Short Questions

A- Industrial Revolution & Design Principles

1. State two significant technological differences between the 3rd and 4th industrial Revolutions

Ans- Industry 3

•Rise in telecommunication and computers

•Invention of the Internet and World Wide Web.

Industry 4

• The rise of interconnectivity and advanced automation

• Invention of advanced technologies such as AI, Gene editing (CRISPR), advanced robotics, self-driving vehicles, and additive manufacturing (3D printing, Digital twins etc.)

2. In Industry 4.0, how can the blockchain improve transparency in the supply chain?

Digital Systems like blockchain may be used to optimise inventory, track shipments and improve overall supply chain efficiency.

3. Revolutions are the adaptation of technologies leading to global impacts. List the technologies specific to Industry 4.0

Ans- Automation, Big data, Cloud computing, IoT, Data management, AI, Smart Sensors.

B- AI (T Kar)

1)Compare between different type of artificial intelligence.

a-Weak Artificial Intelligence -Machine can learn and judge for clearly defined tasks.
b-Strong Artificial intelligence -Machine can think and solve problems independently.
c-Super Artificial intelligence -Machines have intelligence far beyond humans.

2)List the differences among AI, Machine Learning and Deep Learning.

Ans- AI- It is the study or process which enables machines to mimic human behaviour through particular algorithm.
ML-It is the study that uses statistical methods enabling machines to improve with experience.
DEEP LEARNING -It is the study that makes use of neural networks to imitate functionality just like a human brain .

3)Differentiate between strong AI and weak AI with examples.

Ans- Strong AI- Can understand and learn any intellectual tasks that a human being can .
Ex-Cyber Security,Robots with high intellect.
Weak AI-Focuses on one task and can't perform beyond it's limitations.
Ex-Virtual assistants like Siri and self driving cars .

4)What is the difference between artificial intelligence and machine learning?
Ans- AI-
•It is the broader family consisting of ML and DL as it's components.
•AI is a computer algorithm which exhibits intelligence through decision making.
•The aim is to basically increase chances of success and not accuracy.

ML-
•It is the subset of AI.
•It is an AI algorithm which allows system to learn from data.
•The aim is to increase accuracy not caring much about the success ratio.

5)What are neural networks used for in AI?
Ans- Deep Learning uses neural networks which helps the computer to make intelligent decisions with limited human assistance.
Neural networks works as neurons in brain and hence acts like a human brain.

C- Cyber-Physical System (D Rout)

1) Differentiate between an embedded system and a cyber-physical system.
Ans- Cyber-Physical System-
Cyber-physical systems enable the virtual digital world of computers and software to merge through interaction—process management and feedback control—with the physical analogue world, thus leading to an Internet of Things, data, and services.

Embedded System - An embedded system is a computational system embedded within a physical system; the emphasis is on
the computational component. Therefore, we can think of all CPS as containing embedded systems, but the CPS's emphasis is on the communications and physical as well as the computational domains.

2) State three ways of implementing cyber-physical systems with Industry 4.0.

Three ways of implementing CPS in Industry 4.0 are-
- Direct system extension
- System expansion by microcontroller board
- Extension by smart actuators and sensors

3) Identify the CPS reference architecture that supports the whole product lifecycle. Justify.
Ans- IIRA is the CPS reference architecture that supports whole product lifecycle. It emphasizes interoperability among industries,
end-to-end integration, security, scalability, and data analytics.

4) What are the key challenges in integrating cyber physics with the physical world?

Ans- The key challenges in integrating cyber physics with the physical world are:
-Interoperability
-Scalability
-Privacy
-Ethical concerns
-Security

5) How can cyber physics enhance the field of robotics?
Ans- Cyber physics enhances robotics by enabling real-time data processing from sensors and enhancing robot autonomy. This technology allows robots to adapt to their environment, make instant decisions, navigate complex spaces, and interact with objects autonomously.

6) What is the significance of real-time data in cyber physics?
Ans- The data exchange is the most important feature of a CPS, since the data can be linked and evaluated centrally, real-time data in cyber physics is crucial for instant decision-making and adaptive responses. It enables immediate analysis of sensory information, allowing systems to respond swiftly to changing conditions.

D-Cloud Computing (A Pati/ A Basak)

1)What are the deployment models of cloud computing model?
Ans.
(Definitions)
The Public Cloud allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness, e.g., e-mail.
The Private Cloud allows systems and services to be accessible within an organization. It offers increased security because of its private nature.
Community Cloud -The Community Cloud allows systems and services to be accessible by group of organizations.
The Hybrid Cloud is mixture of public and private cloud However, the critical activities are performed using private cloud while the non critical activities are performed using public cloud

(Differences)
Hybrid- Combination of cloud deployment models; has better scalability, security, flexibility, cost efficiency, has medium to high reliability.
Community- offers medium reliability, scalability, flexibility, security has variable cost
Private- business has complete control over the environment offers high reliability, high privacy and security, medium scalability and flexibility has relatively high cost but is fully customizable, has robust management and secure by design.

Public- service is owned and operated by cloud provider, low privacy, medium reliability, lowest cost, high flexibility and scalability. Cloud providers have data centres located at different regions across the world(high redundancy, close to customers).

2. What is a hybrid cloud? How can hybrid clouds help enterprises?

Ans- Hybrid cloud is combination of cloud deployment models, it is mixture of public and private cloud. Example- Amazon, Microsoft, Google, Cisco,etc.

Hybrid clouds help entreprises by the following ways:

- Businesses can keep data which needs to be secured by the standards in their on-premise environment
- Extend on premise infrastructure to the cloud without making further capital investments
- Great flexibility and more deployment options

3. Describe the notion of elasticity within cloud computing and highlight how it differs from scalability.

Ans- Elasticity allows users to automatically request additional space in the cloud or other types of services. Because of the setup of cloud computing services, provisioning can be seamless for the client or user.

Cloud Scalability	**Cloud Elasticity**
Focused on long-term growth	Helps with a sudden influx of workload
Pre-planned notion used by growing businesses	Used as per workflow demands in the industry
Useful to make static changes in a business infrastructure	Crucial in handling dynamic changes in the business database
Mostly used by huge brands and companies to deal with workflow demands	Famously used in smaller businesses to deal with the influx
Aimed at a long-term solution to offer efficient operation of services	Helps meet unexpected fluctuations and seasonal demands
A one-time investment that saves long-term expenditure	"Pay-as-you-go" model that can be recurrent
Assists in recovery from a disaster	Helps prevent disasters in the server

4) Describe the difference between SaaS, PaaS and IaaS.
Ans- INFRASTRUCTURE AS A SERVICE (IAAS)
IaaS provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.
Generally used: Virtual Machine, Servers, Storage, Networks.

PLATFORM AS A SERVICE (PAAS)
PaaS provides the runtime environment for applications, development & deployment tools, etc.
Generally used in databases, web servers, development tools.

SOFTWARE AS A SERVICE (SAAS)
SaaS model allows to use of software applications as a service to end users.
Generally used in CRM, email, games, and virtual desktop.

