouraged to consider the needs of their internal customers. Internal customers are those employees inside the business that rely on the quality of your output. If done correctly, this should encourage teamwork and greater levels of communication. TQM can also be considered a lean production strategy because, in addition to quality, employees are also empowered to reduce waste. **Table 4** outlines some benefits and limitations of TQM.

Table 4. Benefits and limitations of total quality management (TQM).

Benefits of TQM	Limitations of TQM
Motivation. Empowering employees to make changes to product quality raises their engagement with the business, increasing employee satisfaction.	**Reduced productivity.** Having everyone responsible for product quality takes time away from production and can lower output per worker.
Improved quality. Making everyone responsible for product quality is likely to reduce mistakes.	**Training costs.** Employees need to be properly trained to implement TQM, which costs money.
Reduced costs. Quality inspectors may not be needed; better quality and reduced waste can also reduce costs.	**Not suited to every organisation.** Quality circles work best when the organisational culture already has democratic or laissez-faire leadership in place, or where the organisational structure is flatter.

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (critical thinking)

Consider the tensions that exist between lean production and quality management with the help of following questions. You may wish to discuss these with a partner or as a class.

- For a business, does pursuing lean production always lead to improved quality?
  - Consider continuous improvement and JIT. Which one would be more likely to positively affect quality as well as efficiency?

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- If a business judges its efficiency only by looking at costs of production (in other words, whether costs decrease), to what extent might lean production methods worsen quality?

- For a business, to what extent might pursuing improved quality increase costs of production? To what extent might this decrease costs of production?
- How might a for-profit social enterprise and a non-profit social enterprise approach lean production and quality management, and the tensions between them, differently from a for-profit commercial enterprise?

National and international quality standards

Businesses can apply for an inspection and evaluation of their products' quality and quality assurance processes by independent quality standards organisations. After an inspection, the company will receive recommendations for improving its quality assurance procedures. If the business does well enough, it will be given a stamp of approval that it can display on its promotional materials and elsewhere.

Figure 3. ISO certification is an indication of quality for external stakeholders.

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Such certification organisations can exist on a local, national or international level. One prominent organisation is the International Organization for Standardization (ISO) (https://www.iso.org/home.html). Founded in 1947, the ISO is an independent global body that promotes universal commercial standards. ISO 9000 is an international accreditation, which is awarded to businesses for their quality assurance systems. Businesses can apply to be awarded ISO 9000 status. This can be a long and expensive process as businesses must produce comprehensive evidence of their quality processes. There are, however, significant internal operations and marketing benefits of this accreditation, such as:

- **Improved brand image.** Once accredited, companies can display the ISO 9000 logo on their promotional materials. This reassures potential customers that they are purchasing a high-quality product, potentially allowing a higher price to be charged.
- **Widening the target market.** Some companies will only use suppliers that have been awarded ISO 9000; by achieving the ISO 9000 standard, a business can then access this exclusive market.

Activity

Learner profile: Inquirers
Approaches to learning: Research skills (information literacy)

All schools offering the International Baccalaureate must receive authorisation from the International Baccalaureate Organization (IBO). The IBO authorises schools when they start their Primary Years Programme (PYP), Middle Years Programme (MYP), Diploma Programme (DP) or Career-related Programme (CP) offerings and requires that schools be reauthorised every five years. This ensures that schools are following the mission and vision of the IBO, executing the programmes correctly and providing the required training for their teachers. In order to gain first-hand verification of what is happening in schools, IBO representatives conduct school visits, during which they look carefully at the curriculum materials and documentation. They also interview all groups of stakeholders in the school community and carry out classroom visits to see the teaching and learning in action.

Most schools with IBO programmes will also be accredited by other national or international organisations.

- Look at your school's website to find evidence of IBO authorisation and other accreditation. What do you see and where is the evidence located?
- Invite your head of school or another member of the leadership team to the business management class to talk about how authorisation by the IBO or accreditation by other organisations has improved quality in the school.

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3 section questions

Question 1

Which method of quality management focuses on inspecting products at the end of the production process?

Quality control ✓

Accepted answers
Quality control, control

Explanation
Quality control occurs at the end of the production process. Finished goods are inspected to assess whether they meet a set of agreed criteria. A specialist team of inspectors may be employed just to work in the quality control department.

Question 2

Which of the following may be a limitation of benchmarking as a quality management strategy?

1 Transferability from another organisation ✓

2 Quality improvements

3 Understanding competition

4 Customer satisfaction and revenues

Explanation
Benchmarking is the process by which a business compares itself with the industry leaders on certain criteria and sees what it can learn from the techniques used by other organisations. One potential problem with benchmarking is that every business operates in a different internal and external context. This may make it difficult for a business to compare itself to others or adopt similar strategies in areas where it falls short on benchmarking.

The other responses are all related to possible benefits of benchmarking, including improved quality, understanding competitors and their practices better, and increasing consumer satisfaction and total revenues.

Question 3

Which of the following quality management strategies is also most likely to be considered a lean production strategy?

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1 Total quality management (TQM) ✓

2 Benchmarking

3 International quality standards

4 Quality control

Explanation

Lean production focuses on the reduction of waste. In total quality management (TQM) systems, employees are empowered to make decisions that improve the production process and reduce defects, which are a type of waste.

The other options aim to improve quality or maintain quality but do not use the philosophy of the continuous reduction of waste from the production process.

Terminology exercise

Section Student... (0/0) Feedback Print (/study/app/business-hl/sid-351-cid-762729/book/terminology-exercise-id-39487/print/) Assign

Student view

Check that you understand the terminology used in this subtopic by dragging the correct word into each space.

It is important that businesses produce products efficiently and with high quality. The term refers to a set of strategies aimed at reducing in the production process. Businesses strive to increase , which defines how well a business can transform physical, human and financial inputs into outputs. Improved efficiency reduces of production.

