Automated & Emerging Technologies
(Chapter 6)

Syllabus Content:

6.1 Automated systems

Candidates should be able to:	Notes and guidance
1 Describe how sensors, microprocessors and actuators can be used in collaboration to create automated systems	

2 Describe the advantages and disadvantages of an automated system used for a given scenario	• Including scenarios from:
	  – industry
	  – transport
	  – agriculture
	  – weather
	  – gaming
	  – lighting
	  – science

6.2 Robotics

Candidates should be able to:	Notes and guidance
1 Understand what is meant by robotics	• Robotics is a branch of computer science that incorporates the design, construction and operation of robots • Examples include factory equipment, domestic robots and drones

2 Describe the characteristics of a robot	• Including:
	  – a mechanical structure or framework
	  – electrical components, such as sensors, microprocessors and actuators
	  – programmable

3 Understand the roles that robots can perform and describe the advantages and disadvantages of their use	• Robots can be used in areas including:
	  – industry
	  – transport
	  – agriculture
	  – medicine
	  – domestic
	  – entertainment

Syllabus Content:

6.3 Artificial intelligence

Candidates should be able to:

1. Understand what is meant by artificial intelligence (AI)

2. Describe the main characteristics of AI as the collection of data and the rules for using that data, the ability to reason, and can include the ability to learn and adapt

3. Explain the basic operation and components of AI systems to simulate intelligent behaviour

Notes and guidance

- AI is a branch of computer science dealing with the simulation of intelligent behaviours by computers

- Limited to:
  - expert systems
  - machine learning
- Expert systems have a knowledge base, a rule base, an inference engine and an interface
- Machine learning is when a program has the ability to automatically adapt its own processes and/or data

6 | Automated & Emerging Technologies

6.1 | Automated Systems

> **NOTE: Automated Systems is a newly added topic in the Computer Science (2210) syllabus for the session 2023–2025.**

6.1.1 Sensors, Microprocessors & Actuators:

The sensors, microprocessors and actuators can be used in collaboration to create automated systems in fields such as industry, transport, agriculture, weather, gaming, lighting, and science.

Automated System:

It is a combination of software and hardware (sensors, microprocessors, and actuators). It is designed and programmed to work automatically without the need for human intervention. However, such systems often involve human monitoring.

- The sensors are input devices that measure/take physical readings of the surrounding environment and records, indicates, and sends this data to a microprocessor.
  If the data is analogue, it is first converted into a digital format (binary values) using an analogue to digital converter (ADC).
- The microprocessor will process this data and compare it to a pre-set/stored value.
  It will then send a signal and take an action based on its programming.
- This whole process will involve some form of output, usually involving signals sent to actuators to control motors, wheels, solenoids, and so on.

6.1.2 Advantages & Disadvantages of Automated Systems:

In this section, a number of examples will be used to show the advantages and disadvantages of using automated systems. This list simply intends to show the role of sensors, microprocessors, and actuators in the following application areas:

1. Industrial
2. Transport
3. Agriculture
4. Weather
5. Gaming
6. Lighting
7. Science

1) Industrial Applications:

There are many examples of the use of automated systems in industry but only two examples are given below. These two examples can be applied to many other industrial processes with the same keywords and steps/sequence of answering but slight changes can be made according to scenario asked in examination question.

1) Nuclear Power Station:

- The microprocessor is programmed with pre-set values.
- It reads data from the temperature sensors, pressure sensors, flow level sensors, gas sensors and radiation level sensors.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensor readings with pre-set values of all sensors.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuator can operate pumps, valves or even cause an emergency shutdown of system to ensure the system can operate without any human intervention.
- The process is continuous.

A human operator will monitor the process in a remote-control room (monitoring station) where a schematic of the processes will be shown on a large screen. While the process is fully automatic, the human operator can still override the system if necessary.

Advantages of this Automated System:

1. It is much faster than a human operator to take any necessary action.
2. It is much safer as it is more likely to make timely interventions than a human.
3. It is much safer as it keeps human away from a dangerous environment.
4. The process is more likely to run under optimum conditions since any small changes needed can be identified very quickly and action taken.
5. It is less expensive in the long term as it can replace most of the workforce who would need to monitor the process 24 hours every day.

Disadvantages of this Automated System:

1. It is expensive to set up in the first place and needs considerable testing.
2. It is always possible for a set of conditions to occur that were never considered during testing and programming of the system which could have safety implications hence it needs a human operator.
3. It is subject to cyber-attacks as it is a computerized system.
4. It always needs enhanced maintenance which can be expensive.

2) Manufacture of Paracetamol Tablets (locally called Panadol):

- The microprocessor is programmed with pre-set values.
- It reads data from the different sensors during the processes of manufacturing and making of solid tablets.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensor readings with pre-set values of all sensors.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuator can operate pumps, valves, heaters, stirrers, or pistons to ensure both processes can operate without any human intervention.
- The process is continuous.

A human operator will monitor the process in a remote-control room (monitoring station) where a schematic of the processes will be shown on a large screen. While the process is fully automatic, the human operator can still override the system if necessary.

Advantages of this Automated System:

1. It is much faster than a human operator to take any necessary action.
2. It is much safer as it is more likely to make timely interventions than a human.
3. It is much safer as it keeps human away from a dangerous environment.
4. The process is more likely to run under optimum conditions since any small changes needed can be identified very quickly and action taken.
5. It is less expensive in the long term as it can replace most of the workforce who would need to monitor the process 24 hours every day.
6. It ensures more efficient use of materials.
7. It results in higher productivity in manufacturing.
8. It provides more consistent results.

Disadvantages of this Automated System:

1. It is expensive to set up in the first place and needs considerable testing.
2. It is always possible for a set of conditions to occur that were never considered during testing and programming of the system which could have safety implications hence it needs a human operator.
3. It is subject to cyber-attacks as it is a computerized system.
4. It always needs enhanced maintenance which can be expensive.

2) Transportation Applications:

There are many examples of the use of automated systems in transport but only four examples are given below. These four examples can be applied to many other transportation applications with the same keywords and steps/sequence of answering but slight changes can be made according to scenario asked in examination question.

The transport automated systems are still used in manually controlled transport, which includes cars, buses/lorries, trains, and aircraft (autonomous buses/cars, autonomous trains, and unpiloted aircraft).

1) Autonomous Trains:

The modern trains will use an automatic signal control system. If the driver of the train goes through a red (stop) light, then the microprocessor will automatically stop the train.

- The microprocessor is programmed with pre-set values.
- It reads data from the sensors at the side of the train track.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensor readings with pre-set values of the sensors.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuators will be used to apply the brakes and stop the train to ensure the system can operate without any human intervention.
- The process is continuous.

2) Autonomous Airplanes:

- The microprocessor is programmed with pre-set values.
- It reads data from the different sensors during the flight.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensor readings with pre-set values of the sensors.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuators will be used to control the wings, flaps, throttles, and rudders to maintain the correct height, speed, and direction of the plane to ensure the system can operate without any human intervention.
- The process is continuous.

A human pilot will sit in a cockpit (control room/monitoring room) where a schematic of the processes will be shown on different screens. While the process is fully automatic, the human pilot can still override the system if necessary.

3) Self-parking Cars (Autonomous Cars):

The driver goes along the row of parked cars. The on-board sensors and cameras measure the size of any parking spaces and microprocessor warns the driver if a suitable space has been found. The driver then selects auto-parking, and the on-board microprocessor takes over.

- The microprocessor is programmed with pre-set values.
- It reads data from the different sensors in the bumpers of the car which transmit and receive signals.
- The sensors transmit signals that bounce off objects and are reflected back and also give the microprocessor a 3D image of its surroundings.
- The analogue data is converted from analogue to digital using ADC.
- The data from the sensors is compared to the pre-set value to determine the position of any objects.
- If the values are the same, then nothing happens.
- If the values are different, then the microprocessor sends a signal to the actuator.
- The actuators are used to operate the steering rack, brakes, and throttle under full control of the microprocessor.
- This allows the car to fit into its parking space automatically without any human/drivers intervention.

A human driver will sit in the car to monitor the process. While the process is fully automatic, the human driver can still override the system if necessary.

Advantages of this Automated System:

1. It allows the same number of cars to use fewer parking spaces.
2. It avoids traffic disruption in cities as it takes a few seconds to fit into a parking space.
3. The cars can fit into smaller spaces.
4. The cars will suffer fewer dents and scratches so reduced insurance claims.
5. It is much safer since sensors monitor all objects, including young children.
6. It is much safer since the car's manoeuvre will be stopped if any new object is encountered.
7. It provides more consistent results.

Disadvantages of this Automated System:

1. The over-reliance on automated systems by the driver can result in loss of driver's skills.
2. The faulty/dirty sensors or cameras can send false data/images to the microprocessor which could lead to a malfunction.
3. The kerbing of wheel is a common problem since the sensors may not pick-up low kerbs.
4. It is an expensive option that doesn't really save the driver any money.
5. It requires additional maintenance to ensure it functions correctly at all times.

4) Adaptive Cruise Control (Autonomous Cars):

It maintains the set/safe distance between vehicles. A proximity sensor is used to detect how close the vehicle is to the vehicle in front.

- The driver will set a cruising speed in the car.
- The microprocessor is programmed with pre-set values that are set to show the minimum distance from the vehicle in front.
- It reads data from the proximity sensors.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensor readings with pre-set values of the sensors.
- If the values are within range, no action is taken, and speed is maintained.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuator speeds up the vehicle or slows down the vehicle to maintain the set distance.
- When the distance is greater than set/safe distance, the microprocessor will check to see if the current speed equals the cruising speed set by the driver.
- If the speed is different to set speed, the signals are sent to the actuator to increase or decrease the speed.
- The process is continuous.

A human driver will sit in the car to monitor the process. While the process is fully automatic, the human driver can still override the system if necessary.

3) Agricultural Applications:

There are many examples of the use of automated systems in agriculture but only one example is given below. This example can be applied to many other agricultural processes with the same keywords and steps/sequence of answering but slight changes can be made according to scenario asked in examination question.