E- Additive Technology (A Pandey)

1. State 'how Industry 4.0 gets benefited from additive technology
Ans- Industry 4.0 is about making factories and production smarter with technology.Additive technology,like 3D printing,helps a lot in several ways:
1)Design freedom
2)Material options
3)Lightweighting
4)Speed
5)Less waste
6)Cost savings
7)On-Demand Production

2. Give any three industrial applications of additive technology.
Ans- Applications of additive technology:-
(NO NEED TO WRITE ALL THE POINTS)

1. Medical Equipment:
- Prosthetics and orthopaedic implants customized for patients.
- Patient-specific anatomical models for surgical planning and education.
- Dental implants and crowns.
- Medical instruments and equipment prototypes.

2. Toys and Games:
- Customized action figures and collectables.
- Educational toys and puzzles.
- Board game pieces and accessories.
- Prototyping for toy development.

3. Assembly Parts:
    - Production of complex and customized components for machinery.
    - Replacement parts for appliances and equipment.
    - Rapid prototyping for product design and testing.

4. Art and Design:
    - Creation of intricate and artistic sculptures.
    - Customized home decor and furniture.
    - Unique fashion accessories and wearables.
    - Prototyping for product designers and artists.
5. Jewellery:
    - Crafting intricate and personalized jewellery pieces.
    - Custom-made engagement rings and accessories.
    - Prototyping for jewellery designers.
6. Automotive Industry:
    - Production of lightweight and complex car components.
    - Prototyping for new vehicle designs.
    - Customized car parts and accessories.
    - Rapid tooling for manufacturing.
7. Architectural Designs:
    - Architectural models and prototypes.
    - Complex and unique building components.
    - Detailed scale models for presentations.
    - Customized fixtures and fittings.

3. What is the importance of additive manufacturing in the modern automotive industry?
Ans- 3D printing is important in the modern automotive industry:-

1. Lighter Parts: 3D printing makes car parts lighter, helping cars use less fuel.
2. Customization: It lets car parts be made to fit individual needs.
3. Speedy Production: 3D printing makes parts quickly, reducing wait times.
4. Testing Ideas: Car designs and parts can be tested easily with 3D printing.
5. Local Production: Parts can be made nearby, saving transportation hassles.
6. Unique Shapes: 3D printing creates complex and effective part shapes.
7. Cost Savings: It can save money in the long run by using less material.
8. Eco-Friendly: 3D printing produces less waste and uses eco-friendly materials.
9. Less Storage: Car makers don't need huge warehouses for parts.
10. Fixing Old Cars: It's great for making parts for older vehicles.

F- AR & VR (P Sunil)

1. ways can augmented reality improve experiences in the real world?
Ans- Navigation: AR navigation apps can provide visual directions and points of interest, improving navigation in unfamiliar places.
Healthcare: AR can assist in surgeries, diagnostics, and patient education.

Training and Education: AR can be used for immersive learning experiences, such as medical training simulations or interactive history lessons.
Tourism: AR can provide historical or cultural context to landmarks and tourist attractions.

2. What is the Process of Virtual Reality?
Ans- Virtual Reality creates a 3D illusion through a stereoscopic display, showing unique angles to each eye, mimicking depth perception. This immersive technology tricks the brain into believing you are truly in a three-dimensional world, enhancing experiences across various fields like gaming, education, and training.

3. Distinguish between augmented reality and virtual reality
Ans- Reality vs. Immersion:
AR adds digital elements to the real-world environment, enhancing what you see.
VR immerses you entirely in a computer-generated virtual environment, blocking the real world.

Interaction with the Real World:
AR allows users to interact with and remain aware of their physical surroundings.
VR isolates users from the real world, creating a fully digital environment.

Use Cases:
AR is commonly used for tasks like navigation, training, and information overlay in real-world contexts.
VR is frequently used for gaming, simulations, virtual meetings, and immersive experiences.

Immersiveness:
AR enhances real-world experiences with digital information but doesn't replace your surroundings.
VR offers a deeply immersive experience by replacing the real world with a virtual one.

Physical Movement:
AR usually involves less physical movement as it's designed for use in the real world.
VR often requires more physical movement as users interact with the virtual environment.

Motion Tracking:
AR may use simpler motion tracking, like GPS or camera-based tracking.
VR often employs more advanced motion tracking, including external sensors and controllers.

G- Big Data (R Lenka)

1. What are the different types of Data? (IMP)
Extremely large data sets that may be analysed computationally to reveal patterns, trends and associations, especially relating to human behaviour and interaction are known as Big Data.

Types of big data: 1. Structured
2. Unstructured
3. Semi-structured

Structured: Structured data is created using a fixed scheme and is maintained in a tabular format. The elements in structured data are addressable for effective analysis. It contains all the data which can be stored in SQL database in a tabular format. Today most of the data is developed and processed in the simplest way to manage information.
Relational data, Geo-location, credit card numbers, addresses etc.

Unstructured: It is defined as the data that doesn't follow a predefined standard or organised format. This kind of data is also not fit for the relational database because there we can see a predefined way of data. It's very important for the big data domain to manage and store unstructured data there are many platforms to handle it like No-SQL database.
Word, PDF, text, media logs.

Semi-structured: It is information that doesn't reside in a relational database but that has some organisational properties that make it easier to analyse. With some process, you can store them in a relational database but it is very bad for some kind of semi-structured data, but semi-structured data exist to ease space.
XML data.

2. Name some of the important tools useful for Big Data analytics.
Ans:
Before the data is put in a data warehouse or any other storage solution it has to undergo the process of gathering, filtering and cleaning data called as data acquisition. Some important tools that contribute to the process are DBMS (OLTP), NoSQL, Kafka, Flume, HDFS (Hadoop distributed file system), RapidMiner, and Apache Spark.

3. What is a block in Hadoop Distributed File System (HDFS)?
Ans:
In the Hadoop Distributed File System (HDFS), a block is the fundamental unit of storage for a file. HDFS is designed to store and manage very large files, and it achieves this scalability and fault tolerance through the concept of data replication and the use of blocks. HDFS divides files into fixed-size blocks, typically 128 megabytes (MB) or 256 MB in size. Each block is replicated multiple times across different data nodes. They provide fault tolerance, scalability, and parallelism for storing and processing large datasets in Hadoop clusters.

SOME MORE QUESTIONS ON AI

1)Discuss the role of AI in supply chain management and the healthcare sector.
Ans-
ROLE OF AI IN SUPPLY CHAIN MANAGEMENT:

Logistics Optimization: AI-driven route planning and real-time tracking improve delivery efficiency. AI-powered robotics and automation enhance warehouse operations by improving order picking, packing, and sorting processes.
Demand Forecasting: AI models enhance accuracy in forecasting product demand, reducing overstock or shortages and can assess supplier performance on the basis of quality, reliability, and delivery times.
Automation: AI automates routine tasks like order processing and invoicing, improving operational efficiency. AI-powered image recognition and machine learning can be used for quality control along with streamlining order accuracy by order confirmation, routing and invoice generation.
Customer Service: Chatbots and virtual assistants powered by AI can provide real-time customer support and track order statuses. thereby increasing customer satisfaction and reducing human workload.

ROLE OF AI IN HEALTHCARE

Disease Diagnosis : AI algorithms can analyze medical images such as X-rays, MRIs, and CT scans with high accuracy and help prevent various disease.AI accelerate drug discovery by analyzing vast datasets to identify potential drug candidates and predict their effectiveness

Treatment Recommendations: AI systems suggest personalized treatment plans based on patient data and also suggest medications. AI-driven robotic surgical systems assist surgeons in performing complex and minimally invasive procedures with precision, reducing recovery times and complications.

