

Answers to Student's Book

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6 Automated and emerging technologies

Answers to activities

6.1

- a**
- sensors to detect the presence of a bottle are essential
 - level sensors in mixing tank to ensure required volume maintained
 - may be other sensors such as temperature and pH
 - bottle arrives at bottling station
 - sensor sends data back to central computer continuously
 - if bottle is present, computer sends signal to actuator to open valve to allow liquid to fill bottle
 - level sensor used to check correct amount of liquid added
 - once level sensor reading indicates bottle is full, a signal is sent to computer which then sends a signal to an actuator to close the valve
 - computer then sends signal to actuator to open valve and add measured amount of carbon dioxide gas
 - after two seconds, the gas valve is closed
 - next empty bottle arrives and process continues
 - bottle now moves to capping station
 - again sensor detects bottle and computer sends signal to robot arm to place cap on bottle and tighten it
 - then robot arm retracts
 - bottle moves to labelling station
 - sensor detects bottle and computer sends signal to actuator to rotate table through 360° as label is glued to bottle
 - whole process is continuous
- b** Advantages:
- faster than a human operator to take any necessary action

- more consistent – each bottle will have almost exactly the same amount of each ingredient
- less expensive over time as it can replace most of the workforce who would need to monitor the process 24 hours a day
- less wastage and more efficient use of materials
- higher productivity

Disadvantages:

- expensive to set up
- needs considerable testing
- possible for a set of conditions to occur that were never considered during testing
- automated systems always need enhanced maintenance which can be expensive
- any computerised system is subject to cyberattacks

6.2

- needs camera to pick up parallel lines in parking spot
- extra data needs to be width and length of gap (infrared and ultrasonic sensors can be used to find these values)
- data needs to indicate that no vehicle is already in the parking space
- parallel parking will use cameras which will search out white (parallel) lines and ensure that the distance between vehicle and white lines is consistent

6.3

- the computer takes readings from sensors in the car's front bumper ...
- ... to calculate the distance between the car and the vehicle in front
- the computer takes additional sensor readings to determine the speed of the car
- the computer calculates required safe braking distance
- data from the (given) table is then used and the computer determines if the calculated braking distance is greater than the data in the table
- ... if braking distance is greater than safe distance (in table) then brakes are applied and accelerator/throttle also reduced and warning signal/light produced
- if distance between vehicles is OK then no action taken

6.4

Students should produce a table showing all the advantages and disadvantages of using an automated weather station. This will require research using the internet or a local weather station (if it exists). No answer has been supplied because this answer will vary from country to country and students will need to make their own judgements.

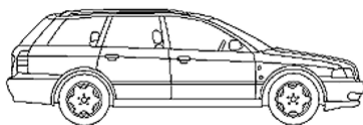
6.5

- 1 • data gathered automatically from various locations around the world ...
- ... could all be collated over time and patterns of global weather changes automatically generated
- automatic projection of key weather data into the future to predict weather could then be checked for its accuracy (by comparison of predicted weather with ACTUAL weather)

- results of this comparison would allow the climate change model to be modified
- 2**
- three sensors needed: temperature, light and moisture
 - all three sensors send data continuously to a microprocessor
 - data would need to be converted to digital (using ADC) if necessary
 - if temperature readings $<$ pre-set value, the microprocessor sends a signal to the actuators ...
 - ... to switch on the heating system/close the windows
 - if temperature readings $\geq$ pre-set value, the microprocessor sends a signal to the actuators ...
 - ... to operate motors to open windows (and switch off heaters)
 - if light level readings $<$ pre-set value, the microprocessor sends a signal to the actuators ...
 - ... to operate motors to open blinds (and turn on artificial lighting)
 - if light level readings $\geq$ pre-set value, the microprocessor sends a signal to the actuators ...
 - ... to operate motors to close blinds (and turn off artificial lighting)
 - if moisture level readings $<$ pre-set value, the microprocessor sends a signal to the actuators ...
 - ... to switch on water pump to irrigate soil
 - if moisture level readings $\geq$ pre-set value, the microprocessor sends signals to the actuators ...
 - ... to switch off water pumps
 - process is continuous
- 3**
- cameras read road signs (60 kph) and software converts the images into a text file
 - ... which allows the microprocessor to interpret road signs
 - if the car's speed $>$ 60 kph, the microprocessor sends a signal to the actuators ...
 - ... to operate motors to apply the brakes and/or reduce throttle position
 - if the car's speed $<$ 60 kph, the microprocessor sends a signal to the actuators ...
 - ... to operate motors to increase throttle position
 - sensors in the car's bumpers/fenders will ensure a safe distance between car and vehicle in front is maintained (by applying brakes and altering throttle as necessary)
 - the Sat Nav calculates the car's position on a map
 - data is sent to a central computer which checks optimum driving conditions
 - if present driving is not the same as stored driving parameters, then computer sends signals to actuators to change gears and apply brakes as necessary