1) Automated Irrigation (Watering) System:

- The microprocessor is programmed with pre-set values.
- It reads data from the water level sensors used in the crop fields that measure the amount of water in the irrigation channels.
- The analogue data is converted from analogue to digital using ADC.
- The microprocessor receives data from an automatic weather station every few minutes.
- It compares the sensor readings with pre-set values of the sensors.
- It also uses sensor readings with the data received from the weather station.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuator then starts or stops a series of water pumps to ensure the system can operate without any human intervention.
- The process is continuous.

A human operator will monitor the process in a remote-control room (monitoring station) where a schematic of the process will be shown on a large screen. While the process is fully automatic, the human operator can still override the system if necessary.

Advantages of this Automated System:

1. It reduces labor costs since the system only needs a human operator to monitor vast areas.
2. It ensures better and more efficient control of the irrigation process.
3. It allows better control of precious resources such as water.
4. It has faster response than a human having to manually check many kilometers of irrigation channels.
5. It is safer as temperatures in the fields could be 40°C and other risks could exist.
6. It is possible to program the microprocessors so that different growing conditions can be maintained simultaneously as different crops may require different irrigation requirements.

Disadvantages of this Automated System:

1. It is expensive to set up initially as expensive equipment needs to be purchased
2. It has very high maintenance costs and requires specialist technicians if a fault occurs.
3. It has increased need to maintain the water channels to ensure the system works correctly as a blocked or collapsed channel would not be picked up by the automated system which could result in some areas being over-watered and some being starved of water.

4) Weather Applications:

There are many examples of the use of automated systems in weather but only one example is given below. This example can be applied to many other weather processes with the same keywords and steps/sequence of answering but slight changes can be made according to scenario asked in examination question.

1) Automated Weather Stations:

- The microprocessor is programmed with pre-set values.
- It reads data from the temperature sensors, humidity sensors, wind speed sensors, level sensors (measuring rainfall), light sensors and pressure sensors.
- The analogue data is converted from analogue to digital using ADC.
- The data is then stored on a central database and automatically sent to places where constant weather data is required (e.g., sent to pilots in the vicinity of the airport).
- An actuator is only used in 'tipping bucket rain gauge'.
- The microprocessor sends a signal to the actuator at a pre-determined time interval.
- The actuator then operates a piston which tips a bucket that was collecting rain water into a vessel.
- The levels sensors are used to measure the amount of rainfall that fell during the required time interval.
- The process is continuous.

A human operator will monitor the process in a remote-control room (monitoring station) where a schematic of the process will be shown on a large screen. While the process is fully automatic, the human operator can still override the system if necessary.

Advantages of this Automated System:

1. It provides accurate measurements and eliminates the risk of human error.
2. It shows real-time weather data as it keeps providing regular and frequent updates.
3. It has low power requirements as it can operate from any power supply (e.g., solar panels, wind turbines etc.)
4. It has a proven reliability.

Disadvantages of this Automated System:

1. The maintenance team needs to be aware of different automated weather systems.
2. There are problems regarding spare parts and calibration.
3. There is non-uniformity in units of measurements.
4. It is made of very delicate devices which are easily affected by the atmospheric condition.

5) Gaming Applications:

The gaming devices involve sensors to give a degree of realism to games:

- The microprocessor is programmed with pre-set values.
- The accelerometer sensor measure acceleration and deceleration and therefore responds to tilting the game device forward/backward and side to side.
- The proximity sensor detects hand/finger position thus increasing user awareness.
- It reads data from the accelerometer sensors and proximity sensors.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensor readings with pre-set values of all sensors.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor allows increased human interaction with the game.
- It allows players to take actions that simulate real events happening giving a more immersive games experience.

6) Lighting Applications:

There are many examples of the use of automated systems in lighting but only one example is given below. This example can be applied to many other lighting processes with the same keywords and steps/sequence of answering but slight changes can be made according to scenario asked in examination question.

1) Automated Lighting System in Houses:

It involves lights in the garden which are turned on automatically when someone enters the garden or it turns dark. It also involves a lighting show that is a part of the microprocessor-controlled water fountain display where the lighting only comes on when it becomes dark.

- The microprocessor is programmed with pre-set values.
- It reads data from the light sensors and infrared sensors.
- The analogue data is converted from analogue to digital using ADC.
- It compares the light sensor readings and infrared sensors readings with pre-set values of the sensors.
- If the values are within range, no action is taken.
- If the light sensor readings are out of range (it becomes dark) or if the infrared sensor readings are out of range (motion is detected), then the microprocessor sends a signal to turn the garden lights on.
- If the light sensors readings are out of range (it becomes dark), then the microprocessor sends a signal to the actuator to turn water pumps on and off according to the changing colors which are pre-programmed in the water fountain display (lighting show is initiated).
- The process is continuous.

Advantages of this Automated System:

1. It is possible to control light sources automatically.
2. It ensures a reduced energy consumption since lights are only turned on when necessary.
3. It allows wireless connections which are much safer as there are no trailing wires.
4. It ensures longer bulb life due to dimming or switching off when not in use.
5. It is possible to program new light displays for various occasions.

Disadvantages of this Automated System:

1. It is expensive to set the system up in the first place.
2. The wireless connections are less reliable than wired systems if chosen for safety reasons.
3. It will require more maintenance, which can be expensive for ensuring consistent performance.

7) Science Applications:

There are many examples of the use of automated systems in scientific research but only one example is given below. This example can be applied to many other scientific processes with the same keywords and steps/sequence of answering but slight changes can be made according to scenario asked in examination question.

1) Automated Chemical Processes:

An experiment is carried out in a pharmaceutical laboratory where two chemicals are reacted together in a vessel. One of the chemicals is being added from a piece of equipment known as a burette (which has a tap operated automatically using a small actuator to control flow of liquid) to a reaction vessel. Once the reaction is complete, it turns a bright orange color (measured by colorimeter) and the whole process is under microprocessor control.

- The microprocessor is programmed with pre-set values.
- It reads data from the level sensors which measure how much liquid is being added from burette.
- It also reads data from a colorimeter next to reaction vessel.
- The analogue data is converted from analogue to digital using ADC.
- It compares the sensors readings with pre-set values of the sensors.
- If the values are within range, no action is taken.
- If the values are out of range, then the microprocessor sends a signal to the actuator.
- The actuator then operates the tap in burette by opening or closing it to ensure the system can operate without any human intervention.
- The process is continuous.

A human operator will monitor the process in a remote-control room (monitoring station) where a schematic of the process will be shown on a large screen. While the process is fully automatic, the human operator can still override the system if necessary.

Advantages of this Automated System:

1. It provides more consistent (repeatable) results.
2. It is less dangerous especially if the chemicals used are hazardous.
3. It provides faster results as several different experiments can be done simultaneously.
4. The several experiments can be carried out at the same time with only one human operator needed to monitor the system.
5. It allows automatic analysis of the results.
6. It needs fewer highly trained staff for each experiment.
7. The results/experiments can be monitored anywhere in the world in real time.

Disadvantages of this Automated System:

1. It is less flexible than when using human technicians.
2. The security risks are always present if the data is being shared globally.
3. The equipment can be expensive to buy and set up in the first place.

There are many automated systems being used in both industry and scientific research that incorporate Artificial Intelligence (AI).

Common Advantages of using AI in Automated Systems:

1. They have the ability to access and store vast amounts of facts which are very important in research.
2. They are able to learn from huge amounts of available data that would overwhelm human (or at the very least take humans many months/years to do the same analysis).
3. They are able to see patterns in results that could be missed by humans.

Common Disadvantages of using AI in Automated Systems:

1. It causes a change in skills set.
2. The AI is dependent on the data which trains it.

Common Benefits for users of Automated Systems/Devices:

1. They no longer have to do manual tasks therefore they have more time to do other things.
2. They can go out of the house when food is being cooked or washing is being done.
3. They can control automated devices remotely.
4. They have a greater sense of security with automated burglar alarms or smoke/fire alarms.
5. They can spend more time with the family.
6. They can do leisure activities/shopping/socializing when it is convenient.
7. They can use automated devices for physical fitness tracking in the home.
8. They can set timers for washing/cooking.
9. The use of smart fridges leads to a healthy diet. The smart fridges also reduce food waste.
10. They can save fuel/money as the heating/air conditioning is not turned on all day.

A few examples are given below which will help you better understand the pattern of answering the Automated System questions and how to make changes in your answer according to question statement and the scenario asked.

The answer to each question is very similar and consists of statements and the same keywords in a sequence. However, the situation would change, and the examiner can give you any scenario and question about the functioning of any Automated System accordingly.

Example 1:

Controlling an automatic cooker:

- The microprocessor stores the required temperature as preset value.
- The microprocessor stores the cooking/start time and end times as preset value.
- The microprocessor subtracts the cooking time from end time and compares the result with current time.
- If the current time and the calculated time are the same, the microprocessor switches on the heater.
- It reads data from the temperature sensors.
- The analogue data is converted from analogue to digital using ADC.
- It compares temperature from sensor to pre-set temperature.
- If the temperature is lower than preset value, it sends a signal to actuators to turn the heater on.
- If the temperature is higher than the pre-set value, it sends a signal to actuators to turn the heater off.
- The microprocessor compares the current time with the end time preset value.
- If the current time is less than end time preset value, then cycle continues else microprocessor sounds buzzer/beeper.

Example 2:

Controlling a burglar alarm:

- The microprocessor checks the input from the user is authentic.
- It is programmed with pre-set values.
- It reads data from the sensors.
- The analogue data is converted from analogue to digital using ADC.
- If the light sensor, contact switch & motion sensor are activated and the pressure, sound & temperature are greater than their pre-set values then it sends a signal to sound the alarm.
- It sends signal automatically to the police station/security company.
- It sends signal to flashing lights/house lights.
- It sends message/text/calls automatically to the owner.

Example 3:

Controlling a car parking barrier (where a light sensor is used to detect the presence of a car and prevent the barrier from dropping onto the car):

- The microprocessor is programmed with pre-set values.
- It reads data from the light sensor.
- The analogue data is converted from analogue to digital using ADC.
- It compares sensor readings with pre-set values.
- If the readings show there is a car present then the microprocessor sends a signal to the actuator.
- The actuator opens/raises the barrier.
- If the readings show no car is present then the microprocessor sends a signal to the actuator.
- The actuator closes/lowers the barrier.