Patient Monitoring: AI monitors patient vitals, alerting healthcare providers to changes in real time. AI-powered chatbots and virtual assistants provide patients with round-the-clock access to medical information, schedule appointments etc.

Administrative Efficiency: AI streamlines administrative tasks, reducing paperwork and improving patient care. AI algorithms can identify anomalies and patterns in insurance claims and reduce healthcare fraud.

2)Discuss in detail about different advantages and disadvantages of AI with example wherever applicable.
Ans- ADVANTAGES
1. Reduction in Human Error
2. Zero Risks and 24x7 Availability
3. Digital Assistance
   Eg. Chatbots , Google assistant

4. New Inventions
Manufacturing of robots.
5. Unbiased Decisions
6. Perform Repetitive Jobs
7. Daily Applications
Eg.smart home assistance
8. AI in Risky Situations
9. Faster Decision-making
10. Pattern Identification
Eg. Eg. Fingerprint recognition, face detection
11. Medical Applications
Eg.virtual health assistance

DISADVANTAGES
1. Substantial dependency on data
2. High Costs
3. No Creativity
4. Unemployment
5. Make Humans Lazy
6. No Ethics
7. Emotionless
8. No Improvement
9. Since artificial intelligence learns and makes judgments by itself, a completely different artificial intelligence may be born that deviates from human development intentions at first.
10. Bias can be planted in AI

3) Discuss the areas of application of Artificial Intelligence.
Ans- APPLICATIONS OF ARTIFICIAL INTELLIGENCE

Healthcare:
Diagnosis and medical imaging, including the detection of diseases in medical images.
Drug discovery and development, including the identification of potential drug candidates.
Personalized treatment plans based on patient data.

Finance:
Fraud detection and prevention in financial transactions.
Algorithmic trading for stock market analysis and decision-making and personalised suggestions for investment strategies.
Credit risk assessment and loan approval processes.

Automotive:
Autonomous vehicles and self-driving car technology.
Traffic management and optimization.
Smart navigation and route planning.

Manufacturing:
Predicts maintenancefor equipments and energy consumption optimisation.
Quality control and defect detection in manufacturing processes.
Process optimization and automation using robotics.
Supply chain management and logistics.

Education:
Adaptive learning platforms that personalize education based on student performance.
Automated grading and assessment.
Virtual reality (VR) and augmented reality (AR) for immersive education experiences.

Agriculture:
Precision agriculture for optimized crop management.
Pest and disease detection using drones and AI along with automated harvesting.
Crop yield prediction and optimization.
Soil analysis and recommendations for farmers.

Entertainment:
Content recommendation systems for streaming services.
Video-audio analysis and Music-art generation using AI algorithms.
Virtual reality (VR) and augmented reality (AR) gaming.

4) Define and Explain "learning". Describe in detail, the range of activities covered by the concept "learning". Justify the statement that "learning is the most important characteristic of intelligence".

Ans- Learning(Machine learning):
In the context of artificial intelligence and computer science, machine learning involves training algorithms to improve performance on specific tasks by analyzing and learning from data patterns.

Learning is an important aspect of AI because it allows them to have better:
i) Problem-Solving: Since the AI has the ability to learn from new data it can also upgrade its problem-solving algorithms for better and efficient results. Eg, chatbots are used for problem-solving and keep on upgrading by the users. This feature allows the AI to give personalised suggestions.

ii)Memory and Recall: AI can use its memory to reason and make inferences based on past experiences and recognize patterns in data, making it easier to remember and recall similar patterns in the future. This feature is useful in pattern recognition.

iii)Continuous Improvement: AI systems are designed to receive feedback from users, sensors, or other data sources which helps them identify areas for improvement.

5) What is the impact of AI on human life? Elaborate all positive and negative aspects.
Ans-
AI has a profound impact on human life, presenting both positive and negative aspects:
Positive Impact:
Automation and Efficiency: AI automates repetitive tasks, enhancing productivity and efficiency in industries like manufacturing, healthcare, and customer service.
Healthcare Advancements: AI aids in disease diagnosis, drug discovery, and personalized treatment, improving healthcare outcomes.
Personalized Experiences: AI powers recommendation systems, tailoring content and services to individual preferences.
Improved Safety: Autonomous vehicles and AI-driven safety systems reduce accidents and save lives.
Language Translation: AI enables real-time translation, fostering global communication.

Negative Impact:
Job Displacement: Automation can lead to job loss in certain industries, necessitating retraining for displaced workers.
Privacy Concerns: AI collects and analyzes vast amounts of personal data, raising privacy and security issues.
Bias and Discrimination: AI can inherit biases from training data, leading to unfair decisions and reinforcing stereotypes.
Ethical Dilemmas: Autonomous weapons and ethical AI use raise moral concerns.
Dependency: Overreliance on AI can erode human skills and decision-making abilities.

6)How AI is transforming Society?
Ans- AI is transforming the society in the following ways:
AI-powered chatbots: They serve various purposes, such as automating customer support, answering queries, and assisting with tasks like appointment scheduling and online shopping. They operate 24/7, improving efficiency, benefiting businesses across industries and providing users with convenience.
AI in healthcare: AI is used in applications in healthcare, including disease diagnosis through medical imaging, personalized treatment plans, drug discovery, and virtual health assistants. It improves patient care with predictive analytics, streamlines administrative tasks and aids in genomic research thus enhancing medical outcomes and efficiency.
AI in entertainment: AI plays a significant role in entertainment by personalizing content recommendations on streaming platforms, optimizing content creation, and enhancing special effects.
AI in cybersecurity: AI is used in cybersecurity by detecting and mitigating threats in real time, analyzing network traffic for anomalies, and identifying vulnerabilities. It aids in rapid threat response and AI-driven tools strengthen defense mechanisms and protect sensitive data.
AI in business: It optimizes supply chains, enhances customer service through chatbots, predicts market trends, and automates routine tasks like data entry. AI-powered insights help in making strategic decisions and improving efficiency starting from the finance to the retail sector.

7) How AI serves as a cornerstone of Industry 4.0?
Ans- Fundamentally, AI technology in the manufacturing sector helps businesses grow by predicting quality and output, maintenance needs and schedules, human-robot interfaces, creating custom designs, market adaptation strategies, and supply chain value addition. All of these tasks can be accomplished by utilising various technologies advancing the fourth industrial revolution. Logistics, robotics, supply chain management, autonomous cars, factory automation, IT, design and manufacturing, warehouse management, process automation, product development, visual inspection, quality control, cybersecurity, etc. are some of the industries where AI is most useful.
Machine vision and image recognition systems powered by AI can evaluate products for flaws more thoroughly and quickly than human inspectors. This guarantees excellent product quality and reduces faults. AI enables mass customization by tailoring products and services to individual customer preferences. AI can analyze vast amounts of data from production processes to identify opportunities for optimization. AI-driven algorithms help optimize supply chains by forecasting demand, managing inventory, and identifying bottlenecks or inefficiencies.