4 Parts **i** and **ii**

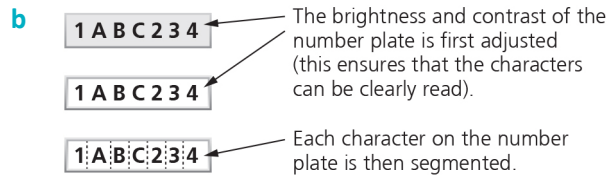
Step 1



A sensor detects a vehicle and sends a signal to instruct a camera to capture an image of the front of the vehicle (often an infrared camera is used to give a clearer image and for use at night).

Step 2

- a** An algorithm is used to locate and isolate the number plate from the image taken by the camera. This algorithm also takes into account the size of the number plate and any damage or orientation.



- c** Each character is then recognised using optical character recognition (OCR) software. The characters are converted into a string of editable text by the software.
- d** This text string is then stored on a database.

Step 3

Once all of this has happened, the car park barrier is raised and the motorist is issued with a ticket. The ticket shows the date and time of entering the car park.

Step 4

When the motorist returns to the car park, they insert their ticket into a machine which calculates the car park charges. The payment is registered on the database.

The motorist then drives to the exit barrier and the ANPR system again reads the number plate and checks its database. If the number plate is recognised (and payment made), the exit barrier is raised.

iii Advantages:

- no need to employ car park security guards which saves money
- much faster system than having to check a ticket at the exit; car parks can issue tickets on entry, but this ticket is simply used for payment purposes by the motorist before leaving the car park and isn't used at the exit since payment will now be linked to the number plate on the car
- can be used to automatically control the entry and exit to a car park or private roads
- can be used as a security system; preventing illegal parking and preventing unauthorised access to private car parks

Disadvantages:

- there is a lack of manned security car park surveillance which could lead to vandalism (and other crimes) since nobody is checking on a regular basis; CCTV is often used, but this is often just used 'after the event'
- invasion of privacy issues due to the recording of driver's number plates
- damaged or very dirty number plates won't be recognised by the system
- number plate cloning; the ANPR system only recognises the number plate and not the car, so it is possible for a car to be fitted with a cloned number plate thus by-passing car park security, for example

6.6

Each student should produce a presentation in the form of a table which highlights the advantages and disadvantages of immersive games consoles. The table should include research into which sensors are used (for example, accelerometers, proximity, magnetic field and pressure), together with a description of the function of each sensor identified.