Example 4:

Controlling/maintaining the set distance between autonomous vehicles (where a proximity sensor is used to detect how close the vehicle is to the vehicle in front):

- The microprocessor is programmed with pre-set values.
- It reads data from the proximity sensor.
- The analogue data is converted from analogue to digital using ADC.
- The data from the proximity sensor is compared to the pre-set value.
- The pre-set value is set to show the minimum distance from the vehicle in front.
- If the values are the same, then nothing happens.
- If the values are different, then the microprocessor sends a signal to the actuator.
- The actuator speeds up the vehicle or slows down the vehicle to maintain the set distance.
- The process is continuous.

Example 5:

Controlling/operating an automatic heater (to switch on at the set time of 16:00 for two hours):

- The microprocessor constantly checks the current time against the start time.
- If the current time is less than the set time nothing happens.
- If they are the same, then the microprocessor sends a signal to the actuator to turn the heater on.
- It calculates the end time by adding 2 hours to the start time.
- It constantly checks the current time against the end time.
- When they are the same, it sends a signal to the actuator to turn the heater off.

6.2 | Robotics

> NOTE: Robotics is a newly added topic in the Computer Science (2210) syllabus for the session 2023–2025.

6.2.1 Meaning of Robotics:

- The robotics is a branch of computer science that incorporates the design, construction, and operation of robots.
- The examples include factory equipment, domestic robots, and drones.

Three Laws of Robotics:

1. A robot may not injure a human through action or inaction.
2. A robot must obey orders given by humans unless it comes into conflict with law 1.
3. A robot must protect itself unless this conflicts with law 1.

Examples of Robots:

The robots can be found in:

1. **Factories (equipment)**
   - welding parts together
   - spray-painting panels on a car
   - fitting windscreens to cars
   - cutting out metal parts to a high precision
   - bottling and labeling plants
   - warehouses (automatic location of items)

2. **Home (domestic)**
   - autonomous floor sweepers
   - autonomous lawn mower
   - ironing robots ('dress man')
   - pool cleaning
   - automatic window cleaners
   - entertainment ('friend' robots)

3. **Drones**
   - unmanned aerial vehicles (UAVs) are drones that are either remotely controlled or totally autonomous using embedded systems.
   - can be used in reconnaissance (observation/examination/inspection by for example, taking aerial photographs)
   - can be used to make parcel deliveries (for example, Amazon)

6.2.2 Characteristics of a Robot:

1. **It has a mechanical structure or framework.**
   It is made up of many parts such as motors, hydraulic pipes, actuators, and circuit boards.

2. **It has electrical components, such as sensors, microprocessors, and actuators.**
   These components allow it to function.

3. **It is programmable.**
   It has a microprocessor (controller) that determines the action to be taken to perform a certain task and the microprocessor (controller) relies on data sent from sensors or cameras etc.
   The microprocessor (controller) is programmable to allow the robot to do certain tasks.

4. **It has the ability to sense its surroundings.**
   This is done via sensors (such as light, pressure, temperature, acoustic, and so on.)
   The sensors allow a robot to recognize its environment and give 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 the sensor data is sent to a microprocessor.

5. **It has a degree of movement.**
   It can make use of wheels, cogs, pistons, gear etc. to carry out functions such as turning, twisting, moving backwards/forwards, gripping, or lifting.
   It can make use of end effectors which are different attachments to allow them to carry out specific tasks such as welding, spraying, cutting, or lifting.

Robotics & Artificial Intelligence (AI):

- It is important to realize that robotics and artificial intelligence (AI) are almost two entirely different fields.
- Many robots do not possess artificial intelligence (AI) since they tend to do repetitive tasks rather than requiring adaptive human characteristics.

Physical & Software Robots:

The physical robots and software robots are different.

Software Robots:

The software robots are not true robots. Their examples include:

- The search engine bots or WebCrawlers roam the internet scanning websites, categorizing them for search purposes.
- The chat bots are programs that pop up on websites that seem to enter some form of conversation with the web user.

Physical Robots:

The physical robots are the true robots. They can be classified as independent or dependent:

(i) Independent Robots:

- They have no direct human control and they are said to be autonomous (e.g., autonomous vehicle).
- They can replace the human activity totally and no human interaction is required for the independent robot to function fully.

(ii) Dependent Robots:

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

6.2.3 Role of Robots and their Advantages & Disadvantages:

The robots are very good at repetitive tasks. However, if there are specialist tasks that require thinking to cope with variable circumstances such as making specialist glassware for some scientific work then it is often better to still use human operators.

Controlling of Robot:

- The control of robots is either through embedded (built-in) microprocessors or directly linked to a computer system.

Programming of Robot:

The robot is programmed to do a series of tasks in following two methods:

Programming of Robot (method 1):

- The robot is programmed with a sequence of instructions which allow it to carry out a series of tasks (e.g., spraying a car body with paint).

Programming of Robot (method 2):

- A human operator manually carries out the series of tasks. This can be done using two ways.

We will assume an object is being painted using a robot arm in this method 2. A robot arm is equipped with a spray gun end-effector. The different end-effectors allow the robot arm to carry out many different tasks.

(i) Programming of Robot using human operator manually carrying out tasks (way 1):

- The robot arm is guided manually by a worker when spraying the object.
- Each movement of the arm is stored as an instruction on the computer.

(ii) Programming of Robot using human operator manually carrying out tasks (way 2):

- The worker straps sensors to his own arm and sprays the object.
- Each movement is stored as a set of instructions on a computer.
- The sensors send back information such as position relative to that object, arm rotation and so on.
- This information forms part of the instructions stored on the computer.

Whichever method is used for programming of robot, once the instructions have been saved, each series of tasks can then be carried out by a robot arm automatically.

Each instruction will be carried out identically every time (e.g., assembling parts in a television) giving a consistent product.

Sensors in Robot:

- The robot is equipped with sensors so it can gather important information about its surroundings.
- It also prevents the robot from taking foolish or unintelligent measures such as stopping a robot spraying a car if no car is present or stop the spraying operation if the supply of paint has run out, and so on.

Advantages of using an existing Robot device rather than developing new one:

1. It is more likely to be reliable as it is known that the device will work.
2. It is cheaper than paying full development costs.
3. It is quicker to get into operation as the device has been built.
4. It has lower maintenance costs as faults will be known.
5. It has lower costs for training staff.

Use of Robots:

The robots are used in a number of areas. We will now consider the use of robots, together with the advantages and disadvantages of using robots in each of the following areas:

1. Industry
2. Transport
3. Agriculture
4. Medicine
5. Domestic (home)
6. Entertainment

> **NOTE:** The Robots are used in a number of areas and they have many advantages and disadvantages in each area accordingly.
>
> However, this makes the list of advantages and disadvantages numerous and it is really difficult for a student to memorize all of them.
>
> Any of the following 5 to 6 general advantages and disadvantages of Robots must be memorized by every student which are the most common in all the applications given on the next few pages. They are the most repeated one and are applicable to almost every area and each scenario.
>
> Apart from these, the students should generally memorize 2-3 advantages and disadvantages which specifically belong to that particular area where robots are used.

General/Common Advantages of using Robots rather than humans:

1. They are more efficient than a human.
2. They are more accurate than a human and make fewer mistakes.
3. They can work 24/7 continuously and do not need to take breaks.
4. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
5. They can replace humans working in a dangerous environment and hazardous conditions.
6. They allow humans to do more skilled work/other tasks.
7. They can produce consistent standard results/output.
8. They have a higher/greater productivity than a human.

General/Common Disadvantages of using Robots rather than humans:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. They can replace labor which leads to unemployment and increased redundancy payments.
4. They can find it difficult to do non-standard tasks.
5. The humans become de-skilled as robots reduce level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
6. If a change is made in the process the robot needs to be reprogrammed, which takes time and increases cost (difficult and expensive to re-program).
7. The robots are not capable of performing tasks autonomously without guidance from humans and they cannot think for themselves.

1) Industry:

Role of Robots:

1. The robots are used for paint spraying of car bodies.
2. The robots are used for welding bodywork on cars.
3. The robots are used for manufacturing of microchips/microprocessors.
4. The robots are used for manufacturing electrical goods.
5. The robots are used to build the lens of the telescope.
6. The robots are used for automatic warehouses.
7. The robots are used as a computerized postal delivery system.

Advantages of using Robots rather than humans:

1. They are more efficient than a human.
2. They are more accurate than a human and make fewer mistakes.
3. They can lift larger and heavier equipment than a human.
4. They can replace humans working in a dangerous environment and hazardous conditions.
5. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
6. They can produce consistent standard results/output.
7. They have a higher/greater productivity than a human.
8. They can work 24/7 continuously and do not need to take breaks.
9. They allow humans to do more skilled work/other tasks.
10. The tasks/job can be carried out much quicker/faster.

Disadvantages of using Robots rather than humans:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. They can replace labor which leads to unemployment and increased redundancy payments.
4. They can find it difficult to do non-standard tasks.
5. The humans become de-skilled as robots reduce level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
6. If a change is made in the process the robot needs to be reprogrammed, which takes time and increases cost (difficult and expensive to re-program).
7. It is expensive to train staff for operating the robots.
8. The factories can now be moved to anywhere in the world where operation costs are lower, leading again to unemployment.
9. The robots are not capable of performing tasks autonomously without guidance from humans and they cannot think for themselves.

10. If they break down, then they are difficult/impossible to repair and the whole process stops.
11. The abilities of robots are suitable only for simple activities in which no major difficulties are met.

(i) Car Production Industry/Factory:

Tasks performed by Robots in the car industry:

1. Spray painting cars
2. Carrying car windscreens/doors
3. Fitting windscreens
4. Fitting the wheels on car
5. Welding body panels
6. Installing transmission system
7. Moving cars from one place to another
8. Moving goods in an automatic warehouse
9. Fitting engine block into car body

Advantages to the Company of using Robots rather than humans in car factories:

1. They are more efficient than a human.
2. They are more accurate than a human and make fewer mistakes.
3. They can lift larger and heavier equipment than a human.
4. They can replace humans working in a dangerous environment and hazardous conditions.
5. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
6. They can produce consistent standard results/output.
7. They have a higher/greater productivity than a human.
8. They can work 24/7 continuously and do not need to take breaks.
9. They allow humans to do more skilled work/other tasks.