Long Questions

A- AI + Bigdata

1. What are the different "V" factors in big data?[10 MARKS]
Ans- Volume: Refers to the sheer amount or quantity of data to be processed.
Example: An e-commerce platform processes a large volume of customer transactions daily.
Velocity: Describes the speed at which data is generated, collected, and processed.
Example: Social media platforms process data with incredible velocity, displaying real-time updates like tweets and comments instantly.
Variety: Encompasses the different formats and types of data, including structured, unstructured, semi-structured, and complex structured.
Example: In healthcare, there's a variety of data types, including structured patient records, unstructured doctor's notes, and semi-structured insurance claims.
Veracity: Refers to the trustworthiness or accuracy of the data.
Example: Financial institutions rely on data veracity to make accurate risk assessments and detect potential fraud.
Variability: Represents the rate of change and the lifespan of data.
Example: Stock market data exhibits high variability, with stock prices changing rapidly, while financial records have a longer lifetime.
Value: Signifies the cost-effectiveness of data and its importance or usefulness to the organization.
Example: Retailers derive value from customer data by offering personalized promotions based on purchase history and preferences.
Visualization: Involves the use of charts and graphs to represent and make sense of large and complex data sets.

Example: Business analysts use data visualization tools to create charts and graphs that help visualize sales trends on interactive dashboards.
Validity: Focuses on the accuracy and reliability of data.
Example: Researchers conducting clinical trials must ensure the validity of patient data to draw accurate conclusions about the effectiveness of a new drug.

2. What are the key steps in big data solutions considering space management?[10 MARKS]

Ans- Data Lifecycle Management: Identify and categorize data by importance and usage. Set retention policies for archiving or deletion.

Compression and Encoding: Reduce storage size with compression. Improve data representation with encoding.

Data Deduplication: Remove duplicate data to save space and speed up retrieval.

Data Archiving: Move infrequent or historical data to cost-effective storage. Use data tiering for performance-cost balance.

Partitioning and Sharding: Divide data into manageable parts. Distribute data for better retrieval and scalability.

Data Cleanup and Purging: Regularly remove outdated data. Automate data purging for freshness.

Storage Optimization: Use algorithms for data storage efficiency. Implement dynamic resource allocation policies.

Compression and Encryption: Secure sensitive data with minimal storage impact.

Storage Tiering: Organize data by access frequency and speed. Match data to appropriate storage tiers.

Monitoring and Capacity Planning: Continuously track storage usage and performance. Forecast future needs for scalable infrastructure.

Cloud Integration: Leverage the cloud for scalability and cost-efficiency. Transfer data based on usage patterns.

Data Purge and Retirement: Develop safe data retirement processes. Document data removal for compliance.

3)How big data analytics can be used in the smart health sector and hospital management system?

Ans- .

Big data analytics has revolutionized the healthcare sector, including both smart health initiatives and hospital management systems. In this extended answer, we'll delve deeper into how big data analytics is transforming these areas:

Smart Health Sector:

Disease Prevention: Big data analytics predicts diseases early by analyzing extensive datasets. This helps healthcare providers take proactive measures to prevent illnesses and improve public health.

Real-time Monitoring: Continuous monitoring of patients in real-time using IoT devices and sensors, combined with big data analytics, enables prompt detection of health issues and timely intervention.

Personalized Treatment: Big data analytics tailors treatment plans based on individual patient data, ensuring that healthcare is more effective and personalized.

Drug Discovery: Big data analytics expedites the discovery of new drugs by analyzing extensive datasets, including genetic information and clinical trial results, reducing the time and cost of drug development.

Hospital Management System:

Patient Flow: Big data analytics predicts patient admission patterns, helping hospitals efficiently manage patient flow and allocate resources as needed.

Inventory Management: Efficient inventory management is crucial to prevent shortages and reduce waste in healthcare facilities. Big data analytics optimizes inventory levels, ensuring supplies are always available when needed.

Better Decisions: Data-driven insights from big data analytics aid healthcare professionals in making informed decisions for improved patient care and operational efficiency.

Quality Improvement: Continuous assessment of patient outcomes and satisfaction through big data analytics drives enhancements in overall healthcare quality, leading to better patient experiences and outcomes.

In conclusion, big data analytics plays a pivotal role in the smart health sector and hospital management systems by enhancing patient care, improving operational efficiency, and enabling data-driven decision-making. As technology and data collection methods continue to evolve, the potential for big data analytics to transform healthcare remains vast and promising.

4. What are the significant steps in deploying a big data platform?[5 MARKS]

Ans- To deploy a big data platform, we can follow the following steps:

1. Choose the Right Model:

Begin by identifying the specific goals and objectives of your organization. Understand what you aim to achieve with your big data platform, whether it's enhancing customer insights, optimizing operations, or improving decision-making.

There are four primary types of big data analytics models to choose from:

Data Mining: Discover patterns and trends within your data to gain valuable insights.
Diagnostic Analytics: Understand why certain events or trends occurred in your data.
Predictive Analytics: Forecast future trends and outcomes based on historical data.
Deep Learning: Utilize neural networks to process unstructured data and make complex predictions.
2. Proper Infrastructure Setup:

Establish a robust infrastructure that can handle the demands of big data. This involves ensuring:
Sufficient Computing Power: Use high-performance servers, clusters, or cloud-based resources to process and analyze data efficiently.
Storage Capacity: Implement scalable storage solutions capable of handling large volumes of data.
Network Bandwidth: Ensure fast and reliable data transfer between components of the big data platform.
3. Managing Data Storage:

Configure data storage solutions to match your data volume and access patterns. Consider:
Setting up a Data Storage Layer: Choose between distributed file systems (e.g., HDFS), NoSQL databases (e.g., Cassandra), or cloud-based storage services (e.g., AWS S3).
Data Partitioning: Divide data into manageable chunks for efficient storage and retrieval.
Data Compression: Implement compression techniques to save storage space and reduce costs.
4. Data Processing:

To ensure smooth data processing and analysis:
Install and Configure Data Processing Frameworks: Utilize tools like Apache Hadoop, Spark, or Flink for distributed data processing.
Create Clusters or Computing Environments: Set up cluster configurations to distribute data processing tasks across multiple nodes.
Optimize for Performance and Scalability: Fine-tune configurations, use load balancing, and implement parallel processing to maximize performance and accommodate growing data volumes.
5. Security:
Given the sensitivity of data, prioritize security measures:
Implement Access Controls: Define user roles and permissions to restrict data access to authorized personnel.
Encryption: Employ encryption techniques to safeguard data during transmission and storage.
Audit Trails: Maintain detailed audit logs to monitor and trace data access and modifications.
Compliance: Ensure your big data platform adheres to industry-specific data security and privacy regulations, such as GDPR or HIPAA.

5. How does cloud computing help in storing and processing big data?

Ans- Cloud computing help in storing and processing big data due to their following characteristics:

1. On demand self services

There is no requirement for human connection with each service provider while providing computer services like email, apps, network, or server service.

Some examples of service providers that provide on demand services include Amazon Web Services (AWS), Microsoft, Google, IBM and Salesforce.com.

2. Cost Efficiency

Pay-as-you-go pricing options are available from cloud service providers, letting you only pay for the services you really utilise. As a result, there is no longer a need for substantial upfront capital expenditures on hardware and data centres. Resources can be scaled up or down as necessary to reduce expenses and prevent overprovisioning.