6.7

- 1 a i flow sensors, temperature sensors
 ii light sensors, infrared/motion sensors
 iii infrared/motion sensors, cameras, pressure sensors

b i Advantages, two from:

- faster response to non-optimum conditions
- more precise monitoring
- greater consistency of product(s)
- 24/7 monitoring

Disadvantages:

- expensive to set up initially and to maintain
- may not respond well to unusual conditions

ii Advantages, two from:

- saves money on unnecessary lighting
- completely automated system
- better control of lighting

Disadvantages, two from:

- expensive to set up
- needs expertise to program the lights exactly as required
- may require specialist equipment

iii Advantages, two from:

- much safer
- fewer staff needed
- fewer delays caused by people pulling emergency cord if someone has an item stuck in the door

Disadvantages, two from:

- still requires human monitoring
- expensive to set up and implement
- requires extensive testing to make sure it works

2

Statement	True	False
Automated systems lead to less consistent results or less consistent products		✓
Automated systems are more expensive to set up than traditional manual systems	✓	
Automated systems would be quickly overwhelmed by the amount of data presented to it		✓
Automated systems are inherently less safe than manual systems		✓
Automated systems generally require enhanced maintenance when compared to manual systems	✓	
Automated systems allow processes to run at optimum conditions at all times	✓	
Software failures, due to unforeseen conditions, are unlikely to impact on an automated system		✓
Automated systems will react more quickly to unusual process conditions	✓	

6.8

Students to produce a table showing all the advantages and disadvantages of the use of robots in agriculture. This may involve research using:

- the chapters in this book
- the companion Information and Communication Technology (ICT) book
- the internet.

Typical advantages might include:

- more accurate
- much faster
- less waste (i.e. picking fruit before it is ripe)
- can work 24 hours a day

Typical disadvantages might include:

- expensive to implement
- will take lots of time to train or program to complete tasks successfully
- different conditions or plants may require more retraining, casual workers will lose their work

6.9

1 Examples:

- harvesting/picking of vegetables and fruit
- weed control
- phenotyping (plant growth and health)
- seed-planting and fertiliser distribution
- autonomous labour-saving devices

Harvesting and picking:

- robots have been designed to do this labour-intensive work; they are more accurate (only picking ripe fruit, for example) and much faster at harvesting
- for the reasons above, this leads to higher yields and reduces waste – for example, Vegebot (Cambridge University) uses cameras to scan, for example, a lettuce and decide whether or not it is ready to be harvested
- a second camera in Vegebot (near the cutting blades) guides an arm to remove the lettuce from its stalk with no damage.

Weed control:

- weed management robots can distinguish between a weed and crop using AI
- examples of weed control robots are being used in France (by Mouton Rothschild) to remove weeds between grape vines in their vineyards; this saves considerably on labour costs and improves vine growth
- weed control robots use GPS tracking to stay on course to move along the rows of vines and remove the weeds; a weed removal blade is operated by an actuator under the control of the controller (microprocessor) in the robot
- very often a drone (flying robot) is used first to do an aerial view of the vineyard, so that a programmed course of action can be produced, which is then sent to the weed control robot's memory.

Phenotyping:

- phenotyping is the process of observing physical characteristics of a plant in order to assess its health and growth
- robots designed to do phenotyping are equipped with sensors (including spectral sensors and thermal cameras) that can create a 3D image/model of the plant, thus allowing it to be monitored for health and growth
- machine learning is used to recognise any issues with leaves (for example, if they have a blight or have the wrong colour) so that the robot can convey this back to the farmer
- these robots are much more accurate and faster at predicting problems than when done manually.

Seed-planting and fertiliser distribution:

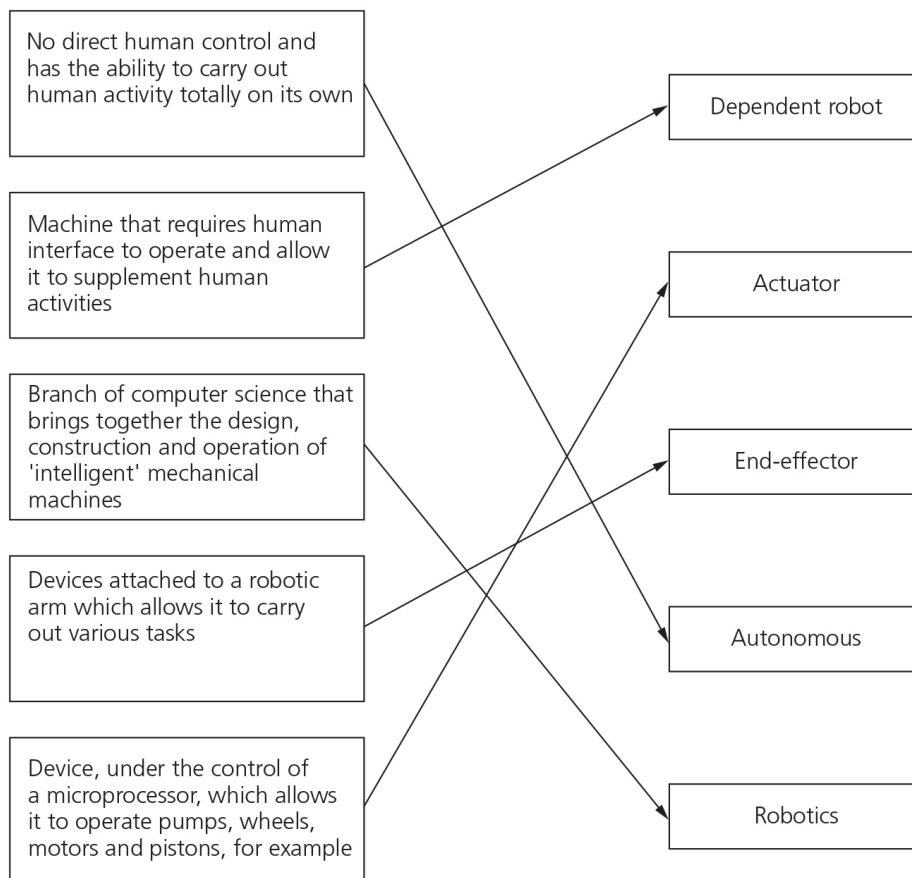
- drones (flying robots) can produce an aerial image of a farm sending back a 'bird's eye view' of the crops and land
- they allow seed-planting to be done far more accurately
- they also allow for more efficient fertiliser-spreading to reduce waste and improve coverage (this is much more efficient than conventional crop spraying)
- drones can also be used in cloud seeding where the drone can add silver iodide crystals to a cloud forcing it to give up its rainwater
- the drones use a very complex camera system to target seeding and allow fertiliser spraying

Autonomous labour-saving devices:

Several of the devices described above could be referred to as autonomous. The following list summarises some of the devices which can work independently of humans:

- grass mowers/cutters
- weeding, pruning and harvesting robots
- seeding robots
- fertiliser spraying
- All of these devices use sensors and cameras to go around obstacles, or they can even be programmed to 'go to sleep' if the weather turns bad.

2



6.10

Essay produced by student on robotics in entertainment including their advantages and disadvantages.

6.11

1

Advantages	Disadvantages
• robots are capable of working in conditions which may be hazardous to humans • robots work 24/7 without the need to stop • robots are less expensive in the long run (since there will be fewer salaries to pay) • robots are more productive than humans (higher productivity) • although not necessarily more accurate, robots are more consistent • robots are better suited to boring, repetitive tasks than humans (therefore less likely to make mistakes) • there will be less cost in heating and lighting (robots don't need good light or warmth)	• robots can find it difficult to do 'non-standard' tasks (for example, windscreen being fitted to a car is cracked) • robots can lead to higher unemployment amongst manual labourers • there is a risk of deskilling when robots take over certain tasks (for example, welding and paint spraying) • factories can now be moved to anywhere in the world where operation costs are lower (leading again to unemployment in some countries) • robots are expensive to buy and set up in the first place

2 Ability to sense its surroundings – two from:

- sensors gather data from surroundings
- allowing robot to recognise its immediate surroundings ...
- ... giving it the ability to determine size, shape, weight, etc.