Disadvantages to the Company of using Robots rather than humans in car factories:

1. They are expensive to buy and set up in the first place/initially.
2. They can replace labor which leads to unemployment and increased redundancy payments.
3. They can find it difficult to do non-standard tasks (e.g., the windscreen being fitted to a car is cracked).
4. The humans become de-skilled as robots reduce the level of skill needed for a job by humans (e.g., welding and paint spraying) therefore if the system breaks down there could be issues completing the work.
5. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).

6. If a change is made in the process the robot needs to be reprogrammed, which takes time and increases cost (difficult and expensive to re-program).
7. It is expensive to train staff for operating the robots.
8. The factories can now be moved to anywhere in the world where operation costs are lower, leading again to unemployment.
9. The robots are not capable of performing tasks autonomously without guidance from humans and they cannot think for themselves.
10. If they break down, then they are difficult/impossible to repair and the whole process stops.
11. The abilities of robots are suitable only for simple activities in which no major difficulties are met.

Advantages to the Workers of using Robots rather than humans in car factories:

1. The workers have to do the less hazardous jobs.
2. The workers do not need to lift heavy loads.
3. The workers can work in a cleaner/healthier working environment.

Effects of using Robots on the job roles and working conditions in a car production factory:

1. It has increased unemployment of manual workers/vehicle production line workers.
2. It has made opportunities of employment as maintenance workers of robots.
3. It results in a more pleasant atmosphere to work in with less noise.
4. The workers are in a safer environment.
5. The workers become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
6. It allows job opportunities for job sharing or part time jobs.

How the use of Robots has affected nature of employment in the car production industry:

1. The introduction of robots has reduced the number of car production factory workers.
2. The vehicle production factories work 24/7 continuously with the use of robots.
3. The workers could be working unsociable hours.
4. The staff become de-skilled as robots reduce the level of skill needed for a job by humans.
5. The use of robots requires an increase in training for the staff.
6. The use of robots has increased the number of supervisors/quality control workers.
7. The use of robots has increased the number of maintenance staff.
8. The use of robots has increased the job sharing/part time jobs.
9. The use of robots has increased the number of staff compressing hours.
10. The use of robots has increased the number of engineers/designers/programmers to build the robots.

(ii) Mining Industry:

- The robots are being used in the mining industry to dig up minerals from under the surface of the Earth.

Advantages of using Robots rather than humans to do this task:

1. They are safer as humans could be injured in rock falls.
2. It is easier to replace a robot rather than train a miner.
3. They are more accurate than a human and make fewer mistakes.
4. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
5. They can work 24/7 continuously and do not need to take breaks.
6. They can replace humans working in a dangerous environment and hazardous conditions.
7. They have a higher/greater productivity than a human.
8. They allow humans to do more skilled work/other tasks.
9. The tasks/job can be carried out much quicker/faster.

Disadvantages of using Robots rather than humans to do this task:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. If a change is made in the mining equipment/rock type the robot needs to be reprogrammed, which takes time and increases cost (difficult and expensive to re-program).
4. The setting up of the robot in the mine will be dangerous for humans.
5. They can replace labor which leads to unemployment and increased redundancy payments.

(iii) Microprocessor Manufacturing Industry:

- The companies that make microprocessors use robots to carry out the task rather than humans.

Advantages of using Robots rather than humans to do this task:

1. They can replace humans working in a dangerous environment and hazardous conditions.
2. They can work 24/7 continuously and do not need to take breaks.
3. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
4. They have a higher/greater productivity than a human.
5. They are more accurate than a human and make fewer mistakes.
6. They can produce consistent standard results/output.
7. They allow humans to do more skilled work/other tasks.
8. The tasks/job can be carried out much quicker/faster.

Disadvantages of using Robots rather than humans to do this task:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. They can replace labor which leads to unemployment and increased redundancy payments.
4. The humans become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.

(iv) Telescopic Lens Manufacturing Industry:

- The European Space Agency (ESA) is building a new space telescope to orbit the Earth and search for distant galaxies.
- The ESA is using computer-controlled robots to build the lens of the telescope.

Advantages of using Robots rather than humans to build the lens:

1. They can work in sterile areas where humans would need protective clothing.
2. They can easily be used for transferring large delicate items.
3. They can work 24/7 continuously and do not need to take breaks.
4. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
5. They are more accurate than a human as the lens needs to be precise and higher quality.
6. They ensure better/more frequent checking of the equipment/lens.
7. They do the boring/laborious work.
8. The issues can be found quicker.
9. The tasks/job can be carried out much quicker/faster.

Disadvantages of using Robots rather than humans to build the lens:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. If a change is made in the process the robot needs to be reprogrammed, which takes time and increases cost (difficult and expensive to re-program).
4. They require backup systems, which are expensive.
5. The humans become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
6. They need constant monitoring/observation, which increases the cost of maintenance crews.

(v) Computerized Postal Delivery System:

- The robots are used as a computerized postal delivery system.
- It drives around the corridors of a set of offices picking up and delivering post.
- If the robot is close to a worker, it stops and waits until the worker moves away.
- The robots are being used more and more in offices to carry out menial (unskilled) tasks, like delivering post.

Advantages of using Robots rather than humans to do this task:

1. They reduce the overall wage bill as there are fewer workers.
2. They have a greater productivity than a human.
3. They are more efficient as they can work all day long.
4. The robot has a set path/route to follow which means that staff know when it is due.
5. The GPS can be used to show where the robot is in the building.
6. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
7. They are more accurate and make less mistakes.
8. They allow humans to do more skilled work than delivering post.
9. They can work 24/7 continuously and do not need to take breaks.

Disadvantages of using Robots rather than humans to do this task:

1. They are expensive to buy and set up in the first place/initially.
2. The robot can only carry out one task.
3. The stairs can be a problem for robot movement.
4. The payload size can be an issue.
5. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
6. They can replace labor which leads to unemployment and increased redundancy payments.

(vi) Automatic Warehouses:

- There is a port which handles a large number of shipping containers.
- The containers are automatically transferred between ships, storage areas and lorries at the port.
- The whole system is operated by robots.

Advantages of using Robots in this type of operation:

1. The port can operate 24/7.
2. The robots can work 24/7 continuously and do not need to take breaks.
3. They reduce the overall wage bill as there is no need to have a massive workforce.
4. They have less health and safety issues.
5. The robot can easily identify each container to quickly transfer to the lorries.
6. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
7. They have a greater precision and accuracy and make less mistakes.
8. They have a higher/greater productivity than a human.
9. They are less likely to drop the containers as they make fewer human errors.

Disadvantages of using Robots in this type of operation:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. They need constant monitoring/observation, which increases the cost of maintenance crews.
4. All containers need to be of the same design and type.
5. If something goes wrong, it may be difficult to easily find the error.
6. They can replace labor which leads to unemployment and increased redundancy payments.

2) Transport:

(i) Role of Robots in Autonomous Cars & Buses:

1. The autonomous cars use sensors, cameras, actuators, and microprocessors together with very complex algorithms to carry out their actions safely.
2. The radar and ultrasonics sensors and cameras allow the control systems in car to perform critical functions by sensing dynamic conditions on a road.
3. The microprocessor processes the data received from cameras and sensors and send signals to actuators to perform physical actions such as:
   1) Change gear
   2) Apply the brakes
   3) Turn the steering wheel
4. The cameras catch visual data from surroundings, while radar and ultrasonics allow the vehicle to build up a 3D image of its surroundings.
5. The control system in the car recognizes the road sign and then checks its database as to what action to take.
   1) If the traffic light shows red, the microprocessor sends signal to actuators to apply brakes and put the gear into 'park'.
   2) It constantly monitors the light until it changes to green.
   3) If the traffic light shows green, the microprocessor sends signal to actuators to put the car into first gear, release the brakes and operate the accelerator (throttle).
   4) The microprocessor must constantly check all sensors and cameras to ensure moving off is safe, for example, if a car in front is broken down or a pedestrian is crossing the road, and so on.

Advantages of Autonomous Vehicles:

1. They are safer since human error is removed leading to fewer accidents.
2. They are better for the environment since vehicles will operate more efficiently.
3. They result in reduced traffic congestion.
4. They ensure increased lane capacity due to better braking and acceleration responses together with optimized distance between vehicles.
5. They result in reduced travel times and therefore less commuting time.
6. They allow stress-free parking for drivers as car will automatically find parking and self-park.

Disadvantages of Autonomous Vehicles:

1. They are very expensive system to set up in the first place as high technology requirements.
2. They are always susceptible to cyber hacking of vehicle's control system.
3. They have security and safety issues as software glitches could be disastrous.

4. They have security and safety issues as software updates must be carefully controlled to avoid potential disaster.
5. They must be well-maintained at all times (cameras need to be kept clean, sensors could fail to function in environmental conditions).
6. The driver and passenger are reluctant to use this new technology.
7. They reduce the need for taxis which could lead to unemployment of cab drivers.

(ii) Role of Robots in Autonomous Trains:

1. The autonomous trains use sensors, cameras, actuators, and microprocessors.
2. They use a system called LiDaR (Light Detection and Ranging) that uses lasers to build up a 3D image of the surroundings.
3. The proximity sensors on train doors and cameras (including infrared cameras) are used to help control the train and maintain safety.
4. The control system in train makes use of global positioning satellite (GPS) technology which allows accurate changes in speed and direction to be calculated.
5. The actuators are used for controlling the train's speed, braking and the opening and closing of the train doors.

Advantages of Autonomous Trains:

1. They improve the punctuality of the trains.
2. They reduce the running costs as fewer staff are required.
3. They improve safety since human error is removed.
4. They minimize energy consumption since there is better control of speed and an optimum service requires less energy.
5. This allows the increase in frequency of trains as automated systems allow for shorter time between trains.
6. It is easier to change train schedules, for example, more trains during busier times.