3. Broad Network Access

Cloud Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms such as mobile phones, laptops and PDAs(Personal Digital Assistant such as phones, etc). Therefore aspects of big data can be accessed anywhere at ease.

4. Resource Pooling

The provider's computing resources are pooled together to serve multiple consumers using multiple-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

5. Elasticity

Elasticity allows the cloud provider's customers to achieve cost savings and this is often a core reason for adoption of cloud services. Rapid elasticity allows users to automatically request additional space in the cloud or other types of services. Because of the setup of cloud computing services, provisioning can be seamless for the client or user.

6.. Hadoop is a distributing process for handling large volumes of data. What are the various core components of Hadoop?

Ans- Hadoop is a database created for the storage and processing of big data.

The various core components of Hadoop are the following:

HDFS (Hadoop Distributed File System)

This is the storage component of Hadoop, which allows for the storage of large amounts of data across multiple machines. It is designed to work with commodity hardware, which makes it cost-effective.

YARN (Yet Another Resource Negotiator)

This is the resource management component of Hadoop, which manages the allocation of resources (such as CPU and memory) for processing the data stored in HDFS.

MapReduce

MapReduce is a programming model for distributed data processing. It enables programmers to create applications that run concurrently throughout a Hadoop cluster, processing data. The two steps of MapReduce are the "Map" phase, which involves filtering and sorting data, and the "Reduce" phase, which involves aggregating the results.

Hadoop also includes several additional modules that provide additional functionality, such as Hive (a SQL-like query language), Pig (a high-level platform for creating MapReduce programs), and HBase (a non-relational, distributed database).

Hadoop is commonly used in big data scenarios such as data warehousing, business intelligence, and machine learning. It's also used for data processing, data analysis, and data mining. It enables the distributed processing of large data sets across clusters of computers using a simple programming model.

B- Cyber- Physical System + Cloud Computing

1. A washing machine manufacturer wants to implement Industry 4.0 to improve the consumer experience. The company intends to transform its conventional washing machines into intelligent ones by connecting to its private cloud and offering users advanced Android app-based connectivity and controls. The company wants you to suggest an implementation model. Suggest an implementation model for the said application. Justify your choice of Implementation.

Ans- The best approach would be to adopt a combination of the IoT (Internet of Things) and Cloud Computing models, along with the integration of mobile app development. A thorough implementation model with explanations for each component is given as follows:

1. Internet of Things (IoT):

IoT enables real-time data collection, allowing for advanced features such as remote monitoring and control, predictive maintenance, and personalised user experiences.

- Sensor Integration:

Equip the washing machines with sensors to collect data on various parameters such as water temperature, load size, detergent levels, cycle status, and machine health. These sensors will continuously monitor and transmit data.

- Connectivity:

Enable IoT connectivity protocols like Wi-Fi, Bluetooth, or Zigbee to allow washing machines to communicate with other devices and the cloud.

- Edge Processing:

Incorporate edge computing capabilities within the washing machines to process basic data locally, reducing latency and enhancing real-time control.

2. Cloud Computing:

A private cloud ensures data security, scalability, and the ability to perform complex data analytics, which is crucial for delivering valuable insights to users.

- Private Cloud:

Establish a private cloud infrastructure to securely store and manage the data collected from the washing machines. This private cloud can be hosted on-premises or in a secure data centre.

- Scalability:
Ensure the private cloud infrastructure is scalable to accommodate increasing data loads as more washing machines are connected and to handle peak usage periods efficiently.
- Data Analytics:
Implement advanced analytics and machine learning algorithms on the private cloud to process the data collected from washing machines. This will enable predictive maintenance, energy optimization, and customised washing suggestions for users.
- Security:
Implement robust security measures, including encryption, access control, and regular security audits, to protect user data and the washing machine's connectivity.

3. Mobile App Development:
An Android app provides users with a convenient and user-friendly interface for interacting with their washing machines, enhancing the consumer experience.
- Android App:
Develop a user-friendly Android mobile application that connects to the private cloud. The app should offer a seamless and intuitive interface for users to control and monitor their washing machines remotely.
- Features:
Include features such as remote start/stop, cycle selection, notification alerts (e.g., cycle completion, maintenance alerts), energy usage monitoring, and customised washing recommendations based on user preferences and machine data.
- User Authentication:
Implement secure user authentication to ensure that only authorised users can access and control their washing machines via the app.

2. Analyze the suitability of the 5C reference architecture for Industry 4.0. Why is the data-to-information conversion at all necessary?
Ans- The 5C reference architecture, also known as the 5C model, is a framework commonly used in the context of Ind 4.0 to design and implement industrial systems. It stands for Cyber-Physical Systems, Communication, and Control, Computation and Configuration. Its suitability for Industry 4.0 can be analyzed as follows:

1) Cyber-Physical Systems (CPS):
It is a system of collaborating computational elements controlling physical entities. CPS are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. They allow us to add capabilities to physical systems by merging computing and communication with physical processes.

2)Communication:
Communication refers to the network infrastructure and protocols that enable data exchange between cyber (digital) and physical systems. This is fundamental in Industry 4.0, as it allows for the seamless flow of data between machines, sensors, and the central control system. //It enables real-time monitoring, remote control, and data sharing across the entire manufacturing ecosystem.//

3)Control:

Control in the 5C model represents the decision-making and control mechanisms. In Industry 4.0, control systems leverage real-time data from CPS and communication infrastructure to make intelligent decisions. This is crucial for achieving goals such as predictive maintenance, quality control, and process optimization.

4)Computation:
The computation component involves data processing and analysis. In Industry 4.0, large volumes of data are generated from CPS and other sources. This data must be processed and analyzed to derive meaningful insights, make informed decisions, and optimise processes.

5)Configuration:
Configuration refers to the ability to adapt and reconfigure systems and processes dynamically. This aspect is important in Industry 4.0 to accommodate changes in production demands, equipment, and processes efficiently.

Data-to-information conversion is essential in Industry 4.0 for several reasons:

Raw data collected from sensors and devices are often in a format that is not directly usable. Conversion involves processing, organizing, and analyzing this data, making it meaningful and actionable. This is vital for informed decision-making.
In Industry 4.0, decisions often need to be made rapidly and accurately. Converting data into information provides decision-makers with the context and knowledge they need to make informed choices. Information derived from data analysis can reveal areas for process improvement and efficiency gains. This is critical for achieving Industry 4.0 goals, such as reducing downtime, improving product quality, and minimizing resource wastage.
Data-to-information conversion enables the customization of processes and services. For example, in smart manufacturing, insights from data can lead to tailored product configurations or personalized user experiences, enhancing customer satisfaction.
Information obtained from data analysis aids in resource allocation, whether it's assigning manpower, scheduling machine usage, or optimizing energy consumption. This helps companies utilize their resources more efficiently and cost-effectively.

Q3. Analyze the significance of machine diagnosis and prognosis in Industry 4.0. How does the CPS reference architecture implement the prognosis and diagnosis functions?

Ans: Machine diagnosis and prognosis are of significant importance in Industry 4.0 for the following reasons:
1. Minimizing Downtime:
By continuously monitoring the health and performance of machines through diagnostics, potential issues can be identified early. Prognostics can predict when a machine might fail or require maintenance. This allows for proactive maintenance and minimizes unplanned downtime, leading to increased productivity and reduced production losses.