One way to reduce waste involves businesses holding regular, scheduled meetings in which staff are invited to give their opinions and to suggest improvements. This strategy is called , or continuous improvement. Another strategy, known as production, involves delivering resources and stock shortly before they are needed for production. This lowers the cost and space needed for stock.

just-in-time | lean production | costs | kaizen | efficiency | waste

Check

Question: 1 of 2 questions

Interactive 1. Lean Production and Quality Management.

5. Operations management / 5.3 Lean production and quality management (HL)

Tool: Gantt chart (HL)

Tool: Gantt chart (HL) Tool: Gantt chart (HL)

Businesses are often engaged in project work. Projects involve a defined piece of work that has the following elements, which are also constraints:

- **Deliverable.** This is the end result of the project. It could be a tangible product, or it could be an intangible outcome such as a change to the organisation. Deliverables usually have required characteristics or qualities. These requirements are design constraints on the project outcome.
- **Time period.** A project has a time allocation with a beginning and an end. There may be rewards for staying within a time constraint or penalties for exceeding it. Internal

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customers in the business may also be relying on the completion of a certain project in order to do their own work.

- **Resources.** Physical, human and financial resources are required to complete a project. These can also place constraints on the project outcome by limiting the inputs.

All of these elements and constraints need to be planned and managed, which can be very difficult with a large, long-lasting, complex project.

A Gantt chart is a business management tool that illustrates a project plan. **Figure 1** shows a sample Gantt chart outlining the tasks involved in writing the IBDP Business Management internal assessment. The numbered columns represent the weeks of the project, where 1 is the first week, 2 is the second week, and so on.

Business management internal assessment	1	2	3	4	5	6	7	8	9	10
Develop 2–3 research questions for teacher feedback or discussion. Include concepts, tools/theories and potential sources for the IA.										
Choose a topic.										
Prepare and maintain/edit a bibliography list of works cited.										
Finish secondary research, and possibly primary research as well. Prepare supporting documents.										
Write an introduction and prepare an analysis outline for teacher feedback/discussion.										
Write an analysis and evaluation.										
Write a conclusion. Submit full first draft to teacher for feedback.										
Revise draft with teacher's feedback, proofread. Check in-text citations, bibliography, and supporting documents.										
Submit final internal assessment.										

Figure 1. A sample Gantt chart for the internal assessment project, showing the tasks to be completed over 10 weeks.

More information for figure 1

The image shows a Gantt chart titled "Business management internal assessment." It outlines several tasks associated with a business management project spanning over 10 weeks. The chart has one column listing tasks and ten columns labeled from 1 to 10, representing the weeks.

Tasks are as follows: 1. Develop 2—3 research questions for teacher feedback or discussion. Include concepts, tools/theories, and potential sources for the IA. Duration: Weeks 2—4. 2. Choose a topic. Duration: Week 2. 3. Prepare and maintain/edit a bibliography list of works cited. Duration: Weeks 1—10 (ongoing). 4. Finish secondary research, and possibly primary research as well. Prepare supporting documents. Duration: Weeks 4—6. 5. Write an introduction and prepare an analysis outline for teacher feedback/discussion. Duration: Weeks 5—7. 6. Write an analysis and evaluation.

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Duration: Weeks 6—8. 7. Write a conclusion. Submit full first draft to teacher for feedback. Duration: Week 9. 8. Revise draft with teacher's feedback, proofread. Check in-text citations, bibliography, and supporting documents. Duration: Weeks 9—10. 9. Submit final internal assessment. Duration: Week 10.

Shaded blue cells indicate the duration of each task across the corresponding weeks.

[Generated by AI]

As **Figure 1** shows, there are two main sections of a Gantt chart. The first column lists the tasks that need to be completed in the project. The other columns, at a minimum, capture information about how long each task will take. This could be in hours, days, weeks, months, or even years. In the case of the Gantt chart in **Figure 1**, you can see that some tasks may take one week, while others may take two weeks. The maintenance of the bibliography/works cited list would be ongoing during the entire project.

Other information can also be included in a Gantt chart, such as:

- start and end dates
- people responsible for each task
- other resources needed, such as equipment and supplies
- information about whether one task is dependent on another
- milestones

Additional columns could be added for these to the Gantt chart between the tasks and time columns.

Gantt charts should be updated as work progresses. Often project tasks take longer than expected or outside resources may become unavailable. Updating the chart allows managers to continue to plan, share changes with a team and foresee potential difficulties before they arise. They can help keep a project on track and reduce expenses that come with delays.

You learned about the human errors in judgement that result in project delays and higher costs in the Theory of Knowledge box in Section 3.9.2 (/study/app/business-hl/sid-351-cid-762729/book/constructing-a-budget-id-39333/), which explains why project budgets are often exceeded.

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Sometimes delays are caused by factors that cannot be controlled. In the process of housebuilding, for example, painting needs to be completed before the installation of heating units and kitchen cupboards. If the weather is rainy and humid, the paint will take longer to dry, so the project would be delayed. The project manager would then need to revise the Gantt chart.

Figure 2. Projects of all sizes, from writing an internal assessment to designing and constructing a building, can benefit from planning with a Gantt chart.

Credit: Kelvin Murray, Getty Images

Like the other tools, the utility of the Gantt chart is limited by the accuracy of the information recorded in it. A chart based on unrealistic or imprecise expectations is not useful. **Table 1** outlines some benefits and limitations of Gantt charts.

Making connections

You can find editable online templates that can be used to make Gantt charts. These save a lot of time when you want to create a project plan. You can also download and use this Gantt Chart template in the Download Button below.

Download file (https://d3vrb2m3yrmyfi.cloudfront.net/media/edusys_2/content_uploads/Basic Gantt Chart Template.df05cb42ac867d8c4460.pdf)

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Table 1. Benefits and limitations of Gantt charts as a business management tool.