Disadvantages of Autonomous Trains:

1. They are a very expensive system to set up in the first place as high capital costs and operational costs initially for buying trains, signaling & control equipment and staff training.
2. They are always susceptible to cyber hacking of vehicle's control system.
3. The system does not work well with very busy services.
4. They cannot ensure that the passenger behavior is acceptable particularly during busy times (jamming doors open on trains or standing too near the edge of platforms and so on).
5. The passengers are reluctant to use this new technology.
6. There will be a need for CCTV to monitor railway stations as there is no driver.
7. They reduce the need for drivers which could lead to unemployment of train drivers.

(iii) Role of Robots in Autonomous (unpiloted) Airplanes:

The airplanes use autopilots to control flights and human pilots only take over during take-off and landing.

1. The autonomous (pilotless) airplanes use sensors, actuators, and microprocessors to control all stages of the flight.
2. They have sensors to detect turbulence to ensure smooth flights.
3. They have an increase in self-testing of all circuits and systems.
4. They have sensors that automatically detect depressurization in the cabin thus allowing for quick stabilization of the airplane.
5. They use GPS for navigation and speed calculations.
6. They use actuators to control throttle, flaps (on the wings) and the rudder.

Advantages of Autonomous (pilotless) Airplanes:

1. They improve the passenger comfort.
2. They reduce the running costs as fewer staff are required.
3. They improve safety since human error is removed.
4. They improve aerodynamics at the front of the airplane since there would no longer be the need to include a cockpit for the pilots.

Disadvantages of Autonomous (pilotless) Airplanes:

1. They have security issues such as handling terrorist attacks with no pilots on-board.
2. The emergency situations during the flight may be difficult to deal with.
3. They are always susceptible to cyber hacking of vehicle's control system.
4. The passengers are reluctant to use this new technology.
5. They have security and safety issues as software glitches could be disastrous.
6. They reduce the need for pilots which could lead to unemployment of airplane pilots.

3) Agriculture:

Role of Robots:

1. **The robots are used for harvesting/picking of vegetables and fruits.**

   The vegebot (agricultural robot) uses one camera to scan, for example, a lettuce and decide whether or not it is ready to be harvested.

   The vegebot uses a second camera located near the cutting blades that guides an arm to remove the lettuce from its stalk with no damage.

2. **The robots are used for weed control.**

   The weed management robots can distinguish between a weed and a crop using Artificial Intelligence (AI).

   The weed control robots can remove weeds between grape vines in the vineyards.

   The weed control robots use GPS tracking to stay on course to move along the row of vines and remove the weeds.

   A weed removal blade is operated by an actuator under the control of the microprocessor in the robot.

   A drone (flying robot) is used 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.

3. **The robots are used for phenotyping (process of observing physical characteristics of a plant to assess the plant's growth and health).**

   The robots are equipped with sensors including spectral sensors and thermal cameras that can create a 3D image/model of the plant.

   They can use machine learning to recognize any issues with leaves e.g., leaf color so that they can convey this back to the farmer.

4. **The robots are used for seed-planting and fertilizer distribution.**

   The drones (flying robots) can produce an aerial image of a farm sending back a 'bird's eye view' of the crops and land.

   The 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 fertilizer spraying.

5. **The robots are used for autonomous agriculture (labor-saving) devices.**

   These devices can work independently of humans. They use sensors and cameras to go around obstacles, or they can even be programmed to 'go to sleep' if the weather is bad.

   Several of the devices described above could be referred to as autonomous.

   The following list summarizes these devices:

   1. grass mowers/cutters
   2. weeding, pruning, and harvesting robots
   3. seeding robots
   4. fertilizer spraying

Advantages of using Robots rather than humans:

Harvesting & picking:

1. They are more accurate (e.g., only pick ripe fruit).
2. They are much faster at harvesting.
3. They lead to higher yields and reduced wastage.
4. They can do the labor-intensive work.

Weed control:

5. They can considerably save labor costs.
6. They can improve vine growth.
7. The drones (flying robots) can provide aerial views of the vineyards.

Phenotyping:

8. They allow plants to be monitored for health and growth.
9. They are much more accurate and faster at predicting problems of plants than when done manually.

Seed-planting & fertilizer distribution:

10. They allow seed-planting to be done far more accurately.
11. They allow for more efficient fertilizer-spreading to reduce waste and improve coverage.
12. The drones (flying robots) can provide aerial views of the crops and land.

Autonomous agriculture (labor-saving) devices:

13. They can work automatically without the need for human intervention.
14. They can considerably save labor costs.
15. They can be turned off automatically to save power in case the weather conditions are bad.

Disadvantages of using Robots rather than humans:

1. They are expensive to buy and set up in the first place/initially.
2. They can lead to higher unemployment of farmers amongst manual labor tasks.
3. They are not affordable for poor farmers.
4. They can find it difficult to do non-standard tasks.
5. The humans become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
6. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).

(i) Automated Farms:

- ■ A large farm uses a robotic system to milk and feed animals.
- ■ This would recently have been carried out by farm workers.

Advantages of using Robots rather than humans in Automated Farms:

1. They can work in areas of the farm that could be dangerous/harmful for a farm worker.
2. They are better at ensuring a continuous supply of feed.
3. They are available to milk and feed 24/7 continuously and do not need to take breaks.
4. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
5. They have a higher/greater productivity due to cows being milked at times of their choice.
6. They are quicker to see illness in animals due to a system checking a number of factors against stored values, so is more objective.
7. They have greater consistency as the same measurements are taken on all the animals every time the robot checks them.
8. They ensure better/more frequent checking of the animals.
9. The robotic tractors can carry out more tasks in a short time.
10. They free up farmers and allow them to do more skilled work.

Disadvantages of using Robots rather than humans in Automated Farms:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. The patterns of animal illness may be found quicker manually.
4. The farm workers become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.

4) Medicine:

Role of Robots:

1. The robots are used in surgical procedures.
2. The robots are used in monitoring patients.
3. The robots are used in performing minor surgery.
4. The autonomous robots are used in disinfecting of rooms and operating theatres.
5. The robots are used in taking blood samples from patients.
6. The microrobots are used in target therapy.
   These use microscopic mechanical components including microprocessor to localize a drug or other therapy to target a specific site causing less damage to surrounding tissue.
7. The prosthetic limbs are mini robots (since they meet the three characterizations of what defines a robot).
   Bionic skins and neural implants that interface with the human nervous system of the damaged limb giving feedback to allow for better control of the prosthetic limb using sensors and actuators to give human-like responses such as grip.

Advantages of using Robots rather than humans:

1. They make the operations safer.
2. They make the surgical procedures quicker and less costly.
3. They are better at determining the appropriate vein which makes it less painful to patients.
4. They are safer to use than doctors and nurses if the patient has an infectious disease.
5. They can free up doctors and nurses to do more skilled work.
6. They can target a specific site causing less damage to the surrounding tissues of a patient.
7. They have greater precision as the robot arm movements are more exact than a human hand.
8. They have a greater range of motion as the robot arm rotates instruments in tight spaces.
9. They provide better and magnified visualization of the surgical areas through a sophisticated camera.
10. They have the ability to do surgery inside the body as the small instruments allow surgeons to perform an operation inside the patient's body instead of making a much larger incision.
11. They ensure less pain during patient recovery.
12. They lower the risk of infection for patients.
13. They ensure reduced blood loss of patients.
14. They make smaller scars on patient's body.

Disadvantages of using Robots rather than humans:

1. They are expensive to buy and set up in the first place/initially.
2. They can lead to higher unemployment of doctors.
3. They can find it difficult to do non-standard tasks.
4. The humans become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
5. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
6. There is always some scope for human error or mechanical failure with robots.
7. A single mechanical malfunction of a robot can cost human lives.
8. The robots are only available in centers that can afford the technology and have specially trained surgeons and the robotic surgeries may be expensive for certain patients.
9. The healthcare provider needs to invest a lot of money and time to train the workforce to handle robots.

(i) Automating Packaging & Dispensing of Medicines:

- The robots are being used in a city hospital to automate its packaging and dispensing of medicines to patients.
- The robotic system identifies the medicine using barcodes.

Advantages to the hospital of using Robots rather than humans to do this task:

1. They can work in environments where humans would have difficulty such as cooler environment and less light.
2. They can work 24/7 continuously and do not need to take breaks.
3. They are less expensive/cheaper in the long run as they reduce running costs, such as wages and overheads because they don't get paid.
4. They reduce the overall wage bill as there are fewer workers.
5. They have a higher/greater productivity than a human.
6. They are more accurate and make fewer mistakes.
7. They allow humans to do more skilled work than picking the tablets.
8. They have greater consistency.

Disadvantages to the hospital of using Robots rather than humans to do this task:

1. They are expensive to buy and set up in the first place/initially.
2. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).
3. They can replace labor which leads to unemployment and increased redundancy payments.
4. If the barcode is damaged the human would read the number but robot cannot think for itself.

5) Domestic:

Role of Robots:

1. **The robots are used as autonomous vacuum cleaners such as Roomba.**
   These use proximity sensors and cameras to avoid bumping into obstacles and allow them to cover a whole room automatically.
   These robots have a microprocessor to control the overall operation of the device and allow the user to program the device.
   The actuators are used to control motors which allow the forward, backward and side to side movement.

2. **The robots are used as autonomous grass cutters (mowers).**
   These use proximity sensors and cameras to avoid bumping into obstacles and allow them to cover the full garden automatically.
   These robots have a microprocessor to control the overall operation of the device and allow the user to program the device.
   The actuators are used to control motors which allow the forward, backward and side to side movement.

3. **The robots are used as personal assistants such as Vector.**
   These robots are controlled by a microprocessor that uses cloud connectivity for internet connection.
   These understand the voice commands using a microphone and they answer the asked questions by the user.
   They also use HD camera to utilize computer vision, hence allowing it to recognize somebody's face as well as for navigation of a room.
   They use proximity sensors and actuators to steer around objects in their ways.

Advantages of using Robots rather than humans:

1. They can do the regular/boring tasks that user don't like.
2. They can save user's time allowing them to do other skilled work/tasks.
3. They can save user's time allowing them to spend time with the kids and family.
4. They make the home more safe and secure as their cameras are self-automated so they can take pictures and videos of the environment.
5. They are infotainment hubs
6. They can help the disabled/handicapped and elderly people.
7. They can track the user's health
8. They can keep a good company for the user.
9. They have strong cleaning functions to keep the house clean.