2. Cost Reduction: Predictive maintenance, made possible by prognosis, helps in optimizing maintenance schedules and resource allocation. This reduces maintenance costs and prevents unnecessary equipment replacement or repairs.

3. Enhancing Product Quality:
Machine diagnostics can identify deviations in machine performance that might affect product quality. By addressing issues promptly, manufacturers can maintain consistent product quality, reducing defects and waste.

4. Resource Efficiency:
Prognosis and diagnosis help in the efficient utilization of resources, such as spare parts and labor. This leads to resource savings and cost efficiency.

5. Safety:
Ensuring the reliability of machines through diagnosis and prognosis contributes to workplace safety by preventing accidents and hazards associated with equipment failures.

The Cyber-Physical Systems (CPS) reference architecture plays a crucial role in implementing diagnosis and prognosis functions in Industry 4.0:

1. Data Collection:
CPS components, such as sensors embedded in machines, continuously collect data on machine performance, operating conditions, and environmental factors.

2. Communication:
CPS enables real-time communication of data from machines to centralized systems or the cloud. This data includes information necessary for diagnosis, such as sensor readings, error codes, and historical performance data.

3. Data Analytics:
The computation component of CPS processes and analyzes the collected data. Machine learning and predictive analytics algorithms can be applied to identify patterns, anomalies, and early signs of machine degradation or failure.

4. Diagnostics:
CPS systems utilize diagnostic algorithms to analyze real-time and historical data to identify current or potential issues with machines. When anomalies are detected, alerts or notifications can be generated for maintenance personnel.

5. Prognostics:
Prognosis functions in CPS leverage predictive modeling techniques to forecast the future state of machines. This includes predicting when maintenance is likely to be needed and estimating remaining useful life. Prognostic algorithms use historical data, machine specifications, and real-time conditions to make these predictions.

6. Decision Support:
The control component of CPS integrates diagnostics and prognostics to provide decision support. When a potential issue is identified, CPS systems can trigger maintenance tasks or adjust production schedules to accommodate maintenance activities.

4. What are the characteristics and benefits of cloud computing, and how has it impacted the IT industry?

Ans- Benefits of Cloud Computing are as follows:-

Faster time to market

You can spin up new instances or retire them in seconds, allowing developers to accelerate development with quick deployments. Cloud computing supports new innovations by making it easy to test new ideas and design new applications without hardware limitations or slow procurement processes.

Scalability and flexibility

Cloud computing gives your business more flexibility. You can quickly scale resources and storage up to meet business demands without having to invest in physical infrastructure.

Companies don't need to pay for or build the infrastructure needed to support their highest load levels. Likewise, they can quickly scale down if resources aren't being used.

Cost savings

Whatever cloud service model you choose, you only pay for the resources you actually use. This helps you avoid overbuilding and overprovisioning your data center and gives your IT teams back valuable time to focus on more strategic work.

Better collaboration

Cloud storage enables you to make data available anywhere you are, anytime you need it. Instead of being tied to a location or specific device, people can access data from anywhere in the world from any device—as long as they have an internet connection.

Advanced security

Despite popular perceptions, cloud computing can actually strengthen your security posture because of the depth and breadth of security features, automatic maintenance, and centralized management.

Reputable cloud providers also hire top security experts and employ the most advanced solutions, providing more robust protection.

Data loss prevention

Cloud providers offer backup and disaster recovery features. Storing data in the cloud rather than locally can help prevent data loss in the event of an emergency, such as hardware malfunction, malicious threats, or even simple user error.

5. Explain in brief the different deployment models available in Cloud computing. Prepare a comparative analysis of the deployment models based on cost vs. Security and scalability vs. control metrics.

Ans-

The Public Cloud allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness,

Example: Using Google Drive for storing and sharing files with anyone online.

The Private Cloud allows systems and services to be accessible within an organization. It offers increased security because of its private nature.
Example: A company sets up an internal private cloud for its employee data and critical business applications.

Community Cloud -The Community Cloud allows systems and services to be accessible by group of organizations.
Example: Multiple universities share a community cloud to collaborate on research projects and securely store educational materials.

The Hybrid Cloud is a mixture of public and private cloud However, the critical activities are performed using private cloud while the non critical activities are performed using public cloud
Example: A company runs its customer-facing website on a public cloud while keeping sensitive financial data on a private cloud.

Comparative analysis of the deployment models:

Public Cloud:
Cost: Cost-effective, pay-as-you-go.
Security: Potentially less secure but managed by the provider.
Scalability: Highly scalable.
Control: Limited control, provider-managed
.
Private Cloud:
Cost: More expensive with dedicated infrastructure.
Security: Highly secure, isolated within the organization.
Scalability: Limited by internal infrastructure.
Control: Full control, tailored configurations.

Community Cloud:
Cost: Cost-effective when shared among organizations.
Security: Better security due to a specific community.
Scalability: Depends on agreements and provider capacity.
Control: Shared control among community members.

Hybrid Cloud:
Cost: Offers cost flexibility by mixing public and private clouds.
Security: Variable, depending on private and public cloud choices.
Scalability: Scalability varies by cloud type.
Control: Mixed control, depending on deployment choices.

C-Additive Technology + AR-VR

1. Differentiate between conventional manufacturing and additive manufacturing.
Ans- *Conventional Manufacturing:*

1. *Cuts Away Material*: It starts with a big piece of material and cuts away to create the final part.
2. *Uses Molds and Tools*: Often needs special molds and tools, which can be expensive.
3. *Creates Waste*: Produces waste material because you're cutting away.
4. *May Require Assembly*: Sometimes, you need to put several parts together.
5. *Less Customization*: Limited ability to make unique or custom parts.
6. *Takes Time*: Longer setup times for production.
7. *Materials*: Typically, it uses a wide range of materials, including metals, plastics, and composites.
8. *Mass Production*: Suited for high-volume production of identical parts.
9. *Tool Wear*: Cutting tools may wear out over time and need replacement.
10. *Traditional Techniques*: Includes processes like machining, casting, forging, and molding.
11. *Surface Finish*: Often requires additional finishing processes like polishing or painting.

Additive Manufacturing (3D Printing):
1. *Builds Layer by Layer*: It creates objects by adding material layer by layer.
2. *No Molds Needed*: No need for expensive molds or tools.
3. *Minimal Waste*: Generates very little waste as it adds material only where needed.
4. *Complex Shapes Easily*: Good for making complex shapes without assembly.
5. *Highly Customizable*: Great for making unique and custom parts.
6. *Faster Setup*: Faster to set up for production.
7. *Materials*: Offers a growing variety of materials, including plastics, metals, ceramics, and even biomaterials.
8. *Customization*: Ideal for low-volume production or one-off customized parts.
9. *No Tool Wear*: No tools to wear out since it's an additive process.
10. *Layered Build*: Constructs parts layer by layer from a digital design file.
11. *Surface Finish*: May require less post-processing due to layering but can be improved with additional steps if needed.

2. Explain briefly about the role of additive technology in Industry 4.0. (10-marks)
Ans- Industry 4.0 is about making factories and production smarter with technology.Additive technology,like 3D printing,helps a lot in several ways:

1) *Design Freedom*:
- With 3D printing, you can create almost any shape or design you can imagine. It's like having a magic tool that makes your ideas come to life.