Benefits of Gantt charts	Limitations of Gantt charts
Big picture. The chart succinctly captures entire projects, making it easier to plan the sequence of steps.	**Estimates may be wrong.** The chart relies on estimates of the time needed to complete the steps of a project, which may change because of dynamic internal or external factors.
Time estimates. The chart gives a better estimate of the time needed for a project, because overlapping tasks can be more easily visualised.	**Does not capture all information.** The chart does not capture all the information about a project, such as the size or complexity of the work involved.

Tool: Critical path analysis (HL)

Critical path analysis (CPA), also known as network analysis, is a project planning tool. It shows the critical path of a project, which is the minimum time period needed for the project to be completed. As with Gantt charts, critical path analysis can be used by project managers to gain an overview of:

- the tasks involved in a project
- how long each task is expected to take
- the order in which the tasks need to be done
- whether any tasks can be completed at the same time
- interim deadlines needed to keep the entire project on track
- whether any steps of the project have buffer time (also called a float time) in case of delays

This section is divided into several parts, to help you construct and interpret a network diagram and the critical path.

Exam tip

The IB Business Management syllabus states that you should be able to complete and analyse a critical path diagram, but that constructing a full critical path diagram is not expected.

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Some activities in this section, however, ask you to construct a critical path. Practising this will ensure that you have a deep understanding of the structure and meaning of the numbers.

Critical path basics

Figure 1 shows a basic critical path (network) diagram for a fictional project – Project X – with some key components labelled. The letters in the diagram (A to F) represent the various tasks (or activities) of Project X. These are separated by circles, called nodes. The nodes represent the start and end of each task. Each node is divided into three parts, and you can number the nodes from left to right, for reference, using the left side of each node.

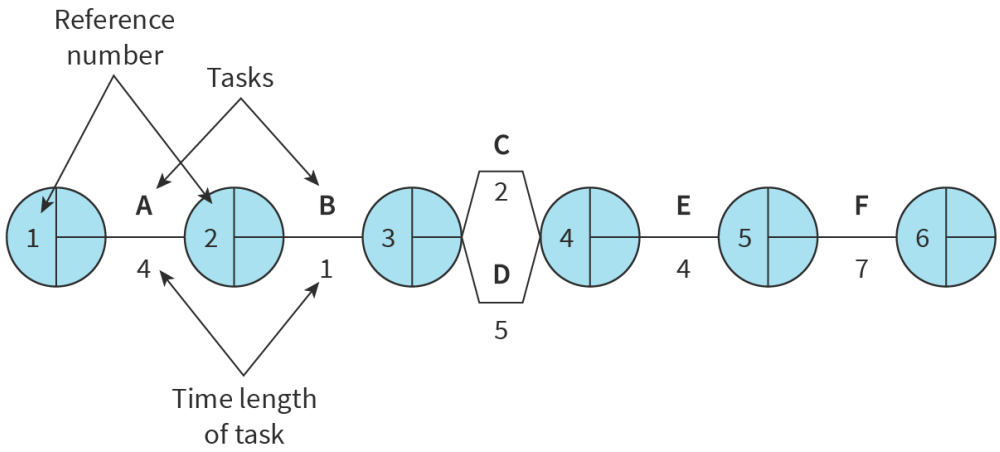

Figure 1. Critical path basics for Project X.

More information for figure 1

This diagram illustrates the basic critical path for a fictional project, Project X. It includes nodes and arrows representing tasks labeled from A to F. The nodes are circles divided into three parts with numbered references. The flow starts with node 1, leading to task A with a time length of 4, moving to node 2. From node 2, task B with a time length of 1 branches out, reaching node 3, then connecting to task C, which has a time length of 2, and task D, with a time length of 5. These tasks merge into node 4. From node 4, task E with a time length of 4 continues to node 5, and task F with a time length of 7 concludes at node 6. The numbering sequence helps in following the path of tasks, showing the start and end points of each task, forming a network diagram.

[Generated by AI]

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So, in **Figure 1**, the first task is A and the final task is F. The node to the left of task A (labelled 1) represents the start of task A. And the node to the right of task F (labelled 6) represents the end of the task F.

You will learn about the other parts of the node later. However, because some activities will be happening concurrently, the reference numbers for the nodes do not necessarily represent the order in which the activities take place.

The number written below the line underneath each task represents the time period for that task. For Project X, the times are in days. So the time period for task A is four days, the time period for task B is one day, and so on. Two tasks in Project X – tasks C and D – are completed at the same time, each with different time periods; task C takes two days and task D takes five days.

The critical path diagram is drawn from left to right. However, the end node for the entire project cannot be drawn until you are sure that all the interim activities are accounted for.

Exam tip

You should take care when constructing a critical path (network) diagram for the practice work in this section.

Use a ruler to make straight lines that extend from the nodes at the midpoint. The lines should not cross one another.

The information from **Figure 1** is summarised in **Table 1** below. In your exam, this is one way that you may be given information, from which you would be asked to draw a critical path (network) diagram.

Table 1. Summary of information for the critical path analysis (network diagram) for Project X.

Task	Preceded by	Duration (days)
A	--	4
B	A	1
C	B	2

Student view

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Task	Preceded by	Duration (days)
D	B	5
E	C and D	4
F	E	7

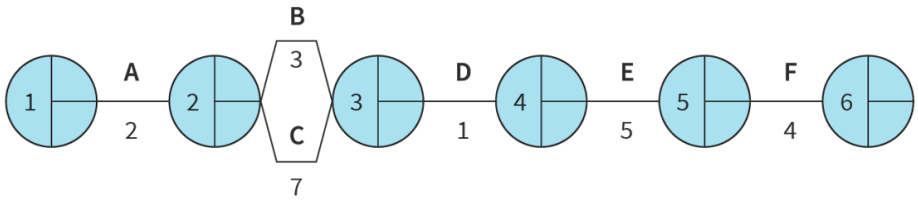
Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (transfer)

Table 2 summarises the tasks involved in Project S, with their dependencies and durations. Use the information in the table to draw a simple critical path (network) diagram for Project S.