Disadvantages of using Robots rather than humans:

1. They are expensive to buy and set up in the first place/initially.
2. They can lead to user's becoming lazy and inactive.
3. They can find it difficult to do non-standard tasks.
4. The humans become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
5. There is always some scope for human error or mechanical failure with robots.
6. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).

6) Entertainment:

Role of Robots:

1. **The autonomous robots are used in theme parks to entertain visitors to the park.**
   These robots are often dressed as cartoon characters and can interact with visitors.
2. **The robots are used in music festivals for controlling lighting (including laser displays), visual effects and animation.**
   This includes superimposing an actor's image onto a robotic cartoon and synchronizing the mouth movements.
   The visual performances can be fully synchronized with the music.
3. **The robots are used to control cameras.**
   They keep the cameras steady and allows auto-focusing when moving around a scene during shooting of a movie/show.
   They are used to give an actor the appearance of moving around in the vacuum of space uncontrollably.
   The robot arms are used to stimulate human behavior and produce life-like moving images.
4. **The humanoid robots (resembling the human body in shape) are used to perform stunt actions in movies/shows.**
   They are either remote-controlled or pre-programmed and they can perform stunt actions tasks that are impossible for a human to do.
   They use computer-generated imagery (CGI) and image capture techniques to generate special effects.
5. **The robots are used to produce special effects.**
   The actions and special effects can be synchronized to within a millisecond and produce fully coordinated/synchronized sound effects such as movement of the mouth to match the sounds produced in a realistic manner.

Advantages of using Robots rather than humans:

1. They can interact with visitors and allow them to engage safely with theme park attractions.
2. They can make the whole theme park experiences more realistic and fun.
3. They can make music festivals much more immersive for the audience.
4. They can create better shots when used to control cameras during shooting of movie/show.
5. They can perform stunt actions which are dangerous and life threatening for the actors to perform themselves.
6. They are capable of producing special effects with a precision, speed and coordination which is beyond human capabilities.
7. They allow synchronization of special effects and actions for producing realistic shots.

Disadvantages of using Robots rather than humans:

1. They are expensive to buy and set up in the first place/initially.
2. They can find it difficult to do non-standard tasks.
3. The humans become de-skilled as robots reduce the level of skill needed for a job by humans therefore if the system breaks down there could be issues completing the work.
4. There is always some scope for human error or mechanical failure with robots.
5. They are expensive to maintain and repair (only less expensive in the long run if their use is not given up).

Exam Style Questions:

Question 1:

Robots are used in a factory to build cars.

(a) One characteristic of a robot is its mechanical structure.

State **two other** characteristics of a robot.

1 ....

2 .... [2]

(b) Suggest **two** advantages of using robots, instead of humans, to build cars in the factory.

1 ....

2 .... [2]

Answer:

Question	Answer	Marks
6(a)	• It has electrical components. • It is programmable.	2
6(b)	Any **two** from: • more efficient than a human • more accurate than a human • can lift larger and heavier equipment than a human • can replace humans working in a dangerous environment • reduces running costs, such as wages and overheads • can produce consistent results/output • can work 24 hours a day // do not need to take breaks.	2

Question 2:

Give **three** specific examples of work that are carried out by a robot in the car industry.

1 ....

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2 ....

....

3 ....

....

[3]

Answer:

Three from:

Putting wheels on cars
Painting car bodies
Welding parts on a car body
Carrying car windscreens/doors
Moving goods in an automatic warehouse
Placing engine block into body
Installing transmission system   [3]

Question 3:

Tick **four** drawbacks to car manufacturers of introducing robots on production lines.

	✓
Redundancy payments to previous workers are expensive	
The cars produced are not of a consistent standard	
Robots are unable to think for themselves	
Robots do not go on strike	
Robots are expensive to buy	
Mistakes are never made	
Maintaining robots costs money	
Car workers have to be paid more	

Answer: [4]

Redundancy payments to former workers are expensive	✓	[1]
The cars produced are not of a consistent standard		
Robots are unable to think for themselves	✓	[1]
Robots do not go on strike		
Robots are expensive to buy	✓	[1]
Mistakes are never made.		
Maintaining robots costs money	✓	[1]
Car workers have to be paid more		

Question 4:

Tick **three** benefits to **workers** of the introduction of robots into car manufacture.

	✓
Once bought robots do not have to be paid	
They have to do less hazardous jobs	
They don't need to lift heavy loads	
They can become deskilled	
It can lead to unemployment	
They work in a cleaner/healthier working environment	
They can work whenever they want	
They get a massive pay rise	

[3]

Answer:

	✓
Once bought robots do not have to be paid	
They have to do less hazardous jobs	✓
They don't need to lift heavy loads	✓
They can become deskilled	
It can lead to unemployment	
They work in a cleaner/healthier working environment	✓
They can work whenever they want	
They get a massive pay rise	

[3]

Question 5:

Car production lines use robots to manufacture the vehicles.

(b) Give **three** advantages to the company of using robots rather than humans to manufacture cars.

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....[3]

(c) Give **three** disadvantages to the company of using robots rather than humans to manufacture cars.

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....

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....[3]

Answer:

(b) Three from:

Running costs are cheaper than paying humans a wage.
Robots can operate continuously.
Cars are built to a more consistent standard.
Robots are more accurate.
Can be used in hazardous conditions.
Greater productivity   [3]

(c) **Three** from:

If a change is made in the manufacturing process the robot needs to be re-programmed.
If a robot makes a mistake it will continue to make the same mistake.
Expensive to set up/maintain
Robots are not capable of performing tasks autonomously without guidance from humans/they cannot think for themselves.
If they break down then they are difficult/impossible to repair.
If the robot breaks down the whole process stops.
The abilities of robots are suitable only for simple activities in which no major difficulties are met. [3]

Question 6:

The managers of a nuclear power plant need to check the radioactivity levels in a chimney stack which needs to be demolished. They intend to use a robot. This device has sensors to read the radioactivity levels.

(b) The managers have been told they can use this robot for other tasks by replacing the existing sensors with different ones.

Give **three** advantages of using an existing robot device rather than developing a new one.

....

....

....

....

....

.... [3]

Answer:

5(b)	Any **three** from: – More likely to be reliable as it is known that the device will work – It is cheaper than paying full development costs – It is quicker to get into operation as the device has been built – Lower maintenance costs as faults will be known – Lower costs for training staff	3

Question 7:

Robots are being used in the mining industry to dig up minerals from under the surface of the Earth.

(a) Give **three advantages** of using robots rather than humans to do this task.

1...

....

2...

....

3...

.... [3]

(b) Give **two disadvantages** of using robots rather than humans.

1...

....

2...

.... [2]

Answer:

16(a)	Any **three** from: – Safer as humans could be injured in rock falls – Easier to replace a robot rather than train a miner – Robots do not require wages hence it is cheaper in the long run – Robots work 24/7 / continuously – Robots can work in hazardous conditions – Robots produce greater productivity	3
16(b)	Any **two** from: – Any changes needed to the mining equipment/rock type requires a reprogramming of the system – Reprogramming takes time – Reprogramming can increase the cost – Setting up the robot in the mine will be dangerous for humans – Expensive to maintain/repair – Initial cost of the robot is expensive	2

Question 8:

Many companies that make microprocessors use robots to carry out the task rather than using humans.

(a) Give **three** advantages of using robots to carry out the task.

1 ....

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2 ....

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3 ....

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[3]

(b) Give **three** disadvantages of using robots to carry out the task.

1 ....

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2 ....

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3 ....

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[3]

Answer:

13(a)	**Three** from: Robots can work in environments where humans would have difficulty Robots can work 24/7 Robots are not paid/cheaper in the long run Productivity is higher Fewer mistakes are made/greater accuracy More consistent Allow humans to do more skilled work/other tasks	3
13(b)	**Three** from: Expensive to maintain/repair Expensive to purchase Replace labour, leads to unemployment Description of de-skilling	3

6.3 | Artificial Intelligence (AI)

> **NOTE: Artificial Intelligence (AI) is a newly added topic in the Computer Science (2210) syllabus for the session 2023–2025.**

6.3.1 Introduction:

- Artificial Intelligence (AI) is a branch of computer science dealing with the simulation of intelligent human behaviors by computers.
- It is often referred to as the cognitive functions of the human brain.
- Cognitive functioning refers to multiple mental abilities, including learning, thinking, reasoning, remembering, problem solving, decision making, and attention.
- All of these cognitive functions can be replicated in a machine.

6.3.2 Characteristics of AI:

The main characteristics of AI are:

1. The collection of data and the rules for using that data.
2. The ability to reason, and the ability to learn and adapt to external stimulation.

Categories of AI:

AI can be split into three categories:

1. **Narrow AI:**

   This occurs when a machine has superior performance to a human when doing one specific task.

2. **General AI:**

   This occurs when a machine is similar (not superior) in its performance to a human when doing one specific task.

3. **Strong AI:**

   This occurs when a machine has superior performance to a human in many tasks.

Reasoning:

■ It is the ability to draw reasoned conclusions based on given data or situations.

Deductive Reasoning:

■ It is where a number of correct facts are built up to form a set of rules.
■ These rules can then be applied to other problems.
■ The machine learns from experience and applies its new rules by modifying its methodology where necessary.
■ Therefore, through some steps, the AI machine can learn and perform tasks more effectively next time.
■ It can also apply its learnings to new/different situations.
■ Therefore, AI systems are capable of learning and adapting to its surroundings.

Examples of AI:

1. It is used in news generation based on live news feeds.

2. It is used in smart home devices such as Amazon Alexa, Google Now, Apple Siri & Microsoft Cortana:

   ■ These AI devices interact with a human by recognizing verbal commands.
   ■ They learn from their environment and the data they receive.
   ■ These devices become increasingly sophisticated in their responses, thus showing the ability to use automated repetitive learning.

3. It is used in chatbots:

   ■ The chatbots interact through instant messaging by artificially replicating patterns of human interactions using AI to respond to typed messages or voice messages.
   ■ Whenever a question is asked, the chatbot responds using the information known at that time.