2) *Material Options*:
- 3D printing lets you use different materials, like plastic, metal, or even special stuff like food or human tissue. You pick the material that fits your needs.

3) *Lightweighting*:

- 3D printing can make parts that are very light but still strong. This is important because lighter things use less energy and work better, like making cars more fuel-efficient.

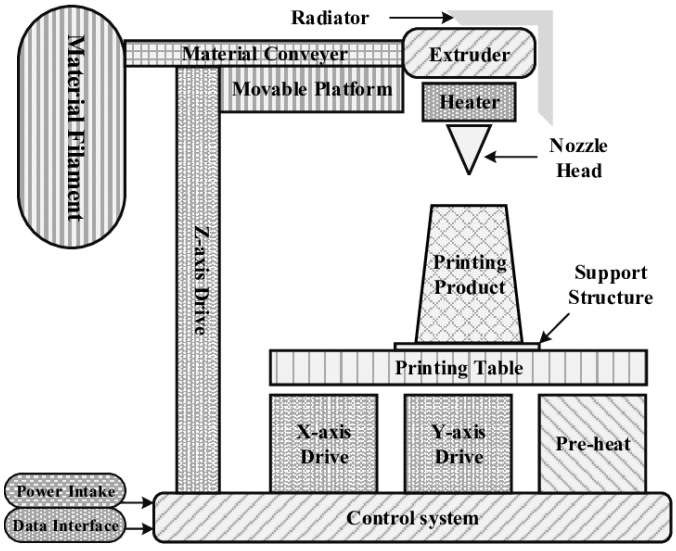
4) *Speed*:
- It's like having a super-fast printer for real objects. You can go from an idea to a physical part in a short time, which is great for making things quickly.

5) *Less Waste*:
- Traditional manufacturing often creates a lot of leftover material. 3D printing is more like using just the right amount of material, so there's less waste, which is better for the environment.

6) *Cost Savings*:
- Even though 3D printers can be expensive at first, they can save money in the long run by using less material and making production more efficient.

7) *On-Demand Production*:
- Instead of making a lot of things and storing them in a warehouse, you can make things when you need them. It's like having a store that only stocks what's needed, reducing storage costs.

3. List the various processes involved in 3D printing or additive manufacturing with a schematic diagram, and what are its advantages and limitations? (10-marks)
SCHEMATIC DIAGRAM



Ans- Few basic processes that are involved in 3D printing which are: -
1. Modeling: 3D printing begins with the process of designing the product in digital form using software like AutoCAD, solid works, etc.
2. STL File Format: STL file format is mostly used in Stereolithography. It is also called Standard Tessellation Language or Standard Triangle Language STL file format is used for describing the surface geometry of an object to be printed by the 3D printer before the process starts.

3. 3D Slicing: 3D slicing is the process of breaking down a design into several layers. A slicer generates a G code which helps in providing instructions to the 3D printer that is how the print process should be carried out.

Advantages:
1. Design freedom
2. Material options
3. Lightweighting
4. Speed
5. Less waste
6. Cost savings
7. On-Demand Production

Disadvantages:
Cost of equipment, Size constraints, Speed for mass production,
Quality control, Complexity, Environmental concerns,

4. What are virtual reality's core elements? Give specifics. (10-marks)
Ans- The core components of Virtual Reality (VR) typically include:

1. *Computing Device*: A powerful computer or gaming console is often necessary to run VR applications smoothly, rendering the virtual environments.

2. *Headset*: The VR headset is the primary hardware worn on your head, covering your eyes and ears to immerse you in the virtual world.

3. *Sensors*: Inside the headset, sensors track your head movements and sometimes even hand movements, allowing you to interact with and navigate the virtual environment.

4. *Input Devices*: Some VR systems come with handheld controllers or gloves that enable you to interact with virtual objects and navigate within the VR space.

5. *Audio System*: VR systems often include 3D audio technology to provide realistic sound experiences, making it seem like sounds are coming from specific directions.

6. *Software*: Specialized software or apps create and control the virtual experiences you encounter in VR, from games to simulations.

7. *Display*: VR headsets have high-resolution screens right in front of your eyes, providing a 3D view of the virtual environment.

8. *Tracking System*: For room-scale VR, there's a tracking system that monitors your physical movement within a defined space.

5. What are augmented reality's difficulties? Provide specifics. (10-marks).
Ans-
1. *Hardware Costs*: AR devices like smart glasses can be expensive, making them less accessible to many people.

2. *Battery Life*: AR apps drain device batteries quickly, limiting usage time.

3. *Tracking Accuracy*: Ensuring that virtual objects stay aligned with the real world accurately can be challenging.

4. *Content Development*: Creating high-quality AR content requires specialized skills and can be time-consuming.

5. *Privacy Concerns*: AR may raise privacy issues due to data collection and sharing.

6. *User Interface Complexity*: Designing intuitive AR interfaces that users understand easily can be tricky.

7. *Motion Sickness*: Some users experience motion sickness or discomfort during AR experiences.

8. *Dependence on Connectivity*: AR often relies on a stable internet connection, which can be problematic in areas with poor connectivity.

9. *Limited Field of View*: AR headsets may have a limited field of view, affecting the immersion level.

10. *Social Acceptance*: People using AR devices in public may face social acceptance challenges and concerns from others.

11. *Safety*: Using AR while walking or driving can lead to accidents and safety risks.

6. Write the advantages and disadvantages of AR and VR.
Ans- Advantages of VR:
Realistic Experiences: Immersive and lifelike environments.
Exploration: Virtual visits to distant places or historical sites.
Enhanced Learning: Interactive and engaging educational content.
Comfort: Safe exploration of challenging or unsafe environments.
Empathy Building: Gaining understanding of others' perspectives.
Medical Training: Realistic training for healthcare professionals.
Product Design: Efficient testing and refinement of products.
Data Visualization: Improved understanding of complex data.
Historical Preservation: Digital preservation of historical sites.
Mental Health: Therapeutic applications for treating conditions.

Disadvantages of VR:
Cost: High initial and maintenance costs.
Motion Sickness: Potential discomfort during extended use.
Isolation: Disconnect from the real world and social interactions.
Health Concerns: Impact on eyesight, posture, and physical activity.
Limited Content: Less content compared to traditional media.
Complex Setup: Difficulties in setting up and dedicating space.
Dependency: Potential addiction and daily life interference.
Privacy: Data collection and privacy concerns.
Compatibility: Limited interoperability between systems.
Safety Risks: Accidents from real-world collisions.

Advantages of AR:
Enhanced Real World: Digital augmentation of the real world.
Interactive Learning: Engaging educational experiences.
Visualization: Improved understanding of complex concepts.
Hands-Free Information: Access information without hands.
Training and Simulation: Realistic training across various fields.
Entertainment: Enhanced gaming and entertainment.
Marketing and Advertising: Interactive and memorable ads.
Remote Assistance: Expert guidance from a distance.
Tourism: Interactive guided tours and historical information.
Accessibility: Improved accessibility for people with disabilities.