Table 2. Dependencies and duration of tasks for Project S.

Task	Preceded by	Duration (days)
A	--	2
B	A	3
C	A	7
D	B and C	1
E	D	5
F	E	4



Critical path (network) diagram for Project S.

Student view

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Adding earliest start time and latest finish time to the nodes

Once you have drawn the basic critical path (network) diagram, you can add information about the earliest start time and latest finish time to each node. This will allow you to understand the time constraints of the project more clearly.

Earliest start time (EST)

The earliest start time (EST) indicates the earliest time that a task can begin. It is written in the upper right segment of the node and refers to the task just after the node, as shown in **Figure 3**.

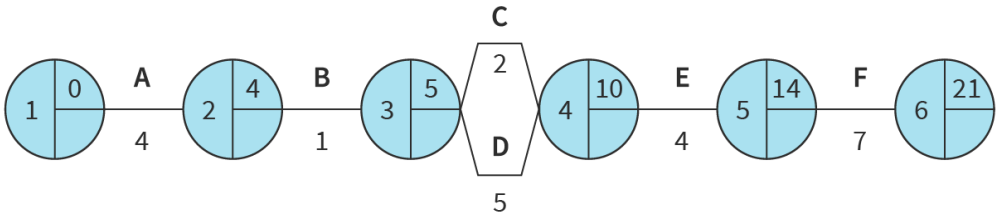

Figure 2. Adding earliest start times to the critical path (network) diagram for Project X.

More information for figure 2

The diagram shows a network diagram for Project X's critical path. The nodes are labeled with numbers representing tasks and the earliest start times. The nodes are connected with lines that show the sequence and duration of tasks. Starting from the left, the first node is labeled 1 with an earliest start time (EST) of 0. It is connected to node 2 with task A between them, and the duration is 4. Node 2 has an EST of 4.

Next, node 2 connects to node 3 with task B between them, with the duration 1, resulting in node 3 having an EST of 5. Node 3 connects simultaneously to node 4 labeled C and node 4 labeled D with tasks C and D between them. The duration for task C is 2 and for task D is 5. Node 4 with task C has an EST of 10.

Node 4 with EST 10 connects to node 5 with task E and duration 4, leading to node 5 having an EST of 14. Finally, node 5 connects to node 6 with task F between them, the duration is 7, and node 6 has an EST of 21.

[Generated by AI]

Student view

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Figure 3 shows that task A is the first task of Project X. It can start immediately, so 0 is written in the upper right segment of the node to the left of task A. Then, working from left to right you can see that:

- Task A will take four days to complete, so the earliest that task B can start is after day 4.
- Task B will take one day to complete. This means that tasks C and D can only start after day 5.
- Tasks C and D take different time periods and task E can only start after both task C and task D have been completed. In this case, you would select the higher of the two time durations for tasks C and D to insert as the earliest start time for task E. Thus, task E can only start after day 10.
- Task E takes four days to complete, so task F can only start after day 14.

The earliest start time for an activity is useful for businesses using just-in-time (JIT) strategies for lean production. Deliveries of resources can be planned to arrive just before the earliest start time for the activity that needs them. That way, storage costs for stock (inventory) can be reduced.

Latest finish time (LFT)

In **Figure 3**, the last node shows the end of Project X. The project should be completed in 21 days. This number is written in both the upper right and lower right segments of the last node. The lower right segment of the node refers to the latest finish time (LFT) that the preceding task should finish in order to keep Project X on track.

It is important to emphasise that the latest finish time (LFT) refers to the task to the **left** of the node. This is different from the earliest start time (EST), which always refers to the task to the **right** of the node.

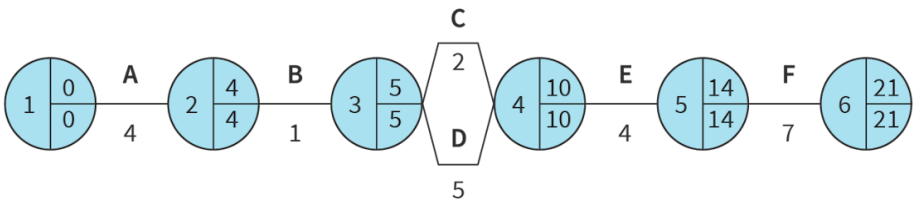

Figure 3. Adding latest finish times to the critical path (network) diagram for Project X.

More information for figure 3

The image is a network diagram illustrating the critical path for Project X. It comprises six nodes labeled 1 through 6, each represented by a circle containing upper and lower numbers. These numbers show the earliest start times (upper numbers) and the latest finish times (lower numbers), which are split within each node.

Student view

- Node 1: Upper and lower numbers both 0.
- Node 2: Upper number 2, lower number 4.
- Node 3: Upper number 3, lower number 5.
- Node 4: Upper number 4, lower number 10.
- Node 5: Upper number 5, lower number 14.
- Node 6: Upper number 6, lower number 21.

Lines connect these nodes as follows: - Node 1 to 2 with task A, duration 4. - Node 2 to 3 with task B, duration 1. - Node 3 to 4 with tasks C and D, durations 2 and 5 respectively. - Node 4 to 5 with task E, duration 4. - Node 5 to 6 with task F, duration 7.

This diagram helps visualize the tasks' durations and the calculation of the critical path, highlighting the latest finish times on the left of each node.