4. It is used in autonomous cars such as Tesla.

5. It is used in facial expression recognition:

   ■ The algorithms identify key facial landmarks such as the corners of the eyebrows, corners of the mouth and so on.
   ■ A combination of these landmarks can be used to map emotions such as anger, fear, joy & surprise.

6.3.3 Operation & Components of AI Systems:

- There are basic operations and components of AI system to simulate intelligent behavior.
- This section considers two types of AI system which are Expert System & Machine Learning.

1) Expert Systems:

- They have a knowledge base, a rule base, an inference engine, and an interface.
- It mimics the decision-making ability of a human by using AI to simulate judgement and behavior of a human/organization that has expert knowledge and experience.

2) Machine Learning:

- It is when a program has the ability to automatically adapt its own processes and/or data.
- It involves training computers with sample data so they can make predictions about new unseen data based on previously learnt sample data.
- They don't have to be specifically programmed for the new unseen data.

1) Expert Systems:

- They mimic human knowledge and experiences.
- They use human knowledge and inference to solve problems or answer questions which normally require a human expert.
- They basically ask a series of questions to gather knowledge from answers.
- Then they provide a conclusion and any suggested actions to take.
- They also give the percentage probability of the accuracy of its conclusions.

Applications using Expert Systems:

1. Oil and mineral prospecting/rock classification
2. Medical diagnosis/diagnosis of a patient's illness
3. Car engine fault diagnosis
4. Fault diagnostics in mechanical and electronic equipment
5. Tax systems and financial calculations
6. Chess games
7. Logistics (efficient routing of parcel deliveries)
8. Identification/classification of animals and plants.
9. Identification of chemical/biological compounds

Advantages of Expert Systems:

- They offer a high level of expertise.
- They offer high accuracy.
- The results are consistent.
- They have the ability to store massive amounts of ideas and facts.
- They can make traceable logical solutions & diagnostics.
- They can possibly have multiple expertise.
- They have very fast response times (much quicker than a human expert).
- They provide unbiased/neutral reporting and analysis of the facts.
- They indicate the probability of any suggested solution being correct.

Disadvantages of Expert Systems:

1. The users of the expert system need considerable training in its use to ensure the system is being correctly used.
2. They have very high set up and maintenance costs.
3. They tend to give very cold responses that may not be appropriate in certain medical situations.
4. They are only as good as the information/facts entered into the system.
5. The users sometimes make the very dangerous assumption that they are error-free.

Components of an Expert System:

The expert systems are made up of the following components:

1. Interactive user interface
2. Inference engine
3. Knowledge base
4. Rules base
5. Explanation system (not explicitly covered in the syllabus)

A typical structure of an expert system looks like the following:
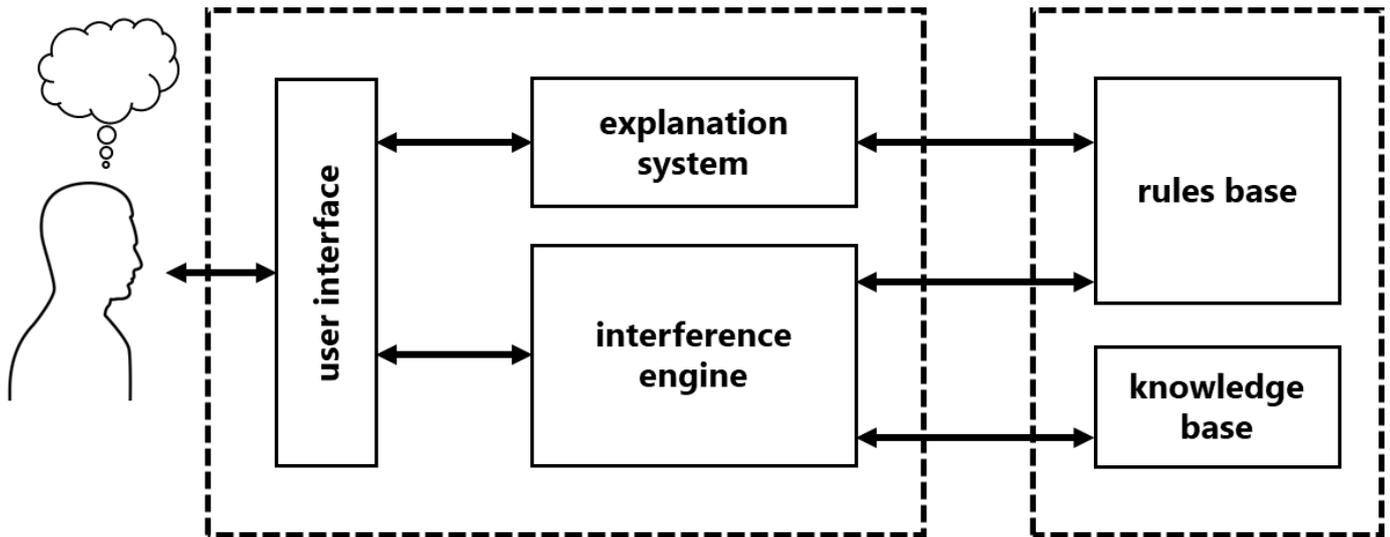
1) Interactive user interface:

■ It is a method of displaying/outputting results and inputting data through which the expert system interacts with a user.

■ This interaction is through dialogue boxes, command prompts or other input methods.

■ The questions being asked usually only have 'Yes' or 'No' answers and further questions are based on previous responses/answers to previous questions.

2) Inference engine:

■ The inference engine compares data with that held in the knowledge base using rules base/set of rules until it finds a match for the queries.

■ It gathers information/data from users by asking a series of questions and applying responses where necessary and each further question being asked is based on previous responses.

■ It solves problems by making use of inference rules in the rules base and examining knowledge base and then uses information gathered from user to find an object that matches.

3) Knowledge base:

- It is a centralized repository of facts (stores and manages facts centrally).
- It stores all the knowledge about an area of expertise obtained from a number of expert resources.
- It is more simply a collection of objects and their attributes.

4) Rules base:

- It is a set of inference rules.
- The inference rules are used by the inference engine to draw conclusions by using methods which closely follow human reasoning.
- They follow logical thinking usually involving a series of 'IF' statements, for example:

    IF grade = "A*" **AND** subject = "Computer Science" **THEN** teacher = "Haseeb Gilani"

Setting-up/Creation of Expert System:

- The data is gathered/collected from the human experts or from written sources.
- A knowledge base is designed/created from information gathered.
- A structure to relate each item in the knowledge base is created.
- The rules base is designed/created.
- The inference engine is designed/created.
- A user interface is designed/created to allow the user and the expert system to communicate (a method of displaying results/inputting data).
- An interrogation technique to access the data is created.
- The system is fully tested once it is set up.
- It is tested by running the system with known outcomes so results can be compared and any changes to the expert system made.

General Working/Use of Expert System:

> **NOTE:** The working/use of expert system given below consists of statements and keywords in a sequence which is generally applicable to all type of scenarios. Memorizing the steps given below will earn you complete marks, but the situation would be changed.
>
> The examiner can give you any scenario and ask the working/use of expert system accordingly. However, the steps stated below will always be the same; you only need to make slight changes in answer according to question statement/scenario.

- It uses an interactive user interface for entering data.
- The questions are asked by the system.
- The user answers the questions with 'Yes' or 'No' that is typed in.
- Further questions are asked based on previous answers.
- The expert system analyses the data, and the inference engine compares data.
- It compares data with that held in the knowledge base using rules base/set of rules until it finds a match/matches are found.
- The system displays the suggested probabilities/possibilities of solutions.
- The explanation system explains the ways it achieved the solutions/conclusions.

Example Questions of Expert System:

> **NOTE:** 4 questions of expert systems are given below with their answers so you can realize the pattern of answering those questions and learn how to make changes in your answer according question statement/scenario given.

Q1. How an expert system works in oil prospecting to help decide where to drill for oil. [6]

- It uses an interactive user interface which asks questions about geological profile.
- The answers to those questions are typed in such as geological profile is typed in.
- Further questions are asked based on previous responses.
- The expert system analyses the data, and the inference engine compares data.
- It compares data with that held in the knowledge base using rules base/set of rules and then matches are found accordingly.
- The system suggests the probabilities of oil being present.
- The depths of likely deposits are suggested.
- The predictions of geological layer/level above the deposits of oil are output.

Q2. How an expert system can be used to help identify newly discovered type of animal. [4]

- It uses an interactive user interface for entering data.
- The questions are asked by the system and the user answers the questions with 'Yes' or 'No'.
- Further questions are asked based on previous answers.
- The expert system analyses the data, and the inference engine compares data.
- It compares data with that held in the knowledge base using rules base/set of rules and then matches are found accordingly.
- The system produces the probabilities/possible types of animal.

Q3. How an expert system can be used to suggest car engine fault diagnoses. [5]

- It uses an interactive user interface for entering data.
- The questions are asked by the system about the car engine fault.
- The user answers the questions with 'Yes' or 'No' that are typed in.
- Further questions are asked based on previous answers.
- The expert system analyses the data, and the inference engine compares data.
- It compares data with that held in the knowledge base using rules base/set of rules until it finds a match/matches are found.
- The system suggests the probabilities/possible solutions.
- The explanation system explains the ways it achieved the solutions/conclusions.

Q4. How an expert system can be used to diagnose illness. [5]

- It uses an interactive user interface for entering data.
- The questions are asked by the system about illness.
- The user answers the questions with 'Yes' or 'No' that are typed in.
- Further questions are asked based on previous answers.
- The expert system analyses the data, and the inference engine compares data.
- It compares data with that held in the knowledge base using rules base/set of rules until it finds a match/matches are found.
- The system displays the suggested probabilities/possibilities of diagnoses and treatments.
- The explanation system explains the ways it achieved the solutions/conclusions.

Exam Style Questions:

Question 1:

Name **three** components of an expert system.

1 ....

2 ....

3 ....

[3]

Answer:

Three from:

Knowledge base
Rules base
Inference engine
Interactive user interface

[3]

Question 2:

Describe how an expert system can be used to suggest car engine fault diagnoses.