Ability to move in some way – two from:

- make use of wheels, cogs, pistons, gears, etc. to carry out turning, twisting, moving, gripping, lifting, etc.
- mechanical structures made up of motors, hydraulic pipes, actuators and circuit boards
- makes use of electronic components
- uses end-effectors to carry out different tasks

A perceived intelligence:

- have a controller which determines the action to be taken to perform a task
- controllers can be programmed to allow the robot to do certain tasks

3 autonomous

sensors

cameras

actuators

light detecting and ranging/radar and ultrasonics

lasers

4 sensors

microprocessor

environment

end-effectors

controller

programs

repetitive

adaptive

- 5 a**
- sensors can use radar/sonar to detect objects under the sea
 - cameras take images which allow device to be recognised
 - if ship recognised, then microprocessor sends signals to actuators to operate digital cameras
 - actuators also used to operate electric motors in undersea robots to allow them to move around the shipwreck
- b i**
- sensors can be used to recognise samples
 - data sent to microprocessor after digital conversion (using ADC)
 - if rock samples recognised, microprocessor sends signals to actuators to ...
 - ... stop robot's motors
 - ... to operate 'claws' to take samples of rock
- ii** camera used to recognise terrain, recognise potential rock samples and to allow manoeuvring safely
- c** Advantages include:
- harsh environment which is dangerous to humans
 - more precise than humans
 - can operate non-stop
 - no need for any humans to be present (useful on long journeys, such as visit to Mars which takes several years)
- Disadvantages include:
- expensive devices to design, test and manufacture
 - difficult to repair such devices remotely if they break down
 - as with any robot, they are limited to the functions programmed in (although some ability to reprogram will exist – they may not have the necessary attachments to carry out a newly required task)
- d** Could be used in defusing bombs, clean-up operations in nuclear plants (for example, Chernobyl), etc.

6.12

- a** knowledge base
- b** explanation system
- c** expert system shell
- d** robotics
- e** rules base

6.13**1** artificial intelligence

cognitive

expert systems

explanation system

inference engine

search engine

inference rules

- 2 a**
- Is there anything showing on the screen?
 - Can sound be heard through internal loud speakers?
 - If external speakers are plugged into another computer, do they work?
 - Are the connections between the speakers and the computer OK?
(or any series of logical questions)

- b**
- oil and mineral prospecting
 - diagnosis of patient's illness
 - tax and financial calculations
 - strategy games, such as chess
 - logistics (parcel deliveries)
 - identification of plants, animals and chemicals (for example)

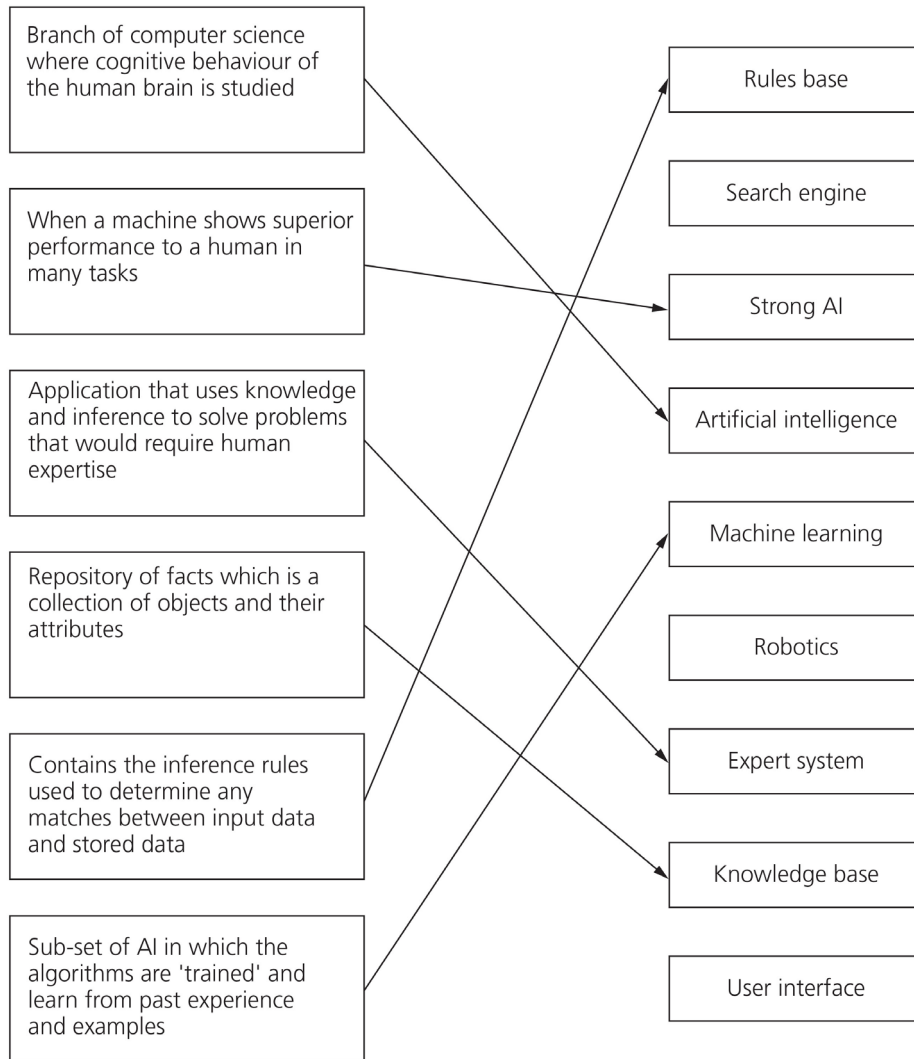
- 3 a**
- sub-set of AI
 - algorithms are trained and learn from past experiences and examples
 - offer fast and accurate outcomes due to very powerful processing capability
 - ability to manage and analyse considerable volumes of complex data
 - machines learn through data acquisition to solve problems
 - can make decisions without being programmed to do so