[Generated by AI]

Now, this time working from right to left, you can insert the latest finish times to each of the previous nodes and see that (as shown in **Figure 3**):

- The project should be completed in 21 days. Task F takes seven days to complete, so the latest finish time for task E is day 14.
- Task E takes four days to complete, so the latest time for tasks C and D to be finished is day 10.
- Tasks C and D take different amounts of time to complete. In this case, you would subtract the larger of the numbers. So the latest finish time for task B is day 5.
- Task B takes one day to complete, so the latest finish time for task A is day 4.

In this simple critical path diagram for Project X, the earliest start times (EST) and the latest finish times (LFT) are the same in each node. In more complex critical path diagrams, this will not always be the case. You will look at a more complex example later in this section.

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (transfer)

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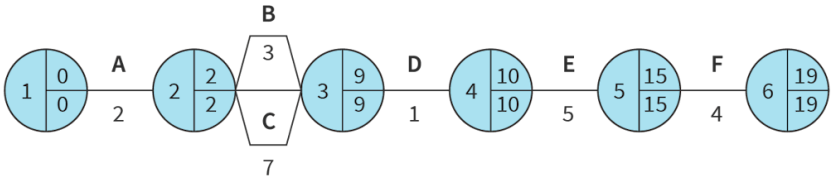
Table 3 is a repeat of **Table 2** from the previous activity, summarising the tasks for Project S with their dependencies and durations. Use the critical path (network) diagram that you have already completed and add in the earliest start times (EST) and latest finish times (LFT) for Project S.

Table 3. Dependencies and duration of tasks for Project S.

Task	Preceded by	Duration (days)
A	--	2
B	A	3
C	A	7
D	C	1
E	D	5
F	E	4



Critical path (network) diagram for Project S including earliest start times and latest finish times.

Calculating free float and total float

The float time refers to the amount of time that a task or activity can overrun its time estimate, but not disrupt the estimated time for the other tasks or for the entire project. There are two calculations for float: free float and total float.

Free float is the amount of time that a task can overrun its time estimate, but not delay the **next** task. It is calculated as follows:

Student view

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Free float of task Y = earliest start time (EST) of the next task – earliest start time (EST) of task Y – duration of task Y

Using the information from Project X, which is shown again in **Figure 4**, the free float for individual tasks can be calculated.

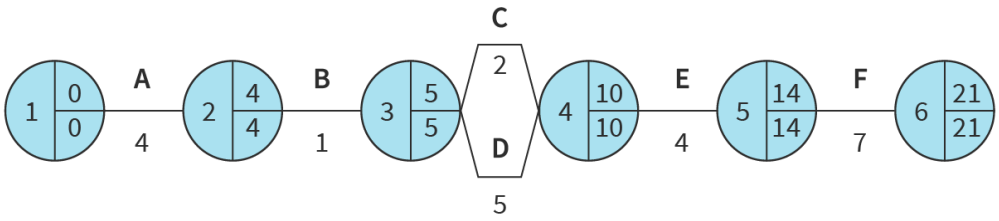

Figure 4. Critical path (network) diagram for Project X.

More information for figure 4

The image is a network diagram for Project X, displaying the sequence of tasks labeled from A to F. Each task is represented by numbers inside circles, connected by lines. The key tasks are as follows:\n\n- **Start Node (0)**: Location 1.\n- **Task A**: Connects nodes 0 to 2 with a duration of 4.\n- **Task B**: Connects nodes 2 to 3 with a duration of 1.\n- **Task C**: Connects nodes 3 to 4 with a duration of 2.\n- **Task D**: Connects nodes 3 to 4 with a duration of 5.\n- **Task E**: Connects nodes 4 to 5 with a duration of 4.\n- **Task F**: Connects nodes 5 to 6 with a duration of 7.\n\nThe diagram's flow illustrates the project's critical path, highlighting the relationships between tasks, their sequential order, and expected completion times. Numerical values inside the nodes indicate event numbers and times.

[Generated by AI]

Free float of task B = EST of task C – EST of task B – duration of task B

= 5 days – 4 days – 1 day

= 0 days

Task B has 0 days free float. It therefore cannot overrun its time estimate without delaying task C.

Free float of task C = EST of task E – EST of task C – duration of task C

= 10 days – 5 days – 2 days

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= 3 days

Task C has 3 days free float. It can therefore overrun its time estimate by three days without delaying task E.

Total float is the amount of time that a task or activity can overrun its time estimate, but not delay the **whole project**. It is calculated as follows:

Total float of task Y = latest finish time (LFT) of task Y – duration of task Y – earliest start time (EST) of task Y

Again, using the information from Project X, the total float for individual tasks can be calculated.

Total float of task E = LFT of task E – duration of task E – EST of task E

= 14 days – 10 days – 4 days

= 0 days

Task E has 0 days total float. This means that task E must finish on time or the entire project will be delayed.

Information about earliest start time (EST), latest finish time (LFT) and total float can be added to the information in **Table 1**. This information is included in **Table 4**. All tasks in Project X that have zero total float can then be identified. These tasks together are called the critical path because they must be completed on time. The critical path is also the minimum amount of time needed to complete the entire project. Note that, in **Table 4**, the total float is calculated using the following formula, with the subscript 'current task' indicating the current task being considered in the row:

$$\text{Total float} = \text{LFT}_{\text{current task}} - \text{EST}_{\text{current task}} - \text{duration}_{\text{current task}}$$

Table 4. Completed summary information for Project X.

Task	Preceded by	Duration (days)	EST	LFT	Total float (days)
A	--	4	0	4	4 — 0 — 4 = 0

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Task	Preceded by	Duration (days)	EST	LFT	Total float (days)
B	A	1	4	5	5 — 4 — 1 = 0
C	B	2	5	10	10 — 5 — 2 = 3
D	B	5	5	10	10 — 5 — 5 = 0
E	C and D	4	10	14	14 — 10 — 4 = 0
F	E	7	14	21	21 — 14 — 7 = 0

According to the total float figures, tasks A, B, D, E and F form the critical path. If any of these activities run over their time estimates, the entire project will be delayed. It is important that project managers pay particular attention to these activities to keep them on track.