Disadvantages of AR:
Technical Requirements: Specialized and potentially expensive hardware.
Battery Drain: Rapid battery consumption in mobile devices.
Privacy Concerns: Data capture and privacy issues.
Limited Field of View: Restricted immersive experience.
Motion Sickness: Potential discomfort during extended use.
Learning Curve: Learning to use AR effectively may take time.
Dependency: Risk of addiction and daily life disruption.
Distraction: Potential for accidents due to distraction.
Content Quality: Varying content quality across applications.
Security Risks: Potential misuse for surveillance or data collection.

D-Evolution & Design Principles

1. Industry 4.0 is a technological convergence of innovation in digital-biological and physical trends. Elaborate on this convergence, highlighting at least four innovations from each trend. (10-marks)
Ans-
Digital Innovations:
Internet of Things (IoT) – allows devices to communicate with each other and the internet, resulting in real-time data collection and analysis.

Artificial Intelligence (AI) – facilitates machine learning and advanced analytics for enhanced decision-making and automation.
Cloud Computing – provides flexible and scalable storage for data, software and applications, enabling remote access and collaboration.
Cybersecurity – secures digital assets against breaches and attacks, ensuring data privacy and integrity.

Biological Innovations:
Biotechnology – uses living organisms or systems to develop new products and processes, such as biofuels and sustainable agriculture.
Pharmaceuticals – creates novel drugs and therapies for treatment and prevention of diseases.
Genomics – studies genetic information to enable personalized medicine and precision agriculture.
Synthetic Biology – designs and constructs biomolecules and organisms for innovative applications in energy, materials, and medicine.

Physical Innovations:
Advanced Robotics – improves efficiency and safety in manufacturing and logistics, and enhances human-robot collaboration in various industries.
Additive Manufacturing (3D Printing) – enables rapid prototyping, customization, and low-volume production, reducing waste and costs.
Advanced Materials – creates high-performance materials with unique properties for diverse applications in aerospace, defense, transportation, and health.
Smart Infrastructure – utilizes sensors and analytics to optimize the use and maintenance of buildings, cities, and utilities, improving sustainability and resilience.

2. Let one of the textile industries has successfully implemented I4.0 technologies at scale. According to you, what are the five significant principles the sector might have adopted as operational changes? Justify your answer. (10-marks)
Ans-
1. Connected and integrated systems: The industry may have implemented IoT-enabled devices to connect machines, operations and data. This allows for seamless communication between different processes, reducing errors and increasing efficiency.

2. Data-driven insights: With big data analytics and machine learning tools in place, the sector may have started using real-time insights to optimize production lines based on demand forecasts, supplier performance evaluation or inventory levels.

3. Agile manufacturing: Adopting lean methodologies like Just-In-Time (JIT) can help textile manufacturers become more responsive to customer needs with flexible production schedules while minimizing waste or overproduction.

4. Automation & robotics-based assembly line : advanced robotics technologies such as autonomous guided vehicles (AGVs), collaborative robots (cobots) ,automated material handling system helps overcome issues of high volume production which requires skilled labour force .

5.Remote Monitoring - Cloud-Based solutions enables operator/officer at distant locations keep a watchful eye with real time metrics monitoring from remotely located/satellite factories/warehouse/hub points etc .

These five operational principles drive the textile industry's success in implementing Industry 4.0 technologies. They enhance communication and efficiency, provide real-time data-driven insights, ensure responsiveness while minimizing waste, streamline production with automation, and enable remote monitoring for proactive measures. Together, these principles optimize operations, reduce costs, and boost competitiveness.

3. A. The third industrial revolution evolved as automation led by digitization. Explain the scope of improvement in automation through the deployment of cyber-physical systems. (5-marks)

Ans- With the deployment of cyber-physical systems, the scope of improvement in automation is immense. Cyber-physical systems combine physical elements like machines and equipment with digital technologies like sensors and software to create a more seamless and synergized production process.

The use of such systems enables faster decision-making based on real-time data, which reduces errors and improves overall efficiency. It also allows for automation across various functions previously handled by human operators.

In addition, cyber-physical systems can provide predictive maintenance capabilities that enhance asset management by capturing performance data in real-time and analyzing it to foresee potential malfunctions before they take place. This helps to reduce downtime caused by sudden breakdowns or accidents and minimize repair costs as well as increases overall plant safety.

Moreover, these systems have vast applications beyond industrial settings - ranging from healthcare facilities to smart cities. Therefore,it plays a significant role in improving our daily lives by making them safer, mobile, and energy-efficient through integration with AI,IOT technology etc.

Overall,the adoption of the cyber-physical system not only brings about technical advancements but also has a positive impact on society at large. Although some challenges remain regarding cybersecurity & skilled personnel.

B. Describe the three-layered framework of Industry 4.0 relating to the hierarchical flow of data. (5-marks)

Ans-

The three-layered framework of Industry 4.0 relates to the hierarchical flow of data in a manufacturing system. The layers, from bottom to top, are

1. Field level: This is where raw data is collected through sensors and other devices that monitor machines, equipment and materials on the factory floor.

2. Control level: Data gathered at the field level is then processed and analyzed by controllers such as programmable logic controllers (PLCs) or edge computing devices for further processing or action.

3. Enterprise level: Finally, data from both the field and control levels is aggregated into a centralized system which allows all relevant stakeholders access to it at any given time.This layer makes use of advanced Big-data analytics,AI-enabled predictive maintenance & decision-making tools etc

This three-layered architecture provides real-time visibility across production lines while increasing transparency between operators,and tracking key performance indicators(KPIs). Moreover,it helps improve overall efficiency and reduces downtime by predicting errors before they occur besides enabling production optimization.

Overall, this allows for better decision-making throughout all levels of an organization based on accurate insights derived from real-world measurements. Although ensuring cybersecurity, and focus on digitization readiness, collaboration between stakeholders needs to be addressed

4. The concept of a digital (virtual) value chain is devised by looking at current internet penetration, computerized designing, and prototyping. Can the digital value chain improve the existing physical value chain? Justify. (10-marks)
Ans-
Certainly, the adoption of a digital (virtual) value chain can substantially enhance the existing physical value chain, leading to numerous advantages. The convergence of internet penetration, computerized designing, and prototyping technologies plays a pivotal role in this transformation.

Firstly, a digital value chain greatly improves visibility and control across the entire supply chain. With real-time data sharing and communication, it fosters seamless collaboration among suppliers, manufacturers, distributors, retailers, and customers. This translates into enhanced coordination of production schedules, more efficient inventory management, and faster, more reliable delivery mechanisms. Reductions in lead time become tangible, enabling companies to respond swiftly to market changes and consumer demands.

Moreover, the digital value chain empowers organizations with predictive capabilities. Advanced analytics and AI-driven tools analyze data from various points along the chain, enabling more accurate demand forecasting. By understanding sales patterns and future demand requirements, companies can optimize their operations and resource allocation, resulting in cost savings and reduced waste.

One notable advantage of the digital value chain is its ability to revolutionize product design and prototyping. Through the integration of 3D printing technology, businesses can expedite the design and prototyping processes. This not only reduces rework costs but also significantly shortens the time required to bring products to market, fostering innovation and competitiveness.
In conclusion, the digital value chain offers a transformative approach to improving the existing physical value chain. It enhances collaboration, provides predictive capabilities, accelerates product development, and optimizes resource allocation. By embracing these advantages, businesses can not only reduce costs but also become more agile, innovative, and competitive in an ever-evolving marketplace.