b

AI	Machine learning
represents simulated intelligence in machines	this is the practice of getting a machine to make decisions without being programmed to do so
the aim is to build machines which are capable of thinking like humans	the aim is to make machines that learn through data acquisition, so that they can solve new problems

- c**
- use web scraping to find key data in websites (search bots)
 - redundant data (collaboration filtering) removed
 - relationship between key words typed in and key words following collaboration filtering is used to train the model
 - these searches are evaluated to further refine the search engine model

4



Answers to exam-style questions

1 a Advantages:

- robots don't need good lighting or working temperatures
- robots can work 24/7
- lower wage bill in the long term
- higher productivity
- fewer errors made
- leaves humans to do more skilled work

Disadvantages:

- expensive to maintain and repair
- expensive to set up initially
- need to pay redundancy money to workers

b

- sensors (proximity) to detect presence of humans
- on sensing a human, the robot will automatically stop its activity
- verbal warning made by robot to indicate its presence

- 2
- accelerometers
 - to measure and respond to tilting of device
 - to respond to forward/backward and side-to-side movement
 - proximity sensors
 - used in smart touch pads ...
 - ... to detect hand/finger positions
 - embedded accelerometers and other sensors in game consoles
 - allow increased human interaction with the game ...
 - ... giving a more immersive games experience
- 3 a
- data from proximity sensor compared to pre-set value
 - pre-set value shows minimum distance
 - if sensor value is the same/lower
 - then the microprocessor sends a signal to actuators to stop the robot
 - if sensor value higher
 - then no action is taken
 - whole process is continuous
- b i
- light sensors in offices
 - light sensors and infrared/motion sensors in offices and corridors
 - if a person is detected entering an office or corridor, a signal is sent by microprocessor to turn on the lights
 - if light sensor value < stored value for office the microprocessor sends signal to turn on lights
- ii Advantages:
- less expensive, because lights only on when office or corridor occupied
 - longer bulb life because switched on for less time
 - possible to program light displays if required
- Disadvantages:
- expensive to set up initially
 - will require more maintenance than a manual system