When you are asked to identify the critical path in the exam, there are two ways of doing this. You can either write out the critical path with arrows or you can use hash marks (//) to indicate the critical path on the diagram itself. Both of these methods are shown in **Figure 5.** Note also the key indicating the elements of the critical path diagram.

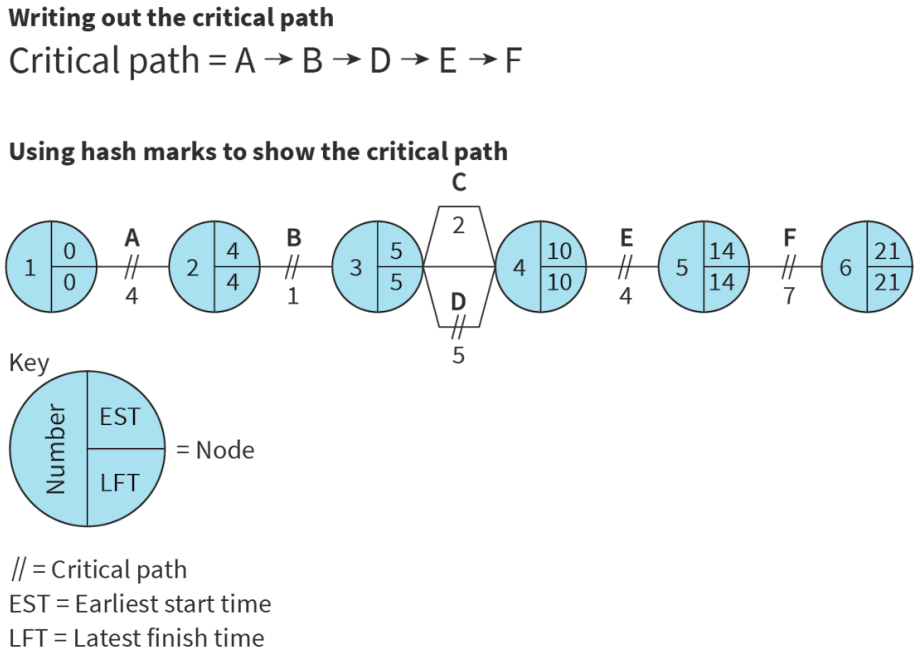

Figure 5. Two different ways of identifying the critical path for Project X.

More information for figure 5

The image contains two sections illustrating how to identify the critical path in a project. The top section, titled "Writing out the critical path," shows a straightforward list denoting the critical path as: A -> B -> D -> E -> F. The bottom section, "Using hash marks to show the critical path," features a series of labeled circular nodes connected by lines representing

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different components of the task sequence. Notable labels are 'A', 'B', 'D', 'E', and 'F.' Nodes contain numerical values indicating early start (EST) and late finish times (LFT) such as "(0, 0)", "(2, 4)", "(3, 5)" and so forth. Hashmarks (//) are depicted along the path of critical segments. A key is included showing: \="Critical path", EST="Earliest Start Time", LFT="Latest Finish Time". The structure visually combines node labels with critical path markers through the task sequence, aiding in identifying tasks' timing and sequence.

[Generated by AI]

Exam tip

You will likely be asked to identify the critical path in the exam. You must state the critical path explicitly or indicate it with hash marks on the diagram itself.

It is a good idea to double check your calculations. It can be very easy to mix up the EST and LFT for the current and next task when calculating free float and total float.

Complex critical path analysis

Until this point, you have been looking at a very simple critical path in order to learn the basics. In the exam, however, you will likely be given information for a more complex critical path analysis, such as the example given in **Figure 6** the following activity.

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (transfer)

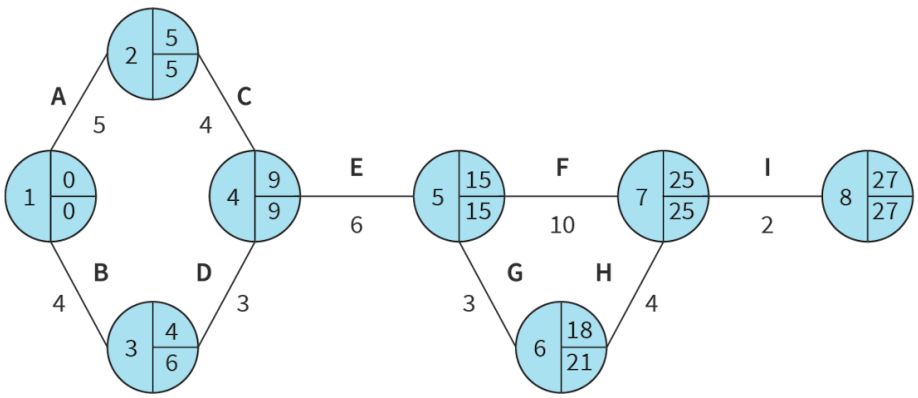

Figure 6. Critical path (network) diagram for Project Q.

More information for figure 6

Student view

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This image is a network diagram used to illustrate the critical path of Project Q. The diagram contains several nodes labeled from A to I, each represented by a circle with split sections containing numbers. The nodes are connected by lines indicating paths between various nodes, with each path labeled with a number representing the length or duration. For instance, node A connects to B with a path labeled '4' and to C with '5'. Node C then connects to D and E with '4' and '9', respectively. From E, there is a path leading to F labeled '6'. Node F connects to H with a label '4' and to node G with '3'. Node H also leads to node I with a path labeled '2', which completes the network. The numbers within the nodes indicate possible timing values for project management. The diagram visualizes the flow and sequence of tasks required to complete Project Q, identifying critical tasks and paths.