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....[5]

Answer:

Question	Answer	Marks
	Any **five** from: Enter data into/use the interactive user interface Questions are asked about the car engine fault The user answers the questions/Yes or No answers to the questions are typed in Further questions are asked based on the previous answers The inference engine compares data Compares data with that held in the knowledge base… …using the rules base/set of rules… …until it finds a match/matches found System suggests probabilities/possible solutions The explanation system explains how the solutions were arrived at	5

Question 3:

(b) Describe **three** benefits of the doctor using an expert system to help diagnose a patient's illness.

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.... [3]

Answer (any three from):

1. An expert system may help the doctor make a more accurate diagnosis.
2. An expert system uses data from many experts therefore it contains more knowledge than a single doctor.
3. It is cheaper than regularly re-training the doctor.
4. The expert system's knowledge may be more up to data than the knowledge of a single doctor.
5. It is cheaper than employing many specialists.
6. The diagnoses given are more consistent.

Question 4:

(a) Identify **two** applications that use expert systems.

1 ....

....

2 ....

....
[2]

(b) Identify **three** components found in an expert system.

1 ....

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2 ....

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3 ....

....
[3]

Answer:

Question	Answer	Marks
(a)	**Two** from: Mineral prospecting Car engine fault diagnosis Medical diagnosis Chess games	2
(b)	**Three** from: Knowledge base Rules base Inference engine Interactive user interface Explanation system	3

Question 5:

Expert systems are used to diagnose illness in patients.

Discuss the advantages and disadvantages of using an expert system to diagnose illness.

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.... [8]

Answer:

Advantages (any four from):

1. They provide more consistent answers.
2. They do not forget to ask a question.
3. They can reduce the time to find the solution/get results/to obtain a diagnosis.
4. They give a number of different possibilities.
5. There is less need for specialists/doctors therefore reduced the cost of finding a solution.
6. It allows the system to be used in parts of the world where experts/medical specialists are not available.
7. They use the collective wisdom of more than one expert (contains more information than one doctor).
8. They can be used online and 24/7.

Disadvantages (any four from):

1. They are machines therefore lack common sense.
2. If the knowledge base contains errors then incorrect decisions can be made.
3. It is expensive to set up in the first place/purchase.
4. It requires the need for training for operators.
5. The cost of training for operators is high.
6. They are expensive to maintain.

Question 6:

(a) Describe how an expert system can be used to diagnose illnesses.

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.... [5]

Answer:

Question	Answer	Marks
(a)	**Five** from: An Interactive user interface appears Questions are asked about the illness Yes and No type answers to the questions Answers lead to other questions The inference engine searches … … the knowledge base … … using the rules base Probabilities / possibilities of diagnoses and treatments are displayed Displays the ways it achieved the solutions / conclusions / explanation system	5

Question 7:

The doctors at the Mumbai Clinic have commissioned a knowledge engineer to create an expert system to help them with their diagnoses of patient illnesses.

(a) Describe how such a system would be created.

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....

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....

....

....[5]

(b) Give **two** other applications apart from diagnostic systems which make use of expert systems.

1 ....

2 ....

[2]

Answer:

(a) **Five** from:

Data is gathered/collected <u>from experts</u>
Knowledge base is designed/created
A structure to relate each item in the database/knowledge base is created
An interrogation technique to access the data is created
A user interface/method of displaying the results/method of inputting data/input screen/output screen is designed/created
The inference engine is designed/created
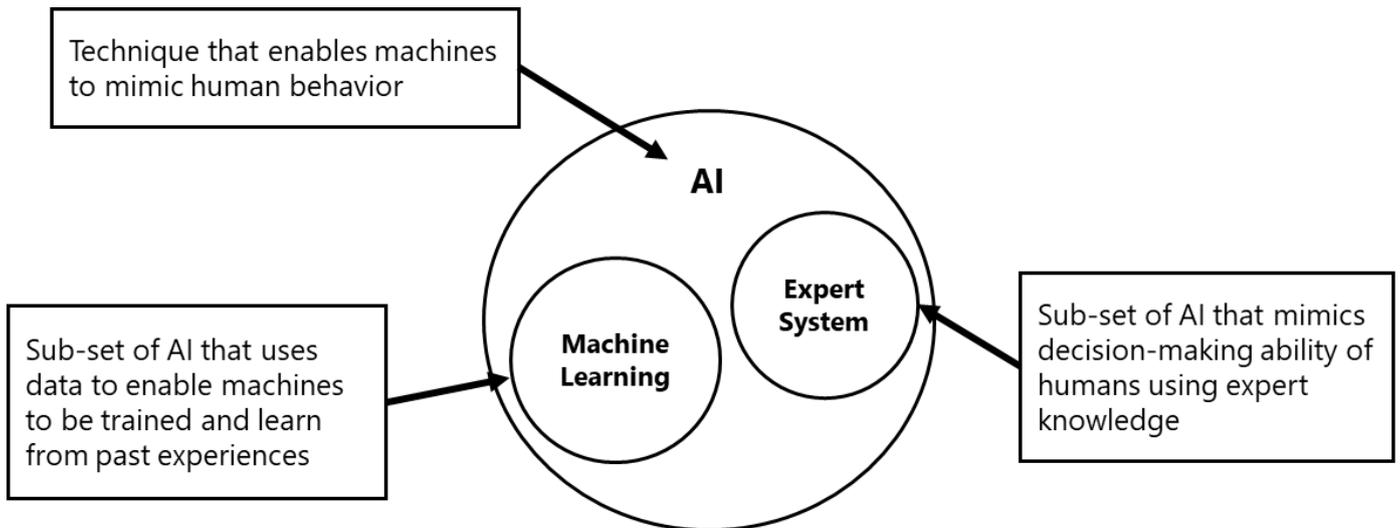The rules base is designed/created
The system is tested   [5]

(b) **Two** from:

Prospecting
Tax
Careers
Chess games
Animal/plant classification/identification   [2]

2) Machine Learning:

The following is a recap of the AI family:

- ■ Machine learning is a sub-set of artificial intelligence (AI), in which algorithms are trained and learn from their past experiences and examples.
- ■ It is possible for the system to make predictions or even take decisions based on previous scenarios/experience.
- ■ They can offer fast and accurate outcomes due to very powerful considerable volume of complex data.

Examples of Machine Learning:

1. Sophisticated search engines
2. Categorizing email as spam
3. Recognizing user buying history
4. Detection of fraudulent activity

1) Sophisticated Search Engines:

- ■ When the user keys in their search criteria into the search engine, the search engine uses search bots to locate websites matching the user's search criteria.
- ■ If the user selects one of the websites found on Page 1 of the search engines hit, then search engine classes this as a success (since the relevant pages were found on Page 1).
- ■ If the user has to navigate to Pages 2, 3 or 4 to find information they are looking for, then search engine classes this as a failure (since the relevant pages were not found on Page 1).
- ■ The search engine will learn from its past performance and so its ability to carry out searches becomes more and more sophisticated and accurate with more experience.

2) Categorizing email as spam:

- A machine learning algorithm collects data about emails, such as email content, headers, senders name/email address and so on.
- It carries out a cleaning process by removing stop words (e.g. the, is, and) and punctuation, leaving only the relevant data.
- The certain words/phrases are frequently used in spam (e.g. lottery, earn, full-refund) and indicate that the incoming email is very likely to be spam.
- The machine learning model is built and a 'training data set' is used to train the model and make it learn using past email known to be spam.
- Once it is evaluated, the model is fine-tuned and tested live.

3) Recognizing user buying history:

- The machine learning establishes a user's buying characteristics from collaboration filtering, which is the process of comparing customers who have similar shopping behavior/pattern to a new customer who has similar shopping behavior/pattern.
- The customer 'A' is very interested in an activity and bought some items.
- The customer 'B' who is also very interested in an activity bought some of the same items as customer 'A'.
- The machine learning algorithms will then recommend that customer 'B' might like to buy some other similar items as 'A' due to similarities between 'A' and 'B' shopping behavior.
- This technique is particularly popular when asking your mobile phone to generate a playlist from your music library based on a few criteria you might select.

4) Detection of fraudulent activity:

- The data is gathered by a survey or web scraping, for example, to detect a credit card fraud, information about customers is gathered, such as types of transactions, shopping habits and certain personal data. (Data Collection)
- The redundant data is then removed carefully so there is no possibility of wrong predictions. (Data Cleaning)
- The machine learning algorithm is trained through real examples of customer purchasing behavior. (Exploration & Analysis)
- A model is built based on learning from the training data, and the machine learning algorithm can then be used to detect fraud (e.g. if a customer spends an unusual amount on a piece of jewelry, there is a high chance a fraudulent activity has taken place). (Building a Model)
- The machine learning model is then fully tested with known data and known outcomes and the system is modified if it hasn't met its criteria to detect fraudulent activity. (Model Evaluation)

Differences between Artificial Intelligence (AI) & Machine Learning

The following table summarizes the differences between AI and Machine Learning:

Artificial Intelligence (AI)	Machine Learning
Artificial Intelligence (AI) represents simulated intelligence in machines.	Machine learning is the practice of getting machines to make decisions without being programmed to do so.
AI aim is to build machines that are capable of thinking like humans.	Machine learning aim is to make machines that learn through data acquisition, so that they can solve new problems

Sample/Model Exam Style Questions (*according to new & updated Syllabus*):

> **NOTE:** These questions are not actual examination questions. This new topic is recently introduced for 2023-2025 session and there are no either past paper questions or specimen paper questions available for this. These questions are not officially taken from any Cambridge examination or resource.
>
> **The following questions are just sample/model questions which you may expect in your upcoming examination, and they have been designed for your practice.**

Question 1:

(a) Define the term **machine learning**.

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(b) Describe how **machine learning** and **artificial intelligence** differ.

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Possible Answer:

Question	Answer	Marks
1(a)	Any **two** from: • Machine learning is a sub-set of artificial intelligence (AI) • Machine learning is when a program has the ability to automatically adapt its own processes and/or data • It is possible for the system to make predictions or even take decisions based on past experiences and examples. • One example of use of machine learning is search engines.	2
1(b)	Any **two** from: • Artificial intelligence (AI) represents simulated intelligence in machines. • Machine learning is practice of getting machines to make decisions without being programmed to do so. • AI aim is to build machines that are capable of thinking like humans. • Machine learning aim is to make machines that learn through data acquisition, so that they can solve new problems.	2