4 a

Task	Control	Monitor	Expert system
automatic control of the atmosphere in a large greenhouse (to ensure ideal growing conditions)	✓		
self-parking system in a car	✓		
playing a strategy game, such as chess			✓
an automatic weather station sending data to pilots flying near an airport		✓	
a 24/7 check on patients in an intensive care unit of a hospital		✓	
automatic system used to diagnose the illness of a patient			✓
automatic closing and opening of the doors on a train	✓		
fault identification in electronic devices together with suggested actions to rectify the fault			✓

b Four from:

- explanation system informs user of the expert system's reasoning behind its conclusions and recommendations
- inference engine is a type of search engine used in an expert system that examines the knowledge base for information that matches the queries
- knowledge base is a repository of facts which contain all the knowledge of the expert system; it is composed of a collection of objects and attributes
- rules base is a collection of inference rules used to draw conclusions, based on inputs
- user interface is a method whereby the expert system interacts with the user; the interaction can be through dialogue boxes or command prompts; questions are often simple Yes/No responses and are based on responses to previous questions

5 a

- sensors (infrared, pressure) indicate the presence of a person trying to leave/enter the train
- cameras can also be used to check that nobody is trapped in the doors
- sensors send data back to a microprocessor ...
- ... after being converted to digital (using an ADC)
- camera data is put through an algorithm which determines if a person is trapped in a door
- if camera or sensor data indicate a trapped person ...
- ... a signal is sent to actuators to operate motors to open doors/halt the closing of doors
- if sensors and camera detect no presence of passenger in door area, ...
- ... signals are sent to actuators to operate motors to close doors
- the train is then able to move

- b**
 - can be fully automatic/no need to manually check every door
 - it is safer since no one can get trapped and train can't move off ...
 - ... until all sensors indicate no passenger presence
 - faster response to 'dangerous' situations
- c**
 - allows driver to make a manual check on whether it is safe to move off (a double safety check)
 - gives passengers confidence if they know there is a manual back-up safety system
- d**
 - i** autonomous means driverless, no human operators

ii Sensors:

- cameras to recognise signals on the track
- radar and ultrasonics to sense the environment and build up a 3D picture of surroundings
- use of LiDaR, laser systems and GPS to track position

Actuators:

- to apply brakes to stop train
- to operate accelerator to control speed of train
- to open and close doors

iii

Advantages of autonomous trains	Disadvantages of autonomous trains
improves the punctuality of the trains	ever-present fear of hacking into the vehicle's control system
reduced running costs (fewer staff are required)	system doesn't work well with very busy services (at the moment)
improves safety because human error is removed	high capital costs and operational costs initially (that is, buying the trains, expensive signalling and control equipment and the need to train staff)
minimises energy consumption since there is better control of speed and an optimum service requires less energy (trains stuck in stations still use energy)	ensuring passenger behaviour is acceptable particularly during busy times (for example, jamming doors open on trains, standing too near the edge of platforms, and so on)
possible to increase the frequency of trains (automated systems allow for shorter times between trains)	passenger reluctance of the new technology
easier to change train scheduling (for example, more trains during busier times)	no drivers mean there will be a need for CCTV to monitor railway stations

6 a Ability to sense their surroundings:

- this is done via sensors (such as light, pressure, temperature, acoustic, and so on)
- sensors allow a robot to recognise its immediate environment and gives it the ability to determine things like size, shape or weight of an object, detect if something is hot or cold, and so on; all sensor data is sent to a microprocessor or computer

Have a degree of movement:

- they can make use of wheels, cogs, pistons, gears (etc.) to carry out functions such as turning, twisting, moving backwards/forwards, gripping or lifting
- they are mechanical structures made up of many parts (for example, motors, hydraulic pipes, actuators and circuit boards)
- they contain many electrical components to allow them to function
- can make use of end effectors (different attachments to allow them to carry out specific tasks such as welding, spraying, cutting or lifting)

Apparent intelligence:

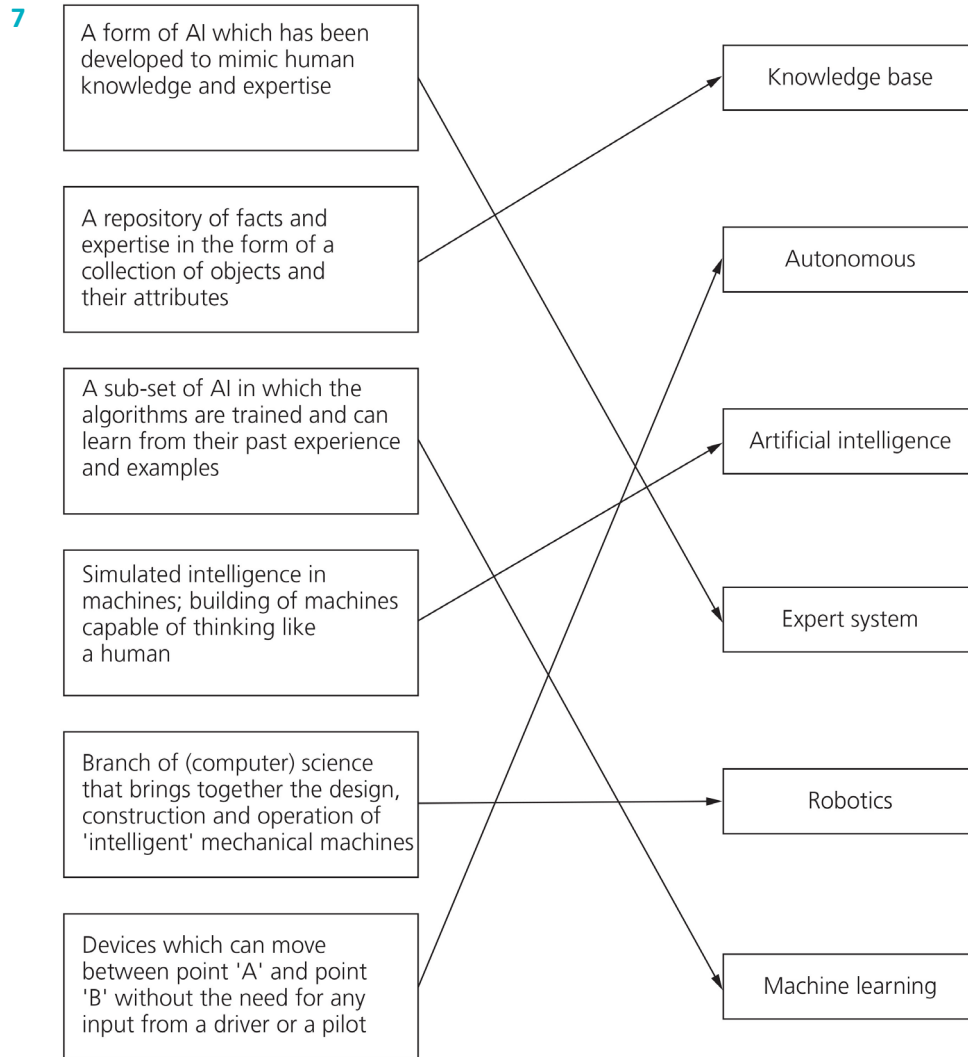
- they have a 'brain' known as a controller which determines the action to be taken to perform a certain task (the controller relies on data sent from sensors or cameras, for example)

b Independent robots:

- have no direct human control (they are said to be autonomous; for example, an autonomous vehicle)
- can replace the human activity totally (no human interaction is required for the robot to function fully)

Dependent robots:

- have a human interfacing directly with the robot (the human interface may be a computer or a control panel)
- can supplement, rather than totally replace, the human activity (for example, in a car assembly plant where both humans and robots work together to produce a car)



- 8
- a end effector
 - b inference engine
 - c autonomous
 - d machine learning
 - e automated systems
 - f artificial intelligence
 - g chatbots
 - h search bot/web crawler
 - i robotics
 - j cognitive
 - k attributes
 - l knowledge base
 - m drone
 - n controller
 - o inference rules