[Generated by AI]

See if you can answer each question using the information from **Figure 6**. You can reveal the solutions to check your understanding.

Questions

1. What is the total number of days that Project Q should take?
2. What is the earliest start time (EST) for task F?
3. What is the latest finish time (LFT) for task D?
4. Create a table to show the tasks, task dependencies, task durations, earliest start times, latest finish times, free float and total float (you will have to calculate these).
5. Identify the critical path for Project Q.

Question 1

The total days for Project Q is 27. You can see this figure in the node at the **end** of the critical path (network) diagram.

Question 2

The earliest start time for task F is 15 days. This figure appears in the upper right segment of the node just **before** task F.

Question 3

The latest finish time for task D is 9 days. This figure appears in the bottom right segment of the node just **after** task D.

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Question 4

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Note that, in the table, free float and total float are calculated using the following formulas, with the subscript 'current task' indicating the current task being considered in the row and the subscript 'next task' indicating the next task.

$$\text{Free float} = \text{EST}_{\text{next task}} - \text{EST}_{\text{current task}} - \text{duration}_{\text{current task}}$$
$$\text{Total float} = \text{LFT}_{\text{current task}} - \text{EST}_{\text{current task}} - \text{duration}_{\text{current task}}$$

So, for example, in the first row the free float for task A is calculated as $\text{EST}_{\text{task C}} - \text{EST}_{\text{task A}} - \text{duration}_{\text{task A}}$.

Completed summary information for Project Q.

Task	Preceded by	Duration (days)	EST	LFT	Free float (days)	
A	-	5	0	5	5 — 0 — 5 = 0	
B	-	4	0	6	4 — 0 — 4 = 0	
C	A	4	5	9	9 — 5 — 4 = 0	
D	B	3	4	9	9 — 4 — 3 = 2	
E	C and D	6	9	15	15 — 9 — 6 = 0	
F	E	10	15	25	25 — 15 — 10 = 0	
G	E	3	15	21	18 — 15 — 3 = 0	
H	G	4	18	25	25 — 18 — 4 = 3	
I	F and H	2	25	27	27 — 25 — 2 = 0	

Question 5

Critical path for Project Q = A → C → E → F → I

Student view

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Exam tip

You may have noticed that — for tasks that are part of the critical path —the EST for the next task is the same as the LFT for the current task. This simply shows that the next task needs to start as soon as the previous task is finished; there is no float.

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (critical thinking, creative thinking)

Bee-have (BH) is a small workshop that makes beehives for beekeepers using scrap wood from a local building supply store. There are eight tasks involved in constructing the beehives at BH, some of which can be executed concurrently. The tasks, task dependencies and task durations in hours are shown in **Table 5.**

Table 5. Tasks needed to complete a beehive at BH.

Task	Preceded by	Duration (hours)	EST	LFT	Free float (hours)	(
A	-	1				
B	-	6				
C	A	2				
D	A	4				
E	C	3				
F	E and D	2				
G	E and D	6				
H	G and B	1				

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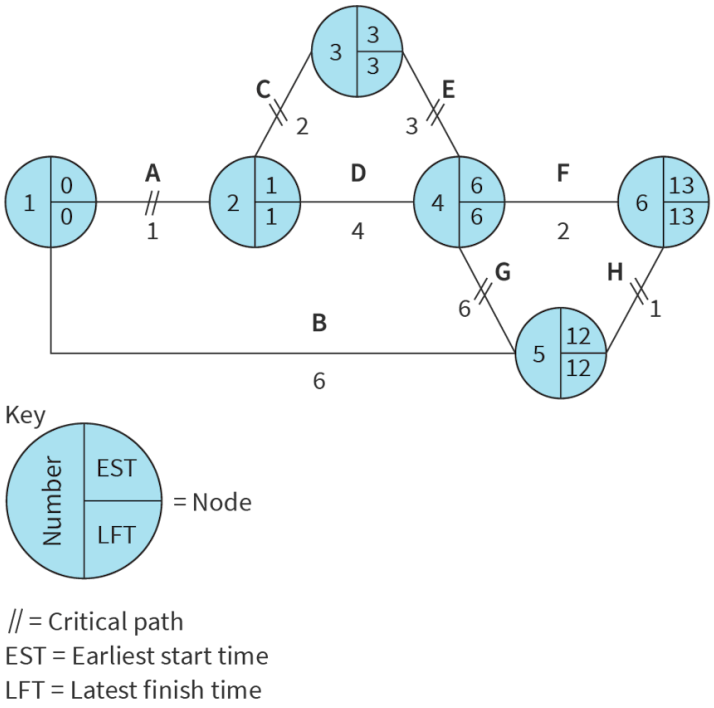
Questions

1. Construct a critical path (network) diagram for the completion of a beehive at BH.
2. State the minimum number of hours needed to make a beehive.
3. Copy and complete the table with the missing information.
4. Identify the critical path for the construction of a beehive at BH.

Question 1



Critical path (network) diagram for BH's beehives.

Question 2

The minimum amount of time needed to make a beehive is 13 hours.

Question 3

The completed table should be as follows. As in the previous activity, free float and total float are calculated using the following formulas, with the subscript 'current task' indicating the current task being considered in the row and the subscript 'next task' indicating the next task.

$$\text{Free float} = \text{EST}_{\text{next task}} - \text{EST}_{\text{current task}} - \text{duration}_{\text{current task}}$$
$$\text{Total float} = \text{LFT}_{\text{current task}} - \text{EST}_{\text{current task}} - \text{duration}_{\text{current task}}$$

Tasks needed to complete a beehive at BH.

Student view

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Task	Preceded by	Duration (hours)	EST	LFT	Free float (hours)
A	--	1	0	1	1 — 0 — 1 = 0
B	--	6	0	12	12 — 0 — 6 = 6
C	A	2	1	3	3 — 1 — 2 = 0
D	A	4	1	6	6 — 1 — 4 = 1
E	C	3	3	6	6 — 3 — 3 = 0
F	E and D	2	6	13	13 — 6 — 2 = 5
G	E and D	6	12	12	12 — 6 — 6 = 0
H	G and B	1	13	13	13 — 12 — 1 = 0

Note that, in this case, the free float and total float have the same results. You should be aware, however, that this is not always the case. The results depend on the dependencies and where the free floats appear in the critical path (network) diagram.

Question 4

Critical path for construction of a beehive = A → C → E → G → H

Activity

Learner profile: Thinkers
Approaches to learning: Thinking skills (critical thinking, creative thinking)

You can really show a deep understanding of the critical path if you can create a problem yourself. Give it a try! Create a table of information about the tasks for a fictional project (Project R), their dependencies and their durations on a piece of paper and complete the critical path diagram for that information on the back of the piece of paper.

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When you have done that:

- Swap your piece of paper with another student who has done the same and look at each other's tables.
- Each of you should create a critical path diagram from the other's table.
- Check your diagram against the other student's diagram. If there are discrepancies, see if you can resolve them to create fully aligned tables and diagrams.
- If your entire class does this, ask your teacher if the class can create a booklet from the work to share for practice.

Dummy activities

In more complex critical path diagrams, you may see a dotted line indicating a dummy activity. A dummy activity has no duration or cost. It is added to the diagram simply to show the relationships between real tasks.

The critical path diagram in **Figure 7** includes a dummy activity to show that task C must be preceded by both tasks A and B. For simplicity, the ESTs and LSTs have been left out; only the node numbers and activity letters are included. In this example, the dummy activity indicates that:

- Task C must come after tasks A and B are finished.
- Task D must come after task B (but not task A).

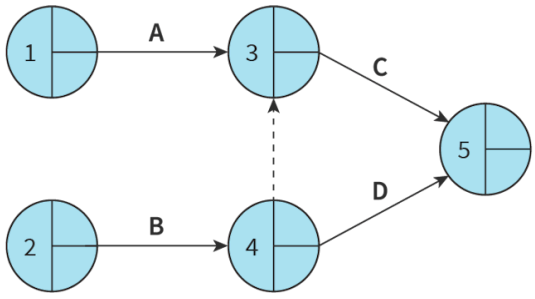

Figure 7. Critical path (network) diagram with a dummy activity included.

More information for figure 7

The image is a critical path network diagram showing the flow of activities between nodes labeled as 1, 2, 3, 4, and 5. Arrows indicate the direction of flow and are labeled with letters A, B, C, and D to signify different activity paths. Node 1 connects to node 3 via path A, node 2 connects to node 4 via path B. Node 3 has two connections, one a solid arrow leading to node 5 via path C, and another a dotted line connecting back to node 4. Finally, node 4 connects to node 5

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via path D. The dotted line represents a dummy activity usually included in network diagrams to maintain correct sequence and logic without contributing to the project's timeline. The arrangement of nodes shows the various paths and dependencies to reach the final node 5, outlining a specific sequence and logic of the workflow.

[Generated by AI]

As noted in a previous exam tip, you will not be required to draw critical path diagrams or any dummy activities within them. However, if you see a dotted line in a critical path diagram in the exam, it is important that you know what it is.

Checklist

Section Student... (0/0) Feedback Print (/study/app/business-hl/sid-351-cid-762729/book/checklist-id-39490/print/) Assign

What you should know

By the end of this subtopic, you should be able to:

- define the following terms: (AO1)
  - lean production
  - waste
  - efficiency
  - continuous improvement (kaizen)
  - just-in-time (JIT)
  - cradle-to-cradle design/manufacturing
  - quality circle
  - benchmarking
  - total quality management (TQM)
  - Gantt chart
  - critical path analysis
- describe the following features of lean production: (AO1)
  - less waste
  - greater efficiency
- explain the following features of lean production: (AO2)
  - continuous improvement (kaizen)

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- just-in-time (JIT)

- explain the features of cradle-to-cradle design and manufacturing (AO2)
- distinguish between quality control and quality assurance (AO2)
- explain the following methods of managing quality: (AO2)
  - quality circle
  - benchmarking
  - total quality management (TQM)
- discuss the impact of lean production and total quality management (TQM) on an organisation (AO3)
- explain the importance of national and international quality standards (AO2)
- apply a Gantt chart in a given context (AO2) (HL)
- prepare and analyse a critical path (network) diagram in a given context (AO4, AO2) (HL)

Reflection

Teacher instructions

The goal of this section is to encourage students to pause at the end of the subtopic and to reflect on their learning. Students can use the questions provided below to guide their reflection. The questions encourage students to look at the bigger picture and to consider how the subtopic's contents might have impacted the way they view the subject.

The following table shows you how each prompt aligns to the DP *Business management guide*:

Prompt #	Syllabus alignment
1	**Learner profile:** Inquirers
2	**Learner profile:** Open-minded
3	**Concept:** Creativity

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Prompt #	Syllabus alignment
4	**Concept:** Ethics

Students can submit their reflections to you by clicking on ‘Submit’. You will then see their answers in the ‘Insights’ part of the Kognity platform.

Reflection

In this subtopic you learned about lean production and quality management.

Take a moment to reflect on your learning so far. You can use the following questions to guide your reflection. If you click ‘Submit’, your answers will be shared with your teacher.

1. Should post-production quality control be the responsibility of the producer as opposed to the end user? Should there be a time limit on such controls?
2. Does quality control necessarily increase costs? Why or why not?
3. How important is creativity in improving efficiency in production methods?
4. Is it the government’s responsibility to ensure that products produced abroad meet national standards?

⚠ Once you submit your response, you won't be able to edit it.

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Submit

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Student view